Summary of Responses from the Water Chemistry and Fisheries Management Questionnaire and Workshops

Statewide Mercury Control Program for Reservoirs

January 2018

CALIFORNIA
Water Boards
STATE WATER RESOURCES CONTROL BOARD
REGIONAL WATER QUALITY CONTROL BOARDS

CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY

EXECUTIVE SUMMARY

To address a statewide mercury problem in reservoirs, the State Water Resources Control Board (State Water Board) has undertaken a statewide program (herein referred to as the "Statewide Mercury Control Program for Reservoirs" or "Program"). The draft Mercury Reservoir Provisions contain a program of implementation for achieving and maintaining mercury water quality objectives. In this Program, staff proposes that reservoir owners and operators will conduct pilot tests of methods to reduce methylmercury concentrations in reservoir fish. A coordinated pilot test among the owners of mercury-impaired reservoirs is proposed such that there will be fewer, focused tests rather than tests in all mercury-impaired reservoirs.

The request for technical information regarding fisheries and water chemistry management stemmed from a June 2016 meeting where reservoir owners discussed current management strategies within their reservoirs for various reasons, such as oxygenation for taste & odor and altering fish stocking practices. Because of that discussion, staff developed a questionnaire regarding water chemistry and fisheries management practices in mercury-impaired reservoirs. The results of the questionnaire will help group, or "bin", reservoirs into groups for coordinated pilot tests.

On June 22, 2017, the State Water Board mailed 131 requests for technical information addressed to the owner of each mercury-impaired reservoir. The questionnaire (see Appendix A), administered via an online form, covered six main topics within 89 questions: reservoir characteristics; water chemistry management; mercury management and monitoring; fisheries management pilot test binning and selection options; and financial and technical contributions to support pilot tests and a technical review committee.

While 119 questionnaire responses have been received, this report summarizes the questionnaire responses from 116 reservoir owners (see Figure 1), representing 91% of the mercury-impaired reservoirs that were sent the questionnaire. Late responses from three reservoir owners were not included in this report; however, these responses did not change the conclusions of this report. From the six main topics, the following bullets provide a general summary of characteristics and management strategies of mercury-impaired reservoirs throughout California.

Reservoir Characteristics

- Almost half of reservoirs (49%) have a dendritic, or branching, shape
- Most reservoir owners (99%) maintain roads, 92% have power supply, and 90% have boat ramps
- Drinking water is directly supplied from 54 reservoirs
- Of 115 reservoirs, 9 are oligotrophic, 85 are mesotrophic/eutrophic, and the trophic status of 21 reservoirs is unknown
- 34% of reservoirs receive source water outside the reservoir's watershed, e.g., Colorado River Aqueduct, State Water Project, groundwater, or piped from outside the watershed

Water Chemistry Management

- Management of oxygen occurs in 19 mercury-impaired reservoirs, primarily to reduce algae growth (13 reservoirs), to reduce general issues drinking water (12 reservoirs), and for fisheries protection (8 reservoirs)

Mercury Management and Monitoring

- 70 reservoir owners have conducted prior total mercury (THg) or methylmercury (MeHg) studies for fish, water, and/or sediment

Fisheries Management

- 46 reservoirs have dedicated fisheries management staff
- 101 reservoirs (86%) of reservoir owners allow fishing in the reservoir
- 16 reservoir owners explicitly do not allow fishing
- Largemouth bass, followed by rainbow trout, channel catfish, carp, and smallmouth bass are the most common species consumed

Pilot Test Binning and Selection Options

- Most reservoir owners suggested that pilot tests should be binned by the source of mercury contamination (e.g., mining, atmospheric, geologic).

Financial and Technical Contributions to Support Pilot Tests and a Technical Review Committee

Pilot Tests

- 2 reservoir owners representing a total of 6 mercury-impaired reservoirs will contribute funding to support coordinated pilot tests
- 7 reservoir owners representing 17 reservoirs indicate they will not contribute financial support towards coordinated pilot tests
- 9 reservoir owners representing 30 reservoirs will provide technical support for pilot tests

Technical review Committee

- 1 reservoir owner, representing 3 mercury-impaired reservoirs will contribute funding for 10 years to support a technical review committee that reviews and advises on pilot tests
- 9 reservoir owners representing 30 reservoirs will provide technical support for a technical review committee

While the proposed draft Mercury Reservoir Provisions do not require that pilot tests be conducted in reservoirs where the reservoir owner holds a Federal Energy Regulatory Commission “FERC” license and the reservoir’s primary purpose is hydropower generation, FERC licensed reservoirs are not precluded from participating in the pilot tests. Therefore, the questionnaire was also sent to these reservoirs to gather as much information as possible about all mercury-impaired reservoirs. Respondents reported 43 reservoirs (37%) hold a FERC license. Twelve agencies/organizations who own 19 FERC license reservoirs responded that they are willing to provide either financial or technical assistance. Owners of 7 FERC licensed reservoirs have volunteered to have a pilot test within their reservoir. While the list of reservoirs subject to this TMDL is not finalized, if the 12 agencies representing 19 FERC licensed reservoirs contribute resources as they indicated in the questionnaire, Phase 1 would encompass 92, or 70% of mercury-impaired reservoirs identified by the Program.

1 BACKGROUND AND GOALS

1.1 Statewide Mercury Control Program for Reservoirs

Harmful levels of methylmercury in fish are a statewide and nationwide problem. Mercury is a bioaccumulative toxic pollutant that results in many reservoir fish having methylmercury levels that pose a risk for humans and wildlife that eat the fish. Mercury does not impair drinking water quality in California reservoirs. The number of reservoirs determined to be impaired by mercury is expected to increase substantially as new fish tissue monitoring data are collected and evaluated. The Statewide Mercury Control Program for Reservoirs applies to the mercury-impaired reservoirs listed on Table 1. Elevated fish methylmercury levels impair the following beneficial uses: commercial and sport fishing (COMM), wildlife habitat (WILD), and rare and endangered species (RARE).

To address the mercury problem in reservoirs, the State Water Resources Control Board (State Water Board) has undertaken the Statewide Mercury Control Program for Reservoirs[1] that has the following main goals:

1. Reduce fish methylmercury concentrations in reservoirs that have already been determined to be mercury-impaired;
2. Have a control program in place that will apply to additional reservoirs when they are determined in the future to be mercury-impaired; and
3. Protect additional reservoirs from becoming mercury-impaired.

To achieve these goals, the State Water Board is proposing to establish a rule titled, “Amendment to the Water Quality Control Plan for Inland Surface Waters, Enclosed Bays, and Estuaries of California—Mercury TMDL and Implementation Program for Reservoirs” (hereinafter, Mercury Reservoir Provisions).

The Mercury Reservoir Provisions include several key elements. The first element is a program of implementation for achieving and maintaining mercury water quality objectives in reservoirs. The program of implementation includes control actions for (1) point and nonpoint sources of mercury, and pilot tests for (2) reservoir water chemistry to reduce methylmercury production and (3) fisheries management to reduce methylmercury bioaccumulation. Implementation would occur over two phases. Phase 1 is expected to last for 10 years, after which the State Water Board will conduct a program review. During Phase 1, reservoir owners and operators (herein referred to simply as reservoir owners) would test feasible reservoir management actions. The State Water Board encourages a coordinated approach for fewer, focused tests rather than tests in all mercury-impaired reservoirs.

Owners and operators of mercury-impaired reservoirs would conduct pilot tests of methods to reduce methylmercury concentrations in reservoir fish. Coordinated pilot tests could be

[1] For more information about the Statewide Mercury Control Program for Reservoirs, visit: https://www.waterboards.ca.gov/water_issues/programs/mercury/reservoirs/

conducted in fewer, targeted reservoirs rather than in all impaired reservoirs. Reservoir owners would convene a third-party independent technical review committee to advise on pilot tests.

Reservoir owners would use lessons learned from pilot tests to develop long-term reservoir and fisheries management plans. During the program review after Phase 1, the technical review committee and the State Water Board would evaluate results of pilot tests and long-term reservoir and fisheries management plans prior to full scale implementation of management practices.

1.2 Questionnaire on Water Chemistry and Fisheries Management

In June 2017, the State Water Board issued a questionnaire to mercury-impaired reservoir owners regarding water chemistry and fisheries management practices in their reservoirs. This request was an outcome from a June 2016 meeting where reservoir owners discussed management strategies currently implemented within their reservoirs for various reasons, such as oxygenation for taste & odor and altering fish stocking practices. It was noted that while the State Water Board has access to basic characteristics for most reservoirs (e.g., physiographic region, surrounding land uses, area mine density, draining area, dam height, reservoir storage volume and capacity), the State Water Board does not maintain information regarding fisheries and water chemistry management practices. This led to the development of a questionnaire to gather management strategies for the initial step of conducting coordinated pilot tests – binning reservoirs into categories.

To ensure the questionnaire was comprehensive and thorough, a draft questionnaire was e-mailed to a focus group of reservoir owners on August 2, 2016. The focus group was asked to review the questions and focus their responses on missing topics and questions that should be included. The focus groups was comprised of six reservoir owners and one association representing many reservoirs. Staff used their feedback to clarify and improve the questionnaire.

On June 22, 2017, the State Water Board mailed 131 requests for technical information addressed to the owner of each mercury-impaired reservoir with a due date of August 6, 2017. The questionnaire (see Appendix A) was administered via an online form for ease of distribution and ease of response analytics. The questionnaire covered seven main topics via 89 questions: reservoir characteristics; water chemistry management; mercury management and monitoring; fisheries management; pilot test binning options; pilot test selection; and willingness for financial and technical contributions to support coordinated pilot tests.

Additional input was obtained during subsequent workshops. The State Water Board hosted two workshops for reservoir owners in October and November 2017 that discussed the initial results from the questionnaire as well as summarized the Staff Report and Mercury Reservoir Provisions. The Staff Report and Mercury Reservoir Provisions were submitted for scientific peer review in April 2017 and was posted to the Program's website for public review prior to the meetings. Attendees were encouraged to review the summary before each meeting and were provided the links to the complete Staff Report and Mercury Reservoir Provisions.

2 QUESTIONNAIRE RESULTS

To date, responses for 119 reservoirs have been received (see Figure 1). The questionnaire covered six topics. Reservoir owners of mercury-impaired reservoirs were encouraged to coordinate completion of the questionnaire with other agencies/organizations if the owner's agency/organization was not responsible for overseeing fisheries and/or water chemistry management. Many questions were conditional questions and some responses did not pertain to all participants, therefore, some statistics presented are based on a subgroup of responses (i.e., if a question had a 'yes' answer, then there were follow up questions). If a statistic was based on a lower response rate, the number of responses is indicated. The following sections discuss questionnaire results and present statistics based on 116 of 131 (89%) possible responses, unless otherwise noted.

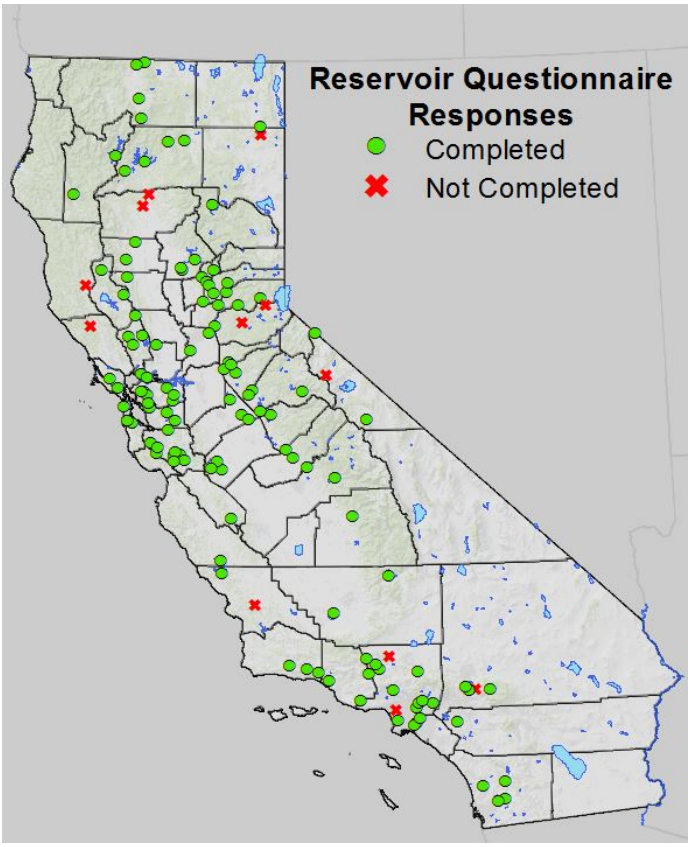

Figure 1: Questionnaire responses were received for 119 of 131 mercury-impaired reservoirs

2.1 Reservoir Characteristics

Ownership Type

A variety of federal, state, county, city municipalities; water districts; homeowner associations; and private companies own mercury-impaired reservoirs. Sixty-three agencies/organizations own the 131 mercury-impaired reservoirs, with 17 owners managing more than one reservoir.

See Figure 2 for the distribution of reservoir ownership types. The reservoirs that have not responded were contacted multiple times. The reservoir owners that did not complete the questionnaire were informed that the answers to this questionnaire would benefit the long-term development of the Program and decisions affecting their reservoir(s) may be made as a result. The distribution of ownership types for the 12 reservoirs that have not responded are: privately-owned reservoirs (5); federally-owned (4); utility, irrigation, or water districts (2); and state-owned (1).

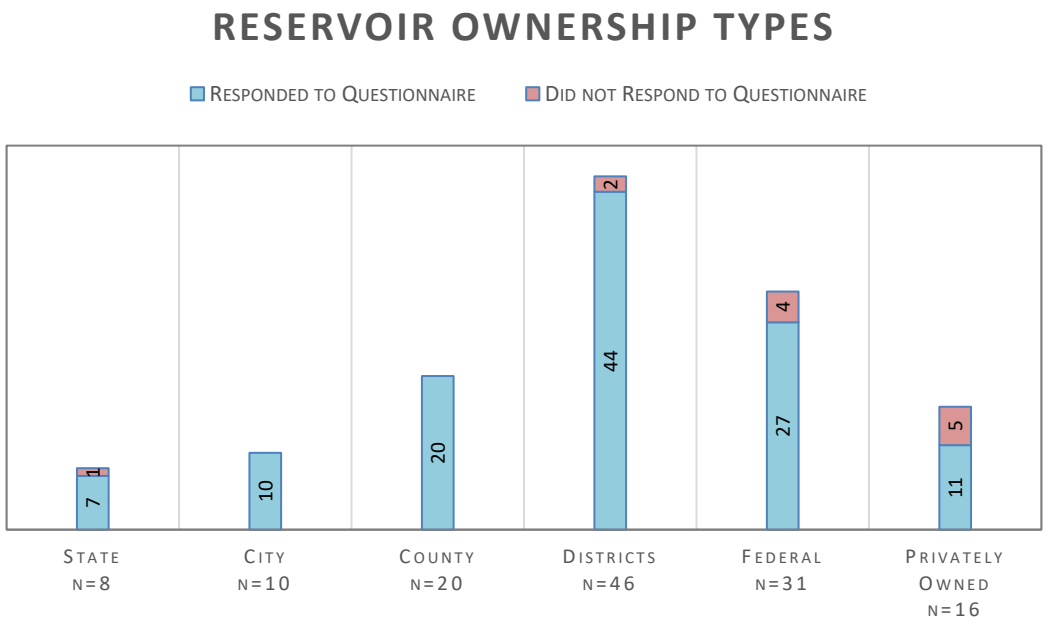

Figure 2: Reservoir ownership types for 131 mercury-impaired reservoirs

FERC license Reservoirs

Respondents reported 43 reservoirs (37%) are associated with a Federal Energy Regulatory Commission “FERC” license. The draft Mercury Reservoir Provisions are not requiring pilot tests in reservoirs where the reservoir owner holds a FERC license and the reservoir’s primary purpose is hydropower generation. However, FERC license reservoirs will not be excluded from participating in the Program and conducting reservoir pilot tests. This leaves 73 reservoirs to either conduct individual pilot tests or initiate a coordinated approach. FERC license reservoirs represent a sizeable portion of mercury-impaired reservoirs and would benefit by engaging in coordinated pilot tests with reservoirs containing similar characteristics. Questionnaire results indicate twelve agencies/organizations who own 19 FERC licensed reservoirs are willing to provide either financial or technical assistance during Phase 1. Owners of 7 FERC licensed reservoirs have volunteered to have a pilot test within their reservoir. If the 12 agencies representing the 19 FERC reservoirs contribute resources, Phase 1 pilot studies would encompass 92, or 70% of the currently identified mercury-impaired reservoirs throughout California.

Geometry

Many reservoirs (49%) have a dendritic, or branching, reservoir shape compared to 25% having a bowl-shaped. Twenty-five percent classify their reservoirs as a combination of the two, with the remaining 1% classified as a series of ponds.

Infrastructure

Most reservoir owners (99%) maintain roads, 92% have power supply, and 90% have boat ramps. Thirty five percent have public camping facilities.

Source Water

Thirty-four percent of reservoirs source their water outside of the reservoir's watershed. The majority of the water sources to these 40 reservoirs originates from the Colorado River Aqueduct, State Water Project, groundwater, or piped from other reservoirs outside the watershed.

Reservoir Trophic Status

Of 115 reservoirs, 9 are oligotrophic (low nutrient concentrations), 85 are mesotrophic/eutrophic (moderate to high nutrient concentrations), and the trophic status of 21 reservoirs is unknown. For the nine reservoirs that are reported to be oligotrophic, reservoirs owners determined this by various methods: owners of 4 reservoirs measure trophic status by total phosphorus data concentrations that are less than 8 micrograms (µg) phosphorous per liter. One reservoir owner calculates trophic status based on summer epilimnetic chlorophyll concentrations that are less than 3 µg chlorophyll per liter; one by Carlson's Trophic State Index; one reservoir owner used information based on prior studies conducted by the United States Geological Survey; and one reservoir owner generally determines trophic status based on water temperature and dissolved oxygen profiles.

Drinking Water Supply

Drinking water is directly supplied from 54 reservoirs, with an additional 18 reservoirs diverting water downstream or via pipeline to drinking water plants or into other drinking water reservoirs.

2.2 Water Chemistry Management

General Management

Greater annual drawdown in reservoir water levels correlates with higher fish methylmercury concentrations. Reservoir owners confirmed drawdown for purposes of drinking or irrigation supply; creation of space for runoff or in advance of storms; hydropower generation; aquatic plant or animal control; protection of the shoreline from the erosion effects of high water. Drawdown also occurs for other reasons such as avoidance of water seepage from damaged concrete, groundwater basin recharge, and downstream fish habitat preservation flow requirements.

Temperature management occurs in approximately 11% of the reservoirs. Twelve reservoirs confirm managing in-reservoir temperature for downstream fisheries while only one reservoir reported temperature management for in-reservoir fisheries. Reservoir stratification may be either the reason or result of temperature management. Three reservoir owners confirm temperature management to encourage stratification, two manage to reduce stratification, and four reservoir owners manage temperature, but stratification is not affected.

Changes in stratification patterns may also be the result of seasonal mixing. While 38% of reservoir owners are not aware if mixing occurs, 42% confirm that their reservoir is monomictic (one mixing, i.e., fall destratification). Three percent are meromictic (little to no mixing), 6% are dimictic (winter ice cover, spring mixing, summer stratification, fall destratification), 7% are polymictic (many mixings per year), while 4% confirm no seasonal mixing occurs. Reservoir owners determine the strength of stratification by reviewing seasonal temperature and dissolved oxygen water column profiles. Some reservoir owners calculate the strength of thermal stratification by calculating the Richardson number, Schmidt's Stability Index, or the slope of the metalimnion. Active, or forced, mixing occurs in 14% of reservoirs, mainly via bubble aeration.

Water quality monitoring parameters and monitoring frequency were reported for temperature, dissolved oxygen, pH, specific conductance, oxygen-reduction potential, chlorophyll-a, phycocyanin, and other parameters such as nutrients, phytoplankton, inorganics, and fecal coliform (Figure 3). Temperature, dissolved oxygen, pH, specific conductance, and turbidity are the water quality parameters most sampled. Very few reservoirs monitor for oxygen reduction potential, chlorophyll-a, or phycocyanin. Fourteen reservoirs, owned by 10 agencies/organizations do not monitor for any parameters within their reservoir.

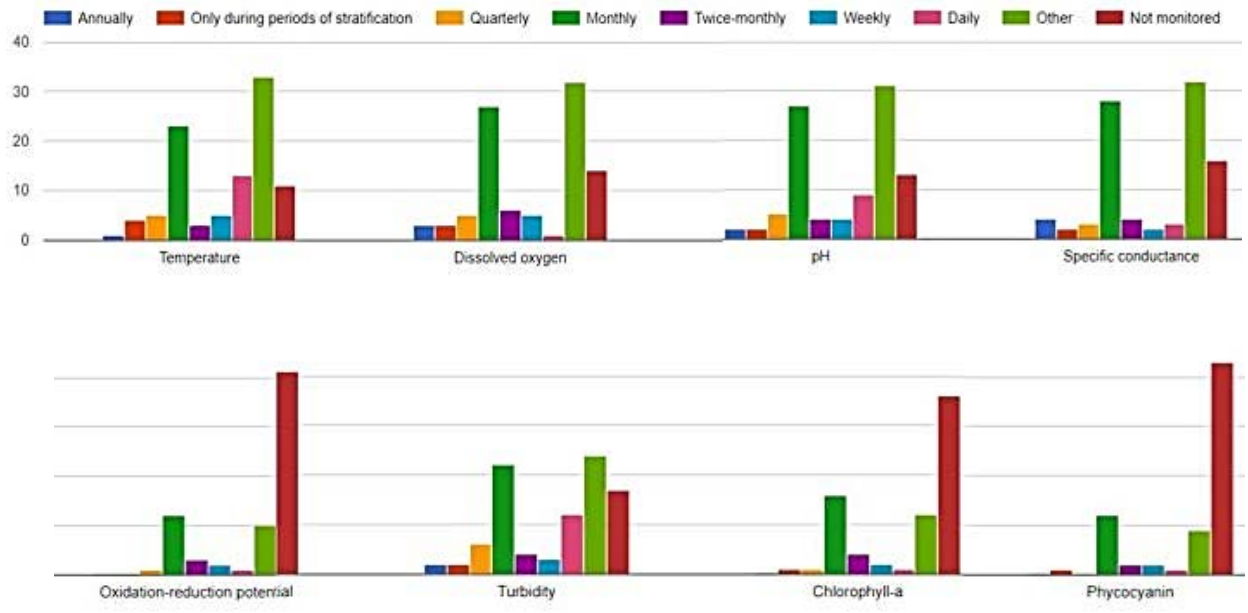

Figure 3: Frequency of water monitoring in mercury-impaired reservoirs

Specialized Management

Specialized management includes addition of oxygen; nutrient management by restoring salmon runs via fish ladders or from minimal additions of nitrogen or phosphorus; and aquatic weed and invasive species physical or chemical controls.

Oxygenation

Management of oxygen occurs in 19 mercury-impaired reservoirs, primarily to reduce algae growth (13 reservoirs), to reduce general issues drinking water (12 reservoirs), and for fisheries protection (8 reservoirs). Other reservoirs oxygenate to suppress the release of iron and phosphorous from the sediments (5 reservoirs), suppress hydrogen sulfide (1 reservoir), reduce manganese (1 reservoirs), and for the experimental control of mercury (1 reservoir).

Four reservoirs oxygenate by surface mixing. Eight reservoirs break stratification during oxygenation and seven confirm the oxygenation does not break stratification. When oxygenation occurs, air is the primary form (66%) followed by pure oxygen (33%). Seven reservoir owners plan to manage for oxygen (though specific reasons were not provided). Regarding feasibility to oxygenate, 77 reservoir owners are unaware if oxygenation is feasible and 22 reservoir owners state oxygenation is feasible. Seven reservoir owners state oxygenation is not feasible, citing lack of power; financial costs; large-scale excavations or other reservoir-wide long-term projects; and the size and depth of the reservoir.

For the seven reservoir owners that plan to manage for oxygen, two reservoir owners plan to install oxygenation systems that will break stratification, one reservoir owner will install oxygenation systems that will not break stratification (e.g., Speece Cone), and the other reservoirs do not know the type of oxygenation system to be installed.

Salmon Run Restoration

Owners of three reservoirs have undertaken physical actions with the goal of restoring historical salmon runs (e.g., fish ladders) and six additional reservoir owners intend to take physical actions with the goal of restoring historical salmon runs. No reservoir agency/organizations have undertaken actions with the goal of restoring nutrients provided by salmon runs prior to dam construction (e.g., minimal additions of nitrogen or phosphorus - including from natural sources like fish pellets or carcasses); however, two reservoirs plan to undertake actions with the goal of restoring nutrients provided by salmon runs.

Aquatic Weed, Invasive Species, and Algae Control

Thirty-four percent of reservoirs are enrolled in the statewide general permit for aquatic weed control applications and 35% of agencies/organizations perform in-reservoir controls for other invasive species (e.g., quagga/zebra mussels). To control algae, application of chemicals or technology (either in-reservoir application or outside reservoir boundaries with potential for chemicals to leach into reservoir) is conducted via application of copper compounds, hydrogen peroxide, light absorbing dyes, and other algaecides such as Triclopyr and PAK27 (sodium carbonate peroxyhydrate).

2.3 Mercury Management and Monitoring

Seventy reservoirs have conducted prior studies for total mercury (THg) or methylmercury (MeHg) in fish, water, and/or sediment, 42 reservoir owners do not know if mercury studies have been conducted, and 9 reservoirs confirm studies have not been conducted. In order of decreasing frequency of types of in-reservoir mercury studies performed, the majority have conducted THg studies in water column; MeHg in fish tissue; and THg in sediment. The majority of the fish studies were conducted a result of State Water Board's Surface Water Ambient Monitoring Program (SWAMP) 2007-2008 fish collection and analysis of contaminants from California lakes and reservoirs. Prior studies were performed by the United States Geological Survey, United States Bureau of Reclamation, the Toxic Substances Monitoring Program, or required during FERC relicensing process.

Reservoir THg or MeHg monitoring is primarily conducted as THg in the water column (34 reservoirs), followed by MeHg in fish (15 reservoirs), THg in sediment (6 reservoirs), and then MeHg in the water column (3 reservoirs). Management practices to reduce methylation, including enhancing demethylation in the sediment or water column (e.g., contaminated sediment removal, oxygenation) has been conducted in four reservoirs. Two in-reservoir sediment removal or encapsulation to address inorganic mercury hotspots such as submerged or near-shore mine sites and mining waste have been performed. Pertaining to managing upstream THg or MeHg sources, 10 reservoirs confirm performing upstream management strategies such as mine or creek bed cleanups.

2.4 Fisheries Management

Forty-six reservoirs have dedicated fisheries management staff. Either the owner, a concessionaire, or the California Department of Fish and Wildlife have stocked seventy reservoirs within the past 10 years. The species of the stocked fish in most reservoirs consist of rainbow trout on an annual basis, but trout are also stocked on weekly, monthly, bi-monthly, and semi-annual basis in many reservoirs. Stocking of largemouth bass occurs in 10 reservoirs; lake trout in 16; brown trout in 11; kokanee in 7; smallmouth bass in 6; spotted bass in 3; and striped bass in 1. Reservoir owners indicate other species of fish, including catfish, are stocked in 32 reservoirs. Introduction of fish into a reservoir may occur through water transfer pipelines. Introduction of either trophic level (TL) 3 or TL 4 fish from outside the reservoir's watershed occurs at 15 reservoirs.

Fish are required to be stocked by California Department of Fish and Wildlife in 8 reservoirs; by the reservoir's FERC license in 7 reservoirs; by other permits or regulations in 5 reservoirs; and for other non-specified reasons in 50 reservoirs, perhaps for recreation and economic reasons. Two reservoir owners actively cull fish from their reservoir.

Eighty-six percent (101) of reservoir owners allow fishing in the reservoir. Sixteen reservoir owners explicitly do not allow fishing and one reservoir owner confirms that fishing is not allowed, although it happens anyways. Fifty-five percent of reservoirs have sport fishing or other managed public fishing events with mostly largemouth bass and subsequently trout being the focus of the events.

Consumption of fish occurs in 75% of reservoirs, confirmed primarily by observation or creel surveys. Largemouth bass, followed by rainbow trout, channel catfish, carp, and smallmouth bass are the most common species consumed. The fish listed below are also consumed:

- Brown trout
- Spotted bass
- Kokanee
- Chinook
- Lake trout
- Bluegill
- Crappie (Black, White)
- Perch (Yellow, Redear)
- Sunfish
- Bullhead (Black, White, Brown)
- Tiger trout
- Crayfish
- Catfish
- Panfish

Statewide advisories for mercury in fish, such as Office of Environmental Health Hazard Assessment's Statewide Advisory for Eating Fish from California's Lakes and Reservoirs (Figure 4) are currently posted at 44 reservoirs, 8 have posted advisories at reservoirs within the past 12 months, 5 within the past 5 years, and 5 plan to post fish advisories for mercury. Forty-Nine percent (59 reservoirs) do not have mercury advisories posted.

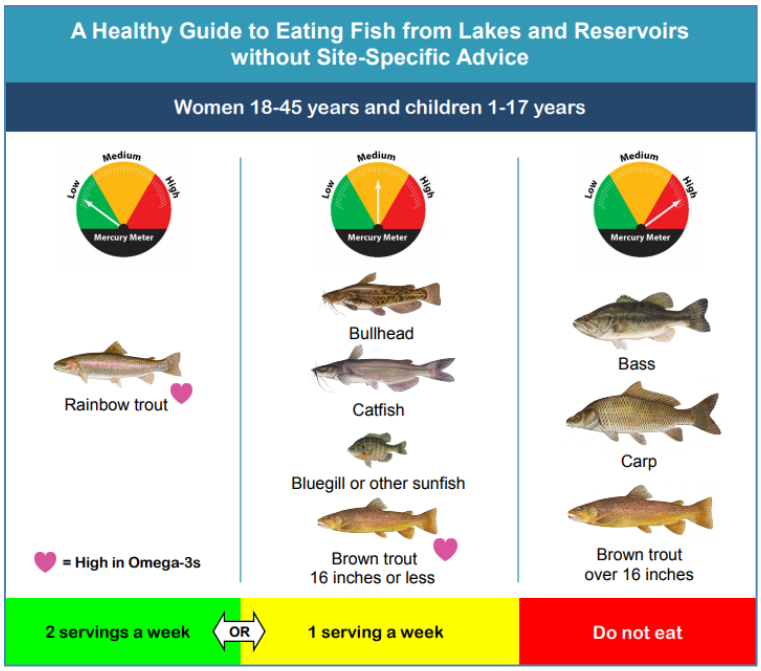

Figure 4: California's Office of Environmental Health Hazard Assessment's Statewide Advisory for Eating Fish from California's Lakes and Reservoirs.

2.5 Pilot Test Binning and Selection Options

A key action proposed for Phase 1 is for owners of mercury-impaired reservoirs to conduct pilot tests to reduce methylmercury concentrations in reservoir fish. Coordinated pilot tests could be conducted in fewer, targeted reservoirs rather than in all impaired reservoirs to be more economically feasible. Therefore, the questionnaire gathered feedback on various options to bin the reservoirs into different categories for the pilot tests. Reservoir owners would convene a third-party independent technical review committee to advise on pilot tests and binning alternatives.

Classification or "Binning" system for pilot tests

Below are the binning options for pilot tests based on 118 responses, see Figure 5. The count of responses for the binning options are listed alongside each option. Selection of multiple options were possible, in addition to a write-in option. The write-in responses are listed below the 'Other' category.

- Potential source of mercury contamination **(60)**
- Reservoir size/shape **(49)**
- Geographic regions – (Klamath/Trinity/Cascade Mountain; Coast Ranges, Valley Floor, Sierra Nevada, Transverse Ranges, and Peninsular Ranges) **(49)**
- Geologic regions: trace mercury, mercury-enriched, or mercury mineralized **(39)**
- Reservoir function **(33)**
- Highest trophic level fish in reservoir **(15)**
- Fish management practices **(13)**
- Elevation **(5)**
- Other binning options:
    - Unsure **(23)**
    - Fish consumption rate **(7)**
    - Source of water **(6)**
    - Urban/non-urban waterbodies **(5)**
    - Targeting reservoirs where new water quality or fisheries management practices are already being planned or will soon be implemented **(1)**
    - Degree of contamination **(1)**

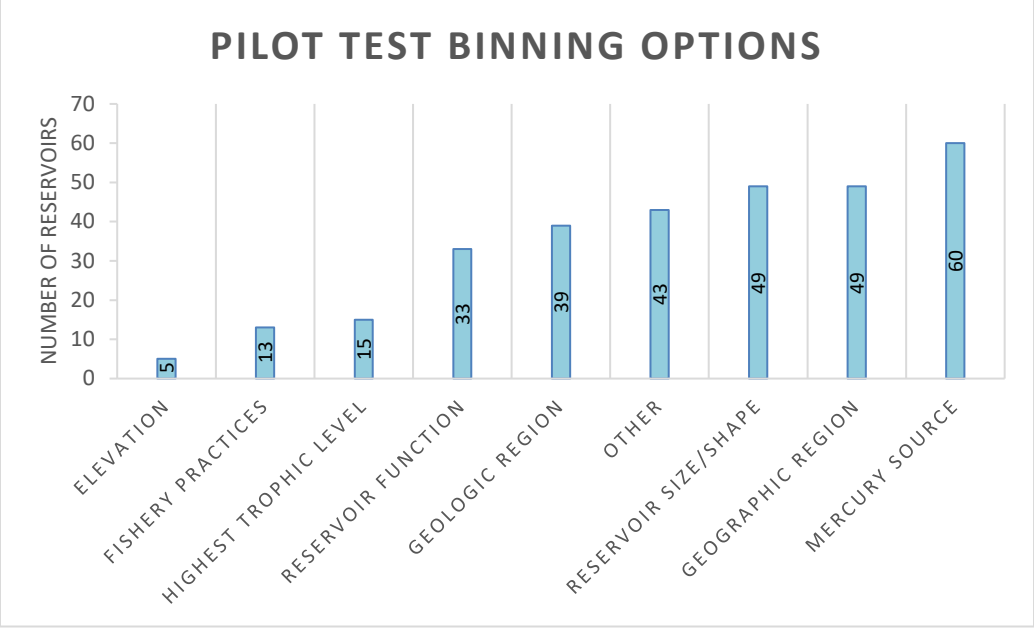

Figure 5: Pilot Test Binning Options.

Most reservoir owners selected the reservoir's primary mercury source (e.g., mining, atmospheric deposition, geologic) as their preferred the pilot test classification option, followed by geographic region. Several binning options are closely related to mercury sources, as the mercury source can be related to geographic areas where soils are naturally mineralized with mercury; where mercury and gold mines were clustered; and in Southern California where atmospheric deposition is the primary source of mercury. While watershed mercury sources will not be within the scope of water chemistry and fisheries management pilot tests, recognizing the importance of these external factors will help inform the final selection of reservoirs for pilot tests based on the different binning options. In addition to the binning options in the bulleted list above, additional binning options could include reservoir trophic status and other reservoir management characteristics.

Targeted Pilot test

While every reservoir will be within a pilot test group, pilot tests will not be conducted in every reservoir. After the initial grouping of reservoirs, the Program's participants may decide which reservoirs to target for the pilot test. Below are the options given to reservoir owners to determine which reservoirs are targeted for pilot tests, see Figure 6.

A. Target reservoirs that need the greatest MeHg reduction in fish **(52)**
B. Target reservoirs where new water quality or fisheries management practices are already being planned or will soon be implemented, and evaluate those practices for effects on mercury **(47)**
C. Target reservoirs that have greatest rates of human consumption of fish **(36)**
D. Target reservoirs that do not need more oxygenation systems installed; it is sufficient to study existing systems for their effects on mercury **(22)**
E. Reservoirs with existing aqueous, fish tissue, and/or sediment mercury data **(19)**
F. Target reservoirs with existing infrastructure and ease of access (e.g., maintained roads, power, boat ramps, etc.) **(18)**
G. Target reservoirs with ease of operations and management (e.g., ability to engineer, install, and maintain pilot tests with limited technical staff and operations management) **(24)**
H. None of the above (23)

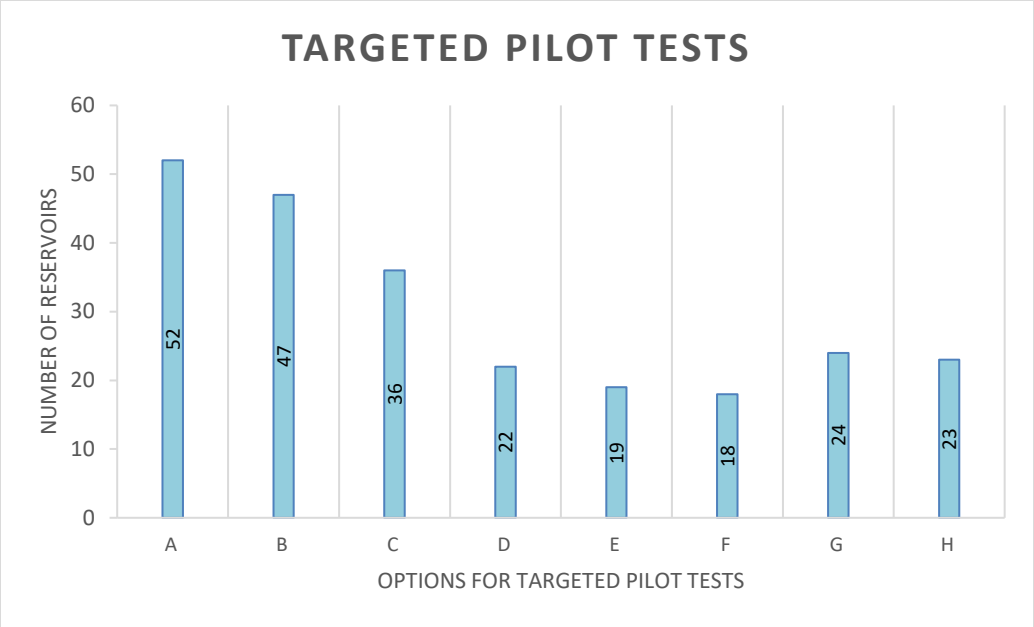

Figure 6: The majority of reservoir owners chose oxidant addition as the pilot test target options appropriate for their or similar reservoirs.

Pilot test options

A list of potential water chemistry and fisheries management pilot tests was provided to reservoir owners. They were asked which management practices their agency/organization supports as a pilot test in either their reservoir or reservoirs similar to theirs and if their agency/organization has additional suggestions. Below is the list with the count of support listed after each option, see Figure 7.

Manage reservoir water chemistry to reduce methylmercury production:

A. Oxidant addition to reservoir bottom waters (near the sediment-water interface) to reduce anoxia or adjust redox potential when reservoirs are stratified to suppress methylation of mercury. Evaluate various oxidants (e.g., dissolved oxygen, ozone, nitrate, others) for (a) efficacy for methylmercury reduction, (b) multiple benefits (e.g., drinking water quality, algal controls), and (c) avoidance of adverse consequences **(29)**
B. In-reservoir sediment removal or encapsulation to address inorganic mercury hotspots such as submerged or near-shore mine sites and mining waste **(13)**
C. Other management practices to reduce methylation, including enhancing demethylation **(17)**

Manage fisheries to reduce fish bioaccumulation of methylmercury:

D. Nutrient management such as minimal additions of nitrogen or phosphorus (including from natural sources such as restoring historical salmon runs) to slightly increase chlorophyll-a concentrations in oligotrophic reservoirs **(4)**
E. Intensive fishing to increase the growth rate of remaining fish **(10)**
F. New or changes to fish stocking practices to increase the abundance of fish with lower methylmercury levels, such as (a) stock low-methylmercury prey fish for reservoir

predator fish to consume, (b) stock more or different sport fish species, such as lower trophic level sport fish, and/or (c) stock large, old predator fish from hatcheries that supply low methylmercury fish **(19)**

G. Assess potential changes to make to fish assemblage that result in top predator fish with lower methylmercury levels **(15)**

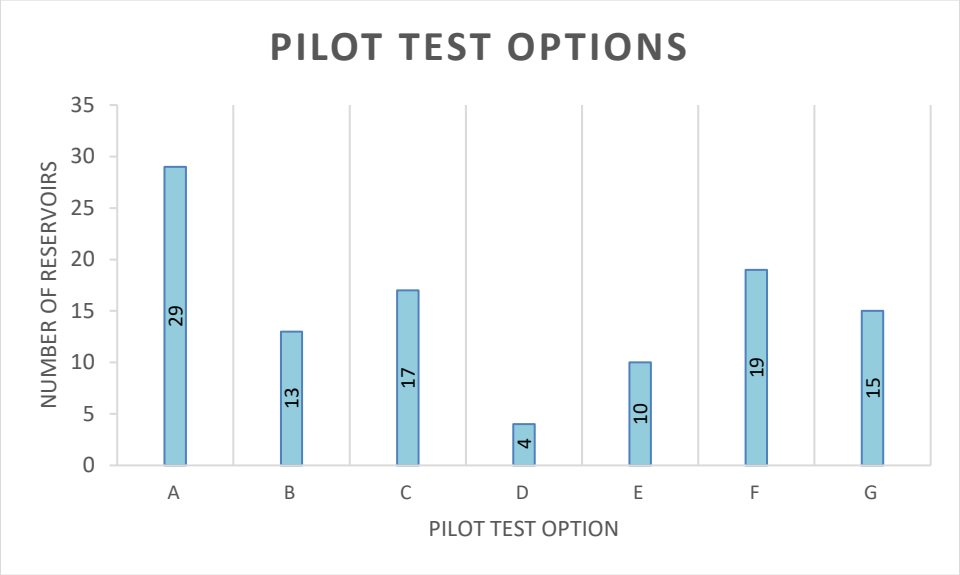

Figure 7: Options A-C are water chemistry and D-G are fisheries management pilot test options, n=107

Reservoir owners confirmed interest in both water chemistry and fisheries pilot test options, with the majority interested in oxidant addition to reservoir bottom waters. Reservoir owners selected water chemistry pilot tests for 55% of the reservoirs compared to 45% for fisheries pilot tests. The interest in different types of pilot tests will allow for a variety of management options to be tested, leading to a robust program of implementation.

Willingness to conduct pilot test in owner's reservoir

Below is a chart (Figure 8) illustrating reservoir agency/organization's willingness to have an applicable pilot test conducted in their reservoir as part of a coordinated pilot test approach, with the understanding if reservoirs participate in pilot tests prior to the Statewide Mercury Control Program for Reservoirs adoption/effective date, the reservoir would not have to repeat those tests. While the majority are unsure at this time, the response ratios are reasonable given that the Statewide Mercury Control Program for Reservoirs is still in the early stages of development and details about expectations are under development. However, in addition to an initial pilot test underway in Lake Hodges and from the responses below, 22 other reservoirs are willing to have a pilot test conducted in their reservoir.

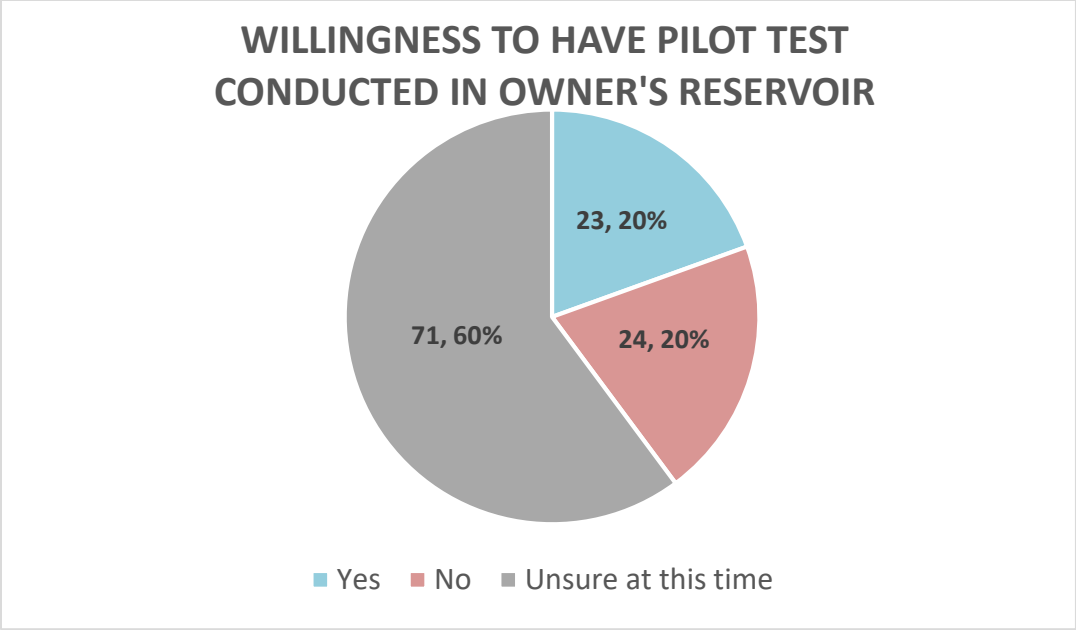

Figure 8: Reservoir owner's willingness to have a pilot test conducted in the owner's reservoir, n=118.

2.6 Financial and Technical Contributions

Financial support for coordinated approach to pilot tests and a Technical Review Committee

Two agencies/organizations representing a total of 6 mercury-impaired reservoirs are willing to contribute funding to support coordinated pilot tests, depending on the funding amount required and provided that costs are shared equitably amongst the organizations. Seven agencies representing 17 reservoirs indicate they are not willing to contribute financial support towards a pilot test since they anticipate conducing an individual pilot study. The remaining reservoirs are unsure at this time. Feedback from reservoir owners when asked about contribution limitations during 2017 workshops is described in Section 3.

Technical support for coordinated approach to pilot tests

Nine agencies/organizations representing 30 reservoirs responded positively when asked if their agency/organization was willing to participate and work collaboratively in a coordinated program of pilot tests by providing technical support. Similarly, the majority are still unsure at this time.

Financial support for Technical Review Committee

One reservoir owner, representing 3 mercury-impaired reservoirs was willing to contribute funding for 10 years to support a technical review committee that reviews and advises on pilot tests, depending on the amount required and provided that a vote on how to share the cost equitably amongst the organizations is conducted.

Technical support for Technical Review Committee

While not the same agencies/organizations, 9 agencies/organizations representing 30 reservoirs responded positively when asked if their agency/organization was willing to dedicate staff time to prepare for and regularly attend coordination meetings, including review sessions with a technical review committee. Similarly, the majority are still unsure at this time. While nine additional agencies/organizations representing 16 reservoirs state they are unable to dedicate staff time to a technical review committee, they support coordination and want to participate to a limited extent.

3 WORKSHOP FEEDBACK

Water Board staff held two workshops in fall of 2017 to seek additional feedback from owners of mercury-impaired reservoirs. In October, staff arranged for a workshop in conjunction with the California Lake Management Society's Annual Conference at Big Bear Lake. In November, staff held a workshop in Sacramento that also allowed for remote access for participants unable to attend in person.

Both meetings presented key Program topics such as the mercury cycle, the extent of the mercury-impairments in reservoirs, the three-pronged approach to implementation (source control, fisheries management, and water chemistry management), and the pilot test program. Prior examples of mercury management practices were presented and ideas for pilot tests during Phase 1 of this Program were outlined. The second part of the workshop summarized the questionnaire results and provided a public forum for participants to offer binning suggestions and for staff to inquire about what additional information is required so that reservoir owners can make informed decisions about how they plan to implement pilot tests. The following paragraphs provide a summary of the conversation prompts and the participant responses.

What binning system do you support? Are there other binning suggestions we did not present?

- Bathymetry
- Bin by mines with upstream responsible parties
- Based on consumption (people) vs focus on high prey fish consumption
- Hydraulic residence time
- Source: Where mercury or methylmercury is produced and enters the food web
- Relative mercury contribution from watershed
- Size of reservoir owner's agency/utility for fairness of cost sharing
- Sediment characteristics, e.g., (a) one naturally enriched in phosphorus, the other not; (b) form of Hg, elemental vs. cinnabar; and (c) sand, clay, silt.
- Reservoir fish trophic status e.g., applicable Mercury Water Quality Objective
- Culling
- Long-term management strategies

What are the biggest limitations to coordinating for pilot tests?

- Unclear about effectiveness and logistics of altering fish stocking practices
- Not knowing what the upfront financial costs to conduct pilot tests would be
- California Department of Fish and Wildlife regulations for culling fish
- Phase I does not include FERC licensed reservoirs. The Program would be more equitable if it did.

What pilot tests would you suggest?

No additional pilot tests were suggested during the October and November workshops. However, one representative noted a disruption of stratification might be infeasible due to the

high energy costs associated with strong stratification patterns associated with high elevation reservoirs.

What additional information is needed to change reservoir owners' responses from 'Unsure at this time' to 'Yes, we will contribute' financial or technical assistance in order to support a collaborative approach?

- Budgets tend to be fixed so owners need to know specific estimates of pilot program participation.
- Reservoir owners are looking for clarity from the State Water Board regarding
    - Pilot test monitoring design and outcomes
    - Expectations during pilot test approval process
    - Outcomes and responsibilities during pilot tests

4 NEXT STEPS

While this Program is still in development, stakeholder outreach continues to be fundamental to the responsible development of this Program. Water Board staff held two workshops in fall of 2017 to present the results from this questionnaire and to seek additional feedback from owners of mercury-impaired reservoirs. In October, staff arranged for a workshop in conjunction with the California Lake Management Society's Annual Conference at Big Bear Lake. In November, staff held a workshop in Sacramento that also allowed for remote access for participants unable to attend in person. In February 2018, staff will host the first Reservoir Working Group meeting where reservoir owners will gather to discuss their how to work towards a coordinated approach. Staff will continue to hold meetings incorporating these results to assist in the development of pilot studies.

Table 1: List of mercury-impaired reservoirs[2]

Reservoir Name	Reservoir Owner	Completed Questionnaire
Almanor, Lake	Pacific Gas and Electric Co.	X
Alondra Park Lake	Los Angeles County Department of Parks and Recreation	X
Amador, Lake	Jackson Valley Irrigation District	X
Anderson Lake	Santa Clara Valley Water District	X
Arrowhead, Lake	Arrowhead Lake Association	
Berryessa, Lake	U.S. Bureau of Reclamation	X
Big Bear Lake	Big Bear Municipal Water District	X
Black Butte Lake	U.S. Army Corps of Engineers	X
Black Crown Lake	Sacramento Regional County Sanitation District	X
Bon Tempe Lake	Marin Municipal Water District	X
Briones Reservoir	East Bay Municipal Utility District	X
Britton, Lake	Pacific Gas and Electric Co.	X
Cachuma, Lake	U.S. Bureau of Reclamation	X
Calaveras Reservoir	San Francisco Public Utility Commission	X
California, Lake	Lake California Property Owners Association	
Camanche Reservoir	East Bay Municipal Utility District	X
Camp Far West Reservoir	South Sutter Water District	X
Casitas, Lake	U.S. Bureau of Reclamation	X
Castaic Lake	California Department of Water Resources	X
Cerritos Park Lake (	Los Angeles County Department of Parks and Recreation	X
Chabot, Lake (Alameda Co.)	East Bay Municipal Utility District	X
Chabot, Lake (Solano Co.)	City of Vallejo	X
Chesbro Reservoir	Santa Clara Valley Water District	X
Collins Lake	Browns Valley Irrigation District	X
Combie, Lake	Nevada Irrigation District	X
Contra Loma Reservoir	U.S. Bureau of Reclamation	X
Copco Reservoir	Pacific Power	X
Coyote Reservoir	Santa Clara Valley Water District	X
Crowley, Lake	City of Los Angeles Department of Water and Power	X
Davis Creek Reservoir	Homestake Mining Co.	X
Del Valle Reservoir	California Department of Water Resources	X
East Park Reservoir	U.S. Bureau of Reclamation	X
Eastman Lake	U.S. Army Corps of Engineers	X
El Capitan Reservoir	City of San Diego	X
El Dorado Park Lakes	City of Long Beach	X
Elderberry Forebay	City of Los Angeles Department of Water and Power	X

[2] Reservoir Name reflects either the reservoir name provided by the questionnaire or as listed on the 303(d) list.

Reservoir Name	Reservoir Owner	Completed Questionnaire
Englebright Lake	U.S. Army Corps of Engineers	X
Finger Lake	Endicott Bert	
Folsom Reservoir	U.S. Bureau of Reclamation	X
Gibraltar, Lake	City of Santa Barbara	X
Gregory, Lake	San Bernardino County Regional Parks	X
Hansen Dam Lake	U.S. Army Corps of Engineers	X
Hell Hole Reservoir	Placer County Water Agency	X
Henne, Lake	Howell Mountain Mutual Water Co	X
Hennessey, Lake	City of Napa	X
Hensley Lake	U.S. Army Corps of Engineers	X
Herman, Lake	City of Benicia	X
Hernandez Reservoir	San Benito County Water District	X
Hetch Hetchy Reservoir	San Francisco Public Utility Commission	X
Hodges Reservoir	City of San Diego	X
Hughes, Lake	U.S. Forest Service	
Indian Valley Reservoir	Yolo County Flood Control & Water Conservation District	X
Iron Gate Reservoir	Pacific Power	X
Isabella, Lake	U.S. Army Corps of Engineers	X
Jameson Lake	Montecito Water District	X
Jennings, Lake	Helix Water District	X
Kaweah, Lake	U.S. Army Corps of Engineers	X
Ken Hahn Park Lake	California Department of Parks and Recreation	
La Mirada Park Lake	Los Angeles County Department of Parks and Recreation	X
Lafayette Reservoir	East Bay Municipal Utility District	X
Legg Lake	Los Angeles County Department of Parks and Recreation	X
Lexington Reservoir	Santa Clara Valley Water District	X
Littlerock Reservoir	Palmdale Water District and Littlerock Creek Irrigation District	X
Loon Lake	Sacramento Municipal Utility District	
Los Banos Reservoir	U.S. Bureau of Reclamation	X
Los Vaqueros Reservoir	Contra Costa County Water District	X
Lower Crystal Springs Reservoir	San Francisco Public Utility Commission	X
Marsh Creek Reservoir	Contra Costa County Flood Control & Water Conservation District	X
Mathews, Lake	Metropolitan Water District of Southern California	X
McClure, Lake	Merced Irrigation District	X
Mendocino, Lake	U.S. Army Corps of Engineers	
Merced, Lake	San Francisco Public Utility Commission	X
Mile Long Pond	California Department of Water Resources	X
Millerton Lake	U.S. Bureau of Reclamation	X

Reservoir Name	Reservoir Owner	Completed Questionnaire
Modesto Reservoir	Modesto Irrigation District	X
Moon Lake	John Hancock Mutual Ins Co	
Nacimiento Reservoir	Monterey County Water Resources Agency	X
Natoma, Lake	U.S. Bureau of Reclamation	X
New Bullards Bar Reservoir	Yuba County Water Agency	X
New Don Pedro Reservoir	Turlock Irrigation District and Modesto Irrigation District	X
New Hogan Lake	U.S. Army Corps of Engineers	X
New Melones Lake	U.S. Bureau of Reclamation	X
Nicasio Reservoir	Marin Municipal Water District	X
Ogier Quarry Ponds	County of Santa Clara	X
O'Neill Forebay	U.S. Bureau of Reclamation	X
Oroville, Lake	California Department of Water Resources	X
Oxbow Reservoir	Placer County Water Agency	X
Pardee Reservoir	East Bay Municipal Utility District	X
Peck Road Park Lake	Los Angeles County Department of Parks and Recreation	X
Pilarcitos Reservoir	San Francisco Public Utility Commission	X
Pillsbury, Lake	Pacific Gas and Electric Co.	X
Pine Flat Lake	U.S. Army Corps of Engineers	X
Piru, Lake	United Water Conservation District	X
Puddingstone Reservoir	Los Angeles County Department of Public Works	X
Pyramid Lake	California Department of Water Resources	X
Rollins Reservoir	Nevada Irrigation District	X
Ruth Lake	Humboldt Bay Municipal Water District	X
San Antonio Reservoir	Monterey County Water Resources Agency	X
San Luis Reservoir	U.S. Bureau of Reclamation	X
San Pablo Reservoir	East Bay Municipal Utility District	X
Santa Fe Dam Park Lake	U.S. Army Corps of Engineers	X
Santa Margarita Lake	U.S. Army Corps of Engineers	
Scotts Flat Reservoir	Nevada Irrigation District	X
Shadow Cliffs Reservoir	Zone 7 Water Agency	X
Shasta Lake	U.S. Bureau of Reclamation	X
Shastina, Lake (Dwinnell Reservoir)	Montague Water Conservation District	X
Sherwood, Lake	Sherwood Valley Home Owners Association & Sherwood Development Company	X
Silverwood Lake	California Department of Water Resources	X
Siskiyou, Lake	Siskiyou County	X
Slab Creek Reservoir	Sacramento Municipal Utility District	
Solano, Lake	U.S. Bureau of Reclamation	X
Sonoma, Lake	U.S. Army Corps of Engineers	

Reservoir Name	Reservoir Owner	Completed Questionnaire
Stevens Creek Reservoir	Santa Clara Valley Water District	X
Stony Gorge Reservoir	U.S. Bureau of Reclamation	X
Sutherland Reservoir	City of San Diego	X
Thermalito Afterbay	California Department of Water Resources	X
Topaz Lake	Walker River Irrigation District	X
Trinity Lake	U.S. Bureau of Reclamation	X
Tulloch Reservoir	South San Joaquin and Oakdale Irrigation Districts (Tri-Dam Project)	X
Tunnel Reservoir	Pacific Gas and Electric Co.	X
Turlock Lake	Turlock Irrigation District	X
Upper San Leandro Reservoir	East Bay Municipal Utility District	X
Upper Twin Lake	Centennial Livestock	
Uvas Reservoir	Santa Clara Valley Water District	X
Vasona Reservoir	Santa Clara Valley Water District	X
Webb, Lake	Kern County Department of Parks & Recreation	X
West Valley Reservoir	South Fork Irrigation District	X
Whiskeytown Lake	U.S. Bureau of Reclamation	X
Wildwood, Lake	Lake Wildwood Association	X
Woodward Reservoir	South San Joaquin Irrigation District	X
Zayac/Swan Lake	Lakewood Association	X

For reference only. Do not mail responses.

Statewide Mercury Control Program for Reservoirs Questionnaire

The State Water Resources Control Board (Water Board) is requesting information from reservoir owners and operators on the current status and strategies regarding water chemistry and fisheries management practices to inform the Statewide Mercury Control Program for Reservoirs ("Program"). These responses will assist in the binning of reservoirs into categories for pilot tests in Phase I of the Program. As described in the draft summary (http://www.swrcb.ca.gov/water_issues/programs/mercury/docs/mercury_resvr_summary_may2016.pdf), implementation of the Statewide Mercury Control Program for Reservoirs would occur over two phases. Phase 1 is expected to last for 10 years and will include pilot tests in select reservoirs, after which the State Water Board will conduct a program review. The Water Board wants to work cooperatively with reservoir owners and operators to ensure success of this program. This is very preliminary binning and no regulatory decisions or requirements will be made at this stage of the Program.

Directions to complete the survey:

Complete one questionnaire per reservoir. The Water Board has sent the questionnaire to both the owners and operators (if applicable) of each reservoir. Because owners and operators have different management responsibilities and may answer different questions, please coordinate your responses to this questionnaire and only submit one questionnaire for each reservoir. The questionnaire must be completed within 45 days of the postmarked letter. Note: all answers will be placed in the public record.

To assist with coordination, a PDF of the survey questions can be found on our website: http://www.swrcb.ca.gov/water_issues/programs/mercury/reservoirs/

For a copy of your submitted response or if questions arise, please contact:

Lauren Smitherman, Environmental Scientist

lauren.smitherman@waterboards.ca.gov

(916) 464-4668

* Required

1. **Email address** *

II. Contact Information

Please provide contact information for representatives of this reservoir.

2. **Reservoir Name:**

3. **The Water Board maintains a list of preferred names for reservoirs. Is there another preferred name for this reservoir otherwise not listed on the mailed questionnaire invitation?**
   Mark only one oval.
   - Yes
   - No

4. **If there is another preferred name for this reservoir, please list below:**

5. **Reservoir owner (e.g. U.S. Bureau of Land Management)**

6. **Reservoir owner contact name**

7. **Reservoir owner contact phone number**

8. **Reservoir owner contact mailing address**

9. **Reservoir owner contact e-mail address**

10. **Reservoir operator (if different than owner)**

11. **Reservoir operator contact name**

12. **Reservoir operator contact phone number**

13. **Reservoir operator contact e-mail address**

14. **Reservoir operator contact mailing address**

15. **Is this a FERC-Project reservoir?** *
Mark only one oval.

- Yes
- No

16. **If so, what is the FERC Project No.:**

17. **Is the holder of the FERC Project No. the:**
Mark only one oval.

- ◯ Reservoir Owner
- ◯ Reservoir Operator
- ◯ None of the above (see next question to explain)

18. **If the holder of the FERC Project No. is 'None of the above', please provide the following FERC Project contact name, e-mail, and mailing address:**

III. Reservoir Characteristics

Water Board staff has compiled readily-available information on reservoir characteristics, such as latitude/longitude, capacity (volume), surface area, watershed land use (forest, agriculture, urban), and many other characteristics (see Attachment A at end of survey). Please provide the following information, which the Water Board does not have and which would be helpful in binning reservoirs for pilot tests.

19. **What is the geometry of this reservoir?**
Mark only one oval.

- ◯ Bowl-shaped
- ◯ Dendritic (branching)
- ◯ Combination
- ◯ Other:

20. **What infrastructure is present (e.g., power, roads, boat ramp)?**

21. **Does this reservoir directly supply drinking water?**
Mark only one oval.

- ◯ Yes
- ◯ No

22. **If this reservoir supplies drinking water, is water directly diverted from this reservoir to any drinking water treatment plants or distribution systems? And if so, please indicate the number of drinking water intakes that service how many drinking water treatment plants, how many drinking water suppliers, and/or how many drinking water distribution systems:**

23. **Is this reservoir oligotrophic?**
Mark only one oval.

- ◯ Yes, based on total phosphorus data concentrations less than 8 µg P/L
- ◯ Yes, based on summer epilimnetic chlorophyll concentrations less than 3 µg Chl/L
- ◯ Yes, calculated differently (see next question)
- ◯ Not oligotrophic (i.e., mesotrophic, eutrophic)
- ◯ Unknown/not sufficient data

24. **If 'Yes, calculated differently', please explain how calculated.**

25. **Does the source water for the reservoir originate outside of the reservoir's watershed?**
Mark only one oval.

- ◯ Yes
- ◯ No

26. **If the source water for the reservoir originates outside of the reservoir's watershed, what is the source of water?**

IV. General Reservoir Water Management

The following section is intended to guide discussion on general reservoir water management practices, including water level, temperature, and general water quality monitoring practices.

27. **Greater annual drawdown in reservoir water levels has been correlated with higher fish methylmercury concentrations. Is water intentionally drawn down in this reservoir? And if so, what is the purpose and frequency?**
Mark only one oval per row.

	Daily	Weekly	Monthly	Yearly	As Needed	Other	N/A
Dry season drawdown (i.e., drinking or irrigation supply)	◯	◯	◯	◯	◯	◯	◯
Creation of space for runoff or in advance of storms (i.e., for flood control)	◯	◯	◯	◯	◯	◯	◯
Hydropower generation	◯	◯	◯	◯	◯	◯	◯
Aquatic plant or animal control	◯	◯	◯	◯	◯	◯	◯
Protection of the shoreline from the erosion effects of high water	◯	◯	◯	◯	◯	◯	◯
None of the above (see next question to explain)	◯	◯	◯	◯	◯	◯	◯

28. **If 'None of the above', please explain the purpose for drawdown below:**

_____

_____

_____

_____

_____

29. **Is water temperature managed at any part of the reservoir?**
Mark only one oval.

- ◯ Yes
- ◯ No

30. **If water temperature is managed, please describe the purpose:**
Mark only one oval.

- ◯ Cold water for downstream fisheries
- ◯ Cold water for in-reservoir fisheries
- ◯ To meet downstream temperature requirements (other than fisheries)
- ◯ Other

31. **If water temperature is managed, is it managed in a manner that affects thermal stratification?**
Mark only one oval.

- ◯ Yes, managed to encourage stratification
- ◯ Yes, managed to reduce stratification
- ◯ Managed, but does not affect thermal stratification
- ◯ Not Applicable

32. **Does seasonal mixing occur in this reservoir?**
Mark only one oval.

- ◯ Meromictic (Little to no mixing)
- ◯ Monomictic (One mixing, i.e., fall destratification)
- ◯ Dimictic (Winter ice cover, spring mixing, summer stratification, fall destratification)
- ◯ Polymictic (Many mixings throughout year)
- ◯ No mixing occurs
- ◯ Unknown

33. **Describe the strength and duration of thermal stratification:**
Mark only one oval.

- ◯ Weakly stratified (partly mixes relatively frequently) and less than 3 months duration
- ◯ Moderately stratified (partly mixes infrequently) and 5–6 months duration
- ◯ Strongly stratified (rarely mixes) and longer than 6 months duration
- ◯ Unknown

34. **How does your agency/organization calculate the strength of thermal stratification?**
Mark only one oval.

- ◯ Does not calculate
- ◯ Richardson number (Ri)
- ◯ Not applicable
- ◯ Other: _____

35. **Is forced (active) mixing performed in this reservoir?**
Mark only one oval.

- ◯ Yes
- ◯ No

36. **If forced mixing is performed, what technology is used (i.e., vertical mixer, mechanical agitator, bubble aerator)?**

_____

_____

_____

_____

_____

37. **Which water quality parameters are monitored and at what frequency?**
Mark only one oval per row.

	Annually	Only during periods of stratification	Quarterly	Monthly	Twice-monthly	Weekly	Daily	Other	Not monitored
Temperature									
Dissolved oxygen									
pH									
Specific conductance									
Oxidation-reduction potential									
Turbidity									
Chlorophyll-a									
Phycocyanin									
None of the above (see next question to explain)									

38. **If 'None of the above' parameters are monitored, which parameters are monitored?**

39. **If parameters are monitored 'Only during periods of stratification', which months/season and what frequency are they sampled?**

V. Specialized Management

Many reservoirs throughout California utilize a variety of monitoring and management practices for constituents other than mercury. The following questions will guide discussion on specialized monitoring and management practices in mercury-impaired reservoirs.

40. **Does your agency/organization manage this reservoir for oxygen?**
Mark only one oval.

- Yes
- No

41. **If managed for oxygen, why is oxygen added?**
Check all that apply.

- [ ] Suppress release of phosphorus and iron from sediments
- [ ] To reduce taste and odor problems in drinking water
- [ ] To reduce problems in drinking water treatment
- [ ] To reduce algae growth
- [ ] Other: _____

42. **If managed for oxygen, how is oxygen added?**
Mark only one oval.

- ◯ Break stratification
- ◯ Fine bubbles that do not break stratification
- ◯ Speece cone that does not break stratification
- ◯ Other: _____

43. **What form of oxygen is added?**
Mark only one oval.

- ◯ Air
- ◯ Pure oxygen (O2)
- ◯ Ozone (O3)
- ◯ Other: _____

44. **If your agency/organization does not currently manage this reservoir for oxygen, does your agency/organization plan to manage this reservoir for oxygen in the future?**
Mark only one oval.

- ◯ Yes
- ◯ No

45. **Is oxygen management technically feasible in this reservoir?**
Mark only one oval.

- ◯ Yes
- ◯ No (please explain in next question)
- ◯ Unknown
- ◯ Other: _____

46. **If oxygen management is not feasible, please explain below:**

_____

_____

_____

_____

_____

47. **If your agency/organization plans to manage this reservoir for oxygen, what type of oxygenation system do you plan to use?**
Mark only one oval.

- ◯ Break stratification
- ◯ Fine bubbles that do not break stratification
- ◯ Speece cone that does not break stratification
- ◯ Unknown
- ◯ Other: _____

48. **If your agency/organization plans to use oxygen, what type of oxygen would be used?**
Mark only one oval.

- ◯ Air
- ◯ Pure oxygen (O2)
- ◯ Ozone (O3)
- ◯ Unknown
- ◯ Other: _____

49. **Has your agency/organization undertaken physical actions with the goal of restoring historical salmon runs (e.g. fish ladders)?**
Mark only one oval.

- ◯ Yes
- ◯ No

50. **Does your agency/organization plan to undertake physical actions with the goal of restoring historical salmon runs (e.g. fish ladders)?**
Mark only one oval.

- ◯ Yes
- ◯ No

51. **Has your agency/organization undertaken actions with the goal of restoring nutrients provided by salmon runs prior to dam construction (e.g., minimal additions of nitrogen or phosphorus - including from natural sources like fish pellets or carcasses)?**
Mark only one oval.

- ◯ Yes
- ◯ No

52. **Does your agency/organization plan to undertake actions with the goal of restoring nutrients provided by salmon runs prior to dam construction (e.g., minimal additions of nitrogen or phosphorus - including from natural sources like fish pellets or carcasses)?**
Mark only one oval.

- ◯ Yes
- ◯ No

53. **Has your agency/organization enrolled in the statewide general permit for aquatic weed control applications for this reservoir?**
Mark only one oval.

- ◯ Yes
- ◯ No

54. **Does your agency/organization perform in-reservoir controls for other invasive species (e.g. quagga/zebra mussels)?**
Mark only one oval.

- ◯ Yes
- ◯ No

55. **Does your agency/organization control algae with application of chemicals or technology (either in-reservoir application or outside reservoir boundaries with potential for chemicals to leach into reservoir)?**
Check all that apply.

- ☐ Apply copper compounds to control algae
- ☐ Apply light absorbing dyes
- ☐ Apply hydrogen peroxide (H202)
- ☐ Barley Straw
- ☐ Lake flushing
- ☐ Forced mixing
- ☐ Herbivorous fish (e.g. silver carp)
- ☐ N/A
- ☐ Other: _____

56. **Does your agency/organization add other chemicals/materials for other water quality concerns?**
Mark only one oval.

- ◯ Yes
- ◯ No

57. **If your agency adds other chemicals/materials for other water quality concerns, please explain the concern and what chemicals/materials are used:**

_____

_____

_____

_____

_____

VI. Mercury Monitoring and Management Section

A few owners and operators of reservoirs throughout California monitor their reservoirs for total mercury (THg) or methylmercury (MeHg) in water, fish, and/or sediment. The following questions will guide discussion on mercury monitoring and management practices in mercury-impaired reservoirs.

58. **Have prior total mercury (THg) or methylmercury (MeHg) studies been conducted in this reservoir for fish, water, and/or sediment?**
Mark only one oval.

- ◯ Yes
- ◯ No
- ◯ Unknown

59. **If prior total mercury (THg) or methylmercury (MeHg) studies have been conducted in this reservoir for fish, water, and/or sediment, please both describe the scope of the studies and provide citations for reports of results for reservoir studies:**

_____

_____

_____

_____

_____

60. **Is this reservoir currently monitored for total mercury (THg) or methylmercury (MeHg)?**
Check all that apply.

- ☐ THg in fish
- ☐ THg in water column
- ☐ THg in sediment
- ☐ MeHg in fish
- ☐ MeHg in water column
- ☐ THg in sediment
- ☐ Not monitored

61. **Are total mercury (THg) or methylmercury (MeHg) sources upstream of the reservoir currently being managed to address elevated mercury levels in fish residing in this reservoir (e.g. mine or creek bed cleanup)?**
Mark only one oval.

- ◯ Yes
- ◯ No
- ◯ Unknown

62. **Has your agency/organization performed any management practices in this reservoir to reduce methylation, including enhancing demethylation in the sediment or water column? (e.g. contaminated sediment removal, oxygenation)?**
Mark only one oval.

- ◯ Yes
- ◯ No

63. **If your agency/organization has performed any management practices in this reservoir to reduce methylation, please describe below:**

64. **Are there known or suspected sediment mercury hotspots in the reservoir (e.g. hot spot in one arm from upstream or inundated mercury or gold mines)?**
Mark only one oval.

- ◯ Yes
- ◯ No
- ◯ Unknown
- ◯ Other: _____

65. **Has your agency/organization performed in-reservoir sediment removal or encapsulation to address inorganic mercury hotspots such as submerged or near-shore mine sites and mining waste?**
Mark only one oval.

- ◯ Yes
- ◯ No

VII. Fishing

Harmful levels of methylmercury in fish are a statewide and nationwide problem. Mercury is a bioaccumulative toxic pollutant that results in many reservoir fish having methylmercury levels that pose a risk for humans and wildlife that eat the fish. The following questions will guide discussion on fish management practices in mercury-impaired reservoirs.

66. **Is publicly-accessible fishing allowed in this reservoir?**
Mark only one oval.

- ◯ Yes
- ◯ No
- ◯ No, but happens anyway

67. **Has your agency/organization, concessionaire, or the State Department of Fish and Wildlife stocked fish in this reservoir within the past 10 years?**
Mark only one oval.

- ◯ Yes
- ◯ No

68. **If fish are stocked, which species are stocked and at what frequency? (If frequency varies, describe peak frequency)**
Mark only one oval per row.

	Weekly	Monthly	Bi-Monthly	Semi-Annually	Annually	Other:____
Largemouth bass						
Smallmouth bass						
Spotted bass						
Striped bass						
Rainbow trout						
Lake trout						
Brown trout						
Kokanee						
Other:_____						

69. **If fish are stocked, why? Answer all that apply:**
Check all that apply.

- [ ] Required by FERC license
- [ ] Required by California Department of Fish and Wildlife
- [ ] Required by Water Rights permit
- [ ] Required by other permit or regulation
- [ ] Other

70. **Do people consume fish from your reservoir?**
Mark only one oval.

- ◯ Yes
- ◯ No
- ◯ Catch and release only
- ◯ Unknown

71. **If fish from your reservoir are consumed by humans, how was this determined?**
Check all that apply.

- [ ] Creel Survey
- [ ] Consumption Survey
- [ ] Observation
- [ ] Other: _____

72. **If so, what species are people likely eating (select all that apply)?**
Check all that apply.

- [ ] Largemouth bass
- [ ] Smallmouth bass
- [ ] Spotted bass
- [ ] Rainbow trout
- [ ] Lake trout
- [ ] Brown trout
- [ ] Kokanee
- [ ] Channel catfish
- [ ] Striped bass
- [ ] Carp
- [ ] Other: _____

73. **Does your agency/organization actively cull fish from this reservoir?**
Mark only one oval.

- ◯ Yes
- ◯ No

74. **Does your agency/organization have fisheries management staff?**
Mark only one oval.

- ◯ Yes
- ◯ No

75. **There are statewide advisories for mercury in fish, such as Office of Environmental Health Hazard Assessment's Statewide Advisory for Eating Fish from California's Lakes and Reservoirs. Are statewide or local fish consumption advisories posted?**
Mark only one oval.

- ◯ Yes, currently posted
- ◯ Yes, in the past 12 months
- ◯ Yes, in the past 5 years
- ◯ No, but planned
- ◯ No

76. **Regardless of within-reservoir stocking practices, are fish at higher trophic levels (TL3 or TL4) entering the reservoir from outside the reservoir's watershed?**
Mark only one oval.

- ◯ Yes
- ◯ No
- ◯ Unknown

77. **Are there sportfishing tournaments or other managed public fishing events held at the reservoir?**
Mark only one oval.

- ◯ No
- ◯ Yes
- ◯ Other: _____

78. **If sportfishing tournaments or other managed public fishing events are held at the reservoir, what fish are the focus of these sporting events?**

_____

_____

_____

_____

_____

VIII. Technical Review Committee and selection of pilot tests

A key action proposed for “Phase 1” is for owners and operators of mercury-impaired reservoirs to conduct pilot tests to reduce methylmercury concentrations in reservoir fish. Coordinated pilot tests could be conducted in fewer, targeted reservoirs rather than in all impaired reservoirs to be more economically feasible. Reservoir owners and operators would convene a third-party independent technical review committee to advise on pilot tests.

79. **What classification system would your agency/organization propose for binning reservoirs for pilot tests?** *
Check all that apply.

- ☐ Geologic regions: trace mercury, mercury-enriched, or mercury mineralized
- ☐ Geographic regions – (Klamath/Trinity/Cascade Mountain; Coast Ranges, Valley Floor, Sierra Nevada, Transverse Ranges, and Peninsular Ranges)
- ☐ Highest trophic level fish in reservoir
- ☐ Fish management practices
- ☐ Elevation
- ☐ Reservoir size
- ☐ Potential source of mercury contamination
- ☐ Reservoir function
- ☐ Other: _____

80. **Where, in your agency/organization's opinion, should pilot tests take place?** *
Check all that apply.

- [ ] Target reservoirs that need the greatest MeHg reduction in fish
- [ ] Target reservoirs that have greatest rates of human consumption of fish
- [ ] Target reservoirs where new water quality or fisheries management practices are already being planned or will soon be implemented, and evaluate those practices for effects on mercury
- [ ] Target reservoirs that do not need more oxygenation systems installed; it is sufficient to study existing systems for their effects on mercury
- [ ] Reservoirs with existing aqueous, fish tissue, and/or sediment mercury data
- [ ] Target reservoirs with existing infrastructure and ease of access (e.g. maintained roads, power, boat ramps, etc.)
- [ ] Target reservoirs with ease of operations and management (e.g. ability to engineer, install, and maintain pilot tests with limited technical staff and operations management)
- [ ] None of the above.

81. **If none of the above, what does your agency/organization recommend, and why?** *

As described in the draft summary, implementation of the Statewide Mercury Control Program for Reservoirs would occur over two phases. Phase 1 is expected to last for 10 years and will include pilot tests in select reservoirs, after which the State Water Board will conduct a 2-year program review. Potential reservoir water chemistry and fisheries management practices for pilot tests include the following:

Manage reservoir water chemistry to reduce methylmercury production:
A) Oxidant addition to reservoir bottom waters (near the sediment-water interface) to reduce anoxia or adjust redox potential when reservoirs are stratified to suppress methylation of mercury. Evaluate various oxidants (e.g., dissolved oxygen, ozone, nitrate, others) for (a) efficacy for methylmercury reduction, (b) multiple benefits (e.g., drinking water quality, algal controls), and (c) avoidance of adverse consequences;
B) In-reservoir sediment removal or encapsulation to address inorganic mercury hotspots such as submerged or near-shore mine sites and mining waste; and
C) Other management practices to reduce methylation, including enhancing demethylation.

Manage fisheries to reduce fish bioaccumulation of methylmercury:
D) Nutrient management such as minimal additions of nitrogen or phosphorus (including from natural sources such as restoring historical salmon runs) to slightly increase chlorophyll-a concentrations in oligotrophic reservoirs;
E) Intensive fishing to increase the growth rate of remaining fish;
F) New or changes to fish stocking practices to increase the abundance of fish with lower methylmercury levels, such as (a) stock low-methylmercury prey fish for reservoir predator fish to consume, (b) stock more or different sport fish species, such as lower trophic level sport fish, and/or (c)

stock large, old predator fish from hatcheries that supply low methylmercury fish; and
G) Assess potential changes to make to fish assemblage that result in top predator fish with lower methylmercury levels.

82. **Above is a list of potential water chemistry and fisheries management pilot tests. Which management practices does your agency/organization support as a pilot test in either your reservoir or reservoirs similar to yours and does your agency/organization have additional suggestions?** *

83. **Would your agency/organization be willing to participate and work collaboratively in a coordinated program of pilot tests by providing financial support?** *

Mark only one oval.

- ◯ Yes, we are willing to contribute funding to support coordinated pilot test(s), depending on the amount required and provided that we have a vote on how to share the cost equitably amongst the organizations.
- ◯ No, we are not willing to contribute financial support towards a pilot test since we anticipate conducing an individual pilot study.
- ◯ Unsure at this time.

84. **If your agency is not willing to provide financial support, please explain why not.**

85. **Would your agency/organization be willing to participate and work collaboratively in a coordinated program of pilot tests by providing technical support?** *

Mark only one oval.

- ◯ Yes, we are willing to devote staff time to provide technical and project management expertise (permitting, contracting, engineering design and construction/installation, operations, management), regular attendance of coordination meetings, including review sessions with a technical review committee
- ◯ No; although we are not able to dedicate staff time to these activities, we support coordination and want to participate to a limited extent
- ◯ No, we are not willing to dedicate staff time to these activities since we anticipate conducing an individual pilot study.
- ◯ Unsure at this time.

86. **If your agency is not willing to provide technical support, please explain why not:**

87. **Would your agency/organization be willing to have an applicable pilot test conducted in your reservoir as part of a coordinated pilot test approach (Note: reservoirs that participate in pilot tests prior to the Statewide Mercury Control Program for Reservoirs adoption/effective date would not have to repeat those tests)?** *
Mark only one oval.

- Yes
- No
- Unsure at this time

88. **Mercury-impaired reservoir owners/operators will be required to convene and fund a technical review committee to advise the Water Board and the owners and operators on reservoir management practices that may reduce levels or bioaccumulation of methylmercury. How would your agency/organization be willing to support a technical review committee?** *
Check all that apply.

- We are willing to contribute funding for 10 years to support a technical review committee that reviews and advises on pilot tests, depending on the amount required and provided that we have a vote on how to share the cost equitably amongst the organizations.
- We are not willing to contribute financial support towards a technical review committee.
- We are willing to dedicate staff time to prepare for and regularly attend coordination meetings, including review sessions with a technical review committee.
- No; although we are not able to dedicate staff time to these activities, we support coordination and want to participate to a limited extent
- No, we are not willing to dedicate staff time to these activities.
- Unsure at this time

89. **If your agency/organization is not willing to contribute financial support towards a technical review committee, please explain why not.**

Attachment A: Known Reservoir Characteristics

Physiographic region

Regional geology

Surrounding land uses

Historic area mine density

Drainage area

Coordinates

Elevation

Year built

Storage volume and capacity (max flood pool)
