

Agenda Item: 5
Meeting Date: May 13, 2004

California Bay-Delta Public Advisory Committee

Mercury Strategy for the Bay-Delta Ecosystem: A Unifying Framework for Science, Adaptive Management, and Ecological Restoration

Description: The Mercury Strategy is a peer-reviewed document developed by a team of independent scientists, with input from other managers, researchers, and stakeholders during two public workshops. The strategy describes the existing state of knowledge on the mercury issue and outlines a strategy for integrated mercury investigations linked to restoration and adaptive management of the Bay and Delta.

Recommended Action: Recommend to the California Bay-Delta Authority that it direct implementation of the Mercury Strategy.

Background

Development of the “Mercury Strategy for the Bay-Delta Ecosystem: A Unifying Framework for Science, Adaptive Management, and Ecological Restoration” was funded by the CALFED Science Program in recognition of the need for an integrated, systematic framework for addressing key management and scientific questions concerning mercury in the Bay-Delta ecosystem. The Mercury Strategy outlines a strategy for integrated mercury investigations linked to restoration and adaptive management of the San Francisco Bay and Sacramento-San Joaquin Delta ecosystem. Ecosystem restoration and management of the Bay-Delta ecosystem are complicated by mercury contamination from historic mining sites in the Sacramento and San Joaquin River watersheds, the principal sources of fresh water for the Bay-Delta System. Mercury-enriched sediment now contaminates extensive downstream reaches of streams and rivers, adjoining floodplains, and the Bay-Delta Estuary and concentrations of methylmercury in some resident fishes exceed the U.S. Environmental Protection Agency's fish-tissue criteria for protecting the health of humans who consume noncommercial freshwater or estuarine fish.

A challenge to scientists and managers involved with restoration of this ecosystem is to avoid increasing exposure to methylmercury, the highly toxic form that readily accumulates in exposed organisms and biomagnifies to high concentrations in fish and wildlife atop aquatic food webs. It would be desirable to eventually decrease

methylmercury exposure in this ecosystem to levels where fishery resources, wildlife, and human health are unaffected; however, the development of an effective approach for achieving such a goal is presently hampered by the limited knowledge of mercury cycling in this ecosystem. Natural processes and human activities--possibly including ecosystem restoration projects--can influence the abundance of methylmercury in the ecosystem and the associated exposure of fish, wildlife and humans.

The strategy provides guidance to the CALFED Ecosystem Restoration Program and others supporting ecological restoration of the mercury-contaminated Bay-Delta ecosystem.

The Mercury Strategy

The goal of the Mercury Strategy is to provide a unifying framework for the integrated investigations needed to build a scientific foundation for ecosystem restoration, environmental planning, and the assessment and eventual reduction of mercury-related risks in the Bay-Delta ecosystem. The strategy was developed by a team of independent scientists (James G. Wiener, Cynthia C. Gilmour, and David P. Krabbenhoft), with input obtained in two public workshops attended by resource managers, environmental planners, scientists, and other stakeholders from the region, as well as external technical experts.

The draft document had opportunities for public comment and was peer reviewed, with comments addressed in the final document. This document briefly describes the Bay-Delta ecosystem, summarizes current knowledge of mercury contamination and cycling in the ecosystem, considers the potential influences of ecosystem restoration activities on mercury cycling and methylmercury exposure, describes the development of the strategy, recommends six interactive core components of a mercury program focused on the ecosystem, and provides guidance for management of that program.

The document does not recommend specific projects for funding, although useful mechanisms for selecting projects and project teams are discussed. In short, the Mercury Strategy provides a cohesive framework for ecosystem managers, partners, and participating scientists and offers guidance on certain, crucial aspects of an interdisciplinary mercury program.

The framework for the Mercury Strategy contains six core components. Each core component addresses one or more management goals and includes specific, supporting objectives pertaining to scientific activities (research and monitoring), management actions, or both. Management actions include source remediation, risk communication,

ecosystem restoration, and landscape management. The six core components and their associated management goals are as follows.

Core Components	Management Goals
1. Quantification and evaluation of mercury and methylmercury sources	To identify mercury sources that contribute most strongly to the production and bioaccumulation of methylmercury
2. Remediation of mercury source areas	To identify remedial actions that can reduce loadings of mercury from sources to surface waters and decrease the exposure of aquatic biota to methylmercury
3. Quantification of effects of ecosystem restoration on methylmercury exposure	To document and understand the effects of ecosystem restoration in wetland, floodplain, and riverine habitats on the production and bioaccumulation of methylmercury in the Bay-Delta ecosystem
4. Monitoring of mercury in fish, health-risk assessment, and risk communication	To protect human health by assessing and reducing exposure to methylmercury-contaminated fish To provide a "performance measure" to gage methylmercury contamination of the Bay-Delta ecosystem during restoration
5. Assessment of ecological risk	To protect fish and wildlife from adverse effects of methylmercury exposure
6. Identification and testing of potential management approaches for reducing methylmercury contamination	To identify and evaluate potential landscape management approaches for reducing the production and abundance of methylmercury in the ecosystem, as well as the associated exposure of resident biota

List of Attachments

Attachment 1 -- Executive Summary, "Mercury Strategy for the Bay-Delta Ecosystem: A Unifying Framework for Science, Adaptive Management, and Ecological Restoration" by James G. Wiener, Cynthia Gilmour, and David Krabbenhoft.

Attachment 2 – News stories related to mercury contamination.

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Mercury Strategy for the Bay-Delta Ecosystem: A Unifying Framework for Science, Adaptive Management, and Ecological Restoration

by

James G. Wiener¹, Cynthia C. Gilmour², and David P. Krabbenhoft³

EXECUTIVE SUMMARY

This document outlines a strategy for integrated mercury investigations linked to restoration and adaptive management of the San Francisco Bay and Sacramento-San Joaquin Delta ecosystem (termed the Bay-Delta ecosystem and defined as the combined watershed, Delta, and Bay). Ecosystem restoration and management of the Bay-Delta ecosystem are complicated by mercury contamination from historic mining sites in the Sacramento and San Joaquin river watersheds, the principal sources of fresh water for the Bay-Delta System. Mercury-enriched sediment now contaminates extensive downstream reaches of streams and rivers, adjoining floodplains, and the Bay-Delta Estuary. Concentrations of methylmercury in some resident fishes exceed 0.3 mg/kg (parts per million) wet weight, the U.S. Environmental Protection Agency's fish-tissue criterion for protecting the health of humans who consume noncommercial freshwater or estuarine fish.

A challenge to scientists and managers involved with restoration of this ecosystem is to avoid increasing exposure of biota to methylmercury, the highly toxic form that readily accumulates in exposed organisms and biomagnifies to high concentrations in fish and wildlife atop aquatic food webs. It would be desirable to eventually decrease methylmercury exposure in this ecosystem to levels where fishery resources, wildlife, and human health are unaffected; however, the development of an effective approach for achieving such a goal is presently hampered by our very limited knowledge of mercury cycling in this ecosystem. The production of methylmercury via the microbial methylation of inorganic divalent mercury in the environment is a key process affecting methylmercury concentrations in biota at all trophic levels. Natural processes and human activities – possibly including ecosystem restoration projects – that alter the net production of methylmercury (i.e., methylation minus demethylation) can influence the abundance of methylmercury in the ecosystem and the associated exposure of resident biota and humans who consume fish and other aquatic biota from the ecosystem.

The strategy provides guidance to the California Bay Delta Authority's Ecosystem Restoration Program, which is supporting ecological restoration of the mercury-contaminated Bay-Delta ecosystem. The overall goals outlined in the strategic plan for the Ecosystem Restoration Program for the Bay-Delta System are (1) to assist and recover at-risk native species, (2) to rehabilitate the Bay-Delta to support native aquatic and terrestrial biotic communities, (3) to maintain or enhance selected species for harvest, (4) to protect and restore functional habitat for both ecological and public values, (5) to prevent the establishment of additional non-native species, and (6) to improve or maintain water and sediment quality. Success in achieving most of these goals will hinge partly on the behavior and mitigation of mercury in the ecosystem, given that methylmercury contamination and exposure can adversely affect the health and reproductive success of native fish and wildlife, can diminish the benefits derived from fisheries, can degrade the quality of water and sediment, and can pose health risks to humans.

The goal of the mercury strategy is to provide a unifying framework for the integrated investigations needed to build a scientific foundation for ecosystem restoration, environmental planning, and the assessment and eventual reduction of mercury-related risks in the Bay-Delta ecosystem. The strategy was developed by a team of independent scientists, with input obtained in two public workshops attended by resource managers, environmental planners, scientists, and other stakeholders from the region, as well as external technical experts. This document briefly describes the Bay-Delta ecosystem, summarizes current knowledge of mercury contamination and cycling in the ecosystem, considers the potential influences of ecosystem restoration activities on mercury cycling and methylmercury exposure, describes the development of the strategy, recommends six interactive core components of a mercury program focused on the ecosystem, and provides guidance for management of that program. The document does not recommend specific projects for funding, although useful mechanisms for selecting projects and project teams are discussed. In short, the mercury strategy provides a cohesive framework for ecosystem managers, partners, and participating scientists and offers guidance on certain, crucial aspects of an interdisciplinary mercury program.

Clear definition of the problem or problems affecting ecosystem or human health is an essential first step in adaptive management, an operational process being used in the California Bay Delta Authority's Ecosystem Restoration Program in restoring the ecological health of the Bay-Delta ecosystem. In a toxicological sense, the primary problem with mercury in aquatic ecosystems can be defined as *biotic exposure to methylmercury*. It follows that an overall challenge for scientists and managers involved with ecological restoration and management in the Bay-Delta ecosystem is *to avoid increasing – and to eventually decrease – biotic exposure to methylmercury*. This challenge should provide a unifying sense of purpose for scientists, ecosystem managers, and other participants, as well as a unifying framework for adaptive management of this mercury-contaminated ecosystem.

The framework for the mercury strategy contains six core components. Each core component addresses one or more management goals and includes specific, supporting objectives pertaining to scientific activities (research and monitoring), management actions, or both. Management actions include source remediation, risk communication, ecosystem restoration, and landscape management. The six core components and their associated management goals are as follows.

Core Components

1. Quantification and evaluation of mercury and methylmercury sources
2. Remediation of mercury source areas
3. Quantification of effects of ecosystem restoration on methylmercury exposure

Management Goals

- To identify mercury sources that contribute most strongly to the production and bioaccumulation of methylmercury
- To identify remedial actions that can reduce loadings of mercury from sources to surface waters and decrease the exposure of aquatic biota to methylmercury
- To document and understand the effects of ecosystem restoration in wetland, floodplain, and riverine habitats on the production and bioaccumulation of methylmercury in the Bay-Delta ecosystem

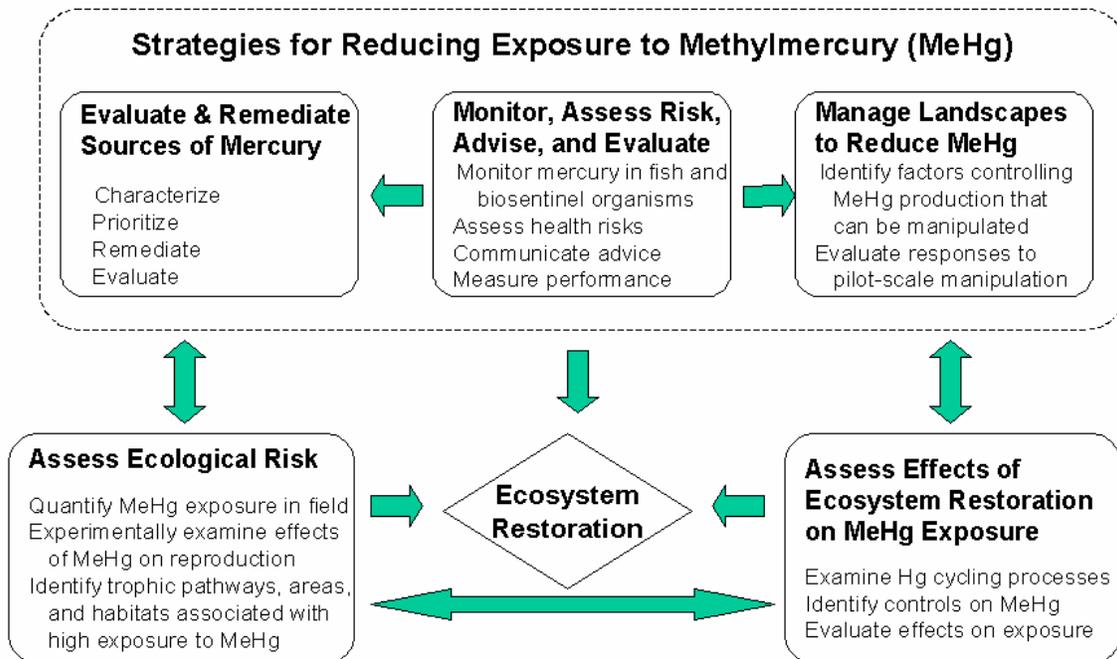
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| 4. Monitoring of mercury in fish, health-risk assessment, and risk communication | To protect human health by assessing and reducing exposure to methylmercury-contaminated fish
To provide a "performance measure" to gage methylmercury contamination of the Bay-Delta ecosystem during restoration |
| 5. Assessment of ecological risk | To protect fish and wildlife from adverse effects of methylmercury exposure |
| 6. Identification and testing of potential management approaches for reducing methylmercury contamination | To identify and evaluate potential landscape management approaches for reducing the production and abundance of methylmercury in the ecosystem, as well as the associated exposure of resident biota |

The six core components are strongly interconnected. The interactions include linkages between scientific research and monitoring and linkages between scientific investigations and management actions. The linkages among the core components are illustrated below, where shaded arrows represent the flows of information and interactions needed to support decisions regarding both refinement of scientific investigations and adaptive management of mercury in the ecosystem. These linkages are utterly crucial for meeting the goals and objectives outlined for the strategy and for providing timely scientific input for adaptive management of mercury in the ecosystem. The evaluation of outcomes is also an important feature of the strategy.



This framework incorporates two approaches that have been applied for decades to reduce exposure to methylmercury: (i) reduction of mercury loadings and (ii) monitoring of mercury in fish as a scientific foundation for providing fish-consumption advice. A third, largely untested approach, management of contaminated landscapes to decrease the *in situ* net production of methylmercury, should be evaluated as a potential means of reducing methylmercury contamination and exposure in this ecosystem.

In evaluating effects of ecosystem restoration on mercury cycling, we recommend that the highest priority be given to examining effects of restoration on (1) the bioavailability of inorganic mercury for methylation and (2) the microbial production of methylmercury. Mercury contamination of aquatic environments is widespread in the Bay-Delta ecosystem. We believe that changes in bioavailability or methylation rates have much greater potential to significantly increase methylmercury exposure in this ecosystem than do changes in the spatial distribution of total (mostly inorganic) mercury. Studies in other aquatic ecosystems have shown that stimulation of methylation can increase the abundance of methylmercury and its uptake in biota by 10- to 20-fold, even in lightly contaminated environments where no mercury was added.

The influence of selenium on the abundance of methylmercury in food webs in the Bay-Delta ecosystem also merits investigation. Parts of this ecosystem, such as the San Joaquin River, are notably contaminated with selenium, which can inhibit the production of methylmercury and

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decrease its bioaccumulation in the food web. The linkage of selected mercury investigations to ongoing or planned studies of selenium biogeochemistry in the Bay-Delta system would be a cost-effective approach for examining interactions between selenium and mercury.

The competitive Proposal Solicitation Package process is an appropriate mechanism for allocating scientific effort to all but one core component (monitoring). An interdisciplinary effort will be needed to implement this strategy and to apply the resulting information towards adaptive management of the Bay-Delta ecosystem. Requests for proposals should, therefore, encourage development of interdisciplinary proposals by multidisciplinary teams of investigators. In addition to judging scientific merit and relevance to ecosystem management, the proposal review and selection process should critically assess the effectiveness of project teams, by considering team leadership, disciplinary composition, relevant experience, technical capabilities, and information transfer. Critical evaluation of the mercury problem in this ecosystem will be complicated by the spatiotemporal dynamics and complexity of the ecosystem, and project teams should contain the range of expertise needed to ensure defensible study design, analyses, and interpretation of data. It is recommended that, on average, about half of the team members on a project be “mercury specialists” and the remainder be scientists who bring other, essential expertise and knowledge on ecosystem processes, organismal biology, wetland ecology, sampling design, statistical analysis, risk assessment, modeling, or other pertinent applications. Project proposals should also demonstrate earnest commitments to provide timely information to ecosystem managers, to engage actively in facilitating the application of project results to adaptive management, and to participate substantively in the syntheses of results from multiple projects.

The establishment of a systematic monitoring program for mercury in fish is a high priority. The development and design of an effective monitoring program will require insightful leadership, input from managers and stakeholders, multidisciplinary technical guidance, and modest budgetary support. We recommend and have outlined a step-wise approach for development of a mercury-monitoring program, which would incorporate input from scientists, managers, and end-users of the monitoring data. Procedures for programmatic oversight of quality assurance should be in place at the onset of monitoring and other funded investigations to establish that the data emanating from multiple teams and laboratories are comparable and valid.

The transfer and sharing of information from mercury investigations should be actively facilitated, given the importance of rigorous interdisciplinary synthesis of results and timely provision of information for adaptive management. Effective mechanisms for rapid information transfer will be essential to ensure that interim data and information are available to facilitate timely information synthesis and application to management decisions. An annual meeting should be convened to provide a forum for sharing, discussion, integration, and review of interim results. Peer review by an external science panel should be a focal point of the meeting, providing constructive feedback at both the project and multi-project levels.

Effective coordination will be absolutely crucial to the success of this overall effort. It is strongly recommended that a full-time “mercury coordinator” be recruited or appointed to serve as a scientific leader, a facilitator, a communicator, and a point of contact on mercury issues for the Bay-Delta Program. The coordinator should have the leadership ability, scientific stature, and communication skills needed for effective synthesis and communication, and should have a

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key role in the organization and oversight of annual review meetings.

Mercury-polluted landscapes present an enormous challenge for ecosystem managers. An integrated mercury program would catalyze essential advances in understanding of the cycling, effects, and remediation of this toxic metal and should also enhance scientific understanding of the Bay-Delta ecosystem.

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Recent Mercury-related News Articles

SAN FRANCISCO BAY

New plan to cut mercury release into bay

San Francisco Chronicle - 5/1/04

By Jane Kay, staff writer

State officials are cracking down on mercury pollution in San Francisco Bay, issuing a plan Friday to reduce the toxic metal in storm water runoff and from old mines and the Central Valley.

After a decade of study, the San Francisco Bay Regional Water Quality Control Board is requiring cities and counties to cut mercury releases by 40 percent over the next 20 years to make the bay clean enough to produce fish that are safe to eat.

The scientists believe that it will take 120 years for the bay's mercury levels to return to pre-Gold Rush days, before the mining of both mercury and gold sent tons of the poison into watersheds and the bay.

Tom Mumley, division chief for planning at the regional water board, called the bay's mercury mess "an unfortunate legacy."

"Even if we stopped all new increases, which obviously isn't possible, it would still take three or four decades for the bay to recover," Mumley said. "It takes a long time for all the mercury to leave the bay. That's just Mother Nature."

Tighter limits on mercury will come, in part, as a result of new conditions on permits that cities and counties must get to operate sewage treatment plants, release storm water runoff into the bay and clean up mine wastes. Much of the new mercury that enters the bay washes off city streets.

"We aren't even sure what the biggest sources are to the bay -- our initial investigation didn't show one big source," said Geoff Brosseau, executive director of the Bay Area Stormwater Management Agencies Association, which encompasses 90 cities and counties.

Under the new plan, mercury in urban storm water runoff must be cut by half in two decades.

Brosseau said consumers could help by taking their fluorescent light bulbs, which contain mercury, for proper disposal, and by exchanging mercury thermometers for digital ones. Consumers can call (800) 253-2687 for locations.

Mercury falling from air pollution on streets is hard to control, Brosseau said. About 90 percent comes from as far away as coal-fired power plants in Asia.

The Santa Clara Valley Water District is one of the agencies responsible for cleaning up mercury from the now-closed New Almaden Quicksilver Mine, the biggest contributor to mercury in the Guadalupe River watershed.

The district is completing a \$1 million study to figure out the cheapest, most effective way of eliminating mercury in wastes. The new plan requires a 95 percent reduction in mercury from the watershed over 20 years.

A nationwide program to go after entrenched water pollutants such as mercury, PCBs and DDT, dates back 25 years. After decades of delay, fights between industry and environmentalists and court battles, the Bay Area is starting to attack its worst pollutant by setting "total maximum daily loads" for mercury.

Mercury damages neurological systems, particularly in the fetus and young child, and can impair learning and physical development. In adults, it can cause tremors and anxiety and affect memory.

Most of the bay's mercury lies embedded in sediments at the bottoms of creeks and bays, contaminating fish and other aquatic species. Leopard shark, striped bass, white sturgeon, California halibut, white croaker and shiner surfperch all carry mercury in their tissue. The California Environmental Protection Agency has issued health warnings for sport and subsistence anglers.

Recovery from mercury pollution occurs differently around the bay, said Michael Connor, executive director of the San Francisco Estuary Institute in Oakland.

"Near the deeper, fast-moving channels, the mercury-laden sediments can flush out of the Golden Gate over 50 to 100 years. In the wetlands at the shallower edges of the bay, cleaner sediments coming down the watersheds eventually bury the dirty sediments to depths below which organisms can live," Connor said.

According to the new plan, about 2,685 pounds of mercury enter the bay every year. The following are some of the sources and the proposed cuts over the next 20 years:

-- Erosion of sediment accumulated on the bay floor, 1,012 pounds, which is expected to decrease over time.

-- Runoff from the Central Valley watershed, 968 pounds, which must be cut by 33 percent.

-- Urban storm water runoff, 352 pounds, which must be cut by 50 percent.

-- Guadalupe River watershed, including the New Almaden Quicksilver Mine above San Jose, 202 pounds, which must be cut by 95 percent.

The regional water board must accept the new mercury plan, then send it to the State Water Resources Control Board and the U.S. Environmental Protection Agency for approval. The finished product may come out in nine months.

On Tuesday, there will be a public meeting on contaminants in the bay and cleanup alternatives. It will be held at the Lawrence Hall of Science in Berkeley from 9 a.m. to 4 p.m. The new plan to control mercury will be discussed in the afternoon. #

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MERCURY CONTAMINATION

Bay report details effects of mercury

Mining legacy: Huge cleanup task

San Jose Mercury News - 4/30/04

By Frank Sweeney, staff writer

More than a century after the California Gold Rush, mining operations in the Sierra Nevada foothills and New Almaden south of San Jose have left a toxic legacy that threatens human health and endangers wildlife in San Francisco Bay.

Those are two major sources of mercury -- a toxic metal -- in the bay, state water officials have determined after a decade of exhaustive studies.

Today, nearly 1,000 pounds of poisonous mercury still flows from the old gold mine tailings down the Central Valley rivers, through the delta and into the bay every year. About 200 pounds annually move from the 19th-century New Almaden quicksilver mines down the Guadalupe River into the bay. Urban storm-water runoff is another major contributor.

``This is the stuff left over from the Gold Rush," said Wil Bruhns, senior engineer for the San Francisco Bay Regional Water Quality Control Board, a state agency. ``People were kind of sloppy in the 1800s."

In fact, Bruhns said, the hydraulic mining in the late 19th century in the Sierra foothills washed so much soil into the rivers that it deposited three feet of new sediment across the bottom of the North Bay. ``There's a lot of mercury in that three feet of dirt."

Said Geoff Brosseau of the Bay Area Storm Water Management Association:

``This is the result of actions taken by our ancestors who just didn't know."

The board today will release a staff report describing the mercury problem and how it affects sport fishing, has caused health officials to recommend limiting how much bay fish we eat, and how it causes egg hatching problems for endangered species.

What to do about nearly 70 tons of mercury now stored in the bay sediments and more than a ton of the toxic metal that continues to flow in from a broad number of sources is the next big question facing the regional water board.

The board's goal is to reduce the amount of mercury in the water by half over the next 120 years, with major reductions over the next 20 years as control strategies are put in place. But Bruhns said it is possible that the mercury in the bay sediment could be reduced by two-thirds in that time frame.

The ultimate solution is nearly certain to mean new regulations that will put the burden on cities, counties and sewage districts to reduce water pollution from so-called ``non-point" sources, such as storm water that washes into creeks and then the bay.

``This identifies the problems and what might be solutions," said Brosseau. ``We need to start experimenting and see how we're doing in five years, 10 years, 20 years."

A critical task will be restoration of wetlands that once ringed the bay and acted as a natural filter, removing pollutants from the water, said David Lewis, executive director of Save the Bay, an environmental organization.

The report says about 2,684 pounds of mercury enters the water of San Francisco Bay every year, including:

- From erosion of mercury-containing sediment on the bay bottom: 1,012 pounds.
- From runoff from the Sierra Nevada foothills into Central Valley rivers: 968 pounds.
- From storm water runoff from urban areas: 352 pounds.
- From the Guadalupe River through San Jose: 202 pounds, most from the quicksilver mines.

But, the studies estimated, 3,080 pounds of mercury already in bay sediments are flushed out through the Golden Gate, evaporates or is dredged from the

bottom and deposited elsewhere. So the bay is cleaning itself naturally, but at a slow rate.

``If you could magically reduce the input to the bay to zero, it would still take 30 to 40 years for what has been in the bottom of the bay to work its way out," Bruhns said.#

Elevated mercury levels in fish spurs proposed health warning
Lake Natoma and lower American River are focus of concern.
Sacramento Bee - 4/30/04
Staff report

The state is considering issuing an advisory to warn about eating fish from Lake Natoma and the lower American River in Sacramento County, an official said Thursday.

The concern is over elevated mercury levels, said the official for the the California Environmental Protection Agency's Office of Environmental Health Hazard Assessment.

"The mercury ... is a legacy of a century of gold mining activity in this region that began with the Gold Rush and continued into the 1950s," Dr. Joan Denton, director of the hazard assessment office, said in a prepared statement.

"The public should still enjoy fishing at these water bodies, but we recommend that people - especially women of childbearing age and children - carefully monitor how much fish they eat."

The mercury is from Gold Rush mines that bleed the toxic metal into waterways after it rains. The problem is widespread over Northern California.

A draft advisory proposes that people limit eating bass, channel catfish and other fish species from Lake Natoma and the lower American River between Nimbus Dam and Discovery Park.

Women of childbearing age and children age 17 and younger are urged not to consume any channel catfish and limit eating all bass, white catfish, pikeminnow and sucker to one meal a month, and bluegill, sunfish and other species to one meal a week, the proposed advisory says.

Women beyond childbearing years and adult men are urged to limit eating channel catfish and bass to one meal a month; white catfish, pikeminnow and sucker to one meal a week; and bluegill, sunfish and other species to three meals a week, the proposal says.#