(DRAFT)

Delta Tributaries Mercury Council
March 4, 2004
Woodland Public Library, Leake Room
Woodland, CA

Facilitator and Meeting Summary: Chris Harris, Harris & Company

Attendees:
Vicki Murphy, Cache Creek Stakeholders
Vicki Fry, SRCSD
Tom Grovhoug, LWA
Ray Krauss, BRBMA
Shelby Lathrop, Shaw Environmental
Edward Salinas, Pacific Eco Risk
Saran Reeves, Dept. of Conservation
Stephen McCord, LWA
Patrick Morris, CVRWQCB
Donna Podger, CA Bay-Delta Authority
Daraj Jones, SWRCD – DWQ
Jim Sanborn, OEHHA
Ben Applestone, Yolo Co. PPWS
Darell Slotton, UCD
Chris Foe, CV RWQCB
Christy Barton, Yolo Co. Flood Control & WCD
Fraser Shilling, UC Davis
Charlie Alpers, USGS
Greg Reller, Tetra Tech
Tom Suchanek, USFWS
G. Fred Lee, G. Fred Lee Assoc.

Agenda:

I. Introductions, Agenda Review, Meeting Summary Approval
II. Update: SRCSD’s Offsets Program – Vicki Fry
III. Darell Slotton – CALFED Cache Creek bioaccumulation and trophic transfer studies
IV. Chris Foe – Pilot transplant studies of Asiatic Clam
V. Stephen McCord – Mercury water column and fish tissue data
VI. Other Updates

- SRWP – Tom Grovhoug
- CALFED Mercury Strategy Implementation Plan – Donna Podger

VII. Next Meeting

Meeting

I. Introductions and Agenda Review

*Introductions:* Meeting participants introduced themselves.

*Agenda Review:* The group reviewed the agenda; no changes were made.

*Meeting Summary Approval:* The group had no changes to the summary of the previous meeting.

II. SRCSD Offsets Program: Vicki Fry reported SRCSD is looking at potential mercury offsets for the District’s treatment plant’s discharges to the Sacramento River. The District has undertaken a stakeholder process that will discuss three potential reduction scenarios:

- Spring/stream restoration to reduce the load from natural and thermal sources
- Mine remediation at Abbot/Turkey Run
- Cache Creek settling basin

Public workshops to discuss the topics shown below were held at the DWQ office at Mather:

- **April 1** Crediting mechanisms – how to “bank” offsets.
- **April 2** Legal liability and the regulatory framework.
- **April 27** Panel of regulators and scientists on the bioavailability of mercury, management questions and how to design the study.

The District will host two additional meetings in the near future: (1) to discuss legal liability issues and (2) to discuss criteria for mass load reduction project.

Question: Would a sedimentation basin on Cache Creek be considered a physical or biological process? The answer is that it would be an expansion to what is already there.

III. Darell Slotton, UC Davis – Results from the CALFED Cache Creek bioaccumulation and trophic transfer studies. Parts of this summary were extracted from D. Slotton, et al’s paper - *Mercury Bioaccumulation and Trophic Transfer in the Cache Creek Watershed of California, in Relation to Diverse Aqueous Mercury Exposure Conditions*, found at: http://loer.tamug.tamu.edu/calfed/Report/Final/
The Turkey Run/Abbott complex of Hg mines and the Sulfur Creek complex of Hg mines and geothermal springs were confirmed to constitute important point sources of elevated THg, MeHg, and MeHg bioaccumulation in the Cache Creek watershed. Results of this study indicate that remediation of Hg discharges from these regions may be expected to significantly reduce MeHg bioaccumulation levels, both locally and potentially more widely in the watershed.

Piscivorous fish at mid Bear Creek, 10 km downstream of Sulfur Creek, demonstrated among the highest muscle Hg levels found to date in California, with most wet weight concentrations at 2.00-4.00 µg/g, ranging to over 6.00 µg/g, all in fish of only 0.6 kg size and smaller. These concentrations were multiple times greater than state, national, or international consumption guidelines.

Even detritivorous Sacramento suckers demonstrated concentrations well above the US FDA 1.00 µg/g action guideline in 83% of samples from this area. At the Harley Gulch location, downstream of the other primary point source region, fish were not present for monitoring but aquatic invertebrates exhibited accumulations of MeHg more elevated than at any other site sampled in the watershed.

While Hg concentrations of all measured parameters were most elevated in the tributary streams draining the point source regions, effects were also apparent well downstream. In the main stem of Cache Creek, MeHg bioaccumulation was shown to increase downstream of the identified point source inflows by approximately 100% in the larger fishes, continuing to the outlet of the creek. While absolute concentrations in the main stem were far less elevated than in tributaries nearer the point sources, piscivorous fish in the effected reaches were well above the EPA 0.30 µg/g criterion in all but young-of-year individuals, with concentrations to approximately 1.50 µg/g. Detritivorous Sacramento suckers were above the EPA criterion in individuals over approximately 400 mm. Minnows and other small fishes contained MeHg above the 0.10 µg/g level recommended for protection of piscivorous wildlife at Cache Creek sites downstream of the identified point source inflows, with dramatically greater concentrations in tributaries nearer the Hg point sources. Comparative large fish muscle and small fish whole body MeHg were generally below the respective guideline levels at upstream control sites, though the Upper Bear Creek site was a notable exception.

The large range of aqueous and biotic Hg concentrations in the Cache Creek watershed allowed Darell Slotten et al to examine potential relationships among and between aqueous and biotic parameters. A number of general predictive relationships could be described and
others dismissed by project results. A recurring conclusion was the importance of examining linkages between Hg parameters on a site-specific basis when possible.

The point source distribution of Hg resulted in a somewhat bi-modal range of exposure and bioaccumulation levels across the watershed, leading to apparent general Hg correlations among and between all of the primary sample types. When examined on an individual site basis, though, aqueous raw MeHg alone was found to be predictive of corresponding MeHg bioaccumulation in low trophic level bioindicator organisms. When aqueous Hg parameters were compared to each other on a site-specific basis, a strong correspondence remained between unfiltered (raw) and filtered THg and between unfiltered and filtered MeHg.

Suspended solids (TSS) were found to be generally predictive of aqueous raw THg on a site-specific basis, but not of MeHg. It was not possible to establish the potentially more critical linkage between TSS or THg (re loading) and MeHg. During portions of each year, particularly in the tributary locations, aqueous MeHg became highly (and variably) elevated relative to corresponding aqueous THg, indicating variably enhanced localized net MeHg production.

It was possible to investigate site-specific relationships by focusing on water and low trophic level biota, both of which varied dynamically with the seasons. For linkages to large fish Hg, it was necessary to average aqueous and low trophic level biotic Hg data by site and then broadly compare site ratios. Largely due to the presence of a range of exposure conditions across the watershed, this approach yielded some surprisingly strong general MeHg relationships between bioindicators and large fish, as well as directly between aqueous MeHg and all of the monitored biota, including large fish. Relatively consistent linkages between water and biota were limited to sites with similar water quality characteristics, while inter-trophic biotic MeHg linkages were more broadly applicable in the watershed.

These general relationships may be used to estimate reductions in fish Hg corresponding to various projected declines in aqueous MeHg, in relation to regulatory and remediation management. However, while pooled data approaches were necessary to estimate general linkages to large fish Hg, it is important to recognize the limitations of such highly reduced data techniques, as compared to the development of site-specific relationships. This watershed was shown to contain some very different site-specific relationships.

Results of this study indicate that the most useful environmental samples for regulatory and remediation monitoring for Hg include unfiltered aqueous MeHg and short-lived, relatively easily obtainable, low trophic level biota, in addition to larger fish of human health
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concern. To be most useful predictively, water must be characterized across annual cycles with numerous samplings. Benthic invertebrates and young-of-year small fish may offer more integrative seasonal measures of relative MeHg exposure. Large fish integrate their Hg bioaccumulation over periods of years. Seasonal comparisons of water vs low trophic level bioindicators at individual sites can provide direct linkages between aqueous MeHg and localized bioaccumulation into the aquatic food web.

Bioindicator MeHg may additionally provide a dynamic, readily assessed, integrative measure of relative MeHg exposure and bioaccumulation that can be linked to ultimate concentrations in co-occurring large fish. These techniques should be useful in future Hg monitoring of the Cache Creek watershed in particular, as well as other watersheds in general.

IV. Chris Foe, Central Valley Regional Water Quality Control Board – Transplant Studies with the Introduced Asiatic Clam, (Corbicula fluminea), to measure Methylmercury Accumulation in the Sacramento-San Joaquin Bay-Delta Estuary. Authors: Chris Foe, Mark Stephenson, and Stacy Stanish. (Additional reference: loer.tamug.tamu.edu/calfed/finalreports.htm)

The objectives of the Transplant Studies with Introduced Asiatic Clam to Measure Methylmercury Accumulation in the Sacramento – San Joaquin Bay-Delta Estuary were:

- Determine temporal and spatial pattern of MHg uptake in the aquatic food chain of the Bay-Delta estuary by measuring changes in the mercury concentrations in the tissue of the introduced Asiatic Clam corbicula.

- Determine if possible primary factor(s) responsible for MHg accumulation in the clam.

Chris Foe began the presentation with a slide showing the correlation of the food chain and mercury biomagnification factors.

Method and materials: Chris’s presentation included a map of Putah Creek and Sacramento River where clams were collected and transplanted. Chris showed photos of the cages constructed for the clams. There were three cages per site, placed 200 to 300 feet apart, always located below water. Ten clams from each cage were sampled. The size of clam for this study was 18 to 19 mm across.

The conceptual model proposed that the clam would represent the phytoplankton effect. Clams, being filter feeders, are particular about how they handle mercury in the water.
Raw methyl mercury was measured in the water and in the clams to conclude how much is bioavailable.

**Control Studies:** Control studies included:
- Comparing MHg tissue concentrations in clams and several common species of fish in the Bay-Delta estuary.
- Determining MHg tissue concentrations as a function of clam size.
- Comparing MHg concentrations in caged and wild clams.
- Determining the length of time for MHg tissue concentration in transplanted clams to become the same as the wild population.

Chris gave an overview of the results of the study. He said that:
- Clams can be used as a surrogate for mercury uptake in fish.
- Concentrations of MHg are independent of clam size. In fish, there is a natural increase of MHg with age and size. Clams must be processing mercury differently.
- While there are *seasonal* differences, wild and caged clams responded to mercury the same.
- A fourth control study examined the length of time for MHg tissue concentration in transplanted clams to become the same as the wild population. The study authors found that 70% of the mercury departed within one month when transplanted from Putah Creek to the Rio Vista site. Conversely, it took four months to transform to levels of wild clams when moved from the Rio Vista site to Putah Creek.

Especially in Putah Creek, the amount of methyl mercury measured in tissue concentration (ppb dry weight) changed with the season (higher in summer months); however, caged and wild clams measured quite similarly. There was much less seasonal influence in the Sacramento River samples; still, caged and wild clams showed similar mercury measurements.

Chris said that the following formula applies:

\[
\text{Tissue concentration}_{T=2} = \text{Tissue concentration}_{T=1} + \frac{D \cdot \text{MHg}_{T1 - T2}}{D \cdot \text{Dry Tissue Weight}_{T1 - T2}}
\]
Where:

\( \Delta \) tissue concentration \( T_1 - T_2 \) and \( T=T_2 \) is the tissue concentration \((ng gm^{-1})\) of an individual clam at Time 1 and 2.

\( \Delta \) methyl mercury \( T_1 - T_2 \) is the change in an individual clam’s body burden \((ng gm^{-1})\) over the same time interval.

\( \Delta \) dry tissue weight \( T_1 - T_2 \) is the change in tissue weight of an individual clam \((gm clam^{-1})\) between Time 1 and 2.

The study saw a statistically significant relationship between growth and chlorophyll. The only MHg that clams see is bound to food. The study shows a strong binding affinity between organics and MHg.

Conclusions of the study: Chris said the study had several conclusions:

- There is a positive correlation between MHg tissue concentration of clams and four of the nine fish species examined.
- Caged and wild clams from the same location had similar seasonal MHg tissue concentration patterns.
- The study attempted to explain changes in caged clam MHg tissue concentrations \((ng-gm^{-1})\) by measuring changes in MHg body burden \((ng-clam^{-1})\) divided by changes in tissue concentration \((gm-clam^{-1})\).
- MHg burden in clams was a function of raw aqueous MHg concentration divided by chlorophyll and phaeophytin.
- Clam tissue growth was a function of temperature, chlorophyll and phaeophytin and reproduction.
- Clam MHg tissue concentration was a function of aqueous MHg concentration divided by the square of the chlorophyll and phaeophytin concentration.

V. Stephen McCord – LWA: Managing Mercury in the Cache Creek Watershed; Draft TMDL Strategic Plan

Steve McCord gave a presentation on work to-date to explore validity of the load reduction hypothesis to managing Hg in fish and watersheds; and the use of BAFs in linkage analysis.

The background of Stephen’s presentation was that the Regional Water Quality Control
Board asked DTMC to review the information and methodology of the draft staff report for the Cache Creek TMDL. The TMDL presents an approach to mercury management in the watershed. Stephen presented the results of an evaluation of the TMDL using some of the concepts presented in the DTMC strategic plan.

Stephen showed a linkage analysis diagram that showed the path of mercury to humans through water, transformations, bioaccumulation and biomagnification, and finally, exposure to consumers. The focus of his presentation is the linkage between MeHg in water and sediments near biota and fish tissue.

In Stephen’s presentation, there were slides showing potential linkage relationships that were linear (1:1 and other), non-linear, and none. The key concept to understand is that the relationships link through multiplication rather than addition. Therefore the weakest relationship tends to control the overall relationship. In other words, a shotgun relationship in any step causes the overall relationship to be a shotgun relationship.

Stephen showed a slide of what a BAF (bioaccumulation factor) implies. A BAF in mercury management implies that changing mercury concentration in one compartment (e.g. water) would result in a change in the related compartment (e.g. fish).

He then showed graphs of relationships that would be addressed in the Cache Creek TMDL. He said that the Cache Creek TMDL concludes that a MeHg ð Prey ð Big Fish relationship exists; and implicitly that a THg ð MeHg ð Prey ð Big Fish relationship exists. In fact, empirical data for the latter (implied) relationship is closer to a shotgun graph than the assumed result. Stephen reported that this is problematic.

He then showed graphs of site-specific data for the Cache Creek watershed. The data for Mid-Bear Creek showed no relationship between aqueous raw THg and aqueous MeHg. Non-zero intercept graphs for Mid-Bear Creek indicated that levels in inverts and small fish will never get to zero. Combining the two graphs showed no statistically significant relationship.

He showed Harley Gulch data graphed for BAF. He said that small TL2 and TL3 fish are present in Harley Gulch but have not been tested for mercury. However, a linkage relationship was derived using the BAF for methylmercury in small fish in Harley Gulch invertebrates. The assumption is that concentrations of methylmercury in small fish in Harley Gulch are similar to levels in invertebrates.

The final point that is not addressed in the Cache Creek TMDL is that a linear relationship is presumed over the full range of fish tissue levels. The results of remediation
effectiveness studies nationwide over the past 30 years shows that there is a leveling-off in fish tissue levels, typically at or above USEPA target levels of 0.3 mg/kg.

Stephen said that this says that load management may help reduce levels in fish in gross exposure circumstances. But we need to pay attention to where starting fish tissue levels are in placing expectations on the success of load management approach in watersheds.

Conclusions:

- DTMC needs to continue to explore the validity of (1) load reduction hypothesis to managing Hg in fish in our watersheds and (2) use of BAF’s in linkage analysis.
- DTMC needs to support targeted data collection and pilot load reduction projects as part of this evaluation.
- DTMC needs to communicate uncertainty where it exists.

VI. Other Updates

- SRWP, Tom Grovhoug – Tom gave a brief update on the SRWP funding status.

VII. Next meeting: May 6, 2004