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Final Report

Localized Mercury Bioaccumulation Study

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Executive Summary

The Sacramento Regional County Sanitation District (SRCSD) operates the Sacramento Regional Wastewater Treatment Plant (SRWTP), which treats wastewater from the Sacramento metropolitan area and discharges approximately 130 million gallons per day of treated wastewater into the Sacramento River. The Central Valley Regional Water Quality Control Board is in the process of developing a mercury Total Maximum Daily Load (TMDL) for the San Francisco Bay-Delta. Although mercury loads from the SRWTP are currently well below the interim maximum specified in its permit, new limits expected in the forthcoming TMDL may require SRWTP to reduce or maintain its existing mercury loads discharged to the Sacramento River. SRCSD has been investigating the potential for using offsets as a means of complying with future permit requirements. An offset program would reduce unregulated mercury loads elsewhere in the watershed, generating SRCSD credits against its mercury wasteload allocation in the TMDL while providing a greater overall load reduction to the Delta.

Hot Spot Concern

The term "hot spot" has been used differently in a variety of policy discussions and regulatory proceedings. In overtly contaminated waters, a hot spot could be defined as an area or reach of river with a several-fold increase in concentration of a pollutant or an anomalous impact to aquatic organisms. Relevant to mercury in the Sacramento River, the term hot spot has been used by policy makers to express concern over localized impact to people and wildlife who consume fish. For the purpose of this study, a "hot spot" is defined as follows:

> **Technical:** The null hypothesis (that there are no spatial or temporal bioaccumulation gradients) is rejected because of a measureable effect of SRWTP effluent. "Rejecting the null hypothesis" is based on a statistical test of the difference between levels measured upstream versus downstream of the outfall. A "significant" difference merely means in this context that the statistical conclusion is highly certain, not that the difference is necessarily large.
>
> ***AND***
>
> **Policy:** Evidence of a localized environmental risk is so clear and convincing that a reasonable decision maker would conclude that some action must be taken locally before an offset project could proceed elsewhere.

To address the concern that a mercury offset program might create a hot spot in the lower Sacramento River, a key element of SRCSD's proposed mercury offset program is this localized mercury bioaccumulation study. The intent of this study was to determine whether an offset program, by focusing reduction efforts elsewhere and thus allowing SRWTP to continue discharging current or greater loads of mercury via its outfall in the lower Sacramento River, would cause a hot spot of localized bioaccumulation substantially above background levels.

Based on effluent and receiving water sampling data, effluent from the SRWTP does not appear to be more bioavailable than mercury from background sources; however, measurements of aqueous concentrations of mercury do not directly quantify either actual or potential

bioaccumulation or inherent risk to consumers. Therefore, it was important to determine whether there is a quantifiable, detrimental, localized mercury bioaccumulation effect in the lower Sacramento River caused by effluent discharged from the SRWTP outfall. The study described in this report was intended to address this question.

Study Components

This study was funded by SRCSD and conducted by a project team consisting of consultants, university researchers, and SRCSD staff. In addition, a Technical Advisory Committee of national experts was assembled during preparation of the work plan to provide independent review and comment on the work plan, its implementation, and the findings in this report.

Monitoring stations were established both upstream and downstream of the outfall, and within the effluent plume (**Figure ES-1**). Monitoring of water, sediments, and biota (the Asiatic clam, *Corbicula fluminea,* and fish) was conducted monthly during a period of low flow in the river (July – December 2006) on the assumption that any differences in mercury concentrations in water, sediments, and biota would be most pronounced during that period, and therefore any effects of SRWTP effluent on the river would be most detectable. Two stations were upstream of the outfall (GB and R-1); one station was within the outfall's mixing zone (R-2b) and two more were farther downstream (R-3 and RM44).

Fish sampling focused on small biosentinel species, which have been shown to provide strong site-specific and time-specific measures of relative methylmercury exposure. Key fish species studied were the Mississippi silverside (*Menidia audens*), prickly sculpin (*Cottus asper*), and juvenile black bass (*Micropterus salmoides, Micropterus punctulatus*). Sampling was conducted in the fall season of 2005 and 2006 at Garcia Bend and River Mile 44, to "bookend" the study reach. In addition, several regional sites as far as 150 miles upstream and throughout the Delta downstream were sampled.

A portion of this study included community education, fish consumption evaluations, and evaluation of the effectiveness of methods of communicating risk from eating fish from the Delta. Anglers on the Sacramento River between River Miles 40 and 50, 4 miles upstream and 6 miles downstream of the SRWTP outfall, were surveyed roughly monthly between June 2006 and June 2007. The project team communicated with fish-consumers about mercury contamination during angler surveys and in meetings with community-based organizations representing some of the groups identified in the surveys.

Clam Results

There was substantial variation among stations and times in the concentrations of methylmercury in both resident and transplanted clams. There was no consistent trend over the study period in methylmercury concentrations for resident clams at any station. For transplanted clams, tissue concentrations decreased during the study period at all stations except RM44.

Mean dry-weight methylmercury concentrations in transplanted clams were 11% higher downstream of the SRWTP outfall. Mean dry-weight methylmercury concentrations in resident clams were 13% higher downstream of the SRWTP outfall and were very similar in magnitude to those for resident clams. However, if station R-2b (within the effluent mixing zone) is removed from this analysis, the upstream reach and the downstream reach have identical mean concentrations of methylmercury, which indicates that the difference between upstream and downstream reaches was due exclusively to high concentrations at station R-2b. Results of

resident clam tissue concentrations are shown along with other regional data in **Figure ES-2**. These data indicate that mercury is a regional problem and that SRWTP does not create a hot spot.

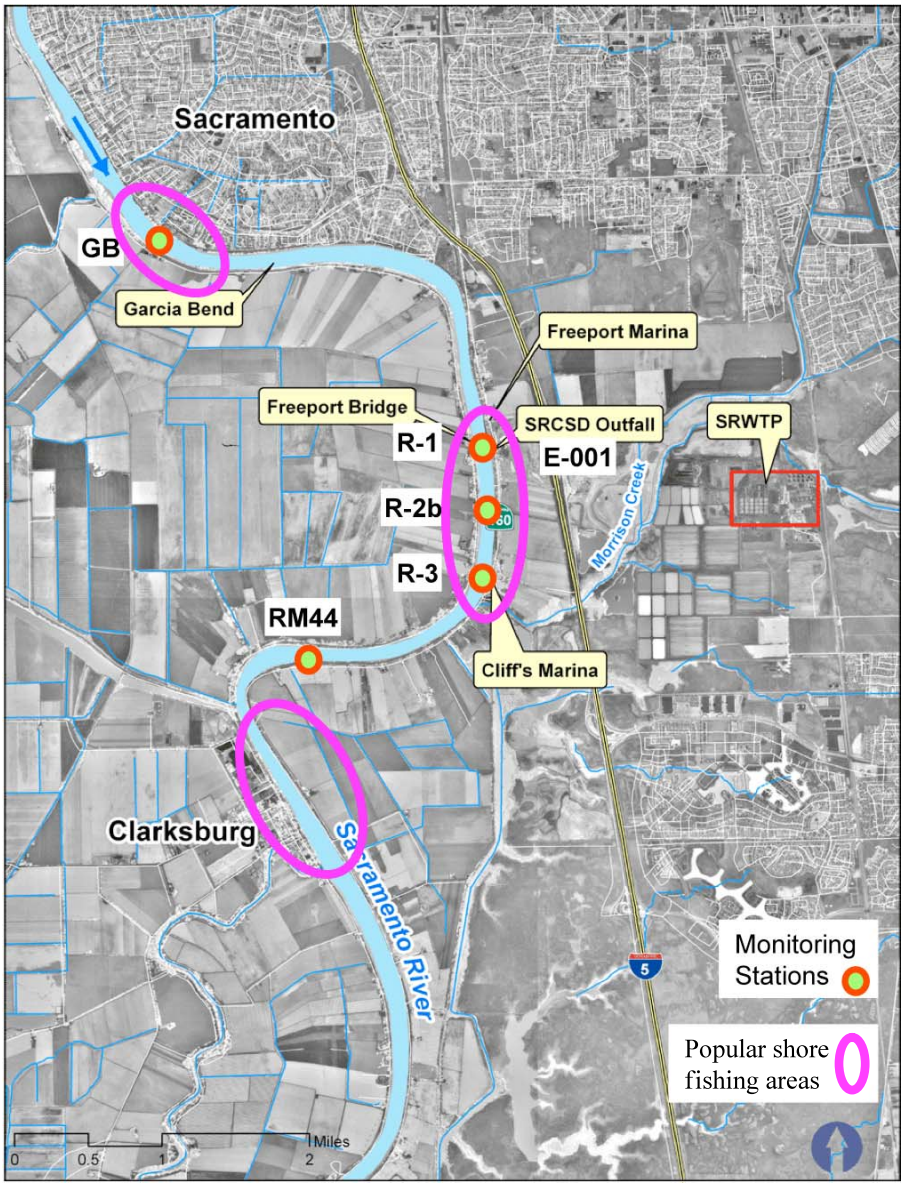

Figure ES-1. Monitoring station locations. River miles 40 and 50 are approximately at the bottom and top of the map, respectively.

Fish

Average and standard error values for mercury concentrations in three fish species sampled upstream and downstream of the SRWTP outfall are shown in **Figure ES-3**. Mercury concentrations in silversides and juvenile bass increased by approximately 12% and 10%, respectively, from Garcia Bend to River Mile 44, indicating potential effects of mercury in SRWTP effluent. The differences were consistent with methylmercury load estimates (~10% increase), and were small compared to other regional sites. However, mercury concentrations in

the longer-living prickly sculpin provided evidence to the contrary, exhibiting a *decrease* of about 10% from Garcia Bend to River Mile 44.

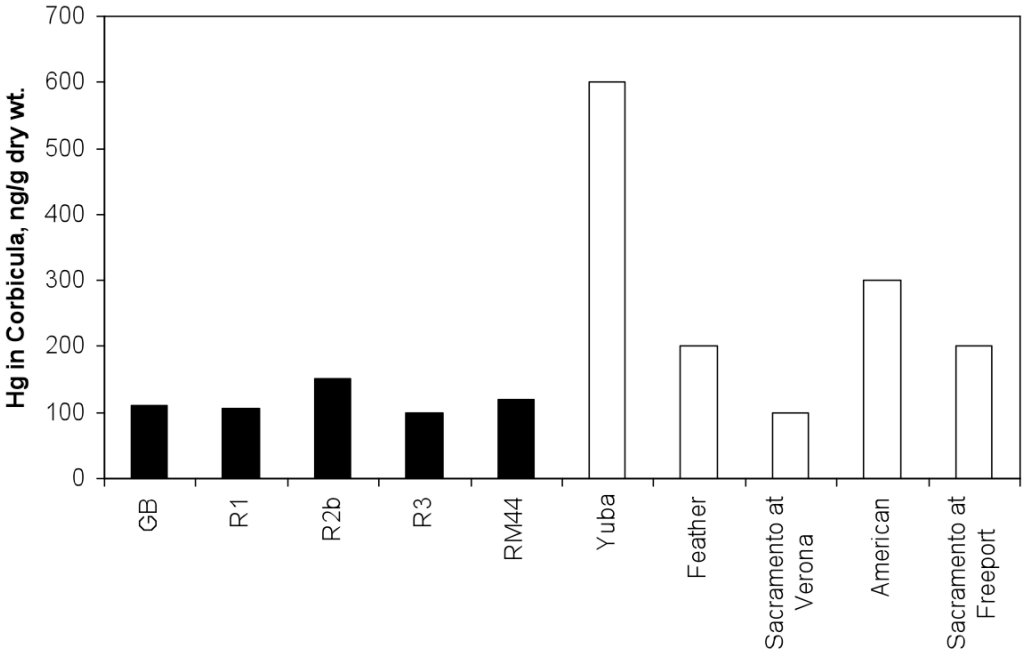

Figure ES-2. Comparison of mercury concentrations in resident *Corbicula* tissues measured in this study (black bars) with concentrations measured by USGS in 1995 as part of the National Water-Quality Assessment program (white bars).

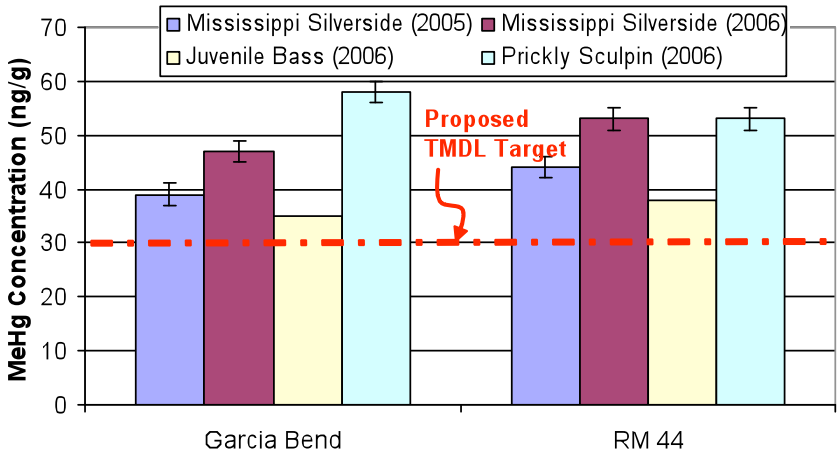

Figure ES-3. Average and standard error methylmercury concentrations in biosentinel fish upstream and downstream of the SRWTP outfall. The proposed TMDL target of 30 ng/g in fish < 50 mm long is shown.

By virtue of their excellent site fidelity and presence in good numbers at all of the extended sampling locations, prickly sculpin provided the strongest measure of relative exposure conditions in the Sacramento River, identifying sources farther upstream as the primary apparent

cause of elevated fish mercury in the lower Sacramento River (**Figure ES-4**). Data from silversides monitored regionally were consistent with this conclusion, identifying tributary areas (partly linked to historic mining), relatively lower levels throughout the Delta, and a secondary rise moving west to the North Bay. The Cosumnes River, Yolo Bypass, Petaluma Marsh, and Mud Slough regions were among the most highly elevated areas (**Figure ES-5**).

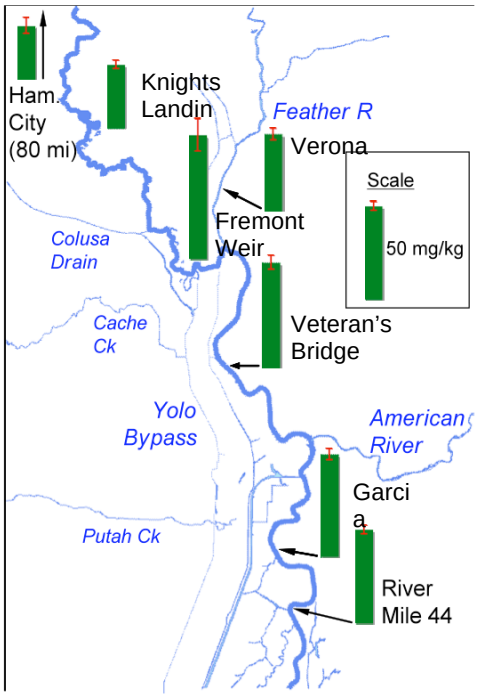

Figure ES-4. Prickly Sculpin mercury concentrations, 2006 sampling event. Error bars indicate 95% confidence intervals.

Sediment and Water Column Results

Mercury concentrations in river sediments were variable from upstream to downstream stations, and showed no statistically significant upstream – downstream differences. Likewise, there is no apparent correlation in sediments between total mercury and methylmercury, nor any apparent upstream-downstream difference. Similarly, mercury concentrations in the water column were highly variable and showed no statistically significant upstream – downstream differences.

Stepwise linear regressions for resident and transplanted clams were performed for dry-weight tissue concentrations of methylmercury to identify significant associations with various other measurements. The resulting correlations were statistically significant, but included inexplicable and anomalous characteristics that do not justify the use of the relationships. Thus, the spatial and temporal variations detected in clams are not definitively explained by any of the physical variables measured.

Community Outreach

Average fish consumption rates in the study area are similar to other rates reported in the Delta and in the US. However, certain ethnicities may have a mean mercury intake rate up to four times the USEPA standard of 0.1 micrograms/day/kg body mass.

As many as half of the anglers and community members surveyed were somewhat informed about mercury levels in fish. However, there appears to be no correlation so far between anglers recalling advice about fish contamination and their reducing fish consumption. Thus, attention should be paid to convincing trusted community liaisons to communicate the information in order to increase the impact of the information on behavior.

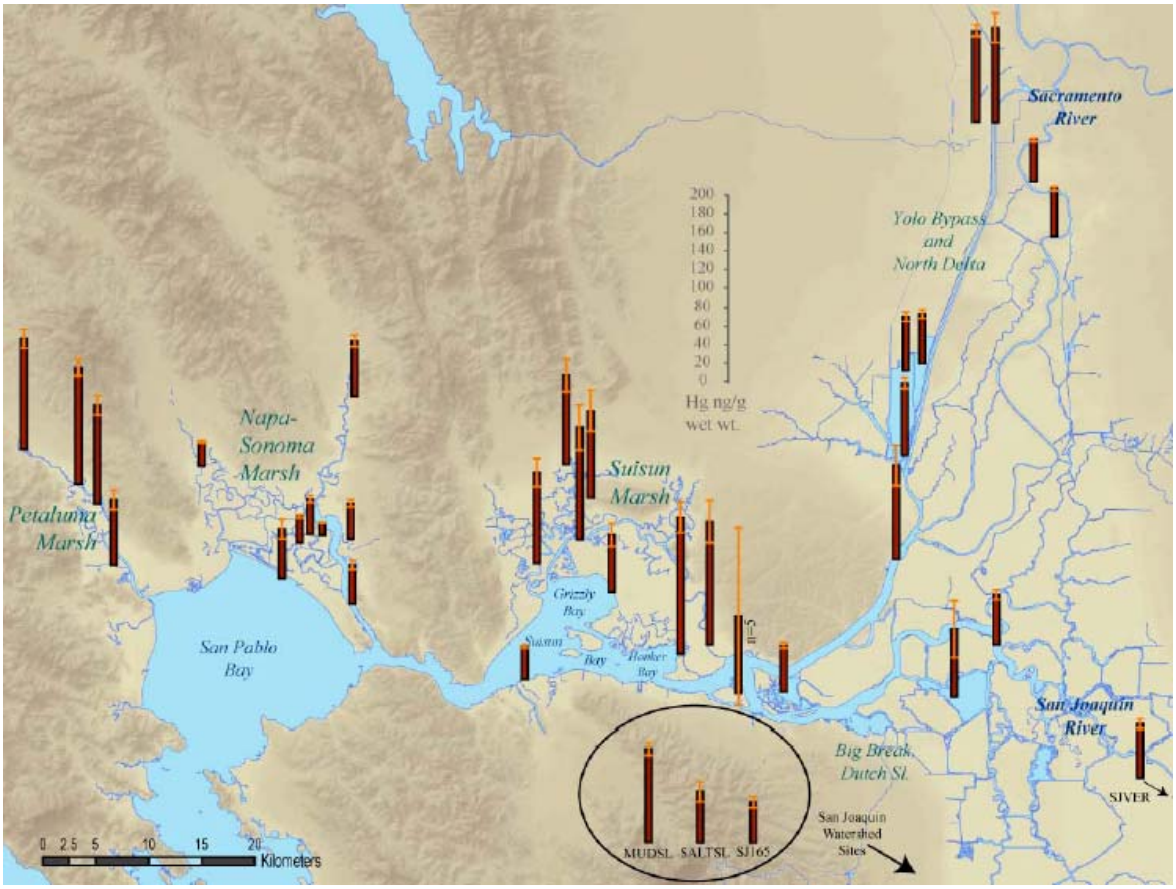

Figure ES-5. Fall 2006 map of silverside spatial mercury distribution. Copied with permission from Slotton et al. (2007).

Overall Conclusions

The null hypothesis used to define a hot spot in a technical sense is rejected by the data presented in this study: there was a measurable (i.e., statistically significant) effect of SRWTP effluent on most bioindicator organisms downstream of the outfall during low-flow river conditions that provide the least amount of dilution. But, the evidence of localized environmental risk is not so clear and convincing that a reasonable decision maker would conclude that some action must be taken locally.

The evidence presented in this report argues that an offset program, which would achieve greater overall reductions in mercury exposure than would an emphasis on continued reductions of mercury in the SRWTP discharge, is acceptable for addressing the regional problem of mercury levels in fish.