South Bay Salt Pond Restoration Project

Restoring the Wild Heart of the South Bay

September 2 2010

San Francisco Bay Regional Water Quality Control Board
1515 Clay Street, Suite 1400
Oakland, CA 94612
Attention: Andree Greenberg

Re: Regional Water Quality Control Board Order No. R2-2008-0078 for mercury monitoring requirements

Ms. Greenberg,

This letter describes how the South Bay Salt Ponds Restoration Project (Project) is approaching monitoring for mercury, mercury methylation and bioaccumulation risks as a result of Project actions. We are submitting this letter and attachments to seek confirmation from the Board that the Project is in compliance with Board Order R2-2008-0078, as requested.

Applied Studies and Directed Studies

Our Adaptive Management Plan (AMP) identifies several Key Uncertainties for Phase 1 (EDAW et al. 2007, Appendix D). We are monitoring and studying several different aspects of how our Phase 1 management actions will affect the environment at all three of the Project complexes (Ravenswood, Alviso, and Eden Landing). The Project released a Request for Proposals (RFP) in December of 2008 and identified these Key Uncertainties and monitoring needs for our Phase 1 actions. All proposals submitted underwent confidential peer review by at least two independent scientific reviewers. A panel of Project scientists and managers reviewed all the proposals and peer review comments, and selected the proposals that best met the research, adaptive management and regulatory needs of the Project. The principal investigators for the selected proposals were then asked to revise their proposals to address peer review comments, and/or submit responses to the peer reviewer's comments.

Table 1 summarizes the study designs for the two Project mercury studies for Phase 1; the Eagles-Smith study (Eagles-Smith et al. 2009; Attachment 1), and the U.S. Geological Survey (USGS) Research Studies (Takekawa et al. 2010; Attachment 2). The research work presented in the latter study focuses on broader research and studies than mercury; the Ackerman portion of the USGS Research Study is focused on addressing mercury issues, and that is the portion of the USGS Research Study which is summarized in Table 1. Figure 1 depicts the sampling location and type of samples for these studies. The RFP studies are referred to as Applied Studies. Additionally, the Project is collaborating with other entities (e.g., SFBBO, USGS) to address additional

monitoring and research needs above and beyond the Applied Studies; these are referred to as Directed Studies. Table 2 provides a summary of all the Applied and Directed Studies for Phase 1, as well as the USGS Research Study.

Table 3 describes the Project's Key Uncertainties and how the various studies will address these in Phase 1. The first Key Uncertainty is related to sediment dynamics and aspects of sediment accretion and movement as a result of the breaches. The Callaway sediment accretion study in the Island Ponds and in Pond A6, along with bathymetric and LiDAR surveys of the shoals areas off SF2 and Pond A6, and Alviso Slough, will address these questions. In addition, the Fulfrost study is using satellite imagery before and after the Phase 1 actions to chart changes in habitat throughout the entire project area.

Uncertainties in bird use of changing habitats is addressed through the Ackerman study of nesting, roosting, foraging behavior of waterbirds in various ponds slated for Phase 1 actions. In addition, the Herzog study will provide baseline bird abundance values as well as development of a salt pond carrying capacity model. We will also study the bird use of the shoals area off of Ponds SF2 and A6 to see how the benthic invertebrates and bird use changes with the restoration in those areas (Thompson Study as well as Takekawa USGS Science funding study). We are also developing a shoals bird carrying capacity model. Finally, we will be continuing to monitor bird use in the salt ponds and managed ponds throughout the entire project area, as well as focused studies such as monitoring of snowy plover nesting, and clapper rail population dynamics.

Other Phase 1 Applied Studies include evaluating the effects to non-avian species through extensive monitoring of fish communities and sentinel fish health in the Hobbs study. Uncertainties regarding mercury mobilization into the food web are being addressed through the Eagles-Smith study as well as the complementary study being conducted by USGS research funding. Effects on water quality and productivity are being addressed through the ongoing water quality monitoring, as well as the Thompson study evaluating benthic invertebrate community composition before and after the Interim Stewardship Plan. Uncertainties concerning invasive species are addressed through a study investigating techniques for early detection of Algerian sea lavender, as well as a study on the California gull movements and predation behavior. Finally, we are addressing uncertainties in how public access will affect foraging behavior of birds through the Trulio study, a recent supplement to the Ackerman study, as well as ongoing monitoring of snowy plover nesting areas.

Some of the above studies will provide supplemental information that will be useful to the water quality and Hg issues of concern to the RWQCB. We are also continuing to monitor water quality per the RWQCB requirements (which we are not detailing in this letter but have been the topic of previous submittals, correspondence, and meetings).

The Eagles-Smith study we are conducting as part of Phase 1 is scheduled to be funded through January 2013, when the final report is due. The USGS research study, which supplements the work of the Eagles-Smith study, is expected to receive funding in FY2011, so we anticipate that study to continue for another year as well. At the end of the two years of study and monitoring, we will evaluate the results against the triggers in the Adaptive Management Plan. The Project Management Team will review the results and decide on the priorities for future management actions and further monitoring/studies with input from the Technical Advisory Committee and the RWQCB.

This is Phase 1 of a very large, multi-year project and monitoring program. Our goal is to focus future studies on better understanding the processes and mechanisms that control mercury methylation and uptake into the food web, and how we might control those processes in future designs of managed ponds and tidal restoration actions so as to minimize mercury methylation and bioaccumulation. If a broader San Francisco Bay

monitoring program is developed, then the Project would like to be active participants in the design of such a program so that the studies and monitoring we perform for the Project are in harmony with any broader, Baywide monitoring goals.

Recent Submittals and Meetings

On November 4, 2009 we submitted the following via email to Andree Greenberg and Robert Schlipf of the San Francisco Bay Regional Water Quality Control Board (RWQCB):

- the final Eagles-Smith study (Eagles-Smith et al. 2009),
- three confidential peer reviews of the original Eagles-Smith proposal, and
- a summary of the peer review comments.

Ms. Greenberg acknowledged the receipt of this study and peer review comments and requested a copy of the South Baylands Mercury Project report when it was finalized. The final South Baylands Mercury Project report (Grenier et al. 2010) was sent to Andree Greenberg via email on February 10, 2010.

On December 9, 2009, Ms. Greenberg submitted two questions on the Project mercury study related to use of song sparrows as biosentinels. Laura Valoppi, the Project lead scientist, responded to these two questions in an email sent on March 10, 2010. On April 22, 2010, RWQCB staff, and Project staff and principal investigators met to discuss compliance with other aspects of the Board Order R2-2008-0078, and we had a short discussion on the mercury studies the Project had planned. We provided a summary table (Table 1) of the two principal studies to address mercury, namely the Eagles-Smith study, and research on mercury in the Project area to be conducted by the U.S. Geological Survey (USGS). A follow-up meeting specifically on the mercury studies for Phase 1 of the Project was held with RWQCB staff, Project staff and their principal investigators, and San Francisco Estuary Institute staff, on June 21, 2010.

Project Responsiveness to Board Order

The following Findings and Provisions are directly related to the issue of mercury. Below each is our description of how we are addressing the specific issue.

Finding 80 – *Potential Water Quality Impact 3.4-3 – Potential to mobilize, transport, and deposit mercury-laden sediments leading to exceedance of numeric water quality objectives, TMDL allocations, and sediment quality guidelines for total mercury. 3.4-4 – Potential increase in net methylmercury production and bioaccumulation in the food web.*

The Eagles-Smith study, supplemented with the USGS Research Study for mercury in water, sediment, and biosentinels will directly address these issue. The Eagles-Smith study is designed to assess mobilization of mercury-laden sediments into Pond A8 through monitoring water, sediment, two biosentinel fish species, and eggs from two biosentinel bird species. This study will also be monitoring mercury in sediment, water, and biosentinel fish within Alviso Slough.

The USGS Research Study will also be evaluating Hg in sediments and biosentinels fish and bird eggs in the Alviso and Ravenswood Complexes. Changes in bathymetry of Alviso Slough and shoal areas off of A6 and SF2 will also be monitored in the USGS Research Study. Thus the potential mobilization, transport and deposition of mercury-laden sediments will be monitored.

Sediment work as part of RFP study of Hg biogeochemistry in surface sediment will include MeHg production rates. The Eagles-Smith study and USGS Research Study have "before and after" designs so that MeHg and bioaccumulation in the food web can be compared before and after the breach at Pond A6 and the opening of Ponds A8 and SF2. The Eagles-Smith study also has monitoring at control sites, and will evaluate any movement of mercury as a result of Phase 1 actions. We have specifically chosen our biosentinels so that the results may be compared to existing TMDL values for mercury in whole bodies of small prey fish, bird eggs, and suspended sediment. Our water sampling focuses on grab samples at the time of collection of sediment and biosentinel samples, so our water sample results will not be able to be directly compared to the water quality objectives, which are based on a 4-day average and a 1-hour average. We expect that focusing our resources on sampling in sediments and biosentinels in the first phase of monitoring provides pertinent and useful information on the processes and mechanisms controlling mercury methylation, and provides information on risk to biological resources of the Project area.

Finding 82 – *Ambient levels of total mercury are above naturally occurring background levels, and can be transformed through natural processes into toxic methylmercury… the resulting concentration of MeHg is dependent on numerous variables…and seasonal variations.*

We are aware of the research showing that the amount of methylmercury produced in a system is a result of complex interactions and is dependent on numerous variables. The Eagles-Smith study will include analyzing a suite of these constituents. We are considering several of these variables in our analysis of water and sediment samples for the Eagles-Smith study, as well as seasonal variability, to better understand the mechanisms and processes affecting mercury methylation in the Project area in relation to our Phase 1 actions.

Measurements of Hg biogeochemistry in surface sediment will include MeHg production rates (via stable isotope tracer $^{202}Hg(II)$ amendment**,** Hg-speciation (total-Hg, MeHg, and reactive Hg(II)), and a suite of key ancillary parameters known to impact Hg-cycling (sulfate reduction via radiotracer $^{35}SO_4^{2-}$ amendment, organic content, pH, redox, total reduced sulfur, solid phase iron (II and III) speciation, grain size and pore water sulfate). Due to budget constraints, microbial rate assays (MeHg production and sulfate reduction) will be limited to Pond A8, A3N and A16 sediment, while all other measurements will be conducted on sediment samples collected from all three Ponds, as well as from Alviso and Mallard Sloughs. Table 2 of the Eagles-Smith study, Attachment 1, provides detailed information on the purpose of each assay and the analytic methods to be used. Sediment collection and associated measurement will occur at all nine locations where water collections occur, sampling six times over two years (between the 2nd quarter of Year-1 and the 4th quarter of Year-2), and in conjunction with six of the ten water/fish sampling events.

Spatial and temporal trends in water column Hg concentration and speciation will be assessed for both dissolved and particulate phases over the study period, and will be related to changes in the quality and quantity of suspended particulate material (i.e., phytoplankton and inorganic particles), dissolved nutrients (nitrate and phosphate), and dissolved organic carbon (DOC) and specific ultra-violet absorption (SUVA, and measure of organic matter quality and origin). Water samples will be collected using trace metal clean sampling techniques (USEPA, 1996), at nine locations per sampling event, on ten occasions (at approximately 2.5 month intervals) to capture the complete seasonal trends before, during and after the construction of the Pond A8 Notch. Further processing and sub-sampling in the laboratory will include the collection of the particulate phase on pre-combusted / pre-weighed glass fiber filters. Non-filter passing particulates will be collected for each of the following analytes: THg, MeHg, total suspended solids (TSS), particulate carbon and nitrogen (PC/PN), and chlorophyll. The filtrate will be subsampled for the following dissolved analytes: THg, MeHg, DOC and nutrients. All particulate samples will be preserved at -80 ^{o}C. Dissolved THg and MeHg samples will be

analyzed on an Automated Hg Analyzer (Tekran Model 2600), according to EPA Method 1631 (USEPA, 2002). Particulate MeHg samples will be analyzed on a Brooks Rand automated MeHg analyzer, following Bloom (1989). Dissolved THg will be quantified on the Tekran Model 2600 Automated Hg Analyzer (USEPA, 2002).

Total suspended solids methods follow (Kendall *et al.* 2001). DOC samples will be analyzed (Qian and Mopper, 1996) on a Total Organic Carbon Analyzer. SUVA will subsequently be calculated from the UV absorption and the DOC concentration (USEPA 2005). Dissolved nutrient samples will be stored frozen and will be subsequently analyzed on an automated Aquakem 250 nutrient analyzer, according to manufacturer recommendations. Details of all the analytical methods are described in Eagles-Smith et al. (2009), Attachment 1.

Finding 83 – *TMDL for Mercury states wetlands may contribute substantially to methylmercury production and subsequent biological exposure to mercury within the Bay. So wetland restoration projects may increase levels of methylmercury and monitoring is a useful tool to evaluate this and inform management decisions. Natural sedimentation occurring via sediments brought in by the tides/creeks may also provide a source of mercury to be methylated.*

We have designed our mercury studies specifically to study the response of the ecosystem to our Phase 1 Actions, as well as meet the monitoring requirements of the Order. The focus of our mercury study is to answer two questions (from the RFP):

1. Will tidal marsh restoration increase MeHg levels in sentinel wildlife species within managed ponds and tidal marsh?
2. Will the scour of Alviso Slough, following restoration of associated salt ponds, increase the bioavailability of MeHg?

We are utilizing an adaptive management approach to answering these questions. The Applied Study, along with the complementary USGS Research Study, are designed to provide answers to these questions for the breaching of Ponds A8 and A6 in the fall of 2010/Spring 2011. Depending on what what conclusions and management implications can be drawn from the data from these studies, data gaps and future monitoring needs will be identified. The Eagles-Smith Study is to be completed in January 2013. The USGS Research Study is funded year to year with Congressional Appropriations; it is USGS intent to continue the work provided there are Congressional Appropriations to support it. Further, one conclusion of the Grenier et al. (2010) study was that mercury methylation should decrease within the footprint of Pond A8 after breaching. This is linked to the fact that the pond is currently very dense in phytoplankton that drives an excess amount of anaerobic benthic processes (including Hg-methylation). Once opened to tidal flushing, the phytoplankton densities should be greatly decreased in the overlying water, and thus the current 'fuel' for the Hg-methylation process will be greatly diminished. While these results are encouraging, the study indicated continued monitoring was needed given the degree of uncertainty. The two mercury studies summarized in Table 1 provide that continued monitoring.

Our Adaptive Management Plan, Table B-8, under "Mercury Project Objective 4" has two Restoration Targets: 1) Levels of Hg in sentinel species do not show significant increases over baseline conditions, and 2) Levels of Hg in sentinel species are not higher in target restoration habitats than in existing habitats. The mercury studies in Table 1 are both designed with "before and after" designs such that we are collecting baseline information of Hg in water, sediment and biosentinels before and after the breach to be able to address the first Restoration Target. We will also be able to address the second Restoration Target because the RFP study design includes control sites that are not breached, and there are already data on Hg in some of sentinel species (avocets, terns,

silversides) to which we can compare Hg concentrations. We can also compare mercury study results to TMDL levels in sentinel species.

Finding 84 – *Sediments in the Alviso pond complex have higher mercury concentration than Bay sediments. Breaching levees in this complex has the potential to generate increased levels of methylmercury. Minimize increases in methylmercury by monitoring and implement project's Adaptive Management Plan.*

The Project is also concerned with the potential mobilization of legacy mercury buried within the sediments of Alviso Slough as a result of restoration of ponds to tidal flow (as when Pond A8 is opened to muted tidal action), and the resulting scour of Alviso Slough bed sediments (Marvin-DiPasquale and Cox, 2007; Grenier et al., 2009). It is estimated that between 66 to 125 kg of total Hg may be mobilized within Alviso Slough due to restoring muted tidal action at Pond A8 (Marvin-DiPasquale and Cox 2007). Sediments scoured from Alviso Slough are most likely to enter Pond A8 on the flood tide cycle and be deposited and retained within that pond. This expectation is based upon recent evaluation of sediment dynamics at the Island Ponds (Ponds A19, 20, and 21) where it was found that the late stage flood tide has the highest suspended sediment concentration, which leads to deposition of the sediment into the ponds and explains the high accumulation rates observed. The sediments were from downstream sources and brought upstream on the incoming tide (Stacey 2010, Callaway et al. 2009). Since the existing fringing marsh is already at an elevation to support the vegetated marsh, we would not expect substantial additional accumulation of sediment (or sediment containing Hg) on the marsh plain.

We are also concerned with increased accumulation of MeHg in biota within Pond A8 due to or through wetting and drying cycles within the managed ponds which appears to enhance MeHg accumulation in biota. The differences between the subtidal sediment and marsh plain environments will also influence MeHg production by methylating bacteria. Reactive Hg, (Hg(II)r), is a surrogate measure of the amount of Hg available to Hg-methylating bacteria responsible for MeHg production. It is likely that sediment deposited within A8, and sediments in subtidal environments that are elevated in reactive Hg, likely have the highest methylation of Hg. This is due to the expected chemically-reducing environment and high levels of organic matter in those environments that fuel the conversion to MeHg by bacteria. In general, more oxidized environments (such as a vegetated marsh plain) are expected to produce less methyl mercury (MeHg) for a given amount of Hg(II)r compared to a reduced environment (such as ditches, channels in ponds and bay) where more MeHg is expected to be produced for a given amount of Hg(II)r (Grenier et al. 2010). So, the oxidizing environment of the marsh plain is not conducive to relatively high levels of MeHg as are the more reducing environments of subtidal and pond habitats (Grenier et al. 2010). In addition, it appears that there is a decoupling between MeHg accumulation in different parts of the marsh habitat, suggesting that marsh plain sediment is not the source of MeHg for all marsh food webs (Grenier et a. 2010). Thus, for reasons related to the chemistry of mercury methylation, as well as the expected sediment dynamics, it is unlikely that a significant accumulation of MeHg would be detected in marsh species monitored along the existing fringing marsh from the breach at Pond A8.

We expect that much of the sediment from the scour of Alviso Slough will deposit within Pond A8, since that seems to be the pattern of deposition seen with the Island Ponds (A19, 20, and 21), as noted above. Thus, we have focused the Hg monitoring to be within Pond A8, as well as subtidal areas within Alviso Slough. It is expected that Pond A8 will continue to function more similarly to a pond for a number of years due to the time required to accrete sediment and develop marsh vegetation. We are concerned with the potential additional exposure of water column species within Pond A8 and Alviso Slough to mobilized Hg (dissolved or attached to suspended sediments), and thus have included monitoring of two biosentinel fish species (stickleback and silverside), in addition to the two bird species which feed and breed within Pond A8 (tern and avocet).

As Pond A8 accretes sediment (likely sediment from both the scour of bed sediments in Alviso Slough, as well as sediments in the water column from throughout the south bay), and as marsh vegetation develops, it may become useful to monitor Hg in biosentinels associated with the marsh plain. We do not anticipate vegetation thresholds for marsh development to be attained for many years, as Pond A8 bed elevations are typically -1.5 feet NAVD 88, which is approximately MLLW, and 9 feet below MHHW (EDAW et al. 2007). Therefore, we have not included marsh biosentinels in the current Eagles-Smith study, which is to study near term (2 years) changes in mercury cycling as a result of Pond A8 breach.

Finding 85 – *Upon completion of the South Baylands Mercury Project (SBMP), a plan will be submitted to the RWQCB for approval of how to monitor the Phase I action at Pond A8.*

The final South Bayland Mercury Project Report (Grenier et al. 2010) was submitted to the RWQCB on February 10, 2010. There was a delay in completing this report partially due to funding issues that arose with the freeze on State Bond funds during that time period. However, we received and reviewed a draft of this report in August of 2009, approximately the same period as we were meeting and corresponding with the Eagles-Smith study principal investigators to address peer review comments and finalize a study plan. Mark Marvin –DiPasquale of the USGS is one of the authors and the SBMP project, and is also a collaborator on the two studies we are doing to monitoring mercury movement and bioaccumulation for our Phase 1 Studies, and therefore his detailed understanding of the SBMP greatly informed the Phase 1 Studies.

The SBMP (Grenier et al. 2010) answered questions raised by the PMT and regulatory agencies to prevent the Pond A8 breach from increasing the risk of Hg bioaccumulation in the south San Francisco Bay ecosystem. The study recommended that erosion of Alviso Slough be monitored to confirm that the breach of Pond A8 will not increase the Hg problems. We are therefore monitoring both the physical scour of Alviso Slough and shoals, as well as establishing an extensive monitoring program for Hg in water, sediment, fish, and birds in the Alviso and Ravenswood complexes (See Figure 1).

The SBMP study (Grenier et al. 2010) also recommended an Hg monitoring program that measures risk to wildlife based on available Hg thresholds established from local and national research. We have chosen biosentinels of fish and bird eggs in the Project Mercury Studies so that concentrations can be compared to TMDLs, as well as measuring Hg in suspended sediment to compare to the TMDL. In addition, concentrations in water, sediment and 5 biosentinels (Forester's tern and American avocet eggs, Mississippi silverside, Threespine stickleback, and longjawed mudsucker whole body fish) can be compared to conditions before and after the Phase 1 actions, as well as to control sites nearby. There are also considerable earlier Hg data collected from avocet and tern eggs, and silverside, which can be compared to data from these studies.

Finding 91 – *Adaptive Management and Applied Study to examine mercury mobilization through sediment accretion and methylation.*

The Eagles-Smith study, Attachment 1, and previously submitted via email, fulfills this requirement. Furthermore, this letters serves as a broader view on how the SBSPR project proposes to approach the issue of Hg in future phases of the monitoring once results from the Phase 1 Studies are reviewed

Several studies are planned to address the specific question of mercury mobilization through sediment accretion and methylation. As part of USGS research study, Bruce Jaffe is conducting side-scan sonar bathymetry/LiDAR all along Alviso Slough and onto A6 mudflat, as well as the shoals area off Pond SF2 before and after the breach. This study will allow us to determine if significant erosion or deposition is occurring in these areas. John Takekawa will be doing monthly invertebrate cores and bird surveys on the

Ponds A6 shoals as well as continuing work on the SF2 shoals. This will allow us to evaluate if any changes in shoal bathymetry is manifest in changes in benthic invertebrates or bird use of these habitats. Assuming USGS continues to receive the USGS research funds through Congress at the same level again next year, we will continue to do the bathymetric/invertebrate/bird surveys after the breaches (Pond A6 in Fall 2010, A8 not until next Spring 2011). Santa Clara Valley Water District is responsible for doing several cross-sections within Alviso Slough as well as monitoring the integrity of the levee on the north side of Alviso Slough. These data will also be useful in interpreting Hg samples in fish and sediments taken as part of the Eagles-Smith mercury study. This study also addresses the specific question of mercury methylation in the food web in areas projected to erode and expose buried mercury in sediments.

Also, an RFP study by Brian Fullfrost is analyzing satellite imagery throughout the entire project area, and we can track changes in habitat types, including lateral marsh gain or loss in Alviso Slough. Finally, John Callaway will be looking at sedimentation rates inside Pond A6 after breaching, similar to the work he did at the Island Ponds. As mentioned above, the affects of mercury in that accreted sediment will be monitored in the Eagles-Smith study by collecting samples before and after the breach at five locations within Pond A8, five locations within Alviso Slough, and one location at Guadalupe Slough. At the same time, Mallard Slough, A16 and A3N reference ponds will also be sampled and analyzed to monitor for changes in ambient concentrations. In addition, USGS Research Study is supplementing these locations with collecting additional locations for Hg in biosentinels in Ponds SF2, A1, A2W, AB1, A3W, A12, A16, and New Chicago Marsh.

Finding 96 - *Monitoring to track project performance for geomorphic evolution, water quality parameters, biosentinel mercury concentrations, vegetation populations, bird populations, and endangered species populations, will take place in all three complexes for at least 15 years.*

We are addressing Finding 96 through implementation of all the Applied Studies to address Key Uncertainties identified in the Adaptive Management Plan, with some exceptions noted in Table 3 (for example, marsh vegetation is not expected to developed yet, so studies focused on marsh species are not yet identified).

Some monitoring will occur in all three pond complexes in Phase 1 (See Tables 2 and 3). However, since we are just in Phase 1, the monitoring efforts needed to be prioritized by complex for monitoring aspects of project performance through for the next 2 – 3 years. The Key Uncertainties as outlined in the FEIS/R and the AMP were used as guides to prioritize these efforts; for example, the Phase 1 action at Pond A8 was specifically designed to address the recommendations of the Grenier et al (2010) study. Therefore, our initial efforts for mercury monitoring are focused more intensively on understanding the effects of that action.

We do not have any plans to monitor MeHg production or bioaccumulation at Eden Landing in the first two years given that previous research has shown the risk in that complex to be relatively low (Miles and Ricca 2010). We are focusing the study of Hg specifically in Pond A8 and the Alviso area because recent studies have shown that the Alviso ponds have higher total Hg and MeHg in sediments than in Eden Landing (Miles and Ricca 2010). Concentrations of Hg in sediments are not necessarily good predictors of mercury bioaccumulation in the food web since complex environmental and chemical processes mediate the conversion of Hg (in its various chemical states) in sediments into MeHg and uptake of Hg into the biological tissues. However, recent work using biosentinels to assess the level of Hg in south San Francisco Bay corroborate that the elevated Hg in Alviso pond sediments correspond to elevated levels of Hg in biota, likely as a result of conditions that enhance methylation of mercury (Grenier et al. 2010). Total Hg in longjaw mudscuckers were elevated in Alviso ponds compared to Eden Landing ponds, though the pattern of mudsuckers collected from the marsh channel was not so consistent. Pond A8 has the highest mercury concentration in mudsucker and

threespine stickleback of any pond in south bay. Conversion of Pond A8 to muted tidal is not expected to increase uptake of Hg in biota (Grenier et al. 2010).

As noted above in response to Finding 91, the adaptive management approach we are using and that was approved is iterative, so future monitoring to track project performance will depend upon the results of these Phase 1 studies. Table 2 summarizes all of the RFP studies and Directed studies we are conducting to monitor all of our Phase 1 actions. Table 3 describes the Key Uncertainties identified in the Adaptive Management Plan, and how the various studies planned will address these in Phase 1.

Uncertainties in bird use of changing habitats is addressed through the Ackerman study of nesting, roosting, foraging behavior of waterbirds in various ponds slated for Phase 1 actions. In addition, the Herzog study will provide baseline bird abundance values as well as development of a salt pond carrying capacity model. We will also study the bird use of the shoals area off SF2 and Pond A6 and see how the benthic invertebrates and bird use changes with the restoration in those areas (Thompson Study as well as Takekawa USGS Science funding study). We are also developing a shoals bird carrying capacity model. Finally, we will be continuing to monitor bird use in the salt ponds and managed ponds throughout the entire project area, as well as focused studies on endangered species such as monitoring of snowy plover nesting, and clapper rail population dynamics.

Uncertainties on effects to non-avian species are being addressed through extensive monitoring of fish communities and sentinel fish health in the Hobbs study. Uncertainties regarding mercury mobilization into the food web are being addressed through the Eagles-Smith study, as well as a complementary study being conducted by USGS research funding (Table 1). Affects on water quality and productivity are being addressed through the ongoing water quality monitoring, as well as the Thompson study evaluating benthic invertebrate community composition before and after the Interim Stewardship Plan. Uncertainties concerning invasive species are addressed through a study investigating techniques for early detection of Algerian sea lavender, as well as a study on the California gull movements and predation behavior. Geomorphic evolution is being tracked by the Fulfrost study, and finally, we are addressing uncertainties in how public access will affect foraging behavior of birds through the Trulio study, as well as ongoing monitoring of snowy plover nesting areas. We are also continuing to monitor water quality per the RWQCB requirements (which we are not detailing in this letter but have been the topic of previous submittals, correspondence, and meetings).

Finding 97 - *The SBMP will provide the basis for the developing a mercury monitoring plan.*

We did review the SBMP and carefully considered the results in the selection of sampling media and biosentinels. In addition, the Eagles-Smith study that was awarded includes one of the principal authors of the SBMP and his opinion of the next monitoring steps were therefore considered important in how best to proceed based on the SBMP results.

Ponds A5, 7 and 8 (1400 acres) are currently managed to be inundated with bay water most of the year and support various waterbirds. Pond A6 (330 acres) is seasonally wet, with no connection to the bay water, and supports a large California gull nesting colony. The only marsh habitat is the small amount of fringing marsh on the outboard side of the levees. Once breached in the fall of 2010, the 330 acres of Pond A6 will begin to become tidal marsh. The elevation is of Pond A6 is relatively high, so we project marsh vegetation threshold will be reached in about 10 years (or less). From our modeling, we estimate approximately 8 – 10% of tidal marsh area would be channel, and 5-7% would be pannes or ponds once the marsh has matured. For Ponds A5, 7 and 8, which will be muted tidal starting in Spring of 2011, we do not yet know what the final habitat type these ponds will be, as the results of the mercury studies will help determine the future restoration actions. If

we are able to restore these ponds to tidal marsh, they are more deeply subsided, and our models estimate it would take 20-30 years for these ponds to reach marsh vegetation thresholds once fully breached. Thus it is critical for us to understand mercury methylation and bioaccumulation in Ponds A5, 7 and 8 and how that would change under a muted tidal regime.

Ponds A5, 7 and 8, which will be restored to muted tidal, are approximately 1400 acres, and Pond A6, which will be restored to fully tidal, is 330 acres. The fringing marsh along the entire length of Alviso Slough is approximately 250 acres, so the proportion of fringing marsh to restored area is very small (combined restoration is over 1700 acres, compared to approximately 250 of fringing marsh). The projections of scour in Alviso Slough for the muted tidal gate in Pond A8 shows a loss of 50-100 feet of fringing marsh, extending from the notch to about half way down the slough. This loss of fringing marsh was accounted for in the permitting for the project. This was one of many considerations in our choosing the biosentinels and locations for the mercury monitoring study.

We expect that much of the sediment from the scour of Alviso Slough will deposit within Pond A8, since that seems to be the pattern of deposition seen with the Island Ponds (A19, 20, and 21) and because these ponds are highly subsided. Thus, we have focused the Hg monitoring to be within Pond A8, as well as subtidal areas within Alviso Slough. Given that Pond A8 will remain as a pond for a number of years, we are concerned with the potential additional exposure of water column species within Pond A8 and Alviso Slough to mobilized Hg (dissolved or attached to suspended sediments), and thus have included monitoring of two biosentinel fish species (stickleback and silverside), in addition to the two bird species which feed and breed within Pond A8 (tern and avocet).

As Pond A8 fills up with sediment (likely sediment from both the scour of bed sediments in Alviso Slough, as well as sediments in the water column from throughout the south bay), and as marsh vegetation develops, it may become useful to monitor Hg in biosentinels associated with the marsh plain. We do not anticipate vegetation thresholds for marsh development to be attained for at least a few years, as Pond A8 bed elevations are typically -1.5 feet NAVD 88, which is approximately MLLW, and 9 feet below MHHW (EDAW et al. 2007). Therefore, we have not included marsh biosentinels in the current Eagles-Smith study, which is to study near term (2 years) changes in mercury cycling as a result of Pond A8 breach.

Finding 100 - *Periodic monitoring of biosentinel species **and/or** sediment and water at the site … after current mercury studies have been analyzed, to determine if mercury methylation poses a potential problem.* (Emphasis added.)

The Eagles-Smith study will intensely evaluate mercury accumulation in sediment and water column as well as through a direct food web to bird eggs and reproductive impairment. In total, the Eagles-Smith study and Ackerman study will collect and analyze up to almost 800 fish, 300 bird eggs, 320 water samples, and 54 sediment samples that will be analyzed for one or more forms of Hg. In addition, stable isotope analysis will be included to evaluate changes in trophic relationships once Pond A8 has been breached. The total cost of these studies is over $738,000. We want to focus our limited funds on intensively studying the species and habitats that we believe have the most potential to be impacted by mercury cycling as a result of Phase I restoration actions. Depending on results of these Phase 1 studies, future studies/monitoring and modifications to the approach may be needed. We are particularly interested in addressing future studies toward understanding the processes and mechanisms governing Hg methylation and bioaccumulation so that we can design future restoration as to minimize Hg methylation, uptake into biota and impacts to the ecosystem.

Finding 101 – *Movement of mercury-contaminated sediments is a potential outcome of Phase I actions…. As a result of historic subsidence and Bay hydrodynamics, essentially all Alviso projects in Phase I would create accretional areas, resulting in a net loss of mercury from the Bay to the Project area.*

As noted above, we also expect much of the sediment that erodes within Alviso Slough in response to the increased tidal prism after the opening of the muted tidal gates at Pond A8, to move into Pond A8 since it is highly subsided. Therefore, it is likely that Phase 1 actions, specifically the breaching of Ponds A8 and A6 in Alviso, will result in a net removal of mercury from the Bay and into the ponds. Consequently, we have focused monitoring for mercury within Pond A8, as it is most likely to accumulate sediment. We are also extensively monitoring the bathymetry and mercury accumulation in water, sediment, and biosentinels within Alviso Slough to monitor the movement and transport of Hg in response to Phase 1 actions.

Finding 102 – *Eden Landing and Ravenswood ponds, there is a risk that the introduction of Bay ambient sediments could increase mercury bioaccumulation within the Project area; however, there is not a significant risk to the regional setting.*

Because Finding 102 notes there is not a significant risk at this region and previous monitoring and evaluation has not identified particular concerns, we have not focused our mercury monitoring studies on Eden Landing or Ravenswood complex ponds. We are focusing the study of Hg specifically in Pond A8 and the Alviso area because recent studies have shown that the Alviso ponds have higher total Hg and MeHg in sediments than in Eden Landing (Miles and Ricca 2010). Concentrations of Hg in sediments are not necessarily good predictors of mercury bioaccumulation in the food web since complex environmental and chemical processes mediate the conversion of Hg (in its various chemical states) in sediments into MeHg and uptake of Hg into the biological tissues. However, recent work using biosentinels to assess the level of Hg in the south San Francisco Bay corroborate that the elevated Hg in Alviso pond sediments correspond to elevated levels of Hg in biota, likely as a result of conditions that enhance methylation of mercury (Grenier et al. 2010). Total Hg in longjaw mudscuckers were elevated in Alviso ponds compared to Eden Landing ponds, though the pattern of mudsuckers collected from the marsh channel was not so consistent. Pond A8 has the highest mercury concentration in mudsucker and threespine stickleback of any pond in south bay. Conversion of Pond A8 to muted tidal is not expected to increase uptake of Hg in biota (Grenier et al. 2010).

Finding 103 - *All pond complexes will be monitored and, if triggers are exceeded in the AMP, then actions will be implemented that avoid significant impacts.*

Monitoring is occurring at all three pond complexes with the joint purpose of meeting our regulatory requirements and answering the Key Uncertainties outlined in the AMP. During this first Phase of restoration actions, we will be using the results of the mercury studies to evaluate what future management actions to take with Pond A8, specifically whether to proceed with restoring it to a tidal wetland. As our adaptive management plan indicates, we are waiting for the results of the Eagles-Smith study and other related studies after the breach to determine the best management actions to take. There is much to be learned of the processes and mechanisms that are controlling methylation of mercury and accumulation in the food web of restored marshes. Mercury is a ubiquitous contaminant in the San Francisco Bay Delta ecosystem due to legacy mercury and gold mining operations throughout the watershed. At the same time, the loss of tidal marsh habitat has had significant impacts on a number of salt marsh-dependent species. We hope to learn more about mercury dynamics in restored marshes so we can understand how best to balance the need for restoration of tidal habitats, while minimizing impacts of legacy mercury contamination.

Finding 104 - *The AMP can examine the interactive effects of varying salinity and hydraulic residence time on net mercury methylation in the Phase I actions.*

Depending on the results of these Phase 1 studies, we envision a series of operational experiments where we learn more about the processes and mechanisms controlling mercury methylation and uptake into the food web, and how we might control those processes through varying salinity, hydraulic residence time, or other parameters so as to minimize mercury impacts. Mark Marvin-DiPasquale et al. (2009) conducted a small experiment on the seasonal dynamics of mercury and primary production on two salt ponds. Their results suggest that pond water "…salinity is the driver of phytoplankton density, which in turn affects the concentration and speciation of Hg in the particulate phase, and ultimately Hg concentration in biota." However, it is not clear what affect partial draining of one of the ponds has on these processes. We will consider future studies to focus on understanding mercury dynamic processes and mechanisms in ponds and restored tidal area so that we can better understand how to design restorations and managed ponds so as to minimize mercury accumulation in the food web.

Finding 107 – *Treatment of the gypsum deposits could mobilize sulfate…and effect mercury methylation.*

Table 2 of the study design for the Eagles-Smith study describes in detail all the specific analytes and their methods for sediment and water, and the reasoning behind including each analyte. In sediment, microbial sulfate reduction and total reduced sulfur in sediment (TRS) will be measured. Sulfate (SO42-) in pore water will be analyzed in additional to total mercury, methyl mercury and other constituents in sediment. The inclusion of these sulfate compounds in the sediment and water, as well as the other analytes being measured in water and sediment, will provide a means to interpret causes and influences on mercury methylation as a result of Phase 1 actions.

In addition, at Eden Landing we are experimentally breaking up portions of the gypsum layer at Pond 8A prior to breaching. The purpose of this action is to see if the mechanical manipulation of the gypsum layer will expedite the establishment of marsh vegetation. While not specifically targeted at mercury, this is a first step in evaluating the effect of gypsum on tidal wetland restoration.

Provision 2 - *Operations Plan and Adaptive Management. The Operations Plan shall also address… mercury methylation... Discharger shall describe how it manages water levels to… minimize methylation of mercury and describe changes in management if data show increased methylation of mercury.*

There appears to be an interrelationship between low dissolved oxygen levels, production of algal blooms, and mercury methylation, based on preliminary studies conducted by USGS on Ponds A12 and 13 (Ackerman, et al. 2009). Once we complete the Phase 1 studies, we would like to explore this relationship further to inform future design of managed ponds and tidal restorations for the Project so as to minimize mercury methylation and other water quality problems.

At this point in time, the basic understanding is that repeatedly wetting and drying may create more changes in redox and create MeHg (Grenier et al. 2010). So generally ponds are managed as either always wet (year-round open water) or seasonal ponds, which are dry during high heat/wind summer evaporative season and wet during the wet season. We acknowledge that there is a need to balance management of the ponds for water quality parameters and specific species needs which factor into decisions on pond operations in addition to managing to minimize mercury methylation.

The following example, from Pond A3W, is typical of managed pond complexes and of how the current Operations Plans further minimize water quality impacts:

If summer monitoring shows that DO levels in discharges from Pond A3W fall below a 10th percentile of 3.3 mg/L (calculated on a calendar weekly basis), the FWS will accelerate receiving water monitoring to weekly, conduct within-pond monitoring and notify and consult with the Water Board as to which Best Management Practices (BMPs) for increasing dissolved oxygen levels in discharge water should be implemented. BMPs include increasing the flows, installing flow diversion baffles, cease nighttime discharge, close discharge gates, and mechanically harvest dead algae.

The pH of the discharge is related to the DO of the discharge. If the pH of the discharge falls outside the range of 6.5 – 8.5, an analysis of the impact of discharging pH on the receiving waters will be performed. If it is determined that discharge is impacting receiving water pH outside the range of 6.5 – 8.5, ammonia monitoring in the receiving water will be done to document potential toxicity affects associated with unionized ammonia.

Provision 9 – *The final monitoring plan shall include mercury monitoring of biosentinel species in accordance with SBMP or other regional program,* ***or*** *mercury in water and sediment; landscape mapping, vegetation mapping, etc.* (Emphasis added.)

We have chosen to monitor mercury in water, sediment and biosentinel species. Evaluation of Hg in the eggs of waterbird species provides information on Hg bioaccumulation from both invertebrate (avocets) and fish-based (terns) prey and is a indicator of potential risk to wildlife reproductive impairment (Ackerman et al. 2007b, 2008). The fish are localized populations that provide comparative information on Hg availability within the same matrix over time and across habitats. The silverside Hg data will be able to be compared to other locations throughout the San Francisco Bay region and silverside have been used extensively for monitoring MeHg exposure throughout the Bay-Delta, particularly in relation to TMDL regulatory considerations (Slotton et al. 2002, 2007). Both mudsuckers and sticklebacks have more localized ranges than silversides and, more importantly, occur in each of the habitats under study (salt ponds, sloughs, tidal marsh, and mudflat). Therefore, these species will be used to assess changes in Hg within biota over time (as Pond A8 and other salt ponds are breached) and among habitats, in order to assess which habitats have the highest potential for Hg bioaccumulation and impairment to wildlife.

The researchers had initially included additional biosentinels (such as song sparrows) in their proposal, but the peer reviews directed us to include sediment MeHg and isotope information. So the tradeoff was to get more information about MeHg cycling and Hg transfer, at the expense of more information on actual Hg concentrations in a broader suite of biosentinels. The combined Eagles-Smith study and the USGS Research Study are monitoring mercury in two bird biosentinels species, three fish biosentinel species, as well as mercury in water and sediment. In total, the mercury studies will collect and analyze up to almost 800 fish, 300 bird eggs, 320 water samples, and 54 sediment samples that will be analyzed for one or more forms of Hg. In addition, stable isotope analysis will be included to evaluate changes in trophic relationships once Pond A8 has been breached. We want to focus our monitoring on intensively studying the species and habitats that we believe have the highest potential to be impacted by mercury cycling from Phase 1 actions. Therefore, we have focused on water-column and sediment dependent species as we believe these have the greatest potential to be impacted by the Phase 1 actions, and can be compared to existing ambient, toxicity and regulatory levels, as well as compared to data collected prior to the Phase 1 actions.

See response to Findings 91, 96, 97, and 100 as well.

Provision 10 - *Mercury Monitoring. SBMP and other South Bay projects will be used to determine triggers in the AMP. If triggers are exceeded, then adaptive management actions will be taken; triggers and actions subject to approval.*

The Eagles-Smith study, along with the mercury portion of the USGS Research Study, provides a comprehensive study that provides insight into mercury dynamics in the foodweb as well as providing monitoring data that can be compared to baseline conditions, similar habitats, regulatory limits, and toxicity levels. A particular strength of this study is the collaboration of researchers involved, all of whom have been leading extensive mercury projects in the South Bay, and their ability to leverage baseline data to clearly demonstrate any changes in MeHg exposure as a result of the Phase 1 management actions.

The study links benthic MeHg production potential, changes in water and sediment column Hg concentration and speciation with MeHg bioaccumulation in four key biosentinel species:

1. Forster's Terns (*Sterna forsteri*) are fish-eating birds that nest in high densities at multiple sites within the South Bay Salt Ponds (Strong et al. 2004) and forage in salt ponds and adjacent marshes (Ackerman et al. 2008a);
2. American Avocets (*Recurvirostra americana*) are invertebrate-foraging shorebirds that are abundant in the region year-round and are the most abundant breeding shorebird in San Francisco Bay (Stenzel et al. 2002, Rintoul et al. 2003). Recent radio telemetry studies (Ackerman et al. 2007a, Demers et al. 2008) have shown that during the eight weeks approaching egg laying, avocet space use is highly localized and occurs predominantly within the ponds where nesting occurs. Thus, avocets are excellent indicators of Hg concentrations in the invertebrate food web at the "individual pond" spatial scale.
3. Threespine stickleback (*Gasterosteus aculeatus*) are a small fish species with well-studied behavior and ecology that occurs widely throughout the restoration area, is strongly linked with water column prey, and which represents an extremely important conduit for Hg transfer through the food web (Eagles-Smith and Ackerman 2009).
4. Mississippi silverside (*Menidia audens*) is a small fish species that provides a food-web linkage from the sloughs to the wider South Bay. Silversides are an abundant and important prey species in the sloughs and Bay margins, with a wealth of comparative data (Greenfield et al. 2006, Slotton et al 2008). Moreover, silversides are relatively localized, and show rapid response to changes in Hg availability.

Our Adaptive Management Plan, Table B-8, under "Mercury Project Objective 4" has two Restoration Targets: 1) Levels of Hg in sentinel species do not show significant increases over baseline conditions, and 2) Levels of Hg in sentinel species are not higher in target restoration habitats than in existing habitats. Our mercury studies (Table 1) are designed with "before and after" analysis such that we are collecting baseline information of Hg in water, sediment and biosentinels before and after the breach to be able to address the first Restoration Target. We will also be able to address the second Restoration Target as the study design includes control sites, and we can compare to existing data on Hg in sentinel species (Grenier et al. 2010). We can also compare mercury study results to TMDL levels for whole bodies of small prey fish, bird eggs, and suspended sediment.

Conclusion

The South Bay Salt Pond Restoration project is conducting a substantial amount of monitoring in support of our AMP, as well as for regulatory compliance. For the above stated reasons, we believe the Project is in compliance with Board Order R2-2008-0078. Table 4 below summarizes which of our Applied Study topics, as well as other studies being done in conjunction with the Project, are directly responding to the Findings and Provisions of the Board Order as they relate to mercury.

Table 4. Matrix Showing SBSPR Monitoring Program to address RWQCB requirements pertaining to mercury.

	Topic 1	Topic 2	Topic 3	Topic 4	Topic 5	Topic 6	Topic 7	Topic 8	Graduate Students	Regular Monitoring	USGS Studies
Findings											
80		X									X
82		X									X
83		X									X
84		X									X
85		X									X
91	X	X	X	X	X	X	X	X	X		X
96	X	X	X	X	X		X		X		X
97		X									X
100		X									X
101	X	X									X
102											X
103	X	X	X	X	X	X	X	X	X		X
104		X									
107		X									
Provisions											
2										X	
9	X	X	X	X	X	X	X	X	X		X
10		X									X

Thank you for your consideration of our request for confirmation that our monitoring program for mercury meets the parameters of our Board Order, and for the ongoing collaboration on how to see this complex project through to completion. Please feel free to contact me if you have further questions at jbourgeois@scc.ca.gov or 408.314.8859 or Laura Valoppi at laura_valoppi@usgs.gov or 916.278.3124.

Sincerely,

John Bourgeois
Executive Project Manager
South Bay Salt Pond Restoration Project

CC: Laura Valoppi, Lead Scientist
Amy Hutzel, Bay Program Director
Eric Mruz, USFWS
John Krause, CDFG

Attachments (#)