Status Report & Revised Project Plan

April 2010

Selenium TMDL in North San Francisco Bay

Status Review - April 2010

The Project Plan to address selenium impairment in the North San Francisco Bay was prepared in July 2007 and first discussed with the interested stakeholders at the Advisory Committee (AC) Meeting held in December 2007. During this meeting we outlined the direction and the approach for the selenium TMDL, and convened an advisory group comprising a diverse cross-section of stakeholders, to provide feedback and actively participate in the development of the TMDL.

Since then we worked together with Tetra Tech, a technical consultant for the project, to identify and characterize selenium sources and processes controlling the uptake of selenium by biota, quantify selenium loads and develop a model to help with the linkage analysis and assessment of attainment measures. The results of the technical analyses are presented in five technical memoranda (TM-2 thru TM-6) which summarize our understanding of selenium fate and cycling in the Bay:

TM-2: North San Francisco Bay Selenium Data Summary and Source Analysis. April 2008

TM-3: North San Francisco Bay Selenium Toxicological Assessment. April 2008

TM-4: Conceptual Model for Selenium in North San Francisco Bay. August 2008

TM-5: Recommendations for Numerical Model Development. August 2008

TM-6: Application of ECoS3 Model for Simulation of Selenium Fate and Transport in North San Francisco Bay. February 2010

In addition to the Advisory Committee, a Technical Review Committee (TRC) was convened in anticipation of technical challenges arising from the inherent complexity of in-bay selenium processes. An expert consultation was sought on three major reports: TM-4, TM-5 and TM-6 that form the basis for developing a model to support the decision-making process for the TMDL. The TRC provided expert reviews on the key steps of the TMDL development as well as credible technical advice on specific issues evolving from the review process. Two joint meetings with the reviewers and the AC members were held to communicate the outcomes of the reviews.

The last of the Technical Memoranda (TM-6) integrates the knowledge gained to date and describes the formulation and implementation of the ECoS3 estuary model and DYMBAM bioaccumulation model for simulation of the fate and transport of selenium in the North Bay. The TRC comments and recommendations on the draft modeling framework for the TMDL were discussed at the combined TRC and AC meeting in April 2009. The TRC and the stakeholders acknowledged the report for the advanced science and comprehensive approach to model development. The rigorous review process took over several months to complete. The

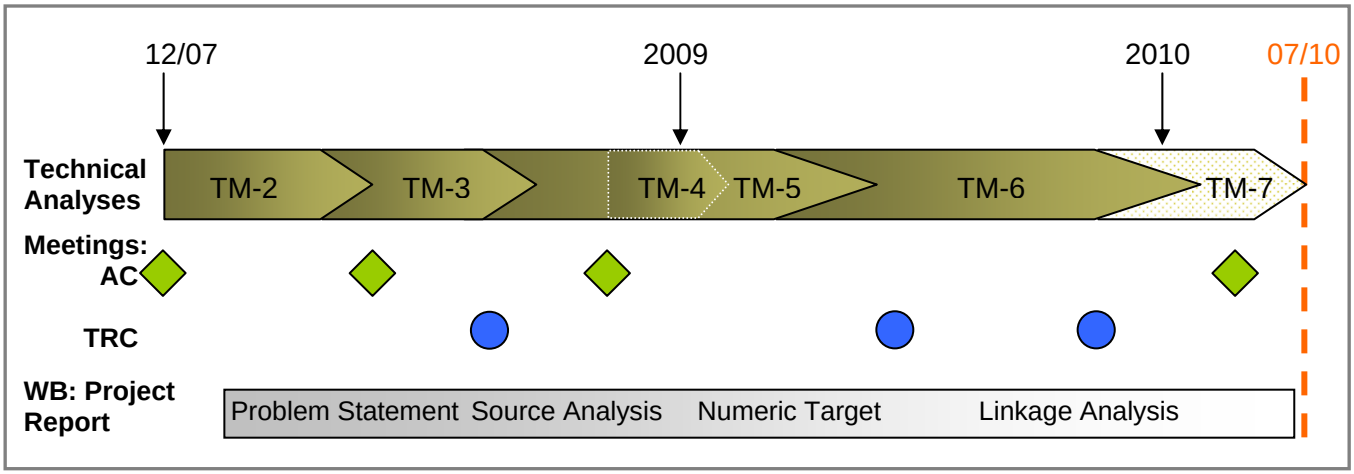
following understanding was reached between the Water Board and the TRC at the end of the review process:

- TM-6 reflects the current state of knowledge of biogeochemical transformations of selenium and processes leading to selenium bioaccumulation in the North Bay.
- All available data have been used in setting-up, testing, calibration and validation of the model.
- The report demonstrates that the model is robust, provides details of the underlying assumptions built into the model, and identifies potential limitations of the model and the available data.

The revised TM-6 provides details of model application for the North Bay and the actions taken in response to the TRC's comments. The report is now available on the project website together with other major technical documents, presentations and materials from the Advisory Committee meetings documenting the progress of the TMDL. Follow this link to the project website:

http://www.waterboards.ca.gov/sanfranciscobay/water_issues/programs/TMDLs/seleniumtmdl.shtml

The figure below depicts the sequence of events since the beginning of the project in late 2007. A more detailed summary of deliverables and completion dates is presented in Attachment A.



Role of *Corbula amurensis* in the impairment

A large body of evidence now exists to confirm that particulate selenium and dietary uptake is the most important exposure pathway for aquatic organisms, especially predators. In the North Bay selenium bioaccumulation is strongly driven by feeding habits and differences in choice of prey. It has been confirmed that the adverse impact of selenium is only evident in the benthic food web that includes the invasive clam *Corbula amurensis*. Significantly slower selenium rate loss exhibited by *C. amurensis* compared to native clams and common crustaceans, results in high tissue concentrations ranging from 4.3 to 14 µg Se/g dw (data collected in November 2008). This, in turn, poses a risk to predators feeding on these clams, mainly diving ducks and white sturgeon. Furthermore, the available data suggest that the presence of *C. amurensis* in the Bay not only exacerbates the potential for selenium bioaccumulation but seems to be a prerequisite trigger of impairment to begin with.

Major concerns and information needs

Despite the greatly improved understanding of selenium processes leading to bioaccumulation as described in the TM-5, and the considerable amount of data available to validate the estuary model (TM-6), there are still uncertainties in our knowledge of the key factors that affect the transfer and potential toxicity of selenium in the ecosystem. One of the major concerns identified is lack of selenium particulate data which is essential to better quantify and confirm the role of the background selenium load entering the Bay.

Particulate selenium in the estuary originates mainly from riverine input, with smaller proportion of selenium coming from sediment resuspension and in-situ transformations. Riverine inputs of particulate selenium can be a significant source of selenium to the North Bay as large amounts of sediments and living and non-living particulate organic material enter the Delta from Sacramento and San Joaquin watersheds.

The model simulations discussed in the TM-6 show that the selected particulate selenium concentrations at the system boundaries (Delta and Golden Gate Bridge) could have a significant effect on the predicted particulate selenium concentrations in the water column that, in turn, is critical to forecasting trophic transfer and bioaccumulation in predators. The modeling results are based on the use of existing data to characterize the boundary conditions. The lack of particulate selenium concentration measurements in the freshwater sections of Sacramento River (e.g. at Freeport) and in the near-shore area beyond the Golden Gate Bridge is potentially a deficiency which also makes the considerations of the appropriate remedial actions challenging.

A selection of other concerns that grew from the technical analyses to date includes the following:

- selenium speciation is critical to understanding its mobility, transformation and partitioning in the environment, yet most of the speciation data available for the North Bay were collected more than a decade ago (1999) and prior to the time when the final impact of the refineries cleanup took full effect
- particulate selenium data that are vital to understanding the assimilative capacity of the Bay are extremely limited
- US EPA recommends the chronic aquatic life criterion to be expressed as concentrations of selenium in fish tissue with a translation to water column concentration, however, the issues surrounding the release of the draft aquatic life criteria in 2004 remain unresolved
- toxicological studies involving selenium are predominantly conducted in the freshwater, hence the toxicological thresholds may not be fully applicable to saltwater and estuarine fish
- procedures for translation of fish tissue concentrations to water column concentrations are still under development

From the findings of the technical analysis and data interpretation to date it became apparent that the existing conceptual model framework and the TMDL would benefit greatly from additional data collection. Extending the project schedule would also allow for addition of the relevant recently conducted studies to increase the accuracy of our interpretations.

Additional data collection and related efforts

The main reasons for a targeted new data collection and the anticipated release of data from recently conducted studies are:

- to better understand and quantify the declines in selenium concentrations in bivalves and fish since 1999 and to confirm that selenium levels observed in the North Bay are causing food web and wildlife impacts
- to improve the accuracy of riverine selenium estimates, and to clarify the effect of the background selenium load on conditions in the Bay
- to confirm the relative contribution and speciation of selenium in refineries'discharge

Three pertinent sources of data have been already identified to accomplish the first purpose. These are: (1) RMP 2009 sport fish status and trends monitoring results; (2) USGS bivalve dataset (1995-2008), and (3) selenium tissue concentrations in archived (1997-2007) Largemouth bass from the Central Valley and Bay Delta. The results are expected to be available later in 2010.

Systematic review of the additional information will strengthen the overall quality of the available data set and the subsequent findings for the TMDL. It is anticipated that the new data will facilitate verification of species of concern in the North Bay and help confirm that the recently observed decreases in concentrations in bivalves are representative of trends over time. Moreover, the RMP monitoring project will investigate the alternative non-lethal sampling (muscle biopsy) in white sturgeon vital for implementing the TMDL and conducting future monitoring of this large and long-lived fish.

The second goal will be met when an "effluent and receiving water selenium characterization study" is conducted by the petroleum refineries, as the Water Board is now requiring via their reissued NPDES permits.

The overall objectives of this study are to characterize: (1) the concentrations and speciation of selenium in effluent and receiving water, (2) the variability of selenium in the refinery discharge, (3) the potential for uptake and conversion of selenium to more bioavailable forms, (4) mixing and dilution in the receiving waters. The data collected to fulfill the NPDES permit provisions will include sampling of the freshwater reaches of Sacramento and San Joaquin Rivers and analyses of particulate selenium content. This will not only support the verification of riverine loads but will also be used to fine-tune the estuary model calibration and enhance the accuracy of model predictions. An indicative timeline for completion of the additional data collection and data interpretations is shown in Attachment A.

By extending the TMDL schedule we also anticipate to take advantage of the new assessment tools and guidelines that are being developed on regional and national scale, such as:

- **California-wide** selenium wildlife criteria (the interagency effort led by the US EPA Region IX in collaboration with US FWS, USGS and NOAA Fisheries).
- **Nation-wide** aquatic life criterion for selenium and guidance on how to adopt and implement criteria based on fish tissue concentrations (US EPA)

Short-term work plan *(April – June 2010)*

Over the next three months, the Water Board staff will integrate and synthesize the results of all technical analyses conducted to date and prepare a preliminary report. This report will provide details on the required TMDL components and the supporting information acquired over the past two years. The following assessments will be also undertaken to assist with preparation of the preliminary report.

For regulatory purposes, such as permit issuance, and to explain the linkages between selenium concentrations in the North Bay and biota, there is a need to relate selenium in white sturgeon to water column concentrations. The USGS developed an approach that facilitates determination of the allowable water concentrations for a given fish tissue target. It was first used to translate the site specific selenium objectives formulated for the San Diego Creek Watershed and Newport Bay TMDL (*undergoing scientific peer review*). A location-specific distribution coefficient (K_d) which is a ratio between particulate and dissolved selenium concentrations is needed to compute the allowable water column concentrations.

The estuary model simulates exchanges between particulate and dissolved selenium on a daily basis and these data series could be used to determine the K_d values that, in turn, will be used to translate the proposed fish tissue target to selenium concentrations in water column. Values of the particulate to water column ratios will be inferred for:

- different zones of North San Francisco Bay, e.g., San Pablo Bay, Suisun Bay, Carquinez Strait.
- different types of hydrologic conditions, average wet and average dry season flows, and critically dry year dry season flows.

This will help interpret the importance of seasonal environmental conditions and potentially identify factors and areas in the Bay that favor selenium bioaccumulation.

Longer-term work plan *(2010 – 2011)*

The next year's work will focus on comprehensive evaluation of the data sets identified in the above sections of this plan. In particular we are planning to re-examine the adverse effects of selenium on biota and aquatic life. The initial results of the "effluent and receiving water selenium characterization study" will be also incorporated into this assessment to help resolve the crucial information gaps and in particular, establish the new boundary conditions and verify calibration of the ECoS3 estuary model. The re-calibrated model will be then used to test the effect of the background selenium loads on water quality in the North Bay and to determine relative importance of refineries' load and speciation during dry flow periods. The new data will also guide development of any future site-specific monitoring and model validation efforts.

Moreover, modeling in the North Bay, supported by data, shows a systematic variation in clam selenium concentrations by season, with higher concentrations during the low flow periods, and lower concentrations during high flow periods. Based on the model conceptualization this might be related to the clam growth cycle and the relative mix of available selenium in the Bay driven by hydrological conditions. Given the seasonal pattern in clam concentrations and inherent uncertainty in the data we will be testing how to aggregate and interpret infrequent and spatially limited clam concentration data against the dietary threshold concentrations.

ATTACHMENT A

Selenium TMDL for North San Francisco Bay: Summary of TMDL deliverables and completion dates			
	Tasks	**Deliverables**	**Completion Date**
TMDL Technical Analyses			
TMDL Technical Components	Project Plan	Project Plan to develop selenium TMDL	June 2007
	Problem Statement	Section, Staff Report	August 2007
	Public Participation: Advisory Committee Meeting #1	*Plan to Develop TMDL*	*December 2007*
	Impairment Assessment	Section, Staff Report	March 2008
	Public Participation: Advisory Committee Meeting #2	*Technical background and preliminary findings*	*April 2008*
	Technical Review Committee Meeting #1	Conceptual Model and recommendations for Numerical Model development	May 2008
	Source Analysis	Preliminary Project Report and revised CM/IA	August 2008
	Public Participation: Advisory Committee Meeting #3	*Selection of Draft Fish-Tissue Numeric Target*	*September 2008*
	Numeric Targets	Section, Staff Report	December 2008
	Linkage Analysis	Develop Modeling Tools	April 2009
	Technical Review Committee Meeting #2	Application of ECoS3 Model for simulation of selenium fate and transport	April 2009
	Revised Modeling Strategy	Revised Modeling Report	September 2009
	Technical Review Committee Virtual Meeting #3	Final endorsement of Revised Modeling Report	October 2009
	Modeling Report	Completion of the Technical Review process and final draft of the Modeling Report	February 2010
	Revised Project Plan	Updated project plan: where to go from here?	April 2010
	Linkage Analysis: critical conditions and seasonality	Design and test additional scenarios to support linkage analysis	April 2010
	Public Participation: Advisory Committee Meeting #4	*Modeling framework, technical limitations, data needs and ways for moving the project forward*	*April 2010*
	TMDL Technical Analyses	Preliminary Project Report	June 2010
	Additional Data Collection	Summary of data and analyses	2011-2012
	Review of new data and update of the Project Report	Project Report and TMDL decision point	2012
Water Board Approval Process			
	Water Board Action	Testimonial/Adoption Hearing	**2013**