June 30, 2008

State Water Board Preliminary Draft
Phase II Sediment Quality Objectives Proposal

Prepared by Chris Beegan, Ocean Unit, Division of Water Quality

Introduction

This report summarizes the State Water Resources Control Board's (State Water Board) preliminary proposal for Phase II sediment quality objectives (SQOs) and the means by which the objectives can be interpreted and implemented within California's enclosed bays and estuaries. Chris Beegan, staff of the State Water Board's Division of Water Quality, prepared this proposal. These approaches described in this proposal have not been endorsed or approved by the State Water Board.

This document summarizes the programmatic approach currently under consideration. Every effort has been made to present an accurate and up-to-date description of the anticipated technical framework and the means of implementation. However, at this early point in the process most technical and policy related issues remain unresolved. As a result, the technical framework and means to implement the SQOs that are eventually proposed for the State Water Board's consideration may differ significantly from those discussed in this document.

This document is not intended to fulfill the State Water Board's formal planning requirements under the Porter-Cologne Water Quality Control Act, the Federal Clean Water Act, or the California Environmental Quality Act. At a later date, a draft staff report/substitute environmental document and draft water quality control plan will be prepared and circulated to fulfill the State Water Board's formal water quality planning obligations.

Background

A 2001 court decision (San Francisco BayKeeper, Inc. v. State Water Resources Control Board, August 2001) ordered the State Water Board to adopt SQOs pursuant to the California Water Code §13393. The law requires the State Water Board to adopt SQOs for toxic pollutants that have been identified in toxic hot spots as part of the Bay Protection and Toxic Cleanup Program (BPTCP) and for other toxic pollutants of concern. SQOs were never developed, as efforts were focused on the identification of hotspots until the program expired. In response to the court decision, the State Water Board immediately initiated technical studies to support the SQOs. Under Phase I of the SQO Program, the State Water Board made significant progress to protect sediment dwelling organisms from *direct* effects caused by exposure to pollutants in sediment within the major enclosed bays and harbors. Phase II is a continuation of the work begun in Phase I.

Under Phase II, staff and the technical team are developing indicators to assess the risk to sediment dwelling organisms from direct effects within estuarine habitats and also a framework and indicators to assess indirect effects to human health exposed through the consumption of fish and shellfish containing contaminants that migrated from bay or estuarine sediments up the food web. Pursuant to a court order in the litigation mentioned above, the State Water Board must complete and publicly circulate its draft Phase II proposal for sediment quality objectives and related implementation policies by June 30, 2008. The proposal must include:

1. A proposed final objective for direct effects for all estuaries in the state.

2. A proposed final objective for indirect effects for all bays and estuaries.
3. An implementation policy for all objectives.

In response to No.1, a final objective that protects sediment dwelling organisms from *direct* effects to pollutants in sediments was adopted in the State Water Board's Water Quality Control Plan for Enclosed Bays and Estuaries-Part 1 Sediment Quality (Part 1) under Resolution No. 2008-0014. The final, adopted narrative SQO applicable to all enclosed bays and estuaries of California states:

Pollutants in sediments shall not be present in quantities that, alone or in combination, are toxic to benthic communities in bays and estuaries of California. This narrative objective shall be implemented using the integration of multiple lines of evidence (MLOE) as described in Section V of Part 1.

In response to No. 2 above, a final narrative objective that protects human health from indirect effects of contaminants in sediments that migrate up the food web into fish and shellfish tissue was also adopted by the State Water Board in Part 1 under Resolution No. 2008-0014. This final, adopted narrative SQO from Section IV of Part 1 states:

Pollutants shall not be present in sediments at levels that will bioaccumulate in aquatic life to levels that are harmful to human health. This narrative objective shall be implemented as described in Section VI of Part 1.

In response to No. 3, a methodology to interpret and implement the narrative objective that protects sediment dwelling organisms from *direct* effects was also adopted into Part 1 under Resolution No. 2008-0014. Interpretation of the SQO is described in Section V and implementation is described in Section VII.

The development of a framework to interpret and implement the narrative objective that protects human health from indirect effects is the principal focus of this document.

In addition, Phase II also includes the development of more robust assessment tools to interpret the direct effects narrative objectives within the Sacramento San Joaquin Delta.

Conceptual Model

Unlike the application of direct effects tools and framework, indirect effects are not implicitly related to a given site. The finding that the tissues of a fish at a specific site contain a chemical pollutant at a concentration that represents a human health concern is not necessarily evidence that the sediment at that site is the source of the contaminant. The source of exposure may be sediments local to the site at which the fish was collected or remote from that area. The relationship between contaminated sediments and the accumulation of toxics in fish and shellfish tissue is influenced by many species-specific and site-specific factors, such as sediment organic content, complexity of the food web, species-specific feeding habits, home range and lipid content; factors that vary with both age and season. In addition, an estimate of human health risk requires accurate estimates of prey consumption rates, which are also regionally-specific and species-specific.

A simplified conceptual model is presented in Figure 1. The conceptual model is intended to depict the aquatic ecosystem processes that are most important for indirect effects of

contaminated sediments. This includes abiotic and biotic components and their linkages. As shown, some degree of contaminant transfer between the sediments and the overlying water column is assumed. Sediment-dwelling invertebrates are exposed to sediment pollutants primarily via dietary uptake and respiratory exposure to sediment porewater. Invertebrates are also exposed to contaminants in the overlying water column as a result of feeding and respiratory exposure. Food-web trophic transfer (as represented by dietary uptake of invertebrates) is the most significant route of exposure for fish. Wildlife (e.g., birds and aquatic mammals) and humans consume contaminated finfish (thick arrows) and invertebrates (thin arrows), resulting in contaminant exposure. The spatial scale of the exposure (depicted at left) increases from the sediment at a given station inhabited by sessile invertebrates up the food web to the home range of fish, which could extend beyond the water body. The conceptual model depicts the linkage between the sediment and the fish tissue and provides the foundation for interpretation of the narrative SQO.

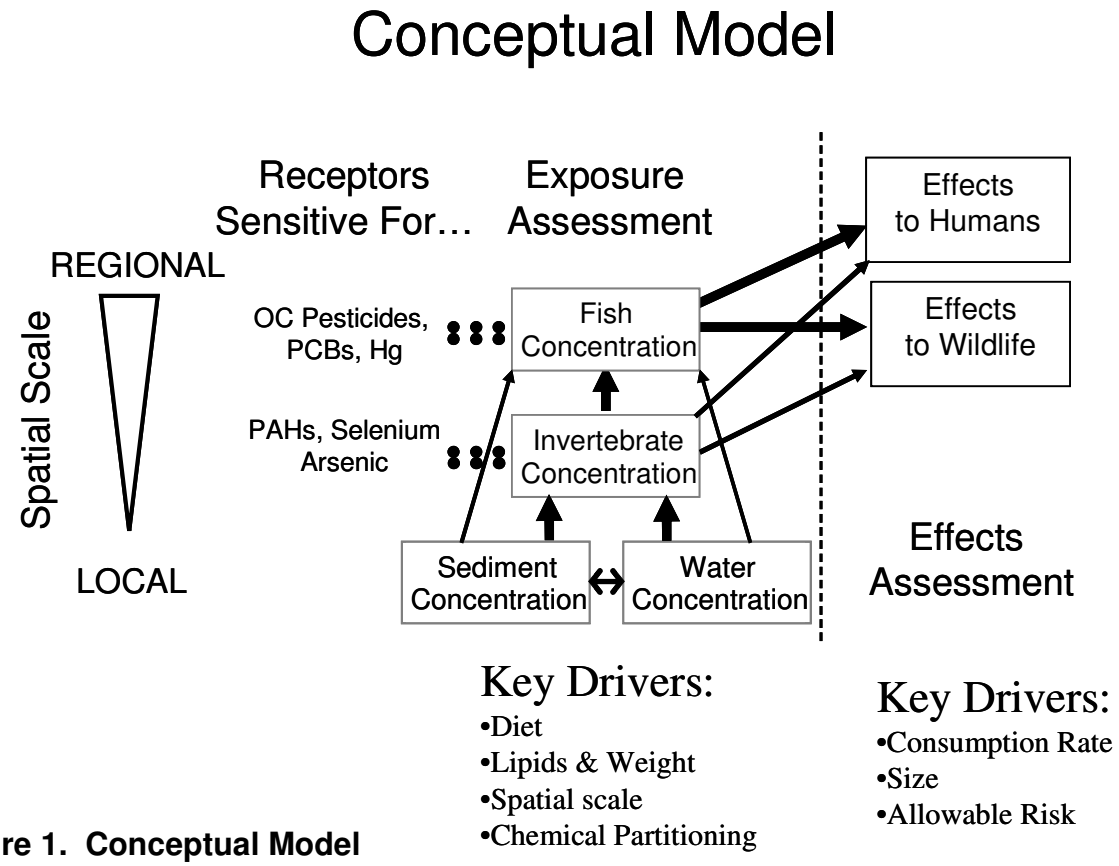

Figure 1. Conceptual Model

Interpreting the Indirect Effects Narrative SQO

The purpose of the indirect effects assessment framework is to determine whether sediments meet the narrative SQO for human health. This assessment will be based on determining whether sediment contamination at a site results in an unacceptable health risk to humans as a result of the consumption of contaminated fish and shellfish. Risk to wildlife is not included in this assessment. It is anticipated that a future Phase (Phase III) would focus on the development of a narrative SQO and assessment framework to protect wildlife or fish from pollutants in sediment as well. It is desirable, but not essential, that the assessment framework for wildlife be similar to that developed for human health.

In order to determine the quality of sediment, the protected condition or risk considered protective of human health must be defined.

The products of the framework should answer two questions:

1. Do pollutant concentrations in fish and shellfish pose unacceptable health risks to human consumers?
2. Is sediment contamination at a site (area of interest within a water body) a significant contributor to the presence of chemical concentrations of concern in prey tissue?

The goal of the indirect effects assessment framework is to differentiate those sediments that meet the narrative human health SQO from those that do not. This framework occupies a central role in the interpretation of monitoring data for several regulatory programs: identifying impaired water bodies, assessing compliance with permit conditions, and prioritizing sites for management action. This role is illustrated in Figure 2 and contains the following key characteristics:

- The framework is used to interpret data from a variety of sources, including regional monitoring programs and National Pollutant Discharge Elimination System (NPDES) permit monitoring.
- Existing data from prior monitoring activities may be used for assessment, rather than data from a study designed specifically for use with the framework.
- Application of the framework should yield consistent results when used with the same input data, regardless of which agency is using the framework.
- The products of the framework will be used by the regulatory agency to determine whether or not the SQO is attained and also to describe the magnitude or confidence of exceedance of the SQO.
- The site-level assessment results will be integrated and used for different purposes in various programs, including determination of 303(d) impairments, assessing permit compliance, Total Maximum Daily Load (TMDL) development, and planning of management actions.
- Once the need for management action has been determined, a more comprehensive and specific risk assessment may be needed to delineate spatial extent, identify sources, and determine chemical concentrations for use as management targets. The design of these additional risk assessments requires site-specific information that is outside the scope of the current SQO project. However, the SQO policy is expected to include guidance for designing these assessments.

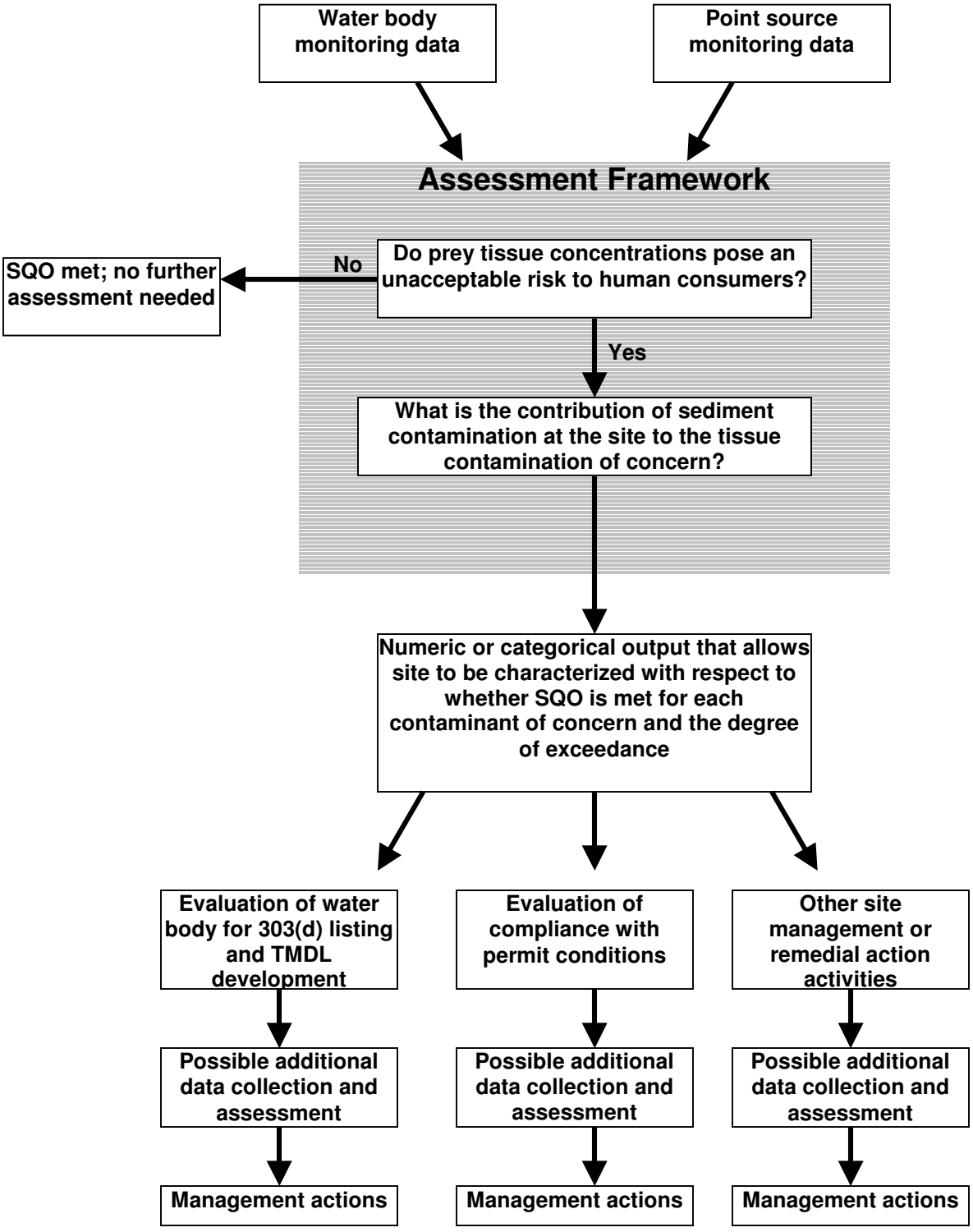

Figure 2. Role of Indirect Effects Framework

Lines of Evidence, Indicators, and Applications

Indirect Effects Tools

This program is based on the use of tools (indicators) that have been applied previously to the assessment of sediment quality for indirect effects. These tools are currently undergoing a variety of analyses similar to those being performed on the direct effects tools. Presented below are the candidate tools being evaluated or those that have been evaluated and appear to yield the most promising results at this time. As stated previously, many of the final analyses have yet to be completed and these findings will be used to help determine which tools are recommended for inclusion in the draft policy.

Pollutant Concentrations in Resident Fish

Pollutants in fish tissue will be used as a surrogate measure of potential human health risks. Currently, the U.S Environmental Protection Agency (U.S. EPA) and the Office of Environmental Health Hazard Assessment (OEHHA) are applying risk factors of one-in-one hundred thousand (10^{-5}) to one-in-one million (10^{-6}). Consumption values are typically derived from average consumption rates for statewide water quality protection programs. The California Toxics Rule applied a value of 6.5 grams per day for derivation of human health water quality criteria. Mean or median consumption values based upon more recent surveys include 21 (median) and 50 (mean) grams per day from OEHHA's Report Consumption of Fish and Shellfish in California and the United States (2001), 23 grams per day (California Ocean Plan) or 32 grams per day used in San Francisco Bay. Values such as these will be considered along with other values if the data is representative and a rationale for inclusion is acceptable for use within the context of a statewide plan.

Pollutant Concentrations in Sediment (Sediment Chemistry)

The following tools for the interpretation of sediment chemistry data may be considered for further evaluation:

- Normalized Biota-Sediment Accumulation Factor (BSAF) (U.S. EPA 2000)
- Bioaccumulation Factor (BAF) (U.S. EPA 2000)
- Food web bioaccumulation model (Arnot and Gobas 2004)

Pollutant Bioaccumulation after Laboratory Exposure

The laboratory bioaccumulation test that appears most promising based upon the studies conducted to date is:

- Sediment bioaccumulation test using the clam *Macoma* spp (U.S. EPA 1993)

Indirect Effects Thresholds

Thresholds would be established for each line of evidence tool proposed for inclusion in the draft policy. There are many site-specific factors such as fish consumption rates and wildlife receptor species that strongly influence tissue and sediment threshold values. A method to use site-specific information to establish thresholds will be described. Finally, a method would be proposed that describes how the results from the three indicators could be combined to make a station level assessment. After the station assessment is completed, a method must be derived for addressing multiple stations.

Indirect Effects Boundaries

Indirect effects SQOs will only be applicable to those habitats where enough data was available to develop and validate the tools. Currently, the sediment and tissue data limits the program to selected marine bays. As data becomes available for those water bodies with sparse data, the

indirect effects implementation tools and thresholds can be expanded to include all bays and estuaries.

Indirect Effects Scale of Application
A key factor in the implementation of indirect effects SQOs is the scale of the application. Can the indirect effects SQO be applied to individual stations, or should the SQO be applied only at the segment, reach, or water body scale? As illustrated in Figure 1, the exposure or accumulation of contaminants in fish tissue occurs throughout the home range of the fish. Therefore, the relationship between the contaminants in tissue and sediment chemistry at a specific station is difficult to establish. As a result, scale will be an important factor in the interpretation and implementation of the indirect effects narrative objective.

Implementation
Until the scale of the assessment is determined, very little can be proposed for implementation beyond the intent shown in Figure 2. Figure 2 identifies where the indirect effects SQO would be applied within NPDES permits, 303(d) Listing, and Toxic Hotspots Identification and Evaluation. An example of how the indirect effects could potentially be applied to point sources is described below.

Application to Conventional Point Source NPDES Permits
SQOs could be applied to conventional point source NPDES permits. Potential approaches used to establish a monitoring program and phased response actions could be described as general guidance. This approach would not prohibit alternative processes, rather it would describe an iterative approach that takes into account some of the limitations associated with the SQOs. The approach would include the initial assessment, followed by source assessment if the SQO is exceeded. If multiple sources of the pollutant of concern are present, a water body wide effort would follow such as a 303(d) Listing and the development of a TMDL. For this example, existing sources must be identified and the loads quantified to determine what portion of the mass loads from each source are contributing to the observed sediment load within the impaired water body. The next step would be the development of wasteload allocations and load allocations (to be subsequently implemented via NPDES permits) and/or sediment management actions, such as dredging, in situ containment, and/or natural attenuation.

When load reductions for specific pollutants are needed to attain SQOs in a given water body, the NPDES permits for discharges to that water body should be modified to reflect the wasteload allocation. Establishment of a Sediment Management Zone (SMZ) may provide adequate time for implementation and realization of benefits of corrective measures as well as to allow for natural attenuation, where deemed appropriate. A SMZ could be established using the criteria similar to that used for mixing zones, where the area and pollutant loading is limited to the extent that beneficial uses are not harmed.

Direct Effects Tools

In fall of 2007, the technical team collected sediment chemistry sediment toxicity and benthic community data from the Sacramento San Joaquin Delta in order to build more robust tools to interpret the SQOs for aquatic life in this waterbody. Although over a hundred stations from the Fall 2007 event were subject to acute toxicity tests and sublethal tests, only 3 samples were substantially toxic. Although this is positive news, and provides an adequate volume to characterize good conditions, the dataset is severely deficient at the other end of the stressor gradient. As a result, additional samples were collected in spring of 2008. Data from this most

recent event is forthcoming. All data will be combined to develop a suite of indicators comparable to those developed for enclosed bays under Phase I.

References

Arnot, J. A. and F. A. P. C. Gobas. 2004. A food web bioaccumulation model for organic chemicals in aquatic ecosystems. *Environmental Toxicology and Chemistry* 23: 2343-2355.

U.S. Environmental Protection Agency (USEPA). 1993. Guidance Manual: Bedded sediment bioaccumulation tests. EPA/600/R-93/183. U.S. Environmental Protection Agency, Office of Research and Development, Washington, DC.

U.S. Environmental Protection Agency (U.S. EPA). 2000. Bioaccumulation testing and interpretation for the purpose of sediment quality assessment status and needs. Washington, D.C., U.S. Environmental Protection Agency**:** 111.

U.S. Environmental Protection Agency (U.S. EPA). 2000. Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories Volume 2 Risk Assessment and Fish Consumption Limits Third Edition. EPA 823-B-00-008. U.S. Environmental Protection Agency, Office of Water, Washington, D.C.