Sediment Quality Objectives for the Protection of Aquatic Life (Direct Effects)

Sediment quality samples are assessed using California's Sediment Quality Objectives (SQOs) for the protection of aquatic life as described in the *Final Staff Report, Water Quality Control Plan for Enclosed Bays and Estuaries, Part 1 – Sediment Quality* (SWRCB-Cal EPA 2008), and in publications by Southern California Coastal Water Research Project. The SQOs are based on a multiple line of evidence (MLOE) approach and include sediment chemistry, sediment toxicity, and benthic community condition. The MLOE results are integrated through the evaluation of the severity of biological effects and the potential for chemically mediated effects to provide a final station level assessment. The specific methods associated with each line of evidence (LOE) and the integrated assessment are described below.

Sediment Chemistry

California Logistic Regression Model

Results of chemicals detected in project sediment samples are compared to the California Logistic Regression Model (CA LRM) and the Chemical Score Index (CSI). The CA LRM is based on the maximum probability model (PMAX). Each regression model estimates the probability of observing toxicity at the concentration of a contaminant of concern (or a class of contaminants of concern) in field-collected sediments. The CA LRM follows Equation 1:

Equation 1

$$p = \frac{e^{B0+B1(x)}}{(1 + e^{B0+B1(x)})}$$

where:

p	=	probability of toxicity for target constituent
B0	=	the intercept parameter
B1	=	the slope parameter
e	=	natural log
x	=	the log of the concentration of the analyte of interest

To calculate the CA LRM, concentrations of each contaminant are entered into the corresponding logistic regression model and the probability for causing toxicity is determined for each contaminant. The individual contaminant with the highest probability for causing toxicity is the PMAX value. The PMAX value determined for each project area is compared to established values and categorized according to the associated exposures (minimal, low, moderate, or high). For example, if the PMAX is determined to be 0.64, then the sample is categorized as "moderate exposure."

Chemical Score Index

The CSI was developed for the SQO assessment and is based on the relationship between sediment chemical concentration and the degree of benthic community disturbance to Southern California benthic macrofauna. The CSI is the weighted mean of benthic community category scores based on guidelines

developed for 13 contaminants with weighting factors for each contaminant as specified in Table 6 of Appendix A of the *Final Staff Report* (SWRCB-Cal EPA 2008). The CSI value determined is categorized according to the associated exposures (minimal, low, moderate, or high).

Integration of Sediment Chemistry Categories
The final sediment LOE category is the average of the two chemistry exposure categories. If the average falls midway in between the two categories, it is rounded up to the higher (more impacted) of the two. For example, if the CA LRM is low exposure and the CSI is moderate exposure, then the final sediment LOE category is moderate exposure.

Sediment Toxicity

Two amphipod (*E. estuarius* and *M. galloprovincialis*) sediment toxicity test results are statistically compared to control test results, normalized to the control survival, and then categorized. The categories depend on whether or not the survival of *E. estuarius* and *M. galloprovincialis* from a station is statistically significant from the survival of organisms in the control. For example, if survival of *E. estuarius* test sediment was 81% (of control survival) and was significantly different from the control survival using the statistical tests described above, then this sample would be categorized as "moderate toxicity."

Benthic Community Condition

Benthic community condition is assessed using a combination of four benthic indices: Benthic Response Index (BRI), Relative Benthic Index (RBI), Index of Biotic Integrity (IBI), and a predictive model based on the River Invertebrate Prediction and Classification System (RIVPACS). The BRI is the "abundance-weighted pollution tolerance score" of infaunal species, with scores increasing from 0 to 100 with greater levels of disturbance. The BRI scores are calculated using the abundances of species and their respective pollution-tolerance values. The RBI is calculated as the weighted sum of: a) four community parameters (total number of taxa, number of crustacean taxa, number of molluscan taxa, and number of crustacean individuals); b) three positive indicator organisms; and c) two negative indicator taxa. The RBI values are scaled from 0 to 1.0, with lower values indicative of higher levels of disturbance. Scores are compared to categorization values to determine the community condition category of the sample. Determination of the IBI involves comparisons of four community measures (total number of taxa, number of molluscan taxa, abundance of *Notomastus sp.*, and percentage of sensitive taxa) to reference conditions for Southern California bays and estuaries. For every metric that exceeds a reference condition, the IBI value is increased by a score of one; therefore, IBI values potentially range from 0 to 4, with lower values indicative of lower levels of disturbance. The RIVPACS index is used to compare the sample benthic community assemblages (Observed) to reference species compositions (Expected) within the same habitat. Calculation of the RIVPACS score involves the following calculations:

- The probability of the test sample belonging to the 12 Southern California reference sample groups
- The expected number of reference species based on probability of group membership
- The Observed/Expected RIVPACS score for comparisons to benthic community categorization values

The four indices are calculated according to guidance developed by Southern California Coastal Water Research Project. Each benthic index result is categorized according to the following four levels of disturbance, with conditions ranging from a reference condition to high disturbance:

- Reference: Equivalent to a least affected or unaffected site
- Low Disturbance: Some indication of stress is present but is within measurement error of unaffected condition
- Moderate Disturbance: Clear evidence of physical, chemical, natural, or anthropogenic stress
- High Disturbance: High magnitude of stress

The final benthic community condition is determined by averaging the four indices into a single category. If the median falls between two categories, the value is rounded to the next higher category to provide the most conservative estimate of benthic community condition.

Integrated Assessment by Station

The SQO direct effects assessment is evaluated at the station level. The toxicity LOE is combined with the benthic community condition LOE to determine a severity of biological effects category. The toxicity LOE is also combined with the sediment chemistry LOE to determine a potential for chemically mediated effects category. Each station level assessment can be determined by then combining the severity of biological effects category as shown in the table below with the potential for chemically mediated effect category, which results in one of six possible station level assessments, including unimpacted, likely unimpacted, possibly impacted, likely impacted, clearly impacted, and inconclusive.

Station Level Assessment Matrix

Severity of Biological Effects Category	Potential for Chemically Mediated Effects Category	Station Level Assessment
Unaffected	Minimal Potential	Unimpacted
Unaffected	Low Potential	Unimpacted
Unaffected	Moderate Potential	Likely Unimpacted
Unaffected	High Potential	Inconclusive
Low Effect	Minimal Potential	Likely Unimpacted
Low Effect	Low Potential	Likely Unimpacted
Low Effect	Moderate Potential	Possibly Impacted or Inconclusive
Low Effect	High Potential	Likely Impacted
Moderate Effect	Minimal Potential	Likely Unimpacted
Moderate Effect	Low Potential	Possibly Impacted
Moderate Effect	Moderate Potential	Likely Impacted
Moderate Effect	High Potential	Clearly Impacted

Severity of Biological Effects Category	Potential for Chemically Mediated Effects Category	Station Level Assessment
High Effect	Minimal Potential	Inconclusive
High Effect	Low Potential	Possibly Impacted
High Effect	Moderate Potential	Likely Impacted
High Effect	High Potential	Clearly Impacted