# San Diego County Municipal Copermittees Sediment Monitoring Plan

**Prepared For:**

**County of San Diego Municipal Copermittees**

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# San Diego County Municipal Copermittees Sediment Monitoring Plan-Final

**Prepared For:**

**County of San Diego Municipal Copermittees**

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## ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| ASTM | American Society for Testing and Materials |
| AVS:SEM | acid-volatile sulfides and simultaneously extracted metals |
| Bight | Southern California Bight Regional Monitoring Program |
| BRI | Benthic Response Index |
| CA EPA | California Environmental Protection Agency |
| CA LRM | California Logistic Regression Model |
| CEDEN | California Environmental Data Exchange Network |
| CDFW | California Department of Fish and Wildlife |
| COC | chain-of-custody |
| Copermittees | San Diego Regional Copermittees |
| CSI | Chemical Score Index |
| DDE | dichlorodiphenyldichloroethylene |
| DDT | dichlorodiphenyltrichloroethane |
| DGPS | Differential Global Positioning System |
| DO | dissolved oxygen |
| DTCS | Department of Toxic Substances Control |
| $EC_{50}$ | median effective concentration |
| ELAP | Environmental Laboratory Accreditation Program |
| IBI | Index of Biotic Integrity |
| ID | inner diameter |
| $LC_{50}$ | median lethal concentration |
| LOE | line of evidence |
| $MgSO_4$ | magnesium sulfate |
| MLLW | mean lower low water |
| MLOE | multiple lines of evidence |
| MS4 | Municipal Separate Storm Sewer System |
| M-AMBI | Multivariate AZTI Marine Biotic Index |
| MW | molecular weight |
| NPDES | National Pollutant Discharge Elimination System |
| OEHHA | Office of Environmental Health Hazard Assessment |
| PAHs | polycyclic aromatic hydrocarbons |
| PCBs | polychlorinated biphenyls |
| pH | hydrogen ion concentration |
| $P_{MAX}$ | maximum probability model |
| QA | quality assurance |
| QA/QC | quality assurance/quality control |
| QAMP | Quality Assurance Management Plan |
| QAPP | Quality Assurance Project Plan |
| QC | quality control |
| RBI | Relative Benthic Index |
| RIVPACS | River Invertebrate Prediction and Classification System |
| RL | Reporting Limit |
| SCAMIT | Southern California Association of Marine Invertebrate Taxonomists |
| San Diego Water Board | San Diego Regional Water Quality Control Board |

| | |
|---|---|
| SOPs | Standard Operating Procedures |
| SPME | solid phase microextraction |
| SQOs | Sediment Quality Objectives |
| State Water Board | State Water Resources Control Board |
| SWAMP | Surface Water Ambient Monitoring Program |
| TIE | toxicity identification evaluation |
| TMDL | Total Maximum Daily Load |
| TOC | total organic carbon |
| U.S. | United States |
| USEPA | United States Environmental Protection Agency |
| WQIP | Water Quality Improvement Plan |

## UNITS OF MEASURE

| | |
|---|---|
| cm | centimeter |
| °C | degrees Celsius |
| ft | feet or foot |
| L | liter |
| $m^2$ | square meters |
| µg/kg | microgram per kilogram |
| mg | milligram |
| mg/kg | milligram per kilogram |
| mg/L | milligram per liter |
| mL | milliliter |
| mm | millimeter |
| ppt | parts per thousand |
| % | percent |

# 1.0 INTRODUCTION

The San Diego County Regional Copermittees (Copermittees) are required to conduct sediment quality monitoring in accordance with the requirements of the San Diego Regional Water Quality Control Board (San Diego Water Board) Order No. R9-2013-0001 (Permit), effective June 27, 2013. The Copermittees are required either individually, in association with multiple Copermittees, or through participation in a waterbody monitoring coalition to perform sediment quality monitoring to assess compliance with the sediment quality receiving water limits applicable to MS4 discharges to enclosed bays and estuaries. Provision D.1.e.(2) of the Permit requires the Copermittees to develop a Sediment Monitoring Plan for incorporation into the Water Quality Improvement Plan (WQIP) which satisfies the requirements of the *Water Quality Control Plan for Enclosed Bays and Estuaries – Part I Sediment Quality* (State Water Resources Control Board [State Water Board] and California Environmental Protection Agency [CA EPA], 2009). On June 5, 2018, the State Water Board adopted Resolution No. 2018-0028 amending this document (now called *Amendments to the Water Quality Control Plan for Enclosed Bays and Estuaries of California – Sediment Quality Provisions* [State Water Board and CA EPA, 2018]; see Appendix A). For the purposes of this monitoring plan, it will hereafter be referred to as the Sediment Control Plan. This Sediment Monitoring Plan, which addresses compliance with the aquatic life objective, was updated to incorporate these amendments and is attached to the 2022-23 WQIP Annual Report.

Provision D.1.e.(1)(b) of the Permit also requires the Copermittees to participate in the Southern California Bight Regional Monitoring Program (Bight Program). The Bight Program occurs every five years and consists of a partnership of multiple local, state, and federal agencies collaborating to address management questions of regional importance regarding offshore, nearshore, and estuarine habitats from Point Conception to the US-Mexican border. The Bight Program, which is overseen by the Southern California Coastal Water Research Program (SCCWRP) and reports to the State Water Board, focuses on water quality, coastal ecology, sediment quality, and shoreline microbiology. Participation in the Bight Program can be used to simultaneously fulfill all or part of the Permit sediment quality monitoring requirement (Provision D.1.e[2]) because sediment monitoring and sediment quality objectives (SQO) analyses are incorporated into the Bight Program to regionally assess the sediment quality of Southern California's enclosed bays, lagoons, and estuaries (herein referred to as waterbodies), including those waterbodies in San Diego County. The Copermittees can also decide to conduct the sediment quality monitoring of San Diego County's water bodies independently of the Bight Program (e.g., if the Bight Program does not assess a stratum that is present in a waterbody such as a freshwater or brackish stratum or if additional stations need to be assessed that are not covered under the Bight Program). Depending upon the outcome of the initial SQO assessments, the Copermittees may need to perform follow-up monitoring or potentially stressor identification studies to meet the Permit requirements.

The following Sediment Monitoring Plan describes the sediment quality sample collection and analysis activities that will be implemented by the Copermittees during the Permit term. As required by the Permit, this Sediment Monitoring Plan includes the elements listed in Sections IV.A.4.c.3 and IV.A.4.d (formerly Sections VII.D and VII.E, respectively) of the Sediment Control Plan (Receiving Water Limits Monitoring Frequency and Sediment Monitoring and Assessment, respectively), a Sediment Monitoring Quality Assurance Project Plan (QAPP) (Appendix B), and a schedule for completion of monitoring and submission of the sediment monitoring results. The Copermittees will incorporate the sediment monitoring results into the WQIP Annual Report.

## 1.1 Background

In 2003, the State Water Board initiated a program to develop SQOs for enclosed bays and estuaries. The primary objective is to protect benthic communities and aquatic life from exposure to contaminants in sediment that have been directly discharged into the waterbody or indirectly discharged into waters draining into the waterbody. The SQOs, which are outlined in the Sediment Control Plan, are based on a multiple lines of evidence (MLOE) approach in which the lines of evidence (LOE) are sediment toxicity, sediment chemistry, and benthic community condition, as described in the Sediment Control Plan (see Appendix A) and in Section 3.2 of this document. The MLOE approach evaluates the severity of biological effects and the potential for chemically mediated effects to provide a final station level assessment. The Sediment Control Plan was approved by the State Water Board and the Office of Administrative Law on September 16, 2008, and on January 5, 2009, respectively, and was subsequently approved by the United States Environmental Protection Agency (USEPA) on August 25, 2009. On June 5, 2018, the State Water Board adopted Resolution No. 2018-0028 amending the Sediment Control Plan.

## 1.2 Monitoring Objective

The primary objective of the sediment monitoring program is to assess compliance with the sediment quality receiving water limits applicable to MS4 discharges to enclosed bays and estuaries of San Diego County. Sediment toxicity, chemistry, and benthic community condition will be assessed using SQOs as described in the Sediment Control Plan (Appendix A). The goals of the SQOs are to determine whether pollutants in sediments are present in quantities that are toxic to benthic organisms and/or will bioaccumulate in marine organisms to levels that may be harmful.

The goal of the Sediment Monitoring Plan is to provide the key elements that are required to successfully conduct field sediment sampling, processing, testing, and analysis of the results. Analyses of chemistry, toxicity, and benthic community condition require that samples be collected, preserved, processed, and analyzed using proper field and laboratory equipment, methods, and techniques. Additionally, the selection of representative station locations is necessary to ensure proper characterization of benthic conditions. The Sediment Monitoring Plan and Sediment Monitoring QAPP (Appendix B) describe the collection and analysis of surface sediment samples necessary to provide representative assessments of in situ conditions for the enclosed bays and estuaries of San Diego County.

# 2.0 MATERIALS AND METHODS

The materials and methods described in this section are designed to meet the requirements of the Sediment Control Plan, Sections IV.A.4.c.3 and IV.A.4.d, as required by Permit Provision D.1.e.(2)(a). The methodology is outlined in Section IV.A.1 of the Sediment Control Plan. This section of the monitoring plan gives a description of how to conduct field sample collection and laboratory processing of sediment samples for SQO analysis; however, a more detailed description of the field collection procedures is provided in the *Sediment Quality Assessment Technical Support Manual* (Bay et al., 2021) on SCCWRP's website at: https://ftp.sccwrp.org/pub/download/DOCUMENTS/TechnicalReports/777_CASQO_TechnicalManual.pdf

Quality assurance methods and procedures needed to maintain consistency in sample collection, processing, and analysis to produce scientifically defensible data are provided in the Sediment Monitoring Quality Assurance Project Plan (QAPP) (Appendix B). The QAPP provides acceptability criteria for the collection and analysis of duplicate field samples, field or equipment rinse blanks, laboratory methods, and laboratory spikes. The QAPP should be used as a reference to ensure proper methods are used consistently throughout the monitoring program. However, if sediment quality monitoring is conducted as part of the Bight Program, the work plans and associated QA/QC documents pertaining to the Bight Program should be followed as the primary documents and the Sediment Monitoring QAPP as the secondary document.

## 2.1 Field Collection Program

### 2.1.1 Station Selection

The Sediment Control Plan applies to subtidal surficial sediments located seaward of the intertidal zone in enclosed bays and estuaries. It does not apply to ocean waters, inland surface waters, sediments consisting of less than 5 percent (%) fines or substrates composed of gravel, cobble, or consolidated rock, or to sediment classified as a pollutant due to physical processes such as burial or sedimentation.

SQOs have been fully developed for only two of California's six enclosed bay habitats: euhaline (salinity = 25 to 32 parts per thousand [ppt]) bays and estuaries south of Point Conception and polyhaline (18 to 25 ppt) central San Francisco Bay. The benthic species assemblage used to calculate the benthic LOE in San Diego bays and estuaries is Habitat C- Southern California Marine Bays, which requires a salinity greater than or equal to (≥) 27 ppt (Bay et al 2021; Ranasinghe et al 2008). In order to select a sampling station applicable to the SQO assessment using Habitat C for the benthic LOE, it is recommended to verify that a proposed sampling station is both subtidal and has salinity ≥ 27 ppt. Salinity measurements should be taken at or near the sediment-water interface at a spring high and low tide to get an estimate of the salinity range for a proposed station. If feasible, it is recommended that salinity should be monitored throughout an entire spring tidal cycle to ensure it meets the salinity criteria prior to sampling, since it is likely that some areas of the enclosed bays and estuaries in San Diego will not meet the criteria under certain conditions. This monitoring can be accomplished by deploying a continuous monitoring device such as a YSI or HOBO water quality data sonde. Water depth should also be measured when visiting the station at a spring low tide or deploying a continuous monitoring device over a spring tidal cycle to ensure the station is subtidal.

Sampling stations can also be selected in areas of estuaries that are identified as a low salinity habitat (i.e., subtidal brackish habitat in which the salinity is less than (<) 27 ppt); however, the station assessment will be conducted in a different manner (see Section 3.2.2). Stations located in low salinity habitats should be in a minimum of six inches of estuary water at a Mean Lower Low Water (MLLW) tide. To ensure that a station is sampleable, it is recommended to conduct reconnaissance of the site close to MLLW and when it is less than or equal to 0.5 feet (ft) on tide charts. Salinity should be measured at or near the sediment-water interface to determine if the station meets sampling requirements (i.e., salinity < 27 ppt) (SCCWRP, 2018).

Sediment monitoring programs should be designed in such a way that selected stations are spatially representative of sediments within a waterbody. All station locations will be selected using a stratified random design approach (where resources permit) when assessing a waterbody. A targeted sampling design of specific areas of a waterbody can be applied if it is determined that there has been an exceedance of a receiving water limit (e.g., a station within a waterbody is assessed as Clearly Impacted) (see Section IV.A.4.c.2 of the Sediment Control Plan for more details). Sampling design should take into consideration pre-existing data (e.g., previously sampled SQO stations) and information regarding the current dynamics and conditions of a waterbody such as water quality (e.g., areas of low salinity habitats), hydrodynamics, depth, land uses, inputs (natural and anthropogenic), and other factors that may affect the chemical, biological, or physical conditions of the sediments.

The number of sampling stations will vary within each San Diego County waterbody based on the spatial extent of the area likely to be impacted. As described in Section IV.A.4.a of the Sediment Control Plan, two or more stations within a waterbody are required to be individually assessed in order to be in compliance with the aquatic life objective. If a stressor identification study becomes necessary following the initial SQO assessment of a waterbody (see Section 4.0), then the number of stations sampled will be based upon the drivers of the impacted scores (e.g., algae, physical factors, or chemical factors), as well as having sufficient samples to statistically support meaningful findings.

### 2.1.2 Permitting

Scientific collecting permits from the California Department of Fish and Wildlife (CDFW) will need to be obtained in order to collect benthic infaunal samples containing invertebrate specimens. At a minimum, it can take up to three weeks to obtain the permit; however, at times it can take several months to receive a scientific collecting permit so applications should be submitted well in advance of the desired sampling dates. A minimum of 24 hours (business day only) prior to collecting benthic infaunal samples in the field, field staff should submit a Notification of Intent to Collect for Scientific Purposes form on CDFW's Scientific Collecting Permit Portal. Submit the notice in Section 1a-Notification of Field Work or Activities on the Scientific Collecting Permit.

Additionally, written authorization may be required from state agencies or private landowners in order to gain access to water bodies that are surrounded by private land, have locked fences or gates, contain threatened or endangered species, or require the use of a private boat launch. Nesting seasons of threatened and endangered bird species may prevent sampling from being conducted or may restrict access around nesting areas during certain times of year, typically mid to late summer months.

### 2.1.3 Monitoring Season and Frequency

Section IV.A.4.d.6 of the Sediment Control Plan requires that samples for SQO programs be collected during the "index period" occurring between June and September. Physical environments and benthic community composition and abundance within enclosed bays and estuaries are generally stable and most similar from year to year during this time (Bay et al., 2021).

According to Section IV.A.4.c.3.a of the Sediment Control Plan, sediment monitoring associated with Phase I stormwater discharges and major discharges shall be conducted a minimum of once during a Permit cycle. Stations that have consistently been classified as Unimpacted or Likely Unimpacted using the MLOE approach (described in Section 3.2 of this document) may also have the sampling frequency reduced to once per permit cycle. The San Diego Water Board may also limit receiving water monitoring to a subset of outfalls to focus where the risk to sediment quality is greatest.

### 2.1.4 Sampling Vessels

Vessels used to collect sediment samples will be both stable and maneuverable and will have a sufficiently shallow draft to navigate shallow waters if sampling in an estuary. If deploying a large sediment grab sampler (e.g., Van Veen), the vessel will be equipped with a davit from which to deploy and retrieve the surface sampling equipment. Small boats deployed in an estuary should accommodate a minimum of two people in addition to all appropriate sampling and safety equipment. The vessel should be anchored in one or more directions with the motor turned off during sampling.

### 2.1.5 Navigation and Site Acceptability

All station locations will be pre-plotted prior to sampling activities. Stations will be identified using a Differential Global Positioning System (DGPS). The system uses U.S. Coast Guard differential correction data and is accurate within 10 ft. Pre-plotted stations are defined by a specific latitude and longitude; however, occupation within a radius limit of 100 meters (m) of the target coordinate will be considered acceptable. The station acceptability criteria are similar to the criteria adhered to in the Bight Program. If a pre-plotted sample station is deemed to be unsuitable for collecting sediment (due to factors such as inaccessibility, disturbance to wildlife, or safety considerations), the station may be abandoned and an alternate station with similar characteristics may be selected within the same strata. Reasons for abandonment will be recorded on field data sheets. All final station locations will be recorded in the field using positions from the DGPS.

### 2.1.6 Sediment Sampling and Handling

Benthic sediments will be collected as surface grabs using an appropriate grab sampler. The recommended grab sampler is a stainless steel Van Veen or modified Van Veen. The size of the grab sampler used for sediment programs in Southern California should be able to sample a surface area of 0.1 square meter ($m^2$). Grab samplers with a smaller surface area (e.g., petite ponar grab) can be utilized provided the grabs are equivalent in quality as to that of a Van Veen grab.

When collecting sediment samples in subtidal brackish habitats of estuaries (i.e., < 27 ppt), it is recommended to follow sampling techniques specifically developed and utilized for low salinity habitats during the 2018 Bight Program (SCCWRP, 2018). For low salinity habitats, sediment chemistry and toxicity samples can be collected with a Van Veen or a petite ponar grab. Benthic infaunal samples should be collected with a Van Veen when possible. When not practical, multiple grabs may be collected using a hand deployed petite ponar to collect an equivalent surface area of a Van Veen grab. If areas are not accessible to deploy a Van Veen or petite ponar grab from a boat, then using a sample coring device is also acceptable. If using a coring device, two 4-inch plastic cores should be directly inserted into the sediment to a depth of 10 centimeters (cm) that will then be composited into one sample. In Bight '18, both Van Veen grabs and a coring device were used to collect benthic infaunal samples. For more details on low salinity habitat sampling procedures refer to the Bight '18 Sediment Quality Assessment Field Operations Manual and Appendices found on SCCWRP's website at:

http://ftp.sccwrp.org/pub/download/BIGHT18/Bight18SedQualityFieldManual.pdf
http://ftp.sccwrp.org/pub/download/BIGHT18/Bight18SedQualityFieldManual_Appendices.pdf)

An appropriate sampler for the collection of benthic sediments will have the following characteristics:

- Constructed of a material that does not introduce contaminants.
- Causes minimal surface sediment disturbance.
- Does not leak or mix during sample retrieval.
- Has a design that enables safe/easy sample verification that samples meet all applicable sampling criteria (e.g., collects sediments to at least 5 cm below the sediment surface, has access doors allowing visual inspection and removal of undisturbed surface sediment, meets surface area requirement for benthic community habitat being sampled).

Sediment grabs will be collected for the following analyses: benthic infauna, chemistry, particle size, and toxicity. Because multiple grabs need to be collected, the benthic infaunal sample is collected first to minimize disturbance of the infaunal community. A sample will be considered acceptable if the surface of the grab is even, there is minimal surface disturbance, and there is a penetration depth of at least 5 cm (or 10 cm for benthic infaunal samples collected in low salinity habitats [i.e., < 27 ppt] if using a core device). Rejected grabs will be discarded, and the station will be re-sampled. Acceptable sediment grabs to be utilized for chemistry, particle size, and toxicity analyses will have the overlying water carefully drained from the sediment surface prior to removing the sediment to be placed in the appropriate sample containers. Overlying water will not be drained from sediment samples collected for benthic infaunal analysis. Station location and grab event data will be recorded on pre-formatted field data sheets (hard copies or via computer). At a minimum, field data will include station identification, station location, date, time of sample collection, depth of water, depth of penetration of grab in sediment (e.g., 5 cm), sediment composition, sediment odor and color, and sample type (e.g., sediment chemistry). While not required, it is recommended that photographs of each sediment sample be taken and stored.

The entire contents of at least one Van Veen grab sample, or multiple petite ponar grabs that equivalate the surface area of one Van Veen grab, will be utilized for benthic community analyses with a minimum penetration depth of 5 cm. If using a coring device in low salinity habitats, then the two core samples should have a penetration depth of 10 cm. Samples collected for benthic infaunal analysis will be rinsed through a 1.0-millimeter (mm) mesh screen. The material retained on the screen will be transferred to a labeled glass or plastic sample container. A 7% magnesium sulfate ($MgSO_4$) seawater solution will be added to the sample container to 85-90% of its volume to relax the collected specimens. The sample container will be gently inverted several times to distribute the relaxant solution. After 30 minutes, add enough sodium borate buffered formalin (50 grams sodium borate per liter of formalin) to top off the sample container. This will make a 10% formalin solution (i.e., 1 part buffered formalin to 9 parts saltwater). Alternatively, the relaxant solution can be decanted and replaced with a pre- mixed 10% buffered formalin solution. Gently invert the container several times to ensure the sample is mixed.

Sediment samples for chemistry and toxicity testing will be collected from the top 5 cm of a grab sample using a pre-cleaned stainless-steel scoop. Sediment within 1 cm of the sides of the grab will be avoided to prevent interaction of any contaminants and the steel sampling device. Chemistry and toxicity sample processing and allocation of sub-samples can be conducted using two different methods: distributed or composited. Distributed samples are separate representative sediment samples for chemistry and toxicity collected from the same grab or multiple grabs that are placed in specific containers for each type of analysis. Sediment aliquots collected in this manner should be representative of the entire 5 cm depth of the surface sediment. If utilizing the homogenized sampling method, then sediment samples are collected from the surface of each grab, placed in an intermediate precleaned mixing container, and homogenized before placing sediment in sample containers. The mixing container and utensils used to mix the sediment should be made of an inert material that will not contaminate the sample (e.g., Teflon bag or Teflon coated mixing bowl and utensils). The homogenization method maximizes comparability of the chemistry and toxicity samples and is the preferred method from a toxicological perspective.

Depending on the study design, the sediment-water interface toxicity test (see Section 2.2.2.2) can be conducted on two different types of sediment samples, either on an undisturbed core sample or on homogenized sediment. If collecting a core sample, a polycarbonate core tube (7.3-cm inner diameter [ID] and 16cm in length) is pressed directly into the top 5 cm of sediment in the grab sampler. To prevent loss of sample, a gloved hand or precleaned acrylic plate can be inserted on the bottom when removing from the grab sampler and capped upon removal. Cores should be stored upright with minimal disturbance during transit to the analytical laboratory. As an alternative, sediment samples can be homogenized in the field as described in the previous paragraph. This method is more practical to implement in the field, maximizes comparability of the chemistry and toxicity samples as stated above, and is consistent with previous sediment quality objective methodology (e.g., Bight protocols and previous lagoon monitoring implemented by the Copermittees). Minimum sample volumes and types of sample containers to be used in the sediment collection are provided in the Sediment Monitoring QAPP (see Appendix B).

All sampling equipment will be cleaned prior to sampling. Between sampling stations, the grab sampler will be rinsed with station water. Stainless steel scoops will be rinsed with seawater and rinsed with de-ionized water between stations. All sediment samples will be logged on a chain-of-custody (COC) form (see Section 2.1.7). Sediment chemistry and toxicity samples will be placed in a cooler on ice until delivered or shipped to the appropriate laboratories. Prior to shipping, sample containers will be placed in sealable plastic bags and securely packed inside the cooler with ice. The original signed COC forms will remain with the samples during shipment. Sediment samples will be shipped or delivered to the analytical laboratory within appropriate holding times (refer to Sediment Monitoring QAPP in Appendix B).

### 2.1.7 Documentation of Chain-of-Custody

This section describes the program requirements for sample handling and COC procedures. Samples are considered to be in custody if they are: (1) in the custodian's possession or view, (2) retained in a secured place (under lock) with restricted access, or (3) placed in a secured container. The principal documents used to identify samples and to document possession are COC records, field logbooks, and field tracking forms. COC procedures will be used for all samples throughout the collection, transport, and analytical process, and for all data and data documentation, whether in hard copy or electronic format.

COC procedures will be initiated during sample collection. A COC record will be provided with each sample or sample group. Each person who has custody of the samples will sign the form and ensure that the samples are not left unattended unless properly secured. Minimum documentation of sample handling and custody will include the following:

- Sample identification.
- Sample collection date and time.
- Any special notations on sample characteristics.
- Initials of the person collecting the sample.
- Date the sample was sent to the laboratory.
- Shipping company and waybill information.

The completed COC form will be placed in a sealable plastic envelope that will travel inside the ice chest containing the listed samples. The COC form will be signed by the person transferring custody of the samples. The condition of the samples will be recorded by the receiver. COC records will be included in the final analytical report prepared by the laboratory and will be considered an integral part of the report.

## 2.2 Laboratory Testing

All samples will be tested in accordance with USEPA or American Society for Testing and Materials (ASTM) methodologies. If appropriate methods do not exist, the Copermittees should use other methods approved by the State Water Board or San Diego Water Board. Analytical laboratories will be certified by the State Water Board's Environmental Laboratory Accreditation Program (ELAP) in accordance with Water Code 13176. Additional information pertaining to laboratory testing is presented in the Sediment Monitoring QAPP (see Appendix B).

### 2.2.1 Physical and Chemical Analysis

Physical and chemical measurements of sediment were selected to comply with the Sediment Control Plan and to provide data on chemicals of potential concern in bays and estuaries located in San Diego County. In accordance with the Sediment Control Plan, the physical and chemical analyses of sediments will include, at a minimum, the constituents outlined in Table 2-1. If sediment quality monitoring is conducted as part of the Bight Program, additional chemical analyses may be included and will be provided in Bight Workplans. Reporting limits (RLs) must be equal to or less than those listed in Table 2-1 in order to generate the chemistry LOE outlined in Section 2.3.3.1. Concentrations associated with the RLs in Table 2-1 are expressed in dry weight. Physical analyses of sediment will include particle size and percent solids. Particle size will be analyzed to determine the general size classes that make up the sediment (e.g., gravel, sand, silt, and clay), whereas percent solids will be measured to convert chemical concentrations from a wet-weight to a dry-weight basis. Chemical analyses of sediment will include total organic carbon (TOC), and the select trace metals, chlorinated pesticides, polychlorinated biphenyls (PCBs), and polycyclic aromatic hydrocarbons (PAHs) shown in Table 2-1.

**Table 2-1. Chemical and Physical Parameters for Sediment Samples**

| Parameter | Reporting Limit |
|---|---|
| **Physical/Conventional Tests** | |
| Particle Size | 1.00 % |
| Percent Solids | 0.10 % |
| Total Organic Carbon (TOC) | 0.01 % |
| **Metals** | |
| Cadmium (Cd) | 0.09 mg/kg |
| Copper (Cu) | 52.8 mg/kg |
| Lead (Pb) | 25.0 mg/kg |
| Mercury (Hg) | 0.09 mg/kg |
| Zinc (Zn) | 60.0 mg/kg |
| **Organochlorine Pesticides** | |
| 2,4′-DDD | 0.50 µg/kg |
| 2,4′-DDE | 0.50 µg/kg |
| 2,4′-DDT | 0.50 µg/kg |
| 4,4′-DDD | 0.50 µg/kg |
| 4,4′-DDE | 0.50 µg/kg |
| 4,4′-DDT | 0.50 µg/kg |
| Chlordane-alpha | 0.50 µg/kg |
| Chlordane-gamma | 0.54 µg/kg |
| Dieldrin | 2.5 µg/kg |
| trans-Nonachlor | 4.6 µg/kg |
| **PCB Congeners** | |
| 2,4'-Dichlorobiphenyl (PCB 8) | 3.0 µg/kg |
| 2,2',5-Trichlorobiphenyl (PCB 18) | 3.0 µg/kg |
| 2,4,4'-Trichlorobiphenyl (PCB 28) | 3.0 µg/kg |
| 2,2',3,5'-Tetrachlorobiphenyl (PCB 44) | 3.0 µg/kg |
| 2,2',5,5'-Tetrachlorobiphenyl (PCB 52) | 3.0 µg/kg |
| 2,3',4,4'-Tetrachlorobiphenyl (PCB 66) | 3.0 µg/kg |
| 2,2',4,5,5'-Pentachlorobiphenyl (PCB 101) | 3.0 µg/kg |
| 2,3,3',4,4'-Pentachlorobiphenyl (PCB 105) | 3.0 µg/kg |

| Parameter | Reporting Limit |
|---|---|
| 2,3,3',4',6-Pentachlorobiphenyl (PCB 110) | 3.0 µg/kg |
| 2,3',4,4',5-Pentachlorobiphenyl (PCB 118) | 3.0 µg/kg |
| 2,2',3,3',4,4'-Hexachlorobiphenyl (PCB 128) | 3.0 µg/kg |
| 2,2',3,4,4',5'-Hexachlorobiphenyl (PCB 138) | 3.0 µg/kg |
| 2,2',4,4',5,5'-Hexachlorobiphenyl (PCB 153) | 3.0 µg/kg |
| 2,2',3,4,4',5,5'-Heptachlorobiphenyl (PCB 180) | 3.0 µg/kg |
| 2,2',3,4',5,5',6-Heptachlorobiphenyl (PCB 187) | 3.0 µg/kg |
| 2,2',3,3',4,4',5,6-Octachlorobiphenyl (PCB 195) | 3.0 µg/kg |
| **PAHs (low molecular weight)** | |
| Acenaphthene | 20.0 µg/kg |
| Anthracene | 20.0 µg/kg |
| Phenanthrene | 20.0 µg/kg |
| Biphenyl | 20.0 µg/kg |
| Naphthalene | 20.0 µg/kg |
| 2,6-Dimethylnaphthalene | 20.0 µg/kg |
| Fluorene | 20.0 µg/kg |
| 1-Methylnaphthalene | 20.0 µg/kg |
| 2-Methylnaphthalene | 20.0 µg/kg |
| 1-Methylphenanthrene | 20.0 µg/kg |
| **PAHs (high molecular weight)** | |
| Benzo(a)anthracene | 80.0 µg/kg |
| Benzo(a)pyrene | 80.0 µg/kg |
| Benzo(e)pyrene | 80.0 µg/kg |
| Chrysene | 80.0 µg/kg |
| Dibenzo(a,h)anthracene | 80.0 µg/kg |
| Fluoranthene | 80.0 µg/kg |
| Perylene | 80.0 µg/kg |
| Pyrene | 80.0 µg/kg |

DDD Dichlorodiphenyldichloroethane
DDE dichlorodiphenyldichloroethylene
DDT dichlorodiphenyltrichloroethane
mg/kg milligrams per kilogram
µg/kg micrograms per kilogram

### 2.2.2 Toxicity Testing

To evaluate the benthic condition of San Diego County's waterbodies, sediment toxicity testing will be conducted in accordance with ASTM and USEPA methods. Toxicity testing involves a short-term survival test, a sublethal endpoint test, and an assessment of sediment toxicity using the SQO response categories. For each test type, more than one specific test is acceptable. The appropriate species tested for a sample will depend on the characteristics of the sample such as particle size, salinity, and suspected toxic constituents, if any. Test organisms used for each method should be acclimated (i.e., with respect to temperature and salinity) to test conditions prior to the start of testing. When historical data are available for a sample location, it is recommended that the same species be used in order to make comparisons and to conduct trend analysis. In addition, if sediment monitoring is conducted as part of the Bight Program, the species selection will be listed in the Bight Workplans. If significant toxicity is observed in the solid phase or sediment-water interface test, a toxicity identification evaluation (TIE) may be conducted as part of stressor identification studies described in Section 4.0. Further descriptions of the test species used in both the short-term survival test and the sublethal endpoint test are provided below.

#### *2.2.2.1 Short-Term Survival Testing*

SQO analysis requires that at least one short-term survival test be conducted. There are three acceptable short-term survival tests, each of which is a 10-day test exposing amphipods to whole sediment. The three acceptable test organisms are *Eohaustorius estuarius*, *Leptocheirus plumulosus*, and *Rhepoxynius abronius*. The *E. estuarius* short-term survival test has been the 10-day test method used in previous San Diego County enclosed bay and estuary monitoring programs where the SQO analytical tool was used to assess aquatic health. This amphipod has also historically been utilized in toxicity tests for both marine (≥ 27 ppt) and low salinity (< 27 ppt) habitats for the Bight Program's SQO analyses. These amphipod bioassays will be conducted in accordance with procedures outlined in *Methods for Assessing Toxicity of Sediment-Associated Contaminants with Estuarine and Marine Amphipods* (USEPA, 1994) and ASTM method E1367-03 (ASTM, 2006). Test conditions are summarized in Table 2-2. If sediment monitoring is conducted as part of the Bight Program, then procedures and test conditions should be in accordance with Bight Workplans.

A water-only reference toxicity test should be conducted concurrently with the whole sediment amphipod test to assess the relative sensitivity of test organisms used in the evaluation of project sediments. Amphipod reference toxicant tests are typically conducted using cadmium. However, using ammonia as the reference toxicant is preferable because the sensitivity of the test organisms to ammonia (often a confounding factor in sediment testing) can be evaluated along with the relative sensitivity of the batch of organisms used in testing. If ammonia is selected as the reference toxicant, pore water ammonia will be measured between sample receipt and test set-up, and again at test initiation. If the un-ionized pore water ammonia concentration in the test initiation sample is 0.8 mg/L or greater, then the ammonia reference toxicant test will be extended from 4 days to 10 days for better comparison to 10-day test sample results.

**Table 2-2. Summary of Conditions for 10-Day Whole Sediment Amphipod Bioassay**

| Test Conditions 10-Day Whole Sediment Bioassay | | | | |
|---|---|---|---|---|
| | Test Species | ***E. estuarius*** | ***L. plumulosus*** | ***R. abronius*** |
| | Test Procedures | USEPA (1994); ASTM E1367-03 (2006) | | |
| | Test Type/Duration | Static - Acute Whole Sediment/10 days | | |
| | Sample Storage Conditions | 0 - 6°C, dark, minimal head space | | |
| | Test Sediment holding time requirements | 2 weeks (recommended), maximum 4 weeks (required) | | |
| | Age/Size Class | 3-5 mm | 2-4 mm; immature | 3-5 mm |
| | Particle Size Tolerance | 0.6-100% sand | 0-100% sand | 10-100% sand |
| Recommended Water Quality Parameters | Temperature | 15 ± 1 °C | 25 ± 1 °C | 15 ± 1 °C |
| | Salinity | 20 ± 2 ppt | 20 ± 2 ppt | 28 ± 2 ppt |
| | Dissolved Oxygen | Maintaining 90% saturation | | |
| | Total Ammonia | < 60 mg/L | < 60 mg/L | < 30 mg/L |
| | Test Chamber | 1 L glass | | |
| | Exposure Volume | 2 cm sediment, 800 mL seawater | | |
| | Replicates/Sample | 5 | | |
| | No. of Organisms/Replicate | 20 | | |
| | Photoperiod | Continuous light | | |
| | Feeding | None | | |
| | Water Renewal | None | | |
| | Aeration | Constant gentle aeration | | |
| | Acceptability Criteria | Mean control survival $\geq$ 90%; $\geq$80% survival in each replicate | | |

mg/L – milligram per liter; mm – millimeter; mL – milliliter; L – Liter; ppt – parts per thousand; °C – degrees Celsius; cm – centimeter

#### *2.2.2.2 Sublethal Testing*

The second type of testing required for SQO analysis is a sublethal test. Either a 48-hour development test exposing embryos of the bivalve *Mytilus galloprovincialis* to the sediment-water interface may be conducted or a 28-day survival and growth test exposing the polychaete worm *Neanthes arenaceodentata* to whole sediment. Test condition summaries for the bivalve and polychaete tests are presented in Table 2-3 and Table 2-4, respectively. The *M. galloprovincialis* sediment-water interface test has been the sublethal test method used in previous San Diego County bay and lagoon monitoring programs where the SQO analytical tool was used to assess aquatic health. This mussel has also historically been utilized in toxicity tests for both marine (≥ 27 ppt) and low salinity (< 27 ppt) habitats for the Bight Program's SQO analyses.

*Mytilus galloprovincialis* Sediment-Water Interface Development Sublethal Test

Sediment-water interface bioassays are performed to estimate the potential toxicity of contaminants fluxing from test sediments into the overlying water. The sediments will be tested in a 48-hour sediment-water interface test using the bivalve *M. galloprovincialis* in accordance with procedures outlined in *Short-Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to West Coast Marine and Estuarine Organisms* (USEPA, 1995) and Assessment of Sediment Toxicity at the Sediment-Water Interface (Anderson et al., 1996). If sediment monitoring is conducted as part of the Bight Program, then procedures and test conditions should be in accordance with Bight Workplans. Sediment-water interface bioassays will be tested on intact cores collected in the field or on homogenized sediment samples as described in Section 2.1.6.

A water-only reference toxicity test should be conducted concurrently with the sediment-water interface bivalve test to assess the relative sensitivity of test organisms used in the evaluation of the project sediments. Bivalve reference toxicant tests are typically conducted using copper. However, using ammonia as the reference toxicant is preferable because the sensitivity of the test organisms to ammonia (often a confounding factor in sediment testing) can be evaluated along with the relative sensitivity of the batch of organisms used in testing. If ammonia is selected as the reference toxicant, pore water ammonia will be measured between sample receipt and test set-up, and again at test initiation. If the un-ionized pore water ammonia concentration in the test initiation sample is 0.8 mg/L or greater, then the ammonia reference toxicant test will be extended from 4 days to 10 days for better comparison to 10-day test sample results.

**Table 2-3. Test Conditions for the 48-Hour *M. galloprovincialis* Sediment-Water Interface Bioassay**

| Test Conditions<br>10-Day Whole Sediment Bioassay | | |
|---|---|---|
| | Test Species | ***M. galloprovincialis*** |
| | Test Procedures | USEPA (1995), Anderson et al. (1996) |
| | Test Type/Duration | Static - Acute sediment-water interface/48 hours |
| | Sample Storage Conditions | 0 - 6°C, dark, minimal head space |
| | Test Sediment holding time requirements | 2 weeks (recommended), maximum 4 weeks (required) |
| | Age/Size Class | < 4-hour old larvae |
| | Particle Size Tolerance | 0-100% sand |
| Recommended Water Quality Parameters | Temperature | 15 ± 1 °C |
| | Salinity | 32 ± 2 ppt |
| | Dissolved Oxygen | Maintaining 90% saturation |
| | Total Ammonia | < 4 mg/L |
| | Test Chamber | Polycarbonate core tube 7.3-cm inner diameter, 16 cm high |
| | Exposure Volume | 5 cm sediment, 300 mL water |
| | Replicates/Sample | 4 |
| | No. of Organisms/Replicate | Approximately 250 larvae |
| | Photoperiod | 16 hours light: 8 hours dark |
| | Feeding | None |
| | Water Renewal | None |
| | Aeration | Constant gentle aeration |
| | Acceptability Criteria | Mean control normal-alive $\geq$ 80% |

mg/L – milligram per liter; mm – millimeter; mL – milliliter; ppt – parts per thousand; °C – degrees Celsius; cm - centimeter

<u>*Neanthes arenaceodentata* Whole Sediment Survival and Growth Sublethal Test</u>

The *N. arenaceodentata* test will be conducted in accordance with ASTM method E1562 (ASTM, 2002) with modifications described in Farrar and Bridges (2011) that have been found to contribute manageability and precision to the ASTM procedure. If sediment monitoring is conducted as part of the Bight Program, then procedures and test conditions should be in accordance with Bight Workplans. A water-only reference toxicity test should be conducted concurrently with the whole sediment polychaete test to assess the relative sensitivity of test organisms used in the evaluation of the project sediments. Polychaete reference toxicant tests are typically conducted using cadmium. However, using ammonia as the reference toxicant is preferable because the sensitivity of the test organisms to ammonia (often a confounding factor in sediment testing) can be evaluated along with the relative sensitivity of the batch of organisms used in testing. If ammonia is selected as the reference toxicant, pore water ammonia will be measured between sample receipt and test set-up, and again at test initiation. If the un-ionized pore water ammonia concentration in the test initiation sample is 0.8 mg/L or greater, then the ammonia reference toxicant test will be extended from 4 days to 10 days for better comparison to 10-day test sample results.

**Table 2-4. Test Conditions for the 28-Day Whole Sediment *N. arenaceodentata* Bioassay**

| Test Conditions<br>10-Day Whole Sediment Bioassay | | |
|---|---|---|
| Test Species | | ***N. arenaceodentata*** |
| Test Procedures | | ASTM E1562 (2002), Farrar and Bridges (2011) |
| Test Type/Duration | | Static - Acute Whole Sediment/28 days |
| Sample Storage Conditions | | 0 - 6°C, dark, minimal head space |
| Test Sediment holding time requirements | | 2 weeks (recommended), maximum 4 weeks (required) |
| Age/Size Class | | ≤ 7 days post-emergence |
| Particle Size Tolerance | | 5-100% sand |
| Recommended Water Quality Parameters | Temperature | 20 ± 1 °C |
| | Salinity | 30 ± 2 ppt |
| | Dissolved Oxygen | Maintaining 90% saturation |
| | Total Ammonia | < 20 mg/L |
| Test Chamber | | 300 mL glass |
| Exposure Volume | | 2 cm sediment, 125 mL seawater |
| Replicates/Sample | | 10 |
| No. of Organisms/Replicate | | 1 |
| Photoperiod | | 12 hours light: 12 hours dark |
| Feeding | | Twice per week |
| Water Renewal | | Weekly |
| Aeration | | Constant gentle aeration |
| Acceptability Criteria | | Mean control survival ≥ 80%; positive growth in controls |

mg/L – milligram per liter; mm – millimeter; mL – milliliter; ppt – parts per thousand; °C – degrees Celsius; cm - centimeter

### 2.2.3 Benthic Infaunal Analysis

The following paragraphs outline a brief description of benthic infaunal sorting and QA/QC procedures. A more detailed description of benthic infaunal laboratory analytical procedures can be found in the *Sediment Quality Assessment Technical Support Manual* (Bay et al., 2021). If sediment monitoring is conducted as part of the Bight Program, then any additional procedures not listed below should be followed in accordance with that Bight Program year's Macrobenthic (Infaunal) Sample Analysis Laboratory Manual.

Benthic infaunal samples will be transported from the field to the laboratory and stored in a formalin solution for a minimum of 48 hours and no longer than 5 days. The samples will then be transferred from formalin to 70% ethanol for laboratory processing. Using a dissecting microscope, the organisms will initially be placed into glass or plastic vials into five major phyletic groups: polychaetes, crustaceans, molluscs, echinoderms, and miscellaneous minor phyla. While sorting, technicians will keep a count for quality control purposes.

A QA/QC procedure will be performed on each of the sorted samples to ensure a 95% sorting efficiency using one of two methods, either a whole sample method or an aliquot method. For consistency, one method should be selected for all samples in a single project and noted on sorting bench sheets. QA/QC procedures should be conducted by a trained senior technician other than the original sorter.

For the whole sample method, a minimum of 10% of each individual sorter's samples should be entirely re-sorted. The percent sorting efficiency is calculated for this method as follows:

$$\% \text{ Efficiency} = 100^* \{\#_{\text{Original}} / (\#_{\text{Original}} + \#_{\text{Resort}})\}$$

For the aliquot method, a 10% aliquot of the sample volume from each sorter's sample will be re-sorted. The number of organisms found in the aliquot will be divided by 10% and added to the total number found in the sample. The original total will be divided by the new total and multiplied by 100 to calculate the percent sorting efficiency (see formula for calculation below). When the sorting efficiency of the sample is below 95%, the remainder of the sample (90%) will be re-sorted.

$$\% \text{ Efficiency} = 100^* \{\#_{\text{Original}} / [\#_{\text{Original}} + (\#_{\text{Resort}} / \text{aliquot fraction})]\}$$

Sample debris left after sorting should be retained by the sorting laboratory until samples can be disposed as dictated by the monitoring program.

Following sorting of organisms, samples will be distributed to qualified taxonomists who will identify each organism to species or to the lowest possible taxon. Identifications and counts of organisms that are considered incidental contaminants (e.g., hard bottom epifaunal organisms, parasites, and other epibionts) should be written on taxonomic bench sheets in the notes but should not be included in the data analysis. Present-day taxonomic nomenclature is typically based on the most recent version of the Southern California Association of Marine Invertebrate Taxonomists (SCAMIT) taxonomic listing. This nomenclature differs from the taxonomic list used to develop the SQOs and benthic LOE indices. Therefore, currently used taxonomic identifications will need to be "rolled back" to the SQO nomenclature and orthography listed on the SCCWRP website prior to SQO benthic LOE calculation. Taxonomists should utilize the nomenclature and orthography in the SQO species list on the *Sediment Quality Assessment Tools* page located on the SCCWRP website (Sediment Quality Assessment Tools - Southern California Coastal Water Research Project (sccwrp.org)) for calculating the benthic LOE.

Taxonomic data QC should include an assessment of the laboratory's organism identifications and counts. A minimum of 10% of the samples should be reanalyzed by secondary taxonomists other than the primary taxonomists who originally conducted the analysis. Secondary QC taxonomists should not have access to the original taxonomic dataset. For more detailed information on taxonomic QC procedures using a secondary taxonomist for reanalysis, see the *Sediment Quality Assessment Technical Support Manual* (Bay et al., 2021).

#### *2.2.3.1 Quality Assurance/Quality Control*

All quality assurance/quality control (QA/QC) samples must be conducted in accordance with the Quality Assurance Management Plan (QAMP) for the State of California's Surface Water Ambient Monitoring Program (SWAMP). The data quality objectives for all analyses conducted by the participating analytical laboratories will be detailed in the Sediment Monitoring QAPP (see Appendix B). The QAPP should be used as a reference to ensure proper methods are used consistently throughout the monitoring program. However, if sediment quality monitoring is conducted as part of the Bight Program, the QA/QC documents pertaining to the Bight Program should be followed as the primary documents and the Sediment Monitoring QAPP as the secondary document.

The results of the laboratory quality control (QC) analyses will be reported with the final data. Any QC samples that fail to meet the specified QC criteria in the methodology or the Sediment Monitoring QAPP (or Bight Program QA/QC documents if participating in that program) will be identified, and the corresponding data will be appropriately qualified in the final report. All QA/QC records for the various testing programs will be kept on file for review by regulatory agency personnel.

# 3.0 DATA REVIEW, MANAGEMENT, AND ANALYSIS

## 3.1 Data Review and Management

All QA/QC data must be conducted in accordance with the QAMP for the State of California's SWAMP and the data quality objectives as outlined in the Sediment Monitoring QAPP (see Appendix B) (or Bight Program QA/QC documents when participating in that program). Data will be reviewed to determine if appropriate corrective actions have been taken, when necessary. Corrective actions taken by the laboratories will be noted in the laboratory report and affected data will be flagged or qualified as appropriate. The laboratories will supply analytical results in both hard copy and electronic formats. Laboratories will have the responsibility of ensuring that both formats are accurate. Monitoring data and analytical results will be uploaded into California Environmental Data Exchange Network (CEDEN).

## 3.2 Data Analysis

Sediment toxicity, chemistry, and benthic community condition will be assessed using California's SQOs as described in the Sediment Control Plan (Appendix A). The goals of the SQOs are to determine whether pollutants in sediments are present in quantities that are toxic to benthic organisms and/or will bioaccumulate in aquatic organisms to levels that may be harmful to humans.

In Southern California, SQOs have been fully developed for only one type of enclosed bay habitat: euhaline bays and estuaries south of Point Conception. The benthic species assemblage used to calculate the benthic LOE in San Diego bays and estuaries is Habitat C- Southern California Marine Bays, which requires a salinity ≥ 27 ppt (Bay et al 2021; Ranasinghe et al 2008). The data analysis methods described in Section 3.2.1 below should be limited to the subtidal areas of the waterbodies where the SQO salinity criteria can be met.

The SQOs are based on a MLOE approach in which sediment toxicity, sediment chemistry, and benthic community condition are the LOE. The MLOE approach evaluates the severity of biological effects and the potential for chemically mediated effects to provide a final station level assessment. The three LOE for euhaline bays and estuaries south of Point Conception will be assessed as described in Section IV.A.1.f-i of the Sediment Control Plan. Brief descriptions of the specific methods associated with each LOE are provided in Section 3.2.1 below. For more detailed calculations and descriptions of each LOE, refer to the Sediment Control Plan (State Water Board and CA EPA, 2018) (see Appendix A).

Due to the tidal nature of Southern California's estuaries and lagoons, it is not uncommon to have subtidal areas within these waterbodies where the salinity is brackish (i.e., < 27 ppt) rather than marine (≥ 27 ppt) (e.g., closer to the mouth of a river or stream where water enters an estuary or lagoon). Because many of the indices and response ranges in the SQO framework were only calibrated and validated for two types of habitats (euhaline bays and estuaries south of Point Conception [Habitat C] and polyhaline central San Francisco Bay [Habitat D]), the station assessment procedures outlined in Section IV.A.1.f-i in the Sediment Control Plan cannot be used to assess stations sampled in low salinity habitats. Instead, a station assessment for these types of habitats will be conducted following Section IV.A.1.j (MLOE Approach to Interpret the Narrative

Objective in Other Bays and Estuaries) of the Sediment Control Plan. While station assessments in low salinity habitats will utilize a similar conceptual approach and analytical tools as the two habitats that were calibrated, each LOE will be evaluated using a different set of metrics as briefly described in Section 3.2.2 below.

## 3.2.1 Southern California Euhaline Bays and Estuaries

### *3.2.1.1 Sediment Toxicity*

Sediment toxicity will be assessed using two tests: a short-term survival test using one of three species of marine amphipods (*E. estuarius*, *L. plumulosus*, or *R. abronius*) and a sublethal test using either *N. arenaceodentata* (a species of polychaete worm) or *M. galloprovincialis* (a species of marine bivalve). Sediment toxicity test results from each station will be statistically compared to control test results; normalized to the control survival; and categorized as nontoxic, low, moderate, or high toxicity according to Table 3-1. The average of the two test response categories (nontoxic, low toxicity, moderate toxicity, and high toxicity) will be calculated to determine the final toxicity LOE category. If the average falls midway between the two categories, it will be rounded up to the higher of the two. For example, if the test response category for the short-term survival test is low toxicity, and the test response category for the sublethal test is moderate toxicity, the final category for sediment toxicity would be moderate toxicity.

**Table 3-1. Sediment Toxicity Categorization Values**

| Test Type | Endpoint | Statistical Significance | Nontoxic[1] | Low Toxicity[2] | Moderate Toxicity[2] | High Toxicity[2] |
|---|---|---|---|---|---|---|
| Short-Term Survival Tests | *E. estuarius* Survival | Significant | 90 to 100 | 82 to 89 | 59 to 81 | <59 |
| | | Not significant | 82 to 100 | 59 to 81 | - | <59 |
| | *L. plumulosus* Survival | Significant | 90 to 100 | 78 to 89 | 56 to 77 | <56 |
| | | Not significant | 78 to 100 | 56 to 77 | - | <56 |
| | *R. abronius* Survival | Significant | 90 to 100 | 83 to 89 | 70 to 82 | <70 |
| | | Not significant | 83 to 100 | 70 to 82 | - | <70 |
| Sublethal Tests | *N. arenaceodentata* Growth | Significant | 90 to 100[2] | 68 to 90 | 46 to 67 | <46 |
| | | Not significant | 68 to 100 | 46 to 67 | - | <46 |
| | *M. galloprovincialis* Normal-Alive | Significant | 80 to 100 | 77 to 79 | 42 to 76 | <42 |
| | | Not significant | 77 to 79 | 72 to 76 | - | <42 |

[1] Expressed as percent.
[2] Expressed as percent of control.

### *3.2.1.2 Sediment Chemistry*

Sediment chemistry will be assessed using the analyte list presented in Table 2-1. Concentrations of chemicals detected in sediments will be compared to the California Logistic Regression Model (CA LRM) and the Chemical Score Index (CSI). The CA LRM is a maximum probability model ($P_{max}$) that uses logistic regression to predict the probability of sediment toxicity. The CSI is calculated independently of the CA LRM and is a predictive index that relates sediment chemical concentration to benthic community disturbance. Sediment chemistry results according to CA LRM and CSI are categorized as having minimal, low, moderate, and high exposure to pollutants (Table 3-2). The final sediment LOE category is the average of the two chemistry exposure categories. If the average falls midway between the two categories, it is rounded up to the higher 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.

**Table 3-2. Sediment Chemistry Guideline Categorization**

| Sediment Chemistry Guideline | | Sediment LOE Category |
|---|---|---|
| CA LRM | CSI | |
| <0.33 | <1.69 | **Minimal Exposure** |
| 0.33 - 0.49 | 1.69 - 2.33 | **Low Exposure** |
| 0.50 - 0.66 | 2.34 - 2.99 | **Moderate Exposure** |
| >0.66 | >2.99 | **High Exposure** |

#### *3.2.1.3 Benthic Community Condition*

Benthic community condition will be assessed using a combination of four benthic indices: the Benthic Response Index (BRI; abundance-weighted average pollution tolerance of sample organisms), the Relative Benthic Index (RBI; the weighted sum of community parameters and abundance of indicator species), the Index of Biotic Integrity (IBI; a measure that identifies benthic community characteristics outside of reference ranges), and a predictive model based on the River Invertebrate Prediction and Classification System (RIVPACS; a comparison of assemblages in a sample to expected species composition). The four indices will be calculated following the January 21, 2008, guidance provided by SCCWRP entitled *Determining Benthic Invertebrate Community Condition in Embayments* for Southern California marine bays. Each benthic index result is categorized according to four levels of disturbance, including reference, low, moderate, and high disturbance.

- Reference: Equivalent to a least affected or unaffected station.
- 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.

Specific categorization values, which are tailored to southern California marine bays, are assigned for each index (Table 3-3) and are based on the specific taxa found within a given sample. To determine the benthic community condition, the four indices will be integrated into a single category. The median of the four benthic index response categories is computed to determine the benthic condition. 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.

**Table 3-3. Benthic Index Categorization Values for Southern California Marine Bays**

| Benthic Community Guideline | | | | Index |
|---|---|---|---|---|
| BRI | IBI | RBI | RIVPACS | |
| <39.96 | 0 | >0.27 | >0.90 to <1.10 | **Reference** |
| 39.96 - 49.14 | 1 | 0.17 - 0.27 | 0.75 - 0.90 or 1.10 - 1.25 | **Low Disturbance** |
| 49.15 - 73.26 | 2 | 0.09 - 0.16 | 0.33 - 0.74 or >1.25 | **Moderate Disturbance** |
| >73.26 | 3 or 4 | <0.09 | <0.33 | **High Disturbance** |

### 3.2.1.4 Integration of MLOE

The station level assessment that indicates whether the aquatic life SQO at a station has been met will be determined by the combination of the three LOE categories to assess the severity of biological effects and the potential for chemically mediated effects. The severity of biological effects will be determined by combining the toxicity and benthic community condition LOEs (Table 3-4). The potential for chemically mediated effects will be determined by combining the toxicity and chemistry LOEs (Table 3-5).

**Table 3-4. Determination of Severity of Biological Effects**

| Combination of Toxicity LOE and Benthic Condition LOE | | Toxicity LOE | | | |
|---|---|---|---|---|---|
| | | **Non-toxic** | **Low Toxicity** | **Moderate Toxicity** | **High Toxicity** |
| **Benthic Community Condition LOE** | **Reference** | Unaffected | Unaffected | Unaffected | Low Effect |
| | **Low Disturbance** | Unaffected | Low Effect | Low Effect | Low Effect |
| | **Moderate Disturbance** | Moderate Effect | Moderate Effect | Moderate Effect | Moderate Effect |
| | **High Disturbance** | Moderate Effect | High Effect | High Effect | High Effect |

**Table 3-5. Determination of Potential for Chemically Mediated Effects**

| Combination of Toxicity LOE and Sediment Chemistry LOE | | Toxicity LOE | | | |
|---|---|---|---|---|---|
| | | **Non-toxic** | **Low Toxicity** | **Moderate Toxicity** | **High Toxicity** |
| **Sediment Chemistry LOE** | **Minimal Exposure** | Minimum Potential | Minimum Potential | Low Potential | Moderate Potential |
| | **Low Exposure** | Minimum Potential | Low Potential | Moderate Potential | Moderate Potential |
| | **Moderate Exposure** | Low Potential | Moderate Potential | Moderate Potential | Moderate Potential |
| | **High Exposure** | Moderate Potential | Moderate Potential | High Potential | High Potential |

Based on the determinations of the severity of biological effects and the potential for chemically mediated effects, a station level assessment (Table 3-6) will be made that categorizes the station as described in the Sediment Control Plan as one of the following:

- Unimpacted: Confident that sediment contamination is not causing significant adverse impacts to aquatic life living in station sediments.
- Likely Unimpacted: Sediment contamination at the station is not expected to cause adverse impacts to aquatic life, but some disagreement among the LOE reduces the certainty that the station is unimpacted.
- Possibly Impacted: Sediment contamination at the station may be causing adverse impacts to aquatic life, but the impacts are either small or uncertain due to disagreement among the LOE.
- Likely Impacted: Evidence for a contaminant-related impact to aquatic life at the station is persuasive, even if there is some disagreement among the LOE.
- Clearly Impacted: Sediment contamination at the station is causing clear and severe adverse impacts to aquatic life.
- Inconclusive: Disagreement among the LOE suggests that either the data are suspect or additional information is needed before a determination can be made.

**Table 3-6. Determination of Final Station Assessment**

| Combination of Severity of Biological Effects and Potential for Chemically-Mediated Effects | | Severity of Biological Effects | | | |
|---|---|---|---|---|---|
| | | Unaffected | Low Effect | Moderate Effect | High Effect |
| Potential for Chemically-Mediated Effects | Minimal Potential | Unimpacted | Likely Unimpacted | Likely Unimpacted | Inconclusive |
| | Low Potential | Unimpacted | Likely Unimpacted | Possibly Impacted | Possibly Impacted |
| | Moderate Potential | Likely Unimpacted | Possibly Impacted or Inconclusive[1] | Likely Impacted | Likely Impacted |
| | High Potential | Inconclusive | Likely Impacted | Clearly Impacted | Clearly Impacted |

[1] When chemistry classification is minimal exposure, benthic response is reference, and toxicity is high.

All 64 possible combinations are presented in Appendix A-4 of the Sediment Control Plan (attached as Appendix A to this document). If a station is consistently classified as Unimpacted or Likely Unimpacted according to the SQO assessments, then the protective condition has been achieved. If the final station assessment result is Likely Impacted or Clearly Impacted, the station is considered degraded and the Copermittees will need to coordinate with the San Diego Water Board to determine if a stressor identification study will need to be conducted. Stations categorized as Inconclusive should not be used to evaluate whether the protective condition at a station has been met. Additional information should be gathered at stations classified as Inconclusive in order to understand why the LOE results show a level of disagreement.

If stations are categorized as Possibly Impacted within a monitored segment, reach, or waterbody that also contain stations that are not categorized as Clearly or Likely Impacted, then confirmation monitoring will be conducted in order to confirm the level of impact at these stations prior to

initiating a stressor identification study. As stated in the *Sediment Quality Assessment Technical Support Manual* (Bay et al., 2021), "the *Possibly Impacted* station assessment is the least certain of all categorizations, and therefore requires the most caution during interpretation. Stations may be classified as *Possibly Impacted* due to low levels of effect for each LOE, indicating a low magnitude of impacts. Alternatively, a *Possibly Impacted* classification may be the result of a large disagreement between LOEs, potentially due to confounding factors or noncontaminant stressors." At a minimum, confirmation monitoring at a Possibly Impacted station will consist of re-sampling and recalculating the SQO to determine if the station results in the same SQO assessment (i.e., Possibly Impacted) or if the assessment is more conclusive as to whether the station is impacted or not (e.g., Unimpacted or Likely Impacted). If the results of the confirmation monitoring determine that the station is Unimpacted or Likely Unimpacted then the protective condition has been achieved at that location. If the station assessment is categorized as Possibly Impacted again or recategorized as Likely Impacted or Clearly Impacted, then the Copermittees will need to coordinate with the San Diego Water Board to determine if a stressor identification study will need to be conducted. If additional monitoring or previous specialized studies at Possibly Impacted stations indicate that factors other than toxic pollutants in sediments are causing observed negative responses, then it may be possible to coordinate with the San Diego Water Board to designate the station as meeting the protective condition. A flow chart of actions to be taken following the initial station assessment is provided in
Figure 3-1.

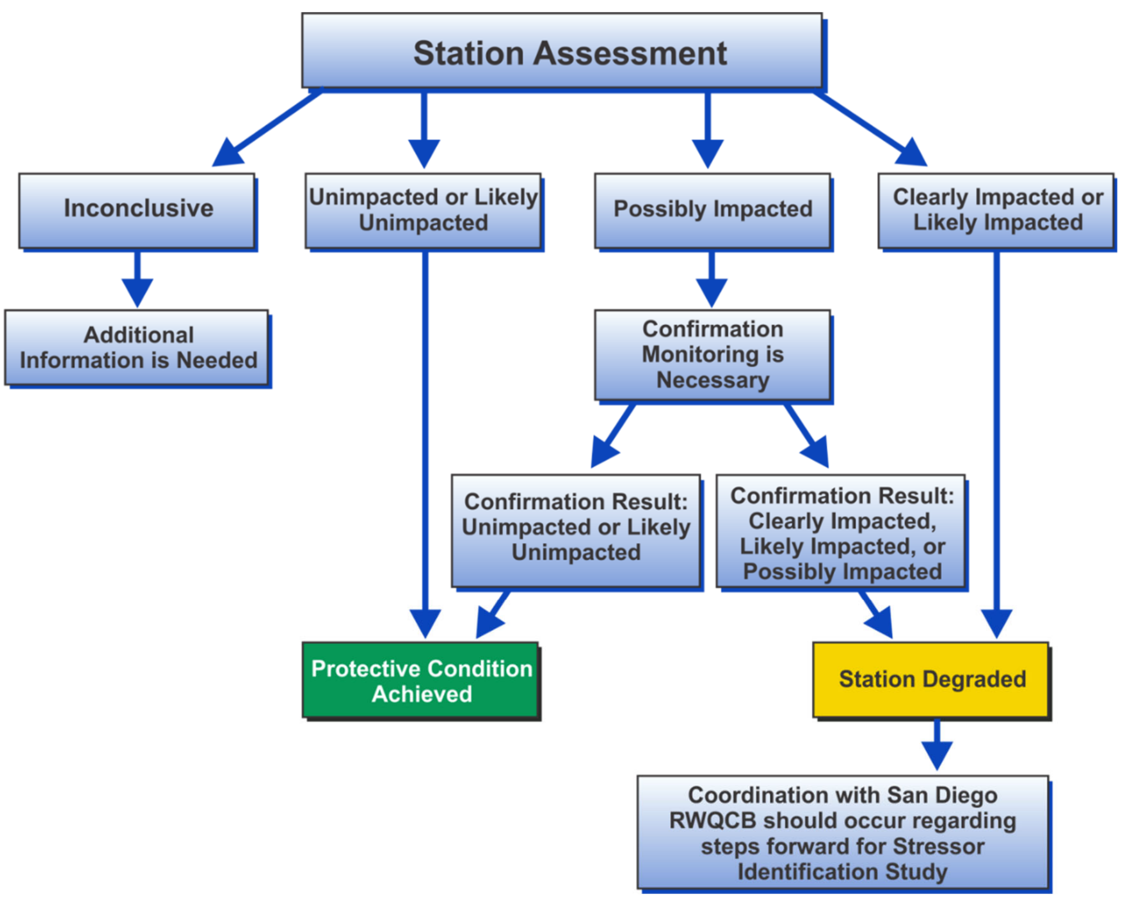


**Figure 3-1. Flow Chart of Actions Following Station Assessment**

### 3.2.2 MLOE Approach to Assess Other Bays and Estuaries

A station assessment approach for integrating the LOEs for enclosed bays and estuaries other than euhaline bays in Southern California and polyhaline San Francisco Bay (e.g., brackish habitats) is presented in this section. Assessments of these types of waterbodies will utilize the same conceptual approach as used for the marine waterbodies; however, a different set of modified indicators will be used to evaluate each of the three LOE. Per the Sediment Control Plan, the evaluation tools and metrics for these other bays and estuaries are presented in Table 3-7. Standardized methods, such as USEPA or ASTM, should be utilized when conducting measurements of each LOE (where available). Thresholds for determining an LOE effect are provided in Table 3-8. Each of these thresholds indicate a “High” response for the evaluation metrics and are equivalent to the classification threshold for determining an LOE effect for Southern California euhaline bays and estuaries (i.e., High Chemical Exposure, High Toxicity, or High Benthic Disturbance).

**Table 3-7. LOE Evaluation Tools and Metrics for Other Bays and Estuaries**

| LOE | Tool | Evaluation Metric or Index |
|---|---|---|
| Sediment Toxicity | 10-Day amphipod survival using species tolerant of salinity and grain size characteristics (e.g., *Eohaustorius estuarius*, *Hyallela azteca*) | Percent of control survival |
| Chemistry | Bulk sediment concentrations of Table 2-1 list of analytes plus other chemicals of concern (optional) | CA LRM $P_{max}$<br>Concentration on a dry weight basis |
| Benthic Community Condition | Invertebrate species identification and abundance | Single Metrics:<br>• Abundance and species richness<br>• Presence of sensitive indicator taxa<br>• Dominance by tolerant indicator taxa<br>• Presence of functional/feeding groups |
| | | Recommended Alternative Method*:<br>M-AMBI score |

*The Multivariate AZTI Benthic Index (M-AMBI) was not listed as evaluation metric in the Sediment Control Plan (State Water Board and CA EPA, 2018) because at the time of the plan's adoption the development and validation of this benthic community index was not complete. However, since 2018, the thresholds for the M-AMBI were modified for better integration into the SQO framework (i.e., the four benthic condition categories correspond to those used in the SQO for euhaline bays and estuaries in Southern California) (see Gillett et. al., 2019).

**Table 3-8. Evaluation Metrics and Threshold Values for Determination of LOE Effects**

| LOE | Metric | Threshold Value for Comparison |
|---|---|---|
| Sediment Toxicity | Amphipod percent of control survival | *E.estuarius*: < 59<br>*H. azteca*: < 62<br>or SWAMP criterion |
| Sediment Chemistry | CA LRM | $P_{max} > 0.66$ |
| | Chemical concentration of other chemicals | Greater than reference range or threshold |
| Benthic Community Condition | Species richness | Less than reference range or interval |
| | Total abundance | Outside of reference range or interval |
| | Abundance of sensitive indicator taxa | Less than reference range or interval |
| | Dominance by tolerant indicator taxa | Greater than reference range or interval |
| | Recommended Alternative Metric: M-AMBI score | Recommended Alternative Threshold: ≤ 0.387[a] |

[a] Recommended threshold to determine if there is a benthic community condition LOE effect (Bay et. al., 2021)

While the Sediment Control Plan outlines methodology to assess other bays and estuaries using the list of indicators in Table 3-7 and Table 3-8, it should be noted that this approach requires the LOE effect (i.e., benthic community disturbance, toxicity, or biologically significant chemical exposure) to be based on comparisons to pre-established numeric response values, reference ranges or confidence intervals that are comparable to those outlined in Sections IV.A.1.f through IV.A.1.h of the Sediment Control Plan (State Water Board and CA EPA, 2018). Currently, there are no reference ranges or confidence intervals established by the State Water Board in the Sediment Control Plan for enclosed bays and estuaries other than euhaline bays and estuaries in Southern California and polyhaline San Francisco Bay (e.g., low salinity habitats < 27 ppt).

For Bight 2018, SCCWRP assessed a brackish stratum in Southern California estuaries to establish a dataset for development of a condition assessment framework for low salinity estuarine habitats. SCCWRP analyzed the sediment samples using the thresholds set for the Southern California euhaline bays and estuaries as outlined in the Sediment Control Plan (State Water Board and CA EPA, 2018) for the chemistry and toxicity LOEs. However, to assess the level of LOE effects for the benthic community condition, SCCWRP utilized a modified U.S. version of the Multivariate AZTI Benthic Index (M-AMBI) (Pelletier et al., 2018; Gillett et al., 2019), which was calibrated and validated for use in all of California's estuaries and embayments. The modified version of this benthic index allowed the sediment samples from the brackish habitats of the estuaries (< 27 ppt) to be "assessed in a context comparable with other habitats in the Southern California Bight" (Gillett et. al., 2022). While the M-AMBI assessment tool was used in Bight 2018 to assess the brackish stratum, Gillett et. al. (2022) recommended that the tool be validated in the estuaries and embayments of Southern California using additional data collected in Bight 2023.

Because there are no established reference stations for calculating reference ranges or intervals for habitats not currently validated by the Sediment Control Plan, and in order to keep both sediment quality data in compliance with the State Water Board Sediment Control Plan and comparable to results produced from the Bight Program, it is recommended to assess impacts to stations in the "Other Bays and Estuaries" category using two different methodologies (Table 3-9). The first methodology is intended for compliance with the Sediment Control Plan (Section IV.A.1.j). The second methodology is intended for comparison to historical and current Bight Program data. More detail on each of the methodologies and thresholds for the individual and integrated assessments of the MLOEs are provided in the sections below.

**Table 3-9. Methodologies to Analyze Other Bays and Estuary Sediments**

| Assessment | LOE | Metric | Threshold Value for Comparison |
|---|---|---|---|
| Compliance with State Water Board Sediment Control Plan | Sediment Toxicity | Amphipod percent of control survival | *E.estuarius*: < 59<br>*H. azteca*: < 62<br>or SWAMP criterion |
| | Sediment Chemistry | CA LRM | $P_{max}$ > 0.66 |
| | Benthic Community Condition | M-AMBI score | ≤ 0.387 |
| Comparability to Historical and Current Bight Program Data | Sediment Toxicity | Short-term survival test using amphipod | see Table 3-1 |
| | | Sub-lethal test using mussel | |
| | Sediment Chemistry | CA LRM and CSI | see Table 3-2 |
| | Benthic Community Condition | M-AMBI score* | Reference: ≥ 0.578<br>Low Disturbance: ≥ 0.483 - < 0.578<br>Moderate Disturbance: ≥ 0.387 - < 0.483<br>High Disturbance: < 0.387 |

*Thresholds based on Gillett et. al., 2019. Modifications to the M-AMBI thresholds were made for improved integration with the SQO framework. The four M-AMBI condition categories were developed to correspond to those of the CA SQO benthic LOE indices.

### *3.2.2.1 Sediment Chemistry*

The first step to evaluate the sediment chemistry LOE is to determine the concentrations of the analytes listed in Table 2-1. Optional chemicals of concern can also be evaluated provided a threshold is available that represents a comparable level of high exposure as to those specified in Sections IV.A.1.f-h of the Sediment Control Plan.

For compliance with the State Water Board Sediment Control Plan, the threshold value used to determine if there is a chemistry LOE effect is if the $P_{max}$ value calculated for the CA LRM is > 0.66 (Table 3-8). $P_{max}$ values greater than this value is considered to have high chemical exposure.

For comparability to Bight Program data, concentrations of chemicals detected in sediments will be compared to the CA LRM and the CSI as presented in Section 3.2.1.2 for Southern California euhaline bays and estuaries. Sediment chemistry results according to the CA LRM and CSI will be categorized as having minimal, low, moderate, and high exposure to pollutants as presented in Table 3-2.

#### 3.2.2.2 Sediment Toxicity

For compliance with the State Water Board Sediment Control Plan, the toxicity test methods for other bays and estuaries are limited to using the 10-day amphipod survival test. The 10-day amphipod test should utilize a test species that is tolerant of the sediment sample salinity and grain size characteristics. Examples of amphipods to utilize for the toxicity test include *Eohaustorius estuarius* or *Hyalella azteca*. If using one of these test species, the percent of control survival below which would indicate an effect on survival should be as follows: < 59 for *E. estuarius* and < 62 for *H. azteca* (Table 3-8). A third option to determine if there is a toxicity LOE effect, is to use an alternative amphipod species and thresholds approved by the SWAMP (Bay et al., 2021).

For comparability to Bight Program data, sediment toxicity will be assessed using two tests: a short-term survival test using the amphipod *E. estuarius* and a sublethal test using the bivalve *M. galloprovincialis*. Sediment toxicity test results from each station will be statistically compared to control test results; normalized to the control survival; and categorized as nontoxic, low, moderate, or high toxicity according to Table 3-1 in Section 3.2.1.1.

#### 3.2.2.3 Benthic Community Condition

The first step to evaluate the benthic community condition LOE is to conduct taxonomic analysis of the benthic macroinfaunal organisms at a station including species identifications and tabulation of organism abundance. The Sediment Control Plan lists four metrics to use for threshold comparison to determine the LOE effect (Table 3-7) in other bays and estuaries. However, the modified version of the M-AMBI benthic index (detailed in Pelletier et al., 2018 with SQO thresholds proposed by Gillett et al., 2019) is recommended for determining the benthic community condition LOE in low salinity habitats in Southern California as well as all habitats in other estuaries and embayments in Southern California regardless of salinity that are not classified as Habitat C – Southern California Marine Bays (salinity ≥ 27 ppt) or Habitat D – Polyhaline San Francisco Bay. The basis of the M-AMBI is a benthic index utilized by the European Union water Framework Directive which has been modified, calibrated, and validated for use in all embayments and estuaries across the United States (U.S.) (Bay et al., 2021). As stated in the *Southern California Bight 2018 Regional Monitoring Program: Volume III. Benthic Infauna* technical report (Gillett et al., 2022), "the M-AMBI of Pelletier et al. (2018) is an index that uses a combination of species diversity, species richness, abundance-weighted pollution tolerance score (AMBI of Gillett et al. 2015) and the relative abundance of oligochaetes. The M-AMBI is applicable in all soft sediment estuarine habitats of California from tidal freshwater to euhaline salinities".

The M-AMBI was not listed as evaluation metric in the 2018 amendment to the Sediment Control Plan (State Water Board and CA EPA, 2018) because at the time of the plan's adoption the development and validation of this benthic community index was not complete. However, since 2018, the thresholds for the M-AMBI have been modified (see Gillett et. al., 2019) for better integration into the SQO framework (i.e., the four benthic condition categories correspond to those used in the SQO for euhaline bays and estuaries in Southern California) (Gillett et al., 2022). Detailed methods for calculating M-AMBI scores are provided in the *Sediment Quality Assessment Technical Support Manual* (Bay et al., 2021) on SCCWRP's website at:

https://ftp.sccwrp.org/pub/download/DOCUMENTS/TechnicalReports/777_CASQO_Technical Manual.pdf

For compliance with the State Water Board Sediment Control Plan, an M-AMBI score of ≤ 0.387 is recommended as the threshold to indicate a benthic community condition LOE effect. Bay et al., 2021 states that using the M-AMBI benthic index is the "preferred method over single metrics such as species richness or indicator species presence, because the M-AMBI score integrates such metrics and has been developed to be applicable across a wide range of habitats".

For comparability to Bight Program data, the four M-AMBI categories listed in Table 3-9 will be used as the thresholds to determine the LOE effects for benthic community condition. The four categories include reference (≥ 0.578), low disturbance (≥ 0.483 - < 0.578), moderate disturbance (≥ 0.387 - < 0.483), and high disturbance (< 0.387). Following Gillett et. al's (2019) modifications of the M-AMBI thresholds, the four categories correspond to those of the SQO benthic LOE used for Southern California euhaline bays and estuaries (Gillett et. al., 2022).

#### *3.2.2.4 Integration of MLOE*

For compliance with the State Water Board Sediment Control Plan, the three LOE categories are integrated using the decision matrix in Table 3-10 to conduct an assessment of an individual station. Each LOE category is assigned a category of No Effect or Effect based on whether it exceeds the appropriate threshold outlined in Table 3-8 (e.g., if the $P_{max}$ for a station is > 0.66, then the chemistry LOE will be categorized as Effect). Similar to the matrix used for euahaline bays and estuaries, the matrix in Table 3-10 combines the categories for each of the LOEs to assign a level of impact for a station. There are eight possible LOE combinations that result in two possible outcomes as described in the Sediment Control Plan as follows:

- Unimpacted – No conclusive evidence of both pollutant exposure and high biological effects present at the site. Evidence of chemical exposure and biological effects may be within natural variability or measurement error.
- Impacted – Confident that sediment contamination present at the site is causing adverse direct impacts to aquatic life.

If a station is assigned a category of Unimpacted, then the protective condition has been achieved.

For comparability with Bight Program data, the three LOE categories are integrated following the methodology used for Southern California euahaline bays and estuaries described in Section 3.2.1.4.

**Table 3-10. Station Assessment Based on Integration of LOE Categories for Other Bays and Estuaries**

| Chemistry LOE Category | Toxicity LOE Category | Benthic Condition LOE Category | Station Assessment |
|---|---|---|---|
| No effect | No effect | No effect | Unimpacted |
| No effect | No effect | Effect | Unimpacted |
| No effect | Effect | No effect | Unimpacted |
| No effect | Effect | Effect | Impacted |
| Effect | No effect | No effect | Unimpacted |
| Effect | No effect | Effect | Impacted |
| Effect | Effect | No effect | Impacted |
| Effect | Effect | Effect | Impacted |

# 4.0 STRESSOR IDENTIFICATION

The highest priority for stressor identification will be assigned to those waterbody segments with the highest percentage of Clearly Impacted or Likely Impacted stations. In cases where segments contain sediments categorized as Possibly Impacted but not Clearly Impacted or Likely Impacted, confirmation monitoring will be conducted prior to requiring stressor identification studies. By reviewing the available data sets, deductive reasoning can be used to narrow the focus of future actions. Based on the outcome of the additional data analysis, steps forward for stressor identification should be coordinated with the San Diego Water Board. If a stressor identification study is required, the Copermittees will develop a clearly defined work plan that has met the approval of the San Diego Water Board prior to beginning work. No formal guidance is given in the Sediment Control Plan on how to conduct a stressor identification study; however, the Sediment Control Plan does give some general guidance on types of stressor identification studies that can be implemented. These studies include confirmation and characterization of pollutant-related impacts, pollutant identification, and source identification and management actions. These types of studies are summarized in the following sections.

### 4.1.1 Pollutant Confirmation and Characterization

When the analyses described in Section 3.2 indicate that pollutants are a likely cause of an SQO exceedance at a station, a variety of tools can be used to determine whether the reason for the narrative objective not being met is due to generic stressors other than toxic pollutants, such as physical alterations or other pollutant-related stressors. Physical disturbances, such as decreased salinity, dredging impacts, and particle size, are confounding factors that may produce conditions mimicking the effects of pollutants. In these cases, the benthic community LOE will indicate degradation, but the toxicity and chemistry LOEs may not. Pollutant-related stressors, such as ammonia, TOC, nutrients, and pathogens, may also be confounding factors. In these cases, the benthic community LOE will indicate degradation, toxicity may be indicated, and chemical concentrations will be low. To determine whether a station is impacted from toxic pollutants, one or more of the following tools may be included in the stressor identification analysis as part of the confirmation:

- Evaluate the spatial extent of the area of concern in relation to anthropogenic sources.
- Evaluate the body burden of the pollutants accumulated in the animals used for exposure testing.
- Evaluate the chemical constituent results in relation to chemical benchmark values.
- Compare chemistry and biology LOE to determine whether correlations exist.
- Alternative biological assessment, such as bioaccumulation experiments, pore water toxicity, or pore water chemistry analyses, may be conducted.
- Phase I TIEs, which are often useful in determining the causative agent or class of compounds causing toxicity may be conducted.

According to the SQO guidelines, “If there is compelling evidence that the SQO exceedances contributing to a receiving water limit exceedance are not due to toxic pollutants, then the assessment area shall be designated as having achieved the receiving water limit.”

### 4.1.2 Pollutant Identification

Pollutant identification investigations may be conducted using one or more of the following types of data: statistical, biological, or chemical investigation data. These investigations should be station-specific and should be based on:

- Correlations between individual chemicals and biological endpoints.
- Gradient analysis of chemical concentrations and the biological responses in comparison to distance from a chemical hotspot.
- Additional TIE procedures.
- Sediment pore water investigations into the bioavailability of pollutants (e.g., acid-volatile sulfides and simultaneously extracted metals [AVS:SEM] analysis, solid phase microextraction [SPME], and/or laboratory desorption studies.
- Verification studies such as spiking or in situ toxicity and bioaccumulation studies.

In cases where stressor identification studies conducted on stations categorized as Possibly Impacted are inconclusive, the Copermittees may implement a one-time augmentation to the study or suspend stressor identification studies in favor of additional routine SQO monitoring.

### 4.1.3 Pollutant Source Identification and Management

Stressor identification studies should include determinations of whether sources are ongoing or legacy and determinations of the number and nature of ongoing sources. If a single or multiple dischargers are responsible for stressor pollutant discharges, the discharger(s) may need to address the SQO exceedance and to reduce the pollutant loading.

According to Section IV.A.4.h of the Sediment Control Plan, the San Diego Water Board may develop station-specific sediment management guidelines to estimate the level of the stressor pollutant in order to meet the SQOs. Guideline development should be initiated only following identification of the stressor and should have an overall goal of establishing a relationship between the organism’s exposure and the biological effect. Upon establishing this relationship, a pollutant-specific guideline may be designated that corresponds with minimum biological effects. Approaches that can be used to establish relationships between exposure and biological effect include the following: correspondence with sediment chemistry, correspondence with bioavailable pollutant concentration, correspondence with tissue residue, and literature review. Additionally, the Sediment Control Plan states that the chemistry LOE, “including the threshold values (e.g., CSI and CA LRM) shall not be used for setting cleanup levels or numeric values for technical TMDLs.”

# 5.0 REPORTING

Provision D.1.e.(2)(c) of the Permit requires the submittal of the sediment monitoring results in the WQIP Annual Report including an evaluation, interpretation, and tabulation of monitoring data; an assessment of whether receiving water limits outlined in the Permit were attained; a sample location map; and a statement of certification that monitoring data and results have been uploaded into CEDEN.

This Sediment Monitoring Plan addresses compliance with the aquatic life objective of the Sediment Control Plan. This narrative objective is implemented using the integration of MLOE as described in Section IV.A.1 of the Sediment Control Plan. Based on the conclusions of the sediment monitoring results, a human health risk assessment may be required by the San Diego Water Board. Provision A.2.a.(3)(b)(ii) of the Permit states that "pollutants shall not be present in sediments at levels that will bioaccumulate in aquatic life to levels that are harmful to human health." The potential risk assessments must consider any relevant information, such as guidelines set forth in the CA EPA's Office of Environmental Health Hazard Assessment (OEHHA) fish consumption policies, CA EPA's Department of Toxic Substances Control (DTSC) risk assessment, and the USEPA human health risk assessment policies. If a human health risk assessment is required, then the narrative objectives will be implemented as described in Section IV.A.2 of the Sediment Control Plan.

# 6.0 SCHEDULE

The schedule for completing the sediment quality monitoring requirements of the Permit and for submitting the sediment monitoring results is shown in Table 6-1:

**Table 6-1. Sediment Monitoring Plan Schedule**

| Activity/Deliverable | Dates(s)* |
|---|---|
| San Diego Water Board Order No. R9-2013-0001 | Adopted May 8, 2013 and effective June 27, 2013 |
| Southern California Bight Regional Monitoring Program – Field Sampling | July-September 2023 |
| Southern California Bight Regional Monitoring Program – Data Assessment | October 2023 – June 2024 |
| Follow-up confirmation monitoring (if required) | To be determined |
| Final sediment monitoring results incorporated into 2023-2024 WQIP Annual Report | January 31, 2025 |
| Potential Stressor ID Studies | To be determined |

*Table does not include future permit cycles

This revised Sediment Monitoring Plan and Sediment Monitoring QAPP (Appendix B) will be submitted with WQIP Annual Reports in January 2024. The San Diego County Regional Copermittees participated in the 2023 Bight Program to satisfy Provisions D.1.e.(1)(b) and D.1.e.(2) of the Permit. Follow-up confirmation monitoring and data assessments will be conducted, if necessary, based on the station assessment results from Bight 2023. Monitoring for the 2023 Bight Program was conducted in accordance with the *Southern California Bight 2023*

*Regional Marine Monitoring Survey (Bight '23) Sediment Quality Assessment Field Operations Manual* (SCCWRP, 2023) and data were collected using methods consistent with previous Bight surveys and the current SQO guidelines as described in with Sediment Control Plan. The sediment monitoring results from Bight 2023 will be incorporated into the 2023-2024 WQIP Annual Report due to the San Diego Water Board on January 31, 2025. Additional sediment quality monitoring or stressor identification studies conducted after 2023 will be included in future WQIP Annual Reports.

# 7.0 REFERENCES

Anderson, B.S., Hunt, J.W., Hester, M., Phillips, B.M. 1996. Assessment of sediment toxicity at the sediment-water interface. In: G.K. Ostrander (ed.) *Techniques in Aquatic Toxicology*. Lewis Publishers, Ann Arbor, MI.

ASTM (American Society for Testing and Materials). 2002. E1562 Standard Guide for Conducting Acute, Chronic, and Life-Cycle Aquatic Toxicity Tests with Polychaetous Annelids. *Annual Book of Standards, Water and Environmental Technology, Vol. 11.05*, West Conshohocken, PA.

ASTM (American Society for Testing and Materials). 2006. E1367-03 Standard Guide for Conducting 10-Day Static Sediment Toxicity Tests With Marine and Estuarine Amphipods. *Annual Book of Standards, Water and Environmental Technology, Vol. 11.05*, West Conshohocken, PA.

Bay, S.M., Greenstein, D.J., Ranasinghe, J.A., Diehl, D.W., Fetscher, A.E. 2021. *Sediment Quality Assessment Technical Support Manual*. Southern California Coastal Water Research Project. Costa Mesa, CA. June 2021.

Farrar, J.D., Bridges, T.S. 2011. 28-Day Chronic Sublethal Test Method for Evaluating Whole Sediments Using an Early Life Stage of the Marine Polychaete *Neanthes arenaceodentata*. ERDC TN-DOER-R14. U.S. Army Corps of Engineers, Vicksburg, MS.

Gillett, D.J., S.B. Weisberg, T. Grayson, A. Hamilton, V. Hansen, E.W. Leppo, M.C. Pelletier, A. Borja, D. Cadien, D. Dauer, R. Diaz, M. Dutch, J.L. Hyland, M. Kellogg, P.F. Larsen, J.S. Levinton, R. Llansó, L.L. Lovell, P.A. Montagna, D. Pasko, Phillips, Calibration of M-C.A., C. Rakocinski, J.A. Ranasinghe, D.M. Sanger, H. Teixeira, R.F. Van Dolah, R.G. Velarde, and K.I. Welch. 2015. Effect of ecological group classification schemes on performance of the AMBI benthic index in US coastal waters. *Ecol. Indic*. 50:99–107.

Gillett, D.J., A.N. Parks, and S.M. Bay. 2019. Calibration of the Multivariate AZTI Marine Biotic Index (M-AMBI) for Potential Inclusion into California Sediment Quality Objective Assessments in San Francisco Bay. SFEI Contribution #939. San Francisco Estuary Institute, Richmond, CA.

Gillett, D.J., W. Enright, and J.B. Walker. 2022. Southern California Bight 2018 Regional Monitoring Program: Volume III. Benthic Infauna. Technical Report 1289. SCCWRP Costa Mesa, CA.

Pelletier, M.C., D.J. Gillett, A. Hamilton, T. Grayson, V. Hansen, E.W. Leppo, S.B. Wesiberg, and A. Borja. 2018. Adaptation and application of multivariate AMBI (M-AMBI) in US coastal waters. *Ecol. Indic.* 89:818-827.

Ranasinghe, J.A., K.I. Welch, P.N. Slattery, D.E. Montagne, D.D. Huff, H. Lee, II, J.L. Hyland, B. Thompson, S.B. Weisberg, J.M. Oakden, D.B. Cadien, and R.G. Velarde. 2008. Habitat related benthic macrofaunal assemblages of bays and estuaries of the western United States. pp. 199-210 In: S.B. Weisberg and K. Miller, Editors. 2008 Annual Report. Southern California Coastal Water Research Project, Costa Mesa, CA.

San Diego Water Board (San Diego Regional Water Quality Control Board). 2013. Order No. R9-2013-0001. NPDES No. CAS0109266. National Pollutant Discharge Elimination System (NPDES) Permit and Waste Discharge Requirements for Discharges from the Municipal Separate Storm Sewer Systems (MS4s) Draining the Watersheds Within the San Diego Region. June 27, 2013.

SCCWRP (Southern California Coastal Water Research Project). 2018. *Southern California Bight 2018 Regional Marine Monitoring Survey (Bight '18) Sediment Quality Assessment Field Operations Manual*. Prepared by Bight '18 Field Sampling & Logistics Committee. July 2018.

SCCWRP (Southern California Coastal Water Research Project). 2023. *Southern California Bight 2023 Regional Marine Monitoring Survey (Bight '23) Sediment Quality Assessment Field Operations Manual*. Prepared by Bight '23 Field Technical Committee. July 2023.

State Water Board (State Water Resources Control Board) – CA EPA (California Environmental Protection Agency). 2009. *Water Quality Control Plan for Enclosed Bays and Estuaries – Part 1 Sediment Quality*. August 25, 2009.

State Water Board – CA EPA. 2018. *Amendments to the Water Quality Control Plan for Enclosed Bays and Estuaries of California – Sediment Quality Provisions*. June 5, 2018.

USEPA (United States Environmental Protection Agency). 1994. *Methods for Assessing Toxicity of Sediment-Associated Contaminants With Estuarine and Marine Amphipods*. EPA/600/R-94/025. EPA Office of Research and Development, Narragansett, Rhode Island. June 1994.

USEPA (United States Environmental Protection Agency). 1995. *Short-Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to West Coast Marine and Estuarine Organisms*. EPA/600/R-95/136. EPA Office of Research and Development.

WESTON (Weston Solutions, Inc.). 2013. *San Diego County Municipal Copermittees Bight 2013 Workplan*. Prepared for the County of San Diego Municipal Copermittees. July 25, 2013.

WESTON (Weston Solutions, Inc.). 2014. *San Diego County Municipal Copermittees 2014 Sampling and Analysis Plan for Bight '13 Follow-up Investigations*. Prepared for the County of San Diego Municipal Copermittees. May 2014.

# Appendix A

# Amendments to the Water Quality Control Plan for Enclosed Bays and Estuaries of California – Sediment Quality Provisions

# AMENDMENTS TO THE WATER QUALITY CONTROL PLAN FOR ENCLOSED BAYS AND ESTUARIES OF CALIFORNIA

## Sediment Quality Provisions

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# I. INTRODUCTION

## A. SEDIMENT

### 1. Intent of the Sediment Quality Provisions of the Water Quality Control Plan for Enclosed Bays and Estuaries of California

It is the goal of the State Water Resources Control Board (State Water Board) to comply with the legislative directive in Water Code section 13393 to adopt sediment quality objectives (SQOs). The Sediment Quality Provisions integrates chemical and biological measures to determine if the sediment-dependent biota are protected or degraded as a result of exposure to toxic pollutants* in sediment in order to protect benthic* communities in enclosed bays* and estuaries*, human health, wildlife, and resident finfish. The Sediment Quality Provisions are not intended to address low dissolved oxygen, pathogens or nutrients including ammonia. The State Water Board will continue to refine benthic community protection indicators for estuarine waters and improve the approach to address sediment quality related human health risk associated with consumption of fish tissue.

### 2. Summary of the Sediment Quality Provisions

The Sediment Quality Provisions include**:**

- Narrative SQO for the protection of aquatic life.
- Narrative SQO for the protection of human health.
- Narrative SQO for the protection of wildlife* and resident finfish*.
- Identification of the beneficial uses that these SQOs are intended to protect.
- A program of implementation for each SQO that contains:
    - o Specific indicators, tools and implementation provisions to determine if the sediment quality at a station or multiple stations meets the narrative objectives;
    - o A description of appropriate monitoring programs; and
    - o A sequential series of actions that shall be initiated when a sediment quality objective is not met, including stressor identification and evaluation of appropriate targets.
- A glossary that defines all terms denoted by an asterisk.

# II. BENEFICIAL USES

## A. SEDIMENT

Beneficial uses of waters protected by the Sediment Quality Provisions and corresponding target receptors are identified in Table 1.

**Table 1. Beneficial Uses and Target Receptors**

| Beneficial Uses* | Target Receptors |
|---|---|
| Estuarine Habitat | Benthic Community/finfish/wildlife |
| Marine Habitat | Benthic Community/ finfish/wildlife |
| Commercial and Sport Fishing | Human Health |
| Aquaculture | Human Health |
| Shellfish Harvesting | Human Health |
| Tribal tradition and Culture | Human Health |
| Tribal Subsistence Fishing | Human Health |
| Subsistence Fishing | Human Health |
| Rare, Threatened, or Endangered Species | finfish/wildlife |
| Preservation of Biological Habitats of Special Significance | finfish/wildlife |
| Wildlife Habitat | Wildlife |
| Spawning Reproduction and Early Development | Finfish |

*Only applicable to those waters where the beneficial use is assigned within a Basin Plan.

# III. WATER QUALITY OBJECTIVES

## A. SEDIMENT

### 1. Use and Applicability of SQOS

#### a. Ambient Sediment Quality

The SQOs and supporting tools shall be utilized to assess ambient sediment quality.

#### b. Relationship to Other Narrative Objectives and Total Maximum Daily Loads

1) Except as provided in paragraph 3) below, the Sediment Quality Provisions supersede all applicable narrative water quality objectives and related implementation provisions in water quality control plans (basin plans), to the extent that the objectives and provisions are applied to protect bay or estuarine benthic communities from toxic pollutants in sediments.

2) Except as provided in paragraph 3) below, the Sediment Quality Provisions also supersede all applicable narrative water quality objectives and related implementation provisions in basin plans, to the extent that the objectives and provisions are applied to protect wildlife and resident finfish from toxic pollutants in sediments, unless the State Water Board approves amendments to a basin plan to incorporate new, more stringent, narrative water quality objectives or implementation provisions.

3) The supersession provisions in paragraphs 1) and 2) above do not apply to existing sediment cleanup activities where a site assessment was completed and submitted to the Regional Water Quality Control Board (Regional Water Board) by February 19, 2008.

4) Implementation provisions described in Chapter IV.A.2. and applicable provisions in Chapter IV.A.4. implementing the objective set forth in Chapter III.A.2.b. below do not apply to dischargers that discharge to receiving waters for which a total maximum daily load (TMDL) has been established, on or before the effective date of the Sediment Quality Provisions, to address the bioaccumulation of organochlorine pesticide or polychlorinated biphenyls from sediment into sportfish tissue within enclosed bays and estuaries unless a TMDL is reconsidered pursuant to its terms, or the applicable Regional Water Board approves the application of such provisions.

### c. Applicable Waters

The Sediment Quality Provisions apply to enclosed bays[1] and estuaries[2] only. The Sediment Quality Provisions do not apply to ocean waters* including Monterey Bay and Santa Monica Bay, or inland surface waters*.

### d. Applicable Sediments

The Sediment Quality Provisions apply to subtidal surficial sediments* that have been deposited or emplaced seaward of the intertidal zone. The Sediment Quality Provisions do not apply to:

1) Sediments characterized by less than five percent of fines (sum of percent silt and percent clay) or substrates composed of gravels, cobbles, or consolidated rock.

2) Sediment as the physical pollutant that causes adverse biological response or community degradation related to burial, deposition, or sedimentation.

### e. Applicable Discharges

The Sediment Quality Provisions are applicable in their entirety to point source* discharges. Nonpoint sources* of toxic pollutants are subject to Chapters II.A., III.A., IV.A.1., IV.A.2., and IV.A.3. of the Sediment Quality Provisions.

## 2. Sediment Quality Objectives

### a. Aquatic Life* - Benthic Community Protection

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 Chapter IV.A.1.

### b. Human Health

Pollutants shall not be present in sediments at levels that will bioaccumulate in aquatic life to levels that are harmful to human health in bays and estuaries of California. This narrative objective shall be implemented as described in Chapter IV.A.2.

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[1] ENCLOSED BAYS are indentations along the coast which enclose an area of oceanic water within distinct headlands or harbor works. Enclosed bays include all bays where the narrowest distance between headlands or outermost harbor works is less than 75 percent of the greatest dimension of the enclosed portion of the bay. This definition includes, but is not limited to: Humboldt Bay, Bodega Harbor, Tomales Bay, Drakes Estero, San Francisco Bay, Morro Bay, Los Angeles Harbor, Upper and Lower Newport Bay, Mission Bay, and San Diego Bay.

[2] ESTUARIES AND COASTAL LAGOONS are waters at the mouths of streams that serve as mixing zones for fresh and ocean waters during a major portion of the year. Mouths of streams that are temporarily separated from the ocean by sandbars shall be considered as estuaries. Estuarine waters will generally be considered to extend from a bay or the open ocean to the upstream limit of tidal action but may be considered to extend seaward if significant mixing of fresh and salt water occurs in the open coastal waters. The waters described by this definition include, but are not limited to, the Sacramento-San Joaquin Delta as defined by Section 12220 of CWC, Suisun Bay, Carquinez Strait downstream to Carquinez Bridge, and appropriate areas of the Smith, Klamath, Mad, Eel, Noyo, and Russian Rivers.

### c. Wildlife and Resident Finfish

Pollutants shall not be present in sediment at levels that alone or in combination are toxic to wildlife and resident finfish by direct exposure or bioaccumulate in aquatic life at levels that are harmful to wildlife or resident finfish by indirect exposure in bays and estuaries of California. This narrative objective shall be implemented as described in Chapter IV.A.3.

# IV. IMPLEMENTATION OF WATER QUALITY OBJECTIVES

## A. SEDIMENT

### 1. Implementation for Assessing Benthic Community Protection

#### a. MLOE Approach to Interpret the Narrative Objective

The methods and procedures described below shall be used to interpret the Narrative Objective described in Chapter III.A.2.a. These tools are intended to assess the condition of benthic communities relative to potential for exposure to toxic pollutants in sediments. Exposure to toxic pollutants at harmful levels will result in some combination of a degraded benthic community, presence of toxicity, and elevated concentrations of pollutants in sediment. The assessment of sediment quality shall consist of the measurement and integration of three lines of evidence (LOE). The LOE are:

- ***Sediment Toxicity***—Sediment toxicity is a measure of the response of invertebrates exposed to surficial sediments under controlled laboratory conditions. The sediment toxicity LOE is used to assess both pollutant related biological effects and exposure. Sediment toxicity tests are of short durations and may not duplicate exposure conditions in natural systems. This LOE provides a measure of exposure to all pollutants present, including non-traditional or unmeasured chemicals.
- ***Benthic Community Condition***—Benthic community condition is a measure of the species composition, abundance and diversity of the sediment-dwelling invertebrates inhabiting surficial sediments*. The benthic community LOE is used to assess impacts to the primary receptors targeted for protection under Chapter III.A.2.a. Benthic community composition is a measure of the biological effects of both natural and anthropogenic stressors.
- ***Sediment Chemistry***—Sediment chemistry is the measurement of the concentration of chemicals of concern* in surficial sediments. The chemistry LOE is used to assess the potential risk to benthic organisms from toxic pollutants in surficial sediments. The sediment chemistry LOE is intended only to evaluate overall exposure risk from chemical pollutants. This LOE does not establish causality associated with specific chemicals.

#### b. Limitations

None of the individual LOE is sufficiently reliable when used alone to assess sediment quality impacts due to toxic pollutants. Within a given site, the LOEs applied to assess exposure as described in Chapter IV.A.1.a. may underestimate or overestimate the risk to benthic communities and do not indicate causality of specific chemicals. The LOEs applied to assess biological effects can respond to stresses associated with natural or physical factors, such as sediment grain size, physical disturbance, or organic enrichment.

Each LOE produces specific information that, when integrated with the other LOEs, provides a more confident assessment of sediment quality relative to the narrative objective. When the exposure and effects tools are integrated, the approach can quantify protection through effects measures and also provide predictive capability through the exposure assessment.

c. Water Bodies

1) The tools described in the Chapters IV.A.1.d. through IV.A.1.i. are applicable to Euhaline* Bays and Coastal Lagoons* south of Point Conception and Polyhaline* San Francisco Bay that includes the Central and South Bay Areas defined in general by waters south and west of the San Rafael Bridge and north of the Dumbarton Bridge.

2) For all other bays and estuaries where LOE measurement tools are unavailable, station assessment will follow the procedure described in Chapter IV.A.1.j.

d. Field Procedures

1) All samples shall be collected using a grab sampler.

2) Benthic samples shall be screened through:

   a. A 0.5 millimeter (mm)-mesh screen in San Francisco Bay and the Sacramento-San Joaquin Delta.

   b. A 1.0 mm-mesh screen in all other locations.

3) Surface sediment from within the upper 5 cm shall be collected for chemistry and toxicity analysis.

4) The entire contents of the grab sample, with a minimum penetration depth of 5 cm, shall be collected for benthic community analysis.

5) Bulk sediment chemical analysis will include at a minimum the pollutants identified in Appendix A-3.

e. Laboratory Testing

All samples will be tested in accordance with U.S. Environmental Protection Agency (USEPA) or American Society for Testing and Materials (ASTM) methodologies where such methods exist. Where no EPA or ASTM methods exist, the State Water Board or Regional Water Boards (collectively Water Boards) shall approve the use of other methods. Analytical tests shall be conducted by laboratories certified by the State Water Board's Environmental Laboratory Accreditation Program (ELAP) in accordance with Water Code Section 13176.

f. Sediment Toxicity

1) Short-Term Survival Tests - A minimum of one short-term survival test shall be performed on sediment collected from each station. Acceptable test organisms and methods are summarized in Table 2.

**Table 2. Acceptable Short-Term Survival Sediment Toxicity Test Methods**

| Test Organism | Exposure Type | Duration | Endpoint* |
|---|---|---|---|
| Eohaustorius estuarius | Whole Sediment | 10 days | Survival |
| Leptocheirus plumulosus | Whole Sediment | 10 days | Survival |
| Rhepoxynius abronius | Whole Sediment | 10 days | Survival |

2) Sublethal Tests—A minimum of one sublethal test shall be performed on sediment collected from each station. Acceptable test organisms and methods are summarized in Table 3.

**Table 3. Acceptable Sublethal Sediment Toxicity Test Methods**

| Test Organism | Exposure Type | Duration | Endpoint |
|---|---|---|---|
| Neanthes arenaceodentata | Whole Sediment | 28 days | Growth |
| Mytilus galloprovincialis | Sediment-water Interface | 48 hour | Embryo Development |

3) Assessment of Sediment Toxicity—Each sediment toxicity test result shall be compared and categorized according to responses in Table 4. The response categories are:

a. Nontoxic—Response not substantially different from that expected in sediments that are uncontaminated and have optimum characteristics for the test species (e.g., control sediments).

b. Low toxicity—A response that is of relatively low magnitude; the response may not be greater than test variability.

c. Moderate toxicity—High confidence that a statistically significant toxic effect is present.

d. High toxicity—High confidence that a toxic effect is present and the magnitude of response includes the strongest effects observed for the test.

**Table 4. Sediment Toxicity Categorization Values**

| Test Species/ Endpoint | Statistical Significance | Nontoxic (Percent) | Low Toxicity (Percent of Control) | Moderate Toxicity (Percent of Control) | High Toxicity (Percent of Control) |
|---|---|---|---|---|---|
| Eohaustorius Survival | Significant | 90 to 100 | 82 to 89 | 59 to 81 | < 59 |
| Eohaustorius Survival | Not Significant | 82 to 100 | 59 to 81 | | <59 |
| Leptocheirus Survival | Significant | 90 to 100 | 78 to 89 | 56 to 77 | <56 |
| Leptocheirus Survival | Not Significant | 78 to 100 | 56 to 77 | | <56 |
| Rhepoxynius Survival | Significant | 90 to 100 | 83 to 89 | 70 to 82 | < 70 |
| Rhepoxynius Survival | Not Significant | 83 to 100 | 70 to 82 | | < 70 |
| Neanthes Growth | Significant | 90 to 100* | 68 to 90 | 46 to 67 | <46 |
| Neanthes Growth | Not Significant | 68 to 100 | 46 to 67 | | <46 |
| Mytilus Normal | Significant | 80 to 100 | 77 to 79 | 42 to 76 | < 42 |
| Mytilus Normal | Not Significant | 77 to 79 | 42 to 76 | | < 42 |

* Expressed as a percentage of the control.

4) Integration of Sediment Toxicity Categories—The average of all test response categories shall determine the final toxicity LOE category. If the average falls midway between categories it shall be rounded up to the next higher response category.

g. Benthic Community Condition

1) General Requirements.

a. All benthic invertebrates in the screened sample shall be identified to the lowest possible taxon and counted.

b. Taxonomic nomenclature shall follow current conventions established by local monitoring programs and professional organizations (e.g., master species list).

2) Benthic Indices—The benthic condition shall be assessed using the following methods:

a. Benthic Response Index (BRI), which was originally developed for the southern California mainland shelf and extended into California's bays and estuaries. The BRI is the abundance-weighted average pollution* tolerance score of organisms occurring in a sample.

b. Index of Biotic Integrity (IBI), which was developed for freshwater streams and adapted for California's bays and estuaries. The IBI identifies community measures that have values outside a reference range.

c. Relative Benthic Index (RBI), which was developed for embayments in California's Bay Protection and Toxic Cleanup Program. The RBI is the weighted sum of: (a) several community parameters (total number of species, number of crustacean species, number of crustacean individuals, and number of mollusc species), and abundances of (b) three positive, and (c) two negative indicator species.

d. River Invertebrate Prediction and Classification System (RIVPACS), which was originally developed for British freshwater streams and adapted for California's bays and estuaries. The approach compares the assemblage at a site with an expected species composition determined by a multivariate predictive model that is based on species relationships to habitat gradients.

3) Assessment of Benthic Community Condition—Each benthic index result shall be categorized according to disturbance as described in Table 5. The disturbance categories are:

a. Reference—A community composition equivalent to a least affected or unaffected site.

b. Low disturbance— A community that shows some indication of stress, but could be within measurement error of unaffected condition.

c. Moderate disturbance—Confident that the community shows evidence of physical, chemical, natural, or anthropogenic stress.

d. High disturbance—The magnitude of stress is high.

4) Integration of Benthic Community Categories—The median of all benthic index response categories shall determine the benthic condition LOE category. If the median falls between categories it shall be rounded up to the next higher effect category.

**Table 5. Benthic Index Categorization Values**

| Index | Reference | Low Disturbance | Moderate Disturbance | High Disturbance |
|---|---|---|---|---|
| **Southern California Marine Bays** | | | | |
| BRI | < 39.96 | 39.96 to 49.14 | 49.15 to 73.26 | > 73.26 |
| IBI | 0 | 1 | 2 | 3 or 4 |
| RBI | > 0.27 | 0.17 to 0.27 | 0.09 to 0.16 | < 0.09 |
| RIVPACS | > 0.90 to < 1.10 | 0.75 to 0.90 or 1.10 to 1.25 | 0.33 to 0.74 or > 1.25 | < 0.33 |
| **Polyhaline Central San Francisco Bay** | | | | |
| BRI | < 22.28 | 22.28 to 33.37 | 33.38 to 82.08 | > 82.08 |
| IBI | 0 or 1 | 2 | 3 | 4 |
| RBI | > 0.43 | 0.30 to 0.43 | 0.20 to 0.29 | < 0.20 |
| RIVPACS | > 0.68 to < 1.32 | 0.33 to 0.68 or 1.32 to 1.67 | 0.16 to 0.32 or > 1.67 | < 0.16 |

h. Sediment Chemistry

1) All samples shall be tested for the analytes identified in Appendix A-3. This list represents the minimum analytes required to assess exposure. In water bodies where other toxic pollutants are believed to pose risk to benthic communities, those toxic pollutants shall be included in the analysis. Inclusion of additional analytes cannot be used in the exposure assessment described below. However, the data can be used to conduct more effective stressor identification studies as described in Chapter IV.A.4.f.

2) Sediment Chemistry Guidelines—The sediment chemistry exposure shall be assessed using the following two methods:

   a. Chemical Score Index (CSI), that uses a series of empirical thresholds to predict the benthic community disturbance category (score) associated with the concentration of various chemicals (Table 6). The CSI is the weighted sum of the individual scores (Equation 1).

Equation 1. $CSI = \Sigma(w_i \times cat_i)/\Sigma w$

Where: $cat_i$ = predicted benthic disturbance category for chemical I;
$w_i$ = weight factor for chemical I;
$\Sigma w$ = sum of all weights.

   b. California Logistic Regression Model (CA LRM), that uses logistic regression models to predict the probability of sediment toxicity associated with the concentration of various chemicals (Table 7 and Equation 2). The CA LRM exposure value is the maximum probability of toxicity from the individual models ($P_{max}$)

Equation 2. $p = e^{B0+B1\,(x)} / (1 + e^{B0+B1\,(x)})$

Where: $p$ = probability of observing a toxic effect;
B0 = intercept parameter;
B1 = slope parameter; and
x = Log (concentration of the chemical).

**Table 6. Category Score Concentration Ranges and Weighting Factors for the CSI**

| Chemical | Units | Weight | Score (Disturbance Category) | | | |
|---|---|---|---|---|---|---|
| | | | 1<br>Reference | 2<br>Low | 3<br>Moderate | 4<br>High |
| Copper | mg/kg | 100 | ≤52.8 | > 52.8 to 96.5 | > 96.5 to 406 | > 406 |
| Lead | mg/kg | 88 | ≤ 26.4 | > 26.4 to 60.8 | > 60.8 to 154 | > 154 |
| Mercury | mg/kg | 30 | ≤ 0.09 | > 0.09 to 0.45 | > 0.45 to 2.18 | > 2.18 |
| Zinc | mg/kg | 98 | ≤ 113 | > 113 to 201 | > 201 to 629 | > 629 |
| PAHs, total high MW | µg/kg | 16 | ≤ 313 | > 313 to 1325 | > 1325 to 9320 | >9320 |
| PAHs, total low MW | µg/kg | 5 | ≤ 85.4 | > 85.4 to 312 | > 312 to 2471 | > 2471 |
| Chlordane, alpha- | µg/kg | 55 | ≤ 0.50 | > 0.50 to 1.23 | > 1.23 to 11.1 | >11.1 |
| Chlordane, gamma- | µg/kg | 58 | ≤ 0.54 | > 0.54 to 1.45 | > 1.45 to 14.5 | > 14.5 |

| | | | | | | |
|---|---|---|---|---|---|---|
| DDDs, total | µg/kg | 45 | ≤ 0.77 | > 0.77 to 3.56 | > 3.56 to 26.37 | > 26.37 |
| DDEs, total | µg/kg | 33 | ≤ 1.19 | >1.19 to 6.01 | > 6.01 to 45.84 | >45.84 |
| DDTs, total | µg/kg | 20 | ≤ 0.61 | > 0.61 to 2.79 | > 2.79 to 34.27 | > 34.27 |
| PCBs, total | µg/kg | 55 | ≤11.9 | > 11.9 to 24.7 | > 24.7 to 288 | > 288 |

**Table 7. CA LRM Regression Parameters**

| Chemical | Units | B0 | B1 |
|---|---|---|---|
| Cadmium | mg/kg | 0.29 | 3.18 |
| Copper | mg/kg | -5.59 | 2.59 |
| Lead | mg/kg | -4.72 | 2.84 |
| Mercury | mg/kg | -0.06 | 2.68 |
| Zinc | mg/kg | -5.13 | 2.42 |
| PAHs, total high MW | µg/kg | -8.19 | 2.00 |
| PAHs, total low MW | µg/kg | -6.81 | 1.88 |
| Chlordane, alpha | µg/kg | -3.41 | 4.46 |
| Dieldrin | µg/kg | -1.83 | 2.59 |
| Trans nonachlor | µg/kg | -4.26 | 5.31 |
| PCBs, total | µg/kg | -4.41 | 1.48 |
| *p,p'* DDT | µg/kg | -3.55 | 3.26 |

3) Assessment of Sediment Chemistry Exposure—Each sediment chemistry guideline result shall be categorized according to exposure as described in Table 8. The exposure categories are:

   a. Minimal exposure—Sediment-associated contamination* may be present, but exposure is unlikely to result in effects.

   b. Low exposure—Small increase in pollutant exposure that may be associated with increased effects, but magnitude or frequency of occurrence of biological impacts is low.

   c. Moderate exposure—Clear evidence of sediment pollutant exposure that is likely to result in biological effects; an intermediate category.

   d. High exposure—Pollutant exposure highly likely to result in possibly severe biological effects; generally present in a small percentage of the samples.

**Table 8. Sediment Chemistry Guideline Categorization Values**

| Guideline | Minimal Exposure | Low Exposure | Moderate Exposure | High Exposure |
|---|---|---|---|---|
| CSI | < 1.69 | 1.69 to 2.33 | 2.34 to 2.99 | >2.99 |
| CA LRM | < 0.33 | 0.33 to 0.49 | 0.50 to 0.66 | > 0.66 |

4) Integration of Sediment Chemistry Categories—The average of all chemistry exposure categories shall determine the final

sediment chemistry LOE category. If the average falls midway between categories it shall be rounded up to the next higher exposure category.

i. Interpretation and Integration of MLOE

Assessment as to whether the aquatic life sediment quality objective has been attained at a station is accomplished by the interpretation and integration of MLOE. The categories assigned to the three LOE, sediment toxicity, benthic community condition and sediment chemistry are evaluated to determine the station level assessment. The assessment category represented by each of the possible MLOE combinations reflects the presence and severity of two characteristics of the sample: severity of biological effects, and potential for chemically-mediated effects.

1) Severity of Biological Effects—The severity of biological effects present at a site shall be determined by the integration of the toxicity LOE and benthic condition LOE categories using the decision matrix presented in Table 9.

2) Potential for Chemically-Mediated Effects—The potential for effects to be chemically-mediated shall be determined by the integration of the toxicity LOE and chemistry LOE categories using the decision matrix presented in Table 10.

**Table 9. Severity of Biological Effects Matrix**

| | | **Toxicity LOE Category** | | | |
|---|---|---|---|---|---|
| | | **Nontoxic** | **Low Toxicity** | **Moderate Toxicity** | **High Toxicity** |
| Benthic Condition LOE Category | Reference | Unaffected | Unaffected | Unaffected | Low Effect |
| | Low Disturbance | Unaffected | Low Effect | Low Effect | Low Effect |
| | Moderate Disturbance | Moderate Effect | Moderate Effect | Moderate Effect | Moderate Effect |
| | High Disturbance | Moderate Effect | High Effect | High Effect | High Effect |

**Table 10. Potential for Chemically-Mediated Effects Matrix**

| | | **Toxicity LOE Category** | | | |
|---|---|---|---|---|---|
| | | **Nontoxic** | **Low Toxicity** | **Moderate Toxicity** | **High Toxicity** |
| Sediment Chemistry LOE Category | Minimal Exposure | Minimal Potential | Minimal Potential | Low Potential | Moderate Potential |
| | Low Exposure | Minimal Potential | Low Potential | Moderate Potential | Moderate Potential |
| | Moderate Exposure | Low Potential | Moderate Potential | Moderate Potential | Moderate Potential |
| | High Exposure | Moderate Potential | Moderate Potential | High Potential | High Potential |

3) Station Level Assessment—The station level assessment shall be determined using the decision matrix presented in Table 11. This assessment combines the intermediate classifications for severity of biological effect and potential for chemically-mediated effect to result in six categories of impact at the station level:

a. Unimpacted—Confident that sediment contamination is not causing significant adverse impacts to aquatic life living in the sediment at the site.

b. Likely Unimpacted—Sediment contamination at the site is not expected to cause adverse impacts to aquatic life, but some disagreement among the LOE reduces certainty in classifying the site as unimpacted.

c. Possibly Impacted—Sediment contamination at the site may be causing adverse impacts to aquatic life, but these impacts are either small or uncertain because of disagreement among LOE.

d. Likely Impacted—Evidence for a contaminant-related impact to aquatic life at the site is persuasive, even if there is some disagreement among LOE.

e. Clearly Impacted—Sediment contamination at the site is causing clear and severe adverse impacts to aquatic life.

f. Inconclusive—Disagreement among the LOE suggests that either the data are suspect or that additional information is needed before a classification can be made.

**Table 11. Station Assessment Matrix**

| | | **Severity of Effect** | | | |
|---|---|---|---|---|---|
| | | **Unaffected** | **Low Effect** | **Moderate Effect** | **High Effect** |
| Potential For Chemically-Mediated Effects | Minimal Potential | Unimpacted | Likely Unimpacted | Likely Unimpacted | Inconclusive |
| | Low Potential | Unimpacted | Likely Unimpacted | Possibly Impacted | Possibly Impacted |
| | Moderate Potential | Likely Unimpacted | Possibly Impacted or Inconclusive[1] | Likely Impacted | Likely Impacted |
| | High Potential | Inconclusive | Likely Impacted | Clearly Impacted | Clearly Impacted |

[1]Inconclusive category when chemistry is classified as minimal exposure, benthic response is classified as reference, and toxicity response is classified as high.

The station assessment resulting from each possible combination of the three LOEs is shown in Appendix A-4. As an alternative to Tables 9, 10 and 11, each LOE category can be applied to Appendix A-4 to determine the overall condition of the station. The results will be the same regardless of the tables used.

4) Relationship to the Aquatic Life – Benthic Community Protection Narrative Objective.

a. The categories designated as **Unimpacted** and **Likely Unimpacted** shall be considered as achieving the protective condition at the station. All other categories shall be considered as degraded except as provided in b. below.

b. The Water Board shall designate the category **Possibly Impacted** as meeting the protective condition if the studies identified in Chapter IV.A.4.f. demonstrate that the combination of effects and exposure measures are not responding to toxic pollutants in sediments and that other factors are causing these responses within a specific reach segment or waterbody. In this situation, the Water Board will consider only the Categories **Likely Impacted** and **Clearly Impacted** as degraded when making a determination on receiving water limits and impaired water bodies described in Chapter IV.A.4.

### j. MLOE Approach to Interpret the Narrative Objective in Other Bays and Estuaries

Station assessments for waterbodies identified in Chapter IV.A.1.c.2. will be conducted using the same conceptual approach and similar tools to those described in Chapters IV.A.1.d. through IV.A.1.h. Each LOE will be evaluated by measuring a set of readily available indicators in accordance with Tables 12 and 13.

1) Station assessment shall be consistent with the following key principles of the assessment approach described in Chapters IV.A.1.d. through IV.A.1.i.:

a. Results for a single LOE shall not be used as the basis for an assessment.

b. Evidence of both elevated chemical exposure and biological effects must be present to indicate pollutant-associated impacts.

c. The categorization of each LOE shall be based on numeric values or a statistical comparison.

2) Lines of Evidence and Measurement Tools—Sediment chemistry, toxicity, and benthic community condition shall be measured at each station. Table 12 lists the required tools for evaluation of each LOE. Each measurement shall be conducted using standardized methods (e.g., EPA or ASTM guidance) where available.

3) Categorization of LOEs—Determination of the presence of an LOE effect (i.e., biologically significant chemical exposure, toxicity, or benthic community disturbance) shall be based on a comparison to a numeric response value or a statistical comparison to reference stations. The numeric values or

statistical comparisons (e.g., confidence interval) used to classify a LOE as Effected shall be comparable to those specified in Chapters IV.A.1.f. through IV.A.1.h. to indicate High Chemical Exposure, High Toxicity, or High Disturbance. Reference stations shall be located in an area expected to be uninfluenced by the discharge or pollutants of concern in the assessment area and shall be representative of other habitat characteristics of the assessment area (e.g., salinity, grain size). Comparison to reference shall be accomplished by compiling data for appropriate regional reference sites and determining the reference envelope using statistical methods (e.g., tolerance interval).

**Table 12. Tools for Use in Evaluation of LOEs**

| LOE | Tools | Metrics |
|---|---|---|
| Chemistry | Bulk sediment chemistry to include existing list (Appendix A-3) plus other chemicals of concern | CA LRM $P_{max}$<br>Concentration on a dry weight basis |
| Sediment Toxicity | 10-Day amphipod survival using a species tolerant of the sample salinity and grain size characteristics. e.g., *Hyalella azteca* or *Eohaustorius estuarius* | Percent of control survival |
| Benthic Community Condition | Invertebrate species identification and abundance | Species richness*<br>Presence of sensitive indicator taxa<br>Dominance by tolerant indicator taxa<br>Presence of diverse functional and feeding groups<br>Total abundance |

**Table 13. Numeric Values and Comparison Methods for LOE Categorization**

| Metric | Threshold value or Comparison |
|---|---|
| CA LRM | Pmax > 0.66 |
| Chemical Concentration | Greater than reference range or interval |
| Percent of Control Survival | *E. estuarius*: < 59<br>*H. azteca*: < 62 or SWAMP criterion |
| Species Richness | Less than reference range or interval |
| Abundance of Sensitive Indicator Taxa | Less than reference range or interval |
| Abundance of Tolerant Indicator Taxa | Greater than reference range or interval |
| Total Abundance | Outside of reference range or interval |

4) Station Level Assessment—The station level assessment shall be determined using the decision matrix presented in Table 14. This assessment combines the classifications for each LOE to result in two categories of impact at the station level:

a. Unimpacted—No conclusive evidence of both high pollutant exposure and high biological effects present at the site. Evidence of chemical exposure and biological effects may be within natural variability or measurement error.

b. Impacted—Confident that sediment contamination present at the site is causing adverse direct impacts to aquatic life.

**Table 14. Station Assessment Matrix for Other Bays and Estuaries**

| Chemistry LOE Category | Toxicity LOE Category | | Benthic Condition LOE Category | Station Assessment |
|---|---|---|---|---|
| No effect | No effect | | No effect | Unimpacted |
| No effect | No effect | | Effect | Unimpacted |
| No effect | Effect | | No effect | Unimpacted |
| No effect | Effect | | Effect | Impacted |
| Effect | No effect | | No effect | Unimpacted |
| Effect | No effect | | Effect | Impacted |
| Effect | Effect | | No effect | Impacted |
| Effect | Effect | | Effect | Impacted |

5) Relationship to the Aquatic Life – Benthic Community Protection Narrative Objective—The category designated as **Unimpacted** shall be considered as achieving the protective condition at the station.

## 2. Implementation for Assessing Human Health

### a. Approach to Interpret Objective for Contaminants Other than Chlorinated Pesticides and PCBs

The narrative human health objective in Chapter III.A.2.b. shall be implemented on a case-by-case basis, based upon a human health risk assessment. In conducting a risk assessment, the Water Boards shall consider any applicable and relevant information, including California Environmental Protection Agency's (CalEPA) Office of Environmental Health Hazard Assessment (OEHHA) policies for fish consumption and risk assessment, CalEPA's Department of Toxic Substances Control (DTSC) Risk Assessment, and U.S. EPA Human Health Risk Assessment policies.

### b. Approach to Interpret Objective for Chlorinated Pesticides and PCBs

The methods and procedures described below shall be used to interpret the narrative objective described in Chapter III.A.2.b. protecting human consumers of locally caught sportfish. These tools and associated assessment framework are intended to address the two components of the sediment quality objective protecting human consumers;

- Assess whether pollutant concentrations in sportfish pose unacceptable chemical exposure to human consumers and
- Assess whether sediment contamination at a site is a significant contributor to the sportfish contamination.

This framework relies on two indicators to address these components; **Chemical exposure indicator** compares sportfish contamination measurements from the site to consumption advisory thresholds. **Site Linkage indicator** compares sportfish contamination measurements to estimated sportfish concentrations that would result from site exposure. Integration of the results from both indicators produces a site assessment, which is a categorical description of the likelihood and magnitude of chemical exposure associated with sediment contamination within the site. The site assessment results are obtained using a categorical decision matrix to integrate the chemical exposure and site linkage indicators.

These indicators are applied within a tiered assessment framework. This assessment framework consists of three tiers:

**Tier 1** is an optional screening assessment to address whether contaminants in sediments at a site pose a potential chemical exposure that warrants further evaluation. For contaminants in site sediments that pose such a potential, a Tier 2 evaluation is performed. Tier 1 requires fewer data relative to Tiers 2 and 3.

**Tier 2** is a complete site assessment to assess sediment quality relative to the sediment quality objective protecting human consumers of locally caught sportfish. Tier 2 requires site specific information and data, including sediment and sportfish tissue chemistry, sediment organic carbon and percent lipid in tissue. The data are used to calculate average chemical exposure from consumption and the probability distribution of linkage between contaminants in sediment and sportfish.

**Tier 3** is a more complex and site-specific assessment intended to supplement the Tier 2 evaluation. Greater flexibility is provided to address unique site conditions, confounding factors or other chemical exposure factors. Tier 3 may be employed only after meeting the conditions described in Chapter IV.A.2.e.2).

1) Limitations

Each indicator is intended to provide specific information for use in the tiered assessment framework. This assessment framework applies only to specific nonpolar chlorinated hydrocarbons: total DDTs, total PCBs, total chlordanes and Dieldrin. The framework may be applied to assess either the entire water body or a portion, provided that the site area is at least 1 $km^2$. For small site areas, limitations on the allowable fish species apply as described in Appendix A-5.

2) Routine Monitoring

This assessment framework and tools are applicable to all enclosed bays and estuaries of California.

3) Field Procedures

All studies shall adhere to the following:

a. All sediment samples shall be collected using a grab sampler.
b. Surface sediment from within the upper 5 cm shall be collected for chemistry analyses.
c. Water samples shall be collected using passive samplers, high volume filtration, or bulk collection.
d. Fish tissue shall be collected from the species identified in Appendix A-6. Secondary species may only be used if primary species cannot be collected from the site.
e. Fish shall be collected by any legal method of take.
f. Fish shall meet sportfish angling size requirements, or, if not possible, as close to the size requirement as practical.

g. Fish shall be collected from within the site boundaries, or, if not possible, as close to the site as practical. Fish collected outside the waterbody of interest shall not be used in this assessment.
h. Specific tissue types (e.g. fillet or whole fish) required for each species are identified in Appendix A-6.
i. Sediment and tissue chemical analysis shall include the constituents identified in Appendix A-7.

Before commencing with sample collection, a study design and workplan must be developed and be approved by the Regional Board. Study design considerations are described in Appendix A-5. The conceptual site model (CSM) shall serve as the basis for the study design, define the site boundaries, guide selection of sportfish species to evaluate, and identify appropriate sediment contamination data.

#### 4) Laboratory Testing

All samples will be tested in accordance with U.S. Environmental Protection Agency (USEPA) or American Society for Testing and Materials (ASTM) methodologies where such methods exist. Where no EPA or ASTM methods exist, the Water Boards shall approve the use of other methods. Analytical tests shall be conducted by laboratories certified by the State Water Board's ELAP in accordance with Water Code Section 13176.

**Table 15. Laboratory Testing Requirements by Tier**

| Tier | Organochlorine Pest/PCBs in Sediment[3] | Total Organic Carbon | Organochlorine Pest/PCBs in Tissue[3] | Percent Lipid | Organochlorine Pest/PCBs in Water[3] |
|---|---|---|---|---|---|
| 1 | Yes[1] | Yes[1] | Yes[2] | No | No |
| 2 | Yes | Yes | Yes | Yes | Yes |
| 3 | Yes | Yes | Yes | Yes | Yes |

1. Necessary if using sediment data for the Tier 1 assessment.
2. Necessary if using tissue for the Tier 1 assessment.
3. Complete list of constituents is included in Appendix A-7

#### 5) Tiered Assessment Framework

The assessment framework is intended for use in conjunction with high quality data representative of site specific conditions and factors. A CSM and study design as described in Chapter IV.A.4.d.5) must be developed prior to data analysis. Sediment and tissue data shall not be used to assess sediments in accordance with this plan, unless they are consistent with the CSM. A well-designed study is necessary to ensure that the relationship between the contaminants in site sediment and fish tissue is assessed appropriately and that conclusions can be made with confidence (see Chapter IV.A.4.d. and Appendix A-5 for study design considerations).

### c. Tier 1 Screening Evaluation

#### 1) Purpose

Tier 1 is an optional screening evaluation that uses standardized conservative methods to evaluate the potential chemical exposure to human consumers of sportfish. The purpose of this tier is to determine whether site sediments pose a sufficient risk to warrant a complete (i.e., Tier 2) site assessment. If potential chemical exposure is below this level, sediments are unimpacted and there is no reason to perform more detailed assessment (either Tier 2 or Tier 3). Tier 1 utilizes conservative assumptions to address uncertainty and reduce the chance of concluding unacceptable chemical exposure does not exist when in fact it does.

A Tier 1 assessment may be performed using either sportfish tissue contaminant concentrations or sediment contaminant concentrations and total organic carbon, depending on what data are available. If both sediment and tissue contamination data are available, the Tier 1 assessment is performed using both data types.

2) Tier 1 Data Requirements

Tier 1 chemical exposure evaluation is obtained using all data that meet the following criteria:

a. Existing sediment and tissue data shall be no more than 6 years old at the time of the assessment and collected within site boundaries.
b. Sediment data must include matching total organic carbon content for site, or an estimate based on other data.
c. Sediment and tissue chemistry must include the constituents identified in Appendix A-7.
d. Only tissue from those primary or secondary species listed in Appendix A-6 shall be used in the analysis.

3) Tissue Evaluation

The tissue-based chemical exposure evaluation is performed by comparing measured tissue concentration to screening thresholds. This comparison shall be based on tissue data from all the species identified in the CSM.

The Tier 1 tissue concentration ($C_{Tis95}$) is equal to the mean of the 95% upper confidence limit (UCL) of the mean tissue concentration for each species.

Equation 3 $C_{Tis95} = [\Sigma\ C_{Tis95}]/n$

Where

$C_{Tis95i}$ = 95%UCL of the mean tissue concentration for sportfish species i (ng/g ww)

Σ is the sum across all species, and n is the number of species.

The minimum number of tissue samples required for Tier 1 assessment is 3.

To assess chemical exposure, the Tier 1 tissue concentration shall be compared to the tissue screening thresholds in Table 16. If the tissue concentration is greater than any tissue screening threshold in Table 16, there is the potential for unacceptable chemical exposure and a Tier 2 evaluation is required. If the tissue concentration is equal to or less than the tissue screening threshold, the chemical exposure is acceptable. Tier 1 assessment of subsistence fishers may be accomplished by applying thresholds based on Office of Environmental Health Hazard Assessment (OEHHA) Advisory Tissue Levels based on five-day consumption rate as described in the OEHHA document titled “Development of Fish Contaminant Goals and Advisory Tissue Levels for Common Contaminants in California Sport Fish: Chlordane, DDTs, Dieldrin, Methylmercury, PCBs, Selenium, and Toxaphene dated June 2008 (OEHHA, 2008), in lieu of those provided in Table 16. Use of subsistence thresholds shall only be applied to those waters where the Tribal Beneficial Uses or Tribal Subsistence Beneficial Uses have been designated by the applicable Regional Water Board.

**Table 16. Tier 1 Tissue Screening Thresholds**

| Parameter | Total DDTs (ng/g ww) | Total PCBs (ng/g ww) | Total Chlordanes (ng/g ww) | Dieldrin (ng/g ww) |
|---|---|---|---|---|
| Tier 1 Threshold[a] | >520 | >21 | >190 | >15 |

[a] Advisory Tissue Level based on three servings per week (OEHHA 2008).

4) Sediment Evaluation

Tier 1 sediment evaluation is also based on chemical exposure. The Tier 1 sediment evaluation is performed by comparing site sediment concentration to sediment screening thresholds. Sediment screening thresholds are calculated for each contaminant evaluated at the site. To conduct the sediment evaluation, compare the 95% UCL of the mean concentration for site sediment to the threshold. The minimum number of sediment samples required for Tier 1 assessment is three.

The sediment threshold is calculated as the tissue threshold divided by a biota-sediment accumulation factor (BSAF):

Equation 4 $T_{Sed} = (T_{Tis})/(BSAF)$

Where

$T_{Sed}$ = sediment screening threshold (ng/g dw)

$T_{Tis}$ = tissue screening threshold in nanograms per gram wet weight (ng/g ww)

BSAF = biota-sediment accumulation factor (BSAF) defined as wet weight chemical concentration in biota divided by dry weight chemical concentration in sediment

The highest BSAF for the dietary guilds identified in the CSM shall be used in calculating the sediment screening threshold. Tissue screening thresholds are provided in Table 16. The biota-sediment accumulation factors (BSAFs) based on the contaminant, fish guild, and site total organic carbon are included in Table 17.

5) Tier 1 Interpretation

The Tier 1 screening evaluation is only applied to assess whether sediment is unimpacted in relation to the sediment quality objective or if a more detailed analysis is required by conducting a Tier 2 assessment. Possible outcomes of the Tier 1 screening are described below.

If only tissue or only sediment is applied in Tier 1 and the result exceeds the threshold for any constituent, Tier 2 is required for those constituents. If both tissue and sediment are applied the possible outcomes are as follows:

a. If both tissue and sediment results fall below the threshold, the sediment quality is **unimpacted**.
b. If tissue results fall below the threshold and sediment equals or exceeds the threshold, the sediment quality is **unimpacted.**
c. If sediment results fall below the threshold and tissue equals or exceeds the threshold, a Tier 2 **assessment is required** for those constituents above Tier 1 thresholds.

d. If both sediment and tissue results equal or exceed the threshold, a Tier 2 **assessment is required** for those constituents above Tier 1 thresholds.

## Table 17. Tier 1 Biota Sediment Accumulation Factors (BSAF) calculated for Percent Total Organic Carbon

| | 1. Piscivore | | | | 2a. Benthic with Piscivory | | | | 2b. Benthic with Piscivory (White catfish only) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TOC (%) | Chlor | DDTs | Diel | PCBs | Chlor | DDTs | Diel | PCBs | Chlor | DDTs | Diel | PCBs |
| 0.1 | 65.8 | 83.1 | 28.1 | 79.0 | 68.6 | 90.8 | 28.5 | 86.8 | 86.6 | 118.3 | 34.1 | 113.6 |
| 0.2 | 33.7 | 43.6 | 14.2 | 41.8 | 35.7 | 48.5 | 14.5 | 46.9 | 44.9 | 63.2 | 17.3 | 61.4 |
| 0.3 | 23.0 | 30.4 | 9.5 | 29.4 | 24.7 | 34.4 | 9.8 | 33.6 | 31.0 | 44.8 | 11.6 | 43.9 |
| 0.4 | 17.6 | 23.7 | 7.2 | 23.1 | 19.2 | 27.3 | 7.5 | 26.8 | 24.0 | 35.5 | 8.8 | 35.1 |
| 0.6 | 12.2 | 17.0 | 4.8 | 16.8 | 13.7 | 20.1 | 5.2 | 20.0 | 17.0 | 26.1 | 6.0 | 26.1 |
| 0.8 | 9.5 | 13.6 | 3.7 | 13.5 | 10.9 | 16.4 | 4.0 | 16.5 | 13.5 | 21.3 | 4.6 | 21.5 |
| 1.0 | 7.9 | 11.5 | 3.0 | 11.6 | 9.3 | 14.2 | 3.3 | 14.3 | 11.4 | 18.4 | 3.8 | 18.6 |
| 1.2 | 6.8 | 10.1 | 2.5 | 10.2 | 8.1 | 12.7 | 2.8 | 12.9 | 9.9 | 16.3 | 3.2 | 16.7 |
| 1.4 | 6.0 | 9.1 | 2.2 | 9.2 | 7.3 | 11.5 | 2.5 | 11.8 | 8.9 | 14.8 | 2.8 | 15.2 |
| 1.6 | 5.4 | 8.3 | 1.9 | 8.4 | 6.7 | 10.7 | 2.2 | 10.9 | 8.1 | 13.7 | 2.5 | 14.1 |
| 1.8 | 5.0 | 7.7 | 1.7 | 7.8 | 6.2 | 10.0 | 2.0 | 10.2 | 7.5 | 12.8 | 2.3 | 13.2 |
| 2.0 | 4.6 | 7.2 | 1.6 | 7.3 | 5.8 | 9.4 | 1.9 | 9.7 | 7.0 | 12.0 | 2.1 | 12.4 |
| 2.5 | 3.9 | 6.2 | 1.3 | 6.4 | 5.1 | 8.3 | 1.6 | 8.6 | 6.1 | 10.6 | 1.7 | 11.0 |
| 3.0 | 3.4 | 5.6 | 1.1 | 5.7 | 4.6 | 7.5 | 1.4 | 7.8 | 5.5 | 9.6 | 1.5 | 10.0 |
| 3.5 | 3.1 | 5.1 | 1.0 | 5.2 | 4.2 | 7.0 | 1.3 | 7.2 | 5.0 | 8.8 | 1.3 | 9.2 |
| 4.0 | 2.8 | 4.7 | 0.9 | 4.8 | 3.9 | 6.5 | 1.2 | 6.7 | 4.6 | 8.2 | 1.2 | 8.6 |

Chlor – Total Chlordanes; Diel – Dieldrin; DDTs – Total DDTs; PCBs – Total PCBs

**Table 17. Tier 1 Biota Sediment Accumulation Factors (BSAF) calculated for percent Total Organic Carbon continued**

| | 3.Benthic and Pelagic with Piscivory | | | | 4. Benthic without Piscivory | | | | 5. Benthic and Pelagic without Piscivory | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TOC (%) | Chlor | DDTs | Diel | PCBs | Chlor | DDTs | Diel | PCBs | Chlor | DDTs | Diel | PCBs |
| 0.1 | 89.0 | 110.6 | 37.2 | 103.9 | 71.7 | 85.6 | 42.7 | 82.4 | 27.6 | 32.9 | 15.9 | 31.6 |
| 0.2 | 45.1 | 56.7 | 18.7 | 53.6 | 37.9 | 47.3 | 21.8 | 46.2 | 14.3 | 17.6 | 8.0 | 17.2 |
| 0.3 | 30.4 | 38.7 | 12.5 | 36.8 | 26.6 | 34.4 | 14.8 | 34.0 | 9.9 | 12.5 | 5.4 | 12.3 |
| 0.4 | 23.1 | 29.7 | 9.4 | 28.3 | 20.9 | 27.9 | 11.3 | 27.9 | 7.6 | 9.9 | 4.1 | 9.8 |
| 0.6 | 15.8 | 20.7 | 6.3 | 19.9 | 15.2 | 21.2 | 7.8 | 21.5 | 5.4 | 7.3 | 2.8 | 7.3 |
| 0.8 | 12.1 | 16.2 | 4.8 | 15.6 | 12.3 | 17.7 | 6.1 | 18.1 | 4.3 | 6.0 | 2.2 | 6.1 |
| 1.0 | 9.9 | 13.5 | 3.9 | 13.1 | 10.6 | 15.6 | 5.0 | 16.0 | 3.6 | 5.1 | 1.8 | 5.3 |
| 1.2 | 8.5 | 11.6 | 3.2 | 11.4 | 9.4 | 14.1 | 4.3 | 14.5 | 3.2 | 4.6 | 1.5 | 4.7 |
| 1.4 | 7.4 | 10.3 | 2.8 | 10.1 | 8.5 | 12.9 | 3.8 | 13.4 | 2.8 | 4.2 | 1.3 | 4.3 |
| 1.6 | 6.6 | 9.3 | 2.5 | 9.2 | 7.8 | 12.0 | 3.5 | 12.5 | 2.6 | 3.8 | 1.2 | 4.0 |
| 1.8 | 6.0 | 8.5 | 2.2 | 8.4 | 7.3 | 11.3 | 3.2 | 11.8 | 2.4 | 3.6 | 1.1 | 3.7 |
| 2.0 | 5.5 | 7.9 | 2.0 | 7.8 | 6.9 | 10.7 | 2.9 | 11.2 | 2.2 | 3.4 | 1.0 | 3.5 |
| 2.5 | 4.6 | 6.8 | 1.6 | 6.7 | 6.1 | 9.5 | 2.5 | 9.9 | 1.9 | 3.0 | 0.8 | 3.1 |
| 3.0 | 4.0 | 6.0 | 1.4 | 6.0 | 5.5 | 8.7 | 2.2 | 9.1 | 1.7 | 2.7 | 0.7 | 2.8 |
| 3.5 | 3.6 | 5.4 | 1.2 | 5.5 | 5.1 | 8.0 | 2.0 | 8.3 | 1.6 | 2.5 | 0.6 | 2.6 |
| 4.0 | 3.2 | 5.0 | 1.1 | 5.0 | 4.7 | 7.4 | 1.8 | 7.8 | 1.5 | 2.3 | 0.6 | 2.4 |

Chlor – Total Chlordanes; Diel – Dieldrin; DDTs – Total DDTs; PCBs – Total PCBs

**Table 17. Tier 1 Biota Sediment Accumulation Factors (BSAF) calculated for Percent Total Organic Carbon continued**

| | 6 Benthic with Herbivory | | | | 7. Benthic and Pelagic with Herbivory | | | | 8. Pelagic with Benthic Herbivory | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TOC (%) | Chlor | DDTs | Diel | PCBs | Chlor | DDTs | Diel | PCBs | Chlor | DDTs | Diel | PCBs |
| 0.1 | 62.0 | 63.7 | 43.3 | 59.2 | 20.7 | 22.3 | 14.0 | 21.0 | 44.3 | 36.9 | 40.7 | 33.4 |
| 0.2 | 32.6 | 34.1 | 22.5 | 32.0 | 10.6 | 11.6 | 7.0 | 11.0 | 23.3 | 19.7 | 21.1 | 18.0 |
| 0.3 | 22.7 | 24.2 | 15.6 | 22.9 | 7.2 | 8.0 | 4.7 | 7.6 | 16.3 | 14.0 | 14.6 | 12.9 |
| 0.4 | 17.8 | 19.2 | 12.1 | 18.3 | 5.5 | 6.2 | 3.6 | 5.9 | 12.7 | 11.1 | 11.3 | 10.3 |
| 0.6 | 12.8 | 14.2 | 8.6 | 13.6 | 3.8 | 4.4 | 2.4 | 4.2 | 9.2 | 8.2 | 8.1 | 7.7 |
| 0.8 | 10.3 | 11.6 | 6.8 | 11.2 | 2.9 | 3.5 | 1.8 | 3.4 | 7.4 | 6.8 | 6.4 | 6.4 |
| 1.0 | 8.8 | 10.0 | 5.8 | 9.8 | 2.4 | 2.9 | 1.5 | 2.9 | 6.3 | 5.9 | 5.4 | 5.6 |
| 1.2 | 7.8 | 8.9 | 5.1 | 8.8 | 2.1 | 2.6 | 1.3 | 2.5 | 5.6 | 5.3 | 4.8 | 5.0 |
| 1.4 | 7.0 | 8.2 | 4.6 | 8.0 | 1.8 | 2.3 | 1.1 | 2.3 | 5.1 | 4.8 | 4.3 | 4.6 |
| 1.6 | 6.5 | 7.5 | 4.2 | 7.4 | 1.7 | 2.1 | 1.0 | 2.1 | 4.7 | 4.5 | 3.9 | 4.3 |
| 1.8 | 6.0 | 7.0 | 3.9 | 7.0 | 1.5 | 1.9 | 0.9 | 1.9 | 4.4 | 4.2 | 3.6 | 4.1 |
| 2.0 | 5.6 | 6.6 | 3.6 | 6.6 | 1.4 | 1.8 | 0.8 | 1.8 | 4.1 | 4.0 | 3.4 | 3.9 |
| 2.5 | 4.9 | 5.9 | 3.2 | 5.8 | 1.2 | 1.6 | 0.7 | 1.6 | 3.7 | 3.6 | 3.0 | 3.5 |
| 3.0 | 4.5 | 5.3 | 2.9 | 5.3 | 1.1 | 1.4 | 0.6 | 1.4 | 3.3 | 3.3 | 2.7 | 3.3 |
| 3.5 | 4.1 | 4.9 | 2.6 | 4.9 | 1.0 | 1.3 | 0.5 | 1.3 | 3.1 | 3.1 | 2.5 | 3.0 |
| 4.0 | 3.8 | 4.5 | 2.5 | 4.5 | 0.9 | 1.2 | 0.5 | 1.2 | 2.9 | 2.9 | 2.3 | 2.9 |

Chlor – Total Chlordanes; Diel – Dieldrin; DDTs – Total DDTs; PCBs – Total PCBs

d. Tier 2 Assessment

1) Purpose

The purpose of the Tier 2 assessment is to determine if site sediments meet the sediment quality objective described in Chapter III.A.2.b. that protects human consumers of resident sportfish from bioaccumulative contaminants in sediment. Tier 2 is based on an evaluation of tissue data and sediment data to assess both chemical exposure to human consumers and the link to contaminants in sediment associated with the site. Chemical exposure is evaluated based on comparison to thresholds established by OEHHA. Evaluation of sediment linkage utilizes a mechanistic food web model to estimate tissue concentrations derived from measured sediment concentrations.

2) Tier 2 Data and Computational Requirements

Tier 2 utilizes a combination of site-specific variables presented in Table 18 and fixed model input parameters. Both types are needed to complete the assessment.

**Table 18. Tier 2 Site-Specific Information**

| Category | Variable | Quantity |
|---|---|---|
| Required | Tissue contaminant concentrations | Minimum of three samples per species, preferably composites; minimum of two species, each representing a different dietary guild, included in assessment |
| Required | Tissue lipid content (%) | One from each tissue composite analyzed above |
| Required | Sediment contaminant concentrations | Minimum of five samples per site |
| Required | Sediment total organic carbon | One from each sediment sample analyzed |
| Required | Site area and length | One measurement |
| Required | Water column contaminant concentrations | Site average or one estimate for site (min) |
| Optional | Total suspended sediment concentration, organic carbon concentration of suspended sediment, dissolved oxygen concentration, dissolved organic carbon concentration | Site average or one estimate for site (min) |
| Optional | Temperature | Site average or one estimate for site |
| Optional | Salinity | Site average or one estimate for site |

Values for optional variables may be based on site measurements (average), or estimated values based on a model (water column concentration) or regional monitoring data.

The fixed or constrained model input parameters consist of the following:

- Proportion of sportfish species consumed
- Sportfish characteristics

- o Diet
- o Home range
- Contaminant characteristics
  - o Octanol water partitioning coefficient
- The bioaccumulation model constants listed in Appendix A-8

None of the parameters listed above may be changed in the Tier 2 assessment.

Tier 2 chemical exposure evaluation is obtained using all data that meets the following criteria:

a. Consistent with CSM as described in Chapter IV.A.4.d. and Appendix A-5.

b. Sediment and tissue chemistry must include the appropriate constituents identified in Appendix A-7.

c. Tissue obtained from among the primary species representing the dietary guilds, which are:

1. California halibut
2a. Spotted sand bass
2b. White catfish
3. Queenfish
4. White croaker
5. Shiner perch
6. Common carp
7. Topsmelt
8. Striped mullet

Secondary species shall only be used as surrogate if the primary species cannot be obtained from the site. Tier 2 model calculations shall be based on primary species parameters when tissue from a secondary species is used. Weighting of species shall be based on equal proportions of each species unless justification for other proportions is provided that is based upon state angling surveys conducted by the California Department of Fish and Wildlife. Primary and secondary species and dietary guilds are presented in Appendix A-6.

3) Chemical Exposure Evaluation

Chemical exposure is assessed by comparing average tissue contaminant concentration to thresholds. The tissue thresholds are based on serving of one, two and three 8-ounce servings over the course of a week. Tissue thresholds are presented in Table 19. Tissue categories and outcomes are presented in Table 20.

**Table 19. Tier 2 Tissue Contaminant Thresholds**

| | Tier 2 Contaminant Threshold | | | |
|---|---|---|---|---|
| Parameter | FCG[1] (ng/g ww) | ATL3[2] (ng/g ww) | ATL2[3] (ng/g ww) | ATL1[4] (ng/g ww) |
| Total Chlordanes | 5.6 | 190 | 280 | 560 |
| Total DDTs | 21 | 520 | 1,000 | 2100 |
| Dieldrin | 0.46 | 15 | 23 | 46 |

| | | | | |
|---|---|---|---|---|
| Total PCBs | 3.6 | 21 | 42 | 120 |

1. FCG - Fish Contaminant Goal based on one 8-ounce serving per week
2. ATL3 - Tissue Advisory Level based on consumption of three 8-ounce servings per week
3. ATL2 - Tissue Advisory Level based on two 8-ounce servings per week
4. ATL1 - Tissue Advisory Level based on one 8-ounce serving per week

**Table 20. Tier 2 Chemical Exposure Categories**

| Tissue Contaminant Concentration | Threshold | Outcome |
|---|---|---|
| Average | < FCG | 1. Very Low |
| Average | < ATL3 | 2. Low |
| Average | < ATL2 | 3. Moderate |
| Average | < ATL1 | 4. High |
| Average | > ATL1 | 5. Very High |

4) Site Linkage Determination

A site linkage factor is calculated by comparing tissue concentrations estimated from site sediments to the observed tissue contaminant concentration for the same species used in the chemical exposure evaluation. Site linkage determination is performed separately for each contaminant class. A Monte Carlo simulation is used to generate a cumulative distribution of the site linkage factor. Percentiles are then compared to thresholds presented in Table 21 to categorize the site linkage for the site. The ratio of the sportfish tissue estimated due to sediment contamination at the site compared to the observed contamination in sportfish tissue serves as the basis for this determination as described in the following equation.

Equation 5 $C_{Est}/C_{Tis}$ = Site Linkage Factor

Where

$C_{Est}$ = Weighted average estimated tissue contaminant concentration based on the proportion of the human diet for each guild (ng/g).

$C_{Tis}$ = Weighted average observed tissue concentration

Estimated tissue concentrations are calculated from measured sediment contaminant concentrations based on the following equation.

Equation 6 $C_{Est\,i} = \Sigma\, C_{Sed} \times BSAF_i \times SUF_i$.

Where:

$C_{Est\,i}$ = estimated tissue contaminant concentration in species i contributed from site sediments

$\Sigma\, C_{Sed}$ = measured average sum contaminant concentration (sum PCBs, sum DDTs, sum chlordanes, or dieldrin) in sediment from the site, spatially weighted if appropriate.

$BSAF_i$ = biota-sediment accumulation factor for species i

$SUF_i$ = site use factor for species i = $SA/HR_i$

SA = site area ($km^2$) or length across the site (km)

$HR_i$ = sportfish home range ($km^2$) or linear movement distance (km) for species i

If significant contaminant heterogeneity or gradients are suspected in site sediments, area weighted averaging may be used to provide a representative mean.

5) Calculation of BSAF

Tier 2 employs the Arnot and Gobas food web model (2004), modified by Gobas and Arnot (2010), to calculate the BSAF for each of the fish guild species. The Arnot and Gobas model is structured to depict contaminant concentration in biota as the mass balance of key uptake and loss processes as described in the following equation:

Equation 7 Biota contaminant concentration = [(Respiratory Uptake x Water Concentration) + (Dietary Uptake x Prey Concentration)] / (Elimination + Fecal Egestion + Growth + Metabolism)

Where water concentration includes freely dissolved porewater and dissolved surface water concentrations, the proportions of which are dependent on the specific environment of each organism in the food web.

The dietary uptake for an organism is represented as:

Equation 8 $k_D * \Sigma(P_i * C_{D,i})$

Where:

$k_D$ = dietary uptake rate constant

$P_i$ = proportion by mass of prey item *i* in the total diet

$C_{D,I}$ = contaminant concentration in prey item *i*

The Arnot and Gobas model, like other food web models, includes numeric inputs that are site-specific and additional parameters that are constants. Site-specific model inputs (e.g., sportfish lipid content, sediment organic carbon, and water quality parameters), are obtained locally and modified in each unique application of the model. Site-specific inputs and food web model constants are tabulated in Appendix A-8. The model structure is specific to each fish species reflecting dietary and food web positions.

A biota contaminant concentration is calculated for each component of the food web. A BSAF is obtained for each sportfish species based on the following equation

Equation 9 BSAF = biota contaminant concentration (wet weight)/ sediment contaminant concentration (dry weight)

BSAF is the ratio of the wet weight contaminant concentration in biota to the average dry weight contaminant concentration in sediment. BSAF is calculated separately for each guild.

6) Calculation of Site Linkage Distribution

Monte Carlo simulation is used to calculate the distribution of the site linkage factor based on variability or uncertainty in average measured sediment concentration data, average measured fish tissue concentration data, average fish home range and the estimated BSAF values. Variability and uncertainty in the sediment and fish tissue concentration data is represented by the standard error of the average. Uncertainty in the estimated BSAF is based on literature values.

The Monte Carlo simulation is conducted using 10,000 random subsamples of the concentration and BSAF distributions on a log-normal basis. Site linkage is calculated for each set of subsamples. See Appendix A-8 for additional details of the calculation.

7) Site Linkage Evaluation

The results of the simulations are compiled to calculate a cumulative probability distribution of sediment linkage. The portion of the distribution less than the sediment linkage threshold is used to determine the site linkage category.

**Table 21. Site Linkage Categories for Tier 2 Evaluation**

| Cumulative % of sediment linkage distribution above threshold | Linkage threshold | Outcome |
|---|---|---|
| 0-25% | 0.5 | 1. Very Low |
| 26-50% | 0.5 | 2. Low |
| 51-75% | 0.5 | 3. Moderate |
| 76-100% | 0.5 | 4. High |

8) Site Assessment

The overall site assessment category is determined using the decision matrix presented in Table 22. Site sediments categorized as Unimpacted or Likely Unimpacted meet the sediment quality objective protecting human consumers for the specific contaminant evaluated. Site sediments categorized as Possibly Impacted, Likely Impacted or Clearly Impacted do not meet the sediment quality objective. This evaluation is performed separately for each chemical contaminant group.

**Table 22. Site Assessment Matrix**

| | | Chemical Exposure | | | | |
|---|---|---|---|---|---|---|
| | | Very Low | Low | Moderate | High | Very High |
| Site Sediment Linkage | Very Low | Unimpacted | Unimpacted | Likely Unimpacted | Likely Unimpacted | Likely Unimpacted |
| | Low | Unimpacted | Unimpacted | Likely Unimpacted | Possibly Impacted | Likely Impacted |
| | Mod | Unimpacted | Likely Unimpacted | Likely Impacted | Likely Impacted | Clearly Impacted |
| | High | Unimpacted | Likely Unimpacted | Likely Impacted | Clearly Impacted | Clearly Impacted |

### e. Tier 3 Assessment

#### 1) Purpose

A Tier 3 assessment may be performed to address unique situations or evaluate additional factors affecting the assessment not considered in Tier 2. Tier 3 may be performed to

- Improve accuracy and precision of the Tier 2 assessment
- Evaluate different risk related assumptions
- Incorporate spatial and temporal factors into the assessment
- Evaluate specific subareas, contaminant gradients or potential hotspots

Tier 3 may be performed at any time, provided that Tier 2 is completed at the same time. A change in any parameter or model from that used in Tier 2 must be justified based on site conditions in comparison to Tier 2 assumptions and values, and approved by the Regional Water Board prior to performing the analysis.

#### 2) Tier 3 Triggering Criteria

In order to proceed with Tier 3 assessment, a site must meet one of the following conditions:

a. Variation in factors or processes are present that affect contaminant bioaccumulation from sediment, resulting in a difference in the sediment linkage category. Examples of the factors include the following:

   i. Differences in the relationship between geochemical characteristics and contaminant bioavailability.
   ii. Differences in physiological processes affecting bioaccumulation model performance, such as growth rate or assimilation efficiency.
   iii. Measured sediment concentrations are not representative of actual fish forage area due to spatial or temporal variations in sediment contaminant distribution, fate, or transport.
   iv. Differences in food web or forage range of target species.
   v. Use of alternate sportfish species other than those in Appendix A-6.
   vi. Changes in exposure factors that result in a difference in chemical exposure category.
   vii. Consumption rate.
   viii. Proportion of each sportfish species consumed by humans.

#### 3) Site Assessment

Tier 3 assessments shall utilize the same framework indicators and decision criteria described in in Tier 2 and presented in Tables 20, 21, and 22, with exception of assessment of substance consumers.

Tier 3 assessments for subsistence consumers may be accomplished by adjusting the chemical exposure thresholds to provide an equivalent level of health protection as described in OEHHA 2008. If chemical exposure assessment requires evaluation of subsistence fishers, thresholds based on Office of Environmental Health Hazard Assessment (OEHHA) Advisory Tissue Level based on four- or five-day consumption rate shall be applied in lieu of those provided in Table 16, in consultation with OEHHA to ensure representative characterization of exposure. Use of subsistence thresholds shall only be applied to those waters where the Tribal Beneficial Uses or Tribal Subsistence Beneficial Uses have been designated by the applicable Regional Water Board.

### 3. Implementation for Assessing Wildlife and Resident Finfish

The narrative wildlife* and resident finfish* objective in Chapter III.A.2.c. shall be implemented on a case-by-case basis, based upon an ecological risk assessment. In conducting an ecological risk assessment, the Water Boards shall consider any applicable and relevant ecological risk information, including policies and guidance from the following sources:

- California Environmental Protection Agency's (CalEPA) Office of Environmental Health Hazard Assessment (OEHHA)
- CalEPA's Department of Toxic Substances Control (DTSC)
- California Department of Fish and Game
- U.S. Environmental Protection Agency
- National Oceanographic Atmospheric Administration
- U.S. Fish and Wildlife Service

When threatened or endangered species are present in enclosed bays and estuaries, the Water Boards shall consult with State and/or Federal Resource Trustee agencies to ensure that these species are adequately protected.

### 4. Program Specific Implementation

#### a. Implementation of Sediment Quality Objectives

Implementation of the Sediment Quality Provisions shall be conducted in accordance with the following provisions and consistent with the process shown in Appendix A-1 and A-2.

Each sediment quality objective is evaluated independently using the applicable methods described in Chapters IV.A.1. through IV.A.3. Because each objective addresses a different receptor and/or exposure pathway, sediments that meet one objective may not meet the other objective. As a result, each determination is also independent. An important difference is the spatial scale of the assessment. Compliance with aquatic life objective is determined based on the individual assessment of two or more stations within a site. Compliance with the sportfish objective is based on an overall assessment of a site that encompasses multiple sediment and tissue samples from the site. As a result, assessment of sediment quality relative to each objective may require a unique study design; however, this does not imply that the same sediment chemistry samples and other data cannot be applied to both aquatic life and sportfish-based assessment frameworks.

#### b. Dredge Materials

1) The Sediment Quality Provisions shall not apply to dredge material suitability determinations.

2) The Water Boards shall not approve a dredging project that involves the dredging of sediment that exceeds the objectives in the Sediment Quality Provisions, unless the Water Boards determine that:

   a. The polluted sediment is removed in a manner that prevents or minimizes water quality degradation.

   b. The polluted sediment is not deposited in a location that may cause significant adverse effects to aquatic life, fish, shellfish, or wildlife or may harm the beneficial uses of the receiving waters, or does not create maximum benefit to the people of the State.

   c. The activity will not cause significant adverse impacts upon a federal sanctuary, recreational area, or other waters of significant national importance.

c. NPDES Permits

1) Receiving Water and Effluent Limits for SQOs

   a. If a Water Board determines that discharge of a toxic or bioaccumulative pollutant to bay or estuarine waters has the reasonable potential to cause or contribute to an exceedance of the SQOs, the Water Board shall apply the objectives as receiving water limits.

   b. The Permittee shall be in violation of such limits if it is demonstrated that the discharge is causing or contributing to the SQO exceedance as defined in Chapter IV.A.4.c.2).

   c. Receiving water monitoring required by an NPDES permit may be satisfied by a Permitee's participation in a regional SQO monitoring program described in Chapter IV.A.4.d.

   d. The sediment chemistry guidelines presented in Tables 6 and 7 shall not be translated into or applied as effluent limits. Effluent limits established to protect or restore sediment quality shall be developed only after the following:

      i. A clear relationship has been established linking the discharge to the degradation,

      ii. The pollutants causing or contributing to the degradation have been identified, and

      iii. Appropriate loading studies have been completed to estimate the reductions in pollutant loading that will restore sediment quality.

These actions are described further in Chapters IV.A.4.f. and IV.A.4.g. Nothing in this chapter shall limit a Water Board's authority to develop and implement waste* load allocations* for Total Maximum Daily Loads. However, it is recommended that the Water Boards develop TMDL allocations using the methodology described herein, wherever possible.

2) Exceedance of Receiving Water Limit

a. Exceedance of a receiving water limit to protect aquatic life as described in Chapter III.A.2.a. is demonstrated when:

i. Any station within the site is assessed as Clearly Impacted as defined in Chapter IV.A.1.i. and IV.A.1.j. or

ii. The total percent area categorized as Possibly Impacted and/or Likely Impacted equals or exceeds 15 percent of the site area over the duration of a permit cycle. Calculation of percent area shall be based on data from spatially representative samples selected using a randomized study design or equivalent spatial analysis. Where impacted stations consist entirely of Possibly Impacted, confirmation monitoring may be conducted to further evaluate the spatial extent of the impacts or confirm the impact is present at the existing stations. The most recent monitoring data from each station will be used for the categorization, and

iii. It is demonstrated that the discharge is causing or contributing to the SQO exceedance, following the completion of the stressor identification studies described in Chapter IV.A.4.f.

iv. If studies by the Permittee demonstrate that other sources may also be contributing to the degradation of sediment quality, the Regional Water Board shall, as appropriate, require the other sources to initiate studies to assess the extent to which these sources are a contributing factor.

b. Exceedance of the receiving water limit to protect human consumers of sportfish as described in Chapter III.A.2.b. is demonstrated when:

i. The site sediments are categorized as Possibly Impacted, Likely Impacted or Clearly Impacted over the duration of a permit cycle. When the site is categorized as Possibly Impacted, confirmation monitoring may be conducted to further evaluate the spatial extent of the impacts or confirm the impact is present at the existing site. The most recent monitoring data for the site will be used for the categorization; and

ii. It is demonstrated that the discharge is causing or contributing to the SQO exceedance.

Exceedance will require the Permittee to perform additional studies as described in Chapters IV.A.4.f.

3) Receiving Water Limits Monitoring Frequency

a. Phase I Stormwater Discharges and Major Discharges—Sediment Monitoring shall not be required less frequently than once per permit cycle. For stations that are consistently classified as Unimpacted or Likely Unimpacted the frequency may be reduced to once per permit cycle. The Water Board may limit receiving water monitoring to a subset of outfalls for Phase I Stormwater Permittees.

b. Phase II Stormwater and Minor Discharges—Sediment Monitoring shall not be required more often than twice per permit cycle or less than once per permit cycle. For stations that are consistently classified as Unimpacted or Likely Unimpacted, the number of stations monitored may be reduced at the discretion of the Water Board. The Water Board may limit receiving water monitoring to a subset of outfalls for Phase II Stormwater Permittees.

c. Other Regulated Discharges and Waivers—The frequency of the monitoring for receiving water limits for other regulated discharges and waivers will be determined by the Water Board.

d. Sediment Monitoring and Assessment

1) Objective—Bedded sediments in bays contain an accumulation of pollutants from a wide variety of past and present sources discharged either directly into the bay or indirectly into waters draining into the bay. Embayments also represent highly disturbed or altered habitats as a result of dredging and physical disturbance caused by construction and maintenance of harbor works, boat and ship traffic, and development of adjacent lands. Due to the multitude of stressors and the complexity of the environment, a well-designed monitoring program is necessary to ensure that the data collected adequately characterizes the condition of sediment in these water bodies.

2) Permitted Discharges—Monitoring may be performed by individual Permittees to assess compliance with receiving water limits, or through participation in a regional or water body monitoring coalition as described under Chapter IV.A.4.d., or both as determined by the Water Board.

3) Monitoring Coalitions—To achieve maximum efficiency and economy of resources, the State Water Board encourages the regulated community in coordination with the Regional Water Boards to establish water body-monitoring coalitions. Monitoring coalitions enable the sharing of technical resources, trained personnel, and associated costs and create an integrated sediment-monitoring program within each major water body. Focusing resources on regional issues and developing a broader understanding of pollutants effects in these water bodies enables

the development of more rapid and efficient response strategies and facilitates better management of sediment quality.

a. If a regional monitoring coalition is established, the coalition shall be responsible for sediment quality assessment within the designated water body and for ensuring that appropriate studies are completed in a timely manner.

b. The Water Board shall provide oversight to ensure that coalition participants are proactive and responsive to potential sediment quality related issues as they arise during monitoring and assessment.

c. Each regional monitoring coalition shall prepare a workplan that describes the monitoring, a map of the stations, participants and a schedule that shall be submitted to the Water Board for approval.

4) Methods—Sediments and tissues collected from each station or site shall be tested and assessed using the methods and metrics described in Chapter IV.A.1. through VI.A.3.

5) Design.

a. The design of sediment monitoring programs, whether site-specific or region wide, shall be based upon a conceptual model. A conceptual model is useful for identifying the physical and chemical factors that control the fate and transport of pollutants and receptors that could be exposed to pollutants in the sediment. See Appendix A-5 for detailed explanation and direction. The conceptual model serves as the basis for assessing the appropriateness of a study design. The detail and complexity of the conceptual model is dependent upon the scope and scale of the monitoring program or tiered assessment. A conceptual model may consider the following:

- Points of discharge into the segment of the waterbody or region of interest
- Tidal flow and/or direction of predominant currents
- Historic and or legacy conditions in the vicinity
- Nearby land and marine uses or actions
- Beneficial uses
- Potential receptors of concern
- Changes in grain size salinity water depth and organic matter
- Other sources or discharges in the immediate vicinity.
- Site boundaries and site size
- Sportfish consumer population characteristics (e.g. consumption rate)
- Sportfish species to be monitored

– Food web associated with sportfish species to be monitored

– Site-specific modifications to the bioaccumulation model parameters (e.g. sportfish movement range or diet) as needed.

A definition of the site boundaries and site size is needed to aid in data collection and data reduction, in addition to being a key input for the sediment linkage indicator as described in Appendix A-5. Selection of sportfish species of interest should, to the extent the information is available, be based on the fishing and consumption practices of local consumers as well as species known to reside in the site, and representing predominant dietary guilds.

b. Sediment monitoring programs shall be designed to ensure that the aggregate stations are spatially representative of the sediment within the water body.

c. The design shall take into consideration existing data and information of appropriate quality.

d. Stratified random design shall be used where resources permit to assess conditions throughout a water body.

e. Identification of appropriate strata shall consider characteristics of the water body including sediment transport, hydrodynamics, depth, salinity, land uses, inputs (both natural and anthropogenic) and other factors that could affect the physical, chemical, or biological condition of the sediment.

f. Targeted designs shall be applied to those Permittees that are required to meet receiving water limits as described in Chapter IV.A.4.c.2).

6) Index Period—All stations shall be sampled between the months of June through September to be consistent with the benthic community condition index period.

7) Regional Monitoring Schedule and Frequency.

a. Regional sediment quality monitoring will occur at a minimum of once every five years.

b. Sediments identified as exceeding the narrative objective must be evaluated more frequently.

8) Confirmation Monitoring – Repeat monitoring conducted at the same and/or additional stations to confirm the categorization of a site or multiple stations as Possibly Impacted. Monitoring methods are the same as those used in the prior assessment.

### e. Evaluating Waters for Placement on the Section 303(d) List

1) Aquatic Life – Benthic Community Protection

In California, water segments are placed on the section 303(d) list for sediment toxicity based either on toxicity alone or toxicity that is associated with a pollutant. The listing criteria are contained in the State Water Board's Water Quality Control Policy for Developing California's Clean Water Act Section 303(d) List (Listing Policy). The Sediment Quality Provisions adds an additional listing criterion that applies only to listings for exceedances of the narrative sediment quality objective for aquatic life protection in Chapter III.A.2.a. The criterion under the Sediment Quality Provisions is described in subchapter a. below and the relationship between the sediment toxicity listing criteria under the Listing Policy and the criterion under the Sediment Quality Provisions is described in subchapter c. and d., below.

a. Water segments shall be placed on the section 303(d) list for exceedance of the narrative sediment quality objective for aquatic life protection in Chapter III.A.2.a. of the Sediment Quality Provisions only if either the following occurs:
    i. Any station within the site is assessed as Clearly Impacted as defined in Chapter IV. A.1.i. and IV.A.1.j., or
    ii. The total percent area categorized as Possibly Impacted and/or Likely Impacted equals or exceeds 15 percent of the site area over the duration of a listing cycle. Calculation of percent area shall be based on data from multiple spatially representative samples selected using a randomized study design or equivalent spatial analysis. Where impacted stations consist entirely of Possibly Impacted, confirmation monitoring may be conducted to further evaluate the spatial extent of the impacts or confirm the impact is present at the existing stations. The most recent monitoring data from each station will be used for the categorization.

b. Data to be evaluated shall include all relevant data collected from monitoring programs conducted over the duration of the listing cycle (6 years).

c. Water segments that exhibit sediment toxicity but that are not listed for an exceedance of the narrative sediment quality objective for aquatic life protection in Chapter III.A.2.a. shall continue to be listed in accordance with Section 3.6 of the Listing Policy.

d. If a water segment is listed under Section 3.6 of the Listing Policy and the Regional Water Board later determines that the applicable water quality standard that is impaired consists of the sediment quality objective in Chapter III.A.2.a. of the Sediment Quality Provisions and a bay or estuarine habitat beneficial use, the Regional Water Board shall reevaluate the listing in accordance with Chapters IV.A.1.i. and IV.A.1.j. If the Regional Water Board reevaluates the listing and determines that the water segment does not meet the criteria in Chapter IV.A.4.e.1) a. above, the Regional Water Board shall delist the water segment.

2) Human Health - Water segments shall be placed on the section 303(d) list for exceedance of the narrative sediment quality objective for human health protection in Chapter III.A.2.b. of the Sediment Quality Provisions if sediments from a site are categorized as Possibly Impacted, Likely Impacted or Clearly Impacted over the duration of the listing cycle (6 years). When the segment is categorized as Possibly Impacted, confirmation monitoring may be conducted to further evaluate the spatial extent of the impacts or confirm the impact is present at the existing site. The most recent monitoring data for the site will be used for the categorization.

3) Segment evaluation for Chapters IV.A.4.e.1) and IV.A.4.e.2) above shall use the methods described in Chapters IV.A.4.d.4) through IV.A.4.d.7) and meet the following requirements:
   a. Data used in the evaluation must be obtained from multiple spatially representative stations.
   b. Data used in the evaluation must be obtained from multiple surveys over a span of at least one year.

4) Water segments shall be removed from the section 303(d) list if the listing thresholds are not exceeded over the duration of the listing cycle and satisfy the requirements under Chapter IV.A.4.e.3) above.

f. Stressor Identification

If sediments fail to meet the narrative SQOs in accordance with Chapters IV.A.1. through IV.A.3., the Water Boards shall direct the regional monitoring coalitions or Permittees to conduct stressor identification.

The Water Boards shall assign the highest priority for stressor identification to those segments or reaches with the highest percentage of sites designated as Clearly Impacted and Likely Impacted.

Where segments or reaches contain Possibly Impacted but no Clearly or Likely Impacted sites, confirmation monitoring shall be conducted prior to initiating stressor identification.

The stressor identification approach consists of development and implementation of a work plan to seek confirmation and characterization of pollutant-related impacts, pollutant identification, and source identification. The workplan shall be submitted to the Water Board for approval. Stressor identification consists of the following studies:

1) Confirmation and Characterization of Pollutant Related Impacts—Exceedance of the aquatic life direct effects SQO at a site indicates that pollutants in the sediment are the likely cause but does not identify the specific pollutant responsible. The MLOE assessment establishes a linkage to sediment pollutants; however, the lack of confounding factors (e.g., physical disturbance, non-pollutant constituents) must be confirmed. There are two generic stressors that are not related to toxic pollutants that may cause the narrative to be exceeded:

a. Physical Alteration—Examples of physical stressors include reduced salinity, impacts from dredging, very fine or coarse grain size, and prop wash from passing ships. These types of stressors may produce a non-reference condition* in the benthic community that is similar to that caused by pollutants. If impacts to a site are purely due to physical disturbance, the LOE characteristics will likely show a degraded benthic community with little or no toxicity and low chemical concentrations.

b. Other Pollutant Related Stressors—These constituents, which include elevated total organic carbon, ammonia, nutrients and pathogens, may have sources similar to chemical pollutants. Chemical and microbiological analysis will be necessary to determine if these constituents are present. The LOE characteristics for this type of stressor would likely be a degraded benthic community with possibly an indication of toxicity, and low chemical concentrations.

2) To further assess a site that is impacted by toxic pollutants, there are several lines of investigation that may be pursued, depending on site-specific conditions. These studies may be considered and evaluated in the work plan for the confirmation effort:

a. Evaluate the spatial extent of the Area of Concern. This information can be used to evaluate the potential risk associated with the sediment, distinguish areas of known physical disturbance or pollution and evaluate the proximity to anthropogenic source gradient from such inputs as outfalls, storm drains, and industrial and agricultural activities.

b. Body burden data may be examined from animals exposed to the site's sediment to indicate if pollutants are being accumulated and to what degree.

c. Chemical specific mechanistic benchmarks* may be applied to interpret sediment chemistry concentrations.

d. Chemistry and biology data from the site should be examined to determine if there is a correlation between the two LOE.

e. Alternate biological effects data may be pursued, such as bioaccumulation* experiments and pore water toxicity or chemical analysis.

f. Other investigations that may commonly be performed as part of a Phase 1 Toxicity Identification Evaluation* (TIE).

If there is compelling evidence that the SQO exceedances contributing to a receiving water limit exceedance are not due to toxic pollutants, then the assessment area shall be designated as having achieved the receiving water limit.

3) Pollutant Identification—Methods to help determine cause may be statistical, biological, chemical or a combination. Pollutant identification studies should be structured to address site-specific conditions, and may be based upon the following:

   a. Statistical methods—Correlations between individual chemicals and biological endpoints (toxicity and benthic community).

   b. Gradient analysis—Comparisons are made between different samples taken at various distances from a chemical hotspot to examine patterns in chemical concentrations and biological responses. The concentrations of causative agents should decrease as biological effects decrease.

   c. Additional Toxicity Identification Evaluation efforts—A toxicological method for determining the cause of impairments is the use of toxicity identification evaluations (TIE). Sediment samples are manipulated chemically or physically to remove classes of chemicals or render them biologically unavailable. Following the manipulations, biological tests are performed to determine if toxicity has been removed. TIEs should be conducted at a limited number of stations, preferably those with strong biological or toxicological effects.

   d. Bioavailability*—Chemical pollutants may be present in the sediment but not biologically available to cause toxicity or degradation of the benthic community. There are several measures of bioavailability that can be made. Chemical and toxicological measurements can be made on pore water to determine the availability of sediment pollutants. Metal compounds may be naturally bound up in the sediment and rendered unavailable by the presence of sulfides. Measurement of acid volatile sulfides and simultaneously extracted metals analysis can be conducted to determine if sufficient sulfides are present to bind the observed metals. Similarly, organic compounds can be tightly bound to sediments. Measurements of sediment organic carbon and other binding phases can be conducted to determine the bioavailable fraction of organic compounds. Solid phase microextraction (SPME) or laboratory desorption experiments can also be used to identify which organics are bioavailable to benthic organisms.

   e. Verification—After specific chemicals are identified as likely causes of impairment, analysis should be performed to verify the results. Sediments can be spiked with the suspected chemicals to verify that they are indeed toxic at the concentrations observed in the field. Alternately, animals can be transplanted to suspected sites for *in situ* toxicity and bioaccumulation testing.

When stressor Identification yields inconclusive results for sites classified as Possibly Impacted, the Water Board shall require the Permittee or regional monitoring coalition to perform a one-time augmentation to that study or, alternatively, the Water Board may suspend further stressor identification studies pending the results of future routine SQO monitoring.

4) Sources Identification and Management Actions.

a. Determine if the sources are ongoing or legacy sources.

b. Determine the number and nature of ongoing sources.

c. If a single discharger is found to be responsible for discharging the stressor pollutant at a loading rate that is significant, the Regional Water Board shall require the discharger to take all necessary and appropriate steps to address exceedance of the SQO, including but not limited to reducing the pollutant loading into the sediment.

d. When multiple sources are present in the water body that discharge the stressor pollutant at a loading rate that is significant, the Regional Water Board shall require the sources to take all necessary and appropriate steps to address exceedance of the SQO. If appropriate, the Regional Water Board may adopt a TMDL to ensure attainment of the sediment standard.

### g. Cleanup and Abatement

Cleanup and abatement actions covered by Water Code section 13304 for sediments that exceed the objectives in Chapter IV shall comply with Resolution No. 92-49 (Policies and Procedures for Investigation and Cleanup and Abatement of Discharges under Water Code Section 13304), Cal. Code Regs., tit. 23, §§ 2907, 2911. In addition, all cleanup and abatement actions must comply with California Environmental Quality Act (CEQA), Public Resources Code §21000 et seq.

### h. Development of Site-Specific Sediment Management Guidelines

The Regional Water Boards may develop site-specific sediment management guidelines where appropriate, for example, where toxic stressors have been identified and controllable sources of these stressors exist or remedial goals are desired.

Development of site-specific sediment management guidelines is the process to estimate the level of the stressor pollutant that will meet the narrative sediment quality objective. The guideline can serve as the basis for cleanup goals or revision of effluent limits described in Chapter IV.A.4.b.4) above, depending upon the situation or sources. All guidelines when applied for cleanup, must comply with Resolution No. 92-49.

1) Aquatic Life Benthic Community Protection - Guideline development should only be initiated after the stressor has been identified. The goal is to establish a relationship between the

organism's exposure and the biological effect. Once this relationship is established, a pollutant specific guideline may be designated that corresponds with minimum biological effects. The following approaches can be applied to establish these relationships:

a. Correspondence with sediment chemistry. An effective guideline can best be derived based upon the site-specific, or reach-specific relationship between the stressor pollutant exposure and biological response. Therefore the correspondence between the bulk sediment stressor concentration and biological effects should be examined.

b. Correspondence with bioavailable pollutant concentration. The concentration of the bioavailable fraction of the stressor pollutants is likely to show a less variable relationship to biological effects than bulk sediment chemistry. Interstitial water analysis, SPME, desorption experiments, selective extractions, or mechanistic models may indicate the bioavailable pollutant concentration. The correspondence between the bioavailable stressor concentration and biological effects should be examined.

c. Correspondence with tissue residue. The concentration of the stressor accumulated by a target organism may provide a measure of the stressor dose for some chemicals (e.g., those that are not rapidly metabolized). The tissue residue threshold concentration associated with unacceptable biological effects can be combined with a biota-sediment accumulation factor or model to estimate the loading or sediment concentration guideline.

d. Literature review. If site-specific analyses are ambiguous or unable to determine a guideline, then the results of similar development efforts for other areas should be reviewed. Scientifically credible values from other studies can be combined with mechanistic or empirical models of bioavailability, toxic potency, and organism sensitivity to estimate guidelines for the area of interest.

e. The chemistry LOE of Chapter IV.A.1.h.2), including the threshold values (e.g. CSI and CALRM), shall not be used for setting cleanup levels or numeric values for technical TMDLs.

2) Human Health Protection - Development of management guidelines for human health should be based upon site-specific biota-sediment accumulation factors for sportfish derived using bioaccumulation modeling. The goal is to determine a sediment contaminant concentration that will result in acceptable levels of

tissue contamination in site sportfish. The following approach can be applied to develop these guidelines:

a. Calculation of sediment concentration (Cs) corresponding to attainment of acceptable sportfish contaminant concentration based on biota-sediment accumulation factor ($BSAF_{95}$).

Equation 10 Cs = Ctt/BSAF95 where:

Cs = sediment management concentration (ng/g dry wt);

Ctt = tissue threshold (ng/g wet wt) corresponding to OEHHA ATL3

$BSAF_{95}$ = highest upper 95th percentile of BSAF derived from bioaccumulation model for species used in the assessment

b. Empirical BSAFs derived from site tissue and sediment data may be used when appropriate model-based BSAFs are not available

c. Calculation of sediment guidelines according to a. and b. (above) are based on the assumption that site sediment contamination is the primary determinant of tissue contamination. In situations where other contamination sources are important, such as water column contamination from offsite areas or watershed inputs, these approaches may not achieve the desired tissue contaminant levels. In such situations, the contributions from these additional sources should be accounted for when deriving management guidelines.

d. Regional background contamination should be taken into account when establishing management guidelines or actions. Regional background is defined as the concentration of contaminant that is primarily attributable to diffuse sources, not attributable to a specific source or release. It is not feasible to establish management guidelines for a site that are below regional background, as they cannot be expected to be attained within a defined timeframe. Instead, such values should be regarded as management goals to inform watershed-based management plans.

3) The assessment categorical results of Unimpacted and Likely Unimpacted may be used as alternative sediment management guidelines in lieu of numeric targets.

# V. GLOSSARY

ADVISORY TISSUE LEVEL (ATL): Developed by CalEPA Office of Environmental Health Hazard Assessment that serve as the basis for consumption advice for consumption of fish in California.

AQUATIC LIFE: For the purpose of the Sediment Quality Provisions, aquatic life refers to benthic invertebrates, shellfish sport fish and finfish.

BAYS: For the purpose of the Sediment Quality Provisions, bays are defined as enclosed bays*.

BENTHIC: Living on or in bottom of the ocean, bays, and estuaries, or in the streambed.

BIOACCUMULATION: A process in which an organism's body burden of a pollutant exceeds that in its surrounding environment as a result of chemical uptake through all routes of chemical exposure; dietary and dermal absorption and transport across the respiratory surface.

BIOAVAILABILITY: The fraction of a pollutant that an organism is exposed to that is available for uptake through biological membranes (gut, gills).

BIOTA-SEDIMENT ACCUMULATION FACTOR (BSAF): wet weight chemical concentration in biota (ng/g) divided by dry weight chemical concentration in sediment (ng/g).

CHEMICALS OF CONCERN (COCS): Pollutants that occur in environmental media at levels that pose a risk to ecological receptors or human health.

CONTAMINATION: An impairment of the quality of the waters of the State by waste to a degree that creates a hazard to the public health through poisoning or through the spread of disease. "Contamination" includes any equivalent effect resulting from the disposal of waste whether or not waters of the State are affected (CWC section 13050(k)).

EFFECT SIZE: The maximum magnitude of exceedance frequency that is tolerated.

ENCLOSED BAYS: Indentations along the coast that enclose an area of oceanic water within distinct headlands or harbor works. Enclosed bays include all bays where the narrowest distance between headlands or outermost harbor works is less than 75 percent of the greatest dimension of the enclosed portion of the bay. This definition includes, but is not limited to: Humboldt Bay, Bodega Harbor, Tomales Bay, Drakes Estero, San Francisco Bay, Morro Bay, Los Angeles Harbor, Upper and Lower Newport Bay, Mission Bay, and San Diego Bay.

ENDPOINT: A measured response of a receptor to a stressor. An endpoint can be measured in a toxicity test or in a field survey.

ESTUARIES AND COASTAL LAGOONS: Waters at the mouths of streams that serve as mixing zones* for fresh and ocean waters during a major portion of the year. Mouths of streams that are temporarily separated from the ocean by sandbars shall be considered as estuaries. Estuarine waters will generally be considered to extend from a bay or the open ocean to the upstream limit of tidal action but may be considered to extend seaward if significant mixing of fresh and salt water occurs in the open coastal waters. The waters described by this definition include, but are not limited to, the Sacramento-San Joaquin Delta as defined by Section 12220 of the California Water Code, Suisun Bay, Carquinez Strait downstream to Carquinez Bridge, and appropriate areas of the Smith, Klamath, Mad, Eel, Noyo, and Russian Rivers.

EUHALINE: Waters ranging in salinity from 25–32 practical salinity units (psu).

FISH CONTAMINANT GOAL (FCG): Developed by CalEPA Office of Environmental Health Hazard Assessment to provide fish tissue goal for pollution mitigation or elimination.

INLAND SURFACE WATERS: All surface waters of the State that do not include the ocean, enclosed bays, or estuaries.

LOAD ALLOCATION (LA): The portion of a receiving water's total maximum daily load that is allocated to one of its nonpoint sources of pollution or to natural background sources.

MECHANISTIC BENCHMARKS: Chemical guidelines developed based upon theoretical processes governing bioavailability and the relationship to biological effects.

MIXING ZONE: A limited zone within a receiving water that is allocated for mixing with a wastewater discharge where water quality criteria can be exceeded without causing adverse effects to the overall water body.

NONPOINT SOURCES: Sources that do not meet the definition of a point source as defined below.

NULL HYPOTHESIS: A statement used in statistical testing that has been put forward either because it is believed to be true or because it is to be used as a basis for argument, but has not been proved.

OCEAN WATERS: Territorial marine waters of the State as defined by California law to the extent these waters are outside of enclosed bays, estuaries, and coastal lagoons. Discharges to ocean waters are regulated in accordance with the State Water Board's California Ocean Plan.

POINT SOURCE: Any discernible, confined and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged. This term does not include agricultural stormwater discharges and return flows from irrigated agriculture.

POLLUTANT: Defined in section 502(6) of the CWA as "dredged spoil, solid waste, incinerator residue, filter backwash, sewage, garbage, sewage sludge, munitions, chemical wastes, biological materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt and industrial, municipal, and agricultural waste discharged into water."

POLLUTION: Defined in section 502(19) of the CWA as the "the man-made or man-induced alteration of the chemical, physical, biological, and radiological integrity of water." *Pollution* is also defined in CWC section 13050(1) as an alternation of the quality of the waters of the State by waste to a degree that unreasonably affects either the waters for beneficial uses or the facilities that serve these beneficial uses.

POLYHALINE: Waters ranging in salinity from 18–25 psu.

REFERENCE CONDITION: The characteristics of water body segments least impaired by human activities. As such, reference conditions can be used to describe attainable biological or habitat conditions for water body segments with common watershed/catchment characteristics within defined geographical regions.

RESIDENT FINFISH: Any species of bony fish or cartilaginous fish (sharks, skates and rays) whose home range occupies all or part of the water body but does not extend into other water bodies.

SPECIES RICHNESS: The number of species in a sample.

SURFICIAL SEDIMENTS: Those sediments representing recent depositional materials and containing the majority of the benthic invertebrate community.

STATISTICAL SIGNIFICANCE: When it can be demonstrated that the probability of obtaining a difference by chance only is relatively low.

TOTAL CHLORDANES: SUM of alpha Chlordane, gamma Chlordane, cis-Nonachlor, trans-Nonachlor, and Oxychlordane.

TOTAL DDTS: Sum of o,p'-DDE, o,p'-DDD, o,p'-DDT, p,p'-DDD, p'p'-DDE, and p,p'-DDT.

TOTAL PCBS: Sum of all PCB congeners listed in Table A-7.

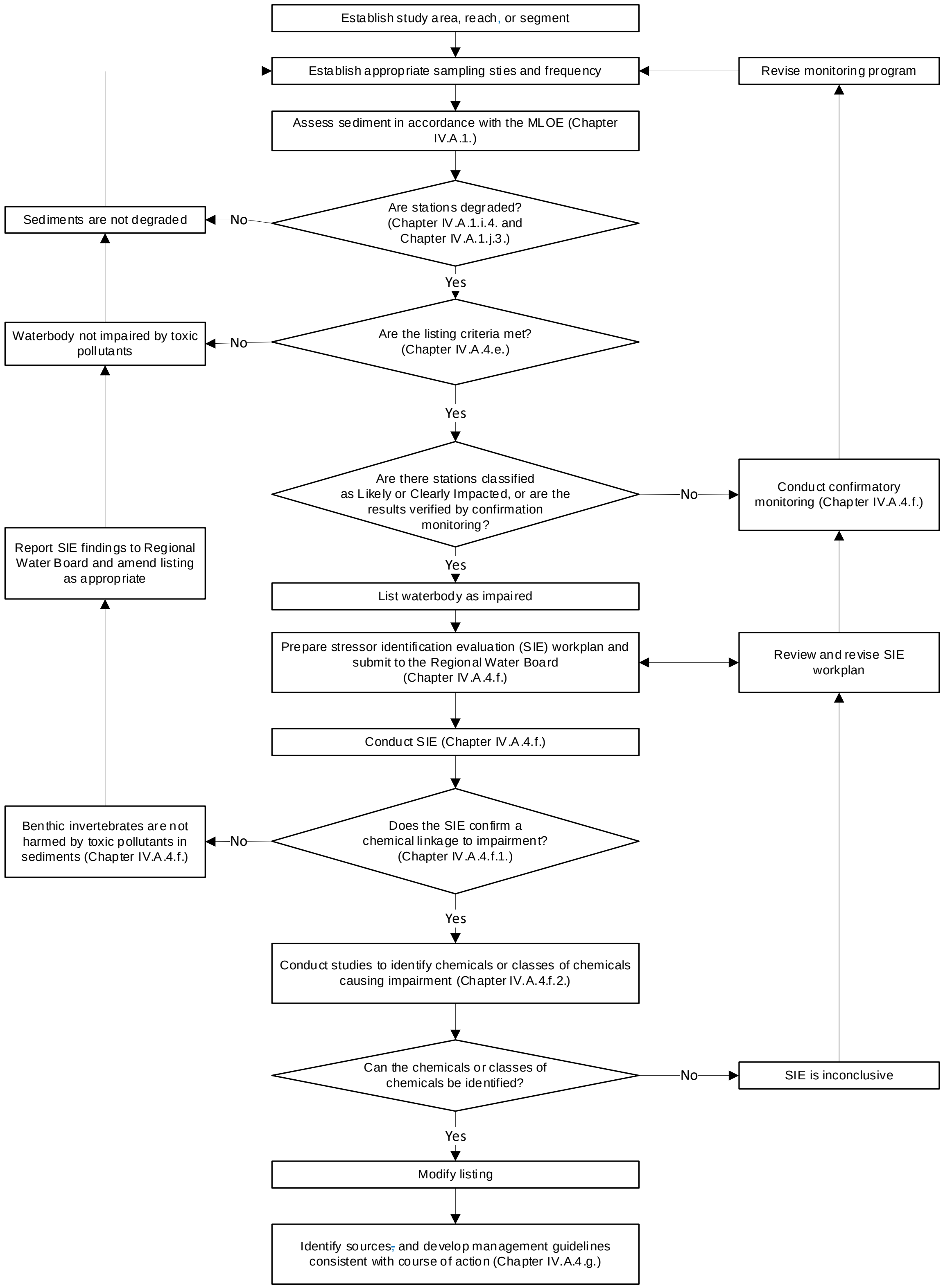
TOXICITY IDENTIFICATION EVALUATION (TIE): Techniques used to identify the unexplained cause(s) of toxic events. TIE involves selectively removing classes of chemicals through a series of sample manipulations, effectively reducing complex mixtures of chemicals in natural waters to simple components for analysis. Following each manipulation the toxicity of the sample is assessed to see whether the toxicant class removed was responsible for the toxicity.

WASTE: As used in this document, waste includes a discharger's total discharge, of whatever origin, i.e., gross, not net, discharge.

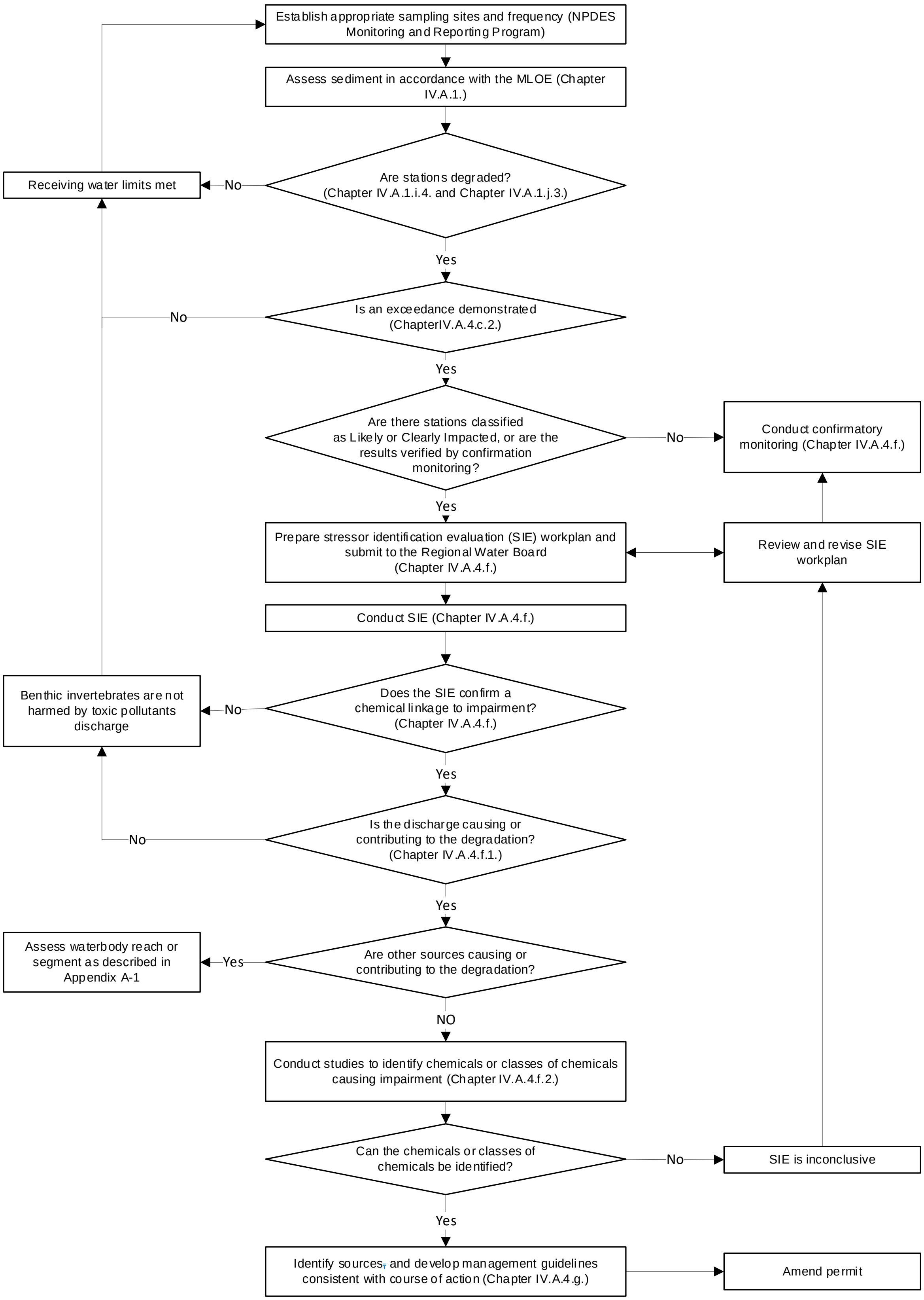
WILDLIFE: All tetrapod vertebrates, including amphibians, reptiles, birds and mammals, inclusive of marine mammals.

# APPENDICIES

# APPENDIX A-1: FIGURE OF WATERBODY ASSESSMENT PROCESS FOR BENTHIC COMMUNITY PROTECTION



# APPENDIX A-2: FIGURE OF POINT SOURCE ASSESSMENT PROCESS FOR BENTHIC COMMUNITY PROTECTION



## APPENDIX A-3: LIST OF CHEMICAL ANALYTES NEEDED TO CHARACTERIZE SEDIMENT CONTAMINATION EXPOSURE AND EFFECT FOR BENTHIC COMMUNITY PROTECTION

| Chemical Name | Chemical Group | Chemical Name | Chemical Group |
|---|---|---|---|
| Total Organic Carbon | General | Alpha Chlordane | Pesticide |
| Percent Fines | General | Gamma Chlordane | Pesticide |
| | | Trans Nonachlor | Pesticide |
| Cadmium | Metal | Dieldrin | Pesticide |
| Copper | Metal | o,p’-DDE | Pesticide |
| Lead | Metal | o,p’-DDD | Pesticide |
| Mercury | Metal | o,p’-DDT | Pesticide |
| Zinc | Metal | p,p’-DDD | Pesticide |
| | | p,p’-DDE | Pesticide |
| | | p,p’-DDT | Pesticide |
| | | | |
| Acenaphthene (L) | PAH | 2,4'-Dichlorobiphenyl(PCB8) | PCB congener |
| Anthracene (L) | PAH | 2,2',5-Trichlorobiphenyl(PCB18) | PCB congener |
| Biphenyl (L) | PAH | 2,4,4'-Trichlorobiphenyl(PCB28) | PCB congener |
| Naphthalene (L) | PAH | 2,2',3,5'-Tetrachlorobiphenyl(PCB44) | PCB congener |
| 2,6-dimethylnaphthalene (L) | PAH | 2,2',5,5'-Tetrachlorobiphenyl(PCB52) | PCB congener |
| Fluorene (L) | PAH | 2,3',4,4'-Tetrachlorobiphenyl(PCB66) | PCB congener |
| 1-methylnaphthalene (L) | PAH | 2,2',4,5,5'-Pentachlorobiphenyl(PCB101) | PCB congener |
| 2-methylnaphthalene (L) | PAH | 2,3,3',4,4'-Pentachlorobiphenyl(PCB105) | PCB congener |
| 1-methylphenanthrene (L) | PAH | 2,3,3’,4’,6-Pentachlorobiphenyl (PCB110) | PCB congener |
| Phenanthrene (L) | PAH | 2,3',4,4',5-Pentachlorobiphenyl(PCB118) | PCB congener |
| Benzo(a)anthracene (H) | PAH | 2,2',3,3',4,4'-Hexachlorobiphenyl(PCB128) | PCB congener |
| Benzo(a)pyrene (H) | PAH | 2,2',3,4,4',5'-Hexachlorobiphenyl(PCB138) | PCB congener |
| Benzo(e)pyrene (H) | PAH | 2,2',4,4',5,5'-Hexachlorobiphenyl(PCB153) | PCB congener |
| Chrysene (H) | PAH | | |
| Dibenz(a,h)anthracene (H) | PAH | 2,2',3,4,4',5,5'-Heptachlorobiphenyl(PCB180) | PCB congener |
| Fluoranthene (H) | PAH | 2,2',3,4',5,5',6-Heptachlorobiphenyl(PCB187) | PCB congener |
| Perylene (H) | PAH | 2,2',3,3',4,4',5,6-Octachlorobiphenyl(PCB195) | PCB congener |
| Pyrene (H) | PAH | | |

(L) = Low molecular weight PAH
(H) = High molecular weight PAH

## APPENDIX A-4: STATION ASSESSMENT CATEGORY RESULTING FROM EACH POSSIBLE MLOE COMBINATION

| LOE Category Combination | Sediment Chemistry Exposure | Benthic Community Condition | Sediment Toxicity | Station Assessment |
|---|---|---|---|---|
| 1 | Minimal | Reference | Nontoxic | Unimpacted |
| 2 | Minimal | Reference | Low | Unimpacted |
| 3 | Minimal | Reference | Moderate | Unimpacted |
| 4 | Minimal | Reference | High | Inconclusive |
| 5 | Minimal | Low | Nontoxic | Unimpacted |
| 6 | Minimal | Low | Low | Likely unimpacted |
| 7 | Minimal | Low | Moderate | Likely unimpacted |
| 8 | Minimal | Low | High | Possibly impacted |
| 9 | Minimal | Moderate | Nontoxic | Likely unimpacted |
| 10 | Minimal | Moderate | Low | Likely unimpacted |
| 11 | Minimal | Moderate | Moderate | Possibly impacted |
| 12 | Minimal | Moderate | High | Likely impacted |
| 13 | Minimal | High | Nontoxic | Likely unimpacted |
| 14 | Minimal | High | Low | Inconclusive |
| 15 | Minimal | High | Moderate | Possibly impacted |
| 16 | Minimal | High | High | Likely impacted |
| 17 | Low | Reference | Nontoxic | Unimpacted |
| 18 | Low | Reference | Low | Unimpacted |
| 19 | Low | Reference | Moderate | Likely unimpacted |
| 20 | Low | Reference | High | Possibly impacted |
| 21 | Low | Low | Nontoxic | Unimpacted |
| 22 | Low | Low | Low | Likely unimpacted |
| 23 | Low | Low | Moderate | Possibly impacted |
| 24 | Low | Low | High | Possibly impacted |
| 25 | Low | Moderate | Nontoxic | Likely unimpacted |
| 26 | Low | Moderate | Low | Possibly impacted |
| 27 | Low | Moderate | Moderate | Likely impacted |
| 28 | Low | Moderate | High | Likely impacted |
| 29 | Low | High | Nontoxic | Likely unimpacted |
| 30 | Low | High | Low | Possibly impacted |
| 31 | Low | High | Moderate | Likely impacted |
| 32 | Low | High | High | Likely impacted |
| 33 | Moderate | Reference | Nontoxic | Unimpacted |
| 34 | Moderate | Reference | Low | Likely unimpacted |
| 35 | Moderate | Reference | Moderate | Likely unimpacted |
| 36 | Moderate | Reference | High | Possibly impacted |
| 37 | Moderate | Low | Nontoxic | Unimpacted |
| 38 | Moderate | Low | Low | Possibly impacted |
| 39 | Moderate | Low | Moderate | Possibly impacted |
| 40 | Moderate | Low | High | Possibly impacted |
| 41 | Moderate | Moderate | Nontoxic | Possibly impacted |
| 42 | Moderate | Moderate | Low | Likely impacted |
| 43 | Moderate | Moderate | Moderate | Likely impacted |
| 44 | Moderate | Moderate | High | Likely impacted |

| LOE Category Combination | Sediment Chemistry Exposure | Benthic Community Condition | Sediment Toxicity | Station Assessment |
|---|---|---|---|---|
| 45 | Moderate | High | Nontoxic | Possibly impacted |
| 46 | Moderate | High | Low | Likely impacted |
| 47 | Moderate | High | Moderate | Likely impacted |
| 48 | Moderate | High | High | Likely impacted |
| 49 | High | Reference | Nontoxic | Likely unimpacted |
| 50 | High | Reference | Low | Likely unimpacted |
| 51 | High | Reference | Moderate | Inconclusive |
| 52 | High | Reference | High | Likely impacted |
| 53 | High | Low | Nontoxic | Likely unimpacted |
| 54 | High | Low | Low | Possibly impacted |
| 55 | High | Low | Moderate | Likely impacted |
| 56 | High | Low | High | Likely impacted |
| 57 | High | Moderate | Nontoxic | Likely impacted |
| 58 | High | Moderate | Low | Likely impacted |
| 59 | High | Moderate | Moderate | Clearly impacted |
| 60 | High | Moderate | High | Clearly impacted |
| 61 | High | High | Nontoxic | Likely impacted |
| 62 | High | High | Low | Likely impacted |
| 63 | High | High | Moderate | Clearly impacted |
| 64 | High | High | High | Clearly impacted |

## APPENDIX A-5: DESIGN CONSIDERATIONS FOR HUMAN HEALTH SQO ASSESSMENT

The first step in site assessment for the human health SQO is to develop a conceptual site model (CSM) that describes the specific site or waterbody characteristics, contaminants, receptors, and sources that are important to the study design. This is needed to determine key assessment design elements, such as site size, sportfish species to monitor, and number of samples to collect. A CSM generally includes a written description of the specific issues associated with a site, as well as a graphical depiction of contaminant sources, processes, and receptors (i.e., target species). The graphical depiction aids in beginning to identify potential linkages, as well as sources of uncertainty, such as what types of anglers capture and consume fish from the site, how frequently does fishing activity occur, and what seafood species occur on the site. The detail and complexity of the conceptual model is dependent upon the scope and scale of the assessment. For Tier 1, a limited CSM that focuses primarily on site boundaries, historical data availability, and basis for the selection of fish species may be appropriate.

The CSM should be based on local information and expertise, and developed in a collaborative process that includes local environmental managers, stakeholders, and scientists. The CSM can be informed by prior and ongoing scientific activities, including literature, prior field data collection, anecdotal evidence, and modeling activities. This information should be documented as part of CSM development. Issues to be considered and addressed include: model assumptions; key processes; spatial and temporal scales of interest; system characteristics and behaviors; available data sources and collection programs; and data gaps. The CSM should be written in clear language with a minimum of jargon.

The CSM should identify water body characteristics, key exposure pathways, and areas of uncertainty. For the human health SQO, exposure pathways are defined, a priori, as human consumption of contaminated sportfish. However, there are site-specific aspects of consumption that should be addressed in the CSM. Specifically, the CSM should contain information needed to determine the following study design parameters:

- Site boundaries and site size
- Sportfish consumer population characteristics (e.g., consumption rate)
- Fish species to be monitored
- Food web associated with target sportfish species
- Site-specific modification to other parameters (e.g., sportfish movement range or diet) as needed
- Sediment contaminant sources
- Contaminant fate and transport mechanisms

A definition of the site boundaries and site size is needed to aid in data collection and data reduction, in addition to being a key input for the sediment contribution indicator. A site for SQO assessment is defined as an area of sufficient size to encompass key elements of the food web responsible for fish tissue contamination. The site should be large enough to include most of the foraging activities of the target sportfish, but not so large as to obscure linkages between sediment and tissue contamination. Site boundaries may be defined based on geomorphic and hydrologic boundaries, fish movement patterns, areas of management concern, previous boundary definitions (e.g., water body segments), and other local considerations.

Site size (area or length) may influence the accuracy of the site linkage indicator. The bioaccumulation modeling approach used in the assessment framework incorporates a site use factor that represents the proportion of sportfish foraging activity that occurs within the site. Use of a site that is substantially smaller than the forage area of the target sportfish will reduce the apparent linkage of the site sediment to fish bioaccumulation and may result in an underestimate of the site linkage. Selection of a very large site for assessment may also result in an underestimate of site linkage because of spatial variation in sediment contamination or foraging activity within the site. For example, the average sediment contaminant concentration over a large area may not accurately represent the concentration in subareas of the site that represent the main forage area or the fish. A minimum site area of 1 $km^2$ is required for Tier 2 assessment, as this area encompasses a large portion of the forage range for most of the primary sportfish species for assessment. Application of the Tier 2 methodology to smaller sites is likely to provide an inaccurate site linkage evaluation because uptake from foraging activities outside of the site is not specifically considered. Assessment of sites <1$km^2$ may require a Tier 3 assessment and use of an alternative bioaccumulation model. For sites of 1 to 10 $km^2$, California halibut or striped mullet should not be included as target species because their forage range is much larger than the site.

Another consideration is the spatial distribution of sediment contamination within a site. Some sites may contain specific areas of elevated contamination ("hotspots"), and it may be worthwhile to perform the assessment at multiple scales, including the hotspots, as well as less contaminated areas, to determine whether the assessment outcome would be different. During the CSM development, it would be useful to compile existing data on contamination in sportfish and sediment, and plot the results to examine the spatial distribution of contamination. Similarly, journal publications and technical reports describing contaminant sources and spatial patterns should be summarized, and local experts consulted, to identify potential hotspot areas.

The seafood consumer population is chosen based on what is known about fishing practices and consumption rates at the site. Selection of an appropriate consumer population will aid in identifying available information on local consumption rates. Surveys from other California water bodies may be employed to determine consumption rates if local data are not available. Selection of seafood species of interest will be based on the fishing and consumption practices of local consumers, as well as species known to reside in the site, and representing predominant dietary guilds. Influence of existing advisories on consumption rates should also be considered.

Additionally, the CSM can describe the broader environmental processes and pathways that affect human exposure to contaminated seafood at the site. This can include a depiction of the historic and current sources and processes that potentially result in elevated or reduced site sediment contamination. Examples of potential sources are legacy contaminated sites, agricultural or urban areas in which the contaminants were historically used. Processes that change site sediment contamination may include erosion or deposition events, or management activities that contribute to or reduce food web exposure to sediment contamination. The CSM may also include a description of other environmental matrices or areas outside the site that could result in food web contaminant exposure (e.g., known hotspots outside the site; ongoing external sources such as tributaries or storm basins). More complex contaminant fate and process information may be incorporated into a Tier 3 assessment, if deemed necessary.

CSM development is a dynamic process. As additional data and information becomes available, they are used to refine the CSM, by adding additional sources, pathways, or targets, or modifying existing linkages. Periodic refinement of the CSM may be needed to address site characteristics impacted by climate change, including changes to the food web or foraging behavior and range.  As proposed in this framework an initial CSM is developed prior to Tier 1 assessment, and there is the opportunity to revisit the CSM prior to Tiers 2 and 3, if the later Tiers are conducted.

## APPENDIX A-6: PRIMARY AND SECONDARY SPECIES AND ASSOCIATED DIETARY GUILD CATEGORIES USED FOR CHEMICAL EXPOSURE AND SITE LINKAGE EVALUATIONS. TISSUE TYPE DENOTED BY F (SKIN OFF FILLET) OR W (WHOLE FISH, WITHOUT HEAD OR INTERNAL ORGANS)

| ***Dietary Guild*** | ***Description*** | ***Primary Guild Species*** | ***Secondary Guild Species*** |
|---|---|---|---|
| Piscivory | The majority of the diet is fish. Large predatory invertebrates (e.g., cephalopods, decapod crustaceans, and echinoderms) are also consumed to some degree. | California halibut (F) | Pacific angel shark (F)<br>Lingcod(F) |
| Benthic diet with piscivory | Diet regularly includes a mixture of benthic invertebrates and forage fish. The most diverse category. Includes two estuarine species: white catfish and channel catfish, each of which is commonly targeted by recreational anglers in the Sacramento-San Joaquin Delta (Shilling et al. 2010). | Spotted sand bass (F)<br>White catfish (F) | Leopard shark(F)<br>Barred sand bass(F)<br>Bat Ray(F)<br>Yellowfin croaker(F)<br>Bonefish<br>White seabass(F)<br>Brown rockfish(F)<br>Brown smoothhound(F)<br>Redtail surfperch(F)<br>Pacific sanddab(F)<br>Grass rockfish(F)<br>Starry flounder(F)<br>Cabezon (F)<br>English sole(F)<br>Channel catfish(F) |
| Benthic and pelagic diet with piscivory | Diet includes a combination of benthic invertebrates, pelagic invertebrates (e.g., zooplankton, shrimp, and mysidae), and forage fish. | Queenfish(F) | Black rockfish(F)<br>Kelp bass(F)<br>Blue rockfish(F) |
| Benthic diet without piscivory | Diet largely composed of small benthic invertebrates, such as amphipods and other crustaceans, bivalve mollusks, and polychaete worms. | White croaker(F) | Spotfin croaker(F)<br>Sargo(F)<br>Striped seaperch(W)<br>White seaperch(W)<br>Pile perch(W)<br>Walleye surfperch(W)<br>Rubberlip seaperch(W)<br>Barred surfperch(W)<br>Fantail sole(F) |
| Benthic and pelagic diet without piscivory | Diet includes a mixture of epibenthic and pelagic invertebrates (e.g., zooplankton, shrimp, and mysids). | Shiner perch(W) | Black perch(W)<br>Dwarf perch(W) |
| Benthic diet with herbivory | Largely consumes benthic invertebrates, benthic algae, and aquatic plants. Includes common carp, an estuarine species captured in the Delta | Common carp(F) | Monkeyface prickleback(F)<br>Señorita(W) |
| Benthic and pelagic diet with herbivory | Diet consists of benthic and pelagic invertebrates and plant material, including benthic algae and phytoplankton. | Topsmelt(W) | |
| Pelagic diet with benthic herbivory | Diet includes largely pelagic invertebrates and benthic algae. This includes a substantial component of benthic algae and attached plants, likely as floating detritus. These benthic plants constitute a potential dietary association with sediment. | Striped mullet(F) | |

## APPENDIX A-7: LIST OF CHEMICAL ANALYTES FOR SEDIMENT, TISSUE, AND WATER SAMPLES NEEDED TO CHARACTERIZE SEDIMENT CONTAMINATION EXPOSURE AND EFFECT FOR HUMAN HEALTH

| Chemical Name | Chemical Group | Chemical Name | Chemical Group |
|---|---|---|---|
| Total Organic Carbon[1] | General | PCB 095 | PCB congener |
| Percent lipids[2] | General | PCB 097 | PCB congener |
| | | PCB 099 | PCB congener |
| alpha Chlordane | Pesticide | PCB 101 | PCB congener |
| gamma Chlordane | Pesticide | PCB 105 | PCB congener |
| cis-Nonachlor | Pesticide | PCB 110 | PCB congener |
| trans-Nonachlor | Pesticide | PCB 114 | PCB congener |
| Oxychlordane | Pesticide | PCB 118 | PCB congener |
| | | PCB 126 | PCB congener |
| Dieldrin | Pesticide | PCB 128 | PCB congener |
| | | PCB 137 | PCB congener |
| o,p'-DDE | Pesticide | PCB 138 | PCB congener |
| o,p'-DDD | Pesticide | PCB 141 | PCB congener |
| o,p'-DDT | Pesticide | PCB 146 | PCB congener |
| p,p'-DDD | Pesticide | PCB 149 | PCB congener |
| p,p'-DDE | Pesticide | PCB 151 | PCB congener |
| p,p'-DDT | Pesticide | PCB 153 | PCB congener |
| | | PCB 156 | PCB congener |
| PCB 008 | PCB congener | PCB 157 | PCB congener |
| PCB 018 | PCB congener | PCB 158 | PCB congener |
| PCB 027 | PCB congener | PCB 169 | PCB congener |
| PCB 028 | PCB congener | PCB 170 | PCB congener |
| PCB 029 | PCB congener | PCB 174 | PCB congener |
| PCB 031 | PCB congener | PCB 177 | PCB congener |
| PCB 033 | PCB congener | PCB 180 | PCB congener |
| PCB 044 | PCB congener | PCB 183 | PCB congener |
| PCB 049 | PCB congener | PCB 187 | PCB congener |
| PCB 052 | PCB congener | PCB 189 | PCB congener |
| PCB 056 | PCB congener | PCB 194 | PCB congener |
| PCB 060 | PCB congener | PCB 195 | PCB congener |
| PCB 064 | PCB congener | PCB 198 | PCB congener |
| PCB 066 | PCB congener | PCB 199 | PCB congener |
| PCB 070 | PCB congener | PCB 200 | PCB congener |
| PCB 074 | PCB congener | PCB 201 | PCB congener |
| PCB 077 | PCB congener | PCB 203 | PCB congener |
| PCB 087 | PCB congener | PCB 206 | PCB congener |
| | | PCB 209 | PCB congener |

1. Sediment only
2. Tissue only

# APPENDIX A-8: BIOACCUMULATION MODEL COMPONENTS

## Bioaccumulation Model Equations

This assessment framework employs the Arnot and Gobas food web model (2004), modified by Gobas and Arnot (2010), to calculate the biota-sediment accumulation factors (BSAFs) for each of the fish guild species. This is a mechanistic bioaccumulation model which has limited complexity to increase ease of application while accurately depicting the primary bioaccumulation processes (Burkhard 1998, Arnot and Gobas 2004). The Arnot and Gobas model is structured to depict contaminant concentration in biota as the mass balance of key uptake and loss processes. The model equation structure accounts for uptake by diet and respiration; loss by egestion, metabolism, and respiratory elimination; and growth dilution:

Biota Concentration ($C_{Biota}$)=
(Respiratory Uptake*Water Concentration+ Dietary Uptake*Prey Concentration) /
(Elimination + Fecal Egestion + Growth + Metabolism)

The model equations presented here are used to calculate biota concentration and BSAF for each model species. All model equations and assumptions have been presented in detail elsewhere (Gobas 1993, Arnot and Gobas 2004, Gobas and Arnot 2005, Gobas and Arnot 2010).

A few minor modifications were made to the Gobas and Arnot model equations for this framework. The first change was to modify the list of PCB congeners to match multiple California regional monitoring programs, as well as the addition of three classes of chlorinated pesticides: chlordanes, dieldrin, and DDTs. The second modification consists of basing temperature and salinity corrected $K_{OW}$ values for each congener on site-specific measurements. Finally, the food-web structure was modified to be more inclusive of the diverse types of sportfish. This included the addition of several sportfish, including the California halibut, spotted sand bass, queenfish, common carp, topsmelt, and striped mullet. Appropriate prey items were also added such as macrophytes and the decapod crab.

This appendix depicts all equations included in the model. Abiotic input parameters and calculations describe key abiotic processes, such as contaminant partitioning between sediment and the water column, and between dissolved and particulate form. This is followed by biotic input parameters and calculations, which are organized separately for primary producers (phytoplankton and macrophytes) and animals (prey organisms and seafood). The primary producer calculations describe net uptake from the water column into phytoplankton and macrophytes at the base of the food web. The animal calculations are performed for each animal taxa, resulting in food web uptake, and ultimately bioaccumulation in the modeled seafood organisms. The model uses a food web structure and dietary proportions specific for each organism (Tables A-8.1 and A-8.2). For each organism, calculations are performed on a congener-specific basis and later summed to provide total contaminant concentration and BSAF values (i.e., total DDTs).

**Table A-8.1. Invertebrate food-web properties. Values indicate the proportion of each diet component.**

| | | P | M | I1 | I2 | I3 | I4 | I5 | I6 | I7 | I8 | I9 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Diet component | S | --- | --- | --- | 0.9 | 0.9 | 0.3 | 0.15 | 0.1 | 0.3 | 0.44 | --- |
| | P | --- | --- | 1 | 0.05 | 0.05 | 0.35 | 0.65 | 0.45 | 0.65 | 0.01 | 0.3 |
| | M | --- | --- | --- | --- | --- | --- | --- | --- | --- | 0.1 | --- |
| | I1 | --- | --- | --- | 0.05 | 0.05 | 0.35 | 0.2 | 0.45 | 0.05 | 0.1 | 0.3 |
| | I2 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| | I3 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| | I4 | --- | --- | --- | --- | --- | --- | --- | --- | --- | 0.2 | --- |
| | I5 | --- | --- | --- | --- | --- | --- | --- | --- | --- | 0.15 | --- |
| | I6 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | 0.4 |
| | I7 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| | I8 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| | I9 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| | F1 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| | F2 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| | F3 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| | F4 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| | F5 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| | F6 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Physical properties | PW Respir. (mp) | 0 | 0 | 0 | 0.05 | 0.05 | 0 | 0 | 0 | 0.05 | 0.05 | 0 |
| | Lipid (%) | 0.12 | 0.38 | 1.00 | 0.75 | 0.75 | 1.00 | 1.00 | 1.00 | 0.86 | 1.25 | 2.00 |
| | Mass (kg) | --- | --- | 7.10E-08 | 1.00E-07 | 1.10E-04 | 3.13E-06 | 5.00E-06 | 1.50E-05 | 1.12E-02 | 5.00E-03 | 3.72E-04 |

S-sediment
P-phytoplankton
M-macrophytes
I1-zooplankton
I2-small polychaete
I3-large polychaete

I4-amphipod
I5-cumacean
I6-mysid
I7-bivalve mollusk
I8-decapod crab
I9-crangon shrimp

F1-forage fish-herbivore (juvenile jacksmelt)
F2-forage fish-planktivore (northern anchovy)
F3-forage fish-primarily benthivore (juvenile white croaker)
F4-forage fish-benthivore (yellowfin goby)
F5-forage fish-mixed diet I (juvenile shiner perch)
F6-forage fish-mixed diet ii (plainfin midshipman)

PW Respir.-porewater respiration proportion

**Table A-8.2. Fish food-web properties. Values indicate the proportion of each diet component.**

| | | F1 | F2 | F3 | F4 | F5 | F6 | SP1 | SP2a | SP2b | SP3 | SP4 | SP5 | SP6 | SP7 | SP8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Diet component | S | --- | --- | 0.05 | --- | 0.05 | 0.05 | --- | --- | --- | --- | 0.05 | 0.05 | 0.29 | 0.05 | 0.3 |
| | P | 0.8 | 0.2 | 0.05 | --- | 0.1 | --- | --- | 0.01 | --- | --- | --- | 0.1 | 0.04 | 0.2 | 0.1 |
| | M | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | 0.2 | 0.2 | 0.35 |
| | I1 | 0.2 | 0.35 | 0.2 | --- | 0.2 | --- | --- | --- | --- | --- | --- | 0.1 | 0.11 | 0.08 | 0.1 |
| | I2 | --- | --- | 0.15 | 0.2 | 0.05 | 0.05 | --- | --- | --- | 0.06 | 0.2 | 0.1 | --- | --- | --- |
| | I3 | --- | --- | 0.15 | 0.2 | 0.05 | 0.1 | --- | --- | --- | 0.05 | 0.2 | 0.1 | 0.01 | 0.01 | --- |
| | I4 | --- | 0.2 | 0.1 | 0.15 | 0.25 | 0.15 | --- | 0.01 | 0.2 | 0.12 | 0.2 | 0.2 | 0.1 | 0.4 | 0.03 |
| | I5 | --- | 0.15 | 0.1 | 0.15 | 0.25 | 0.15 | --- | --- | --- | 0.02 | 0.2 | 0.2 | 0 | 0.01 | --- |
| | I6 | --- | 0.1 | 0.1 | --- | 0.05 | 0.2 | 0.01 | --- | 0.06 | 0.24 | 0.1 | 0.15 | 0.06 | 0.05 | 0.02 |
| | I7 | --- | --- | --- | --- | --- | --- | --- | 0.28 | 0.08 | --- | --- | --- | 0.14 | --- | 0.1 |
| | I8 | --- | --- | --- | --- | --- | --- | --- | 0.35 | 0.11 | --- | --- | --- | 0.04 | --- | --- |
| | I9 | --- | --- | 0.1 | 0.25 | --- | 0.2 | 0.01 | --- | --- | 0.03 | 0.05 | --- | --- | --- | --- |
| | F1 | --- | --- | --- | --- | --- | --- | 0.08 | --- | --- | --- | --- | --- | --- | --- | --- |
| | F2 | --- | --- | --- | --- | --- | 0.05 | 0.45 | 0.1 | --- | 0.48 | --- | --- | --- | --- | --- |
| | F3 | --- | --- | --- | --- | --- | --- | 0.25 | --- | --- | --- | --- | --- | --- | --- | --- |
| | F4 | --- | --- | --- | --- | --- | --- | 0.1 | 0.15 | 0.25 | --- | --- | --- | 0.01 | --- | --- |
| | F5 | --- | --- | --- | 0.05 | --- | 0.05 | | --- | 0.3 | --- | --- | --- | --- | --- | --- |
| | F6 | --- | --- | --- | --- | --- | --- | 0.1 | 0.1 | --- | --- | --- | --- | --- | --- | --- |
| Physical properties | PW Respir (mp) | 0 | 0 | 0 | 0 | 0 | 0.05 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Lipid (%) | 1.20 | 2.50 | 1.80 | 3.00 | 2.00 | 3.00 | m | m | m | m | M | m | m | m | m |
| | Mass (kg) | 4.00E-03 | 2.15E-02 | 1.50E-02 | 3.00E-02 | 1.31E-03 | 1.30E-01 | 1.46 | 0.60 | 1.00 | 0.05 | 0.37 | 0.05 | 2.00 | 0.02 | 1.23 |

S-sediment
P-phytoplankton
M-macrophytes
I1-zooplankton
I2-small polychaete
I3-large polychaete
I4-amphipod
I5-cumacean
I6-mysid

I7-bivalve mollusk
I8-decapod crab
I9-crangon shrimp
F1-forage fish-herbivore (Juvenile jacksmelt)
F2-forage fish-planktivore (Northern anchovy)
F3-forage fish-primarily benthivore (Juvenile white croaker)
F4-forage fish-benthivore (Yellowfin goby)
F5-forage fish-mixed diet i (Juvenile shiner perch)
F6-forage fish-mixed diet ii (Plainfin midshipman)

SP1-piscivore (California halibut)
SP2-benthic diet with piscivory (a:Spotted sand bass, b:White catfish)
SP3-benthic and pelagic with piscivory (Queenfish)
SP4-benthic without piscivory (White croaker)
SP5-benthic and pelagic without piscivory (Shiner perch)
SP6-benthic with herbivory (Common carp)
SP7-benthic and pelagic with herbivory (Topsmelt)
SP8-pelagic with benthic herbivory (Striped mullet)
PW Respir.-porewater respiration proportion

## Model Constants

The Arnot and Gobas model, like other food web models, includes numeric inputs that are site specific and additional numeric inputs that are generic constants. Site specific model inputs (e.g., seafood lipid content, sediment organic carbon, and water quality parameters), are obtained locally and modified in each unique application of the model. In contrast, model constants (Table A-8.3) are standard constants based on physical principles, not locally available or measured. The model utilizes constants assembled by the model authors (Arnot and Gobas 2004, Gobas and Arnot 2010) based on fitting model equations to datasets developed in global literature reviews. An exception is octanol-water partitioning coefficient ($K_{OW}$) for pesticides and some PCBs, which was not included in prior model documentation. Methods for $K_{OW}$ development are documented below.

### Octanol-water partitioning coefficient ($K_{OW}$)

The octanol-water partitioning coefficient governs compound partitioning between tissue lipids versus water, and between sediment and porewater. PCB $K_{OW}$ values used in the assessment framework were obtained from Gobas and Arnot (2005). For those PCBs not evaluated in Gobas and Arnot, $K_{OW}$ values were the median of results combined from five published sources: Li *et al.* (2003), Mackay *et al.* (2000), Beyer *et al.* (2002), Hansen *et al.* (1999), and Hawker and Connell (1988). Pesticide $K_{OW}$ values were taken from Shen and Wania (2005), or Leatherbarrow *et al.* (2006), which compiled $K_{OW}$s from Mackay *et al.* (2000).

Literature $K_{OW}$s are generally calculated at temperatures of 25°C, which is higher than many California bays and estuaries. Therefore, PCB $K_{OW}$s are temperature corrected to correspond to the water body temperature, based on the site-specific data. Following Gobas and Arnot (2005, 2010), and references cited therein, the $K_{OW}$ values were temperature corrected using the following equation (Li *et al.* 2003):

$$\log K_{OW}E_T = \log K_{OW}D_T - \frac{\Delta U_{ow}}{\ln(10) * R} * \left(\frac{1}{E_T} - \frac{1}{D_T}\right)$$

Where:

$E_T$ = the environmental temperature (Kelvin)

$D_T$ = the data collection temperature (Kelvin)

$\Delta U_{OW}$ = the internal energy of octanol-water phase transfer

R = the gas law constant (0.0083145 kJ/mol K)

Empirically-derived $\Delta U_{OW}$ were unavailable for some congeners, and were estimated to be -28 kJ/mol, the median of empirical $\Delta U_{OW}$ data for other PCB congeners, and -25 kJ/mol for the pesticides.

Following Gobas and Arnot (2005, 2010), and references cited therein, $K_{OW}$ values are also salinity corrected to correspond to the measured water body average salinity. Salinity corrections followed Xie *et al.*(1997):

$$K_{OW}S = K_{OW}T \times 10^{(SPC \cdot Vh \cdot MCS \cdot Sal / 35)}$$

Where:

SPC = the Setschenow proportionality constant (0.0018 L/$cm^3$)

Vh = the LeBas molar volume ($cm^3/mol$) of the chemical (calculated following Tucker and Nelken 1982)

MCS = the molar concentration of seawater at 35 practical salinity units (0.5)

Sal = the salinity for the system of interest (psu)

Summary tables of the PCB and pesticide physical-chemical parameters (Vh, $\Delta U_{OW}$, and $LogK_{OW}$ values) are listed in tables A-8.4 and A-8.5, respectively.

**Table A-8.3. Constant values used for bioaccumulation model calculations.**

| Bioaccumulation Parameters and Constants | Parameter Name | Value | Units |
|---|---|---|---|
| Density of lipid | dLipid | 0.9 | kg/L |
| Disequilibrium factor for particulate organic carbon (POC) partitioning | dPOC | 1 | unitless |
| Disequilibrium factor for dissolved organic carbon (DOC) partitioning | dDOC | 1 | unitless |
| Proportionality constant describing phase partitioning of POC | alphaPOC | 0.35 | unitless |
| Proportionality constant describing phase partitioning of DOC | alphaDOC | 0.08 | unitless |
| Non-lipid organic carbon (NLOC) proportionality constant | lipcf | 0.35 | unitless |
| Non-lipid organic matter (NLOM) proportionality constant | lipcfp | 0.035 | unitless |
| NLOC for plants | NLOC | 6.00 | % |
| NLOM for animals | NLOM | 20.00 | % |
| NLOM for bivalves | NLOM/2 | 10.00 | % |
| Metabolic rate constant | kM | 0 | 1/day |
| Constant for phytoplankton aqueous uptake rate | pA | 6.0E-5 | 1/day |
| Constant for phytoplankton aqueous uptake rate | pB | 5.5 | 1/day |
| Growth rate for phytoplankton | kGp | 0.080 | 1/day |
| Growth rate for macrophytes | kGm | 0.125 | 1/day |
| Invertebrate Growth Rate Coefficient | IGR | 3.5E-4 | unitless |
| Fish Growth Rate Coefficient | FGR | 7E-4 | unitless |
| Particle scavenging efficiency for filter feeders | scav | 100 | % |
| Invertebrate Lipid Digestion Efficiency (alpha) | alphaI | 0.75 | Unitless |
| Invertebrate NLOM Digestion Efficiency (beta) | betaI | 0.75 | unitless |
| Invertebrate Water Digestion Efficiency (chi) | chiI | 0.55 | unitless |
| Zooplankton Lipid Digestion Efficiency (alpha) | alphaZ | 0.75 | unitless |
| Zooplankton NLOM Digestion Efficiency (beta) | betaZ | 0.75 | unitless |
| Zooplankton Water Digestion Efficiency (chi) | chiZ | 0.55 | unitless |
| Fish Lipid Digestion Efficiency (alpha) | alphaF | 0.92 | unitless |
| Fish NLOM Digestion Efficiency (beta) | betaF | 0.6 | unitless |
| Fish Water Digestion Efficiency (chi) | chiF | 0.55 | unitless |
| Ed - Constant A - Invertebrates and Fish | A | 8.50E-8 | Unitless |
| Ed - Constant B - Invertebrates and Fish | B | 2 | unitless |

Table A-8.4. PCB congener list with physical-chemical property values.

| PCB Congener | LeBas molar volume (Mackay 2006) | ΔUow at 25 °C (kJ/mol) | Log $K_{OW}$ at 25 °C |
|---|---|---|---|
| PCB 8 | 226.4 | -22.7 | 5.12 |
| PCB 11* | 226.4 | -28 | 5.27 |
| PCB 18 | 247.3 | -25 | 5.3 |
| PCB 27 | 247.3 | -28 | 5.4 |
| PCB 28 | 247.3 | -26.3 | 5.66 |
| PCB 29 | 247.3 | -28 | 5.6 |
| PCB 31 | 247.3 | -25.9 | 5.78 |
| PCB 33 | 247.3 | -26 | 5.65 |
| PCB 37* | 247.3 | -28 | 5.78 |
| PCB 44 | 268.2 | -26 | 5.82 |
| PCB 49 | 268.2 | -27 | 5.95 |
| PCB 52 | 268.2 | -27.3 | 5.91 |
| PCB 56 | 268.2 | -30 | 6.02 |
| PCB 60 | 268.2 | -30 | 6.12 |
| PCB 64 | 268.2 | -28 | 5.79 |
| PCB 66 | 268.2 | -28 | 6.01 |
| PCB 70 | 268.2 | -28 | 6.1 |
| PCB 74 | 268.2 | -28 | 6.11 |
| PCB 77 | 268.2 | -28 | 6.26 |
| PCB 81* | 268.2 | -28 | 6.25 |
| PCB 87 | 289.1 | -28 | 6.35 |
| PCB 95 | 289.1 | -28 | 6.06 |
| PCB 97 | 289.1 | -28 | 6.27 |
| PCB 99 | 289.1 | -28 | 6.36 |
| PCB 101 | 289.1 | -23.8 | 6.33 |
| PCB 105 | 289.1 | -28.6 | 6.82 |
| PCB 110 | 289.1 | -28 | 6.31 |
| PCB 114 | 289.1 | -28 | 6.65 |
| PCB 118 | 289.1 | -28.5 | 6.69 |
| PCB 119* | 289.1 | -28 | 6.4 |
| PCB 123* | 289.1 | -28 | 6.64 |
| PCB 126 | 289.1 | -28 | 6.77 |
| PCB 128 | 310 | -28 | 6.79 |
| PCB 132* | 310 | -25 | 6.54 |
| PCB 137 | 310 | -28 | 6.83 |
| PCB 138 | 310 | -25 | 7.22 |
| PCB 141 | 310 | -25 | 6.77 |
| PCB 146 | 310 | -28 | 6.87 |

## Table A-8.4. Continued

| PCB Congener | LeBas molar volume (Mackay 2006) | ΔUow at 25 °C (kJ/mol) | Log Kow at 25 °C |
|---|---|---|---|
| PCB 149 | 310 | -25 | 6.62 |
| PCB 151 | 310 | -25 | 6.6 |
| PCB 153 | 310 | -31.1 | 6.87 |
| PCB 156 | 310 | -23 | 7.01 |
| PCB 157 | 310 | -28 | 7.18 |
| PCB 158 | 310 | -23 | 6.87 |
| PCB 167* | 310 | -28 | 7.28 |
| PCB 168* | 310 | -28 | 7.11 |
| PCB 169 | 310 | -28 | 7.42 |
| PCB 170 | 330.9 | -25 | 7.18 |
| PCB 174 | 330.9 | -28 | 7.03 |
| PCB 177 | 330.9 | -28 | 7.01 |
| PCB 180 | 330.9 | -29.1 | 7.16 |
| PCB 183 | 330.9 | -28 | 7.12 |
| PCB 187 | 330.9 | -28 | 7.09 |
| PCB 189 | 330.9 | -28 | 7.3 |
| PCB 194 | 351.8 | -28 | 7.76 |
| PCB 195 | 351.8 | -28 | 7.45 |
| PCB 198 | 351.8 | -28 | 7.43 |
| PCB 199 | 351.8 | -28 | 7.2 |
| PCB 200 | 351.8 | -28 | 7.27 |
| PCB 201 | 351.8 | -28 | 7.51 |
| PCB 203 | 351.8 | -28 | 7.53 |
| PCB 206 | 372.7 | -28 | 7.8 |
| PCB 209 | 393.6 | -28 | 8.18 |

*Optional, not required (See Appendix A-7)

**Table A-8.5. Pesticide congener list with physical-chemical property values.**

| PCB Congener | LeBas molar volume (Mackay 2006) | ΔUow at 25 °C (kJ/mol) | Log Kow at 25 °C |
|---|---|---|---|
| cis-Chlordane | 340.5 | -25 | 6.20 |
| trans-Chlordane | 340.5 | -25 | 6.27 |
| cis-Nonachlor | 361.4 | -25 | 5.70 |
| trans-Nonachlor | 361.4 | -25 | 5.70 |
| Oxychlordane | 250 | -25 | 2.60 |
| Dieldrin | 332.2 | -25 | 5.48 |
| op-DDD | 312.6 | -25 | 5.34 |
| op-DDE | 305.2 | -25 | 5.63 |
| op-DDT | 333.5 | -25 | 5.70 |
| pp-DDD | 312.6 | -25 | 6.33 |
| pp-DDE | 305.2 | -25 | 6.93 |
| pp-DDT | 333.5 | -25 | 6.39 |

## Abiotic site-specific input parameters

TOC = organic carbon proportion in sediment (%)

DOCw = DOC concentration in $H_2O$ (kg/L)

POCw = POC concentration in $H_2O$ (kg/L)

T = mean water temperature (°C)

Sal = water salinity (PSU)

DO = dissolved oxygen concentration (mg $O_2$/L)

SSC = concentration of suspended solids (kg/L)

## Congener-specific abiotic parameters

$K_{OW}T$ = octanol-water partitioning coefficient (temperature corrected)

$K_{OW}S$ = octanol-water partitioning coefficient (corrected for temperature and salinity)

$K_{OC}$ = octanol-organic carbon partitioning coefficient (uses the $K_{OW}S$ value)

csed = contaminant concentration in sediment (ng/g dry weight)

cpw = dissolved contaminant concentration in porewater (ng/mL)

cwatD = dissolved contaminant concentration in surface water (ng/mL)

cwat = total contaminant concentration in surface water (ng/mL)

phi = ratio of dissolved contaminant concentration to total contaminant concentration in surface water (unitless)

### Congener-specific abiotic calculations

$logK_{OW}T = logK_{OW}D_T - \frac{\Delta U_{ow}}{\ln(10)*R} * \left(\frac{1}{T} - \frac{1}{D_T}\right)$

Where:

$logK_{OW}D_T$ = $logK_{OW}$ at 25 °C or 298K in Tables A-8.4 and A-8.5.

$logK_{OW}T$ = temperature corrected $logK_{OW}$ at the site-specific temperature (T)

$K_{OW}S = K_{OW}T \times 10^{(SPC \cdot Vh \cdot MCS \cdot Sal / 35)}$

$K_{OC} = 0.35*K_{OW}S$

cpw = csed/(TOC*$K_{OC}$)

cwatD = measured dissolved water concentration or estimated from total concentration as:

cwatD = phi*cwat

phi = 1/(1 + POCw*dPOC*alphapoc*$K_{OW}S$ + DOCw*dDOC*alphadoc*$K_{OW}S$)

The model compares measured surface water concentration to that estimated from site sediment concentration in order to minimize the influence of off-site sources on bioaccumulation. This estimation is based on the organic carbon partitioning used in the calculation of porewater concentration. Empirical data were used to determine the relationship between calculated porewater concentrations and measured dissolved surface water concentrations of the contaminants used in the model. This resulted in a median dilution factor of eight, as presented in the equation below:

Estimated cwatD = csed/(TOC*$K_{OC}$*8)

The lowest value (measured or estimated) for each congener is used as cwatD in the model calculations.

### Organism-specific parameters

Wb = body weight (kg)

Gv = gill ventilation rate (L/day)

lipid = tissue lipid content (%)

wc = tissue water content (kg water/kg organism ww)= 1-lipid-NLOM (animals), 1-lipid-NLOC (phytoplankton and macrophytes), 1-lipid-(NLOM/2) (bivalves)

Gd = feeding rate (kg food/day)

kG = organism growth rate (1/day)

vld = proportion of diet that is lipid (calculated based on diet proportion of prey and prey lipid content, unitless)

vcd = proportion of diet that is non-lipid organic carbon (calculated based on diet proportion of prey and prey NLOC content, unitless)

vnd = proportion of diet that is non-lipid organic matter (calculated based on diet proportion of prey and prey NLOM content, unitless)

vwd = proportion of diet that is water (calculated based on diet proportion of prey and prey water content, unitless)

vlg = lipid fraction of gut (kg lipid/kg organism ww)

vcg = NLOC fraction of gut (kg NLOC/kg organism ww)

vng = NLOM fraction of gut (kg NLOM/kg organism ww)

vwg = water fraction of gut (kg water/kg organism ww)

mp = proportion of respiration or transpiration due to porewater (Tables A-8.1 and A-8.2, unitless)

mo = proportion of respiration or transpiration due to overlying water column (unitless)

### Contaminant-specific model variables

Ew = contaminant-specific gill chemical uptake efficiency (unitless)

Ed = contaminant-specific dietary chemical transfer efficiency (also called gut uptake efficiency, unitless)

k1 = aqueous uptake rate constant (L/kg·day)

kbw = biota-water partition coefficient (i.e., bioconcentration factor, L/kg organism ww)

k2 = elimination rate constant (1/day)

kd = dietary uptake rate constant (kg food/kg organism·day)kG = growth rate (1/day)

Gf = fecal egestion rate (kg feces/kg organism·day)

kgb = gut-biota partition coefficient (unitless)

ke = fecal egestion rate constant (1/day)

$p_i$ = proportion of diet by mass that is prey item i (unitless)

$p_s$ = proportion of diet by mass that is sediment (unitless)

cD = contaminant concentration in diet (weighted average across all prey items, ng/g ww)

$cbiota_i$ = contaminant concentration in biota organism i (ng/g organism ww)

BSAF = biota-sediment accumulation factor (unitless)

### Calculations for phytoplankton and aquatic macrophytes

$k1 = 1/(pA + pB/K_{OW}S)$

$kbw = (lipid*K_{OW}S/dLipid+ nloc*lipcf*K_{OW}S + wc)$

$k2 = k1/kbw$

$cbiota=k1*(cwatD)/ (k2 + kGp^*)$ [*kGp for phytoplankton and kGm for macrophyte]

BSAF = cbiota/csed

### Calculations for animals (prey organisms and seafood)

$Ew = 1/(1.85+155/K_{OW}S)$

$Ed = 1/(A*K_{OW}T + B)$

$Gv = (1400*Wb^{0.65})/DO$

$k1 = Ew*Gv/Wb$

$kbw = K_{OW}S *(lipid/dLipid + nlom*lipcfp) + wc$

$k2 = k1/kbw$

$Gd = 0.022 * (Wb^{0.85}) * e^{0.06*T}$ [For fish and nonfilter feeding invertebrates]

$Gd = Gv*SSC*scav$ [For filter feeding invertebrates]

kd = Ed*Gd/Wb

kG = IGR * $Wb^{-0.2}$ [For invertebrates]

kG = FGR * $Wb^{-0.2}$ [For fishes]

vld= $\sum_{i=1}^{n} p_i * lipid_i$; vcd= $\sum_{i=1}^{n} p_i * nloc_i$ ; vnd= $\sum_{i=1}^{n} p_i * nlom_i$ ; vwd= $\sum_{i=1}^{n} p_i * water_i$

where i = [1…n] represent individual prey taxa

Gf=Gd*((1-alpha)*vld+ (1-beta)*(vcd + vnd)+ (1-chi)*vwd)

vlg= (1-alpha)*vld/ ((1-alpha)*vld+ (1-beta)*(vcd + vnd)+ (1-chi)*vwd)

vcg= (1-beta)*vcd/ ((1-alpha)*vld+ (1-beta)*(vcd + vnd)+ (1-chi)*vwd)

vng= (1-beta)*vnd/ ((1-alpha)*vld+ (1-beta)*(vcd + vnd)+ (1-chi)*vwd)

vwg= (1-chi)*vwd/ ((1-alpha)*vld+ (1-beta)*(vcd + vnd)+ (1-chi)*vwd)

kgb=((vlg/dLipid + vng*lipcf + vcg*lipcfp)*$K_{OW}$T + vwg)/ ((lipid/dLipid + nlom*lipcfp)*$K_{OW}$T + wc)

ke = Gf*Ed*kgb/Wb

mo = 1 – mp

cD = $p_s * csed + \sum_{i=1}^{n} p_i * cbiota_i$

where i = [1…n] represent individual prey taxa

cbiota = (k1*(mo*cwatD + mp*cpw)+ kd*cD) / (k2 + ke + kG + kM)

BSAF = cbiota/csed

## Site Assessment Calculations

### Chemical Exposure Evaluation

Calculate the weighted average observed tissue concentration based on the diet proportion for each fish species represented and measured tissue concentration for total chlordanes, Dieldrin, total DDTs, and total PCBs. Compare this weighted average to the chemical exposure thresholds in Table 16 for Tier 1 evaluation and Table 19 for Tier 2 evaluation.

### Site Linkage Determination

In evaluation of the site linkage, Monte-Carlo Simulation (MCS) is used to incorporate the variability of both the measured sediment and tissue concentrations, the fish guild home range (HR), and the estimated BSAF values. For this analysis, a lognormal distribution is used for BSAF and sediment concentrations, and the appropriate distributions for each home range is indicated in Table A-8.6. A total of 10,000 iterations should be used for the simulation.

Site linkage = $C_{Est}/C_{Tis}$

$C_{Est}$ = weighted average estimated tissue concentration based on the proportion of the human diet for each guild (ng/g).

Calculate the average estimated tissue concentration for each guild, i, and contaminant class (i.e., total DDTs) using the following equation:

$C_{Est,i} = \Sigma C_{Sed} \times SUF_i \times BSAF_i$

$\Sigma C_{Sed}$ = lognormal distribution of sediment concentration using the measured mean and standard error

$SUF_i$ = site use factor for species i = $SA/HR_i$. SA is the area or length of site depending on the basis of the HR. HR distribution is calculated using the HR mean and HR standard deviation (SD) listed in Table A-8.6. If the calculated SUF is less than 1, use the calculated value. If the SUF is equal to or greater than 1, use the value of 1.

$BSAF_i$ = lognormal distribution of the mean BSAF for guild, i, from the model prediction and the calculated BSAF SD.

BSAF SD = CVBSAF*BSAF

CVBSAF = 0.782

The CVBSAF was estimated from empirical data using the following equations:

$$SD = \sqrt{(m^2)(e^{\sigma^2} - 1)}$$

$$CV = \frac{\sqrt{(m^2)(e^{\sigma^2} - 1)}}{m} = \sqrt{(e^{\sigma^2} - 1)}$$

Where σ = lognormal standard deviation

m = mean (this value cancels out)

CV = coefficient of variation

$C_{Tis}$ = weighted average observed tissue concentration

Use a lognormal distribution for measured mean tissue data and standard error for each guild for total chlordanes, total dieldrin, total DDTs, and total PCBs.

Calculate the weighted average for each contaminant class based on the proportion of the human diet for each guild (ng/g).

**Table A-8.6. Home range parameters for each sportfish guild.**

| Species | Guild | HR Basis | HR Mean | HR SD | HR Distribution |
|---|---|---|---|---|---|
| California halibut | Piscivore | Site length (km) | 29.3 | 60 | Lognormal distribution |
| Spotted sand bass | Benthic diet with piscivory | Site area ($km^2$) | 0.0071 | 0.0073 | Lognormal distribution |
| White Catfish | Benthic diet with piscivory | Site length (km) | 6.9 | 9.6 | Lognormal distribution |
| Queenfish | Benthic and pelagic with piscivory | Site area ($km^2$) | 3 | 4.689 | Lognormal distribution |
| White croaker | Benthic without piscivory | Site area ($km^2$) | 3 | 4.689 | Lognormal distribution |
| Shiner perch | Benthic and pelagic without piscivory | Site area ($km^2$) | 0.0012 | 0.000804 | Lognormal distribution |
| Common carp | Benthic with herbivory | Site length*1000 (km) | 1.05 | 9904 | Inverse gamma cumulative distribution* |
| Topsmelt | Benthic and pelagic with herbivory | Site area ($km^2$) | 0.0012 | 0.000804 | Lognormal distribution |
| Striped mullet | Pelagic with benthic herbivory | Site length (km) | 28.2 | 80.34 | Lognormal distribution |

HR mean = mean home range of seafood species under consideration (km or $km^2$, depending on taxa).

HR SD = standard deviation of home range of seafood species

*Inverse gamma cumulative distribution requires 3 terms:

Probability= a random number uniformly distributed over $0 \leq x < 1$

Alpha= HR mean value (shape parameter)

Beta= HR SD value (scale parameter)

## 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.

Beyer, A., F. Wania, T. Gouin, D. Mackay and M. Matthies. 2002. Selecting internally consistent physicochemical properties of organic compounds. *Environmental Toxicology and Chemistry* 21:941-953.

Burkhard, L.P. 1998. Comparison of two models for predicting bioaccumulation of hydrophobic organic chemicals in a Great Lakes food web. *Environmental Toxicology and Chemistry* 17:383-393.

Gobas, F.A.P.C. 1993. A model for predicting the bioaccumulation of hydrophobic organic chemicals in aquatic food-webs: application to Lake Ontario. *Ecological Modelling* 69:1-17.

Gobas, F.A.P.C. and J. Arnot. 2005. San Francisco Bay PCB food-web bioaccumulation model. Simon Fraser University. Vancouver, BC.

Gobas, F.A.P.C. and J. Arnot. 2010. Food web bioaccumulation model for polychlorinated biphenyls in San Francisco Bay, California, USA. *Environmental Toxicology and Chemistry* 29:1385-1395.

Hansen, B.G., A.B. Paya-Perez, M. Rahman and B.R. Larsen. 1999. QSARs for Kow and Koc of PCB congeners: A critical examination of data, assumptions and statistical approaches. *Chemosphere* 39:2209-2228.

Hawker, D.W. and D.W. Connell. 1988. Octanol-water partition coefficients of polychlorinated biphenyl congeners. *Environmental Science and Technology* 22:382-387.

Leatherbarrow, J.E., N. David, B.K. Greenfield, J.J. Oram and J.A. Davis. 2006. Organochlorine pesticide fate in San Francisco Bay. 433. San Francisco Estuary Institute. Oakland, CA.

Li, N., F. Wania, Y. Lei and G. Daly. 2003. A comprehensive and critical compilation, evaluation, and selection of physical-chemical property data for selected polychlorinated biphenyls. *Journal of Physical and Chemical Reference Data* 32:1545-1590.

Mackay, D., W.Y. Shiu and K.C. Ma. 2000. Physical-Chemical Properties and Environmental Fate Handbook. Chapman & Hall. Boca Raton, FL.

Shen, L. and F. Wania. 2005. Compilation, evaluation and selection of physical-chemical property data for organochlorine pesticides. *Journal of Chemical and Engineering Data* 50:742 - 768.

Xie, W.H., W.Y. Shiu and e. al. 1997. A review of the effect of salts on the solubility of organic compounds in seawater. *Marine Environmental Research* 4.

# Appendix B

# Sediment Monitoring Plan QAPP

# FINAL
# APPENDIX B

## SAN DIEGO COUNTY MUNICIPAL COPERMITTEES
## SEDIMENT MONITORING
## QUALITY ASSURANCE PROJECT PLAN

**Prepared for:**

**County of San Diego Municipal Copermittees**

**Prepared by:**

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**2236 Rutherford Rd, Suite 101**
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**9177 Sky Park Court**
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November 2014
Revised January 2024

# GROUP A: PROJECT MANAGEMENT

## ELEMENT 1 TITLE AND APPROVAL SHEET

Final

Appendix B

San Diego County Municipal Copermittees
Sediment Monitoring
Quality Assurance Project Plan

January 2024

## APPROVAL SIGNATURES

San Diego County Watershed Management Area Lead:

| Organizational Affiliation | Title | Name | Signature | Date |
|---|---|---|---|---|
| City of San Diego | Project Lead | Andre Sonksen | [illegible] | 1/19/2024 |
| City of Imperial Beach | Environmental & Natural Resources Director | Chris Helmer | Chris Helm | 1/18/24 |
| City of Carlsbad | Senior Program Manager | Tim Murphy | Tim Murphy | 1/18/24 |
| County of San Diego | Water Resources Manager | Neil Searing | Neil Searing | 1/18/24 |
| Riverside County Flood Control District | Environmental Project Manager | Rebekah Guill | Rebekah Guill | 1/18/24 |

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# LIST OF ACRONYMS

| | |
|---|---|
| ASTM | American Society for Testing and Materials |
| Bight | Southern California Bight Regional Monitoring Program |
| BPJ | best professional judgement |
| CA EPA | California Environmental Protection Agency |
| CA LRM | California Logistic Regression Model |
| CEDEN | California Environmental Data Exchange Network |
| COC | chain of custody |
| Copermittees | San Diego County Regional Copermittees |
| CRM | certified reference materials |
| CSI | Chemical Score Index |
| CVAA | cold vapor atomic absorption |
| DDD | dichlorodiphenyldichloroethane |
| DDE | dichlorodiphenyldichloroethylene |
| DDT | dichlorodiphenyltrichloroethane |
| DGPS | Differential Global Positioning System |
| DQO | data quality objective |
| DTSC | Department of Toxic Substances Control |
| $EC_{50}$ | median effect concentration |
| EPA | Environmental Protection Agency |
| GC/ECD | gas chromatography/ electron capture detector |
| GC/MS | gas chromatography/ mass spectrometry |
| HDPE | high density polyethylene |
| ICP/MS | inductively coupled mass spectrometry |
| ID | inner diameter |
| $LC_{50}$ | median lethal concentration |
| LCS | laboratory control sample |
| LOE | line(s) of evidence |
| $MgSO_4$ | magnesium sulfate |
| MLLW | Mean Lower Low Water |
| MLOE | multiple lines of evidence |
| MS/MSD | matrix spike/matrix spike duplicate |
| MS4 | municipal separate storm sewer system |
| OEHHA | Office of Environmental Health Hazard Assessment |
| PAHs | polynuclear aromatic hydrocarbons |
| PCBs | polychlorinated biphenyls |
| QA | quality assurance |
| QAPP | Quality Assurance Project Plan |
| QC | quality control |
| RL | reporting limit |
| RPD | relative percent difference |
| San Diego Water Board | San Diego Regional Water Quality Control Board |
| SCAMIT | Southern California Association of Marine Invertebrate Taxonomists |
| SCCWRP | Southern California Coastal Water Research Project |
| SRM | standard reference material |
| SWAMP | Surface Water Ambient Monitoring Program |

| | |
|---|---|
| State Water Board | State Water Resources Control Board |
| SIM | selective ion capture |
| SM | Standard Method |
| SOP | standard operating procedure |
| SP | solid phase |
| SQO | sediment quality objective |
| SWI | sediment water interface |
| TBD | to be determined |
| TOC | total organic carbon |
| USEPA | United States Environmental Protection Agency |
| WQIP | Water Quality Improvement Plan |

## Units of Measure

| | |
|---|---|
| ppt | parts per thousand |
| ft | feet |
| $m^2$ | square meters |
| L | liter |
| cm | centimeter |
| mm | millimeter |
| % | percent |
| mL | milliliter |
| ºC | degrees Celsius |
| kg | kilogram |
| mg | milligram |
| µg | microgram |

# ELEMENT 3 DISTRIBUTION LIST

Table 1 identifies those individuals who will receive one copy of the approved Sediment Monitoring Quality Assurance Project Plan (QAPP).

**Table 1. Quality Assurance Project Plan Distribution List**

| Title | Name (Affiliation) | Telephone No. | QAPP No. |
|---|---|---|---|
| Project Lead | Andre Sonksen (City of San Diego) | (858) 541-4317 | 01 |
| Environmental & Natural Resources Director | Chris Helmer (City of Imperial Beach) | (619) 628-1370 | 02 |
| Senior Program Manager | Tim Murphy (City of Carlsbad) | (442) 339-2587 | 03 |
| Water Resources Manager | Neil Searing (County of San Diego) | (619) 629-8627 | 04 |
| Environmental Project Manager | Rebekah Guill (Riverside County Flood Control District) | (951) 955-2901 | 05 |

# ELEMENT 4 PROJECT/TASK ORGANIZATION

## Involved Parties and Roles

Table 2 lists the WMA Leads who are responsible for conducting and managing the sediment monitoring project for each of the WMAs, what organization they are affiliated with, and contact information. The name and contact information for a QA officer will be assigned based on the team assembled who will conduct the sediment monitoring for each of the WMAs.

**Table 2. Key Personnel Responsibilities and Contact Information**

| Name | Organizational Affiliation | Title | Contact Information (telephone number, fax number and email address) |
|---|---|---|---|
| Andre Sonksen | City of San Diego | Compliance Manager | (858) 541-4317<br>ASonksen@sandiego.gov |
| Chris Helmer | City of Imperial Beach | Environmental & Natural Resources Director | (619) 628-1370<br>chelmer@imperialbeachca.gov |
| Tim Murphy | City of Carlsbad | Senior Program Manager | (442) 339-258<br>Tim.Murphy@carlsbadca.gov |
| Neil Searing | County of San Diego | Water Resources Manager | (619) 629-8627<br>Neil.Searing@sdcounty.ca.gov |
| Rebekah Guill | Riverside County Flood Control District | Environmental Project Manager | (951) 955-2901<br>rguill@rivco.org |

## Quality Assurance Officer Role

The project Quality Assurance (QA) Officer will be responsible for the overall QA and quality control (QC) procedures found in this plan as part of the sampling and field analyses, laboratory analysis, and the overall quality of the data.

## Persons Responsible for QAPP Update and Maintenance

Changes and updates to this QAPP may be made after a review of the evidence for change by the WMA Lead and QA Officer. The WMA Lead will assign appropriate staff to work with the QA Officer to revise the QAPP. The assigned staff member will be responsible for making the changes, submitting drafts for review to the WMA Lead, preparing a final amended copy, and submitting the final for signature. Project work must be halted while revisions to the QAPP are made, unless authorized by the WMA Lead.

# ELEMENT 5 PROBLEM DEFINITION/BACKGROUND

## Problem Statement

The Copermittees are required to conduct sediment quality monitoring in accordance with the requirements of the San Diego Regional Water Quality Control Board (San Diego Water Board) Order No. R9-2013-0001 (Permit), effective June 27, 2013. The Copermittees are required, either individually, in association with multiple Copermittees, or through participation in a water body monitoring coalition to perform sediment quality monitoring to assess compliance with the sediment quality receiving water limits applicable to municipal separate storm sewer system (MS4) discharges to enclosed bays and estuaries. Urban runoff from the MS4 poses a risk to beneficial uses in receiving waterbodies. An understanding of the quality of sediments in relation to MS4 discharges is needed to direct and prioritize management actions.

Provision D.1.e.(2) of the Permit requires the Copermittees to develop a Sediment Monitoring Plan for incorporation into the Water Quality Improvement Plan (WQIP) which satisfies the requirements of the *Water Quality Control Plan for Enclosed Bays and Estuaries of California – Part I Sediment Quality* (State Water Quality Control Board [State Water Board] and California Environmental Protection Agency [CA EPA], 2009). On June 5, 2018, the State Water Board adopted Resolution No. 2018-0028 amending this document (now called *Amendments to the Water Quality Control Plan for Enclosed Bays and Estuaries of California – Sediment Quality Provisions* [State Water Board and CA EPA, 2018]). For the purposes of this QAPP, it will hereafter be referred to as the Sediment Control Plan. This QAPP supports the Sediment Monitoring Plan by describing the sampling, analysis, and quality assurance procedures that are needed to comply with Permit-required sediment quality monitoring.

## Decisions or Outcomes

The primary objective of the sediment monitoring program is to assess compliance with the sediment quality receiving water limits applicable to MS4 discharges to enclosed bays and estuaries of San Diego County. Sediment toxicity, chemistry, and benthic community condition will be assessed using SQOs as described in the Sediment Monitoring Plan. The goals of the SQOs are to determine whether pollutants in sediments are present in quantities that are toxic to benthic organisms and/or will bioaccumulate in aquatic organisms to levels that may be harmful.

The goal of the Sediment Monitoring Plan and Sediment Monitoring QAPP is to provide the key elements that are required to successfully conduct field sediment sampling, processing, testing, and analysis of the results in accordance with SQO guidelines. Analyses of chemistry, toxicity, and benthic community condition require that samples be collected, preserved, processed, and analyzed using proper field and laboratory equipment, methods, and techniques. The Sediment Monitoring Plan and Sediment Monitoring QAPP describe the collection and analysis of surface sediment samples necessary to provide representative assessments of in-situ conditions for the enclosed bays and estuaries of San Diego County. By adhering to SQO protocols, sediment quality in subtidal marine and estuarine habitats can be assessed as to whether it is protective of aquatic life and human health.

# ELEMENT 6 PROJECT/TASK DESCRIPTION

## Work Statement and Produced Products

The San Diego County Regional Copermittees (Copermittees) are required to conduct sediment quality monitoring in accordance with the requirements of the *Water Quality Control Plan for Enclosed Bays and Estuaries of California – Part I Sediment Quality* (Sediment Control Plan; State Water Board and CA EPA, 2009). On June 5, 2018, the State Water Board adopted Resolution No. 2018-0028 amending this document (now called *Amendments to the Water Quality Control Plan for Enclosed Bays and Estuaries of California – Sediment Quality Provisions* [State Water Board and CA EPA, 2018]; see Appendix A). For the purposes of this QAPP, it will hereafter be referred to as the Sediment Control Plan. The Sediment Control Plan outlines a multiple lines of evidence (MLOE) approach to determine whether pollutants in sediments are present in quantities that are toxic to benthic organisms and/or will bioaccumulate in aquatic organisms to levels that may be harmful to humans. Sediment monitoring will be conducted a minimum of once during a Permit cycle. Stations that have been consistently classified as Unimpacted or Likely Unimpacted using the MLOE approach may also have the sampling frequency reduced to once per permit cycle. The San Diego Water Board may also limit receiving water monitoring to a subset of outfalls to focus where the risk to sediment quality is greatest.

Sediment samples will be analyzed for toxicity, chemistry, and benthic infauna at a designated number of stations (station selection is outlined in ELEMENT 10) within a waterbody. An SQO analysis will be conducted on each station to determine a final station assessment that indicates whether the aquatic life SQO has been met. Depending on the outcome of the SQO assessments at the designated stations located in San Diego County waterbodies, follow-up monitoring may be necessary to meet all of the Permit requirements. Sediment quality monitoring results will be incorporated into the WQIP Annual Report. An additional stressor identification study may be required by the San Diego Water Board for stations not meeting SQOs.

Provision D.1.e.(1)(a) of the Permit also requires the Copermittees to participate in the Southern California Bight Regional Monitoring Program. Participation in the Bight Program can be used to simultaneously fulfill all or part of the sediment quality monitoring requirement (Provision D.1.e[2]) because sediment monitoring and SQO analyses are incorporated into the Bight Program to regionally assess the sediment quality of Southern California's waterbodies. The Copermittees can also decide to conduct the initial sediment quality monitoring of San Diego County's water bodies independently of the Bight Program. Depending upon the outcome of the initial SQO assessments, the Copermittees may need to perform follow-up monitoring to meet all the Permit requirements.

## Constituents to be Monitored and Measurement Techniques

Chemical and toxicity analyses of all sediment samples collected as part of the SQO assessment must be tested in accordance with United States Environmental Protection Agency (USEPA) or American Society for Testing and Materials (ASTM) protocols. If appropriate protocols do not exist, the State Water Board or San Diego Water Board may approve the use of other methods. All analytical laboratories must be certified by the State Water Board's Environmental Laboratory Accreditation Program (ELAP) in accordance with Water Code 13176.

Physical and chemical measurements of sediment were selected to comply with the Sediment Control Plan and to provide data on chemicals of potential concern in bays and estuaries located in San Diego County. The physical and chemical analyses of sediments will include, at a minimum, grain size, percent solids, total organic carbon (TOC), trace metals, organochlorine pesticides, polychlorinated biphenyl (PCBs) congeners, and polynuclear aromatic hydrocarbons (PAHs). Chemical analyses of these constituents are necessary in order to compare to the California Logistic Regression Model (CA LRM) and the Chemical Score Index (CSI) for SQO analyses. Additional physical or chemical analyses may be included in order to aid in the interpretation of the individual lines of evidence (LOEs) (e.g., pyrethroids or ammonia).

Sediment toxicity testing will be performed for each station using a minimum of one short-term survival toxicity test and one sublethal toxicity test. Acceptable short-term sediment survival tests include the *Eohaustorius estuarius* 10-day survival test, the *Leptocheirus plumulosus* 10-day survival test, or the *Rhepoxynius abronius* 10-day survival test. Acceptable sublethal sediment toxicity tests include the the *Mytilus galloprovincialis* sediment-water interface (SWI) 48-hour embryo development test or the *Neanthes arenaceodentata* whole sediment 28-day growth test. The *E. estuarius* short-term survival test and the *M. galloprovincialis* sublethal toxicity test have been the test methods used in previous San Diego County bay and estuary monitoring programs including the Bight program where the SQO analytical tool was used to assess aquatic health.

Benthic community condition samples will be screened by field personnel and then sorted and identified to the lowest possible taxon by qualified taxonomists. Present-day taxonomic nomenclature is typically based on the most recent version of the Southern California Association of Marine Invertebrate Taxonomists (SCAMIT) taxonomic listing. This nomenclature differs from the taxonomic list used to develop the SQOs and benthic LOE indices. Therefore, currently used taxonomic identifications will need to be "rolled back" to the SQO nomenclature and orthography listed on the SCCWRP website prior to SQO benthic LOE calculation. Taxonomists should utilize the nomenclature and orthography in the SQO species list on the *Sediment Quality Assessment Tools* page located on the Southern California Coastal Water Research Project (SCCWRP) website (Sediment Quality Assessment Tools - Southern California Coastal Water Research Project (sccwrp.org)) for calculating the benthic LOE.

For the purposes of this QAPP, the constituent list for chemical analyses includes only those analytes that are required for compliance with SQO analyses and physical analyses that will aid in the interpretation of the SQO data. Analytical physical and chemistry methods provided in Table 3 are suggested methods that have been used in previous sediment monitoring programs within San Diego County's waterbodies (e.g., Bight), but are not the only acceptable methods. A detailed list of individual analytes is provided in Element 13.

**Table 3. Analyte list and Suggested Testing Methods for SQO analyses**

| Analyte/ Test | Method |
|---|---|
| ***Physical Analyses*** | |
| Grain size | Plumb 1981 or use of a Horiba LA920 (Laser Particle Analyzer) |
| Percent solids | SM 2540B |
| TOC | USEPA 9060A |
| ***Chemical Analyses*** | |
| Trace Metals | USEPA 6020A (Mercury- 7471B) |
| Oganochlorine pesticides | USEPA 8081B |
| PCB congeners | USEPA 8082A |
| PAHs | USEPA 8270D |
| ***Toxicity*** | |
| Short-term amphipod survival using *Eohaustorius estuarius* | USEPA (1994) *Methods for Assessing Toxicity of Sediment-Associated Contaminants with Estuarine and Marine Amphipods*, ASTM E1367-03 |
| Sublethal testing using *Mytilus galloprovincialis* | USEPA (1995) *Short-Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to West Coast Marine and Estuarine Organisms;* Anderson et al. (1996) *Assessment of Sediment Toxicity at the Sediment-Water Interface* |
| Sublethal testing using *Neanthes arenaceodentata* | ASTM E1562 with modifications described in Farrar and Bridges (2011) |
| ***Benthic Infauna*** | |
| Benthic Community Condition | See Element 13 |

Short-term survival toxicity testing will be performed in accordance with procedures for amphipod testing outlined in *Methods for Assessing Toxicity of Sediment-Associated Contaminants with Estuarine and Marine Amphipods* (USEPA, 1994) and ASTM method E1367-03 (ASTM, 2006). Sublethal sediment toxicity testing for *Mytilus galloprovincialis* should follow procedures outlined in *Short-Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to West Coast Marine and Estuarine Organisms* (USEPA, 1995) and *Assessment of Sediment Toxicity at the Sediment-Water Interface* (Anderson et al., 1996), whereas sublethal sediment toxicity testing for *Neanthes arenaceodentata* should follow ASTM method E1562 (ASTM, 2002) with modifications described in Farrar and Bridges (2011) that have been found to contribute manageability and precision to the ASTM procedure.

## SQO Analyses

Protocols for assessing sediment chemistry, toxicity, and benthic community conditions for San Diego County waterbodies using California's SQOs are described in Section 3.2 of the Sediment Monitoring Plan.

## Project Schedule

The schedule for completing the sediment quality monitoring requirements of the Permit and for submitting the sediment monitoring results is shown in Table 4.

**Table 4. Sediment Monitoring Program Schedule**

| Activity/Deliverable | Dates(s)* |
|---|---|
| San Diego Water Board Order No. R9-2013-0001 | Adopted May 8, 2013 and effective June 27, 2013 |
| Southern California Bight Regional Monitoring Program - Field Sampling | July-September 2023 |
| Southern California Bight Regional Monitoring Program - Data Assessment | October - June 2024 |
| Follow-up confirmation monitoring (if required) | To be determined |
| Final sediment monitoring report incorporated into 2023-2024 WQIP Annual Report | January 31, 2025 |
| Potential Stressor ID Studies | To be determined |

*Table does not include future permit cycles

This revised Sediment Monitoring Plan and Sediment Monitoring QAPP will be submitted with WQIP Annual Reports in January 2024. The San Diego County Regional Copermittees participated in the 2023 Bight Program to satisfy Provisions D.1.e.(1)(b) and D.1.e.(2) of the Permit. Follow-up confirmation monitoring and data assessments will be conducted, if necessary, based on the station assessment results from Bight 2023. Monitoring for the 2023 Bight Program was conducted in accordance with the *Southern California Bight 2023 Regional Marine Monitoring Survey (Bight '23) Sediment Quality Assessment Field Operations Manual* (SCCWRP, 2023) and data were collected using methods consistent with previous Bight surveys and the current SQO guidelines as described in with Sediment Control Plan. The sediment monitoring results from Bight 2023 will be incorporated into the 2023-2024 WQIP Annual Report due to the San Diego Water Board on January 31, 2025. Additional sediment quality monitoring or stressor identification studies conducted after 2023 will be included in future WQIP Annual Reports.

## Constraints

Sediment monitoring must occur in subtidal areas located within a waterbody between the months of June through September. SQOs have been fully developed for only two of California's six enclosed bay habitats: euhaline (salinity = 25 to 32 parts per thousand [ppt]) bays and estuaries south of Point Conception and polyhaline (18 to 25 ppt) central San Francisco Bay. The benthic species assemblage used to calculate the benthic LOE in San Diego bays and estuaries is Habitat C- Southern California Marine Bays, which requires a salinity greater than or equal to (≥) 27 ppt (Bay et al 2021; Ranasinghe et al 2008). While the State Water Board SQOs have not been fully developed for low salinity subtidal habitats (i.e., less than [<] 27 ppt), these types of habitats can still be sampled in embayments with some slight sampling modifications and different data assessment tools. In order to select a sampling station applicable to the SQO assessment using Habitat C for the benthic LOE or a station applicable for low salinity habitats, it is recommended to verify the water depth at a proposed sampling station to ensure it is subtidal and to measure the salinity to determine which type of habitat it falls into. Salinity measurements should be taken at or near the sediment-water interface. Sediment samples will be collected with a 0.1 $m^2$ Van Veen grab sampler or other similar device. Certain types of benthic habitat such as hard clay, cobble, coarse sand, and areas with thick eel grass (SQO benthic community metrics are not calibrated for eelgrass environments) may be difficult to sample using this type of device. A slight relocation of the target sampling location may be necessary to avoid areas in which obtaining acceptable grab samples is not achievable.

Nesting periods for threatened or endangered bird species inhabiting coastal water bodies may prevent or delay sampling during certain summer months. Species of particular concern include least terns, snowy plovers, California clapper rails, and Belding’s savannah sparrows. Permission from California Fish and Wildlife may be required to enter restricted areas that are known to contain these species. Additionally, permission from private landowners may be necessary to gain access to private property and/or private boat launches.

# ELEMENT 7 QUALITY OBJECTIVES AND CRITERIA FOR MEASUREMENT DATA

All quality assurance/quality control (QA/QC) data for chemistry and toxicity samples must be conducted in accordance with the QAPP for the State of California's Surface Water Ambient Monitoring Program (SWAMP) (SWAMP Quality Assurance Team, 2008). The data quality objectives (DQOs) are summarized by category in Table 5. This QAPP should be used as the primary document to ensure proper methods are used consistently throughout the monitoring program. However, if sediment quality monitoring is conducted as part of the Bight Program (i.e., SQO analysis as stated in the Sediment Control Plan), the work plans and associated QA/QC documents pertaining to the Bight Program should be followed as the primary documents and the Sediment Monitoring QAPP as the secondary document.

**Table 5. Summary of Data Quality Objectives**

| Measurement or Analysis Type | Applicable Data Quality Objective |
|---|---|
| Chemistry Laboratory Analyses | Accuracy, precision, and completeness |
| Toxicity Laboratory Analyses | Precision and completeness |
| Benthic Infauna Analyses | Accuracy and completeness |

Acceptance criteria will be based on the implementation of acceptable and recognized QA/QC procedures. Acceptable data must have proper sample collection and handling methods, sample preparation and analytical procedures, holding times, stability issues, and QA protocols.

Accuracy is a measure of how closely the analytical result or field measurement represents the true quantity found in the sample. Evaluation of the accuracy of laboratory samples will be achieved through the preparation and analysis of either reference materials (e.g., certified or standard reference materials [CRM/SRM]) or laboratory control samples [LCS]) with each analytical batch. For sediment toxicity samples, the accuracy of sediment toxicity tests cannot be determined since a reference material of known toxicity is not available. The accuracy of benthic infaunal sorting and taxonomic identifications of benthic infaunal organisms will be evaluated via a QA/QC procedure that ensures a 95% sorting efficiency of each sample and a minimum of 10% of the taxonomic samples should be re-identified by secondary taxonomists other than the primary taxonomist who originally conducted the analysis. For more detailed information on taxonomic QC procedures using a secondary taxonomist for reanalysis, see the *Sediment Quality Assessment Technical Support Manual* (Bay et al., 2021).

Precision is the measure of agreement among repeated measurements of the same property under identical or substantially similar conditions calculated as either the range or as the standard deviation. The precision of chemistry laboratory measurements will be controlled by comparison of the sample to either a laboratory duplicate or a laboratory matrix spike/matrix spike duplicate (MS/MSD). For toxicity samples, a water only reference toxicant test will be run with every batch of test samples in order to document organism relative sensitivity and test precision. Reference toxicant test results that fall outside of control chart limits (2 standard deviations of the mean) will trigger a review of test procedures and a possible retest of the corresponding sediment samples. A negative control will be run with each test batch for both the short-term survival and sublethal toxicity tests.

Completeness is a measure of the percentage of sample results that are collected and analyzed and determined to be valid. A goal of 90% completeness exists for each measurement process. Completeness will be assessed in all chemistry samples with qualifiers indicating the reasons for any samples that did not meet acceptance criteria. All toxicity tests will be run with toxicity control tests to assess validity of the toxicity test results. Benthic infaunal samples that do not meet acceptance criteria will be re-sorted.

“Representative” is a qualitative term that expresses “the degree to which data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition” (ANSI/ASQC, 1994). Best professional judgement (BPJ) will be used in the field to evaluate whether measurements are made, and physical samples collected in such a manner that the resulting data appropriately reflect the environment or condition being measured or studied. Sample selection and use of approved/documented analytical methods will control to the best extent possible that the measurement data represent the conditions at the investigation site.

Quality control samples and data quality objectives for analyzing chemistry and toxicity samples collected as part of the sediment monitoring program must be conducted in accordance with the QAPP for the State of California’s SWAMP (SWAMP Quality Assurance Team, 2008) if SWAMP quality objectives are available. The quality objectives are outlined in Table 6 through Table 8. Depending on the physical or chemical analysis of the sediment samples, the following QA/QC sample types may be required to be included in the analytical run:

- A laboratory blank to determine the likelihood of contamination in the samples.
- A laboratory duplicate sample to estimate the precision of the results through the calculation of the relative percent difference (RPD) between the sample and the duplicate sample.
- A certified or standard reference material to determine the accuracy of the analyses.
- A matrix spike to determine if interference has occurred between the sample matrix and the analysis of the target analyte.
- A surrogate compound to estimate losses of the target analyte during the sample extraction phase and analysis of the sample (for organic measurements only).

SWAMP quality control measurements for toxicity testing of marine sediments are provided in Table 7. It is recommended that quality control measurements for the other test species use the same guidelines listed in Table 7. For the SQO analysis, quality assurance recommendations for toxicity testing are also provided in SCCWRP’s *Sediment Quality Assessment Technical Support Manual* (Bay et al., 2021).

### Table 6. Frequency of Chemistry Analysis for Laboratory Quality Assurance/Quality Control Samples

| Analysis Type | Laboratory Blanks | Laboratory Duplicate | SRM or LCS[1] | Matrix Spikes | Matrix Spike Duplicates | Surrogate |
|---|---|---|---|---|---|---|
| Total solids | 1 per analytical batch | 1 per analytical batch | N/A | N/A | N/A | N/A |
| Total organic carbon | 1 per analytical batch | 1 per analytical batch | 1 per 20 samples or 1 per analytical batch, whichever is more frequent | N/A | N/A | N/A |
| Grain size | N/A | 1 per analytical batch | N/A | N/A | N/A | N/A |
| Trace Metals | 1 per 20 samples or 1 per analytical batch, whichever is more frequent | 1 per 20 samples or 1 per analytical batch, whichever is more frequent | 1 per 20 samples or 1 per analytical batch, whichever is more frequent | 1 per 20 samples or 1 per analytical batch, whichever is more frequent | 1 per 20 samples or 1 per analytical batch, whichever is more frequent | N/A |
| Organochlorine Pesticides | 1 per 20 samples or 1 per analytical batch, whichever is more frequent | N/A | 1 per 20 samples or 1 per analytical batch | 1 per 20 samples or 1 per analytical batch, whichever is more frequent | 1 per 20 samples or 1 per analytical batch, whichever is more frequent | Included in all samples and all QC samples |
| PCB Congeners | 1 per 20 samples or 1 per analytical batch, whichever is more frequent | N/A | 1 per 20 samples or 1 per analytical batch | 1 per 20 samples or 1 per analytical batch, whichever is more frequent | 1 per 20 samples or 1 per analytical batch, whichever is more frequent | Included in all samples and all QC samples |
| PAHs | 1 per 20 samples or 1 per analytical batch, whichever is more frequent | N/A | 1 per 20 samples or 1 per analytical batch | 1 per 20 samples or 1 per analytical batch, whichever is more frequent | 1 per 20 samples or 1 per analytical batch, whichever is more frequent | Included in all samples and all QC samples |

LCS = Laboratory control sample

N/A = not applicable

SRM = standard reference material

[1] When a Standard Reference Material is not available, an LCS will be analyzed.

## Table 7. Quality Control Measurements for Sediment Toxicity Testing

| QC Control | Frequency of Analysis and Control Limits |
|---|---|
| Negative Controls<br>Laboratory Control Water | Laboratory Control water consistent with Section 7 of appropriate EPA method/manual must be tested with each analytical batch/<br>Laboratory control water must meet all test acceptability criteria for the species of interest. |
| Negative Controls<br>Conductivity/Salinity Control Water | A conductivity or salinity control must be tested when these parameters are above or below the species tolerance/<br>Follow EPA guidance on interpreting data. |
| Negative Controls<br>Additional Control Water | Additional method blanks are required whenever manipulations are performed on one or more of the ambient samples within each analytical batch/<br>There must be no statistical difference between the laboratory control water and each additional control water within an analytical batch. |
| Negative Controls<br>Sediment Control | Sediment control consistent with Section 7 of the appropriate EPA method/manual must be tested with each analytical batch of sediment toxicity tests/<br>Sediment control must meet all data acceptability criteria for the species of interest. |
| Positive Controls<br>Reference Toxicant Tests | Reference toxicant tests must be conducted monthly for species that are raised within a laboratory, or per analytical batch for commercially supplied or field-collected species/<br>Last plotted data point (LC50 or EC50) must be within 2 SD of the cumulative mean (n=20). Reference toxicant tests that fall outside of recommended control chart limits are evaluated to determine the validity of associated tests. An out-of-control reference toxicant test result does not necessarily invalidate associated test results. More frequent and/or concurrent reference toxicant testing may be advantageous if recent problems have been identified in testing. |
| Sample Duplicate | 5% of total project sample count/<br>Recommended acceptable RPD<20% |

## Table 8. Data Quality Objectives for Laboratory Measurements

| Group | Parameter | Accuracy | Precision | Completeness |
|---|---|---|---|---|
| **Sediment Samples** | | | | |
| Laboratory analyses | Total Solids | N/A | Laboratory duplicate RPD < 25% | 90% |
| Laboratory analyses | TOC | Laboratory Blank <RL or <30% of lowest sample; SRM or LCS with 80–120% recovery of true value | Laboratory duplicate RPD < 25% | 90% |
| Laboratory analyses | Grain Size | N/A | Laboratory duplicate RPD < 25% | 90% |
| Laboratory Analyses | Trace Metals | Laboratory Blank< RL for target analyte; SRM or LCS 75-125% recovery | Laboratory duplicate, MSD RPD < 25%; MS/MSD 75-125% recovery | 90% |
| Laboratory Analyses | Organochlorine Pesticides | Laboratory Blank< RL for target analyte; SRM 70-130% recovery if certified, otherwise 50-150% recovery; if using LCS 70-130% recovery | MSD RPD < 25%; MS/MSD 50-150% recovery or based on historical laboratory control limits (average ±3SD); surrogates based on historical lab control limits (50-150% or better) | 90% |
| Laboratory Analyses | PCB Congeners | Laboratory Blank< RL for target analyte; SRM 70-130% recovery if certified, otherwise 50-150% recovery; if using LCS 70-130% recovery | MSD RPD < 25%; MS/MSD 50-150% recovery or based on historical laboratory control limits (average ±3SD); surrogates based on historical lab control limits (50-150% or better) | 90% |
| Laboratory Analyses | PAHs | Laboratory Blank< RL for target analyte; SRM 70-130% recovery if certified, otherwise 50-150% recovery; if using LCS 70-130% recovery | MSD RPD < 25%; MS/MSD 50-150% recovery or based on historical laboratory control limits (average ±3SD); surrogates based on historical lab control limits (50-150% or better) | 90% |

## Table 8. Data Quality Objectives for Laboratory Measurements

| Group | Parameter | Accuracy | Precision | Completeness |
|---|---|---|---|---|
| **Toxicity Samples** | | | | |
| Toxcity Testing | Short-term 10-day Amphipod Survival Tests | N/A | Reference toxicity testing; test results within 2 standard deviations of the mean are re-evaluated. | 90% |
| Toxicity Testing | Sublethal Sediment Toxicity Tests | N/A | Reference toxicity testing; test results within 2 standard deviations of the mean are re-evaluated. | 90% |
| **Benthic Infauna Samples** | | | | |
| Benthic Infauna | Benthic Infaunal Sorting | 95% sorting efficiency | N/A | 90% |
| Benthic Infauna | Taxonomic Identifications | Minimum of 10% of samples re-identified by a secondary taxonomist other than primary taxonomist who originally conducted analysis. | NA | 90% |

# ELEMENT 8 SPECIAL TRAINING NEEDS/CERTIFICATION

## Specialized Training or Certifications

*Field Sampling*

Field personnel will have current and relevant experience in the aspects of standard field monitoring, including use of relevant field equipment such as boats, field instruments, and monitoring equipment. Field personnel will also have been trained and have experience in the collection and handling of samples, and chain-of-custody (COC) procedures. Training will be reviewed in proper field sampling and sample-handling techniques prior to sampling and only those staff with proficiency will be permitted to conduct field work.

*Analytical Laboratory*

All analytical tests including chemistry and toxicity will be conducted by laboratories certified by the State Water Board's ELAP in accordance with Water Code Section 13176.

## Training and Certification Documentation

Personnel are responsible for complying with QA/QC requirements that pertain to their organizational/technical function. Each technical staff member must have a combination of experience and education to adequately demonstrate a specific knowledge of their particular function and a general knowledge of laboratory operations, test methods, QA/QC procedures, and records management.

*Field Sampling*

Field personnel training will be documented, and records kept in the project files at each organization's offices.

*Analytical Laboratory*

Training documents for each subcontracting laboratory will be detailed in the individual QAPPs for each laboratory.

## Training Personnel

The Project Manager and/or Field Task Manager will provide training for field personnel in proper field sampling techniques prior to work initiation to ensure consistent and appropriate sampling, sample handling/storage, and COC procedures.

# ELEMENT 9 DOCUMENTS AND RECORDS

Each Copermittee or their subcontractor(s) will document and track the aspects of the sample collection process, including generating field logs at each site and COC forms for the samples collected. COC forms will accompany samples to the appropriate laboratory for analysis. Each laboratory will document and track the aspects of receipt and storage, analyses, and reporting related to their respective samples.

A database of information collected during the sediment monitoring will be maintained by each Copermittee or their subcontractor(s). The database will include field observations, data sheets, COC records, and analytical results. The original data sheets, statistical worksheets, and reports produced will be accumulated into project-specific files maintained in file cabinets following submittal of the draft report. Data from outside contractors will be kept exactly as received. Monitoring data and analytical results will be uploaded into California Environmental Data Exchange Network (CEDEN).

Persons responsible for maintaining records for this project will be specified by the project manager and will be tasked with overseeing the operations of the project, and maintaining the sample collection, sample transport, COC, field analysis forms, and laboratory data. They will also be responsible for arbitrating any issues relative to records retention and any decisions to discard records.

Copies of this QAPP will be distributed to all parties identified previously in Element 3. Updates to this QAPP will be distributed in a similar manner, and previous versions will be discarded from the project file. The WMA Lead under the direction, supervision, and review of the QA Officer, will be responsible for distributing an updated version of the QAPP.

Copies of the final report, including laboratory results and field records, will be maintained for a minimum of five years after project completion.

# GROUP B:
# DATA GENERATION AND ACQUISITION

# ELEMENT 10 SAMPLE PROCESS DESIGN

## Station Selection

The selection of suitable station locations is critical to assessing benthic conditions. Justification for selecting locations for sediment sampling is provided in Section 2.1.1 of the Sediment Monitoring Plan. The number of sampling stations will vary within each San Diego County waterbody based on the spatial extent of the area likely to be impacted. As described in Section IV.A.4.a of the Sediment Control Plan, two or more stations within a site are required to be individually assessed in order to be in compliance with the aquatic life objective. If a stressor identification study becomes necessary following the initial SQO assessment of a waterbody, then the number of stations will be based upon the drivers of the impacted scores (e.g., algae, physical factors, or chemical factors) and statistical power (i.e., having enough samples to statistically support meaningful findings).

All station locations will be pre-plotted prior to sampling activities. Locations will be identified in the field using a Differential Global Positioning System (DGPS). The system uses U.S. Coast Guard differential correction data and is accurate within 10 feet (ft). All final station locations will be recorded in the field using positions from the DGPS.

In the event that a pre-plotted sample location is found to be unsuitable for collecting sediment, because of factors such as inaccessibility, disturbance to wildlife, or safety considerations, the station may be abandoned and an alternate station with similar characteristics may be selected within the same strata. Reasons for abandonment should be recorded on field data sheets.

## Monitoring Season and Frequency

Sediment for SQO programs must be collected between June and September. Physical environments and benthic community composition and abundance within enclosed bays and estuaries are generally most stable during this time of year (Bay et al., 2021).

According to Section IV.A.4.c.3.a of the Sediment Control Plan, sediment monitoring associated with Phase I stormwater discharges and major discharges shall be conducted a minimum of once during a Permit cycle. Stations that have consistently been classified as Unimpacted or Likely Unimpacted using the MLOE approach (described in Section 3.2 of the Sediment Monitoring Plan) may have the sampling frequency reduced to once per permit cycle. The San Diego Water Board may also limit receiving water monitoring to a subset of outfalls to focus where the risk to sediment quality is greatest.

# ELEMENT 11 SAMPLING METHODS

## Sediment Sampling

Information regarding the sampling vessel and site acceptability is provided in Sections 2.1.4 and 2.1.5 of the Sediment Monitoring Plan. Benthic sediments will be collected as surface grabs using an appropriate grab sampler. The recommended grab sampler is a stainless steel Van Veen or modified Van Veen. The size of the grab sampler used for sediment programs in Southern California should be able to sample a surface area of 0.1 square meter ($m^2$). Grab samplers with a smaller surface area (e.g., petite ponar grab) can be utilized provided the grabs are equivalent in quality as to that of a Van Veen grab.

When collecting sediment samples in subtidal brackish habitats of estuaries (i.e., < 27 ppt), it is recommended to follow sampling techniques specifically developed and utilized for low salinity habitats during the 2018 Bight Program (SCCWRP, 2018). For low salinity habitats, sediment chemistry and toxicity samples can be collected with a Van Veen or a petite ponar grab. Benthic infaunal samples should be collected with a Van Veen when possible. When not practical, multiple grabs may be collected using a hand deployed petite ponar to collect an equivalent surface area of a Van Veen grab. If areas are not accessible to deploy a Van Veen or petite ponar grab from a boat, then using a sample coring device is also acceptable. If using a coring device, two 4-inch plastic cores should be directly inserted into the sediment that will then be composited into one sample. In Bight '18, both Van Veen grabs and a coring device were used to collect benthic infaunal samples. For more details on low salinity habitat sampling procedures refer to the Bight '18 Sediment Quality Assessment Field Operations Manual and Appendices found on SCCWRP's website at:

http://ftp.sccwrp.org/pub/download/BIGHT18/Bight18SedQualityFieldManual.pdf
http://ftp.sccwrp.org/pub/download/BIGHT18/Bight18SedQualityFieldManual_Appendices.pdf)

An appropriate sampler for the collection of benthic sediments will have the following characteristics:

- Constructed of a material that does not introduce contaminants.
- Causes minimal surface sediment disturbance.
- Does not leak or mix during sample retrieval.
- Has a design that enables safe/easy sample verification that samples meet all applicable sampling criteria (e.g., collects sediments to at least 5 cm below the sediment surface, has access doors allowing visual inspection and removal of undisturbed surface sediment, meets surface area requirement for benthic community habitat being sampled).

Sediment grabs will be collected for the following analyses: benthic infauna, chemistry, particle size, and toxicity. Because multiple grabs need to be collected, the benthic infaunal sample is collected first to minimize disturbance of the infaunal community. A sample will be considered acceptable if the surface of the grab is even, there is minimal surface disturbance, and there is a penetration depth of at least 5 cm (or 10 cm for benthic infaunal samples collected in low salinity habitats [i.e., < 27 ppt] if using a core device). Rejected grabs will be discarded, and the station will be re-sampled. Acceptable sediment grabs to be utilized for chemistry, particle size, and toxicity analyses will have the overlying water carefully drained from the sediment surface prior to removing the sediment to be placed in the appropriate sample containers. Overlying water will not be drained from sediment samples collected for benthic infaunal analysis. Station location and grab event data will be recorded on pre-formatted field data sheets (hard copies or via computer). At a minimum, field data will include station identification, station location, date, time of sample collection, depth of water, depth of penetration of grab in sediment, sediment composition, sediment odor and color, and sample type (e.g., sediment chemistry, toxicity, etc.). While not required, it is recommended that photographs of each sediment sample be taken and stored.

The entire contents of at least one Van Veen grab sample, or multiple petite ponar grabs that equivalate the surface area of one Van Veen grab, will be utilized for benthic community analyses with a minimum penetration depth of 5 cm. If using a coring device in low salinity habitats, then the two core samples should have a penetration depth of 10 cm. Samples collected for benthic infaunal analysis will be rinsed through a 1.0-millimeter (mm) mesh screen. The material retained on the screen will be transferred to a labeled glass or plastic sample container. A 7% magnesium sulfate ($MgSO_4$) seawater solution will be added to the sample container to 85-90% of its volume to relax the collected specimens. The sample container will be gently inverted several times to distribute the relaxant solution. After 30 minutes, add enough sodium borate buffered formalin (50 grams sodium borate per liter of formalin) to top off the sample container. This will make a 10% formalin solution (i.e., 1 part buffered formalin to 9 parts saltwater). Alternatively, the relaxant solution can be decanted and replaced with a pre- mixed 10% buffered formalin solution. Gently invert the container several times to ensure the sample is mixed.

Sediment samples for chemistry and toxicity testing will be collected from the top 5 cm of a grab sample using a pre-cleaned stainless-steel scoop. Sediment within 1 cm of the sides of the grab will be avoided to prevent interaction of any contaminants and the steel sampling device. Chemistry and toxicity sample processing and allocation of sub-samples can be conducted using two different methods: distributed or composited. Distributed samples are separate representative sediment samples for chemistry and toxicity collected from the same grab or multiple grabs that are placed in specific containers for each type of analysis. Sediment aliquots collected in this manner should be representative of the entire 5 cm depth of the surface sediment. If utilizing the homogenized sampling method, then sediment samples are collected from the surface of each grab, placed in an intermediate precleaned mixing container, and homogenized before placing sediment in sample containers. The mixing container and utensils used to mix the sediment should be made of an inert material that will not contaminate the sample (e.g., Teflon bag or Teflon coated mixing bowl and utensils). The homogenization method maximizes comparability of the chemistry and toxicity samples and is the preferred method from a toxicological perspective.

Depending on the study design, the sediment-water interface toxicity test can be conducted on two different types of sediment samples, either on an undisturbed core sample or on homogenized sediment. If collecting a core sample, a polycarbonate core tube (7.3-cm inner diameter [ID] and 16cm in length) is pressed directly into the top 5 cm of sediment in the grab sampler. To prevent loss of sample, a gloved hand or precleaned acrylic plate can be inserted on the bottom when removing from the grab sampler and capped upon removal. Cores should be stored upright with minimal disturbance during transit to the analytical laboratory. As an alternative, sediment samples can be homogenized in the field as described in the previous paragraph. This method is more practical to implement in the field, maximizes comparability of the chemistry and toxicity samples as stated above, and is consistent with previous sediment quality objective methodology (e.g., Bight protocols and previous lagoon monitoring implemented by the Copermittees).

All sampling equipment will be cleaned prior to sampling. Between sampling locations, grab sampling equipment will be scrubbed with a brush and rinsed with site water. Stainless steel scoops will be rinsed with seawater and rinsed with de-ionized water between stations. Clean gloves will be worn by sampling personnel at each new station.

# ELEMENT 12 SAMPLE HANDLING CUSTODY

Sediment samples will be uniquely identified with sample labels in indelible ink. All sample containers will be identified with the project title, appropriate identification number, date and time of sample collection, and preservation method. All samples will be kept on wet ice from the time of sample collection until delivery or transport to the analytical laboratory. All samples will be transferred to the appropriate laboratory and analyses initiated within the method specified holding time (Table 9). Sample volumes required for each analysis will be dictated by the analytical laboratory conducting the analyses.

**Table 9. List of Analytes with Container Type, Holding Time, and Preservation Method**

| Analyte | Recommended Container Type | Required Holding Time | Recommended Preservation |
|---|---|---|---|
| **Field Measurements** | | | |
| Salinity (conductivity & temperature if using a YSI sonde) | *In situ* | | |
| Depth | | | |
| **Sediment Chemistry** | | | |
| Total Solids | Glass jar | 7 days | Cool to ≤6 °C |
| Total Organic Carbon | Glass jar | 28 days at ≤6 °C; 1 year at ≤- 20°C | Cool to ≤6 °C or freeze to ≤ -20°C |
| Grain Size | HDPE, Glass jar, or plastic bag | 1 year | Wet ice to ≤6 °C in the field, then refrigerate at ≤6 °C |
| Trace Metals | Glass jar | 1 year; samples must be analyzed within 14 days of collection or thawing | Cool to ≤6 °C within 24 hours, then freeze to ≤-20°C |
| Organochlorine Pesticides | Glass jar | 1 year; samples must be extracted within 14 days of collection or thawing and analyzed within 40 days of extraction | Cool to ≤6 °C within 24 hours, then freeze to ≤-20°C |
| PCB Congeners | Glass jar | None | Cool to ≤6 °C within 24 hours, then freeze to ≤-20°C |
| PAHs | Glass jar | 1 year; samples must be extracted within 14 days of collection or thawing and analyzed within 40 days of extraction | Cool to ≤6 °C within 24 hours, then freeze to ≤-20°C |
| **Sediment Toxicity** | | | |
| **Toxicity Testing** | 10L Teflon bag or 1-L glass jars | < 14 days (recommended) or < 4 weeks (required) | Wet or blue ice in field; 0 - 6°C refrigeration for storage (do not freeze); dark at all times (required) |
| **Benthic Infauna** | | | |
| **Benthic Community Condition** | 1-L HDPE or 1-L Glass jar – sample volume will vary so may need multiple jars per sample | Formalin: 2-5 days 70% Ethanol: Indefinite- sample jars should be periodically checked for evaporation of ethanol | Initially samples are placed in 10% Buffered Formalin for 2-5 days; samples are then transferred to 70% ethanol |

## Chain-of-Custody Procedures

Samples will be considered to be in custody if they are (1) in the custodian's possession or view, (2) retained in a secured place (under lock) with restricted access, or (3) placed in a container and secured with an official seal such that the sample could not be reached without breaking the seal. The principal documents used to identify samples and to document possession will be COC records, field logbooks, and field tracking forms. COC procedures will be used for samples throughout the collection, transport, and analytical process.

COC procedures will be initiated during sample collection. A COC record will be provided with each sample or group of samples. Each person who will have custody of the samples will sign the form and ensure the samples will not be left unattended unless properly secured. Documentation of sample handling and custody includes the following:

- Sample identifier.
- Sample collection date and time.
- Any special notations on sample characteristics or analysis.
- Initials of the person collecting the sample.
- Date the sample was sent to the analytical laboratory.
- Shipping company and waybill information.

Completed COC forms will be placed in a plastic envelope and kept inside the cooler containing the samples. Once delivered to the analytical laboratory, the COC form will be signed by the person receiving the samples. The condition of the samples will be noted and recorded by the receiver. COC records will be included in the final reports prepared by the analytical laboratories and are considered an integral part of the report.

## Sampling Transport, Shipping, and Storage Procedures

Sediment samples collected in the field for chemistry and toxicity analyses will initially be placed on ice and stored in the dark. Prior to shipping or transport, sample containers will be packed inside coolers with ice. COC forms will be filled out, and the original signed COC forms will be inserted in a sealable plastic bag and placed inside the coolers. The cooler lids will be securely taped shut and then samples will be delivered or shipped on ice to the appropriate analytical laboratory for analysis. Sediment designated for benthic infauna analysis will be screened on location by field personnel. The material and organisms retained on the screen will be put into appropriate 1-L containers, treated with magnesium sulfate relaxant, and preserved with formalin. Once preserved, benthic infauna samples will be delivered with accompanying COC forms to the laboratory tasked with sorting macroinvertebrates into broad taxonomic groupings. Following sorting, taxonomic samples will be shipped/ delivered to specialized taxonomists who will identify benthic macroinvertebrates to the lowest possible taxon.

# ELEMENT 13 ANALYTICAL METHODS

## Field Analytical Methods

A YSI water quality data sonde (e.g., YSI 6600 Multiparameter Sonde) or similar device can be utilized to take salinity measurements at each station location. Operation of field equipment will be conducted as per manufacturer instructions. Calibrations will be performed and recorded to ensure accurate functionality. Salinity measurements should be taken approximately six inches above the SWI. At a minimum, it is recommended that salinity measurements should be taken at a spring high and low tide to get an estimate of the salinity range for a proposed station. If feasible, it is recommended that salinity should be monitored throughout an entire spring tidal cycle to ensure it meets the salinity criteria prior to sampling. Water depth should also be measured when visiting the station at a spring low tide or deploying a continuous monitoring device over a spring tidal cycle to ensure the station is subtidal.

Stations located in low salinity habitats should be in a minimum of six inches of estuary water at a Mean Lower Low Water (MLLW) tide. To ensure that a station is sampleable, it is recommended to conduct reconnaissance of the site close to MLLW and when it is less than or equal to 0.5 feet (ft) on tide charts. Salinity should be measured at or near the sediment-water interface to determine if the station meets low salinity habitat sampling requirements (salinity < 27 ppt) (SCCWRP, 2018).

## Laboratory Analytical Methods

### *Chemistry Samples*

A list of sediment chemical constituents and maxiumum reporting limits (RLs) for analytes that are required for SQO analysis are provided in Table 10. Additional physical parameters including grain size and TOC are also listed. While these physical parameters are not required to calculate the chemistry LOE, they should be analyzed in order to provide additional information to aid in the interpretation of the toxicity and benthic LOEs. Percent solids must be measured to convert concentrations of the chemical parameters from a wet-weight to a dry-weight basis.

Target RLs listed in Table 10 are those that are provided in the *Sediment Quality Assessment Technical Support Manual* (Bay et al., 2021) for SQO analyses. The maximum RLs provided in Table 10 are based on the CSI classification ranges and are expressed on a dry weight basis. Lower RLs may be achievable depending on available analytical methods. As stated in Element 6, the analytical methods listed in Table 8 are suggested methods that have been used in previous sediment monitoring programs within San Diego County's waterbodies (e.g. Bight) but are not the only acceptable methods. Chemical analyses of all sediment samples collected as part of the SQO assessment must be tested in accordance with USEPA or ASTM protocols. If appropriate protocols do not exist, the State Water Board or San Diego Water Board may approve the use of other methods.

## Table 10. Physical and Chemical Parameters, Suggested Methods, and Maximum Reporting Limits for SQO Analysis

| Parameter | Method | Procedure | Maximum Reporting Limit (dry weight) |
|---|---|---|---|
| **Physical/ Conventional** | | | |
| Grain Size | Plumb 1981 | Wet sieving | 1.00 % |
| Percent Solids | SM 2540B | Gravimetric | 0.10 % |
| Total Organic Carbon (TOC) | USEPA 9060A | Combustion/ oxidation | 0.01 % |
| **Chemistry** | | | |
| **Trace Metals** | | | |
| Cadmium (Cd) | USEPA 6020A | ICP/MS | 0.09 mg/kg |
| Copper (Cu) | USEPA 6020A | ICP/MS | 52.8 mg/kg |
| Lead (Pb) | USEPA 6020A | ICP/MS | 25.0 mg/kg |
| Mercury (Hg) | USEPA 7471B | CVAA | 0.09 mg/kg |
| Zinc (Zn) | USEPA 6020A | ICP/MS | 60.0 mg/kg |
| **Organochlorine Pesticides** | | | |
| 2,4′-DDD | USEPA 8081B | GC/MS | 0.50 µg/kg |
| 2,4′-DDE | USEPA 8081B | GC/MS | 0.50 µg/kg |
| 2,4′-DDT | USEPA 8081B | GC/MS | 0.50 µg/kg |
| 4,4′-DDD | USEPA 8081B | GC/MS | 0.50 µg/kg |
| 4,4′-DDE | USEPA 8081B | GC/MS | 0.50 µg/kg |
| 4,4′-DDT | USEPA 8081B | GC/MS | 0.50 µg/kg |
| Chlordane-alpha | USEPA 8081B | GC/MS | 0.50 µg/kg |
| Chlordane-gamma | USEPA 8081B | GC/MS | 0.54 µg/kg |
| Dieldrin | USEPA 8081B | GC/MS | 2.5 µg/kg |
| trans-Nonachlor | USEPA 8081B | GC/MS | 4.6 µg/kg |
| **PCB Congeners** | | | |
| 2,4'-Dichlorobiphenyl (8) | USEPA 8082A | GC/MS ECD | 3.0 µg/kg |
| 2,2',5-Trichlorobiphenyl (18) | USEPA 8082A | GC/MS ECD | 3.0 µg/kg |
| 2,4,4'-Trichlorobiphenyl (28) | USEPA 8082A | GC/MS ECD | 3.0 µg/kg |
| 2,2',3,5'-Tetrachlorobiphenyl (44) | USEPA 8082A | GC/MS ECD | 3.0 µg/kg |
| 2,2',5,5'-Tetrachlorobiphenyl (52) | USEPA 8082A | GC/MS ECD | 3.0 µg/kg |
| 2,3',4,4'-Tetrachlorobiphenyl (66) | USEPA 8082A | GC/MS ECD | 3.0 µg/kg |
| 2,2',4,5,5'-Pentachlorobiphenyl (101) | USEPA 8082A | GC/MS ECD | 3.0 µg/kg |
| 2,3,3',4,4'-Pentachlorobiphenyl (105) | USEPA 8082A | GC/MS ECD | 3.0 µg/kg |
| 2,3,3',4',6-Pentachlorobiphenyl (110) | USEPA 8082A | GC/MS ECD | 3.0 µg/kg |
| 2,3',4,4',5-Pentachlorobiphenyl (118) | USEPA 8082A | GC/MS ECD | 3.0 µg/kg |
| 2,2',3,3',4,4'-Hexachlorobiphenyl (128) | USEPA 8082A | GC/MS ECD | 3.0 µg/kg |
| 2,2',3,4,4',5'-Hexachlorobiphenyl (138) | USEPA 8082A | GC/MS ECD | 3.0 µg/kg |
| 2,2',4,4',5,5'-Hexachlorobiphenyl (153) | USEPA 8082A | GC/MS ECD | 3.0 µg/kg |
| 2,2',3,4,4',5,5'-Heptachlorobiphenyl (180) | USEPA 8082A | GC/MS ECD | 3.0 µg/kg |
| 2,2',3,4',5,5',6-Heptachlorobiphenyl (187) | USEPA 8082A | GC/MS ECD | 3.0 µg/kg |
| 2,2',3,3',4,4',5,6-Octachlorobiphenyl (195) | USEPA 8082A | GC/MS ECD | 3.0 µg/kg |
| **Low Molecular Weight PAHs** | | | |
| Acenaphthene | USEPA 8270D | GC/MS SIM | 20 µg/kg |
| Anthracene | USEPA 8270D | GC/MS SIM | 20 µg/kg |

**Table 10. Physical and Chemical Parameters, Suggested Methods, and Maximum Reporting Limits for SQO Analysis**

| Parameter | Method | Procedure | Maximum Reporting Limit (dry weight) |
|---|---|---|---|
| Phenanthrene | USEPA 8270D | GC/MS SIM | 20 µg/kg |
| Biphenyl | USEPA 8270D | GC/MS SIM | 20 µg/kg |
| Naphthalene | USEPA 8270D | GC/MS SIM | 20 µg/kg |
| 2,6-Dimethylnaphthalene | USEPA 8270D | GC/MS SIM | 20 µg/kg |
| Fluorene | USEPA 8270D | GC/MS SIM | 20 µg/kg |
| 1-Methylnaphthalene | USEPA 8270D | GC/MS SIM | 20 µg/kg |
| 2-Methylnaphthalene | USEPA 8270D | GC/MS SIM | 20 µg/kg |
| 1-Methylphenanthrene | USEPA 8270D | GC/MS SIM | 20 µg/kg |
| **High Molecular Weight PAHs** | | | |
| Benzo(a)anthracene | USEPA 8270D | GC/MS SIM | 80 µg/kg |
| Benzo(a)pyrene | USEPA 8270D | GC/MS SIM | 80 µg/kg |
| Benzo(e)pyrene | USEPA 8270D | GC/MS SIM | 80 µg/kg |
| Chrysene | USEPA 8270D | GC/MS SIM | 80 µg/kg |
| Dibenzo(a,h)anthracene | USEPA 8270D | GC/MS SIM | 80 µg/kg |
| Fluoranthene | USEPA 8270D | GC/MS SIM | 80 µg/kg |
| Perylene | USEPA 8270D | GC/MS SIM | 80 µg/kg |
| Pyrene | USEPA 8270D | GC/MS SIM | 80 µg/kg |

DDD Dichlorodiphenyldichloroethane
DDE dichlorodiphenyldichloroethylene
DDT dichlorodiphenyltrichloroethane
mg/kg milligrams per kilogram
µg/kg micrograms per kilogram

### *Toxicity Samples*

To evaluate the benthic condition of San Diego County's waterbodies, sediment toxicity testing will be conducted in accordance with ASTM and USEPA methods. Toxicity testing involves a short-term survival test, a sublethal endpoint test, and an assessment of sediment toxicity using the SQO response categories. For each test type, more than one specific test is acceptable. The appropriate species tested for a sample will depend on the characteristics of the sample such as grain size, salinity, and suspected toxic constituents, if any. Test organisms used for each method should be acclimated (i.e., with respect to temperature and salinity) to test conditions prior to the start of testing. When historical data are available for a sample location, it is recommended that the same species be used in order to make comparisons and to conduct trend analysis. In addition, when testing is conducted as part of a regional monitoring program such as the Bight program, the species selection will be dictated by the program.

#### *Short-Term Survival Testing*

SQO analysis requires that at least one short-term survival test be conducted. There are three acceptable short-term survival tests, each of which is a 10-day test exposing amphipods to whole sediment. The three acceptable test organisms are *Eohaustorius estuarius*, *Leptocheirus plumulosus*, and *Rhepoxynius abronius*. The *E. estuarius* short-term survival test has been the 10-day test method used in previous San Diego County enclosed bay and estuary monitoring programs where the SQO analytical tool was used to assess aquatic health. This amphipod has also historically been utilized in toxicity tests for both marine (≥ 27 ppt) and low salinity (< 27 ppt) habitats for the Bight Program's SQO analyses. These amphipod bioassays will be conducted in accordance with procedures outlined in *Methods for Assessing Toxicity of Sediment-Associated Contaminants with Estuarine and Marine Amphipods* (USEPA, 1994) and ASTM method E1367-03 (ASTM, 2006). Test conditions are summarized in Table 11. If sediment monitoring is conducted as part of the Bight Program, then procedures and test conditions should be in accordance with Bight Workplans.

A water-only reference toxicity test should be conducted concurrently with the whole sediment amphipod test to assess the relative sensitivity of test organisms used in the evaluation of project sediments. Amphipod reference toxicant tests are typically conducted using cadmium. However, using ammonia as the reference toxicant is preferable because the sensitivity of the test organisms to ammonia (often a confounding factor in sediment testing) can be evaluated along with the relative sensitivity of the batch of organisms used in testing. If ammonia is selected as the reference toxicant, pore water ammonia will be measured between sample receipt and test set-up, and again at test initiation. If the un-ionized pore water ammonia concentration in the test initiation sample is 0.8 mg/L or greater, then the ammonia reference toxicant test will be extended from 4 days to 10 days for better comparison to 10-day test sample results.

**Table 11. Summary of Conditions for 10-Day Whole Sediment Amphipod Bioassay**

| **Test Conditions<br>10-Day Whole Sediment Bioassay** | | | | |
|---|---|---|---|---|
| | Test Species | ***E. estuarius*** | ***L. plumulosus*** | ***R. abronius*** |
| | Test Procedures | USEPA (1994); ASTM E1367-03 (2006) | | |
| | Test Type/Duration | Static - Acute Whole Sediment/10 days | | |
| | Sample Storage Conditions | 0 - 6 °C, dark, minimal head space | | |
| | Test Sediment holding time requirements | 2 weeks (recommended), maximum 4 weeks (required) | | |
| | Age/Size Class | 3-5 mm | 2-4 mm; immature | 3-5 mm |
| | Grain Size Tolerance | 0.6-100% sand | 0-100% sand | 10-100% sand |
| Recommended Water Quality Parameters | Temperature | 15 ± 1 °C | 25 ± 1 °C | 15 ± 1 °C |
| | Salinity | 20 ± 2 ppt | 20 ± 2 ppt | 28 ± 2 ppt |
| | Dissolved Oxygen | Maintaining 90% saturation | | |
| | Total Ammonia | < 60 mg/L | < 60 mg/L | < 30 mg/L |
| | Test Chamber | 1 L glass | | |
| | Exposure Volume | 2 cm sediment, 800 mL seawater | | |
| | Replicates/Sample | 5 | | |
| | No. of Organisms/Replicate | 20 | | |
| | Photoperiod | Continuous light | | |
| | Feeding | None | | |
| | Water Renewal | None | | |
| | Aeration | Constant gentle aeration | | |
| | Acceptability Criteria | Mean control survival $\geq$ 90%; $\geq$80% survival in each replicate | | |

mg/L – milligram per liter; mm – millimeter; mL – milliliter; L – Liter; ppt – parts per thousand; °C – degrees Celsius; cm – centimeter

***Sublethal Testing***

The second type of testing required for SQO analysis is a sublethal test. Either a 48-hour development test exposing embryos of the bivalve *Mytilus galloprovincialis* to the sediment-water interface may be conducted or a 28-day survival and growth test exposing the polychaete worm *Neanthes arenaceodentata* to whole sediment. Test condition summaries for the bivalve and polychaete tests are presented in Table 12 and Table 13, respectively. The *M. galloprovincialis* sediment-water interface test has been the sublethal test method used in previous San Diego County enclosed bay and estuary monitoring programs where the SQO analytical tool was used to assess aquatic health. This mussel has also historically been utilized in toxicity tests for both marine (≥ 27 ppt) and low salinity (< 27 ppt) habitats for the Bight Program's SQO analyses.

<u>*Mytilus galloprovincialis* Sediment-Water Interface Development Sublethal Test</u>

Sediment-water interface bioassays are performed to estimate the potential toxicity of contaminants fluxing from test sediments into the overlying water. The sediments will be tested in a 48-hour sediment-water interface test using the bivalve *M. galloprovincialis* in accordance with procedures outlined in *Short-Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to West Coast Marine and Estuarine Organisms* (USEPA, 1995) and Assessment of Sediment Toxicity at the Sediment-Water Interface (Anderson et al., 1996). If sediment monitoring is conducted as part of the Bight Program, then procedures and test conditions should be in accordance with Bight Workplans. Sediment-water interface bioassays will be tested on intact cores collected in the field or on homogenized sediment samples as described in Section 2.1.6 of the Sediment Monitoring Plan.

A water-only reference toxicity test should be conducted concurrently with the sediment-water interface bivalve test to assess the relative sensitivity of test organisms used in the evaluation of the project sediments. Bivalve reference toxicant tests are typically conducted using copper. However, using ammonia as the reference toxicant is preferable because the sensitivity of the test organisms to ammonia (often a confounding factor in sediment testing) can be evaluated along with the relative sensitivity of the batch of organisms used in testing. If ammonia is selected as the reference toxicant, pore water ammonia will be measured between sample receipt and test set-up, and again at test initiation. If the un-ionized pore water ammonia concentration in the test initiation sample is 0.8 mg/L or greater, then the ammonia reference toxicant test will be extended from 4 days to 10 days for better comparison to 10-day test sample results.

**Table 12. Test Conditions for the 48-Hour *M. galloprovincialis* Sediment-Water Interface Bioassay**

| Test Conditions<br>10-Day Whole Sediment Bioassay | | |
|---|---|---|
| Test Species | | ***M. galloprovincialis*** |
| Test Procedures | | USEPA (1995), Anderson et al. (1996) |
| Test Type/Duration | | Static - Acute sediment-water interface/48 hours |
| Sample Storage Conditions | | 0 - 6 °C, dark, minimal head space |
| Test Sediment holding time requirements | | 2 weeks (recommended), maximum 4 weeks (required) |
| Age/Size Class | | < 4-hour old larvae |
| Recommended Water Quality Parameters | Temperature | 15 ± 1 °C |
| | Salinity | 32 ± 2 ppt |
| | Dissolved Oxygen | Maintaining 90% saturation |
| | Total Ammonia | < 4 mg/L |
| Test Chamber | | Polycarbonate core tube 7.3-cm inner diameter, 16 cm high |
| Exposure Volume | | 5 cm sediment, 300 mL water |
| Replicates/Sample | | 4 |
| No. of Organisms/Replicate | | Approximately 250 larvae |
| Photoperiod | | 16 hours light: 8 hours dark |
| Feeding | | None |
| Water Renewal | | None |
| Aeration | | Constant gentle aeration |
| Acceptability Criteria | | Mean control normal-alive ≥ 80% |

mg/L – milligram per liter; mm – millimeter; mL – milliliter; ppt – parts per thousand; °C – degrees Celsius; cm - centimeter

*Neanthes arenaceodentata* Whole Sediment Survival and Growth Sublethal Test

The *N. arenaceodentata* test will be conducted in accordance with ASTM method E1562 (ASTM, 2002) with modifications described in Farrar and Bridges (2011) that have been found to contribute manageability and precision to the ASTM procedure. If sediment monitoring is conducted as part of the Bight Program, then procedures and test conditions should be in accordance with Bight Workplans. A water-only reference toxicity test should be conducted concurrently with the whole sediment polychaete test to assess the relative sensitivity of test organisms used in the evaluation of the project sediments. Polychaete reference toxicant tests are typically conducted using cadmium. However, using ammonia as the reference toxicant is preferable because the sensitivity of the test organisms to ammonia (often a confounding factor in sediment testing) can be evaluated along with the relative sensitivity of the batch of organisms used in testing. If ammonia is selected as the reference toxicant, pore water ammonia will be measured between sample receipt and test set-up, and again at test initiation. If the un-ionized pore water ammonia concentration in the test initiation sample is 0.8 mg/L or greater, then the ammonia reference toxicant test will be extended from 4 days to 10 days for better comparison to 10-day test sample results.

**Table 13. Test Conditions for the 28-Day Whole Sediment *N. arenaceodentata* Bioassay**

| Test Conditions<br>10-Day Whole Sediment Bioassay | | |
|---|---|---|
| Test Species | | ***N. arenaceodentata*** |
| Test Procedures | | ASTM E1562 (2002), Farrar and Bridges (2011) |
| Test Type/Duration | | Static - Acute Whole Sediment/28 days |
| Sample Storage Conditions | | 0 - 6°C, dark, minimal head space |
| Test Sediment holding time requirements | | 2 weeks (recommended), maximum 4 weeks (required) |
| Age/Size Class | | ≤ 7 days post-emergence |
| Grain Size Tolerance | | 5-100% sand |
| Recommended Water Quality Parameters | Temperature | 20 ± 1 °C |
| | Salinity | 30 ± 2 ppt |
| | Dissolved Oxygen | Maintaining 90% saturation |
| | Total Ammonia | < 20 mg/L |
| Test Chamber | | 300 mL glass |
| Exposure Volume | | 2 cm sediment, 125 mL seawater |
| Replicates/Sample | | 10 |
| No. of Organisms/Replicate | | 1 |
| Photoperiod | | 12 hours light: 12 hours dark |
| Feeding | | Twice per week |
| Water Renewal | | Weekly |
| Aeration | | Constant gentle aeration |
| Acceptability Criteria | | Mean control survival ≥ 80%; positive growth in controls |

mg/L – milligram per liter; mm – millimeter; mL – milliliter; ppt – parts per thousand; °C – degrees Celsius; cm - centimeter

### *Benthic Infaunal Samples*

The benthic infaunal samples will be transported from the field to the laboratory and stored in a formalin solution for a minimum of 48 hours and no longer than 5 days. The samples will then be transferred from formalin to 70% ethanol for laboratory processing. The organisms will initially be sorted using a dissecting microscope into five major phyletic groups: polychaetes, crustaceans, molluscs, echinoderms, and miscellaneous minor phyla. While sorting, technicians will keep a count for quality control purposes.

Following sorting of organisms, samples will be distributed to qualified taxonomists who will identify each organism to species or to the lowest possible taxon. Identifications and counts of organisms that are considered incidental contaminants (e.g., hard bottom epifaunal organisms, parasites, and other epibionts) should be written on taxonomic bench sheets in the notes but should not be included in the data analysis. Present-day taxonomic nomenclature is typically based on the most recent version of the Southern California Association of Marine Invertebrate Taxonomists (SCAMIT) taxonomic listing. This nomenclature differs from the taxonomic list used to develop the SQOs and benthic LOE indices. Therefore, currently used taxonomic identifications will need to be “rolled back” to the SQO nomenclature and orthography listed on the SCCWRP website prior to SQO benthic LOE calculation. Taxonomists should utilize the nomenclature and orthography in the SQO species list on the *Sediment Quality Assessment Tools* page located on the SCCWRP website (Sediment Quality Assessment Tools - Southern California Coastal Water Research Project (sccwrp.org)) for calculating the benthic LOE. If sediment monitoring is conducted as part of the Bight Program, then any additional procedures not listed above should be followed in accordance with that Bight Program year's Macrobenthic (Infaunal) Sample Analysis Laboratory Manual.

# ELEMENT 14 QUALITY CONTROL

## QA/QC Field Procedures

Field measurements for salinity will be made using a water quality probe, such as a YSI data sonde, that has been calibrated according to manufacturer specifications. Operation of field equipment will be conducted as per manufacturer instructions. Calibrations will be performed and recorded to ensure accurate functionality. Proper storage and maintenance procedures will be followed.

QA/QC for sampling processes begins with proper collection of the samples to minimize the possibility of contamination. Sediment samples will be collected in appropriate containers, kept on wet ice during the sampling event, and placed into coolers along with completed COC for transfer to the analytical laboratory. Field crews will ensure that sampling containers are being filled properly and the requirement to avoid contamination of samples at all times is met. The field data log sheets will include empirical observations of the site and water quality characteristics. Field duplicates will be collected at a minimum of 5% of total project sample count. A minimum of one equipment blank will be collected during the monitoring event. The equipment blank will be analyzed for the same target SQO analytes specified for the sediment samples (excluding grain size and percent solid analyses).

## QA/QC Laboratory Analyses

### Chemistry Analyses

The chemistry analysis of the samples will be performed under the guidelines of the analytical laboratories respective standard operationg procedures (SOPs) and QAPPs as well as meet the DQOs and quality objectives set forth in this QAPP. This includes analyzing the appropriate QC laboratory controls for each analysis in accordance with SWAMP criteria such as laboratory blanks and duplicates, MS/MSDs, certified or standard reference materials, and surrogates (see Element 7 for frequency of analysis and DQOs for QC laboratory controls).

### Toxicity Analyses

A water-only reference toxicity test will be conducted concurrently with each batch of sediment tests to establish the sensitivity of the test organisms used in the evaluation of the sediments and to evaluate the potential influence of ammonia toxicity on the test organisms. Typically, amphipod and polychaete reference toxicant tests are conducted using cadmium and bivalve reference toxicant tests are typically conducted using copper. However, using ammonia as the reference toxicant is preferable because the sensitivity of the test organisms to ammonia (often a confounding factor in sediment testing) can be evaluated along with the relative sensitivity of the batch of organisms used in testing. The $LC_{50}$ and/or $EC_{50}$ values of the reference toxicant test will be compared to historical laboratory data for each respective test species. The results of these reference toxicant tests will be used in combination with the control mortality to assess the health of the test organisms.

## Benthic Infauna Analyses

A QA/QC procedure will be performed on each of the sorted samples to ensure a 95% sorting efficiency using one of two methods, either a whole sample method or an aliquot method. For consistency, one method should be selected for all samples in a single project and noted on sorting bench sheets. QA/QC procedures should be conducted by a trained senior technician other than the original sorter.

For the whole sample method, a minimum of 10% of each individual sorter's samples should be entirely re-sorted. The percent sorting efficiency is calculated for this method as follows:

$$\% \text{ Efficiency} = 100^* \{\#_{\text{Original}} / (\#_{\text{Original}} + \#_{\text{Resort}})\}$$

For the aliquot method, a 10% aliquot of the sample volume from each sorter's sample will be re-sorted. The number of organisms found in the aliquot will be divided by 10% and added to the total number found in the sample. The original total will be divided by the new total and multiplied by 100 to calculate the percent sorting efficiency (see formula for calculation below). When the sorting efficiency of the sample is below 95%, the remainder of the sample (90%) will be re-sorted.

$$\% \text{ Efficiency} = 100^* \{\#_{\text{Original}} / [\#_{\text{Original}} + (\#_{\text{Resort}} / \text{aliquot fraction})]\}$$

Taxonomic data QC should include an assessment of the laboratory's organism identifications and counts. A minimum of 10% of the samples should be reanalyzed by secondary taxonomists other than the primary taxonomists who originally conducted the analysis. Secondary QC taxonomists should not have access to the original taxonomic dataset. For more detailed information on taxonomic QC procedures using a secondary taxonomist for reanalysis, see the *Sediment Quality Assessment Technical Support Manual* (Bay et al., 2021).

# ELEMENT 15 INSTRUMENT/EQUIPMENT TESTING, INSPECTION, AND MAINTENANCE

## Field Sampling

Prior to conducting field sampling, field technicians will be responsible for preparing sampling kits that include field logs, COC forms, sample labels, sampling containers, decontamination equipment and tools. Field measurement equipment should be checked for operation in accordance with the manufacturer's specifications. Equipment should be inspected prior to use and when returned from use for damage.

## Analytical Laboratories

All analytical laboratories including chemistry, toxicity, and benthic infaunal will maintain their equipment in accordance with their SOPs, which include those specified by the manufacturer and those specified by the method. Each laboratory's QAPP will specify equipment and system evaluations.

# ELEMENT 16 INSTRUMENT/EQUIPMENT CALIBRATION AND FREQUENCY

The equipment and instruments used at each analytical laboratory will be operated and calibrated according to manufacturer recommendations as well as by criteria defined in each analytical laboratory's SOPs. Operation and calibration will be performed by properly trained personnel. Documentation of routine and special calibration information will be recorded in appropriate logbooks and reference files. If a critical measurement is found to be out of compliance during analysis, the results of that analysis will not be reported, corrective action will be taken and documented, and the analysis will be repeated.

## Field Equipment

Water quality instruments used for salinity measurements will be calibrated per manufacturer's specifications prior to each monitoring event. Complete records of calibration will be maintained for each field instrument that requires periodic calibration.

## Analytical Laboratories

All analytical labortatories including chemistry, toxicity, and benthic infaunal will calibrate their instrumentation at a frequency that ensures the validity of the results. Each laboratory's calibration procedures must follow EPA guidelines and the recommendations of the instrument manufacturer. Each laboratory's QAPP should provide detailed information on calibration procedures.

# ELEMENT 17 INSPECTION/ACCEPTANCE OF SUPPLIES AND CONSUMABLES

It is the duty of each person who is responsible for equipment ordering to inspect equipment and materials for quality and report any equipment or materials that do not meet acceptance criteria to the Project Manager, Laboratory Manager, and/or QA Officer, as appropriate. Upon receipt of materials or equipment, a designated employee must receive and sign for the materials. The items will then be reviewed to ensure the shipment is complete, prior to delivery to the proper storage location. Chemicals must be dated upon receipt. Supplies will be stored appropriately and discarded on their expiration date. The equipment and supplies purchased for use in field sampling activities will be inspected for damage as they are received. Confirmation that sample bottles are laboratory-certified clean will be made when received.

**Critical Supplies and Consumables**

***Chemistry Sample Bottles*** – Chemistry sample bottles will be provided by the analytical laboratory. They will be shipped from the laboratory and stored appropriately by the field sampling team prior to use in the field. Confirmation that sample bottles are laboratory-certified clean will be made when received from the analytical laboratories. Preservatives may be required for the analysis of certain analyte groups and the laboratory supplied bottles should already contain any required preservatives.

***Toxicity Sample Containers*** – Clean, Teflon bags (for example: Teflon® Liners | Teflon® PFA Pail Liners | Fluorolab) capable of holding up to 20-L, or clean glass jars with Teflon-lined lids should be used as the sample container for sediment toxicity samples. If bags are used, the Teflon bag can be placed into a food grade, polypropylene bag lining a 3 to 5-gallon bucket. Samples should be double bagged to prevent accidental tearing of the Teflon bag, twisted at the top with excess air removed, and cable tied to ensure sample integrity.

***Benthic Infauna Jars***– Clean, 1-L HDPE or glass sample jars should be used as containers for benthic infaunal samples following sediment processing in the field. Additionally, magnesium sulfate and 10% formalin solutions that are used for processing benthic infaunal samples will need to be on hand during sampling events and should be provided by each Copermittee or their subcontractor(s). Benthic infaunal samples will be transferred from the formalin mixture to 70% ethanol (do not use denatured alcohol) for long-term storage.

# ELEMENT 18 NON-DIRECT MEASUREMENTS

Data will be reviewed against DQOs in Section 7 prior to SQO analysis. Only data meeting the DQOs will be used in the SQO analysis.

# ELEMENT 19 DATA MANAGEMENT

Data will be maintained as described in Element 9. The original data sheets and reports produced will be accumulated into project-specific files that are kept by either the Copermittee (WMA Lead) or Contractor Project Manager.

The Contractor Project Manager or Field Task Manager will document and track the aspects of the sample collection process, including generating field logs at each site and COC forms for the samples collected. COC forms will accompany samples to the appropriate laboratories for analysis. Each analytical laboratory will document and track the aspects of sample receipt and storage, analyses, and reporting. Each analytical laboratory's results will be stored in a database system at their office and will be provided to the Copermittee (WMA Lead) or Contractor Project Manager both electronically and by hard copy. Further details of each laboratory's data management protocols can be found in each laboratory's respective QAPP.

Field logs and analytical data will be entered into or transferred to the Copermittee (WMA Lead) or Contractor's database. After the data is added to the database, the Contractor Project QA Officer will validate the data by checking for errors and ensure the data is complete. The database will be updated with finalized data. The results of the laboratory QC analyses will be reported with the final data. Any QC samples that fail to meet the specified QC criteria in the methodology or the DQOs described in Element 7 will be identified, and the corresponding data will be appropriately qualified in the final report. All QA/QC records will be kept on file for review by regulatory agency personnel. Once data is finalized, all monitoring data and analytical results will be formatted and uploaded into CEDEN. All records should be maintained for at least five years.

# GROUP C: ASSESSMENT AND OVERSIGHT

# ELEMENT 20 ASSESSMENTS AND RESPONSE ACTIONS

## Corrective Actions

The following sections identify the responsibilities of key project members and corrective actions to be taken if issues arise during field sampling or laboratory analyses that may result in noncompliance with protocols established in the Sediment Monitoring Plan.

### Field Sampling

The initial responsibility for monitoring the quality of field measurements lies with the field personnel. A Field Task Manager (or Field Lead) is responsible for verifying that QC procedures are followed. This requires that the Field Task Manager assess the accuracy of the field methods as well as the ability to meet QA objectives and make a value judgment regarding the impact a procedure has on field objectives and subsequent data quality. If a problem is identified that might jeopardize the integrity of the project, hinder a QA objective, or impact data quality, the Field Task Manager will notify the Contractor Project Manager who would then notify the WMA Lead. Corrective action measures are then decided upon and implemented. The Field Task Manager documents the situation, the field objective affected, the corrective action taken, and the results of that action. Copies of the documentation are provided to the Copermittee (WMA Lead) or Contractor Project Manager and the QA Officer.

### Laboratory

The need for corrective action comes from several sources, including equipment malfunction, failure of internal QA/QC checks or to follow-up on performance or system audit findings, and noncompliance with QA requirements. All laboratory personnel are responsible for documenting and correcting problems that might affect quality. When measurement equipment or analytical methods fail QA/QC requirements, the problem(s) will be brought immediately to the attention of the Laboratory Manager and QA Officer. Corrective measures will depend entirely on the type of analysis, the extent of the error, and whether or not the error is determinant. The corrective action is determined by either the Laboratory Manager, technicians, the Copermittee (WMA Lead) or Contractor Project Manager, the QA Officer, or by all of them in conference, if necessary, but final approval is the responsibility of the Copermittee (WMA Lead) or Contractor QA Officer and/or Project Manager.

If failure is due to equipment malfunction, the equipment will not be used until repaired. Precision and accuracy will be reassessed, and the analysis will be rerun. Attempts will be made to reanalyze the affected parts of the analysis so that in the end, the product is not affected by failure of QC requirements. When a result in a performance audit is unacceptable, the laboratory will identify the problem(s) and implement corrective actions immediately. A step-by-step analysis and investigation to determine the cause of the problem will take place as part of the corrective action program. If the problem cannot be controlled, the laboratory will analyze the impact on data. If the data is affected, the problem will be documented and the Copermittee (WMA Lead) or Contractor QA Officer and/or Project Manager will be notified. When a system audit reveals an unacceptable performance, work will be suspended until corrective action has been implemented and performance has been proven acceptable. If the problem is instrumental or specific only to preparation of a sample batch, samples are reprocessed after the instrument is repaired and recalibrated. In the event that a QC measure is out-of-control, and the data are to be reported, qualifiers are reported together with sample results.

# ELEMENT 21 PROJECT REPORTS

The Copermittee (WMA Lead) or Contractor Project Manager is responsible for preparation and submittal of all project deliverables. Each analytical laboratory's QA Officer is responsible for the preparation of all data packages and laboratory reports originating from their laboratory. Provision D.1.e.(2)(c) of the Permit requires submittal of the sediment monitoring results in the WQIP Annual Report including an evaluation, interpretation, and tabulation of monitoring data; an assessment of whether receiving water limits outlined in the Permit were attained; a sample location map; and a statement of certification that monitoring data and results have been uploaded into CEDEN.

This Sediment Monitoring Plan addresses compliance with the aquatic life objective of the Sediment Control Plan. This narrative objective is implemented using the integration of MLOE as described in Section IV.A.1 of the Sediment Control Plan. Based on the conclusions of the sediment monitoring results, a human health risk assessment may be necessary in order to determine whether human health objectives have been obtained at each sample location. Provision A.2.a.(3)(b)(ii) states that "pollutants shall not be present in sediments at levels that will bioaccumulate in aquatic life to levels that are harmful to human health." The potential risk assessments must consider any relevant information, such as guidelines set forth in the CA EPA's Office of Environmental Health Hazard Assessment (OEHHA) fish consumption policies, CA EPA's Department of Toxic Substances Control (DTSC) risk assessment, and the USEPA human health risk assessment policies. If a human health risk assessment is required, then the narrative objectives will be implemented as described in Section IV.A.2 of the Sediment Control Plan.

The Copermittees will include the sediment monitoring results from Bight 2023 in the 2023-2024 WQIP Annual Report due to the San Diego Water Board on January 31, 2025 to satisfy Provisions D.1.e.(1)(b) and D.1.e.(2) of the Permit. Additional sediment quality monitoring or stressor identification studies conducted after 2023 will be included in future WQIP Annual Reports.

The schedule for completing the sediment quality monitoring requirements of the Permit and for submitting the sediment monitoring results is shown in Table 14.

**Table 14. Sediment Monitoring Reporting Schedule**

| Activity/Deliverable | Dates(s)* |
|---|---|
| San Diego Water Board Order No. R9-2013-0001 | Adopted May 8, 2013 and effective June 27, 2013 |
| Southern California Bight Regional Monitoring Program – Field Sampling | July-September 2023 |
| Southern California Bight Regional Monitoring Program – Data Assessment | October 2023 – June 2024 |
| Follow-up confirmation monitoring (if required) | To be determined |
| Final sediment monitoring results incorporated into 2023-2024 WQIP Annual Report | January 31, 2025 |
| Potential Stressor ID Studies | To be determined |

*Table does not include future permit cycles

# GROUP D:
# DATA VALIDATION AND USABILITY

# ELEMENT 22 DATA REVIEW, VERIFICATION, AND VALIDATION

Data reduction, verification, validation, and reporting are ongoing processes, which involve the field technicians, laboratory technicians, Laboratory Managers, and QA personnel. Data generated by the sediment monitoring activities including field sampling and laboratory analyses will be reviewed against the DQOs presented in Element 7 and the QA/QC practices cited in this QAPP. This includes field logbooks, COC forms, and all data related to laboratory analytical procedures (e.g., sample preparation logs, instrument logs, etc.). Data entry of field sampling data will be reviewed to check for accuracy and completeness. Analytical laboratory electronic data deliverables and hard copy reports will be reviewed to ensure that the proper QC elements are included (e.g., blanks, lab duplicates, etc.), all sample analyses are correct, holding times were met, and data failing to meet QC criteria are properly qualified. Data that does not meet the DQOs will be evaluated to determine the impact of the failure on the data quality. If sufficient evidence is found to support the use of the data, the data will be qualified, and entered into the database.

# ELEMENT 23 VERIFICATION AND VALIDATION METHODS

After each sampling event, the field data sheets will be removed from the field logbooks, and the sheets will be checked for completeness and accuracy by the QA Officer or Project Manager. The appropriate field sheets must be present. If there are any questions, clarification from the Field Task Manager (or Field Lead) will be obtained as soon as possible.

In the laboratory, sample preparation activities will be documented in bound laboratory notebooks or on bench sheets. Data validation includes dated and signed entries by technicians on the data sheets and logbooks used for the samples, the use of sample tracking and numbering systems to track the progress of samples through the laboratory, and the use of QC criteria to reject or accept specific data. The laboratory generating the data will have the prime responsibility for the accuracy and completeness of the data. Each laboratory will review the data to ensure that the following information is correct and complete: sample description information, analysis information, results, and documentation of the data. Further data validation is performed by the Laboratory Manager. Validation is accomplished through routine audits of the data collection and flow procedures and by monitoring of QC sample results. In the data review process, the data will be compared to information such as the sample's history, sample preparation, and QC sample data to evaluate the validity of the results. Corrective action will be minimized through the development and implementation of routine internal system controls. Analysts are provided with specific criteria that must be met for each procedure, operation, or measurement system.

# ELEMENT 24 RECONCILIATION WITH USER REQUIREMENTS

The QA personnel will review data after each survey to determine if DQOs have been met. If data do not meet project specifications, the QA personnel will review errors and determine if the problem is due to calibration/maintenance, sampling techniques, or other factors, and they will suggest corrective action. It is expected that the problem would be correctible through personnel re-training, technique revision, or supplies/equipment replacement. If not, the DQOs will be reviewed for feasibility. If specific DQOs are not achievable, the QA personnel will recommend appropriate modifications. Any revisions would need approval by the Copermittee (WMA Lead) or Contractor Project Manager.

# ELEMENT 25 REFERENCES

Anderson, B.S., Hunt, J.W., Hester, M., Phillips, B.M. 1996. Assessment of sediment toxicity at the sediment-water interface. In: G.K. Ostrander (ed.) *Techniques in Aquatic Toxicology*. Lewis Publishers, Ann Arbor, MI.

ASTM (American Society for Testing and Materials). 2002. E1562 Standard Guide for Conducting Acute, Chronic, and Life-Cycle Aquatic Toxicity Tests with Polychaetous Annelids. *Annual Book of Standards, Water and Environmental Technology, Vol. 11.05*, West Conshohocken, PA.

ASTM (American Society for Testing and Materials). 2006. E1367-03 Standard Guide for Conducting 10-Day Static Sediment Toxicity Tests With Marine and Estuarine Amphipods. *Annual Book of Standards, Water and Environmental Technology, Vol. 11.05*, West Conshohocken, PA.

Bay, S.M., Greenstein, D.J., Ranasinghe, J.A., Diehl, D.W., Fetscher, A.E. 2021. *Sediment Quality Assessment Technical Support Manual*. Southern California Coastal Water Research Project. Costa Mesa, CA. June 2021.

Farrar, J.D., Bridges, T.S. 2011. 28-Day Chronic Sublethal Test Method for Evaluating Whole Sediments Using an Early Life Stage of the Marine Polychaete *Neanthes arenaceodentata*. ERDC TN-DOER-R14. U.S. Army Corps of Engineers, Vicksburg, MS.

San Diego Water Board (San Diego Regional Water Quality Control Board). 2013. Order No. R9-2013-0001. NPDES No. CAS0109266. National Pollutant Discharge Elimination System (NPDES) Permit and Waste Discharge Requirements for Discharges from the Municipal Separate Storm Sewer Systems (MS4s) Draining the Watersheds Within the San Diego Region. June 27, 2013.

SCCWRP (Southern California Coastal Water Research Project). 2018. *Southern California Bight 2018 Regional Marine Monitoring Survey (Bight '18) Sediment Quality Assessment Field Operations Manual*. Prepared by Bight '18 Field Sampling & Logistics Committee. July 2018.

State Water Board (State Water Resources Control Board) – CA EPA (California Environmental Protection Agency). 2009. *Water Quality Control Plan for Enclosed Bays and Estuaries – Part 1 Sediment Quality*. August 25, 2009.

State Water Board – CA EPA. 2018. *Amendments to the Water Quality Control Plan for Enclosed Bays and Estuaries of California – Sediment Quality Provisions*. June 5, 2018.

SWAMP (Surface Water Ambient Monitoring Program) Quality Assurance Team. 2008. The State of California's Surface Water Ambient Monitoring Program Quality Assurance Program Plan. September 1, 2008.

USEPA (United States Environmental Protection Agency). 1994. *Methods for Assessing Toxicity of Sediment-Associated Contaminants With Estuarine and Marine Amphipods*. EPA/600/R-94/025. EPA Office of Research and Development, Narragansett, Rhode Island. June 1994.

USEPA (United States Environmental Protection Agency). 1995. *Short-Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to West Coast Marine and Estuarine Organisms*. EPA/600/R-95/136. EPA Office of Research and Development.

WESTON (Weston Solutions, Inc.). 2013. *San Diego County Municipal Copermittees Bight 2013 Workplan*. Prepared for the County of San Diego Municipal Copermittees. July 25, 2013.

WESTON (Weston Solutions, Inc.). 2014. *San Diego County Municipal Copermittees 2014 Sampling and Analysis Plan for Bight ’13 Follow-up Investigations*. Prepared for the County of San Diego Municipal Copermittees. May 2014.