Draft Staff Report

Beneficial Reuse of Dredged Materials: Sediment Screening and Testing Guidelines

May 2000

For Planning Purposes Only

This document is for planning uses and the determination of general suitability of dredged material for beneficial reuse projects. The permits needed for beneficial reuse of dredged material will be based on site-specific conditions.

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Executive Summary

In this staff report, we present guidelines for testing requirements and evaluation of test results for the placement of dredge materials in beneficial reuse environments. The beneficial reuse options addressed are: wetland creation and restoration, levee maintenance, construction fill, and daily cover at sanitary landfills. This document updates a previous San Francisco Bay Regional Water Quality Control Board document (SFBRWQCB, 1992) and contains updated information on ambient concentrations of contaminants in San Francisco Bay sediments and updated biological effects concentrations (ER-Ls and ER-Ms). This report proposes screening values based on sediment and elutriate chemistry and acute toxicity characteristics and the potential for leaching of contaminants from dredged material after placement. We also propose the use of fine-grained reference sediments for biological testing. These guidelines are based on the Regional Board's current understanding of the appropriate physical, chemical and biological quality requirements of dredge materials for various beneficial reuse placement options.

This document establishes screening values to be used to make general suitability determinations (that is, not specific to a particular reuse project) for the reuse of dredged material in beneficial environments, in the absence of specific criteria that may be defined as part of the permitting process for beneficial reuse projects. Compliance with the screening values does not by itself indicate that any particular dredged material will be found suitable for reuse. In addition, compliance with the screening values and a general suitability determination do not circumvent the need for site-specific permits for each reuse project. Those permits may have more (or less) stringent "acceptance criteria" depending on the site-specific conditions.

Table 1 summarizes the testing framework and screening guidelines recommended in this document.

1 Introduction

This document establishes screening values that will be used by San Francisco Bay Regional Water Quality Control Board (Regional Board) staff when evaluating the suitability of dredged material for beneficial reuse projects. It also provides guidance to project proponents on appropriate sediment testing to support suitability determinations. Suitability determinations are based on best professional judgment, using a preponderance of evidence approach. Therefore, compliance with the screening values does not by itself indicate that dredged material will be found suitable for beneficial reuse. In addition, compliance with the screening values does not circumvent the requirement for site-specific permits for each reuse project. Such permits may have more (or less) stringent “acceptance criteria” depending on the site-specific conditions. This document is intended to assist in planning beneficial reuse projects by establishing general screening guidelines and general sediment testing requirements for beneficial reuse projects. Beneficial reuse project proponents are encouraged to coordinate with agency staff and other interested parties early in the project planning process.

This document considers wetland and upland beneficial reuses of dredged material. Wetland reuse is the use of dredged materials to restore appropriate elevations to subsided diked baylands or other areas in order to create tidal wetlands. Upland reuses include levee maintenance, construction fill, and landfill daily cover.

Since 1992, testing of dredged materials for proposed beneficial reuse projects has followed recommendations in Regional Board Resolution No. 92-145, *Sediment Screening Criteria and Testing Requirements for Wetland Creation and Upland Beneficial Reuse* (SFBRWQCB, 1992). Resolution 92-145 was published to establish screening criteria for the beneficial reuse of dredged sediments in the San Francisco Bay area, especially for the creation and restoration of wetland habitats. The recommended screening criteria in Resolution 92-145 were based on 1992 estimates of ambient chemical concentrations in sediments and soils, and on the National Oceanographic and Atmospheric Administration’s (NOAA) effects-based sediment concentrations of chemical constituents of concern (Long et. al., 1988; Long and Morgan, 1990; Shacklette and Boerngen, 1984). Since the publication of Resolution 92-145, the Regional Board has published new data on ambient chemical concentrations, and NOAA has revised the effects-based concentrations (Long et. al., 1995). The Regional Board has also published new data on reference sediment toxicity conditions of San Francisco Bay sediments (SFBRWQCB, 1998a and 1998b). Several other organizations have published ambient concentrations of metals in California soils (Bradford et. al., 1996; LBNL, 1995). The Regional Board's evolving understanding of ambient concentrations and toxicity, and effects-based guidelines called for a revision of Resolution 92-145. This document presents an update of Resolution 92-145 incorporating the Regional Board's and NOAA's new data.

Other recent documents related to dredging and dredged material disposal in San Francisco Bay include:

- *Evaluation of Dredged Material Proposed for Discharge in Waters of the U.S. - Testing Manual* (USEPA and USACE, 1998) also known as the Inland Testing Manual or ITM
- U.S. Army Corps of Engineers Public Notice 99-3, "Proposed Guidelines for Implementing the Inland Testing Manual within the USACE San Francisco District"
- U.S. Army Corps of Engineers Public Notice 99-4, "Proposed Guidance for Sampling and Analysis Plans (Quality Assurance Project Plans) for Dredging Projects within the USACE San Francisco District"
- *Long Term Management Strategy for the Placement of Dredged Material in the San Francisco Bay Region – Final Policy Environmental Impact Statement/Programmatic Environmental Impact Report* (LTMS, 1998)
- *Long Term Management Strategy for the Placement of Dredged Material in the San Francisco Bay Region – Record of Decision* (USEPA and USACE, 1999).

The Long Term Management Strategy EIS/EIR (LTMS, 1998) and Record of Decision (USEPA and USACE, 1999) identified the preferred alternative for long-term management of dredged material disposal to be minimization of dredged material disposal in San Francisco Bay, with increased use of the ocean disposal site and beneficial reuse of dredged material. The goal is to reduce aquatic disposal within San Francisco Bay to 20% of the historical average annual dredging volume and to increase both ocean disposal and beneficial reuse to 40% of the historical average annual dredging volume. Potential beneficial reuses of dredged material are wetland restoration, levee repair and landfill daily cover. Several efforts to increase beneficial reuse of dredged material in the San Francisco Bay area are currently being planned. This document is intended to facilitate those planning efforts by indicating the kinds of information Regional Board staff will typically use in reviewing beneficial reuse projects.

The screening values included in this document are guidelines and may be modified by Regional Board staff on a case-by-case basis. These screening values are not intended as cleanup goals, acceptance criteria or screening values for other types of projects, although some of the data and reasoning used in this document may be applicable to other types of projects involving potentially contaminated sediments. This document does not provide information on obtaining permits for upland and wetland reuse projects, but typically information regarding the disposal and reuse of dredged material can be obtained from the Dredged Material Management Office (DMMO)[1] or the Regional Board[2].

The potential routes of exposure to non-human biological receptors considered by the screening guidelines are:

- direct exposure to sediments
- exposure to effluent from sediments during placement of material at reuse site, and
- exposure to leachate after material placement.

These screening guidelines do not address human exposure. While most of the chemical screening values are below levels of concern for human health (e.g.EPA Region IX Preliminary Remediation Goals), some of the constituents can cause adverse impacts to humans with long-term direct contact. If long-term human contact is expected, the screening guidelines presented here may not be appropriate.

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2 Beneficial Reuse Options

Potential beneficial reuses of dredged material were identified in the LTMS EIS/EIR (LTMS, 1998) as habitat development, levee maintenance and rehabilitation, construction fill, and daily cover at existing sanitary landfills. The most common form of habitat development using dredged material is the creation or restoration of tidal wetlands.

Wetland Creation and Restoration

Wetland projects using dredged material from the San Francisco Bay Region usually involve creation or restoration of wetland habitat in areas that have been previously diked and drained. For such projects, the dredged material is used to restore proper elevations for subsided land, cover unsuitable substrate, or to create favorable drainage patterns.

This document makes a distinction between surface and foundation materials (see below).

Wetland Surface Material

Wetland surface material is dredged material placed in the biotic zone during a wetland creation or restoration project. This material is in contact with wetland flora and fauna. Screening guidelines for surface material are intended to be protective of the most sensitive potential biological receptors in a wetland environment that are exposed to sediments, effluent discharge during material placement, and leachate after material placement.

Wetland Foundation Material

Foundation material is dredged material used in a wetland creation or restoration project that is covered by surface material. This material is not in contact with wetland flora and fauna. Foundation material has a potential for biological effects if directly exposed to organisms, so it must be placed in a manner that will isolate it from biological receptors. The maximum depth of biological activity in wetlands is conservatively estimated at three feet, and thus surface material must be at least three feet thick when overlaying foundation material. Project proponents are encouraged to maximize surface material thickness. Considerations for the placement of foundation materials include: depth of the root zone, burrowing depth of fauna, potential for future erosion of the site, and potential mobility of chemicals of concern in the foundation material. Although biological receptors will not be directly exposed to foundation material, leachate from the material may be mobile and reach the biotic zone.

The screening guidelines placed on foundation material are intended to protect biological receptors that may be exposed to effluent discharge during material placement and leachate after placement, and to minimize adverse environmental effects if the foundation material were to become exposed to the surface environment.

Beneficial Reuse at Upland Sites

Upland reuse of dredged material includes levee maintenance, construction fill, and use as daily cover at sanitary landfills. These options often require a rehandling facility prior to final reuse.

Levee Maintenance and Construction Fill

Dredged material, after drying, may be appropriate for use in levee maintenance projects and as fill for construction projects. Usually material used for these purposes will not be in contact with biological receptors. Screening guidelines for these uses are designed to protect biological receptors that may be exposed to effluent discharge during material placement and leachate after placement.

Landfill Daily Cover

Dredged material may be appropriate for use as daily cover at landfills. Title 23, Chapter 15, and Title 27, Chapter 3 of the California Code of Regulations regulate disposal of materials in landfills. The Regional Board issues permits to each landfills; these permits define testing requirements and acceptability criteria for material. The testing and screening guidelines in this document will aid in planning for reuse of material at landfills, but specific requirements of individual landfills must also be consulted.

Rehandling facilities

In many cases, dredged materials taken to upland locations are dried either at the final placement site or a rehandling facility. Other types of treatment, such as mixing with other soils, sediments or cements can be done at a rehandling facility to improve geotechnical or agricultural properties, or to immobilize contaminants.

Rehandling facilities must be authorized by all appropriate regulatory agencies. Authorization from the SFBRWQCB will include requirements and prohibitions on discharges from such facilities to protect aquatic resources.

3 Screening Guidelines for Beneficial Reuse of Dredged Material

There are two basic levels of screening guidelines for beneficial reuse of dredged material: screening guidelines for wetland surface material, and screening guidelines for wetland foundation material. Dredged material that meets the screening guidelines for wetland surface material is likely to be found suitable for that use as well as for all the other categories of beneficial reuse discussed in this paper. Dredged material that does not meet the screening guidelines for wetland surface material but does meet the guidelines for wetland foundation material is likely to be found suitable for wetland foundation use, as well as for levee maintenance, construction fill, and landfill daily cover.

The screening guidelines include consideration of sediment and sediment elutriate chemistry, mobility of contaminants, and results of acute toxicity bioassays for sediments and sediment elutriate. Each of these considerations is discussed below.

Sediment Chemistry

Screening values for sediment chemistry are based on ambient levels of contaminants in San Francisco Bay sediments and on sediment concentrations of contaminants that are predicted to cause biological effects. The ambient concentrations for San Francisco Bay sediments were statistically derived from data collected by the Regional Monitoring Program for Trace Substances (San Francisco Estuary Institute, 1999) and the Bay Protection and Toxic Substances Cleanup Program Reference Study (State Water Resources Control Board, 1998), and are listed in Table 2. Several databases have been developed in order to predict the levels of sediment chemistry that have a high or low probability of causing adverse biological effects. Long et al. (1995) used the extensive sediment chemistry and toxicity database of the National Oceanographic and Atmospheric Administration (NOAA) to determine levels of sediment chemistry below which biological effects are unlikely (Effects Range-Low or ER-L) and levels above which biological effects are likely (Effects Range-Median or ER-M). The Florida Department of Environmental Protection (FDEP, 1994) has also developed sediment chemistry values below which biological effects are unlikely (Threshold Effects Levels or TELs) and above which biological effects are likely (Probable Effects Levels or PELs). Table 3 lists these biological effects-based numbers.

For wetland surface material, screening values for sediment chemistry are based primarily on ambient sediment chemistry levels (SFBRWQCB, 1998) for San Francisco Bay. The ambient values are chosen for the upper screening value for Wetland Surface Reuse for two reasons. First, ambient values for San

Francisco Bay are generally less than ER-L values and so are unlikely to cause adverse biological effects. Where San Francisco Bay ambient values exceed ER-Ls (for nickel and chromium) these values have not been found to be associated with adverse biological effects during local testing of dredged sediments. Second, since any restored tidal wetland will eventually take on the characteristics of the ambient sediments in nearby areas of the open bay, efforts to restore the wetland with sediments that are "cleaner" than ambient conditions, may be a waste of resources.

For wetland foundation material, screening values for sediment chemistry are based levels of chemicals that are believed to be protective of biological receptors. The values where biological effects are likely are the upper screening levels for Wetland Foundation Reuse, with the ER-Ms (where available) taking precedence over the PELs, since the NOAA values were derived using data from the San Francisco Bay area. The sediment screening values for Wetland Foundation Reuse are based on ER-Ms in most cases, except that PEL values are used for chemicals with no published ER-M value. Sediments with these chemical characteristics would be unlikely to adversely impact organisms of San Francisco Bay, if the foundation material were inadvertently uncovered.

Table 4 summarizes the screening guidelines for sediment chemistry for wetland surface and foundation materials.

Acute Toxicity of Sediments

The acute toxicity screening guideline for benthic bioassays for wetland cover material is no significant toxicity. Benthic tests are interpreted following the guidelines in Public Notice 99-3. For benthic bioassays, mortality in a test sediment that is statistically significant and 10 percentage points greater (20 percentage points for amphipods) than that in the reference is considered to be indicative of acute toxicity.

There are no screening guidelines for acute toxicity in benthic bioassays for wetland foundation material because this material is not expected to be in contact with biological receptors.

Contaminant Mobility

There are no screening levels for contaminant mobility for wetland surface material, because this material will be in direct contact with biological receptors. If levels of contaminants are at or below ambient levels for the Bay, and sediments do not cause toxicity, then mobility of contaminants is not of concern.

The screening levels for wetland foundation material are based on local Water Quality Objectives found in the Basin Plan (SFBRWQCB, 1995, or current edition). While this material is not expected to be in direct contact with biological receptors, levels of contaminants in effluent discharged during material placement, in leachate produced after material placement (as described in Section 4, measured with the modified Waste Extraction Test, using deionized water or disposal site water as the extractant) must be below levels of concern. When chemicals are shown to be potentially mobile, placement of the dredged material in a subsurface environment may not be suitable depending on the water quality objectives for the receiving water. This will ensure that any chemical constituents mobilized at the disposal site will only be at concentrations below levels of concern.

Elutriate Chemistry and Toxicity

If dewatering will occur at the beneficial reuse site as part of material placement, discharged water must meet screening guidelines for both chemistry and toxicity. The screening guidelines for discharged water chemistry are the Water Quality Objectives listed in the current version of the Basin Plan. The screening guideline for toxicity is no significant toxicity. For the elutriate bioassay, this is met when the survival of organisms in effluent has a median value of not less than 90%, and a 90^{th} percentile value of not less than 70% survival.

Suitability determinations - Wetland Surface Reuse

Dredged materials that meet the screening guidelines described above for wetland surface reuse are likely to be found suitable for this use, as well as for all the other uses described in this paper, subject, of course, to any project-specific limitations.

Suitability determinations - Wetland Foundation Reuse

Dredged materials with statistically significant toxicity in one or more bioassays, may be found suitable for Wetland Foundation Reuse if the material passes the screens for sediment chemistry and contaminant mobility. Reuse of such materials will be limited (by reuse site permitting) to locations that are designed to eliminate the threat of exposure. A wetland restoration design should include at least three feet of material suitable for Wetland Surface Reuse (or equivalent safeguards) and placement of the material in a location that is not threatened by erosion.

Suitability determinations - Other reuses

Material that is suitable for Wetland Foundation Reuse would be suitable for upland reuses where the leaching characteristics are not more aggressive than those modeled with the leachability test used and where direct human contact with the material has been evaluated or eliminated. While most of the chemical screening values for Wetland Foundation Reuse are below levels of concern for human health (e.g.EPA Region IX Preliminary Remediation Goals, or PRGs), some of the constituents have ambient concentrations greater than residential PRGs (e.g. arsenic). While this human health exposure is not an issue for sediments placed in wetlands or dispersed in the waters of the Bay, it could be an issue if the sediments are used where humans will have continual contact (e.g. residential property or recreational property). Placement of dredged material in other environments shall be addressed on a site specific basis.

Citrate WET test results need to be screened with soluble threshold limit concentrations (STLC) or other landfill-specific criteria.

4 Testing Guidelines

In order to facilitate the beneficial reuse of dredged material as much as possible, in accordance with the goals of the LTMS, we have tried to develop a sediment evaluation framework similar to those in place for sediments proposed for ocean and in-Bay disposal. This similarity in testing guidelines should enable project applicants testing sediments for in-Bay or ocean disposal to also generate information necessary to evaluate beneficial reuse as a disposal option without excessive additional testing costs. Dredging project proponents are encouraged to coordinate sediment testing to allow for evaluation of sediments for beneficial reuse options in addition to evaluation for aquatic disposal options, unless beneficial reuse options have been determined to be unavailable or impracticable.

In preparing and implementing sediment sampling plans, project proponents should refer to Public Notices 99-3 and 99-4 for more specific guidance on sampling, analysis and reporting than is contained in this document. Project proponents may also wish to refer to the ITM and the Green Book (USACE/USEPA, 1991) for background information on sediment evaluation frameworks.

The testing guidelines below (summarized in Figure 1) should provide sufficient information to make general suitability determinations for beneficial reuse options, but Regional Board staff may consider other testing programs. For some beneficial reuse projects different or additional testing may be required because of site-specific conditions or concerns.

Wetland Surface Material

As described in Section 3, the screening guidelines for upland surface material are based on sediment chemistry and toxicity, and, in the event of effluent discharge, on effluent chemistry and toxicity. Testing programs intending to evaluate sediments for this use should provide information sufficient to evaluate these characteristics.

Sediment chemistry analyses should include the list of analytes listed in Table 5. For further information on appropriate methods, detection limits, and QA/QC procedures, see the guidance provided in Public Notice 99-3.

Sediment toxicity assessment may be performed with two 10-day acute toxicity bioassays, using appropriate sensitive organisms representing three benthic life history stages (filter-feeding, burrowing, and deposit feeding). Testing protocol and QA/QC procedures should follow those outlined in Public Notice 99-3.

If placement of the dredged material at the reuse site will include the discharge of effluent from the placement site, the testing program must provide information to characterize sediment elutriate chemistry and toxicity. Elutriate chemistry may be characterized by measuring the analytes listed in Table 5 for sediment elutriate, using appropriate methods, detection limits, and QA/QC procedures. The biological tests for elutriate toxicity testing recommended in Public Notice 99-3 (including protocols and QA/QC procedures) may be used to characterize effluent toxicity.

Wetland Foundation Material

Screening guidelines for wetland foundation material are based on sediment chemistry and leaching characteristics of the sediments. The testing program for sediments proposed for this disposal option should provide sufficient information to evaluate these characteristics.

Evaluation of sediment chemistry as described above in the section on wetland surface material should provide sufficient information to evaluate this characteristic.

Evaluation of the leaching characteristics of proposed dredged sediments may be performed using a modified Waste Extraction Test (WET), as defined in the Title 23 of the California Code of Regulations, using either de-ionized water or water from the proposed reuse site for the extraction.

If water is to be discharged from the beneficial reuse site during material placement, the chemistry and toxicity of sediment elutriate should be evaluated. See the discussion under "Wetland Surface Material," above, for suggested methods.

Tiered Testing

In order for dredged material to be found suitable for use in a particular beneficial reuse project, compliance with the screening guidelines above should be demonstrated. In many cases, it may be appropriate to approach sediment characterization in a tiered fashion, similar to that promulgated in the federal guidance for evaluating material suitability for in-Bay and ocean disposal. A tiered testing framework is intended to match the level of testing to the degree of uncertainty about the potential environmental impacts of reuse of dredged material in a particular environment. Project proponents may propose a tiered approach to sediment evaluation in sediment Sampling and Analysis Plans. The steps for testing shown in Figure 1, for example, may be the basis of a tiered testing framework.

Use of Previously Collected Data

Data from previous sampling events and site history will be considered when suitability determinations are made. These data should be made available to the regulatory agencies, preferably included in the sediment Sampling and Analysis Plan. If sufficient data from previous testing exist to make a suitability determination, further testing may not be required, or a modified testing protocol may be recommended. This is analogous to a "Tier I" exclusion from testing used in some instances for in-Bay and ocean disposal suitability determinations.

Reference Sediments for Benthic Bioassays

Evaluation of acute toxicity bioassays requires comparison of results with results from bioassays run using reference sediment The reference sediment must have similar physical characteristics as the dredged material, i.e. particle size distribution, organic carbon content and salinity. In-bay disposal has usually required the use of a reference from the Alcatraz "Environs" stations. These sediments are coarse grained, whereas much of the dredged material from the San Francisco Bay is fine grained. As part of the BPTCP, fine-grained reference sediments were investigated (SWRCB, 1998). These reference sediments are more typical of the physical parameters of the majority of dredged material in San Francisco Bay. Based on these studies, two fine-grained reference sites are recommended as sources of reference sediments for biological testing of fine-grained dredged material for beneficial reuse environments. Locations and physical and chemical properties of the fine-grained reference sites are presented in Table 6.

Design of Sampling Plan and Reporting Guidelines

Public Notice 99-3 provides important guidance on sampling program design, including issues such as sample locations, compositing, and frequency. Public Notice 99-4 provides guidance to dredging project proponents on Sampling and Analysis Plans and on reporting test results. Project proponents proposing beneficial reuse of dredged material should consult both these documents when designing a sediment sampling program.

Sampling and Analysis Plans for sediment testing should be submitted to the DMMO for approval prior to commencing sediment sampling. Results reports should also be submitted to the DMMO. The DMMO will make recommendations to the respective member agencies regarding the suitability of the sediments for the proposed placement environment(s), according to the current Memorandum of Understanding signed by the DMMO member agencies.

As with any data acquisition activity, setting data quality objectives prior to dredged material sampling and testing is critical to a successful project.

The recommended minimum number of sediment samples for dredging projects is presented in Table 7, which is based on Public Notice 99-3. The number of samples collected is based on the volume of each dredging project. Sampling frequency may differ on a site-specific basis, and the rationale for deviation should be clearly stated in the SAP.

A successful dredging and beneficial reuse project requires good documentation. The minimum documentation will include:

- a SAP following DMMO guidance, including appropriate QA/QC protocols (Public Notice 99-4);
- a report of dredged materials testing results following DMMO guidance (Public Notice 99-4); and
- a post-dredging report (which should include the location where the dredged material was reused or disposed and documentation of any restrictions on the use of the material or monitoring requirements).

Disclaimer: The above screening values are used as guidelines only. The weight of evidence of all data may result in different interpretation of the results in case specific projects. This document is for planning uses and the determination of general suitability of dredged material for beneficial reuse. The permits needed to reuse or dispose of dredged material in beneficial reuse projects will be based on site-specific conditions.

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Tables

Table 1: Summary of Recommended Testing and Screening Guidelines

Beneficial reuse environment	**Potential routes of exposure for non-human biological receptors**	**Recommended chemistry test**	**Recommended bioassays**	**Recommended leachate chemistry**	**Screening guidelines for:** 1) chemistry 2) toxicity 3) leachate chemistry
Wetland surface	Direct exposure to sediments	Sediment chemistry for analytes in Table X	Two benthic species covering three life history stages, see PN 99-3	None	1) ambient or ER-L concentrations 2) no significant toxicity 3) not applicable
Wetland foundation, levees, and construction fill	Potential but unlikely direct exposure to sediments On-site exposure to leachate after placement	Sediment chemistry for analytes in Table X	None	Modified WET	1) ER-M or PEL 2) not applicable 3) Basin Plan WQO's
Landfill daily cover	No exposure	Testing and acceptability criteria specific to each landfill; contact individual landfills for requirements.			
Any project involving discharges from dewatering dredged material	Receiving waters exposed to effluent discharge during placement	Elutriate chemistry for analytes in Table X	One species sediment elutriate bioassay	Not Applicable	1) Basin Plan WQO's 2) no significant toxicity 3) not applicable

Table 2: Ambient Concentrations of Analytes in San Francisco Bay Sediments (Page 1 of 2)

Analyte	S.F. Estuary Sediment Ambient Concentrations	
	<40 % fines	<100 % fines
METALS (mg/kg)		
Arsenic	13.5	15.3
Cadmium	0.25	0.33
Chromium	91.4	112
Copper	31.7	68.1
Lead	20.3	43.2
Mercury	0.25	0.43
Nickel	92.9	112
Selenium	0.59	0.64
Silver	0.31	0.58
Zinc	97.8	158
PESTICIDES AND PCBs (mg/kg)		
Aldrin	0.42	1.1
Chlordane	0.18	0.44
Chlordanes, total	0.42	1.1
Dieldrin	0.18	0.44
Endrin	0.31	0.78
HCH, total	0.31	0.78
DDTS, total of 6 isomers	2.8	7
PCBs, total	5.9	14.8
PCBs, total (SFEI 40 list)	8.6	21.6

Table 2: Ambient Concentrations of Analytes in San Francisco Bay Sediments (Page 2 of 2)

Analyte	S.F. Estuary Sediment Ambient Concentrations	
	<40 % fines	<100 % fines
POLYCYCLIC AROMATIC HYDROCARBONS (mg/kg)		
PAHs, total	211	3390
High molecular weight PAHs, total	256	3060
Low molecular weight PAHs, total	37.9	434
1-Methylnaphthalene	6.8	12.1
1-Methylphenanthrene	4.5	31.7
2,3,5-Trimethylnaphthalene	3.3	9.8
2,6-Dimethylnaphthalene	5	12.1
2-Methylnaphthalene	9.4	19.4
2-Methylphenanthrene	11.3	26.6
Acenaphthene	2.2	31.7
Acenaphthylene	11.3	26.6
Anthracene	9.3	88
Benz(a)anthracene	15.9	244
Benzo(a)pyrene	18.1	412
Benzo(b)fluoranthene	32.1	371
Benzo(e)pyrene	17.3	294
Benzo(g,h,i)perylene	22.9	310
Benzo(k)fluoranthene	29.2	258
Biphenyl	6.5	12.9
Chrysene	19.4	289
Dibenz(a,h)anthracene	3	32.7
Fluoranthene	78.7	514
Fluorene	4	25.3
Indeno(1,2,3-c,d)pyrene	19	382
Naphthalene	8.8	55.8
Perylene	24	145
Phenanthrene	17.8	237
Pyrene	64.6	665

Table 3: Selected Biological Effects-Based Concentrations of Analytes in Sediments (Page 1 of 2)

ANALYTE	ER-L 1995	ER-M 1995	TEL	PEL
METALS (mg/kg)				
Arsenic	8.2	70	7.24	41.6
Cadmium	1.2	9.60	0.676	4.21
Chromium, total	81	370	52.3	160
Copper	34	270	18.7	108
Lead	46.7	218	30.2	112
Mercury	0.15	0.71	0.13	0.696
Nickel	20.9	51.6	15.9	42.8
Selenium				
Silver	1	3.7	0.733	1.77
Zinc	150	410	124	271
PESTICIDES AND PCBs (mg/kg)				
Aldrin				
Chlordane			2.26	4.79
Chlordanes, total				
Dieldrin			0.715	4.3
Endrin				
Heptachlor				
Hexachlorocyclohexane-delta				
Hexachlorocyclohexane-gamma (Lindane)			0.32	0.99
HCB, total				
Methoxychlor				
Mirex				
Toxaphene				
p,p'-DDD (or DDD ?)			1.22	7.81
p,p'-DDE (or DDE ?)	2.20	27	2.07	374
p,p'-DDT (or DDT ?)			1.19	4.77
DDTS, total of 6 isomers	1.58	46.1	3.89	51.7
PCBs, total	22.7	180	21.6	189
PCBs, total (SFEI 40 list)				

Table 3: Selected Biological Effects-Based Concentrations of Analytes in Sediments (Page 2 of 2)

ANALYTE	ER-L 1995	ER-M 1995	TEL	PEL
ACID/BASE NEUTRALS (mg/kg)				
Bis(2-ethylhexyl) phthalate			182	2,647
Dibenzofuran				
Di-n-butyl phthalate				
Hexachlorobenzene (HCB)				
Phthalates, total				
POLYCYCLIC AROMATIC HYDROCARBONS (mg/kg)				
PAHs, total	4,022	44,792	1,684	16,770
High molecular weight PAHs, total	1,700	9,600	655	6,676
Low molecular weight PAHs, total	552	3,160	312	1,442
1-Methylnaphthalene				
1-Methylphenanthrene				
2,3,5-Trimethylnaphthalene				
2,6-Dimethylnaphthalene				
2-Methylnaphthalene	70	670	20.2	201
2-Methylphenanthrene				
3-Methylphenanthrene				
Acenaphthene	16	500	6.71	88.9
Acenaphthylene	44	640	5.87	128
Anthracene	85.3	1,100	46.90	245
Benz(a)anthracene	261	1,600	74.8	693
Benzo(a)pyrene	430	1,600	88.8	763
Benzo(b)fluoranthene				
Benzo(g,h,i)perylene				
Benzo(k)fluoranthene				
Biphenyl				
Chrysene	384	2,800	107.8	846
Dibenz(a,h)anthracene	63.4	260	6.22	135
Fluoranthene	600	5,100	113	1494
Fluorene	19	540	21.2	144
Indeno(1,2,3-c,d)pyrene				
Naphthalene	160	2,100	34.6	391
Perylene				
Phenanthrene	240	1,500	86.7	543.5
Pyrene	665	2,600	153	1,398

Table 4: Recommended Sediment Chemistry Screening Guidelines for Beneficial Reuse of Dredged

ANALYTE	Wetland Surface Material		Wetland Foundation Material	
	Concentration	Decision Basis	Concentration	Decision Basis
METALS (mg/kg)				
Arsenic	15.3	Ambient Values	70	ER-M
Cadmium	0.33	Ambient Values	9.6	ER-M
Chromium	112	Ambient Values	370	ER-M
Copper	68.1	Ambient Values	270	ER-M
Lead	43.2	Ambient Values	218	ER-M
Mercury	0.43	Ambient Values	0.7	ER-M
Nickel	112	Ambient Values	120	ER-M
Selenium	0.64	Ambient Values		
Silver	0.58	Ambient Values	3.7	ER-M
Zinc	158	Ambient Values	410	ER-M
ORGANOCHLORINE PESTICIDES/PCBS (mg/kg)				
DDTS, sum	7.0	Ambient Values	46.1	ER-M
Chlordanes, sum	2.3	TEL	4.8	PEL
Dieldrin	0.72	TEL	4.3	PEL
Hexachlorocyclohexane, sum	0.78	Ambient Values		
Hexachlorobenzene	0.485	Ambient Values		
PCBs, sum	22.7	ER-L	180	ER-M
POLYCYCLIC AROMATIC HYDROCARBONS (mg/kg)				
PAHs, total	3,390	Ambient Values	44,792	ER-M
Low molecular weight PAHs, sum	434	Ambient Values	3,160	ER-M
High molecular weight PAHs, sum	3,060	Ambient Values	9,600	ER-M
1-Methylnaphthalene	12.1	Ambient Values		
1-Methylphenanthrene	31.7	Ambient Values		
2,3,5-Trimethylnaphthalene	9.8	Ambient Values		
2,6-Dimethylnaphthalene	12.1	Ambient Values		
2-Methylnaphthalene	19.4	Ambient Values	670	ER-M
2-Methylphenanthrene		Ambient Values		
3-Methylphenanthrene		Ambient Values		
Acenaphthene	26.0	Ambient Values	500	ER-M
Acenaphthylene	88.0	Ambient Values	640	ER-M
Anthracene	88.0	Ambient Values	1,100	ER-M
Benz(a)anthracene	412	Ambient Values	1,600	ER-M
Benzo(a)pyrene	371	Ambient Values	1,600	ER-M
Benzo(e)pyrene	294	Ambient Values		
Benzo(b)fluoranthene	371	Ambient Values		
Benzo(g,h,i)perylene	310	Ambient Values		
Benzo(k)fluoranthene	258	Ambient Values		
Biphenyl	12.9	Ambient Values		
Chrysene	289	Ambient Values	2,800	ER-M
Dibenz(a,h)anthracene	32.7	Ambient Values	260	ER-M
Fluoranthene	514	Ambient Values	5,100	ER-M
Fluorene	25.3	Ambient Values	540	ER-M
Indeno(1,2,3-c,d)pyrene	382	Ambient Values		
Naphthalene	55.8	Ambient Values	2,100	ER-M
Perylene	145	Ambient Values		
Phenanthrene	237	Ambient Values	1,500	ER-M
Pyrene	665	Ambient Values	2,600	ER-M

Table 5: Routine Parameters and Target Analytes for Evaluation of Dredged Material (Page 1 of 3)

Parameter	Target Detection Limit[1]
Conventional Parameters	
Grain size	NA
Total organic carbon	0.1 percent
TRPH	20
Total solids/water content	0.1 percent
Metals (mg/kg)	
Arsenic	0.1
Cadmium	0.1
Chromium	0.1
Copper	0.1
Lead	0.1
Mercury	0.02
Nickel	0.1
Selenium	0.1
Silver	0.1
Zinc	1
Organic Compounds (mg/kg)	
PAH Compounds	0.02 each
PCB Arochlors	0.02 each
Pesticides	0.002 each
Butyltins	0.001 each

Table 5: Routine Parameters and Target Analytes for Evaluation of Dredged Material (Page 2 of 3)

Parameter	Target Detection Limit[1]
Butyltins (µg/kg)	
Monobutyltin	10
Dibutyltin	10
Tributyltin	10
Tetrabutyltin	10
Total Butyltins	NA
PCBs (µg/kg)	
Aroclor 1242	20
Aroclor 1248	20
Aroclor 1254	20
Aroclor 1260	20
Total Aroclors	NA
Pesticides (µg/kg)	
Aldrin	2
α-BHC	2
β-BHC	2
δ-BHC	2
γ-BHC (Lindane)	2
Chlordane	2
2,4'-DDD	2
4,4'-DDD	2
2,4'-DDE	2
4,4'-DDE	2
2,4'-DDT	2
4,4'-DDT	2
Total DDT	NA
Dieldrin	2
Endosulfan I	2
Endosulfan II	2
Endosulfan sulfate	2
Endrin	2
Endrin aldehyde	2
Heptachlor	2
Heptachlor epoxide	2
Toxaphene	20

Table 5: Routine Parameters and Target Analytes for Evaluation of Dredged Material (Page 3 of 3)

Parameter	Target Detection Limit[1]
PAHs (µg/kg)	
1-Methylnaphthalene	20
1-Methylphenanthrene	20
2,3,5-Trimethylnaphthalene	20
2,6-Dimethylnaphthalene	20
2-Methylnaphthalene	20
2-Methylphenanthrene	20
3-Methylphenanthrene	20
Acenaphthene	20
Acenaphthylene	20
Anthracene	20
Benz(a)anthracene	20
Benzo(a)pyrene	20
Benzo(b)fluoranthene	20
Benzo(e)pyrene	20
Benzo(g,h,i)perylene	20
Benzo(k)fluoranthene	20
Biphenyl	20
Chrysene	20
Dibenz(a,h)anthracene	20
Fluoranthene	20
Fluorene	20
Indeno(1,2,3-c,d)pyrene	20
Naphthalene	20
Perylene	20
Phenanthrene	20
Pyrene	20
Low molecular weight PAHs, sum	NA
High molecular weight PAHs, sum	NA
PAHs, total	NA

1) Reported in a dry weight basis

Table 6: Reference Sediment Sample Locations, Parameters, and Chemistry (Page 1 of 2)

PARAMETERS	San Pablo Bay/Carquinez Reference Sites		
	Paradise Cove	**Tubbs Island**	**Island #1**
Latitude	37°53'95"N	38°06'87"N	38°06'72"N
Longitude	122°27'86"W	122°25'16"W	122°19'71"W
CONVENTIONAL PARAMETERS			
Total Organic Carbon (ppm)	1.12	1.38	0.98
Percent Fines	92.9	99.4	99
METALS (mg/kg)			
Arsenic	11.5	10.3	13.4
Cadmium	0.23	0.24	0.25
Chromium	217	208	192
Copper	51.8	65.8	50.2
Lead	24.4	30.2	23.9
Mercury	0.304	0.35	0.274
Nickel	102.4	129	89
Selenium	0.22	0.199	0.17
Silver	0.304	0.29	0.244
Zinc	146	178	145
ORGANOCHLORINE PESTICIDES/PCBs (μg/kg)			
DDTS, sum	6.7	6.42	38.9
Chlordanes, sum	1.8	ND	ND
Dieldrin	ND	ND	ND
Hexachlorocyclohexane, sum	ND	ND	ND
PCBs, sum of Arochlors	12.1	6.85	3.25
POLYCYCLIC AROMATIC HYDROCARBONS (μg/kg)			
PAHs, total	4280	1477	1101
Low molecular weight PAHs, sum	287	169	113
High molecular weight PAHs, total	3995	1308	968
1-Methylnaphthalene	9.4	6.81	6.35
1-Methylphenanthrene	15.8	10.7	8.66
2,3,5-Trimethylnaphthalene	ND	ND	ND
2,6-Dimethylnaphthalene	ND	ND	ND
2-Methylnaphthalene	17.3	13	11.2
2-Methylphenanthrene	NA	NA	NA
3-Methylphenanthrene	NA	NA	NA
Acenaphthene	10.6	5.2	5.1
Acenaphthylene	20	5.99	5.7
Anthracene	36.2	17.2	12.4
Benz(a)anthracene	220	54	53.4
Benzo(a)pyrene	480	168	138

Table 6: Reference Sediment Sample Locations, Parameters, and Chemistry (Page 2 of 2)

PARAMETERS	San Pablo Bay/Carquinez Reference Sites		
	Paradise Cove	Tubbs Island	Island #1
POLYCYCLIC AROMATIC HYDROCARBONS (µg/kg) – cont'd			
Benzo(b)fluoranthene	617	148	122
Benzo(g,h,i)perylene	379	138	120
Benzo(k)fluoranthene	253	54.5	45.7
Biphenyl	11.5	8.55	6.98
Chrysene	236	51.7	53.2
Dibenz(a,h)anthracene	83.1	20.8	19
Fluoranthene	352	154	154
Fluorene	12.7	8.04	6.1
Indeno(1,2,3-c,d)pyrene	394	142	118
Naphthalene	35.6	21.4	20.1
Perylene	139	94.9	73.7
Phenanthrene	115	68.6	63.1
Pyrene	544	194	182

Table 7: Recommended Sampling Frequency for Evaluation of Dredged Material

Dredge Volume (cubic yards)	Total Number of Samples	Number of Samples per Composite	Total Number of Tests
5,000-20,000	4	4	1
20,000-100,000	8	4	2
100,000-200,000	12	4	3
200,000-300,000	16	4	4
300,000-400,000	20	4	5
400,000-500,000	24	4	6

Figures

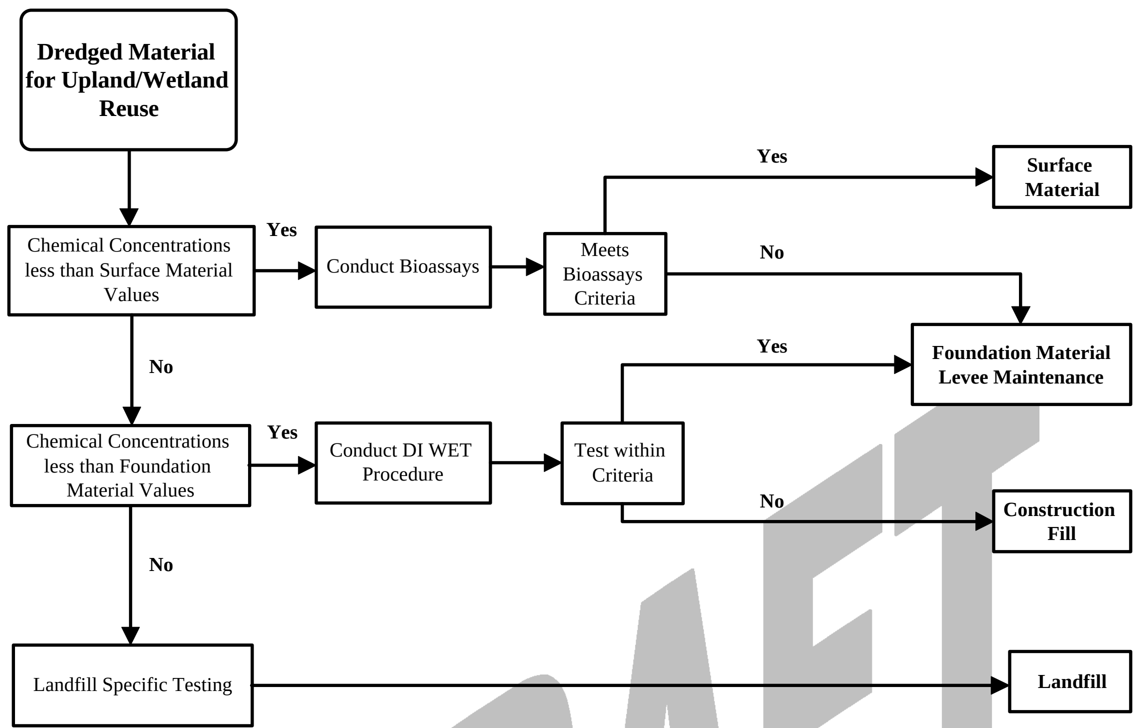

Figure 1. Recommended Testing Protocols for Wetland/Upland Dredged Material Disposal in the San Francisco Bay Region