CHAPTER 5. Characterization and Assessment of Delta Sediments Based on the DREDGE Database

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CHAPTER 5 CHARACTERIZATION AND ASSESSMENT OF DELTA SEDIMENTS BASED ON THE DREDGE DATABASE

Over the next several years, CALFED may initiate dredging operations in the Delta to create new aquatic and upland habitat for fish and wildlife. This effort will involve disturbing large quantities of sediment and thus, contaminants that may affect the fish and wildlife that will benefit from the creation of the new habitat. Over the last 20 years, a large body of information has been gathered by various state and federal agencies and private consultants concerning the presence of various contaminants of sediments in the Delta. These data have been scattered among several agencies, and no effort has been made to combine the data into a database that would facilitate analysis of the data for types and levels of contaminants. The database DREDGE was created as a result of the Delta Dredging and Reuse Strategy; the database is a summation of existing sediment quality data. The data in DREDGE were compared to guidelines that have been used to assess sediment quality in the Delta.

Contaminants present in Delta sediments were assessed by gathering historical data into a database (DREDGE) and comparing the data against various solid-borne SQAGs (also referred to this in this report as soil screening levels or SSLs) and water-borne discharge limitations. The preliminary guidelines were used to provide a yardstick for evaluating sediment quality in the Delta. From this information, lists of COCs and COPCs were generated. The analysis that follows assumes that:

- All significant contaminants were identified,
- The contaminant data were accurate and representative of the sediments, and
- The SQAGs and discharge limitations represent levels below which impacts are not expected to occur.

METHODS

DREDGE Database of Delta Sediments

DREDGE is a database in Microsoft Access developed by DFG that contains available physical, chemical, and biological (i.e., toxicity) data on sediment samples collected from the Delta. The majority of the data originated from dredging activities. Many of the dredge sites are located in the Sacramento and Stockton Deep Water Ship Channels and in marinas throughout the Delta.

Summary of Reviewed Studies

The available data on the physical, chemical, and biological characteristics of dredge sediment from the Delta were reviewed, summarized, and assessed to identify COCs. The data came from 50 studies conducted between 1986 and 2000 (Table 5-1). The data were grouped into three broad categories based on their location: (1) deep water ship channels and ports (Ship Channel); (2) small pleasure boat marinas (Marinas); and (3) other river areas, canals, backwaters, and sloughs (Riverine).

Most of the data came from studies associated with waste discharge requirements for dredging operations with disposal to upland environments (Table 5-2 and Figure 5-1). Several research studies in the riverine locations were conducted by DWR and other state government agencies. Only three of the studies were completed before 1992, the vast majority having been conducted since 1994. In general, where samples of bulk sediments were collected for pre-dredge testing, one sample was collected for each 25,000 cy of sediments dredged. Regardless of their location, these studies primarily focused on metal residues. The bulk sediment samples almost always were analyzed for concentrations of metals, using EPA-approved methods. Samples from the ship channel and riverine locations and, to a lesser extent marina locations, also were analyzed for concentrations of pesticides and specific semi-volatile and volatile organic compounds, using EPA-approved methods. The analyses of bulk sediments and sediment elutriates were used to help determine the suitability of the sediments for upland disposal.

In addition to analyses of bulk sediments, sediment elutriates were generated using one of three techniques, depending on sediment disposal location and other factors. Water from the dredge site was used to produce the MET that is designed to protect surface water quality from effluent at the dredge material disposal sites. MET analyses for metals and specific organic compounds also have been used to help determine the suitability of the sediments for aquatic disposal and to identify possible compounds that could pose a risk to aquatic life from entrainment of sediment remobilized during the dredging operations.

Other elutriate tests also were generated to protect surface water and groundwater quality from leaching and runoff. The elutriates from the WET with standard citric acid buffer or the DIWET, depending on the acid-generating potential of the sediment, were analyzed for soluble metals. The WET simulates leaching of metals that would occur in acidic environments, and the DIWET simulates the leaching that would occur in more neutral environments. Both of the tests are designed to protect water quality resulting from runoff into surface water or percolation into groundwater at the upland disposal site.

All but one of the ship channel studies were conducted by the Corps. The Corps used the same laboratories for the analyses of the sediment samples, and the sample collection methodologies and detection limits for the sediment analyses generally were consistent among studies and among years. In contrast, for studies conducted in the marina and riverine locations, methodologies and laboratories varied considerably. The riverine and marina studies were fragmented in time and space.

Table 5-1. Statistics of Studies on Delta Sediments

	Marina	Riverine	Ship Channel
Number of studies	13	17	20
Years	1989–2000	1988–2000	1986–2000
Primary investigators	Consultants	Consultants, government agencies	U.S. Army Corps of Engineers
Number of samples	39	255	169
Number of sites	11	9	4
Types of samples	Cores, grabs	Cores	Cores
Bulk analyses	Metals	Metals, pesticides, SVOCs	Metals, pesticides, SVOCs
Elutriate analyses	DIWET: metals WET: metals MET: metals	DIWET: metals WET: metals MET: metals, organics	DIWET: metals WET: metals MET: metals, organics

Notes:

DIWET = Deionized water waste extraction test.
MET = Modified elutriate test.
SVOCs = Semi-volatile organic compounds.
WET = Waste extraction test.

Table 5-2. Delta Studies in the DREDGE Database

Study Name	Site (Number of Stations)	Reference[a]
Marina		
Antioch Marina	Antioch Municipal Marina (1)	City of Antioch (1997)
Stockton Sailing Club	Buckley Cove/Stockton Sailing Club (3)	Kjeldsen, Sinnock, and Neudeck (1995)
Del's Harbor	Del's Harbor (6)	DWR (2000a)
Kie-Con Barge Landing	Kie-Con Barge Landing/Antioch (1)	Aquifer Sciences, Inc. (1997)
Korth's Pirates Lair	Korth's Pirates Lair/Andrus Island (1)	DCC Engineering Co., Inc. (1989)
Pirates Lair	Korth's Pirates Lair/Andrus Island (1)	Advanced Biological Testing, Inc. (1997)
Lauritzen Marina	Lauritzen Marina/Antioch (6)	Aquifer Sciences, Inc. (1992)
Lauritzen Marina	Lauritzen Marina/Antioch (6)	DuPont Environmental Remediation Services (1997)
Lost Isle Harbor	Lost Isle Marina/Acker Island (1)	Lost Isle Partners of Sunol (1998)
New Bridge Marina	New Bridge Marina/Antioch (6)	Salt River Construction-Tiburon, CA (1995)
Orwood Marina	Orwood Marina (1)	Anderson Engineering (1997)
Oxbow Marina	Oxbow Marina/Andrus Island (2)	Advanced Biological Testing, Inc. (1994)
Sugar Barge Marina	Sugar Barge Marina/Bethel Island (2)	Aquifer Sciences, Inc. (1996)
Sediment Sampling Report	Village West Marina/Stockton (3)	Kjeldsen, Sinnock, and Neudeck (1999a)
Riverine		
Bethel Island	Bethel Island (1)	Wes Anderson Engineering (1994a)
Bethel Island	Bethel Island (2)	Wes Anderson Engineering (1994b)
South Delta Improvements Program	Grantline Canal (8)	DWR (2000b)
Harbor Marina Project	Harbor Marina/Andrus Island (4)	Raney Geotechnical (1988)
Harbor Marina Project	Harbor Marina/Andrus Island (10)	R. B. Krone (1990)
McMullin Tract	McMullin Tract (4)	Kjeldsen, Sinnock, and Neudeck (1994)
North Delta Program	North Delta Project (7)	DWR (1990)
North Delta Program	North Delta Project (13)	DWR (1995a)
PG&E Contra Costa	PG&E Power Plant (1)	MEC Analytical Systems, Inc. (1997)
Environmental study for the Interim South Delta Program	South Delta Project (17)	DWR (1994)
South Delta Program	South Delta Project (6)	DWR (1995b)
Old River	South Delta Project (6)	DWR (1997)
Old Middle River	South Delta Project (12)	Huitt (1999)
Cumulative Monitoring Report	Staten Island (4)	DWR (1996)
Tyler Island	Tyler Island (4)	Kjeldsen, Sinnock, and Neudeck (1997)
Tyler Island	Tyler Island (4)	Kjeldsen, Sinnock, and Neudeck (1999b)

Table 5-2. Continued

Study Name	Site (Number of Stations)	Reference[a]
Ship Channel		
Mormon Channel[b]	Mormon Channel/Port of Stockton (3)	MEC Analytical Systems, Inc. Bioassay Division (1993)
Sacramento DWSC	Sacramento DWSC (16)	Corps (1986)
Report of Waste Discharge	Sacramento DWSC (4)	Corps (1995b)
Sacramento DWSC	Sacramento DWSC (4)	Corps (1997a)
Notice of Intent	Sacramento DWSC (7)	Corps (1998b)
Post-Dredging Notice	Sacramento DWSC (4)	Corps (1998a)
Sacramento DWSC	Sacramento DWSC (8)	Corps (1999a)
Sacramento DWSC	Sacramento DWSC (14)	Corps (2000a)
Stockton DWSC (river miles 41–39.18)	Stockton DWSC (12)	Corps (1994)
Report of Waste Discharge	Stockton DWSC (6)	Corps (1995c)
San Joaquin River	Stockton DWSC (4)	Toxscan, Inc./Kinnetic Laboratories, Inc. (1995)
Pre-Dredge Sediment Program	Stockton DWSC (10)	Corps (1996)
Notice of Intent	Stockton DWSC (13)	Corps (1997b)
Post-Dredging Notice	Stockton DWSC (3)	Corps (1998c)
Notice of Intent	Stockton DWSC (7)	Corps (1998d)
Stockton DWSC	Stockton DWSC (16)	Corps (1999b)
Stockton DWSC	Stockton DWSC (14)	Corps (2000b)
Suisun Channel	Suisun Bay/New York Slough (6)	Toxscan, Inc./Kinnetic Laboratories, Inc. (1994)
Suisun Bay Channel	Suisun Bay/New York Slough (7)	Toxscan, Inc./Kinnetic Laboratories, Inc. (1998)
Suisun Bay/New York Slough	Suisun Bay/New York Slough (6)	Toxscan, Inc./Kinnetic Laboratories, Inc. (1999)

Notes:

Corps = U.S. Army Corps of Engineers.
DWR = California Department of Water Resources.
DWSC = Deep Water Ship Channel.
PG&E = Pacific Gas and Electric Company.

[a] All references are found in Chapter 7, "References."

[b] Mormon Channel is a U.S. Environmental Protection Agency Superfund cleanup site. Dredging would occur only as part of Superfund cleanup efforts.

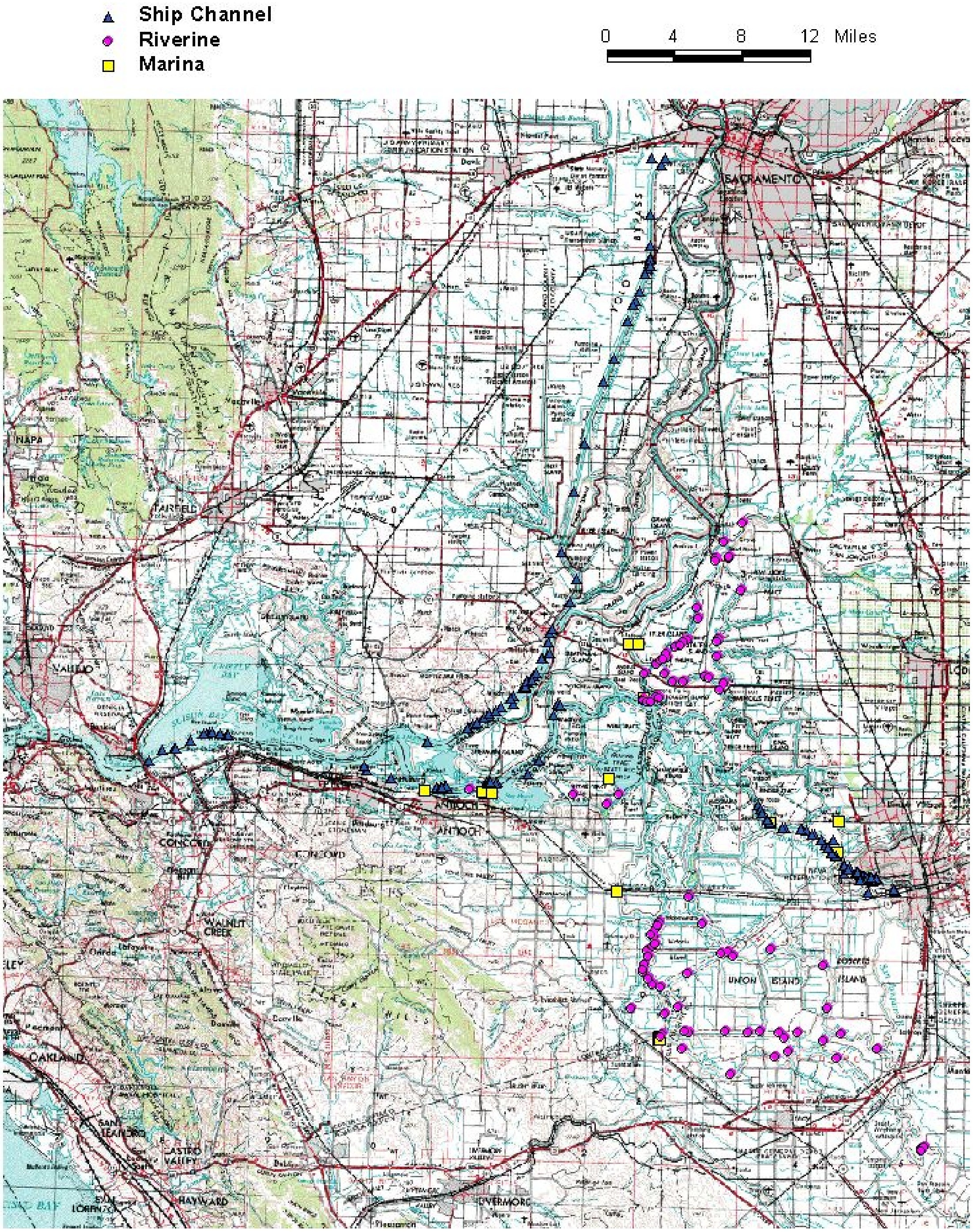


Figure 5-1. Collection locations utilized in DREDGE for assessment of sediment quality.

Database Structure

The DREDGE database consists of a series of 12 related data tables: (1) SITE, (2) STUDY, (3) STATION, (4) SAMPLE, (5) CHEM, (6) ELUCHEM, (7) CHEMDICT, (8) BIOELU, (9) BIOSED, (10) SPECIES, (11) TESTDICT, and (12) QUALIFY. Figure 5-2 shows the relationships between each of the data tables. The fields for each data table are described in Appendix I.

Characterizing Sediments in DREDGE

The sediments generally are characterized using three types of tests: physical, chemical, and biological. The types of data that were collected on sediments from the Delta and their relevance to determining impacts are described below.

Physical Characteristics

Physical analyses are important because they help to indicate how the sediment may behave during dredging and disposal operations. These analyses also may indicate the need for subsequent chemical and biological testing. Usually, the following analyses were made on the physical characteristics of the sediments in DREDGE:

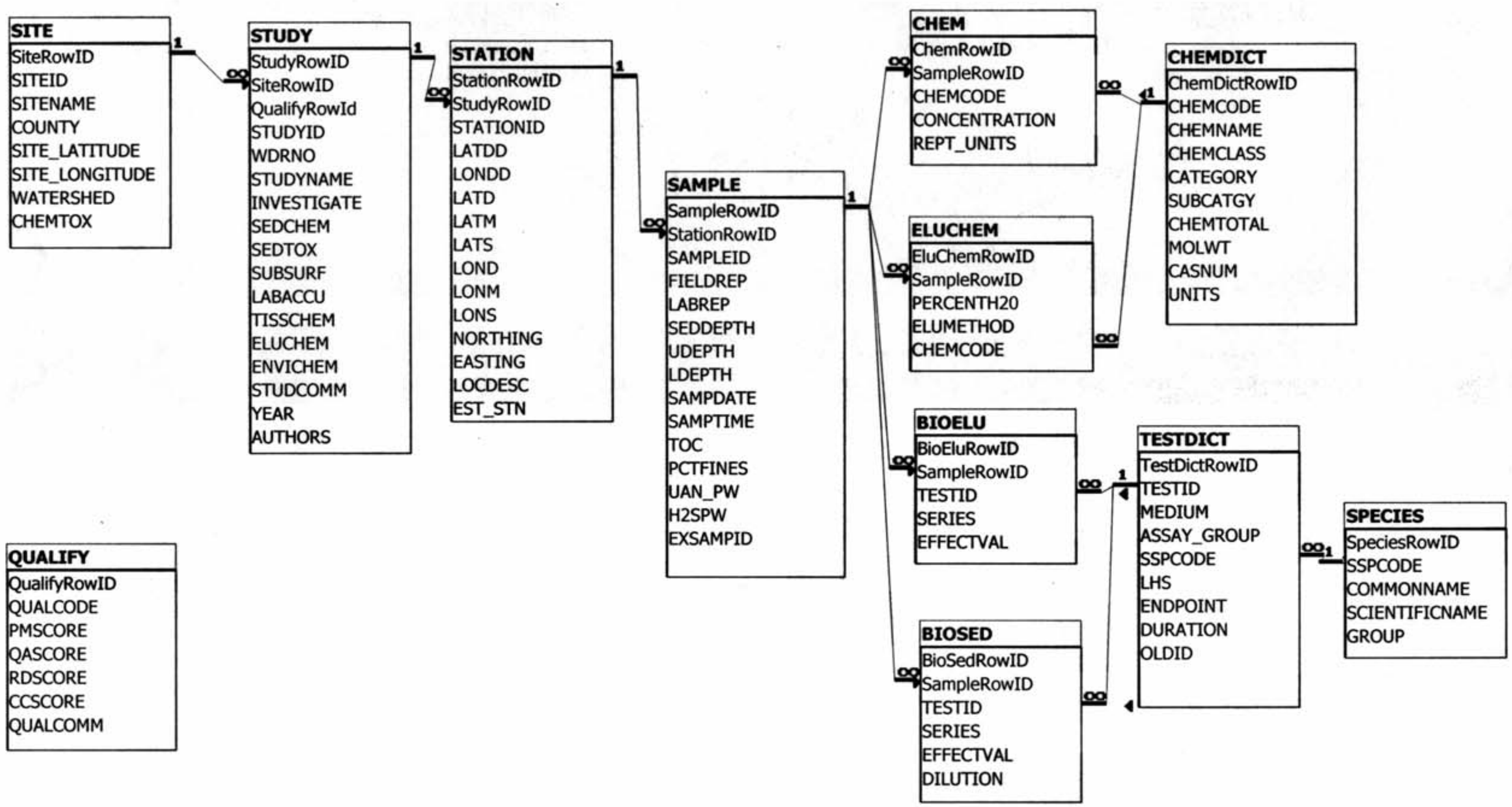
- Grain size (percent sand, silt, and clay),
- Percent solids (dry matter),
- Density or specific gravity, and
- Organic matter (as total organic carbon [TOC]).

When dredge material is being considered for beneficial uses, details on the engineering properties of material, such as its permeability, settling characteristics, plasticity, and mineralogy, usually also are needed.

Chemical Characteristics

Chemical or contaminant analyses are important because of the potential for contaminants to affect human health, surface water and groundwater qualities, air quality, and fish and wildlife. The following metals have been determined for most of the samples used in DREDGE: cadmium, copper, mercury, zinc, chromium, lead, and nickel. The following organic and organo-metallic compounds have been determined in most cases, except when the sediments are predominantly coarse and the TOC content is low: polychlorinated biphenyl (PCB) congeners, polycyclic aromatic hydrocarbons (PAHs), and tributyltin compounds and degradation products.

Relationships for DREDGE



Depending on the location, date of study, and sources of contamination, other analyses that may have been investigated include the following: antimony, other chlorbiphenyls, OP pesticides, petroleum hydrocarbons, OC pesticides, other trace elements, and polychlorinated dibenzodioxins (PCDDs) and dibenzofurans (PCDFs).

Biological Characteristics

Neither physical nor chemical properties provide a direct measure of biological impact. If the potential impacts of the dredge material cannot be adequately assessed on the basis of the chemical and physical characterization, biological characteristics generally are measured. The selection of an appropriate biological test method depends on the particular questions addressed and the level of contamination present. Toxicity tests are completed to provide direct measures of the effects of all sediment constituents working together and taking into account their bioavailability. To evaluate the effects of dredge material, acute (survival) and chronic (growth or reproduction) toxicity tests can be performed with pore water, an elutriate, or the whole sediment. Other important biological tests on sediments include biomarkers of resident organisms, microcosm and macrocosm experiments, and field observations on the resident benthic communities. Contaminant concentrations in resident biota also may be investigated. DREDGE contains only toxicity tests from a few sediment samples. Generally, toxicity tests were required if aquatic disposal was proposed.

Exposure Pathways

Contaminants in sediments must be in a bioavailable form to cause a biological effect. Animals can be exposed to contaminants in sediments directly through ingestion or direct contact with the sediment or sediment pore water. Indirectly, they may be exposed through contaminated surface water or groundwater, or by eating other plants or animals that have taken up contaminants from the sediments. Different basic exposure pathways and potential risks are associated with disposal of dredge material in the various types of placement environments (i.e., aquatic, wetland, and upland).

Dredging and aquatic disposal can affect animals in the water column and the benthos. The location of the dredging and disposal sites in relation to resources of concern, and whether a disposal site is subject to erosion or deposition, are important factors in determining exposure pathways. There are also important overall exposure differences when dredge materials are placed in upland versus aquatic sites. Sediments placed in upland locations can affect a different mix of plants and animals, as well as surface water quality, groundwater quality, and air quality.

The different placement environments also differ in the ability to engineer disposal sites in order to manage the exposure pathways. Generally, it is not possible to control exposure to dredge material at dispersive, unconfined aquatic sites. At non-dispersive, confined aquatic sites, exposure can be limited. In contrast, design features can be included at confined aquatic disposal sites and at many upland/wetland reuse sites to limit exposure. A basic understanding of how the exposure pathways differ among the placement environments is essential to determine the need for specific management restrictions, and to design and implement placement site design features that are truly effective at minimizing or eliminating potential impacts.

Aquatic and Wetland Environments

To date, disposal of dredge material in an aquatic environment in the Delta has been limited. Water column effects occur when contaminants on sediment particles are dissolved. This may happen when sediments are disturbed from the bottom and resuspended during dredging and disposal. Benthic effects can result from physical burial of benthic organisms at the disposal site and long-term exposure of local animals to the sediments on the bottom after disposal has ceased.

Reduced, anaerobic conditions often found in sediments favor sulfide generation that makes metals biologically unavailable. Under these conditions, some sediment contaminants may not be directly available to many aquatic organisms. During dredging and disposal activities, the exposure of anaerobic sediments to oxygenated water can be sufficiently short term so that the reduced characteristics to the sediment may not change appreciably.

Specific contaminants are associated with sediments through sorption onto their surfaces or being dissolved in interstitial (pore) water. The same processes that preferentially bind these contaminants to sediment particles make it relatively difficult for the contaminants to disassociate from the particles and return to the aqueous phase during dredging and aquatic disposal. Water column impacts, therefore, are evaluated by comparisons with water quality criteria and standards, and evaluation of the potential for short-term toxicity.

Potential water column effects usually can be managed by selection of appropriate dredging and disposal methods in conjunction with designation of an appropriate mixing zone. Mixing zones are areas outside of which water quality standards must be met and beneficial uses of the waterbody must be protected. Mixing zones should not be sufficiently large to inhibit the movement or migration of aquatic species or to allow degraded water quality to extend throughout a significant portion of a waterbody. Narrative water quality criteria in California include wording such that water outside mixing zones cannot include “toxic substances in toxic amounts.” Pre-disposal testing for potential water column impacts evaluates both water quality (numeric criteria) and short-term toxicity.

Generally, dredging is not expected to result in significant direct impacts on most aquatic organisms, except in certain circumstances. These circumstances could include the following:

- Dredging highly contaminated sediments or sediments with unusually high oxygen demand,
- Dredging within constricted areas where water column mixing is inadequate,
- Dredging or discharging near specific resources of concern, and
- Dredging or discharging at locations where increased suspended sediments would directly affect particular species of concern.

Benthic exposure to dredge material is usually long term. On-site benthic infauna and epifauna can be exposed long enough that any contaminants in the dredge material can directly affect them, or they can accumulate bioavailable contaminants to such a degree that animals that prey on them may be adversely affected.

In March 1995, the Pajaro River flooded across adjoining farm fields and flowed into the headwaters of Elkhorn Slough, in Monterey County, California. As a result, a large quantity of sediments from the river and associated soils from the farmland were deposited in Elkhorn Slough. In May and June of that year, the Caspian tern breeding colony in Elkhorn Slough suffered a complete failure. An investigation revealed that greatly elevated levels of chlorinated pesticides and industrial compounds such as PCBs were present in the dead chicks and in the eggs (Parkin 1998; Parkin et al. manuscript in prep; DFG unpublished reports P-1743, P-1800, and P-1819). Investigation also found greatly elevated levels of these same compounds in fish collected from Elkhorn Slough and the Pajaro River compared to samples collected in years prior to the flood event (Parkin 1998; Parkin et al. manuscript in prep). A concentration gradient of these same compounds was found in the sediments deposited in the slough from the flood event. The evidence indicates that the chlorinated compounds were present in the sediments of the river and were remobilized during the flood and subsequently deposited in the slough. A similar incident occurred in Michigan, in Saginaw Bay, a few years earlier—also resulting in the failure of a large Caspian tern breeding colony (Ludwig et al. 1993).

At predominantly depositional sites, such as wetlands, dredge material is expected to remain on the bottom. Therefore, monitoring site performance and confirming that unacceptable adverse effects are not occurring or taking corrective action is more easily accomplished. Adverse effects in the vicinity of a depositional disposal site can be determined much more readily than at a dispersive site, whether due to dredge material disposal or some other cause.

Upland Environments

Important physical and chemical changes occur when sediments begin to dry in an upland environment. Sediments will oxidize and become lighter in color as they dry and cracks form. Salt deposits will develop on the surface and the edge of the cracks. Rain will tend to dissolve these salts and remove them in surface runoff, and accumulations of now-oxidized metals may be carried away with the runoff. Organic complexes oxidize and decompose. Sulfide complexes also oxidize to sulfate salts, and acidity may increase (pH may drop). A lowered pH can affect the speciation and reactivity of various metals (generally making them more soluble, bioavailable, and toxic). These transformations can promote the release of contaminants into surface water and groundwater; plants and animals exposed to these water sources, or to the site itself, may readily take up these released contaminants.

Upland placement of dredge material can potentially affect surface water quality through direct runoff during drying, rainwater runoff from the site after the material has dried, and seepage from the site into other adjacent surface waters. Groundwater quality may be affected where underlying groundwater is high. Wildlife may be attracted to the site while it is flooded and in the early stages of the drying process when the sediments are still settling and consolidating. Other wildlife may be attracted to the site after the sediments have dried. Plant uptake of contaminants from the dried sediments can occur (especially metals, which can be taken up into plant tissues from the surface, oxygenated layer of the sediment). Bioaccumulation of contaminants into plant tissues can be of concern for wildlife, which may be exposed to the contaminants by eating the plants. Risks to human health from dredge material at upland sites depend on the type and level of contaminants in the material and site-specific factors.

Approaches of Assessing Sediment Quality

The DREDGE database largely contains chemical (contaminant) data. Very few toxicity tests were completed on aquatic or terrestrial plants and animals. Thus, there is little evidence of potential impact or lack of potential impact from the reuse and disposal of sediments. To assist in the identification of COCs and interpretation of historical contaminant data, SQAGs can be used. These guidelines are based on scientifically derived weight-of-evidence (empirical data) or theoretical approaches; the data originates from a variety of sources, including toxicity tests, scientific principles, and field observations. Because of different exposure pathways, SQAGs in solids have been developed to assist in assessing both aquatic (Table 5-3) and upland (Table 5-4) reuse and disposal. To protect against waterborne concentrations of contaminants, a variety of SQAGs for water have been proposed (Table 5-5).

Aquatic Disposal

CONTAMINANTS IN SOLIDS

A variety of approaches have been devised to formulate SQAGs for assessing contaminants in solids in the aquatic environment. These approaches have been reviewed and summarized by Chapman (1989), Persaud et al. (1989), Beak (1987;1988), EPA (1989a;1989b), the Sediment Criteria Subcommittee (1989;1990), MacDonald et al. (1991), and MacDonald (1993). Other approaches focus on site-specific assessment of sediment quality through extensive chemical, biological, and toxicological testing of sediment as described by EPA (1989a) and MacDonald et al. (1991). The following eight major approaches were reviewed and are summarized in Appendix J for methodology, advantages, and disadvantages:

- Sediment background approach (SBA),
- Spiked sediment bioassay approach (SSBA),
- Equilibrium partitioning approach (EqPA),
- Tissue residue approach (TRA),
- Screening level concentration approach (SLCA),
- Sediment quality triad approach (SQTA),
- Apparent effects threshold approach (AETA), and
- National status and trends program approach (NSTPA).

Currently, no SQAGs for solid analyses are used for aquatic disposal in the Delta since little, if any, aquatic disposal of sediments currently occurs.

Table 5-3. Comparison of Threshold Effect Level and Probable Effect Level SQAGs for Contaminants in Solids Associated with Aquatic Disposal of Sediments

Contaminant	Threshold Effect Level	Probable Effect Level
Metals (ppm)		
Arsenic	5.9	17
Cadmium	0.0596	3.53
Chromium	37.3	90
Copper	35.7	197
Lead	35	91.3
Mercury	0.174	0.486
Nickel	18	36
Zinc	123	315
Total PCBs (ppb)	34.1	277
Polycyclic aromatic hydrocarbons (ppb)		
Phenanthrene	41.9	515
Benz[a]anthracene	31.7	385
Benz[a]pyrene	31.9	782
Chrysene	57.1	862
Fluoranthene	111	2,355
Pyrene	53	875
Pesticides (ppb)		
Chlordane	4.5	8.9
Dieldrin	2.85	6.67
p,p-DDD	3.54	8.51
p,p-DDE	1.42	6.75
Total DDT	7	4,450
Endrin	2.67	62.4
Heptachlor epoxide	0.6	2.74
Lindane	0.94	1.38

Notes:

PCBs = Polychlorinated biphenyls.
ppb = Parts per billion.
ppm = Parts per million.
SQAGs = Sediment quality assessment guidelines.

All values are expressed as dry weight.

Source: Smith et al. 1996.

Table 5-4. Comparison of SQAGs for Contaminants in Solids (ppm)

Contaminant	ORNL[a]	EPA Eco-SSL[b]	CCME[c]	CVRWQCB[d]	SFBRWQCB[e]	
					Surface[f]	Foundation[g]
Metals and non-metals						
Aluminum	50 Pl[h]					
Antimony	5 Pl	21 Ma[i]				
Arsenic	10 Pl	37 Pl	12		15.3 A[j]	70 M[k]
Barium	500 Pl					
Beryllium	10 Pl					
Bromine	10 Pl					
Cadmium	4 Pl	29 Pl	1.4	21[l]	0.33 A	9.6 M
Chrome III		21 Av[m]				
Total chromium	0.4 Si[n]	5 Pl	64		112 A	370 M
Cobalt	20 Pl	32 Av				
Copper	50 Si	61 Si	63	61[l]	68.1 A	270 M
Lead	50 Pl		70	400	43.2 A	218 M
Mercury	0.1 Si		6.6	0.2[O]	0.43 A	0.7 M
Molybdenum	2 Pl					
Nickel	30 Pl				112 A	120 M
Selenium	1 Pl			0.3[p] 390	0.64 A	
Silver	2 Pl				0.58 A	3.7 M
Thallium	1 Pl					
Vanadium	2 Pl		130			
Zinc	50 Pl	120 Si	200	120[l]	158 A	410 M
Organics						
Acenaphthene	20 Pl				26.0 A	500 M
Acenaphthylene					88.0 A	640 M
Aldrin				0.029		
Anthracene				600[p] 22,000	88.0 A	1,100 M
Benzene			0.05			
Benzo(a)anthracene				0.08[p] 0.62	412 A	1,600 M
Benzo(b)fluoranthene				0.2[p] 0.62	371 A	
Benzo(k)fluoranthene				2[p] 0.61	258 A	
Benzo(g,h,i)perylene					310 A	
Benzo(a)pyrene			0.1	0.4[p] 0.062	371 A	1,600 M
Benzo(e)pyrene					294 A	
Bis(2-ethylhexyl) phthalate					182 T[q]	2,647 P[r]
Chlordane				1.6	2.3 T	4.8 P

Table 5-4. Continued

Contaminant	ORNL[a]	EPA Eco-SSL[b]	CCME[c]	CVRWQCB[d]	SFBRWQCB[e]	
					Surface[f]	Foundation[g]
Organics (continued)						
Chrysene				8[p] 6.1	289 A	2,800 M
4,4-DDD				2.4	1.22 T	7.81 P
4,4-DDE				1.7	2.07 T	27 M
4,4-DDT				1.7	1.19 T	4.77 P
Total DDT (6 isomers)					7.0 A	46.1 M
Dibenzo(a,h)anthracene				0.08[p] 0.62	32.7 A	260 M
2,4-dinitrophenol	20 Pl					
Di-n-butyl phthalate	200 Pl					
Dieldrin		0.011 Av		0.011[s]	0.72 T	4.3 P
Diethylphthalate	100 Pl					
Endosulfan				9[p] 370		
Endrin				5[p] 18		
Ethyl benzene			0.1			
Fluoranthene				200[p] 2,300	514 A	5,100 M
Fluorene				30[p] 2,600	25.3 A	540 M
Heptachlor				0.11		
Heptachlor epoxide				0.052		
Hexachlorobenzene					0.485 A	
Alpha-hexachlorocyclo-hexane				0.09		
Beta-hexachlorocyclo-hexane				0.032		
Gamma-hexachlorocyclo-hexane (lindane)				0.44	0.32 T	0.99 P
Total hexachlorocyclo-hexane					0.78 T	
Hexachlorocyclopentadiene	10 Pl			420		
Indeno(1,2,3-cd)pyrene				0.62	382 A	
Naphthalene			0.1	4[p] 56	55.8 A	2,100 M
Pentachlorophenol (PCP)	3 Pl		7.6			
Phenanthrene					237 A	1,500 M
Phenol	70 Pl		3.8			
PCB 1016				0.39		
PCB 1221				0.22		
PCB 1232				0.22		
PCB 1242				0.22		
PCB 1248				0.22		
PCB 1254				0.22		

Table 5-4. Continued

Contaminant	ORNL[a]	EPA Eco-SSL[b]	CCME[c]	CVRWQCB[d]	SFBRWQCB[e]	
					Surface[f]	Foundation[g]
Organics (continued)						
PCB 1260				0.22		
Total PCBs	40 Pl				22.7 L	180 M
Pyrene				200[p] 2,300	665 A	2,600 M
Styrene	300 Pl					
Tetrachloroethylene			0.1			
Toluene	200 Pl		0.1			
Toxaphene				0.44		
Trichloroethylene			0.1			
2,4,5-trichlorophenol	4 Pl					
Xylene			0.1			
Polycyclic aromatic hydrocarbons					3,390 A	44,792 M

Notes:

CCME = Canadian Council of Ministers of the Environment.
CVRWQCB = Regional Water Quality Control Board, Central Valley Region.
EPA = U.S. Environmental Protection Agency.
FDEP = Department of Environmental Protection for the State of Florida.
ORNL = Oak Ridge National Laboratories.
PCBs = Polychlorinated biphenyls.
ppm = Parts per million.
SFBRWQCB = Regional Water Quality Control Board, San Francisco Bay Region.
SQAGs = Sediment quality assessment guidelines.

All values are expressed as dry weight.

[a] ORNL 1997 benchmark values (Efroymson et al. 1997a and 1997b).
[b] EPA ecological soil screening level (Draft, 2000).
[c] CCME recommended Canadian soil quality guidelines, agricultural land use (1997).
[d] CVRWQCB General Order values (2001) (unless noted otherwise, these are EPA human preliminary remediation goal residential values).
[e] SFBRWQCB dredged sediment screening criteria (Draft, 2000).
[f] Wetlands surface sediment contaminant concentration criteria.
[g] Wetlands foundation sediment/ levee maintenance concentration criteria.
[h] Plant benchmark value (Efroymson et al. 1997a).
[i] EPA ecological soil screening level (mammalian).
[j] Ambient sediment concentration.
[k] Effects range - median (ER-M) (Long et al. 1995).
[l] EPA ecological preliminary remediation goal (soil Invertebrates).
[m] EPA ecological soil screening level (avian).
[n] Soil invertebrate benchmark value (earthworm) (Efroymson et al. 1997b).
[o] CVRWQCB screening value.
[p] EPA human soil screening level (residential).
[q] FDEP 1994 threshold effect level.
[r] FDEP 1994 probable effect level.
[s] EPA ecological preliminary remediation goal (avian).

Source: All references are found in Chapter 7, “References.”

Table 5-5. Comparison of SQAGs for Waterborne Contaminants (ppm)

Contaminant	ORNL[a] (Plant)	ORNL[b] (Mammal)	ORNL[b] (Avian)	CVRWQCB[c]
Metals and non-metals				
Aluminum	0.3	65.31	323.3	
Antimony		4.23		
Arsenic	0.001	4.264	93.3	0.01
Barium		123.8	302.9	0.1
Beryllium	0.5	4.13		
Bromine	10			
Cadmium	0.1	60.32	145.28	0.005
Chrome III		17117	36.32	
Chrome VI		82.17		0.0002
Total chromium	0.05			0.05
Cobalt	0.06	125.2	448.2	
Copper	0.06			0.009
Iron	10			
Lead	0.02	500.3	82.08	0.0025
Lithium	3	117.6		
Manganese	4	1776	7242	
Mercury	0.005	8.13	6.54	0.00005
Molybdenum	0.5	8.80	256.42	
Nickel	0.5	500.3	777.26	0.052
Selenium	0.7	2.064	5.811	0.005
Silver	0.1			
Thallium	0.05	0.468		
Vanadium	0.2	12.192	82.81	
Zinc	0.4	2001.2	951.6	0.1
Organics				
Acenaphthene	0.1			
Aldrin		6.25		<0.000005
Anthracene				9.6
Benzene		892.0		
Benzo(b)fluoranthene				0.0000044
Benzo(k)fluoranthene				0.0000044
Benzo(a)pyrene		33.84		0.0000044
Chlordane		31.1	77.7	<0.0001
2-chlorophenol	60			
Chrysene				0.0000044
Diazinon				0.00005
Dibenzo(a,h)anthracene				0.0000044
2,4-dichlorophenol	20			

Table 5-5. Continued

Contaminant	ORNL[a] (Plant)	ORNL[b] (Mammal)	ORNL[b] (Avian)	CVRWQCB[c]
4,4-DDD		25.02	0.203	<0.00005
Organics (continued)				
4,4-DDE		25.02	0.203	<0.00005
4,4-DDT		25.02	0.203	<0.00001
Total DDT (6 isomers)		25.02	0.203	
Di-n-butyl phthalate		6203.0	7.99	
Dieldrin		1.251	0.559	<0.00001
Diethylphthalate	20	15508.0		
Endosulfan I				<0.00002
Endosulfan II				<0.00001
Endosulfan sulfate				<0.00005
Endosulfan		0.94	72.6	
Endrin		3.113	0.726	<0.00001
Endrin aldehyde				<0.00001
Fluoranthene				0.3
Fluorene				1.3
Heptachlor		8.131		<0.00001
Heptachlor epoxide				<0.00001
Alpha-hexachlorocyclo-hexane				<0.00001
Beta-hexachlorocyclo-hexane		12.51		<0.000005
Gamma-hexachlorocyclo-hexane (lindane)		50.03	145.28	<0.00002
Hexachlorocyclopentadiene	0.1			<0.00001
Indeno(1,2,3-cd)pyrene				0.0000044
Malathion				0.00043
Methoxychlor				<0.0001
Naphthalene	10			0.620
Nitrobenzene	8			
4-nitrophenol	10			
Pentachlorophenol (PCP)	0.03	15.01		
Phenol	10			
PCB 1016		27.89		
PCB 1221				
PCB 1232				
PCB 1242		5.61	2.978	
PCB 1248		1.216		
PCB 1254		2.31	13.8	
PCB 1260				
Total PCBs				0.00000017
Pyrene				0.960
Toluene	10	879.8		

Table 5-5. Continued

Contaminant	ORNL[a] (Plant)	ORNL[b] (Mammal)	ORNL[b] (Avian)	CVRWQCB[c]
Toxaphene		50.0		
Organics (continued)				
Xylene	100	8.798		

Notes:

CVRWQCB = Regional Water Quality Control Board, Central Valley Region.
ORNL = Oak Ridge National Laboratories.
PCBs = Polychlorinated biphenyls.
ppm = Parts per million.
SQAGs = Sediment quality assessment guidelines.

[a] ORNL benchmark values for plants (Efroymson et al. 1997a).
[b] ORNL toxicological benchmarks for wildlife (1996 revision [Sample et al. 1996]).
[c] CVRWQCB General Order values (2001).

CONTAMINANTS IN EFFLUENTS

The Basin Plan contains a variety of water quality standards for contaminants in water that are designed to protect water quality and beneficial uses of water. The results of the MET on the proposed dredged sediment are compared against these standards to judge the potential impacts on water quality in the Delta.

Upland Disposal

CONTAMINANTS IN SOLIDS

A variety of approaches have been devised to formulate SQAGs (i.e., soil screening levels) to assess contaminants in solids in the upland environment. Most approaches have been developed by or for government agencies to perform ecological risk assessments at hazardous waste sites. The purpose of these screening levels is to identify contaminants in the soils that are **not** of potential concern for exposure to terrestrial ecological receptors or humans (EPA 2000a). A reasonable extension of this purpose could be their use in assessing contaminants in dredge sediments for potential upland placement, particularly in association with the creation or enhancement of wildlife habitat.

Several sources are available for deriving soil screening levels (SSLs). The methodology, advantages, and disadvantages of seven major approaches are summarized in Appendix L:

- Canadian Council of Ministers of the Environment (CCME) levels for protection of the environment and humans,
- EPA levels for protection of plants and animals,
- EPA levels (preliminary remediation goals) for protection of humans,
- Oak Ridge National Laboratories (ORNL) levels for protection of the environment,
- Long et al. (1995) levels for the protection of the environment,
- Florida Department of Environmental Protection (FDEP) (1994) levels for the protection of the environment, and
- ambient or background concentrations of contaminants in soils of upland areas.

Although the Long et al. (1995) and the FDEP (1994) values generally apply to aquatic uses of sediments, the values have been used, at least in part, for screening dredge materials for some upland placement.

CONTAMINANTS IN RUNOFF

Exposure of terrestrial plants and animals to contaminants also may occur through exposure to runoff from deposited sediments. For animals, exposure may be through consumption of runoff water; for plants, exposure may be through absorption of runoff through the soil into the roots. ORNL has developed a series of guidelines in water that are protective of terrestrial plants, birds, and mammals. These guidelines were reviewed and compared to the Basin Plan standards (Table 5-4). The results of the DIWET and the WET on the proposed dredge sediments are compared against these standards to judge the potential impacts on water quality in the Delta.

Evaluation Using Guidelines

AQUATIC ENVIRONMENTS

SQAGs could be used to assess the quality and, thus, the usability of sediments in the Delta and to assist in the identification of contaminants of concern. The Corps recommends the use of SQAGs and SSLs for initial screening, to assist in determining whether sediments are contaminated (Corps 1998e). To date, no effects-based SQAGs have been developed that are known to apply directly to conditions in the Delta. There is a need to verify and develop SQAGs to support environmental management decisions in the Delta—particularly for wetland or other aquatic-based projects funded by CALFED.

The eight approaches for the derivation of numerical SQAGs were reviewed, and each has advantages and disadvantages (Appendix J). The current contract among DFG, the Regional Board, and the DPC with CALFED provides limited resources to support the development and implementation of SQAGs. The limitations placed on the current agreement make collection of significant quantities of additional data improbable. Therefore, the assessment of DREDGE was based on numerical SQAGs that are currently available.

Evaluation criteria for assessing the various approaches should include their potential to consider the factors that control the bioavailability of sediment-associated contaminants, to consider cause-and-effect relationships, and to apply all classes of contaminants and contaminant mixtures that are expected to occur in the Delta. These criteria also should be compatible with other interpretive and regulatory tools, such as existing water quality objectives of the Basin Plan. The SQAGs need to address Delta-wide specific associations and co-occurrences among toxicity, contaminants, and biological effects to be generally predictive.

The SQAGs should address the specific needs of agencies that are charged with managing environmental quality in the Delta. The SQAGs should identify the contaminants and sites that are likely to be associated with adverse biological effects. This would help identify the need for further investigations at sites with concentrations of contaminants that exceed the SQAGs. Finally, the SQAGs should contribute to regulatory programs by helping to evaluate source control measures and the need for further biological and chemical testing to support regulatory decisions. Ideally, SQAGs for the Delta would be developed from detailed laboratory-derived dose-response data that describe the acute and chronic toxicity of contaminants from native sediments to sensitive life stages of resident species of aquatic organisms. The results then could be validated in field trials and benthic surveys. However, insufficient data currently are available to support this ideal approach.

Using the NSTPA, a biological effects database for sediments (BEDS) was developed to derive SQAGs for freshwater sediments (Smith et al. 1996). Matching chemical and biological data were compiled and evaluated from numerous studies conducted in freshwater sediments throughout North America. Overall, 56 publications were used in the development of the freshwater BEDS. Two sediment quality assessment values, the threshold effect level (TEL) and the probable effect level (PEL) were derived for each chemical. The TEL was meant to estimate the concentration of a chemical below which adverse biological effects occurred only rarely. The PEL was intended to estimate the concentration of a chemical above which adverse biological effects frequently occurred. In Canada, the TEL typically is recommended as an interim sediment quality guideline. Smith et al. (1996) found a high internal reliability of the TELs for the majority of the chemicals, suggesting that these values are good estimates of sediment-associated chemical concentrations below which adverse biological effects are not expected to occur. Conversely, Smith et al. (1996) found that the PELs may not adequately identify sediment-associated chemical concentrations above which adverse biological effects are expected to occur frequently (i.e., these may be too conservative for use as screening tools). Ideally, data from field validation studies conducted in Delta locations with gradients in the concentrations of contaminants in sediments would provide site-specific information on toxicity of bulk sediments to resident species and effects on benthic community characteristics.

The use of the TEL values of Smith et al. (1996) (Table 5-3) provides a pragmatic means of assessing the sediment data from the Delta, since the data set contains the largest number of SQAGs available. The use of these values also may provide the most robust assessment possible as the data originated from a large number of studies on freshwater sediments. Using the TEL values of Smith et al. (1996) (Table 5-3), sediment quality was assessed from the three areas of the Delta (Tables 5-1 and 5-2) in DREDGE. COCs were identified as having greater than 50% of the samples with detected residues that exceeded the TEL values of Smith et al. (1996). Values from corresponding METs done on the sediments were compared to values in the Basin Plan and Regional Board General Orders (CVRWQCB 2001) to protect water quality. COCs were identified as having greater than 50% of the samples with detected residues that exceeded the current Regional Board regulatory limits.

Upland Environments

SSLs or benchmark values (Appendix K) are intended to be used to identify those contaminants that do not appear to pose a risk for ecological receptors or public health. The Corps recommends the use of SQAGs and SSLs for initial screening, to assist in determining whether sediments are contaminated (Corps 1998e). Unlike many of the SQAGs for aquatic uses that are more dependent on local conditions, these levels are intended to be used generically in sites around the country. For detailed risk analyses at contaminated hazardous waste sites, the SQAGs for upland disposal may need some modification to account for changes in fauna diversity and abundance in various parts of the country.

However, like the SQAGs used in aquatic disposal, these guidelines can be used in an initial assessment to assist in the design of monitoring programs or assess the quality of the sediments for a particular reuse. Screening values have not been developed for all contaminants (see *"Contaminants in* Effluents

The Basin Plan contains a variety of water quality standards for contaminants in water that are designed to protect water quality and beneficial uses of water. The results of the MET on the proposed dredged sediment are compared against these standards to judge the potential impacts on water quality in the Delta.

Upland Disposal*" on page 5-21*). Also, guideline values have been developed for multiple trophic levels (herbivore vs. carnivore) and types (earthworm vs. red-tailed hawk) of ecological receptors (EPA 2000b). Different sources also may identify different ecological receptors and screening concentrations for the same compound. Where either of these situations occurs, it is best to use the lowest value. The lowest value should conservatively protect the greatest number of receptors; it is likely that most environments will support all receptors. For example, there is little value in assessing impacts of sediments on animals but not plants (or vice versa) as both normally will be present.

The Regional Board has maintained contaminant concentration screening values for upland disposal of dredged sediments from the Delta. In the past, these SQAGs were determined on a case-by-case basis when laboratory analyses of sediments were reviewed to determine whether those sediments met the criteria for an "inert waste" as defined in Title 23 Chapter 15 of the CCR. In February 2001, new SQAGs were included as part of the draft General Orders proposed for Corps dredging activities for the Sacramento and the San Joaquin Deep Water Ship Channels (CVRWQCB 2001). The draft General Orders contain a variety of SQAGs, including ambient concentrations, human preliminary remediation goal (PRG) values, and Eco-SSL values (Table 5-4). In addition to the bulk sediment guidelines, the Regional Board has developed a series of regulatory limits for metals from the DIWET and WET (Table 5-5) analyses that generally reflect the Basin Plan objectives. These values are intended to provide protection from specific contaminants in runoff from sediments in an upland setting over time.

The SFBRWQCB (2000) produced a draft staff report on the beneficial reuse of dredged sediments. These sediments are from San Francisco Bay, rather than the Delta, but the values may have merit for consideration as SQAGs. Sediments from San Francisco Bay are divided into two categories for beneficial reuse: (1) suitable for use as surface soils in reestablishing wetlands; and (2) suitable for use as wetland foundation materials, levee maintenance, or daily cover at landfills. The SQAGs are different for both categories (Table 5-4). The guidelines for the wetland surface soils are lower than those for the foundation materials. The two primary sources of contaminant guideline concentrations used by the SFBRWQCB (2000) are Long et al. (1995) and FDEP (1994). The ERL or TEL values from these sources were used as the guideline values for wetland surface materials; the effect range median and PEL values from these sources were used as the guideline values for wetland foundation or levee maintenance. The SFBRWQCB (2000) noted that the ambient concentrations for some contaminants in San Francisco Bay sediments exceed the ERL or TEL values. Where this occurred, the ERL or TEL value was replaced with the ambient concentration for that contaminant (SFBRWQCB 2000). The guideline concentrations identified for the wetlands surface sediments are intended to be protective in an aquatic environment and, therefore, may be applicable for placement of sediments on the top and/or waterside of levees in the Delta. One of the specific uses for sediments meeting the guideline concentrations for wetland foundation materials was levee maintenance (SFBRWQCB 2000). Over 50% of the levee maintenance work performed in the Delta is funded under Chapter 601 of the California Water Code. This legislation dictates that levee maintenance work will not result in a net loss but rather a net gain in wildlife habitat on the levees in the Delta. Most levees in San Francisco Bay do not support significant wildlife habitat. Therefore, guideline values for evaluating sediments for levee maintenance in San Francisco Bay may not be suitable for screening Delta sediments. For example, the guideline values for metals in San Francisco Bay sediments appear to be higher than those recommended for ecological receptors (Efroymson et al. 1997a, 1997b; Sample et al. 1996) (Table 5-4).

The SQAGs values in the Regional Board General Orders (CVRWQCB 2001) (Table 5-4) were used to assess the quality of sediments from the three areas of the Delta (Tables 5-1 and 5-2). COCs were indicated as having greater than 50% of the samples with concentrations above the SQAGs. Data from the DIWET and WET analyses were compared against the Basin Plan objectives as a means of identifying COCs. COCs were identified as having greater than 50% of the samples with concentrations above the Basin Plan objectives.

CHARACTERISTICS AND ASSESSMENT OF DELTA SEDIMENTS

Physical, Chemical, and Toxicological Characteristics

Physical Locations and Characteristics

The sediment data for the Sacramento and San Joaquin Deep Water Ship Channels, Mormon Slough (Stockton Deep Water Port), and Suisun Bay/New York Slough Ship Channels were assigned to the "ship channel" group. The sites in this group receive traffic from ocean-going cargo vessels. These sites typically are dredged and maintained by the Corps. The sediments in this group are primarily sandy, having average percent fines (silt and clay fractions) of 22.15% and a low in organic carbon of 0.1% (Table 5-6). TOC in the sediment samples was measured and reported for 12.9% of the samples. Percent fines were reported for 54.7% of the samples (Table 5-6).

The sediment data for 12 sites were included in the marina group (Table 5-2). These sites provide moorings for small boats and pleasure craft in the Delta. The sediments typically have a high percentage of fines (mean of 64.63%) and are relatively high in organic carbon at 0.77% (Table 5-6). TOC was reported for 5.1% of the samples in the marina group. Percent fines were reported for 28.2% of the samples (Table 5-6).

Table 5-6. Mean (∀ SD) Physical Characteristics, Number [in brackets], and Range (in Parentheses) of Bulk Sediment Samples by Area from the Delta

Sediment Characteristics	Marina	Riverine	Ship Channel
Total organic carbon (%)	0.77 ∀0.056 [2] (0.73-0.81)	0.56∀0.999 [63] (0.0-6.29)	0.1∀0.107 [22] (0.0-0.38)
Fines (% silt and clay)	64.63∀39.30 [11] (12.8-100.0)	37.83∀30.48 [68] (0.0-96.34)	22.15∀29.52 [93] (0.0-98.5)

The sites in the riverine group included all of the other sites with sediment data in the Delta. These sites included canals (i.e., Grantline Canal), actual riverine sites (i.e., Staten Island and instream islands), and water pumps (i.e., irrigation pumps for agricultural purposes). The mean percent fines and organic carbon for these sites were intermediate to that of the marinas and ship channels, with fines at 37.83 % and organic carbon at 0.56 % (Table 5-6). The sediments at these sites typically were not located behind breakwaters like the marinas but were subjected to water currents. This condition could result in less opportunity for fine sediment deposition and accumulation of organic carbon. TOC was reported for 30.7% of the samples, and percent fines were reported for 33.2% of the samples.

Chemical Characteristics

The bulk sediments and WET, DIWET, and MET elutriates were analyzed for approximately 182 different inorganic and organic compounds (Appendices L and M, respectively). The frequency of analysis for specific chemicals varied from 1 (1,1,1 – trichloroethane) to 389 (copper) in bulk sediments.

METALS

Mean concentrations (dry weight) of metals in samples of bulk sediment varied from about 6 to 7 parts per million (ppm) (milligrams per kilogram [mg/kg]) for arsenic, 1 to 2 ppm for cadmium, 41 to 56 ppm for chromium, 38 to 49 ppm for copper, 11 to 16 ppm for lead, 0.3 to 1.2 ppm for mercury, 53 to 68 ppm for nickel, 0.1 to 4.8 ppm for selenium, and 73 to 80 ppm for zinc. Generally, cadmium, lead, and silver were higher for marina sites, and higher levels of mercury and selenium were noted for the riverine sites (Table 5-7).

Mean concentrations (micrograms per liter [ug/l]) of metals in the WET elutriates (Table 5-8) were generally higher than comparable concentrations in the DIWET elutriates (Table 5-9), which were generally higher than comparable concentrations in the MET (Table 5-10). For example, mean concentrations for WET, DIWET, and MET from riverine sediments were 148.6, 12.1, and 11.2 ug/l, respectively, for arsenic; 338.9, 70.9, and 19.2 ug/l, respectively, for chromium; 194.4, 12.3, 66.7 ug/l, respectively, for copper; 226.2, 26.3, 18.0 ug/l, respectively, for lead; and 1,016, 85.1, 74.2 ug/l, respectively, for zinc.

ORGANOMETALS

The highest mean concentrations of monobutyltin, dibutyltin, and tributyltin in bulk sediments were found in marina sites compared to riverine and ship channel sites (Table 5-7). Concentrations at marina sites typically were three to eight times higher than those at riverine sites. There were no detections of organotin compounds in the WET (Table 5-8), and only ship channel sediments were assayed for the tributyltin in the DIWET (Table 5-9) and MET (Table 5-10).

Table 5-7. Mean Concentration, Number of Samples [in Brackets], and Range (in Parentheses) of Contaminants Detected in Bulk Sediment Samples from the Delta

Chemical	Marina	Riverine	Ship Channel	Total All Areas
Metals (ppm)				
Aluminum	11000 [1] (11000)	17781.05 [3] (8500 - 23666.67)	N/A	16085.79 [4] (8500-23666.67)
Antimony	0.601 [4] (0.230-0.770)	0.14 [1] (0.14)	0.418 [45] (0.001-1.8)	0.43 [50] (0.001-1.8)
Arsenic	7.461 [27] (0.913-33.333)	7.058 [156] (0.263-72.0)	6.275 [126] (0.50-36.50)	6.774 [309] (0.263-72.0)
Barium	130.771 [20] (16.200-292.683)	84.13 [15] (34-120)	164.73 [76] (0.001-570.00)	147.719 [111] (0.001-570.00)
Beryllium	0.353 [12] (0.200-.620)	0.246 [24] (0.110-0.432)	0.174 [5] (0.10-0.28)	0.2685 [41] (0.10-0.620)
Cadmium	2.115 [12] (0.067-4.242)	0.972 [59] (0.050-7.070)	1.833 [19] (0.10-10.22)	1.306 [90] (0.050-10.22)
Chromium	39.189 [29] (6.600-98.000)	41.292 [211] (1.070-119.60)	56.495 [27] (0.50-88.00)	42.601 [267] (0.50-119.60)
Cobalt	7.472 [12] (1.720-15.094)	11.493 [15] (4.40-18.0)	13.83 [6] (11.00-16.00)	10.456 [33] (1.720-18.0)
Copper	49.793 [39] (5.550-296.970)	38.171 [210] (1.20-91.160)	40.06 [136] (0.50-438.00)	40.0156 [385] (0.50-438.0)
Iron	13633.333 [6] (12700-14500)	0 [0]	0 [0]	13633.333 [6] (12700-14500)
Lead	16.438 [28] (0.786-51.515)	10.728 [176] (0.990-29.80)	10.69 [127] (0.50-71.40)	11.1964 [331] (0.50-71.40)
Mercury	0.331 [29] (0.039-3.636)	1.228 [111] (0.020-37.00)	0.271 [111] (0.01-9.35)	0.7011 [251] (0.01-37.00)
Molybdenum	0.323 [8] (0.115-0.740)	7.533 [4] (0.330-12.0)	0 [0]	[12] (0.115-12.0)
Nickel	53.322 [34] (8.130-106.897)	44.458 [210] (0.161-111.690)	68.38 [34] (10.20-190.00)	48.4678 [278] (0.161-190.00)
Selenium	0.524 [8] (0.050-1.763)	4.773 [27] (0.426-21.00)	0.106 [10] (0.04-0.2)	2.9805 [45] (0.04-21.00)
Silver	2.030 [12] (0.120-4.828)	0.925 [55] (0.067-2.82)	0.586 [13] (0.05-1.88)	1.03566 [80] (0.05-4.828)
Sodium	678.33 [6] (468 - 860)	N/A	N/A	678.33 [6] (468-860)
Thallium	24.864 [2] (0.100-49.628)	3.878 [20] (0.05-7.60)	0.262 [84] (0.052-0.67)	1.4085 [106] (0.05-49)
Vanadium	46.295 [18] (0.100-99.406)	35.933 [15] (12.00-58.00)	101.67 [6] (89-120)	50.8288 [39] (0.100-120)
Zinc	73.322 [37] (0.100-244.828)	73.174 [206] (3.85-200.00)	79.51 [127] (0.50-250.00)	75.3636 [370] (0.100-250.00)
Non-metals (ppm)				
Chloride	N/A	230 [1] (230)	N/A	230 [1] (230)

Table 5-7. Continued

Chemical	Marina	Riverine	Ship Channel	Total All Areas
Organometals (ppt)				
Dibutyltin	85.121 [8] (2.900-269.697)	10.894 [10] (0.64-67.60)	0 [0]	43.8837 [18] (0.64-269.697)
Monobutyltin	8.188 [7] (1.200-15.152)	1.56 [2] (0.82-2.30)	0 [0]	6.7151 [9] (0.82-15.152)
Tributyltin	100.454 [28] (2.00-586.207)	35.633 [12] (2.40-317.00)	5.33 [3] (1.00-10.00)	75.7278 [43] (1.00-586.207)
Tetrabutyltin	17.241 [1] (17.241)	N/A	N/A	17.241 [1] (17.241)
Ketones (ppb)				
Acetone	N/A	70 [1] (70)	N/A	70 [1] (70)
Polycyclic aromatic hydrocarbons (ppb)				
Anthracene	26 [1] (26)	10 [1] (10)	3.9 [1] (3.9)	13.3 [3] (3.9-26)
Benzo(A)anthracene	140.000 [1] (140.00)	50.00 [1] (50.00)	9.00 [3] (6.80-13.00)	43.4 [5] (6.80-140.00)
Benzo(A,H)anthracene	N/A	N/A	3.9 [1] (3.9)	3.9 [1] (3.9)
Benzo(A)pyrene	140.000 [1] (140.00)	50.00 [1] (50.00)	10.40 [2] (9.80-11.00)	52.70 [4] (9.80-140.00)
Benzo(E)pyrene	N/A	N/A	7.05 [2] (1 - 11)	7.05 [2] (1-11)
Benzo(B)fluoranthene	160 [1] (160)	100 [1] (100)	9.6 [4] (4.4 - 14)	49.733 [6] (4.4-160)
Benzo(G,H,I)perylene	51 [1] (51)	30 [1] (30)	12 [1] (12)	31 [3] (12-51)
Benzo(K)fluoranthene	120 [1] (120)	N/A	8.43 [4] (4.2 - 12)	30.744 [5] (4.2-120)
Chrysene	150.000 [1] (150.00)	70.00 [1] (70.00)	19.00 [1] (19.00)	79.667 [3] (19-150.0)
Fluoranthene	160.000 [1] (160.00)	155.125 [4] (67.70-359.00)	15.175 [4] (6.70-22.00)	93.4667 [9] (6.70-359)
Indeno(1,2,3-CD)pyrene	58 [1] (58)	20 [1] (20)	8.07 [3] (4.1 - 11)	20.442 [5] (4.1-58)
Phenanthrene	60.5 [2] (21 -100)	30 [1] (30)	6.58 [4] (2.9 - 11)	25.3314 [7] (2.9-100)
Pyrene	71.333 [3] (21.000-160.000)	110.00 [1] (110.00)	18.00 [4] (6.00-26.00)	37.875 [8] (6.00-160.00)
Polychlorinated biphenyls (ppb)				
Aroclor 1016	0 [0]	0 [0]	0 [0]	0 [0]
Aroclor 1221	0 [0]	0 [0]	0 [0]	0 [0]
Aroclor 1232	0 [0]	60.00 [1] (60.00)	0 [0]	60.00 [1] (60.00)
Aroclor 1242	0 [0]	0 [0]	0 [0]	0 [0]
Aroclor 1248	276.968 [1] (276.968)	0 [0]	0 [0]	276.968 [1] (276.968)
Aroclor 1254	0 [0]	0 [0]	0 [0]	0 [0]
Aroclor 1260	0 [0]	0 [0]	0 [0]	0 [0]

Table 5-7. Continued

Chemical	Marina	Riverine	Ship Channel	Total All Areas
Pesticides (ppb)				
4,4-DDD	3.000 [1] (3.00)	4.180 [3] (3.00-6.00)	0 [0]	3.885 [4] (3.00-6.00)
4,4-DDE	2.8 [1] (2.800)	9.024 [5] (3.00-21.00)	4.199 [2] (3.81-4.586)	7.03975 [8] (2.80-21.00)
4,4-DDT	0 [0]	9.00 [2] (3.00-15.00)	0 [0]	9.00 [2] (3.00-15.00)
Acenaphthylene	N/A	6 [1] (6)	N/A	6 [1] (6)
Aldrin	0 [0]	0 [0]	0 [0]	0 [0]
Chlordane	0 [0]	0 [0]	0 [0]	0 [0]
Dieldrin	0 [0]	0 [0]	0 [0]	0 [0]
Endosulfan I	0 [0]	0 [0]	0 [0]	0 [0]
Endosulfan II	0 [0]	0 [0]	0 [0]	0 [0]
Endosulfan Sulfate	0 [0]	0 [0]	0 [0]	0 [0]
Endrin	0 [0]	0 [0]	0 [0]	0 [0]
Lindane	0 [0]	0 [0]	0 [0]	0 [0]
Methoxychlor	0 [0]	0 [0]	0 [0]	0 [0]
Toxaphene	0 [0]	0 [0]	0 [0]	0 [0]
Petroleum hydrocarbons (ppm)				
Diesel	0 [0]	2.27 [4] (1.429-3.03)	0 [0]	2.27 [4] (1.429-3.03)
Gasoline	0 [0]	0 [0]	0 [0]	0 [0]
Kerosene	2.9 [1] (2.9)	N/A	N/A	2.9 [1] (2.9)
Oil and grease	217.507 [10] (35.516-754.712)	170.126 [42] (0.13-1196.97)	20.00 [1] (20.00)	176.2332 [53] (0.13-1196.97)
Phthalates (ppb)				
Di-N-butylphthalate	N/A	109.5 [2] (12 - 207)	15.20 [5] (12 - 18)	42.1428 [7] (12-207)
Bis(2-ethylhexyl)phthalate	N/A	4100 [1] (4100)	15.67 [6] (11 - 29)	599.1457 [7] (11-4100)
Di-N-octylphthalate	N/A	12 [1] (12)	N/A	12 [1] (12)
Diethylphthalate	N/A	N/A	39.33 [6] (12 - 89)	3933 [6] (12-89)

Notes:

ppb = Parts per billion.
ppm = Parts per million.
ppt = Parts per trillion.

Table 5-8. Mean Concentration (ug/l), Number of Samples [in Brackets], and Range (in Parentheses) of Contaminants Detected in WETs from Sediments Collected in the Delta

Chemical	Marina	Riverine	Ship Channel	Total All Areas
Metals				
Antimony	95.667 [9]	N/A	8.333 [3]	73.8335 [12]
	(9.0-284.0)		(2.0-13.0)	(2.0-284.0)
Arsenic	251.625 [8]	148.631 [122]	261.315 [11]	163.2656 [141]
	(140.0-298.0)	(13.0-410.0)	(0.10-1500.0)	(0.10-)1500.0)
Barium	3433.333 [3]	N/A	1335.875 [8]	1907.909 [11]
	(2400.0-4800.0)		(17.0-2000.0)	(17.0-4800.0)
Beryllium	21.438 [8]	N/A	N/A	21.438 [8]
	(7.0-53.0)			(7.0-53.0)
Cadmium	7.286 [7]	9.0 [10]	3.70 [1]	8.039 [18]
	(3.0-15.0)	(1.0–18.0)	(3.70)	(1.0-18.0)
Chromium	238.2 [10]	338.867 [113]	48.457 [6]	317.5559 [129]
	(110.0-371.0)	(42.0-759.0)	(0.170-160.0)	(0.170-759.0)
Cobalt	N/A	N/A	265.0 [2]	265.0 [2]
			(260.0-270.0)	(260.0-270.0)
Copper	127.364 [11]	194.434 [76]	109.032 [11]	117.3198 [98]
	(15.0-350.0)	(11.0-700.0)	(0.110-210.0)	(0.110-700.0)
Lead	472.714 [7]	226.220 [116]	99.276 [10]	229.6487 [133]
	(185.0-1170.0)	(0.50-1800.0)	(0.10-230.0)	(0.10-1800)
Mercury	11.05 [2]	1.788 [17]	0.651 [7]	2.1943 [26]
	(9.1-13.0)	(0.10-10.0)	(0.018-1.50)	(0.018-13.0)
Molybdenum	163.0 [2]	N/A	5.650 [2]	84.325 [4]
	(116.0-210.0)		(4.10-7.20)	(4.10-210.0)
Nickel	799.900 [10]	590.510 [143]	170.506 [7]	585.2217 [160]
	(180.0-1120.0)	(30.0-12050.0)	(0.370-640.0)	(0.370-12050.0)
Selenium	6.571 [7]	17.50 [2]	N/A	8.9997 [9]
	(5.0-8.0)	(10.0-25.0)		(5.0-25.0)
Silver	154.0 [9]	12.667 [3]	1.50 [2]	101.9286 [14]
	(2.0-1340.0)	(1.0-25.0)	(1.30-1.70)	(1.0-1340.0)
Thallium	0.5 [1]	15.0 [2]	N/A	10.3333 [3]
	(0.5)	(15.0)		(0.5-15.0)
Vanadium	238.833 [3]	N/A	385.0 [2]	297.2998 [5]
	(5.50-700.0)		(350.0-420.0)	(5.50-700.0)
Zinc	874.333 [12]	1016 [138]	314.511 [12]	953.544 [162]
	(32.0-1990.0)	(16.0-16000.0)	(0.420-1200.0)	(0.420-16000.0)
Non-metals				
Chlorine	N/A	12000.0 [7]	N/A	12000.0 [7]
		(1000.0-15000.0)		(1000.0-15000.0)

Notes:

N/A = No analysis.
ug/l = Micrograms per liter; equivalent to parts per billion.
WET = Waste extraction test.

Table 5-9. Mean Concentration (ug/l), Number of Samples [in Brackets], and Range (in Parentheses) of Contaminants Detected in DIWETs from Sediments Collected in the Delta

Chemical	Marina	Riverine	Ship Channel	Total All Areas
Metals				
Aluminum	21.50 [2] (10.0-33.0)	4950.0 [2] (4700.0-5200.0)	N/A	2485.75 [4] (10.0-5200.0)
Antimony	4.82 [11] (0.3-12.0)	0.60 [1] (0.60)	2.371 [14] (1.0-5.0)	3.339 [26] (0.3-12.0)
Arsenic	18.31 [18] (1.0-130.0)	12.105 [57] (1.0-80.0)	4.50 [74] (0.940-42.0)	9.0776 [149] (0.940-130.0)
Barium	89.85 [23] (2.0-820.0)	77.100 [7] (19.60-240.0)	5865.92 [18] (73.0-100000.0)	2254.0158 [48] (2.0-100000.0)
Cadmium	10.025 [2] (0.05-20.0)	N/A	1.50 [2] (1.0-2.0)	5.7625 [4] (0.05-20.0)
Chromium	3.14 [16] (1.0-12.0)	70.941 [34] (1.0-300.0)	10.80 [10] (0.180-25.0)	42.83723 [60] (0.180-300.0)
Cobalt	1.350 [2] (0.20-2.50)	0.667 [3] (0.40-0.80)	N/A	0.9402 [5] (0.20-2.50)
Copper	15.72 [23] (2.0-79.0)	12.333 [66] (1.0-110.0)	33.02 [10] (1.20-140.0)	15.20747 [99] (1.0-140.0)
Iron	297.167 [9] (2.50-900.0)	N/A	N/A	297.167 [9] (2.50-900.0)
Lead	65.940 [10] (0.30-520.0)	26.341 [37] (0.90-77.0)	37.40 [5] (3.0-120.0)	35.01955 [52] (0.30-520.0)
Lithium	7.80 [5] (5.0-14.0)	N/A	N/A	7.80 [5] (5.0-14.0)
Magnesium	19.0 [1] (19.0)	N/A	N/A	19.0 [1] (19.0)
Manganese	326.0 [4] (12.0-597.0)	N/A	N/A	326.0 [4] (12.0-597.0)
Mercury	0.810 [1] (0.810)	0.460 [10] (0.30-1.0)	0.249 [9] (0.015-0.820)	0.38255 [20] (0.015-1.0)
Molybdenum	6.436 [11] (0.90-22.0)	3.0 [3] (1.0-6.0)	N/A	5.6997 [14] (0.90-22.0)
Nickel	2.74 [19] (1.0-9.0)	7.909 [33] (1.0-30.0)	149.60 [7] (1.0-910.0)	23.0552 [59] (1.0-910.0)
Selenium	2.025 [4] (1.0-4.0)	72.70 [10] (1.0-523.0)	N/A	52.50714 [14] (1.0-523.0)
Strontium	168.571 [7] (31.0-254.0)	N/A	N/A	168.571 [7] (31.0-254.0)
Sodium	39175.0 [4] (26100.0-58300.0)	N/A	N/A	39175.0 [4] (26100.0-58300.0)
Thallium	0.50 [1] (0.50)	N/A	0.535 [2] (0.070-1.0)	0.52333 [3] (0.070-1.0)
Vanadium	80.325 [4] (5.30-290.0)	N/A	8.90 [3] (6.70-11.0)	49.71428 [7] (5.30-290.0)
Zinc	9.27 [16] (2.20-23.0)	85.090 [58] (1.20-400.0)	128.67 [19] (1.10-500.0)	80.94913 [93] (1.10-500.0)

Table 5-9. Continued

Chemical	Marina	Riverine	Ship Channel	Total All Areas
Organometals				
Tributyltin	N/A	N/A	0.019 [2] (0.011-0.027)	0.019 [2] (0.011-0.027)
Non-metals				
Bromine	N/A	333.333 [9] (300.0-400.0)	N/A	333.333 [9] (300.0-400.0)
Chlorine	N/A	1666.667 [9] (1000.0-2000.0)	N/A	1666.667 [9] (1000.0-2000.0)
Fluoride	N/A	N/A	133.33 [2] (70-170)	133.33 [2] (70-170)

Notes:

DIWET = Deionized water waste extraction test.
N/A = No analysis.
ug/l = Micrograms per liter; equivalent to parts per billion.

Table 5-10. Mean Concentration (ug/l), Number of Samples [in Brackets], and Range (in Parentheses) of Contaminants Detected in METs from Sediments Collected in the Delta

Chemical	Marina	Riverine	Ship Channel	Total All Areas
Metals				
Aluminum	N/A	27.50 [3] (19.0-42.0)	N/A	27.50 [3] (19.0-42.0)
Arsenic	25.286 [7] (18.0-37.0)	11.214 [7] (1.50-20.0)	8.50 [25] (1.20-55.0)	12.0 [39] (1.2-55.0)
Barium	N/A	N/A	235.56 [16] (20.0-1200.0)	235.56 [16] (20.0-1200.0)
Beryllium	7.143 [7] (5.0-8.0)	N/A	N/A	7.143 [7] (5.0-8.0)
Cadmium	3.714 [7] (2.0-5.0)	1.667 [3] (1.0-3.0)	0.767 [14] (0.050-2.0)	1.74 [24] (0.050-5.0)
Chromium	242.571 [7] (210.0-302.0)	19.178 [9] (2.60-41.0)	N/A	116.91 [16] (2.60-302.0)
Cobalt	N/A	N/A	9.10 [1] (9.1)	9.10 [1] (9.1)
Copper	285.714 [7] (193.000-441.000)	66.70 [10] (20.0-100.0)	17.56 [42] (1.20-130.0)	57.70 [59] (1.2-441.0)
Lead	244.857 [7] (108.0-448.0)	18.0 [3] (12.0-24.0)	8.15 [32] (1.0-68.0)	48.30 [42] (1.0-448.0)
Mercury	[1] (1.0)	N/A	0.687 [27] (0.010-4.0)	0.70 [28] (0.01-4.0)
Nickel	352.143 [7] (306.0-411.0)	36.0 [1] (36.0)	34.650 [18] (5.0-300.0)	120.18 [26] (5.0-411.0)
Selenium	1.20 [5] (1.0-2.0)	N/A	24.0 [2] (24.0)	7.71 [7] (1.0-24.0)
Silver	2.0 [7] (1.0-3.0)	N/A	[1] (1.0)	1.88 [8] (1.0-3.0)
Thallium	1.40 [5] (1.0-2.0)	N/A	N/A	1.40 [5] (1.0-2.0)
Zinc	919.50 [6] (673.0-1390.0)	74.20 [10] (48.0-93.0)	55.78 [41] (2.0-540.0)	149.93 [57] (2.0-1390.0)
Organometals				
Tributyltin	N/A	N/A	7300 [3] (210.0-1400)	7300 [3] (210.0-1400)
Polychlorinated biphenyls				
Aroclor 1260	N/A	N/A	0.001 [1] (0.001)	0.001 [1] (0.001)
Pesticides				
2,4-Dichlorophenoxyacetic acid	N/A	N/A	3.725 [4] (0.60-12.0)	3.725 [4] (0.60-12.0)
4,4-DDT	N/A	N/A	7.147 [3] (0.240-14.0)	7.147 [3] (0.240-14.0)
Alpha hexachlorocychlohexane	N/A	N/A	0.025 [3] (0.010-0.050)	0.025 [3] (0.010-0.050)
Atrazine	N/A	N/A	4.773 [3] (0.40-13.50)	4.773 [3] (0.40-13.50)

Table 5-10. Continued

Chemical	Marina	Riverine	Ship Channel	Total All Areas
Pesticides (continued)				
Beta hexachlorocychlohexane	N/A	N/A	0.285 [2] (0.030-0.540)	0.285 [2] (0.030-0.540)
Carbaryl	N/A	N/A	6.250 [2] (4.20-8.30)	6.250 [2] (4.20-8.30)
Heptachlor	N/A	N/A	0.258 [6] (0.040-0.530)	0.258 [6] (0.040-0.530)
Lindane	N/A	N/A	0.075 [6] (0.005-0.320)	0.075 [6] (0.005-0.320)
Malathion	N/A	N/A	2.393 [3] (0.080-4.30)	2.393 [3] (0.080-4.30)
Phenols				
2,4,5-TP	N/A	N/A	0.607 [4] (0.050-1.80)	0.607 [4] (0.050-1.80)
Petroleum hydrocarbons				
Oil and grease	N/A	378.571 [7] (160.0-690.0)	N/A	378.571 [7] (160.0-690.0)
Total dioxins	N/A	N/A	0.002 [3] (.001-.005)	0.002 [3] (.001-.005)
Methylene chloride	N/A	N/A	3.33 [8] (1.5-1.7)	3.33 [8] (1.5-1.7)
Bis (2-ethylhexyl) phthalate	N/A	N/A	1.5 [2] (1.5)	1.5 [2] (1.5)

Notes:

MET = Modified elutriate test.
N/A = No analysis.
ug/l = Micrograms per liter; equivalent to parts per billion.

POLYCYCLIC AROMATIC HYDROCARBONS, POLYCHLORINATED BIPHENYLS, AND PESTICIDES

Generally, insufficient data were available (few samples with concentrations above detection limits) to determine the distribution of many of these compounds in bulk sediment samples from the Delta. Many of these compounds were detected only occasionally in bulk sediment samples (one to five times), if at all (Table 5-7). No PAH compounds were detected in the MET (Table 5-10). There was one detection of PCBs (0.001 ug/l) and several detections of pesticides (from 0.02 to 7.1 ug/l) in MET from sediments in the ship channel sites (Table 5-10). These compounds were not analyzed in WET (Table 5-8) or DIWET (Table 5-9).

PETROLEUM HYDROCARBONS

Concentrations of oil and grease were slightly higher in the samples of bulk sediments from marinas, with a mean concentration of 218 ppm compared to the riverine areas with a mean concentration of 170 ppm (Table 5-7). This difference may be due to increased boating activity in marina areas. Oil and grease also were identified in the MET for riverine areas (Table 5-10). Typically, these compounds were not analyzed in WET (Table 5-8) or DIWET (Table 5-9).

Toxicological Characteristics

Two studies determined bulk sediment and sediment elutriate toxicity for the Delta. One study involved the proposed Harbor Marina on Andrus Island (Site 0004) and the other study was a general survey by the Regional Board (Site 0036).

The elutriates derived from sediment samples that were collected from the site of the proposed dredging for Harbor Marina and the proposed aquatic deposition site indicated significant toxicity to *Ceriodaphnia dubia* in both the acute (48-hour) and chronic (7-day) toxicity tests. The 7-day chronic test did not meet control reproductive criteria to be considered a valid test. Chronic (7-day) toxicity tests using the fathead minnow (*Pimephales promelas)* also indicated significant toxicity of the elutriates. Other toxicity tests with *Pimephales promelas* acute (48-hour) and *Selenastrum capricornutum* chronic (96-hour) did not indicate toxicity. Toxicity tests were not performed on the bulk sediments.

In 1997, the Moss Landing Marine Laboratory (MLML) collected sediment samples from 18 sites throughout the Delta as part of a Delta sediment characterization project (MLML unpubl. data). *Ceriodaphnia dubia* and *Hyalella azteca* were used in toxicity tests on the bulk sediments from all of the sites. All toxicity tests met acceptable control criteria and did not exhibit any significant toxicity. Unfortunately, chemical analyses of the bulk sediment samples were not available for comparison with toxicity data (Fairey pers. comm.).

COCS AND COPCS IN DELTA SEDIMENTS

The analytical results for any contaminant can be segregated into two categories, (1) those with results above the detection limit (positive analyses), and (2) those with results below the detection limit (negative analyses). The results can be segregated further by assessing their relationship to the SQAG (solid-borne) or the discharge limitation (liquid-borne).

A COC was identified when greater than 50% of the positive analyses exceeded the SQAG or discharge limitation in the Regional Board General Orders (CVRWQCB 2001). Separate analyses were conducted for aquatic and upland disposal.

When a contaminant was not detected but the limit of detection was greater than the SQAG or the discharge limitation, an assessment of the contaminant could not be performed. In these situations, the contaminant may be of potential concern. A contaminant was identified as a COPC if the sum of (1) the number of positive analyses with concentrations exceeding the SQAG and (2) the number of negative analyses where the detection limit exceeded the SQAG was greater than 50% of the total number of analyses. Separate analyses were conducted for aquatic and upland disposal.

Aquatic Disposal

Assessments were performed using the results of chemical analyses from bulk sediments and MET. The bulk sediment analyses were compared against the solid-borne SQAG values (TELs) developed by Smith et al. (1996) (Table 5-3). The MET analyses were compared against the water-borne discharge limitations in the Regional Board General Orders (CVRWQCB 2001) (Table 5-3).

Metals

SOLIDS

When comparing bulk sediment analyses with the SQAG values for aquatic disposal, cadmium, chromium, mercury, and nickel were identified as COCs (Table 5-11). Nickel exceeded the guideline of 18 ppm in 97%, 87%, and 91% of the sediment material from ship channel, riverine, and marina sites, respectively. Chromium exceeded the guideline of 37.3 ppm in 56% and 81% of the sediment material from riverine and ship channel sites, respectively. Overall, cadmium, nickel, and chromium concentrations exceeded the SQAGs 97%, 85%, and 51% of the time (Table 5-12 and Figures 5-3 and 5-4). In 68% of the bulk sediment samples, cadmium concentrations were below the detection limits. However, the detection limits exceeded the SQAG in 97% of the negative analyses (Table 5-13). For solids, no metal was identified as a COPC that was not also identified as a COC (Table 5-12 and Figures 5-3 and 5-4).

Table 5-11. Number of Bulk Sediment Samples with Concentrations above Detection Limits and Percentage of Those Samples That Exceeded the SQAGs for Aquatic Disposal

	Marina		Riverine		Ship Channel	
Contaminant	**N**	**>SQAGs (%)**	**N**	**>SQAGs (%)**	**N**	**>SQAGs (%)**
Metals (ppm)						
Arsenic	27	37.04	156	49.36	126	1
Cadmium	12	100.0	59.0	94.92	19	100
Chromium	29	45.0	211	49.76	27	81.48
Copper	39	46.15	210	45.71	136	37.50
Lead	28	3.57	176	0	127	3.15
Mercury	29	51.72	111	69.37	111	20.75
Nickel	34	91.18	210	81.43	34	97.06
Zinc	37	18.92	206	19.42	127	15.75
Total PCBs (ppb)	1	100.0	1	100.0	0	0
Polycyclic aromatic hydrocarbons (ppb)						
Phenanthrene	2	50.0	1	0	4	0
Benzo(a)anthracene	1	100.0	1	100.0	3	0
Benzo(a)pyrene	1	100.0	1	100.0	2	0
Chrysene	1	100.0	1	100.0	1	0
Fluoranthene	1	100.0	4	50.0	4	0
Pyrene	3	33.3	1	100	4	0
Pesticides (ppb)						
Chlordane	0	0	0	0.0	0	0
Dieldrin	0	0	0	0	0	0
Pp-DDD	1	0	3	66.67	0	0
Pp-DDE	1	100.0	5	100	2	100.0
Total DDT	0	0	5	80.0	2	0
Endrin	0	0	0	0	0	0
Heptachlor epoxide	0	0	0	0	0	0
Lindane	0	0	0	0	0	0

Notes:

N = Number of samples.
PCBs = Polychlorinated biphenyls.
ppb = Parts per billion.
ppm = Parts per million.
SQAGs = Sediment quality assessment guidelines.

The State Water Resources Control Board is developing criteria for aquatic disposal. The SQAGs in this table are based on Smith et al. 1996.

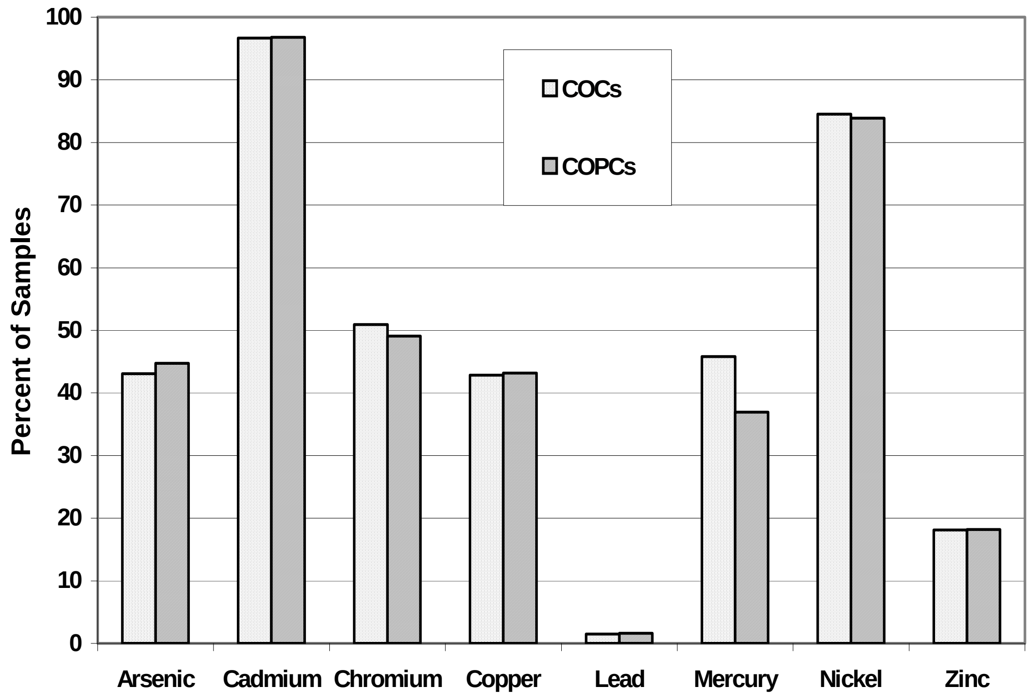
Table 5-12. COCs and COPCs for Aquatic Disposal of Sediments (Bulk Sediments)

Contaminant	COCs	COPCs	N for COCs	N for COPCs
Metals				
Arsenic	43.04	44.7	133	166
Cadmium	96.67	96.8	87	276
Chromium	50.94	49.1	136	137
Copper	42.86	43.2	165	169
Lead	1.51	1.6	5	6
Mercury	45.82	36.9	115	129
Nickel	84.53	83.9	235	239
Zinc	18.11	18.2	67	68
Organics				
Total PCBs	100	97.4	2	232
Benzo(A)pyrene	50	3.4	2	4
Chrysene	66.67	2.5	2	3
Chlordane	0	99.5	0	194
Dieldrin	0	73.7	0	165
pp-DDD	50	60.9	2	134
pp-DDE	100	97.7	8	212
Total DDT	57.14	31.9	4	70
Endrin	0	81.9	0	186
Heptachlor epoxide	0	99.6	0	227
Lindane	0	99.6	0	227

Notes:

COC = Contaminant of concern.
COPC = Contaminant of potential concern.
N = Number of samples.
PCBs = Polychlorinated biphenyls.

Figure 5-3. Aquatic Disposal Metal COCs and COPCs for Bulk Delta Sediments

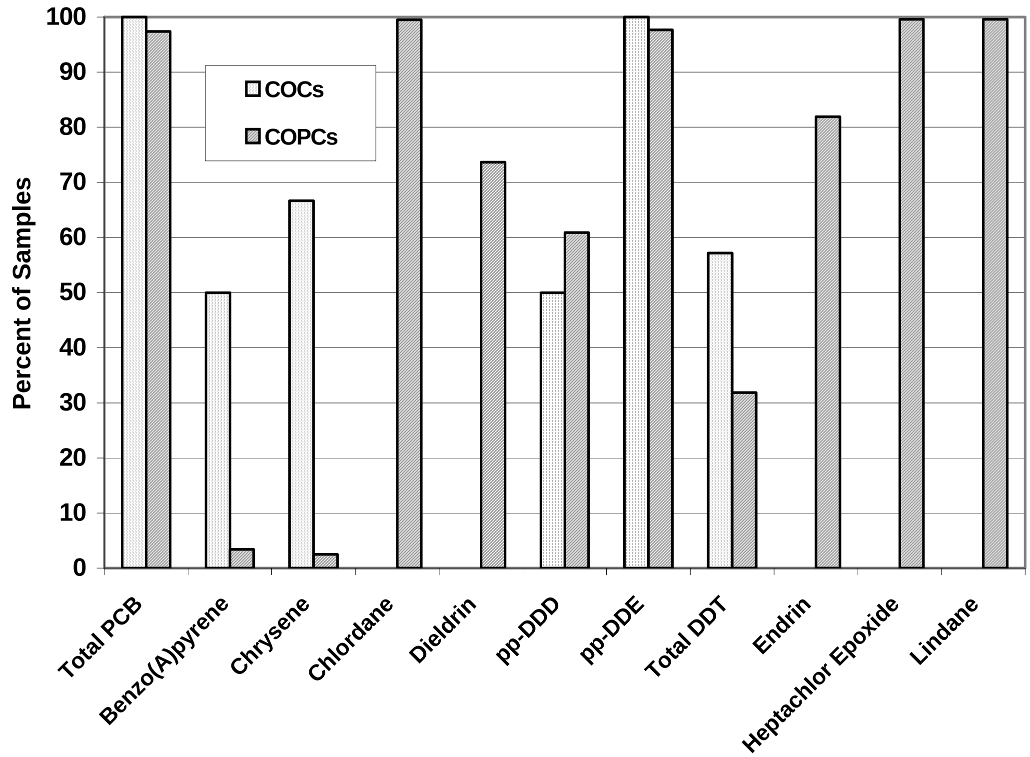


Notes:

COC = Contaminant of concern.
COPC = Contaminant of potential concern.

Source: Smith et al. 1996.

Figure 5-4. Aquatic Disposal Organic COCs and COPCs for Bulk Delta Sediments



Notes:

COC = Contaminant of concern.
COPC = Contaminant of potential concern.

Source: Smith et al. 1996.

Table 5-13. Number of Bulk Sediment Samples with Concentrations below Detection Limits and Percentage of Those Samples with Detection Limits That Exceeded the SQAGs for Aquatic Disposal

	Marina		Riverine		Ship Channel	
Contaminant	**N**	**DL>SQAGs (%)**	**N**	**DL>SQAGs (%)**	**N**	**DL>SQAGs (%)**
Metals (ppm)						
Arsenic	3	0	59	56	1	0
Cadmium	26	77	154	100	15	100
Chromium	3	0	2	50	7	0
Copper	0	0	6	67	0	0
Lead	3	0	40	2.5	0	0
Mercury	2	0	81	16	16	6.3
Nickel	4	25	3	100	0	0
Zinc	1	0	4	25	0	0
Total PCBs (ppb)	31	88	174	100	31	94
Polycyclic aromatic hydrocarbons (ppb)						
Phenanthrene	7	14	84	1.2	20	0
Benzo(a)anthracene	8	25	84	1.2	21	0
Benzo(a)pyrene	8	13	84	1.2	22	0
Chrysene	8	13	84	0	23	0
Fluoranthene	8	13	65	9.2	20	0
Pyrene	6	33	84	7.1	20	0
Pesticides (ppb)						
Chlordane	23	100	169	100	3	67
Dieldrin	31	87	166	83	27	15
Pp-DDD	30	90	163	60	27	30
Pp-DDE	30	100	162	99	25	52
Total DDT	31	83	162	20	27	30
Endrin	31	87	169	90	27	26
Heptachlor epoxide	31	100	170	99	27	100
Lindane	31	100	170	99	27	100

Notes:

DL = Detection limit.
N = Number of samples.
PCBs = Polychlorinated biphenyls.
ppb = Parts per billion.
ppm = Parts per million.
SQAGs = Sediment quality assessment guidelines.

The State Water Resources Control Board is developing criteria for aquatic disposal. The SQAGs in this table are based on Smith et al. 1996.

ELUTRIATES

When comparing the MET analyses with the Regional Board General Orders (CVRWQCB 2001), barium, copper, lead, and mercury were identified as COCs (Table 5-14). Overall, barium, copper, lead, and mercury concentrations exceeded the discharge limitations 75%, 57.6%, 78.6%, and 60.7% of the time, respectively. For elutriates, hexavalent chromium was the only COPC that was not also identified as a COC (Tables 5-15 and 16 and Figures 5-5 and 5-6); 100% of the samples were reported with concentrations below detection limits.

Organic Compounds

SOLIDS

When comparing bulk sediment sample analyses with the SQAGs , total PCBs (benzo[a]pyrene and chrysene) as well as the pesticides (pp-DDD, pp-DDE and total DDT) were identified as COCs (Table 5-11); however, only eight samples or less typically were involved for each contaminant (Table 5-12 and Figures 5-3 and 5-4). The chlorinated pesticides (chlordane, dieldrin, endrin, heptachlor epoxide, pp-DDD, pp-DDE, and lindane) were identified as COPCs due to the large percentage and number (in some cases, in excess of 200) of negative samples with detection limits exceeding the SQAGs (Tables 5-11 and 5-12, and Figures 5-3 and 5-4).

ELUTRIATES

None of the MET samples from marina sites were analyzed for organic compounds, including organotin compounds. Total PCBs and the pesticides alpha-BHC, beta BHC, pp-DDT, heptachlor, lindane and malathion were determined to be COCs (Table 5-14); however, only six samples or less typically were involved for each contaminant (Table 5-16 and Figures 5-5 and 5-6). Several PAHs, including (benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[a]pyrene, chrysene, dibenzo-[a,h]anthracene, and indeno[1,2,3-cd]pyrene); and the pesticides aldrin, hexachlorocyclopentadiene and methoxychlor were identified as COPCs (Table 5-15).

Upland Disposal

Assessments were performed using the results of chemical analyses from bulk sediments and DIWET and WET. The bulk sediment analyses were compared against the solid-borne SQAG values (Table 5-4) from the aquatic disposal SQAGs (Table 5-3) and current values in the Regional Board General Orders (CVRWQCB 2001). The DIWET and WET analyses were compared to the water-borne discharge limitations in the Regional Board General Orders (CVRWQCB 2001) (Table 5-5).

Table 5-14. Number of Sediment METs with Concentrations above Detection Limits and Percentage of Those Samples That Exceeded the Criteria for Aquatic Disposal in CVRWQCB General Orders (2001)

	Marina		Riverine		Ship Channel	
Contaminant	N	>Criteria (%)	N	>Criteria (%)	N	>Criteria (%)
Metals						
Arsenic	7	100	7	57	25	12
Barium	N/A		N/A		16	75
Cadmium	7	0	3	0	14	0
Total chromium	7	100	9	0	2	0
Chrome VI	N/A		N/A		0	0
Copper	7	100	10	100	42	40
Lead	7	100	3	100	32	72
Mercury	1	100	0	0	27	59
Nickel	7	100	1	0	18	11
Selenium	5	0	0	0	2	100
Zinc	6	100	10	0	41	15
Organometals						
Tributyltin	N/A		0	0	3	0
Polycyclic aromatic hydrocarbons						
Acenaphthene	N/A		0	0	0	0
Anthracene	N/A		0	0	0	0
Benzo(b)fluoranthene	N/A		0	0	0	0
Benzo(k)fluoranthene	N/A		0	0	0	0
Benzo(a)pyrene	N/A		0	0	0	0
Chrysene	N/A		0	0	0	0
Dibenzo(a,h)anthracene	N/A		0	0	0	0
Fluoranthene	N/A		0	0	0	0
Fluorene	N/A		0	0	0	0
Indeno(1,2,3-cd)pyrene	N/A		0	0	0	0
Naphthalene	N/A		0	0	0	0
Pyrene	N/A		0	0	0	0
Total PCBs (ppb)	N/A		0	0	1	100
Organophosphorous pesticides						
Diazinon	N/A		N/A		0	0
Malathion	N/A		N/A		3	67
Organochlorine pesticides						
Aldrin	N/A		0	0	0	0
Alpha BHC	N/A		0	0	3	67
Beta BHC	N/A		0	0	2	100
Lindane	N/A		0	0	6	50
Chlordane	N/A		0	0	0	0
4,4-DDD	N/A		0	0	0	0
4,4-DDE	N/A		0	0	0	0

Table 5-14. Continued

Contaminant	Marina		Riverine		Ship Channel	
	N	>Criteria (%)	N	>Criteria (%)	N	>Criteria (%)
Organochlorine pesticides (continued)						
4,4-DDT	N/A		0	0	3	100
Dieldrin	N/A		0	0	0	0
Endosulfan I	N/A		0	0	0	0
Endosulfan II	N/A		0	0	0	0
Endosulfan sulfate	N/A		0	0	0	0
Endrin	N/A		0	0	0	0
Endrin aldehyde	N/A		0	0	0	0
Heptachlor	N/A		0	0	6	100
Heptachlor epoxide	N/A		0	0	0	0
Hexachlorocyclopentadiene	N/A		N/A		0	0
Methoxychlor	N/A		N/A		0	0

Notes:

CVRWQCB = Regional Water Quality Control Board, Central Valley Region.
MET = Modified elutriate test.
N/A = No analysis.
PCBs = Polychlorinated biphenyls.
ppb = Parts per billion.

Table 5-15. Number of Sediment METs with Concentrations below Detection Limits and Percentage of Those Samples with Detection Limits That Exceeded the Criteria for Aquatic Disposal in CVRWQCB General Orders (2001)

	Marina		Riverine		Ship Channel	
Contaminant	**N**	**DL>Criteria (%)**	**N**	**DL>Criteria (%)**	**N**	**DL>Criteria (%)**
Metals						
Arsenic	0	0	0	0	22	4.6
Barium	N/A		N/A		3	0
Cadmium	0	0	7	43	23	0
Total chromium	0	0	1	0	21	0
Chrome VI	N/A		N/A		8	100
Copper	0	0	0	0	4	25
Lead	0	0	7	100	15	6.7
Mercury	6	100	7	100	20	55
Nickel	0	0	6	17	19	21
Selenium	2	0	7	0	32	38
Zinc	1	100	0	0	6	0
Organometals						
Tributyltin	N/A		7	100	6	0
Polycyclic aromatic hydrocarbons						
Acenaphthene	N/A		7	0	3	0
Anthracene	N/A		7	0	3	0
Benzo(b)fluoranthene	N/A		7	100	3	100
Benzo(k)fluoranthene	N/A		7	100	3	100
Benzo(a)pyrene	N/A		7	100	3	100
Chrysene	N/A		7	100	3	100
Dibenzo(a,h)anthracene	N/A		7	100	3	100
Fluoranthene	N/A		7	0	3	0
Fluorene	N/A		7	0	3	0
Indeno(1,2,3-cd)pyrene	N/A		7	100	3	100
Naphthalene	N/A		7	0	3	0
Pyrene	N/A		7	0	3	0
Total PCBs	N/A		7	100	22	100
Organophosphorous pesticides						
Diazinon	N/A		N/A		16	0
Malathion	N/A		N/A		13	0
Organochlorine pesticides						
Aldrin	N/A		7	14	24	100
Alpha BHC	N/A		7	14	20	35
Beta BHC	N/A		7	100	21	100
Lindane	N/A		7	14	17	24
Chlordane	N/A		7	100	19	16
4,4-DDD	N/A		7	14	23	26
4,4-DDE	N/A		7	14	22	0

Table 5-15. Continued

Contaminant	Marina		Riverine		Ship Channel	
	N	DL>Criteria (%)	N	DL>Criteria (%)	N	DL>Criteria (%)
Organochlorine pesticides (continued)						
4,4-DDE	N/A		7	14	22	0
4,4-DDT	N/A		7	100	20	35
Dieldrin	N/A		7	14	23	17
Endosulfan I	N/A		7	100	23	30
Endosulfan II	N/A		7	43	23	30
Endosulfan sulfate	N/A		7	100	23	30
Endrin	N/A		7	14	23	30
Endrin aldehyde	N/A		7	100	23	30
Heptachlor	N/A		7	14	17	41
Heptachlor epoxide	N/A		7	100	23	30
Hexachlorocyclopentadienne	N/A		N/A		3	100
Methoxychlor	N/A		N/A		7	100

Notes:

CVRWQCB = Regional Water Quality Control Board, Central Valley Region.
DL = Detection limit.
MET = Modified elutriate test.
N/A = No analysis.
PCBs = Polychlorinated biphenyls.

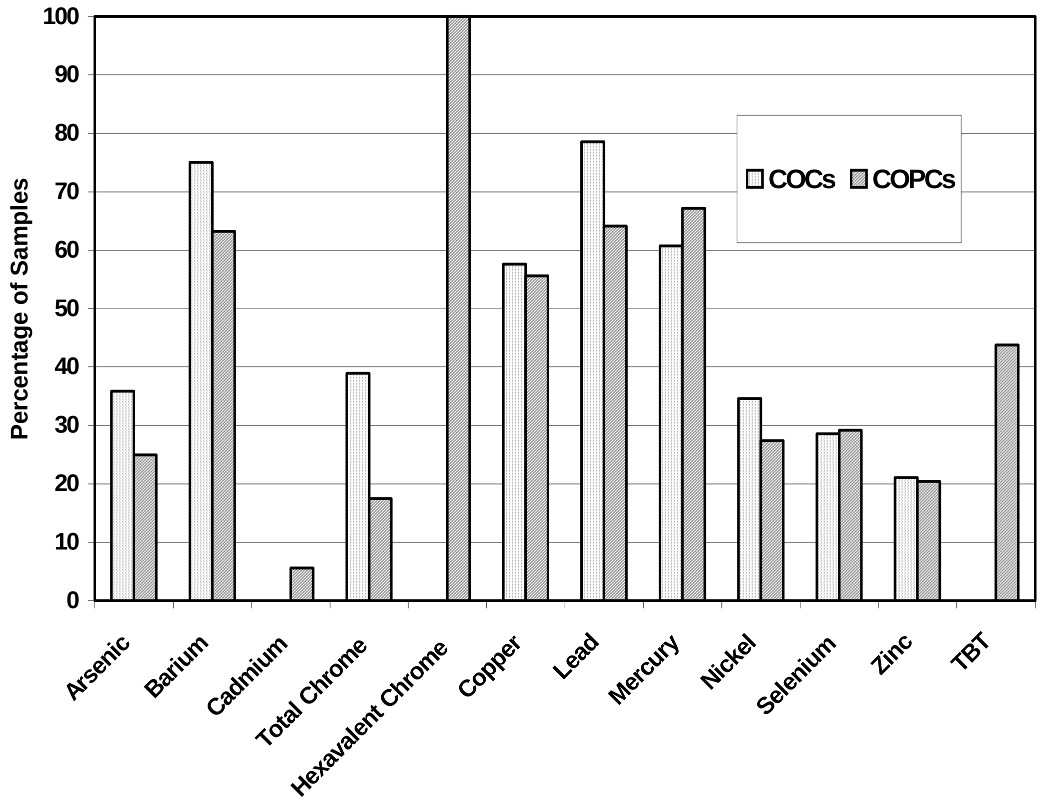
Table 5-16. COCs and COPCs for Aquatic Disposal of Sediments (MET)

Contaminant	COCs	COPCs	N for COCs	N for COPCs
Metals				
Arsenic	35.9	24.95	14	15
Barium	75	63.2	12	12
Cadmium	0	5.6	0	3
Total chromium	38.89	17.5	7	7
Chrome VI	0	100	0	8
Copper	57.63	55.6	34	35
Lead	78.57	64.1	33	41
Mercury	60.71	67.2	17	41
Nickel	34.62	27.4	9	14
Selenium	28.57	29.2	2	14
Zinc	21.05	20.4	12	13
Organometals				
Tributyltin	0	43.8	0	7
Organics				
Total PCBs	100	96.7	1	30
Benzo(B)fluoranthene	0	100	0	10
Benzo(K)fluoranthene	0	100	0	10
Benzo(A)pyrene	0	100	0	10
Chrysene	0	100	0	10
Dibenzo(a,h)anthracene	0	100	0	10
Indeno(1,2,3-cd)pyrene	0	100	0	10
Malathion	66.67	12.5	2	2
Aldrin	0	80.6	0	25
Alpha BHC	66.67	33.4	2	10
Beta BHC	100	100	2	30
Lindane	50	26.7	3	8
pp-DDT	100	56.7	3	17
Heptachlor	100	46.7	6	14
Hexachlorocyclopentadiene	0	100	0	3
Methoxychlor	0	100	0	7

Notes:

COC = Contaminant of concern.
COPC = Contaminant of potential concern.
MET = Modified elutriate test.
N = Number of samples.
PCBs = Polychlorinated biphenyls.

Figure 5-5. Aquatic Disposal Metal COCs and COPCs from MET Analysis of Delta Sediments

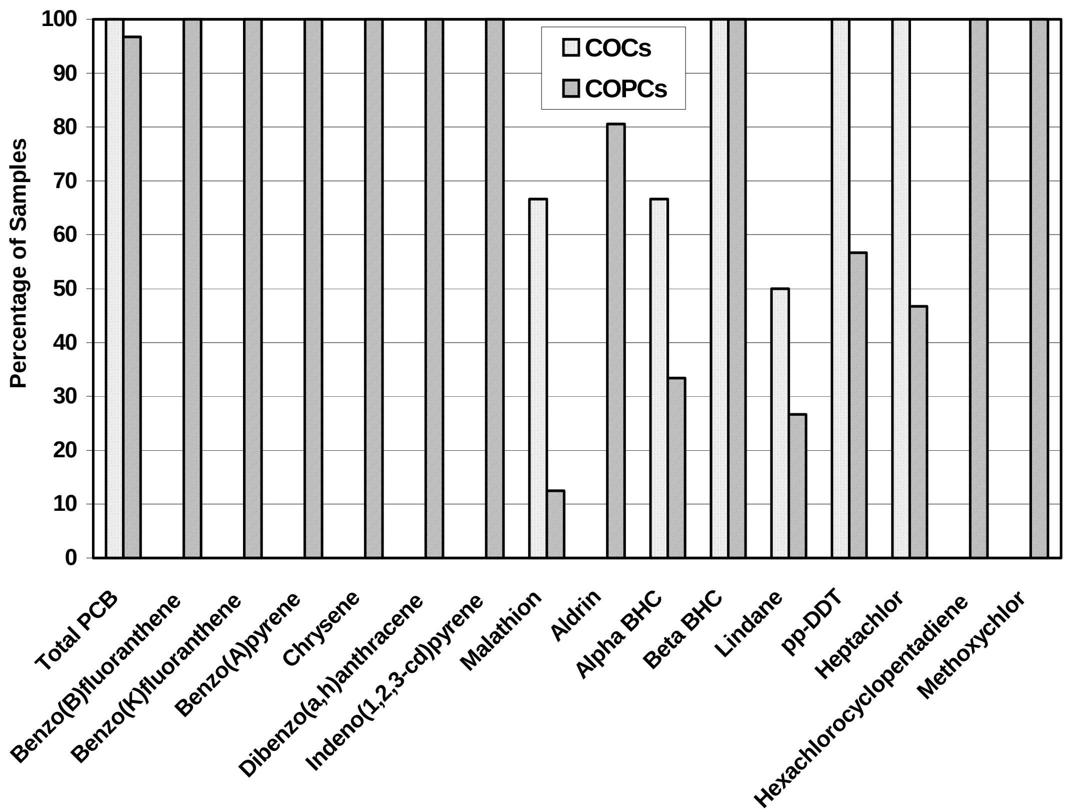


Notes:

COC = Contaminant of concern.
COPC = Contaminant of potential concern.
MET = Modified elutriate test.

Source: CVRWQCB 2001.

Figure 5-6. Aquatic Disposal Organic COCs and COPCs from MET Analysis of Delta Sediments



Notes:

COC = Contaminant of concern.
COPC = Contaminant of potential concern.
MET = Modified elutriate test.

Source: CVRWQCB 2001.

Metals

Solids

Metals in bulk sediment samples that were identified as COCs for upland disposal included total chromium, mercury, nickel and selenium (Tables 5-17 and 5-18, and Figures 5-7 through 5-9). Total chromium levels exceeded the SQAGs in 85%, 70%, and 76% of the sediment material from ship channel, riverine, and marina areas, respectively. Likewise, mercury levels exceeded the SQAGs in 61% and 45% of the sediment from riverine and marina areas respectively. Nickel levels exceeded the 25-ppm guideline in 97%, 70%, and 82% of the sediment material from ship channel, riverine, and marina areas, respectively (Table 5-17). All COPCs also were identified as COCs (Tables 5-18 and 5-19, and Figures 5-7 through 5-9).

Elutriates

Metals in the DIWET that were identified as COCs included lead and mercury for all three areas of the Delta (Tables 5-20 and 5-21, and Figure 5-10). Copper and hexavalent chrome were identified as COPCs (Tables 5-21 and 5-22). Almost all of the metals in the WET were identified as COCs for all three areas of the Delta (Tables 5-23 and 5-24, and Figure 5-11). No metal was identified as a COPC for the WET that was not also identified as a COC (Tables 5-24 and 5-25).

Organic Compounds

Solids

No COCs or COPCs were identified for bulk sediments (Tables 5-17 and 5-19, and Figures 5-7 through 5-9). As for upland disposal, assessments of PCB, PAH, and pesticide compounds in samples of bulk sediments from the Delta for upland disposal, were difficult because concentrations of many of the organic compounds were not present above the detection limits (Table 5-17). The PAH concentrations of most sediment samples were less than the detection limits, and very few samples had detection limits that exceeded the SQAG values (Table 5-19). The same was true for the chlorinated pesticides, except for dieldrin and toxaphene in marina areas (Table 5-19).

Elutriates

The DIWET and WET samples were not analyzed for organic contaminants.

Table 5-17. Number of Bulk Sediment Samples with Concentrations above Detection Limits and Percentage of Those Samples That Exceeded the Criteria for Upland Disposal in CVRWQCB General Orders (2001)

	Marina		Riverine		Ship Channel	
Contaminant	**N**	**>Criteria (%)**	**N**	**>Criteria (%)**	**N**	**>Criteria (%)**
Metals (ppm)						
Arsenic	27	0	156	0.64	126	0
Cadmium	12	0	59	0	19	0
Total chrome	29	76	211	70	27	85
Copper	39	26	210	24	136	15
Lead	28	0	176	0	127	0
Mercury	29	45	111	61	111	14
Nickel	34	82	210	70	34	97
Selenium	8	63	27	100	10	0
Zinc	37	19	206	20	127	20
Polycyclic aromatic hydrocarbons (ppb)						
Acenaphthene	0	0	0	0	0	0
Anthracene	1	0	1	0	1	0
Benzo(a)anthracene	1	100	1	0	3	0
Benzo(b)fluoranthene	1	0	1	0	4	0
Benzo(k)fluoranthene	1	0	1	0	4	0
Benzo(a)pyrene	1	0	1	0	2	0
Chrysene	1	0	1	0	1	0
Dibenzo(a,h)anthracene	0	0	2	0	1	0
Fluoranthene	1	0	4	0	4	0
Fluorene	0	0	1	0	0	0
Indeno(1,2,3-cd)pyrene	1	0	1	0	3	0
Naphthalene	0	0	0	0	2	0
Pyrene	3	0	1	0	4	0
Polychlorinated biphenyls (ppb)						
Arochlor 1016	0	0	0	0	0	0
Arochlor 1221	0	0	0	0	0	0
Arochlor 1232	0	0	1	0	0	0
Arochlor 1242	0	0	0	0	0	0
Arochlor 1248	1	100	0	0	0	0
Arochlor 1254	0	0	0	0	0	0
Arochlor 1260	0	0	0	0	0	0

Table 5-17. Continued

Contaminant	Marina		Riverine		Ship Channel	
	N	>Criteria (%)	N	>Criteria (%)	N	>Criteria (%)
Pesticides (ppb)						
Aldrin	0	0	0	0	0	0
a-BHC	0	0	0	0	0	0
b-BHC	0	0	0	0	0	0
Lindane	0	0	0	0	0	0
Chlordane	0	0	0	0	0	0
4,4-DDD	1	0	3	0	0	0
4,4-DDE	1	0	5	0	2	0
4,4-DDT	0	0	2	0	0	0
Dieldrin	0	0	0	0	0	0
Endosulfan	0	0	0	0	0	0
Endrin	0	0	0	0	0	0
Heptachlor	0	0	0	0	0	0
Heptachlor epoxide	0	0	0	0	0	0
Hexachlorocyclopentadiene	0	0	0	0	0	0
Methoxychlor	0	0	0	0	0	0
Toxaphene	0	0	0	0	0	0

Notes:

CVRWQCB = Regional Water Quality Control Board, Central Valley Region.
N = Number of samples.
ppb = Parts per billion.
ppm = Parts per million.

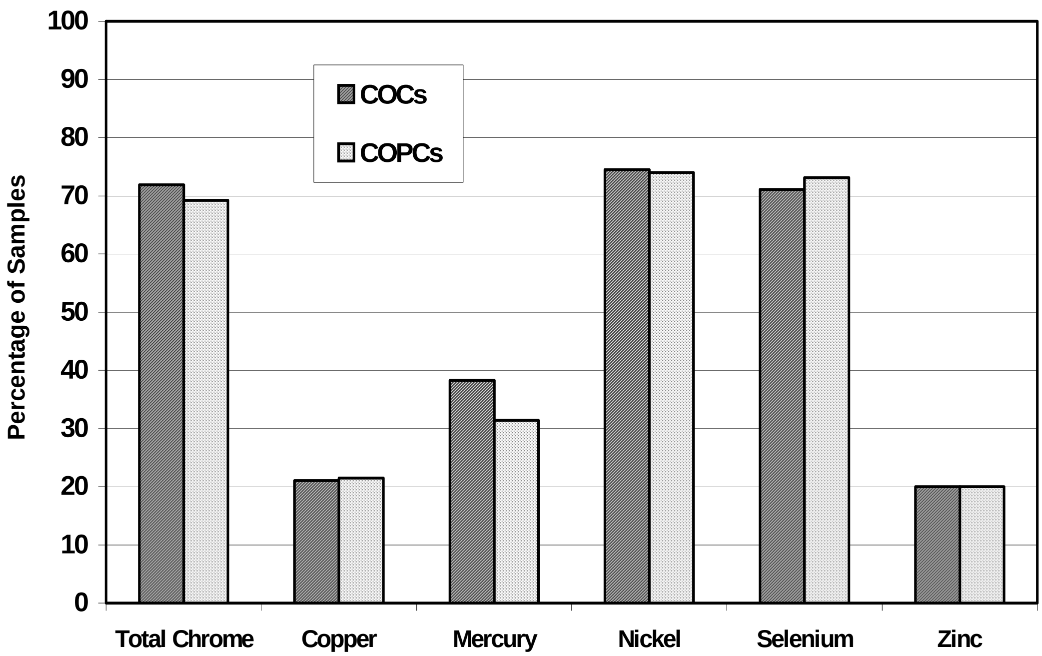
Table 5-18. COCs and COPCs for Upland Disposal of Sediments (Bulk Sediments)

Contaminant	COCs	COPCs	N for COCs	N for COPCs
Metals				
Total chromium	71.91	69.2	192	193
Copper	21.04	21.5	81	84
Mercury	38.25	31.4	96	110
Nickel	74.46	74	207	211
Selenium	71.11	73.1	32	201
Zinc	20	20	74	75
Organics				
PCB 1221	0	30	0	65
PCB 1232	0	30.4	0	66
PCB 1242	0	28	0	66
PCB 1248	100	28.4	1	67
PCB 1254	0	27	0	64
PCB 1260	0	27.4	0	65
Aldrin	0	13.5	0	30
Beta BHC	0	14.3	0	32
Dieldrin	0	20.1	0	45
Heptachlor epoxide	0	10.5	0	24
Toxaphene	0	16.5	0	37

Notes:

COC = Contaminant of concern.
COPC = Contaminant of potential concern.
N = Number of samples.
PCBs = Polychlorinated biphenyls.

Figure 5-7. Upland Disposal Metal COCs and COPCs for Bulk Sample Sediment Analysis of Delta Sediments

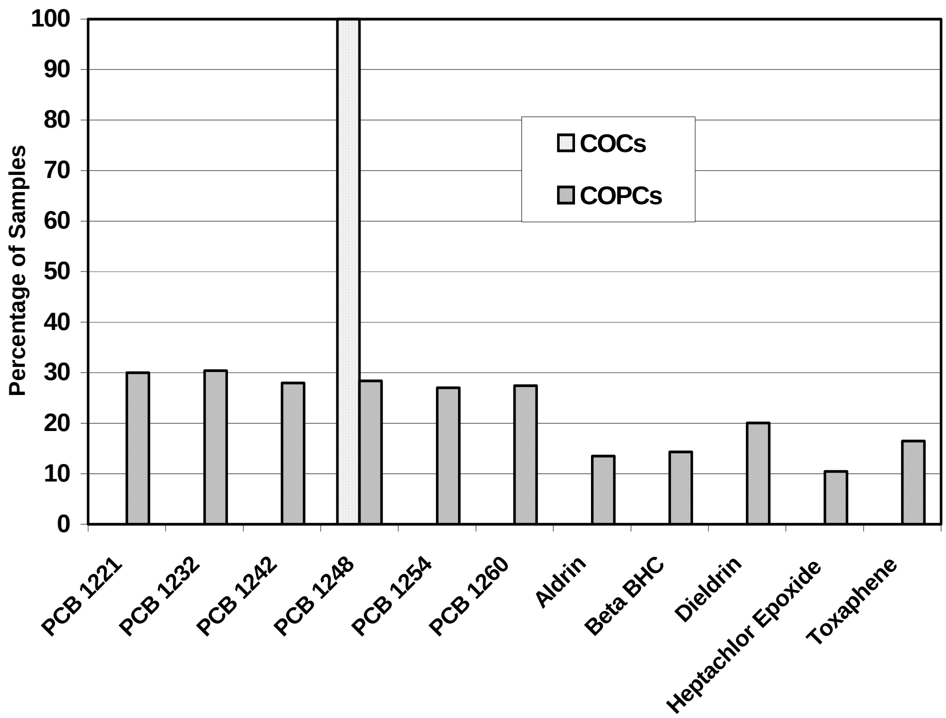


Notes:

COC = Contaminant of concern.
COPC = Contaminant of potential concern.

Source: CVRWQCB 2001.

Figure 5-8. Upland Disposal Organic COCs and COPCs for Bulk Sample Sediment Analysis of Delta Sediments

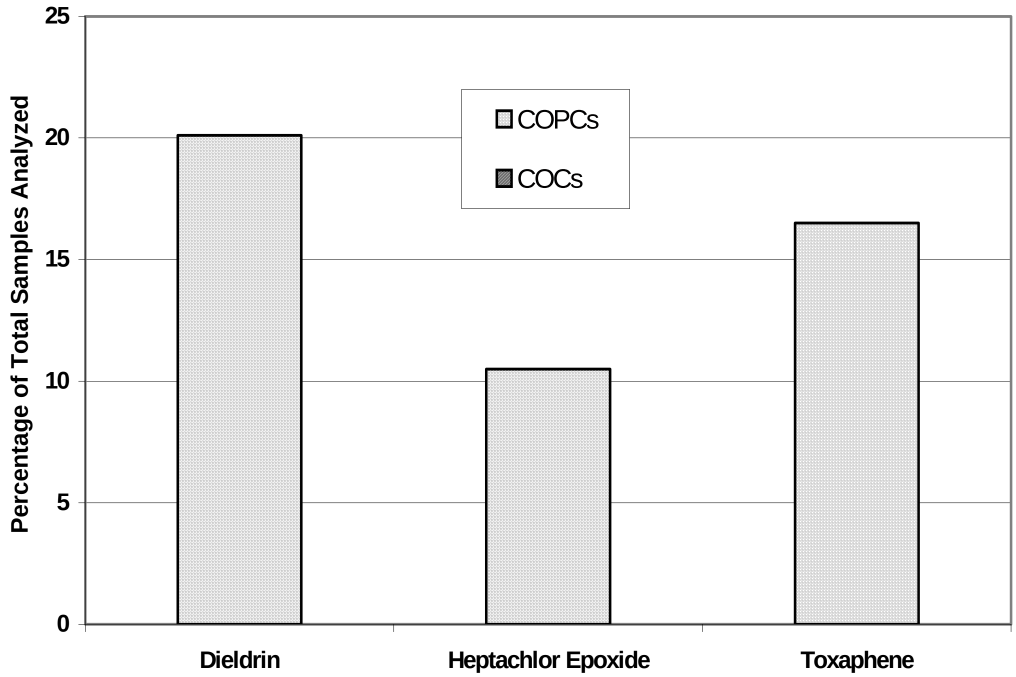


Notes:

COC = Contaminant of concern.
COPC = Contaminant of potential concern.

Source: CVRWQCB 2001.

Figure 5-9. Upland Pesticide COPCs in Bulk Delta Sediments



Notes:

COC = Contaminant of concern.
COPC = Contaminant of potential concern.

Source: CVRWQCB 2001.

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Stack Table 5-19 (page 2 of 2)

Stack Table 5-20 (page 1 of 1)

Stack Table 5-21 (page 1 of 1)

Stack Figure 5-10 (page 1 of 1)

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Stack Table 5-23 (page 1 of 1)

Stack Table 5-24 (page 1 of 1)

Stack Figure 5-11 (page 1 of 1)

Stack Table 5-25 (page 1 of 1)

SUMMARY OF COCS AND COPCS FROM THE DREDGE DATABASE

Contaminants of Concern

Except for zinc and arsenic and discounting the results of the WET, all of the metals were COCs for either upland exposure, aquatic exposure, or both (Table 5-26). Although there were no organic COCs for upland disposal, several chlorinated compounds (DDT, BHC, heptachlor, and lindane) and PAHs (benzo[a]pyrene and chrysene) were COCs for aquatic exposure.

Contaminants of Potential Concern

Only hexavalent chromium and copper were determined to be COPCs for upland exposure (Table 5-27). A number of chlorinated compounds and PAHs were identified as COPCs for aquatic exposure.

LIMITATIONS OF DREDGE DATABASE

The existing studies on Delta sediments were fragmented in time and space. Different analytical methods, detection limits, and other discrepancies limit the descriptive and predictive utilities of DREDGE.

Geographic Limitations

A review of the map of the sediment sample collection stations (Figure 5-1) indicates that sediment samples have not been collected uniformly throughout the Delta. This is not surprising because the samples in DREDGE came primarily from dredge projects; therefore the data reflect the locations of the dredged sites, not the entire Delta. A large portion of the central Delta has been sampled—the area roughly between State Highway 12 to the north, the Mokelumne Aqueduct to the south, and Stockton to the east. This data gap leaves a significant void in the characterization of Delta sediments.

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Analytical Limitations

The data used were gathered from a wide number of sources. Sediment samples were analyzed by a number of different laboratories, and the data were reported in a wide array of formats ranging from copies of laboratory analytical reports to summary tables and graphs. The following limitations should be kept in mind when using DREDGE:

- Not all sediment samples were analyzed for the same contaminants. In some cases, only a value for a specific contaminant was reported. This can lead to a biased representation of that contaminant in the Delta.

- The analytical laboratories, methods, and detection limits were not the same for all of the samples. The samples were analyzed over a period of 20 years, and analytical techniques and instrument sensitivities have changed significantly. Thus, the quality of the data in DREDGE is not constant.

- The methods of reporting the results were not consistent. Data were reported on wet and dry weight basis. An attempt was made to provide uniform data on a dry weight basis. Where only wet weight concentrations were reported, the dry weight value was calculated if the sample percent moisture was reported. Where only wet weight values were reported and no percent moisture was given, the wet weight value was recorded and noted as "wet weight."

- Data recorded for METs frequently failed to identify whether the results were for filtered or unfiltered samples. All of the MET analyses should be assumed to represent unfiltered samples unless otherwise noted. However, many of the discharge limitations are for filtered samples. Thus, there may be invalid assessments for the MET.

- The units reported for concentration of individual contaminants were not consistent. To facilitate comparison of the data between sampling stations, all concentrations for metals were reported in ppm and concentrations of all organic contaminants (including organotin compounds) were recorded in parts per billion in DREDGE. However, the conversion of concentrations to appropriate units has introduced some rounding error to the recorded values.

- In many reports, information on some of the basic physical characteristics of the sediment samples was not provided. These data include percent moisture, percent TOC, and percent fines. This information is important in characterizing sediments.

Toxicological and Biological Limitations

Only two studies reported toxicity testing of sediments from the Delta. One study involved the proposed Harbor Marina on Andrus Island (Krone and Assoc. 1990), and the other study was an early attempt to characterize the sediments of the Delta by the Regional Board (MLML unpublished data). There are no accompanying sediment chemistry data for the samples from the Regional Board study. The DREDGE database includes data for toxicity tests conducted on a total of 19 bulk sediment samples. DREDGE does not include any data on bioaccumulation of contaminants in tissues. There were no studies on benthic invertebrate abundance or diversity.

Quality Assurance and Quality Control

The reports are not consistent in providing or reporting laboratory and sample collection quality assurance and quality control (QA/QC) information. If the same entity (for example, the Corps) conducted several studies, the QA/QC information tended to remain constant because the same laboratories were characteristically used to conduct the analyses. However, this was not the case among other entities. Summary reports with tabular data usually did not provide information on laboratory or sampling QA/QC. Other reports included copies of the actual laboratory analytical sheet, which often included copies of the laboratory QA/QC data. Other reports provided a brief summary of laboratory QA/QC results without significant discussion of possible reasons for questionable results. In most cases, there was no discussion of sampling QA/QC procedures.

Data Source Report Limitations

The data for DREDGE were gathered from a wide variety of reports written for several different purposes. There was great diversity among reports in the style of writing, presentation of data, discussion of sampling protocols, and discussion of analyses. There was a good degree of uniformity in the Corps dredging reports for both the Sacramento and the Stockton Deep Water Ship Channels. The overall format of most of the reports (other than those from the Corps), was highly variable and contributed to missed data or misinterpreted data during the data entry phase. A standardized reporting structure would have facilitated data entry and identification of missing or incomplete data.

OTHER POSSIBLE DATA SOURCES

Subsequent to the completion of the data entry phase for DREDGE, the availability of additional data was reported. Although not included in DREDGE, the other possible sources of sediment data were evaluated.

The Sacramento Coordinated Monitoring Program and the Sacramento River Watershed Program, coordinated by Larry Walker Associates, have conducted a limited amount of sediment sampling for toxicity testing. The samples focused on the Sacramento River and its tributaries upstream of Sacramento. They collected one set of samples downstream of Sacramento at Freeport. The report summarizing the 1998 and 1999 data provided information on chemical analysis of water samples but not of sediment (Larry Walker Associates 2001). The sediment samples collected were used for toxicity tests, but the data were not provided in the report. No sediment samples were collected in 2000 and 2001.

The San Francisco Estuary Institute routinely conducts monitoring of the water, sediments, and benthos in the San Francisco Bay and Estuary (San Francisco Estuary Institute 2001). Sampling sites are located at the mouths of both the Sacramento and San Joaquin Rivers in Suisun Bay. Data collected includes tissue contaminant concentrations in benthic invertebrates (bivalves), water chemistry (including pesticides, trace elements, and industrial pollutants), and sediment chemistry.

The San Francisco Estuary Institute has a database on contaminants in tissues of fish collected from the Delta. The database was not available to review species of fish, collection locations, or contaminants.

The U.S. Geological Survey has collected sediment samples from locations in the Delta (LeBlanc, pers comm.). Studies have focused mainly on suspended sediments. Some bedded sediment samples also have been analyzed. Studies have included chemical analyses and toxicity testing. A current study includes investigations into adsorption of compounds from sediments and digestion of samples of suspended sediments using polychaete digestive fluids to imitate consumption and exposure (LeBlanc pers comm.).

DWR also may have additional reports with data on Delta sediments. Several additional reports were referenced in reviewed reports but were not themselves located in DWR files.

SUMMARY OF THE DREDGE DATABASE STUDY

State water quality criteria (also referred to as discharge limitations) are major management tools for protecting beneficial uses of water, including biological resources of the Delta. However, these criteria provide limited means of managing sediment quality. SQAGs (or SSLs) are needed to address contamination of ecosystems with substances that tend to accumulate in the sediment. Concerns relative to sediment contamination fall into four general categories: urban storm water runoff, agricultural runoff, domestic wastewater, and industrial wastewater. Although nutrients and sediments are the most prevalent pollutants in urban storm water, metals, PAHs, and other toxic substances also may be transported into receiving water systems by runoff. High yields of agricultural products in California require the use of substantial quantities of fertilizers and pesticides. The principal contaminants associated with agricultural runoff include nutrients, sediments, herbicides, insecticides, and other pesticides. Upgrades to wastewater treatment plants have resulted in improved water quality in many areas; however, progress toward the effective management of domestic wastewater treatment plant effluents often is hampered by rapid urbanization. Contaminants commonly associated with wastewater treatment plant effluents include nutrients, metals, halogenated methanes, and various chlorinated organic substances. Heavy manufacturing industries are not common in the Delta watershed; nevertheless, industrial wastewaters from plastics, petroleum refining, and pulp and paper industries are discharged. Industrial activities have resulted in the release of quantities of PCBs, polychlorinated bibenzo-p-dioxins (and related substances) at several superfund sites in the watershed.

The list of COCs from the DREDGE database study for bulk sediment are cadmium, chromium, mercury, nickel, selenium, benz(a)anthracene, benzo(a)pyrene, total PCBs, and DDT (Table 5-28). COPCs for bulk sediment also include aldrin/dieldrin, chlordane, endrin, heptachlor expoxide, and lindane. The identification of most of these contaminants is based on hundreds of analyses (Table 5-28). The COCs for the elutriates are barium, copper, lead, mercury, total PCBs, DDT, heptachlor, and lindane. The COPCs include hexavalent chromium, copper, benz(a) anthracene, benzo(a)pyrene, chrysene, dibenzo(a,h)antracene, and aldrin/dieldrin. The metal COCs and COPCs were from a smaller number of analyses, and it is not known whether the samples were filtered. The organic contaminants are based on a much smaller number of analyses.

While this initial assessment of sediment quality provides an indication of the potential for biological effects of sediment-based contaminants, the assessment alone should not be used to make management decisions regarding sediment quality. Further, limited toxicity data were available on these sediments. The results suggest that several metals and manmade organic compounds may be present at levels of concern. However, the probable origin of the metals was not considered as part of the assessment—in particular, the degree that metals were naturally or anthropogenically induced.

From this process, four areas of recommendations have been developed: (1) use of appropriate SQAGs for pre-project review that reflects end uses of the sediment; (2) a process for further evaluation of dredge sediments; (3) a Delta-wide sediment and soil survey; and (4) validation and development of Delta-specific SQAGs.

Sediment Quality Assessment Guidelines

To evaluate the suitability of dredge sediments for any type of disposal or beneficial reuse option, the contaminants present in the sediments must be identified and concentrations compared to screening values that can help to identify potential risks arising from the proposed end use. It is impossible to develop SQAGs for every substance that may be found in Delta sediments. However, SQAGs should be developed for at least all COCs and COPCs identified in the DREDGE database study (Table 5-28).

Aquatic Disposal and Reuse

The various approaches to assessing sediment quality for aquatic disposal were evaluated. The Regional Board has not proposed solid-based SQAGs for aquatic disposal and beneficial reuse. In the absence of any guidelines proposed by the Regional Board, the TELs identified in Smith et al. (1996) were used to assess the availability of bulk sediments in the Delta for aquatic disposal and beneficial reuse. Other values could be used, including those of MacDonald et al. (2000). The Regional Board has proposed water-borne MET guideline values for contaminants in effluents. The MET values are intended to protect the aquatic environment from contaminants remobilized during the dredging process and discharged in water from sediment settling basins. As CALFED begins to create wetlands, solid-based SQAGs will be needed for use in evaluating pre-project contaminant data.

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Upland Disposal and Reuse

The Regional Board has proposed new guidelines for specific metals and organic compounds in recent General Orders governing upland disposal of dredge sediments in the Delta (CVRWQCB 2001). The guidelines for bulk sediments are based primarily on protection of human health as identified by the EPA. In addition to the bulk sediment guidelines, the Regional Board has proposed a limited number of guidelines for DIWET and WET analyses (Table 5-4). These guidelines are designed to protect the environment from runoff from upland disposal sites and appear to be adequate for the current upland uses for dredge sediments (landfill daily cover, construction, fill material, levee structural enhancement). However, these SQAGs or screening levels do not appear to be adequate for evaluating the suitability of dredge sediments in which the proposed end use is intended to be wildlife habitat creation or habitat enhancement. The EPA and other organizations (ORNL, CCME) have developed guidelines for contaminants in soils that are intended to protect terrestrial environmental receptors. When CALFED begins to create or enhance existing upland wildlife habitat using dredge sediments, a suite of solid-based and elutriate-based SQAGs should be identified that will be protective of environmental receptors.

Background Levels

Several of the metal contaminants present in the sediments were identified as COCs or COPCs. These include arsenic, barium, cadmium, chromium, hexavalent chromium, copper, lead, mercury, nickel, selenium and zinc. It is possible that ambient, naturally occurring, sediment and soil concentrations for one or more of these metals are above the SQAGs. A survey of ambient soil values should be conducted for these metals from the Delta to determine whether any contaminants are naturally occurring at elevated concentrations and do not actually warrant classification as COCs or COPCs.

Future Evaluation of Dredged Sediments

It is inescapable that all future dredging projects will be required to evaluate the possible contaminants present in the sediments. The Delta Dredging and Reuse Strategy identifies the availability of a wide range of SQAGs that can be used to evaluate dredge sediments. Some of these SQAGs have been used to evaluate historical data on Delta sediments with certain contaminants or classes of contaminants being identified as possible problems for future disposal or reuse options. This evaluation also has identified contaminants that do not appear to pose any problems in the future. For those materials that do not appear to cause any problems, further requirements for expensive analyses could be dropped, or at least the frequency of required analysis for these contaminants could be decreased.

Evaluation of COPCs

This Delta Dredging and Reuse Strategy identifies a number of contaminants as COPCs. Future analytical procedures should be required to demonstrate limits of detection that are no higher than one-half of the SQAG identified for the contaminant. As additional data on sediment contaminants are gathered from future projects, COPCs can be re-evaluated and either removed from future analyses or identified for closer scrutiny as COCs.

Tiered Evaluation and Testing of Dredge Sediment

The Regional Board has an established list of SQAGs for upland disposal of dredge sediments and for discharge of effluents from dredging operations back to the waters of the Delta. These SQAGs appear adequate for evaluating sediments for suitability for landfills, industrial reuse, and levee (landside) placement. They do not appear adequate to evaluate proposed aquatic placement of sediments or upland placement of sediments that will be used as future wildlife habitat.

A tiered approach should be developed for evaluation of dredge sediments. Based on the proposed end use or disposal option, the sediments would be required to be analyzed for a specific set of contaminants. The concentrations of these contaminants then would be evaluated, using the appropriate set of SQAGs. These sets of SQAGs should be dynamic, encompassing the most current available information from the published scientific, peer-reviewed literature. The sets may be derived from one source (Smith et al. 1996; MacDonald et al. 2000) or they may be hybrids, with values from several different sources (i.e., CVRWQCB General Orders [2001], ORNL benchmark values, and CCME environmental protection levels). SQAGs are trigger values that, if exceeded, prompt further measurements and testing. The TEL values for aquatic disposal (Table 5-3) and the ecological values for upland disposal (Tables 5-4 and 5-5) are good estimates of sediment-associated chemical concentrations below which adverse biological effects are not expected to occur. If these triggers are exceeded, appropriate terrestrial or aquatic toxicity tests with representative species, bioaccumulation tests, and ecological tests may be required to demonstrate the lack of a potential hazard. If the concentrations of a significant number of contaminants exceed the SQAGs established for the proposed end use, it may be necessary to either revise the proposed end use or perform a risk assessment to demonstrate that the proposed use will not create an unacceptable risk to the environment.

Delta-Wide Sediment and Soil Survey

CALFED needs a suitable supply of sediment for environmental restoration and levee maintenance activities. The sediment quality data collected to date have mostly been chemical residues, lacking accompanying toxicity and benthos measurements. The toxicity data that have been collected, for the most part, have not been accompanied by chemical residue information or benthos measurements. Limited benthos composition, diversity, and indicator species data are available for Delta sediments; but no data are available in conjunction with contaminant monitoring.

The chemical analyses in DREDGE lack consistency in analyses employed and have varying limits of detection. For some contaminants (i.e., PCBs), the limits of detection are higher than levels believed to be of concern to the environment. In addition, no chemical, toxicological, or benthos data are available for a rather large area of the central Delta. These inadequacies translate into a general lack of understanding where the good and bad sediments are in the Delta. A Delta-wide survey is needed to collect sediment toxicity and benthos data in conjunction with chemical data at levels below those of concern. The plans for such a survey should be prepared as a proposal to submit to CALFED for funding in the future.

Validation and Development of Delta-Specific SQAGs/SSLs

Contaminants from natural and anthropogenic sources and processes are ubiquitous in sediments. A meaningful and pragmatic Delta Dredging and Reuse Strategy requires SQAGs/SSLs to judge the acceptability of sediments containing contaminants for various uses. Although several different types of SQAGs are available for both aquatic and terrestrial environments, their applicability to Delta sediments remains unknown. A review and evaluation of the data gathered through the Delta-wide soil and sediment survey would allow for existing SQAGs to be validated and/or other SQAGs to be developed. Due to the inadequacies identified previously in this Delta Dredging and Reuse Strategy, the current DREDGE database is not capable of deriving SQAGs. Delta-specific SQAGs/SSLs would greatly assist in regulating decisions on uses of dredge Delta sediments.