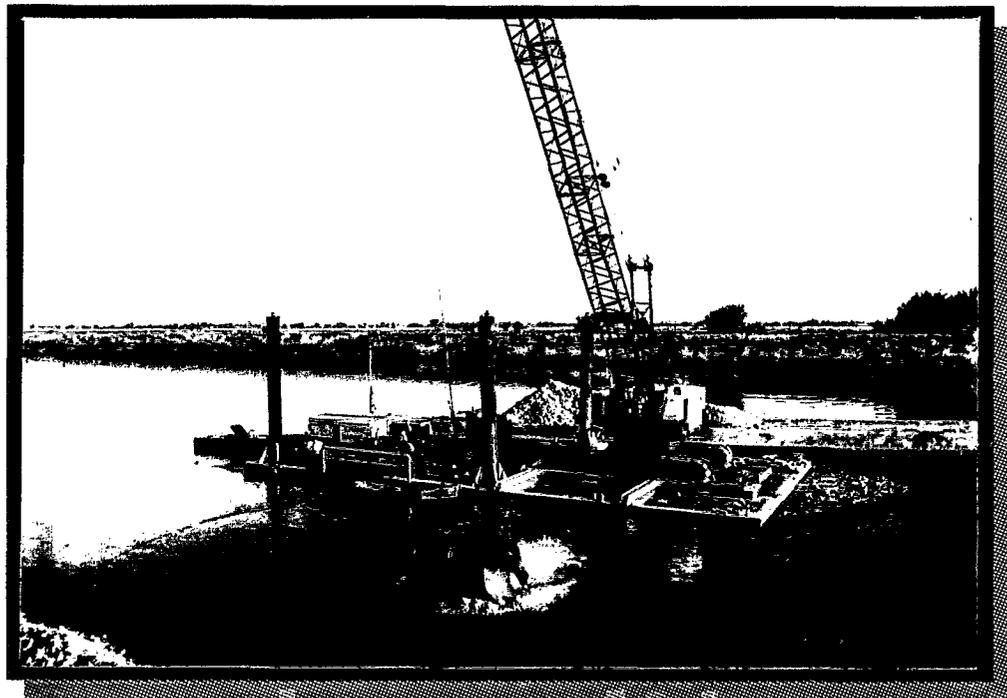


Environmental Study
for the
Interim North Delta Program

Water, Sediment and Soil Quality



Division of Planning
Division of Local Assistance
May 1995



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Interim North Delta Program
Water, Sediment and Soil Quality Report

May 1995

Prepared by the
Department of Water Resources
Division of Planning
Division of Local Assistance

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Interim North Delta Program (INDP)

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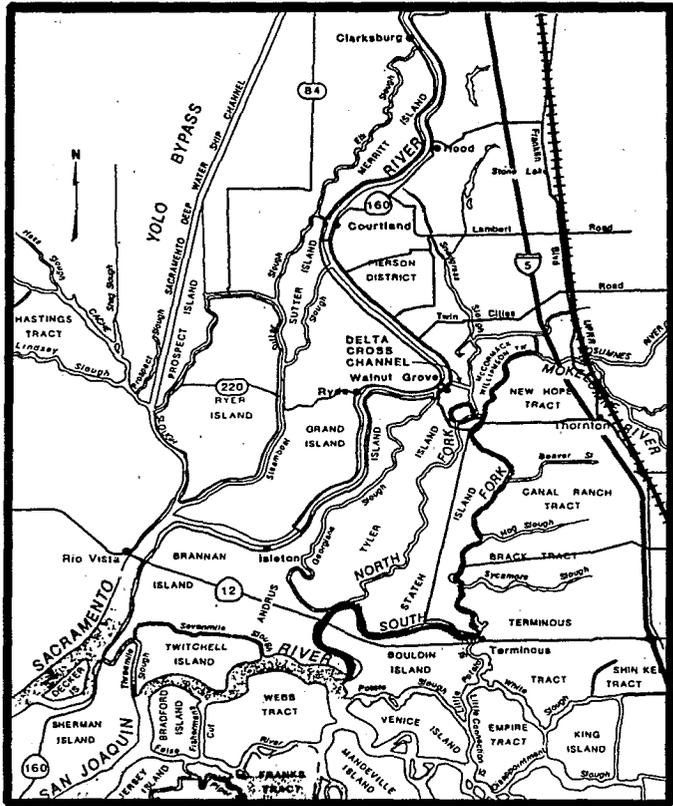
Executive Summary

The Interim North Delta Program (INDP) proposed by the California Department of Water Resources (DWR) is a public water management program designed to address water management issues in the northern Sacramento-San Joaquin Delta. The main purposes of the INDP are to improve the State Water Project (SWP) reliability through reduction in reverse flow and to improve flood protection in the lower Mokelumne River system. All of the alternatives being considered under the INDP include a component that consists of dredging in the South and North Mokelumne Rivers; from New Hope Landing to the San Joaquin River plus dredging of the channels from the Delta Cross Channel to New Hope Landing. (See Figure 1.) The dredge material from channel dredging will be placed on the backside of levees to provide additional stability of the levees. The INDP study area generally comprises the lands and channels south of Sacramento, north of the San Joaquin River, east of Rio Vista and west of Thornton. The area is mostly utilized for irrigated agriculture, but also consists of waterways, natural areas, levees, and lands devoted to residential, industrial, and municipal uses.

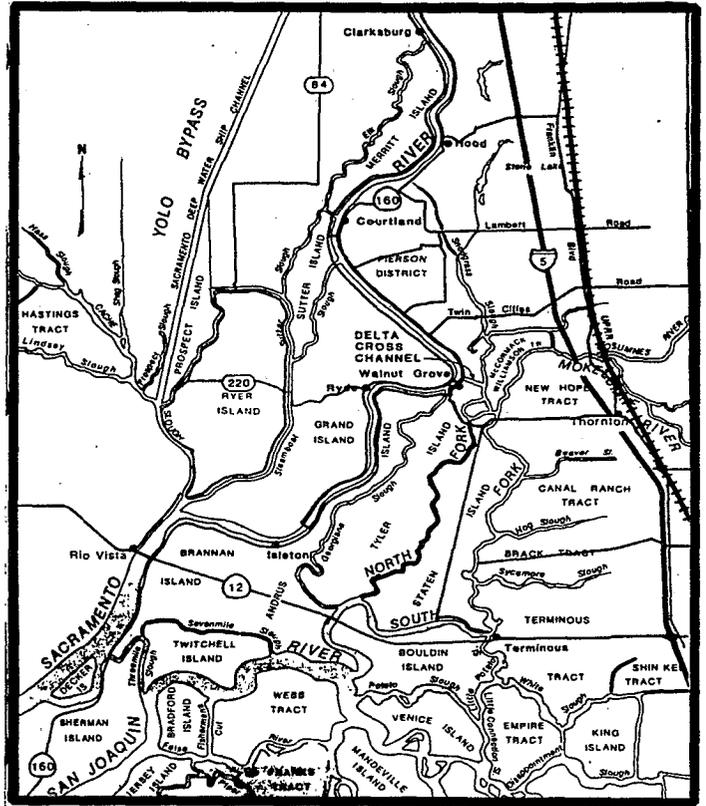
An environmental study was conducted to help determine any impacts that would result from proposed dredging activities associated with the INDP including the effects of the physical and chemical components of the dredged material on the environment. In this study, representative areas including areas of potential environmental concern within project boundaries were evaluated and the environmental impacts of a potentially larger project predicted. Samples for the study included samples of: channel water, dredged sediment, island soil and soil on the land side of the levees. After collection, the samples were sent to a laboratory and analyzed for chemicals of environmental concern. The results of this investigation are presented here.

The primary environmental concern with using dredge material for levee reinforcement is the release of contaminants from the dredge material and their possible introduction into the aquatic system. The major reactions involved in the release of contaminants are oxidation and acidification. Results of the environmental study indicate that pesticides and polychlorinated biphenyls are either not-detected or are present in very low concentrations which are unlikely to pose a threat to aquatic life. Analysis of the samples for metals indicated there is a possibility of metal contamination; however, any release of metals would likely occur slowly and in small concentrations.

Figure 1. Dredging Component for Interim North Delta Program



South Mokelumne Dredging



North Mokelumne Dredging

Introduction

The California Department of Water Resources (DWR) proposes to implement the Interim North Delta Program (INDP). In an effort to define the potential environmental impact that would result from proposed dredging that could occur in the North Delta area, a field investigation was conducted in fall and winter of 1992 to collect samples and analyze them for chemicals of environmental concern. The results of the field investigation are presented here.

In order to add to the database of information for the INDP assessment, results and assessments from other North Delta studies and projects are included in this report as well. This includes sediment and/or water quality data from samples collected during actual dredging operations in the 1992, 1993 and 1994 Staten Island Test Projects, samples collected during monitoring of a dredging project on the South Fork Mokelumne River near Staten Island in 1991, and samples from initial sediment sampling of the North Delta in 1990. The results of the 1992 INDP investigation are presented first, followed by the results of the additional studies.

Program Background

Location of INDP

The location of the INDP study area includes the islands and channels south of Sacramento, north of the San Joaquin River, east of Rio Vista, and west of Thornton. The Sacramento River, the Mokelumne River, the Cosumnes River, Dry Creek, Morrison Creek, and Deer Creek converge in the North Delta to form a network of meandering channels and sloughs. Interstate 5, State Highway 12 and 160, and local roads traverse the North Delta area. A number of small communities along the Sacramento and Mokelumne Rivers provide agricultural, recreational and other services in the area. These communities include Thornton, Courtland, Locke, Clarksburg, Hood, Walnut Grove, Isleton, and Terminous.

The Delta supports hundreds of species of fish, wildlife, and plants. It is a part of an interconnected estuary system that includes the Suisun Marsh and San Francisco Bay and provides a passageway to and from the Pacific Ocean for migrating fish. Water projects divert water from Delta channels to meet the needs of about two-thirds of the State's drinking water supply, and to irrigate about 4.5 million acres of agricultural land.

Purpose of INDP

The Interim North Delta Program is designed to address problems related to flooding, reverse flow, water quality, fisheries impacts and water supply reliability. The flood in February, 1986 demonstrated the urgent need for new flood control work in the North Delta area. The 1986 flooding forced the evacuation of 1,600 people from small towns and various homes in the area, causing \$20 million worth of direct damage, and flooding Interstate 5 and numerous local roads.

The INDP will reduce flooding in the north Delta by improving the conveyance capacity of the lower Mokelumne River by dredging. The INDP will improve the water quality by reducing reverse flow and allowing export water to flow in a direct path, thus avoiding ocean bromides and reducing precursors for trihalomethanes (THM's). Fisheries impacts will also be reduced by the reduction of reverse flow. The INDP will improve water supply flexibility,

reliability and efficiency of the State Water Project (SWP).

Project alternatives for achieving the water management objectives in the North Delta involve various components including the dredging of channels, enlarging the Delta Cross Channel gates and creating a 2000 cfs diversion at the city of Hood. Dredging is a common element in all INDP alternatives; however, dredging locations and the combination of actions vary with each proposed alternative.

Dredging of Channels and its Potential Impacts

Location of INDP Dredge Materials Study Area

The INDP study area incorporates parts of Tyler Island, McCormack-Williamson Tract, New Hope Tract, Staten Island, Canal Ranch Tract, Brack Tract, Terminous Tract, Bouldin Tract, as well as the North Fork Mokelumne River, South Fork Mokelumne River, and other Mokelumne River reaches extending from the San Joaquin River to Interstate 5. The Delta Cross Channel and Snodgrass Slough south of the Delta Cross Channel are also a part of the study area.

Method of Dredging

Two types of dredging were considered for this study: clamshell (mechanical) dredging and hydraulic dredging. Clamshell dredging is the preferred method of dredging for this project because it allows for quick drying and placement of dredged material. In contrast, hydraulic dredging is only capable of pumping 12 and 18 percent solids and requires settling ponds. Settling ponds have many disadvantages including: the disruption of other (agricultural) uses of the land where they are located, water quality problems resulting from the necessity to pump supernatant back in the channel, foundation and other potential problems from the settling ponds on the peat; and potential water quality problems due to seepage.

Potential Turbidity from Dredging Activity

During construction, a potentially acute problem associated with dredging of contaminated sediments is resuspension of the sediments, and the resulting movement of volatile and soluble compounds into the water column. Resuspension occurs due to dredging action at the sediment-water interface, during transfer of the sediment to a transporting vessel, due to slop or leakage from the vessel, and during disposal.

Method of Disposal of Dredge Material

Utilization of the dredged sediment for levee reinforcement may be of benefit to this project. However, prior to dredging, it must be shown that the dredging and utilization and disposal of dredged material can be done safely, without harm to the environment.

Once removed from the channel, the deposited sediment will be immediately transported to be placed on a levee to provide additional stability. The levee reinforcement will proceed as directed by the project's engineering specifications.

Possible short and long term problems with the use of dredge material for levee reinforcement are the release of contaminants from the dredge material and their possible introduction into the aquatic system. The major reactions resulting in contaminant release are oxidation and acidification. In the water environment, most sediments exist in an anoxic, or oxygen free environment. The diffusion of oxygen in sediment is so slow that the oxygen content declines rapidly with increasing depth. A strong oxygen concentration gradient usually exists over a depth of millimeters.

Upon transfer of the sediment to land, previously anoxic sediments slowly became oxygenated, or oxidized. This process may take a period of years, depending on the amount of dredge material, the redox potential of the sediment, and the amount of oxidizable matter. During the oxidation process, metals, trace elements and other contaminants associated with the oxidizable fractions may be released.

Oxidation of the dredge material may also result in acidification of the sediment. Oxidation reactions result in the production of hydrogen ions, and lower the pH of the sediment. The amount of acidification is dependent on the neutralization capacity of the sediment. Acidification may result in the displacement and release of metals by the increased concentration of hydrogen ions.

The loading of contaminants into the aquatic environment could potentially cause adverse impacts to aquatic life if concentrations are above the California Regional Water Quality Control Board's Water Quality Objectives, or other water quality criteria.

Objectives of Environmental Study

The primary objective of the Environmental Study is to help determine the impact to be expected as a result of proposed dredging activities associated with the INDP, including the effects of the physical and chemical components of the dredged material on the environment. The management strategy proposed for the project is a tiered approach to testing. The decision-making framework includes compliance with the California and federal water and sediment quality criteria, and standard quality assurance/quality control principles. Where criteria are lacking, historical sediment data are considered. In this study, representative areas, including areas of potential environmental concern within project boundaries were evaluated, and the environmental impacts of a potentially larger project predicted. Objectives are to:

- Determine the suitability of dredged materials with respect to environmental concerns.
- Document and better understand the existing baseline conditions before construction begins. The proposed baseline testing was for the purpose of evaluating current conditions in the project area with respect to chemical and physical properties of channel water, channel sediment, and soil on the land side of existing levees.
- Provide data sufficient to obtain a Section 404 permit from the U.S. Army Corps of Engineers, and a Section 401 Water Quality Certificate or Waiver or waste discharge permit from the CVRWQCB.
- Provide information to regulatory agencies which have jurisdiction over the protection of fish, wildlife and water quality. These agencies include the Central Valley Regional Water Quality Control Board, California Department of Fish and Game, U.S. Fish and Wildlife, and the U.S. Army Corps of Engineers.
- Predict whether there will be water quality impacts as a result of dredging and transport of sediments associated with the project.
- Determine potential long term adverse environmental impacts at the sediment deposition area.

Design of Environmental Study

INDP staff selected 13 sites along the Mokelumne River for water and sediment analysis. (See Figure 2) Test sites were selected to represent a variety of possible project dredge conditions. Specific areas of concern including: marinas, populated areas, towns, agricultural drainage areas and river junctions, were identified as points of value for testing. For each project site, selected test sites were used for baseline sampling. Sites were selected that have differing soil types to allow for analysis of a reasonable mixture of field conditions.

Nineteen land sites were selected throughout the project area in an attempt to document baseline conditions for future disposal of dredge material on the backside of levees, and for construction of setback levees. Many of these sites correspond to the sites used for sediment sampling (See Figure 3). Figure 4 shows a Baseline Study Cross Section.

General Description of Test

The sampling and testing procedures followed the guidelines in the INDP & SDWMP work plan (Appendix B). This plan was approved by the CVRWQCB prior to initiation of sample collection. Permits that were obtained for this environmental study were the 1601 Streambed Alteration Permit from the Department of Fish and Game and the Nationwide Permit 6 from the U.S. Army Corps of Engineers to work on or in water, and seven Temporary Access Permits to work on the sites.

Water Test Description

Table 3 lists the parameters, reporting limits and EPA methods for the water analyses.

Water samples requiring filtration were filtered through 0.45 micron Millipore membranes, using a plastic filtration apparatus. Both unfiltered and filtered water samples for analysis of fluoride, chloride, hardness, electrical

**Figure 2. North Delta Program
Sediment and Water Sampling Locations**

● Sediment / Water Sampling Site

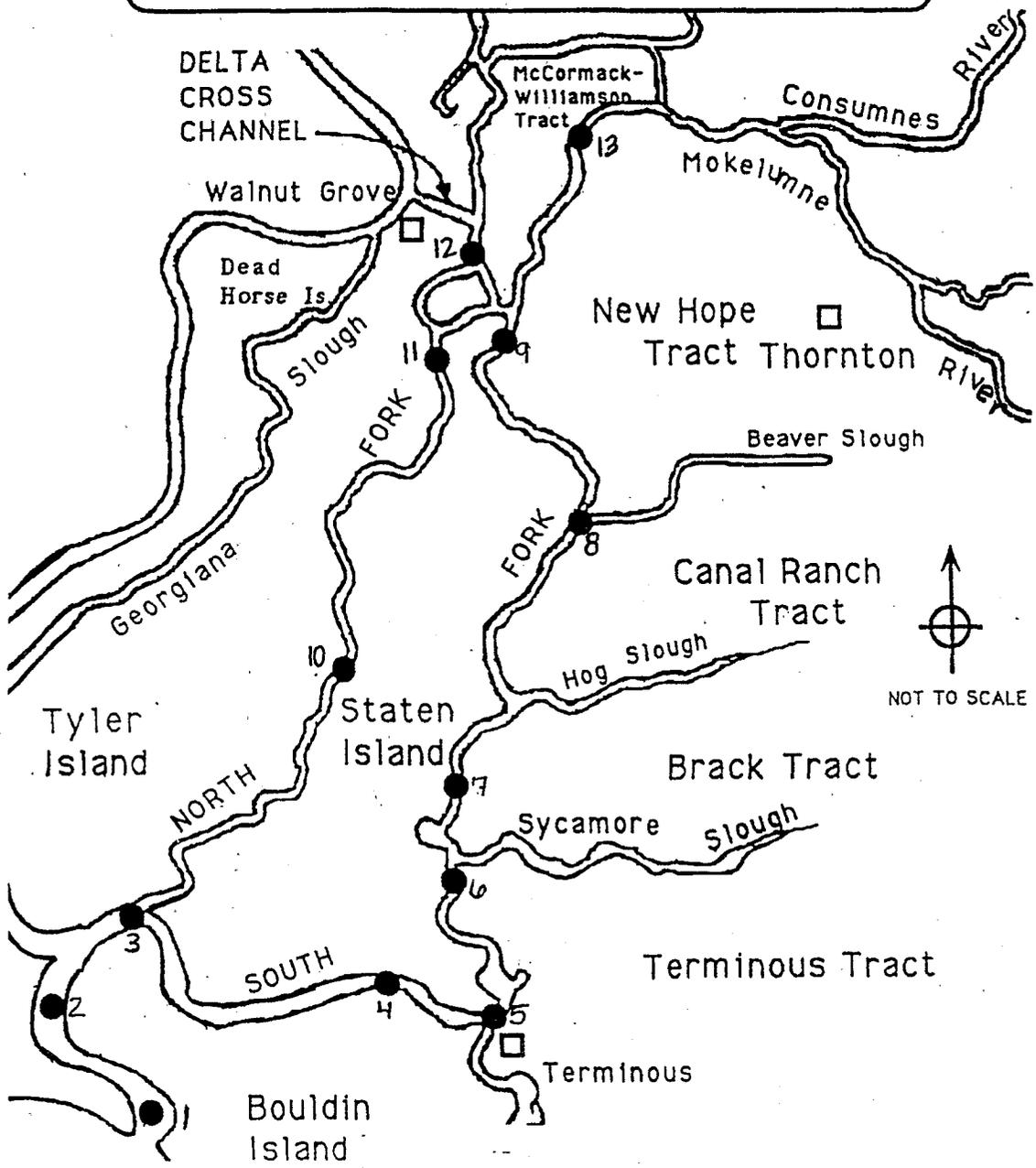


Table 1. Fall 1992 Sediment and Water Sample Site Descriptions

Site No.	Site Description
1	200 feet upstream of Pirates Lair Marina
2	1.1 road miles downstream, along Brannan Island Rd. from Hwy 12 overcrossing
3	200 feet downstream of mouth of South Fork Mokelumne River at south end of Staten Island
4	4000 feet downstream from junction of Little Connection Slough and South Fork Mokelumne River
5	At junction of Little Connection Slough and South Fork Mokelumne River
6	350 feet downstream of the confluence of Sycamore Slough and South Fork Mokelumne River
7	1 mile upstream from site #6
8	200 feet downstream of Beaver Slough
9	1000 feet downstream of Walnut Grove Rd. Bridge on South Fork Mokelumne River
10	4 miles upstream of mouth of North Fork Mokelumne River at south end of Staten Island
11	500 feet downstream from the southern tip of Dead Horse Island on North Fork Mokelumne River
12	100 feet downstream from junction of Dead Horse Cut and Snodgrass Slough
13	200 feet downstream of easterly end of Long East-West Farm Rd., on McCormack-Williamson Tract

Figure 3. NORTH DELTA PROGRAM

Locations for Soil Sampling Within Project Boundaries



Test Site For Backside of Levees, Levee Setbacks, & Channel Excavation Analysis



Test Site For Backside of Levee Analysis Only

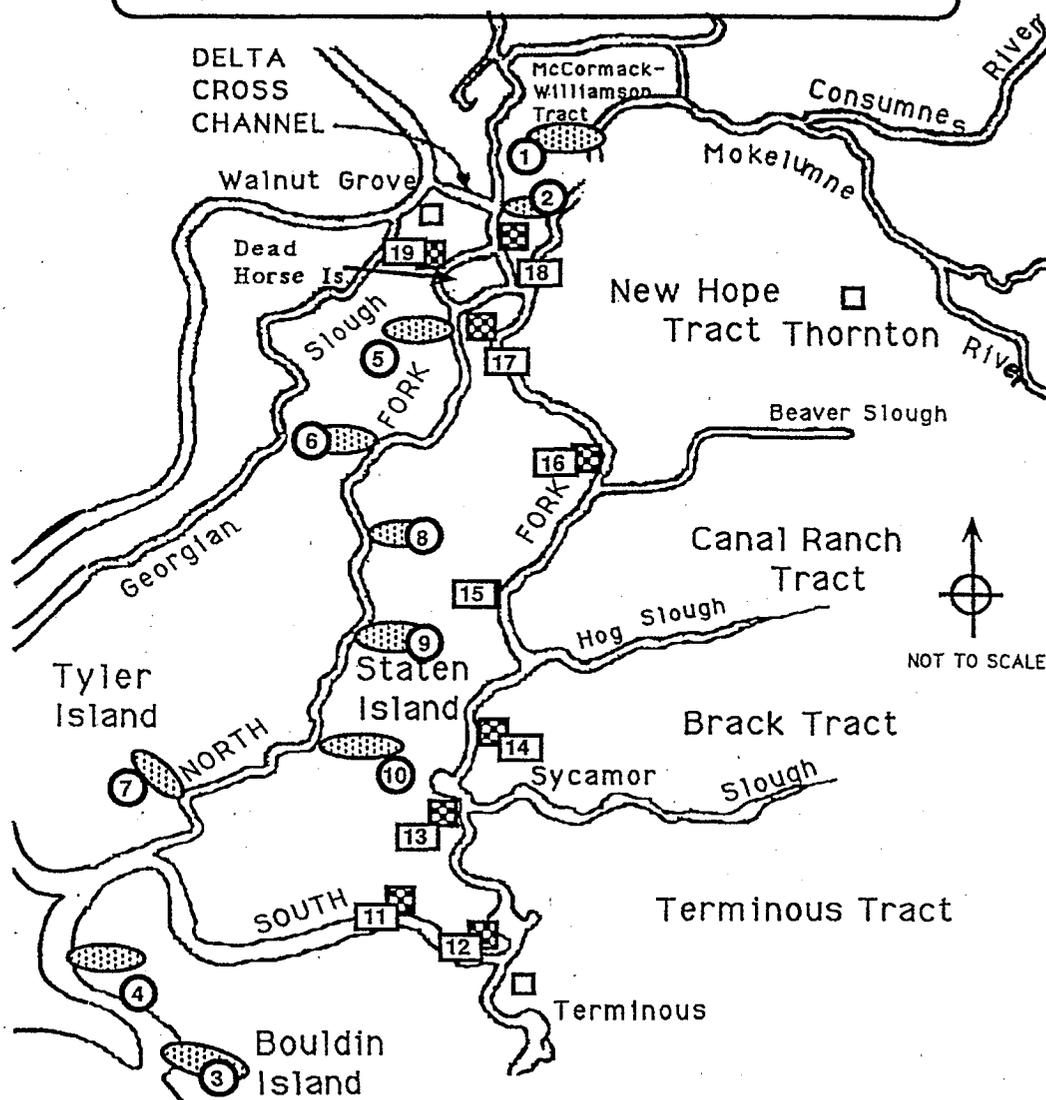
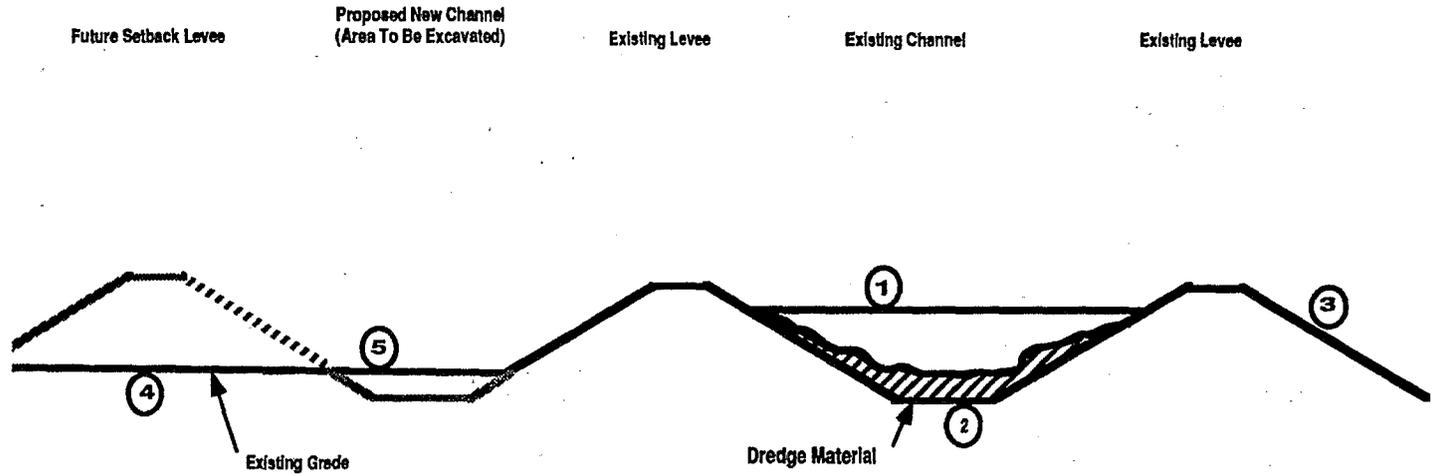


Table 2. Fall 1992 Inland, Drill and Levee Soil Sample Site Descriptions

Site No.	Site Description
1	4400 feet upstream from the confluence of North Mokelumne River and south Mokelumne River
2	3900 feet upstream from the confluence of North Mokelumne River and South Mokelumne River
3	2000 feet upstream on Mokelumne River from the confluence of Mokelumne River and San Joaquin River
4	1.8 miles upstream on Mokelumne River from confluence of Mokelumne River and San Joaquin River
5	900 feet downstream on North Mokelumne River from the confluence of Snodgrass Slough and North Mokelumne R.
6	2 miles downstream on North Mokelumne River from the confluence of Snodgrass Slough and North Mokelumne R.
7	1 mile upstream from head of North Mokelumne River where it splits from Mokelumne River
8	1.4 miles downstream from site #6
9	1.1 miles downstream from site #8
10	1.42 miles downstream from site #9
11	1.33 miles upstream on South Mokelumne River from the confluence of Little Potato Slough and South Mokelumne River
12	3000 feet upstream on South Mokelumne River from the confluence of Little Potato Slough and South Mokelumne River
13	750 feet upstream on South Mokeumne River from the confluence of Sycamore Slough and South Mokelumne River
14	4800 feet upstream from site #13
15	5000 feet upstream of South Mokelumne River from confluence of Hog Slough and South Mokelumne River
16	1500 feet upstream on South Mokelumne River from the confluence of Beaver Slough and South Mokelumne River
17	2.2 miles upstream from site #16
18	On the corner of Dead Horse Cut and Snodgrass Slough in McCormack-Williamson Tract
19	3200 feet upstream on Snodgrass Slough from confluence of North Mokelumne River and Snodgrass Slough

Figure 4. Baseline Study Cross Section

Areas of Analysis



LEGEND / PAGE REFERENCE

- ① SURFACE WATER / PG. 47
- ② CHANNEL SEDIMENT / PG. 52
- ③ LEVEE SOIL / PG. 70
- ④ INLAND SOIL / PG. 83
- ⑤ DRILL SITE SOIL / PG. 76

Table 3. Parameters for Chemical Analysis of Water Samples

Constituent	Units	DWR Reporting Limit	EPA Test Method
Pesticides & PCB's			
Aroclor - 1016	µg/L	0.1	608
Aroclor - 1221	µg/L	0.1	608
Aroclor - 1232	µg/L	0.1	608
Aroclor - 1242	µg/L	0.1	608
Aroclor - 1248	µg/L	0.1	608
Aroclor - 1254	µg/L	0.1	608
Aroclor - 1260	µg/L	0.1	608
Alachlor	µg/L	0.05	608
Aldrin	µg/L	0.01	608
Atrazine	µg/L	0.02	608
BHC - alpha	µg/L	0.01	608
BHC - beta	µg/L	0.01	608
BHC - delta	µg/L	0.01	608
BHC - gamma	µg/L	0.01	608
Captan	µg/L	0.02	608
Chlordane	µg/L	0.05	608
Chlorothalonil	µg/L	0.01	608
Chlorpropham	µg/L	0.02	608
Chlorpyrifos	µg/L	0.01	608
CDPA	µg/L	0.01	608
DDD	µg/L	0.01	608
DDE	µg/L	0.01	608
DDT	µg/L	0.01	608
Dichloran	µg/L	0.01	608
Dicofol	µg/L	0.01	608
Dieldrin	µg/L	0.01	608
Diuron	µg/L	0.05	608

Table 3. Parameters for Chemical Analysis of Water Samples, cont'd

Constituent	Units	DWR Reporting Limit	EPA Test Method
Endosulfan I	µg/L	0.01	608
Endosulfan II	µg/L	0.01	608
Endosulfan Sulfate	µg/L	1	608
Endrin	µg/L	0.01	608
Endrin Aldehyde	µg/L	0.01	608
Heptachlor	µg/L	0.01	608
Heptachlor Epoxide	µg/L	0.01	608
Methoxychlor	µg/L	0.01	608
PCNB	µg/L	0.01	608
Trace Metals			
Aluminum	mg/L	0.01	202.2
Arsenic	mg/L	0.001	206.3
Barium	mg/L	0.05	208.2
Boron	mg/L	0.1	I-2115-85 ^a
Cadmium	mg/L	0.005	213.2
Calcium	mg/L	1.0	215.1
Chloride	mg/L	1.0	325.2
Chromium	mg/L	0.005	218.2
Chromium (+6)	mg/L	0.01	218.5
Copper	mg/L	0.005	6010
Fluoride	mg/L	0.1	340.2
Iron	mg/L	0.005	236.2
Lead	mg/L	0.005	239.2
Magnesium	mg/L	1.0	242.1
Manganese	mg/L	0.005	243.2
Mercury	mg/L	0.001	245.1
Nickel	mg/L	0.005	249.2
Selenium	mg/L	0.001	270.2
Sodium	mg/L	1.0	273.1
Zinc	mg/L	0.005	289.2

Table 3. Parameters for Chemical Analysis of Water Samples, cont'd

Constituent	Units	DWR Reporting Limit	EPA Test Method
Other Inorganics			
Electrical Conductivity	mg/L	1.0	120.1
Hardness	mg/L	5.0	calc.
Nitrate	mg/L	0.1	353.2
Oil and Grease	mg/L	5.0	413.1
pH	mg/L	0.1	150.1
Dissolved Solids	mg/L	1.0	160.1
Suspended Solids	mg/L	1.0	160.2
Dissolved Sulfate	mg/L	1.0	375.2
Total Alkalinity	mg/L	1.0	310.1

^a USGS method

conductivity, total dissolved solids, pH and suspended solids samples were collected and placed in one quart plastic containers. Samples for total and dissolved metals were placed in acid washed plastic containers and preserved with nitric acid. Oil and grease samples consisted of unfiltered sample water placed into a one quart glass jar, and preserved with sulfuric acid. Chromium VI water samples were filtered through a 0.45 micron Millipore membrane and placed into acid washed plastic containers.

Samples were taken from between 18 and 36 inches below the water surface. The sampling took place October 26-27, 1992.

Sediment Test Description

Table 4 lists the parameters, reporting limits, and EPA methods for sediment and soil analysis. Channel sediment samples were collected under contract with Taber Consultants, with assistance from Department staff. The samples were collected using a barge-mounted Concore drill rig. Figure 5 shows a drill rig similar to the one used to collect sediment samples from rivers and channels. Samples were collected in 30 inch long, 2.5 inch diameter mild steel Shelby tubes. The mild steel Shelby tubes were specifically used so as to reduce the potential for sample contamination. The Shelby tubes were primarily driven by a hydraulically driven "Gus" undisturbed sampler. However, in dense sand where the hydraulically driven sampler was unable to penetrate the sediment, a 140-pound hammer dropping 30 inches into the sediment was used to advance the Shelby tube.

Depending upon the depth, between two to five Shelby tubes were taken at each sampling site and individually labeled. Each sediment core was continuous from the channel bottom to a depth of 20 feet below mean sea level.

After collection, the sediment samples were sent to PACE Laboratory, Novato, California, for compositing. The individual core samples were homogenized with instruments which would not cause

contamination. A subsample was taken from each sample, and subsamples from the same site were composited. The individual samples were retained for 90 days in the event further testing of non-volatile constituents was required. If the composite analytical results indicated no field or analytical problems, then the individual samples were discarded. If problems were apparent, then the individual samples were reanalyzed for the parameter in question. The laboratory followed the preservation, storage, and handling requirements of the analytical method.

The three composite samples with the highest metal concentrations in the INDP area were analyzed using the Waste Extraction Test (WET) for soluble metals, as defined under the California Code of Regulations Title 22 for Criteria of Hazardous Wastes. The sediment samples were taken beginning October 6, 1992 and ending on October 21, 1992.

The acid generation potential test was performed on samples from all sites. This test is used to predict the chances of a soil (or sediment) to become acidic. The test is based on two measurements: the acid forming potential and the neutralizing potential. The acid forming potential is a measurement of the acid-producing forms of sulfur. These forms of sulfur can be converted to sulfuric acid (H_2SO_4). The neutralizing potential is a measure of the neutralizing bases, such as carbonates, present in the soil. The acid generation potential is the quotient of the measured neutralizing potential and the acid-forming potential (N/A). A quotient of one indicates that the two potentials are equal and the soil can neutralize all the acid produced.

The CVRWQCB criterion for the acid generation potential test is a N/A quotient of three. If the N/A ratio is greater than three, then the likelihood that the soil will become acidic is low. If the ratio less than three, the soil has the potential to become acidic. The criterion of three was selected to account for the greater leachability of the neutralizing minerals as compared to the acid forming minerals, and to account for the uneven distribution of these minerals.

Soil Test Description

Table 4 lists the parameters for which the soil samples were analyzed. Samples were collected from the

following areas: the backsides of levees, levee setback construction areas, and future excavated channel areas.

Borrow sites have not been identified.

For soil on the backside of levees and soil in levee setback construction areas, composite samples were collected for each sample site. Soil from the backside of levees and levee setback construction areas was removed from the existing surface to a depth of up to 12 inches below the ground surface. Samples were taken using a stainless steel trowel. Up to three areas within a ten foot radius were combined to make one composite, homogenized sample for testing.

Soil samples from excavated channel areas were samples taken from the existing ground surface to -20.0 feet msl. Six core samples were taken for each drilling site. One sample was taken every 1.5 feet using a 2-inch by 18-inch long California sampler to a depth of 20 feet. The six samples from each drill site were later composited by the lab into one soil sample for analysis.

Soil sampling procedures followed the ASTM D1587 - Standard Practice for Thin-Walled Tube Sampling of Soils. The soil sampling took place between December 10, 1992 and December 21, 1992.

Table 4. Parameters for Chemical Analysis of Sediment/Soil

Constituent	Units	PACE Reporting Limit ^a	EPA Test Method
Pesticides & PCB's			
Aldrin	µg/kg	1.0	608
BHC - alpha	µg/kg	1.0	608
BHC - beta	µg/kg	1.0	608
BHC - delta	µg/kg	1.0	608
BHC - gamma	µg/kg	1.0	608
PCB - 1016	µg/kg	70	608
PCB - 1221	µg/kg	70	608
PCB - 1232	µg/kg	70	608
PCB - 1242	µg/kg	70	608
PCB - 1248	µg/kg	70	608
PCB - 1254	µg/kg	70	608
PCB - 1260	µg/kg	70	608
Chlordane	µg/kg	20	608
DDD	µg/kg	2.0	608
DDE	µg/kg	2.0	608
DDT	µg/kg	2.0	608
Dieldrin	µg/kg	2.0	608
Endosulfan I	µg/kg	1.0	608
Endosulfan II	µg/kg	2.0	608
Endosulfan Sulfate	µg/kg	2.0	608
Endrin	µg/kg	2.0	608
Endrin Aldehyde	µg/kg	2.0	608
Heptachlor	µg/kg	1.0	608
Heptachlor Epoxide	µg/kg	1.0	608
Methoxychlor	µg/kg	20	608
Toxaphene	µg/kg	30	608

Table 4. Parameters for Chemical Analysis of Sediment/Soil, cont'd

Constituent	Units	PACE Reporting Limit ^a	EPA Test Method
Tributyltin Chloride	µg/kg	2.0	
Trace Metals			
Arsenic	mg/kg	5.0	206.3
Cadmium	mg/kg	1.0	213.2
Chromium	mg/kg	1.0	218.2
Copper	mg/kg	1.0	6010
Lead	mg/kg	10	239.2
Mercury	mg/kg	0.02	245.1
Nickel	mg/kg	2.0	249.2
Selenium	mg/kg	5.0	270.2
Silver	mg/kg	1.0	273.1
Zinc	mg/kg	2.0	289.2
Other Inorganics			
Moisture Content	%	0.01	413.1
pH	units	0.1	150.1
Total Oil and Grease	mg/kg	50	310.1

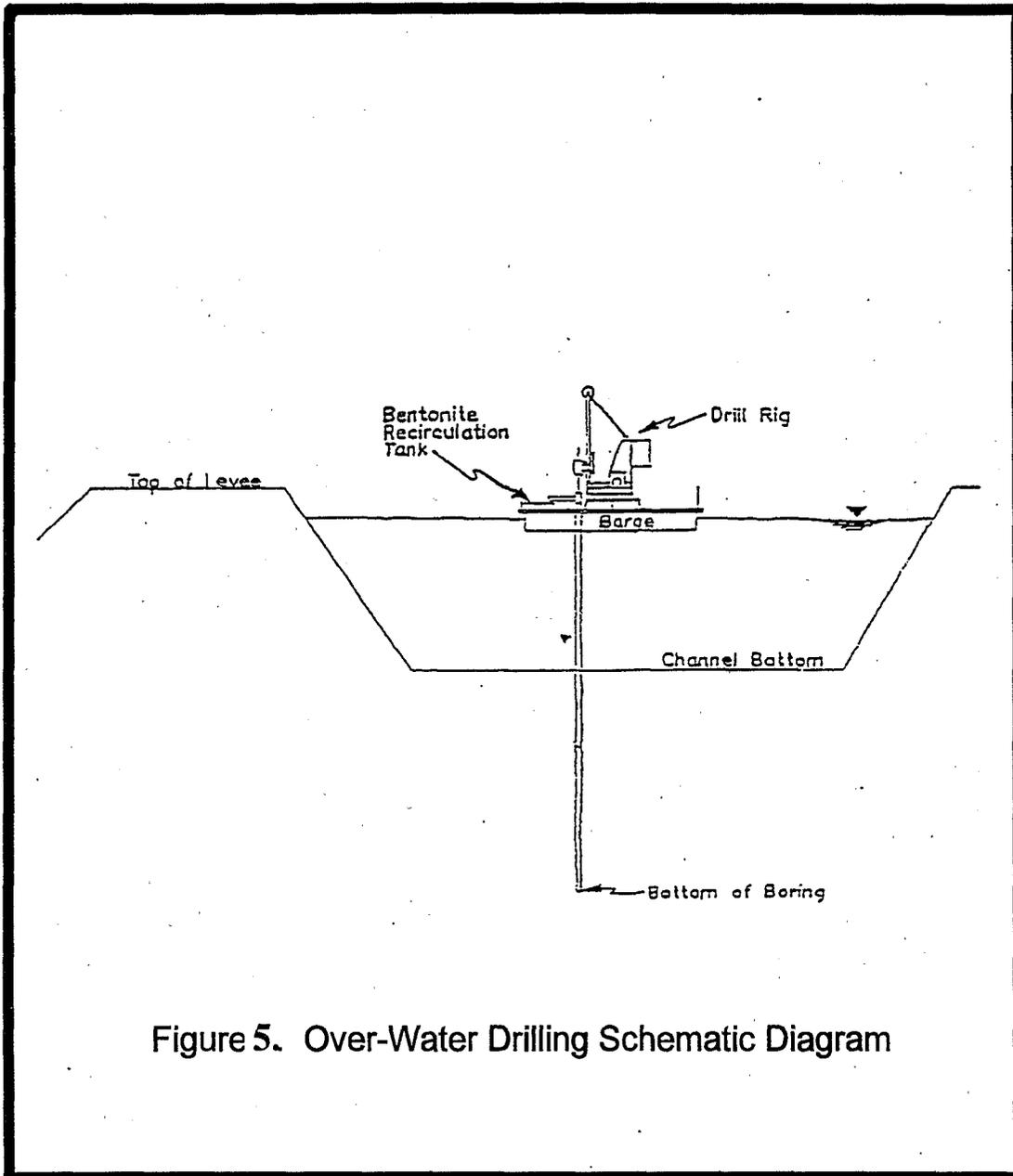


Figure 5. Over-Water Drilling Schematic Diagram

Quality Assurance/Quality Control

PACE Inc. was contracted to analyze the sediment, equipment blank samples, and tributyltin in water. CL Technology and Quality Assurance Laboratory, subcontracted by PACE Inc. analyzed the sediment and soil for TBT. DWR Bryte Chemical Laboratory analyzed the channel water samples. Acid generation potential tests were performed by ETS, Environmental Technical Services, Petaluma, California. Acute toxicity tests (Staten Island 92 and 93) were performed by Aqua Terra Technologies, Walnut Creek, California.

Quality Control for Water Analysis

Field Quality Control

The field quality control samples consisted of duplicates and field blanks. During the collection of water samples, the field crew collected one duplicate for every ten samples collected. To prepare the labor duplicate a composite sample was thoroughly homogenized. The homogenized samples were split into two samples which were analyzed separately. The results are used to assess the precision in the sampling and analytical procedures.

The field crew collected one field blank a day per sampling event. The field blanks consisted of distilled water that was exposed to the sampling environment. One field blank was transferred to a clean sample container without being filtered, while the other field blank was filtered through the field filtering apparatus and then transferred to a clean sample container. The field blanks measure incidental sample contamination during the sample transport, storage, preparation, and analysis process.

The duplicates and field blanks were analyzed along with the collected samples, without the analytical laboratory being aware of the sample identity. EPA methods for sample collection, preservation, handling and storage were followed.

Laboratory Quality Control

Laboratory quality control procedures listed in EPA methods were followed. This included the analysis of a blank sample (distilled water) and a matrix spike along with every batch processed.

Quality Control for Sediment Analysis

Field Quality Control

EPA methods for sample collection, preservation and handling of sediment material were followed. Equipment blanks were made by collecting the distilled water used to rinse sampling equipment (rinsate) prior to sampling (See Figure 6). These equipment blanks, which were taken between sampling sites, are used as a qualitative check for contamination that may have occurred through contact with the sampling equipment. These equipment blank samples were sent to PACE laboratory for analysis (Table 5). Potential sources of contamination include metal paint from painted equipment and surface corrosion products. Equipment blanks are also used to check for potential cross contamination of samples.

Laboratory Quality Control

The EPA methods include detailed quality control procedures which were followed by the analytical laboratory. These procedures include specific requirements for the analysis of spike and duplicate laboratory control samples; the use of surrogate samples, and the maximum holding times for environmental samples.

Figure 6. Equipment Blank Collections

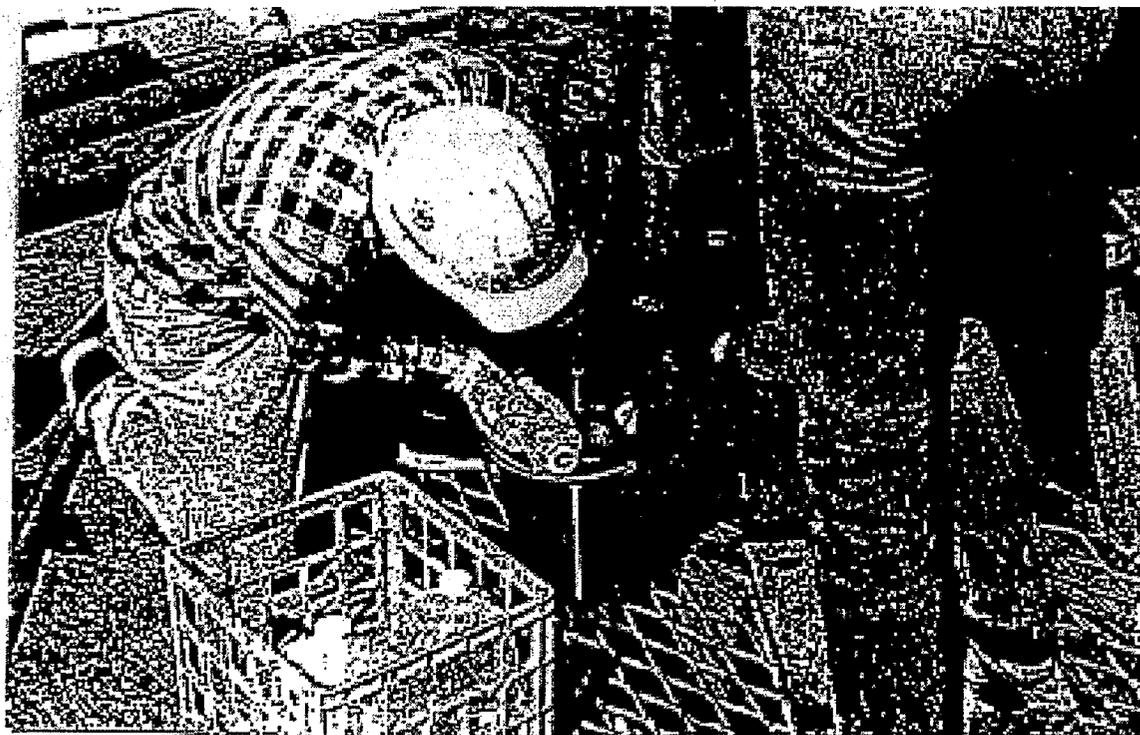


Table 5. Parameters for Chemical Analysis of Equipment Blank Samples

Constituent	Units	PACE Reporting Limit	EPA Test Method
Pesticides & PCB's			
Aldrin	µg/L	0.01	608
BHC - alpha	µg/L	0.01	0.01
BHC - beta	µg/L	0.03	608
BHC - delta	µg/L	0.01	608
BHC - gamma	µg/L	0.01	608
PCB - 1016	µg/L	2.0	608
PCB - 1221	µg/L	2.0	608
PCB - 1232	µg/L	2.0	608
PCB - 1242	µg/L	2.0	608
PCB - 1248	µg/L	2.0	608
PCB - 1254	µg/L	1.0	608
PCB - 1260	µg/L	1.0	608
Chlordane	µg/L	0.5	608
DDD	µg/L	0.01	608
DDE	µg/L	0.01	608
DDT	µg/L	0.02	608
Dieldrin	µg/L	0.01	608
Endosulfan I	µg/L	0.01	608
Endosulfan II	µg/L	0.01	608
Endosulfan Sulfate	µg/L	0.02	608
Endrin	µg/L	0.01	608
Endrin Aldehyde	µg/L	0.02	608
Heptachlor	µg/L	0.01	608
Heptachlor Epoxide	µg/L	0.01	608
Methoxychlor	µg/L	0.5	608
Toxaphene	µg/L	0.8	608
Trace Metals			

Table 5. Parameters for Chemical Analysis of Equipment Blank Samples, cont'd

Arsenic	mg/L	0.005	7060
Cadmium	mg/L	0.005	6010
Chromium	mg/L	0.02	6010
Copper	mg/L	0.01	6010
Lead	mg/L	0.1	6010
Mercury	mg/L	0.0002	7471
Nickel	mg/L	0.02	6010
Selenium	mg/L	0.1	7740
Silver	mg/L	0.005	6010
Zinc	mg/L	0.01	6010
Other Inorganics			
pH	units	0.1	9045
Total Oil and Grease	mg/L	5.0	9071

Quality Control for Soil Analysis

Field Quality Control

EPA methods for sample collection, preservation and handling of soil were followed. As with the sediment samples, equipment blanks were collected between sampling sites.

Laboratory Quality Control

The laboratory followed the quality control procedures required by the appropriate EPA methods.

Data Quality Assessment

Sample Representativeness

The INDP is evaluating four alternatives which cover a large portion of the North Delta. The purpose of this survey was to evaluate the current water, sediment and soil conditions in an area which could encompass all possible sites. The project was not intended to be a comprehensive evaluation of the sediment, soil and water quality. Sediment samples were collected from sixteen sites in the Delta channels. Soil samples were collected from the backside of levees at nineteen different sites. Water samples were collected from thirteen sites.

Laboratory Data Validation

A data quality assessment was performed on all the data to determine whether the data collected were acceptable for the intended use. Laboratory data were evaluated for precision, accuracy, and comparability. Laboratory methods, procedures and quality control data were reviewed to assess data quality. The results of the data quality assessment indicate that overall the data are of good quality. However, there were a few instances where the data did not meet the quality requirements. If the data was found not to conform to the quality requirements it was either 1) tagged and not included in our evaluation of the results or 2) used in our evaluation but marked as estimated due to possibility of bias. A detailed discussion of the assessment follows.

Several laboratory control sample (LCS) recoveries were found to be below the laboratory quality control (QC) limits. Laboratory control samples provide information about how close to the "true" value sample results are likely to be. Laboratory control samples are prepared by adding a known concentration of method analyte(s) to a clean matrix. Generally, one laboratory control sample is prepared for every ten samples, otherwise known as a "batch". PACE's laboratory control limit for recovery of inorganic laboratory control samples in water and soil is 80-120 percent. Several sediment samples analyzed for arsenic had LCS recoveries of 79 percent, below the

laboratory control limits. However, the duplicate LCS recoveries were 83 percent, within the limits. Since the LCS recovery was only slightly below the acceptable recovery limit, and the duplicate recovery was within the limits, the data was considered acceptable for use in this study. However, the data were tagged as estimated due to potentially low bias. Three water samples analyzed for arsenic had LCS recovery below the laboratory control limits (71 percent). However the duplicate LCS recovery was 84 percent. As with the sediment results, the water results are considered acceptable for use in this study, but were tagged as estimated. Three sediment samples were extracted using the Waste Extraction Test. The resulting leachate was analyzed for inorganics including arsenic. The LCS and duplicate LCS recovery for arsenic was 70 and 73 percent. These recoveries are below the control limit of 80-120 percent. Therefore, the sample results were tagged as estimated.

Comparison of duplicate sample results provides information about the precision of the analyses. The relative percent difference (RPD) of the duplicates was compared to a laboratory control limit. The laboratory RPD limit for LCS duplicates is 20% for inorganics in water and soil. None of the LCS duplicate samples had RPDs greater than 20%.

Several samples were found to exceed the U.S. EPA's maximum holding time for the method of analysis. Four sediment samples were analyzed for mercury (EPA Method 7471) one day past the maximum holding time (28 days). Since the holding time was only exceeded by one day, the samples were used in the study, but were tagged as estimated due to potentially low bias. One water sample analyzed for chlorinated pesticides and PCBs (EPA Method 8080) was held one day past the maximum holding time for extraction (7 days). Since the holding time was only slightly exceeded, it was considered acceptable for use in this study, but was tagged as estimated. One sediment sample analyzed for chlorinated pesticides and PCB's (EPA Method 8080) was held one day past the maximum holding time (14 days). As with the water sample, it is considered acceptable for use but is tagged as estimated. Three sediment samples extracted using the Waste Extraction Test and analyzed for mercury were held 107 days before analysis. The maximum holding time for mercury analysis in water and sediment is 28 days. Therefore the samples were held 79 days past the holding time. Due to the large discrepancy in holding times, the WET results for mercury are not considered acceptable for use in our study and are not reported.

Field Blanks

Four field blanks were sent to the DWR's Bryte Chemical Laboratory for analysis. Two of the blanks were filtered, the other two were not. The blanks were analyzed for trace metals. Results of the analyses found non-detectable concentrations for all constituents measured indicating that no significant or detectable contamination occurred during the sampling process (See Table 3 for reporting limits).

Equipment Blanks

The purpose of the equipment blanks was to determine possible sampling equipment contamination which could affect the sample integrity. Equipment blanks were taken during sediment and soil sampling. The equipment blanks were analyzed for the same constituents as the sediment and soil samples (Table 5). A total of 29 equipment blanks were collected: 15 during sediment sampling, 3 during levee soil sampling, 10 during drill sampling, and 1 during inland soil sampling.

The results of the organic analyses of the equipment blanks showed non-detectable concentrations for all the parameters tested (See Table 3 for reporting limits). This indicates that there was no contamination of the sampling equipment by these organic parameters. Unlike the organics, a few metals were found at detectable concentrations in the equipment blanks. Silver was found in one equipment blank sample at a concentration of 0.012 mg/L. However, no silver was detected in the sediment sample. Therefore, the contamination did not appear to have an effect on the sample integrity. Mercury and zinc were found in several equipment blanks (See Table 6). Mercury was found in concentrations ranging from 0.0002 to 0.001 mg/L. This indicates that there may have been a source of mercury contamination in the sediment and/or the soil sampling equipment. However, the concentrations are very low and are not likely to bias the samples. For instance, two sites found to have mercury contamination in the equipment blanks had non-detectable concentrations in the sediment samples. As with mercury, zinc was found in both the soil and sediment equipment blanks. Concentrations ranged from 0.01 to 0.03 mg/L. Again, these concentrations are very low and are not likely to cause sample bias.

Field Duplicates

Duplicate water samples were collected at two sites. The duplicate samples were analyzed for the same parameters as the other water samples. The results were evaluated by calculating the relative percent difference (RPD) of the duplicate sample results. The sample results and the RPDs are listed in Table 7. In cases where both samples had non-detectable concentrations of a parameter, that parameter was not listed in Table 7.

**Table 6. Equipment Blank Results
(values in mg/L)**

Site	Mercury	Zinc
Sediment Samples		
1	0.0002	0.03
2		0.02
3	0.0003	
4	0.0004	
5	0.0005	
6	0.0007	0.07
7	0.0005	0.017
8	0.0004	
9	0.0006	
11A1		0.03
11A2		0.03
10	0.0004	
13	0.0004	0.02
Levee Samples		
1	0.0010	
Inland Samples		
17	0.0007	
Drill Samples		
8		0.01
9	0.0002	

As a general rule for duplicate water samples, a RPD of up to 25% is acceptable for inorganics and other miscellaneous water quality parameters such as pH, suspended solids, etc. Reviewing the duplicate sample results in Table 7 shows that the majority of parameters have RPDs below 25%. However, there are a couple of exceptions. Both Site 1 and Site 7 duplicates had RPDs above 25% for aluminum and iron. This indicates there may be a problem with either the field sampling procedures or the laboratory analytical procedures. As a corrective action, the aluminum and iron sample results will be tagged as questionable.

Table 7. Duplicate Water Sample Results

Parameter	Site 1	Site 1 dup.	RPD	Site 7	Site 7 dup	RPD
Aluminum	0.028	0.02	33	0.025	0.019	27
Arsenic	0.002	0.002	0	0.002	0.002	0
Calcium	13	13	0	13	13	0
Chloride	10	10	0	12		
Hardness	66	66	0	66	66	0
Magnesium	8	8	0	8	8	0
Nitrate	3.2	3.4	6	2.8		
Sodium	13	13	0	13		
Dissolved Solids	109	109	0	112	110	2
Sulfate	11	11	0	11		
Total Alkalinity	61	60	2	62		
Iron	0.044	0.032	32	0.035	0.049	33
Manganese	0.017	0.016	6	0.014	0.014	0
EC	184	32	0	190	189	1
Suspended Solids	7.0	9	25	9	9	0

Results and Discussion

Surface Water

The results of the water sample analyses were compared to standards for the protection of aquatic life and human health. These include the California Inland Surface Waters Plan Water Quality Objectives (WQO) for the protection of aquatic life (4-day average), and the U. S. Environmental Protection Agency and California Department of Health Services Maximum Contaminant Levels (MCL) for the protection of drinking water. When comparing the results to the federal and State MCLs the more stringent of the two criteria was used. In some cases, the WQO may be lower than the laboratory method detection limit, and a constituent cannot be detected at low enough concentrations to determine compliance with the WQO.

The Central Valley Regional Water Quality Control Board has established a list of acceptable laboratory methods for analyses. According to the CVRWQCB, if the appropriate method of analyses is used and the laboratory makes a diligent effort to achieve the lowest possible detection limit, a non-detectable concentration will be considered in compliance, even if the reporting limit (RL) is above the WQO. Table 8 contains a list of the WQOs, the CVRWQCB approved laboratory methods, and the MCLs.

Organic Analyses

Results of the pesticide and polychlorinated biphenyl (PCB) analyses revealed non-detectable results for all sites. Since the appropriate method of analysis as recommended by the CVRWQCB was used, the non-detectable results are considered in compliance with the WQOs. Comparison of the reporting limits with the MCLs shows that the laboratory reporting limits for some parameters were too high to determine compliance with the MCL. As a general rule, to accurately determine compliance with a MCL, the reporting limit for that parameter should be three to five times lower than the respective MCL. Reporting limits are adjusted by the laboratory depending on the sample matrix and the reliability of the measurement. Three pesticides had reporting limits that were too high to determine compliance: Chlordane (RL = 0.05 $\mu\text{g/L}$), Heptachlor (RL = 0.01 $\mu\text{g/L}$), and Heptachlor Epoxide (RL = 0.01 $\mu\text{g/L}$).

Table 8. Water Quality Standards

Constituent	Water Quality Objective ($\mu\text{g/L}$)	RWQCB Approved EPA Method	Drinking Water Primary MCL (mg/L)
Aluminum			1
Antimony			0.006
Arsenic	190	206.3	0.05
Barium			1
Beryllium			0.004
Cadmium	0.55	213.2	0.005
Chloride			
Chromium	11	218.2	
Copper	5.4	220.2	250 ^a
Cyanide	5.2	335.2 or 335.3	0.05
Fluoride			1.3
Iron			0.2
Lead	0.99	239.2	1.4-2.4 ^b
Manganese			0.05 ^a
Mercury			0.002
Nickel	73	200.7	0.1
Nitrate			10
Nitrite			0
Total Nitrate and Nitrite			10
pH			6.5-8.5 ^a
Selenium	5.0	270.3	0.01
Silver			0.05
Sulfate			250 ^a
TBT	0.02	**	
Thallium			0.002
Total Dissolved Solids (TDS)			500 ^a

Table 8. Water Quality Standards, cont'd

Constituent	Water Quality Objective ($\mu\text{g/L}$)	RWQCB Approved EPA Method	Drinking Water Primary MCL (mg/L)
Zinc	49	200.7	5.0 ^a
Alachlor			0.002
Aldrin			
Atrazine			0.003
BHC - alpha			
BHC - beta			
BHC - delta			
BHC - gamma	0.08*		
Captan			
Chlordane	0.0043*		0.0001
Chlorothalonil			
Chlorpropham			
Chlorpyrifos			
DCPA			
4,4 DDD	0.001*		
4,4 DDE	0.001*		
4,4 DDT	0.001*	608	
Dichloran			
Dicofol			
Dieldrin	0.0019	608	
Diuron			
Endosulfan I	0.056	608	
Endosulfan II	0.056	608	
Endosulfan Sulfate	0.056	608	
Endrin	0.0023	608	0.0002
Endrin Aldehyde			

Table 8. Water Quality Standards, cont'd

Constituent	Water Quality Objective (µg/L)	RWQCB Approved EPA Method	Drinking Water Primary MCL (mg/L)
Heptachlor	0.0038	608	0.00001
Heptachlor Epoxide			0.00001
Methoxychlor			0.04
PCB's(total)	0.014 ^a	608	0.0005
PCNB			
Simazine			0.004
Thiobencarb			0.07
Toxaphene	0.0002	608	0.003

* - Daily Average

** - Submit Test Method for Approval

MFL - Million Fibers per Liter

^a - Secondary MCL

^b - Depends on annual average of maximum daily air temperatures

^c - 1 NTU (Nephelometric Turbidity Unit); monthly average, 5 NTU two-day consecutive average

Trace Metal Analyses

Several of the trace metals were found in non-detectable concentrations. Most of the reporting limits were low enough to determine compliance with the WQO or MCL. Cadmium and mercury had reporting limits (0.005 mg/L and 0.001 mg/L, respectively) that were too high to determine compliance with the MCLs. However, both metals were in compliance with the WQOs. None of the detectable trace metals were found in concentrations exceeding their respective WQO or MCL. (Figures 7 through 10).

Mineral Analyses

A few minerals were found in detectable concentrations including nitrate, sulfate and total dissolved solids (Figures 11-13). Nitrate was found to exceed the MCL (10 mg/L) at one site (54 mg/L). No other sites had nitrate concentrations that exceeded the MCL. The sulfate and total dissolved solids concentrations were all less than the respective MCLs.

Tributyltin Analyses

Results of the tributyltin (TBT) analyses revealed non-detectable results for all samples, with a reporting limit of 0.10 $\mu\text{g/L}$. The WQO for TBT is 0.02 $\mu\text{g/L}$. At this time, no standard test method for TBT exists. The methodology is developed by each individual laboratory. Non-detectable values are considered in compliance with the CVRWQCB WQO.

Figure 7. Aluminum Concentrations in Water Samples

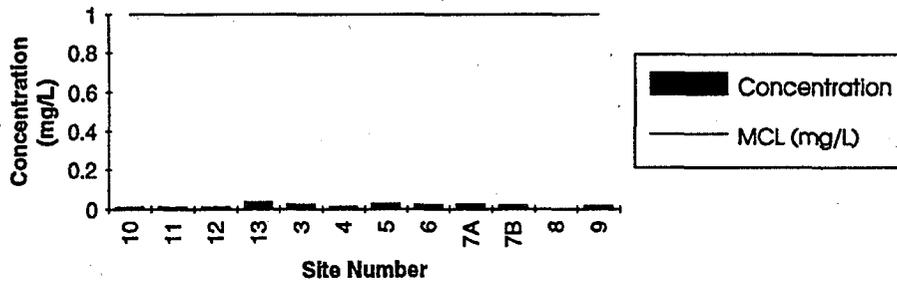


Figure 8. Arsenic Concentrations in Water Samples

MCL = 0.05 mg/L

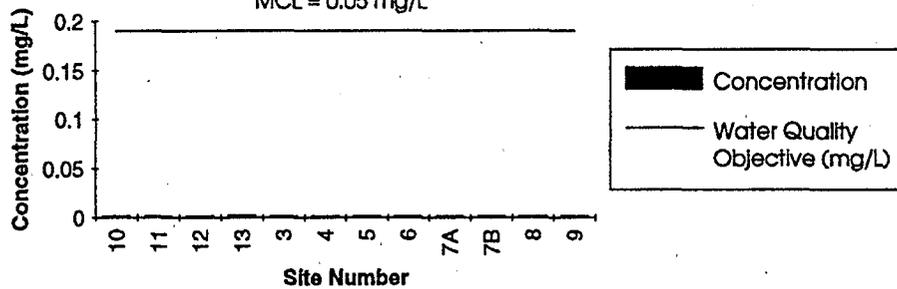


Figure 9. Iron Concentrations in Water Samples

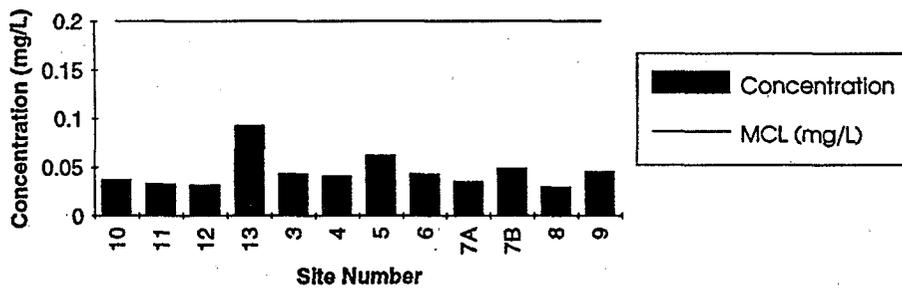


Figure 10. Manganese Concentrations in Water Samples

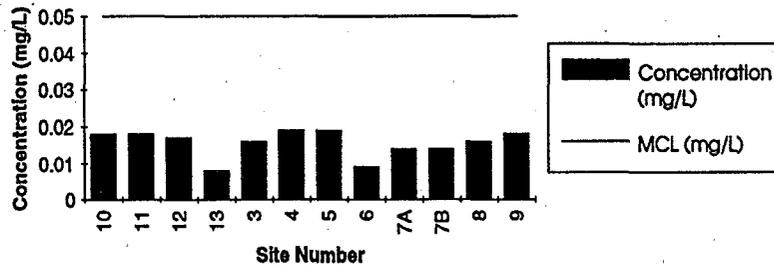


Figure 11. Nitrate Concentrations in Water Samples

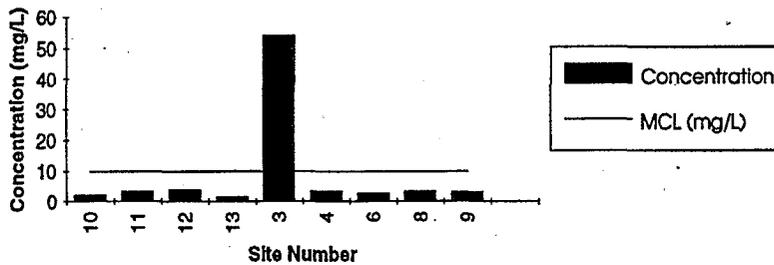


Figure 12. Sulfate Concentrations in Water Samples

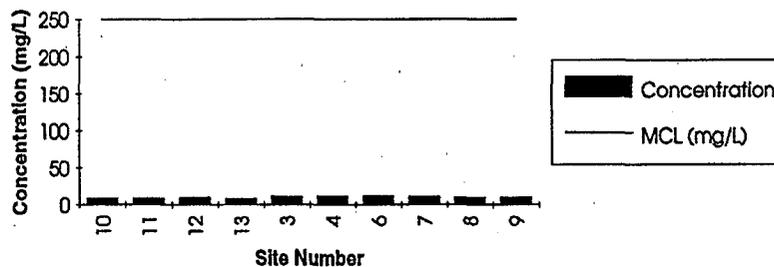
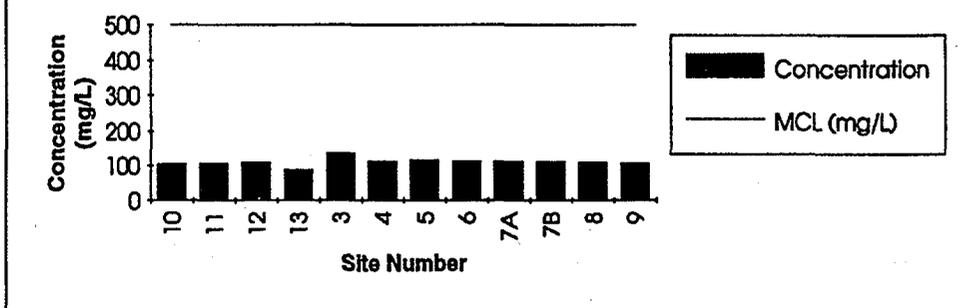


Figure 13. Total Dissolved Solids Concentrations in Water Samples



Channel Sediment

In an effort to evaluate the quality of the sediment data, we compared the data to enforceable, and non-enforceable California and federal sediment criteria. The California Total Threshold Limit Concentration and Soluble Threshold Limit Concentration are the only existing enforceable criteria that can be applied to dredged sediment. Under Title 22 of the California Code of Regulations, these criteria are used to classify waste as hazardous or non-hazardous in the State of California. Non-enforceable criteria applied include the San Francisco Bay Regional Water Quality Control Board's Disposal Option Sediment Screening Criteria for Levee Restoration. They are used as a guideline for dredged material disposal and apply only to areas within the San Francisco Bay Region. However, these criteria were applied in this study in absence of any criteria developed or adopted by the Central Valley Regional Water Quality Control Board. Also used were the U. S. Environmental Protection Agency's Sediment Quality Criteria. These are proposed criteria for the protection of benthic organisms from chemicals associated with sediment. A list of the criteria and a description of each is provided in Table 9.

Organic Analyses

Review of the sediment results revealed that, with three exceptions, all of the organic analyses had non-detectable results. Site 1 was found to have detectable concentrations of DDD at 0.0023 mg/kg wet weight or 0.0035 mg/kg dry weight; and DDE at 0.0032 mg/kg wet weight or 0.0049 mg/kg dry weight. Site 7 was found to have DDE at concentrations of 0.0035 mg/kg wet weight or 0.0072 mg/kg dry weight DDE. All results were below the respective RWQCB and TTLC criteria.

In order to compare non-detectable results to the criteria, the reporting limits must be expressed in the same units as the criteria. The laboratory reports the analytical results in units of mg/kg (or $\mu\text{g}/\text{kg}$) wet weight. In the case of the RWQCB criteria, the laboratory data must be converted to dry weight. In the case of the EPA criteria, the criteria is converted from $\mu\text{g}/\text{g}_{\text{oc}}$ to $\mu\text{g}/\text{kg}$.

Table 9. Sediment Standards and Criteria
(values in mg/kg, dry weight unless otherwise noted)

Contaminants	TTLC (wet wt.)	STLC (mg/L)	Wisc. Criteria	Ontario's Prov. Sediment Quality Guidelines			U.S. EPA SQC (ug/g _{oc})	CA RWQCB Criteria
				NEL	LEL	SEL (ug/g _{oc}) (organics only)		
Arsenic	500	5.0	10		6	33		3.3
Cadmium	100	1.0	1.0		0.6	10		5.0
Chromium	2500	5	100		26	110		220
Copper	2500	25	100		16	110		90
Lead	1000	5.0	50		31	250		50
Mercury	20	0.2	0.1		0.2	2.0		0.35
Nickel	2000	20	100		16	75		140
Selenium	100	1.0	1.0					0.7
Silver	500	5						1.0
Zinc	5000	250	100		120	820		160
Aldrin	1.4	0.14	0.01		0.002	8.0		0.8
BHC - alpha					0.006	10		1.0
BHC - beta					0.005	21		21
BHC - gamma								
BHC - delta								
Dieldrin	8.0	0.08	0.01	0.0006	0.002	91	9.03	91
4,4 DDE	1.0	0.1			0.005	19		19
4,4 DDD	1.0	0.1			0.008	6.0		6.0
4,4 DDT	1.0	0.1	0.01		0.007	12		12
Endosulfan Sulfate								
Endosulfan I								
Endosulfan II								
Endrin	0.2	0.02	0.05	0.0005	0.003	130	4.03	130

Table 9. Sediment Standards and Criteria, cont'd
(values in mg/kg, dry weight unless otherwise noted)

Contaminants	TTLC (wet wt.)	STLC (mg/L)	Wisc. Criteria	Ontario's Prov. Sediment Quality Guidelines			U.S. EPA SQC (ug/g _{oc})	CA RWQCB Criteria
				NEL	LEL	SEL (ug/g _{oc}) (organics only)		
Endrin Aldehyde								
Methoxychlor	100	10						
PCB (total)	50	5	0.05	0.01	0.07	530		53
PCB - 1016					0.007	53		
PCB - 1248					0.03	150		
PCB - 1254					0.06	34		
PCB - 1260					0.005	24		
Toxaphene	5	0.5	0.05					

TTLC: California Department of Toxic Substances and Control - Total Threshold Limit Concentrations. The TTLCs are standards set by the California Code of Regulations, Chapter 11. The TTLC represents the total concentration of a constituent that may be present before a waste is classified as a hazardous waste.

STLC: California Department of Toxic Substances and Control - Soluble Threshold Limit Concentrations. As with the TTLCs, the STLCs are standards set by the California Code of Regulations, Chapter 11. The STLC represents the amount of a constituent that may be present in the waste extract, as determined using the Waste Extraction Test (CCR, Division 4.5, Chapter 11, Appendix II) before a waste is classified as a hazardous waste.

Wisconsin Criteria: Wisconsin Department of Natural Resources - In-Water Sediment Disposal Criteria. Criteria developed to determine the suitability of dredged material for in-water disposal. Disposal of sediments in water is prohibited if concentrations of any of the contaminants are more than 125% of the criteria or if the concentrations of three or more contaminants are more than 110% of the criteria.

Ontario's Provincial Sediment Quality Guidelines: Ontario's Ministry of the Environment. These guidelines were developed for the protection of aquatic biological resources. They are designed to protect organisms that are directly impacted by contaminated sediment. They establish three levels of protection:

- No Effect Level (NEL) - Concentration at which no toxic effects have been observed in aquatic organisms.
- Lowest Effect Level (LEL) - Level of sediment contamination at which the majority of benthic organisms are unaffected.
- Severe Effect Level (SEL) - Level at which pronounced disturbance of the sediment dwelling community can be expected.

U.S. EPA SQC: U.S. Environmental Protection Agency - Proposed Sediment Quality Criteria. The SQC are proposed to provide protection of benthic organisms from biological impacts from chemicals associated with sediment. They are the EPA's best recommendation of the concentrations of a substance in sediment that will not unacceptably affect benthic organisms. The SQC are intended to apply to sediments permanently inundated with water, intertidal sediments, and to sediments inundated periodically for durations sufficient to permit development of benthic assemblages.

CA RWQCB Criteria: California Regional Water Quality Control Board - Disposal Option Sediment Screening Criteria for Levee Restoration. These criteria provide sediment screening criteria for the beneficial reuse of dredged material such as levee restoration. The criteria are set for the protection of biological organisms.

The reporting limits are converted to dry weight units using the percent moisture for each individual sample. This results in several different reporting limits for one analyte. In most cases the reporting limit was significantly below any of the sediment quality criteria. However, a few exceptions did occur. The reporting limit for DDT was 0.002 mg/kg wet weight. Converted to dry weight the reporting limit ranged from 0.0025 to 0.0133 mg/kg dry weight. The RWQCB criterion for DDT is 0.003 mg/kg dry weight. Eight of the sites had reporting limits (0.0031 to 0.013 mg/kg dry weight) that were too high to compare to the RWQCB criterion. The remainder of the sites had reporting limits (0.0025 to 0.0029 mg/kg dry weight) below the RWQCB criterion. All sites had reporting limits below the TTLC of 1.0 mg/kg wet weight.

The wet weight reporting limit for the polychlorinated biphenyls (PCBs) was 0.07 mg/kg wet weight for PCB-1016, -1221, -1232, -1242, and -1248, and 0.03 mg/kg wet weight for PCB-1254 and -1260. Converted to dry weight, the reporting limit ranged from 0.086 to 0.466 mg/kg dry weight for the PCBs -1016, -1221, -1232, -1242, and -1248, and 0.037 to 0.200 mg/kg dry weight for PCBs -1254 and -1260. The RWQCB criteria for total PCBs is 0.05 mg/kg dry weight. The reporting limits for PCBs -1016, -1221, -1232, -1242, and -1248 were all too high to provide comparison with the RWQCB criterion. Three of the sites had reporting limits for PCBs -1254 and -1260 that were too high to provide comparison with the RWQCB criterion. All sites had wet weight reporting limits low enough to compare with the TTLC (50 mg/kg wet weight).

The U.S. Environmental Protection Agency's Sediment Quality Criteria (SQC) are given in units of $\mu\text{g}/\text{g}_{\text{oc}}$ and, therefore, cannot be directly compared to the analytical results given in mg/kg without conversion. In order to convert the criteria to mg/kg units, the organic carbon content of the sediment samples must be known. The North Delta samples were not analyzed for organic carbon content; therefore, an estimate must be made. Figure 14 shows the composition of soils in the Sacramento-San Joaquin Delta area, and the approximate locations of the North Delta sediment sampling sites. The soils are divided into mineral soils, intermediate organics, and peaty organic. The range of organic carbon in these categories is 10% or less for mineral soils, 10-50% for intermediate organics, and 50-80% for peaty organics. Review of Figure 14 shows that the majority of the sampling sites occur in intermediate or peaty organic soils, with the exception of sites 12 and 13 which occur in a mineral soil area. Consequently, it is likely that the percent organic carbon in the majority of samples ranged from approximately 10-80%.

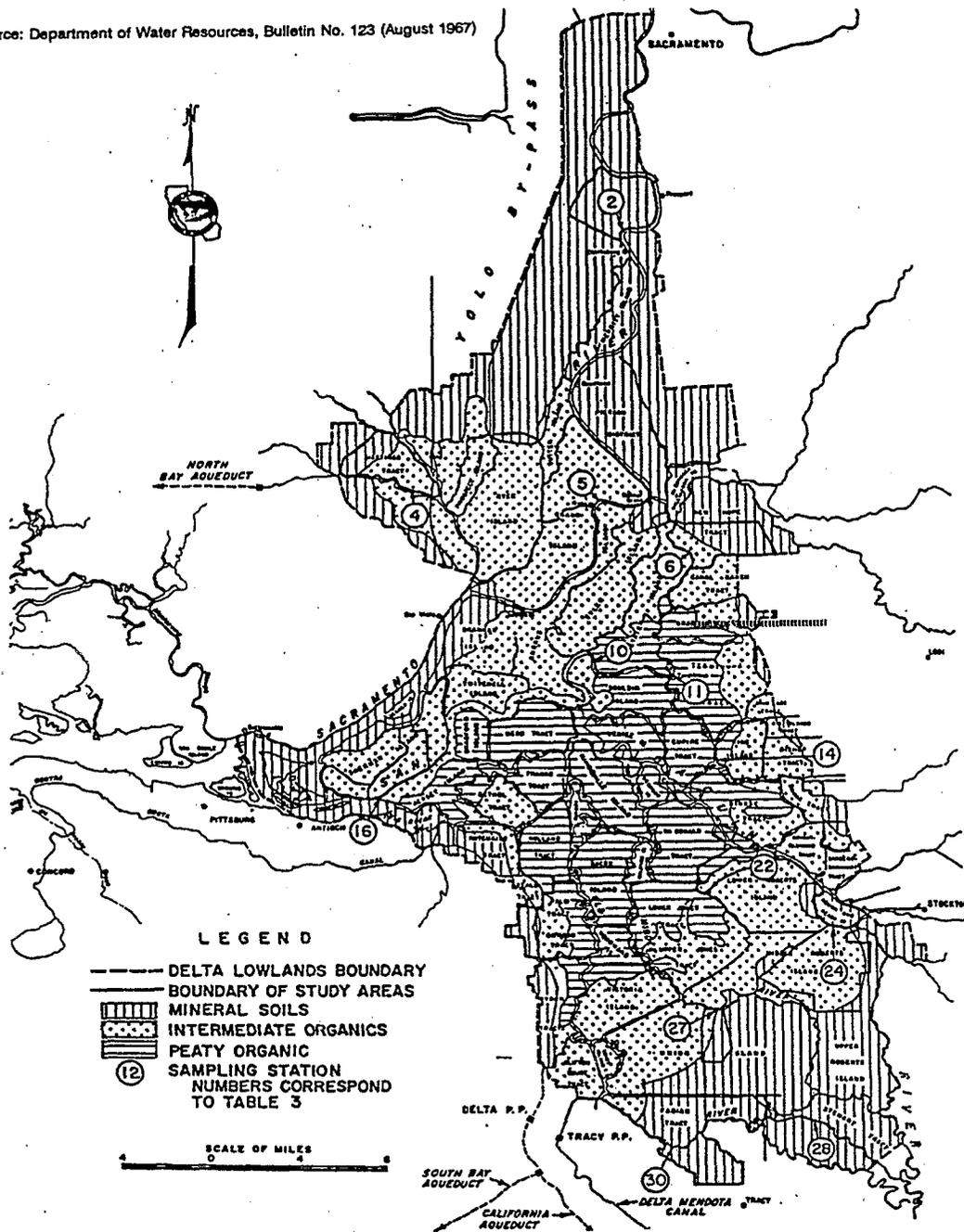


Figure 14. Composition and Distribution of Soils in the Sacramento-San Joaquin Delta Lowlands

The SQC are converted to mg/kg by multiplying the given value (in $\mu\text{g/gOC}$) by the percent organic carbon in the sample. The lower the percent organic carbon, the more stringent the resulting SQC. Since the exact amount of organic carbon in the samples is unknown, a worst case SQC value was calculated. Using an organic carbon content of 10%, SQC of 1.1 mg/kg wet weight for Dieldrin, and 0.420 mg/kg wet weight for Endrin were calculated. The reporting limit for both constituents was 0.0020 mg/kg wet weight. These reporting limits are low enough to provide comparison with the calculated SQC criteria. Since all results were not-detected, no sites exceeded the calculated SQC criteria.

Trace Metal Analyses

Unlike the organic parameters, detectable concentrations of metals were found at most sites. Arsenic was found in detectable concentrations at seven sites. It should be noted that thirteen of the sixteen sites had results with possibly low bias. The detectable concentrations ranged from 5.8 to 18 mg/kg wet weight and 7.8 to 25.0 mg/kg dry weight (Figure 15). The California Regional Water Quality Control Board (RWQCB) screening criterion for arsenic is 33 mg/kg dry weight. No sites exceeded the RWQCB criterion or the California TTLC (500 mg/kg wet weight).

Cadmium was not detected at any sites. The reporting limit was 1 mg/kg wet weight. Converted to dry weight the reporting limit ranged from 1.2 to 6.7 mg/kg dry weight. One sample had a dry weight reporting limit (6.7 mg/kg dry weight) that was too high to provide comparison with the RWQCB criterion (5.0 mg/kg dry weight). The reporting limits for the remaining samples (1.2 to 2.2 mg/kg dry weight) were below the RWQCB criterion. The wet weight reporting limit for all samples was below the TTLC (100 mg/kg wet weight).

Chromium was detected at all sites with concentrations ranging from 5 to 62 mg/kg wet weight and 6 to 81 mg/kg dry weight (Figure 16). No sites exceeded the RWQCB criterion of 220 mg/kg dry weight. The TTLC (2,500 mg/kg wet weight) was also not exceeded.

Copper was also found at all sites (Figure 17). Concentrations ranged from 5 to 50 mg/kg wet weight and 6 to 70 mg/kg dry weight. Neither the RWQCB criterion (90 mg/kg dry weight) nor the TTLC (2,500 mg/kg wet weight)

was exceeded at any sites.

Lead was only detected at four sites (Figure 18). Two sites were found to have 12 mg/kg lead wet weight, while the other two sites had 13 mg/kg lead wet weight. The dry weight concentrations ranged from 16 to 20 mg/kg dry weight. The RWQCB criterion for lead is 50 mg/kg dry weight. No sites were found to exceed the RWQCB criterion. No sites exceeded the TTLC (1,000 mg/kg wet weight).

Mercury was detected at thirteen sites. It should be noted that results for four of the sites are estimated for potentially low bias due to holding time exceedences (Figure 19). The detectable concentrations ranged from 0.02 to 0.18 mg/kg wet weight and 0.02 to 0.28 mg/kg dry weight. The RWQCB criterion of 0.35 mg/kg dry weight and the TTLC of 20 mg/kg wet weight were not exceeded.

Nickel was detected at all sites (Figure 20). The wet weight concentrations ranged from 5 to 86 mg/kg wet weight. The dry weight concentrations ranged from 6 to 111 mg/kg dry weight. Neither the RWQCB criterion (140 mg/kg dry weight) nor the TTLC (2,000 mg/kg wet weight) were exceeded.

Selenium was not detected at any sites. The wet weight reporting limit was 5 mg/kg wet weight. The dry weight reporting limit ranged from 6 to 33 mg/kg dry weight. These reporting limits are too high to provide comparison with the RWQCB criterion of 0.7 mg/kg dry weight. However, the reporting limits can be compared to the TTLC of 100 mg/kg wet weight.

Figure 15. Arsenic Concentrations in Sediment Samples

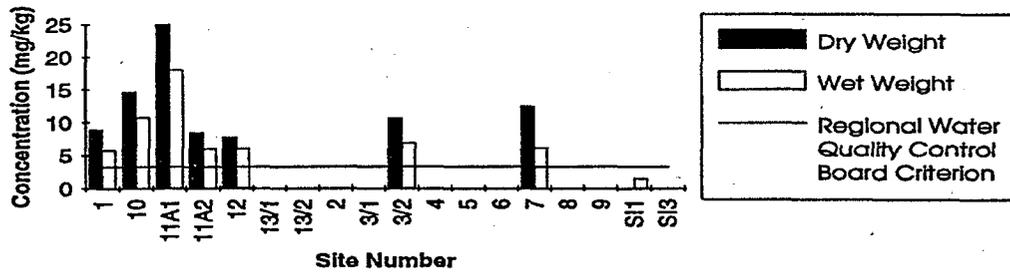


Figure 16. Chromium Concentrations in Sediment Samples

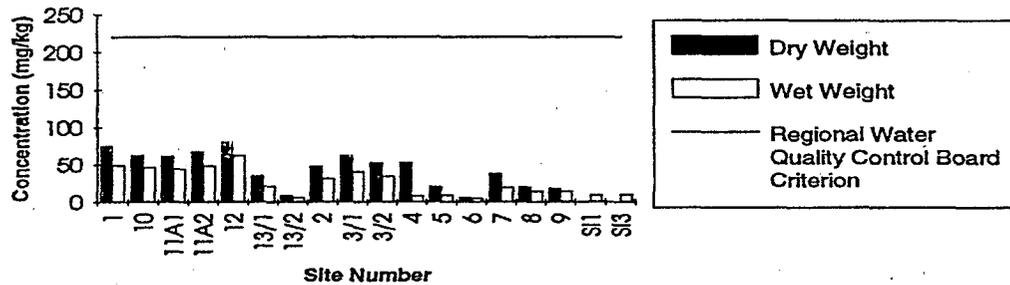


Figure 17. Copper Concentrations in Sediment Samples

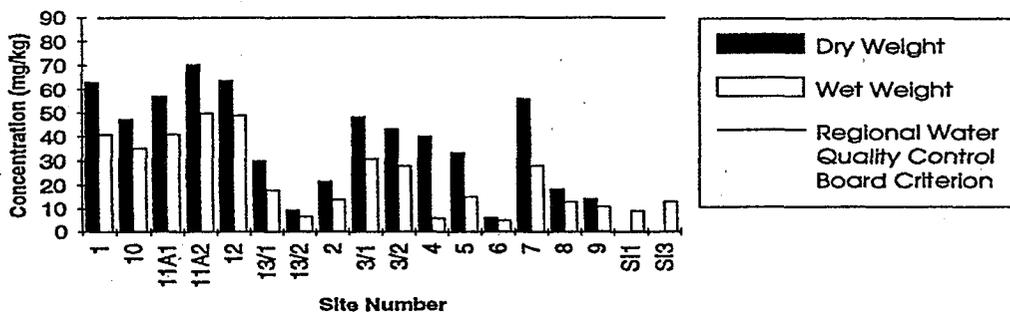


Figure 18. Lead Concentrations in Sediment Samples

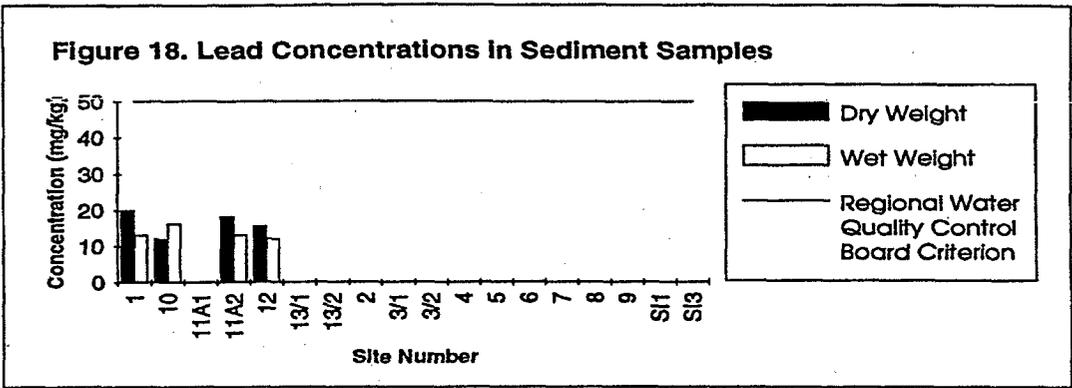


Figure 19. Mercury Concentrations in Sediment Samples

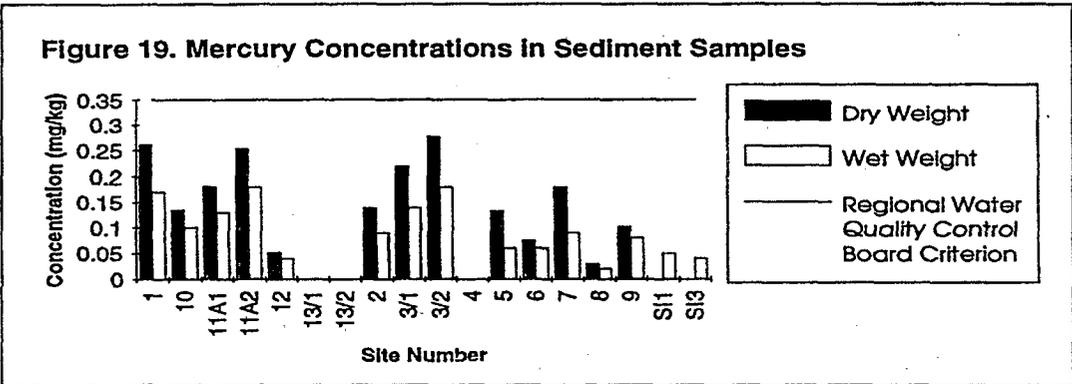
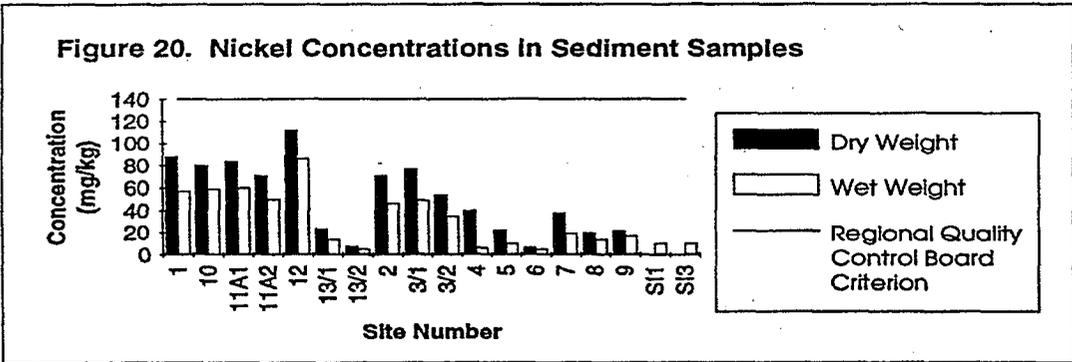


Figure 20. Nickel Concentrations in Sediment Samples



Zinc was detected at all sites (Figure 21). Concentrations ranged from 6 to 130 mg/kg wet weight and 40 to 200 mg/kg dry weight. Three sites exceeded the RWQCB criterion of 160 mg/kg dry weight. No sites exceeded the TTLC criterion (5,000 mg/kg wet weight).

Waste Extraction Test

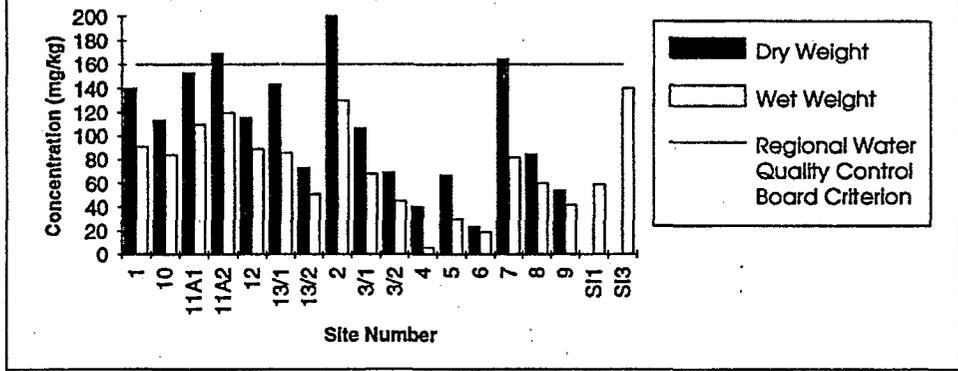
In addition to the above, three of the sediment samples (1, 11A1, and 12) were selected for analysis using the Waste Extraction Test (California Code of Regulations, Title 22, Chapter 11, Article 5). The WET is used to determine the amount of extractable metal in a sample. The resulting extract from the WET is analyzed for standard metals. The results of the WET are compared to the California Department of Toxic Substances and Control Soluble Threshold Limit Concentrations. All results were significantly below the associated STLC. However, the mercury results cannot be considered for comparison because of invalidation due to exceedence of EPA's maximum holding time for the method.

Since none of the constituents analyzed was found in concentrations exceeding their respective TTLC or STLC, the sediment is not considered hazardous waste under Title 22 of the California Code of Regulations.

Tributyltin Analyses

In addition to the above analyses, all sediment samples were analyzed for tributyltin (TBT). At this time, there is no standard EPA method for analysis, and no known sediment criterion for TBT. In an effort to evaluate the environmental samples, historical TBT data were used to establish background TBT concentrations in sediments (Table 10). The historical data are based on samples collected by the SWRCB, U.S. Navy, U.S. Corps of Engineers (USACE), and Ontario, Canada.

Figure 21. Zinc Concentrations in Sediment Samples



Sediment sample results showed non-detectable levels of TBT at all sites, with a reporting limit of 2.0 $\mu\text{g}/\text{kg}$ wet weight and 2.5 to 13.3 $\mu\text{g}/\text{kg}$ dry weight. The SWRCB's TBT range for sediments from coastal and delta water was 0.23 - 23 $\mu\text{g}/\text{kg}$ dry weight, while the range for Ontario sediment was 30 - 540 $\mu\text{g}/\text{kg}$ dry weight. The U.S. Navy sampled areas at Mare Island, CA and San Diego, CA for total butyltin. The areas were separated into naval, commercial and ecological habitat. The samples from the ecological habitat areas had total butyltin concentrations of 3.5 and 9.1 $\mu\text{g}/\text{kg}$ dry weight, respectively. The USACE sampled five sites near Alcatraz Island, CA for TBT to use as background levels for the area. The samples had TBT concentrations ranging from non-detectable to less than 1.3 $\mu\text{g}/\text{kg}$ dry weight. The reporting limit for the non-detectable samples was not provided. With the exception of the USACE values, the North Delta sediment samples appear to be well within the above background concentrations for TBT. The USACE value of 1.3 $\mu\text{g}/\text{kg}$ dry weight is below the reporting limit (2.5 to 13 $\mu\text{g}/\text{kg}$ dry weight) for the North Delta samples, so it is not possible to compare those results with the USACE values.

Acid Generation Potential

Analysis of acid forming potential and acid neutralizing potential was also done at all sites. These results can be used to predict the capability of a sediment to neutralize acids that may be generated. The acid forming potential is a measurement of the acid-producing forms of sulfur. These forms of sulfur are available to convert to sulfuric acid (H_2SO_4). The neutralizing potential is a measure of the neutralizing bases, such as carbonates, present in the soil. The acid generation potential is determined by dividing the measured neutralizing potential by the acid forming potential (N/A ratio). A quotient of one indicates that the two potentials are equal and the soil can neutralize all the acid produced. The Central Valley RWQCB has set a N/A quotient of three as the criteria for determining if a soil will become acidic. If the N/A ratio is greater than three, than the likelihood that the soil will become acidic is low. If the ratio less than three, the soil has the potential to become acidic. The criteria of three was selected to account for the greater leachability of the neutralizing minerals as compared to the acid forming minerals, and to account for the uneven distribution of these minerals.

Table 10. Butyltin Historical Sediment Data

Study	Sample Site	TBT	DBT	MBT	TTBT
		(ppb dry weight)			
SWRCB	CA Coastal and Delta Waters	0.23-23	0.26-27	0.36-60	
US Navy	Mare Island				
	Naval				4.6
	Commercial				4.7
	Ecological Habitat				3.5
	San Diego				
	Naval				87
	Commercial				178
	Ecological Habitat				9.1
US Corps of Engineers	Battelle, Jan 92	ND	0.6	1.0	
	Battelle, Jun 92	ND	ND	1.1	
	Battelle, Sept 92	ND	ND	ND	
	Oakland berths 7, 8, 9 & 25	<1.1	<1.1	<1.1	
	Port of SF Berth 35E	<1.3	<1.3	<1.3	
Canada	Ontario	30-540	9-350	14-580	

Site 12/1 has a N/A ratio of 1.4. Therefore, the acid neutralizing potential just slightly exceeds the acid generating potential, and a possibility of acidification exists. None of the metals at this site were found at concentrations exceeding the RWQCB or TTLC criteria. Therefore, even if acidification occurs, there is not likely to be a concern for metals release.

Site 3/2 has a N/A ratio of 2.4. This indicates a small a possibility of acidification. None of the sediment criteria were exceeded at this site. Consequently, the probability of a significant release of metals is small.

The remainder of the sites had N/A ration of three or greater. Acidification of the sediments at these sites is very unlikely because of the natural neutralizing ability of the sediment.

Levee Soil

The levee soil samples were collected from the backside of the existing levees. Under the proposed North Delta Plan the existing levees will become a series of islands. The RWQCB and EPA criteria used in the previous section (Table 9) apply to sediment only. However, since the levee soil has the potential to become partially inundated with water, the RWQCB and EPA criteria were considered applicable for use in this evaluation.

Organic Analyses

The majority of the organic constituents had non-detectable results. However, a few were found in detectable concentrations. DDD was found at five sites, in concentrations ranging from 0.0030 to 0.0067 mg/kg wet weight and 0.0032 to 0.0082 mg/kg dry weight. No sites exceeded the TTLC of 1.0 mg/kg. No RWQCB criterion exists for DDD.

DDE was also found at several sites. Wet weight concentrations ranged from 0.0027 to 0.0094 mg/kg wet weight. Concentrations in dry weight ranged from 0.0037 to 0.0118 mg/kg dry weight. The TTLC criterion (1.0 mg/kg wet weight) was not exceeded at any sites. As with DDD, no RWQCB criterion exists.

DDT was found at six sites in concentrations ranging from 0.0032 to 0.014 mg/kg wet weight and 0.0037 to 0.015 mg/kg dry weight (See Figure 22). All sites exceeded the RWQCB criteria of 0.003 mg/kg dry weight. However, no sites exceeded the TTLC of 1.0 mg/kg wet weight.

Dieldrin was found at five sites. Concentrations ranged from 0.0028 to 0.0073 mg/kg wet weight and 0.0035 to 0.0109 mg/kg dry weight. The EPA SQC for Dieldrin in the North Delta Project area is 1.1 mg/kg wet weight. No sites exceeded the SQC. The TTLC (8.0 mg/kg wet weight) was also not exceeded. No RWQCB criterion exists for Dieldrin.

The remainder of the organics had non-detectable results. With the exception of the PCBs, all the parameters had reporting limits low enough to provide comparison with the RWQCB and TTLC criteria. The reporting limit for the PCBs in the levee soil was the same as in the sediment. (Please refer to the previous section for a detailed discussion).

Trace Metal Analyses

Metals were detected at several sites (Figures 23 through 29). No metals were found to exceed their respective TTLC criterion. However, mercury and silver were found at concentrations exceeding the RWQCB criteria. Mercury concentrations ranged from 0.03 to 2.10 mg/kg wet weight and 0.04 to 2.29 mg/kg dry weight. Four sites were found to exceed the RWQCB criterion for mercury (0.35 mg/kg dry weight).

Silver was detected at three sites. Concentrations ranged from 1 to 3 mg/kg wet weight and 1.4 to 3.3 mg/kg dry weight. All detectable concentrations exceeded the RWQCB criterion of 1.0 mg/kg dry weight.

Cadmium and selenium were not detected at any sites. The reporting limit for selenium was 5.0 mg/kg wet weight and 5 to 9 mg/kg dry weight. These reporting limits are too high to provide comparison with the RWQCB criterion (0.7 mg/kg dry weight). However, the reporting limit was sufficiently low to provide comparison with the TTLC (100 mg/kg wet weight). The reporting limits for cadmium were below the RWQCB criterion. No sites

exceeded the TTLC for cadmium or selenium.

Tributyltin Analyses

As with sediment, no criteria were available for tributyltin in soil. Unfortunately, no historical values for TBT in soil could be found. Therefore, the historical sediment TBT concentrations were used to evaluate the soil results. The wet weight TBT values ranged from 2 to 38 $\mu\text{g}/\text{kg}$ wet weight (See Figure 30). The majority of the samples ranged from 2 to 14 $\mu\text{g}/\text{kg}$ wet weight, with site 17 having a concentration of 38 $\mu\text{g}/\text{kg}$ wet weight. The dry weight concentrations ranged from 2 to 48 $\mu\text{g}/\text{kg}$ dry weight, with most concentrations ranging between 2 and 16 $\mu\text{g}/\text{kg}$ dry weight. These values appear to generally be within the background sediment TBT values.

Drill Site Soil

The drill soil samples were taken from the proposed excavated channel sites. Since the samples represent the soil that will become the channel bottom, the RWQCB and EPA criteria, as well as the TTLC criteria, were used to evaluate the sample results.

Organic Analyses

Out of twenty six organic constituents that were analyzed for, only four constituents, beta-BHC, DDE, Dieldrin, and oil and grease, were found in detectable concentrations. Beta-BHC was found at one site (out of ten sites) at a concentration of 0.0040 mg/kg wet weight and 0.0091 mg/kg dry weight. Unfortunately, no criteria are available for evaluation of the beta-BHC results.

Figure 22. DDT Concentrations in Levee Soil Samples

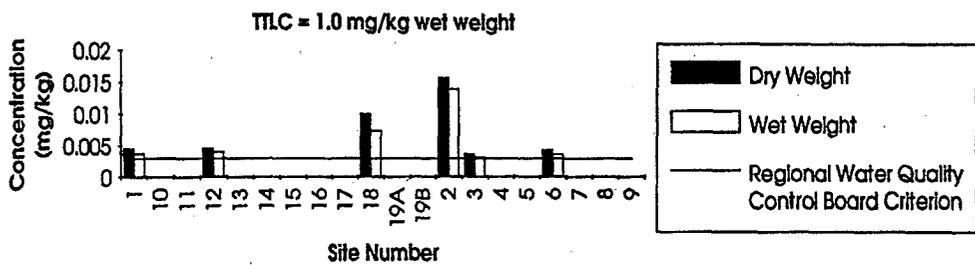


Figure 23. Arsenic Concentrations in Levee Soil

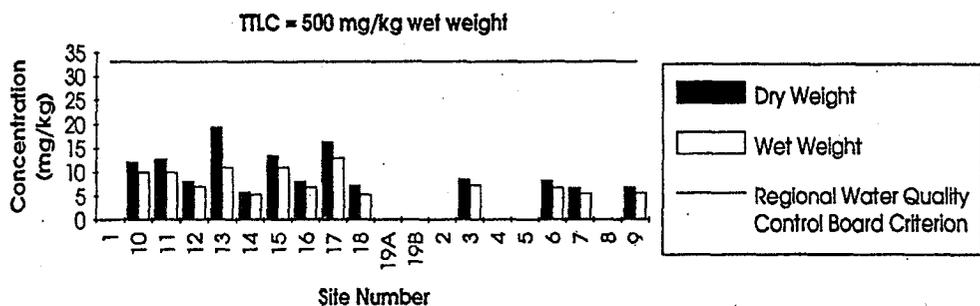


Figure 24. Chromium Concentrations in Levee Soil Samples

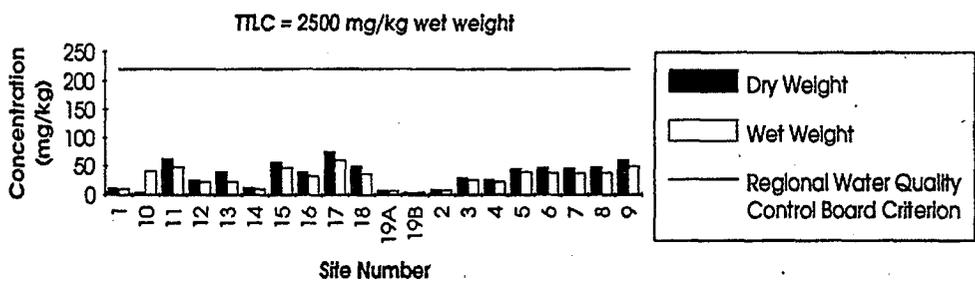


Figure 25. Copper Concentrations in Levee Soil Samples

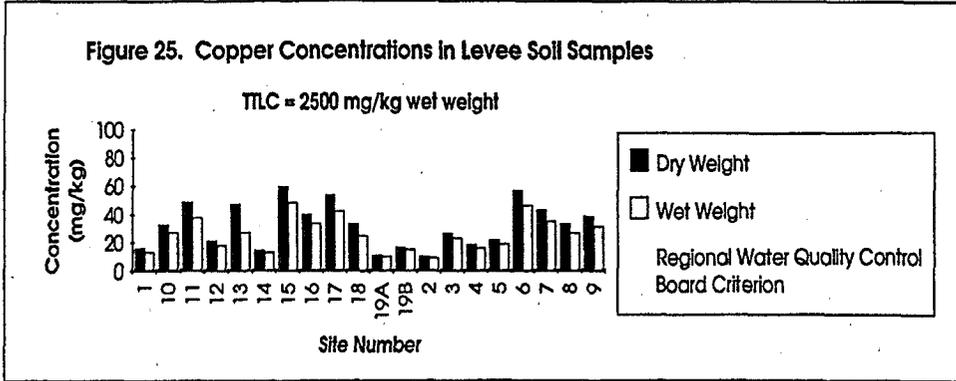


Figure 26. Lead Concentrations in Levee Soil Samples

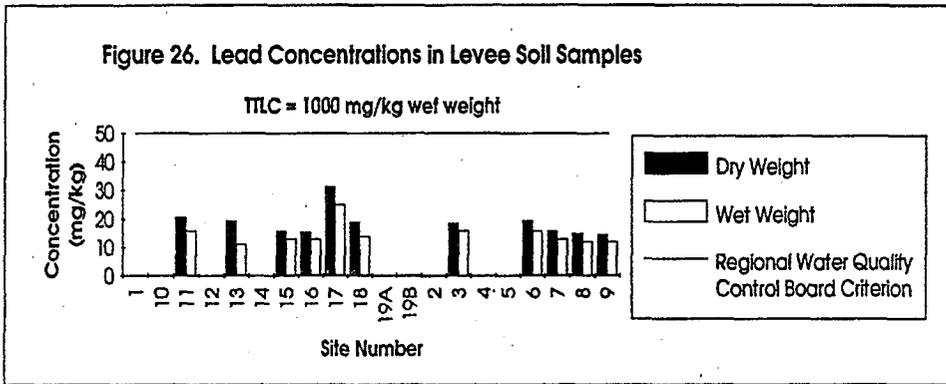


Figure 27. Mercury Concentrations in Levee Soil Samples

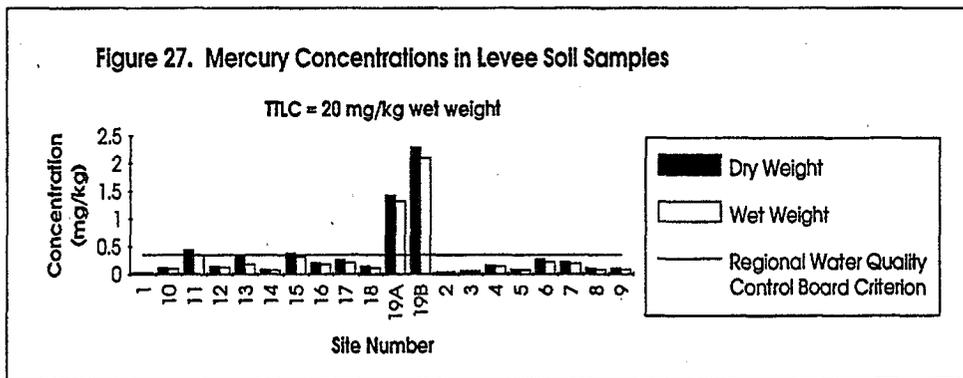


Figure 28. Nickel Concentrations in Levee Soil Samples

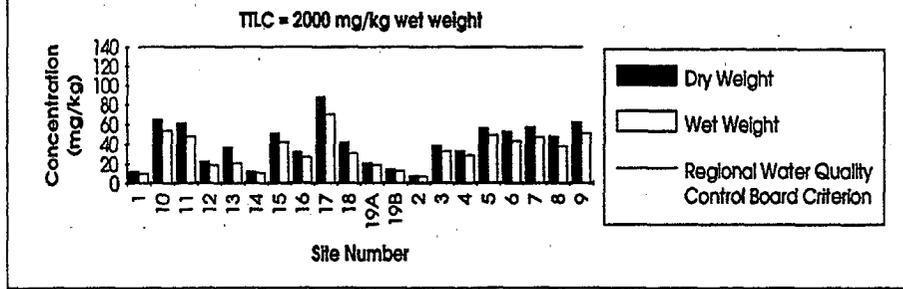


Figure 29. Silver Concentrations in Levee Soil Samples

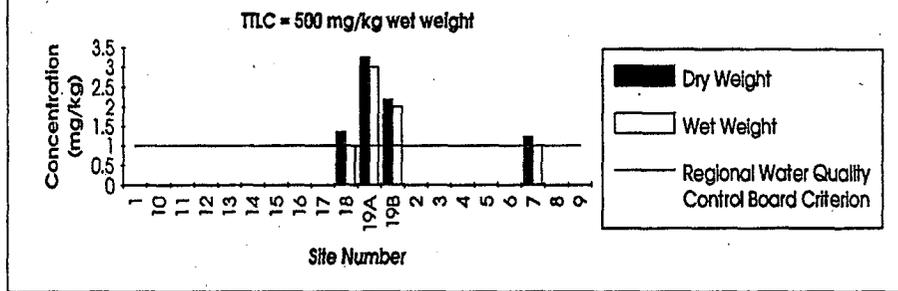
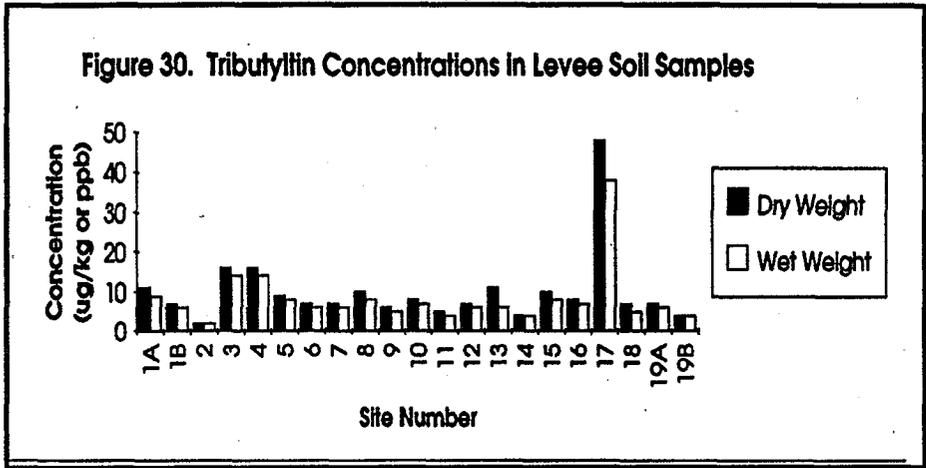


Figure 30. Tributyltin Concentrations in Levee Soil Samples



DDE was found at four sites (out of ten sites) in concentrations ranging from 0.0021 to 0.014 mg/kg wet weight and 0.0040 to 0.018 mg/kg dry weight (see Figure 31). No sites exceeded the TTLC for DDE of 1.0 mg/kg wet weight. No RWQCB sediment criterion exists for DDE.

Dieldrin was found at concentrations ranging from 0.007-0.085 mg/kg dry weight (0.009-0.110 mg/kg wet weight) at seven out of the ten sites (See Figure 32). The Dieldrin concentrations were much less than the TTLC (8.0 mg/kg wet weight) and no RWQCB sediment criterion exists for Dieldrin.

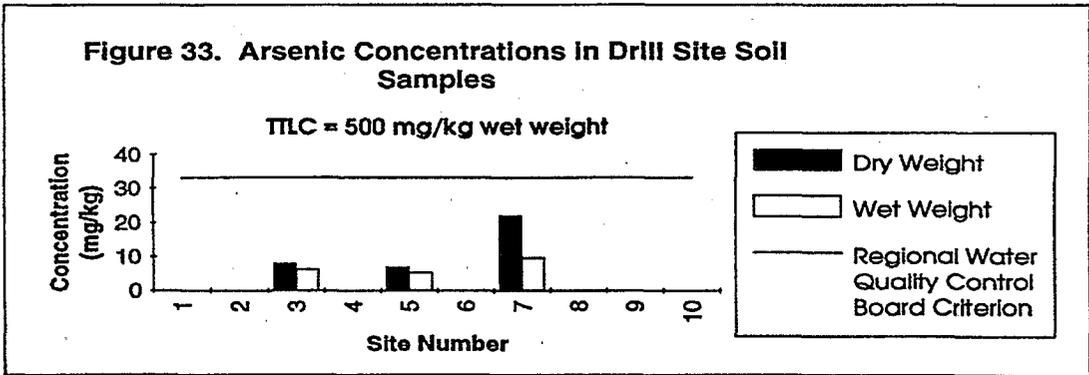
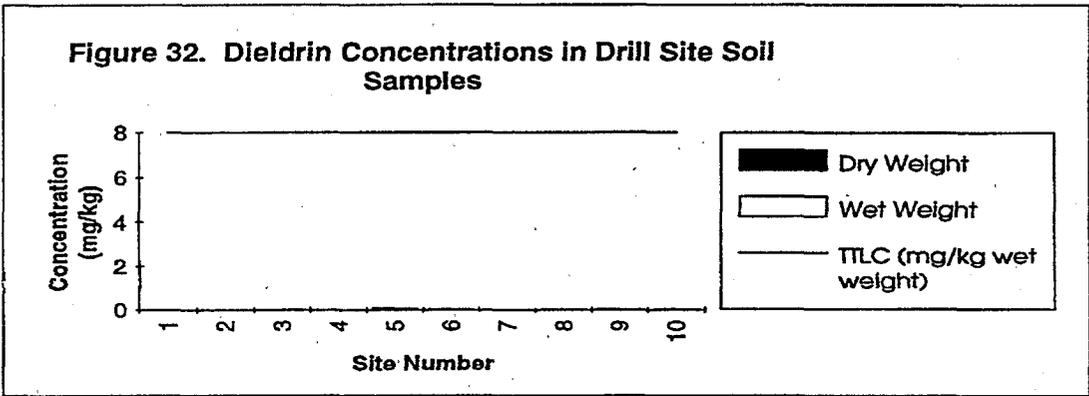
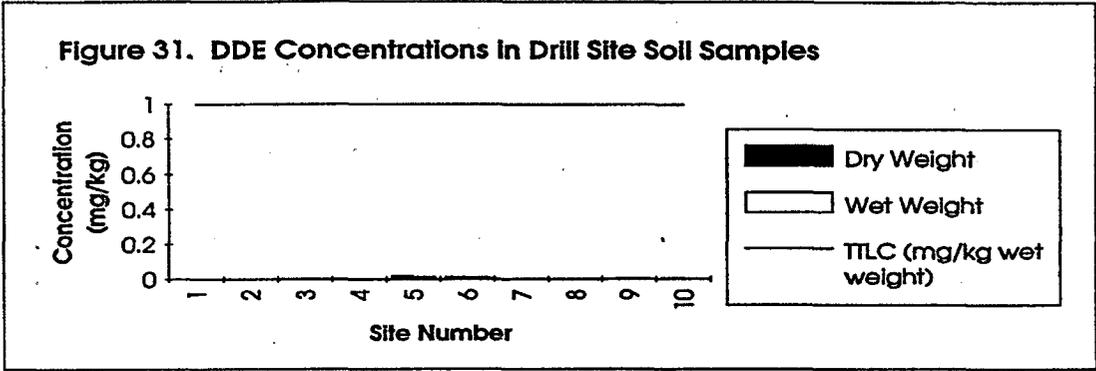
Analysis for oil and grease found detectable concentrations at four of the ten sites. Concentrations ranged from 67 to 220 mg/kg wet weight and 100 to 367 mg/kg dry weight. No criteria are available for comparison.

The remaining organics had non-detectable results. With the exception of the PCBs, all the parameters had reporting limits low enough to provide comparison with the RWQCB, TTLC, and EPA criteria. The reporting limits for the PCBs in the drill soil were the same as the reporting limits in sediment and inland soil (See Table 4) (Please refer to the channel sediment section for a detailed discussion of PCBs and reporting limits).

Trace Metal Analyses

Cadmium, silver, and selenium had non-detectable results at all sites. Cadmium and silver both had RLs of 1 mg/kg wet weight and 1.2 to 2.3 mg/kg dry weight. The dry weight RLs were below the RWQCB criterion for cadmium (5.0 mg/kg dry weight). However, the dry weight RLs for silver were too high to provide evaluation with the RWQCB criterion (1.0 mg/kg dry weight). The wet weight RLs were below the TTLC for both metals (See Table 9 for TTLCs).

The RLs for selenium were 5 mg/kg wet weight and 6.1 to 11.3 mg/kg dry weight. The dry weight RLs exceed the RWQCB criterion of 0.7 mg/kg dry weight. However, the wet weight RL does not exceed the TTLC of 100 mg/kg wet weight.



The remaining metals all had detectable concentrations at one or more sites (Figures 33 through 38). No sites exceeded either the RWQCB or TTLC criteria.

Tributyltin Analyses

The results of the TBT analyses showed non-detectable concentrations at all sites. The reporting limits were 2.0 mg/kg wet weight and 2.4 to 4.5 mg/kg dry weight. These results are within the established background sediment data.

Inland Soil

The inland soil samples were collected from the proposed setback levee sites. The samples represent soil that will be covered and likely not be exposed to the aquatic environment. However, to provide a worst case evaluation, the sample results will be compared with the RWQCB and EPA criteria as well as the TTLC criteria.

Organic Analyses

Several organic constituents were found in detectable concentrations. DDD was found at one site at a concentration of 0.0072 mg/kg wet weight or 0.0097 mg/kg dry weight. This is significantly below the TTLC criterion of 1.0 mg/kg wet weight. No RWQCB criterion exists for DDD. DDE was found at seven sites (out of nine sites) in concentrations ranging from 0.0028 to 0.014 mg/kg wet weight and 0.0034 to 0.020 mg/kg dry weight (See Figure 39). As with DDD, the DDE values were well below the TTLC criterion for DDE of 1.0 mg/kg wet weight. DDT was found in detectable concentrations at four of the nine sites (See Figure 40). The concentrations ranged from 0.0021 to 0.012 mg/kg wet weight and 0.0033 to 0.016 mg/kg dry weight. The RWQCB criterion for DDT is 0.003 mg/kg dry weight. All of the sites exceeded this criterion. However, no samples exceeded the TTLC criterion of 1.0 mg/kg wet weight.

Figure 34. Chromium Concentrations in Drill Site Soil Samples

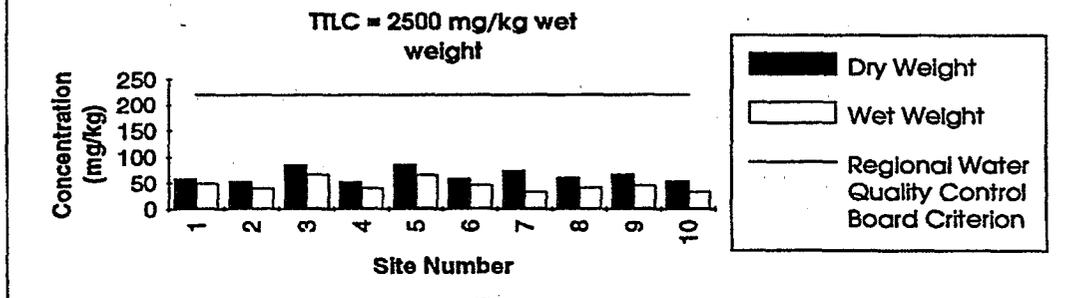


Figure 35. Copper Concentrations in Drill Site Soil Samples

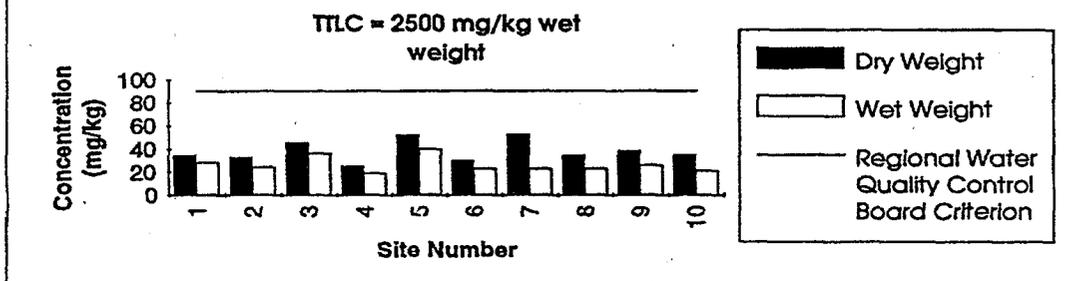


Figure 36. Lead Concentrations in Drill Site Soil Samples

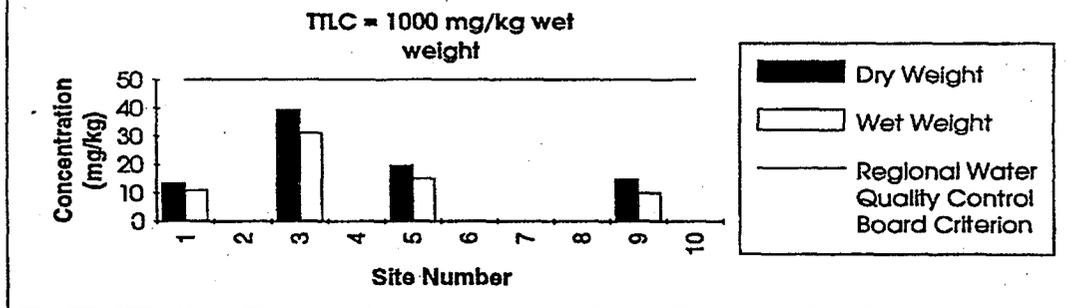


Figure 37. Mercury Concentrations in Drill Site Soil Samples

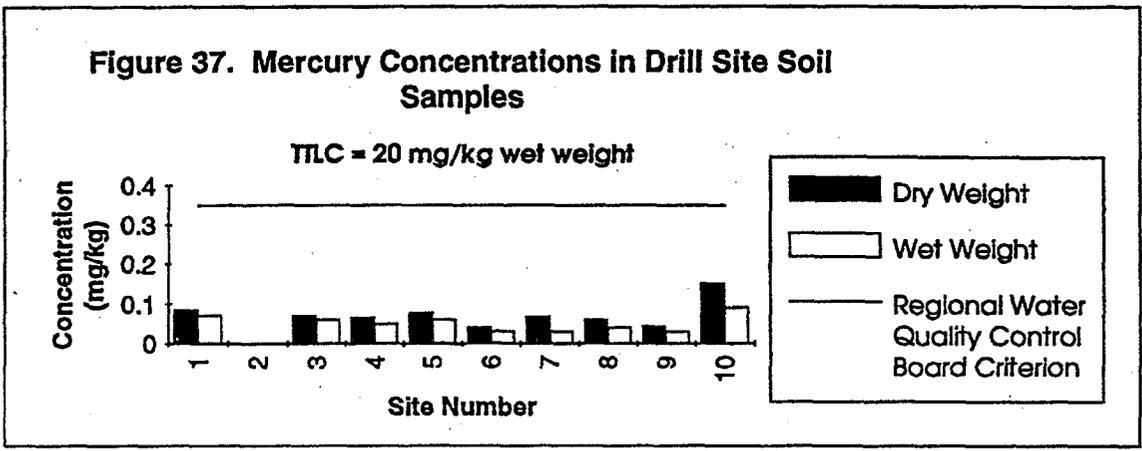
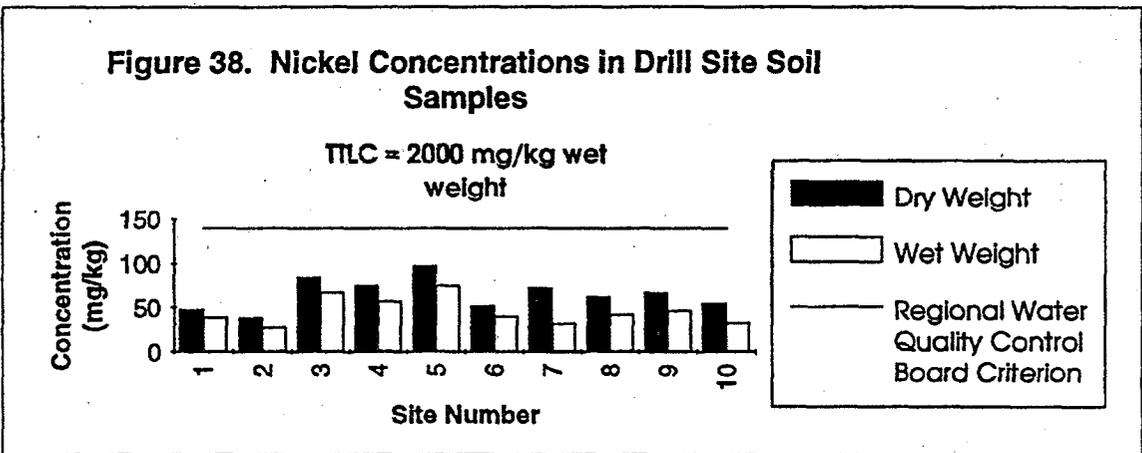


Figure 38. Nickel Concentrations in Drill Site Soil Samples



Dieldrin was detected at several sites (See Figure 41). Concentrations ranged from 0.0065 to 0.270 mg/kg wet weight and 0.0092 to 0.422 mg/kg dry weight. The EPA SQC for Dieldrin in the North Delta Project area is 1.1 mg/kg wet weight. No sites exceeded the EPA criterion. In addition, no sites exceeded the TTLC criterion of 8.0 mg/kg wet weight.

Endosulfan I and Endosulfan II were both detected at site 17. No other sites had detectable concentrations of either parameter. Endosulfan I was found at a concentration of 0.013 mg/kg wet weight or 0.015 mg/kg dry weight. Endosulfan II was found at a concentration of 0.088 mg/kg wet weight or 0.104 mg/kg dry weight. No criteria exist for either Endosulfan I or Endosulfan II.

Total oil and grease were found in detectable concentrations at eight out of nine sites. The detectable concentrations ranged from 77 to 210 mg/kg wet weight and 108 to 346 mg/kg dry weight. No criteria were available for oil and grease.

The remaining organics had non-detectable results. With the exception of the PCBs, all parameters had reporting limits low enough to provide comparison with the RWQCB, TTLC, and EPA criteria. The reporting limits for the PCBs in the levee soil were the same as the sediment samples and the drill and inland soil samples. (Please refer to the channel sediment section for a detailed discussion of PCBs and reporting limits).

Trace Metal Analyses

Cadmium and selenium had non-detectable results at all sites. Cadmium had reporting limits of 1 mg/kg wet weight and 1.2 to 2.0 mg/kg dry weight. These limits are low enough to provide evaluation with both the RWQCB criterion (5.0 mg/kg dry weight) and the TTLC criterion (100 mg/kg wet weight). Selenium had reporting limits of 5.0 mg/kg wet weight and 6 to 10 mg/kg dry weight. The dry weight reporting limits are too high to provide evaluation with the RWQCB criterion of 0.7 mg/kg dry weight. However, the wet weight reporting limit provides comparison with the TTLC criterion (100 mg/kg wet weight).

Figure 39. DDE Concentrations in Inland Soil Samples

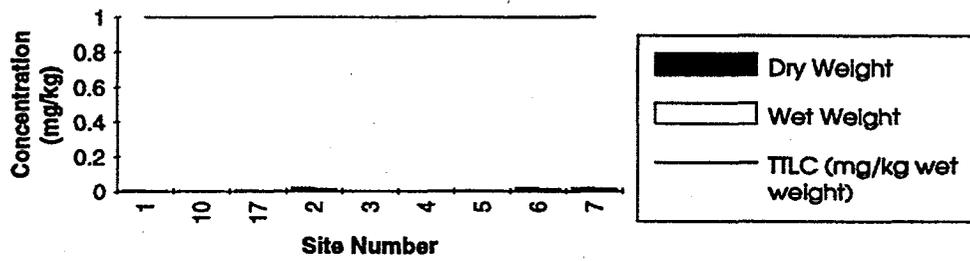


Figure 40. DDT Concentrations in Inland Soil Samples

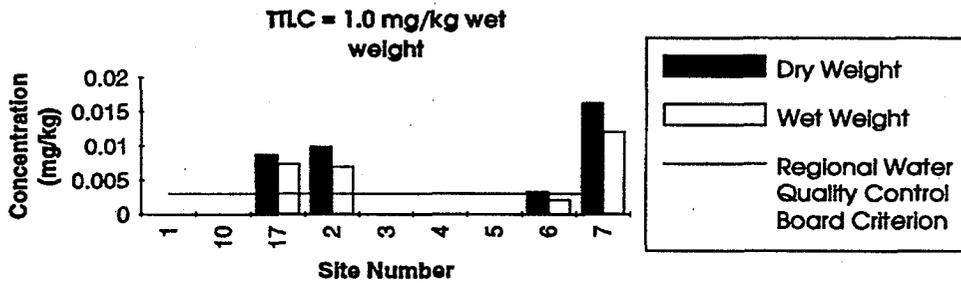
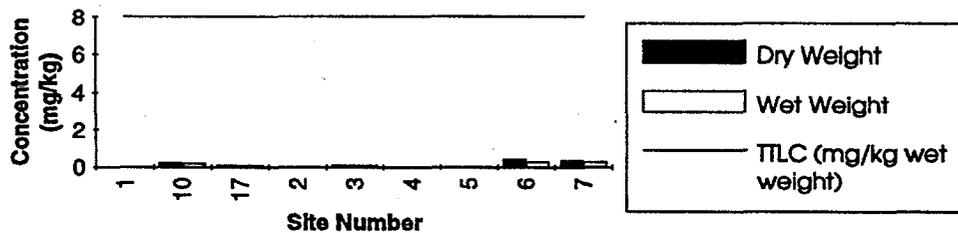


Figure 41. Dieldrin Concentrations in Inland Soil Samples



The remaining metals and trace elements all had detectable concentrations at one or more sites (Figures 42 through 49). With the following exceptions, most were found at concentrations below both the RWQCB criteria and the TTLC criteria.

Lead was found to exceed the RWQCB criterion (50 mg/kg dry weight) at one site (out of nine sites) (See Figure 45). The lead concentration was 56 mg/kg wet weight or 66 mg/kg dry weight. However, the TTLC criterion of 1,000 mg/kg wet weight was not exceeded at any sites.

Mercury was detected at all nine sites (Figure 46). Concentrations ranged from 0.06 to 0.27 mg/kg wet weight and 0.08 to 0.38 mg/kg dry weight. Site 1 (0.38 mg/kg dry weight) slightly exceeded the RWQCB criterion of 0.35 mg/kg dry weight. The remaining sites were below the RWQCB criterion. The TTLC (20 mg/kg wet weight) was not exceeded at any sites.

Silver was detected at two of the nine sites (Figure 48). Both sites had silver concentrations of 1 mg/kg wet weight and 1.4 mg/kg dry weight. The dry weight concentration slightly exceeds the RWQCB criterion of 1.0 mg/kg dry weight. However, The TTLC (500 mg/kg wet weight) was not exceeded.

Tributyltin Analysis

TBT concentrations ranged from non-detectable to 7 μ g/kg wet weight and 14 μ g/kg dry weight (Figure 50). These values are well within the background sediment values.

Figure 42. Arsenic Concentrations in Inland Soil Samples

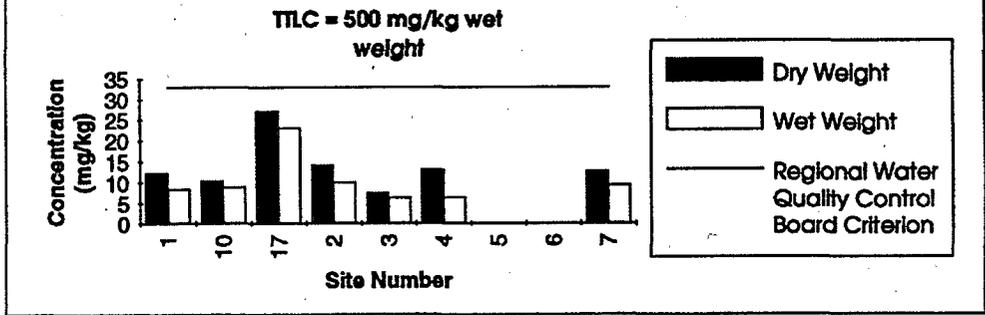


Figure 43. Chromium Concentrations in Inland Soil Samples

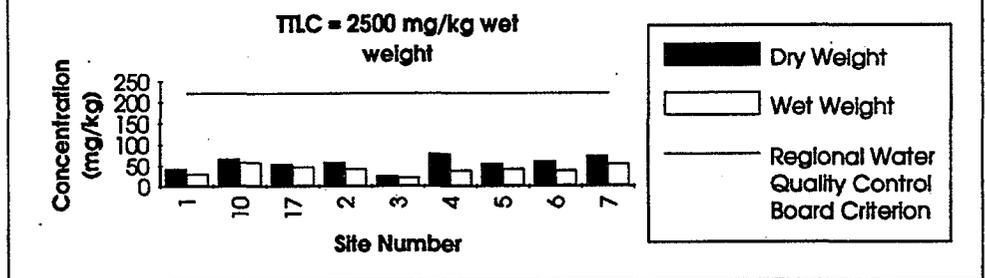


Figure 44. Copper Concentrations in Inland Soil Samples

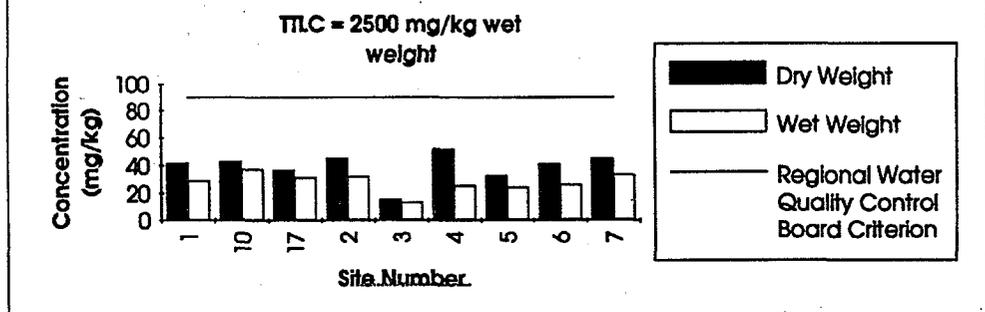


Figure 45. Lead Concentrations in Inland Soil Samples

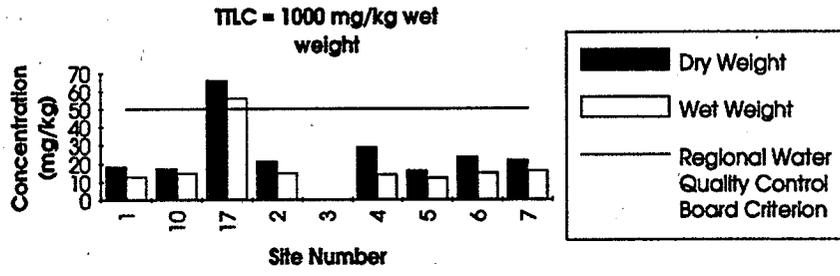


Figure 46. Mercury Concentrations in Inland Soil Samples

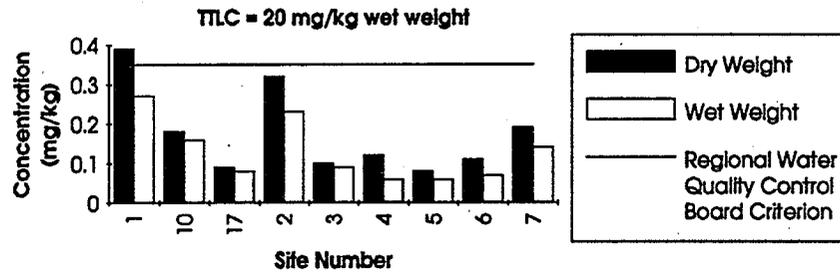


Figure 47. Nickel Concentrations in Inland Soil Samples

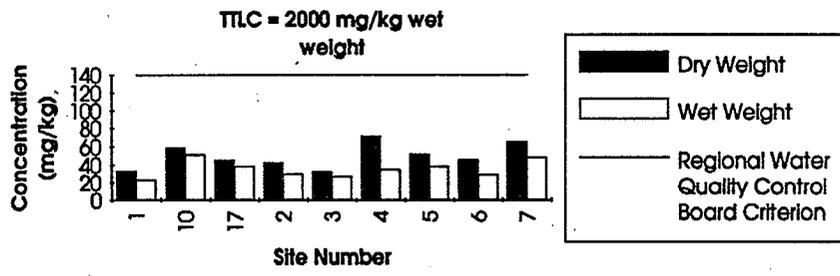


Figure 48. Silver Concentrations in Inland Soil Samples

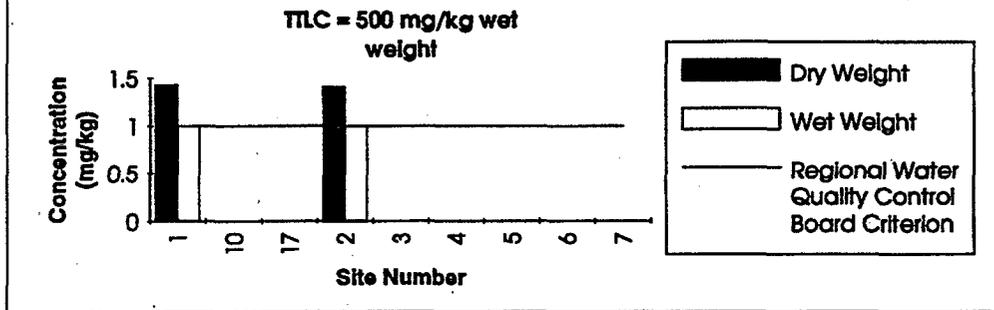


Figure 49. Zinc Concentrations in Inland Soil Samples

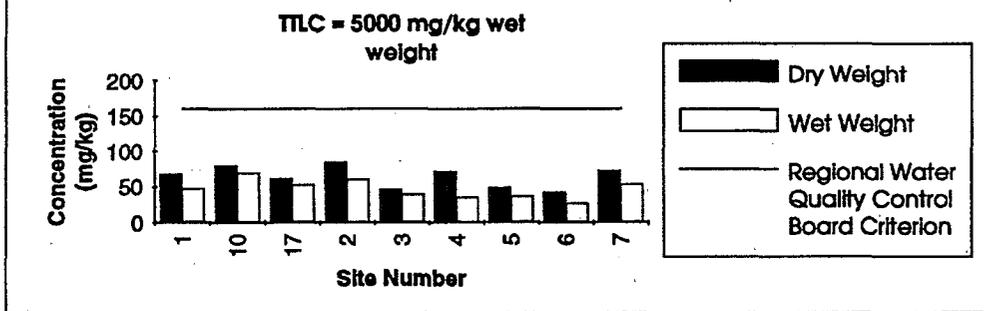
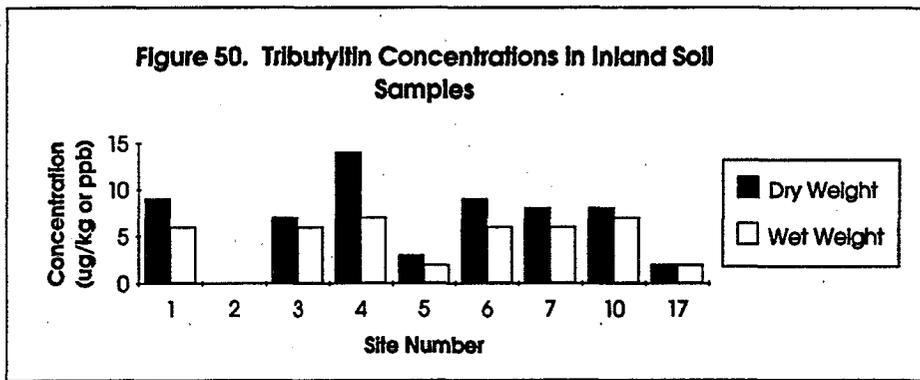


Figure 50. Tributyltin Concentrations in Inland Soil Samples



Discussion and Summary

With the use of dredge material for levee construction and/or reinforcement, there is the potential for release of contaminants from the dredge material and their possible introduction into the aquatic system. The major reactions resulting in contaminant release are oxidation and acidification. In the water environment, most sediments exist in an anoxic, or oxygen-free environment. The diffusion of oxygen in sediment is so slow that the oxygen content declines rapidly with increasing depth of the sediment. A strong oxygen concentration gradient usually exists over a depth of millimeters. Upon transfer of the sediment to land, previously anoxic sediments slowly become oxygenated or oxidized. This process may take a period of years, depending upon the amount of dredge material, the reduction-oxidation potential of the sediment, and the amount of oxidizable matter. During the oxidation process, trace metals may be released, although one would expect the kinetics of this reaction to be very slow.

The acid generation potential results indicated that the acid-producing sulfur fraction of the samples was small. Therefore, the sediment is not likely to become acidic due to the oxidation of sulfur-containing minerals. Because the N/A quotients were less than three, the sediment will be monitored in post-project monitoring for pH, acid-generation, and metals release. The sediment, however, will only release metals through the process of acidification if metals are present in high enough concentrations.

Analysis of the sediment samples indicates that they are not likely to pose a threat to aquatic life. All the organics had not-detectable results, with reporting limits below or near the criteria. With the exception of zinc, all the metals and trace elements were below the RWQCB criteria. Zinc only exceeded the RWQCB criterion (160 mg/kg dry weight) at three sites. No sites exceeded either the TTLC or STLC. In addition, only two sites had an acid generation potential of less than three, indicating that the majority of the sites are not likely to become acidified.

The soil samples also appeared to be unlikely to pose a threat to aquatic life. With the exception of DDT, no organics were found in concentration exceeding the EPA SQC or the RWQCB criteria. The RWQCB criteria for DDT (0.003 mg/kg dry weight) was exceeded in both the levee soil samples and the inland soil samples. However, it should be noted that the RWQCB criteria apply to sediment, and neither the levee or inland soil samples are likely to

become inundated. No organic constituents were found in concentrations exceeding the TTLC.

The majority of the metals and trace elements were found at concentrations below the RWQCB criteria. Mercury was found to exceed the RWQCB criteria (0.35 mg/kg dry weight) at 5 sites: 4 levee soil sites and one inland site. Silver exceeded the RWQCB criteria (1.0 mg/kg dry weight) at 5 sites also: 3 levee soil sites and 2 inland soil sites. Lead slightly exceeded the RWQCB criteria (50 mg/kg dry weight) at one site, an inland soil site. As with DDT, it should be noted that none of these sample sites are likely to be inundated with water. Therefore, although the RWQCB criteria are exceeded, it does not imply that there will be an adverse impact to aquatic life. No TTLC criteria were exceeded at any of the soil sites.

**Staten Island
Channel Island Restoration Project
1994**

Project Description

The Staten Island Channel Island Restoration Project was designed to restore shaded riverine aquatic habitat (SRAH) on four channel islands contiguous to Staten Island on the South Fork Mokelumne River. The project also included the restoration and protection of a black-crowned night heron rookery on a fifth Delta island on the South Fork Mokelumne River. The project proponents are M & T Staten Ranch (M & T) of Staten Island, San Joaquin County, in consultation with the Department of Fish and Game (DFG) and the State Lands Commission (SLC).

The four channel islands were fortified on their deep water side to hold a foundation for the establishment of approximately 1.5 miles of SRAH. Sycamore Island did not receive any dredge material, but was revegetated and various methods used to protect the aquatic habitat. The project sites are listed as "Channel Island No. 3, Channel Island No. 4, Channel Island No. 5, Channel Island No. 7", and "Island No. 6 or Rookery Island" (see Figures 51 and Figure 52). The islands range in size from 150 feet long and 30 feet wide at low tide (Island No. 7) to 2,650 feet long and about 80 feet wide at low tide (Island No. 5).

Figure 51. Overview Map Showing General Area of Staten Island SRAH Projects

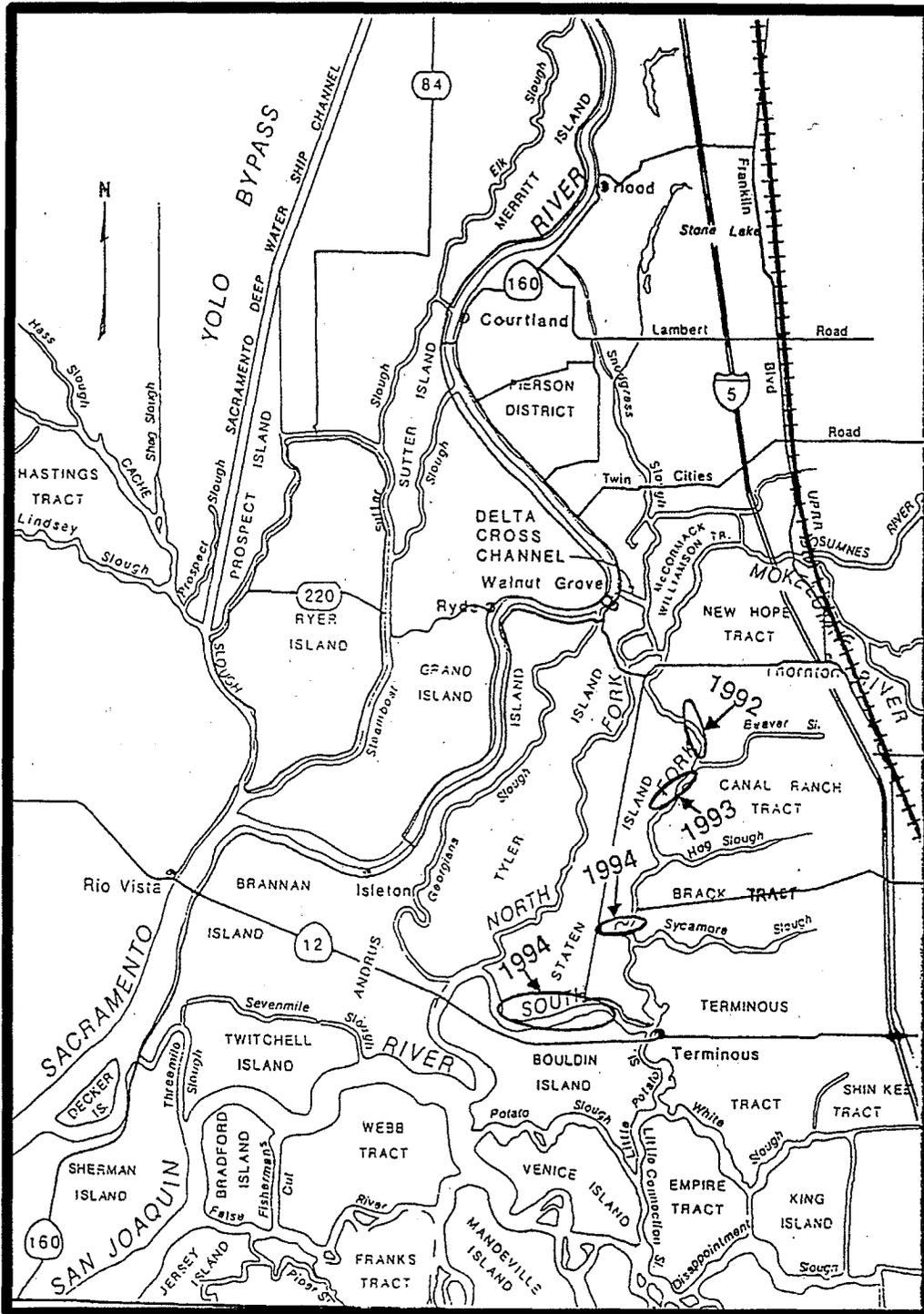


Figure 52. Location of Staten Island 1994 SRAH Project

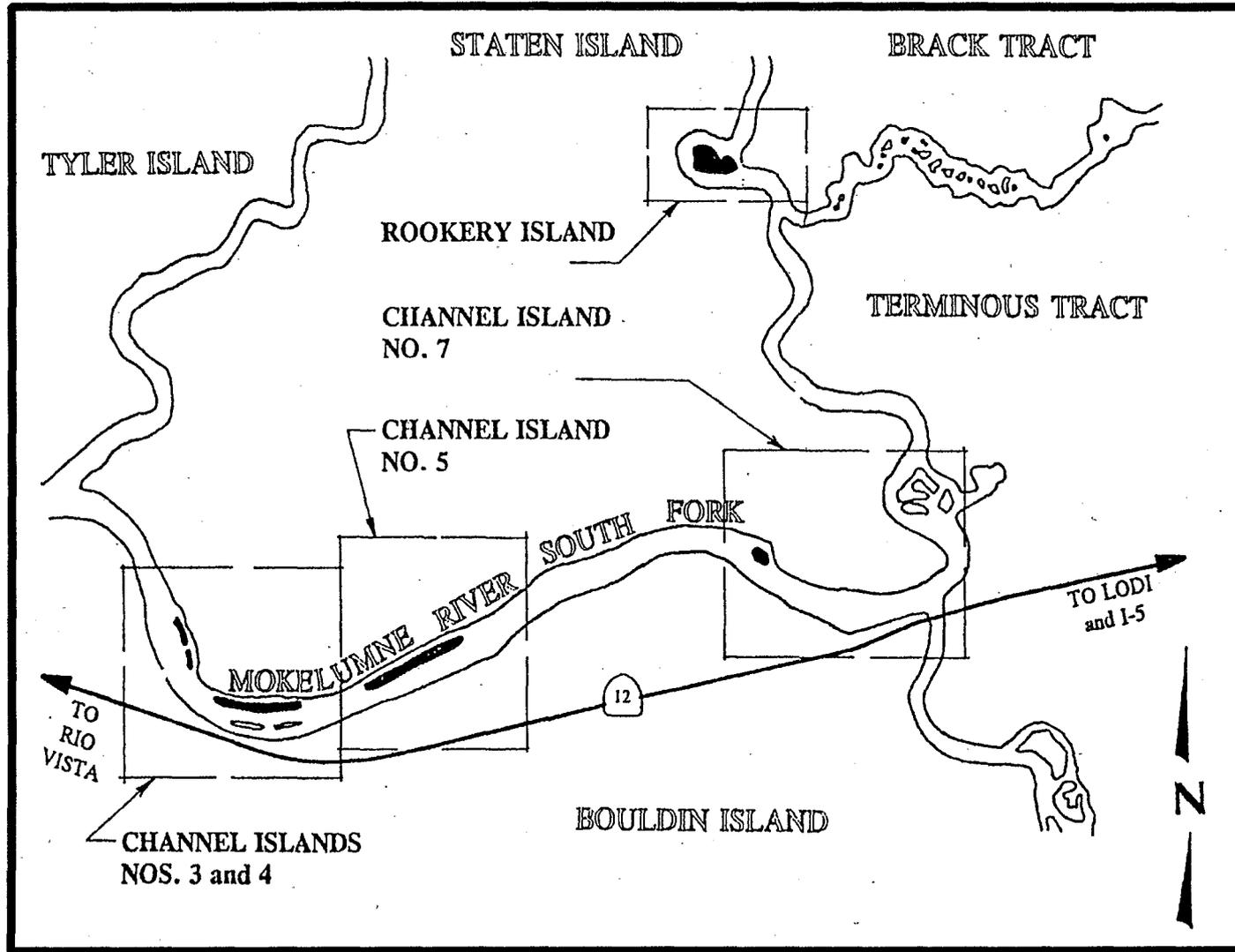
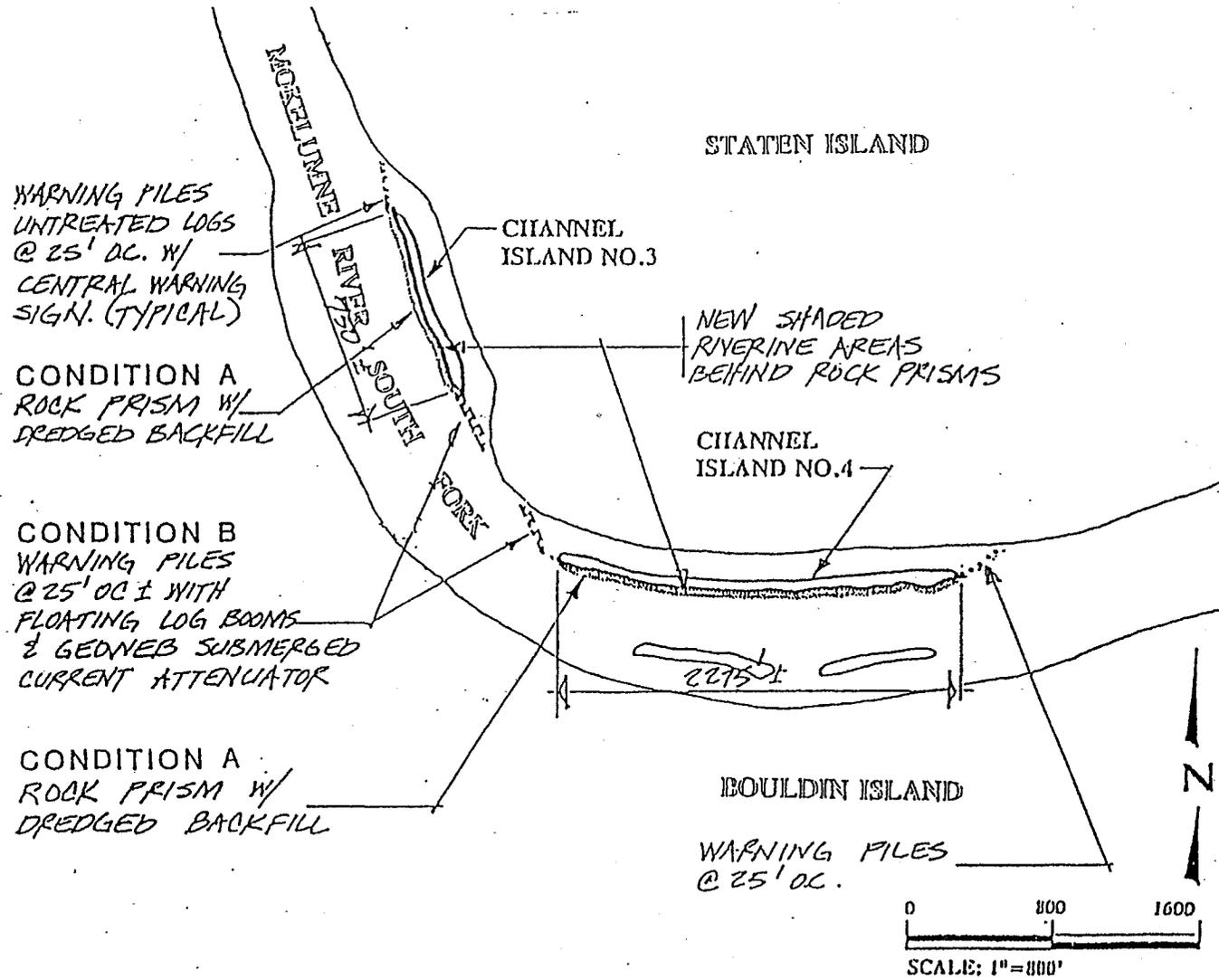


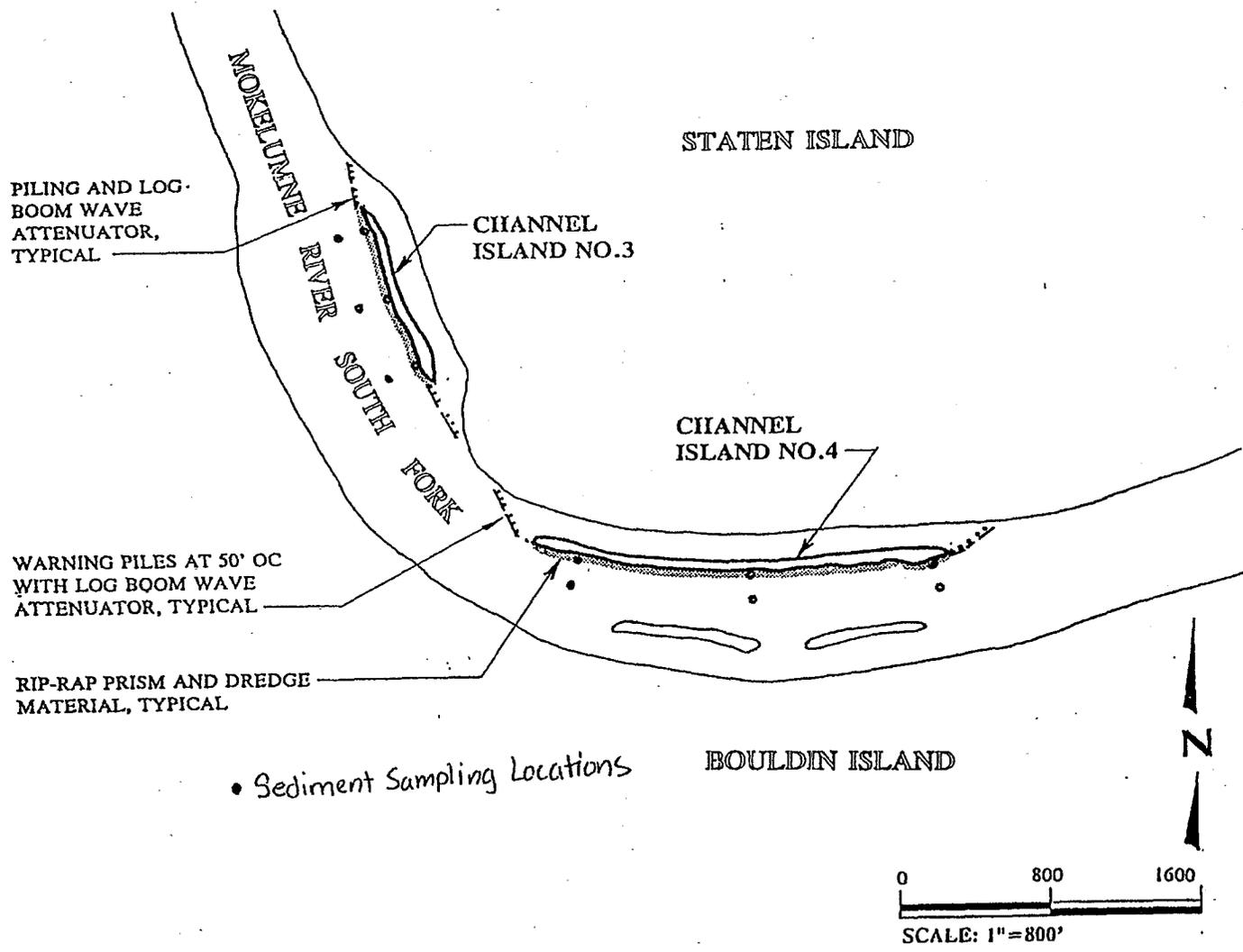
Figure 53A. Project Description for Channel Islands 3 and 4



-80-

D-040203

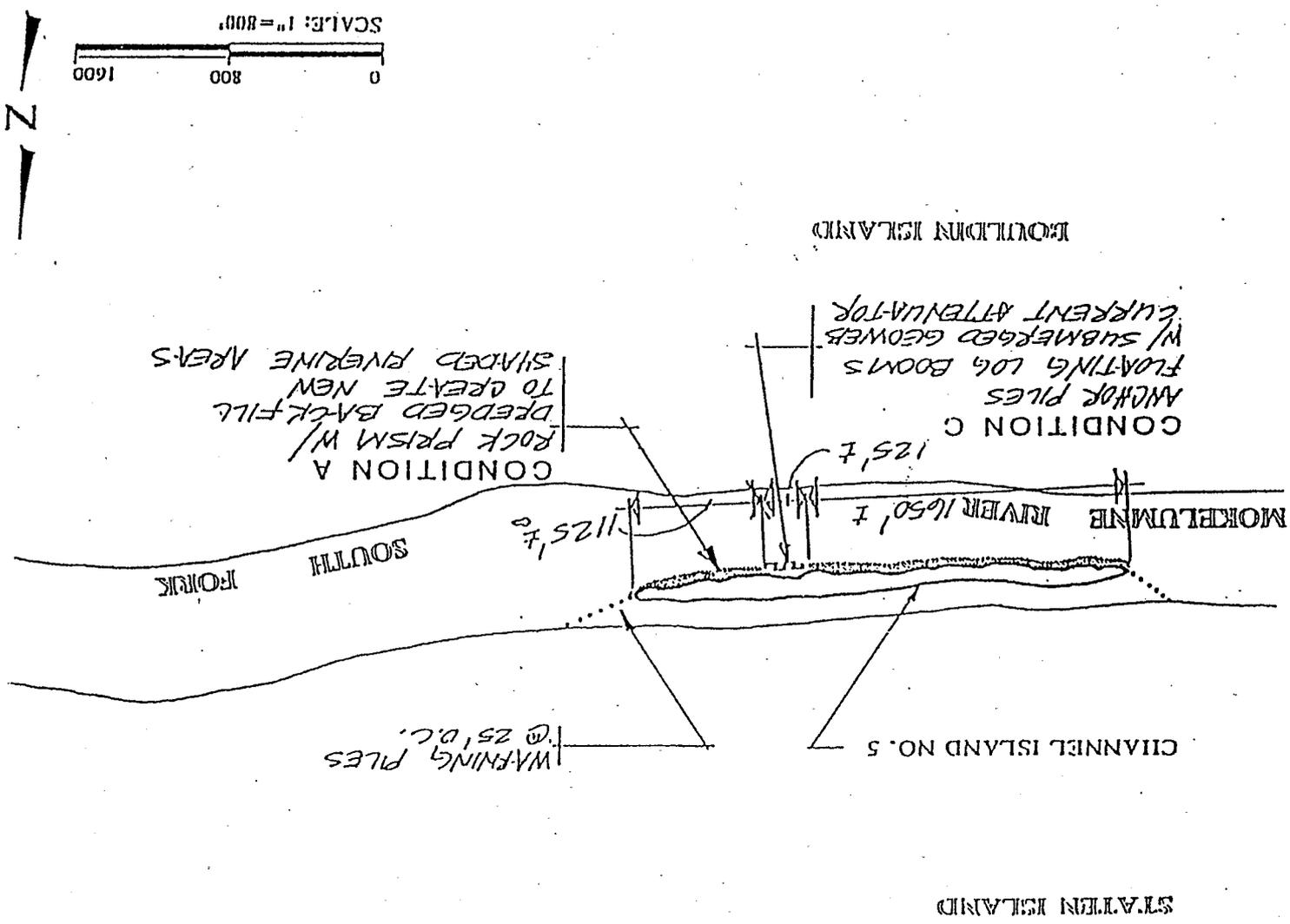
Figure 53B. Project Description for Channel Islands 3 and 4



-18-

D-040204

Figure 54A. Project Description for Channel Island 5

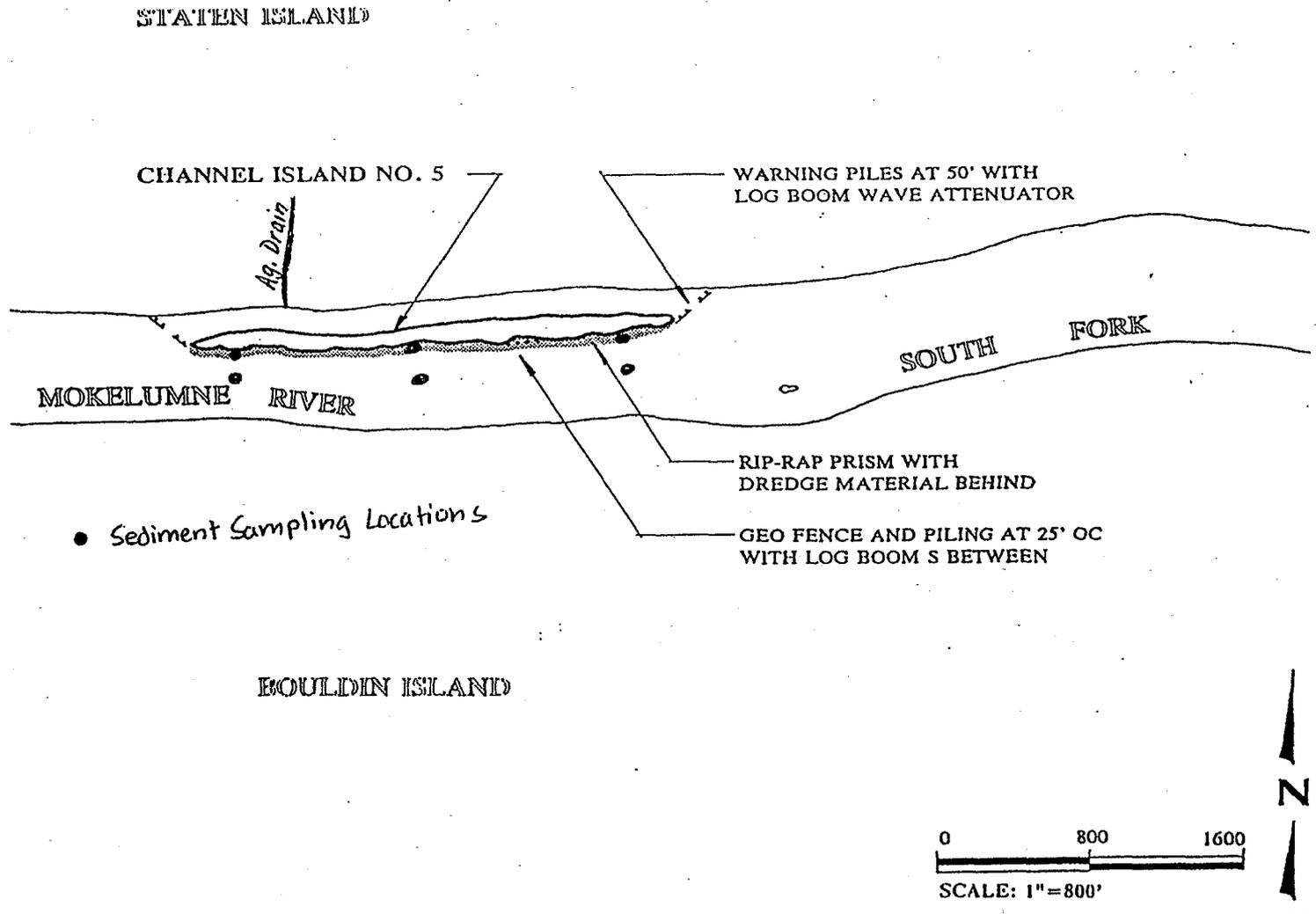


D-040205

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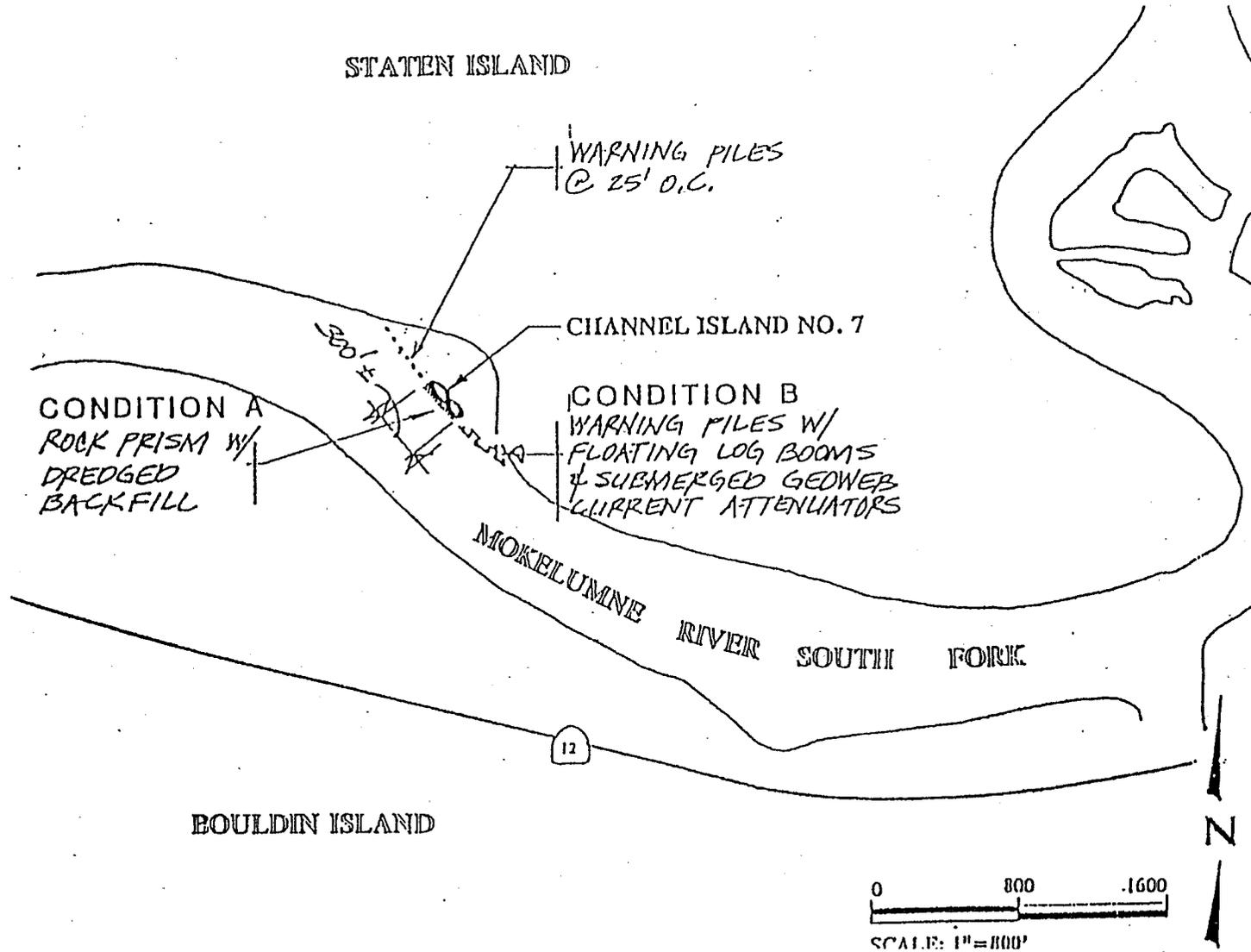
Figure 54B. Project Description for Channel Island 5

-83-



D-040206

Figure 55A. Project Description for Channel Island 7



D-040208

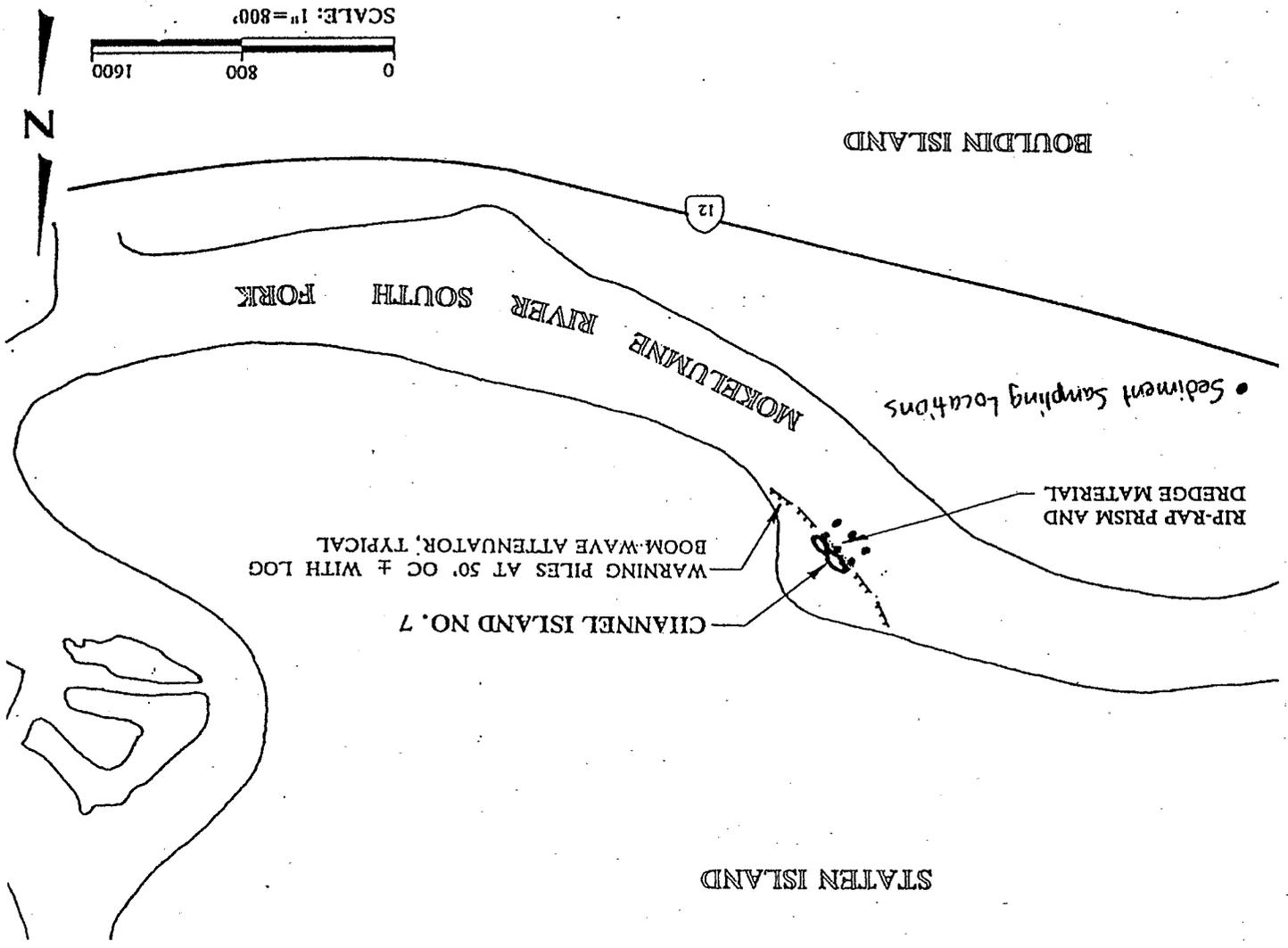
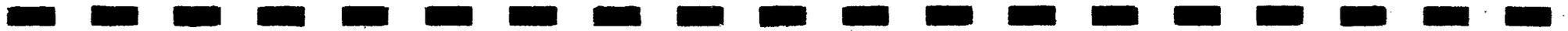
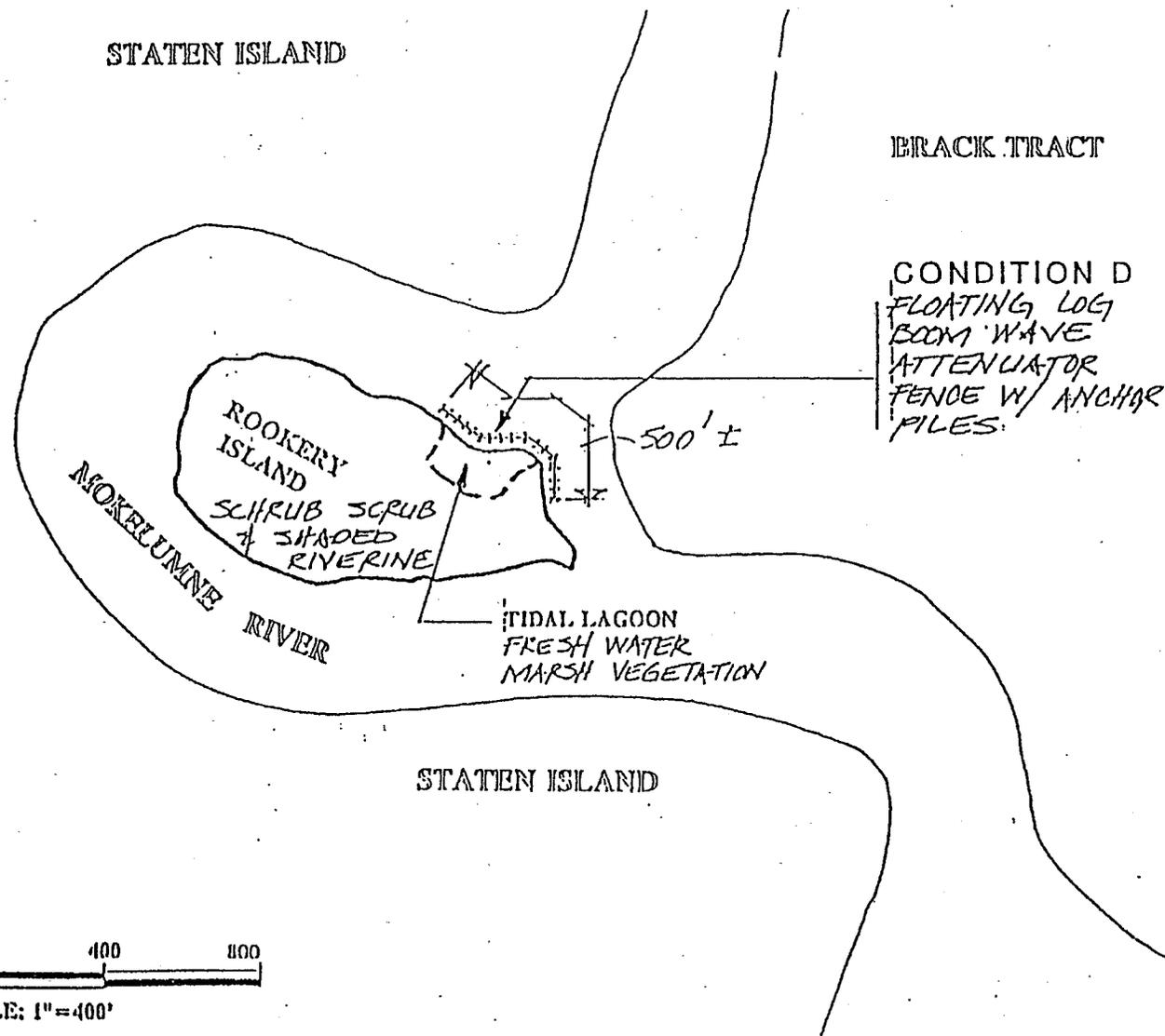


Figure 55B. Project Description for Channel Island 7



D-040208

Figure 56A. Project Description for Rookery Island



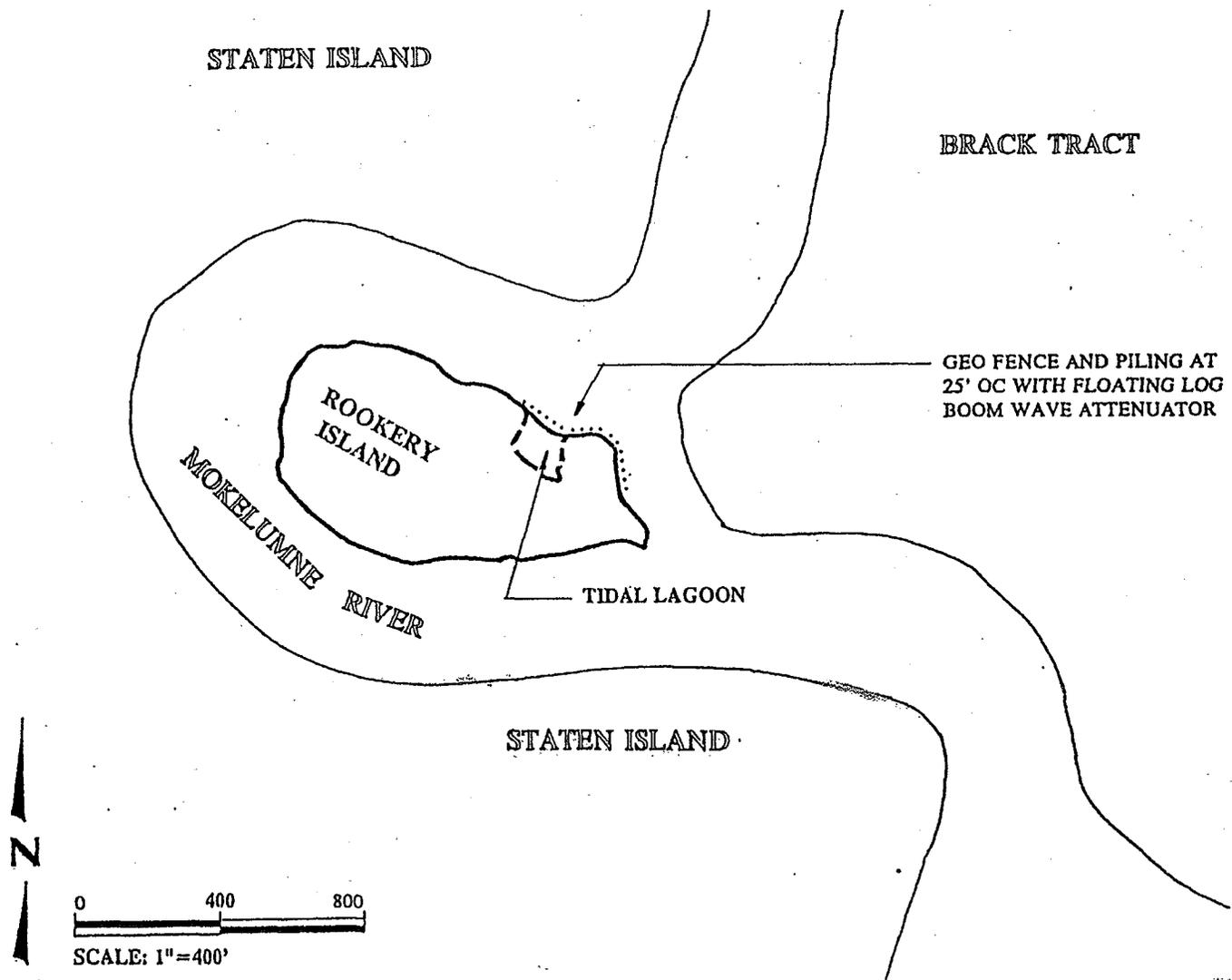
-86-

D-040209

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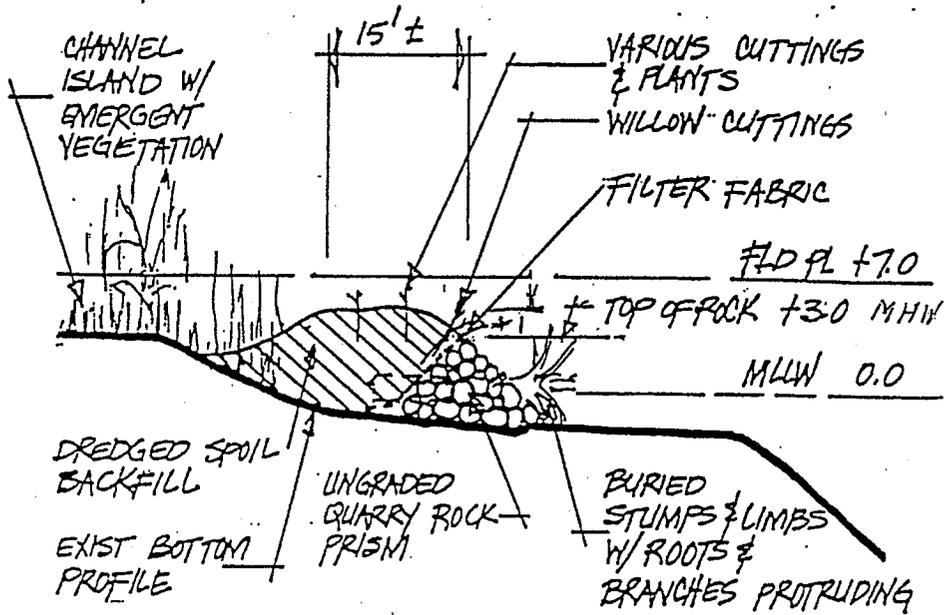
Figure 56B. Project Description for Rookery Island

-87-

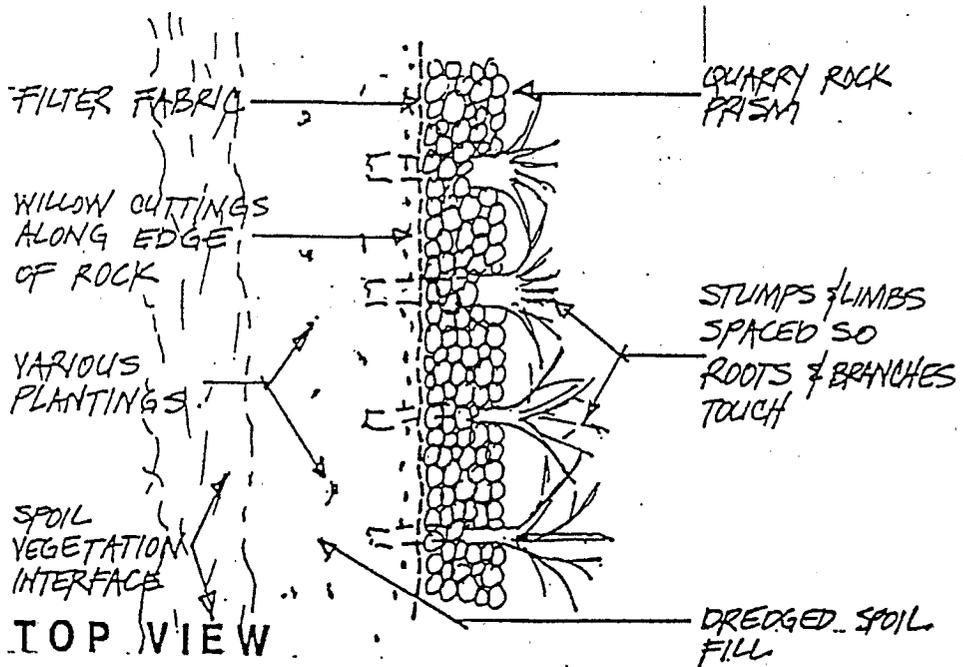


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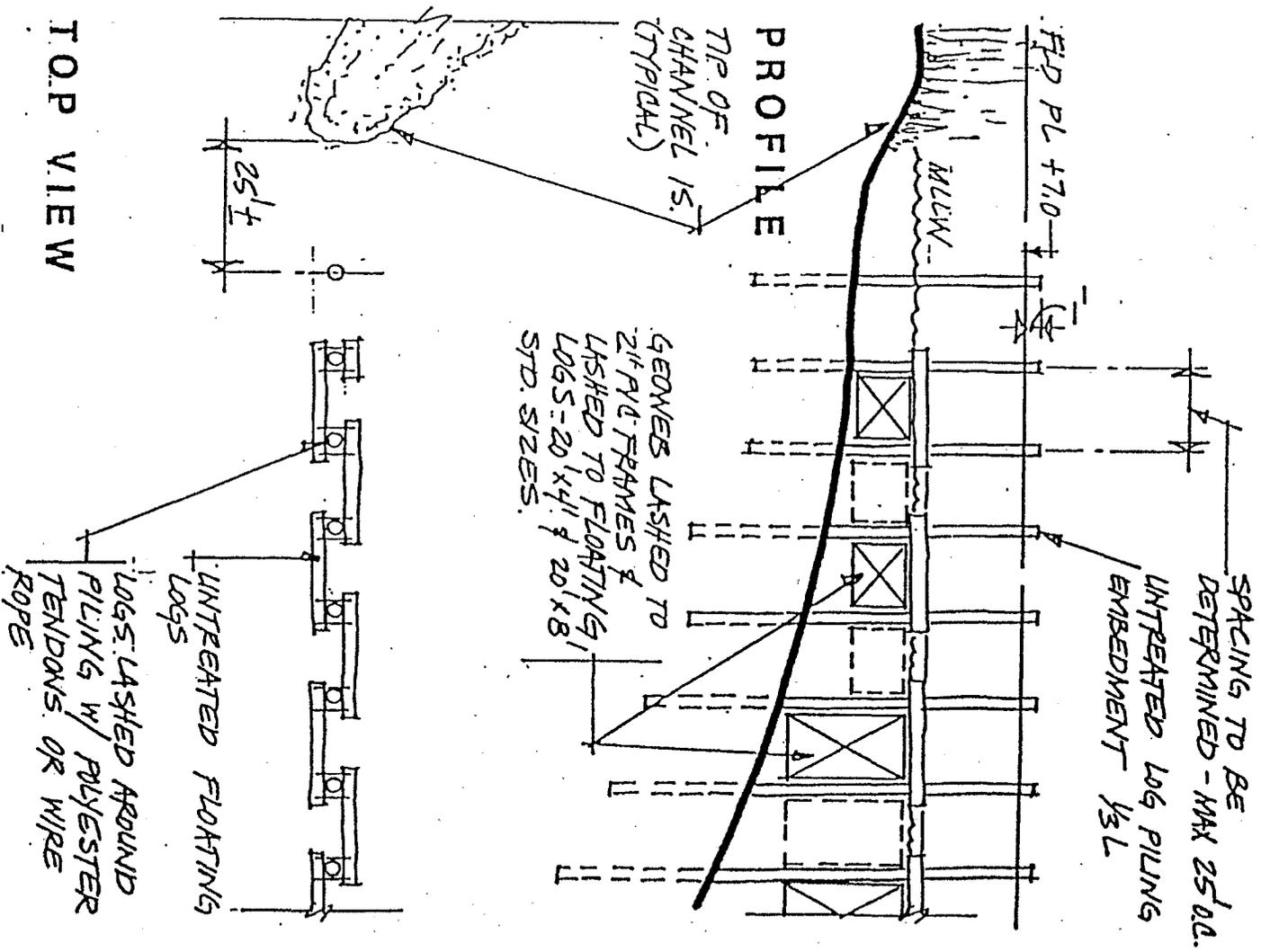
Condition A. Construction Detail for SRAH



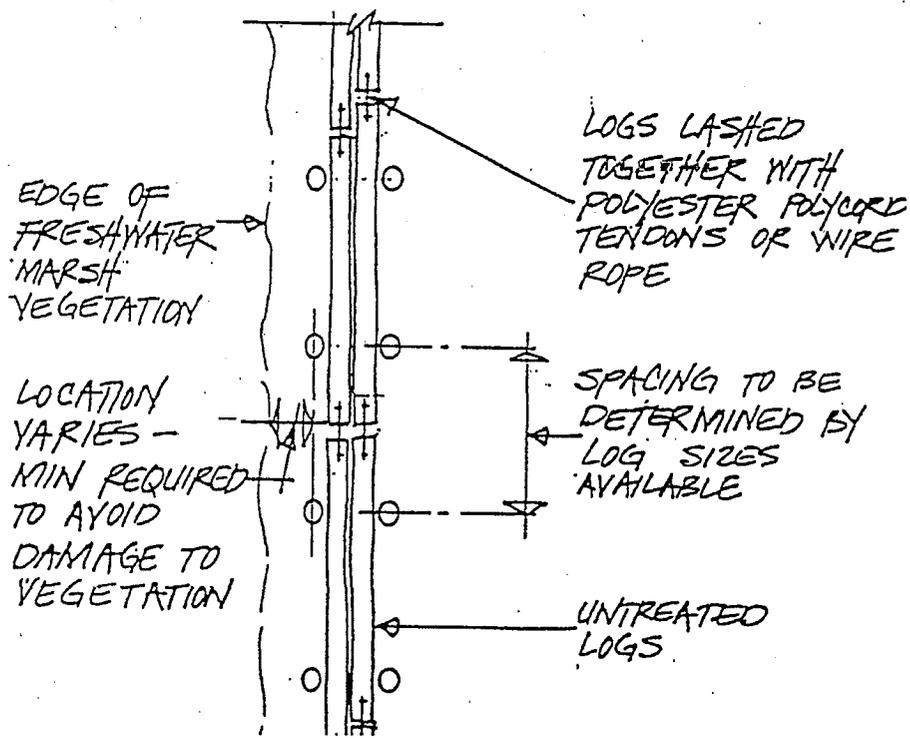
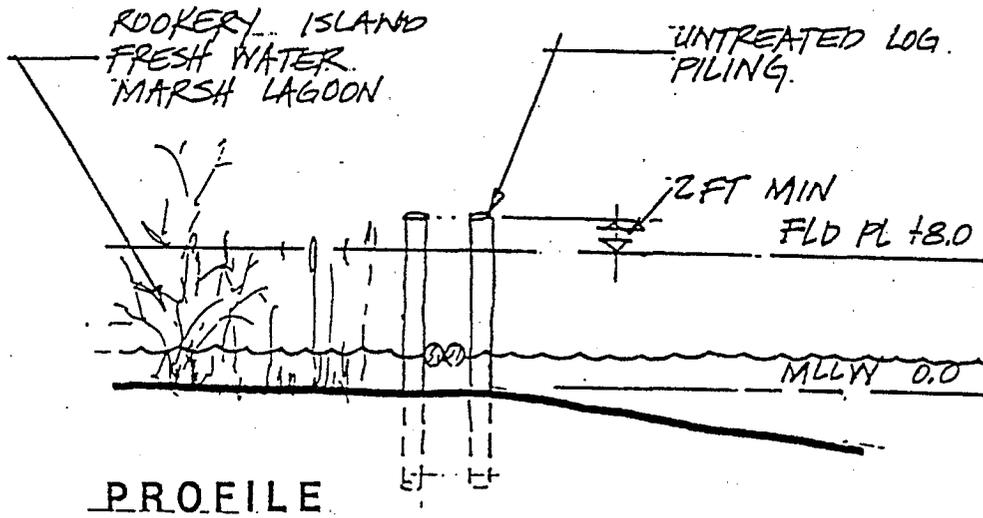
PROFILE



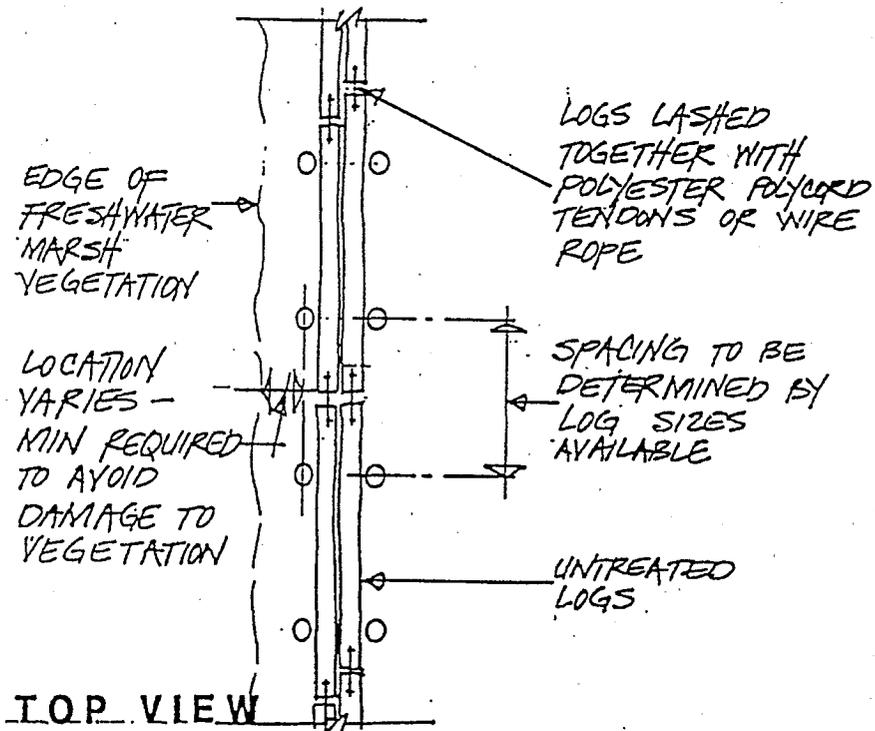
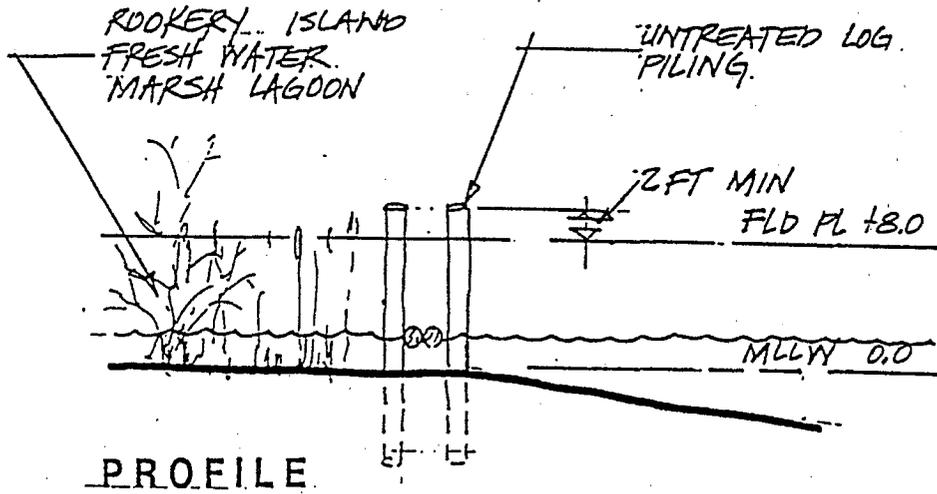
Condition B. Construction Detail for SRAH and Log Piling



Condition C. Construction Detail for Rock Prism Dike and Fill



Condition D. Construction Detail for SRAH on Rookery Island



Environmental Sampling

Pre-Project Sampling

In order to obtain baseline water and soil samples and to characterize the sediment material that would be dredged, environmental samples were collected prior to the dredging project.

Water Samples

Four water samples were collected as follows:

Table 11. Pre-Project Water Samples

Sample No.	Location (Channel Island)	Comments
C41517	Between Islands No. 4 and No. 5	Downstream of channel island 5
C41518	Between Islands No. 5 and No. 7	Downstream of channel island 7
C41519	South Fork Mokelumne River @ Staten Island (DWR EC station)	Upstream of all channel islands
C41520	100' West of No. 3	Downstream of all channel islands

All samples were collected from a depth between 18 and 36 inches below the water surface. Water samples were analyzed for basic field parameters (temperature, dissolved oxygen, specific conductance, pH, and turbidity), minerals, miscellaneous analyses such as oil and grease and suspended solids, and metal analyses.

Sediment Samples

Twelve individual sediment samples (four composite samples) were collected as follows:

For each channel island, three samples were taken within one hundred feet of the shoreline (see Figures 53B-55B and Figure 57). The samples were taken at a minimum depth of nine feet. This material represents the material that will be dredged during the project.

Table 12. Pre-Project Sediment Samples

Sample No.	Location (Channel Island)	Comments
C41480 C41481 C41482	Channel Island No. 3	Composite Sample
C41483 C41484 C41485	Channel Island No. 4	Composite Sample
C41489 C41490 C41491	Channel Island No. 5	Composite Sample
C41495 C41496 C41497	Channel Island No. 7	Composite Sample

Soil Samples

For each channel island, three samples were taken within twenty feet of the shoreline to represent the soil on the channel island (see Figures 53B-55B and Figure 57). Note that it was not possible to sample channel island soil in the center of the channel islands because the islands were submerged and it was dangerous to approach too closely with the sampling boat.

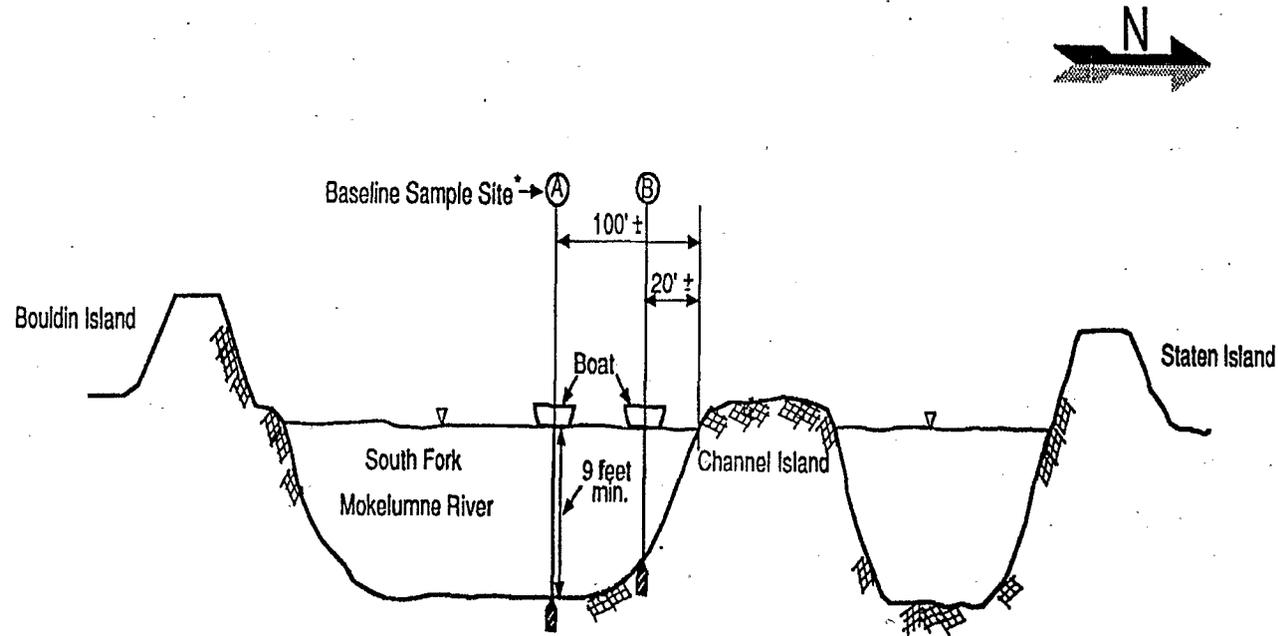


Figure 57. Baseline Sediment Sampling Locations

* If it's too difficult to sample at 100 feet from channel island, move closer to island for less turbulent water.
 - Maintain at least 9 feet depth to channel bottom

Ⓐ = Site in vicinity of dredging

Ⓑ = Site in vicinity where dredge spoil will be placed

Sampling During the Dredging Project

Water Samples

During the dredging project, two water samples, one upstream and one downstream of each dredging site were collected (see Table 13). Due to miscommunication with the dredger, the water samples were not taken for channel island #3 during the dredging operation.

Table 13. Water Samples Taken During the Dredging Project

Sample No.	Location (Channel Island)	Comments
C41597	No. 3, upstream of plume	Not taken because of miscommunication with dredger
C41599	No. 3, in plume	Not taken because of miscommunication with dredger
C41586	No. 4, upstream of plume	
C41588	No. 4, in plume	
C41575	No. 5, upstream of plume	
C41577	No. 5, in plume	
C41607	Upstream of all sites (SF Mokelumne EC station)	Biotoxicity sample
C41606	Downstream of all sites (100' West of No. 3)	Biotoxicity sample

In addition to the water samples taken for laboratory water quality analyses, field measurements were taken at different sites at the time of dredging (see Results section).

Sediment Samples

Sediment samples were collected from all three channel islands where dredge material was deposited. In the case of channel island 3, most of the dredging occurred on a single day, and therefore, all three samples were collected on that day and composited. In the case of channel islands 4 and 5, dredging occurred over several days, and therefore, the sediment samples were analyzed separately.

Table 14. Sediment Samples Taken During the Dredging Project

Sample No.	Location (Channel Island)	Comments
C41601 C41602 C41603	No. 3	Composite Sample
C41590	West end of No. 4	
C41591	Center of No. 4	
C41592	East end of No. 4	
C41579	West end of No. 5	
C41580	Center of No. 5	
C41581	East end of No. 5	

Post-Project Sampling- First Quarterly Monitoring

Water Samples

Table 15. Water Samples Taken for First Quarterly Monitoring

Sample No.	Location (Channel Island)	Comments
C42151	Between Islands No. 3 and No. 4	Downstream of No. 4, Upstream of No. 3
C42150	Between Islands No. 4 and No. 5	Downstream of No. 5, Upstream of No. 4
C42265 C42267 C42269	Upstream of all sites (SF Mokelumne EC station)	Biotoxicity samples
C42264 C42266 C42268	Downstream of all sites (100' West of No. 3)	Biotoxicity samples

Water samples for the first of the quarterly monitoring sampling were collected in November. Water samples were collected Monday, Wednesday, Friday of one week, with double samples collected on Friday for a seven-day chronic biotoxicity test.

Sediment Samples

Table 16. Sediment Samples Taken for the First Quarterly Monitoring

Sample No.	Location (Channel Island)	Comments
C42271 C42272 C42273	No. 3	Composite Sample
C42274 C42275 C42276	No. 4	Composite Sample
C42279 C42278 C42277	No. 5	Composite Sample

Sediment samples were collected in December from all three Channel Islands.

Post-Project Sampling- Second Quarterly Monitoring

Water Samples

Table 17. Water Samples Taken for Second Quarterly Monitoring

Sample No.	Location (Channel Island)	Comments
C50562	East of No. 4, West of No. 5	Upstream of No. 4, Downstream of No. 5
C50563	East of No. 3, West of No. 4	Upstream of No. 3, Downstream of No. 4
C50561	Upstream of all Islands (SF Mokelumne EC station)	
C50564	Downstream of all Islands (100' West of No. 3)	
C50578 C50601 C50633	Upstream of all sites (SF Mokelumne EC station)	Biototoxicity samples
C50579 C50602 C50634	Downstream of all sites (100' West of No. 3)	Biototoxicity samples

Water samples for the second quarterly monitoring sampling were collected in March. Water samples were

collected Monday, Wednesday, Friday of one week, with double samples collected on Friday for a seven-day chronic biotoxicity test. The water samples collected on Monday were also used for an acute biotoxicity test.

Sediment Samples

Table 18. Sediment Samples Taken for the Second Quarterly Monitoring

Sample No.	Location (Channel Island)	Comments
C50568 C50569 C50570	No. 3	Composite Sample
C50572 C50571 C50573	West end of No. 4	
C50574	West end of No. 5	Not taken due to boat failure.
C50575	Center of No. 5	Not taken due to boat failure.
C50576	East end of No. 5	

Sediment samples were collected from the channel islands in March. Due to boat failure, only one of the three samples was taken from channel island 5. Therefore, the sediment sample from channel island 5 was a discrete sample that was not composited.

Data Quality Assessment

Pre-Project Monitoring Samples

Water Samples

In general, the data quality of the water samples was good. There were no exceedances of EPA method holding time requirements. Both the filtered and the unfiltered metals blanks had no detectable concentrations of metals. Laboratory control sample recoveries and matrix spike sample recoveries were all within control limits.

One field duplicate was taken. The relative percent difference (RPD) of most parameters was less than 20%. However, the RPDs for iron and manganese samples were 29% and 26%, respectively indicating questionable precision for these parameters.

Sediment Samples

One of two equipment blanks had a detectable concentration of iron (0.015 mg/L). No other metals were detected in the equipment blanks.

The results of laboratory duplicates of copper and zinc were tagged as estimated due to questionable precision. Laboratory duplicate results of oil and grease analyses were also tagged due to questionable precision.

Laboratory duplicate results of deionized water WET copper, lead, mercury and zinc had RPDs above 50% and therefore, these parameters were tagged as estimated as well.

Project Monitoring Samples

Water Samples

For most of the parameters holding times were not exceeded. All of the samples analyzed for oil and grease were qualified as estimated because the samples were kept one day past the holding time.

Two set of field blanks were analyzed for metals (one for channel island 4 and one for channel island 5). No metals were detected in either the filtered or nonfiltered blanks indicating no apparent contamination from the field equipment.

All laboratory control samples were within control limits indicating acceptable accuracy. All matrix spike samples were within the matrix spike control limits indicating acceptable accuracy and no significant matrix interference with the analyses.

Two sets of field duplicates were analyzed for all parameters. All RPDs were below the 25% limit for acceptability except for the RPD for TBT which was unacceptably high. The TBT sample results were, therefore, disqualified and not reported in this study.

Sediment Samples

For most of the parameters, holding times were not exceeded. The extraction holding time for some of the total petroleum hydrocarbon, chlorinated organic and PCB analyses were exceeded by up to seven days. Therefore, the TPH, chlorinated organic and PCB results were qualified as estimated due to exceedance of the extraction holding times.

Two equipment blanks (one for channel island 4 and one for channel island 5) were analyzed for metals and pesticides. All parameters were nondetect indicating no apparent contamination of the samples by the sampling equipment.

All matrix spike samples were within the matrix spike control limits indicating acceptable accuracy and no significant matrix inference with the analysis. All of the RPDs for which there were multiple matrix spikes were less than the upper control limits indicating acceptable analytical precision in the matrix.

Post-Project Monitoring Samples- First Quarterly Monitoring

Water Samples

None of the holding times for any of the parameters were exceeded. One set of field blanks was analyzed for metals. No metals were detected in either the filtered or the nonfiltered blank indicating no contamination to the samples from the field equipment.

All of the laboratory control samples analyzed were well within the laboratory control limits indicating acceptable analytical accuracy. All matrix spike samples were within the matrix spike control limits indicating acceptable accuracy and no significant matrix interference with the analyses.

One set of field duplicates was analyzed for all parameters. All RPDs were below the 25% limit for acceptability

except for the RPD for nitrate which was 53%. The nitrate sample results were, therefore, qualified as estimated.

Sediment Samples

None of the holding times for any of the parameters were exceeded and therefore, no results were qualified due to holding time violations. One equipment blank was analyzed for metals and pesticides. All parameters were nondetect indicating no contamination from the sampling equipment on the environmental samples.

All matrix spike recoveries were within the matrix spike control limits indicating no matrix effects on analytical accuracy. The RPDs for the matrix spike duplicates were all below the upper control limit for RPDs indicating no matrix interference with the analytical precision.

Post-Project Monitoring Samples- Second Quarterly Monitoring

Water Samples

For most of the parameters, holding times were not exceeded. The results of the metals analyses are not available yet; therefore, there is not yet a holding time analysis of these data.

No mineral matrix spikes were performed with the environmental samples in this report. The metals analysis data are not yet available. One set of field duplicates were analyzed for all parameters. All mineral and miscellaneous analyses had RPDs less than 25% and therefore these analyses have acceptable precision.

One set of field duplicates was analyzed for all parameters. The metals analyses for the field blanks are not yet available; therefore, there is not yet a holding time analysis of these data.

Sediment Samples

None of the holding times for the metals analyses were exceeded. The holding time for the extraction of the pesticide samples was slightly exceeded, but the results were not qualified.

Laboratory control samples for mercury and pesticides were analyzed. The recoveries were well within control limits indicating acceptable analytical accuracy and the RPD between the two recoveries was less than the upper control limit indicating acceptable precision.

All matrix spike recoveries were within the matrix spike control limits indicating no matrix effects on analytical accuracy. The RPDs for the matrix spike duplicates were all below the upper control limit for RPDs indicating no matrix interference with the analytical precision.

Results of Environmental Data Analyses

Discussion of the results is provided below. The results are tabulated in Appendix A.

Pre-Project Sampling

Water Samples

The water samples had specific conductances ranging from about 120 to 140 microohms/cm, pH values ranging from 7.1 to 7.6, dissolved oxygen from 8.2 to 9.4, and turbidity values from 6 to 15 NTUs.

The results of mineral analysis show mineral concentrations much less than MCLs. The results of total and dissolved metal analyses show concentrations less than the reporting limit or less than the water quality objectives and MCLs. In some cases (cadmium, lead and nickel) the reporting limit was slightly higher than the water quality objectives.

All four water samples were analyzed for tributyltin (TBT). The water samples had nondetectable concentrations of TBT with a reporting limit of 1.0 micrograms/L. Because the RL of 1.0 ug/L is greater than the WQO of 0.02 micrograms/L, it is not possible to compare the nondetectable concentrations with the water quality objective.

Sediment Samples

Organics Analyses

All of the organic analyses had nondetectable results. In most cases, the RLs were well below any of the applicable sediment quality criteria. However, in the case of PCBs and DDT, some of the RLs were greater than the applicable criteria.

The RLs for the five individual PCBs was 0.070 mg/kg wet weight for all sites. Conversion of these RLs to dry weight values results in RLs ranging from 0.13 to 0.17 mg/kg dry weight. These RLs were too high to provide comparison with the SFRWQCB sediment screening criteria for total PCBs (0.05 mg/kg dry weight).

Metals Analyses

All of the metals concentrations (in wet weight) measured are much less than the respective TTLCs, State of California hazardous waste criteria. Most of the metals concentrations (in dry weight) are less than the San Francisco Bay Regional Water Quality Control Board sediment screening criteria except for the composite sediment samples at channel islands 5 and 7 that had mercury concentrations of 0.37 and 0.52 mg/kg dry weight, respectively, slightly greater than the

SF RWQCB sediment screening criterion of 0.35 mg/kg dry weight.

The metals concentrations were in most cases less than the Severe Effect Levels of the Ontario sediment quality guidelines. Composite sediment samples at channel islands 3 and 4 had nickel concentrations (85 and 96 mg/kg dry weight, respectively) greater than the SEL of 75 mg/kg dry weight. Most of the other metals concentrations were in the range of the Lowest Effect Levels of the Ontario sediment quality guidelines.

Acid Generation Potential

Analysis of acid forming potential and acid neutralizing potential was performed on all sediment samples. These results can be used to predict the capability of a sediment to neutralize acids that may be generated. The acid forming potential is a measurement of all the acid-producing forms of sulfur that may be converted to sulfuric acid (H_2SO_4).

The neutralizing potential is a measure of the neutralizing bases, such as carbonates, present in the soil. The acid generation potential is determined by dividing the measured neutralizing potential by the acid forming potential (N/A ratio). A quotient of one indicates that the two potentials are equal and that the soil can neutralize all the acid produced.

The CVRWQCB has set a N/A quotient of three as the criterion for determining if a soil will become acidic (CVRWQCB, Designated Level Methodology for Waste Classification and Cleanup Level Determination, updated June 1989). The N/A quotients for the sediment samples were in the range 0.13 to 4.96 indicating a potential to generate acid that is greater than the neutralization potential. However, the sediment samples had sulfur values in the low to moderate range (200-2000 ppm total sulfur).

Waste Extraction Test

The results of the citrate and deionized water WET results were compared to drinking water quality criteria. After citrate extraction of the sediment samples from all channel islands, many of the metals were not detected at concentrations above the RLs. However, arsenic, chromium, copper, nickel, lead and zinc were detected in some samples. In many cases, these concentrations were greater than the applicable water quality criteria.

For the metals that were not detected above the RL, many of the RLs were slightly greater than the water quality criteria. For example, the RL for cadmium was 0.05 mg/L, greater than the MCL of 0.005 mg/L and the WQO of 0.00055 mg/L.

After deionized water extraction, only copper, lead and zinc were detected in all sediment samples, and arsenic and nickel were detected only in the channel island 3 composite sample. All metal concentrations were less than the respective MCLs, but in some cases, the metal concentrations exceeded WQOs.

Soil Samples

Organics Analyses

All of the organic analyses except one had nondetectable results. A sediment sample from channel island 2 had a DDE concentrations of 0.002 mg/kg wet weight. This concentration is far less than the TTLC of 1.0 mg/kg wet weight. There is no SFRWQCB sediment screening criterion for DDE.

All of the channel island soil sample metals concentrations were much less than the TTLCs, State of California, hazardous waste criteria. The composite sample at channel island 5 had a copper concentration that was slightly higher (91 mg/kg dry weight) than the SF RWQCB sediment screening criterion of 90 mg/kg dry weight. The composite sediment samples at channel islands 3, 4 and 7 had mercury concentrations (0.38-0.49 mg/kg dry weight) slightly higher than the mercury sediment screening criterion of 0.35 mg/kg dry weight. All of the other metals concentrations were less than the SFRWQCB sediment screening criteria.

All of the sediment samples had metals concentrations in the soil less than the Ontario SELs except for the composite sediment sample at channel island 5 that had a nickel concentration of 106 mg/kg dry weight greater than the SEL of 75 mg/kg dry weight. All other samples had metals concentrations lower than the SELs. Most of the composite sediment samples had metals concentrations in the range of the LELs.

Project Sampling

Water Samples

Field Analyses

The water samples had specific conductances ranging from about 147 to 182 microohms/cm, pH values ranging from 7.3 to 7.7, dissolved oxygen measurements from 5.8 to 8.6, and turbidity values from 9 to 235 NTUs.

Mineral Analyses

All mineral analyses results were less than applicable water quality criteria. Most of the metals analyses were less than the reporting limits. In some cases, the reporting limits were greater than the applicable criteria. For example, the reporting limit for cadmium (0.002 mg/L) is slightly greater than the WQO of 0.0055 mg/L and the reporting limit for lead (0.002 mg/L) is greater than the WQO of 0.00099 mg/L.

Metal Analyses

There were no metal analyses that exceeded either a water quality objective or a primary MCL. One water sample, taken in the dredging plume of channel island 4, had a manganese concentration (0.68 mg/L) slightly greater than the secondary manganese MCL of 0.05 mg/L. The other water samples taken had manganese concentrations that were less than this secondary MCL.

Organic Analyses

The pesticide results were nondetect for chlorinated organics and PCBs.

Bioassay Analyses

No toxicity was detected in the bioassay taken downstream of all the dredging sites.

Sediment Samples

Metals Analyses

All of the metals concentrations are much less than the Title 22 hazardous waste criteria. Most of the metals concentrations were less than the SFRWQCB sediment screening criteria. However, there were some mercury, silver and a zinc sample that had concentrations equal to or greater than the SFRWQCB sediment screening criteria.

Three of the seven samples analyzed for mercury had concentrations of 0.5 mg/kg dry weight, slightly higher than the SFRWQCB criterion of 0.35 mg/kg dry weight. Five of the seven sediment samples had silver concentrations (1.1-2.4 mg/kg dry weight) greater than the SFRWQCB criterion of 1.0 mg/kg dry weight. One of the seven sediment samples analyzed for zinc had a concentration equal to the SFRWQCB sediment screening criterion of 160 mg/kg dry weight. Although all of the sediment samples analyzed for selenium were nondetect, the reporting for selenium (1.5-1.7 mg/kg dry weight) was greater than the SFRWQCB sediment screening criterion of 0.7 mg/kg dry weight.

When compared to Ontario's Sediment Quality Guidelines, many of the sediment samples had concentrations slightly greater than the respective Lowest Effect levels, but less than the Severe Effect levels. The only samples to exceed a SEL were four of the seven nickel samples that had concentrations of 80-88 mg/kg dry weight, slightly greater than the SEL of 75 mg/kg dry weight. All other metal concentrations were less than the respective SELs.

WET Analyses

The sediment samples were also analyzed after Waste Extraction Tests with both citrate and deionized water

were performed. Most of the metals concentrations after WET analysis were nondetect. Lead, chromium, nickel and zinc were detected in some samples after citrate extraction. All metal concentrations were less than the reporting limits after the deionized water extraction.

After citrate extraction, the composite sample from channel island 3 had a lead concentration of 1.8 mg/L. The discrete samples from channel islands 4 and 5 had lead concentrations of 0.2 mg/L. These concentrations are greater than the WQO of 0.00099 mg/L and in one case greater than the MCL of 1.4-2.4 mg/L.

After citrate extraction, all of the sediment samples (from channel island 3, 4 and 5) had chromium concentrations of 0.5 mg/L. These concentrations are greater than the WQO of 0.011 mg/L.

The sediment samples after citrate extraction had nickel concentrations ranging from 0.7 to 1.0 mg/L. These concentrations are greater than the MCL for nickel of 0.002 mg/L.

The sediment samples after citrate extraction had zinc concentrations ranging from 1.1-2.8 mg/L at channel islands 3, 4 and 5. These concentrations are greater than the WQO of 0.049 mg/L. All of these concentrations are less than the secondary zinc MCL of 5 mg/L.

Organic Analyses

Total organic carbon ranged from 6825 mg/kg dry weight to 14,531 mg/kg dry weight. Total petroleum hydrocarbons ranged from 25 mg/kg dry weight to 188 mg/kg dry weight.

All of the sediment samples had nondetect results for PCBs. DDD was detected in one of three discrete samples from channel island 4 (0.028 mg/kg dry weight) and in one of three discrete samples from channel island 5 (0.069 mg/kg dry weight). These DDD concentrations are less than the TTLC and SFRWQCB sediment screening criteria. The concentrations (0.028 mg/kg dry weight and 0.069 mg/kg dry weight) are less than the Ontario Sediment Quality Guideline Severe Effect Level of 6.0 mg/kg dry weight, but greater than the Lowest Effect Level of 0.008 mg/kg dry weight. DDE was detected in one sample from channel island 5 at a concentration of 0.016 mg/kg dry weight, less than the SEL of 19 mg/kg dry weight, but greater than the LEL of 0.005 mg/kg dry weight.

Tributyltin Analyses

Tributyltin was detected above the reporting limit of 1.5 mg/kg dry weight in three of the seven sediment samples analyzed. TBT concentrations 1.6 mg/kg to 3.3 mg/kg dry weight. No criteria are available for butyltins in sediment.

Acid Generation Potential

The sediment samples were analyzed for acid generation potential. The composite sample from channel island 3 had an extremely low potential to generate acid (N/A = 13). Two of the three discrete sediment samples from channel island 5 also had extremely low AGPs (N/A = 9 and 21). However, one of the three samples from channel island 5 and two of the three samples from channel island 4 had N/A quotients less than 3 indicating acid generating potential that exceeds the neutralization potential.

Post-Project Sampling- First Quarterly Monitoring

Water Samples

Field Analyses

The water samples had specific conductances ranging from about 189 to 197 microohms/cm, pH values ranging from 7.3 to 7.9, dissolved oxygen measurements from 8.8 to 9.4, and turbidity values from 7 to 93 NTUs.

Mineral Analyses

All mineral analyses results were less than the applicable water quality criteria.

Metal Analyses

All of the metal analyses results were less than the respective water quality criteria. However, the lead reporting limit (0.005 mg/L) was slightly greater than the WQO of 0.00099 mg/L.

Bioassay Analyses

No toxicity was detected in the water samples taken upstream and downstream of all the dredging sites.

Sediment Samples

Mineral Analyses

Specific conductances ranged from 130 to 200 microohms/cm. Chloride and bromide concentrations were less than the reporting limits and pH ranged from 6.5 to 7.3.

Metals Analyses

All sediment samples had metals concentrations less than TTLCs, hazardous waste criteria. Except for selenium, all of the metals concentrations were less than the SFRWQCB sediment screening criteria. The composite samples for channel islands 3 and 4 had selenium concentrations less than the reporting limit of 1.5 mg/kg dry weight. The composite sample for channel island 5 had a selenium concentration of 1.5 mg/kg dry weight, greater than the SFRWQCB sediment screening criterion of 0.7 mg/kg dry weight.

Waste Extraction Test Metals Analyses

After the WET test with citrate, most of the metals concentrations were less than applicable water quality criteria. However, the composite samples for channel islands 3 and 4 had arsenic concentrations greater than the MCL (0.05 mg/L) but less than the WQO (0.19 mg/L). The composite sample for channel island 5 had an arsenic concentration (0.28 mg/L) greater than both water quality criteria.

The composite samples for channel island 5 had a cadmium concentration of 0.018 mg/L, greater than the MCL of 0.005 mg/L and the WQO of 0.00055 mg/L.

The WET was also conducted with deionized water to more closely simulate the leaching process in a nonacidic situation. Most metals results were nondetect and most results were less than the primary MCLs. The composite sample from channel island 3 had an arsenic concentration (0.055 mg/L) slightly greater than the primary MCL (0.05 mg/L), but less than the WQO of 0.19 mg/L. The composite samples from channel islands 3, 4 and 5 had lead concentrations (0.028-0.056 mg/L) that were greater than the WQO of 0.00099 mg/L.

Organic Analyses

Composite sediment samples from channel island 3, 4 and 5 were analyzed for organochlorine pesticides and PCBs. DDE was found in the composite samples from channel islands 3 and 5 at concentrations (0.005-0.01 mg/kg dry weight) lower than the TTLC (1.0 mg/kg dry weight) and the SFRWQCB sediment screening criterion of 19 mg/kg dry weight, but slight greater than the Ontario sediment quality guideline LEL of 0.005 mg/kg dry weight. All other pesticide results were nondetect.

Acid Generation Potential

The composite samples from all three channel islands, 3,4 and 5, had low N/A quotients (4.68-5.63) indicating the capacity to neutralize any acid generation.

Post-Project Sampling- Second Quarterly Monitoring

Water Samples

Field Analyses

The water samples had specific conductances ranging from about 134 to 177 microohms/cm, pH values ranging from 7.1 to 7.4, dissolved oxygen measurements from 9.1 to 9.7, and turbidity values from 13 to 20 NTUs.

Mineral Analyses

All mineral analyses results were less than the applicable water quality criteria.

Metal Analyses

The metals analyses results have not yet been received from the laboratory.

Bioassay Analyses

Water samples were collected during the week of March 8, 1995 for acute and chronic biotoxicity tests. The methods used were the Methods for Measuring the Acute Toxicity of Effluents to Freshwater and Marine Organisms (EPA/600/4-90/027) and Short-Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Water to Freshwater Organisms (EPA/600/4-89/001). Samples were collected from two sites; one site upstream of all channel islands and one site downstream from all channel islands.

The results of the acute toxicity test, the 96-Hour Growth Test with the algae, Selenastrum capricornutum, for both upstream and downstream samples passed the acceptability criteria for both growth and variance. No significant difference was found between the control mean and the sample water mean (100% water sample). Therefore, the Lowest Observed Effect Concentration (LOEC) was greater than 100%.

The acute toxicity 96-Hour Static Percent Survival Test was conducted on threespine stickleback (Gasterosteus aculeatus). There are 90% survival in the 100% sample water taken upstream of all channel islands. There was also 90% survival in the 100% sample water taken downstream of all channel islands.

The species, Pimephales promelas, Ceriodaphnia dubia, and Selenastrum capricornutum were used for the chronic toxicity bioassays. The results of the cladoceran (Ceriodaphnia dubia) 7-Day Survival and Reproduction Test for both the upstream and downstream water samples show no significant difference between the control mean and the

100% sample water means. Therefore the No Observed Effect Concentration (NOEC) and the LOEC are greater than 100%.

The results of the 7-Day Survival and Growth Test with fathead minnow (*Pimephales promelas*) for both upstream and downstream samples showed no significant difference between the control mean and the 100% sample water means. Therefore the No Observed Effect Concentration (NOEC) and the LOEC are greater than 100%.

The results of the chronic toxicity test, the 96-Hour Growth Test with the algae, *Sleenastrum capricornutum*, for both upstream and downstream samples passed the acceptability criteria for both growth and variance. No significant difference was found between the control mean and the sample water mean (100% water sample). Therefore, the LOEC and NOEC were greater than 100%.

Sediment Samples

Mineral Analyses

Specific conductances ranged from 75 to 93 microohms/cm and pH ranged from 7.0 to 7.5.

Metals Analyses

All sediment samples had metals concentrations less than TTLCs, hazardous waste criteria. All of the metals concentrations were less than the SFRWQCB sediment screening criteria though the selenium reporting limit (2 mg/kg dry weight) was greater than the sediment screening criterion of 0.7 mg/kg dry weight.

Waste Extraction Test Metals Analyses

After the WET test with citrate, most of the metals concentrations were less than applicable water quality criteria. In the citrate extract, chromium, copper, nickel, lead and zinc were detected at concentrations greater than the RLs. Except for nickel, these concentrations were less than the primary MCLs. Some of these concentrations exceed the WQOs.

All of the WET results from the WET conducted with deionized water were less than the RLs.

Organic Analyses

The composite sediment samples from channel island 3 and 4 had nondetect results for organochlorine pesticides and PCBs. DDD and DDE were found in the single sediment sample taken at channel island 5. DDD was measured at concentrations (0.004-0.009 mg/kg dry weight) lower than the TTLC (1.0 mg/kg dry weight) and the SFRWQCB sediment screening criterion of 19 mg/kg dry weight, but slight greater than the Ontario sediment quality guideline LEL of 0.005 mg/kg dry weight. DDE was measured at a concentration of 0.003 mg/kg dry weight. All other pesticide results

were nondetect.

Acid Generation Potential

The composite samples from channel islands, 3 and 4 had N/A quotients (0.01 and 0.31) indicating the capacity to generate acid greater than the capacity to neutralize acid generation, whereas the single sediment sample from channel island 5 had an N/A quotient of 3.11, indicating greater neutralization potential than acid generating potential.

Discussion and Summary

There does not appear to have been a lasting effect on the sediment and water quality of the channel islands from the dredging project. Some parameters such as specific conductance, total dissolved solids, turbidity and hardness increased during the dredging project. However, after the first and second quarterly monitoring, these parameters decreased to near pre-project levels. Comparing the upstream of the channel islands and downstream stations during the dredging project, one can see that the downstream station had a slight 4 microohms/cm greater specific conductance, a 0.1 pH decrease, a dissolved oxygen increase of 0.6 and a rather large turbidity increase of 225 NTUs. However, one week later the downstream turbidity had decreased to within 8 NTU of the upstream turbidity.

Dissolved metals concentrations in the water samples remained relatively constant, in most cases below reporting levels, from before the dredging project to the time of the first quarterly monitoring, three months after the dredging project. The only metals to show a slight increase in concentration were zinc, aluminum and manganese and these concentrations remained below the applicable water quality criteria. Metals results from the second quarterly monitoring which took place in March are not yet available.

The metals concentrations in sediment remained relatively constant throughout the dredging project however, the concentrations of some metals did decrease. Arsenic, mercury, nickel and zinc concentrations decreased moderately. The concentration of lead in the sediment appeared to increase slightly.

Most of the metals measured in the sediments after the waste extraction test were at concentrations below the reporting limits and applicable criteria. Greater metals concentrations were seen in the citrate extract, although the citrate extract may or may not simulate the actual leaching process. It is likely that metals release through leaching are released slowly to the environment.

The acid generation potential measured in the sediment samples seemed to vary greatly from sample to sample. It is not clear if the acid generation potential was moderated over time as would be expected.

In summary, many of the effect of the dredging seem to have been temporary. The decreases of some of the metal concentrations in the sediment did not correspond to increases in the metal concentrations in the water above the reporting limits or above the applicable water quality criteria. Although the results from the remaining two quarterly monitoring sampling events are not yet available, they will also be useful in interpreting the existing data.

Staten Island SRAH Test Projects

1992 & 1993

On separate occasions in 1992 and 1993, the Department of Water Resources (DWR) joined with the owners of Staten Island (M & T Ranch), the State Lands Commission (CEQA Lead Agency), and the Department of Fish and Game (DFG) to work on a test project to find a satisfactory new technique to protect levees and restore lost shaded riverine aquatic habitat (SRAH).

DWR took the opportunity during the small scale projects to conduct water quality analyses and test dredged material from adjacent water channels. Aquatic Toxicity (bioassay) tests were also performed both years.

The results of the testing and analyses from the test projects will be used to support studies conducted to obtain a Section 404 Permit from the U.S. Army Corps of Engineers, and approval from the California Regional Water Quality Control Board, Central Valley Region to work on larger scale projects.

Program Background

Location of Projects

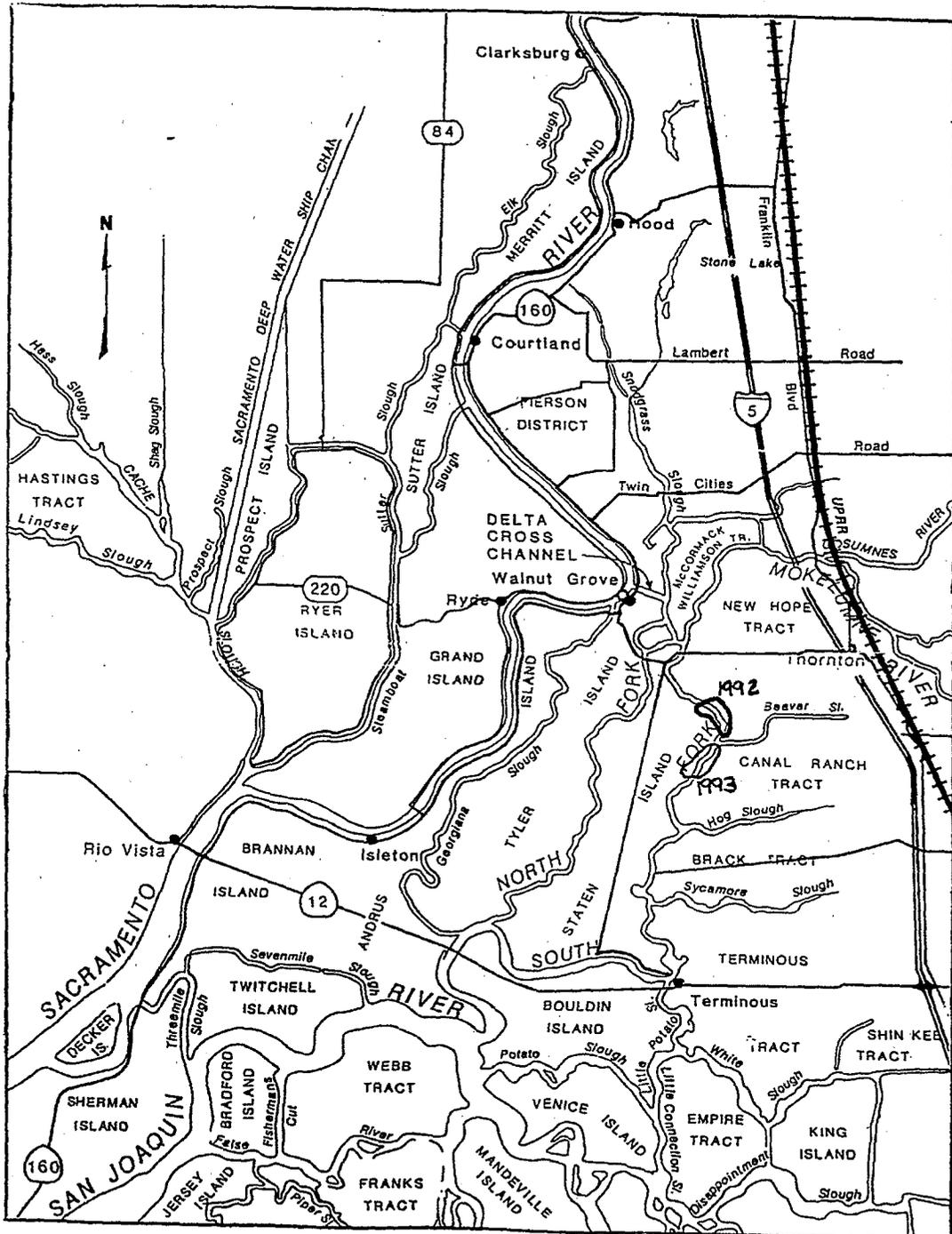
In 1992, the berm test project was conducted along the banks of Staten Island on the South Fork of the Mokelumne River, north of Beaver Slough. The southern boundary of the project area is directly across from the mouth of Beaver Slough and extends nearly 2500 lineal feet upstream (See Figure 58).

In 1993, the test project was also conducted along the banks of Staten Island on the South Fork of the Mokelumne River, but was south of Beaver Slough. The northern boundary of the project is directly across from the mouth of Beaver Slough and extends nearly 3000 lineal feet downstream (See Figure 58). All of the sites have experienced extensive erosion of the mud shoal areas and loss of the riparian vegetation.

Project Purpose

Several levees along Staten Island have experienced severe erosion from wave wash caused by tidal action, boat traffic, and wind-induced waves. Without efforts to stabilize these sites from wave action, further erosion and loss of habitat is expected to occur. With little or no protection, Delta levees will deteriorate and become unstable, consequently increasing the probability of the Delta Islands being flooded. The test projects of 1992 and 1993 have the potential to create shaded riverine aquatic habitat, using dredged material, to protect levees from wave erosion.

Figure 58. 1992 and 1993 Staten Island SRAH Test Project Areas



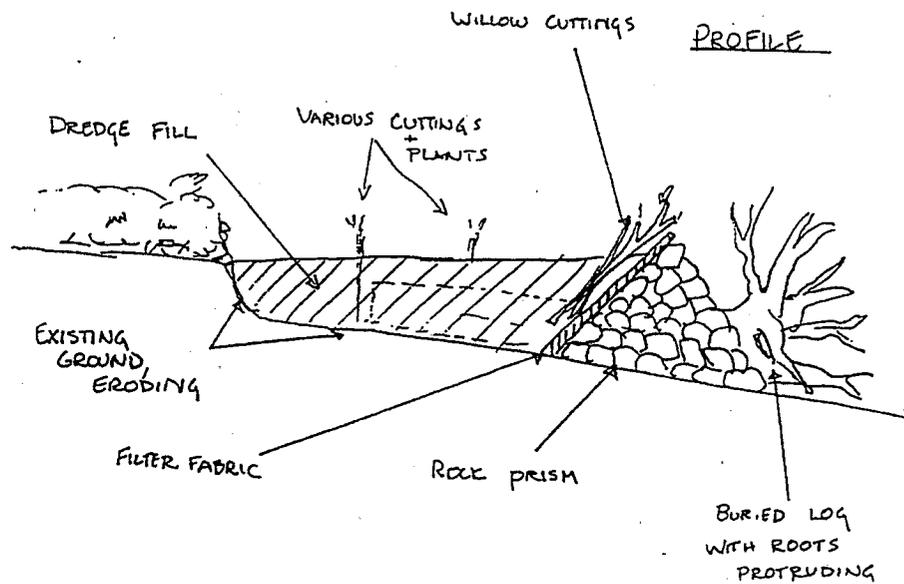
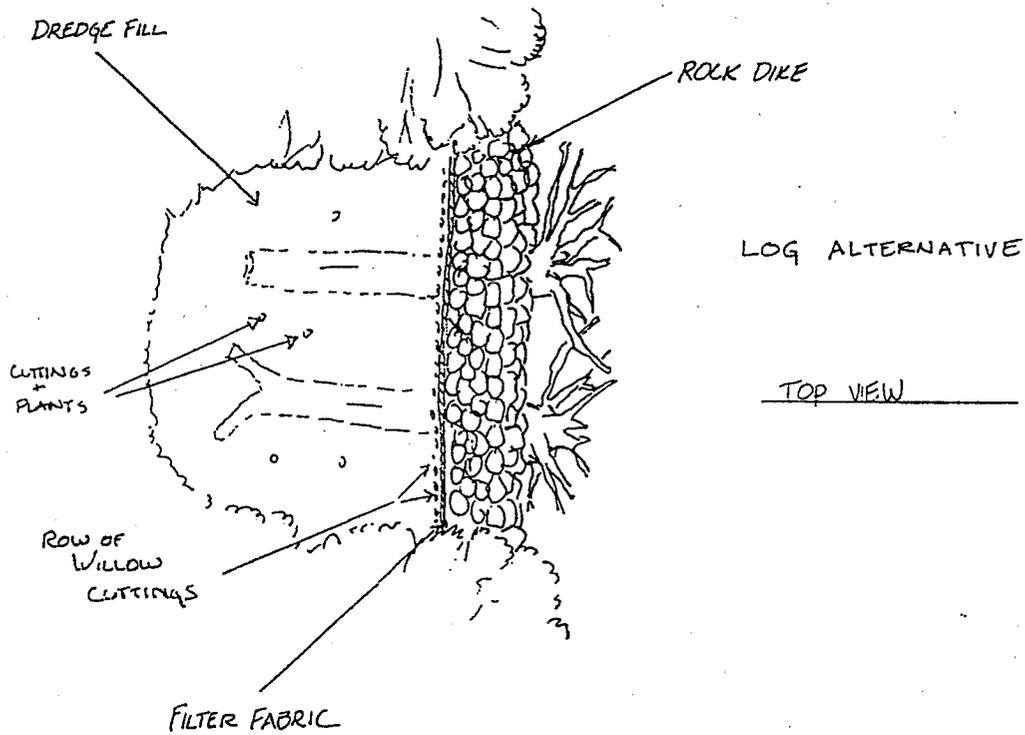
For the test projects, Jim Shanks, Manager of M&T Staten Ranch, obtained permits to dredge material from the South Fork of the Mokelumne River and construct berms along the shoreline level. The rock was piled in long narrow strips parallel to the levee. This defined the waterside edge of the berm. A filter fabric was then placed on the rock to prevent the fine sediment of the dredged material from washing back into the river. The dredging removed sediment from near the center of the river channel and placed the dredged spoil fill on the landward side of a rock berm. Figure 59 shows the plan view and profile of a modified channel.

Dredging of Channels and Potential Impacts

The dredging was performed with a clamshell dredger because it allowed for easier placement of dredged material in the construction of berms (Refer to Figure 59) Since the actual dredging operation was in progress, DWR had the opportunity to study turbidity more closely.

Dredging activities disturb the channel bottom sediment by creating turbidity and resuspending toxics. Since clamshell dredging causes a high level of turbidity and channel bed disturbance, the dredging activities were closely monitored and any occurrences of sediment contamination in the area were documented. In addition, water samples taken from the dredge plume were used in performing acute toxicity (bioassay) tests on fish.

Figure 59. 1993 Staten Island SRAH Test Project Channel Profile



Design of Environmental Study

The objective of the environmental studies of both test projects (1992 & 1993) was to investigate the current conditions at the project areas with respect to chemical and physical properties of channel water and channel sediment. The test projects gave DWR an opportunity to obtain information about the composition of sediment in the channel.

In 1992 and 1993, DWR's staff sampled the dredged material and the water column in the vicinity of the dredger during the dredging operation (See Figure 60 and Tables 19 and 20). A laboratory performed analyses of the samples to assess potential impacts to fish and wildlife. The following sediment and water samples were collected for the 1992 test project:

- Two (2) water samples upstream of dredge plume
- Four (4) water samples within dredge plume
- Three (3) water samples downstream of dredge plume
- Four (4) sediment samples .

In 1993, because the project was smaller in scale, DWR's staff collected fewer samples: (See Figure 60 and Table 20)

- One (1) water sample upstream of the dredging barge
- Two (2) water samples in the dredging plume
- One (1) water sample downstream of the plume
- Three (3) sediment samples

Taber Consultants was contracted to do the actual sampling with assistance from DWR staff. Pace Incorporated Laboratory did the sediment and soil sample analysis. Bryte Chemical Laboratory of Department of Water Resources did the water analysis. Environmental Technical Services was subcontracted through PACE to perform the Acid Generation Tests, and Western Bioassay Laboratories to perform the Aquatic Toxicity Tests.

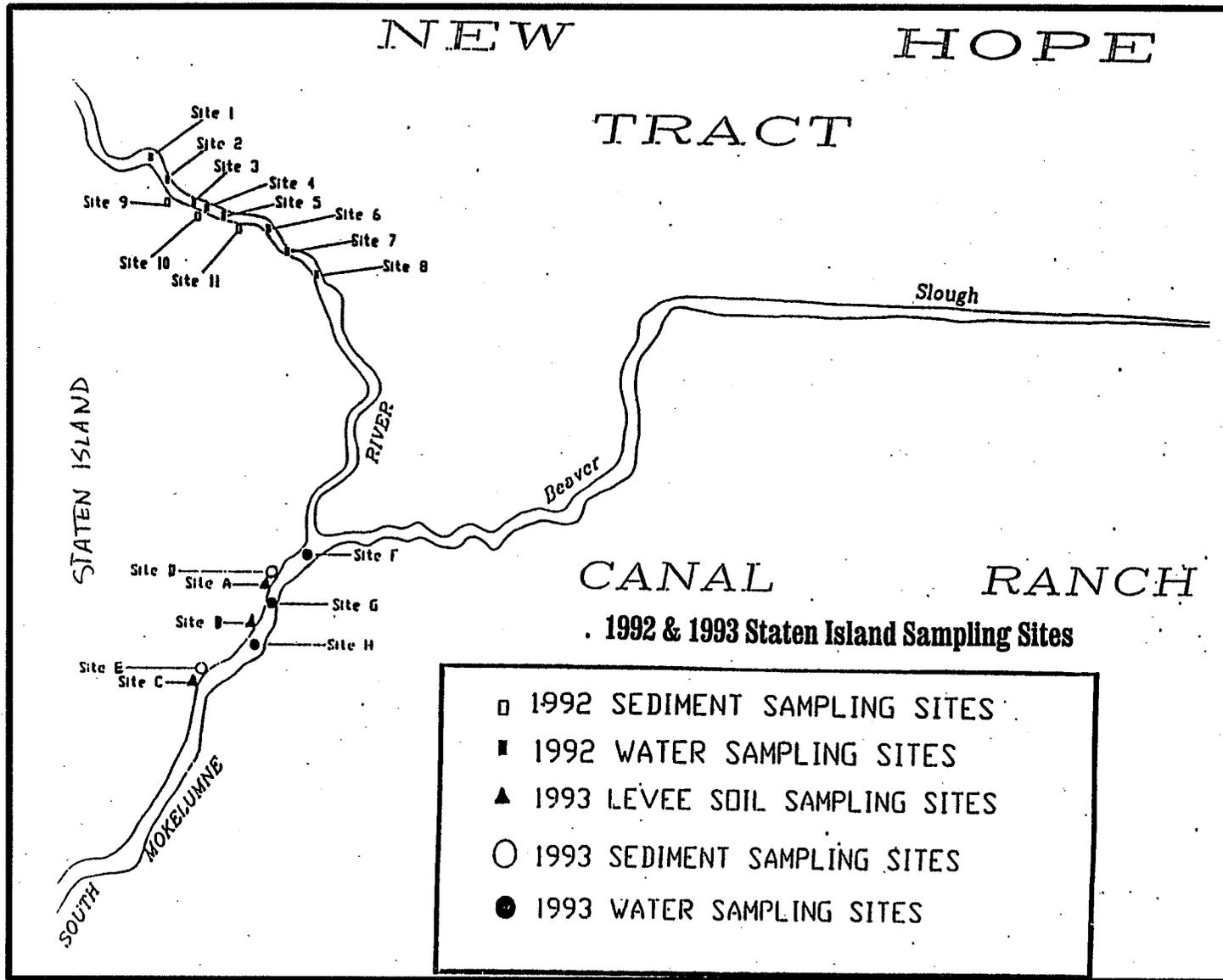


Figure 60. 1992 and 1993 Staten Island SRAH Sampling Sites

Table 19. 1992 Staten Island Sample Site Descriptions

Site No.	Site Description
1	2500 feet upstream from the confluence of South Fork Mokelumne River and Beaver Slough
2	2450 feet upstream from the confluence of South Fork Mokelumne River and Beaver Slough
3	2300 feet upstream from the confluence of South Fork Mokelumne River and Beaver Slough
4	2250 feet upstream from the confluence of South Fork Mokelumne River and Beaver Slough
5	2200 feet upstream from the confluence of South Fork Mokelumne River and Beaver Slough
6	1800 feet upstream from the confluence of South Fork Mokelumne River and Beaver Slough
7	1700 feet upstream from the confluence of South Fork Mokelumne River and Beaver Slough
8	1600 feet upstream from the confluence of South Fork Mokelumne River and Beaver Slough
9	2100 feet upstream from the confluence of South Fork Mokelumne River and Beaver Slough
10	2260 feet upstream from the confluence of South Fork Mokelumne River and Beaver Slough
11	2350 feet upstream from the confluence of South Fork Mokelumne River and Beaver Slough
12	2430 feet upstream from the confluence of South Fork Mokelumne River and Beaver Slough

Table 20. 1993 Staten Island Sample Site Descriptions

Site No.	Site Description
A	1250 feet downstream from the confluence of South Fork Mokelumne River and Beaver Slough
B	1750 feet downstream from the confluence of South Fork Mokelumne River and Beaver Slough
C	3000 feet downstream from the confluence of South Fork Mokelumne River and Beaver Slough
D	1150 feet downstream from the confluence of South Fork Mokelumne River and Beaver Slough
E	2750 feet downstream from the confluence of South Fork Mokelumne River and Beaver Slough
F	250 feet downstream from the confluence of South Fork Mokelumne River and Beaver Slough
G	1400 feet downstream from the confluence of South Fork Mokelumne River and Beaver Slough
H	1900 feet downstream from the confluence of South Fork Mokelumne River and Beaver Slough

General Description of Tests

Water Testing

Water samples were collected from a boat. All of the water samples were taken using properly cleaned sample collection equipment. Extra care was taken to prevent floating material from entering the sampler. Samples were collected from representative sample areas as the boat traveled upstream into the plume. The samples were collected from the front of the boat so that the engine oil didn't contaminate the samples.

Water samples requiring filtration were filtered through 0.45 micron Millipore membranes, using a plastic filtration apparatus. Both unfiltered and filtered samples for fluoride, chloride, hardness, electrical conductivity, total dissolved solids, pH and suspended solids analyses were collected and placed in one quart plastic containers. Samples for total and dissolved metals were placed in acid washed plastic containers and preserved with nitric acid. Samples for oil and grease analysis consisted of unfiltered sample water, placed into a one quart glass jar, and preserved with sulfuric acid. Chromium VI samples were filtered through a 0.45 micron Millipore membrane and placed into an acid washed plastic container. Samples were taken from between 18 and 36 inches below the water surface.

The parameters analyzed were the same as those used in the Fall 1992 Environmental Study (See Table 4).

Sediment Testing

After the dredger deposited a sample, the top portion of the soil sample was cleared off and the portion that had not come in contact with the metal on the clamshell was taken for analysis. A hand trowel was used to collect 1-1/2 pounds of soil up to 12 inches deep from the deposited dredged material.

Each sample was tested for the parameters listed in Table 4 as well as the Waste Extraction Test (WET) for soluble metals, and the Acid Generation Potential Test.

Acute Toxicity Test

This test was done only for samples from Staten Island for the Staten Island Berm Test Project, 1992 & 1993. Dredging activities disturb channel bottom sediment, resulting in increased turbidity which may potentially cause adverse impacts to aquatic life. The bioassays were performed to determine the impacts of dredging on aquatic life. In 1992, one (1) 96-hour Acute Renewal Percent Survival Test with threespine stickleback (*Gasterosteus aculeatus*) and one (1) 96-hour Static Algal Growth Test with *Selenastrum* algae were performed. In 1993, two 96-hour Static Percent Survival Tests with threespine stickleback (*Gasterosteus aculeatus*) were performed.

Quality Assurance/Quality Control

Quality Control During Water Collection and Analysis

Field Quality Control

During the collection of water samples, one duplicate was collected. EPA methods for sample collection, preservation and handling were followed.

Laboratory Quality Control

Reference material samples were submitted by the Department's Quality Assurance/Quality Control Program as an external check on the laboratory quality control. A reference material is a sample with a known concentration of one or more parameters of interest. It is prepared by a laboratory other than the laboratory being evaluated. The standard reference material provides a check on the ability of the laboratory to analyze for one or more parameters using a given method. The sample is submitted to the laboratory along with the environmental samples. The laboratory results for the reference material are compared with the certified concentrations. Laboratory quality control procedures listed in EPA methods were followed (See Table 7). This includes the analysis of a procedural blank and a matrix spike along with every batch processed.

Quality Control During Sediment Collection and Analysis

Field Quality Control

During the collection of sediments, at least one (1) duplicate sample was collected for the two sediment samples collected. EPA methods for sample collection, preservation and handling of sediment material were followed.

Laboratory Quality Control

The EPA methods for the analysis of parameters listed in Table 7 include detailed quality control procedures which were followed by the laboratory. As with the water analysis, standard reference material provided by the Department's Quality Assurance/Quality Control Program was submitted to the contract laboratory to check on performance.

Data Quality Assessment

Sample Representativeness

The samples collected during the 1992 and 1993 Staten Island Berm Test Projects were collected to provide information regarding the current sediment and water quality conditions at the project areas. The study was not intended to be a comprehensive evaluation of the sediment and water quality. The data will be used as baseline information, and added to a database of Delta sediment and water quality.

Laboratory Data Validation

A data quality assessment was performed on all the data to determine whether the data collected were acceptable for the intended use. Laboratory data were evaluated for precision, accuracy, and comparability. Analysis dates were reviewed to check for holding time violations. Laboratory methods, procedures and quality control data were reviewed to assess data quality.

The results of the data quality assessment show that, for the most part, the data are of good quality. One equipment blank sample was held two days past the holding time for EPA Method 8080 (pesticides and polychlorinated biphenyls (PCBs)). Since the holding time was only slightly exceeded, the data is considered acceptable for use in this study. However, it will be tagged as estimated due to potentially low bias. One laboratory control sample for arsenic had a percent recovery of 78%, slightly below the laboratory control limits of 80-120%. However, the duplicate laboratory control sample had a recovery of 80%, within the laboratory control limits. The associated environmental samples will be considered acceptable for our use, but tagged as estimated due to potentially low bias.

The aquatic bioassay tests were also evaluated for appropriate QA/QC. Information reviewed included control survival, number of organisms, number of replicates, and holding time. Bioassays were conducted for both the 1992 and 1993 studies. The results of the review indicate that all bioassays were conducted following EPA QC guidelines. All fish and algal bioassays had 100 percent survival for all dilution ratios in the control groups.

Field Blanks

During the 1992 sampling study one filtered field blank was collected. The results of the analyses showed non-detectable concentrations for all parameters except zinc. Zinc was found at a concentration of 0.012 mg/L. This is a significant concentration considering the associated environmental samples had zinc concentrations ranging from non-detectable to 0.019 mg/L. The results indicate that there may be a source of zinc contamination in the field operations. The zinc results for the 1992 samples will be tagged as questionable due to potentially high bias.

In association with the 1993 study, two field blanks were sent to DWR's Bryte Chemical Laboratory for analysis. One blank was filtered and the other blank was unfiltered. The blanks were analyzed for aluminum, arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, selenium, silver, and zinc. The reporting limits for the preceding metals are shown in Table 3. The results of the analyses show non-detectable concentrations for all metals. Therefore, it appears as though no contamination occurred during the field operations.

Equipment Blanks

Two equipment blanks were collected during the 1993 sampling; one was collected during the sediment sampling and one was collected during the soil sampling. The sediment samples were analyzed for organics and trace metals. The parameters and the corresponding reporting limits are shown in Table 4. The results of the analyses show non-detectable concentrations for all parameters in both samples. It should be noted that the equipment blank collected with the sediment samples was held two days past the holding time for PCBs and pesticide analyses (EPA Method 8080). Therefore, it is possible that the sample results are biased low. However, it appears that no contamination occurred from the field operations.

Field Duplicates

Water

One field duplicate was collected with the 1992 water samples. The results for the relative percent differences (RPD) are shown in Table 21. The standard maximum acceptable RPD for inorganics in water is 25%. With one exception, the RPDs were all below 25%. Nitrate was the only exception, with a RPD of 42%. The duplicate sample results were 2.9 mg/L and 1.9 mg/L, respectively. It was noted on the field sheets that a tear was found in the filter used to filter the duplicate sample. This may account for the high nitrate concentration in the duplicate (2.9 mg/L) and subsequently for the high RPD. These environmental data for nitrate will not be used. No duplicate water samples were collected in the 1993 study.

Sediment

One duplicate was collected with the 1992 sediment samples. The duplicate results and the associated RPDs are shown in Table 22. The maximum acceptable RPD for field sediment duplicates was taken from the 1991 U.S. Bureau of Reclamation Quality Assurance Guidelines for Water Quality Investigations. Sediment duplicate results may vary by 35% or one times the detection limit. RPD data that varies by more than 35% (or one times the detection limit) but less than 50% should be qualified as estimated (1991, USBR).

Table 21. Duplicate 1992 Staten Island Water Sample Results

Parameter	Site 1	Site 1 dup	RPD
Arsenic	0.003	0.002	40
Calcium	14	14	0
Chloride	21	21	0
EC	206	207	0
Hardness	68	68	0
Magnesium	8	8	0
Nitrate	2.9	1.9	42
Potassium	1.6	1.5	6
Sodium	14	14	0
Sulfate	10	10	0
Suspended Solids	34	33	3
Total Alkalinity	55	56	2
Zinc	0.006	0.006	0

The higher acceptable RPD for sediments as opposed to water is due to the inherent variability of sediments and the higher level of difficulty associated with sediment analysis. RPDs for chromium, copper, nickel and zinc were 45%, 40%, 40%, and 51% respectively. These samples will be tagged as estimated because of the high RPDs. The zinc RPD, 51%, exceeds the acceptable maximum and, therefore, the zinc samples are considered unacceptable for use in this study.

Soil

One duplicate was collected with the 1993 soil samples. The results are shown in Table 23. As with the sediment, the maximum acceptable RPD for soil is 35% or one times the detection limit (1991, USBR). The RPD for DDE is 39% which is slightly greater than the above criterion. Therefore, the DDE samples will be tagged as questionable. The only other component to exceed the RPD criterion was total oil and grease. The total oil and grease analyses had a RPD of 60%, greater than the 50% maximum acceptable RPD. The high RPD may be due to improper sampling methodology, improper sample preparation, or problems in laboratory analysis. The oil and grease results are considered unacceptable for use in this study.

Standard Reference Material

Two standard reference material (SRM) samples were submitted with the Staten Island Program samples. This included one SRM for sediment and one for water.

Water

One SRM was sent to DWR's Bryte Chemical Laboratory to check for metal recovery in water. The sample was analyzed for arsenic, selenium and lead. Bryte recovered 96% of the arsenic and 100% of the lead and selenium. These results are excellent, indicating a high level of accuracy for the Staten Island Project water sample results for these parameters.

Table 22. Duplicate 1992 Staten Island Sediment Sample Results

Parameter	Site 9	Site 9 dup	RPD
Chromium	12	19	45
Copper	21	14	40
Nickel	8	12	40
Zinc	83	140	51

Table 23. Duplicate 1993 Staten Island Soil Sample Results

Parameter	Site 2	Site 2 dup	RPD
Arsenic	4.8	4.6	4
Chromium	16	18	12
Copper	17	19	11
DDE	7.7	5.2	39
DDT	14	13	7
Mercury	0.03	0.04	29
Moisture Content	7.8	7.7	1
Nickel	15	13	14
Oil and Grease	70	130	60
Zinc	50	48	4

Sediment

A SRM was submitted to PACE laboratory for selenium and zinc analyses in sediment. Results found zero percent recovery for selenium and 80 percent recovery for zinc. Acceptable SRM recovery for metals in sediment is 80-120 percent. Therefore, PACE had unacceptable selenium recovery and the selenium data will not be used in this report. Another SRM was sent to PACE to test for butyltin recovery in sediment. The laboratory recovered approximately 13, 15, and 3.2 percent of the tributyltin, dibutyltin, and monobutyltin, respectively. These are unacceptably low recoveries and the sample results will be tagged as estimated due to potentially low bias.

Sample Results and Discussion

Channel Water

The results of the water sample analyses were compared to the same standards used in the 1992 INDP Study (Table 7). These standards include the California Inland Surface Waters Plan Water Quality Objectives for the protection of aquatic life (4-day average), and the U.S. Environmental Protection Agency and California Department of Health Services Maximum Contaminant Levels for the protection of drinking water. For a more complete discussion please see the "Sample Results and Discussion - Channel Water" section of the 1992 INDP Study.

Organics

The 1992 water samples were analyzed for trace metals and inorganics only. The 1993 samples were analyzed for pesticides and PCB's as well as trace metals and inorganics. None of the 1993 water samples contained organic compounds at concentrations above their respective reporting limits. In the case of the constituents, Chlordane, DDT and its metabolites (DDE and DDD), Dieldrin, PCBs, Simazine, Thiobencarb and Toxaphene, the RLs were above the water quality objectives. Therefore, the non-detect values were in compliance with the MCLs, but cannot be compared to the SWRCB water quality objectives.

Trace Metal Analyses

All metals were either below the RLs or below the applicable water quality objectives. Only two metals, arsenic and zinc, were detected above their RLs (See Figures 61 and 62). The RL for arsenic is 0.01 mg/L and the RL for zinc is 0.005 mg/L. In a few cases, the RLs were greater than the respective SWRCB water quality objectives. The RL for cadmium (0.005 mg/L) is greater than the WQO (0.00055 mg/L), but equal to the MCL (0.005 mg/L). The RL for lead (0.005 mg/L) is greater than the WQO (0.00099 mg/L), but less than the MCL (1.4-2.4 mg/L). Therefore, the non-detect values were in compliance with the MCLs, but cannot be compared to the SWRCB water quality objectives.

Mineral Analyses

Fluoride, nitrate and sulfate were present at levels below the applicable water quality criteria.

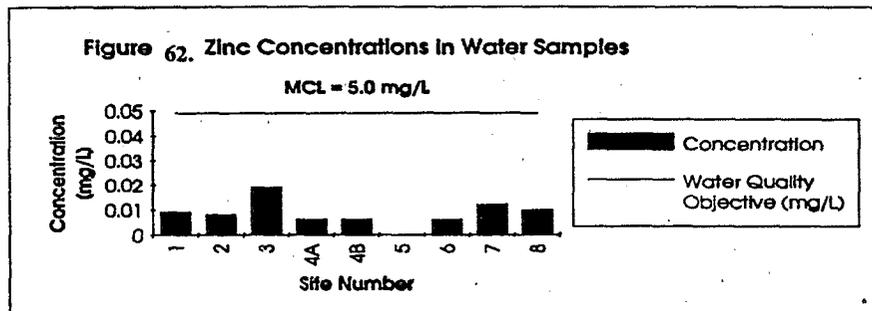
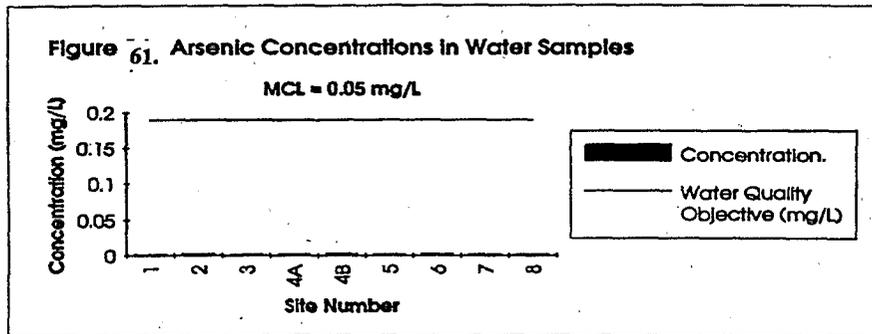
Bioassay Results

In 1992, bioassays were performed on water samples collected from a site within the dredge plume (Site 4), using the 96-hour acute static renewal percent survival test with Threespine Stickleback (*Gasterosteus aculeatus*), and the

chronic 96-hour static growth test with the green algae *Selenastrum capricornutum*. In 1993, two samples were collected, one upstream of the dredge plume, and one within the plume (Sites F and G). The 96-hour acute static renewal percent survival test with Threespine Stickleback was conducted on both samples. Results of the acute bioassays showed 95 percent survival in the 1992 sample and 100 percent survival in the 1993 samples. Results of the chronic bioassay found no change in algal growth between the control and the sample. The SWRCB defines acute toxicity as less than 90 percent survival in undiluted effluent. Chronic toxicity is defined in chronic toxicity units (TUc). The SWRCB's chronic toxicity objective is 1 TUc. According to the SWRCB definitions of acute and chronic toxicity, no acute or chronic toxicity was found in the sample upstream of the dredge plume, or in any of the samples from within the dredge plume.

Tributyltin Analyses

Water samples for the 1993 sites were analyzed for tributyltin (TBT). The only criterion for TBT in water is the SWRCB water quality objective of 0.02 ug/L. The water samples had non-detectable concentrations of TBT with a RL of 1.0 ug/L. Because the RL (1.0 ug/L) is greater than the water quality objective (0.02 ug/L), it is not possible to compare the non-detectable concentrations with the water quality objective.



Channel Sediment

The sediment data were compared to TTLCs and STLCS as well as to non-enforceable California and federal sediment criteria (Table 9). A complete discussion of the applicability of these criteria is presented in the "Sample Results and Discussion - Channel Sediment" section of the 1992 INDP Study.

The 1992 sediment samples were analyzed for trace metals only. The 1993 sediment samples were analyzed for pesticides, PCBs, and trace metals.

Organic Analyses

Evaluation of the sediment results shows that all of the organic analyses had non-detectable results. The RLs provided by the analytical laboratory are given in wet weight units. In order to provide comparison with criteria given in dry weight, the RLs must be converted to dry weight. The RL can be converted using the percent moisture of the sample. Conversion of the RL results in different RLs for each individual sample. In most cases, the RLs were well below any of the applicable sediment quality criteria. However, in the case of PCBs and DDT, some of the RLs were greater than the applicable criteria.

The RL for the five individual PCBs was 0.070 mg/kg wet weight for all sites except Site D (1993) where the RL was 1.750 mg/kg wet weight. Conversion of these RLs to dry weight values results in RLs ranging from 0.094 to 2.21 mg/kg dry weight. These RLs were too high to provide comparison with the San Francisco Bay RWQCB sediment screening criteria for total PCBs (0.05 mg/kg dry weight). All of the samples; however, had RLs that were less than the TTLC for total PCBs (50 mg/kg wet weight).

In the case of DDT, one of the sediment RLs for DDT (0.0639 mg/kg dry weight) was greater than the sediment criterion (0.003 mg/kg dry weight). The other sediment RL for DDT (0.0027 mg/kg dry weight) was less than the sediment criterion. In summary, all of the PCB and DDT samples were non-detect and most of the RLs were below the applicable criteria.

The U.S. Environmental Protection Agency's Sediment Quality Criteria (SQC) are given in units of ug/goc and therefore cannot be directly compared to the analytical results given in mg/kg without conversion. In order to convert the criteria to mg/kg units, the organic carbon content of the soil/sediment samples must be known. The Staten Island samples were not analyzed for organic carbon content; therefore, an estimate was made using a map of the composition of soils in the Sacramento-San Joaquin Delta area, and the approximate locations of the Staten Island sediment sampling sites. See the "Sample Results and Discussion" section in the INDP Study for a complete description of the procedure.

Using an organic carbon content of 10%, SQC of 1.1 mg/kg for Dieldrin, and 0.42 mg/kg for Endrin were calculated. The soil and sediment samples had non-detectable concentrations of Dieldrin and Endrin. The RLs for the measurement of both Dieldrin and Endrin were much less than the respective SQCs. Since all of the results were non-detect and the RLs were lower than the respective SQC, then no sites exceeded the calculated sediment quality criteria.

Trace Metal Analyses

In most of the soil samples, trace metal concentrations were below their respective reporting limits. In several samples, arsenic, cadmium, chromium, copper, mercury and nickel were detected at levels below the applicable criteria (RWQCB sediment criteria and TTLCs) (See Figures 63 through 69).

Arsenic was found at one of the five sites at a concentration of 1.5 mg/kg wet weight or 1.9 mg/kg dry weight (Figure 63). This level is less than the RWQCB sediment criterion of 33 mg/kg dry weight. The concentration of 1.5 mg/kg wet weight is much less than the TTLC of 500 mg/kg wet weight.

Cadmium was found at one of the five sites (Figure 64). The sample had a cadmium concentration of 2.9 mg/kg dry weight (2 mg/kg wet weight) which is less than both the RWQCB sediment criterion (5 mg/kg dry weight) and the TTLC (100 mg/kg wet weight). All of the other sediment samples had non-detectable concentrations of cadmium. The RLs were 0.0063-0.0068 mg/kg dry weight, which is less than the RWQCB sediment criterion of 5 mg/kg dry weight. The RL, 0.005 mg/kg wet weight, is much less than the TTLC of 100 mg/kg wet weight. Therefore, neither the RWQCB criteria nor the TTLC were exceeded at any sites.

Chromium was detected at values ranging from 14-28 mg/kg dry weight or 12-20 mg/kg wet weight at all five sites (Figure 65). These values are less than the RWQCB sediment criterion (220 mg/kg dry weight) and the TTLC (2500 mg/kg wet weight); therefore, the samples do not exceed the applicable criteria.

Copper was detected at concentrations of 11-28 mg/kg dry weight (Figure 66). These results are significantly lower than the RWQCB sediment criterion of 90 mg/kg dry weight. The concentration range in wet weight, 9-20 mg/kg wet weight, was much less than the TTLC (2500 mg/kg wet weight).

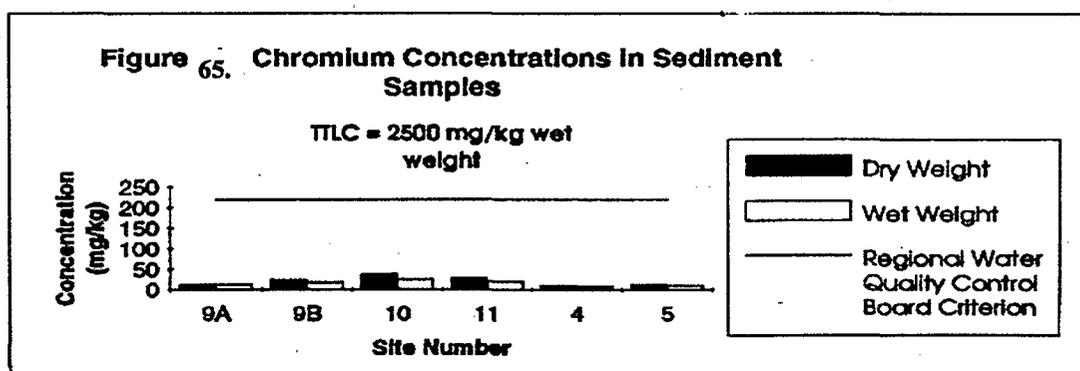
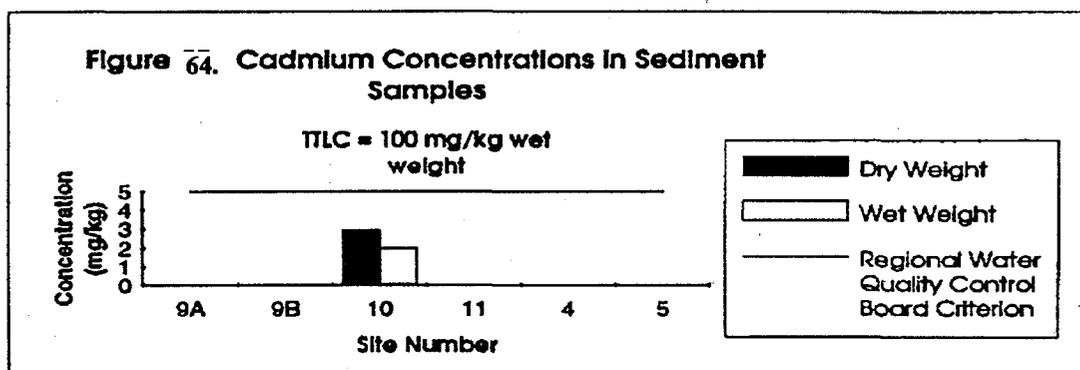
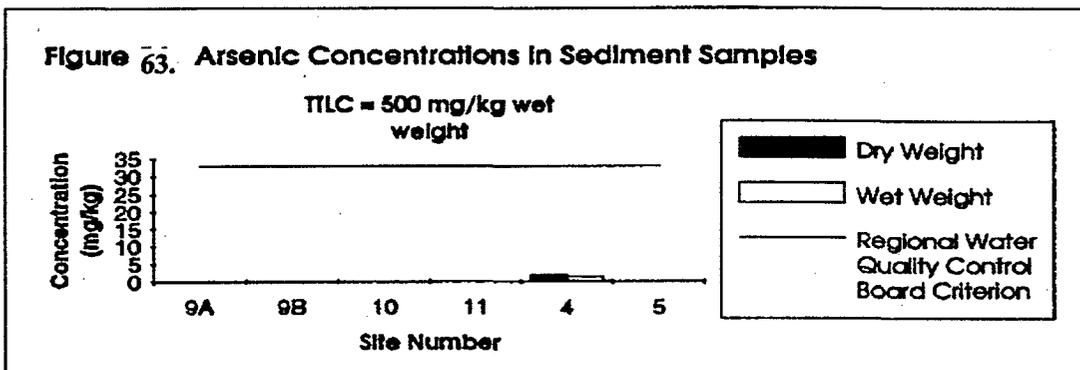
Lead was not found at any of the five sites. The RLs for lead were 12.66-13.51 mg/kg dry weight, significantly below the RWQCB criterion of 50 mg/kg dry weight. The RL, 10 mg/kg wet weight, is much less than the TTLC of 1000 mg/kg wet weight.

Mercury was detected at concentrations of 0.04-0.08 mg/kg wet weight or 0.05-0.11 mg/kg dry weight (Figure 67). These values are less than the RWQCB sediment criterion (0.35 mg/kg dry weight) and the TTLC (20 mg/kg wet

weight).

Nickel was detected at concentrations of 10-29 mg/kg dry weight, significantly less than the RWQCB sediment criterion of 140 mg/kg dry weight (Figure 68). The wet weight concentrations (8-20 mg/kg wet weight) are much less than the TTLC (2000 mg/kg wet weight).

Silver was not detected at any of the five sites. The RLs for silver (1.27-1.35 mg/kg dry weight) are slightly greater than the RWQCB sediment criterion of 1.0 mg/kg dry weight. Thus, comparison of the RLs with the sediment criterion is not possible. The RL for silver (1 mg/kg wet weight) is much less than the TTLC (500 mg/kg wet weight).



Acid Generation Potential

Analysis of acid forming potential and acid neutralizing potential was performed on all sediment samples. A complete discussion of the test and criteria for evaluating the results can be found in the 1992 INDP "Sample Results and Discussion".

The N/A quotients for the 1992 sediment samples were all above 3.0 (range 5-455) indicating low to extremely low acidification potential of the sediment. The 1993 sediment sites; however, had N/A quotients below 3.0. Site D had a N/A quotient of 0.46, while Site E had a quotient of 1.87. Therefore, there is potential for the sediment to become acidic. Review of the sediment analyses at these sites shows that, in general, the metals are present in very low concentrations. All metals except for zinc are below both the RWQCB sediment screening criteria and the TTLCs. Since the metals are generally found in low concentrations, it is probable that any acidification of the sediment would result in minimal metals release.

Waste Extraction Test

In addition to the above analyses, a Waste Extraction Test (California Code of Regulations, Title 22, Chapter 11, Article 5) was performed on samples from all of the sediment sites. The extraction was performed with a citrate buffer. The resulting extracts were analyzed for standard metals. The WET is used to determine the amount of extractable metal present in the sample. The results of the WET were compared to the Soluble Threshold Limit Concentrations (Table 9). The results were not compared to water quality criteria because the citric acid extraction used in the WET test does not simulate actual field conditions. Several metals were found at detectable levels; however, these metals were well below the associated STLCs. For example, arsenic was detected at a range of 0.11 mg/L to 0.14 mg/L, whereas the STLC is 5 mg/L, and copper was detected at a range of 0.05 mg/L to 0.3 mg/L, whereas the STLC is 25 mg/L. Some metals were not detected and the corresponding RLs for these metals were well below the associated STLCs. For example, mercury was not detected at a RL of 0.002 mg/L, which is much less than the STLC (0.2 mg/L). Since none of the constituents which were analyzed exceeded the STLCs, the sediment is not considered a hazardous waste in the State of California.

Tributyltin Analyses

All of the 1992 sediment samples, and samples from two of the 1993 sediment sites (Sites 4 and 5) were analyzed for tributyltin (TBT). At this time, no criteria exist for TBT in sediment. In an effort to evaluate the environmental sample, historical TBT data were used to establish a background TBT concentration range in sediments (Table 10). The historical data are based on samples collected by the California State Water Resources Control Board, U.S. Navy, U.S. Corps of Engineers, and Ontario, Canada (See INDP 1992 section).

All of the sediment samples had non-detectable concentrations of TBT except for Site 10 which had a

concentration of 4 ug/kg wet weight (5.7 ug/kg dry weight). The RL was 1 ug/kg wet weight (1.3 ug/kg dry weight) for all samples. All of the sediment samples were tagged as estimated, however, due to potentially low bias (See discussion under Data Quality Assessment section/ Standard Reference Materials). The SWRCB's TBT range for sediments from coastal and delta water was 0.23-23 ug/kg dry weight, while the range for Ontario, Canada sediment was 30-540 ug/kg dry weight. The U.S. Navy sampled areas at Mare Island, CA and San Diego, CA for total butyltin. The areas were separated into naval, commercial and ecological habitat. The samples from the ecological habitat areas had total butyltin concentrations of 3.5 and 9.1 ug/kg dry weight, respectively. The U.S. Corps of Engineers sampled five sites near Alcatraz Island, CA for TBT to use as background levels for the area. The samples had TBT concentrations ranging from non-detectable to less than 1.3 ug/kg dry weight. The RL for the non-detectable samples was not provided. The North Delta sediment samples, with an estimated reporting limit of 1.3 ug/kg dry weight and only one sample with 5.7 ug/kg dry weight TBT, appear to be within the background concentrations for TBT measured by the above agencies.

Figure 66. Copper Concentrations in Sediment Samples

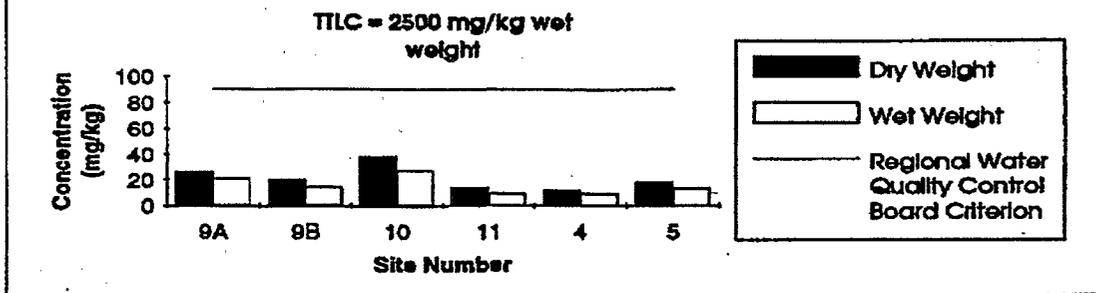


Figure 67. Mercury Concentrations in Sediment Samples

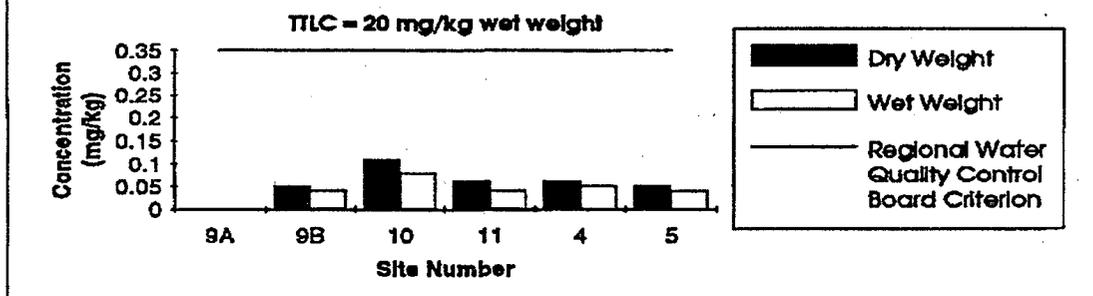


Figure 68. Nickel Concentrations in Sediment Samples

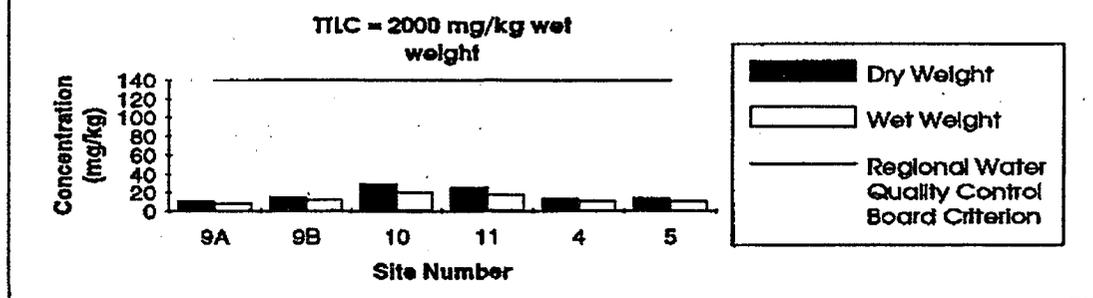
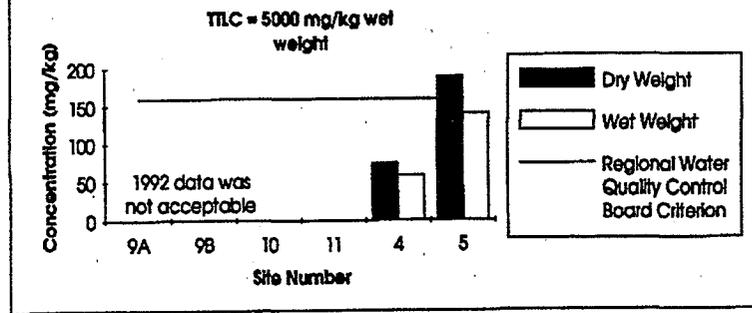


Figure 69. Zinc Concentrations in Sediment Samples



Levee Soil

Levee soil samples were taken in 1993. The levee soil samples were baseline soil samples taken on the land side of the levee. These samples represent the baseline soil quality of the levees that will be reinforced with dredge material. The soil samples were compared to TTLC values exclusively. The RWQCB sediment screening criteria are primarily for the protection of aquatic organisms, and therefore, are not applicable to soil. No soil samples were analyzed using the Waste Extraction Test.

Organic Analyses

In most of the levee soil samples, the concentrations of organic compounds were below the RLs, and the RLs are much less than the applicable TTLCs. In a few cases, DDE, DDT, and Dieldrin were detected at concentrations above the RLs. However, all the concentrations measured were below the respective TTLCs. For DDE, the soil samples had concentrations of 5.2-7.7 ug/kg wet weight, significantly below the TTLC of 1000 ug/kg (See Figure 70). For DDT, the soil samples had concentrations of

13-15 ug/kg wet weight, much less than the TTLC of 1000 ug/kg (Figure 71). One of the three sites (Site C) had detectable concentrations of Dieldrin. The Dieldrin concentration, 3.8 ug/kg wet weight, however, was significantly below the applicable TTLC (8000 ug/kg wet weight). The other sample site had non-detectable concentrations of Dieldrin.

Trace Metal Analyses

In many of the soil samples, metal concentrations were below the RLs. In a few samples, arsenic, chromium, copper, mercury and nickel were reported. However, all of the samples had concentrations of metals that were far below their respective TTLCs (See Figures 72-76).

Figure 70. DDE Concentrations in Levee Soil Samples

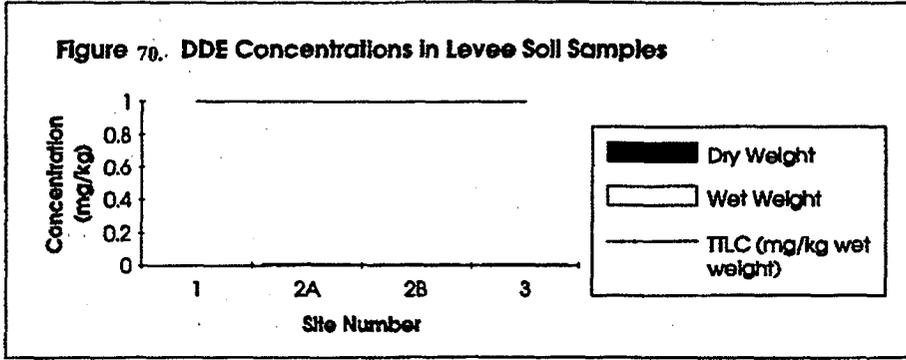


Figure 71. DDT Concentrations in Levee Soil Samples

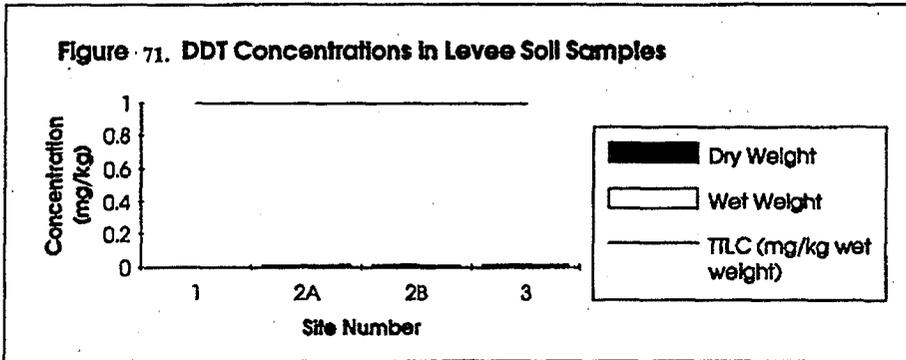


Figure 72. Arsenic Concentrations in Levee Soil Samples

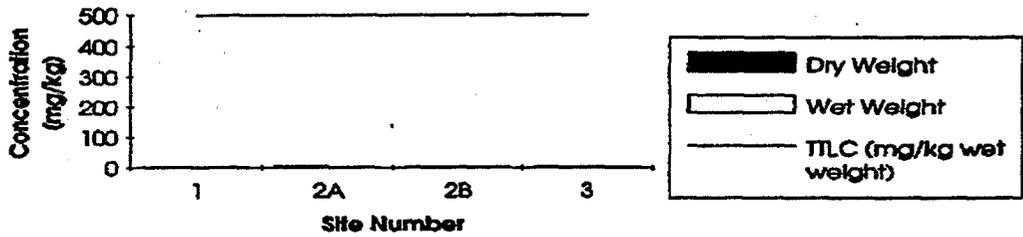


Figure 73. Chromium Concentrations in Levee Soil Samples

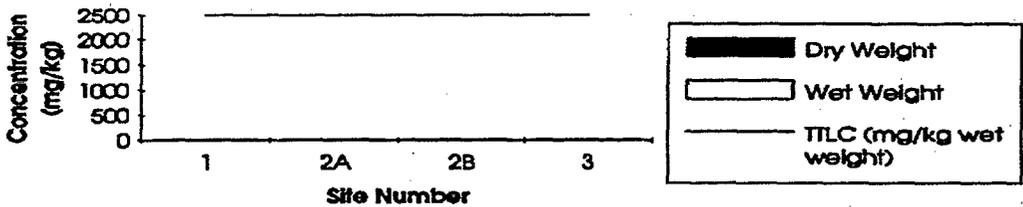


Figure 74. Copper Concentrations in Levee Soil Samples

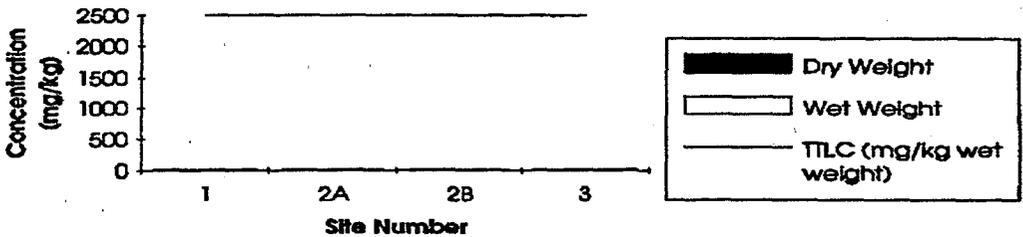


Figure 75. Nickel Concentrations in Levee Soil Samples

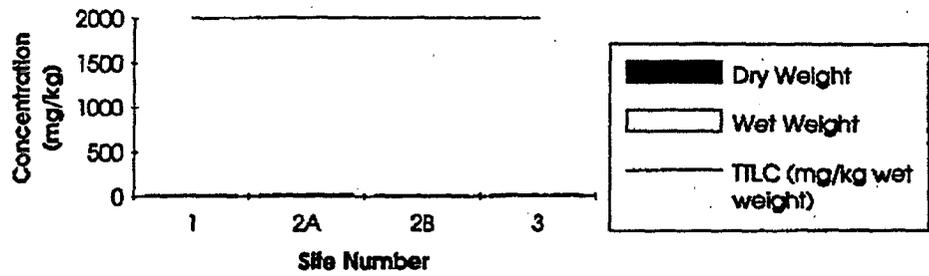
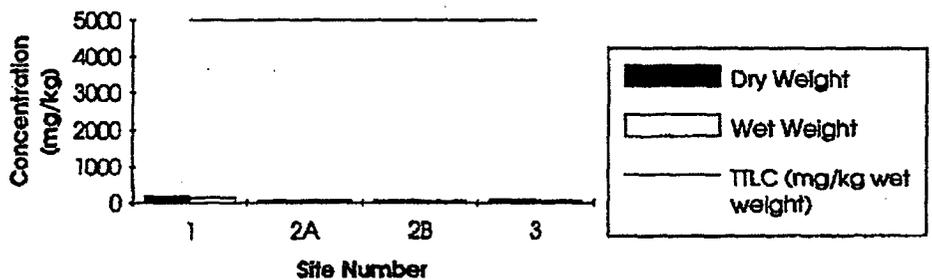


Figure 76. Zinc Concentrations in Levee Soil Samples



Acid Generation Potential

The N/A quotient for the three 1993 levee soil sites was below 3.0. Site A had a N/A quotient of 2.32, Site B had N/A quotients of 0.15 and 0.27, and Site C had a N/A quotient of 1.19. Therefore, there is potential for the levee soil to become acidic. Review of the soil analyses at these sites shows that, in general, the metals are present in very low concentrations. All metals are below their respective TTLCs. Since the metals are generally found in low concentrations, it is probable that any acidification of the sediment would result in minimal metals release.

Waste Extraction Test

A Waste Extraction Test (California Code of Regulations, Title 22, Chapter 11, Article 5) using citrate buffer was performed on the levee site samples (Sites A, B and C). The resulting extract was analyzed for standard metals. All metals were reported at concentrations below the associated STLCs. For example, arsenic was reported at concentrations ranging from 0.08 to 0.15 mg/L, much less than the STLC of 5 mg/L; and copper was reported at concentrations ranging from 0.13 to 0.34 mg/L, much less than the STLC of 25 mg/L. All metals with non-detect results had RLs which were well below the associated STLCs. For example, cadmium was not detected with a RL of 0.005 mg/L, much less than the STLC (1.0 mg/L). Since none of the constituents analyzed exceeded the STLCs, the levee soil is not considered a hazardous waste in the State of California.

Tributyltin Analyses

Soil samples at the 1993 sites were analyzed for the presence of TBT. TBT was not reported at any sites with a RL of 1.0 ug/kg wet weight. No background data for TBT concentrations in soil was available. However, comparison to the historical sediment data indicates the soil samples are at comparatively low concentrations.

Summary

Analysis of the samples for metals indicated that there is not likely to be a concern with metal contamination. The DDE and zinc samples were unusable because of unacceptable quality control. For all the other parameters, the RWQCB criteria and TTLCs were not exceeded at any sites.

Staten Island Test Project 1991

Purpose of Study

In 1991 a Staten Island maintenance dredging operation was performed on the South Mokolumne River (Figure 77). During the dredging, the Department took the opportunity to perform sediment sampling and analyses. The purpose of the sampling was to add to the existing baseline sediment data.

Design of Study

The maintenance dredging was performed using a clamshell dredger to deposit dredge material on top of the levees. After the dredger deposited a sample, the top portion of the soil sample was cleared off and the portion that had not come in contact with the metal on the clamshell was taken for analysis. A hand trowel was used to collect 1-1/2 pounds of soil up to 12 inches deep from the deposited dredged material. Six samples were taken and analyzed for the constituents listed in Table 4 as well as Acid Generation Potential. One sample was split into samples 5 and 7 for QA/QC analysis. Pace Incorporated Laboratory performed the sediment and soil analyses and Toxscan was subcontracted to do the TBT analysis.

Figure 77. 1991 Sampling Sites on the South Fork Mokelumne River

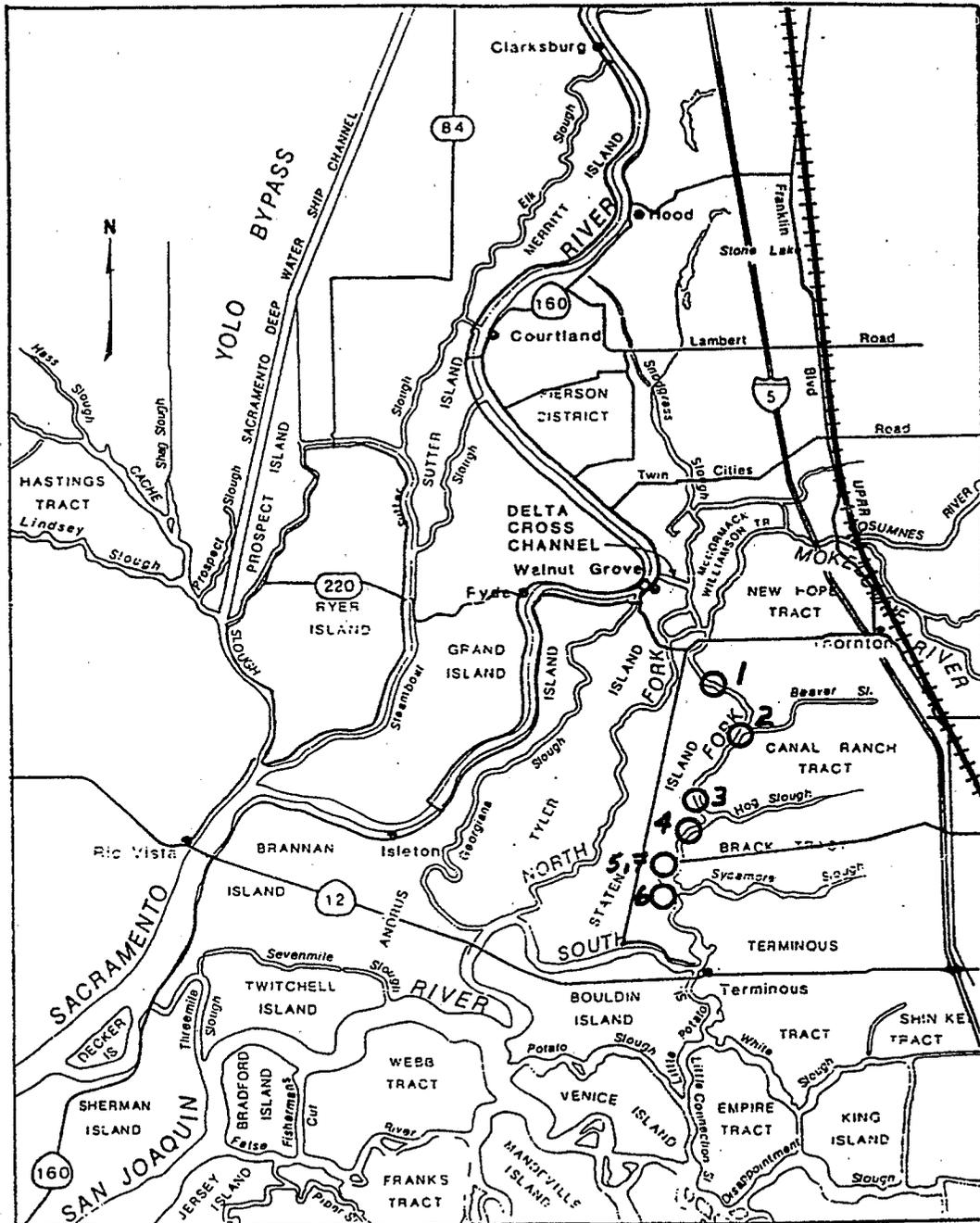


Table 24. 1991 Sample Site Descriptions

Site No.	Site Descriptions
1	1300 feet upstream from the confluence of South Mokelumne River and Beaver Slough
2	100 feet downstream from the confluence of South Mokelumne River and Beaver Slough
3	300 feet upstream from the confluence of South Mokelumne River and Hog Slough
4	150 feet downstream from the confluence of South Mokelumne River and Hog Slough
5	400 feet upstream from the confluence of South Mokelumne River and Sycamore Slough
6	Across from the confluence of South Mokelumne River and Sycamore Slough

Data Quality Assessment

Laboratory Data Validation

Evaluation of the data indicates that in most cases the data are of acceptable quality. However, there were a few instances where the quality control requirements were not met.

Review of the inorganic analyses shows that poor matrix spike recovery was found for chromium (VI), silver and zinc. Chromium (VI) had matrix spike and spike duplicate recoveries of 16% and 17%, respectively. However, the recovery for the laboratory control sample was 109%, within the standard control limits of 80-120% for inorganics. This low matrix spike recovery indicates that it is possible that the environmental sample results are biased low. The chromium (VI) sample data will be used in this study, but will be tagged as estimated due to potentially low bias.

Silver and zinc both had high matrix spike recoveries. The matrix spike recovery for zinc was 485%, while the matrix spike recovery for silver exceeded 999%. Both these recoveries are extremely high. The laboratory control sample recoveries for both metals were within the laboratory control limits of 80-120%. The LCS recovery for silver was 100%, while the LCS recovery for zinc was 94%. It is unusual that matrix spikes have such high recoveries. In most cases, matrix interference results in low recovery of the spike. The high recoveries could be attributed to insufficient or inadequate laboratory sample preparation; however, this could not be confirmed. Due to the high matrix spike recovery, the silver and zinc sample data will not be used in this study.

Field Duplicates

Field duplicates are used to assess total precision, including both laboratory and sampling variability. The variability of the duplicates is determined by evaluating the relative percent difference (RPD). The acceptable RPD for duplicate soil samples is 35% or one times the detection limit. RPD data that varies by more than 35% (or one times the detection limit) but less than 50% should be qualified as estimated (1991, USBR). One set of field duplicates was collected. The results for the detectable constituents and the RPDs are shown in Table 25. The RPDs for all of the metals were below 35%. However, DDE and DDT had RPDs of 137% and 82% respectively. These RPDs exceed the maximum acceptable RPD criterion (50%) and therefore, these data were not used in this study.

Table 25. Duplicate 1991 Sediment Sample Results

Parameter	Site No. 5	Site No. 5 dup	RPD
Arsenic	7	7	0
Chromium	26	23	12
DDD	9.3	11	17
DDE	16	3	137
DDT	7.4	3.1	82
Fluoride	1.3	1.4	7
Mercury	0.17	0.17	0
pH	5	4.9	2
Sulfate	140	140	0
Zinc	180	200	11

Sample Results and Discussion

Channel Sediment

The sediment data were compared to the California TTLC and STLC as well as to non-enforceable California and federal sediment criteria (See Table 9). For a complete discussion of the sediment criteria, see the corresponding section in the INDP 1992 study. The sediment samples were analyzed for trace metals and pesticides. As in the previous study, the wet weight concentrations were converted to dry weight concentrations for comparison with the RWQCB sediment criteria. Because moisture content for the sediment samples was not reported, dry weight concentrations were estimated using an estimated 50% moisture content. This is based on the procedure used by the San Francisco Bay Regional Water Quality Control Board in developing their table of sediment screening criteria for disposal options of dredged material.

Organic Analyses

Most of the organic analyses had non-detectable results; however, DDD was detected in some samples. 4,4-DDD was measured at concentrations above the RL at sites 5 and 6 (out of six sites). The 4,4-DDD concentrations were 0.005 mg/kg and 0.003 mg/kg wet weight, respectively for sites 5 and 6. No RWQCB sediment criteria exist for 4,4-DDD. However, the sediment samples have values much lower than the TTLC (1.0 mg/kg wet weight).

In order to compare the sample value with the Environmental Protection Agency's Sediment Quality Criterion (SQC), the SQC must be converted from units of $\mu\text{g}/\text{g}_{\text{oc}}$ to mg/kg wet weight. The SQC is converted to mg/kg by multiplying the SQC (in $\mu\text{g}/\text{g}_{\text{oc}}$) by the percent organic carbon. Because the environmental sample was not analyzed for organic carbon content, the organic carbon content was estimated. The estimate was made using a map of the composition of soils in the Sacramento-San Joaquin Delta area, and the approximate location of the sample sites. See the corresponding section in the 1992 INDP Study for a detailed discussion of the procedure. A worst case scenario, 10% organic carbon content, is assumed and the SQC is calculated to be 1.1 mg/kg wet weight. The sample value from site 5 (0.016 mg/kg wet weight) is, therefore, much less than the USEPA SQC (1.1 mg/kg wet weight).

None of the organics measured exceed the TTLC. Therefore, the sediment is in compliance with Title 22, and the sediment is not considered hazardous waste in the State of California.

Trace Metal Analyses

In most of the soil samples, trace metal concentrations were below their respective detection levels. In several samples, arsenic, chromium, and mercury were detected, but at levels below the applicable criteria (RWQCB sediment

criteria and TTLCs) (See Figures 78 through 80). No metals were found to exceed the RWQCB sediment criteria.

Arsenic was detected at concentrations above the RL in four of the seven sediment samples. The arsenic concentrations ranged from 6 to 7 mg/kg wet weight (12-14 mg/kg dry weight). These concentrations are less than the RWQCB sediment criterion (33 mg/kg dry weight) and less than the TTLC (500 mg/kg wet weight) (Figure 78). All other sediment samples were non-detect with respect to arsenic. The RL (20 mg/kg dry weight) was below both the RWQCB sediment criterion and the TTLC. Therefore, there was no exceedence of the applicable criteria for arsenic.

Chromium was measured at concentrations above the RL, but below the applicable criteria. Chromium was detected at concentrations of 9-29 mg/kg wet weight (18-58 mg/kg dry weight) (Figure 79). However, these values are tagged as estimated due to potentially low bias because of low spike recovery (See Laboratory Data Validation section). These values are much less than the RWQCB sediment criterion (220 mg/kg dry weight) and the TTLC (2500 mg/kg wet weight). Therefore, none of the sediment samples exceeded the sediment quality criteria for chromium.

Copper was not detected at any of the sites. The reporting limit for copper (2 mg/kg dry weight) is also less than the RWQCB sediment criterion (90 mg/kg dry weight) and the TTLC (2500 mg/kg wet weight). Therefore, the non-detect results are in compliance with the applicable criteria.

Lead was not detected at any of the sites. The estimated dry weight RL for lead was 20 mg/kg, less than the RWQCB criterion of 50 mg/kg dry weight. The wet weight RL, 10 mg/kg, is much less than the TTLC of 1,000 mg/kg. Therefore, the non-detect results for lead are in compliance with the RWQCB criterion and the TTLC.

Mercury was measured at concentrations ranging from 0.03 to 0.17 mg/kg wet weight (0.06-0.34 mg/kg dry weight) (See Figure 80). The highest mercury concentration (0.34 mg/kg dry weight) is close to the RWQCB sediment criterion (0.35 mg/kg dry weight). However, this dry weight mercury concentration is an estimate based on a conservative estimate of 50% moisture content. All of the mercury concentrations are much less than the TTLC (20 mg/kg wet weight).

Selenium was not detected at concentrations above the RL at any of the sites. The RL for selenium (10 mg/kg dry weight or 5.0 mg/kg wet weight) is greater than the RWQCB sediment criterion (0.7 mg/kg dry weight), but less than the TTLC (100 mg/kg wet weight). Therefore, the non-detect results cannot be compared with the RWQCB sediment criterion, but are less than the TTLC.

Tributyltin Analyses

Samples from all of the sediment sites were analyzed for tributyltin (TBT) and other butyltin species. The

sediment data were then compared to historical butyltin data in sediments (Table 10). The historical data are based on samples collected by the California SWRCB, U.S. Navy, U.S. Corps of Engineers, and Ontario, Canada (See 1992 INDP Study section).

Most of the 1991 sediment samples had non-detect concentrations of all butyltin species, but a few samples had detectable concentrations of TBT (See Figure 81). Sites 5 and 6 had dry weight tributyltin concentrations of

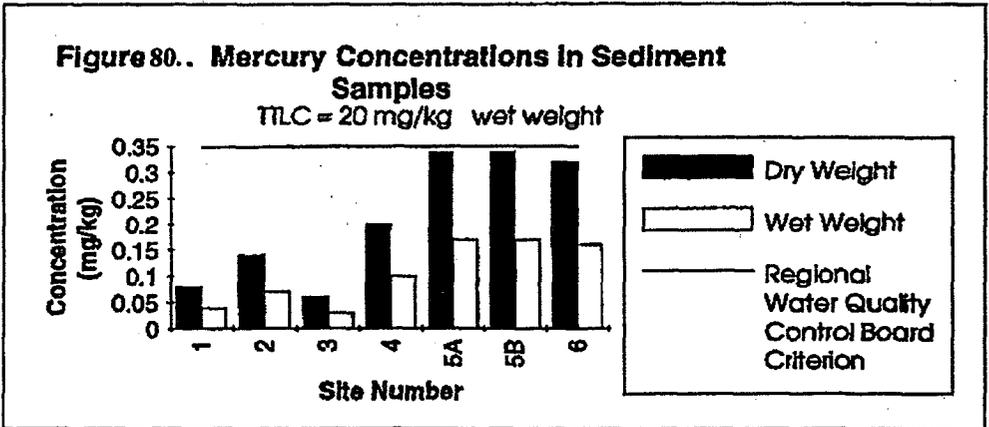
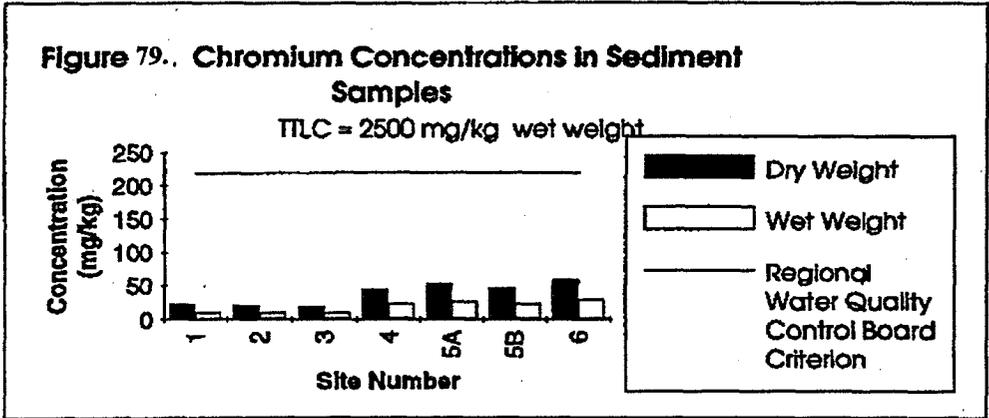
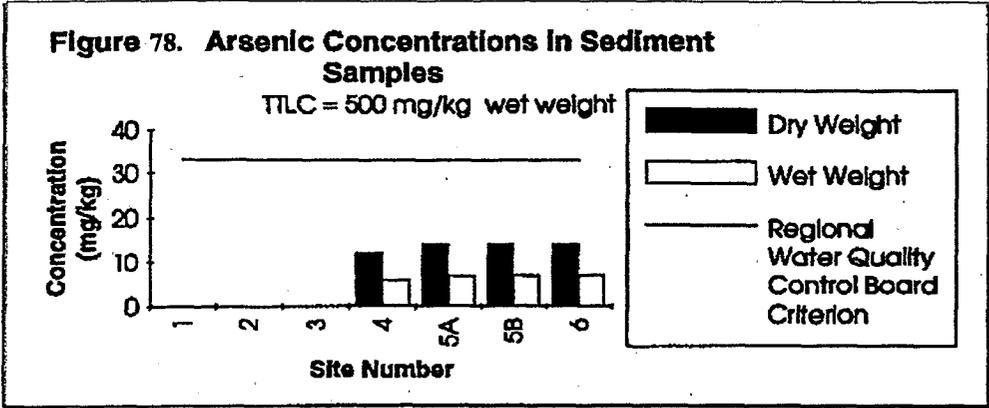
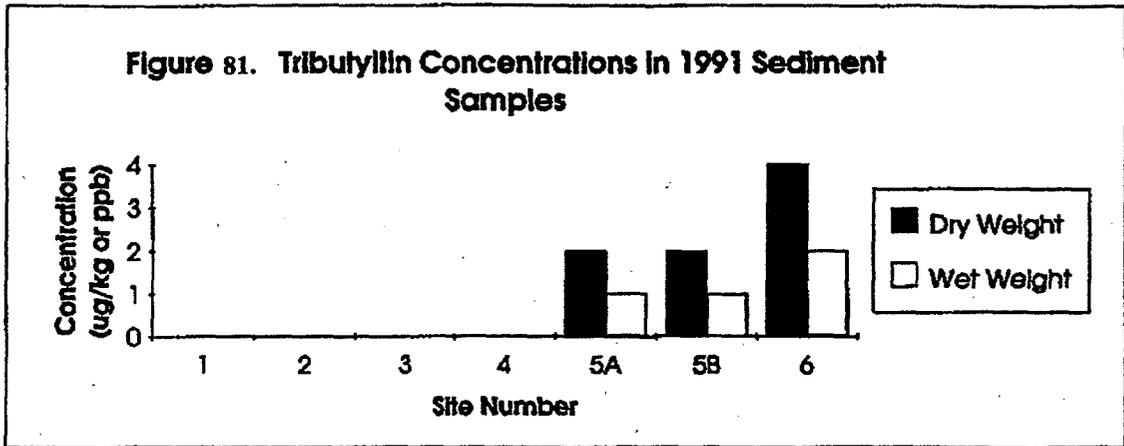


Figure 81. Tributyltin Concentrations in 1991 Sediment Samples



2 to 4 $\mu\text{g}/\text{kg}$ dry weight. All of the other sites had non-detectable concentrations of TBT. The reporting limit was 2 $\mu\text{g}/\text{kg}$ dry weight. All of the sediment samples were tagged as estimated due to the fact that no quality control data was submitted with the environmental data (See discussion under the Data Quality Validation section).

The range of TBT concentrations measured in this study ($<2\text{-}4 \mu\text{g}/\text{kg}$ dry weight) is within the range of background TBT concentrations measured by the SWRCB (0.23-23 $\mu\text{g}/\text{kg}$ dry weight), but slightly higher than the range of TBT concentrations measured by the USACE ($<1.3 \mu\text{g}/\text{kg}$). The range of total butyltin concentrations (in this case, equal to the TBT concentrations) is much less than the range of total butyltin concentrations measured by the U.S. Navy (30-540 $\mu\text{g}/\text{kg}$). Therefore, the butyltin concentrations measured in 1991 are within the background range of butyltin concentrations measured by the SWRCB and the U.S. Navy, and just slightly higher than the background range reported by the USACE.

Summary

Analysis of the sediment revealed mostly non-detectable concentrations of organics in the sediment. DDE and DDT sediment data were unusable because of poor quality control. DDD was detected but was found in concentrations that were less than the TTLC. In general, there were no significant quantities of organic compounds in the sediment.

The sediment samples contained metals in small amounts. In all cases, the metals concentrations were less than the RWQCB sediment screening criteria and the TTLCs. Therefore, no significant metals contamination of the sediment was measured in this study.

Staten Island Test Project 1990

Purpose of Study

In late 1989, the North Delta Program Dredge Material Testing Program was initiated to determine the composition of channel bed material from potential dredge sites in the North Delta. The samples collected were analyzed for several constituents of concern. The results were used to evaluate the potential for using dredge material for levee reinforcement.

Design of Study

Six sites on the Mokelumne River system were selected on the basis of probable toxicity from low to high. Figure 82 shows the locations of these six sites. At site #5, the sample was split and sent to the laboratory to use as a check for validity (However, this sample was later invalidated because of inadequate QC).

Sediment Test Description

For the 1990 test project, samples (about 6 to 12 inch depth) of dredge material from the channel bottom were taken for analysis at each site. A Ponar dredge sampler was used. PACE, Incorporated and the Department's Soil Concrete Laboratory received the dredge material samples on March 29, 1990. PACE, Incorporated conducted the chemical analyses (Table 4) while the Department's soil and concrete laboratory conducted a soil classification test. Each sample was additionally analyzed for by the Waste Extraction Test (WET) for soluble metals, as defined under Title 22 for Hazardous Wastes. Some of the extractable organics (EPA 8270) and metals included as constituents for analysis in the 1990 study are now excluded from testing by the CVRWQCB.

Figure 82. 1990 Staten Island Test Project Sampling Sites

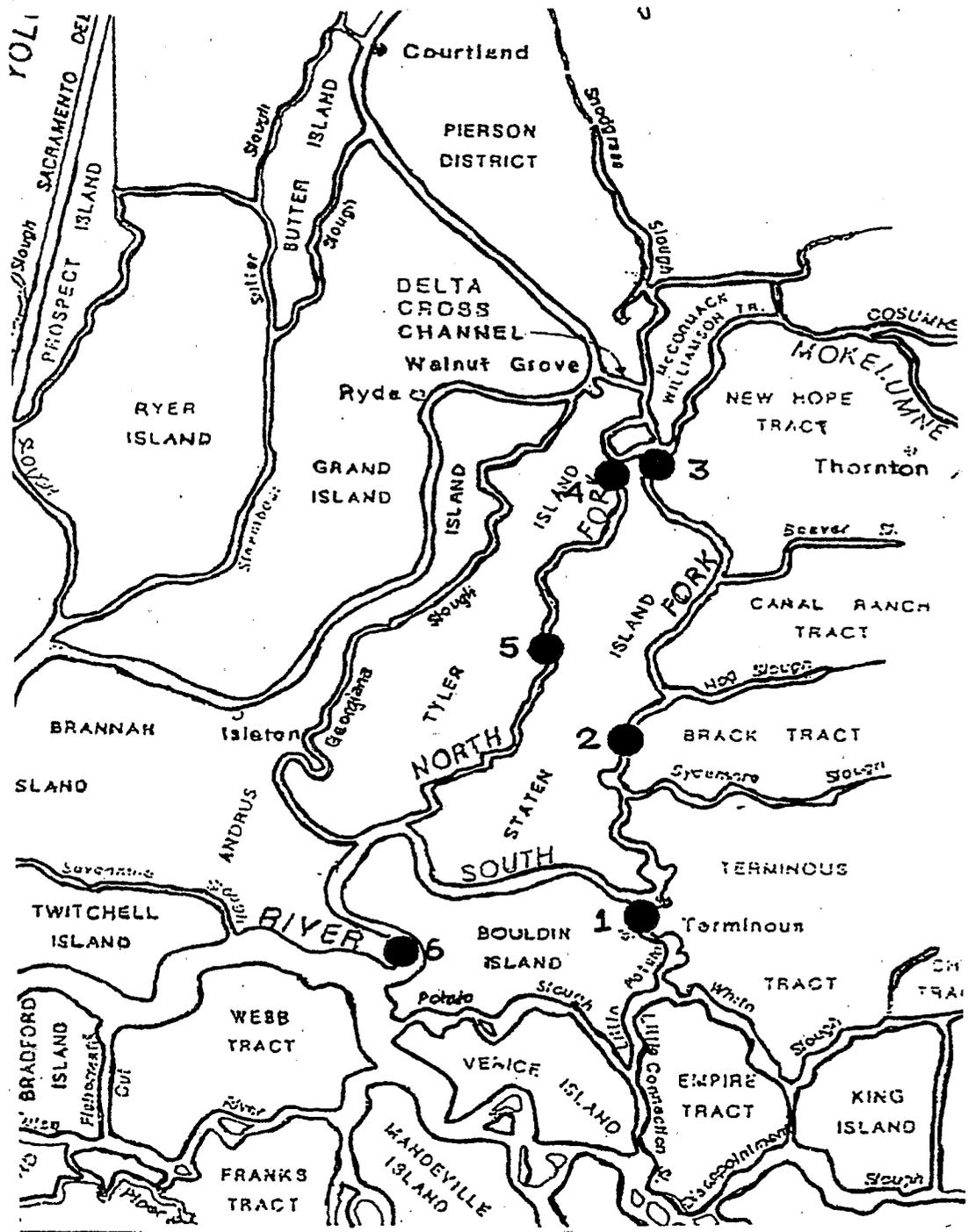


Table 26. 1990 Sample Site Descriptions

Site No.	Site Description
1	Little Potato Slough and south end of Terminous Boat Dock
2	South Mokelumne at end of Woodbridge Road
3	South Mokelumne 0.2 miles south of Walnut Grove Bridge
4	North Mokelumne River at USGS Stream Mile 4.5
5	North Mokelumne River near Walnut Grove Bridge
6	Mokelumne River at Korth's Pirates Lair Marina

The samples that were analyzed showed an unusually high concentration of mercury. Because laboratory quality control was questionable, these samples were retaken and re-analyzed. (See Data Quality Validation section for a complete discussion.) Three laboratories, Pace Laboratories (California and Minnesota) and Enseco Laboratory (West Sacramento, California) participated in an interlaboratory comparison study. The samples were taken on November 14, 1990 and the laboratory re-analysis was done on December 1990.

Data Quality Assessment

1990 Staten Island Study

Laboratory Data Validation

Evaluation of the laboratory QC data indicates that the majority of the sediment data are within acceptable quality control guidelines. However, a few exceptions were found. The matrix spike recovery for antimony was fairly low, 31%. One explanation for the low matrix spike recovery is matrix interference. The sample matrix (sediment) may make extraction of the analyte of interest difficult. Another explanation for the low matrix spike recovery is laboratory sample preparation. Improper spike additions or incomplete sample homogenization could result in poor spike recovery. In either case, the low matrix spike recovery is likely due, in part, to matrix interference and/or sample preparation procedures, not entirely on method limitations. No laboratory control samples were prepared for this batch. The results from the laboratory control samples would have indicated if the low recovery was potentially due to matrix interference. The low recovery indicates that the environmental samples may have a low bias; therefore, the samples will be tagged as estimated.

Recovery of 4-nitrophenol in the matrix spike was only 14%. In addition, the relative percent difference between the duplicate matrix spikes was 67%. As with antimony, no LCS sample was prepared. Therefore, it is again difficult to determine the cause of the low recovery. To provide a conservative evaluation of the data quality, the environmental sample results for 4-nitrophenol will be tagged as estimated due to potentially low bias.

The RPD for the 2,4-dinitrotoluene batch duplicates was 53%. This indicates a high variability between duplicate sample measurements. To be conservative, the 2,4-dinitrotoluene results will be tagged as estimated.

Field Duplicates

Field duplicates are used to assess total precision, including both laboratory and sampling variability. The variability of the duplicates is determined by evaluating the relative percent difference (RPD) between sample results. The acceptable RPD for duplicate soil samples is 35% or one times the detection limit. RPD data that varies by more than 35% (or one times the detection limit) but less than 50% should be qualified as estimated (1991, USBR). One set of field duplicates was collected. The duplicate results and the calculated RPD are shown in Table 28. Two constituents were found to have RPD's greater than 50%. Mercury was found to have a RPD of 192%, and zinc had a RPD of 95%. These results indicate that there were problems with either sample collection or analytical procedures. In either case, the variability associated with the mercury and zinc duplicates is outside of the acceptable QC limits.

Due to the extremely high RPD, the mercury samples were considered not acceptable for use in this study. Therefore, the mercury samples were resampled and reanalyzed (See the following section 1991 Mercury Study). The zinc RPD was considered unacceptable for the purposes of this study as well. The remainder of the constituents had RPD values within the acceptance limit.

1991 Mercury Study

Laboratory Data Validation

Because the mercury samples in the original sampling had unacceptable quality control, sediment samples were retaken in late 1990. The sediment samples were homogenized by stirring, then split into three subsamples. Each subsample was then sent to a different laboratory for chemical analysis. The laboratory data validation is discussed for each laboratory.

Table 27. Duplicate 1990 Sediment Sample Results

Parameter	Site No. 4	Site No. 4 dup	RPD
Barium	80	89	10
Chromium	37	39	5
Cobalt	8.8	10	13
Copper	38	40	5
DBT	4.1	4	2
Mercury	7.6	0.15	192
Nickel	39	40	3
Selenium	20	17	16
TBT	3.5	4.2	18
Vanadium	30	33	10
Zinc	30	84	55

Laboratories

Enseco

Review of the Enseco QC data indicates that the data for total mercury may be biased low. The matrix spike recovery for total mercury had a percent recovery of only 66. However, the laboratory control sample recovery for the batch was 108%, well within the laboratory control limits of 84-126%. The low recovery of the matrix spike may be

due to matrix interference, laboratory preparation procedures, and/or method limitations. In either case, the environmental samples for total mercury will be tagged as estimated due to potentially low bias. No other concerns were found.

Pace, California

A review of the California PACE data for mercury reveals that there are no discrepancies. All the QC data are within the acceptable limits.

Pace, Minnesota

No QC is available for the Minnesota PACE data. The data will be tagged and noted that a laboratory data evaluation was not performed.

Split Sample Evaluation

The mercury study results from the three laboratories were compared to check the accuracy of the data. The RPDs between the three laboratories for each sample are shown in Table 29. The RPDs for most of the samples were less than 50% indicating good precision between the laboratories. One sample, however, had an RPD of 160%. For this sample, PACE (California) obtained a result of 0.1 mg/kg wet weight, while PACE (Minnesota) obtained a result of 0.89 mg/kg wet weight. Enseco obtained a ND result with a MDL of 0.10 mg/kg wet weight. Considering the good precision between the laboratories with the other samples, it is likely that the poor precision of this sample is due to the anomously high result (0.89 mg/kg wet weight) obtained by PACE (Minnesota) for this sample. This anomously high sample result could be due to inherent variability in the sediment and/or insufficient sample preparation. Because of the imprecision of this sample, this sample was not used in the data analysis. In general, the precision between the laboratories is good, indicating each laboratory can produce accurate results.

Table 28. 1991 Mercury Study Split Sample Results

Site No.	Enseco	PACE, CA	PACE, MN	RPD
1	0.10	0.09	0.07	25
2	0.13	0.10	0.10	22
3		0.03	0.02	40
4A		0.10	0.07	35
4B		0.10	0.89	160
5	0.10	0.10	0.08	17
6	0.10	0.11	0.08	22

Standard Reference Materials

Standard reference materials were submitted in the mercury study. SRM results provide information about the ability of the laboratory to accurately analyze for a given parameter. A SRM sample was sent to each of the three laboratories. Both PACE laboratories (California and Minnesota) had 98% recovery of the SRM. Enseco had a recovery of 93%. These recoveries are excellent, indicating all three laboratories can accurately recover mercury.

Sample Results and Discussion

Channel Sediment

The sediment samples were analyzed for trace metals and pesticides. To evaluate the sediment quality, the sediment data were compared to TTLCs and STLCs as well as to non-enforceable RWQCB sediment screening criteria (See corresponding section in the INDP 1992 Study and Table 9). In order to compare concentrations of these constituents to the RWQCB sediment criteria, the wet weight concentrations had to be converted to dry weight. Because moisture content for the sediment samples was not reported, dry weight concentrations were estimated. Wet weight concentrations were converted to dry weight using 50% moisture, the value used by the RWQCB in their development of their table of sediment screening criteria.

Organic Analyses

Evaluation of the sediment results shows that all of the sediment samples had non-detectable results for organics. The 4-nitrophenol and the 2,4-dinitrotoluene results, however, were tagged as estimated. Excepting 4-nitrophenol and 2,4-dinitrotoluene, whose true concentrations are not known, the sediment has organic compound concentrations less than the applicable criteria. The sediment is also in compliance with Title 22 and is, therefore, not considered hazardous waste in the State of California.

Trace Metal Analyses

In most of the soil samples, trace metal concentrations were below their respective RLs. In several samples, chromium, copper, mercury and nickel were measured at concentrations above the respective RLs but below the RWQCB sediment criteria and TTLCs (See Figures 83 through 87). The selenium and a few of the zinc samples exceeded RWQCB sediment criteria; however, they did not exceed their respective TTLC criteria.

Arsenic was not detected at concentrations above the RL at any of the sediment sites. The RL for arsenic (10 mg/kg wet weight or 20 mg/kg dry weight) was below both the RWQCB sediment screening criterion (33 mg/kg dry weight) and the TTLC (500 mg/kg wet weight). Therefore, the non-detect results for arsenic are in compliance with the applicable criteria for arsenic.

Cadmium was not detected at concentrations above the RL at any of the sediment sites. The RL for cadmium (1 mg/kg wet weight or 2 mg/kg dry weight) is less than the RWQCB sediment criterion (5 mg/kg dry weight) and much less than the TTLC (100 mg/kg wet weight). The RL for cadmium is less than the applicable criteria; and therefore, the non-detect results are in compliance with the applicable criteria for cadmium.

Chromium was reported at concentrations below the applicable criteria. Chromium concentrations ranged from 6-46 mg/kg wet weight (12-84 mg/kg dry weight) (Figure 83). These values are much less than the RWQCB sediment criterion (220 mg/kg dry weight) and the TTLC (2500 mg/kg wet weight). Therefore, none of the chromium concentrations exceed the applicable chromium criteria.

Copper was reported at concentrations below the applicable criteria. The copper concentrations ranged from 6-40 mg/kg wet weight (12-80 mg/kg dry weight concentrations) (Figure 84). These values are less than the RWQCB sediment criterion (90 mg/kg dry weight) and less than the TTLC (2500 mg/kg wet weight). The copper concentrations are, therefore, in compliance with the applicable criteria.

Lead was not detected at values above the RL at any of the sites. The RL for lead was 20 mg/kg dry weight (10 mg/kg wet weight), less than the RWQCB criterion of 50 mg/kg dry weight and much less than the TTLC of 1000 mg/kg wet weight. Therefore, the non-detect results for lead are in compliance with the RWQCB criterion and the TTLC.

As discussed in the Laboratory Data Validation Section, the original mercury samples taken were not of acceptable quality for use in this study. Therefore, additional samples were taken and analyzed for mercury. These additional samples had acceptable QC. Each sediment sample was analyzed independently by three different analytical laboratories.

Figure 82. Chromium Concentrations in Sediment Samples

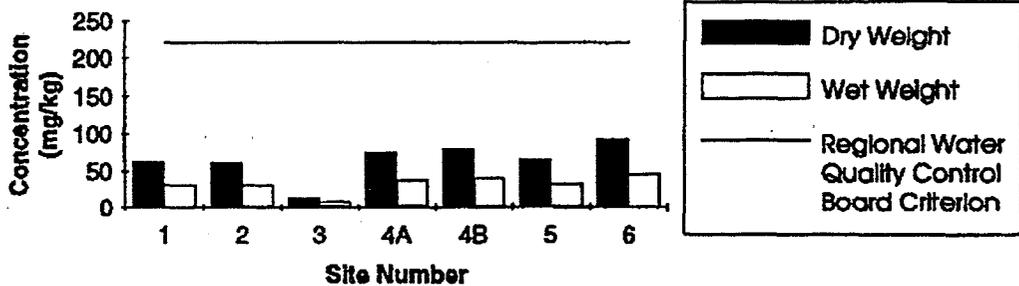


Figure 83. Copper Concentrations in Sediment Samples

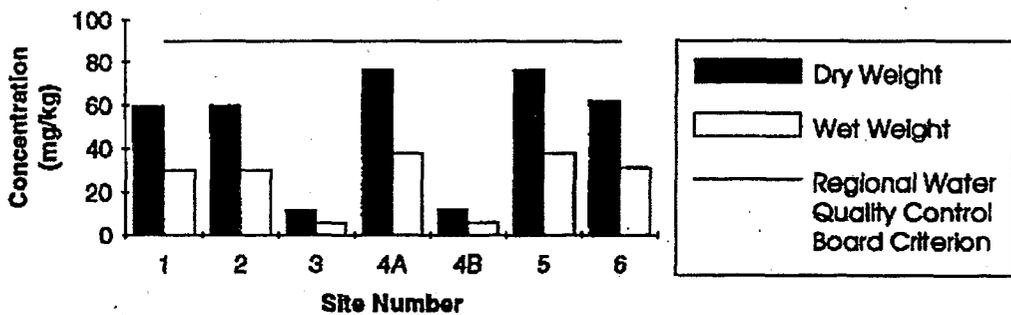


Figure 84. Mercury Concentrations in Sediment Samples

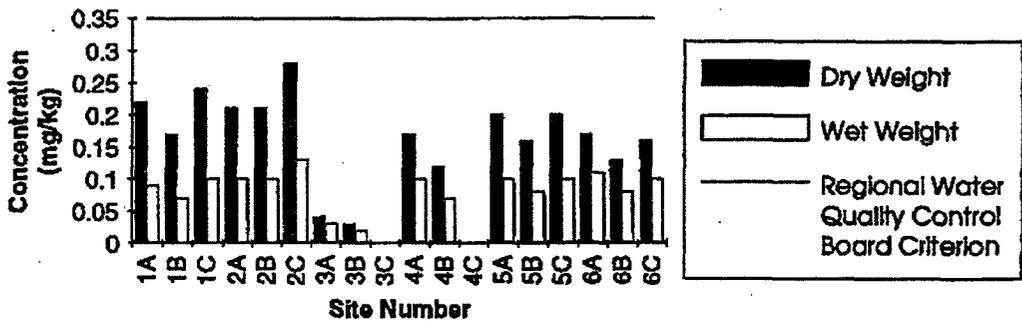


Figure 84 shows the results of the three different laboratory analyses conducted for each sample. The samples labeled A were analyzed by PACE, California, the samples labeled B were analyzed by PACE, Minnesota, and the samples labeled C were analyzed by Enseco. Mercury concentrations ranged from <0.02 to 0.13 mg/kg wet weight (0.03-0.28 mg/kg dry weight). The quality control evaluation showed that the Enseco samples may be biased low. The PACE-Minnesota samples were tagged as estimated because no quality control data was submitted, and the PACE-California samples had acceptable quality control. All of these concentrations are less than the RWQCB sediment criterion (0.35 mg/kg dry weight) and much less than the TTLC (20 mg/kg wet weight). Therefore, the sediment samples are in compliance with the RWQCB sediment criterion and the TTLC.

Nickel was detected at concentrations of 10-92 mg/kg dry weight, less than the RWQCB sediment criterion of 140 mg/kg dry weight (Figure 85). The wet weight concentrations (5-46 mg/kg wet weight) are much less than the TTLC (2000 mg/kg wet weight).

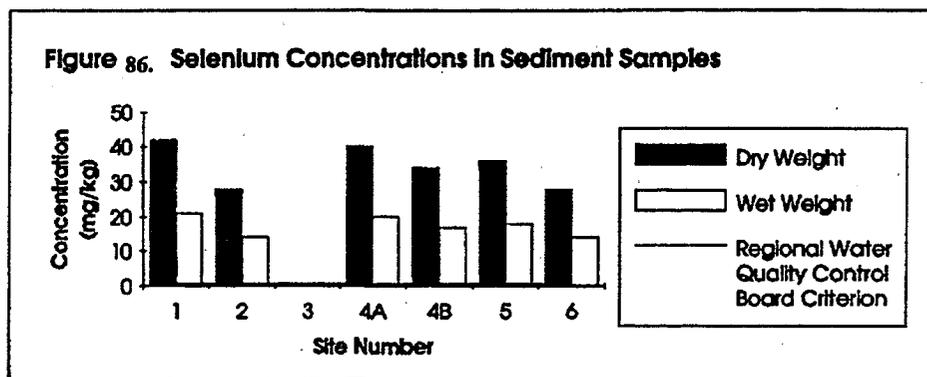
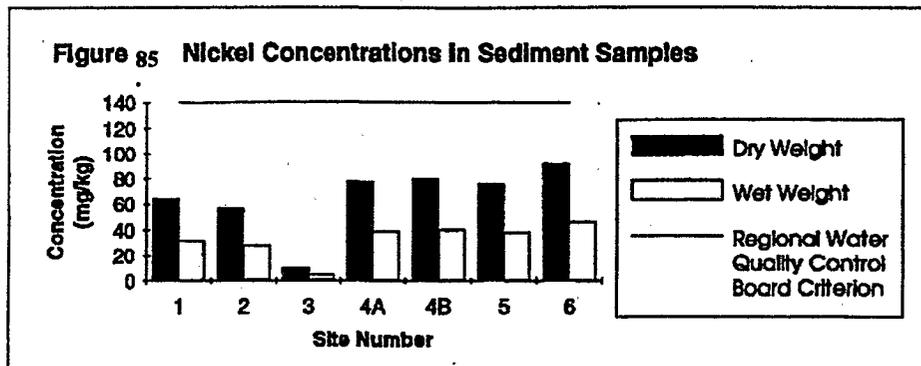
Selenium was found in detectable concentrations at five out of the six sites. Selenium was measured at concentrations ranging from 14 to 21 mg/kg wet weight (Figure 86). The estimated (using the 50% moisture conversion) concentrations are 28 to 42 mg/kg dry weight. Except for the one non-detect site (Site #3), these values exceed the RWQCB sediment screening criterion (0.7 mg/kg dry weight). These values are greater than the RWQCB sediment criterion (0.7 mg/kg dry weight), but are less than the TTLC (100 mg/kg wet weight).

Silver was not detected at concentrations above the RL at any of the sites. The RL for silver (2 mg/kg dry weight or 1 mg/kg wet weight) is greater than the RWQCB sediment criterion (1.0 mg/kg dry weight), but less than the TTLC (500 mg/kg wet weight). Therefore, the non-detect results for silver cannot be compared to the RWQCB sediment screening criterion, but are in compliance with the TTLC.

Waste Extraction Test

In addition to the above analyses, a Waste Extraction Test (California Code of Regulations, Title 22, Chapter 11, Article 5) was performed on all the sediment sites. The resulting extracts were analyzed for standard metals. The WET is used to determine the amount of extractable metal present in the sample. The results of the WET were compared to the STLCs.

Several metals were found at concentrations above the RLs for WET metals (Figures 87-92). These metal concentrations, however, were well below the associated STLCs. For example, arsenic was detected at a range of <0.005 mg/L to 0.09 mg/L, much less than the STLC (5 mg/l). Copper was detected at a range of <0.01 mg/L to 0.23 mg/L, far below the STLC of 25 mg/L. Some metals were not detected above the RL. The corresponding RLs for these metals were well below the associated STLCs. For example, mercury was not detected, at a RL of 0.0002 mg/L, much less than the STLC of 0.2 mg/L. Since none of the constituents which were analyzed exceeded the STLCs, the sediment is not considered a hazardous waste in the State of California.



Tributyltin Analyses

All of the sites were analyzed for tributyltin (TBT) in the sediment. Because no criteria exist for TBT in sediment, the samples were compared to historical TBT data (Table 10).

The range of TBT measured in the samples in this project ($<2-10.8 \mu\text{g}/\text{kg}$ dry weight) was within the range of TBT reported by the SWRCB ($0.23-23 \mu\text{g}/\text{kg}$ dry weight) and less than the range of TBT measured in Ontario, Canada ($30-540 \mu\text{g}/\text{kg}$ dry weight). However, six of the seven samples measured in this project ($4.8-10.8 \mu\text{g}/\text{kg}$ dry weight) had higher concentrations than the background concentrations measured by the U.S. Army Corps of Engineers ($<1.3 \mu\text{g}/\text{kg}$ dry weight). (See Figure 93)

The sediment samples in this study had total butyltin concentrations ($<1.2-22.6 \mu\text{g}/\text{kg}$ dry weight) that were in the range of the total butyltin monitoring data taken by the U.S. Navy (3.5 and $9.0 \mu\text{g}/\text{kg}$ dry weight). Although some of the samples had TBT and total butyltin concentrations that were slightly higher than some of the monitoring data, the butyltin concentrations measured in this project are in the general range of background concentrations measured by other regulatory agencies.

Figure 87. WET Arsenic Concentrations In Sediment Samples

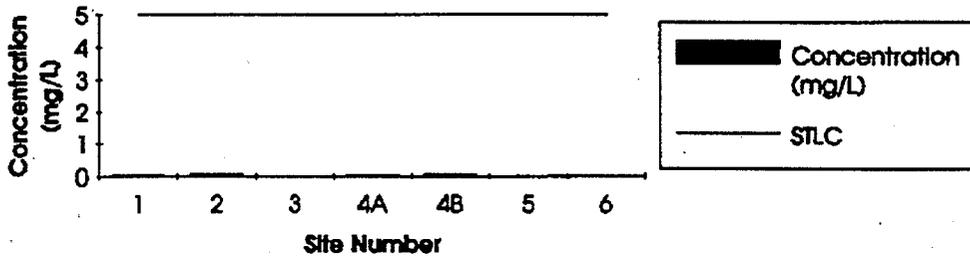


Figure 88. WET Chromium Concentrations In Sediment Samples

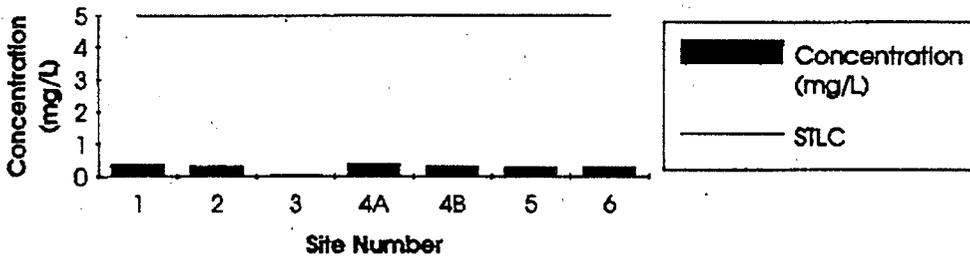


Figure 89. WET Copper Concentrations In Sediment Samples

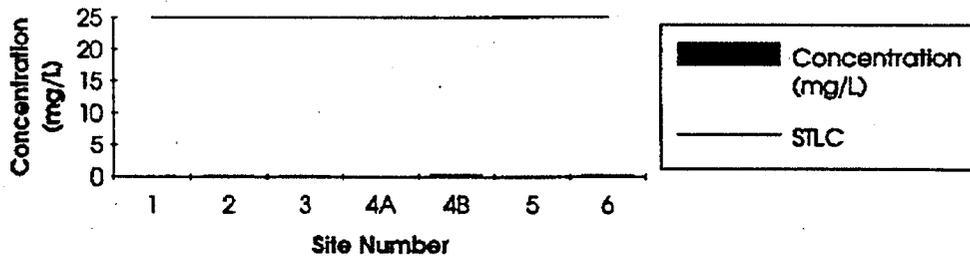


Figure 90. WET Lead Concentrations in Sediment Samples

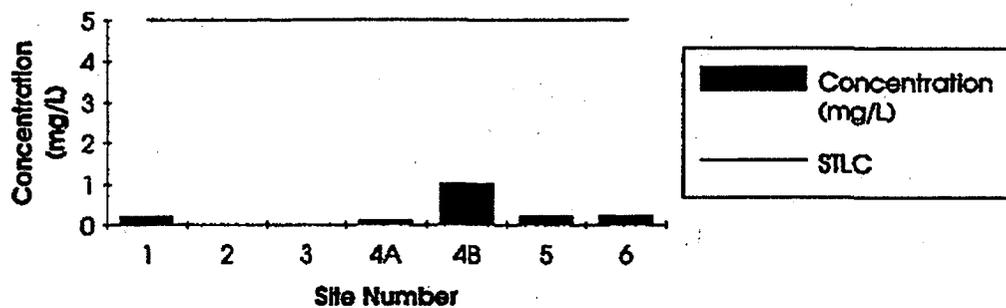


Figure 91. WET Nickel Concentrations in Sediment Samples

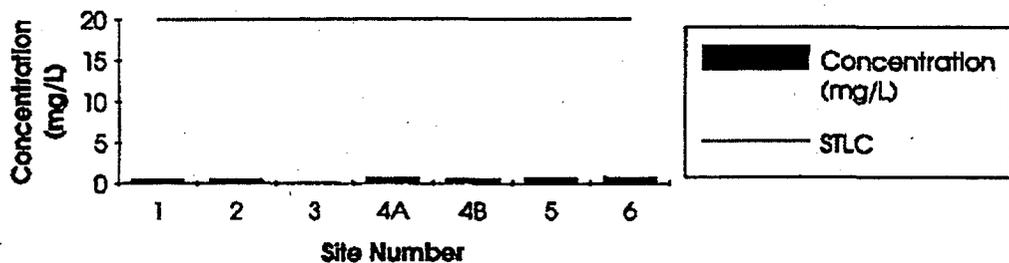


Figure 92. WET Zinc Concentrations in Sediment Samples

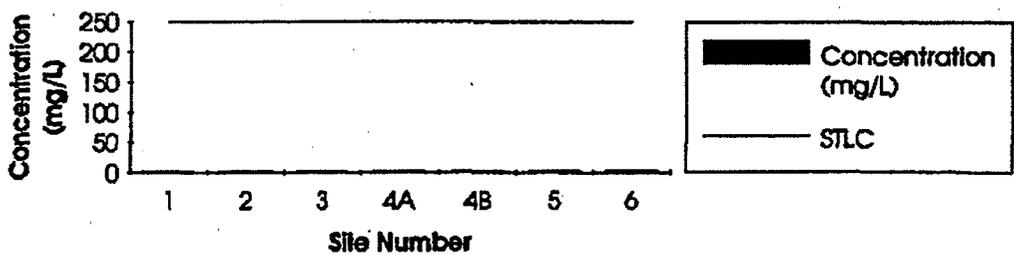
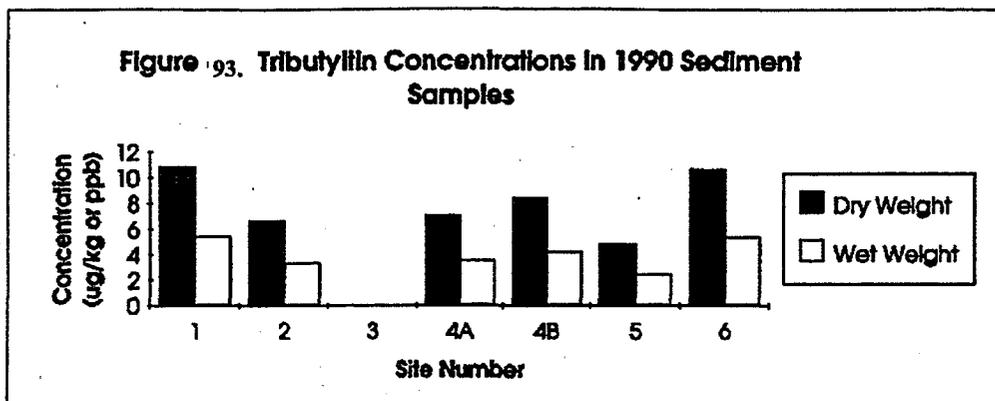


Figure 93. Tributyltin Concentrations in 1990 Sediment Samples



Summary

The sediment analytical results indicate that the sediment is not contaminated with respect to organic compounds and most metals. Most of the sites had selenium values in excess of the RWQCB screening criterion. All of the metals that were reported, including selenium, had concentrations that were less than the respective TTLCs.

Conclusions

The primary supporting data for this project is the 1992 North Delta Project data. Water, sediment and soil samples from the 1992 North Delta Project sampling contained no organics and only small concentrations of metals. In sediment, the only metal found to exceed a San Francisco Bay RWQCB sediment screening criterion was zinc. The zinc concentration, however, was much less than the STLC and TTLC criteria. Although the STLC and TTLC criteria are not necessarily indicative of toxic effect on aquatic life, they are the only sediment/soil criteria that exist for the Delta area. The San Francisco Bay RWQCB sediment screening criteria are nonenforceable and not necessarily applicable to the more inland Delta. Therefore, although the zinc concentrations were greater than the San Francisco Bay RWQCB sediment screening criterion, it is not clear that these zinc concentrations will have an effect on aquatic life. It is likely that the elevated zinc concentrations result from the use of zinc compounds as fertilizers in the Delta agricultural lands.

In levee soil, the only metals to exceed the San Francisco Bay sediment screening criteria were mercury, silver and lead. These metal concentrations only slightly exceeded the RWQCB sediment screening criteria and were much less than the TTLC criteria. Moreover the levee soil sites where these metals concentrations were measured are not likely to be inundated with water. Therefore, the concentrations of these metals in the levee soil should not affect the water quality after dredging. In the additional studies included in this report, mercury, silver, and lead concentrations in sediment or soil did not exceed the San Francisco Bay RWQCB criteria.

In the other North Delta studies (Staten Island 1990-1994), sediment and soil samples had mostly non-detectable concentrations of organics and metals. The only organic constituent detected in sediment and soil samples above the reporting levels was DDD. DDD was detected in 1991 sediment samples at concentrations less than the TTLC. In the other studies, DDD was not detected or DDD data were unusable because of poor data quality.

In the 1990 Staten Island study, selenium was detected above the reporting level and above the RWQCB sediment criterion in sediment samples. In all of the other studies, selenium was not detected above the reporting levels in either sediment or soil samples. The selenium concentrations in 1990 may be slightly elevated because percent moisture data were not available for the 1990 data and therefore a conservative assumption of 50% moisture was used to calculate the selenium dry weight concentrations which were compared to the RWQCB sediment criteria.

For the years subsequent to 1990, selenium was not detected above the reporting levels in either soil or sediment. However, the reporting limits for the selenium analyses are in most cases greater than the RWQCB sediment screening criterion for selenium (0.7 mg/kg dry weight). For example, the reporting limits for selenium in sediment were 10 mg/kg dry weight in 1991, 6-7 mg/kg dry weight in 1992 (Staten Island), 0.5-0.6 mg/kg dry weight in 1993, ## mg/kg dry weight in 1994, and 6-33 mg/kg dry weight in the 1992 North Delta study. Therefore, in many cases, it was not possible to compare the sediment screening criterion with the non-detect results for selenium.

Most of the water, sediment, and soil samples had constituent concentrations that were less than the applicable regulatory criteria. In addition, the 1992 North Delta soil sites were not prone to acidification (low acid generation potentials). Therefore, release of organics or metals into Delta waters as a result of dredging in the North Delta Project site is not likely to result in degradation of Delta water quality.

The WET test performed with citrate buffer is designed to simulate the acidic conditions of a landfill. However, the agricultural lands of the Delta accumulate salts and therefore, have moderate to high neutralizing capacity. Therefore, rainfall (near neutral pH) would percolate through the soil and be neutralized to some degree by dissolution of minerals salts in the soil. A more appropriate extraction solution for the WET test to simulate the natural condition is deionized water. Deionized water was not used in any of the studies except in the 1994 Staten Island SRAH environmental study. It was used based upon the CVRWQCB's recommendation.

In addition to the fact that the citrate buffer WET does not represent the natural leaching situation in the Delta. There are number of processes which would take place that would attenuate the concentration of any metals produced in the leachate.

1) Chelation. The peaty soils of the Delta and the channel waters are rich in organic acids. These acids have the ability to chelate metals making them biologically unavailable. Chelation by organic acids fixed in the soils/sediment would immobilize the metals. Chelation by organic acids in the water column would detoxify the metals.

2) Sorption. The likelihood of sorption of metals to the clay or organic materials of the Delta sediment/soil before reaching a point of intake for drinking water supply is good. Delta water and sediment have relatively high concentrations of organic materials and clay. In the case of copper, the most important environmental fate pathway in Delta water for copper will probably be the binding of copper to organic material. Both copper and arsenic are also likely to sorb onto clay minerals. Zinc is an exception, in that while zinc will bind to clay minerals, it is very soluble and will most likely remain in the soluble form. However, most metals will likely sorb to suspended particulates in the water column or sediments before reaching a drinking water supply intake.

3) Dilution. Most of the water of the deposited dredged sediment will drain quickly. The sandy dredged sediment will be placed on peaty soil that is rich in clay and organic matter. The water in the dredged sediment will rapidly filter through the deposited sediment, pool at the sand-peat interface and then drain in a lateral direction through the more porous sand. Most metals will remain adsorbed to the sediment material, having little time to dissolve in the drainage water. Any metals that are dissolved in the drainage solution would be diluted by the large volume of drainwater. Over time, leachate is produced from rainwater that percolates through the deposited sediment. Any metals concentration, however, in this

leachate will be diluted upon mixing with the rapidly flowing waters of the Mokelumne River.

4) Groundwater. The islands on which dredge material will be placed in this project are small islands that will be at most a few feet above the channel water at high tide. As stated before, the sandy dredge material for this project will be placed in this project are small islands that will be at most a few feet above the channel water at high tide. As stated before, the sandy dredge material for this project will be placed onto more dense peat Delta soil. Therefore any leachate that is produced would be likely to drain laterally along the peat-sand interface towards the channel water. Therefore, it is not likely that leachate will affect groundwater.

5) Metal Uptake by Marsh Plants. Some metals are actively taken up by reedy vascular plants. Cadmium, for example, is taken up marsh plants. The colonization of the channel islands with aquatic vegetation will certainly result in some degree of metal attenuation as plants take up metals (some in the form of nutrients).

Recommendations

For most of the constituents, it appears unlikely that significant environmental impacts due to contamination from dredge material will occur. The metals that were detected are either not likely to have a water quality effect (i.e., they were detected in levee soil) or were measured only in a few samples at concentrations that exceeded the San Francisco Bay RWQCB sediment screening criteria. In the case of selenium, selenium levels were above the RWQCB sediment screening criterion in 1990, but were not detected in the following years. In addition, the analytical method for selenium is such that the reporting levels for selenium are much higher than the RWQCB sediment screening criterion. Therefore, further testing for selenium would most likely result in non-detectable concentrations. In general, this study indicates that dredging is not likely to have an environmental impact. Therefore, the Department recommends that no further environmental studies be initiated for this Environmental Study.