SAN FRANCISCO ESTUARY

MONITORING PROGRAM

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SAN FRANCISCO ESTUARY MONITORING PROGRAM

I. INTRODUCTION

The purpose of this report is to present an overview of the Regional Board's proposed monitoring activities planned for the San Francisco Estuary. In addition, the results of activities currently underway or completed are also presented. This document establishes a framework for the development of a systematic data collection program for the San Francisco Estuary.

Monitoring is the collection of data for a specific purpose or goal. For the State and Regional Boards, monitoring is conducted to determine compliance with objectives established for the protection of beneficial uses. The Bay Protection and Toxic Cleanup Program (BPTCP) recognizes that sufficient data need to be collected through monitoring to establish objectives and identify areas of concern or "toxic hotspots". These "toxic hotspots", in general, are areas where objectives are exceeded or the designated beneficial uses are not supported.

Several efforts have been undertaken in the past to develop monitoring programs for the San Francisco Estuary (METC 1977, Horne, et. al. 1982, and AHI 1988). These efforts have generally failed due to lack of clearly defined objectives and financial support. A unique opportunity exists through the BPTCP which requires the development of a monitoring program for enclosed bays and estuaries. The overall goal of such a monitoring effort should be to evaluate management strategies used to restore, maintain and enhance the resources of enclosed bays and estuaries such as the San Francisco Estuary.

The potential scope of a monitoring program can be expansive; evaluating such parameters as pathogens in shellfish, benthic community composition, and pollutant concentration in the water column. As the mandate of the BPTCP is to evaluate the distribution of toxic pollutants, the scope of this initial monitoring effort will be limited to toxic pollutants. The monitoring program will cover the entire Estuarine system and provide information on the concentrations of pollutants in water, sediment and biota. It is necessary to take this multimedia approach to determine the ultimate fate and transport of pollutants in this complex estuarine system.

Monitoring can be divided into three general categories: regulatory compliance monitoring, trend monitoring (long-term) and detection of cause and effect relationships. Each of these areas produces information that can be used in the decision-making process. Uses of this information include system characterization, compliance with and development of water quality objectives, compliance with and development of sediment quality objectives, transport and fate modelling of pollutants, wasteload allocations, implementation of the Mass Emission Strategy contained in the Pollutant Policy Document and effluent limit derivation.

The development of this monitoring program for the San Francisco Estuary will require a phased approach. Current efforts by the State and Regional Board will be used as pilot studies for developing the long-term multimedia monitoring program. Additional efforts including bioaccumulation analysis will be developed as further pilot projects and implemented on a regional or local basis as appropriate. In addition, the field methodologies and analytical techniques developed as part of this program will be transferable to other enclosed bays and estuaries throughout the State.

II. GOALS

The broad goal of a regulatory monitoring program is to evaluate the changes in resource characteristics in response to natural and anthropogenic variables mainly by measuring compliance with numerical objectives. In addition, a monitoring program can provide an early indication of potential resource damage before a critical stage is reached. This second goal allows the implementation of management options at potentially greatly reduced costs. The first goal allows for the assessment of the effectiveness of past management strategies.

The program objectives address the following subject areas: protection, characterization/definition, remediation, and prevention. The program objectives are to determine the occurrence of toxic pollutants in the estuary; the rates and sources of addition of toxic pollutants to the estuary, biological effects of documented exposures to resident biota and human health; and methods of extrapolating between sediment quality and concentrations and effects in biota. To accomplish the program objectives, as stated previously, a multi-media examination of water, sediment and biota must be undertaken.

III. SPECIFIC OBJECTIVES

The specific objectives in the proposed monitoring program are aimed at the determination of pollutant trends over space and time in San Francisco Bay , a complex estuarine system. The specific objectives will be to:

- Determine trends in factors that may endanger human health; and
- Determine trends in natural and anthropogenic inputs that affect biota.

Each of these objectives requires the collection of certain types of information for the evaluation of potential risk to human health or aquatic resources. This information includes, but is not limited to, toxic chemicals in water and the tissue of biota, pathogens in the water column and sediment, toxic chemicals in sediment, toxicity of the water column and sediment, nutrient concentrations, primary productivity, and pollutant inputs.

The information would be used to:

- o Determine attainment of current water quality objectives;
- o Provide data for the establishment of new water quality objectives;
- o Determine the magnitude and duration of seasonal fluctuations of pollutant concentrations throughout the estuary;
- o Provide data for the development of sediment quality objectives or screening values;
- o Provide data for inclusion in pollutant exposure fate and transport assessment models; and
- o Development and implementation of Wasteload Allocations in selected areas and the Mass Emission Strategy.

Meeting these specific objectives will lead to the description and identification of "toxic hotspots" as required in the BPTCP in the San Francisco Estuary. The information will also aid the State and Regional Boards to formulate strategies to prevent the development of "toxic hotspots". These specific objectives will be met through a long-term program at a frequency and areal coverage consistent with the goals of the monitoring program. The information will be consolidated in a data management system. The overall intent of the pilot studies is to develop a long-term program at a frequency and areal coverage consistent with the goals of the monitoring program. This is a major effort and will require coordination and cooperation of the public and dischargers.

IV. CURRENT ACTIVITIES

Over the past two years, the Regional Board has been conducting pilot studies in the areas of direct toxicity of San Francisco Estuary waters, concentrations of metals in water and concentrations of pollutants in sediment and toxicity of sediment. The funding for these pilot studies came from both federal and state monies. The results of these efforts are being used to refine the pilot studies design for inclusion in the long-term monitoring program. In addition, review of existing activities has aided pilot study development to meet the goals and objectives of the monitoring program.

AMBIENT TOXICITY EVALUATIONS

During the 1986 Basin Plan review, the San Francisco Bay Regional Water Quality Control Board (Regional Board) embarked on an ambitious Toxicity Control Program. This involved the adoption of 10 water quality objectives and a study based approach to evaluate complex mixture toxicity. These complex mixtures include both effluent and ambient waters. The Effluent Toxicity Characterization Program (ETCP) is being conducted by 21 dischargers within the region and is the most extensive program in the nation. To complement this effort and determine compliance with toxicity objectives, preliminary surveys of ambient toxicity have been conducted in segments were there is potentially significant toxicity. Toxicity is determined through direct exposure of a fish, invertebrate or plant species to San Francisco Estuary waters.

The key findings of the current ambient toxicity program have been the detection of toxicity in marsh environments in the San Francisco Bay Region and potential transient toxic effects in the entire estuarine system. In addition, acute toxic effects have been observed in the Contra Costa Canal, the conveyance system supplying water to Contra Costa County. Three surveys of "background conditions" in the San Francisco Estuary were conducted in April, August and December during 1989 by sampling at 12 fixed stations. In all cases, toxicity was observed using the echinoderm (sea urchin) assay, but no toxicity was observed with the other species. Data from the effluent program indicate that the echinoderm assay is no more sensitive to effluents than other species. Consequently, these findings are unexpected, and will be thoroughly reviewed in the upcoming final report due in the summer of 1990.

WATER QUALITY OBJECTIVES ATTAINMENT

In the 1986 Basin Plan Triennial Review, the Board adopted water quality objectives for several metals such as nickel, zinc and lead. The actual concentrations of these pollutants and their behavior in the estuary are not well understood. It has been documented that certain water quality objectives are exceeded or potentially are not attainable in the San Francisco Estuary (SBDA 1987; Girvin et. al. 1978; Eaton 1979; Kuwabara et. al. 1989). These studies have been limited in their areal coverage of the San Francisco Estuary.

The measurement of trace metals in a complex estuarine system has proven to be a formidable task. The first year effort has been focussed on field and laboratory methodologies for the collection and detection of low concentrations of trace metals and elements. Twenty-six (26) stations (Table 1) located from the Sacramento River to the Golden Gate to the lower South Bay were sampled in April, August and December 1989. This study used "ultra-clean" techniques that detected metals concentrations in the parts per trillion range (ng/kg). Water Quality Objectives in

the Basin Plan are expressed in parts per billion (ug/kg or ug/l)). Compliance with water quality objectives can thus be determined. The complete results of the first year study will be available in the fall of 1990.

Dissolved and total metal concentrations were measured for lead, zinc, silver, cadmium, copper, and nickel at each station. Preliminary results for total metals are presented in Tables 2-6. As expected, total copper concentrations exceeded EPA marine water quality criteria throughout the estuary on all three occasions. Total nickel concentrations exceeded the marine water quality objective (7.1 micrograms per liter) in 6 of the 78 samples analyzed. The maximum exceedance was observed in the bay margin near Hayward (13.59 micrograms per liter). Three of the exceedances were observed in the South Bay at or below the Dumbarton Bridge. Dissolved concentrations, in general, did not exceed water quality objectives. However, dissolved copper did exceed the EPA marine water quality criteria at sites in the Central and South Bays.

The applicability of the EPA criteria for both copper and nickel to the San Francisco Estuary was a question raised during the 1986 Basin Plan review. This issue was identified as a priority issue for Basin Plan funding. A request for proposals is currently being circulated and it is anticipated that a contractor will complete this work by December 1991. Expansion of this current activity is planned through Basin Plan funding including the addition of eight stations to the overall network. This would make 34 stations that would be sampled in the estuary. Also planned are to examine concentrations of metals throughout the entire water column versus one meter below the surface sampling.

SEDIMENT QUALITY ASSESSMENT

The Regional Board, through the University of California at Santa Cruz, is performing a cooperative study with the National Oceanic and Atmospheric Administration (NOAA) in San Francisco Bay. This activity is examining sediment toxicity and pollutant concentrations at 45 sites in the South and Central Bay. This activity is being funded by State funds and federal funds through the Clean Water Act 205(j) program. The local sponsor for the 205(j) program is the Bay Planning Coalition. This program is underway and is planned to be completed by early 1991.

V. PROPOSED ACTIVITIES

TOXICITY EVALUATION AND ASSESSMENT

The objectives of this proposed activity are to determine ambient toxicity throughout the Estuary. Two system-wide surveys and eight focused evaluations are proposed. Focused evaluations of toxicity will assess waters in the vicinity of sources, both point and nonpoint (stormwater), which exhibit significant toxicity. Short-term

methods for evaluating chronic toxicity developed by the U.S. Environmental Protection Agency will be employed. The source evaluations will complement discharger efforts by evaluating far-field water column toxicity. For system wide surveys, water samples will be taken at 12 of the 34 discrete locations utilized in the water quality objectives attainment program. The purpose of the monitoring is to demonstrate compliance with the toxicity water quality objectives and the degree and extent of toxicity observed over time.

The focus of this element will be on acute and chronic toxicity through direct exposure of fish, invertebrates and plants to estuarine waters. In addition, other techniques for the evaluation of other potential toxic effects which have been developed but never field verified in an estuarine environment will be considered. Only those techniques that are applicable to multimedia exposures and varying salinities will be considered. Highly experimental efforts are beyond the scope and intent of this work; rather, the focus will be on developed assays and their applicability to long-term monitoring. The results of such assays can provide an indication of potential resource damage.

BIOACCUMULATION ASSESSMENT

Toxic pollutants accumulated in the tissue of biota may directly affect the animals or may, in the case of selected toxic pollutants, be transferred through the food chain. There is a need to determine baseline levels both to evaluate potential biological and ecological problems, and determine the availability of toxic pollutants to biota.

A "mussel watch" approach is recommended because it allows an assessment of toxic pollutants released from sediments to the water and fluctuations that may be attributable to recent discharges. Levels of pollutants will be determined in transplanted mussels or other organisms following an exposure period of 30 to 60 days. The techniques for this type of approach have been thoroughly developed for marine and freshwater environments. Salinity variations in estuaries may preclude the use of a single organism as a biomonitor. Field comparisons of candidate species will be made in saline and freshwater environments. The initial program will use a subset of the 34 stations in the water quality objectives attainment assessment.

The information collected will be used to:

- Determine spatial and temporal trends of toxic pollutants in mussels or other test organisms; and

- Identify areas of existing or potential problems of toxic pollution

WATER QUALITY OBJECTIVES ATTAINMENT - ORGANIC POLLUTANTS

The vast water of San Francisco Bay is the major media in which toxic pollutants are transported. Organic pollutants include such compounds as DDT, PCBs and polynuclear aromatic hydrocarbons (PAHs). Monitoring of the water column provides information on the transport and fate of pollutants on a systemwide basis. Coupled with information on ambient toxicity and bioaccumulation, the effects on biological populations may be ascertained.

The proposed activity will investigate the concentrations of, but not be limited to, pesticides, polynuclear aromatic hydrocarbons and organic acids (i.e. phenolic compounds). The sampling program will be patterned after and conducted in conjunction with the metals study.

SEDIMENT QUALITY

The objectives of this proposed activity are to determine the spatial and temporal concentrations and the bioavailability of selected metals, pesticides, polynuclear aromatic hydrocarbons, and other organics in sediments and toxicity of sediment and pore waters throughout the San Francisco Estuary. This project will add to the existing data base on sediment quality of the San Francisco Estuary and aid in the development of sediment quality criteria.

The proposed work will include sediment and pore water toxicity tests and chemical analyses at the same sites where water column and bioaccumulation will be monitored throughout the Estuary including the Delta. The results of this activity will provide a assessment of sediment quality entering the Estuary from rivers, streams, point and nonpoint sources. The information will also be used to complete an inventory of contaminated sites.

PROGRAM DEVELOPMENT/DATA MANAGEMENT

The objectives of this activity are to provide integration of the pilot studies into a long-term monitoring strategy and the development of a data management strategy for the information produced from each pilot study. This activity will also develop alternatives for the future financial support of the long-term monitoring program. This long-term financial support will clearly not come from state and federal resources. The most likely source will be fees from dischargers, both point and nonpoint, that affect the Estuary.

The pilot studies will be conducted by several different contractors. The management of these data will require the development of a data management strategy to integrate the work of the various contractors. A data management system

that is expandable yet meets the present need for the integration of the "pilot studies" will be developed.

Detailed scopes of work for each pilot study will be developed. Potential contractors include the University of California, Department of Fish and Game, Department of Health Services, and United States Geological Survey. Technical review will be provided through such forums as the San Francisco Estuary Project and the BPTCP Monitoring Task Force. Coordination with other groups, such as the Interagency Ecological Study Group, will also be conducted.

The estimated costs for the proposed activities are based on current activity costs or similar activities currently under contract to the State. The final costs may vary dependent on the final scope of work negotiated with the proposed contractor. The funding source is the BPTCP and Basin Plan funding. Estimated costs are presented in Table 8.

VI. SUMMARY

A framework of goals and objectives for monitoring in the San Francisco Estuary has been presented in this report. These goals and objectives will form the framework for the development of a long-term monitoring program. The development of the long-term program will be done in a phased approach through pilot studies.

Initial results of certain pilot studies have provided information on the levels of selected metals and toxicity in the San Francisco Estuary. These results are considered preliminary and need to be examined in relation to other physical factors of the estuary such as water year classification. Additional pilot studies are proposed based on this work. Periodic reports on the pilot studies and monitoring program will be made to the Regional Board.

TABLE 1

STATION LOCATION

STATION NAME	LONGITUDE	LATITUDE	CODE
Extreme South Bay	37.29	122.05	1-XSB
Dumbarton Bridge	37.30	122.07	2-DB
Redwood Creek	37.33	122.11	3-RC
San Bruno Shoals	37.37	122.17	4-SBS
Hayward Flats (aka Oakland E. Flats)	37.38	122.13	5-HF
S.F. Airport (aka S.P. W. Flats)	37.37	122.20	6-SFO
San Leandro Channel (aka Alameda)	37.45	122.18	7-SLC
Hunter Point Channel	37.43	122.20	8-HPC
Angel Island / Treasure Island	37.50	122.23	9-AI
Alcatraz	37.50	122.25	10-AZ
Golden Gate	37.49	122.28	11-GG
San Rafael Bridge Channel	37.55	122.26	12-SRBC
San Rafael Bridge Nearshore	37.55	122.24	13-SRBN
San Pedro Point	37.59	122.26	14-SPP
Berkeley Flats	37.50	122.20	15-BF
Petaluma River	38.02	122.24	16-PR
Pinole Shoal Channel	38.03	122.19	17-PSC
Pinole Shoal Nearshore	38.01	122.19	18-PSN
Benicia Bridge	38.02	122.08	19-BB
Pacheco Creek	38.02	122.05	20-PCK
Grizzly Bay	38.06	122.02	21-GB
Honker Bay	38.04	121.56	22-HB
Port Chicago	38.03	122.01	23-PTC
Stake Point (near Buoy #20)	38.03	121.57	24-SP
Chip's Island (near Buoy #20)	38.02	121.55	25-CI
Sacramento River	38.03	121.51	26-SR
New York Slough	38.01	121.51	27-NYS

TABLE 2

TOTAL COPPER CONCENTRATIONS
(ng/kg)

STATION NAME	1989 SURVEYS April	August	December
1. Extreme South Bay	5959.97	5810.34	1743.56
2. Dumbarton Bridge	2421.28	5737.36	5390.56
3. Redwood Creek	3766.23	5537.70	4240.53
4. San Bruno Shoals	2649.05	4952.85	3434.55
5. Hayward Flats (aka Oak. E. Flats)	1697.40	8901.71	3560.77
6. S.F. Airport (aka S.F.W. Flats)	2513.18	3703.05	4350.15
7. San Leandro Channel (aka Alameda)	1820.68	3422.07	4688.51
8. Hunter Point Channel	1115.20	2724.84	5366.03
9. Angel Island/Treasure Island	1946.11	1904.49	4630.56
10. Alcatraz	862.16	1641.98	2161.65
11. Golden Gate	1062.59	1183.92	1534.43
12. San Rafael Bridge Channel	2102.95	2502.77	2410.87
13. San Rafael Bridge Nearshore	1516.10	2688.70	2152.93
14. San Pedro Point	2111.59	2846.12	3517.86
15. Berkeley Flats	1602.02	2623.35	2354.43
16. Petaluma River	2582.25	4551.49	NA
17. Pinole Shoal Channel	1811.08	4853.33	4142.96
18. Pinole Shoal Nearshore	3757.85	3928.02	5075.62
19. Benicia Bridge	3400.22	3958.71	3277.19
20. Pacheco Creek	5497.16	4217.28	3459.47
21. Grizzly Bay	6142.58	4677.04	4135.81
22. Honker Bay	7207.93	4360.22	5439.57
23. Port Chicago	5526.48	4179.35	3528.82
24. Stake Point	5160.70	4568.68	NA
25. Chipp's Island	NA	4618.29	4082.59
26. Sacramento River	5533.25	3635.16	3955.43
27. New York Slough	4608.40	3857.75	4947.82

TABLE 3

TOTAL ZINC CONCENTRATIONS
(ng/kg)

STATION NAME	1989 SURVEYS April	August	December
1. Extreme South Bay	11297.89	5386.24	17360.39
2. Dumbarton Bridge	4154.98	5406.34	9906.19
3. Redwood Creek	4020.66	5139.53	6309.50
4. San Bruno Shoals	2405.11	7016.59	3993.13
5. Hayward Flats (aka Oak.E. Flats)	2885.37	16124.73	3722.66
6. S.F. Airport (aka S.F.W. Flats)	3284.89	4384.97	6786.65
7. San Leandro Channel (aka Alameda)	2755.66	3699.02	7846.23
8. Hunter Point Channel	1902.00	2802.91	11985.60
9. Angel Island/Treasure Island	3404.70	2622.96	3041.48
10. Alcatraz	1815.00	2005.67	4557.91
11. Golden Gate	1417.98	1682.85	2811.4
12. San Rafael Bridge Channel	3096.33	2462.39	4615.72
13. San Rafael Bridge Nearshore	2039.56	4676.48	3869.73
14. San Pedro Point	3696.82	3662.77	6890.11
15. Berkeley Flats	2770.82	4283.45	3925.91
16. Petaluma River	9105.54	6123.56	NA
17. Pinole Shoal Channel	3048.67	6406.24	7586.67
18. Pinole Shoal Nearshore	6611.58	4874.40	9173.11
19. Benicia Bridge	4187.82	4077.61	4107.36
20. Pacheco Creek	6536.55	4499.80	4201.67
21. Grizzly Bay	8494.33	5877.30	5074.83
22. Honker Bay	9974.29	5018.46	8300.32
23. Port Chicago	7725.57	4669.35	3844.90
24. Stake Point	6554.58	5940.36	NA
25. Chipp's Island	NA	5681.98	5170.25
26. Sacramento River	7180.52	4516.22	4380.42
27. New York Slough	5930.09	4944.99	6427.59

TABLE 4

TOTAL NICKEL CONCENTRATIONS
(ng/kg)

STATION NAME	1989 SURVEYS April	August	December
1. Extreme South Bay	10733.2	6812.8	11282.4
2. Dumbarton Bridge	5064.8	7016.1	8390.0
3. Redwood Creek	4529.6	6194.7	5186.7
4. San Bruno Shoals	2807.7	6675.9	3465.1
5. Hayward Flats (aka Oak. E. Flats)	2974.7	13593.4	3954.1
6. S.F. Airport (aka S.F.W. Flats)	3099.7	4957.0	5364.3
7. San Leandro Channel (aka Alameda)	2970.3	4496.5	6491.7
8. Hunter Point Channel	2275.8	2970.6	8238.0
9. Angel Island/Treasure Island	3166.1	2294.0	2425.4
10. Alcatraz	1979.5	2057.1	3030.0
11. Golden Gate	1595.1	1215.7	1963.9
12. San Rafael Bridge Channel	2856.7	2702.8	3093.6
13. San Rafael Bridge Nearshore	3236.8	4068.4	2769.9
14. San Pedro Point	2276.5	3714.8	5200.9
15. Berkeley Flats	2505.4	3691.0	2515.1
16. Petaluma River	7436.0	5645.5	NA
17. Pinole Shoal Channel	3026.6	5500.7	5776.5
18. Pinole Shoal Nearshore	4592.4	4517.2	6879.5
19. Benicia Bridge	4153.7	3808.9	3698.0
20. Pacheco Creek	6333.7	3967.0	3713.9
21. Grizzly Bay	6161.3	4495.6	4622.1
22. Honker Bay	6899.8	3819.5	6463.0
23. Port Chicago	5341.4	3574.1	3280.6
24. Stake Point	4594.7	4253.6	NA
25. Chipp's Island	NA	4052.5	4052.9
26. Sacramento River	4942.5	2680.5	3494.3
27. New York Slough	3897.2	2965.8	4756.2

TABLE 5

TOTAL CADMIUM CONCENTRATIONS
(ng/g)

STATION NAME	1989 SURVEYS April	August	December
1. Extreme South Bay	0.0812	0.1586	0.1245
2. Dumbarton Bridge	0.0867	0.1446	0.0930
3. Redwood Creek	0.0851	0.1315	0.1108
4. San Bruno Shoals	0.0782	0.1333	0.1155
5. Hayward Flats (aka Oak. E. Flats)	0.0783	0.1365	0.1172
6. S.F. Airport (aka S.F.W. Flats)	0.0734	0.1264	0.1032
7. San Leandro Channel (aka Alameda)	NA	0.1458	0.1298
8. Hunter Point Channel	0.0692	0.1458	0.1047
9. Angel Island/Treasure Island	0.0629	NA	0.0663
10. Alcatraz	0.0617	0.1097	0.0549
11. Golden Gate	0.0646	0.0881	0.0482
12. San Rafael Bridge Channel	0.0603	0.1128	0.0646
13. San Rafael Bridge Nearshore	0.0588	0.1011	0.0557
14. San Pedro Point	0.0585	0.1145	0.0663
15. Berkeley Flats	0.0670	0.1153	0.0945
16. Petaluma River	0.0574	0.1026	NA
17. Pinole Shoal Channel	0.0567	0.0941	0.0666
18. Pinole Shoal Nearshore	0.0736	0.0742	0.0737
19. Benicia Bridge	0.0445	0.0704	0.0703
20. Pacheco Creek	0.0377	0.0562	0.0736
21. Grizzly Bay	0.0343	0.0355	0.0775
22. Honker Bay	0.0392	0.0311	0.0624
23. Port Chicago	0.0263	0.0388	0.0499
24. Stake Point	0.0216	0.0233	NA
25. Chipp's Island	NA	0.0185	0.0551
26. Sacramento River	0.0341	0.0200	0.0511
27. New York Slough	0.0271	0.0054	0.0483

TABLE 6

TOTAL SILVER CONCENTRATIONS
(ng/kg)

STATION NAME	1989 SURVEYS April	August	December
1. Extreme South Bay	76.6	33.6	100.5
2. Dumbarton Bridge	17.5	28.8	55.5
3. Redwood Creek	17.0	45.8	34.0
4. San Bruno Shoals	13.6	51.5	30.8
5. Hayward Flats (aka Oak.E. Flats)	13.1	125.1	26.0
6. S.F. Airport (aka S.F.W. Flats)	13.6	40.0	52.3
7. San Leandro Channel (aka Alameda)	12.3	24.7	33.9
8. Hunter Point Channel	8.1	35.4	59.2
9. Angel Island/Treasure Island	13.3	16.9	10.4
10. Alcatraz	3.0	13.0	15.7
11. Golden Gate	3.2	4.3	9.4
12. San Rafael Bridge Channel	6.3	13.9	13.2
13. San Rafael Bridge Nearshore	7.0	19.7	13.0
14. San Pedro Point	5.0	15.5	21.6
15. Berkeley Flats	7.2	24.6	13.5
16. Petaluma River	32.7	29.0	NA
17. Pinole Shoal Channel	7.7	27.1	21.7
18. Pinole Shoal Nearshore	13.0	19.6	28.8
19. Benicia Bridge	10.9	10.8	10.1
20. Pacheco Creek	29.5	12.4	11.5
21. Grizzly Bay	26.0	11.1	8.9
22. Honker Bay	29.9	11.9	18.3
23. Port Chicago	20.1	7.7	5.1
24. Stake Point	16.1	9.8	NA
25. Chipp's Island	NA	9.1	11.2
26. Sacramento River	17.8	6.5	7.0
27. New York Slough	14.0	6.6	7.1

TABLE 7

TOTAL LEAD CONCENTRATIONS
(ng/kg)

STATION NAME	1989 SURVEYS April	August	December
1. Extreme South Bay	3538.21	732.07	3283.67
2. Dumbarton Bridge	840.28	784.50	2407.10
3. Redwood Creek	639.86	797.23	1157.69
4. San Bruno Shoals	360.53	1340.13	563.23
5. Hayward Flats (aka Oak. E. Flats)	429.93	3731.36	504.89
6. S.F. Airport (aka S.F.W. Flats)	515.77	658.68	1420.29
7. San Leandro Channel (aka Alameda)	549.65	547.29	1499.73
8. Hunter Point Channel	272.37	294.20	2512.72
9. Angel Island/Treasure Island	606.16	312.20	370.55
10. Alcatraz	246.55	210.89	851.54
11. Golden Gate	215.13	146.36	500.27
12. San Rafael Bridge Channel	429.99	243.26	766.55
13. San Rafael Bridge Nearshore	274.21	578.36	550.67
14. San Pedro Point	496.57	485.36	1343.49
15. Berkeley Flats	472.32	778.35	436.26
16. Petaluma River	2431.61	1045.84	NA
17. Pinole Shoal Channel	370.34	1051.97	1489.30
18. Pinole Shoal Nearshore	877.47	706.48	2014.13
19. Benicia Bridge	669.16	606.80	557.37
20. Pacheco Creek	1970.99	711.41	576.04
21. Grizzly Bay	1999.22	1034.86	713.48
22. Honker Bay	2666.24	853.28	1689.80
23. Port Chicago	1746.93	692.81	469.78
24. Stake Point	1434.97	1046.21	NA
25. Chipp's Island	NA	1001.89	849.31
26. Sacramento River	1773.61	609.12	730.45
27. New York Slough	1611.75	1043.28	1164.10

TABLE 8

ESTIMATED COSTS

WATER QUALITY OBJECTIVES - METALS	$302,000.
SITE-SPECIFIC OBJECTIVES FOR COPPER AND NICKEL	$300,000.
AMBIENT TOXICITY EVALUATIONS	$300,000.
BIOACCUMULATION	$250,000.
WATER QUALITY OBJECTIVES - ORGANIC POLLUTANTS	$250,000.
SEDIMENT QUALITY	$300,000.
PROGRAM DEVELOPMENT/DATA MANAGEMENT	$100,000.
TOTAL	$1,800,000.