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GLOSSARY OF ACRONYMS

µg/L	Micrograms per liter, or parts per billion
AMEL	Average Monthly Effluent Limit
Ave.	Average
BACWA	Bay Area Clean Water Agencies
BAPPG	Bay Area Pollution Prevention Group
BASMAA	Bay Area Stormwater Management Agencies Association
BMP	Best Management Practice
BOD	Biological Oxygen Demand
CFR	Code of Federal Regulations
CMSA	Central Marin Sanitation Agency
CTR	California Toxics Rule
Cu	Copper
CV	Coefficient of variation
EBDA	East Bay Discharger's Association
EBMUD	East Bay Municipal Utility District
ECA	Effluent Concentration Allowance
EOA	Eisenberg, Olivieri, and Associates
ERS	Electronic Reporting System
FSSD	Fairfield Suisun Sanitary District
g/day	Grams per day
GE	General Electric
I/I	Inflow & Infiltration
IPBL	Interim performance-based effluent limits
LGVSD	Las Gallinas Valley Sanitary District
LTA	Long-term average
MDEL	Maximum Daily Effluent Limit
MEC	Maximum Effluent Concentration
MGD	Million gallons per day
MMWD	Marin Municipal Water District
NDB	North of Dumbarton Bridge
Ni	Nickel
NPDES	National Pollutant Discharge Elimination System
P2	Pollution Prevention
POTW	Publicly Owned Treatment Works
RMP	Regional Monitoring Program
RO	Reverse Osmosis
RWQCB	Regional Water Quality Control Board
SD	Sanitary District
SEED	School Environmental Education Docents
SF	San Francisco
SFO	San Francisco Airport
SIP	Policy for Implementation of Toxics Standards for Inland Surface Waters, Enclosed Bays, and Estuaries of California; aka State Implementation Policy
SSO	Site-Specific Objective
TOC	Total Organic Carbon
TSS	Total Suspended Solids
US EPA	United States Environmental Protection Agency
WQO	Water Quality Objective
WWTP	Wastewater Treatment Plant

EXECUTIVE SUMMARY

Introduction

Site-specific saltwater aquatic life-based water quality objectives for copper and nickel in the San Francisco Bay north of the Dumbarton Bridge are being considered to modify the existing objectives contained in the amended Basin Plan. The results from the studies performed to date indicate that existing saltwater objectives for copper and nickel should be modified to reflect the best available scientific information pertaining to the toxicity of those metals to aquatic organisms in San Francisco Bay. As part of the process of considering adoption of site-specific objectives, the Regional Water Quality Control Board (RWQCB) must present technical and administrative documentation to support adoption of the proposed site-specific objectives (SSOs) to meet the requirements in the *Policy for Implementation of Toxics Standards for Inland Surface Waters, Enclosed Bays, and Estuaries of California* (State Implementation Policy or SIP), dated March 2001.

Case Studies

The proposed SSOs will be applicable the San Francisco Bay north of the Dumbarton Bridge. Therefore, to address these SIP SSO request requirements, three (3) north of Dumbarton Bridge (NDB) municipal agencies were selected as representative examples of the 40 plus agencies that discharge treated wastewater NDB. The three agencies selected include: (1) a small, shallow water secondary treatment discharger, (2) a medium shallow water advanced secondary treatment discharger, and (3) a large deepwater secondary treatment discharger, respectively. To demonstrate that these three dischargers are reasonably representative of other NDB dischargers, available effluent copper and effluent nickel data from the period 2001 through 2003 from all NDB dischargers was compiled from the RWQCB's Electronic Reporting System (ERS).

To address SIP protocols, existing final effluent limits and potential future effluent limits for copper and nickel were obtained/calculated for each facility, based on existing water quality objectives for copper and nickel. Current effluent quality was compared with these effluent limits to establish the ability to comply and thus the need for SSOs for the three representative agencies. Additionally, an overview analysis of other NDB dischargers was made to validate that the compliance assessment for the three pilot facilities represented the full suite of potentially impacted agencies.

Final Effluent Limit Calculations and Translators

Final average monthly effluent limits (AMELs) and maximum daily effluent limits (MDELs) derived from existing copper and nickel objectives were calculated to be used as the baseline for evaluating whether the three representative treatment plants will be able to comply with them. Translator selection is an important variable.

Ability to comply with final effluent limits in Infeasibility Studies has been determined by comparing the final CTR/SIP based effluent limits to the observed maximum effluent concentration (MEC) and/or the statistically projected maximum.

For copper, none of the case study facilities could consistently comply with final CTR based copper effluent limits calculated with the translators used for the latest NPDES permits. It can be estimated that LGVSD would exceed a 3.4 µg/L limit 100% of the time. FSSD would exceed its 4.8 µg/L limit about 40% of the time. EBMUD would exceed its 7.6 µg/L limit about 75% of the time. This is consistent with the fact that each facility already has interim copper effluent limits given the demonstrated inability to comply with final effluent limits documented in their respective Infeasibility Studies. If updated translators were to be used based on pooled North of Dumbarton study and associated RMP station data, they would still be in non-compliance with calculated copper final limits

For nickel, these three facilities appear as though they could comply with final CTR based effluent limits calculated with the translators used for the latest NPDES permits. This is consistent with the fact that each discharger has final nickel effluent limits in their permits.

Overview Compliance Analysis of Full Suite of NDB Dischargers

For nickel, the three case study plants examined do not exhibit compliance problems with effluent limits derived from the existing nickel objectives. However, examination of effluent data for the full suite of NDB dischargers reveals that potential compliance problems would exist for several industrial dischargers. An additional consideration is that many (over 20) municipal and industrial plants have maximum observed effluent concentrations that exceed the current objective of 8.2 µg/L. This creates a reasonable potential determination under the SIP, necessitating effluent limits and pollutant minimization activities. If site-specific nickel objectives based on best available scientific information were adopted, between 7 to 15 of these plants would not have effluent limits and would not have the incumbent pollutant minimization responsibility.

Existing Treatment & Source Control Measures

Information is presented on each of the three representative discharger's wastewater treatment plant and reclamation facilities and on their source control and pollution prevention programs. The feasibility and cost of potential additional measures required to achieve compliance are also evaluated.

Potential Measures & Economic Impacts to Achieve Compliance

All three facilities also have long-established and well performing source control and pollution prevention programs in place. The majority of influent copper is these and most systems is believed to be a function of the relative corrosivity of the potable water supply and corrosion of copper piping and plumbing fixtures.

Reverse Osmosis is a treatment technology that forces effluent through a very fine molecular sieve, under pressure, to remove contaminants. The byproduct of reverse osmosis is concentrated brine that can (depending on its composition) require treatment as a hazardous waste. The estimated additional annual treatment cost (in 2004 costs) for reverse osmosis treatment at these three facilities is $116 million per year.

Based on the expense of RO, it is appropriate to pursue development and adoption of one or more SSO for copper for the Bay north of the Dumbarton Bridge. This would provide Bay-wide consistency with the fact that similar SSOs for copper and nickel previously been adopted for the Bay south of the Dumbarton Bridge.

Conclusions

This analysis addresses the SIP Section 5.2 requirements that the Regional Board must address in its consideration of site-specific copper and nickel objectives in San Francisco Bay North of Dumbarton Bridge. This analysis illustrates a number of municipal and industrial dischargers operating secondary or advanced secondary treatment plants will suffer compliance problems and unreasonable costs to comply with effluent limits based on existing water quality objectives for copper in San Francisco Bay. Industrial plants may suffer compliance problems relating to nickel. Effluent data and probable effluent limits presented in the above report illustrate the breadth and magnitude of compliance problems.

As a result of the above analysis, and in combination with the findings of the site-specific objectives derivation, it is concluded that action to consider and adopt science-based site-specific copper and nickel saltwater objectives for San Francisco Bay north of the Dumbarton Bridge is warranted and complies with requirements of the SIP and other regulatory requirements.

1. INTRODUCTION

Bioavailability and toxicity of copper and nickel are dependent on site-specific factors such as pH, hardness, suspended solids, dissolved oxygen (i.e., Redox state), dissolved carbon compounds, salinity, and other constituents. Because of the potential for spatial inaccuracies in the national aquatic-life criterion, USEPA has provided guidance concerning three procedures that may be used to convert a national criterion into a site-specific criterion [USEPA, 1994]. One of these, the Indicator Species procedure, is based on the assumption that characteristics of ambient water may influence the bioavailability and toxicity of a pollutant. Acute toxicity in site water and laboratory water is determined in concurrent toxicity tests using either resident species or acceptable sensitive non-resident species that can be used as surrogates for the resident species. The ratio of the ambient to the laboratory water toxicity values, deemed a water effects ratio (WER), can be used to convert a national concentration criterion for a pollutant to a site-specific concentration criterion (or site-specific objective (SSO) in California terminology).

Several prior studies of San Francisco Bay, plus Regional Monitoring Program (RMP) data from 1993 through 1998, have provided evidence that the Bay may not be impaired by ambient levels of dissolved copper and nickel, and that SSOs may be appropriate for the Bay. Calculating proper SSOs will help dischargers establish more reasonable compliance goals.

Site-specific saltwater aquatic life-based water quality objectives for copper and nickel in the San Francisco Bay north of the Dumbarton Bridge are being considered to modify the existing objectives contained in the amended Basin Plan. Site-specific objectives have been developed based on scientific studies performed in accordance with protocols established by USEPA. The results from the studies performed to date indicate that existing saltwater objectives for copper and nickel should be modified to reflect the best available scientific information pertaining to the toxicity of those metals to aquatic organisms in San Francisco Bay. The site-specific studies and resulting site-specific objectives are described in detail in a separate document (SSO Derivation Report, 2004).

As part of the process of considering adoption of site-specific objectives, the Regional Water Quality Control Board (RWQCB) must present technical and administrative documentation to support adoption of the proposed site-specific objectives (SSOs) to meet the requirements in the *Policy for Implementation of Toxics Standards for Inland Surface Waters, Enclosed Bays, and Estuaries of California* (State Implementation Policy or SIP), dated March 2001.

The SIP Section 5.2 (3) requires specific information when dischargers are requesting that the RWQCB develop and adopt SSOs. This information must demonstrate:

"that the discharger cannot be assured of achieving the criterion or objective and/or effluent limitation through reasonable treatment, source control, and pollution prevention measures. This demonstration may include, but is not limited to, as determined by the RWQCB:

- *(a) an analysis of compliance and consistency with all relevant federal and State plans, policies, laws and regulations;*
- *(b) a thorough review of historical limits and compliance with those limits;*
- *(c) thorough review of current technology and technology-based limits; and*

(d) an economic analysis of compliance with the priority pollutant criterion or objective of concern."

The purpose of this document is to provide information to address the above requirements.

2. SIP SECTION 5.2 (3), ITEM (a)

Item (a) above is addressed by the fact that all the involved dischargers to San Francisco Bay are currently operating their wastewater treatment facilities as required by the terms and conditions of their NPDES permits. These NPDES permits implement the federal and State plans, policies, laws, and regulations relevant to these discharges. Items (b), (c), and (d) above are addressed in the remainder of this section.

3. SIP SECTION 5.2 (3), ITEMS (b) AND (c)

The ability to comply with effluent limits for copper and nickel is dependent on two factors: (1) effluent quality for the level of treatment provided and (2) the magnitude of dilution factors and translator values used in the derivation of effluent limits.

3.1 Effluent Quality for the Level of Treatment Provided

As a first step, available effluent data was assembled and analyzed to develop an overall perspective on the performance of Bay area municipal and industrial treatment plants. This information is summarized in the following figures and tables.

Table 1 identifies the secondary treatment, advanced secondary treatment, and industrial plants. **Figure 1** depicts effluent data from secondary and advanced secondary municipal treatment plants discharging to San Francisco Bay. The boxes plots present the median, the 25th percentile, the 75th percentile, extreme values and outliers. The lower and upper boundaries of the box represent the 25th and 75th percentiles, respectively. The horizontal line inside the box represents the median. The length of the box corresponds to the inter-quartile range, which is the difference between the 75th and 25th percentiles. The box plot includes two categories of cases with outlying values. Cases with values that are more than three box-lengths from the upper or lower edge of the box are designated extreme values and are shown with asterisks. Cases with values that are between 1.5 and 3 box-lengths from the upper or lower edge of the box are outliers and shown with circles. The largest and smallest observed values that are not outliers are also shown. Lines (referred to as whiskers) are drawn from the ends of the box to these values.

Table 1. Treatment Plant Categories

Secondary	Advanced Secondary	Industrial
City of Benicia	Fairfield-Suisun Sewer District	Chevron Richmond Refinery
Burlingame	Mt. View Sanitary District	ConocoPhillips (at Rodeo)
Central Contra Costa	Palo Alto	Dow Chemical Company Permit
Delta Diablo Sanitation District	Petaluma Permit	General Chemical Permit
Dublin San Ramon Services District Permit	San Jose & Santa Clara	General Electric Company
EBDA	South Bay System Authority	GWF E 3rd St (Site I) Permit
EBMUD	Sunnyvale	GWF Nichols Rd (Site V) Permit
Las Gallinas Valley SD Permit		Martinez Refining Company
Millbrae		Morton Permit
Novato Sanitary District Permit:		Rhodia Basic Chemicals Permit
Pinole-Hercules		S.F.Airport, Industrial
Rodeo Sanitary District Permit		SAM Permit
S.F. Airport, Water Quality Control Plant		Tesoro Golden Eagle Refinery
San Francisco City & County Southeast		USS - Posco
San Francisco City & County Wet Weather (Bayside)		Valero Benicia Refinery
San Francisco Oceanside		
Sausalito-Marin Sanitary District Permit		
Sewerage Agency of Southern Marin Permit		
Sonoma Valley Permit		
South San Francisco & San Bruno		
Vallejo San & Flood Control District		
North San Mateo		
San Mateo City		
Pacifica Calera Creek		
Tiburon Treatment Plant Permit		
US Navy Treasure Island Permit		
West County/Richmond Permit		

Figure 1. Daily Maximum Effluent Copper and Nickel Concentrations: Secondary vs. Advanced Secondary Municipal Plants (2001 – 2003)

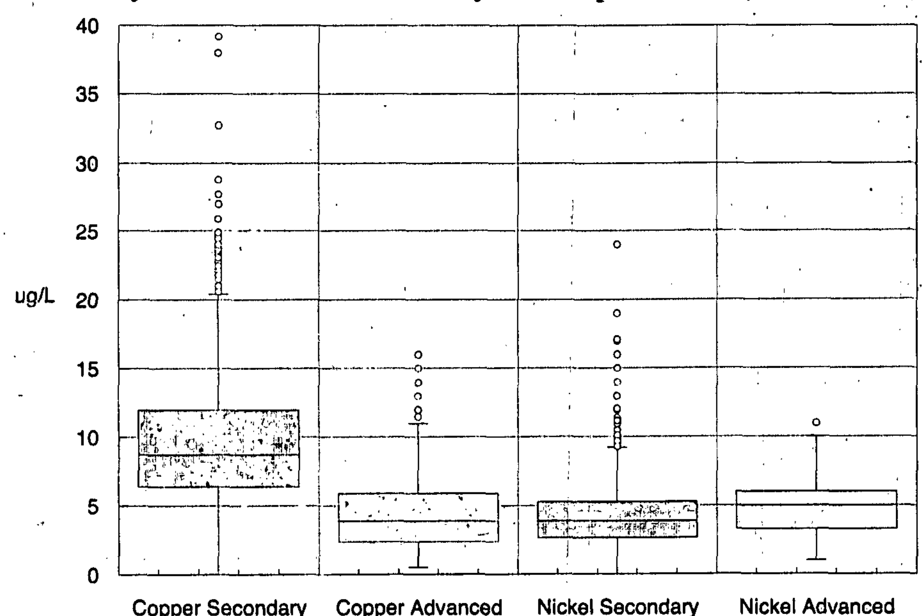
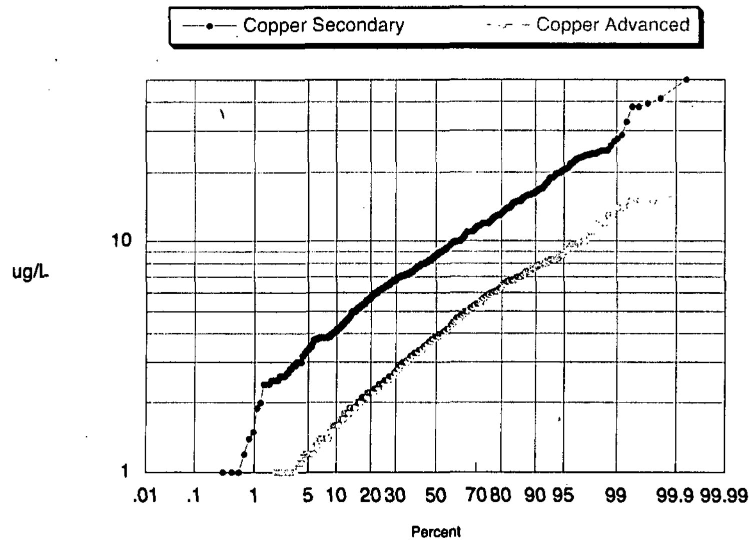
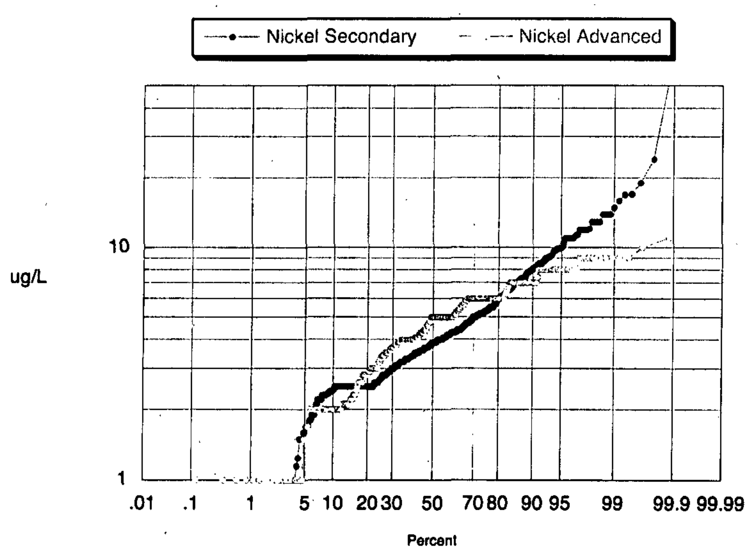


Figure 2 shows the probability plots for effluent copper and nickel from the same group of Bay area treatment plants. As shown in these figures, copper concentrations from advanced secondary plants are almost 50 percent lower than copper concentrations from secondary plants. On the other hand, effluent nickel concentrations are, for the most part, equivalent for the two treatment categories.

Figure 2. Probability Plots for Secondary and Advanced Secondary Treatment Plants (2001 – 2003)





One point (93 µg/L) shown off scale to expand view of remaining datapoints. The point was not censored, just the graph scale truncated.

The above information is derived from available data from individual plants. A listing of those plants and the current average discharge from those facilities is provided in **Table 2**. The copper and nickel effluent data for these plants is summarized in **Tables 3** and **4**.

Table 2. Dischargers Categorized by Current Average Effluent Flow

Discharger	Ave. Flow MGD	Plant Size
Morton Permit	0.027	<1 MGD
GWF E 3rd St (Site I) Permit	0.043	
GWF Nichols Rd (Site V) Permit	0.047	
General Electric Company	0.052	
Rhodia Basic Chemicals Permit	0.109	
Dow Chemical Company Permit	0.26	
General Chemical Permit	0.32	
US Navy Treasure Island Permit	0.417	
S.F. Airport, Industrial	0.69	
Tiburon Treatment Plant Permit	0.706	
S.F. Airport, Water Quality Control Plant	0.75	
Rodeo Sanitary District Permit	0.76	
ConocoPhillips (at Rodeo)	1.49	1-10 MGD
Sausalito-Marin Sanitary District Permit	1.67	
SAM Permit	1.71	
Millbrae	1.86	
Mt. View Sanitary District	1.96	
Novato: Novato Plant	2.01	
Valero Benicia Refinery	2.07	
City of Benicia	3.02	
Sewerage Agency of Southern Marin Permit	3.11	
Pinole-Hercules	3.2	
Novato Sanitary District Permit: Overall	3.25	
Sonoma Valley Permit	3.32	
Las GallinasValley SD Permit	3.34	
Pacifica Calera Creek	3.59	
Burlingame	4.02	
Tesoro Golden Eagle Refinery	4.22	
Novato: Ignacio Plant	4.49	
EBDA: San Leandro	5.45	
Martinez Refining Company	5.98	
Chevron Richmond Refinery	6.32	
North San Mateo	6.83	
Petaluma	7.3	
USS – Posco	7.6	
West County/Richmond Permit	8.87	
South San Francisco & San Bruno	9.91	
Delta Diablo Sanitation District	9.94	
Central Marin	10.43	10-30 MGD
Dublin San Ramon Services District Permit	10.52	
Sunnyvale	12.73	
San Mateo City	12.81	
EBDA: Hayward	13.07	
Vallejo San & Flood Control District	14.02	
EBDA: Castro Valley	15.37	
San Francisco Oceanside	16.38	
Fairfield-Suisun Sewer District	16.57	
South Bay System Authority	16.91	
San Francisco City & County Bayside (wet)	22.75	
Palo Alto	25.1	
EBDA: Overall	27.56	
EBDA: Union SD	29.1	
Central Contra Costa	43.89	40-75 MGD
San Francisco City & County Southeast	71.17	
EBMUD	73.49	
EBDA: E-001	74.96	
San Jose & Santa Clara	110.16	> 100 MGD

Table 3. Daily Maximum Effluent Copper (2001 – 2003)

	Concentration [µg/L]					
Discharger	Min	Max	Median	Mean	SD	n
Burlingame	4.4	38	8	9.8	7.4	34
Central Contra Costa	2	11	6.7	6.6	1.7	27
Central Marin	1.4	4.5	2.7	2.8	0.8	32
Chevron Richmond Refinery	1	15	2.2	3.5	3.4	24
City of Benicia	1.9	27	6.1	6.8	3.8	53
ConocoPhillips (at Rodeo)	1.8	20	6.4	6.7	4	32
Delta Diablo Sanitation District	2.5	16	7.5	7.6	2.1	65
Dow Chemical Company Permit	4.1	25	10	12.2	6.9	29
Dublin San Ramon Services District Permit	21	80	40	44.2	16.3	35
EBDA:	3.8	50	12.3	13.9	7	142
E-001	3.8	18.3	12.5	12.3	2.9	27
Castro Valley	3.9	19	9.6	9.7	3.2	28
Hayward	14.8	50	22.2	24.1	7.7	28
San Leandro	3.9	16.3	8.4	9.1	3.3	28
Union SD	8.1	24.7	14.5	14.3	4	31
EBMUD	3	25.9	9	10.1	5	50
Fairfield-Suisun Sewer District	2.2	9	4.2	4.4	1.4	57
General Chemical Permit	0	5	5	3.7	2.2	11
General Electric Company	5	10	10	8.3	2.4	8
GWF E 3rd St (Site I) Permit	12.2	32.8	21.8	21.9	4.3	40
GWF Nichols Rd (Site V) Permit	13.6	28	19.9	20	3.8	39
Las Gallinas Valley SD Permit	8	25	11	12.6	4.9	10
Martinez Refining Company	2	12	5	5.4	2.2	32
Millbrae	5	14	8	8.8	2.3	35
Morton Permit	1.9	30.5	5	10.6	13.3	4
Mt. View Sanitary District	2.5	8.3	4.7	5	1.4	31
North San Mateo	10	100	11	22.5	31.4	8
Novato Sanitary District Permit:	5.2	11	8.1	8.1	4.1	2
Ignacio Plant	5.2	5.2	5.2	5.2	5.2	1
Novato Plant	11	11	11	11	11	1
Pacifica Calera Creek	2.8	9.3	5.3	5.6	1.7	30
Palo Alto	3.3	11.5	6.3	6.4	1.4	139
Petaluma Permit	1.7	6	3.7	3.6	1.2	15
Pinole-Hercules	1.4	9	4.1	4.6	1.9	31
Rhodia Basic Chemicals Permit	1	22	11	10.7	6	30
Rodeo Sanitary District Permit	0	5	3.4	3.2	1.3	23
S.F. Airport, Water Quality Control Plant	1.2	14.8	6.7	7	3.6	32
S.F.Airport, Industrial	0.3	24.5	4.8	5.5	4.2	34
SAM Permit	15.3	15.3	15.3	15.3	0	1
San Francisco City & County Bayside (wet)	28.5	64.3	50.2	48.2	13.8	10
San Francisco City & County Southeast	6.3	23.8	12.8	13.7	4.2	100
San Francisco Oceanside	5.5	23.9	15.3	16	4.2	30
San Jose & Santa Clara	1.2	6.7	3.2	3.3	1.1	170
San Mateo City	3.2	14	5.6	6	2.2	30
Sausalito-Marin Sanitary District Permit	0	16	11	11.2	2.8	29
Sewerage Agency of Southern Marin Permit	8.3	24	16	15.5	3.6	29
Sonoma Valley Permit	2.9	12	7.7	7.7	1.7	57
South Bay System Authority	4	16	9.7	10.1	2.9	37
South San Francisco & San Bruno	4.6	32.7	10.3	10.6	4.8	32
Sunnyvale	0.5	4.8	1.7	1.9	1	121
Tesoro Golden Eagle Refinery	1.3	20	4	4.6	2.8	122
Tiburon Treatment Plant Permit	5.2	30	20	18.2	6.2	16
US Navy Treasure Island Permit	8.2	23.1	10.8	12.5	3.9	29
USS - Posco	2	4.7	2.5	2.7	0.8	32
Valero Benicia Refinery	1.4	13	8	7.6	2.7	68
Vallejo San & Flood Control District	3.6	11.8	6.3	6.4	1.6	40
West County/Richmond Permit	5	11	7	7.4	1.9	11

Table 4. Daily Maximum Effluent Nickel (2001 – 2003)

Discharger	Concentration [µg/L]					
	Min	Max	Median	Mean	SD	n
Burlingame	0.3	6.6	3.2	3.5	1.2	34
Central Contra Costa	0.5	3.2	1.6	1.6	0.7	27
Central Marin	3.1	7.2	4.1	4.2	0.8	32
Chevron Richmond Refinery	3	26	19.1	18.9	4.7	24
City of Benicia	2.8	8.5	4.4	4.7	1.2	51
ConocoPhillips (at Rodeo)	1.1	13	3	3.3	2.1	32
Delta Diablo Sanitation District	3.8	14	8	8.3	2.7	28
Dow Chemical Company Permit	2.7	40	10	17.1	16	29
Dublin San Ramon Services District Permit	2	5.1	2.8	2.9	0.8	30
EBDA:	5	93	5.4	7.5	7.9	139
E-001	5	19	5.3	6.6	2.9	27
Castro Valley	5	5	5	5	0	28
Hayward	5.4	93	8.6	12.5	16.2	28
San Leandro	5	9.1	5	5.6	1	28
Union SD	5	14	6.4	7.7	2.9	28
EBMUD	5	16	6.7	7.2	2.4	50
Fairfield-Suisun Sewer District	1.5	6.6	3.8	3.9	1	57
General Chemical Permit	2.6	5.5	5	4.8	0.9	8
GWF E 3rd St (Site I) Permit	7.9	58.4	15.2	16.8	7.6	48
GWF Nichols Rd (Site V) Permit	7	92.9	9.7	12.7	16.1	27
Las Gallinas Valley SD Permit	4.2	8.2	4.8	5.5	1.4	10
Martinez Refining Company	10	38	19	20.4	7.7	32
Millbrae	2.6	6.5	3.5	3.6	0.7	48
Morton Permit	1	13	10	8.5	5.2	4
Mt. View Sanitary District	1.7	5.9	3.9	3.7	1.1	20
North San Mateo	50	50	50	50	0	9
Novato Sanitary District Permit:	2.2	2.3	2.3	2.3	0.1	2
Ignacio Plant	2.2	2.2	2.2	2.2	0	1
Novato Plant	2.3	2.3	2.3	2.3	0	1
Pacifica Calera Creek	2.1	5.4	3.2	3.2	0.8	30
Palo Alto	2.8	6	4	4.2	0.8	32
Petaluma Permit	3	6.8	4.1	4.3	1	15
Pinole-Hercules	1.6	7	4.3	4.4	1.1	24
Rhodia Basic Chemicals Permit	7.2	37	20.4	20.4	10.1	10
Rodeo Sanitary District Permit	2.2	6	3.1	3.6	1.2	9
S.F. Airport, Water Quality Control Plant	0.3	5.4	2.3	2.5	0.9	32
S.F.Airport, Industrial	0.5	30	5.4	6.5	6	32
SAM Permit	3.1	3.1	3.1	3.1	0	1
San Francisco City & County Bayside (wet)	2.4	6.6	5.1	4.7	1.5	10
San Francisco City & County Southeast	0.5	17	3.7	4.1	1.8	101
San Francisco Oceanside	1.1	5	2.3	2.4	0.7	30
San Jose & Santa Clara	4	10	6	6.3	1.3	170
San Mateo City	2.8	17	4.2	5.1	3.1	30
Sausalito-Marin Sanitary District Permit	0	7.3	4.3	4.3	1.6	29
Sewerage Agency of Southern Marin Permit	3	5.2	4.3	4.3	0.6	14
Sonoma Valley Permit	1	6	2.6	3	1.4	9
South Bay System Authority	4	11	5.4	5.7	1.4	37
South San Francisco & San Bruno	3.7	17.1	5.2	6.7	3.5	32
Sunnyvale	1	5.7	2	2.1	0.9	83
Tesoro Golden Eagle Refinery	10	87	14	16.5	7.9	122
Tiburon Treatment Plant Permit	2	10	10	6.9	4.2	5
US Navy Treasure Island Permit	1.2	5.7	2.2	2.5	1.1	29
USS - Posco	2	4.7	2.5	2.7	0.8	32
Valero Benicia Refinery	3.3	100	10	12.3	9.9	135
Vallejo San & Flood Control District	2.3	3.6	2.9	2.9	0.4	38
West County/Richmond Permit	5	11	6.9	7.3	2.3	11

Copper and nickel effluent data for individual industrial plants is shown in **Figures 3** and **4**.

Figure 3. Daily Maximum Copper Concentrations in Industrial Effluent (2001 – 2003)

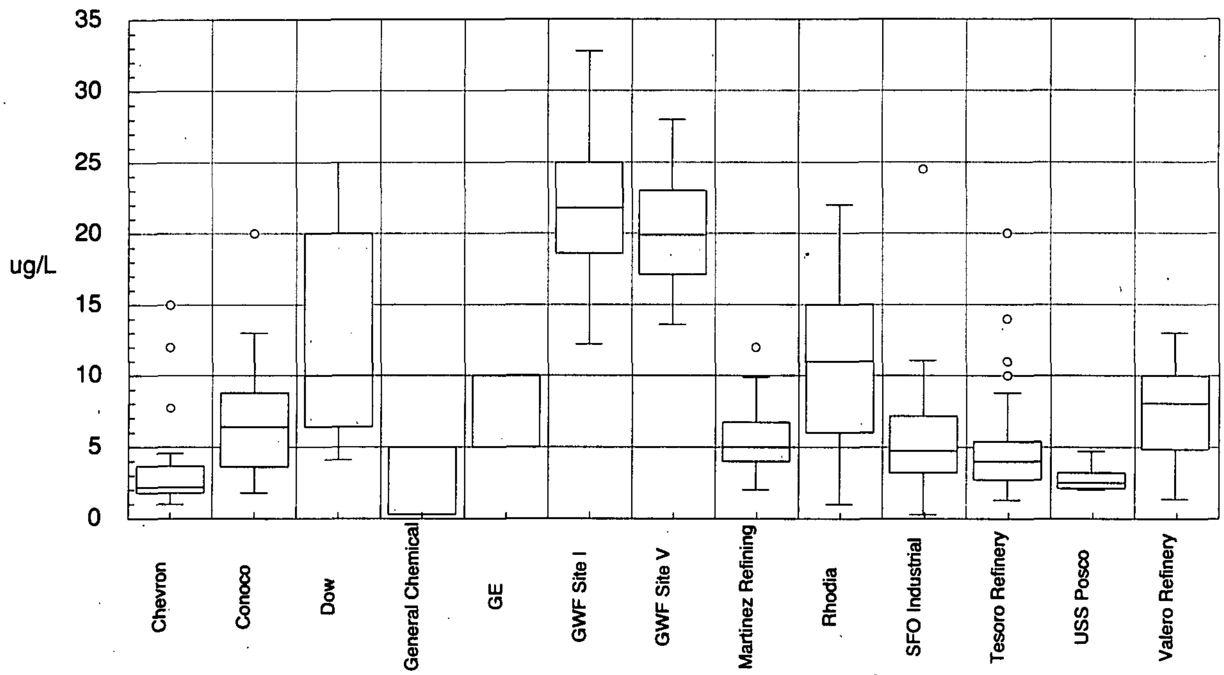


Figure 4. Daily Maximum Nickel Concentrations in Industrial Effluent (2001 – 2003)

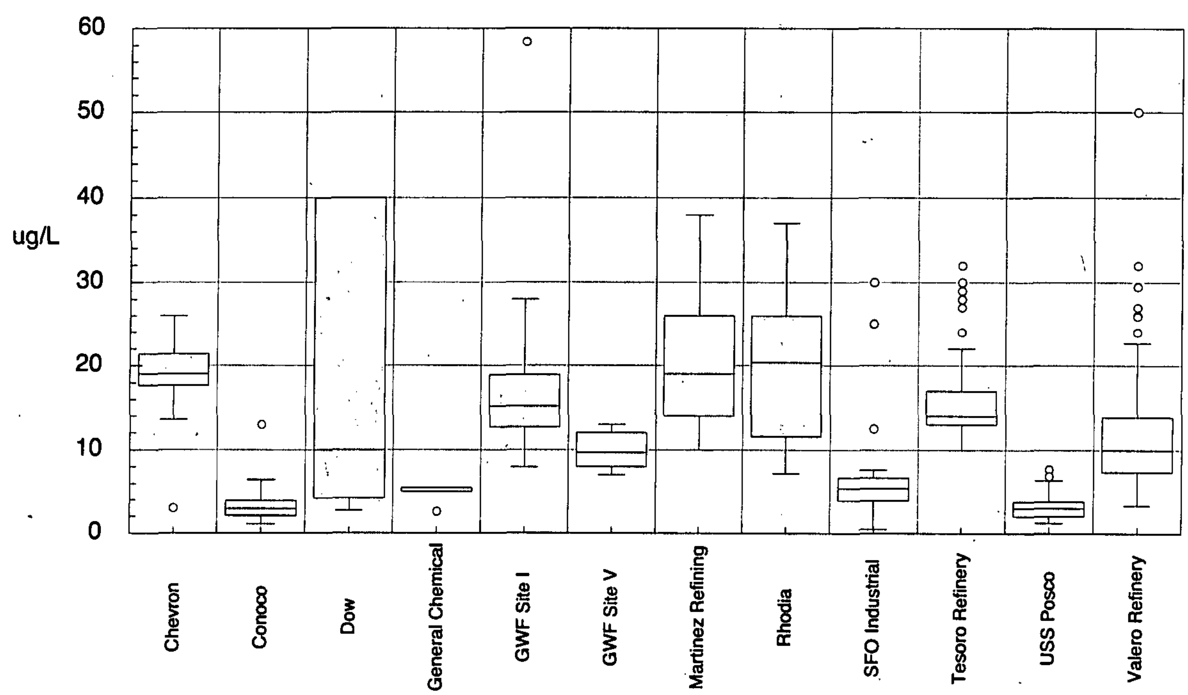


Figure 5. Probability Plots for Industrial Treatment Plants (2001-2003)

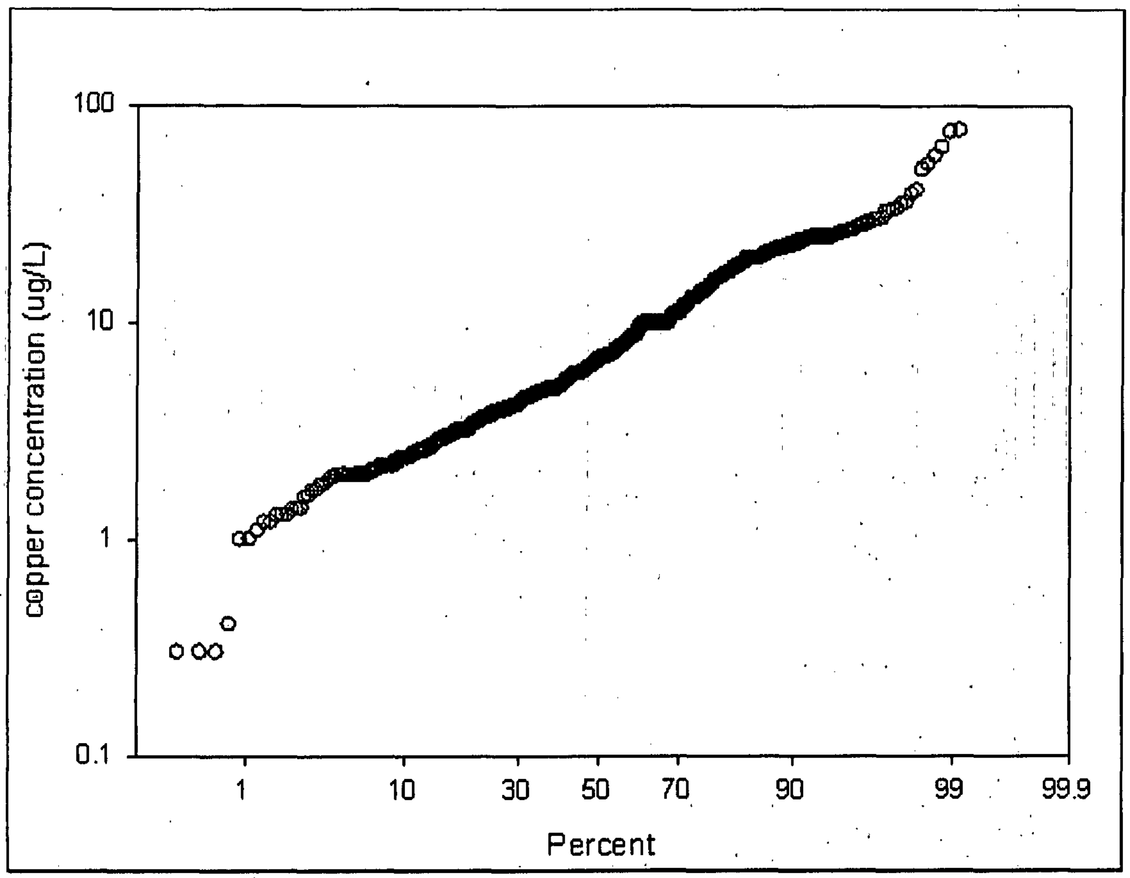
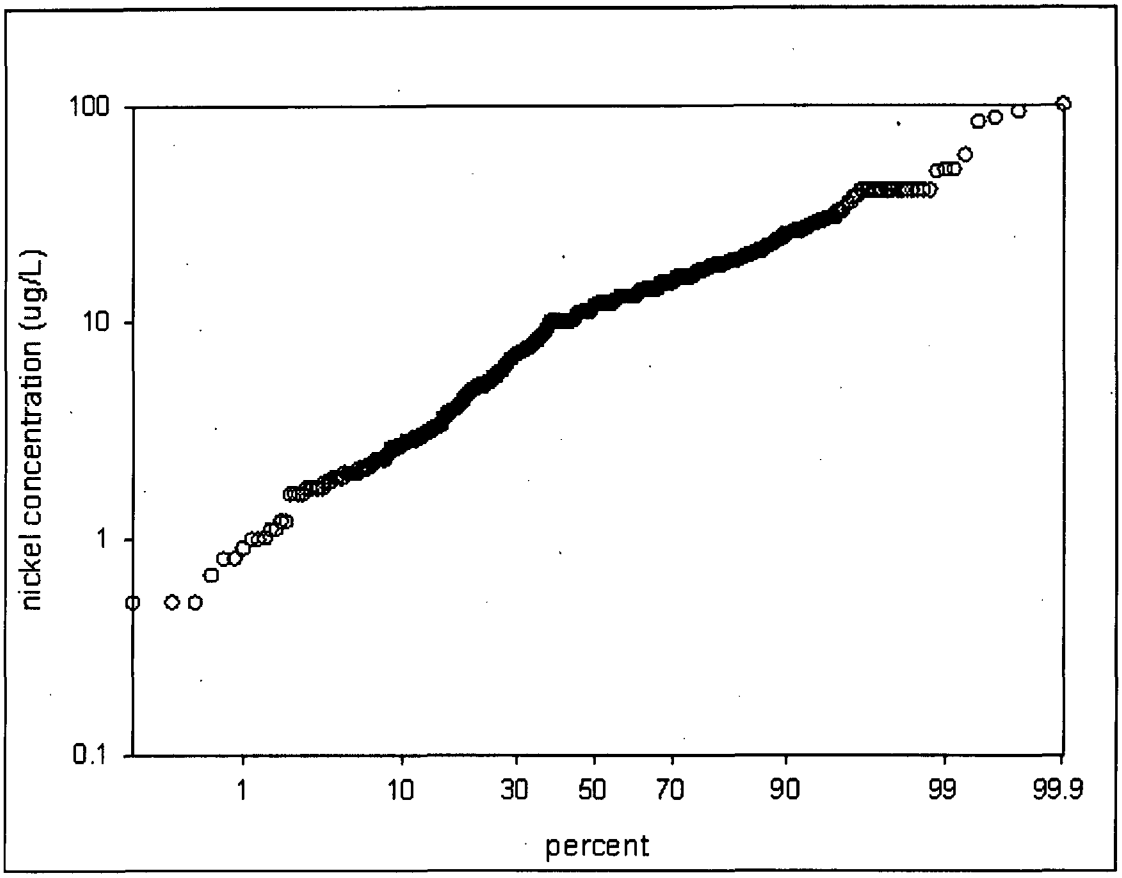


Figure 6. Probability Plots for Industrial Treatment Plants (2001-2003)



The magnitude of copper and nickel loadings from individual municipal and industrial plants to the Bay is shown in **Tables 5** and **6**.

Table 5. POTW Effluent Copper and Nickel Concentrations and Loads (2001-2003)

Discharger	Ave. Flow MGD	Mean Cu µg/L	Cu Load g/day	Mean Ni µg/L	Ni Load g/day
City of Benicia	3.02	6.8	78.0	4.7	53.4
Burlingame	4.02	9.8	149.7	3.5	53.1
Central Contra Costa	43.89	6.6	1091.5	1.6	262.7
Central Marin	10.43	2.8	110.5	4.2	165.8
Delta Diablo Sanitation District	9.94	7.6	285.3	8.3	310.8
Dublin San Ramon Services District Permit	10.52	44.2	1758.3	2.9	115.7
EBDA:	27.56	13.9	1452.9	7.5	780.1
E-001	74.96	12.3	3498.8	6.6	1863.1
Castro Valley	15.37	9.7	565.5	5.0	290.9
Hayward	13.07	24.1	1192.0	12.5	620.3
San Leandro	5.45	9.1	188.2	5.6	115.2
Union SD	29.1	14.3	1572.3	7.7	844.6
EBMUD	73.49	9.9	2743.0	6.6	1821.9
Fairfield-Suisun Sewer District	16.57	4.4	274.6	3.9	242.6
Las Gallinas Valley SD Permit	3.34	12.6	159.7	5.5	69.8
Millbrae	1.86	8.8	62.2	3.6	25.5
Mt. View Sanitary District	1.96	5.0	37.2	3.7	27.5
North San Mateo	6.83	22.5	581.7	50.0	1292.6
Novato Sanitary District Permit:	3.25	8.1	99.6	2.3	27.7
Ignacio Plant	4.49	5.2	88.4	2.2	37.4
Novato Plant	2.01	11.0	83.7	2.3	17.1
Pacifica Calera Creek	3.59	5.6	75.8	3.2	43.5
Palo Alto	25.1	6.4	609.2	4.2	394.3
Petaluma Permit	7.3	3.6	99.1	4.3	119.7
Pinole-Hercules	3.2	4.6	55.8	4.4	52.9
Rodeo Sanitary District Permit	0.76	3.2	9.1	3.6	10.3
S.F. Airport, Water Quality Control Plant	0.75	7.0	19.7	2.5	7.1
San Francisco City & County Southeast	71.17	13.7	3695.5	4.1	1099.9
San Francisco City & County Bayside (wet)	22.75	48.2	4146.1	4.7	405.1
San Francisco Oceanside	16.38	16.0	994.9	2.4	150.0
San Jose & Santa Clara	110.16	3.3	1362.2	6.3	2629.3
San Mateo City	12.81	6.0	291.6	5.1	248.1
Sausalito-Marin Sanitary District Permit	1.67	11.2	70.5	4.3	27.1
Sewerage Agency of Southern Marin Permit	3.11	15.5	183.0	4.3	50.9
Sonoma Valley Permit	3.32	7.7	96.7	3.0	38.0
South Bay System Authority	16.91	10.1	643.5	5.7	363.3
South San Francisco & San Bruno	9.91	10.6	398.5	6.7	251.5
Sunnyvale	12.73	1.9	92.0	2.1	102.1
Tiburon Treatment Plant Permit	0.706	18.2	48.5	6.9	18.5
US Navy Treasure Island Permit	0.417	12.5	19.7	2.5	3.9
Vallejo San & Flood Control District	14.02	6.4	341.1	2.9	153.3
West County/Richmond Permit	8.87	7.4	248.5	7.3	245.7

Table 6. Industrial Effluent Copper and Nickel Concentrations and Loads (2001-2003)

Discharger	Ave. Flow	Mean Cu	Cu Load	Mean Ni	Ni Load
	MGD	µg/L	g/day	µg/L	g/day
Chevron Richmond Refinery	6.32	3.5	83.1	18.9	451.8
ConocoPhillips (at Rodeo)	1.49	6.7	37.7	3.3	18.7
Dow Chemical Company Permit	0.26	8.8	8.7	10.9	10.7
General Chemical Permit	0.32	3.7	4.5	4.8	5.8
General Electric Company	0.052	8.3	1.6	4.8	0.9
GWF E 3rd St (Site I) Permit	0.043	21.9	3.6	16.8	2.7
GWF Nichols Rd (Site V) Permit	0.047	20.0	3.6	12.7	2.3
Martinez Refining Company	5.98	5.4	122.6	20.4	462.6
Morton Permit	0.027	10.6	1.1	8.5	0.9
Rhodia Basic Chemicals Permit	0.109	10.7	4.4	20.4	8.4
S.F. Airport, Industrial	0.69	5.5	14.5	6.5	17.1
SAM Permit	1.71	15.3	99.0	3.1	20.1
Tesoro Golden Eagle Refinery	4.22	4.6	74.1	16.5	262.9
USS - Posco	7.6	2.7	78.9	2.7	78.9
Valero Benicia Refinery	2.07	7.6	59.3	12.3	96.5

3.2 Translator Values used in the Derivation of Effluent Limits

The existing California Toxics Rule (CTR) and San Francisco Bay Basin Plan aquatic life water quality objectives for metals are expressed as dissolved concentrations. The objectives for copper are 4.8 µg/L (acute) and 3.1 µg/L (chronic), and for nickel 74 µg/L (acute) and 8.2 µg/L (chronic). However, by federal regulations (40 CFR 122.45(c)), NPDES permit limits must be expressed as total recoverable metal. Thus an additional factor, a translator, is required to convert the dissolved criteria into total recoverable effluent limits. Translators are unitless values ranging from zero to one that represent the ratio of dissolved metals concentration to total metals concentration in receiving waters:

$$\text{translator} = \frac{\text{dissolved metal concentration}}{\text{total metal concentration}}$$

The most conservative translator is a value of one, implying that all metals discharged in an effluent to a receiving water body will be present in the dissolved form. Effluent limits derived using a translator of 1.0 simply treat the CTR dissolved criteria as total recoverable values.

The next option is to use the EPA's "conversion factor" (listed in the CTR) as a default translator. The federal saltwater copper criteria conversion factor is 0.83; the nickel conversion factor is 0.99. The dissolved CTR criteria are adjusted to a total recoverable basis by dividing by these conversion factors. Effluent limits derived using the default conversion factors would be slightly higher than those based on a unity translator.

$$\text{total metal criteria} = \frac{\text{dissolved metal criteria}}{\text{translator}}$$

The third option is to develop a site-specific translator based on an analysis of receiving water samples. The SIP Section 1.4.1 describes the conditions under which site-specific translators may be used.

In *The Metals Translator: Guidance for Calculating A Total Recoverable Permit Limit from a Dissolved Criterion (June 1996)*, EPA identifies three methods for calculating a site-specific translator. One is direct measurement of the dissolved and total recoverable metal concentrations in receiving water samples. The translator can then be calculated as the ratio of dissolved to total concentrations. For the second method, if a relationship between translators and total suspended solids (TSS) is found, a translator can be calculated by developing an appropriate regression equation and plugging in a representative (EPA recommends median) TSS concentration. The third method is determination of a translator indirectly by means of a partition coefficient, which is functionally related to the number of binding sites associated with the adsorbent. The partition coefficient may be derived as a function of TSS and other factors such as pH, salinity, TOC, etc.

4. CASE STUDIES

The proposed SSOs will be applicable to the San Francisco Bay north of the Dumbarton Bridge. Therefore, to address these SIP SSO request requirements, three north of Dumbarton Bridge (NDB) municipal agencies were selected from the 40 plus agencies that discharge treated wastewater NDB. The three agencies selected include: (1) a small, shallow water secondary treatment discharger, (2) a medium shallow water advanced secondary treatment discharger, and (3) a large deepwater secondary treatment discharger, respectively. The agencies chosen to try to represent the average discharger are the Las Gallinas Valley Sanitary District (LGVSD) Wastewater Treatment Plant, the Fairfield Suisun Sewer District (FSSD), and the East Bay Municipal Utility District (EBMUD).

To demonstrate that these three dischargers are reasonably representative of other NDB dischargers, available effluent copper and effluent nickel data from the period 2001 through 2003 from all NDB dischargers was compiled from the RWQCB's Electronic Reporting System (ERS). The ERS contains data for these facilities and most other municipal and industrial NPDES dischargers to San Francisco Bay. The data were grouped into industrial, POTW secondary treatment and POTW advanced secondary treatment categories, similar to the approach used for the Regional Board's pooled mercury data effluent limit analysis (as prepared by Ken Katen, RWQCB, June 2001). The results of this effort are shown graphically in **Figures 1** and **2**. Examination of these figures indicates that the effluent quality for the three selected dischargers is reasonably representative of other facilities in their respective categories.

Figure 7. Dissolved Copper Case Study Data

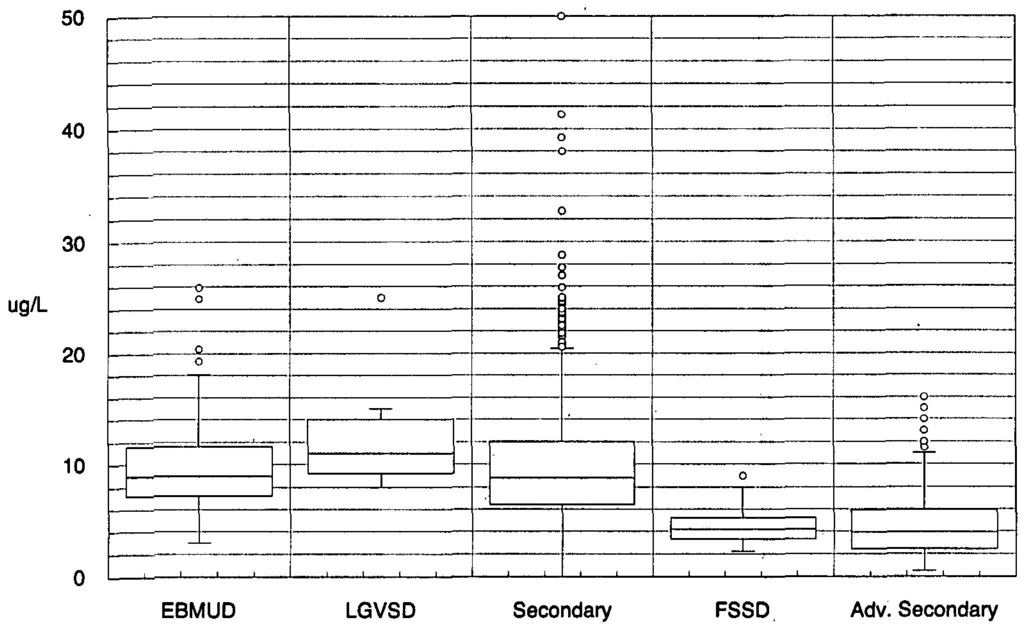


Figure 8. Dissolved Nickel Case Study Data

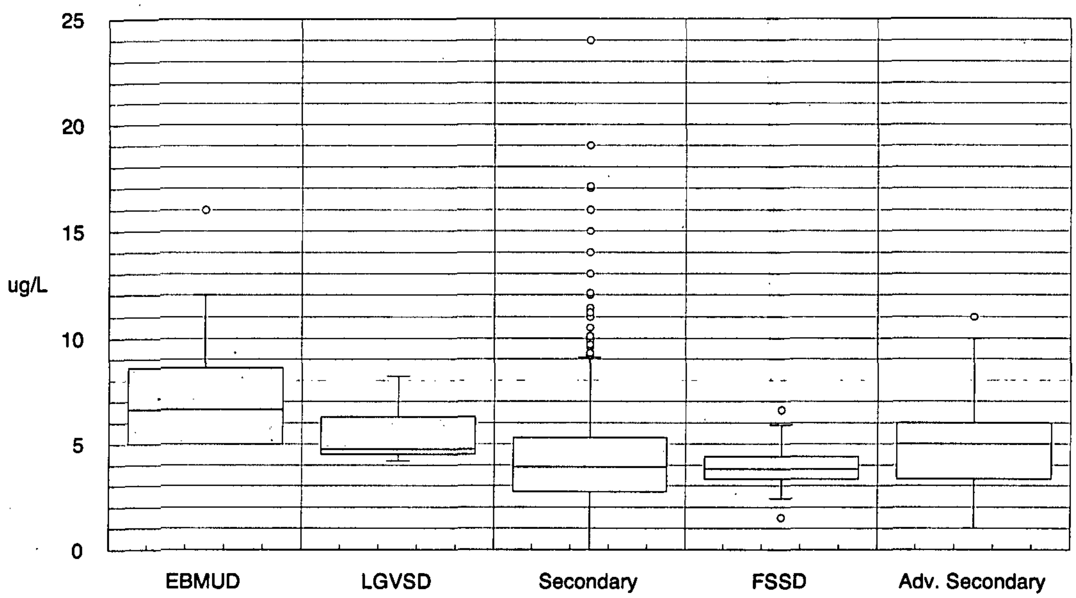


Figure 9. Case Study: Daily Maximum Effluent Copper Probability Data (2001 – 2003)

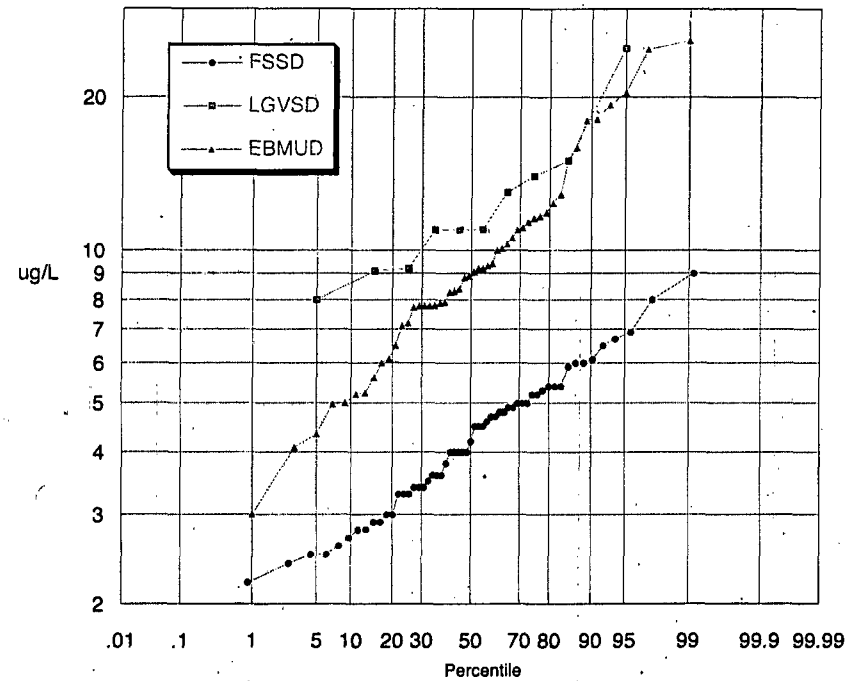
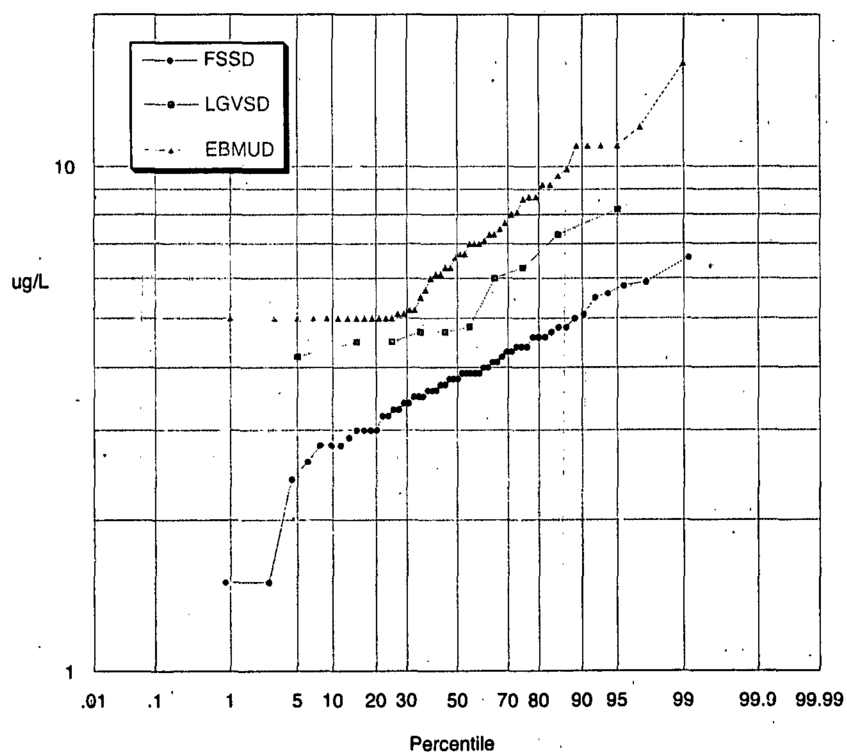


Figure 10. Case Study: Daily Maximum Effluent Nickel Probability Data (2001 – 2003)



To address Items (b) and (c), existing final effluent limits and potential future effluent limits for copper and nickel were obtained/calculated for each facility, based on existing water quality objectives for copper and nickel. Current effluent quality was compared with these effluent limits to establish the ability to comply and thus the need for SSOs for the three representative agencies. Additionally, an overview analysis of other NDB dischargers was made to validate that the compliance assessment for the three pilot facilities represented the full suite of potentially impacted agencies.

5. FINAL EFFLUENT LIMIT CALCULATIONS

Final average monthly effluent limits (AMELs) and maximum daily effluent limits (MDELs) derived from existing copper and nickel objectives are calculated here to be used as the baseline for evaluating whether the three representative treatment plants will be able to comply with them. The approach used is consistent with that that has been used in prior Infeasibility Studies.

Section 1.4 of the SIP contains the applicable steps for calculating final effluent limitations. The first step is to identify the applicable water quality criteria and to adjust the criteria (for translators, hardness or pH) if appropriate. Translator selection is an important variable and is discussed below. The next step is to calculate the effluent concentration allowance (ECA), which incorporates any allowable dilution credit. Dilution credit is only applicable if the background concentration is less than the adjusted water quality criteria and the discharger is a deep-water discharger (e.g. EBMUD). Background concentrations are not used in the shallow water effluent limit calculations because such dischargers (e.g. FSSD and LGVSD) do not receive dilution credit. With a dilution credit of zero, the effluent concentration allowance (ECA) values are set equal to the associated criteria.

For deepwater dischargers such as EBMUD, the allowable dilution credit has historically been limited to 10:1 in this Region. The SIP requires that the observed maximum background concentration be used in the effluent limit calculations. It is unclear at this time what ambient background station(s) should be used and whether total metals or translated dissolved metals data (see below) should be used. Yerba Buena Island RMP Station (BC10) data have been used in the past for RPAs for Central Bay dischargers.

For each ECA based on acute and chronic aquatic life criteria, long-term averages (LTAs) are calculated by multiplying the ECA with a multiplier that adjusts for effluent variability. There is both an acute and chronic ECA multiplier, based on the coefficient of variation (CV) of the discharger's effluent data. The more variable the discharger's effluent data, the higher the CV, the lower the ECA multiplier and the lower (the more stringent) the LTA. The lowest of the calculated acute and chronic LTAs is then selected. Average monthly (AMEL) and maximum daily (MDEL) effluent limits are calculated as the product of the lowest LTA (either chronic or acute) and a second set of multipliers based on the CV of the discharger's effluent data and the number of samples collected per month.

Final effluent limits are the lower of the AMEL and MDEL based on aquatic life criteria or the AMEL and MDEL based on the human health criteria. For copper and nickel the marine aquatic life criteria are the most stringent.

5.1 LGVSD Effluent Limit Options

Table 7 presents alternative effluent limits based on five different translator options, CTR dissolved water quality objectives, and 2001 – 2003 effluent data. The translator options include (from top to bottom):

1) Default translator of 1.0,
2) CTR default conversion factors,
3) LGVSD Miller Creek Translator study "Downstream" 3-station pooled values (the values used in the current permit),
4) RMP Station BD20 (San Pablo Bay) based values, and
5) North of Dumbarton Bridge Study pooled North Bay stations plus associated RMP station based values.

Option 3 – 5 translators are dissolved-to-total ratio based values. Complete calculations are presented in Appendix A.

Table 7. LGVSD Effluent Limit Options

WQO/SSO Dissolved (μg/L)		Translator		AMEL	MDEL	Translator Option
		Median	90th %	Monthly Ave	Daily Max	
Chronic	Acute	Chronic	Acute			
Copper						
3.1	4.8	1	1	2.7	4.5	1
		0.83	0.83	3.3	5.4	2
		0.56	**0.83**	**3.5**	**5.8**	**3**
		0.38	0.66	4.4	7.3	4
		0.38	0.67	4.4	7.2	5
Nickel						
8.2	74	1	1	7.5	10.6	1
		0.99	0.99	7.6	10.7	2
		0.56	**0.82**	**13.4**	**18.9**	**3**
		0.21	0.52	35.7	50.4	4
		0.27	0.57	26.7	37.6	5

Bolded values represent the translator option used in LGVSD's current permit.

5.2 FSSD Effluent Limit Options

Table 8 presents alternative effluent limits based on five different translator options, CTR dissolved water quality objectives, and 2001 – 2003 effluent data. The translator options include (from top to bottom):

1) Default translator of 1.0,
2) CTR default conversion factors,
3) FSSD site-specific study values (the values used in the current permit),
4) RMP Station BF20 (Grizzly Bay) based values, and
5) North of Dumbarton Bridge Study pooled North Bay stations plus associated RMP station based values.

Complete calculations are presented in Appendix A.

Table 8. FSSD Effluent Limit Options

WQO/SSO Dissolved (µg/L)		Translator		AMEL	MDEL	Translator Option
		Median	90th %	Monthly Ave	Daily Max	
Chronic	Acute	Chronic	Acute			
Copper						
3.1	4.8	1	1	2.8	4.3	1
		0.83	0.83	3.3	5.2	2
		0.46	**0.64**	**4.8**	**7.5**	**3**
		0.33	0.51	6.1	9.5	4
		0.38	0.67	4.6	7.2	5
Nickel						
8.2	74	1	1	7.5	10.6	1
		0.99	0.99	7.6	10.7	2
		0.51	**0.91**	**14.7**	**20.7**	**3**
		0.19	0.39	19.2	27.1	4
		0.27	0.57	27.8	39.2	5

Bolded values represent the translator option used in FSSD's current permit.

5.3 EBMUD Effluent Limit Options

Table 9 presents alternative effluent limits based on five different translator options, CTR dissolved water quality objectives, 2001 – 2003 effluent data, ambient concentrations from RMP station BC10 (Yerba Buena Island), and 10:1 dilution. The translator options include (from top to bottom):

1) Default translator of 1.0,
2) CTR default conversion factors,
3) NA (the CTR CFs were used in the current permit),
4) RMP Station BC10 based values, and
5) North of Dumbarton Bridge Study pooled Central Bay plus associated RMP station based values.

Option 4 – 5 translators are dissolved to total ratio based values. Complete calculations are presented in Appendix A.

Table 9. EBMUD Effluent Limit Options

WQO/SSO		Translator		AMEL	MDEL	Translator Option
Dissolved (µg/L)		Median	90th%	Monthly Ave	Daily Max	
Chronic	Acute	Chronic	Acute			
Copper						
3.1	4.8	1	1	2.6	4.8	1
		0.83	0.83	3.7	6.9	2
		0.83	**0.83**	**3.7**	**6.9**	**3**
		0.68	0.81	10.7	19.7	4
		0.74	0.88	7.6	13.9	5
Nickel						
8.2	74	1	1	42.0	66.0	1
		0.99	0.99	43.0	67.0	2
		0.99	**0.99**	**43.0**	**67.0**	**3**
		0.58	0.78	95.0	149.0	4
		0.65	0.85	82.0	127.0	5

Bolded values represent the translator option used in EBMUD's current permit.

The January 14, 2003 *Draft Additional Analysis of RMP Station BA30 Zinc Translator Information* memo by EOA discussed the issue of how to adjust California Toxics Rule (CTR) dissolved metals based water quality objectives (criteria) and dissolved metals receiving water concentrations, to a total metals basis. This adjustment is required since Federal Regulations require that effluent limitations be expressed on a total metals basis and thus effluent data are collected and analyzed for total metals concentrations. Thus CTR WQOs need to be adjusted from dissolved-to-total concentration to allow comparison to the maximum effluent concentrations (MEC) in the EPA based RPA (the first RPA trigger). For consistency under the State Implementation Plan RPA Section 1.3, Step 6 (the second RPA trigger), background receiving water dissolved metals concentrations need to be similarly adjusted to total metals to allow comparison to the adjusted CTR WQOs developed and used for the MEC comparison.

In this SIP SSO justification analysis, the issue needs to be addressed for calculation of deepwater final effluent limits. Ambient concentrations are not an issue in the calculations for shallow water dischargers, since they are negated out in the formulae by the zero dilution credit. For the deepwater discharger calculations (or RPAs) it can make a large difference whether a total metals or a translated dissolved metals ambient value is used. The above cited memo documents the differences and concludes that it is most scientifically defensible, and consistent, to use translated dissolved metals ambient values.

For purposes of comparison with projected plant effluent concentrations, the calculated limits shown in bold will be used. For LGVSD and FSSD these are the values based on the local site-specific translators used by RWQCB staff in the December 2003 and July 2003 permit reissuances (Option 3). For EBMUD, the north of Dumbarton pooled Central Bay translator based limits will be used (Option 5). For the earlier (June 2001) EBMUD re-issuance, the EPA default conversion factors (Option 2) were used for the Infeasibility Study copper analysis. The Basin Plan 7.1 µg/L total nickel WQO was used for effluent limit derivation so nickel translators were not needed.

5.4 Plant Performance and Ability to Comply

Summary statistics of influent and effluent copper and nickel concentrations are presented below for comparison with the final effluent limits developed above.

Table 10. Case Study Influent Copper and Nickel Summary Statistics

	Influent Copper (µg/L)			**Influent Nickel (µg/L)**		
	LGVSD	**FSSD**	**EBMUD**	**LGVSD**	**FSSD**	**EBMUD**
# samples	11	36	154	11	36	154
# NDs	0	0	0	0	0	0
Geo. mean	27.8	41.3	62	7.98	8.55	8.40
Geo. std. dev	1.62	1.23	1.35	1.43	1.39	1.49
95th percentile[1]	71.7	61.7	112	16.2	16.4	18.3
99th percentile[1]	96.5	70.1	135	20.2	20.1	23.4
99.87th percentile[1]	118.5	76.5	154	23.6	23.1	27.7
Maximum	57	67	163	16	20.5	46

Notes:
1. Assuming log-normal distrib: Values are: geomean*std dev^1.96; geomean*std dev^2.576; geomean*std dev^3

Table 11. Case Study Effluent Copper and Nickel Summary Statistics

	Effluent Copper (µg/L)			**Effluent Nickel (µg/L)**		
	LGVSD	**FSSD**	**EBMUD**	**LGVSD**	**FSSD**	**EBMUD**
# samples	10	57	50	10	57	50
# NDs	0	0	6	0	2	12
Geo. Mean	11.98	4.17	9.13	5.38	3.74	6.82
Geo. std. dev.	1.38	1.37	1.58	1.26	1.32	1.35
95th percentile[1]	22.7	7.77	22.3	8.47	6.44	12.2
99th percentile[1]	27.7	9.46	29.5	9.77	7.63	14.7
99.87th percentile[1]	31.8	10.8	35.8	10.8	8.59	16.7
Maximum	25.0	9.0	25.9	8.2	6.6	16.0

Notes:
1. Assuming log-normal distrib: Values are: geomean*std dev^1.96; geomean*std dev^2.576; geomean*std dev^3

Table 12. Effluent Copper (µg/L), Effluent Limits, and Compliance Status

	LGVSD	Comply?	FSSD	Comply?	EBMUD	Comply?
AMEL	**3.5**		**4.8**		**7.6**	
95th percentile[1]	22.7	No	7.77	No	22.3	No
99th percentile[1]	27.7	No	9.46	No	29.5	No
99.87th percentile[1]	31.8	No	10.8	No	35.8	No
Maximum	25	No	9.0	No	25.9	No

Notes:
1. Assuming log-normal distrib: Values are: geomean*std dev^1.96; geomean*std dev^2.576; geomean*std dev^3

Table 13. Effluent Nickel (µg/L), Effluent Limits, and Compliance Status

	LGVSD	Comply?	FSSD	Comply?	EBMUD	Comply?
AMEL	**13.4**		**14.7**		**82**	
95th percentile[1]	8.47	Yes	6.44	Yes	12.2	Yes
99th percentile[1]	9.77	Yes	7.63	Yes	14.7	Yes
99.87th percentile[1]	10.8	Yes	8.59	Yes	16.7	Yes
Maximum	8.2	Yes	6.6	Yes	16.0	Yes

Notes:
1. Assuming log-normal distrib: Values are: geomean*std dev^1.96; geomean*std dev^2.576; geomean*std dev^3

Ability to comply with final effluent limits in Infeasibility Studies has been determined by comparing the final CTR/SIP based effluent limits to the observed maximum effluent concentration (MEC) and/or the statistically projected maximum. The latter is defined and calculated in the same manner as interim performance-based effluent limits (IPBL). Since effluent data are typically log-normally distributed IPBLs are often based on the mean plus three standard deviations of the log-transformed effluent data. IPBLs calculated in this manner approximate the 99.87th percentile of plant performance, a value that the plant would only be expected to exceed once every three years. These values are believed to be a more representative and appropriate measure of likely future plant performance since they are based on the underlying distribution of the data set versus the single occurrence MEC value.

For copper, the above tables demonstrate that <u>none of these facilities could consistently comply with final CTR based copper effluent limits calculated with the translators used for the latest NPDES permits</u>. From the probability plots in **Figure 9** it can be seen that LGVSD would exceed the 3.4 µg/L limit 100% of the time. FSSD would exceed its 4.8 µg/L limit about 40% of the time. EBMUD would exceed its 7.6 µg/L limit about 75% of the time. This is consistent with the fact that each facility already has interim copper effluent limits given the demonstrated inability to comply with final effluent limits documented in their respective Infeasibility Studies. If updated translators were to be used based on pooled North of Dumbarton study and associated RMP station data, they would still be in non-compliance with calculated copper final limits. For nickel, these three facilities appear as though they could comply with final CTR based effluent limits calculated with the translators used for the latest NPDES permits. This is consistent with the fact that each discharger has final nickel effluent limits in their permits.

5.5 Overview Compliance Analysis of Full Suite of NDB Dischargers

For municipal facilities NDB, projected compliance with copper limits appears to be adequately represented by the results of the 3 plants described above. A brief analysis of compliance for all NDB dischargers (**Table 14**) shows that the three case study plants were fairly accurate in their assessment of noncompliance. Average Monthly Effluent Limits (AMELs) were calculated for one plant in each region, and for a shallow and deep discharger in each of these regions using regional translators and WERs. These calculations provided regional AMELs to assess compliance with copper limits.

Table 14. Copper Compliance Status for All Dischargers

SHALLOW WATER DISCHARGERS ABILITY TO COMPLY:

Region 1

WER	Chronic SSO	AMEL	FSSD		GWF E 3rd St		USS - Posco	
			MEC	99.87%	MEC	99.87%	MEC	99.87%
			9.0	10.8	32.8	39.3	4.7	5.9
1.0	2.5	1.8	no	no	no	no	no	no
1.0	3.1	2.3	no	no	no	no	no	no
2.4	6.0	8.5	no	no	no	no	yes	yes
2.4	7.4	8.5	no	no	no	no	no	no

no = could not comply with AMEL
yes = could comply with AMEL

Region 2

WER	Chronic SSO	AMEL	LGVSD		Novato		Petaluma		Sonoma Valley	
			MEC	99.87%	MEC	99.87%	MEC	99.87%	MEC	99.87%
			25.0	31.8	11.0	37.1	6.0	10.0	12.0	15.3
1.0	2.5	2.2	no	no	no	no	no	no	no	no
1.0	3.1	2.7	no	no	no	no	no	no	no	no
2.4	6.0	9.9	no	no	no	no	no	no	no	no
2.4	7.4	10.0	no	no	no	no	yes	yes	no	no

no = could not comply with AMEL
yes = could comply with AMEL

DEEP WATER DISCHARGERS ABILITY TO COMPLY:

Region 1

WER	Chronic SSO	AMEL	City of Benicia		Delta Diablo		Dow Chemical		General Chemical	
			MEC	99.87%	MEC	99.87%	MEC	99.87%	MEC	99.87%
			27.0	26.6	16.0	18.0	25.0	58.4	5.0	5.0
1.0	2.5	3.1	no	no	no	no	no	no	no	no
1.0	3.1	7.6	no	no	no	no	no	no	yes	yes
2.4	6.0	71.0	yes	yes	yes	yes	yes	yes	yes	yes
2.4	7.4	71.0	yes	yes	yes	yes	yes	yes	yes	yes

WER	Chronic SSO	AMEL	Martinez Refining		SAM Permit		GWF Nichols		Valero Refinery	
			MEC	99.87%	MEC	99.87%	MEC	99.87%	MEC	99.87%
			12.0	16.5	15.3	15.3	28.0	34.8	13.0	26.5
1.0	2.5	3.1	no	no	no	no	no	no	no	no
1.0	3.1	7.6	no	no	no	no	no	no	no	no
2.4	6.0	71.0	yes	yes	yes	yes	yes	yes	yes	yes
2.4	7.4	71.0	yes	yes	yes	yes	yes	yes	yes	yes

WER	Chronic SSO	AMEL	Tesoro Refinery		Conoco Phillips		Morton Permit	
			MEC	99.87%	MEC	99.87%	MEC	99.87%
			20.0	18.8	20.0	34.4	30.5	200.0
1.0	2.5	3.1	no	no	no	no	no	no
1.0	3.1	7.6	no	no	no	no	no	no
2.4	6.0	71.0	yes	yes	yes	yes	yes	no
2.4	7.4	71.0	yes	yes	yes	yes	yes	no

no = could <u>not</u> comply with AMEL
yes = could comply with AMEL

Region 2

WER	Chronic SSO	AMEL	Central Marin		CCCSD		Chevr Refinery		Pinole-Hercules	
			MEC	99.87%	MEC	99.87%	MEC	99.87%	MEC	99.87%
			4.5	6.2	11.0	15.9	15.0	19.3	9.0	15.1
1.0	2.5	5.4	yes	no	no	no	no	no	no	no
1.0	3.1	11.0	yes	yes	yes	no	no	no	yes	no
2.4	6.0	85.0	yes	yes	yes	yes	yes	yes	yes	yes
2.4	7.4	87.0	yes	yes	yes	yes	yes	yes	yes	yes

WER	Chronic SSO	AMEL	Rodeo Sanitary		Rhodia Chem		Vallejo San & Flood	
			MEC	99.87%	MEC	99.87%	MEC	99.87%
			5.0	32.8	22.0	80.4	11.8	13.2
1.0	2.5	5.4	yes	no	no	no	no	no
1.0	3.1	11.0	yes	no	no	no	no	no
2.4	6.0	85.0	yes	yes	yes	yes	yes	yes
2.4	7.4	87.0	yes	yes	yes	yes	yes	yes

no = could <u>not</u> comply with AMEL
yes = could comply with AMEL

Region 3

WER	Chronic SSO	AMEL	Burlingame		DSRSD		EBMUD		EBDA	
			MEC	99.87%	MEC	99.87%	MEC	99.87%	MEC	99.87%
			38.0	33.1	80.0	121.4	25.9	35.8	50.0	50.9
1.0	2.5	7.4	no	no	no	no	no	no	no	no
1.0	3.1	12.0	no	no	no	no	no	no	no	no
2.4	6.0	38.0	yes	yes	no	no	yes	yes	no	no
2.4	7.4	50.0	yes	yes	no	no	yes	yes	yes	no

WER	Chronic SSO	AMEL	Millbrae		North San Mateo		Pacifica		SF Oceanside	
			MEC	99.87%	MEC	99.87%	MEC	99.87%	MEC	99.87%
			14.0	18.2	100.0	157.0	9.3	13.4	23.9	38.1
1.0	2.5	7.4	no	no	no	no	no	no	no	no
1.0	3.1	12.0	no	no	no	no	yes	no	no	no
2.4	6.0	38.0	yes	yes	no	no	yes	yes	yes	no
2.4	7.4	50.0	yes	yes	no	no	yes	yes	yes	yes

WER	Chronic SSO	AMEL	SF Southeast		SF Bayside		Sausalito-Marin		San Mateo City	
			MEC	99.87%	MEC	99.87%	MEC	99.87%	MEC	99.87%
			23.8	33.2	64.3	159.3	16.0	18.3	14.0	14.7
1.0	2.5	7.4	no	no	no	no	no	no	no	no
1.0	3.1	12.0	no	no	no	no	no	no	no	no
2.4	6.0	38.0	yes	yes	no	no	yes	yes	yes	yes
2.4	7.4	50.0	yes	yes	no	no	yes	yes	yes	yes

WER	Chronic SSO	AMEL	SFO, WQCP		SFO, Industrial		SASM		Tiburon	
			MEC	99.87%	MEC	99.87%	MEC	99.87%	MEC	99.87%
			14.8	32.8	24.5	255.0	24.0	31.1	30.0	72.8
1.0	2.5	7.4	no	no	no	no	no	no	no	no
1.0	3.1	12.0	no	no	no	no	no	no	no	no
2.4	6.0	38.0	yes	yes	yes	no	yes	yes	yes	no
2.4	7.4	50.0	yes	yes	yes	no	yes	yes	yes	no

WER	Chronic SSO	AMEL	US Navy Tr. Island		West County	
			MEC	99.87%	MEC	99.87%
			23.1	28.1	11.0	15.0
1.0	2.5	7.4	no	no	no	no
1.0	3.1	12.0	no	no	yes	no
2.4	6.0	38.0	yes	yes	yes	yes
2.4	7.4	50.0	yes	yes	yes	yes

no = could <u>not</u> comply with AMEL
yes = could comply with AMEL

Region 4

WER	Chronic SSO	AMEL	S SF & San Bruno	
			MEC	99.87%
			32.7	29.8
1.0	2.5	1.6	no	no
1.0	3.1	2.0	no	no
2.8	7.0	31.0	no	yes
2.8	8.7	42.0	yes	yes

no = could <u>not</u> comply with AMEL
yes = could comply with AMEL

For nickel, the three plants examined do not exhibit compliance problems with effluent limits derived from the existing nickel objectives. However, examination of effluent data for the full suite of NDB dischargers reveals that potential compliance problems would exist for several industrial dischargers. An additional consideration is that many (over 20) municipal and industrial plants have maximum observed effluent concentrations that exceed the current objective of 8.2 μg/L. This creates a reasonable potential determination under the SIP, necessitating effluent limits and pollutant minimization activities. If site-specific nickel objectives based on best available scientific information were adopted, between 7 to 15 of these plants would not have effluent limits and would not have the incumbent pollutant minimization responsibility.

Finally, adoption of the site-specific nickel objective may also avoid unnecessary 303(d) listings for dissolved nickel in San Francisco Bay. With the randomized sampling design that has been adopted by the Regional Monitoring Program, more instances of sampling results that exceed the current nickel objective could occur. Use of the more scientifically defensible site-specific objective would avoid unwarranted listings.

While the selected case study dischargers may be able to comply, review of the complete effluent dataset presented above shows that 4 of 15 industries would not be able to comply, based on the current nickel objective of 8.2 μg/L. It is apparent that industrial NPDES dischargers in particular would be at greater risk of non-compliance for nickel.

6. SIP SECTION 5.2, ITEM (D)

The SIP justification for SSOs to address measures to comply with effluent limits is similar to the justification required by the SIP Section 2.1 for interim effluent limits (i.e. Infeasibility Studies). SIP Section 2.1 requires the discharger to:

a) Document that diligent efforts have been made to quantify pollutant levels in the discharge and sources of the pollutant in the waste stream, and the results of those efforts;
b) Document source control and/or pollution minimization efforts currently underway or completed;

c) Propose schedule for additional or future source control measures, pollution minimization actions, or waste treatment; and
d) Demonstrate that the proposed schedule is as short as practicable.

Each of the three dischargers has completed an Infeasibility Study as part of their most recent permit re-issuances; LGVSD in December 2003, FSSD in July 2003, and EBUMD in June 2001. The Infeasibility Studies included the following analyses: SIP calculated final effluent limits, review of historical plant effluent data, compliance analysis with historical data, review of historical source control and pollution prevention activities, discussion of potential pollution prevention actions based on sources of pollutants and treatment improvements. This SIP SSO justification report uses to the greatest extent possible the large amount of directly pertinent information from these prior Infeasibility Studies.

7. EXISTING TREATMENT AND SOURCE CONTROL MEASURES

The following section presents information on each of the three representative discharger's wastewater treatment plant and reclamation facilities and on their source control and pollution prevention programs. The feasibility and cost of potential additional measures required to achieve compliance are evaluated in the subsequent section.

7.1 Las Gallinas Valley Sanitary District: Existing Wastewater Treatment Plant and Reclamation Facilities

The LGVSD treatment plant provides secondary treatment of wastewater from domestic and commercial sources within the northern area of the City of San Rafael. The District's primarily residential service area has a population of about 30,000. The treatment plant has an average dry weather flow design capacity of 2.92 million gallons per day (MGD). There is no discharge to Miller Creek from June 1 to October 31, as required by the District's permit. All treated effluent is instead stored and reused for pasture and landscape irrigation, and for maintaining water levels in the constructed wetland and marsh areas. The treatment process consists of aerated grit chambers, screen, primary sedimentation clarifier, twin trickling filters and intermediate clarifiers, fixed film reactor, secondary clarifier, deep-bed filters, disinfection with chlorination and dechlorination (dechlorination is not used during the non-discharge season).

The District has and continues to explore possible methods to improve treatment plant performance with the goal of reducing effluent copper, nickel, and other metal concentrations. Most of these efforts are aimed at improving solids removal through the treatment processes. Methods that have been evaluated by the District include chemical addition at the #2 biofilter effluent box, reconfiguration of biofilter recirculation flows to reduce hydraulic loading on the secondary clarifier, and pilot testing of continuously backwashing sand filters. The District's new (November 2002) Plant Superintendent is committed to continued efforts to optimize treatment process efficiency.

The District's Board of Directors has given approval for several capital projects and capital equipment purchases to improve the reliability and efficiency of the LGVSD plant. Several Capital Projects will be completed over the next three years. These include a new biofilter pump station to increase control and flexibility of loading rates, replacement filter media, and a new plant SCADA system. The new SCADA system will enable operators to collect more precise "real time" data and fine tune treatment processes. In addition to WWTP improvements, LGVSD continues to invest significantly in its ongoing infiltration and inflow (I/I) program to reduce peaks wet weather flows to the WWTP.

The District operates a wastewater reclamation project that includes a 20-acre wildlife marsh pond, 40-acres of storage ponds, 200-acres of irrigated pasture and 3-1/2 miles of public trails. In addition, Marin Municipal Water District (MMWD) operates a tertiary filtration water reclamation facility located immediately adjacent to the treatment plant. MMWD treats the District's secondary effluent to produce tertiary disinfected recycled water, which it distributes for a number of uses ranging from landscape irrigation to indoor second plumbing systems. Currently, about 1180 acre-ft/yr (about 48% of the plant's average dry weather flow) is recycled. About 40% of annual recycled water is recycled via the Discharger's pasture irrigation system, and the remaining 60% is recycled via MMWD's recycled water system. The District strives to maximize the length of the non-discharge season beyond the minimum permit requirements when seasonal demands allow.

LGVSD influent and effluent data for total suspended solids (TSS) and biological oxygen demand (BOD) from November 1998 – December 2002 from during the discharge season only (the same time period presented in the Infeasibility Study) are summarized below. These data on conventional pollutant removals are included to address the SIP Section 5.2(3)(c) requirement to demonstrate that the providing reasonable treatment and compliance with technology based limits (TSS, BOD).

The statistical summary of TSS and BOD data below show that the LGVSD plant provides a consistent and above average level of secondary treatment. Long-term average BOD and TSS concentrations were 9.3 and 14.1 mg/L, representing 94% and 91% removals, respectively, well above the 85% removal stipulated in the Federal secondary treatment regulations.

Table 15. LGVSD BOD and TSS Performance

	Effluent BOD (mg/L)	**Effluent TSS** (mg/L)	**Influent BOD** (mg/L)	**Influent TSS** (mg/L)	**% Removal BOD**	**% Removal TSS**
# samples	115	298	113	110	108	90
# NDs	8	0	298	113	110	108
Average	9.3	14.1	188	198	94%	91%
Std. deviation	4.0	7.1	61.2	65.5	4%	5%
95th percentile[1]	17.2	28.0	308	327		
99th percentile[1]	19.6	32.3	346	367		
99.7th percentile[1]	21.3	35.3	372	395		
Geo. mean	8.5	12.4	178	188	94%	91%
Geo. std. dev	1.56	1.70	1.44	1.39		
95th percentile[2]	20.4	35.0	364	361		
99th percentile[2]	26.8	48.6	456	442		
99.7th percentile[2]	32.4	60.8	533	509		
Maximum	21	54	380	530		

7.1.1 Source Control and Pollution Prevention

LGVSD is not required to institute a Pretreatment Program because the average dry weather flow is less than 5 MGD, and because there are no categorical dischargers or dischargers generating greater than 25,000 gallons per day. Nonetheless, the District, beginning in 1993/94, developed a strong pollution prevention (P2) program regulating targeted commercial facilities, educating the public and coordinating with other local and regional programs. Copper control has been a primary focus.

Since June 1994, the District has had an agreement with the Central Marin Sanitation Agency (CMSA) for pollution prevention services to help implement the District's pollution prevention program. District staff, working with CMSA staff, participate in public education activities at local events. District and CMSA staff have developed and purchased a display board and several promotional items for use at these events. The District coordinates its pollution prevention program with activities of other agencies and organizations including School Environmental Education Docents (SEED) a non-profit, grassroots, volunteer program dedicated to youth environmental awareness and stewardship, CMSA, North Bay Watershed Association (NBWA), San Francisco Bay Area Pollution Prevention Program, MCSTOPPP and MMWD.

The District's commercial facility program includes inspecting and permitting automotive facilities, and inspecting printers, photo-processors, dentists and medical facilities. The District has also expanded its program to contact laboratories, facilities with cooling towers and dry cleaners.

The District's P2 Program address potential sources of copper primarily through regulation of automotive facilities (most of which are now zero-discharge) and of printers. The Program's general P2 and public outreach activities (such as discouraging use of copper-based root killers) may also result in reductions in copper loading. It is worth noting that the Marin Municipal Water District's (MMWD's) use of zinc orthophosphate as a water supply corrosion inhibitor (a practice which the District opposes) is driven by MMWD's need to comply with the Lead and Copper rule. MMWD has made the point that any reduction in corrosion control effectiveness, which it believes would occur if it were to switch to a non-zinc based inhibitor, could result in an increase in copper loadings to the treatment plant.

Specific activities related to copper and nickel pollution prevention include: distributing information on alternatives to copper sulfate root killer; distributed BAPPG's copper sulfate root killer brochure to plumbers, distributed letter to local retailers and plumbers about the ban of copper-based root killer and more effective options for root control, conduct quarterly sanitary sewer line sampling at residential and commercial areas, working with automotive facilities to make them all zero discharge except car wash and steam cleaning facilities, and inspecting and sampling car wash and steam cleaning facilities.

The District maintains an active Pollution Prevention Program, which seeks to leverage its efforts by partnering with other agencies and organizations. The resources committed to public outreach, and in particular to the elementary school education program are quite significant for a discharger of its size. The District is committed to continuing these efforts in the future. Although P2 programs can potentially reduce the levels of toxics in the overall environment, there are chemical and physical limitations on how low the reductions will translate to in the effluent. In terms of immediate compliance, source control would provide no possibility of achieving short-term compliance with the projected effluent limits. As a result, it must be judged that additional source control activities do not provide a feasible solution for immediate compliance with projected limits.

7.2 Fairfield-Suisun Sewer District

The Fairfield-Suisun Wastewater Treatment Plant provides tertiary level treatment of wastewater from domestic, commercial and industrial sources within the City of Fairfield, City of Suisun City and, by contract, some unincorporated properties in Solano County. The Discharger's service area currently has a population of approximately 130,000 people (2003).

The Plant has an average dry weather flow design capacity of 17.5 MGD and can treat up to approximately 34.8 MGD during wet weather. The Plant presently treats an annual average flow of 16.1 MGD (2000-2002), with an average dry weather flow of 14.1 MGD (total effluent, 2000-2002). Of the total flow treated, an annual average of 14.4 MGD was discharged, with 1.7 MGD reclaimed for agricultural irrigation.

Approximately 90% of the treated effluent is discharged to the Boynton Slough Outfall. Treated effluent is also discharged intermittently from turnouts located on the Boynton Slough Outfall pipeline to privately owned and managed duck ponds in the Suisun Marsh. The Solano Irrigation District and the Department of Fish and Game determine the frequency and volume of these discharges (primarily based on seasonal rainfall). These duck ponds are waters of the State and United States.

Approximately 10% of the treated effluent is recycled for agricultural irrigation, landscape irrigation, and industrial cooling through the Recycling Outfall, which discharges into irrigation water conveyance and distribution facilities owned and operated by the Solano Irrigation District and the Fairfield-Suisun Sewer District. The discharges of reclaimed water to land are regulated by a separate Order, Water Reclamation Requirements Order No. 91-147, adopted by the Board on October 16, 1991.

7.2.1 Source Control and Pollution Prevention

In addition to its pretreatment program, which regulates 11 industries and 3 groundwater remediation sites, the District has an active pollution prevention program that has been in place since 1992. Currently, the District considers mercury, organophosphate pesticides, perchloroethylene, copper, nickel, lead and zinc to be pollutants of concern. Mercury has the highest priority (A) while pesticides and perchloroethylene are assigned a B priority and the metals are priority C. The District has implemented a variety of activities targeting these pollutants over the years. The activities for copper and nickel are highlighted in **Table 16**.

Table 16. Fairfield-Suisun Pollution Prevention Program Activities

Pollutant of Concern	Source Control Activities
Copper, Nickel	Inspections/ BMPs for vehicles service facilities, metal fabricators, and industry; surface cleaner workshops

Several of the activities listed above have been conducted in cooperation with other local agencies in Vacaville, Vallejo, Fairfield and Suisun City. The District is also an active participant and supporter of several regional groups and programs, including:

- Bay Area Pollution Prevention Group (BAPPG)
- Bay Area Clean Water Agencies (BACWA)
- Bay Area Stormwater Management Agencies Association (BASMAA)
- North Bay Source Control Group
- Napa/ Solano Regional Environmental Public Education Group
- Solano County Environmental Management Local Task Force
- Napa/Solano Air Resource Team

The District has identified copper as a pollutant of concern and has conducted pollution prevention targeting copper sources including corrosion of copper plumbing, root control products, vehicle service facilities, mobile surface cleaners, and metal fabricators. Pollution prevention activities have contributed to a 34% reduction in copper influent levels between 1992 (59 µg/L) and 2000 (39 µg/L). The District has conducted source control for most of the common copper sources so it is not clear how much more reduction may be achieved. The District will review its current copper pollution prevention activities and modify as needed.

7.3 East Bay Municipal Utility District

East Bay Municipal Utility District (EBMUD), Special District No. 1 Water Pollution Control Plant provides secondary treatment of wastewater from domestic, commercial and industrial sources from the cities of Albany, Alameda, Berkeley, Emeryville, Oakland and Piedmont, and from the Stege Sanitary District. EBMUD's service area has a present population of about 636,635.

The wastewater treatment process consists of odor control, grit removal, primary clarification, high purity oxygen activated sludge, secondary clarification, disinfection, dechlorination, and blending of primary and secondary effluent during periods of effluent flows in excess of the secondary treatment capacity. Sludge is currently thickened, anaerobically digested and dewatered before reuse by land application or alternative daily cover in an authorized sanitary landfill. EBMUD discharges treated wastewater through a submerged diffuser adjacent to the San Francisco-Oakland Bay Bridge about 5,664 feet off shore at a depth of 45 feet below mean lower low water. Based on a study conducted by the discharger, the outfall achieves a worst case initial dilution greater than 15:1 and a typical initial dilution of 45:1.

The treatment plant has an average dry weather flow design capacity of 120 million gallons per day (MGD). For wet weather flows, the facility can provide partial secondary treatment up to 325 MGD. Of this, approximately 157 MGD receive primary treatment and up to 168 MGD receive secondary treatment. The plant presently discharges an annual average daily flow of 79.6 MGD.

EBMUD has a separate NPDES permit (Order No. 98-005, NPDES Permit No. CA0038440) to regulate the discharge from its wet weather treatment facilities. These facilities provide for the storage of wet weather sewerage and blending of primary and secondary effluent during wet weather periods when the secondary capacity is exceeded. This Order permits the discharge of overflows from the collection system during rainfall events greater than the 5-year design storm. The U.S. EPA and the Board have classified EBMUD discharge as a major discharge.

In response to the listing of copper and nickel as impairing pollutants for most of the San Francisco Bay, a coalition of dischargers, including EBMUD, believes that additional monitoring data and scientific research may support the de-listing of these two pollutants (in 2002). These dischargers, in conjunction with the Regional Board and through the RMP, are gathering data towards the de-listing.

7.3.1 Source Control and Pollution Prevention

EBMUD has been a leader in Bay area pretreatment and pollution prevention activities since 1974 and has been the recipient of the U.S. EPA National First Place Award as an outstanding pretreatment and pollution prevention program on three separate occasions (1989, 1993 and 1997). A summary of the District's recent source control activities is provided in the *2000 EBMUD Pretreatment and Pollution Prevention Report* dated February 2001.

7.3.1.1 Copper

The District has conducted a number of programs aimed at the identification and reduction of copper sources. The District has developed the following estimates of copper sources as a percentage of total influent loading:

Source Category	% of Influent Loading
Tap Water	58%
Commercial	22%
Other	8%
Human Waste	5%
Industrial	4%
Other Residential	3%
Total	100%

The District has monitored tap water to derive its estimates of water supply contributions of copper. The relatively high contribution from tap water is a result of the relatively corrosive nature of the District's water supply from the Sierra Nevada Mountains. EBMUD's source water is very low in total dissolved solids since it is primarily snowmelt. It is well known that water of this high quality is relatively aggressive and acts as an excellent solvent in an effort to dissolve compounds and become more stable.

The District has also performed sewer system monitoring to quantify copper loadings from residential and commercial sources. Industrial monitoring has been performed under the District's Industrial Pretreatment and Pollution Prevention Program.

7.3.2 Completed or Ongoing Source Control and Pollutant Minimization Measures

The District has implemented the following copper source reduction and pollution minimization actions:

- Water supply corrosion control through pH adjustment (to pH 8.8-9.0) using lime and sodium hydroxide.
- Various activities under the Industrial Categorical Pretreatment Program, including issuing discharge minimization permits to 86 major industrial users, conducting approximately 3,800 discharge monitoring and inspections, and taking enforcement actions.
- Various activities under the Commercial Pollution Prevention Program, including issuance of approximately 1,500 pollution prevention permits to commercial businesses (including potential copper sources such as printing shops, boatyard, auto repair shops, vehicle washing facilities), prohibitions on discharge from specific commercial categories and distribution of a Pollution Prevention Self-audit Checklist.
- Distributed educational information notifying plumbing contractors and hardware stores about the ban on copper sulfate root eradicator.
- Created a "P2 Excellence Award", given annually to industrial and commercial users who have demonstrated consistent compliance and innovative approaches to pollution prevention.
- Developed and implemented a public education program focusing on industrial and commercial entities and the general public since 1988. This outreach program include bill inserts mailing, multi-lingual P2 brochures, public meetings, technical workshops, meetings with trade associations, school program, Earth Day events, Inter-agency referral program, etc.
- Coordinating the pollution prevention activities with the BAPPG, Alameda County Green Business Program and other agencies in the Bay area.

EBMUD estimates that since 1988, the above copper source control activities have resulted in a 35 percent reduction in influent loading to the treatment plant. The estimated reduction in effluent copper load from the EBMUD plant since 1988 has been about 15%.

It must be noted that influent reductions do not necessarily equate to reductions in effluent. Although pollution prevention programs will eliminate the pollutants from the environment, there are chemical and physical limitations on how low the reductions will translate to reductions in effluent concentrations.

8. POTENTIAL MEASURES AND ECONOMIC IMPACTS TO ACHIEVE COMPLIANCE

8.1 Copper

As documented in this report, LGVSD, FSSD, and EBMUD all provide a consistent and high level of wastewater treatment in full compliance with Federal secondary treatment requirements. As documented in their respective Infeasibility Studies, plant operations are already highly optimized and all there are no known plant additional optimization methodologies that would significantly reduce effluent concentrations.

All three facilities also have long-established and well performing source control and pollution prevention programs in place. Potential commercial and industrial copper sources discharging to the collection have long been targeted by these programs and continue to be tracked, inspected, and monitored. There are no known significant additional sources to target that may result in the level of reductions necessary to comply with the potential final limits. Even if there were, at the current influent concentrations, and high level of reductions across the plants, reducing influent concentrations has minimal impact on effluent concentrations (influent versus effluent plots show no minimal to no correlation).

The majority of influent copper is these and most systems is believed to be a function of the relative corrosivity of the potable water supply and corrosion of copper piping and plumbing fixtures. The water purveyors in each of the three dischargers service areas have had corrosion control programs in place for years, as mandated to comply with the Safe Drinking Water Act Lead and Copper Rule.

In a study of Bay Area dischargers, corrosion of copper plumbing was identified as the largest source of copper to wastewater treatment plant influent. For example, the three South Bay POTWs (Palo Alto, San Jose, and Sunnyvale) have estimated that corrosion accounts for 30-58% of the copper loading in their respective influents. Five POTWs attributed reductions in influent or effluent copper levels to reduced corrosivity of the water supply through pH adjustment. Other efforts that were reported to contribute to measurable impacts on influent or effluent copper levels include industrial source control and P2 programs targeting vehicle service facilities and printers. Two POTWs attributed reductions to industrial source control and two POTWs attributed reductions to commercial source control actions.

Recent tests conducted at the LGVSD treatment plant indicate that levels of <u>dissolved</u> copper in the plant effluent are generally above 5 µg/L, which exceeds the all of the calculated AMELs for total copper under different translator assumptions. Therefore, the plant could not consistently meet the AMEL based on the current CTR criteria through further plant optimization or installation of more sophisticated effluent filtration. Even with full treatment capacity effluent filtration, FSSD is unable to comply with the final copper limits. Examination of the effluent copper concentrations for Bay area advanced secondary (i.e. secondary plus filtration) facilities in **Figures 1** and **2** indicates that compliance problems would persist for these facilities. Based on this fact, it is assumed that conventional effluent filtration processes would not be adequate if added at other facilities to achieve compliance. Advanced treatment, such as reverse osmosis, is believed to be the only technology available that would allow facilities to comply with projected copper effluent limits resulting from application of the existing copper objectives.

Reverse Osmosis is a treatment technology that forces effluent through a very fine molecular sieve, under pressure, to remove contaminants. The byproduct of reverse osmosis is concentrated brine that can (depending on its composition) require treatment as a hazardous waste. The estimated cost for reverse osmosis is described below.

Annual treatment cost (i.e. annualized capital costs plus annual operation and maintenance costs) per million gallons per day (MGD) for Reverse Osmosis is based on information contained in *Managing Wastewater in Coastal Environments*, NRC, 1993. In 2004 costs, an estimated annual unit cost of $0.82 million per MGD of design capacity for reverse osmosis treatment will be used in this analysis. For the three plants in question, the current design capacities of those plants are FSSD (17.5 MGD), EBMUD (120 MGD) and LGVSD (<5 MGD). Therefore, the estimated additional annual treatment cost for reverse osmosis treatment at these three facilities is $116 million per year.

The above estimates do <u>not</u> include engineering and project administration costs (capital cost estimates typically include an estimating contingency of 20 percent, a construction contingency of 10 percent, and costs for engineering, legal, environmental and administration of 35 percent), land costs, and RO brine disposal (typically consists of 20 percent of the total treated flow). It is not conceivable that wastewater brine disposal would be allowed through direct discharge to the bay, particularly by a shallow water discharger. Further treatment, concentration, or evaporation of the brine would add considerable extra costs (costs of conveyance or treatment and conveyance of brine to ultimate disposal are potentially of the same magnitude as the base reverse osmosis costs, depending on the vicinity of brine disposal sites) and leave a highly concentrated liquid or crystalline waste product to be disposed of. Energy requirements for reverse osmosis at the magnitude required to attain compliance are extraordinary. For these reasons, reverse osmosis is not believed to be a viable treatment option for attaining compliance.

Based on the above analysis, it is appropriate to pursue development and adoption of one or more SSO for copper for the Bay north of the Dumbarton Bridge. This would provide Bay-wide consistency with the fact that similar SSOs for copper and nickel previously been adopted for the Bay south of the Dumbarton Bridge.

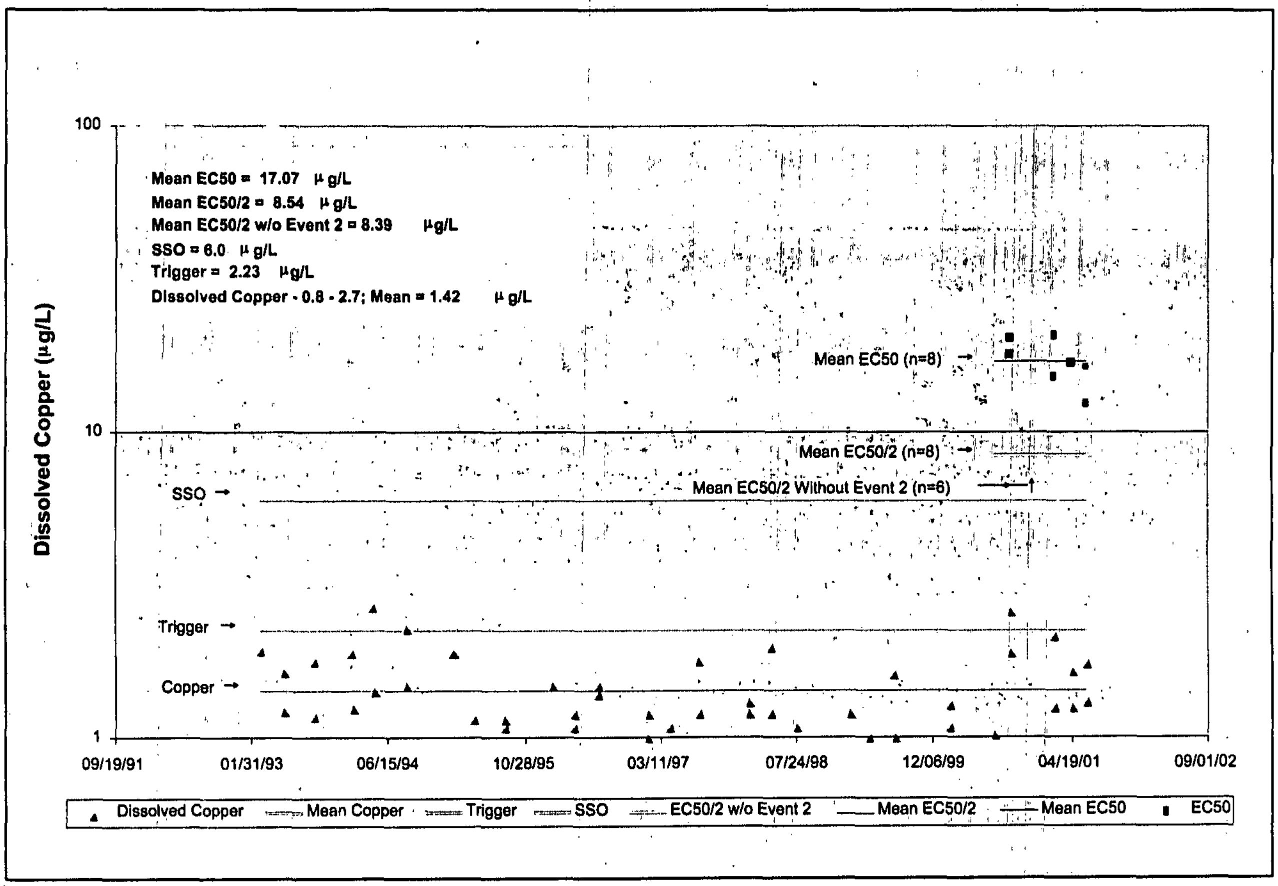
8.2 Nickel

For those dischargers with compliance problems with nickel, the above analysis of costs to achieve compliance would apply. In the case of nickel, industrial dischargers appear to have the greatest potential difficulty with compliance.

9. COORDINATING COMMITTEE MEETINGS

The Copper and Nickel workgroup met several times to discuss the SSOs that would be appropriate for the Bay north of the Dumbarton Bridge (see Appendix E for meeting notes). Discussions were held regarding appropriate segmentation of the Bay and calculations of WERs and translators for these segments. The City of San Jose prepared several slides illustrating the proposed SSOs, existing copper concentrations, potential trigger levels, and copper EC50s (**Figure 11**). **Figure 11** illustrates that the existing copper concentrations in the Bay are well below the SSO. Additionally, this figure indicates how conservative the trigger value is in efforts to assure that the SSO will not be exceeded. Similar figures, and additional information that was presented can be found in Appendix D.

Figure 11. Region 3 Copper Concentrations; Toxicity Values; Potential Trigger, and SSO



Members of the workgroup reviewed and commented on all work products. Their comments on this report have been addressed and are presented in Appendix C.

10. CONCLUSIONS

The above analysis addresses the SIP Section 5.2 requirements that the Regional Board must address in its consideration of site-specific copper and nickel objectives in San Francisco Bay North of Dumbarton Bridge. This analysis illustrates a number of municipal and industrial dischargers operating secondary or advanced secondary treatment plants will suffer compliance problems and unreasonable costs to comply with effluent limits based on existing water quality objectives for copper and nickel in San Francisco Bay. The compliance problems that will occur will not be remedied through source control measures or treatment process optimization. Bay area treatment plants have previously performed source control activities aimed specifically at copper control. The opportunity for additional improvement in influent or effluent levels of copper is therefore very limited. Effluent data and probable effluent limits presented in the above report illustrate the breadth and magnitude of compliance problems.

As a result of the above analysis, and in combination with the findings of the site-specific objectives derivation, it is concluded that action to consider and adopt science-based site-specific copper and nickel saltwater objectives for San Francisco Bay north of the Dumbarton Bridge is warranted and complies with requirements of the SIP and other regulatory requirements.

11. REFERENCES

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Appendix A

SSO-to-POTW Limit Calculations

In the absence of specific guidance and precedents on point of application for deriving translators for a given discharge (i.e. in San Pablo Bay, Miller Creek, overall North Bay), this section presents a range of site-specific translator options for copper and nickel. These were derived from three studies/datasets: 1) the North of Dumbarton Bridge Cu/Ni Study with associated RMP station data, 2) the LGVSD Translator Study Miller Creek data, and 3) RMP San Pablo Bay station (BD20) data. Subsequent FSSD and EBMUD sections contain a more abbreviated discussion of options, focusing on those deemed most probable for use near-term in calculating effluent limits.

The USEPA translator guidance document recommends using a minimum of 8 to 10 pairs of data points (dissolved and total metals) that are representative spatially and temporally (seasonally) of the receiving water to calculate a translator. Each of the three above datasets studies met these criteria and includes data adequate and sufficient to calculate translators.

The *Staff Report on Proposed Site-specific Water Quality Objectives and Water Quality Attainment Strategy for Copper and Nickel for San Francisco Bay South of the Dumbarton Bridge* (RWQCB May 15, 2002, Appendix E) used a pooled data set to calculate copper and nickel translators. In that study, data from two of 12 stations (sloughs) were excluded from the analysis to improve the regression relationship and have the translator better reflect overall conditions in the main (i.e. far field) receiving water.

The July 18, 2003 EOA memo *Cu/Ni North of Dumbarton Bridge – Preliminary Translator Data Analysis Including Both Step 1 and RMP Data* outlined a pooled approach that was consistent with the South Bay Copper/Nickel Study. In that analysis, a range of potential translators was derived using both the simple ratio method and the TSS regression method, and for both individual station and pooled station datasets (all stations, North Bay, Central Bay). The pooled data sets in the North of the Dumbarton Bridge Study showed potentially significant differences between the North and Central Bay groupings of stations versus all stations combined. Differences between ratio and regression based translators were minimal.

LGVSD conducted a site-specific translator study for zinc, copper and nickel as directed in the 1998 permit. The District's *Copper and Nickel Translator Study Update* memo (EOA, March 26, 2003) included individual station and pooled data translators for the Miller Creek sample locations that were from 20 feet downstream from the discharge point to 3,500 feet downstream of the discharge location. The distance from the plant outfall to the San Pablo Bay along the creek is approximately 4,500 feet. At the station located 20 feet downstream from the discharge point E-002 the water depth typically varies from less than one foot at low tide to over five feet at high tide.

The EPA translator guidance document states the "approach to collecting samples <u>beyond</u> the edge of the mixing zone may be especially valuable in estuarine" locations. Therefore, collecting samples located close to the outfall or closely spaced together to capture the exact edge of a mixing zone may not be necessary or appropriate compared to samples collected from locations well beyond the mixing zone. If this latter approach were to be taken, the farthest location downstream (in Miller Creek) or a location in San Pablo Bay would appear to be the most appropriate sampling location(s) from which to calculate a translator.

The table below shows selected translators from the above studies. Translators calculated based on the RMP BD20 data and the North of Dumbarton plus RMP North Bay pooled data are consistent and lower than those based on Miller Creek data. The District's reissued permit (December 2003) used the Miller Creek Special Study three station pooled "downstream locations" (in bold) dataset from which to calculate the acute (90th percentile) and chronic (median) translators used in that permit's reasonable potential analysis and Infeasibility Study.

	Translator	
	Median	90th%
Copper		
N. Dumbarton Bridge Study & RMP Data		
All Stations	0.50	0.83
Central Bay	0.71	0.88
North Bay	0.37	0.67
LGVSD Miller Creek Study		
Downstream Locations	0.56	0.83
All Locations & RMP BD20 Data	0.53	1.0
RMP BD20 data		
San Pablo Bay	0.38	0.66
Nickel		
N. Dumbarton Bridge Study & RMP Data		
All Stations	0.38	0.42
Central Bay	0.60	0.64
North Bay	0.25	0.25
LGVSD Miller Creek Study		
Downstream Locations	0.56	0.82
All Locations & RMP BD20 Data	0.51	1.0
RMP BD20 data		
San Pablo Bay	0.21	0.52

The impact of selection of the above translator values on effluent limits is shown in the tables below.

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MARCH 2005

Clean Estuary Partnership

North of Dumbarton Bridge Copper and Nickel Site-Specific Objectives State Implementation Policy Justification Report

Prepared by:

EOA, Inc.

LARRY WALKER ASSOCIATES

LARRY WALKER ASSOCIATES

Table A-1. From SSO-to-POTW Limit: Las Gallinas Valley Sanitary District (COPPER)

WER	Dissolved SSO (WQO)		Dilution	Translator		ECA		CV = 0.39					Translator Reference Study
				Median	90th %			LTAchronic	LTAacute	Lowest	Monthly Ave	Daily Max	
	Chronic	Acute		Chronic	Acute	Chronic	Acute	mult=0.65	mult=0.45	LTA	AMEL=1.35	MDEL=2.24	
1	2.5	3.9	0	1	1	2.5	3.9	1.6	1.8	1.6	2.2	3.6	Translator = 1
	(2.5)	(3.9)		0.83	0.83	3.0	4.7	2.0	2.1	2.0	2.6	4.4	CTR Default Conversion Factor
				0.56	0.83	4.5	4.7	2.9	2.1	2.1	2.9	4.7	Miller Creek Downstream (NPDES permit value)
				0.38	0.66	6.6	5.9	4.3	2.7	2.7	3.6	6.0	BD20 station from North D.B. Study & RMP
				0.38	0.67	6.6	5.8	4.3	2.6	2.6	3.5	5.9	North D.B. Study N. Bay stations w/RMP data
1	3.1	4.8	0	1	1	3.1	4.8	2.0	2.2	2.0	2.7	4.5	Translator = 1
	(3.1)	(4.8)		0.83	0.83	3.7	5.8	2.4	2.6	2.4	3.3	5.4	CTR Default Conversion Factor
				0.56	0.83	5.5	5.8	3.6	2.6	2.6	3.5	5.8	Miller Creek Downstream (NPDES permit value)
				0.38	0.66	8.2	7.3	5.3	3.3	3.3	4.4	7.3	BD20 station from North D.B. Study & RMP
				0.38	0.67	8.2	7.2	5.3	3.2	3.2	4.4	7.2	North D.B. Study N. Bay stations w/RMP data
2.4	6	9.4	0	0.56	0.83	10.7	11.3	7.0	5.1	5.1	6.9	11.4	Miller Creek Downstream (NPDES permit value)
	(2.5)	(3.9)		0.38	0.66	15.8	14.2	10.3	6.4	6.4	8.6	14.3	BD20 station from North D.B. Study & RMP
				0.38	0.67	15.8	14.0	10.3	6.3	6.3	**8.5**	14.1	North D.B. Study N. Bay stations w/RMP data
2.4	7.4	11.5	0	0.56	0.83	13.3	13.9	8.6	6.2	6.2	8.4	14.0	Miller Creek Downstream (NPDES permit value)
	(3.1)	(4.8)		0.38	0.66	19.6	17.5	12.7	7.9	7.9	10.6	17.6	BD20 station from North D.B. Study & RMP
				0.38	0.67	19.6	17.2	12.7	7.7	7.7	**10.4**	17.3	North D.B. Study N. Bay stations w/RMP data
2.8	7	10.9	0	0.56	0.83	12.5	13.2	8.1	5.9	5.9	8.0	13.3	Miller Creek Downstream (NPDES permit value)
	(2.5)	(3.9)		0.38	0.66	18.4	16.5	12.0	7.4	7.4	10.1	16.7	BD20 station from North D.B. Study & RMP
				0.38	0.67	18.4	16.3	12.0	7.3	7.3	**9.9**	16.4	North D.B. Study N. Bay stations w/RMP data
2.8	8.7	13.4	0	0.56	0.83	15.5	16.2	10.1	7.3	7.3	9.8	16.3	Miller Creek Downstream (NPDES permit value)
	(3.1)	(4.8)		0.38	0.66	22.8	20.4	14.8	9.2	9.2	12.4	20.5	BD20 station from North D.B. Study & RMP
				0.38	0.67	22.8	20.1	14.8	9.0	9.0	**12.2**	20.2	North D.B. Study N. Bay stations w/RMP data

MEC = 25.0 μg/L
GM = 12.0 μg/L
GSD = 1.4 μg/L

Table A-2. From SSO-to-POTW Limit: Las Gallinas Valley Sanitary District (NICKEL)

WER	Dissolved SSO (WQO) Chronic	Dissolved SSO (WQO) Acute	Dilution	Translator Median Chronic	Translator 90th % Acute	ECA Chronic	ECA Acute	CV = 0.25 LTAchronic mult=0.75	LTAacute mult=0.58	Lowest LTA	Monthly Ave AMEL=1.22	Daily Max MDEL=1.72	Translator Reference Study
1	8.2	74	0	1	1	8.2	74.0	6.2	42.9	6.2	7.5	10.6	Translator = 1
				0.99	0.99	8.3	74.7	6.2	43.4	6.2	7.6	10.7	CTR Default Conversion Factor
				0.56	0.82	14.6	90.2	11.0	52.3	11.0	13.4	18.9	Miller Creek Downstream (NPDES permit value)
				0.21	0.52	39.0	142.3	29.3	82.5	29.3	35.7	50.4	BD20 station from North D.B. Study & RMP
				0.27	0.57	30.4	129.8	22.8	75.3	22.8	27.8	39.2	North D.B. Study N. Bay stations w/RMP data
1	11.9	62.4	0	1	1	11.9	62.4	8.9	36.2	8.9	10.9	15.4	Translator = 1
				0.99	0.99	12.0	63.0	9.0	36.6	9.0	11.0	15.5	CTR Default Conversion Factor
				0.56	0.82	21.3	76.1	15.9	44.1	15.9	19.4	27.4	Miller Creek Downstream (NPDES permit value)
				0.21	0.52	56.7	120.0	42.5	69.6	42.5	51.9	73.1	BD20 station from North D.B. Study & RMP
				0.27	0.57	44.1	109.5	33.1	63.5	33.1	**40.3**	56.9	North D.B. Study N. Bay stations w/RMP data
1	16.4	62.4	0	1	1	16.4	62.4	12.3	36.2	12.3	15.0	21.2	Translator = 1
				0.99	0.99	16.6	63.0	12.4	36.6	12.4	15.2	21.4	CTR Default Conversion Factor
				0.56	0.82	29.3	76.1	22.0	44.1	22.0	26.8	37.8	Miller Creek Downstream (NPDES permit value)
				0.21	0.52	78.1	120.0	58.6	69.6	58.6	71.5	100.7	BD20 station from North D.B. Study & RMP
				0.27	0.57	60.7	109.5	45.6	63.5	45.6	**55.6**	78.4	North D.B. Study N. Bay stations w/RMP data
1	20.9	62.4	0	1	1	20.9	62.4	15.7	36.2	15.7	19.1	27.0	Translator = 1
				0.99	0.99	21.1	63.0	15.8	36.6	15.8	19.3	27.2	CTR Default Conversion Factor
				0.56	0.82	37.3	76.1	28.0	44.1	28.0	34.1	48.1	Miller Creek Downstream (NPDES permit value)
				0.21	0.52	99.5	120.0	74.6	69.6	69.6	84.9	119.7	BD20 station from North D.B. Study & RMP
				0.27	0.57	77.4	109.5	58.1	63.5	58.1	**70.8**	99.9	North D.B. Study N. Bay stations w/RMP data

MEC = 8.2 µg/L
GM = 5.4 µg/L
GSD = 1.3 µg/L

Table A-3. From SSO-to-POTW Limit: Fairfield-Suisun Sanitary District (COPPER)

WER	Dissolved SSO (WQO)		Dilution	Translator		ECA		CV = 0.4					Translator Reference Study
				Median	90th %			LTAchronic	LTAacute	Lowest	Monthly Ave	Daily Max	
	Chronic	Acute		Chronic	Acute	Chronic	Acute	mult=0.69	mult=0.5	LTA	AMEL=1.29	MDEL=2.01	
1	2.5 (2.5)	3.9 (3.9)	0	1	1	2.5	3.9	1.7	2.0	1.7	2.2	3.5	Translator = 1
				0.83	0.83	3.0	4.7	2.1	2.3	2.1	2.7	4.2	CTR Default Conversion Factor
				0.46	0.64	5.4	6.1	3.8	3.0	3.0	3.9	6.1	FSSD site specific study (NPDES permit value)
				0.33	0.51	7.6	7.6	5.2	3.8	3.8	4.9	7.7	BF20 station from North D.B. Study & RMP
				0.38	0.67	6.6	5.8	4.5	2.9	2.9	3.8	5.9	North D.B. Study N. Bay stations w/RMP data
1	3.1 (3.1)	4.8 (4.8)	0	1	1	3.1	4.8	2.1	2.4	2.1	2.8	4.3	Translator = 1
				0.83	0.83	3.7	5.8	2.6	2.9	2.6	3.3	5.2	CTR Default Conversion Factor
				0.46	0.64	6.7	7.5	4.7	3.8	3.8	4.8	7.5	FSSD site specific study (NPDES permit value)
				0.33	0.51	9.4	9.4	6.5	4.7	4.7	6.1	9.5	BF20 station from North D.B. Study & RMP
				0.38	0.67	8.2	7.2	5.6	3.6	3.6	4.6	7.2	North D.B. Study N. Bay stations w/RMP data
2.4	6 (2.5)	9.36 (3.9)	0	0.46	0.64	13.0	14.6	9.0	7.3	7.3	9.4	14.7	FSSD site specific study (NPDES permit value)
				0.33	0.51	18.2	18.4	12.5	9.2	9.2	11.8	18.4	BF20 station from North D.B. Study & RMP
				0.38	0.67	15.8	14.0	10.9	7.0	7.0	**9.0**	14.0	North D.B. Study N. Bay stations w/RMP data
2.4	7.4 (3.1)	11.5 (4.8)	0	0.46	0.64	16.2	18.0	11.2	9.0	9.0	11.6	18.1	FSSD site specific study (NPDES permit value)
				0.33	0.51	22.5	22.6	15.6	11.3	11.3	14.6	22.7	BF20 station from North D.B. Study & RMP
				0.38	0.67	19.6	17.2	13.5	8.6	8.6	**11.1**	17.3	North D.B. Study N. Bay stations w/RMP data
2.8	7 (2.5)	10.9 (3.9)	0	0.46	0.64	15.2	17.1	10.5	8.5	8.5	11.0	17.1	FSSD site specific study (NPDES permit value)
				0.33	0.51	21.2	21.4	14.6	10.7	10.7	13.8	21.5	BF20 station from North D.B. Study & RMP
				0.38	0.67	18.4	16.3	12.7	8.1	8.1	**10.5**	16.4	North D.B. Study N. Bay stations w/RMP data
2.8	8.7 (3.1)	13.4 (4.8)	0	0.46	0.64	18.9	21.0	13.0	10.5	10.5	13.5	21.1	FSSD site specific study (NPDES permit value)
				0.33	0.51	26.3	26.4	18.1	13.2	13.2	17.0	26.5	BF20 station from North D.B. Study & RMP
				0.38	0.67	22.8	20.1	15.8	10.0	10.0	**12.9**	20.2	North D.B. Study N. Bay stations w/RMP data

MEC = 9.0 µg/L
GM = 4.2 µg/L
GSD = 1.4 µg/L

Table A-4. From SSO-to-POTW Limit: Fairfield-Suisun Sanitary District (NICKEL)

WER	Dissolved SSO (WQO) Chronic	Dissolved SSO (WQO) Acute	Dilution	Translator Median Chronic	Translator 90th % Acute	ECA Chronic	ECA Acute	CV=0.3 LTAchronic mult=0.75	LTAacute mult=0.58	Lowest LTA	Monthly Ave AMEL=1.22	Daily Max MDEL=1.72	Translator Reference Study
1	8.2	74	0	1	1	8.2	74	6.2	42.9	6.2	7.5	10.6	Translator = 1
				0.99	0.99	8.3	75	6.2	43.4	6.2	7.6	10.7	CTR Default Conversion Factor
				0.51	0.91	16.1	81	12.1	47.2	12.1	14.7	20.7	FSSD site specific study (NPDES permit value)
				0.39	0.19	21.0	389	15.8	225.9	15.8	19.2	27.1	BF20 station from North D.B. Study & RMP
				0.27	0.57	30.4	130	22.8	75.3	22.8	27.8	39.2	North D.B. Study N. Bay stations w/RMP data
1	11.9	62.4	0	1	1	11.9	62	8.9	36.2	8.9	10.9	15.4	Translator = 1
				0.99	0.99	12.0	63	9.0	36.6	9.0	11.0	15.5	CTR Default Conversion Factor
				0.51	0.91	23	69	17.5	39.8	17.5	21.4	30.1	FSSD site specific study (NPDES permit value)
				0.39	0.19	31	328	22.9	190.5	22.9	27.9	39.4	BF20 station from North D.B. Study & RMP
				0.27	0.57	44	109	33.1	63.5	33.1	**40.3**	56.9	North D.B. Study N. Bay stations w/RMP data
1	16.4	62.4	0	1	1	16	62	12.3	36.2	12.3	15.0	21.2	Translator = 1
				0.99	0.99	17	63	12.4	36.6	12.4	15.2	21.4	CTR Default Conversion Factor
				0.51	0.91	32	69	24.1	39.8	24.1	29.4	41.5	FSSD site specific study (NPDES permit value)
				0.39	0.19	42	328	31.5	190.5	31.5	38.5	54.2	BF20 station from North D.B. Study & RMP
				0.27	0.57	61	109	45.6	63.5	45.6	**55.6**	78.4	North D.B. Study N. Bay stations w/RMP data
1	20.9	62.4	0	1	1	21	62	15.7	36.2	15.7	19.1	27.0	Translator = 1
				0.99	0.99	21	63	15.8	36.6	15.8	19.3	27.2	CTR Default Conversion Factor
				0.51	0.91	41	69	30.7	39.8	30.7	37.5	52.9	FSSD site specific study (NPDES permit value)
				0.39	0.19	54	328	40.2	190.5	40.2	49.0	69.1	BF20 station from North D.B. Study & RMP
				0.27	0.57	77	109	58.1	63.5	58.1	**70.8**	99.9	North D.B. Study N. Bay stations w/RMP data

MEC = 6.6 µg/L
GM = 3.7 µg/L
GSD = 1.3 µg/L

Table A-5. From SSO-to-POTW Limit: East Bay Municipal Utility District (COPPER)

WER	Dissolved SSO (WQO)		Dilution (B=3.66)	Translator		ECA		CV=0.5 LTAchronic	LTAacute	Lowest	Monthly Ave	Daily Max	Translator Reference Study
				Median	90th %								
	Chronic	Acute		Chronic	Acute	Chronic	Acute	mult=0.59	mult=0.38	LTA	AMEL=1.44	MDEL=2.64	
1	2.5	4.8	10	1	1	2.5	15	1.5	5.7	1.5	2.1	3.9	Translator = 1
	(2.5)	(3.9)		0.83	0.83	3.0	25	1.8	9.5	1.8	2.6	4.7	CTR Default Conversion Factor
				0.83	0.83	3.0	25	1.8	9.5	1.8	2.6	4.7	CTR Default CF (NPDES permit value)
				0.68	0.81	3.8	26	2.3	10.0	2.3	3.2	6.0	BC10 station from North D.B. Study & RMP
				0.74	0.88	3.4	22	2.0	8.2	2.0	2.9	5.3	North D.B. Study N. Bay stations w/RMP data
1	3.1	4.8	10	1	1	3.1	15	1.8	5.7	1.8	2.6	4.8	Translator = 1
	(3.1)	(4.8)		0.83	0.83	4.4	25	2.6	9.5	2.6	3.7	6.9	CTR Default Conversion Factor
				0.83	0.83	4.4	25	2.6	9.5	2.6	3.7	6.9	CTR Default CF (NPDES permit value)
				0.68	0.81	12.6	26	7.5	10.0	7.5	10.7	19.7	BC10 station from North D.B. Study & RMP
				0.74	0.88	9.0	22	5.3	8.2	5.3	7.6	13.9	North D.B. Study N. Bay stations w/RMP data
2.4	6	9.36	10	0.83	0.83	39	80	23.2	30.3	23.2	33.4	61.3	CTR Default CF (NPDES permit value)
	(2.5)	(3.9)		0.68	0.81	55	83	32.6	31.4	31.4	45.2	82.9	BC10 station from North D.B. Study & RMP
				0.74	0.88	48	73	28.4	27.9	27.9	**40.2**	73.7	North D.B. Study N. Bay stations w/RMP data
2.4	7.4	11.5	10	0.83	0.83	57	106	33.5	40.2	33.5	48.2	88.3	CTR Default CF (NPDES permit value)
	(3.1)	(4.8)		0.68	0.81	76	109	45.1	41.5	41.5	59.8	109.6	BC10 station from North D.B. Study & RMP
				0.74	0.88	68	98	39.9	37.2	37.2	**53.6**	98.3	North D.B. Study N. Bay stations w/RMP data
2.8	7	10.9	10	0.83	0.83	51	99	30.3	37.5	30.3	43.7	80.1	CTR Default CF (NPDES permit value)
	(2.5)	(3.9)		0.68	0.81	70	102	41.3	38.7	38.7	55.7	102.2	BC10 station from North D.B. Study & RMP
				0.74	0.88	62	91	36.4	34.6	34.6	**49.9**	91.4	North D.B. Study N. Bay stations w/RMP data
2.8	8.7	13.4	10	0.83	0.83	72	129	42.3	49.0	42.3	60.9	111.6	CTR Default CF (NPDES permit value)
	(3.1)	(4.8)		0.68	0.81	95	133	55.9	50.5	50.5	72.8	133.4	BC10 station from North D.B. Study & RMP
				0.74	0.88	84.4	120	49.8	45.5	45.5	**65.5**	120.2	North D.B. Study N. Bay stations w/RMP data

Note: When the adjusted SSO is less than the background concentration the chronic ECA was calculated with ECA=adjusted SSO, without dilution.

MEC = 25.9 µg/L
GM = 9.1 µg/L
GSD = 1.6 µg/L

Table A-6. From SSO-to-POTW Limit: East Bay Municipal Utility District (NICKEL)

WER	Dissolved SSO		Dilution (B=3.81)	Translator		ECA		CV=0.33					
				Median	90th %			LTAchronic	LTAacute	Lowest	Monthly Ave	Daily Max	Translator Reference Study
	Chronic	Acute		Chronic	Acute	Chronic	Acute	mult=0.69	mult=0.5	LTA	AMEL=1.29	MDEL=2.01	
1	8.2	74	10	1	1	47.7	706	32.9	353	32.9	42	66	Translator = 1
				0.99	0.99	48.5	713	33.5	357	33.5	43	67	CTR Default Conversion Factor
				0.99	0.99	48.5	713	33.5	357	33.5	43	67	CTR Default CF (NPDES permit value)
				0.58	0.78	107.1	914	73.9	457	73.9	95	149	BC10 station from North D.B. Study & RMP
				0.65	0.85	91.9	836	63.4	418	63.4	82	127	North D.B. Study N. Bay stations w/RMP data
1	11.9	62.4	10	1	1	84.7	590	58.4	295	58.4	75	117	Translator = 1
				0.99	0.99	85.9	596	59.3	298	59.3	76	119	CTR Default Conversion Factor
				0.99	0.99	85.9	596	59.3	298	59.3	76	119	CTR Default CF (NPDES permit value)
				0.58	0.78	171	766	117.9	383	117.9	152	237	BC10 station from North D.B. Study & RMP
				0.65	0.85	149	700	102.7	350	102.7	**132**	206	North D.B. Study N. Bay stations w/RMP data
1	16.4	62.4	10	1	1	130	590	89.5	295	89.5	115	180	Translator = 1
				0.99	0.99	131	596	90.6	298	90.6	117	182	CTR Default Conversion Factor
				0.99	0.99	131	596	90.6	298	90.6	117	182	CTR Default CF (NPDES permit value)
				0.58	0.78	248	766	171.4	383	171.4	221	345	BC10 station from North D.B. Study & RMP
				0.65	0.85	218	700	150.4	350	150.4	**194**	302	North D.B. Study N. Bay stations w/RMP data
1	20.9	62.4	10	1	1	154	590	106.1	295	106.1	137	213	Translator = 1
				0.99	0.99	156	596	107.4	298	107.4	139	216	CTR Default Conversion Factor
				0.99	0.99	156	596	107.4	298	107.4	139	216	CTR Default CF (NPDES permit value)
				0.58	0.78	290	766	200.1	383	200.1	258	402	BC10 station from North D.B. Study & RMP
				0.65	0.85	255	700	176.0	350	176.0	**227**	354	North D.B. Study N. Bay stations w/RMP data

Note: When the adjusted SSO is less than the background concentration the chronic ECA was calculated with ECA=adjusted SSO, without dilution.

MEC = 16.0 µg/L
GM = 6.8 µg/L
GSD = 1.4 µg/L

Appendix B

Influent and Effluent Time Series Plots

Figure B-1. LGVSD Influent and Effluent Time Series for Copper.

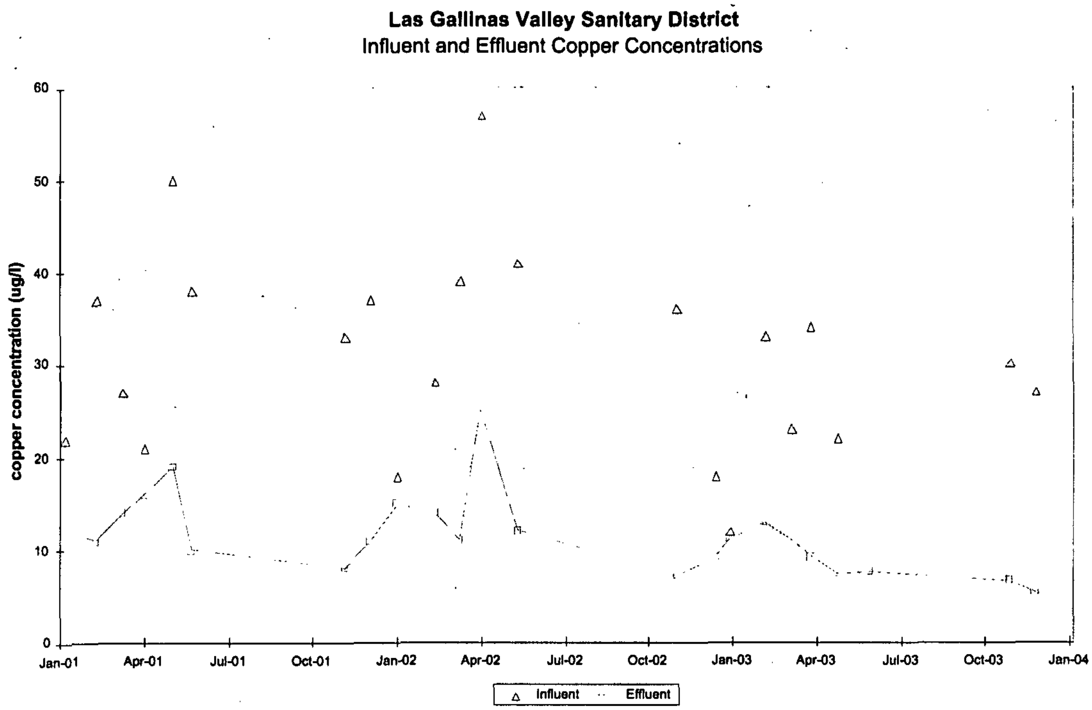


Figure B-2. LGVSD Influent and Effluent Time Series for Nickel.

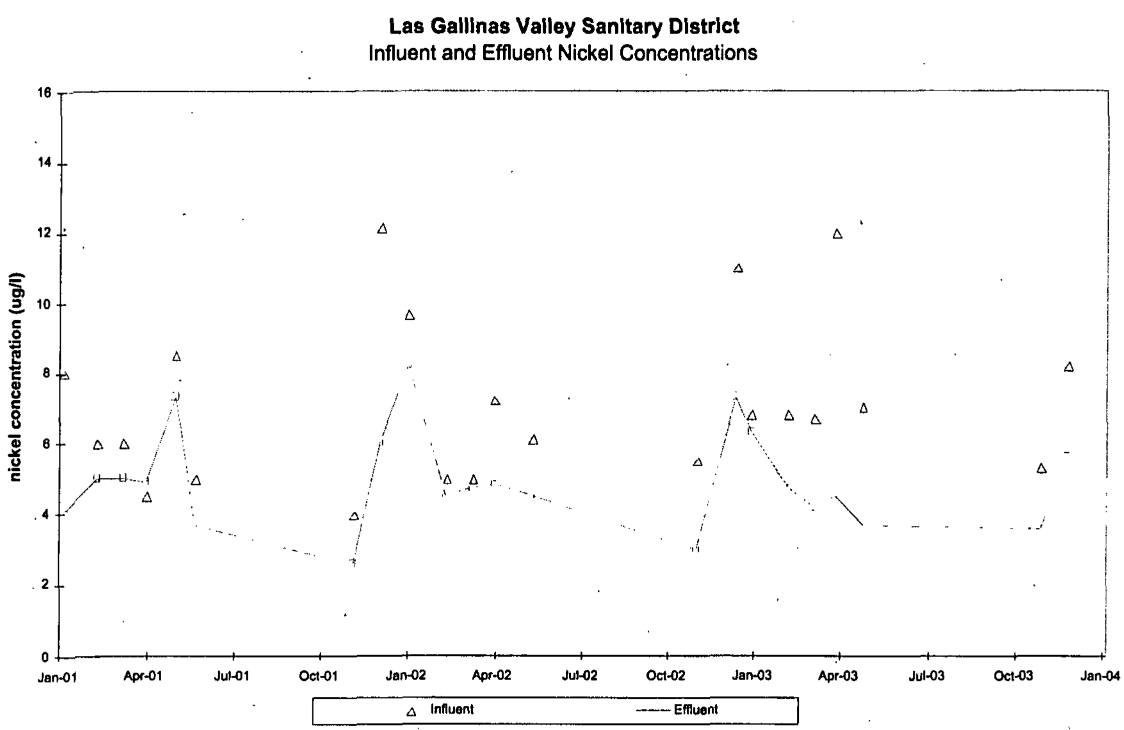


Figure B-3. FSSD Influent and Effluent Time Series for Copper.

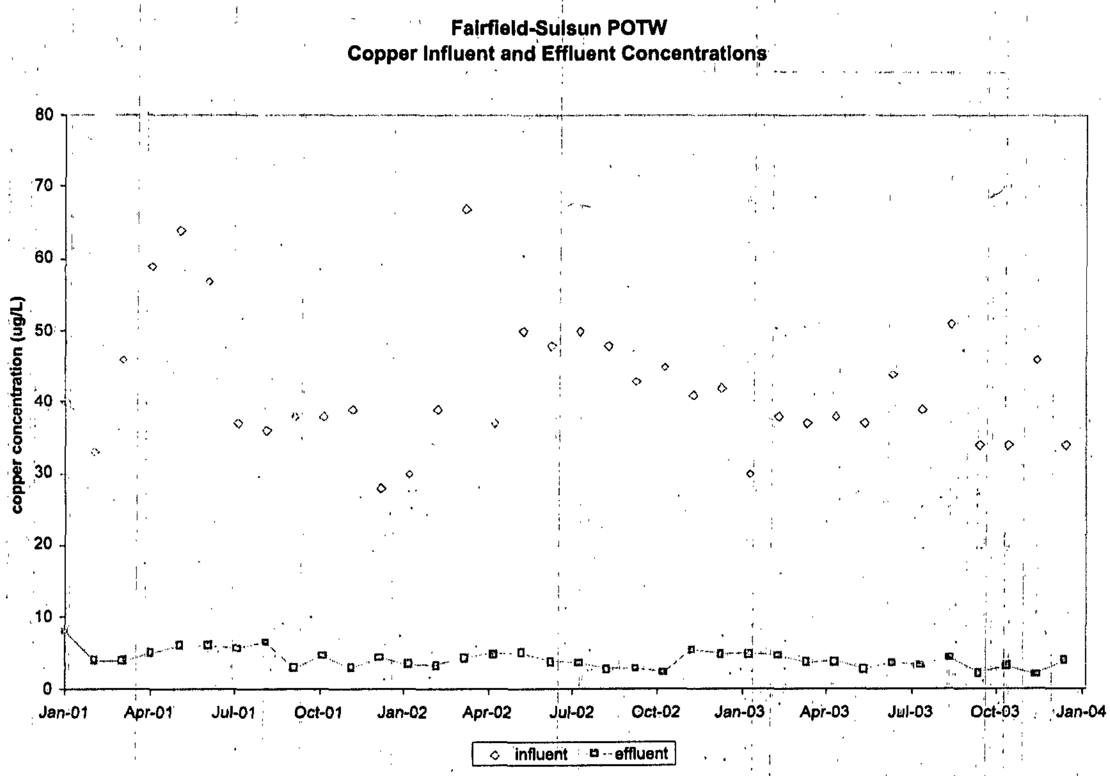


Figure B-4. FSSD Influent and Effluent Time Series for Nickel.

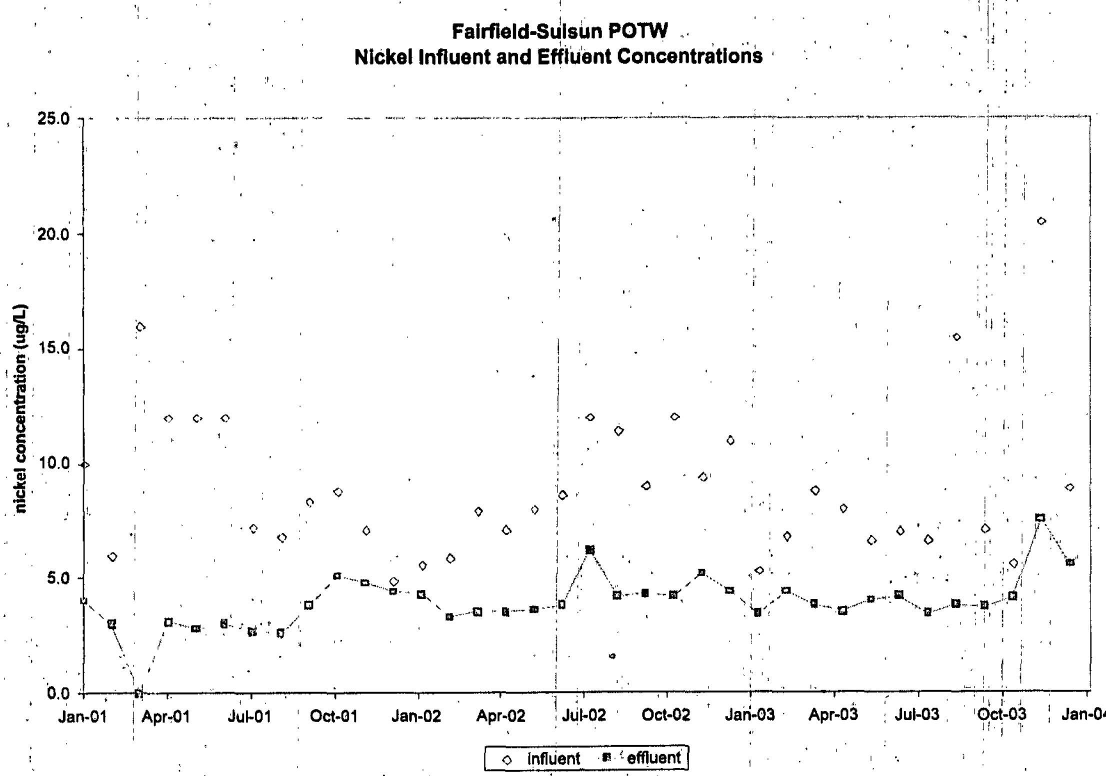


Figure B-5. EBMUD Influent and Effluent Time Series for Copper.

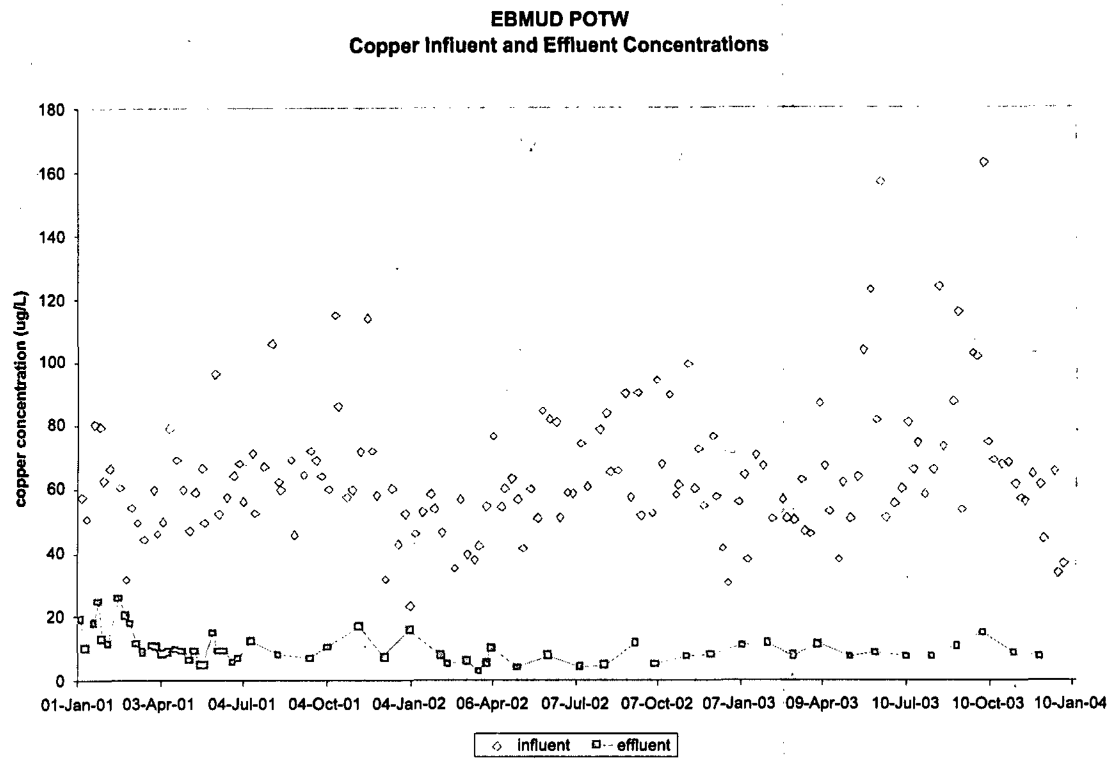
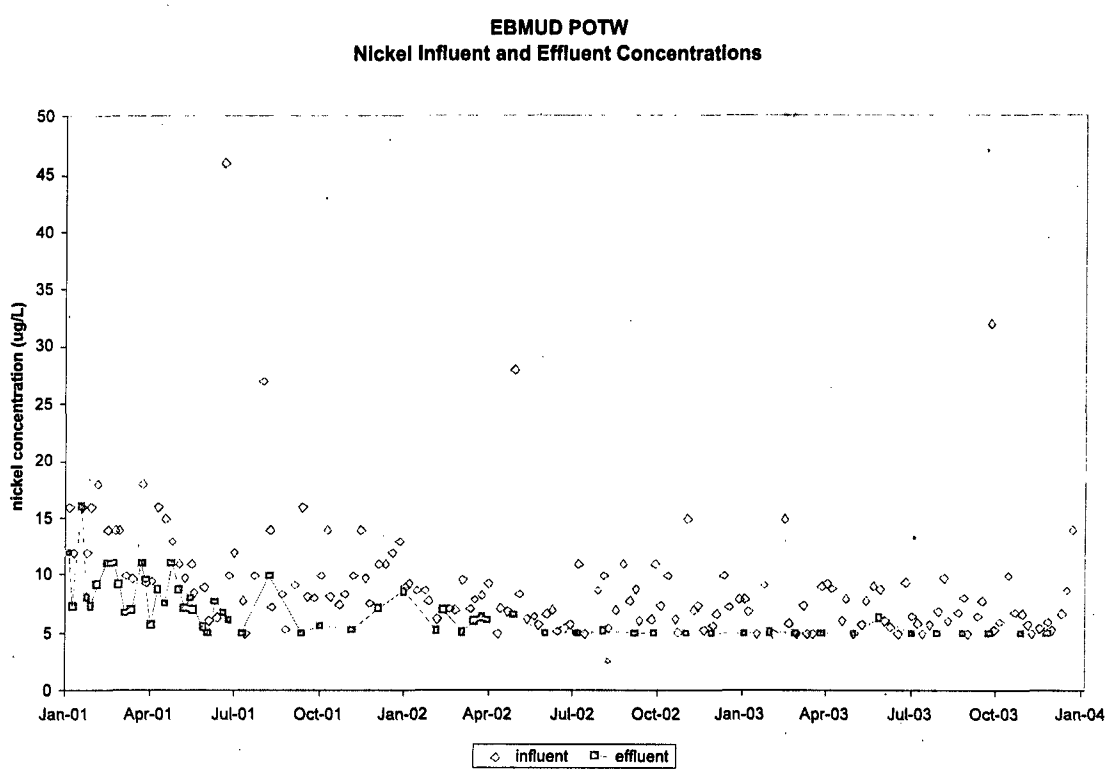


Figure B-6. EBMUD Influent and Effluent Time Series for Nickel.



Appendix C

Response to Comments

Richard Looker's Comments

1) The report is a helpful summary of data. Overall, the document presents a satisfactory (after some concerns are addressed) argument for a copper SSO and a weak argument for a nickel SSO.

Response: *No response necessary.*

2) It is not valid to compare the AMEL to maximum values if there was monitoring more than once per month for certain facilities. When reporting on ability to comply, please use the AMEL compared to monthly means (if they exist) and the MDEL compared to single values. If only one sample per month is available, it is ok to compare it to the AMEL but you should say that it is just one sample.

Response: *There are very few monthly means available. For the majority of the plants, they only sample once per month for metals and compliance therefore this has to be evaluated relative to the AMEL.*

3) The report did not present a convincing argument that the effluent limits could **NOT** be met through reasonable treatment, source control, and pollution prevention measures. I will give specifics later.

Response: *See Attachment C-1 for additional nickel data analysis. Additional supporting information will be developed as part of the follow-up CEP funded copper/nickel 04/05 Basin Plan Amendment assistance project. Information previously submitted to the RWQCB on these topics was reported by reference rather than repetition here. WWTP treatment plant performance data is submitted in monthly and annual Self-Monitoring Reports. Bay area municipal dischargers have been providing a minimum of secondary treatment since at least the early 1980s. TSS is probably the best indicator of secondary treatment plant performance. WWTPs over 5 mgd submit annual and semi-annual Federal Pretreatment Program reports detailing regulation of categorical and significant industrial users. These pretreatment programs have been in place since at least the early to mid-1980s. Source control and pollution prevention programs have been required since 1988 and earlier for shallow water dischargers. Results are required to be reported to the RWQCB in annual reports. (See January 23, 2002 RWQCB Item 13, "Status Report of Pretreatment and Pollution Prevention Programs" for a comprehensive history of these activities).*

4) Page 2: define the box and whisker plots

Response: *Added definition of box & whisker plots upfront.*

5) Page 13: EBMUD does not appear to be a good representative for secondary plants – it seems on the high side.

Response: *The next phase of work on this project will expand the analysis to all plants, beyond the three-plant case study analysis provided for in the scope of work for the FY 03-04 phase of the project that produced this report (CEP 04/05 Basin Plan Amendment assistance project). Representativeness was a qualitative decision taking into account size, service area (urban/industrialized), treatment facilities, discharge location, history of good operations and maintenance (past national awards), extensive pretreatment and pollution prevention programs (received USEPA 2004 first place award for pretreatment), and source water in the service area (mainly potentially corrosive Sierra snowmelt/runoff from Pardee Reservoir). EBMUD also discharges into the Central Bay, different from the San Pablo and*

Suisun Bays that LGVSD and FSSD discharge to. If the comment is referring strictly to the relative nickel concentration, EBMUD's median value is about 6.5 µg/L vs the pooled secondary value of about 4 µg/L. Both are quite low relative to even the unadjusted CTR dissolved WQO of 8.2 µg/L.

6) Page 19: Why did you bring up this issue of the translation of ambient metals here? Did you use this technique here to compute the effluent limits here? You mainly just confused me. What method did you actually use in this report? I guess I need more background on this issue that is contained here.

Response: *It is important to look at ambient total metals concentrations for comparison to total effluent limits when assessing compliance issues (i.e. comparison to MECs), especially for deepwater dischargers who receive dilution credit. SIP protocols for calculating effluent limits were used, which include translation of ambient concentrations. This issue of selection and use of translators is complex in part because of a lack of region-wide policy guidance. Translator decisions are being made on a permit by permit basis. Additional information on how translators were used in this report for calculating effluent limits is provided in Tables A-1 to A-3 of this report and in the separate Translator Derivation Report. An extensive evaluation of alternative methods of using translators relative to deriving background concentrations for effluent limit calculations was prepared by EOA and included as part of the reissuance of the South Bay permits in 2003. A copy is posted on the RWQCB website with each permit as "EOA memo" for the RWQCB August 20, 2003 meeting. To reduce the complexity of this report, discussion of potential compliance with effluent limits under different translator and site-specific objective alternatives for the three case studies was included in the separate SSO derivation report (Tables 11 – 13).*

7) Page 19: Why are the EBMUD EL so low? Do they not get dilution credit? Thought those limits would be higher. Please give an appendix showing the details of the calcs.

Response: *EBMUD does normally receive dilution credit (10:1). However, when ambient (RMP) total copper values are used in the SIP effluent limit calculations with the CTR WQO of 3.1 µg/L, dilution credit is not allowed. This relates in part to the unresolved translator selection and application policy issues discussed in the response immediately above. More details are provided in Table A-3 of Appendix A.*

8) Pages 21-22: last paragraph – not a strong argument for nickel. There is minimal compliance challenge. From what is presented here, there is not enough for me to use to demonstrate that the SSO for nickel is a necessity. The arguments about triggering RPA and avoiding listings are not strong either.

Response: *See Attachment C-1. Additional supporting information will be developed as part of the follow-up CEP funded copper/nickel 04/05 Basin Plan Amendment assistance project.*

9) Pages 22-29: The material here does not add up to addressing "that the discharger cannot be assured of achieving the criterion and/or effluent limitation through reasonable treatment, source control, and pollution prevention measures".

Response: *Additional supporting information will be developed as part of the follow-up CEP funded copper/nickel 04/05 Basin Plan Amendment assistance project, including information regarding plant awards for treatment, source control and/or pollution prevention. Most of this information was obtained from previously submitted, and approved, Infeasibility Studies for the three case study dischargers. At that time, the level of detail provided was deemed sufficient to conclude that the POTWs could not comply* *with CTR based copper limits, and that it was appropriate to include interim performance based limits in each of the three permits.*

10) There are unsupported claims (page 25 for Las Gallinas) that "...additional source control activities do not provide a feasible solution for immediate compliance with projected limits." For FSSD, the report mentions the reductions in copper influent from 1992 and 2000 and then says "it is not clear how much more reduction may be achieved". There is no credible evidence presented that FSSD is doing all reasonable source control. At least for EBMUD, you point out that it is an award-winning facility with respect to P2 so this is tangible evidence that they are doing the reasonable activities.

Response: *This subject will be documented more thoroughly in the next phase of work. (CEP 04/05 Basin Plan Amendment assistance project). Also as noted above, information previously submitted to the RWQCB on these topics was reported by reference (i.e. in annual P2reports) rather than repeated here.*

11) Page 29: You only made the case that Las Gallinas was in full compliance with the Federal secondary requirements. FSSD is a tertiary, and you gave no information regarding EBMUD in this regard. I have nothing on which to evaluate whether they are doing all reasonable treatment.

Response: *This subject will be documented more thoroughly in the next phase of work. (CEP 04/05 Basin Plan Amendment assistance project). Also as noted above, information previously submitted to the RWQCB on these topics was reported by reference (monthly and annual SMRs) rather than repetition here. Effluent TSS/BOD time series data will be compiled as part of the follow-up work to document "reasonable treatment."*

12) Page 29: You refer to low influent metal concentrations for these facilities, but I have no basis of comparison to evaluate this statement. Thus, I cannot evaluate the conclusion that this is evidence of optimum P2/source control programs.

Response: *The reference to low influent concentration has been removed, since this is a subjective statement. Influent metals data are not currently submitted to the ERS so the requested data are more time consuming to compile. Available influent data show that copper in the 40-60 µg/L range is quite common with some areas, such as some that are served Hetch Hetchy potable water, may have influent concentrations closer to 100 µg/L. Influent total nickel values for some facilities are less than the 8.2 µg/L CTR dissolved WQO. The proposed influent/effluent "report card" time series plots will show comparative influent performance information.*

13) Page 29: You say that there is not much relationship between influent and effluent concentrations in the second paragraph from the end. Yet, you imply that the 35% reduction in EBMUD influent copper occurred over the same period of time that a 15% reduction in copper load occurred for that facility. The report also states that FSSD influent copper was reduced 34% over the period 1992 to 2000, but there was not a corresponding statement about impacts to effluent concentrations or loading. The statements seem contradictory.

Response: *There is subsequent reduction in effluent due to reduction in influent, to a point. At some point, continual reduction of the influent does not result in any noticeable reduction in effluent. This topic will be addressed further in the next phase of work where influent and effluent data will be presented (CEP 04/05 Basin Plan Amendment assistance project).*

14) Page 32: The report did not make a strong argument for nickel SSOs. The report did not make the argument that compliance problems could be addressed through source control or treatment process optimization – it just said it without proof. Very little argument was presented that improvement opportunities are limited to reduce influent or effluent levels of copper.

Response: *See Attachment C-1. This subject will be documented more thoroughly in the next phase of work. (CEP 04/05 Basin Plan Amendment assistance project). Also as noted above, information previously submitted to the RWQCB on these topics was reported by reference rather than repetition here.*

15) I think that the case can be made stronger for copper with some more information about influent concentrations.

Response: *This topic will be addressed further in the next phase of work where more influent and effluent data will be presented (CEP 04/05 Basin Plan Amendment assistance project) through the use of plant "Report Cards."*

16) Can you make the case, by showing me longer time series of influent concentrations, that we have reached a plateau and that influent concentrations have been steady for some time AND that those influent concentrations are low compared to some reasonable metric? You say they are low, but how would I know if the statement was true?

Response: *This topic will be addressed further in the next phase of work where influent and effluent data will be presented (CEP 04/05 Basin Plan Amendment assistance project) through the use of plant "Report Cards." Most of the dramatic reductions in influent concentrations referred to occurred during the 1980s, following implementation of the pretreatment and pollution prevention programs at most WWTPs. Influent/effluent plots as will be generated for plants for the last several years or more show them to be in "maintenance" mode, i.e. maintaining consistent WWTP performance and maintaining implementation of pretreatment/P2 programs. Figure 1 of the January 23, 2002 RWQCB status report on Pretreatment and P2 shows that most of the heavy metal loading reduction for the Region occurred between 1986 and 1991. That Figure also shows that loadings have been generally flat from 1992 to 1999 even though flows increased, indicating that some concentration reductions were still occurring.*

17) Can you provide evidence that EBMUD is performing better than it needs to be according to federal secondary guidelines?

Response: *Data has been compiled on effluent TSS/BOD concentrations to show performance relative to the 30/30 mg/L federal secondary treatment limits (see below). The absence of Mandatory Minimum Penalties is also an indicator that the plant has been operating satisfactorily.*

EBMUD BOD Results (mg/L):

Month	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
JAN	23	18	18	18	19	20	19	18	12	14	14	13	15	19	14
FEB	26	22	23	17	20	21	15	32	17	15	17	15	11	13	20
MAR	31	19	21	18	22	20	14	25	10	12	17	14	11	12	13
APR	18	19	21	16	21	16	19	24	11	15	15	13	14	12	15
MAY	16	21	19	15	14	18	17	28	14	13	15	10	10	14	12
JUN	14	22	14	17	17	21	16	27	18	11	11	11	11	10	10
JUL	14	20	14	15	19	21	16	24	14	14	9	12	11	8.6	9
AUG	12	18	13	15	18	23	18	20	14	15	8.0	8.9	10	13	10
SEP	13	22	13	15	20	19	24	24	15	13	11	11	10	14	
OCT	18	17	14	17	17	15	24	14	15	11	12	10	11	13	
NOV	17	16	17	14	17	18	23	17	14	17	11	13	14	11	
DEC	18	18	17	17	15	15	20	13	14	16	13	15	18	14	
AVE	**18.3**	**19.3**	**17.0**	**16.2**	**18.3**	**18.9**	**18.8**	**22.2**	**14.0**	**13.8**	**12.7**	**12.2**	**12.2**	**12.8**	**12.8**

EBMUD TSS Results (mg/L):

Month	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
JAN	21	11	16	21	17	19	18	22	19	13	17	12	18	19	16
FEB	25	15	22	16	24	22	13	19	21	17	20	16	10	12	26
MAR	33	15	20	15	20	17	13	17	13	13	16	14	11	12	14
APR	15	14	17	15	18	18	18	23	14	19	19	13	13	14	14
MAY	17	20	18	16	15	22	17	19	13	11	15	12	9	15	15
JUN	13	15	13	19	17	22	16	22	19	12	12	14	12	14	15
JUL	12	17	12	17	19	22	18	21	21	18	10	15	15	12	13
AUG	9	15	10	16	21	27	17	20	18	19	11	13	12	16	20
SEP	9	18	10	15	21	21	19	22	14	14	10	16	12	20	
OCT	13	14	11	16	19	16	13	11	11	14	12	13	15	13	
NOV	13	13	11	13	19	21	14	20	13	17	11	18	16	17	
DEC	14	17	16	14	15	14	18	14	12	17	13	15	25	16	
AVE	**16.2**	**15.3**	**14.6**	**16.1**	**18.8**	**20.1**	**16.2**	**19.2**	**15.7**	**15.3**	**13.8**	**14.3**	**14.0**	**15.0**	**16.6**

18) Can you provide some evidence that there are no or small possible reductions in effluent concentrations that can be gained through P2/source control or treatment process improvement? You say this, but I did not really see evidence that I can point to when I have to make this argument.

Response: *This topic will be addressed further in the next phase of work where influent and effluent data will be presented (CEP 04/05 Basin Plan Amendment assistance project) through the use of plant "Report Cards."*

19) For nickel, I do not see much here for me to make the case that an SSO is needed.

Response: *See page 31 and Attachment C-1. It appears most appropriate to proceed with a weight of evidence type approach for justifying a nickel SSO rather than simply a compliance necessity approach.*

Andy Gunther's Comments

20) This is a very technical report on a very specific subject, and I just want to verify that it is meant for a very technical audience. The narrative assumes a significant amount of background knowledge on the subject (both in general and specifically regarding certain cited reports), and I had some difficulty following some of the discussion. This is only a problem if it is necessary for neophytes like me to understand everything, which may not be required (for a CMIA report a different standard would apply). I have made some specific suggestions for a little background to help folks like me below. As a CEP document, I would recommend that an executive summary be prepared that provides the problem, the analysis, and the conclusion. I think it could be easily created by quickly editing a cut and paste of a few paragraphs.

Response: *An Executive Summary has been added to the report.*

21) I'd like to see just a bit more overview at the beginning to set the stage. As I understand it, if best available scientific information indicates current standards are overprotective, then we CAN adopt SSOs. But we only NEED to undertake this when not doing so would leave dischargers unable to comply even after taking reasonable measures. Thus, we've prepared this document to show that SSOs are needed? (If I'm wrong here, you get my point in #1!). If I'm right, it would be great to have a simple explanation like that to kick off the analysis.

Response: *Introduction now includes broader overview of the work.*

22) Would attaching as an appendix the executive summary of the previous study that calculates and justifies SSOs that are still protective of the environment be too much trouble? It would have been helpful for me.

Response: *There is a separate companion SSO report to this SIP justification report that describes the range of WER based SSOs that could be justified. The executive summary from the July 2002 WER report that describes the derivation of the WERs will be appended to the SSO report.*

23) P. 1 At the end of paragraph 1, the document referenced should be cited.

Response: *Citation has been added.*

24) P. 2 The "whiskers" on the plots are not explained in the caption. What do the boxes, bars, and dots represent?

Response: *Added definition of box & whisker plots upfront.*

25) P. 3 The rationale for tossing the outlier should be described, and then the outlier should be eliminated from the nickel data that are displayed in Figure 2.

Response: *The text will be changed to read "One point (93 µg/L) shown off scale to expand view of remaining datapoints. The point was not censored, just the graph scale truncated.*

26) P. 12 The statement at the end of paragraph 2 needs more support. What criteria are used to decide that the dischargers are "reasonably representative?" Clearly, there are many secondary plants with higher concentrations in their effluent than the two that were selected.

Response: *Added text to this section to clarify. See earlier responses.*

27) P. 16 It would help to show the equations here...the number of acronyms being generated can be overwhelming for the uninitiated. What "unresolved policy issues" are referred to in the second paragraph? Statements like that leave the reader wondering how fundamental these "issues" are. If I understand it, the issue is what station do we select to represent background? If so, just state why you selected certain stations. The way it's worded now can raise unnecessary alarm.

Response: *Added translator equations, added a glossary of acronyms at the front of the report, and removed reference to "unresolved policy issues."*

28) P. 17-19 From the text, I understand that the bold line of numbers in the tables represent the translator option used facility's last permit? That should be stated in the caption

Response: *Added captions on the appropriate tables.*

29) P. 19 RPA is Reasonable Potential Analysis? This is not defined. In the middle paragraph, the arguments that are used to identify the "most scientifically defensible" method should be included here or an appendix. Especially since the document you cite is labeled "draft." It seems to me that the argument here is for using derived rather than measured values, which seems a bit unusual.

Response: *Added a glossary of acronyms, included methods, and evaluated the appropriate methods. The referenced document was an attachment ("EOA Memo") to the three South Bay POTW permits that were reissued In 2003. See RWQCB website and Board meeting agenda for August 20, 2003 Items 11, 12, and 13. Translators are also addressed in a separate CEP translator derivation report.*

30) P. 21 Since you have three industrial plants that have nickel problems, doesn't this suggest that your three municipal examples do not adequately represent the industrial facilities?

Response: *Evaluation has been edited to include all dischargers (see Attachment C-1). The industrial and municipal facilities performances are more similar than dissimilar. There were collectively only a very small number of elevated nickel effluent values (see page 31).*

31) P. 25 "P2" I assume means Pollution Prevention? This should be defined, as should BAPPG.

Response: *Added a glossary of acronyms.*

32) P. 26 End of second paragraph concludes "regulated by this Order." What order are we talking about? 4th paragraph ends with reference to Table X, which I assume should be Table 14?

Response: *Removed reference to Order and fixed table reference(s).*

33) P. 29 In the second paragraph under the copper subheading, it is stated that the three plants have low copper influent concentrations. As there is no reference provided, it is not possible to determine if this is fact or speculation.

Response: *Removed reference to low influent concentrations to avoid confusion.*

Arleen Feng's Comments

34) It looks like BASMAA is rather peripheral for this document, but in general I agree with Andy that it is hard to follow and gets so focused on analytical "trees" it fails to make its "forest" points more compelling. A few additional comments

Response: *No response necessary.*

35) It would be helpful to if this document defined the list, number and/or categories of NDB dischargers requesting the SSOs, and clarified which subsets of this universe are referenced in various Figures or Tables. Tables 1-3 do not list names in the same sequence, making it hard to compare/peruse although one assumes that the reference to "available data" accounts for some of the differences. If the reader is not really meant to look at the content of these tables, just note their bulk and proceed to the analysis, then consider putting them in an appendix.

Response: *Sorted tables in same sequence (alphabetical) for consistency and created a table identifying secondary plants, advanced secondary plants, and industrial plants.*

36) Historical limits are not mentioned till Page 16; I suggest moving background on WQ objectives and translators to bottom of page 1, and/or at least insert a narrative summary of where this analysis is going before plunging into step 1.

Response: *Moved translator discussion forward to Section 3.*

37) It's hard to follow the text through the thickets of tables. References seem to be missing/incorrect for several figures and/or tables; also inconsistent use of Attachment / Appendix A.

Response: *Clarified references to tables/figures and fixed inconsistencies.*

Attachment C-1. Nickel Evaluation

The Policy for Implementation of Toxics Standards for Inland Surface Waters, Enclosed Bays, and Estuaries of California (State Implementation Policy, SIP) indicates that a site-specific objective may be developed under three conditions. These conditions, as well as how they have been addressed, are discussed below.

(1) A written request for a site-specific study, accompanied by a preliminary commitment to fund the study, subject to development of a workplan, is filed with the RWQCB;

A work plan was prepared in 2000 [Grovhoug, T. and Salvia, S. Work Plan for Copper and Nickel Impairment Assessment to Assist in Preparation of 2002 303(d) List: San Francisco Bay, North of Dumbarton Bridge. August 17, 2000] to provide data which fairly characterized existing ambient water column levels of copper and nickel in San Francisco Bay north of the Dumbarton Bridge. One intended use of this data was the development of site-specific water quality objectives.

(2) Either:

(a) a priority pollutant criterion or objective is not achieved in the receiving water; or

(b) a holder of an NPDES permit demonstrates that they do not, or may not in the future, meet an existing or potential effluent limitation based on the priority pollutant criterion or objective;

An assessment of discharger compliance with effluent limits based on four potential chronic nickel site-specific objectives. These four include the CTR objective of 8.2 µg/L, and potential SSOs of 11.9 µg/L, 16.4 µg/L, or 20.9 µg/L. The table below lists the lowest of these four potential SSOs with which certain discharger's can comply (see Attachment 1 for full analysis tables). For instance, GWF 3rd Street would not be in compliance with the 8.2 µg/L, 11.9 µg/L, 16.4 µg/L SSOs, but can comply with the 20.9 µg/L SSO. Likewise, Hayward, Rhodia, Tesoro and GWF Nichols cannot comply with the 8.2 µg/L objective, but could comply with the 11.9 µg/L SSO.

SHALLOW WATER DISCHARGERS				
Chronic SSO	AMEL	MEC	99.87%	Discharger
20.9	70.8	58.4	43.2	GWF 3rd Street (Site I)

DEEP WATER DISCHARGERS				
Chronic SSO	AMEL	MEC	99.87%	Discharger
11.9	132	93.0	50.8	Hayward
11.9	132	37.0	92.4	Rhodia
11.9	132	87.0	37.2	Tesoro
11.9	132	92.9	43.5	GWF Nichols (Site V)

all units are µg/L
SSO = site-specific objective
AMEL = average monthly effluent limit
MEC = maximum effluent concentration
99.87% = 3 standard deviations about the mean

*(3) A demonstration that the discharger cannot be assured of achieving the criterion or objective and/or effluent limitation through reasonable treatment, source control, and *pollution prevention measures. This demonstration may include, but is not limited to, as determined by the RWQCB:*

> *(a) an analysis of compliance and consistency with all relevant federal and State plans, policies, laws, and regulations;*
> *(b) a thorough review of historical limits and compliance with those limits;*
> *(c) a thorough review of current technology and technology-based limits; and*
> *(d) an economic analysis of compliance with the priority pollutant criterion or objective of concern.*

Based on the assessment above, there are three dischargers who would not have been able to comply in at least one instance with effluent limits based on the CTR nickel objective of 8.2 µg/L, one who could not comply with limits based on an SSO of 16.4 µg/L, and one who could not comply with limits based on an SSO of 20.9 µg/L. Time-series plots are provided below to show trends in effluent concentrations for each plant. Efforts toward addressing reasonable treatment, source control, and pollution prevention measures for each discharger is outside the scope of work performed to date. As additional work toward the Basin Plan amendment progresses, these issues will be addressed.

Discharger	Ave Flow (MGD)	N	# Exceedances of AMEL	99.87% (µg/L)	MEC (µg/L)	Next Max (µg/L)	Ave w/MEC (µg/L)	Ave w/o MEC (µg/L)
GWF 3rd Street	0.043	48	2	43.2	58.4	28.0	16.8	15.9
GWF Nichols	0.047	27	1	43.5	92.9	13.0	12.6	9.6
Rhodia	0.109	10	0	92.4	37.0	32.0	18.5	15.9
Tesoro	4.22	12 2	1	37.2	87.0	32.0	16.0	16.0
EBDA - Hayward	13.07	28	1	50.8	93.0	24.0	12.5	9.6

<u>GWF 3rd Street</u>
There were 2 daily maximum effluent data points (58.4 and 28 µg/L) that exceeded the Shallow Water discharger AMEL of 27.8 µg/L. The average of all effluent data was 16.8 µg/L, well below 27.8 µg/L.

<u>GWF Nichols</u>
There was 1 daily maximum effluent data point (92.9 µg/L) that exceeded the Deep Water discharger AMEL of 82 µg/L. The next highest data point was 13 µg/L. The average of all effluent data was 12.6 µg/L with the 92.9 µg/L value and 9.6 without the 92.9 µg/L.

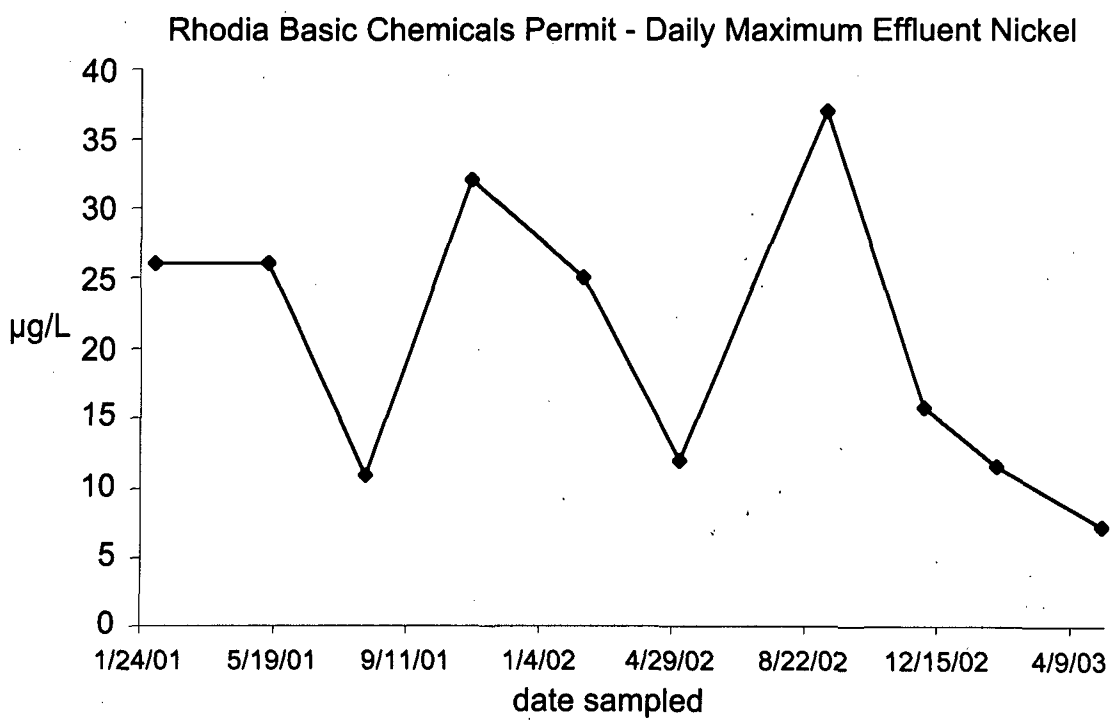
<u>Rhodia</u>
There were no daily maximum effluent data points that exceeded the Deep Water discharger AMEL of 82 µg/L. The 99.87th percentile (92.4 µg/L) exceeded the AMEL of 82 µg/L.

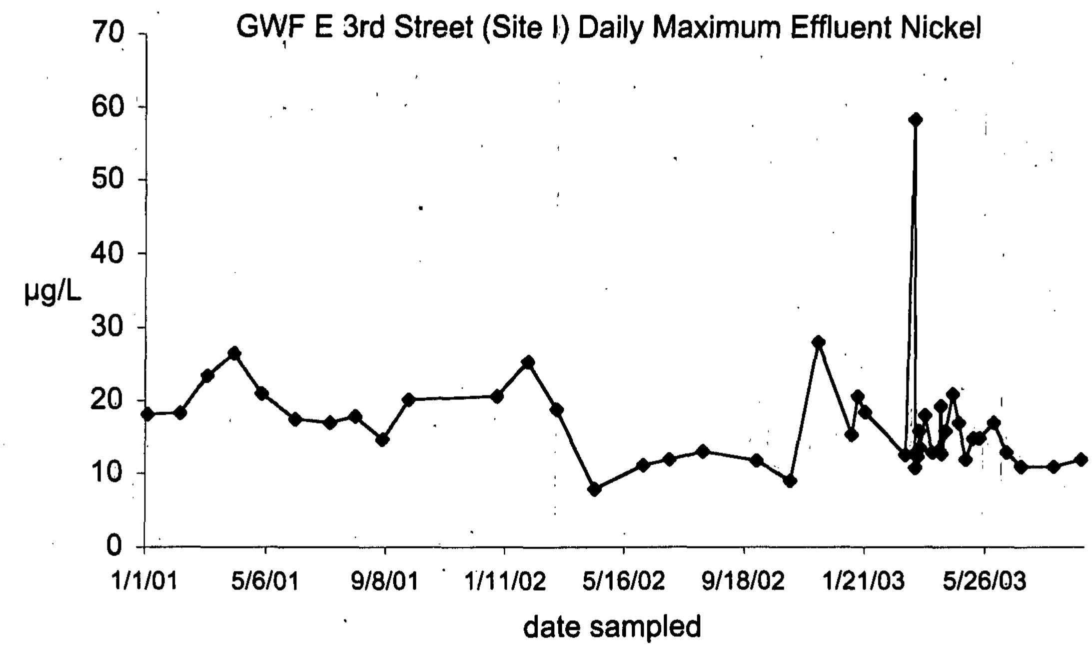
Tesoro

There was 1 daily maximum effluent data point (87 µg/L) that exceeded the Deep Water discharger AMEL of 82 µg/L. The next highest data point was 32 µg/L. The average of all effluent data was 16 µg/L with or without the 87 µg/L value.

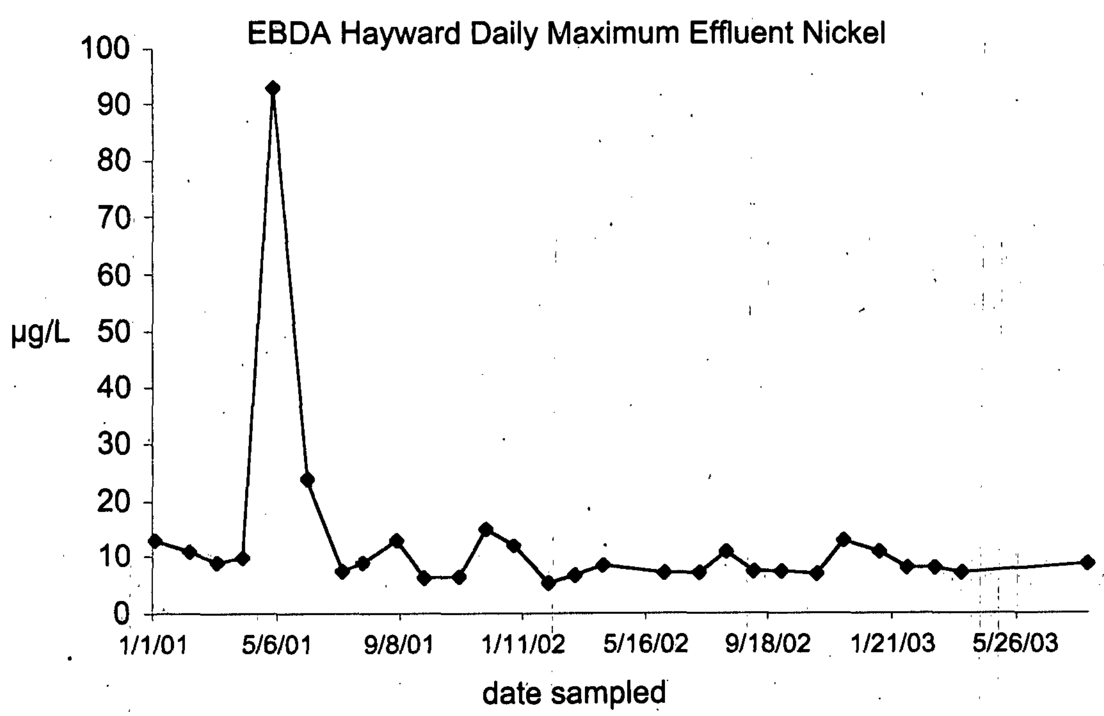
EBDA – Hayward

There was 1 daily maximum effluent data point (93 µg/L) that exceeded the Deep Water discharger AMEL of 82 µg/L. The next highest data point was 24 µg/L. The average of all effluent data was 12.5 µg/L with the 93 µg/L value and 9.6 without the 93 µg/L. However, the compliance point for Hayward is the combined EBDA discharge, and there were no exceedances in the combined flow.

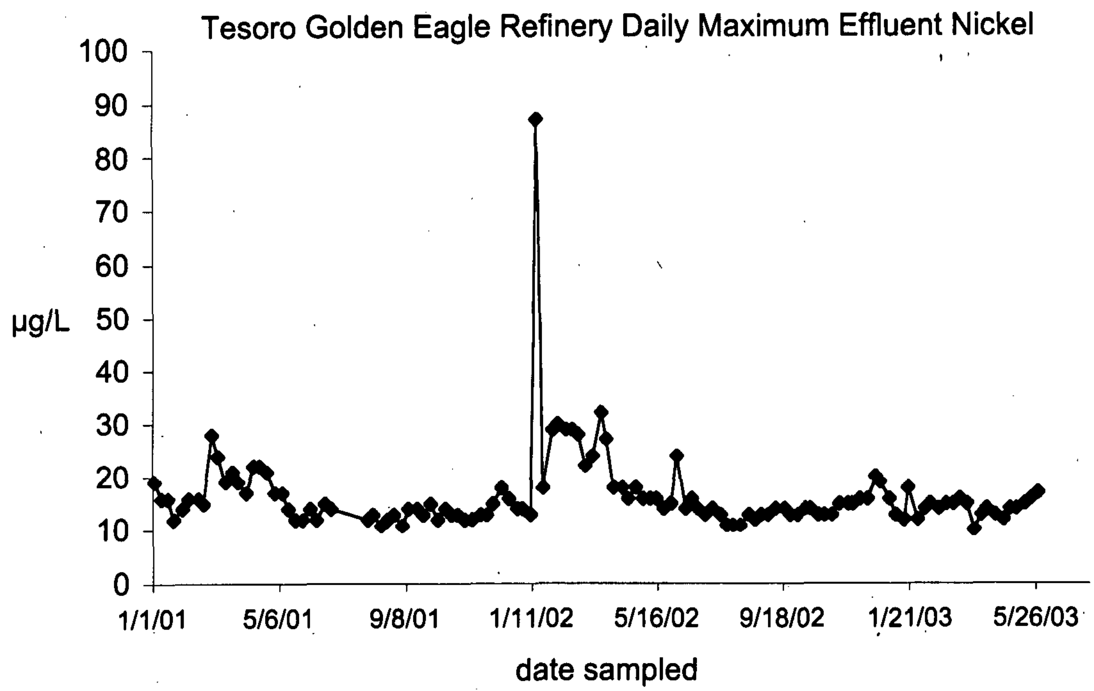


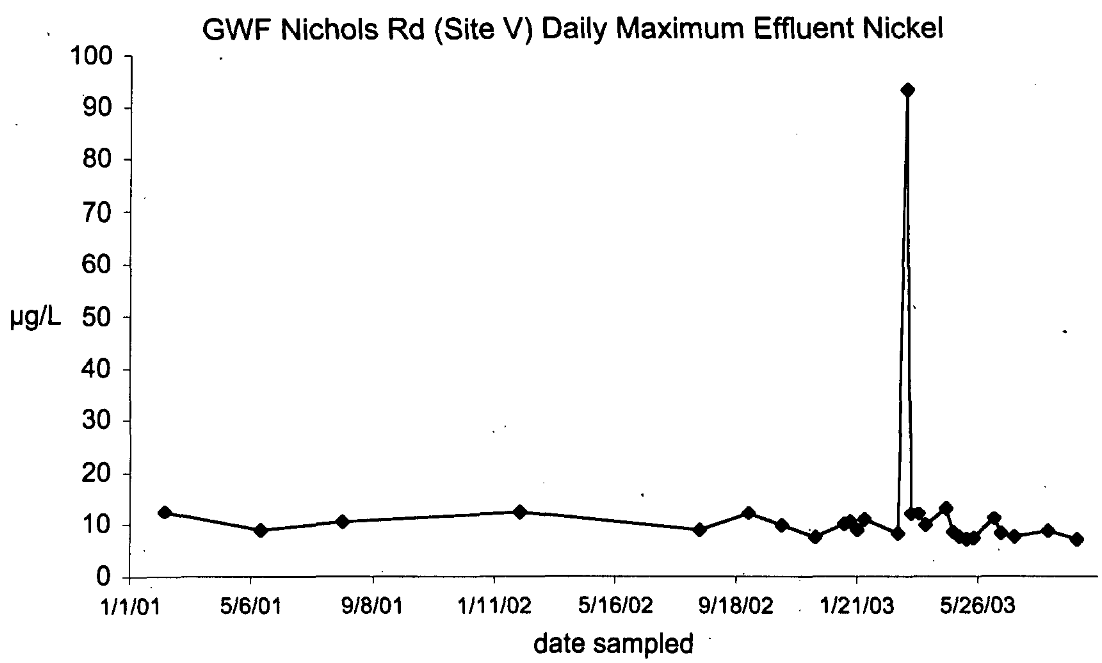


GWF E 3rd Street (Site I) Daily Maximum Effluent Nickel
70
60
50
40
μg/L
30
20
10
0
1/1/01
5/6/01
9/8/01
1/11/02
5/16/02
9/18/02
1/21/03
5/26/03
date sampled



EBDA Hayward Daily Maximum Effluent Nickel
100
90
80
70
60
μg/L
50
40
30
20
10
0
1/1/01
5/6/01
9/8/01
1/11/02
5/16/02
9/18/02
1/21/03
5/26/03
date sampled


Tesoro Golden Eagle Refinery Daily Maximum Effluent Nickel
100
90
80
70
60
µg/L
50
40
30
20
10
0
1/1/01
5/6/01
9/8/01
1/11/02
5/16/02
9/18/02
1/21/03
5/26/03
date sampled


GWF Nichols Rd (Site V) Daily Maximum Effluent Nickel
100
90
80
70
60
µg/L
50
40
30
20
10
0
1/1/01
5/6/01
9/8/01
1/11/02
5/16/02
9/18/02
1/21/03
5/26/03
date sampled

Appendix D

Powerpoint Presentations from June 3, 2004 Workgroup Meeting

Selection of NDB Copper WERs

Use Of The *Mytilus* Embryo Assays to Derive SSOs for San Francisco Bay North of Dumbarton Bridge

Environmental Services Department
City of San Jose
June 3, 2004

Approach to SSO Development NDB

- Indicator Species Procedure
- A biologically-based adjustment to the EPA national copper criterion
- Adjustment accounts for differences between clean laboratory seawater and the specific characteristics of the site water

Water-Effect Ratio Procedure

- Collect: Site Water - presumed to have high binding capacity
  Laboratory Water - "clean" natural seawater with low binding capacity
- Spike with varying amounts of copper
- Inoculate with sensitive embryos
- Determine EC50s

WER & SSO Calculation

- WER = Site Water EC50/Lab Water EC50
- Final WER (FWER) = Geometric mean WER
- SSO = FWER X National Criterion
- $$\text{SSO} = \frac{\text{Site Water EC50}}{\text{Lab Water EC50}} \times \text{Lab Water (National) Criterion}$$

Definition of Terms

- EC50 - 50% effect concentration; acute endpoint
- FAV - Final Acute Value (Regression of 4-most-sensitive genera)
- CMC - Criterion Maximum Concentration (FAV/2) - EPA acute criterion
- ACR - Acute-to-Chronic Ratio (acute endpoint divided by the chronic endpoint of the same material under the same conditions)
- FCV - Final Chronic Value (FAV/ACR)
- CCC - Criterion Continuous Concentration (the lower of the FCV, the Final Plant Value, or the Final Residue Value

EPA Procedure

- Review acute & chronic tests, assemble acute & chronic databases and rank species
- Minimum Data Requirements
  - 8 Families represented in database, etc.
- Derive FAV by Regression method; derive CMC
- Derive ACR - 8 methods listed in the 1995 EPA Saltwater Copper Addendum
- Derive CCC directly or indirectly

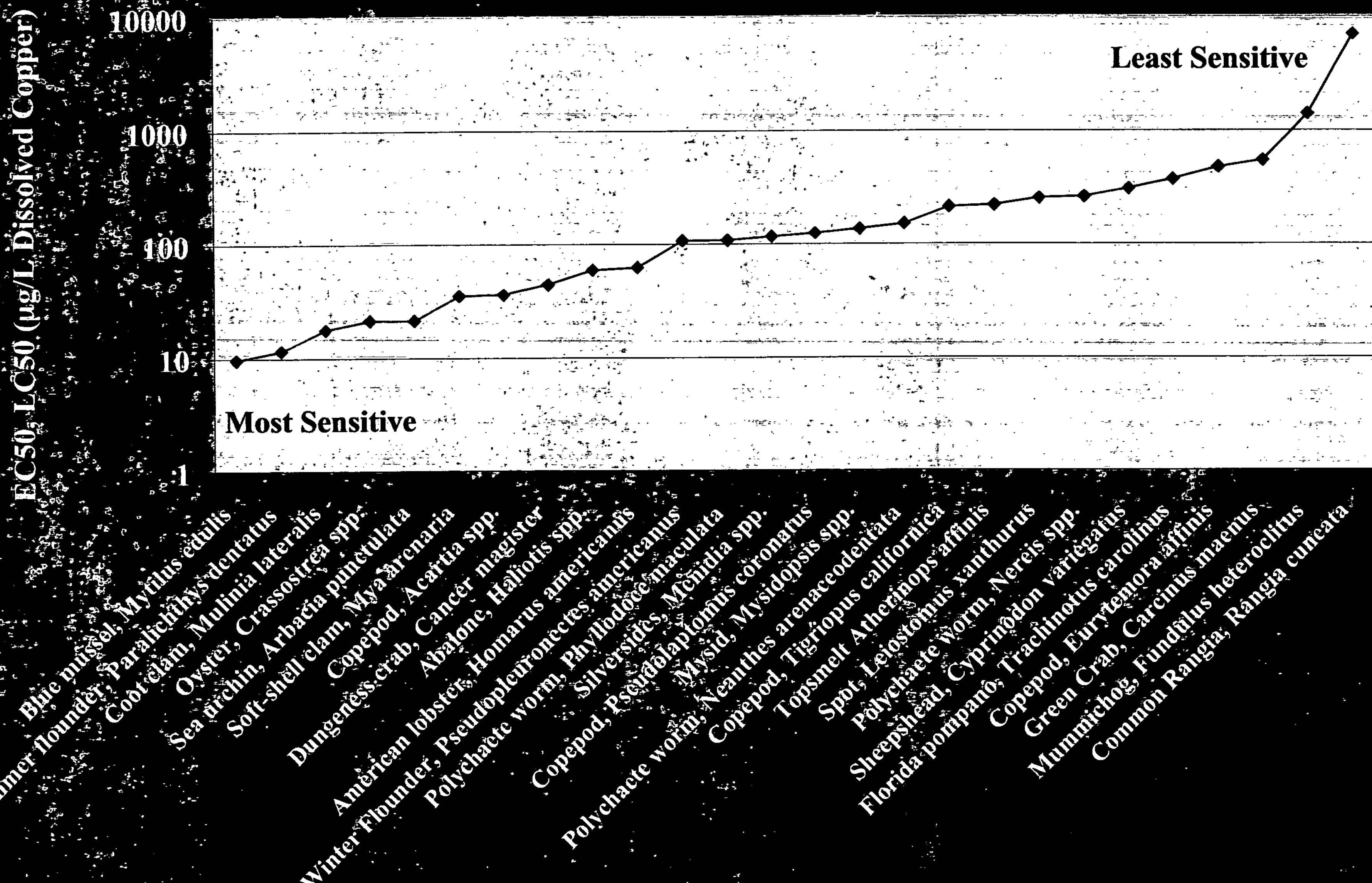
EPA 1995 Saltwater Copper Addendum

ACR Derivation - Method 4

"When acute tests used to derive the FAV are from embryo/larval tests with molluscs, and a limited number of other taxa, it has been considered appropriate to assume that the ACR is 2.0; thus the CMC equals the CCC [e.g., copper (SW), cyanide (SW)]"

The current (CTR) Copper ACR is 3.127

Ranked Genus Mean Acute Values for Saltwater Copper Criteria (From: 1995 Saltwater Copper Addendum)

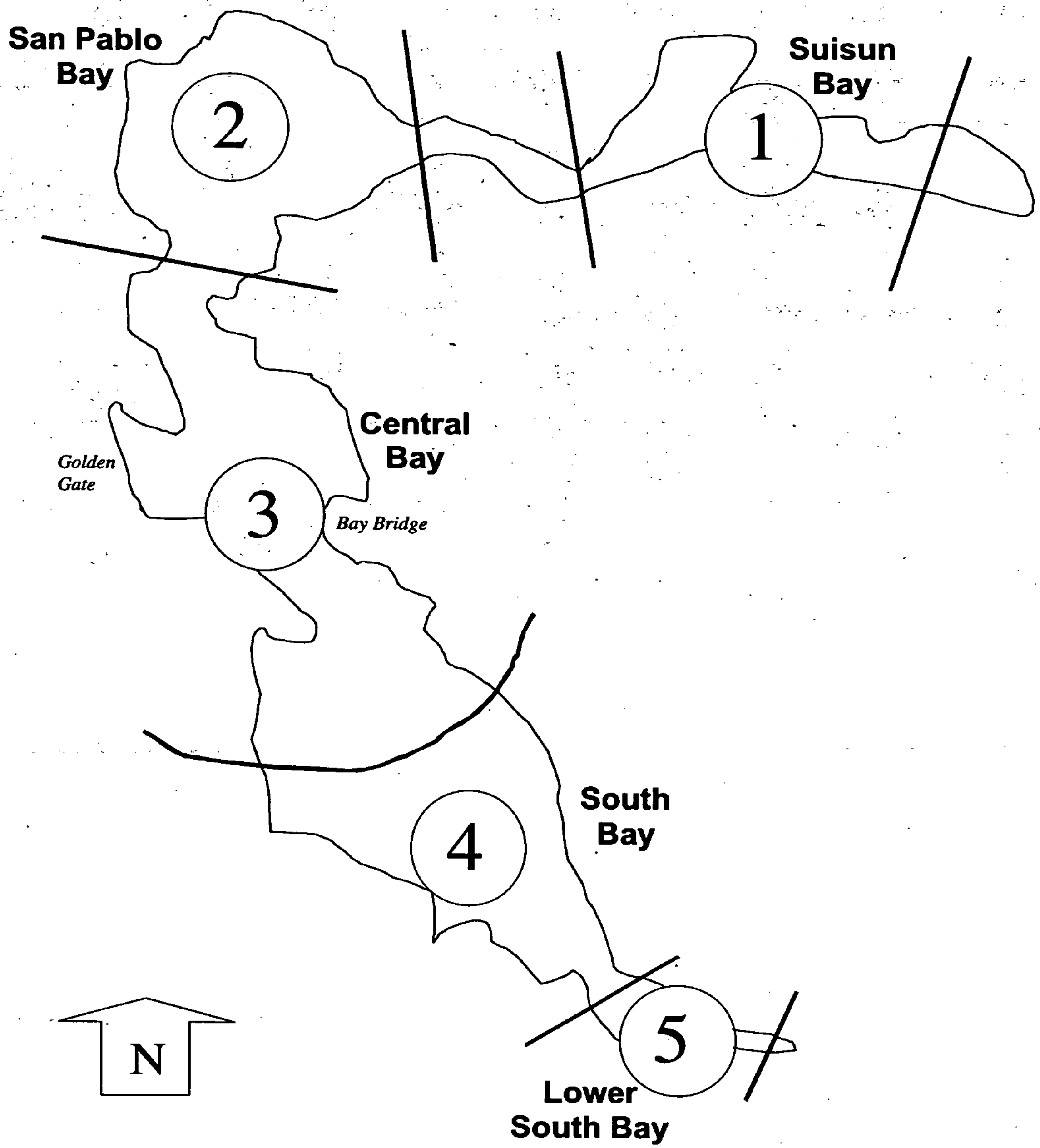


Sensitivity Revisited

- Copper FAV lowered from 10.39 to 9.625 ppb to protect *Mytilus* sp.
- Mytilus embryo/larval development tests conducted on very sensitive life stage
- ACR (3.127) not based on *Mytilus* sp. but on *Daphnia, Gammarus, Physa* & *Mysidopsis* (now *Americamysis*)
- National Criterion modified by current Mytilus Lab Water data from 3.1 to 2.5 ppb

More Definition of Terms

- Power Analysis - Statistical method used to develop an ambient concentration trigger
- Trigger - The smallest increment that can be statistically detected in future sampling given a specific n (number of samples) and a specific variability (variance) in existing data.


San Pablo Bay
2
Suisun Bay
1
Central Bay
Golden Gate
3
Bay Bridge
South Bay
4
5
Lower South Bay
N

Bay Region Mean Water-Effect Ratios

	Region 1	Region 2	Region 3	Region 4	Region 5
Arith. Mean	2.6	2.51	2.48	3.01	2.806
Geo. Mean	2.49	2.40	2.44	2.9	2.771
n	6	20	8	16	40

San Jose Recommendation

- Adopt Ni WER of 2.4 for Bay Regions 1-3
- Adopt Ni SSO of 6.0 for Bay Regions 1-3
  - (2.4 X 2.5 = 6)

- Adopt Ni WER of 2.771 for Bay Region 4
  - (lowered from 2.9 to 2.771)
- Adopt Ni SSO of 6.9 for Bay Region 4

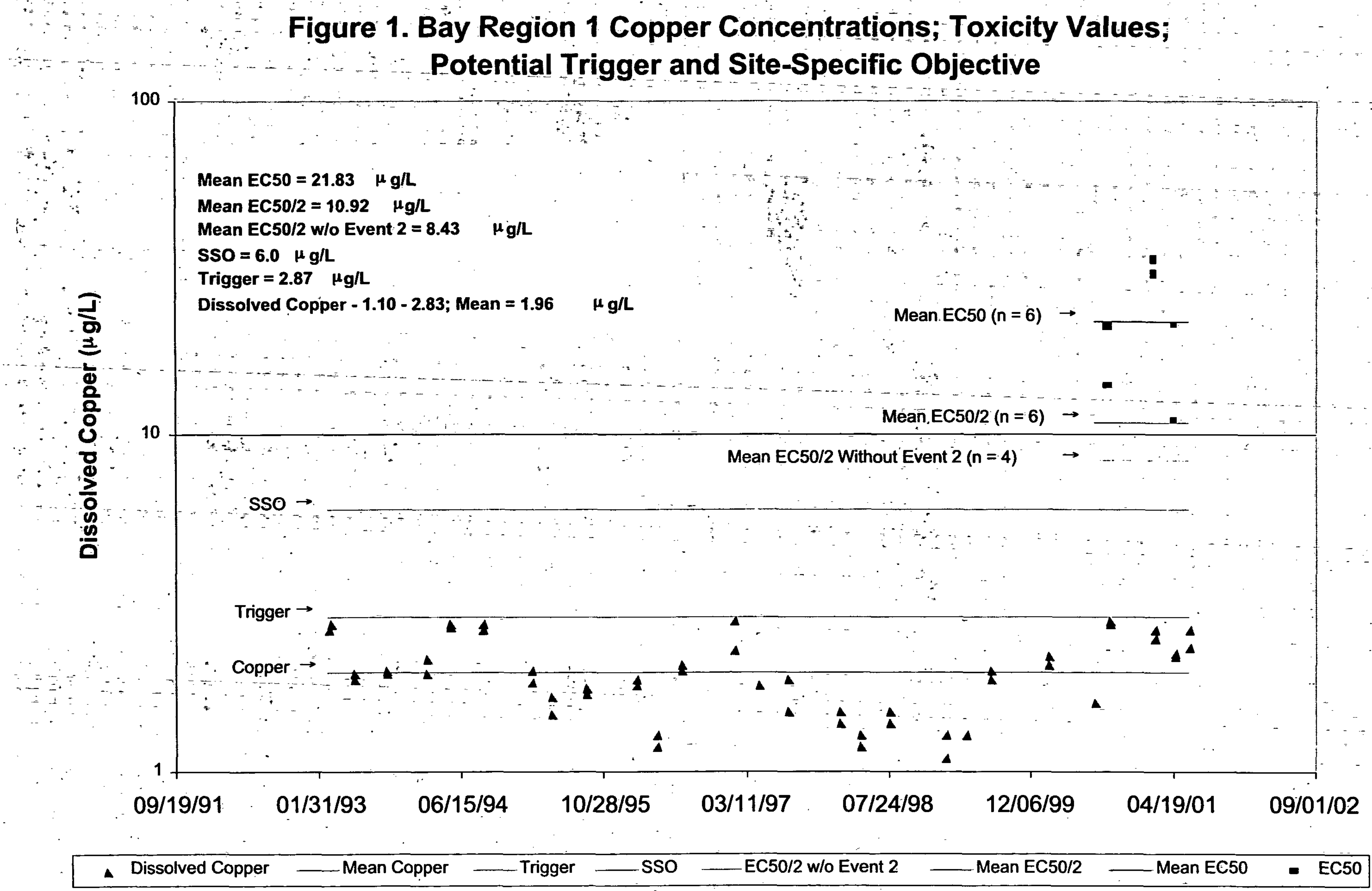


Figure 1. Bay Region 1 Copper Concentrations; Toxicity Values; Potential Trigger and Site-Specific Objective
Mean EC50 = 21.83 µ g/L
Mean EC50/2 = 10.92 µg/L
Mean EC50/2 w/o Event 2 = 8.43 µ g/L
SSO = 6.0 µ g/L
Trigger = 2.87 µg/L
Dissolved Copper - 1.10 - 2.83; Mean = 1.96 µ g/L
Mean EC50 (n = 6)
Mean EC50/2 (n = 6)
Mean EC50/2 Without Event 2 (n = 4)
SSO
Trigger
Copper
Dissolved Copper (µ g/L)
100
10
1
09/19/91
01/31/93
06/15/94
10/28/95
03/11/97
07/24/98
12/06/99
04/19/01
09/01/02
Dissolved Copper
Mean Copper
Trigger
SSO
EC50/2 w/o Event 2
Mean EC50/2
Mean EC50
EC50

Figure 2. Bay Region 2 Copper Concentrations; Toxicity Values; Potential Trigger and Site-Specific Objective

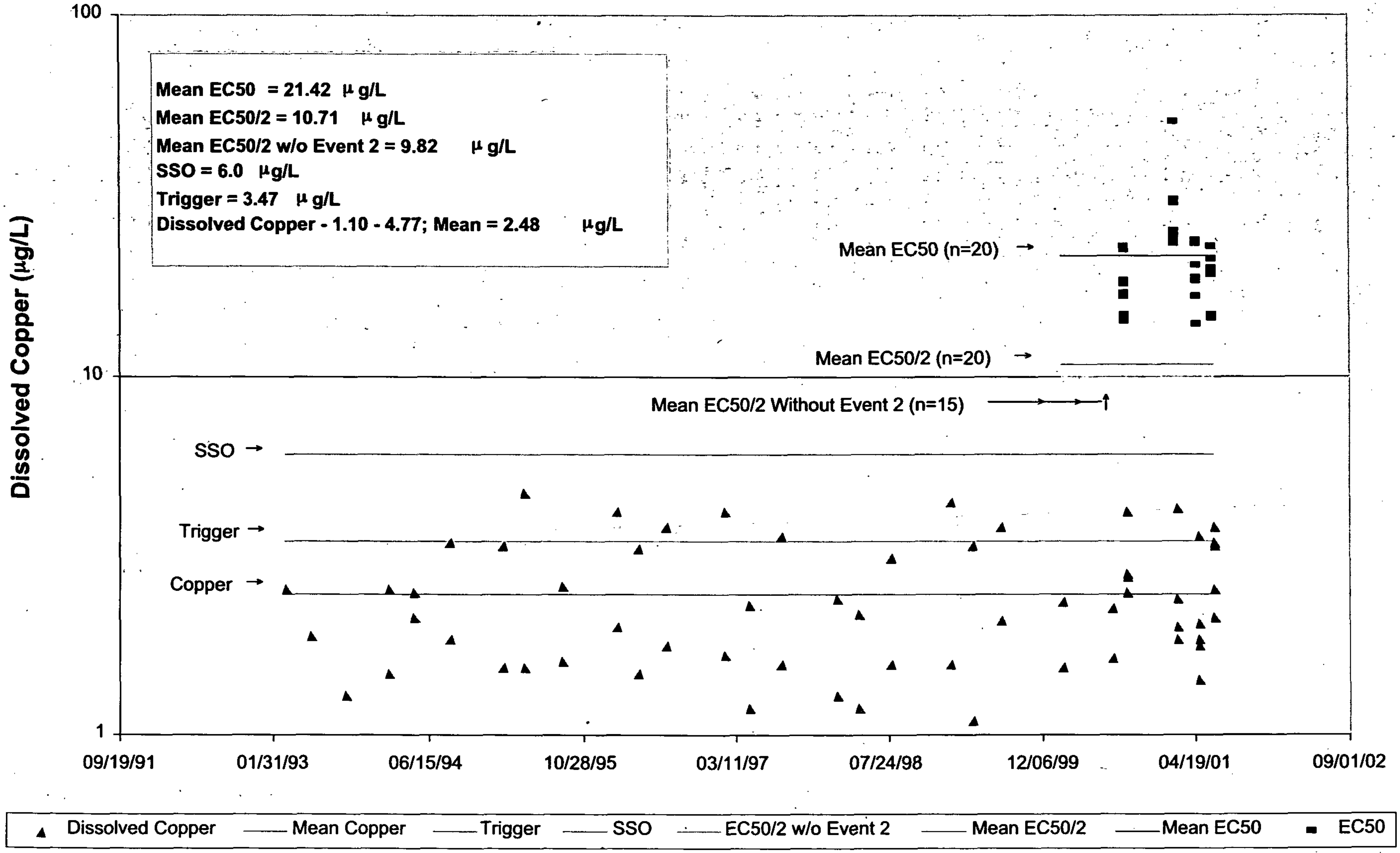


Figure 3. Bay Region 3 Copper Concentrations; Toxicity Values; Potential Trigger and Site-Specific Objective

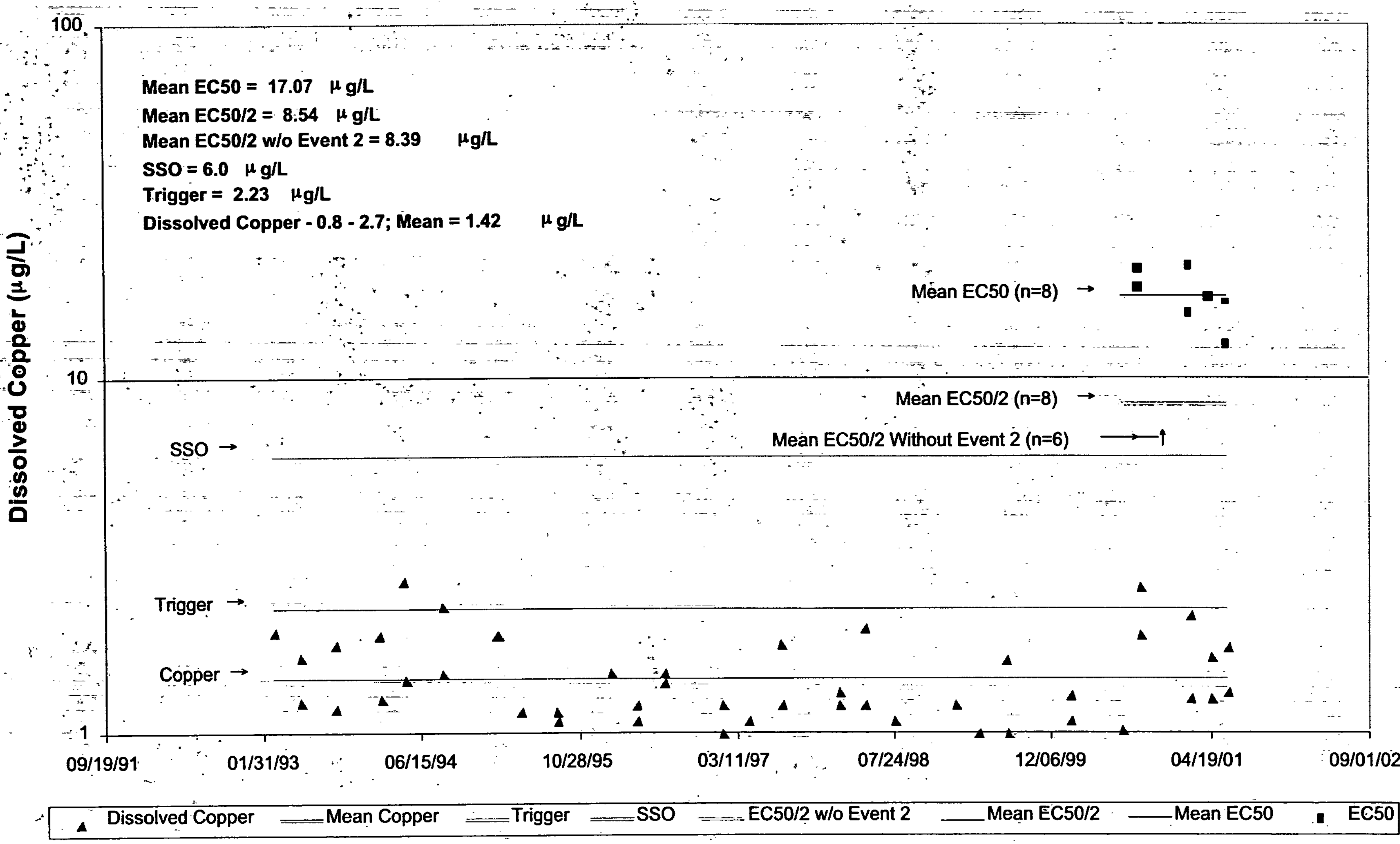


Figure 4. Bay Region 4 Copper Concentrations; Toxicity Values; Potential Trigger and Site-Specific Objective

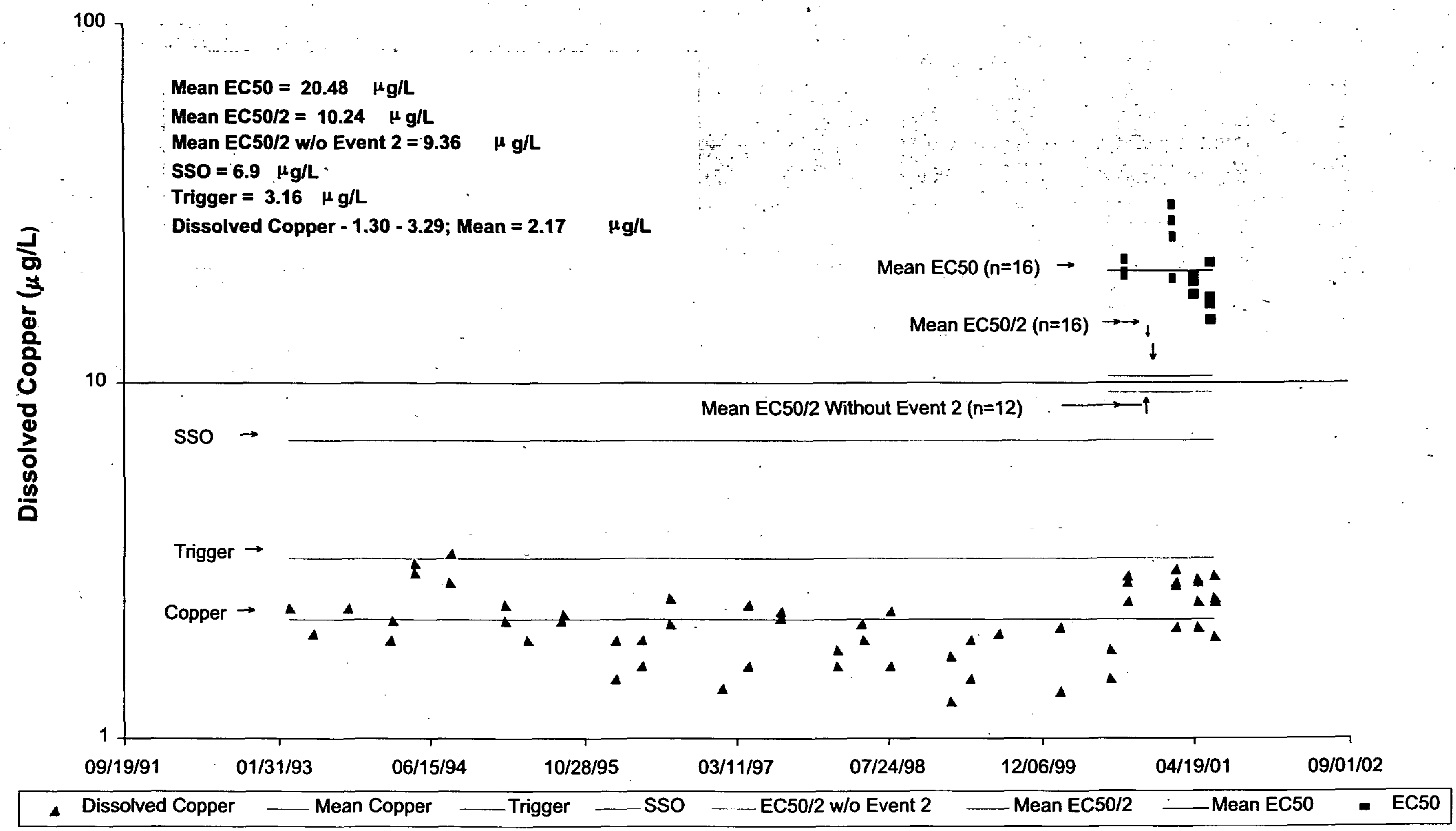
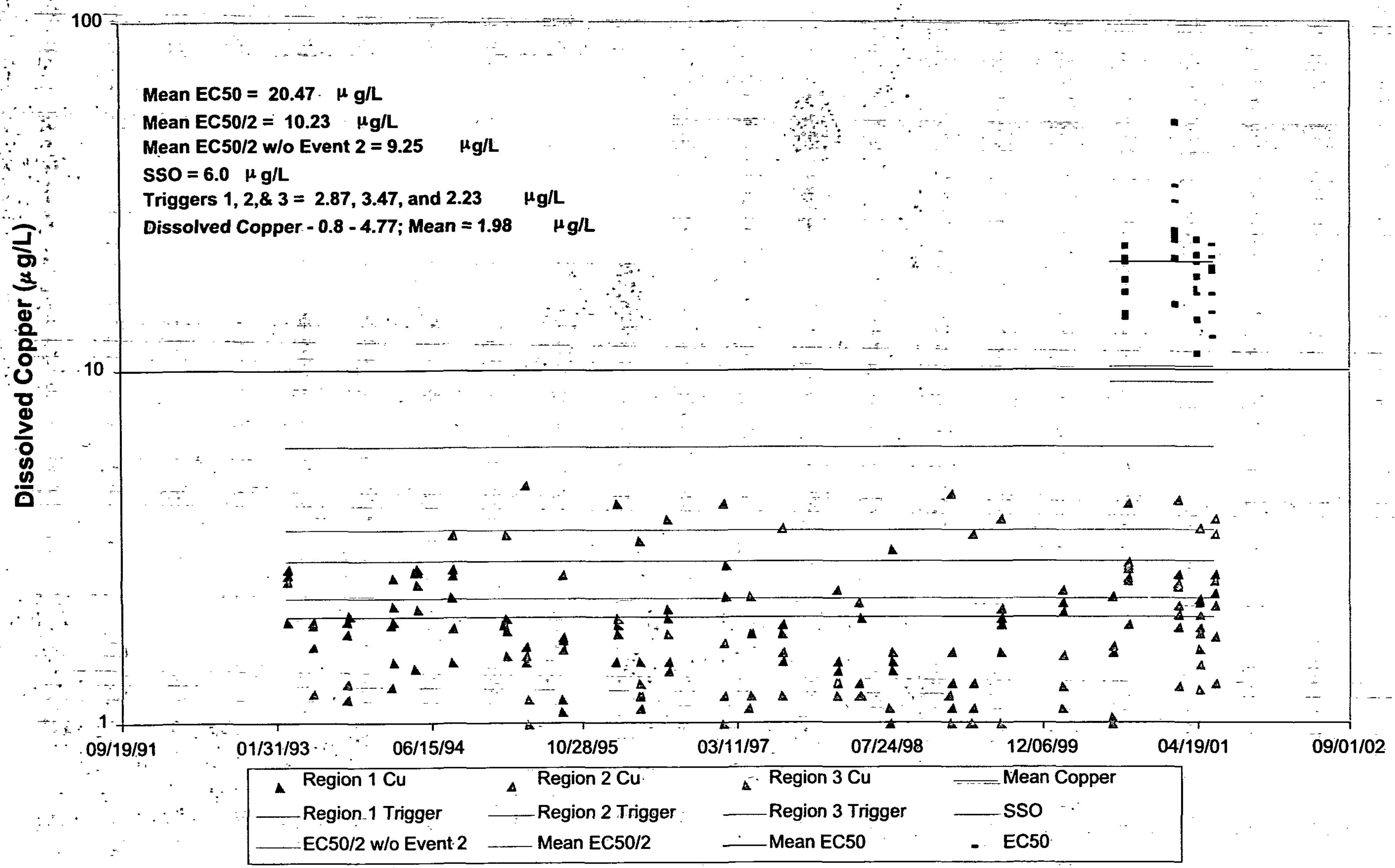
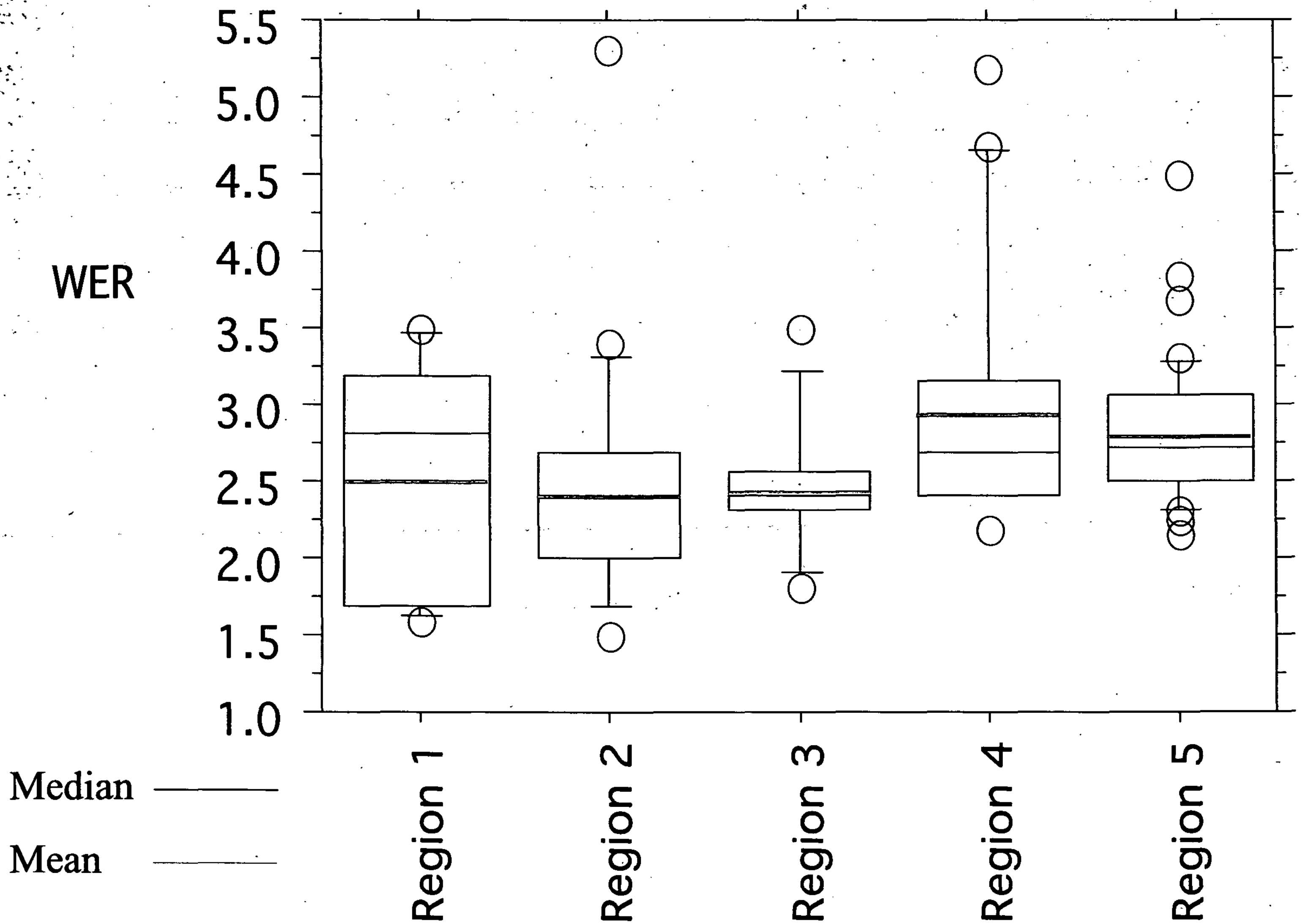


Figure 5. Bay Regions 1-3 Copper Concentrations; Toxicity Values; Potential Triggers and Site-Specific Objective

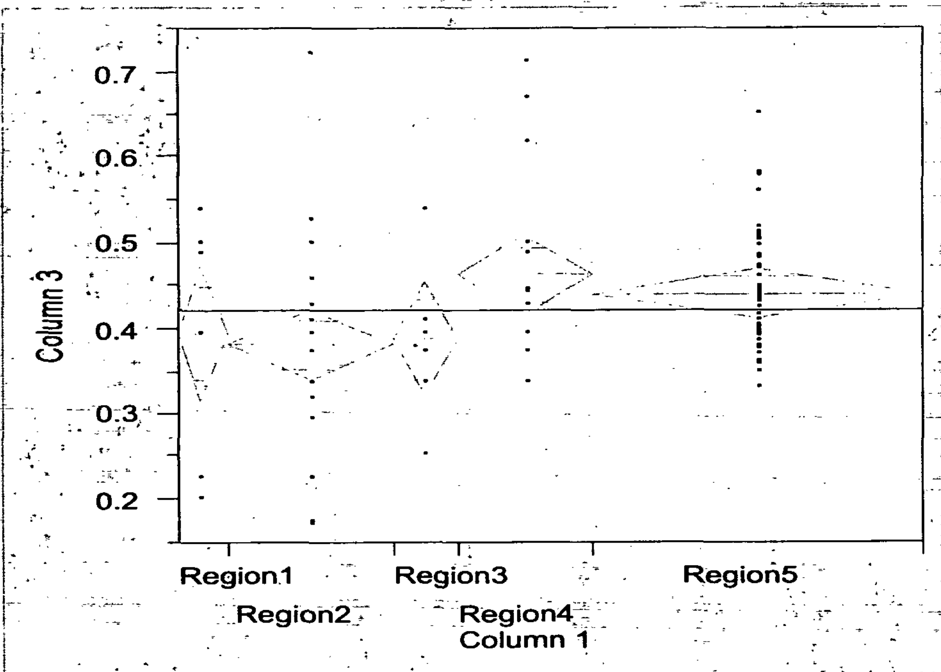


Geometric Mean WERs by Bay Region



ANOVA of Mean log WERs by Bay Region

Column 3 By Column 1



Oneway Anova

Summary of Fit

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	4	0.09099623	0.022749	2.4028
Error	85	0.80476062	0.009468	Prob>F
C Total	89	0.89575685	0.010065	0.0560

Legend

Height = 95% Confidence Interval

Width = n

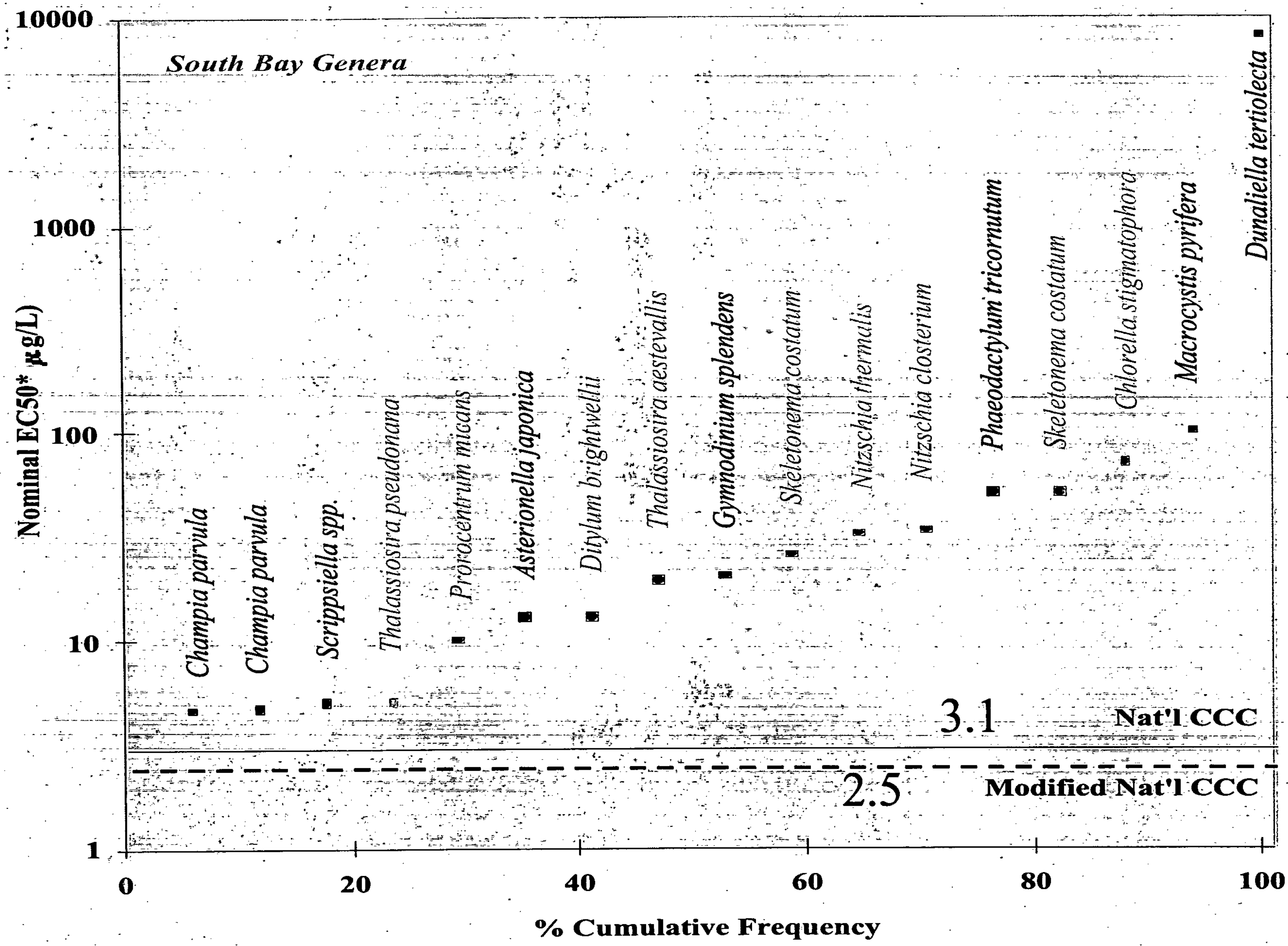
Horizontal Lines = Mean of Logs +/- 1s

Black dots = Individual WERs

Protection of Plants

- Evaluate Primary Production (surveys of species abundance and composition)
- Evaluate factors affecting phytoplankton (light, nutrients, grazing, hydrodynamics, etc.)
- Evaluate current research (e.g. Dr. Bruland speciation results)
- Can evidence of impacts to phytoplankton be linked to copper?
- EPA Final Plant Value - Value obtained by selecting the lowest result from a test with an important aquatic plant species in which the concentration of test material was measured and the endpoint was biologically important (EPA Office of Water). The Final Plant Value must be obtained from a chronic test using vascular plants or a macrophyte such as Champia (Dave Hansen, personal communication)

Sensitivities of saltwater plants to copper



WER studies with Algae

- Unicellular Algae
  - Regional Board Study with *Thalassiosira* sp.
    - Dissolved Copper WER = 2.3
    - Total Copper WER = 6.1
- Multicellular Algae
  - NY/NJ Harbor Study with *Champia* sp.
    - Dissolved Copper WER = 2.17
- Both Studies produced higher WERs for algae than for animals

Development of a S.F. Bay Site-Specific Chronic Criterion for Nickel

Using the EPA Recalculation Procedure and Modification of the EPA Nickel Saltwater Acute-To-Chronic Ratio

Environmental Services Department
City of San Jose
June 3, 2004

Background

- The City of San Jose's NPDES nickel limit dropped from 100 μg/l in 1989 to 8.3 μg/l in 1993.
- Regional Board implemented San Francisco Bay nickel WQC of 8.3 μg/l (1994).
- City of San Jose performed site-specific studies in 1989 & recalculation on nickel (1996). These studies were of limited usefulness but helped point out data gaps (chronic and ACR data)

Result of Initial Recalculation

- National & San Francisco Bay saltwater nickel CCC of 10.2 µg/l proposed following the recalculation procedure (with corrections and additions to the 1986 EPA database for nickel)
- Current Nickel Final ACR based on 2 freshwater and 1 saltwater species (FACR=17.99)

Introduction to ACR Study

- EPA establishes acute and chronic aquatic life protection for pollutants using toxicity data
- Chronic values are most often calculated from acute data employing an acute-to-chronic ratio (ACR)
- Few chronic saltwater values are available for nickel toxicity
- This study presents acute and chronic nickel toxicity data for 3 West Coast saltwater species

Acute-to-Chronic Ratio

- Acute endpoint divided by the chronic endpoint of the same test material under the same test conditions

Current Acute-to-Chronic Values

Pimephales promelas (Fathead minnow)	35.58
Daphnia magna (Water flea)	29.86
Americamysis bahia (Mysid shrimp)	5.478
Final ACR	17.99

ACR Study Objectives

- Produce acute & chronic nickel toxicity data on 3 West Coast saltwater species
- Use flow-through conditions
- Verify (<u>measure</u>) concentrations in test water
- Recalculate a Final ACR for nickel
- Evaluate SF Bay site-specific Ni criteria

Summary statistics for *Atherinops affinis*, (topsmelt)

Species	Endpoints	Values
Atherinops affinis	Acute Endpoint: 96-h Survival	
	<u>Acute Value</u>, LC50 (µg/L):	26,560
	Most Sensitive Chronic Endpoint: 40-d Survival	
	Lower Chronic Limit (µg/L):	3,240
	Upper Chronic Limit (µg/L):	5,630
	<u>Chronic Value</u> (geo. mean of upper and lower limits, µg/L):	4,270
	<u>Acute</u>-to-<u>Chronic</u> Ratio:	6.22

Summary statistics for *Haliotis rufescens*, (red abalone)

Species	Endpoints	Values
Haliotis rufescens	Acute Endpoint: 48-h Development	
	Acute Value, EC50 (μg/L):	145.46
	Most Sensitive Chronic Endpoint: 20-d Juvenile Growth	
	Lower Chronic Limit (μg/L):	21.5
	Upper Chronic Limit (μg/L):	32.5
	Chronic Value (geo. mean of upper and lower limits, μg/L):	26.43
	Acute-to-Chronic Ratio:	5.50

Summary statistics for *Mysidopsis intii* (mysid Shrimp)

Species	Endpoints	Values
Mysidopsis intii	**Acute Endpoint: 96-h Survival**	
	Acute Value, LC50 (μg/L):	148.60
	Most Sensitive Chronic Endpoint: 28-d Survival	
	Lower Chronic Limit (μg/L):	10.0
	Upper Chronic Limit (μg/L):	48.8
	Chronic Value (geo. mean of upper and lower limits, μg/L):	22.09
	Acute-to-Chronic Ratio:	6.73

Re-Recalculation: Applying current acute toxicity data to saltwater nickel re-calculation

National Water Quality Criterion			San Francisco Bay Site-Specific WQC		
Rank #	Species	GMAV	Rank #	Species	GMAV
4	*Mysidopsis (bigelowi & intii)*	306.9	4	*Mercenaria mercenaria*	310
3	*Mercenaria mercenaria*	310	3	*Heteromysis formosa*	151.7
2	*Heteromysis formosa*	151.7	2	*Mysidopsis intii*	148.6
1	*Haliotis rufescens*	145.5	1	*Haliotis rufescens*	145.5

Re-calculation of national and site-specific nickel FAVs and CMCs

	EPA 1986 National Ni WQC	Revised National Ni WQC	SF Bay Site-Specific Ni WQC
Number GMAVs in dataset	20	26	24
Final Acute Value	149.2	145.5	124.8
Criterion Maximum Concentration	74.6	72.8	62.4

Application of ACRs in re-calculations of saltwater Final ACR and CCC

Acute-to-Chronic Ratios (ACRs); Saltwater Only				
Species	Species Mean ACR	Calculated FACR	Revised Nat'l CCC	SF Bay Site-Specific CCC
Americamysis bahia (Mysidopsis bahia)	5.478	[redacted]	[redacted]	[redacted]
Atherinops affinis	6.22	[redacted]	[redacted]	[redacted]
Mysidopsis intii	6.73	[redacted]	[redacted]	[redacted]
Haliotis rufescens	5.50	5.959	24.42	20.94

Re-calculations of Final ACRs (combined) and CCCs

Acute-to-Chronic Ratios (ACRs); Combined Freshwater & Saltwater				
Species	Species Mean ACR	Calculated FACR	Revised Nat'l CCC	SF Bay Site-Specific CCC
Pimephales promelas	35.58			
Daphnia magna	29.86	[redacted]	[redacted]	[redacted]
Americamysis bahia (Mysidopsis bahia)	5.478	17.99	8.293	9.805
Atherinops affinis	6.22	[redacted]	[redacted]	[redacted]
Mysidopsis intii	6.73	[redacted]	[redacted]	[redacted]
Haliotis rufescens	5.50	10.50	13.86	11.89

Conclusions

- ACRs for saltwater species are significantly lower than those for freshwater species
- Chronic nickel Water Quality Criterion is highly dependent on the Final ACR
- A national CCC would be 24.42 and 13.86 ppb, respectively, based on saltwater and combined saltwater/freshwater ACRs
- S.F. Bay Site-Specific CCCs would be 20.94 and 11.89, respectively, based on saltwater and combined saltwater/freshwater ACRs

Nickel SSO is Conservative

- EPA (Dr. Thursby) July 28, 1998 commented that "...the data from the present study could be used to make a case that saltwater and freshwater ACRs may be different. This could substantially lower the FACR for the calculation of a nickel site-specific (objective) for South San Francisco Bay."
- Recalculated Nickel SSO lower than re-calculated national criterion

Adopted Chronic Criterion

- Water Board approved a site-specific objective for the South Bay of 11.9 ppb
- This SSO is applicable to the entire S.F. Bay

Application to S.F. Bay NDB?

- Water Board (Richard Looker) comments on NDB SIP Ni Justification - "From what is presented here, there is not enough for me to use to demonstrate that the SSO for nickel is a necessity. The arguments about triggering RPA and avoiding listings are not strong either.
- EPA (Alexis Strauss) comment on Mercury: "Aquatic Life standards for toxic pollutants are generally applied with an allowable exceedance frequency of no greater than once in any three year period (see 40 CFR 131.36(c)(2) at Table 4 Notes 1 and 2, 40 CFR 131.38(c)(2), and Technical Support Document for Water Quality-based Toxics Control, EPA 1991."

Application to S.F. Bay?

- During Event 2 of the NDB Cu/Ni Study, station BD15 (Petaluma River) had a dissolved nickel concentration of 17.2 ppb.
- Given a 3-year averaging period, isn't this likely to happen again?
- Isn't avoidance of a 303(d) listing sufficient reason to adopt an appropriate SSO for nickel for S.F. Bay NDB?
- Adopting a marine ACR would set the Nickel SSO at 20.94 ppb, above 17.2 ppb found at BD15.

Nickel ACR Report:

www.ci.san-jose.ca.us/esd/pub_res.htm

Appendix E

Copper & Nickel Workgroup Meeting Notes

Copper and Nickel Impairment Assessment Study
North of Dumbarton Bridge
CEP Workgroup Meeting June 3, 2004
EOA, 1410 Jackson Street, Oakland

Meeting Handouts:
- Agenda
- *Copper and Nickel North of the Dumbarton Bridge: Impairment Assessment and Site Specific Objectives Project* slides from presentation given by Tom Hall & Tom Grovhoug during meeting.
- San Jose response to Water Board staff comments
- *Development of a S.F. Bay Site-Specific Chronic Criterion for Nickel* slides from presentation given by Pete Schafer during meeting.
- *Selection of NDB Copper WERs* slides from presentation given by Pete Schafer during meeting.

Attendees:
- Tom Foley (City of American Canyon)
- Giti Hernvian (City of American Canyon)
- Pete Schafer (City of San Jose)
- Karen McDonough (City of San Jose)
- Jim Ervin (City of San Jose)
- Ray Arnold – on phone (Cu Development Assoc.)
- Michael Yu (Sonoma County Water Agency)
- Kristine Corneillie (LWA, for City of Petaluma)
- Andy Gunther (AMS/CEP)
- Paul Salop (AMS/CEP)
- Arlene Feng (BASMAA/ACPWA)
- Larry Bahr (FSSD)
- Steve Moore (Water Board)
- Richard Looker (Water Board)
- Tom Hall (EOA)
- Tom Grovhoug (LWA)

General Announcements:
Richard Looker recently attended the Bay Planning Coalition Meeting, where Tracy Collier, NOAA, gave a presentation on PAHs and sublethal effects of copper. The mode of action is that it affects the ability to smell, particularly in juvenile fish, making them more susceptible to predators. A significant drop in the ability to smell was seen at dissolved copper concentrations of 5 ug/L, and effects were seen at as low as 2-3 ug/L. Richard will email the PowerPoint presentation, once he receives it from Tracy. This issue will need to be addressed as part of this NDB copper site specific objective project. Since the studies were performed in freshwater, it may not be as applicable or an issue for the Bay.

Richard also brought up the subject of the proposed new national criterion for copper. The new objective would change the current saltwater objective of 3.1 ug/L to 2.4 ug/L. However, it was discussed that EPA does not appear to have yet addressed any of the comments received on this change. San Jose's data was incorrectly used. San Jose provided EPA with corrected data and clarification for recalculation during the comment period. Relevant data from the NDB project was also provided to EPA (by EOA). It was also mentioned that there is consideration of a variable criterion based on site-specific water chemistry (similar to freshwater criteria).

Copper/Nickel Project Overview

Five draft reports have been prepared as part of the CEP FY 03-04 scope of work.

- Copper and Nickel Site Specific Objectives North of the Dumbarton Bridge – State Implementation Plan Justification Report (Draft February 2004);
- North of Dumbarton Bridge of Copper and Nickel Site Specific Objective (SSO) Derivation (Draft March 2004);
- North of Dumbarton Bridge Copper and Nickel Development and Selection of Finals Translators (Draft March 2004);
- North of Dumbarton Bridge Copper and Nickel Conceptual Model and Impairment Assessment Report (Draft April 2004); and
- Copper Sources in Urban Runoff Information Update (title subject to change, Draft March 2004).

Purpose of Meeting

Tom Hall discussed the agenda and the goals of the meeting which were to agree on the meeting format and process for reviewing reports, comments, and responses to comments. The group was then to discuss approaches for selecting SSOs and translators for NDB and as appropriate, discuss recommendations for specific SSOs and translators. The agenda and approach to achieving desired outcomes were approved.

Step 1 Water Effects Ratio (WER) Study Summary

Tom Hall and Tom Grovhoug presented the background of the Copper & Nickel Step 1 Impairment Assessment Work (handout):

- Step 1 work occurred between 1999 – 2002, with the final report being published in July 2002. The work was funded by BACWA, BASMAA and WSPA.
- Step 1 work was a direct extension of the City of San Jose's work in the South Bay. The report also addressed the issue of whether deep vs. shallow areas of the Bay would result in very different WERs or copper concentrations.
- Four sampling events over one year at 13 stations provided adequate data to account for spatial and temporal variability. The study design was reviewed and approved by the Technical Review Committee after the first sampling event.

SIP SSO Report:

- The SSO report is a requirement of the SIP. The original report outline included the use of 3 POTWs as case studies to evaluate compliance with CTR versus SSO based copper and nickel effluent limits. Available effluent data from the Electronic Reporting System (ERS) database for other POTWs and industries were also evaluated. A concern was raised that the arguments in the report did not adequately demonstrate "that the discharger cannot be assured of achieving the criterion and/or effluent limitation through reasonable treatment, source control, and pollution prevention measures" (per SIP Section 5.2(3)).

  Action Item: Look at all dischargers, not just a representative sampling to get a more complete picture of economic impacts to each discharger relative to complying with CTR based effluent limits. Better documentation of nickel compliance problems is needed.

- This discussion brought up the translator issue – how could regional translators be calculated/applied in a manner that is "fair" to everyone? (See later item on agenda)
- The three case study POTWs were:
    - FSSD (medium advanced secondary treatment, zero dilution)
    - EBMUD (large secondary treatment, 10:1 dilution)
    - LGVSD (small secondary treatment, zero dilution)
- Probability plots for POTWs and Industrial dischargers were presented as well as tables of probable effluent limits showing the case studies' ability to comply with these limits.

Development of a S.F. Bay Site-Specific Chronic Criterion for Nickel - Pete Schafer presentation (see Powerpoint handout).

- The City of San Jose performed studies in 1996-1998 to develop a nickel site-specific objective (SSO). This included a recalculation of the national nickel criterion and a study to develop Acute-to-Chronic Ratios (ACR) for three additional marine species. ACRs are a way to calculate chronic criteria from acute values when sufficient chronic data is not available to directly calculate a Final Chronic Value. The current nickel ACR is based on acute and chronic data for 3 species (2 freshwater species and 1 saltwater species). Nickel ACRs for saltwater species appear to be considerably lower than the freshwater ACRs.

  The lower the Final ACR is, the higher the calculated chronic criterion using a given Final Acute Value. The average ACR for the current 3 species is 17.99. The 3 new (saltwater) species tested by the City of San Jose produced ACRs of 6.22, 5.50, and 6.73 (all significantly lower than current 17.99). The City then used the new ACR data to recalculate both chronic National criteria and site-specific objectives first using Final ACRs derived first exclusively from marine species and second from a combination of marine and freshwater species. Chronic SSOs recalculated in these ways are applicable bay-wide, not just to the Lower South Bay.

- The four derived options for a final chronic value were thus **24.42** ppb (revised national criterion using an ACR based only on marine species), **20.94** ppb (derived SSO using an ACR based only on marine species), **13.86** ppb (revised national criterion using an ACR based on a combination of marine and freshwater species), and **11.89 ppb** (derived SSO using an ACR based on a combination of marine and freshwater species). The final number approved in the Lower South Bay effort was 11.89 ppb, the most conservative of all of the derived nickel chronic criteria.

- A question was posed as to whether marine species tend to have different ACRs than freshwater species, but no one present had a definitive answer. There are various approaches that the EPA uses to derive ACRs. Usually, sensitive species have sensitive ACRs, but sometimes there is no relationship between these two variables. Since chronic data are typically lacking, the EPA often uses both freshwater and marine ACRs in combination to derive final ACRs, especially for marine species. In the case of nickel, however, there appears to be a significant difference between ACRs for freshwater and marine species.

  Marine species appear to have lower ACRs (which produce higher final chronic SSOs). The chronic nickel SSO approved for Lower South Bay is thus quite conservative since it was based on a combination of marine and freshwater ACRs. A chronic nickel SSO of 20.94 ppb based on the more technically robust marine-only ACR may have been as appropriate (or more appropriate) than the approved SSO of 11.89 ppb.

- The report on nickel recalculation can be found on the City of San Jose's website http://www.ci.san-jose.ca.us/esd under Publications & Research.

- After Pete's presentation, the representatives from the Water Board (Steve Moore & Richard Looker) discussed "Where do we go from here?" They had no disagreements on the science. However, they indicated that a potential roadblock is that the Staff Report needs to outline why this SSO process got started (compliance issues, etc.). Currently, nickel NDB doesn't appear to present the same level of compliance issues that copper does. The federal antidegradation policy states "this is a tier 2 water body...water quality can be decreased to meet social or economic needs". One policy issue to address then becomes "why do we need to decrease water quality when there is no burden on the discharger?" A related policy and public perception issue discussed was "does raising the objective result in lower water quality?"

  Discharger representatives noted that increasing the objective to 11.9 ug/L or 20.94 ug/L does not mean they can or will increase discharged nickel concentrations. Water Board staff noted that the Office of Administrative Law reviews changes to objectives and in part has to make a "determination of necessity," i.e. are there compliance problems or other reasons for having to adopt an SSO? The only documented area in the bay exceeding the CTR 8.2 ug/L dissolved nickel WQO is at the mouth of the Petaluma River. This area already has its own 303(d) listing. Others mentioned that some industrial dischargers may not be able to comply with CTR based limits. The group agreed to further investigate this issue as part of subsequent work on the SIP SSO justification report, including documentation of what dischargers with potential compliance issues have already done or could do to comply, and the associated costs.

NDB Copper WERs - Tom Hall and Tom Grovhoug presented background information on the NDB Copper & Nickel Work and 50 resultant WER datapoints.

- Plots of dissolved copper WERs were presented and the Water Board attendees suggested that it would be good to change "Event 1, Event 2, etc" notation to "dry weather, wet weather, etc" notation.
- The Biotic Ligand Model work performed by the Copper Development Association (CDA) was discussed in terms of how it was a good check of the model and of the Cu/Ni study data.
- In the Step 1 work effort, the Bay was separated in to North and Central areas. Upon the restructuring of the RMP efforts, the data collected in Step 1 were then re-evaluated using the Region 1, 2, 3, 4, 5 designations.

NDB Copper SSOs by Bay Region - Pete Shafer continued his presentation on the City of San Jose's recommended options for WERs and SSOs (handouts).

- Pete discussed that the copper criteria ultimately approved for the Bay NDB must be protective and he provided graphs of ambient copper, trigger, toxicity values, and potential SSOs to show that the City's recommended SSOs appeared to be protective. The City's approach would create two SSOs for the entire Bay. **These potential SSOs were 6.0 ppb for Bay regions 1-3** (Suisun Bay (1), San Pablo Bay (2), and Central Bay (3)) and **6.9 ppb for Bay regions 4 & 5** (South Bay (4) and Lower South Bay (5) below Dumbarton Bridge). This approach protects

Mytilus sp., the most sensitive species in the EPA database and a commercially important species.

- Ambient dissolved copper monitoring trigger levels were discussed. Pete clarified that based on the lower South Bay approach, for a trigger to be exceeded, the <u>mean</u> of the annual dataset would need to increase to the trigger level, not just one data point.
- It was also pointed out that it is important to watch seasonal variation. Dissolved copper concentrations are typically lower during the winter and higher in the summer.

After Pete's presentation, Richard Looker and Steve Moore said the SSO work "looks good" and they could support the two proposed WER values (2.4 for Regions 1-3; 2.7 for Regions 4-5). San Bruno Shoal was identified as the line between Regions 3 and 4.

- Individual dischargers will need provide input on the compliance impacts of the proposed SSOs since under one policy scenario there could be different translators for each discharger, resulting in different effluent limits for each (see next section below). The CEP group agreed to incorporate a more detailed compliance analysis into the final report.\
- Water Board staff noted that it is important to be careful as we move forward with SSOs about sending messages such as "copper and nickel are not a problem". There was concern that such statements could be construed as license to back off on current levels of control efforts. Copper and nickel can more appropriately be viewed as a lesser threat now, based on the greater level of knowledge available.
- Jim Ervin of the City of San Jose mentioned that it is important to be cautious in recommending alternatives to copper products that may result in other unanticipated adverse impacts (i.e., pesticides or endocrine disruptors).

Translators - The next topic discussed was the issue of choosing translators for the Bay NDB. The initial translator analysis used both the direct ratio method and the TSS regression method and incorporated both the NDB study data and historic RMP data. Given the large amount of data available, the relatively low r-squared values in the regression plots, and the small differences in the resultant values between the two methods, use of the direct ratio calculation results were recommended.

- Richard Looker indicated that pursuant to the SIP, the Water Board staff appears to be open to discussing possible site specific dilution studies for Bay Area dischargers. Development of a revised dilution policy has been identified as part of the Basin Plan trienniel review process as an important but potentially complex and resource intensive issue to pursue.
- The proposed Regional translator approach was presented.
- A example table was presented showing case study POTW compliance with copper effluent limits based on a WER of 2.4. EBMUD could comply with effluent limits calculated using 2.4, FSSD could comply sometimes, and LGVSD could not comply based on historic data.
- To date, absent regional translator policy guidance, translators have most commonly been applied on a discharger by discharger, case-by-case basis by NPDES permit writers. However, it was recognized that one or more pooled, regional translators, particularly for deep-water dischargers, may be appropriate. Shallow-water dischargers may need to evaluate site-specific translators, develop a rationale for using regional RMP-based translators, or create groupings based on shallow regions (i.e., Napa River region). Translator issues need to be addressed on a regional basis by dischargers, permit writers, Basin Plan staff, and TMDL staff. Translator issues were recommended to be discussed as part of the Basin Plan triennial review.

- It was decided the best short-term translator approach may be to proceed with the Basin Plan Amendment for the SSOs including one or more translators for deep water dischargers and to address shallow discharger translators outside of the BPA process so as to not unduly hold up the SSO approval process. Waiting to develop the more complex policy guidance for translators for shallow-water dischargers may be acceptable, as long as the issue does not get lost once the SSO is adopted. Larry Bahr proposed to take this phased translator approach to BACWA for discussion.

Next Steps

- The draft NDB Cu/Ni Conceptual Model Impairment Assessment Report (CMIAR) summarizes and updates the status of scientific uncertainties regarding copper impairment from the South Bay study. Hydrodynamic modeling (w/sediment) may help with answering some of the remaining questions (i.e., accumulation of Cu in sediment and effects on ambient conditions) but would be costly (~$50,000).
- The CEP is currently looking at available models. Jay Davis created a 1-box model of the Bay for PCBs. It is recognized that the Bay is not a single box, and different regions likely behave very differently. The USGS has created a 41-box model that takes into account sediment transport. The 41-box model is currently being calibrated on salinity and bathymetry. SFEI is converting the USGS model to a multi-box model using the five Bay segments for the RMP, and taking the first cut to determine how it can be improved and what other information is needed (erosion, deposition) to do so. Easily manipulated models are necessary.
- The Brake Pad Partnership Proposition 13 funded copper fate and transport study will be using the USEPA BASINS watershed model to generate bay-wide estimates of copper loading. These loading estimates will be used as input to the URS/SFO hydrodynamic/sediment model for bay-wide copper fate and transport modeling during 2006.
- The City of San Jose indicated they would be resistant to funding more modeling that would only be applicable to copper. San Jose could support modeling that could be used for multiple parameters and region wide.
- Andy Gunther encouraged people to fill in CEP project description forms re: developing models for multiple parameters.

Finalize CEP Reports. No one indicated a desire to provide further comments on the draft reports, so the four reports will be finalized based on the comments received as of this 6/4/04 meeting.

6/21/04 CEP Cu/Ni workgroup meeting. The FY 04-05 CEP Cu/Ni Basin Plan Amendment (BPA) technical assistance draft scope of work and the next steps for the Copper and Nickel Action Plans are scheduled to be discussed in more detail at the 6/21 meeting. In response to a question from Andy Gunther, Richard confirmed that supporting CAP development is a vital part of the CEP's task to assist the BPA process.

CEP Cu/Ni Workgroup Meeting June 21, 2004
Bay-Wide C/NAP Development
Process Meeting
RWQCB, Oakland
10:00 – 1:00

Key Issues Discussed:

- Work Group Role and Ground Rules - The ground rules and general role of CEP Cu/Ni Work Group were discussed. Richard Looker is the Chair of the Work Group. Other members formally designated by the Technical Committee include Larry Bahr (BACWA), Arlene Feng (BASMAA), Goeff Brosseau (BASMAA Alternate), Kevin Buchan (WSPA), Steve Overman (WSPA contact on Cu, Ni, Cn), Dan Cloak (Environmental Technical Representative), Karen McDonough and Pete Schafer (South Bay liaisons and technical experts). Co-Project Manager Tom Hall led the meeting. The roles and responsibilities of the CEP Cu/NI Work Group versus the previously established larger more broadly based Coordinating Committee were discussed. It was agreed that separate support activities for the Coordinating Committee seemed unnecessary, given that the copper/nickel site specific objective project is now being conducted under the auspices of the CEP and the CEP Copper / Nickel Workgroup.

  It was agreed that an e-mail (through the Cu/Ni Coordinating Committee Yahoo users group) would be distributed announcing the disbanding of the Coordinating Committee and formal transition to the CEP Cu/NI Work Group. The e-mail would provide options on how interested parties could stay involved with the CEP process and reiterated the roles and responsibilities of the CEP process and Work Groups. It was also decided that Paul Salop will maintain the e-mail list and distribute Work Group communications. Environmental and WSPA representatives will be courtesy cc'd on all Work Group lists but are not assumed to be active members unless they have indicated a desire to participate as such on an individual project.

- Overview Of Copper/Nickel Action Plan Effort to Date- Tom Hall briefly described the five draft CEP work products have been prepared to date. These documents will provide information to be used in the Site Specific Objective (SSO) Basin Plan amendment package.

- Existing Copper Control Programs/Reporting NDB- Most POTWs are implementing some level of copper control measures which are already being reported on within pretreatment program reports and pollution prevention program reports. POTW permits reissued since the SIP adoption (May 2000) contain requirements based on SIP Section 2.4.5.1 to develop and implement Pollutant Prevention and Minimization Programs (PMP) for "pollutants of concern." It was noted that PMP requirements appear to address most if not all of the topics and issues being discussed relative to POTW copper/nickel action plan (C/NAP) responsibilities (except for ambient monitoring "triggers").

  There was general acknowledgement that CAP reporting doesn't necessarily have to be in a separate document and it would be desirable to minimize redundant reporting of the same information. The group discussed that if done properly, it may be possible to report by reference to where applicable copper control information is contained in other reports. There was little enthusiasm for generating or reviewing the 50 or 60 additional reports that would result if each and every POTW and stormwater program bay-wide had to submit a separate annual report as part of a bay-wide CAP effort.

Recently reissued stormwater permits have requirements to develop pollutant reduction plans (PRP) for copper and other pollutants of concern. Summaries of pollutant reduction plan activities are reported within Annual Reports. The ACCWP copper PRP table of activities for FY 03-04 was briefly discussed as a potential model or starting point for stormwater program CAP purposes. It was agreed that the additional descriptive information contained in the full ACCWP copper PRP would be provided to the workgroup to facilitate further discussions of what else may need to be added for it to serve as a potential bay-wide template.

{*Update*: More detailed information on the ACCWP copper PRP was summarized in a draft August 2004 report by EOA titled "*History of San Francisco Bay Area Municipal Stormwater Program Copper Control Activities*." The report was distributed to the workgroup in late September for review."}

- Marine anti-fouling coatings- Marine anti-fouling coatings, identified within the draft *Copper Sources in Urban Runoff (and Shoreline Activities)* report, are potentially a significant copper source to certain areas of the Bay. However, copper from these coatings is not a source within urban runoff. The group agreed that the report title should be changed and a disclaimer added to the preface to clarify this fact. It was suggested that the focus on anti-fouling coating follow-up should be on documenting the magnitude of the source. It was noted that the Department of Pesticide Regulation (DPR) has more direct regulatory authority than the Water Board over anti-fouling coatings. The DPR workgroup is reviewing if a statewide effort is needed.
- P2 Menu Project- Kristine Corneillie provided an update of the P2 Menu Project. The Project, which has been on-going for approximately one year, provides pollutants of concern (i.e., copper mercury, pesticides and fats, oils and greases), their potential sources and control techniques. It was asked if the final P2 Menu could be used as a reference document for selecting future Bay-wide CAP baseline activities. Richard said that he would consider its use for this purpose. However, it is necessary to review the P2 Menu to see what is missing. {Update: final comments focusing on relative effectiveness assessments and costs are being accepted through October 2nd. The P2 Menu steering committee is meeting 9/22/04 to discuss next steps.}
- Website Projects- John Fusco and Tom Hall provided a brief update regarding SCVURPPP's development of prototype web-based projects to 1) track impairment assessment uncertainty studies (SFEI staff assisting), and 2) set up an environmental clearinghouse that will contain links to other sites with information on copper pollution prevention activities. Both activities are being conducted in accordance with SCVURPPP's Copper Action Plan. The environmental clearinghouse is targeted for completion in December 20004. Once developed, SCVURPPP envisions a yet to be determined bay-wide entity will need to take over responsibility for their updating and maintenance.
- Bay-wide C/NAP Development Process- When developing the CAP, it was suggested that the Work Group look at the short list in the draft *Copper Sources in Urban Runoff (and Shoreline Activities)* report as a starting point. Regional Board staff stated that reporting should include a purpose and goal of each action. Two things will be required for each action: a performance or effectiveness measure/metric and an activity measure/metric.
- Draft FY 04-05 CEP Cu/Ni Scope of Work – The draft FY 04-05 scope was briefly reviewed. It was agreed to add a new first task to develop a proposed framework/outline for the bay-wide CAP. While there was general awareness of the various "pieces" of the CAP, this framework effort would assist the workgroup in developing a more detailed CAP outline. It was also agreed to include in

the Basin Plan Amendment assistance task selected items from Richard Looker's 1/14/04 email on that subject. {Update: Scope changes made and approved by the CEP in July}.

- Action Items- Kristine will contact Betsy E. about the availability of P2 menus for review.

Next Steps:

- Distribute an e-mail (through the Yahoo users group) announcing the disbanding of the Coordinating Committee and formal transition to the CEP Cu/NI Work Group. The e-mail will provide options on how to move on, identify future involvement and clarify the roles and responsibilities of the Work Group. {Update: An email (copy attached) was sent out disbanding the CC users group as of the end of August 2004}.

Issue Bin:

- Administrative review of annual Water Quality Attainment Strategy reports. Should member agencies combine the individual reports into one bay-wide summary report? If so, who will be the lead agency? CEP?

[redacted]

MARCH 2005 842

Clean Estuary Partnership

North of Dumbarton Bridge Copper and Nickel Site-Specific Objective (SSO) Derivation

Prepared by:

EOA, Inc.

LARRY WALKER ASSOCIATES

LARRY WALKER ASSOCIATES

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Appendix A. Individual Sample Station Calculated SSOs Compared to Ambient Dissolved Copper Concentrations

Appendix B. Executive Summary to *Bay Area Clean Water Agencies Copper & Nickel North of the Dumbarton Bridge Step 1: Impairment Assessment Report Ambient Concentrations and WERs September 2000 – June 2001*

Appendix C. Response to Comments

Appendix D. June 3, 2004 Copper & Nickel Workgroup Meeting Materials

- June 3, 2004 Copper & Nickel Workgroup Meeting Agenda
- June 3, 2004 Copper & Nickel Workgroup Meeting Notes
- San Jose PowerPoint Presentation from June 3, 2004 Copper & Nickel Workgroup Meeting: *Selection of NDB Copper WERs: Use Of The Mytilus Embryo Assays to Derive SSOs for San Francisco Bay North of Dumbarton Bridge*
- San Jose PowerPoint Presentation from June 3, 2004 Copper & Nickel Workgroup Meeting: *Development of a S.F. Bay Site-Specific Chronic Criterion for Nickel Using the EPA Recalculation Procedure and Modification of the EPA Nickel Saltwater Acute-To-Chronic Ratio*

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GLOSSARY OF ACRONYMS

μg/L	Micrograms per liter, or parts per billion
ACR	Acute-to-Chronic Ratio
AMEL	Average Monthly Effluent Limit
ANOVA	Analysis of Variance
BACWA	Bay Area Clean Water Agencies
BASMAA	Bay Area Stormwater Management Agencies Association
BLM	Biotic Ligand Model
CC	Coordinating Committee
CCC	Criterion Continuous Concentration
CMC	Criterion Maximum Concentration
CMIA	Conceptual Model and Impairment Assessment Report
CTR	California Toxics Rule
Cu	Copper
CV	Coefficient of variation
DOC	Dissolved Organic Carbon
EBMUD	East Bay Municipal Utility District
EC50	50% Effect Concentration (concentration that adversely effects 50% of the species tested)
FACR	Final Acute-to-Chronic Ratio
FAV	Final Acute Value
FSSD	Fairfield Suisun Sanitary District
FWER	Final Water-Effects Ratio
LGVSD	Las Gallinas Valley Sanitary District
LSB	Lower South Bay
MEC	Maximum Effluent Concentration
NDB	North of Dumbarton Bridge
Ni	Nickel
PER	Pacific EcoRisk Laboratory
POTW	Publicly Owned Treatment Works
ppb	Parts per billion
ppt	Parts per thousand
p-value	Significance probability value
QA/QC	Quality Assurance/Quality Control
RMP	Regional Monitoring Program
RWQCB	Regional Water Quality Control Board
SAIC	Science Applications International Corporation
SDB	South of the Dumbarton Bridge
SIP	Policy for Implementation of Toxics Standards for Inland Surface Waters, Enclosed Bays, and Estuaries of California; aka State Implementation Policy
SMAV	Species Mean Acute Value
SSO	Site-Specific Objective
TMDL	Total Maximum Daily Load
TOC	Total Organic Carbon
TRC	Technical Review Committee
TSS	Total Suspended Solids
U.S. EPA	United States Environmental Protection Agency
WER	Water-Effects Ratio
WQC	Water Quality Criteria
WQO	Water Quality Objective
WSPA	Western States Petroleum Agencies

EXECUTIVE SUMMARY

Introduction
This report describes the methodologies and rationale for the establishment of site-specific water quality objectives for copper and nickel in San Francisco Bay North of the Dumbarton Bridge (NDB). Methodologies used conform with U.S. EPA guidance for development of site-specific objectives and are consistent with approaches used in the development and approval of site-specific objectives for copper and nickel in the Lower South Bay.

USEPA SSO Calculation Methodologies
Because a national aquatic life criterion might be more or less protective than intended for the aquatic life in most bodies of water, the U.S. EPA has provided guidance concerning three procedures that may be used to derive a site-specific criterion (U.S. EPA, 1994). These procedures are discussed in this report

San Jose Nickel SSO Approach
For nickel, a combination of the Recalculation procedure and modification of the U.S. EPA recommended Acute-to-Chronic Ratio (ACR) was used by San Jose to develop site-specific modifications to the national water quality criterion. In 1995, Watson, et al. (1996) recalculated the numeric nickel national water quality criterion using the procedure outlined by the U.S. EPA (Carlson, et al. 1984). The corrections, additions, and deletions resulted in a proposed criterion of 10.2 µg/L using the most conservative approach. During this recalculation process, it became obvious that there were no recent chronic data that could be used to recalculate the Final Acute-to-Chronic Ratio (FACR).

In 1997, Watson, et al. (1999) designed and conducted acute and chronic flow-through bioassay tests on three marine species (topsmelt fish, *Atherinops affinis*; red abalone, *Haliotes rufescens*; and the mysid shrimp, *Mysidopsis intii*). The resultant acute-to-chronic ratios for all three marine species tested by San Jose were remarkably similar, ranging from 5.50 to 6.73. These values were in turn comparable to the ACR value previously reported for *M. bahia* of 5.48 (U.S. EPA 1986). A FACR derived solely from a geometric mean of these four marine species ACRs would be 5.959. An alternative FACR of 10.50 was also developed, using a combination of the four marine ACRs plus two freshwater ACRs.

Watson, et al (1996, 1999) updated the national data-set by deleting non-native species, eliminating questionable data from the data set, adding additional saltwater acute and chronic test data to the dataset, and recalculating both new "proposed" national and site-specific criteria for nickel.

Copper Site-Specific Objective Development and Selection
The Copper Site-Specific Objectives (SSO) Development and Selection Section presents a brief summary of the copper Water Effect Ratio (WER) chemical and toxicological methods used in the North of Dumbarton Bridge (NDB) WER study, followed by a presentation of the individual station and sampling event WER results, the pooled station WER results, and then use of the WER results to derive a range of potential SSOs for the Bay NDB.

WER Results

The NDB WER study developed and presented the WER results by individual station and event (paired bar graphs); pooled by station (all four events); pooled by event (all 13 stations); and pooled for All sites, North Bay and Central Bay. In addition, a more limited analyses for All sites (except BD15); and shallow water and deep water sites (given their lower significance as a grouping factor) was developed and presented.

San Jose Approach to Final WER and SSO Selection

This section reviews the approach and reasoning used by the City of San Jose in their WER study (May 1998) in evaluating final WERs (FWERs) and calculating alternative SSOs for the bay SDB. The discussion below focuses on the reasoning employed when evaluating the pros and cons of different data (station) pooling alternatives. Many of the variables assessed by San Jose for SDB are relevant to the FWER decisions to be made NDB.

NDB Final WER and SSO Selection

The current copper WQO applicable to San Francisco Bay NDB is the CTR CCC value of 3.1 μg/L times a WER (the default WER is 1.0). Appendix A shows the complete set of individual NDB calculated site-specific WER based SSOs for each of the four events at each sampling station. These are the copper objective alternatives that are directly sanctioned by the CTR.

The CTR WQO based SSOs for all four events ranged from 5.2 μg/L (BF20) to 8.4 μg/L (BA40 and BD15). While some of the ambient copper values approached the non-WER adjusted 3.1 μg/L level, most would be a factor of two to three below a SSO based on the WERs developed in the NDB study and either the CTR or recalculated WQOs.

NDB Site-Specific CCC (SSO) Recommendation

A primary goal of the NDB WER study was to produce scientifically defensible WER values that could be used with confidence by State and U.S. EPA regulators, dischargers and stakeholders to establish one or more SSOs for the Bay north of Dumbarton Bridge. Several conservative measures were employed in both studies including: using *M. edulis*, the most sensitive species listed in the marine criteria data set for copper, as the test species; and consideration of lowering the national CCC from 3.1 to 2.5 μg/L dissolved copper by incorporating the site-specific laboratory water results into the national copper data set.

The U.S. EPA guidance suggests using geometric means for FWER selection. The arithmetic means ranged from 2.5 to 2.8 while the geometric means ranged from 2.4 to 2.7. The All Sites arithmetic and geometric means are 2.7 and 2.6, respectively, in the middle of the already relatively narrow Central to North Bay range cited. The prior statistical analysis had shown there to be no significant differences between results at shallow versus deep water stations so those groupings are not considered further in the SSO selection analysis.

The prior statistical analysis found only a minor difference in WERs (0.5) between a pooling of Lower Bay versus San Pablo Bay stations. It further found that 0.5 was approximately the difference between the upper and lower 95% confidence intervals for the All Sites pooled WER alternative. Additional analysis showed there to be no statistically significant difference between the Central Bay and the North Bay pooled WERs.

These relatively small differences between the various pooled dataset provides some support for selecting a single NDB SSO using all the available data. If arithmetic averages are used (given that the data are normally distributed), an All Sites NDB SSO could range from 6.8 to 8.4 µg/L, depending on whether the CTR or recalculated WQO is used as the basis of adjustment by the All Sites FWER of 2.7.

Revised SSO Recommendation
Since the time of the WER study, the RMP has reevaluated the regional definitions in the Bay. The RMP now recognizes 5 regions:

1. Suisun Bay
2. San Pablo Bay
3. Central Bay
4. South Bay
5. Lower South Bay

Rather than keeping the SDB work separate from the NDB work, it has been found that it is more appropriate to integrate the studies and create two SSOs for the entire Bay. These potential SSOs are calculated as 6.0 ppb for Bay Regions 1-3 and 6.9 ppb for Bay Regions 4 & 5. This approach protects *Mytilus* sp., the most sensitive species in the U.S. EPA database and a commercially important species. These SSOs are the result of two proposed WER values (2.4 for Regions 1-3; 2.7 for Regions 4-5).

Biotic Ligand Model
The Biotic Ligand Model (BLM) predicts metal toxicity to aquatic organisms based on the chemical characterization of a given water body. The model takes into consideration several water quality parameters, including hardness, DOC, chloride, pH, and alkalinity. The BLM was used to predict copper toxicity in the NDB WER study water samples from San Francisco Bay, and in the laboratory water samples from the Granite Canyon Marine Laboratory in Carmel, CA. BLM input chemistry was measured in the second, third, and fourth sampling events. This model was previously developed with toxicity data from South San Francisco Bay WER study (Paquin et al., 2000). The model was used to predict EC50s "blind", i.e. without knowing the measured values until after predictions were made.

Compliance Evaluation with SSO Based Effluent Limits
The *SIP SSO Justification Request Report* (September 2004) included an evaluation of the ability of three case study POTWs to comply with non-WER adjusted CTR based copper and nickel effluent limits. Copper compliance continues to be an issue for shallow water (zero dilution) municipal secondary treatment plants such as LGVSD no matter what WER/SSO is selected. Copper compliance may also continue to be an issue also for shallow water advanced secondary plants such as FSSD, depending on the SSO selected. Deepwater secondary treatment dischargers (with 10:1 dilution) with performance equivalent to EBMUD would appear to have minimal compliance issues with any SSO based limit.

Secondary treatment POTWs and industries without dilution credit will have moderate to significant copper compliance problems even with the upper range of SSO based effluent limits. Advanced secondary POTWs without dilution may have minor compliance problems if relatively low WER based SSOs are selected. A small percentage of facilities with 10:1 dilution may have copper compliance problems if relatively low copper WER based SSOs are selected.

1. INTRODUCTION

This report describes the methodologies and rationale for the establishment of site-specific water quality objectives for copper and nickel in San Francisco Bay North of the Dumbarton Bridge (NDB). Methodologies used conform with U.S. EPA guidance for development of site-specific objectives and are consistent with approaches used in the development and approval of site-specific objectives for copper and nickel in the Lower South Bay. Information used to develop site-specific objectives NDB was developed through a peer reviewed effort that was coordinated with interested parties including the Regional Water Quality Control Board, U.S. EPA Region IX, Bay Area Clean Water Agencies (BACWA), Bay Area Stormwater Management Agencies Association (BASMAA), Western States Petroleum Association (WSPA), San Francisco Baykeeper, and the Copper Development Association.

1.1 USEPA SSO Calculation Methodologies

Because a national aquatic life criterion might be more or less protective than intended for the aquatic life in most bodies of water, EPA has provided guidance concerning three procedures that may be used to derive a site-specific criterion (U.S. EPA, 1994):

1.1.1 Recalculation Procedure

The Recalculation Procedure is intended to take into account relevant differences between the sensitivities of the aquatic organisms in the national dataset and the sensitivities of organisms that occur at the site. This procedure involves eliminating non-resident species from the national data set of aquatic species whose toxicity test results are used to compute the water quality criterion, and then recalculating a site-specific objective with the modified set of species.

1.1.2 Indicator Species Procedure

The Indicator Species procedure is based on the assumption that characteristics of ambient water may influence the bioavailability and toxicity of a pollutant. Acute toxicity in site water and laboratory water is determined in side-by-side toxicity tests using either resident species or acceptable sensitive non-resident species, which are used as surrogates for the resident species. The Indicator Species Procedure allows for modification of the national criterion by using a site-specific multiplier that accounts for ambient water quality characteristics that may affect the bioavailability of the pollutant in question. As part of this procedure, a water effects ratio (WER) is determined using results from toxicity tests performed in ambient water and laboratory water.

A WER is the ratio of toxicity of a compound to an aquatic organism when the tests are performed using standard laboratory water versus the toxicity when the tests are performed using ambient water. A WER is expected to appropriately take into account the (a) site-specific toxicity of a compound and (b) interactions with other constituents of the site water that may either reduce or increase the toxicity of the compound in question. If the value of the water effect ratio exceeds 1.0, the pollutant is less toxic in the site water than in laboratory water. The difference in toxicity values, expressed as a WER, is used to convert a national water quality criterion for a pollutant to a site-specific water quality criterion.

The City of San Jose used the Indicator Species Procedure in its Impairment Assessment for copper. Observed WER values ranged from 2.5 to 5.2 based on measured dissolved copper. The recommended range of chronic SSOs for the lower South Bay resulting from the Impairment Assessment was 5 to 12 µg/L dissolved copper. U.S. EPA reviewed this work and found that the species used were appropriate, the data valid and the conclusions reasonable (USEPA July 27, 1998).

1.1.3 Resident Species Procedure

This procedure is used to account for differences in resident species' sensitivity and differences in bioavailability and toxicity of a material due to the physical and chemical characteristics of the ambient water. The Resident Species Procedure allows for modification of the national criterion by concurrently testing resident species for chronic and acute toxicity in ambient site water.

2. SAN JOSE NICKEL SSO APPROACH

For nickel, a combination of the Recalculation procedure and modification of the U.S. EPA recommended Acute-to-Chronic Ratio (ACR) was used by San Jose to develop site-specific modifications to the national water quality criterion. In 1995, Watson, et al. (1996) recalculated the numeric nickel national water quality criterion using the procedure outlined by the U.S. EPA (Carlson, et al. 1984). The corrections, additions, and deletions resulted in a proposed criterion of 10.2 µg/L using the most conservative approach. During this recalculation process, it became obvious that there were no recent chronic data that could be used to recalculate the Final Acute-to-Chronic Ratio (FACR).

The FACR derived in 1986 (17.99) was based on two freshwater and one marine species. There was a large difference between the freshwater and saltwater ACR values that contributed to the FACR. The ACR for the freshwater minnow, *Pimephales promelas*, was 35.58 and that for the waterflea, *Daphnia magna*, was 29.86. Only one marine species, the mysid shrimp, *Mysidopsis bahia* (since reclassified as *Americamysis bahia*), had verifiable chronic data which resulted in a single marine ACR value of 5.48.

In 1997, Watson, et al. (1999) designed and conducted acute and chronic flow-through bioassay tests on three marine species (topsmelt fish, *Atherinops affinis*; red abalone, *Haliotes rufescens*; and the mysid shrimp, *Mysidopsis intii*). The topsmelt is a native to Lower South San Francisco Bay, while the other two species are West Coast natives and commonly used surrogate resident species. Abalone and mysids were found to be far more sensitive to nickel than was topsmelt. Chronic values for abalone and mysids were similar (26.43 and 22.09 µg/L, respectively), and were lower than available literature values. The chronic value for the topsmelt was 4,270 µg/L.

The resultant acute-to-chronic ratios for all three marine species tested by San Jose were remarkably similar, ranging from 5.50 to 6.73. These values were in turn comparable to the ACR value previously reported for *M. bahia* of 5.48 (U.S. EPA, 1986). A FACR derived solely from a geometric mean of these four marine species ACRs would be 5.959. An alternative FACR of 10.50 was also developed, using a combination of the four marine ACRs plus two freshwater ACRs.

Watson, et al (1996, 1999) updated the national data-set by deleting non-native species, eliminating questionable data from the data set, adding additional saltwater acute and chronic test data to the dataset, and recalculating both new "proposed" national and site-specific criteria for nickel.

Since abalone is a commercially important species, the calculated Final Acute Value (FAV) that would normally be used for criteria derivation was replaced in the national dataset by the lower (more conservative) abalone Species Mean Acute Value (145.5 μg/L) in order to protect this species. Thus, the recalculated potential national and "South San Francisco Bay" site-specific FAVs were 145.5 μg/L and 124.8 μg/L, respectively. While the San Jose reports used the terminology "South San Francisco Bay" SSOs, the approach taken resulted in a range of SSO values applicable throughout the Bay and potentially to the West Coast. This report will use the "Resident Species" terminology for this SSO approach.

Using the two updated FACRs (marine and combined freshwater plus marine) and the two recalculated FAVs (national and resident species), four alternative SSOs can be derived using the Formula: FAV ÷ ACR = CCC

1) Recalculated National Criterion/Combined Freshwater and Marine ACR;
   145.5 μg/L ÷ 10.50 = 13.86 μg/L

2) Recalculated National Criterion/Marine ACR
   145.5 μg/L ÷ 5.959 = 24.42 μg/L

3) SF Bay Resident Species/Combined Freshwater and Marine ACR; and
   124.8 μg/L ÷ 10.50 = 11.89 μg/L

4) SF Bay Resident Species/Marine ACR;
   124.8 μg/L ÷ 5.959 = 20.94 μg/L

The chronic values of 22.09 and 26.43 ug /L for mysids and abalone, respectively indicate that all but option 2) (24.42 μg/L) of the above four potential nickel SSOs would be protective (in clean laboratory water) of the more sensitive mysid (and abalone) and, as such, be protective of the Beneficial Uses San Francisco Bay and North and South of the Dumbarton Bridge. It should be noted, however, that these SSO values are based on clean laboratory toxicity test results and do not include any of the ambient "apparent complexing capacity" present in the Bay that may be responsible for making nickel even less bioavailable to aquatic organisms.

The U.S. EPA reviewed this San Jose work and found that the species and methodologies used were appropriate for developing site-specific modifications to the national water quality criterion for nickel. As such, no additional toxicity testing is required to derive a nickel SSO for other regions of the Bay. Use of the resident species dataset, while more conservative, would appear appropriate for establishing a NDB SSO, versus use of the recalculated national dataset.

Decisions are required as to whether it is more technically appropriate to use the four species marine ACR versus the combined freshwater/marine (used for the LSB) given the relative robustness of the marine ACR dataset.

3. COPPER SITE-SPECIFIC OBJECTIVE DEVELOPMENT AND SELECTION

This Copper Site-Specific Objectives (SSO) Development and Selection Section presents a brief summary of the copper Water Effect Ratio (WER) chemical and toxicological methods used in the North of Dumbarton Bridge (NDB) WER study, followed by a presentation of the individual station and sampling event WER results, the pooled station WER results, and then use of the WER results to derive a range of potential SSOs for the Bay NDB.

3.1 Laboratory Procedures

To address the aquatic toxicity of copper and nickel in San Francisco Bay, well-defined sampling, laboratory and quality assurance/quality control (QA/QC) procedures were used in the NDB Water Effects Ratio (WER) Study, based in large part on the San Jose WER studies. Detailed descriptions and information relating to sampling, laboratory and QA/QC procedures are provided in Sections 2 through 4 (and associated Appendices 2 through 4) of the NDB copper WER study (July 2002) and in Appendix 1 (Study Work Plan) of that study. The procedures and results of NDB WER study were reviewed by the Coordinating Committee (CC) and the Technical Review Committee (TRC) as documented in the CC meeting notes (provided within Appendix 1of the NDB WER study) and the response to the TRC comments on the interim and the draft final report (Appendix 8 of the NDB WER study).

The NDB copper WER study closely followed the basic San Jose WER study approach by using the indicator species *Mytilus edulis* as the test organism. The *Mytilus edulis* toxicity test used for the North of Dumbarton Bridge WER study (NDB WER study) followed the guidelines established by the USEPA manual [U.S. EPA, 1995b]. *M. edulis* is an almost ideal organism for use in WER copper studies. When deriving a site-specific criterion, it is desirable to use a test species that is sensitive at Criterion Continuous Concentrations (CCC) or Criterion Maximum Concentrations (CMC). The concentrations that affected *M. edulis* approximate the criteria concentrations. *M. edulis* is the most appropriate species to use as a surrogate for brackish water species that inhabit the North Bay and for setting a North Bay site-specific criterion for copper. This conclusion is based on several factors:

- The CTR criterion for copper is determined exclusively by *M. edulis* for protection of a commercially important species. Since it is used exclusively for setting the current national criterion, it is appropriate to use it exclusively for setting a site-specific criterion for the North Bay.

- It is the most sensitive species in the national saltwater database. It is not only a good surrogate for invertebrate species (which tend to be more sensitive to copper than vertebrates) and mollusks (a phylum sensitive to copper – the 3rd, 4th, and 6th most sensitive species in the national copper database are mollusks), but it is a good surrogate for any sensitive saltwater animal (at any salinity above ~ 2 parts per thousand (ppt)).

- The most sensitive freshwater species to copper are daphnids (water fleas). In soft water (where copper is more bioavailable), they are about as sensitive *as M. edulis* (Genus Mean Acute Value (GMAV) of 14.48 parts per billion (ppb) for the genus *Daphnia*, 9.92 ppb for *Ceriodaphnia* and 9.63 ppb for *Mytilus*). However, daphnids would be poor surrogates for animals living in brackish water (e.g., at typical 5 ppt salinity at BF 10 and BF 20 sites) since the acute toxicity values for freshwater animals are more significantly dependent on hardness than saltwater animals. For example, the estimated acute value for *Ceriodaphnia* (at a hardness of 5 ppt salinity seawater) would be so high as to be effectively meaningless.

The methodology for copper spiking and test solution preparation was developed in conjunction with San Jose researchers. Water used for laboratory water and reference toxicant tests was 1 µm sand-filtered natural seawater obtained from the Granite Canyon Marine Laboratory in Carmel, CA. Test concentrations were prepared by spiking one-liter aliquots of the salinity-adjusted laboratory and site waters with a certified commercial copper nitrate standard. To confirm that *Mytilus edulis* embryos were responding to toxic stress in a typical fashion, a reference toxicant test was run concurrently with each set of site water (and lab water) tests. All reference toxicant results were within acceptable limits (±2 standard deviations about the mean).

Once toxicity testing was completed, guidance within the U.S. EPA memorandum entitled *Interim Guidance on the Determination and Use of Water Effect Ratios for Metals* was used to select test solutions for chemical analysis [U.S. EPA, 1994]. Consistent with the City of San Jose's study, WER calculations were based on initial copper concentrations as opposed to a time-weighted average of initial and final values. San Jose studies (and the TRC) found this approach to be more conservative since a proportionately greater copper recovery is expected in site water than in lab water when measured at the test conclusion [San Jose, 1998].

EC50 values were calculated using the Trimmed Spearman-Karber Method. EC50 values for total and dissolved copper in lab water exhibited high precision, with a coefficient of variation (CV) of 16.1% and 17.3% respectively. This compares favorably with the CV of 23.1% and 22.0%, respectively reported for the City of San Jose study.

Dissolved copper EC50 values were used to calculate the WERs for each station and event:

$$\text{WER} = \frac{\text{Site Water EC50}}{\text{Lab Water EC50}}$$

There were a total of 50 valid site water EC50s and eight lab water EC50s developed in the NDB WER study. There were two laboratory water results developed for each event, to coincide with the Central Bay and North Bay samples were collected and run on separate days.

The NDB WER study and associated analyses were performed consistent with RMP-type monitoring and analysis activities, some of which use research based methods to obtain the highest quality data possible. Rigorous quality control/quality assurance practices were maintained during all aspects (sampling, testing, chemical analysis) of the NDB WER study.

This is evidenced by the high quality, low variability results obtained in compliance with the individual lab's QA/QC criteria.

The eight laboratory water tests all generated results acceptable for calculating WERs and for calculating national criteria. The laboratory water EC50 value (Final Acute Value (FAV)) used to derive the national WQC for copper is 9.625 µg/L. This FAV is based on the *M. edulis* SMAV of 9.625. The WER guidance document (U.S. EPA 1994) defines laboratory water test results as being acceptable if they are within a factor of 1.5 of the national results (i.e., 6.417 to 14.468 for copper). The eight PER laboratory water results readily met this criterion since they are within a factor of about 1.25 of the national results (PER arithmetic and geometric means of 7.75 and 7.66, respectively). In addition, the PER lab water results were quite consistent with a 1.28 standard deviation and 16.5% coefficient of variation.

Overall, the results from the four sampling events were found to have sufficient QA to support the reported chemical and toxicological bioassay data. The Coordinating Committee and Technical Review Committee reviewed the WER report Work Plan and methods; the results after the first sampling event (per WER guidance); and the NDB WER study final results. The TRC comments and the project team's response to comments are summarized in the NDB WER study and included in their entirety within Appendix 8 of the NDB WER study. The TRC found that the WER and associated data were of high quality and suitable to be used for calculating site-specific objectives.

3.2 WER Results

The NDB WER study developed and presented the WER results by individual station and event (paired bar graphs); pooled by station (all four events); pooled by event (all 13 stations); and pooled for All sites, North Bay and Central Bay. In addition, a more limited analyses for All sites (except BD15); and shallow water and deep water sites (given their lower significance as a grouping factor) was developed and presented.

3.2.1 Individual WER Results

The NDB WER study developed 50 overall WERs (four events, thirteen stations per event with eleven valid results in Event 4). Dissolved copper WERs at each station (**Figure 1**) showed general consistency between events, except at stations BD15, LCB01, LCB02, and BA40 where there were moderate to significant spikes during Event 2. In addition, total suspended solids (TSS), total organic carbon (TOC), and dissolved organic carbon (DOC) concentrations trended higher at these sites during Event 2. Spatially there were no readily discernible trends or patterns. The Grizzly Bay station (BF20) had some of the lowest WERs while the next closest station Pacheco Creek (BF10) had some moderately high values. The mouth of the Petaluma River (BD15) station had consistently elevated values (see discussion in CMIA report). The other northern and central bay station WERs were typically in the 2-3 range with the exception of the southern most station Redwood Creek (BA40) with values closer to 3.

Box and whisker plots have been used for the various pooled data presentations to show the median, the 25th percentile, the 75th percentile, extreme values and outliers. The lower and upper boundaries of the box represent the 25th and 75th percentiles, respectively. The horizontal line inside the box represents the median. The length of the box corresponds to the inter-quartile range, which is the difference between the 75th and 25th percentiles. The box plot includes two categories of cases with outlying values. Cases with values that are more than three box-lengths from the upper or lower edge of the box are designated extreme values and are shown with asterisks. Cases with values that are between 1.5 and 3 box-lengths from the upper or lower edge of the box are outliers and shown with circles. The largest and smallest observed values that are not outliers are also shown. Lines (referred to as whiskers) are drawn from the ends of the box to these values.

The upper plot (**Figure 2a**) shows spatial (station-by-station) results and the lower plot (**Figure 2b**) shows temporal (event-by-event) results. It is important to note that the station-by-station boxes include only four data points. Therefore, the 25th and 75th percentile values have minimal significance in these plots. However, these are still useful for illustrating differences between stations.

Figure 2a shows that there is some variability in dissolved Cu WERs from site-to-site but again no clear-cut spatial pattern or trend. The median WER values range only between approximately 2 and 3, while the smallest and largest observed values range from approximately 1.5 to 5.5. BD15 showed the most variability in dissolved Cu WER. BB15 and BC10 showed only slight variation from event-to-event. Based on the position of the median bar, the BA40, BB15, LCB01, LCB02, BB30, BD15 and BF20 WER data are skewed slightly negatively. That is, the dark line in the box is not in the center but closer to the bottom of the box. This is reflective of the significant difference in Event 2 WERs compared to the consistent WERs during the other three events at these stations. For example, at LCB01 the event 2 WER was 4.7 versus 2.5, 2.4, and 2.4 during other three events (**Figure 1** and **Table 1**).

The individual station dissolved copper WER results are pooled and summarized by event in **Figure 2b**. The main conclusion to be drawn is that when compared to the other three events, Event 2 had higher dissolved Cu WER values at most stations. Median values for all sites combined for each of the four events ranged from approximately 2.5 to 3.2. Data are slightly skewed (positive) for Events 1 and 3. Events 1, 3 and 4 do not show major variability based on the comparatively short lengths of the boxes and whiskers. However, Event 2 showed dissolved Cu WER values ranging from approximately 2.5 to 5.5.

General summary statistics were calculated for the individual stations and events and reviewed for evidence of patterns or trends (**Table 1**). The two highest WERs recorded during this study occurred during Event 2 at the mouth of the Petaluma River (BD15) (5.3) and at Pacheco Creek (BF10) (3.1). The two lowest occurred at San Pablo Bay (BD20) (1.5) during Event 4 and at Grizzly Bay (BF20) (1.6) during Event 3. Overall median WERs by event were 2.4, 3.2, 2.7, and 2.2 for Events 1 through 4, respectively. The overall grand median WER was 2.5. Station dissolved copper WER median values are presented in **Table 2**. Median values ranged from 1.7 at BF20 to 3.1 at the adjacent BF10 station.

Table 1. Dissolved Copper WER Summary Statistics by Event

Station		Event 1	Event 2	Event 3	Event 4
Central Bay	BA40	2.7	4.2	2.7	3.1
	BB15	2.4	3.2	2.7	2.5
	LCB01	2.5	4.7	2.4	2.4
	LCB02	2.4	5.2	2.8	2.2
	BB30	2.5	3.5	2.4	2.4
	BC10	2.2	2.6	2.4	1.8
North Bay	BD20	2.2	2.6	2.0	1.5
	SPB01	2.0	2.6	2.9	2.0
	BD15	2.7	5.3	3.4	2.4
	SPB02	1.7	3.2	2.4	2.2
	SPB03	1.7	2.5	2.7	2.1
	BF10	2.5	3.5	3.1	*
	BF20	1.7	3.2	1.6	*
number		13	13	13	11
minimum		1.7	2.5	1.6	1.5
maximum		2.7	5.3	3.4	3.1
a. mean		2.3	3.5	2.6	2.3
g. mean		2.2	3.4	2.5	2.2
90^{th} Percentile		2.7	5.1	3.1	2.5
5^{th} Percentile		1.7	2.5	1.8	1.7
median		2.4	3.2	2.7	2.2
Std. deviation		0.4	1.0	0.5	0.4

*data did not meet QA/QC criteria and were not used in calculations

Table 2. Individual Station Dissolved Copper WER Median Values

Station		Median
Central Bay	BA40	2.9
	BB15	2.6
	LCB01	2.5
	LCB02	2.6
	BB30	2.5
	BC10	2.3
North Bay	BD20	2.1
	SPB01	2.3
	BD15	3.0
	SPB02	2.3
	SPB03	2.3
	BF10	3.1
	BF20	1.7

Figure 1. Dissolved Copper WER at Each Station for Each Event (µg/L)

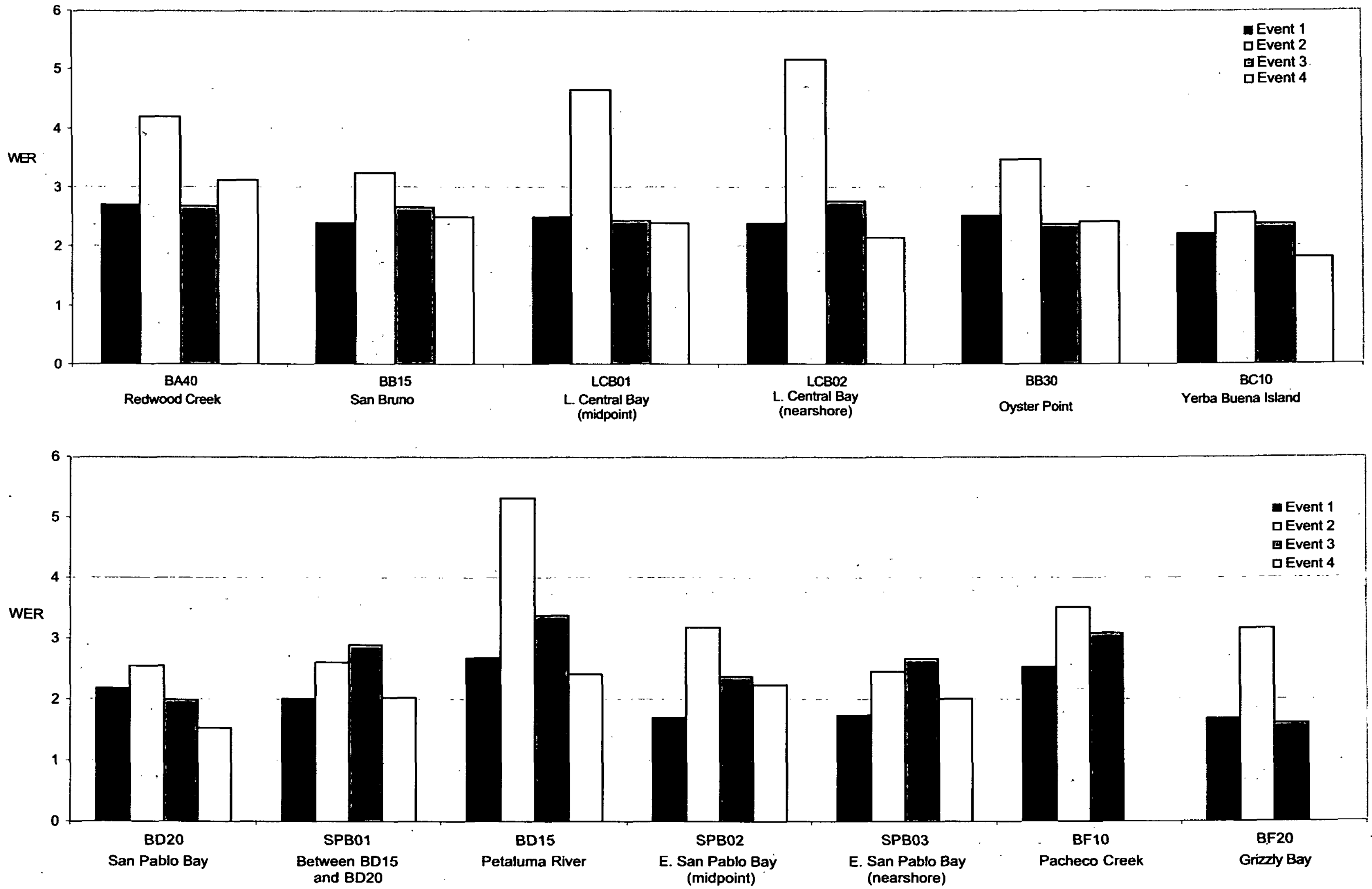


Figure 2a. Dissolved Copper WER Results by Sampling Station

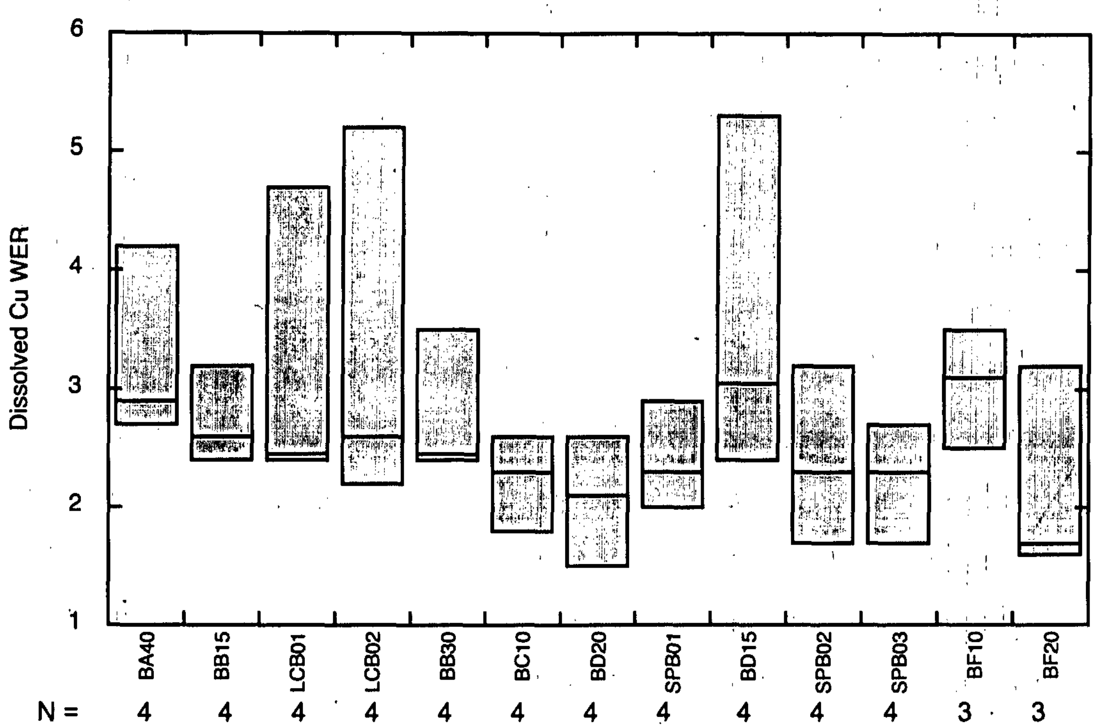
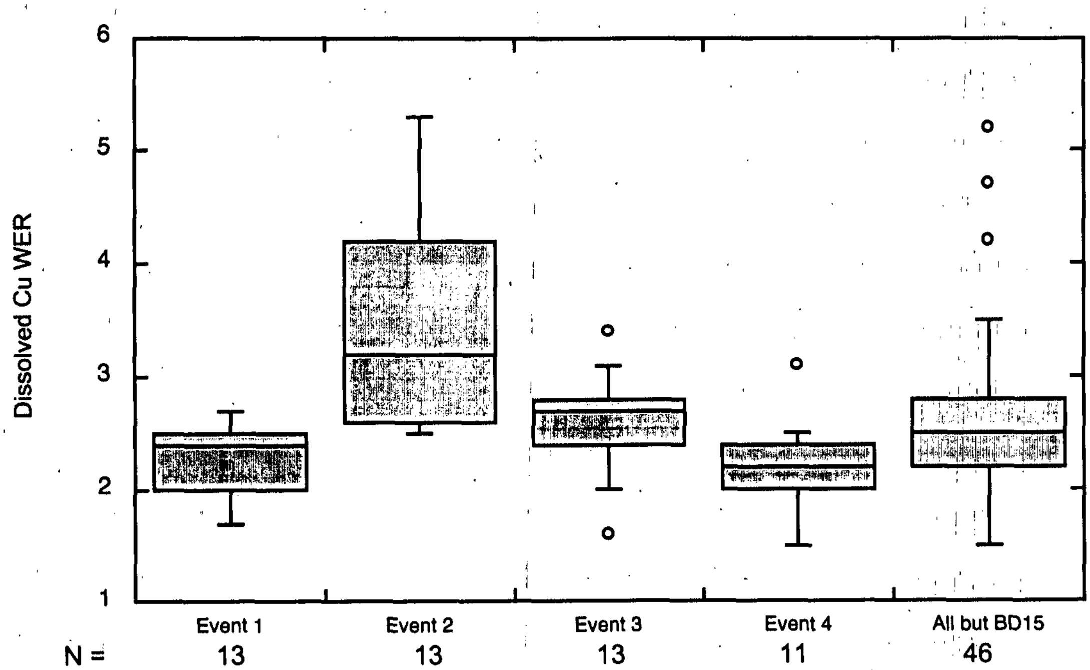


Figure 2b. Dissolved Copper WER Results by Event



3.2.2 Pooled WER Results

One goal of the NDB WER project was to determine whether significant spatial differences existed that would warrant having more than one WER and resultant SSO NDB. The graphical and simple statistical review of the individual station and event results presented above did not show strong evidence of spatial patterns. In terms of temporal variability, three of the four events showed similar results and the fourth showed consistently elevated WERs, representing conditions when copper would be even less bioavailable.

To investigate the potential for spatial variability issue further, individual WER values from the 13 sampling sites were pooled into six qualitative categories based on the available data. The categories and number of stations within each are shown below.

- Central Bay (6)
- North Bay (7)
- All Sites (13)
- All sites except BD15
- Shallow water sites (5)
- Deep water sites (8)

The categories do not strictly mirror the hydrodynamic RMP redesignation segmentation or the "old" Basin Plan Bay segmentation. The Central Bay includes the sampling sites starting near the Bay Bridge at Yerba Buena Island (BC10) and extending south of the San Mateo Bridge to Redwood Creek (BA40). A portion of the Lower Bay is thus included in the Central Bay designation.

The North Bay grouping includes the sampling sites north and east of the San Pablo Bay Station (BD20) and roughly all areas upstream of the Richmond-San Rafael Bridge. The All Sites grouping includes all 13 Central and North Bay sites. The "All sites but BD15" grouping was analyzed to investigate to what extent the atypical results at the mouth of the Petaluma River (BD15) might skew the overall data set if included.

Shallow water (or mudflat) sites refer to the five new transect or "near-shore" sites that were selected to investigate the existence of potential gradients from RMP "spine" stations towards the shore. Three such shallow water sites were included in the study in the North Bay and two in the Central Bay. Deep water sites refer to the eight existing RMP spine stations included in the NDB WER study. The spine stations are in channelized areas of San Francisco Bay but are not necessarily in physically deep water given the overall shallowness of the Bay. Four deep water sites were included in each of the North and Central Bays. The three physically deepest sites (30-40 feet) include Redwood Creek (BA40), Oyster Point (BB30) and Pacheco Creek (BF10). The other sites were generally less than thirteen feet deep when sampled.

Summary statistics for pooled dissolved copper WERs are found in **Table 3**. Within each pooled grouping there was a fairly even distribution of samples collected (e.g., 24 samples from the Central Bay and 26 from the North Bay, or 20 shallow or near-shore water samples versus 30 deep water of RMP spine samples).

When comparing statistics between these pooled groupings, it is evident that there is minimal variability in all rows. For instance, the maximum WER values for all categories range from 5.2 – 5.3. Similarly, the 5^{th} percentile values range from 1.6 – 2.2. Central tendency WERs (arithmetic mean, geometric mean and median) were quite consistent across all the groupings evaluated with values between 2.4 and 2.8 These consistencies may indicate that a Bay-wide versus region specific WER would be appropriate. Additional statistical evaluation of spatial and temporal variability is presented below.

Table 3. Dissolved Copper Pooled WER Summary Statistics

Summary Statistics	Central Bay	North Bay	All Sites	All but BD15	Shallow Sites	Deep Sites
number	24	26	50	46	20	30
minimum	1.8	1.5	1.5	1.5	1.7	1.5
maximum	5.2	5.3	5.3	5.2	5.2	5.3
a. mean	2.8	2.5	2.7	2.6	2.6	2.7
g. mean	2.7	2.4	2.6	2.5	2.5	2.6
90th Percentile	4.0	3.3	3.5	3.4	3.3	3.5
5th Percentile	2.2	1.6	1.7	1.7	1.7	1.6
median	2.5	2.4	2.5	2.5	2.4	2.5
Std. deviation	0.8	0.8	0.8	0.7	0.9	0.8

3.2.3 Additional WER Data Statistical Analyses

The NDB WER Report (July 2002 – Section 6.5) presented a more detailed statistical evaluation of the WER pooled results presented above to further evaluate the extent of variability and clustering of the data. Selected results from that evaluation are summarized below.

The results of the Kolmogorov-Smirnov goodness-of-fit tests and inspection of normal probability plots conducted had indicated that the WER data were approximately normally distributed. Therefore, no transformation of these data was necessary for subsequent repeated measures of analysis of variance (ANOVA) tests and other statistical analyses.

Repeated measures ANOVA results showed that whether a site was shallow or deep had no significant effect on the WER. The effect of "Event" was not significantly different for shallow and deep sites. Mean WERs were found to vary significantly between events. **Table 4a** shows that there was a significant difference between WERs at each site during all four sampling events (i.e., p-value < 0.05 indicates significant difference with 95% confidence). Event 4 had a lower 95% confidence level value with a WER of 1.96, while Event 2 had a lower 95th % confidence value of 2.97.

Table 4. Mean WERs with 95% Confidence Intervals

a.

	DF	t-Value	P-value	**Mean WER**	95% Lower Confidence	95% Upper Confidence
Event 1	12	12.258	<0.0001	**2.25**	2.03	2.47
Event 2	12	9.349	<0.0001	**3.56**	2.97	4.16
Event 3	12	12.302	<0.0001	**2.58**	2.30	2.86
Event 4	10	9.929	<0.0001	**2.24**	1.96	2.51

b.

Shallow	19	8.276	<0.0001	**2.63**	2.22	3.04
Deep	29	11.939	<0.0001	**2.70**	2.41	2.99

c.

Total	49	14.530	<0.0001	**2.67**	2.44	2.90

Plots illustrating mean WERs and 95% confidence intervals are provided below. **Figure 3** illustrates that there was no significant difference between deep and shallow mean WERs when data were combined for all events. **Figure 4** shows that there was little variation between deep and shallow WERs between events. However, there was some variability in mean WERs between events (i.e., higher WERs in Event 2). The pattern of variation was consistent for deep and shallow water sites. **Figure 5** combined shallow and deep water site WERs into one mean for each event and then for all events.

The mean WER for all events is 2.67 (**Figure 4c**). The lower 95 % confidence for this combined WER is 2.44 and the upper 95 % confidence is 2.90.

Figure 3. Mean WERs: Deep versus Shallow

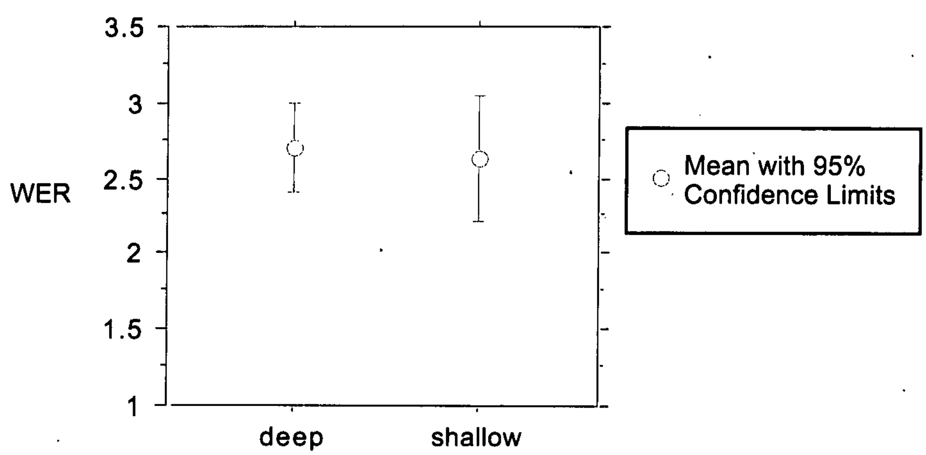


Figure 4. Mean WERs: Deep versus Shallow for Each Event

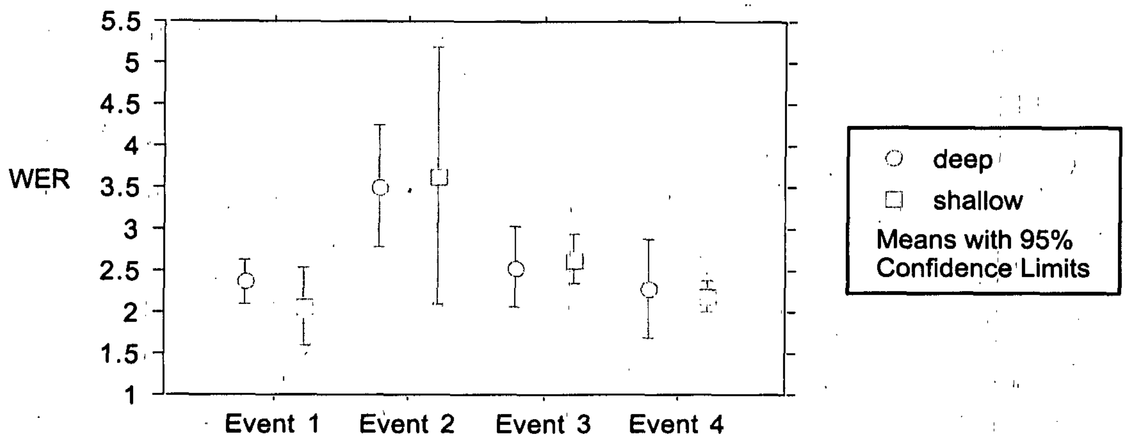
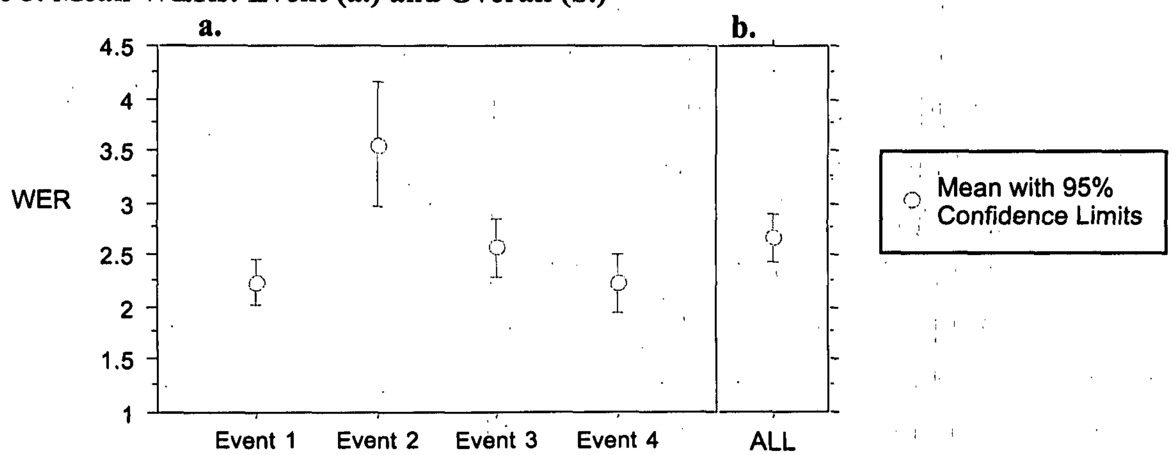


Figure 5. Mean WERs: Event (a.) and Overall (b.)



3.2.4 Site-to-Site Variations

To extend the potential Bay WER segmentation analysis presented previously, the sites sampled in this study were also grouped into four areas instead of two, as indicated in **Table 5** below. This grouping follows the historic Basin Plan segmentation (since superceded as part of the RMP redesign). A limitation of this pooling approach is that there are only four datapoints for the Central Bay and 6 for Suisun Bay and 20 datapoints each for the Lower and San Pablo Bay groupings.

Table 5. Major Subsections of San Francisco Bay North of the Dumbarton Bridge

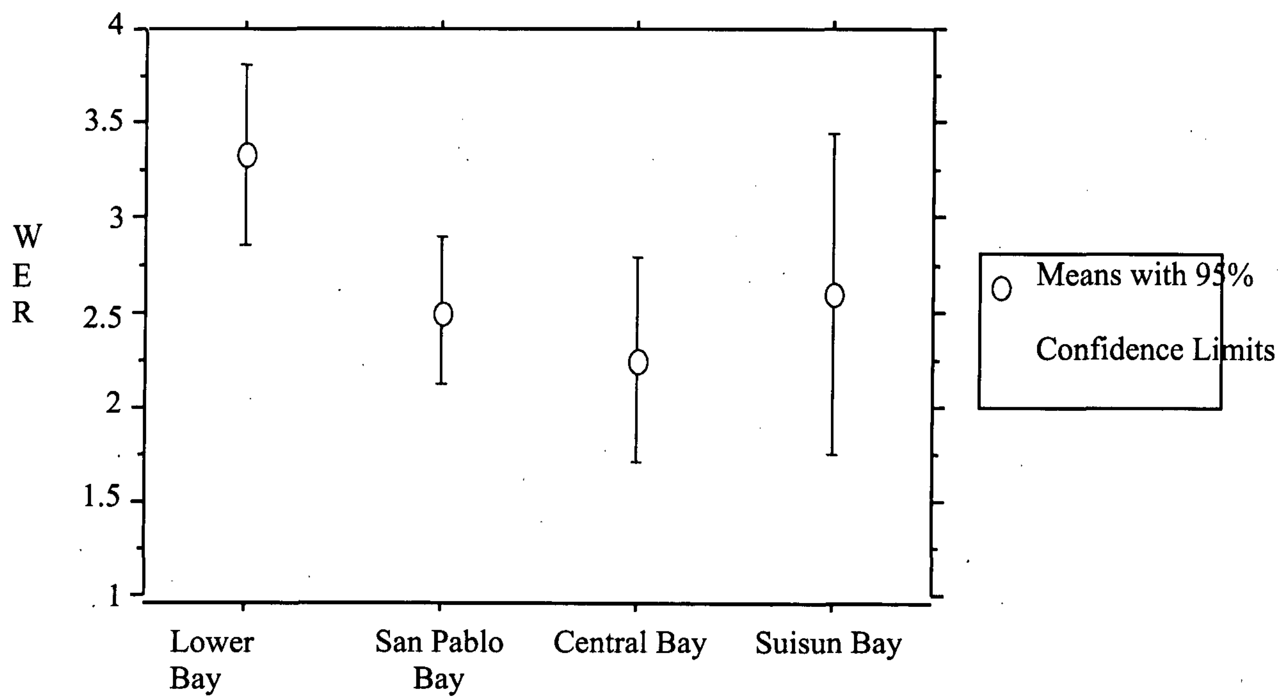
Lower Bay		Central Bay	San Pablo Bay		Suisun Bay
BB30	LCB01	BC10	BD15	LCB01	BF10
BB15	LCB02		BD20	LCB02	BF20
BA40				LCB03	

When using this grouping approach, there is a slight but statistically significant difference between the "Lower Bay" and "San Pablo Bay" sites ($p < 0.05$). **Table 6** shows p-values for comparisons between each of the groupings. **Figure 6** illustrates the different mean WERs in each of the subsections. These results could be interpreted to indicate that it may be appropriate to compute separate WERs for the San Pablo Bay and Lower Bay areas of the NDB WER study. However, further comparison shows that the difference between these two areas is small and that alternatively an average WER ± 0.5 could be considered for application to the entire Bay north of the Dumbarton Bridge. As shown in **Table 4c**, 0.5 is approximately the range between the upper and lower 95% confidence intervals for the Total (All Sites) pooled WER alternative.

Table 6. Subsection Comparisons and P-values

Site Comparisons:	P-value
Lower Bay – Central Bay	0.2691
Lower Bay – San Pablo Bay	**0.0004**
Lower Bay – Suisun Bay	0.7526
Central Bay – San Pablo Bay	0.6301
Central Bay – Suisun Bay	0.4234
San Pablo Bay – Suisun Bay	0.3124

Figure 6. Mean WERs in Distinct Areas of San Francisco Bay



3.2.5 Sample Specific WER Results

An aspect of spatial variability not directly addressed by WER measurements involves evaluating whether the measured ambient copper concentrations are exceeding toxicity threshold values (Hypothesis H7 in the NDB WER report). However the WER data can be used in an indirect manner to evaluate this issue by conducting what the WER guidance describes a "sample-specific WER approach" [U.S. EPA, 1994].

$$\frac{\text{Measured Cu } (\mu g/L)}{(3.1\ \mu g/L)(\text{Cu WER})}$$

In this approach, a quotient is calculated by dividing the concentration of dissolved copper (at each station) for each event by the product of the national WQC (3.1 µg/L) times the WER obtained for each station.

The WER guidance states that "when the quotient for a sample is less than 1.0, the concentration of the metal in that sample is acceptable, when the quotient for a sample is greater than 1.0, the concentration of metal in that sample is too high [U.S. EPA, 1994]."

A table of these values using the NDB data showed that all such quotients were less than 1.0 (**Table 7**). Similar results were submitted in 2001 and 2002 and part of the 2002 303(d) listing process to support the fact that the bay was not being impaired by ambient copper concentrations.

Table 7. Sample-Specific WER Approach Results

Station		Event 1	Event 2	Event 3	Event 4
Central Bay	BA40	0.3	0.2	0.3	0.3
	BB15	0.4	0.2	0.2	0.3
	LCB01	0.3	0.2	0.4	0.3
	LCB02	0.4	0.2	0.3	0.4
	BB30	0.3	0.2	0.2	0.2
	BC10	0.3	0.2	0.2	0.2
North Bay	BD20	0.4	0.2	0.2	0.4
	SPB01	0.4	0.3	0.2	0.4
	BD15	0.5	0.3	0.3	0.5
	SPB02	0.5	0.2	0.3	0.5
	SPB03	0.5	0.3	0.2	0.5
	BF10	0.4	0.2	0.2	*
	BF20	0.5	0.3	0.4	*

*data did not meet QA/QC criteria and were not used in WER analyses

3.3 San Jose Approach to Final WER and SSO Selection

This section reviews the approach and reasoning used by the City of San Jose in their WER study (May 1998) in evaluating final WERs (FWERs) and calculating alternative SSOs for the bay SDB. The discussion below focuses on the reasoning employed when evaluating the pros and cons of different data (station) pooling alternatives. Many of the variables assessed by San Jose for SDB are relevant to the FWER decisions to be made NDB.

3.3.1 FWER Selection

The San Jose study used both total and dissolved copper WER results from three stations (Dumbarton North, Dumbarton South and Coyote Creek) in their development and ultimate selection of a final Water Effects Ratio and calculation of a SSO. {Based on the greater variability in total WER results and the U.S. EPA support (since 1993) for dissolved WQOs, total WERs were calculated for and included in the WER report Appendices but were not considered for adoption as part of the NDB WER study}.

For San Jose, results from the two Dumbarton stations were very similar for all aspects of water quality, toxicology and determined WERs. The significant differences in WER values between the northern (two Dumbarton stations) and southern (Coyote Creek station) portions of the South Bay suggested that two site-specific criteria could be applied to the South Bay. For instance, a higher criterion based only on Coyote Creek WERs could be established for the southernmost portion of the South Bay (nearer to POTW flows) and a lower criterion established for the northern portion of the South Bay based on WERs from the Dumbarton Bridge stations. A concern about this multi-WER alternative was that it may have needed additional supporting information (e.g., dilution modeling involving all three POTWs in the South Bay). Nevertheless, it recognized the unique water quality characteristics and protection provided by different portions of the Bay, a factor to be considered in setting appropriate (i.e. neither under protective nor overprotective) site-specific criteria in the Bay.

In recognition of the regulatory complexities associated with a multiple SSO approach, two alternatives were developed by San Jose for the derivation and use of a single FWER value for the South Bay. These were a three-station pooled FWER (n=60) and a two-station pooled (Dumbarton) FWER (n=40). The uncertainty, albeit small, associated with the three-station FWER's protectiveness at the northern end of the study site led San Jose to suggest use of the two-station FWER of 2.771 to determine a site-specific criterion versus the three-station WER of 3.005.

3.3.2 Recalculation of the National Copper Criterion

A site-specific criterion is the product of the selected FWER and the national criterion (National Criterion * FWER = Site-Specific Criterion). The WER guidance (U.S. EPA, 1994a) suggests that the national criterion should first be evaluated and, as appropriate, modified using suitable quality site-specific data, prior to calculating the site-specific criterion. The current national saltwater copper Criterion Maximum Concentration (CMC) and Criterion Continuous Concentration (CCC) are 4.8 and 3.1 µg/L dissolved copper, respectively (U.S. EPA, 1995a). Prior to using the national criterion in the calculation, San Jose first recalculated it based upon the new information provided by the results from its study. The new data consisted of three

EC50 values for *Strongylocentrotus purpuratus* and six new EC50 values for *M. edulis*. Using the new data and following the appropriate national criteria derivation process (U.S.EPA, 1985), modified national criteria (CMC & CCC) were produced.

The current national saltwater copper Final Acute Value (FAV) is 10.39 µg/L based on the four most sensitive species. However, this FAV was lowered to 9.625 µg/L, the Species Mean Acute Value (SMAV) for *M. edulis*, in order to protect this commercially important species pursuant to USEPA guidance. As a result, the current national saltwater copper CMC is 4.8 µg/L (9.625/2=4.8). The current national saltwater copper CCC is 3.1 µg/L, which is the quotient of the SMAV of 9.625 µg/L and the current (U.S. EPA, 1995c) Acute/Chronic Ratio of 3.127 (9.625/3.127=3.1). This SMAV is derived from four SAIC (1993) and three ToxScan (1991a, b & c) values (**Table 8**).

When the six reference toxicant test dissolved copper EC50 values from the San Jose study were added to the above seven values, the new SMAV for *M. edulis* decreased from 9.625 µg/L to 7.888 µg/L (**Table 8**). This resulted in a new CMC of 3.9 µg/L dissolved copper (7.888/2=3.9) and a new CCC of 2.5 µg/L dissolved copper (7.888/3.127=2.5; **Table 8**).

This San Jose recalculation of the national copper criteria (CMC & CCC) was intended to produce conservative, scientifically defensible WER results. Whether this approach and permanent inclusion of the San Jose data (for *M. edulis* and *S. purpuratus*) into the national copper database is appropriate for other copper WER and SSO studies is subject to additional regulatory review.

3.3.3 San Jose SSO Selection

The U.S. EPA procedure and formula for calculating site-specific criteria (National Criterion * WER = Site-Specific Criterion) were used to calculate site-specific CCC values for the Lower South Bay WER study. The San Jose results supported either a two-station or a three-station FWER in deriving an appropriate site-specific CCC for the South Bay. The three-station dissolved FWER, based on the geometric mean of corrected dissolved WER values from all three stations in the study site (n=60) was 3.005. The two-station dissolved FWER, based on the geometric mean of corrected dissolved WER values for the two Dumbarton stations (n=40) was 2.771. Multiplying the three-station FWER by the modified national CCC of 2.5 µg/L produced a site-specific CCC of 7.5 µg/L dissolved copper. Multiplying the two-station FWER by the modified national CCC produced a site-specific CCC of 6.9 µg/L dissolved copper.

There were significant differences in WER values between the two Dumbarton Bridge stations and the Coyote Creek station. Therefore, this criterion (7.5 µg/L) would simultaneously under-protect the northern portion of the site (Dumbarton Bridge CCC = 6.9 µg/L) and overprotect the southern portion of the site (Coyote Creek CCC = 8.8 µg/L). This simultaneous overprotection and under-protection reflected an inherent drawback of implementing a single site-specific criterion in a site where the data demonstrated the potential need for a multiple criteria approach.

The pooled two-station Dumbarton Bridge site-specific CCC of 6.9 µg/L was the value ultimately supported by the TMDL workgroup and adopted by the RWQCB into the Basin Plan.

Table 8. Current and Modified National Copper Criteria to reflect the addition of NDB WER study data into the San Jose study modified EPA National Copper Criteria database.

Data Source	Dissolved Copper Criteria*		
	Proposed National Criteria (EC50) Data (USEPA 1995a)	Six San Jose (1998) EC50 Values Plus Proposed National Criteria Data (USEPA 1995a)	National Criterion Data, San Jose Data Plus Eight NDB Values (July 2002)
SAIC (1993)	12.5	12.5	12.5
SAIC (1993)	14.1	14.1	14.1
SAIC (1993)	11.3	11.3	11.3
SAIC (1993)	11.9	11.9	11.9
ToxScan (1991a)	5.787	5.787	5.787
ToxScan (1991b)	8.889	8.889	8.889
ToxScan (1991c)	6.278	6.278	6.278
San Jose (1998)		5.024	5.024
San Jose (1998)		4.392	4.392
San Jose (1998)		7.497	7.497
San Jose (1998)		6.789	6.789
San Jose (1998)		6.822	6.822
San Jose (1998)		7.806	7.806
NDB Study			8.05
NDB Study			8.32
NDB Study			5.64
NDB Study			9.36
NDB Study			7.08
NDB Study			6.91
NDB Study			6.80
NDB Study			9.44
FAV	9.625	7.888	7.776
CMC	4.8	3.9	3.9
ACR	3.127	3.127	3.127
CCC	3.1	2.5	2.5

FAV = Final Acute Value
CMC = Criterion Maximum Concentration
ACR = Currently proposed Acute-Chronic Ratio (U.S. EPA, 1995c)
CCC = Criterion Continuous Concentration
CMC = FAV/2; CCC = FAV/ACR
* The proposed national copper criteria are based solely on results with *Mytilus edulis* in order to protect this commercially important species.

3.4 NDB Final WER and SSO Selection

The current copper WQO applicable to San Francisco Bay NDB is the CTR CCC value of 3.1 µg/L times a WER (the default WER is 1.0). **Table A1** in Appendix A shows the complete set of individual NDB calculated site-specific WER based SSOs for each of the four events at each sampling station. These are the copper objective alternatives that are directly sanctioned by the CTR.

For comparative purposes, also shown are the equivalent individual station SSOs derived from the WERs multiplied by the San Jose (and NDB) adjusted national criterion of 2.5 µg/L. As shown in **Table 8**, adding in the eight labwater samples from the NDB study to the combined San Jose (1998) and national criterion dataset, produced the same recalculated CCC value of 2.5 µg/L as derived using the San Jose and national dataset.

The CTR WQO based SSOs for all four events ranged from 5.2 µg/L (BF20) to 8.4 µg/L (BA40 and BD15). While some of the ambient copper values approached the non-WER adjusted 3.1 µg/L level, most would be a factor of two to three below a SSO based on the WERs developed in the NDB study and either the CTR or recalculated WQOs (**Table A1**).

3.4.1 Comparison of North Of Dumbarton Study and San Jose Study WER Results

Results of the north of Dumbarton study are quite consistent with results obtained during the 1996-1997 San Jose study (**Table 9**). The Redwood Creek station (BA40) was investigated in both studies (in 2000 – 2001 and 1996 – 1997) and results were comparable (averages of 2.75 and 2.2). The City of San Jose used the BA40 results for comparative purposes but not for calculation of a final WER. Lab water results from the two studies were also in agreement, supporting the validity of comparing the two studies [see WER report and **Table 8**].

Table 9. Comparison of North of Dumbarton and San Jose Dissolved Copper WER Results

North of Dumbarton Study

Summary Statistics	Central Bay	North Bay	All Stations	All Stations Except BD15	Shallow Stations	Deep Stations
Number	24	26	50	46	20	30
Minimum	1.8	1.5	1.5	1.5	1.7	1.5
Maximum	5.2	5.3	5.3	5.2	5.2	5.3
a. mean	2.8	2.5	2.7	2.6	2.6	2.7
g. mean	2.7	2.4	2.6	2.5	2.5	2.6
Std. Deviation	0.8	0.8	0.8	0.7	0.9	0.8

San Jose Study

Summary Statistics	San Mateo	North of Dumbarton Bridge	South of Dumbarton Bridge	Coyote Creek
Number	7	20	20	20
Minimum	1.7	2.2	2.2	2.5
Maximum	2.4	3.9	4.5	4.8
a. mean	2.2	2.7	2.9	3.6
g. mean	2.1	2.7	2.8	3.5
Std. Deviation	0.3	0.4	0.6	0.8

3.4.2 NDB Site-Specific CCC (SSO) Recommendation

A primary goal of the NDB WER study was to produce scientifically defensible WER values that could be used with confidence by State and U.S. EPA regulators, dischargers and stakeholders to establish one or more SSOs for the Bay north of Dumbarton Bridge. Several conservative measures were employed in both studies including: using *M. edulis*, the most sensitive species listed in the marine criteria data set for copper, as the test species; and consideration of lowering the national CCC from 3.1 to 2.5 µg/L dissolved copper by incorporating the site-specific laboratory water results into the national copper data set.

As shown in **Table 9** there was a relatively small variation in the WERs for the different pooling alternatives. The statistical analysis had shown the WER data to be normally distributed. The USEPA guidance suggests using geometric means for FWER selection. The arithmetic means ranged from 2.5 to 2.8 while the geometric means ranged from 2.4 to 2.7. The All Sites arithmetic and geometric means are 2.7 and 2.6, respectively, in the middle of the already relatively narrow Central to North Bay range cited. The prior statistical analysis had shown there to be no significant differences between results at shallow versus deep water stations so those groupings are not considered further in the SSO selection analysis.

Site-specific CCC (SSO) values and associated summary statistics were calculated and shown below (**Table 10**) for the each of the four different sets of pooled station WER data. For comparative purposes, results are shown for SSOs derived from both the currently applicable CTR WQO (CCC) value of 3.1 µg/L and the San Jose and NDB data recalculated national value of 2.5 µg/L (**Table 8**). The prior statistical analysis found only a minor difference in WERs (0.5) between a pooling of Lower Bay versus San Pablo Bay stations. It further found that 0.5 was approximately the difference between the upper and lower 95% confidence intervals for the All Sites pooled WER alternative. Additional analysis showed there to be no statistically significant difference between the Central Bay and the North Bay pooled WERs.

These relatively small differences between the various pooled dataset provides some support for selecting a single NDB SSO using all the available data. If arithmetic averages are used (given that the data are normally distributed), an All Sites NDB SSO could range from 6.8 to 8.4 µg/L, depending on whether the CTR or recalculated WQO is used as the basis of adjustment by the All Sites FWER of 2.7.

Table 10. NDB Pooled Station Dissolved Copper SSO Summary Statistics

Summary Statistics	North Bay		Central Bay		All Sites		All but BD15	
	CTR SSO	Recalc SSO	CTR SSO	Recalc SSO	CTR SSO	Recalc SSO	CTR SSO	Recalc SSO
Minimum	5.6	4.5	4.7	3.8	4.7	3.8	4.7	3.8
5^{th} Percentile	6.8	5.5	5.0	4.0	5.3	4.3	5.3	4.3
Median	7.8	6.3	7.4	6.0	7.8	6.3	7.8	6.4
a. mean	8.7	7.0	7.8	6.3	8.4	6.8	8.1	6.5
g. mean	8.4	6.8	7.4	6.0	8.1	6.5	7.8	6.3
90^{th} Percentile	12.4	10.0	10.2	8.3	10.9	8.8	10.5	8.5
Maximum	16.1	13.0	16.4	13.3	16.4	13.3	16.1	13.0

Arithmetic Means	North Bay	Central Bay	All Sites	All Sites but BD15
CTR SSO	8.7	7.8	**8.4**	8.1
Recalc SSO	7.0	6.3	**6.8**	6.5

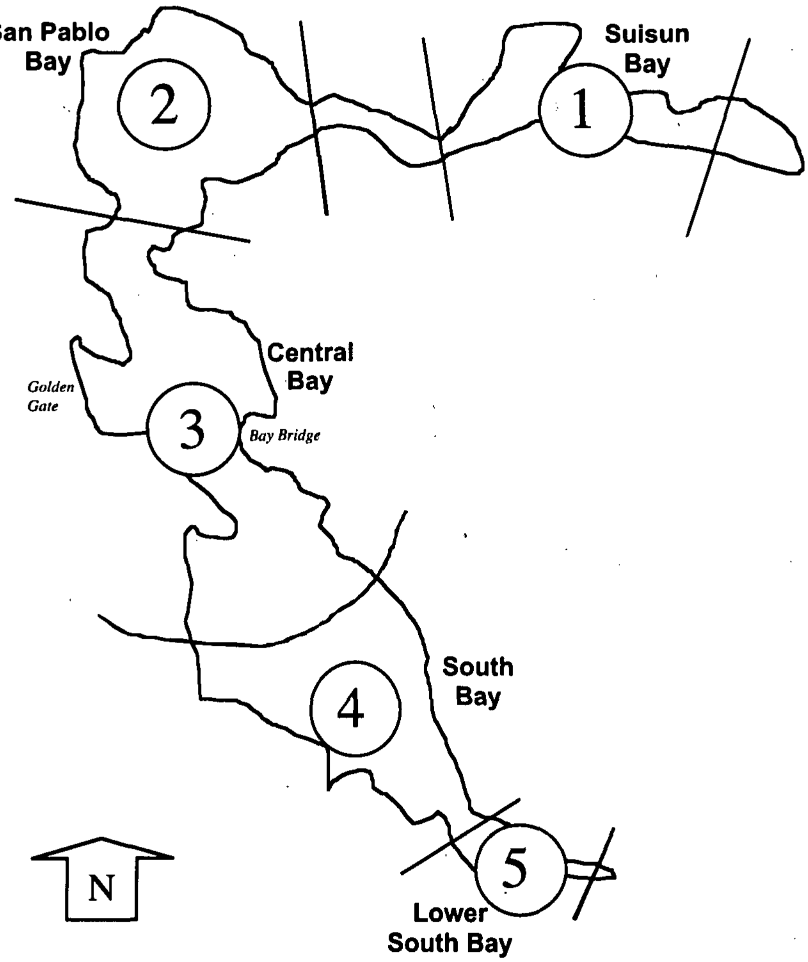
The low end of All Sites range is close to the Lower South Bay SSO value of 6.9 µg/L. The copper speciation results (Bruland 2003) provide an independent line of evidence that a SSO value in that range could be considered protective bay-wide. The report calculated that if the concentration of dissolved copper increased to a value of 6.9 µg/L, or 108 nM, it would raise the ambient [Cu^{2+}] to 10^{-11} M, a concentration that could impair the health and viability of the plankton. The study found that strong copper-complexing ligands dominate the chemical speciation of dissolved copper throughout San Francisco Bay, including the Central Bay (Yerba Buena Island station). The concentrations of these ambient organic ligands exceeded the total dissolved copper concentrations at every site, and these ligands complexed greater than 99.9% of the dissolved copper. Regardless of site or season, the [Cu^{2+}] values throughout San Francisco Bay did not exceed 10^{-13} M, a value deemed to be suitably below the toxicity limit for aquatic organisms.

3.4.3 Revised SSO Recommendation

Since the time of the WER study, the RMP has reevaluated the regional definitions in the Bay. The RMP now recognizes 5 regions (see **Figure 7**):

1. Suisun Bay
2. San Pablo Bay
3. Central Bay
4. South Bay
5. Lower South Bay

Figure 7. RMP Newly Defined Regions of San Francisco Bay



Rather than keeping the SDB work separate from the NDB work, it has been found that it is more appropriate to integrate the studies and create two SSOs for the entire Bay. These potential dissolved copper SSOs are calculated as 6.0 ppb for Bay Regions 1-3 and 6.9 ppb for Bay Regions 4 & 5. This approach protects *Mytilus* sp., the most sensitive species in the EPA database and a commercially important species. These SSOs are the result of two proposed WER values (2.4 for Regions 1-3; 2.7 for Regions 4-5). San Bruno Shoal was identified as the line between Regions 3 and 4. Further discussions on this approach can be found in Appendices C and D.

4. BIOTIC LIGAND MODEL

The Biotic Ligand Model (BLM) predicts metal toxicity to aquatic organisms based on the chemical characterization of a given water body. The model takes into consideration several water quality parameters, including hardness, DOC, chloride, pH, and alkalinity. The BLM was used to predict copper toxicity in the NDB WER study water samples from San Francisco Bay, and in the laboratory water samples from the Granite Canyon Marine Laboratory in Carmel, CA.

BLM input chemistry was measured in the second, third, and fourth sampling events. This model was previously developed with toxicity data from South San Francisco Bay WER study (Paquin et al., 2000). The model was used to predict EC50s "blind", i.e. without knowing the measured values until after predictions were made.

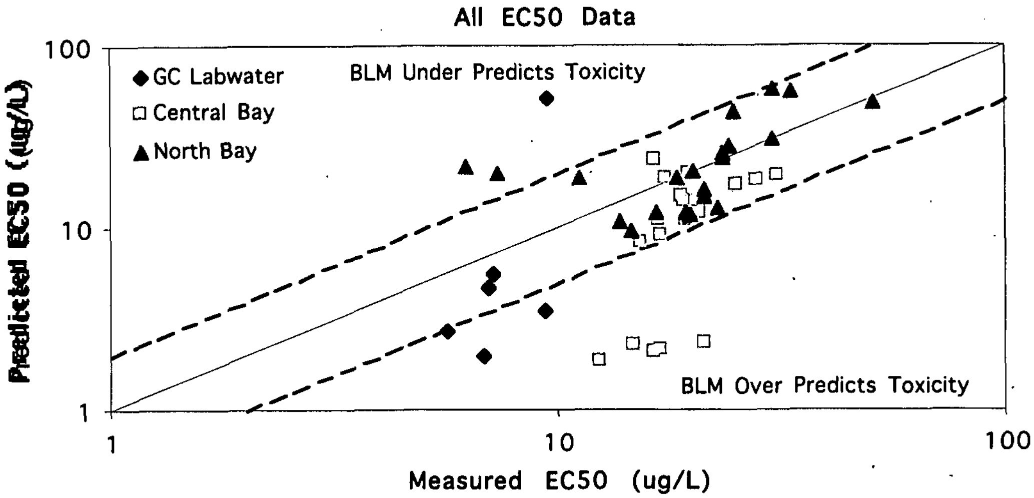
Previous comparisons of BLM predictions with measured toxicity data have established plus or minus a factor of 2 as a standard comparison indicating good agreement between predicated and measured values (Santore et al., 2001). Comparison of measured and predicted EC50 values in these results initially showed a number of samples that fell outside the plus or minus a factor of 2 zones that indicates good agreement (**Figure 8 upper**). The DOC concentration was reported as less than detection for many of these samples where the BLM predicted EC50s significantly different than measured values. Comparison of the measured DOC concentrations for each round of samples taken from a given station shows that these below detection limit values are anomalously low for these samples. Additionally, a reported DOC concentration of 11 mg/L for a Granite Canyon seawater sample appears to be anomalously high with a DOC concentration much higher than any of the field samples.

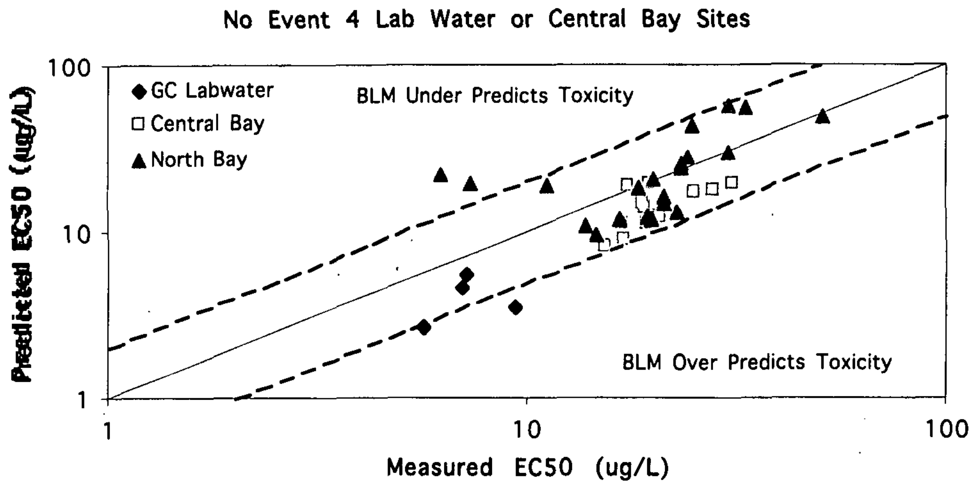
All of these samples with very low or high DOC concentrations were also cases where the BLM predictions based on those reported DOC concentrations did not match well with measured values. When these suspect TOC samples are censored, the comparison of predicted and measured Cu EC50s improves dramatically (**Figure 8 middle**). As discussed in the July 2002 WER report, two North Bay Event 4 toxicity test results were determined to be unreliable and not used is the WER calculations. When these values are censored (**Figure 8 bottom**) the model predictions improve further, with only 1 out of 58 samples falling slightly outside the range of good agreement.

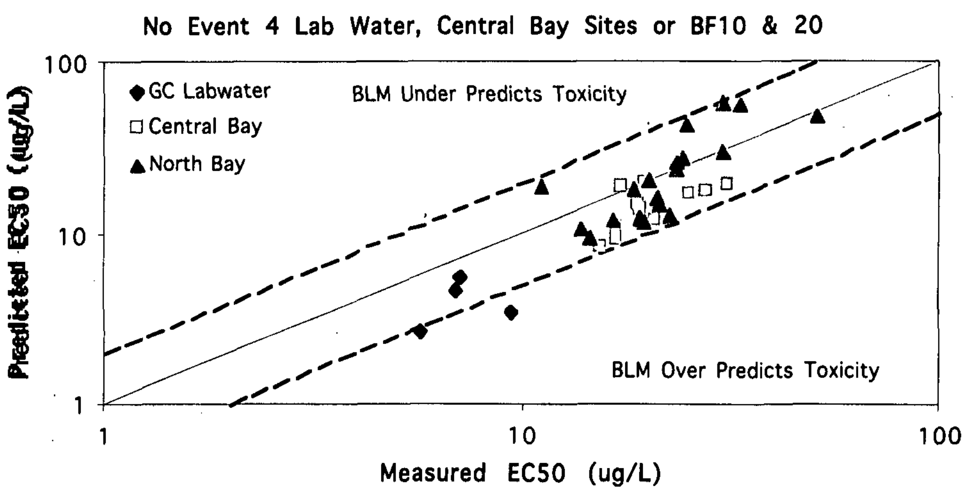
There does appear to be a systematic bias in the model results showing predictions that are too low at DOC concentrations below 4.0 mg C/L, and too high at DOC concentrations above this value. In general, the Cu BLM applied to estuarine data appears to predict too strong an impact of DOC on copper toxicity. This discrepancy has not been seen in freshwater datasets. The USEPA is currently reviewing the BLM as a potentially less resource intensive option to WER studies for the development of site-specific criteria.

Overall, the BLM results provided an independent confirmation of the high quality and reliability of the toxicity test data used to develop the NDB copper WERs and resultant SSOs.

Figure 8. Comparison of BLM Predicted versus NDB Study Measured Toxicity (*Mytilus* EC50)







5. COMPLIANCE EVALUATION WITH SSO BASED EFFLUENT LIMITS

The *SIP SSO Justification Request Report* (Draft February 27, 2004) included an evaluation of the ability of three case study POTWs to comply with non-WER adjusted CTR based copper and nickel effluent limits. **Tables 11** to **14** present similar compliance evaluations except with effluent limits calculated using a range of copper SSOs developed in this report based on the range of arithmetic and geometric mean WERs for the pooled North and Central Bay stations (2.4 – 2.8). These effluent limits use the associated pooled North and Central Bay median and 90th percentile translators (depending on discharge location) presented in the companion to this report the *Translator Development and Derivation Report* (Draft March 12, 2004).

Copper compliance continues to be an issue for shallow water (zero dilution) municipal secondary treatment plants such as LGVSD no matter what WER/SSO is selected (**Table 11**). Copper compliance may also continue to be an issue also for shallow water advanced secondary plants such as FSSD, depending on the SSO selected. Deepwater secondary treatment dischargers (with 10:1 dilution) with performance equivalent to EBMUD would appear to have minimal compliance issues with any SSO based limit.

Compliance with any of the SSO based nickel effluent limits does not appear to be an issue with these POTWs (**Table 12**).

Tables 13 and **14** show the projected percentage of all dischargers to comply with the range of SSO based effluent limits as read from the probability plots generated from the pooled ERS 2001 – 2003 effluent dataset (see the *SIP SSO Justification Report*). Secondary treatment POTWs and industries without dilution credit will have moderate to significant copper compliance problems even with the upper range of SSO based effluent limits. Advanced secondary POTWs without dilution may have minor compliance problems if relatively low WER based SSOs are selected. A small percentage of facilities with 10:1 dilution may have copper compliance problems if relatively low copper WER based SSOs are selected (**Table 13**).

A small percentage of industries without dilution credit may have compliance problems with effluent limits derived from the low end of the SSO range (**Table 14**).

Table 11. Copper SSO Based Effluent Limits – Case Study Compliance Evaluation

		LGVSD			FSSD			EBMUD		
WER	Chronic SSO (µg/L)	AMEL (µg/L)	MEC Comply? (25 µg/L)	99.87% Comply? (31.8 µg/L)	AMEL (µg/L)	MEC Comply? (9.0 µg/L)	99.87% Comply? (10.8 µg/L)	AMEL (µg/L)	MEC Comply? (25.9 µg/L)	99.87% Comply? (35.8 µg/L)
1.0	2.5	3.5	**No**	**No**	3.8	**No**	**No**	2.9	**No**	**No**
1.0	3.1	4.4	**No**	**No**	4.6	**No**	**No**	7.6	**No**	**No**
2.4	6.0	8.5	**No**	**No**	9.0	Yes	**No**	40.2	Yes	Yes
2.4	7.4	10.4	**No**	**No**	11.1	Yes	Yes	53.6	Yes	Yes
2.8	7.0	9.9	**No**	**No**	10.5	Yes	**No**	49.9	Yes	Yes
2.8	8.7	12.2	**No**	**No**	12.9	Yes	Yes	65.5	Yes	Yes

Note: AMELs assume use of NDB pooled North Bay or Central Bay metals translators and total metals ambient concentrations. EBMUD 10:1 dilution.

Table 12. Nickel SSO Based Effluent Limits – Case Study Compliance Evaluation

		LGVSD			FSSD			EBMUD		
WER	Chronic SSO (µg/L)	AMEL (µg/L)	MEC Comply? (8.2 µg/L)	99.87% Comply? (10.8 µg/L)	AMEL (µg/L)	MEC Comply? (6.6 µg/L)	99.87% Comply? (8.6 µg/L)	AMEL (µg/L)	MEC Comply? (16.0 µg/L)	99.87% Comply? (16.7 µg/L)
1.0	8.2	27.8	Yes	Yes	27.8	Yes	Yes	82	Yes	Yes
1.0	11.9	40.3	Yes	Yes	40.3	Yes	Yes	132	Yes	Yes
1.0	16.4	55.5	Yes	Yes	55.6	Yes	Yes	194	Yes	Yes
1.0	20.9	70.8	Yes	Yes	70.8	Yes	Yes	227	Yes	Yes

Note: AMELs assume use of NDB pooled North Bay or Central Bay metals translators and total metals ambient concentrations. EBMUD 10:1 dilution.

Table 13. Copper SSO Based Effluent Limits – All Dischargers Compliance Evaluation

		Shallow Water Dischargers Compliance (zero dilution)				Deepwater Dischargers Compliance (10:1 dilution)			
WER	Chronic SSO (µg/L)	AMEL (µg/L)	POTW % Secondary	POTW % Adv. Secondary	Industry %	AMEL (µg/L)	POTW % Secondary	POTW % Adv. Secondary	Industry %
1.0	2.5	3.5	6	45	20	2.9	4	33	15
1.0	3.1	4.4	12	57	30	7.6	40	89	55
2.4	6.0	8.5	50	94	58	40.2	>99.9	99.8	98
2.4	7.4	10.4	63	97	65	53.6	>99.9	>99.9	98.4
2.8	7.0	9.9	60	97	60	49.9	>99.9	>99.9	98.3
2.8	8.7	12.2	75	98	72	65.5	>99.9	>99.9	98.8

Note: AMELs assume use of NDB pooled North Bay or Central Bay metals translators and total metals ambient concentrations. EBMUD 10:1 dilution.

Table 14. Nickel SSO Based Effluent Limits – All Dischargers Compliance Evaluation

		Shallow Water Dischargers Compliance (zero dilution)				Deepwater Dischargers Compliance (10:1 dilution)			
WER	Chronic SSO (µg/L)	AMEL (µg/L)	POTW % Secondary	POTW % Adv. Secondary	Industry %	AMEL (µg/L)	POTW % Secondary	POTW % Adv. Secondary	Industry %
1.0	8.2	27.8	99.7	>99.9	92	82	>99.9	>99.9	99.5
1.0	11.9	40.3	>99.9	>99.9	98	132	>99.9	>99.9	>99.9
1.0	16.4	55.5	>99.9	>99.9	99.2	194	>99.9	>99.9	>99.9
1.0	20.9	70.8	>99.9	>99.9	99.4	227	>99.9	>99.9	>99.9

Note: AMELs assume use of NDB pooled North Bay or Central Bay metals translators and total metals ambient concentrations. EBMUD 10:1 dilution.

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Appendix A

Individual Sample Station Calculated SSOs Compared to Ambient Dissolved Copper Concentrations

Table A1. Comparison of Individual Station Calculated Site-Specific Dissolved Copper Water Quality Objectives with Ambient Dissolved Copper Concentrations. SSO Results Shown Based on both Existing CTR 3.1 µg/L WQO and Adjusted WQO of 2.5 µg/L

		Event 1 - September (dry)				Event 2 - February (wet)				Event 3 - April (spring)				Event 4 - June (dry)			
Station		WER	CTR SSO	Recalc SSO	Diss. Cu	WER	CTR SSO	Recalc SSO	Diss. Cu	WER	CTR SSO	Recalc SSO	Diss. Cu	WER	CTR SSO	Recalc SSO	Diss. Cu
			µg/L				µg/L				µg/L				µg/L		
Central Bay	BA40	2.7	8.4	6.8	2.9	4.2	13.0	10.5	2.7	2.7	8.4	6.8	2.5	3.1	9.7	7.8	2.9
	BB15	2.4	7.5	6.0	2.9	3.2	10.0	8.0	2.1	2.7	8.3	6.8	2.1	2.5	7.8	6.3	2.0
	LCB01	2.5	7.8	6.3	2.5	4.7	14.4	11.8	2.7	2.4	7.6	6.0	2.8	2.4	7.4	6.0	2.5
	LCB02	2.4	7.5	6.0	2.8	5.2	16.1	13.0	3.0	2.8	8.6	7.0	2.8	2.2	6.7	5.5	2.5
	BB30	2.5	7.8	6.3	2.6	3.5	10.8	8.8	2.2	2.4	7.4	6.0	1.6	2.4	7.5	6.0	1.7
	BC10	2.2	6.9	5.5	1.9	2.6	8.0	6.5	1.3	2.4	7.4	6.0	1.3	1.8	5.7	4.5	1.3
North Bay	BD20	2.2	6.8	5.5	2.5	2.6	7.9	6.5	1.9	2.0	6.2	5.0	1.5	1.5	4.8	3.8	2.1
	SPB01	2.0	6.2	5.0	2.5	2.6	8.1	6.5	2.4	2.9	9.0	7.3	1.8	2.0	6.3	5.0	2.5
	BD15	2.7	8.4	6.8	4.2	5.3	16.5	13.3	4.3	3.4	10.5	8.5	3.6	2.4	7.5	6.0	3.8
	SPB02	1.7	5.3	4.3	2.8	3.2	9.9	8.0	2.0	2.4	7.4	6.0	1.9	2.2	7	5.5	3.4
	SPB03	1.7	5.4	4.3	2.8	2.5	7.6	6.3	2.0	2.7	8.3	6.8	2.0	2.1	6.5	5.3	3.4
	BF10	2.5	7.9	6.3	2.8	3.5	10.9	8.8	2.5	3.1	9.6	7.8	2.3	*	*	*	2.7
	BF20	1.7	5.2	4.3	2.8	3.2	9.9	8.0	2.6	1.6	5.0	4.0	2.2	*	*	*	2.3

CTR SSO = WER X 3.1 µg/L
Recalc = WER X 2.5 µg/L
*Data did not meet QA/QC criteria and were not used in calculations

Appendix B

Executive Summary to
Bay Area Clean Water Agencies
Copper & Nickel North of the Dumbarton Bridge
Step 1: Impairment Assessment Report
Ambient Concentrations and WERs
September 2000 – June 2001

EXECUTIVE SUMMARY

Introduction

In accordance with Section 303(d) of the Clean Water Act, States are required to list waters that will not comply with adopted water quality objectives after imposition of technology-based controls on point source discharges. San Francisco Bay was listed on the 1998 303(d) list for California due to levels of total recoverable copper and nickel which exceeded 1986 Basin Plan total recoverable metals objectives and/or USEPA national criteria. These exceedances were the basis for a concern that copper and nickel were impairing aquatic uses in the Bay by producing either acute or chronic toxicity in sensitive aquatic organisms.

Events have occurred since the 1998 listing, which have given rise to re-evaluation of the listing. In the California Toxics Rule (CTR) of 2001, new water quality objectives for copper and nickel were adopted. Those objectives are based on the dissolved forms of copper and nickel, consistent with USEPA national policy, and provide for site-specific adjustments. Also, in South San Francisco Bay, work performed by the City of San Jose has indicated that modification of the CTR objectives for copper and nickel is appropriate. The studies in South Bay have indicated that 303(d) listing for copper and nickel is not appropriate.

To assess whether the 303(d) listings for copper and nickel in the rest of San Francisco Bay (north of the Dumbarton Bridge) should be modified or eliminated, it was recognized that complementary scientific work to that conducted by the City of San Jose should be conducted.

A bay-wide stakeholder group (Coordinating Committee, CC) consisting of regulators, municipal and industrial dischargers, and environmental group members was assembled to oversee development and implementation of a Work Plan that is consistent with the South Bay technical approach [Work Plan, 2000].

The primary purpose of the study outlined in the Work Plan was to collect data to improve the understanding of the aquatic toxicity of copper and nickel in San Francisco Bay north of the Dumbarton Bridge. The study was designed to provide information useful to the State in preparing the year 2002 303(d) list for San Francisco Bay. To meet this objective, the study was designed (1) to provide data which is scientifically defensible (accurate, reproducible, etc.), (2) to provide data which fairly characterizes existing ambient water column levels of copper and nickel in San Francisco Bay north of the Dumbarton Bridge, (3) to provide data which will be useful in the development of a site-specific water quality objective for copper for San Francisco Bay north of the Dumbarton Bridge, and (4) to provide data that will be useful in the derivation of "translator" values (relating dissolved and total ambient water column concentrations) which are used in deriving NPDES permit limits for copper and nickel.

The Work Plan for this project included convening a Technical Review Committee (TRC) to provide an independent outside critique of the project design and results.

This project has included participation from members of the following groups since its inception: North Bay Dischargers Group (NBDG), Bay Area Clean Water Agencies (BACWA), the

Western States Petroleum Association (WSPA), Bay Area Association of Stormwater Management Agencies (BAASMA), San Francisco BayKeeper (SF BayKeeper), Regional Water Quality Control Board staff (RWQCB), US Environmental Protection Agency staff (USEPA), San Francisco Estuary Institute (SFEI) and the Copper Development Association (CDA).

Sampling Procedures

Sampling was conducted at thirteen stations selected by the Coordinating Committee (CC) and described in the August 17, 2000 Work Plan (Work Plan). In December 2000, the technical review committee (TRC) for this study met to review the Work Plan and results of the first sampling run. As a result of the TRC meeting and subsequent Coordinating Committee discussion, it was decided to complete the study using the original thirteen north of Dumbarton Bridge stations sampled during Event 1. Sample site selection was based on existing RMP data, results from hydrodynamic modeling, and the need to explore shallow areas of the Bay. Sample events included 8 RMP sample sites (located in main channels of the Bay) and 5 shallow water sites (located in mudflat areas) sampled over a two-day period. The shallow water sites were chosen to create transects anchored on deep water RMP sites, in order to develop information on possible gradients extending into the shallows.

Sampling events were conducted during the period from September 2000 to June 2001. The goal of the sampling and toxicity testing was to produce four WER events (two from the dry season and two from the wet season). The rationale behind the sampling event selection was to capture the dominant hydrological conditions observed during the year. The selected number of events also represented a balancing of temporal coverage with the need for extensive spatial coverage to address representative areas of the Bay north of Dumbarton, both deep water and shallow water.

Clean sampling techniques were used for all fieldwork. All tubing and sample containers used for the collection of ambient water samples were cleaned following USEPA guidelines.

Laboratory Procedures

Laboratory tests used in the study included bioassay testing and chemical testing.

Mytilus edulis is the ideal organism for use in copper bioassays needed to determine Water Effect Ratio (WER) values due to its sensitivity to copper. WER values are used to establish site-specific adjustments to copper objectives, per the CTR. The *Mytilus edulis* toxicity test used for this study followed the guidelines established by the USEPA manual *Short-Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to West Coast Marine and Estuarine Organisms (EPA/600/R-95/136).*

Chemical analyses performed for this study followed USEPA clean techniques and procedures.

Quality Assurance/Quality Control (QA/QC)

The objective of this QA/QC analysis was to assess the acceptability of data generated during the four sampling events. Holding times, analytical accuracy and precision, potential contamination, and conformance to data acceptability criteria were investigated to determine if results needed qualification. Furthermore, any questionable results or missing data were identified and investigated.

Analytical chemistry accuracy and precision were monitored throughout the four sampling events of this study. Blanks, duplicate samples, and matrix-spikes were performed for each set of 20 samples. Accuracy was assessed through percent recovery analysis of external reference standards and matrix-spike experiments. Precision of methods was determined through the calculation of relative percent difference (RPD) between matrix duplicate and field duplicate analyses. Control limits for precision and accuracy for these analyses were 20% maximum RPD, and 75% minimum to 125% maximum recovery, respectively. Potential for contamination of environmental samples was evaluated through the analysis of lab, field, method, filtered, and procedure blanks to determine if contamination arose at the various stages of sampling and analysis.

With few exceptions, the results presented for the four sampling events were completed with sufficient QA data to support the validity of the reported data.

Results

The following summary highlights the key data obtained for copper and nickel. The analysis of data for other parameters assessed in this study are provided in the body of the main report.

Results of ambient copper and nickel monitoring from the four sampling events during this study were consistent with previous results from the San Francisco Bay Regional Monitoring Program (RMP). Median values of dissolved Cu at all stations during each of the four events ranged from 2.05 to 2.67 ug/L. Dissolved copper levels were higher at the Petaluma River mouth during each event, with a four-event median value of 3.98 ug/L. Dissolved nickel concentrations were typically well below the CTR dissolved nickel criterion. Again, dissolved nickel concentrations were highest at the mouth of the Petaluma River site. The median nickel value for all events and stations, excluding the Petaluma River site, was 2.48 ug/L.

Of the four sampling events, Event 2 (February 2001) yielded the highest values for major parameters, including ambient copper and nickel, copper EC50, copper dissolved WER.

In comparing results between sites, site BD15, located at the mouth of the Petaluma River, had consistently highest values for ambient copper, nickel, TSS, TOC and manganese. Copper toxicity was low at this site, apparently due to the elevated levels of organic and inorganic complexing material at this site. The sediment characteristics at BD15 were also unique, with predominantly fine grains site and clays present at this site.

The dissolved chronic saltwater copper water quality objective for the Bay is 3.1 ug/L times a water effect ratio (WER) (USEPA, CTR, 2000). A water effect ratio is an empirical value derived as the ratio between toxicity observed in site water versus toxicity observed in laboratory water. The WER provides the capability for site-specific adjustment of the copper objective. The only site that consistently exceeded a dissolved copper concentration of 3.1 ug/L was at the mouth of the Petaluma River (BD15). Two of the shallow water sites along transects in San

Pablo Bay (SPB02, SPB03) exceeded a dissolved copper concentration of 3.1 ug/L during Event 4.

The Basin Plan objective for nickel is 7.1 ug/L as total recoverable nickel. The CTR saltwater dissolved nickel criterion is 8.2 ug/L times a WER. The Regional Board planning staff is proposing a Basin Plan amendment, which will formally adopt this dissolved objective for San Francisco Bay. Studies in the South Bay indicate that the CTR nickel objective should be modified to be in the range from 12 ug/L to 24 ug/L. During this study, dissolved nickel concentrations only exceeded 8.2 ug/L during one event at the mouth of the Petaluma River. Total recoverable nickel concentrations exceeded the Basin Plan objective of 7.1 ug/L on a number of occasions. However, the common understanding is that these total recoverable exceedances are not indicative of adverse effects on aquatic life in the Bay.

Rigorous evaluation of copper toxicity and compliance with objectives requires consideration of the WER values for copper in San Francisco Bay. This study determined a range in dissolved copper WER values from site-to-site. The median WER values fall between 2.2 and 3.2, while the smallest and largest observed values range from 1.5 to 5.5. BD15 showed the most variability in dissolved copper WER, while sites such as BB15 and BC10 showed only slight variation from event-to-event.

Summary statistics and evaluation of hypotheses

As noted above, a number of prior studies have been performed in San Francisco Bay to address the aquatic toxicity of copper and nickel. The results were summarized briefly in the August 2000 Work Plan for this study and more extensively by the City of San Jose in its *Task 2 Impairment Assessment Report for Copper and Nickel in Lower South San Francisco Bay* [Tetra Tech, 2000]. The South Bay impact assessment indicated that the toxicity of copper and nickel to sensitive aquatic species in Lower South San Francisco Bay (south of the Dumbarton Bridge) was not as severe as predicted by current USEPA criteria or by existing Basin Plan objectives. USEPA criteria experts have reviewed and support these findings (USEPA July 27, 1998). The stakeholder process concluded that copper and nickel impairment is unlikely in the Lower South Bay based on ambient dissolved metals concentrations. The method used by the City of San Jose to calculate a nickel site-specific objective for the South Bay is applicable to the Bay north of the Dumbarton Bridge. The City of San Jose determined that a dissolved nickel objective within a range of 12 to 24 ug/L is technically defensible.

A site-specific copper water quality objective for the Bay north of Dumbarton can be calculated from the results of this study as the product of the WER and the national dissolved copper criterion value of 3.1 ug/L. This study developed 52 overall WERs (4 events, 13 stations/event). Overall median WERs, by event, were 2.41, 3.24, 2.67, and 2.24 for Events 1-4 respectively. The overall median WER, excluding station BD-15 was 2.48. Multiplying these median event WERS times the 3.1 ug/L national criterion would yield a range of possible dissolved copper objectives of 6.9 to 10.0 ug/L. A different range could be generated if the use of different WER values is justified.

Development and selection of one or more copper SSOs for the Bay north of Dumbarton is beyond the scope of this Step 1 Impairment Assessment study. Consistent with the South Bay approach, it is anticipated that additional technical information will need to be developed, such as translators, and alternative SSOs reviewed through the stakeholder process, before SSOs, and ultimately effluent limits, could be calculated for dischargers north of Dumbarton. This additional work is scheduled to be conducted as a follow-up to this effort.

Results from this study regarding copper WER values were compared to the results obtained in South Bay. Results for a common station (Redwood Creek) were comparable. The median WER values for this study were comparable to the median WER values observed at the north of Dumbarton site studied in the South Bay effort.

A number of hypotheses were identified at the outset of the study as a basis for the study design. The results obtained in the study were used to address those hypotheses. Statistical methods, including use of repeated measures analysis of variance (ANOVA), were employed in the hypothesis evaluation. The major findings from this evaluation are as follows:

- The study results conclusively indicate that the observed copper WER values for San Francisco Bay north of the Dumbarton Bridge are greater than the USEPA default value of 1.0. This means that an upward adjustment of the CTR copper objective is warranted.

- Copper WER values do not differ between sites located on the spine of the Bay and sites located in shallow, mudflat areas. This means that sub-region-specific or Bay-specific copper objectives may be appropriate.

- The number of sampling events was not sufficient to confirm whether seasonal effects influence copper toxicity. The high WER values observed during one of the four events were not sufficiently robust to demonstrate a seasonal effect.

- Ambient levels of dissolved copper in San Francisco Bay north of the Dumbarton Bridge did not exceed any of the range of WER-adjusted copper objectives during the study period. Except at the mouth of the Petaluma River, dissolved nickel concentrations do not exceed CTR chronic objective of 8.2 ug/L. If the recalculated nickel objective developed in South Bay is used, no nickel compliance problems would have been observed.

TRC/Coordinating Committee Comments/Responses

The TRC and CC have provided technical review and oversight functions over the course of this study effort. In additional to careful review of the ambient and bioassay elements of this study, comments have been received from the TRC and CC in the following topical areas: (1) concern for increased sediment concentrations of copper if objectives or effluent limits are less stringent, (2) concerns for phytoplankton toxicity due to copper, (3) impact of copper speciation on toxicity, (4) content and timing of "action plans", and (5) impacts of diurnal TSS variability on ambient concentrations of metals.

This summary addresses the sediment and phytoplankton questions. Other topics are addressed in the body of the report.

A concern was raised that increasing the discharge limits for copper concentrations may produce an increase in the concentration of copper in the sediments of the Bay. Based on the relatively small point source contribution of copper to sediments, it does not appear that the concerns of increased sediment concentrations will be realized. One potential approach to ensuring that copper levels in surface sediments do not increase significantly is to continue to monitor various areas of the Bay. If unacceptable increases in sediment concentrations of copper are detected, significant sources with linkage to the increase would be required to implement copper source control alternatives.

A concern also exists that existing dissolved copper levels in the Bay are toxic to various phytoplankton species. This issue had been raised previously in the review of the draft Impairment Assessment Report prepared for South San Francisco Bay as part of the Copper and Nickel TMDL program in that region. In that case, stakeholders had identified articles in the scientific literature, which indicated that marine species of phytoplankton, in particular species of cyanobacteria, were highly sensitive to copper. Additionally, some studies in San Francisco Bay had suggested that cyanobacteria species were not commonly found in the Bay. The Coordinating Committee for the north of Dumbarton Bridge study agreed that these concerns should be addressed in the Bay north of Dumbarton Bridge. After an initial level of research, it was noted that results from recent available studies in San Francisco Bay (Tetra Tech, Murrell and Hollibaugh, Palenik and Flegal) indicate that copper toxicity to phytoplankton is not in evidence. It was decided that phytoplankton field studies or toxicity studies would not be included as part of the current study. Rather, the decision was reached to utilize the results of ongoing phytoplankton studies in San Francisco Bay to further evaluate this issue.

Appendix C

Response to Comments

This Appendix includes:

- City of San Jose Comment Letter
- Responses to all comments received

City of San Jose Comment Letter

April 1, 2004

Tom Hall
Eisenberg, Olivieri and Associates
1410 Jackson Street
Oakland, CA 94612

RE: Comments on the March 2004 Clean Estuary Partnership Draft report entitled *North of Dumbarton Bridge Copper and Nickel Site Specific Objective (SSO) Derivation* prepared by EOA, Inc. and Larry Walker Associates

Dear Mr. Hall:

The City of San José (City) appreciates the opportunity to submit comments on the Clean Estuary Partnership (CEP) report entitled *North of Dumbarton Bridge Copper and Nickel Site Specific Objective (SSO) Derivation* (SSO Report) on behalf of the City and the San José/Santa Clara Water Pollution Control Plant. The City supports CEP's effort to develop technically defensible site-specific objectives for San Francisco Bay north of the Dumbarton Bridge (NDB). City staff has reviewed the SSO Report and offers the following observations and comments.

City staff concurs with the report's contention that three of the four options for deriving a chronic nickel criterion (ranging from 11.89 to 20.94 μg/L) are technically sound for the entire San Francisco Bay. Although 11.89 μg/L (rounded to 11.9) was the water quality objective promulgated for San Francisco Bay south of the Dumbarton Bridge, the City recognizes the scientific merits of a "marine species only" Acute-to-Chronic Ratio, which would support a chronic nickel criterion of 20.94 μg/L for the entire Bay.

The discussion of copper WERs and SSOs focuses on grouping the data into North and Central Bay areas (i.e. combining Bay Regions 4 & 3 and Bay Regions 1 & 2 together). A case is made for a Bay-wide SSO of 6.9 μg/L (Table 10 of the report). The City recognizes that a Bay-wide SSO of 6.9 μg/L is one potential approach. However, City staff has reviewed the NDB WER data and concluded that the most appropriate approach is to evaluate the NDB WERs by Bay region and to include Bay Region 5 (South of Dumbarton Bridge) in the evaluation.

The discussion of regional WERs in the report, however, is brief. It reverts to the historic "Basin Plan segmentation" rather than using the redesigned RMP regions as had been done in previous reports. Most importantly, it is inaccurate. Table 6 of the report, and the discussion preceding it, indicate that the WERs for Lower Bay (Bay Region 4) are statistically significantly different from WERs for San Pablo Bay (P=0.0004). Statistical analysis by City staff indicates that this conclusion is incorrect. Therefore, our staff's statistical analysis and the City's recommendation for an NDB approach to Final WERs are presented below.

City staff developed the following table of regional WERs based on the 2002 RMP regional monitoring design (Table 1).

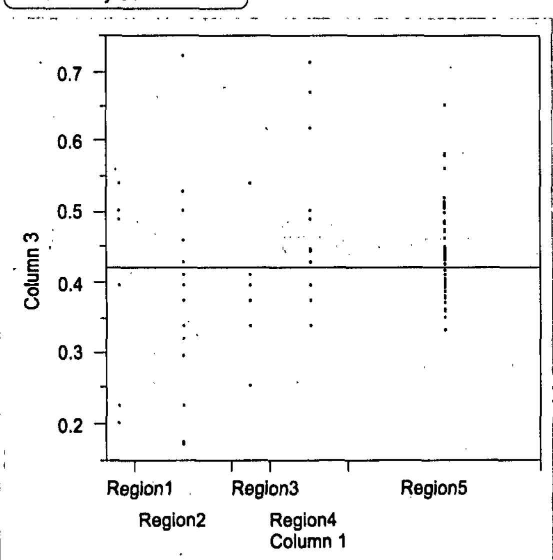
Table 1. Mean Water-Effect Ratios* by Bay Region

	Region 5	Region 4	Region 3	Region 2	Region 1
Arithmetic Mean WER	2.806	3.01	2.48	2.51	2.60
Geometric Mean WER	2.771	2.90	2.44	2.40	2.49
n	40	16	8	20	6

Region 5 is located south of the Dumbarton Bridge. Regions 4-1 proceed northward and eastward through the Bay with Region 1 being located at the mouth of the Delta.

Table 2. Analysis of Variance of WER results by Bay Region.

Column 3 By Column 1



Oneway Anova

Summary of Fit

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	4	0.09099623	0.022749	2.4028
Error	85	0.80476062	0.009468	Prob>F
C Total	89	0.89575685	0.010065	0.0560

City staff completed an analysis of variance (ANOVA) to determine whether Bay regional mean WERs were significantly different (Table 2). This analysis was performed on the log-transformed WER data (corresponding to the geometric mean WER data shown in Table 1). The log transformation improved the normality of the data. There was no significant difference among WERs based on Bay region ($P<0.05$, Table 2), whether or not Region 5 data were included. However, the probability of differences in WERs among regions increased to near significance ($p=0.0560$) with the addition of Region 5 data (Table 2).

Two conclusions can immediately be made from this technical analysis. It would be more appropriate to combine Region 3 WERs (geometric mean WER of 2.44) with those of Regions 1 and 2 (geometric mean WERs of 2.49 & 2.40, respectively) rather than with those of Region 4, based on means and the range of data. Region 4 WERs (geometric mean of 2.90) are more similar to those determined for Region 5, below Dumbarton Bridge (geometric mean WER of 2.771).

Recommendation:

The City recommends that the Final WER and SSO derived for Bay Region 5 of 2.771 and 6.9 µg/L, respectively, be extended to include Bay Region 4. It is also recommended that WERs for Bay Regions 1, 2, and 3 be combined to derive a Final WER of 2.4 for that area of the Bay. This results in two SSOs for the entire Bay.

City staff invites your comments and questions concerning this analysis and recommendation. If you should have any further questions, please contact me.

Sincerely,

Steven A. Osborn
Program Manager
Watershed Protection
Environmental Services Department
(408) 945-5303

cc: Bay Area Clean Water Agencies
Bay Area Stormwater Management Agencies Association
Larry Walker Associates

Response to Comments

Richard Looker Comment: For computing copper SSOs, I support use of the 2.5 µg/L dissolved CCC developed with the additional reference toxicant tests from the Lower South SF Bay and the North Bay study.

Response: *No response necessary.*

Richard Looker Comment: Did you adjust the FWERs due to the bias introduced through reduction of copper binding capacity in laboratory waters? (see page 33- of the SJ report "Development of a site-specific water quality criterion for copper in South SF Bay").

San José Response: *In the NDB WER study, laboratory waters were not adjusted to the salinity of site waters. No bias was introduced and no adjustment factors were needed.*

Richard Looker Comment: I suggest ignoring results from event 2 in selecting final WER(s). These results are high across the board and probably skew the results at all stations such that the overall central tendencies do not well-represent the typical conditions at those sites. I think it would be good to show summary statistics without consideration of event 2 to help with deliberations. This is analogous to the approach in the Lower South Bay where results from the southernmost station were not considered in computing the final WER, based on similar concerns.

San José Response: *EPA's metals criteria division chief, Glen B. Thursby, noted in his approval letter for the South Bay that "Region 9 will have to evaluate whether...using a WER of 2.8 for the CC sub-area would be too over protective." Thus, the analogy that REL is suggesting is that NDB stakeholders should evaluate whether the WERs from events 1,3 & 4 are overprotective of the wet season. There is really no analogy between the overprotection at Coyote Creek and the NDB wet weather WERs. All NDB events sampled the same stations. REL is comparing a spatial difference to a seasonal difference. To complete the analogy, REL would have to suggest that stakeholders evaluate whether the FWER derived for Bay Regions 1-3 would be overprotective if applied to all seasons. Indeed, this may be the case.*

The SSOs derived from the City's recommended FWERs for each Bay Region are shown in the attached figures. The mean toxicity values for event 2, which REL noted were somewhat higher than EC50 values for the other three events, are also shown in the attached figures. The City agrees with the conclusion that deleting the Event 2 data would be overly conservative and that the SSOs derived with WER results from all four events are protective (see Figures 1-4). In evaluating protectiveness, it is helpful to keep in mind the averaging period (4 days) and return frequency (cannot be exceeded more than once every 3 years) for SSOs.

Richard Looker Comment: There will be a problem in selecting a single WER value far above 2 because the typical value at Grizzly Bay (ignoring event 2) is more like 1.6 or 1.7. I could perhaps support a single WER in the neighborhood of 2 to be protective everywhere.

San José Response: *Grizzly Bay may have the least amount of bioavailable (i.e. toxic) copper of any of the NDB sites. Table 1 of the 2004 Buck and Bruland paper showed that the lowest* *observed [Cu^{2+}] concentrations during the January and March 2003 samplings were $10^{-15.5}$ M for Grizzly Bay.*

The City continues to support a FWER of 2.4 for Bay Regions 1, 2, and 3 and a FWER of 2.77 for Bay Region 4. This would result in SSOs of 6.9 and 6.0 for Bay Region 4 and Bay Regions 1-3, respectively. Using WERs from all events appears to be protective (see attached Figures 1-4).

Richard Looker Comment: We should re-check those copper speciation titration plots provided by Bruland as a cross-check of SSO values. We now have the ability to predict what the free ionic concentration would be under various SSO scenarios and this is useful to eliminate worries over harming phytoplankton. For example, below are two titrations (from two different sites) where the presumed threshold for phytoplankton toxicity is reached well below 6.9 µg/L

San José Response: *It may be overly conservative to regulate on phytoplankton since they have been shown to respond to ambient conditions differently than animal species. For example, they may regulate copper concentrations in their environment by producing exudates that bind ionic copper. Also, amelioration of copper toxicity to phytoplankton can occur with the presence of other competitive ions such as iron and manganese.*

City of San José Comment: The City of San José (City) appreciates the opportunity to submit comments on the Clean Estuary Partnership (CEP) report entitled *North of Dumbarton Bridge Copper and Nickel Site-specific Objective (SSO) Derivation* (SSO Report) on behalf of the City and the San José/Santa Clara Water Pollution Control Plant. The City supports CEP's effort to develop technically defensible site-specific objectives for San Francisco Bay north of the Dumbarton Bridge (NDB). City staff has reviewed the SSO Report and offers the following observations and comments.

Response: *No response necessary.*

City of San José Comment: City staff concurs with the report's contention that three of the four options for deriving a chronic nickel criterion (ranging from 11.89 to 20.94 mg/L) are technically sound for the entire San Francisco Bay. Although 11.89 mg/L (rounded to 11.9) was the water quality objective promulgated for San Francisco Bay south of the Dumbarton Bridge, the City recognizes the scientific merits of a "marine species only" Acute-to-Chronic Ratio, which would support a chronic nickel criterion of 20.94 mg/L for the entire Bay.

Response: *No response necessary.*

City of San José Comment: The discussion of copper WERs and SSOs focuses on grouping the data into North and Central Bay areas (i.e. combining Bay Regions 4 & 3 and Bay Regions 1 & 2 together). A case is made for a Bay-wide SSO of 6.9 mg/L (Table 10 of the report). The City recognizes that a Bay-wide SSO of 6.9 mg/L is one potential approach. However, City staff has reviewed the NDB WER data and concluded that the most appropriate approach is to evaluate the NDB WERs by Bay region and to include Bay Region 5 (South of Dumbarton Bridge) in the evaluation.

Response: *The Regional Board agreed to this at 6/3/04 meeting. Text regarding this approach is included in Section 3.4.3.*

<u>City of San José Comment:</u> The discussion of regional WERs in the report, however, is brief. It reverts to the historic "Basin Plan segmentation" rather than using the redesigned RMP regions as had been done in previous reports. Most importantly, it is inaccurate. Table 6 of the report, and the discussion preceding it, indicate that the WERs for Lower Bay (Bay Region 4) are statistically significantly different from WERs for San Pablo Bay (P=0.0004). Statistical analysis by City staff indicates that this conclusion is incorrect.

Response: *Further statistical analysis of the WER data from the NDB study has found the following results (significant difference when P<0.05):*

Comparison	P-value
Region 1 vs Region 2	0.7626
Region 1 vs Region 3	0.7320
Region 1 vs Region 4	0.2112
Region 1 vs Region 5	0.4866
Region 2 vs Region 3	0.9155
Region 2 vs Region 4	0.0292
Region 2 vs Region 5	0.1064
Region 3 vs Region 4	0.0721
Region 3 vs Region 5	0.2079
Region 4 vs Region 5	0.3179

The conclusions of this analysis confirm that WERs from Regions 1-3 can be combined into one WER (no significant difference between them) but that Region 4 is statistically significantly different from those Regions. Region 4 data should be compared to Region 5 data to assess the combination of Region 4 and 5 WERs.

<u>City of San José Comment:</u> The City recommends that the Final WER and SSO derived for Bay Region 5 of 2.771 and 6.9 mg/L, respectively, be extended to include Bay Region 4. It is also recommended that WERs for Bay Regions 1, 2, and 3 be combined to derive a Final WER of 2.4 for that area of the Bay. This results in two SSOs for the entire Bay.

Response: *The Regional Board agreed to this at 6/3/04 meeting. Text regarding this approach is included in Section 3.4.3.*

Appendix D

June 3, 2004
Copper & Nickel Workgroup
Meeting Materials

The following items are included in this Appendix:

- June 3, 2004 Copper & Nickel Workgroup Meeting Agenda
- June 3, 2004 Copper & Nickel Workgroup Meeting Notes
- San Jose PowerPoint Presentation from June 3, 2004 Copper & Nickel Workgroup Meeting: *Selection of NDB Copper WERs: Use Of The Mytilus Embryo Assays to Derive SSOs for San Francisco Bay North of Dumbarton Bridge*
- San Jose PowerPoint Presentation from June 3, 2004 Copper & Nickel Workgroup Meeting: *Development of a S.F. Bay Site-Specific Chronic Criterion for Nickel Using the EPA Recalculation Procedure and Modification of the EPA Nickel Saltwater Acute-To-Chronic Ratio*

Copper and Nickel Impairment Assessment Study
North of Dumbarton Bridge
CEP WORKGROUP MEETING

June 3, 2004, Thursday

1:00 p.m. to 5:00 p.m.

at EOA Office, 1410 Jackson Street, Oakland

DRAFT AGENDA

Proposed Time	Topic
1:00	**1. Introductions and Meeting Logistics**
1:10	**2. Purpose of Meeting** Review agenda. Desired Outcome: Agree on meeting format and process for reviewing reports, comments, and responses to comments. Discuss approach for selecting Site Specific Objectives (SSOs) and translators for north of Dumbarton Bridge (NDB).
1:20	**3. Copper/Nickel Project Overview** Project managers will present a summary of the CEP sponsored work conducted since the September 2003 workgroup meeting and the four resultant reports prepared by EOA/LWA.
1:45	**4. SIP SSO Justification Report Summary** Review the case study approach and information included in February 2004 SIP SSO Justification report. Desired Outcome: Determine what if any additional information is needed to justify adoption of copper and nickel SSOs NDB.
2:00	**5. Nickel SSO for NDB** Review the technical work conducted by San Jose summarized in the March 2004 SSO report that allowed for recalculation of the nickel water quality objective. Discuss pros and cons of using resident species vs national species and using a marine vs a combined marine/freshwater acute to chronic ratio (ACR) value for deriving an SSO. Desired Outcome: Provide consensus recommendation on a nickel SSO for NDB.
2:30	**6. Break**

2:45	**7. Copper SSO Selection for NDB** Review the Step 1 Water Effects Ratios (WER) work summarized in the March 2004 SSO report. Discuss variability in the data and alternative approaches for grouping the WER data and deriving one or more SSOs. Review copper speciation and Biotic Ligand Model (BLM) comparative information. Desired Outcome: 1) Provide consensus recommendation on one or more copper SSOs for NDB or 2) Agree on additional information or analysis needed before a recommendation can be made.	
4:15	**8. Copper and Nickel Translators for NDB** Review the copper/nickel translator work summarized in the March 2004 Translator report. Discuss variability in the data and alternative approaches for grouping the data and deriving one or more translators for NDB. Review implications for calculation of deepwater and shallow water effluent limitations. Desired Outcome: 1) Provide consensus recommendation on one or more copper and nickel translators for NDB or 2) Agree on additional information or analysis needed before a recommendation can be made.	
4:45	**9. Next Steps** Review the status of the copper/nickel action plan work and general agenda for the 6/21/04 CAP process meeting. Identify what if any additional technical work, such as modeling, is needed to address remaining scientific uncertainties as summarized in the Conceptual Model/Impairment Assessment report (CMIAR). Desired Outcome: Understand the process and remaining technical work needed to help prepare the Basin Plan Amendment SSO package.	
4:55	**10. Review Action Items**	
5:00	**11. Adjourn**	
For Additional Information, call Tom Hall 510-832-2852 x 110 or Tom Grovhoug 530-753-6400		

Copper and Nickel Impairment Assessment Study
North of Dumbarton Bridge
CEP Workgroup Meeting June 3, 2004
EOA, 1410 Jackson Street, Oakland

Meeting Handouts:

- Agenda
- *Copper and Nickel North of the Dumbarton Bridge: Impairment Assessment and Site Specific Objectives Project* slides from presentation given by Tom Hall & Tom Grovhoug during meeting.
- San Jose response to Water Board staff comments
- *Development of a S.F. Bay Site-Specific Chronic Criterion for Nickel* slides from presentation given by Pete Schafer during meeting.
- *Selection of NDB Copper WERs* slides from presentation given by Pete Schafer during meeting.

Attendees:

- Tom Foley (City of American Canyon)
- Giti Hernvian (City of American Canyon)
- Pete Schafer (City of San Jose)
- Karen McDonough (City of San Jose)
- Jim Ervin (City of San Jose)
- Ray Arnold – on phone (Copper Development Assoc.)
- Michael Yu (Sonoma County Water Agency)
- Kristine Corneillie (LWA, for City of Petaluma)
- Andy Gunther (AMS/CEP)
- Paul Salop (AMS/CEP)
- Arlene Feng (BASMAA/ACPWA)
- Larry Bahr (FSSD)
- Steve Moore (Water Board)
- Richard Looker (Water Board)
- Tom Hall (EOA)
- Tom Grovhoug (LWA)

General Announcements:
Richard Looker recently attended the Bay Planning Coalition Meeting, where Tracy Collier, NOAA, gave a presentation on PAHs and sublethal effects of copper. The mode of action is that it affects the ability to smell, particularly in juvenile fish, making them more susceptible to predators. A significant drop in the ability to smell was seen at dissolved copper concentrations of 5 ug/L, and effects were seen at as low as 2-3 ug/L. Richard will email the PowerPoint presentation, once he receives it from Tracy. This issue will need to be addressed as part of this NDB copper site specific objective project. Since the studies were performed in freshwater, it may not be as applicable or an issue for the Bay.

Richard also brought up the subject of the proposed new national criterion for copper. The new objective would change the current saltwater objective of 3.1 ug/L to 2.4 ug/L. However, it was discussed that EPA does not appear to have yet addressed any of the comments received on this change. San Jose's data was incorrectly used. San Jose provided EPA with corrected data and clarification for recalculation during the comment period. Relevant data from the NDB project was also provided to EPA (by EOA). It was also mentioned that there is consideration of a variable criterion based on site-specific water chemistry (similar to freshwater criteria).

Copper/Nickel Project Overview

Five draft reports have been prepared as part of the CEP FY 03-04 scope of work.

- Copper and Nickel Site Specific Objectives North of the Dumbarton Bridge – State Implementation Plan Justification Report (Draft February 2004);
- North of Dumbarton Bridge of Copper and Nickel Site Specific Objective (SSO) Derivation (Draft March 2004);
- North of Dumbarton Bridge Copper and Nickel Development and Selection of Finals Translators (Draft March 2004);
- North of Dumbarton Bridge Copper and Nickel Conceptual Model and Impairment Assessment Report (Draft April 2004); and
- Copper Sources in Urban Runoff Information Update (title subject to change, Draft March 2004).

Purpose of Meeting

Tom Hall discussed the agenda and the goals of the meeting which were to agree on the meeting format and process for reviewing reports, comments, and responses to comments. The group was then to discuss approaches for selecting SSOs and translators for NDB and as appropriate, discuss recommendations for specific SSOs and translators. The agenda and approach to achieving desired outcomes were approved.

Step 1 Water Effects Ratio (WER) Study Summary

Tom Hall and Tom Grovhoug presented the background of the Copper & Nickel Step 1 Impairment Assessment Work (handout):

- Step 1 work occurred between 1999 – 2002, with the final report being published in July 2002. The work was funded by BACWA, BASMAA and WSPA.
- Step 1 work was a direct extension of the City of San Jose's work in the South Bay. The report also addressed the issue of whether deep vs. shallow areas of the Bay would result in very different WERs or copper concentrations.
- Four sampling events over one year at 13 stations provided adequate data to account for spatial and temporal variability. The study design was reviewed and approved by the Technical Review Committee after the first sampling event.

SIP SSO Report:

- The SSO report is a requirement of the SIP. The original report outline included the use of 3 POTWs as case studies to evaluate compliance with CTR versus SSO based copper and nickel effluent limits. Available effluent data from the Electronic Reporting System (ERS) database for other POTWs and industries were also evaluated. A concern was raised that the arguments in the report did not adequately demonstrate "that the discharger cannot be assured of achieving the criterion and/or effluent limitation through reasonable treatment, source control, and pollution prevention measures" (per SIP Section 5.2(3)).

Action Item: Look at all dischargers, not just a representative sampling to get a more complete picture of economic impacts to each discharger relative to complying with CTR based effluent limits. Better documentation of nickel compliance problems is needed.

- This discussion brought up the translator issue – how could regional translators be calculated/applied in a manner that is "fair" to everyone? (See later item on agenda)
- The three case study POTWs were:
  - o FSSD (medium advanced secondary treatment, zero dilution)
  - o EBMUD (large secondary treatment, 10:1 dilution)
  - o LGVSD (small secondary treatment, zero dilution)
- Probability plots for POTWs and Industrial dischargers were presented as well as tables of probable effluent limits showing the case studies' ability to comply with these limits.

Development of a S.F. Bay Site-Specific Chronic Criterion for Nickel - Pete Schafer presentation (see Powerpoint handout).

- The City of San Jose performed studies in 1996-1998 to develop a nickel site-specific objective (SSO). This included a recalculation of the national nickel criterion and a study to develop Acute-to-Chronic Ratios (ACR) for three additional marine species. ACRs are a way to calculate chronic criteria from acute values when sufficient chronic data is not available to directly calculate a Final Chronic Value. The current nickel ACR is based on acute and chronic data for 3 species (2 freshwater species and 1 saltwater species). Nickel ACRs for saltwater species appear to be considerably lower than the freshwater ACRs.

  The lower the Final ACR is, the higher the calculated chronic criterion using a given Final Acute Value. The average ACR for the current 3 species is 17.99. The 3 new (saltwater) species tested by the City of San Jose produced ACRs of 6.22, 5.50, and 6.73 (all significantly lower than current 17.99). The City then used the new ACR data to recalculate both chronic National criteria and site-specific objectives first using Final ACRs derived first exclusively from marine species and second from a combination of marine and freshwater species. Chronic SSOs recalculated in these ways are applicable bay-wide, not just to the Lower South Bay.

- The four derived options for a final chronic value were thus **24.42** ppb (revised national criterion using an ACR based only on marine species), **20.94** ppb (derived SSO using an ACR based only on marine species), **13.86** ppb (revised national criterion using an ACR based on a combination of marine and freshwater species), and **11.89 ppb** (derived SSO using an ACR based on a combination of marine and freshwater species). The final number approved in the Lower South Bay effort was 11.89 ppb, the most conservative of all of the derived nickel chronic criteria.

- A question was posed as to whether marine species tend to have different ACRs than freshwater species, but no one present had a definitive answer. There are various approaches that the EPA uses to derive ACRs. Usually, sensitive species have sensitive ACRs, but sometimes there is no relationship between these two variables. Since chronic data are typically lacking, the EPA often uses both freshwater and marine ACRs in combination to derive final ACRs, especially for marine species. In the case of nickel, however, there appears to be a significant difference between ACRs for freshwater and marine species.

  Marine species appear to have lower ACRs (which produce higher final chronic SSOs). The chronic nickel SSO approved for Lower South Bay is thus quite conservative since it was based on a combination of marine and freshwater ACRs. A chronic nickel SSO of 20.94 ppb based on the more technically robust marine-only ACR may have been as appropriate (or more appropriate) than the approved SSO of 11.89 ppb.

- The report on nickel recalculation can be found on the City of San Jose's website http://www.ci.san-jose.ca.us/esd under Publications & Research.

- After Pete's presentation, the representatives from the Water Board (Steve Moore & Richard Looker) discussed "Where do we go from here?" They had no disagreements on the science. However, they indicated that a potential roadblock is that the Staff Report needs to outline why this SSO process got started (compliance issues, etc.). Currently, nickel NDB doesn't appear to present the same level of compliance issues that copper does. The federal antidegradation policy states "this is a tier 2 water body...water quality can be decreased to meet social or economic needs". One policy issue to address then becomes "why do we need to decrease water quality when there is no burden on the discharger?" A related policy and public perception issue discussed was "does raising the objective result in lower water quality?"

  Discharger representatives noted that increasing the objective to 11.9 ug/L or 20.94 ug/L does not mean they can or will increase discharged nickel concentrations. Water Board staff noted that the Office of Administrative Law reviews changes to objectives and in part has to make a "determination of necessity," i.e. are there compliance problems or other reasons for having to adopt an SSO? The only documented area in the bay exceeding the CTR 8.2 ug/L dissolved nickel WQO is at the mouth of the Petaluma River. This area already has its own 303(d) listing. Others mentioned that some industrial dischargers may not be able to comply with CTR based limits. The group agreed to further investigate this issue as part of subsequent work on the SIP SSO justification report, including documentation of what dischargers with potential compliance issues have already done or could do to comply, and the associated costs.

NDB Copper WERs - Tom Hall and Tom Grovhoug presented background information on the NDB Copper & Nickel Work and 50 resultant WER datapoints.

- Plots of dissolved copper WERs were presented and the Water Board attendees suggested that it would be good to change "Event 1, Event 2, etc" notation to "dry weather, wet weather, etc" notation.
- The Biotic Ligand Model work performed by the Copper Development Association (CDA) was discussed in terms of how it was a good check of the model and of the Cu/Ni study data.
- In the Step 1 work effort, the Bay was separated in to North and Central areas. Upon the restructuring of the RMP efforts, the data collected in Step 1 were then re-evaluated using the Region 1, 2, 3, 4, 5 designations.

NDB Copper SSOs by Bay Region - Pete Shafer continued his presentation on the City of San Jose's recommended options for WERs and SSOs (handouts).

- Pete discussed that the copper criteria ultimately approved for the Bay NDB must be protective and he provided graphs of ambient copper, trigger, toxicity values, and potential SSOs to show that the City's recommended SSOs appeared to be protective. The City's approach would create two SSOs for the entire Bay. **These potential SSOs were 6.0 ppb for Bay regions 1-3** (Suisun Bay (1), San Pablo Bay (2), and Central Bay (3)) and **6.9 ppb for Bay regions 4 & 5** (South Bay (4) and Lower South Bay (5) below Dumbarton Bridge). This approach protects *Mytilus* sp., the most sensitive species in the EPA database and a commercially important species.

- Ambient dissolved copper monitoring trigger levels were discussed. Pete clarified that based on the lower South Bay approach, for a trigger to be exceeded, the <u>mean</u> of the annual dataset would need to increase to the trigger level, not just one data point.
- It was also pointed out that it is important to watch seasonal variation. Dissolved copper concentrations are typically lower during the winter and higher in the summer.

After Pete's presentation, Richard Looker and Steve Moore said the SSO work "looks good" and they could support the two proposed WER values (2.4 for Regions 1-3; 2.7 for Regions 4-5). San Bruno Shoal was identified as the line between Regions 3 and 4.

- Individual dischargers will need provide input on the compliance impacts of the proposed SSOs since under one policy scenario there could be different translators for each discharger, resulting in different effluent limits for each (see next section below). The CEP group agreed to incorporate a more detailed compliance analysis into the final report.
- Water Board staff noted that it is important to be careful as we move forward with SSOs about sending messages such as "copper and nickel are not a problem". There was concern that such statements could be construed as license to back off on current levels of control efforts. Copper and nickel can more appropriately be viewed as a lesser threat now, based on the greater level of knowledge available.
- Jim Ervin of the City of San Jose mentioned that it is important to be cautious in recommending alternatives to copper products that may result in other unanticipated adverse impacts (i.e., pesticides or endocrine disruptors).

Translators - The next topic discussed was the issue of choosing translators for the Bay NDB. The initial translator analysis used both the direct ratio method and the TSS regression method and incorporated both the NDB study data and historic RMP data. Given the large amount of data available, the relatively low r-squared values in the regression plots, and the small differences in the resultant values between the two methods, use of the direct ratio calculation results were recommended.

- Richard Looker indicated that pursuant to the SIP, the Water Board staff appears to be open to discussing possible site specific dilution studies for Bay Area dischargers. Development of a revised dilution policy has been identified as part of the Basin Plan trienniel review process as an important but potentially complex and resource intensive issue to pursue.
- The proposed Regional translator approach was presented.
- An example table was presented showing case study POTW compliance with copper effluent limits based on a WER of 2.4. EBMUD could comply with effluent limits calculated using 2.4, FSSD could comply sometimes, and LGVSD could not comply based on historic data.
- To date, absent regional translator policy guidance, translators have most commonly been applied on a discharger by discharger, case-by-case basis by NPDES permit writers. However, it was recognized that one or more pooled, regional translators, particularly for deep-water dischargers, may be appropriate. Shallow-water dischargers may need to evaluate site-specific translators, develop a rationale for using regional RMP-based translators, or create groupings based on shallow regions (i.e., Napa River region). Translator issues need to be addressed on a regional basis by dischargers, permit writers, Basin Plan staff, and TMDL staff. Translator issues were recommended to be discussed as part of the Basin Plan triennial review.

- It was decided the best short-term translator approach may be to proceed with the Basin Plan Amendment for the SSOs including one or more translators for deep water dischargers and to address shallow discharger translators outside of the BPA process so as to not unduly hold up the SSO approval process. Waiting to develop the more complex policy guidance for translators for shallow-water dischargers may be acceptable, as long as the issue does not get lost once the SSO is adopted. Larry Bahr proposed to take this phased translator approach to BACWA for discussion.

Next Steps

- The draft NDB Cu/Ni Conceptual Model Impairment Assessment Report (CMIAR) summarizes and updates the status of scientific uncertainties regarding copper impairment from the South Bay study. Hydrodynamic modeling (w/sediment) may help with answering some of the remaining questions (i.e., accumulation of Cu in sediment and effects on ambient conditions) but would be costly (~$50,000).
- The CEP is currently looking at available models. Jay Davis created a 1-box model of the Bay for PCBs. It is recognized that the Bay is not a single box, and different regions likely behave very differently. The USGS has created a 41-box model that takes into account sediment transport. The 41-box model is currently being calibrated on salinity and bathymetry. SFEI is converting the USGS model to a multi-box model using the five Bay segments for the RMP, and taking the first cut to determine how it can be improved and what other information is needed (erosion, deposition) to do so. Easily manipulated models are necessary.
- The Brake Pad Partnership Proposition 13 funded copper fate and transport study will be using the USEPA BASINS watershed model to generate bay-wide estimates of copper loading. These loading estimates will be used as input to the URS/SFO hydrodynamic/sediment model for bay-wide copper fate and transport modeling during 2006.
- The City of San Jose indicated they would be resistant to funding more modeling that would only be applicable to copper. San Jose could support modeling that could be used for multiple parameters and region wide.
- Andy Gunther encouraged people to fill in CEP project description forms re: developing models for multiple parameters.

Finalize CEP Reports. No one indicated a desire to provide further comments on the draft reports, so the four reports will be finalized based on the comments received as of this 6/4/04 meeting.

6/21/04 CEP Cu/Ni workgroup meeting. The FY 04-05 CEP Cu/Ni Basin Plan Amendment (BPA) technical assistance draft scope of work and the next steps for the Copper and Nickel Action Plans are scheduled to be discussed in more detail at the 6/21 meeting. In response to a question from Andy Gunther, Richard confirmed that supporting CAP development is a vital part of the CEP's task to assist the BPA process.

Selection of NDB Copper WERs

Use Of The *Mytilus* Embryo Assays to Derive SSOs for San Francisco Bay North of Dumbarton Bridge

Environmental Services Department
City of San Jose
June 3, 2004

Approach to SSO Development NDB

- Indicator Species Procedure
- A biologically-based adjustment to the EPA national copper criterion
- Adjustment accounts for differences between clean laboratory seawater and the specific characteristics of the site water

Water-Effect Ratio Procedure

- Collect: Site Water - presumed to have high binding capacity
  Laboratory Water - "clean" natural seawater with low binding capacity
- Spike with varying amounts of copper
- Inoculate with sensitive embryos
- Determine EC50s

WER & SSO Calculation

- WER = Site Water EC50/Lab Water EC50
- Final WER (FWER) = Geometric mean WER
- SSO = FWER X National Criterion
- $$\text{SSO} = \frac{\text{Site Water EC50}}{\text{Lab Water EC50}} \times \text{Lab Water (National) Criterion}$$

Definition of Terms

- EC50 - 50% effect concentration; acute endpoint
- FAV - Final Acute Value (Regression of 4-most-sensitive genera)
- CMC - Criterion Maximum Concentration (FAV/2) - EPA acute criterion
- ACR - Acute-to-Chronic Ratio (acute endpoint divided by the chronic endpoint of the same material under the same conditions)
- FCV - Final Chronic Value (FAV/ACR)
- CCC - Criterion Continuous Concentration (the lower of the FCV, the Final Plant Value, or the Final Residue Value

EPA Procedure

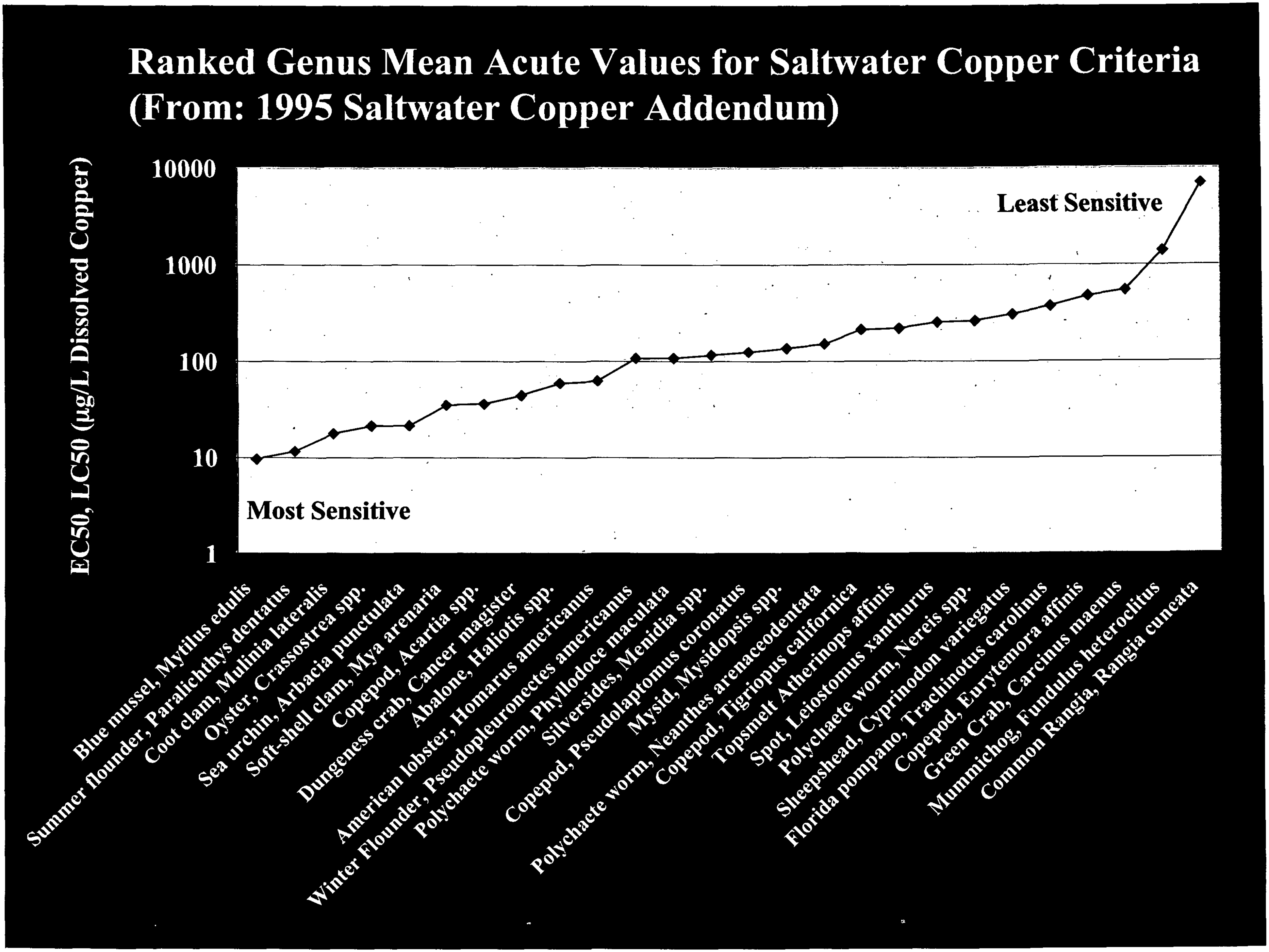
- Review acute & chronic tests, assemble acute & chronic databases and rank species
- Minimum Data Requirements
  - 8 Families represented in database, etc.
- Derive FAV by Regression method; derive CMC
- Derive ACR - 8 methods listed in the 1995 EPA Saltwater Copper Addendum
- Derive CCC directly or indirectly

EPA 1995 Saltwater Copper Addendum

ACR Derivation - Method 4

"When acute tests used to derive the FAV are from embryo/larval tests with molluscs, and a limited number of other taxa, it has been considered appropriate to assume that the ACR is 2.0; thus the CMC equals the CCC [e.g., copper (SW), cyanide (SW)]"

The current (CTR) Copper ACR is 3.127



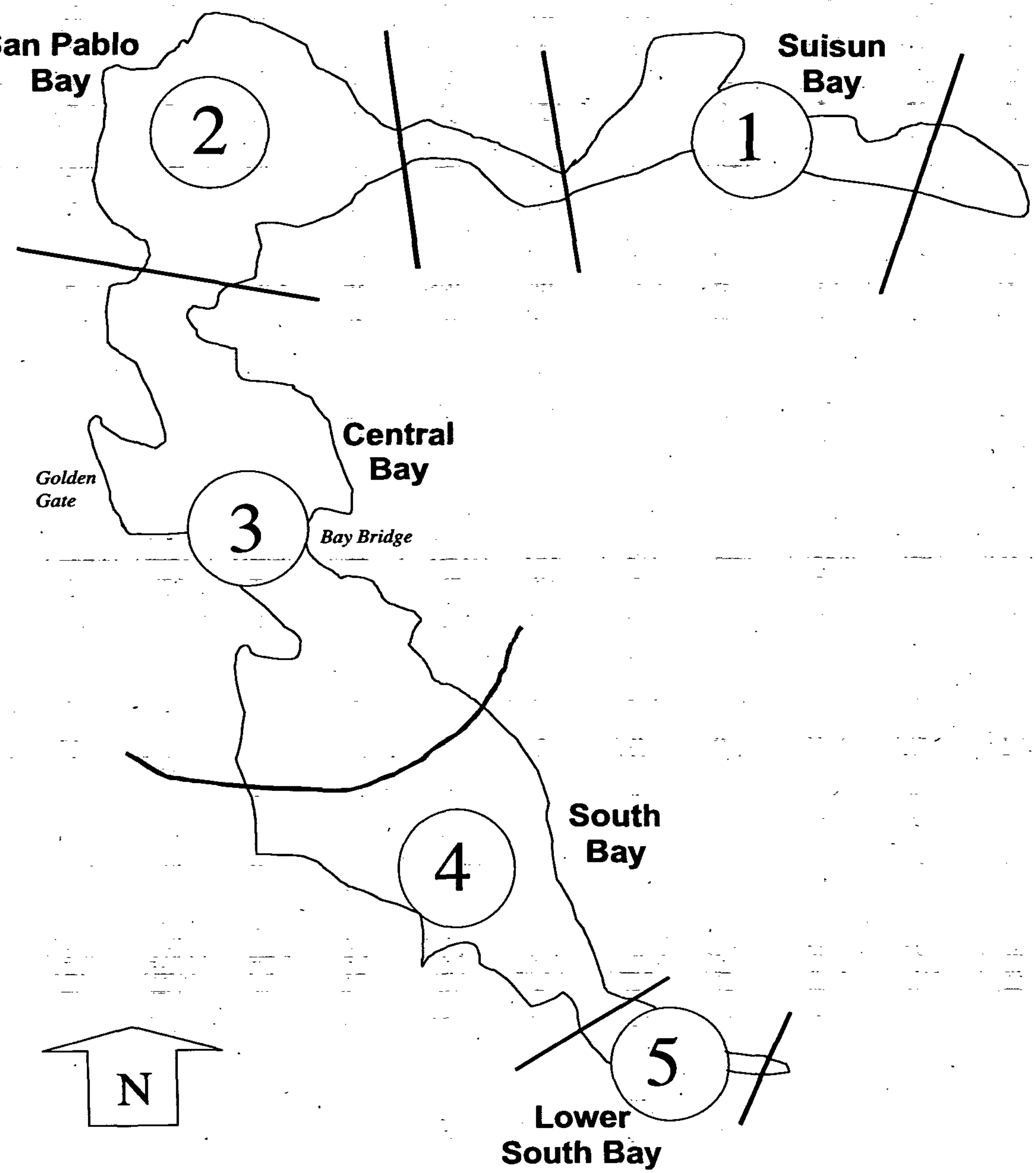
Ranked Genus Mean Acute Values for Saltwater Copper Criteria (From: 1995 Saltwater Copper Addendum)
EC50, LC50 (µg/L Dissolved Copper)
10000
1000
100
10
1
Least Sensitive
Most Sensitive
Blue mussel, Mytilus edulis
Summer flounder, Paralichthys dentatus
Coot clam, Mulinia lateralis
Oyster, Crassostrea spp.
Sea urchin, Arbacia punctulata
Soft-shell clam, Mya arenaria
Copepod, Acartia spp.
Dungeness crab, Cancer magister
Abalone, Haliotis spp.
American lobster, Homarus americanus
Winter Flounder, Pseudopleuronectes americanus
Polychaete worm, Phyllodoce maculata
Silversides, Menidia spp.
Copepod, Pseudolaptomus coronatus
Mysid, Mysidopsis spp.
Polychaete worm, Neanthes arenaceodentata
Copepod, Tigriopus californica
Topsmelt Atherinops affinis
Spot, Leiostomus xanthurus
Polychaete worm, Nereis spp.
Sheepshead, Cyprinodon variegatus
Florida pompano, Trachinotus carolinus
Copepod, Eurytemora affinis
Green Crab, Carcinus maenus
Mummichog, Fundulus heteroclitus
Common Rangia, Rangia cuneata

Sensitivity Revisited

- Copper FAV lowered from 10.39 to 9.625 ppb to protect *Mytilus* sp.
- Mytilus embryo/larval development tests conducted on very sensitive life stage
- ACR (3.127) not based on *Mytilus* sp. but on *Daphnia, Gammarus, Physa* & *Mysidopsis* (now *Americamysis*)
- National Criterion modified by current Mytilus Lab Water data from 3.1 to 2.5 ppb

More Definition of Terms

- Power Analysis - Statistical method used to develop an ambient concentration trigger
- Trigger - The smallest increment that can be statistically detected in future sampling given a specific n (number of samples) and a specific variability (variance) in existing data.


San Pablo Bay
2
Suisun Bay
1
Central Bay
Golden Gate
3
Bay Bridge
South Bay
4
Lower South Bay
5
N

Bay Region Mean Water-Effect Ratios

	Region 1	Region 2	Region 3	Region 4	Region 5
Arith. Mean	2.6	2.51	2.48	3.01	2.806
Geo. Mean	2.49	2.40	2.44	2.9	2.771
n	6	20	8	16	40

San Jose Recommendation

- Adopt Ni WER of 2.4 for Bay Regions 1-3
- Adopt Ni SSO of 6.0 for Bay Regions 1-3
  - (2.4 X 2.5 = 6)

- Adopt Ni WER of 2.771 for Bay Region 4
  - (lowered from 2.9 to 2.771)
- Adopt Ni SSO of 6.9 for Bay Region 4

Figure 1. Bay Region 1 Copper Concentrations; Toxicity Values; Potential Trigger and Site-Specific Objective

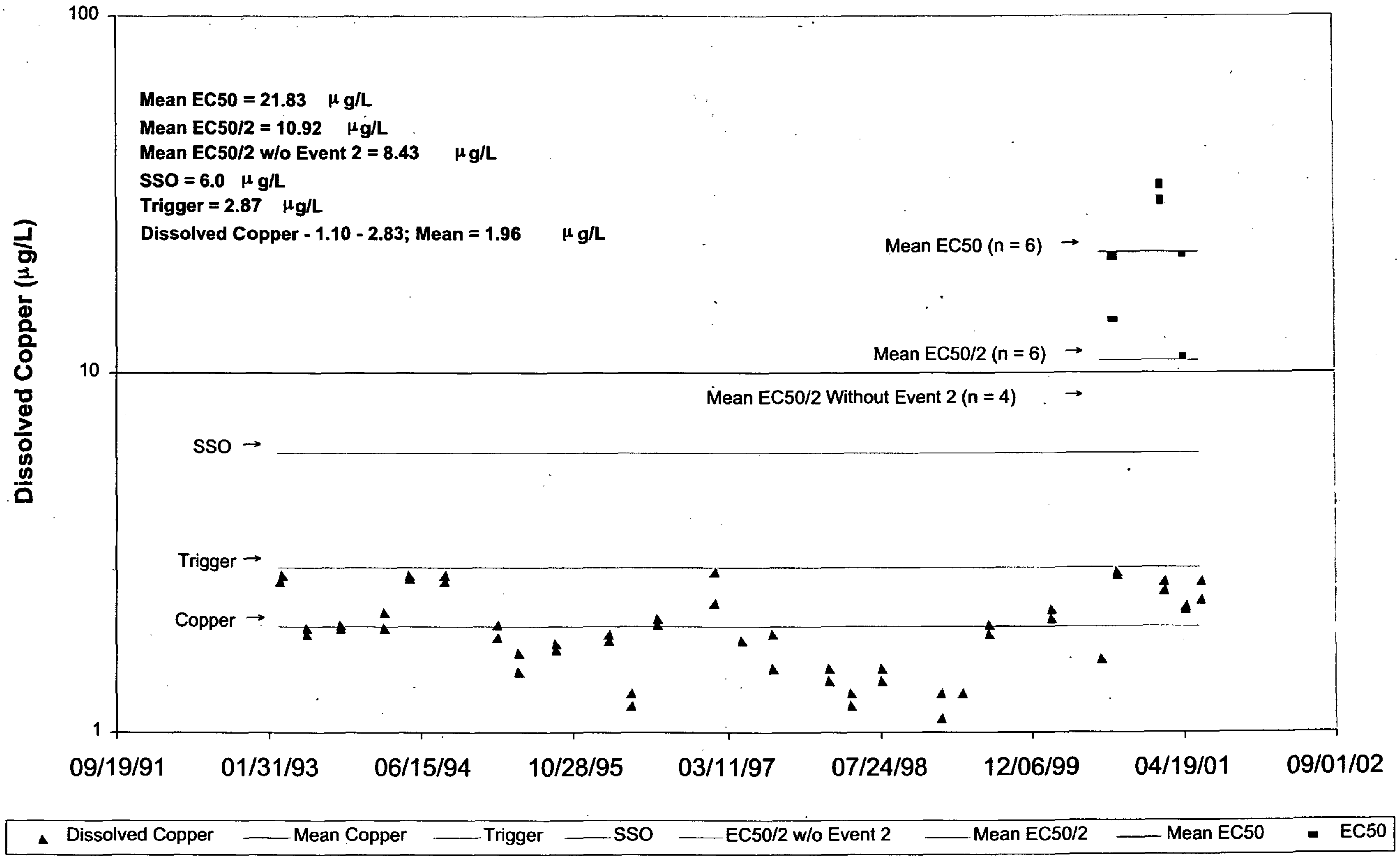


Figure 2. Bay Region 2 Copper Concentrations; Toxicity Values; Potential Trigger and Site-Specific Objective

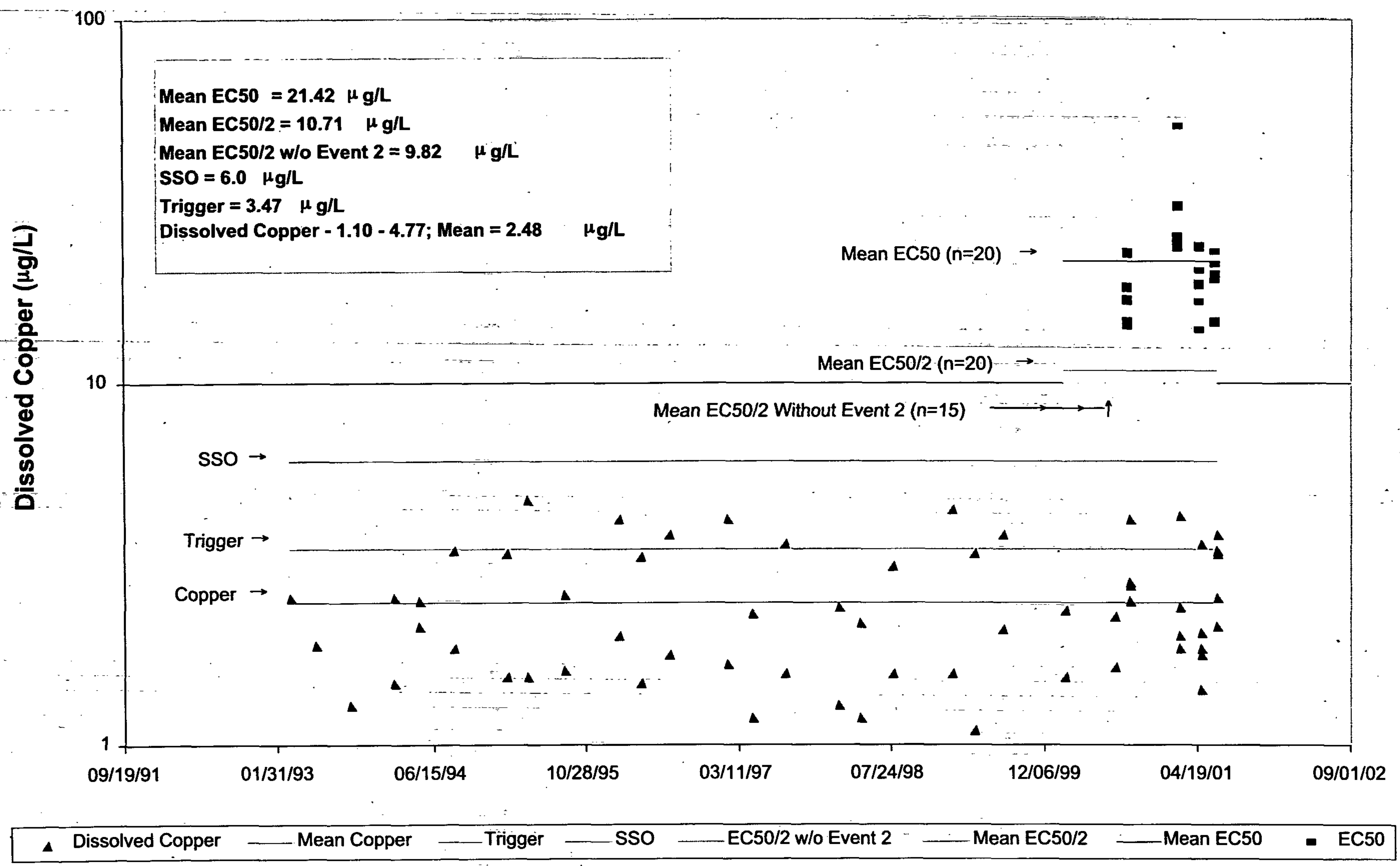


Figure 3. Bay Region 3 Copper Concentrations; Toxicity Values; Potential Trigger and Site-Specific Objective

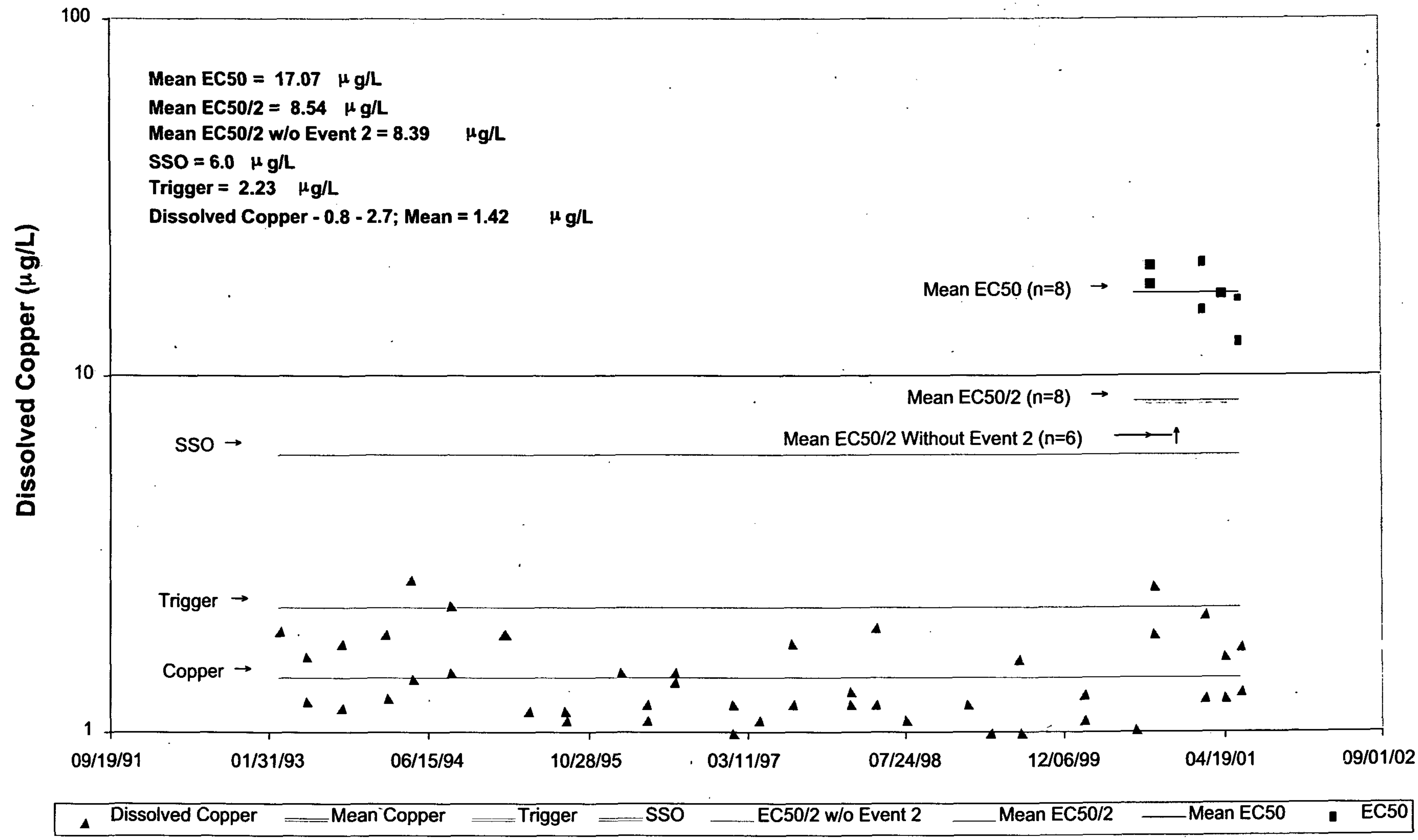


Figure 4. Bay Region 4 Copper Concentrations; Toxicity Values; Potential Trigger and Site-Specific Objective

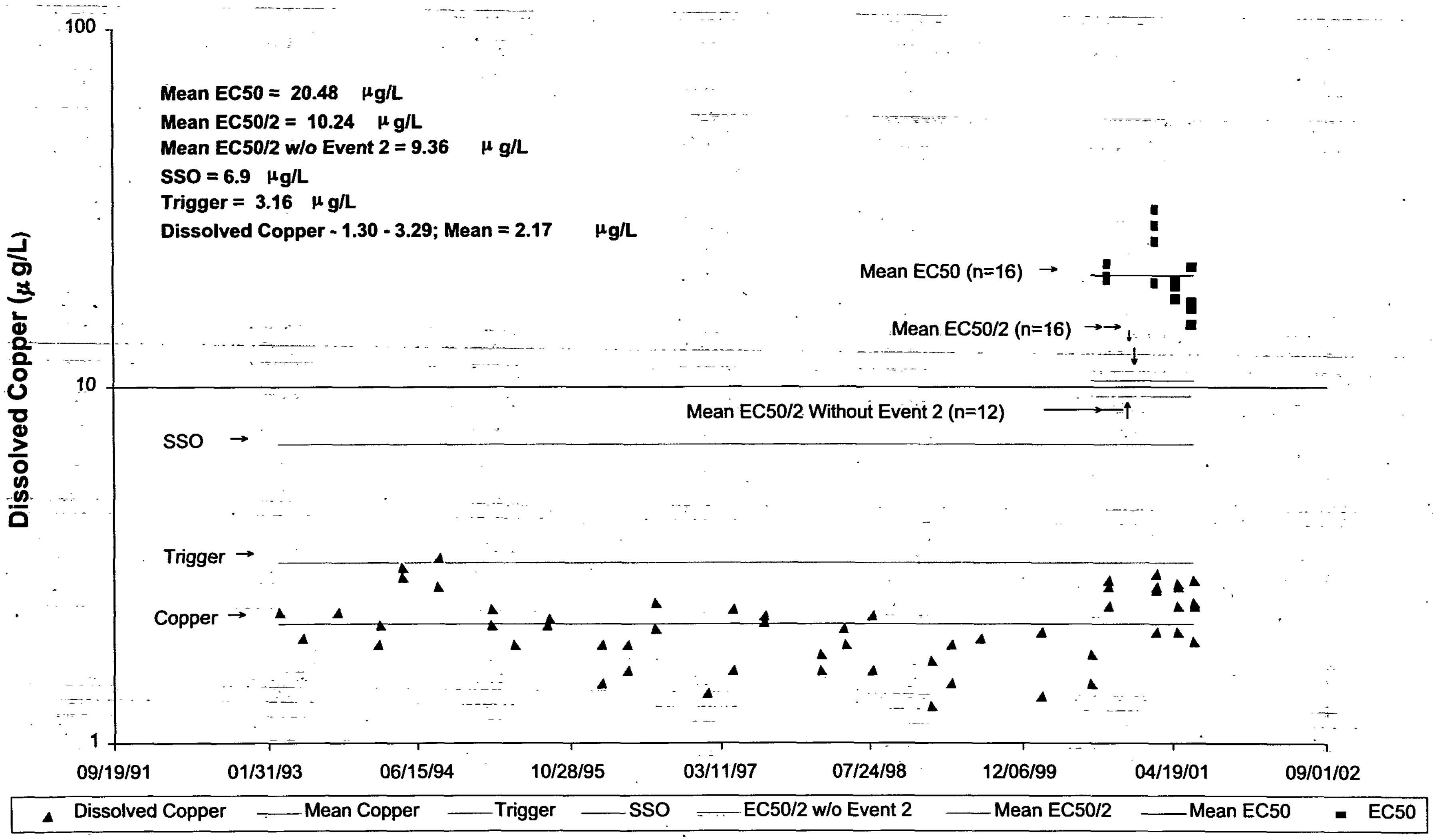
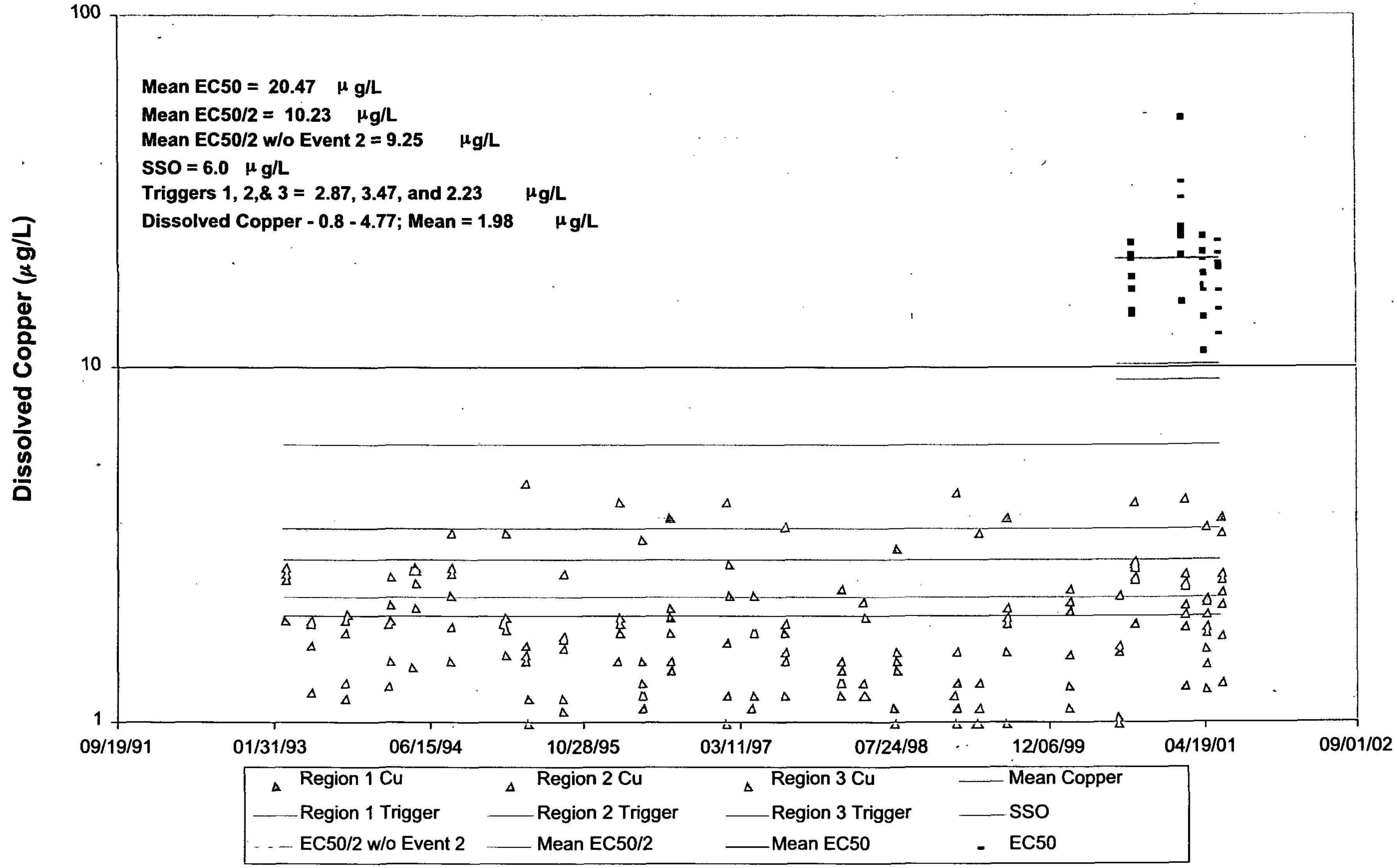
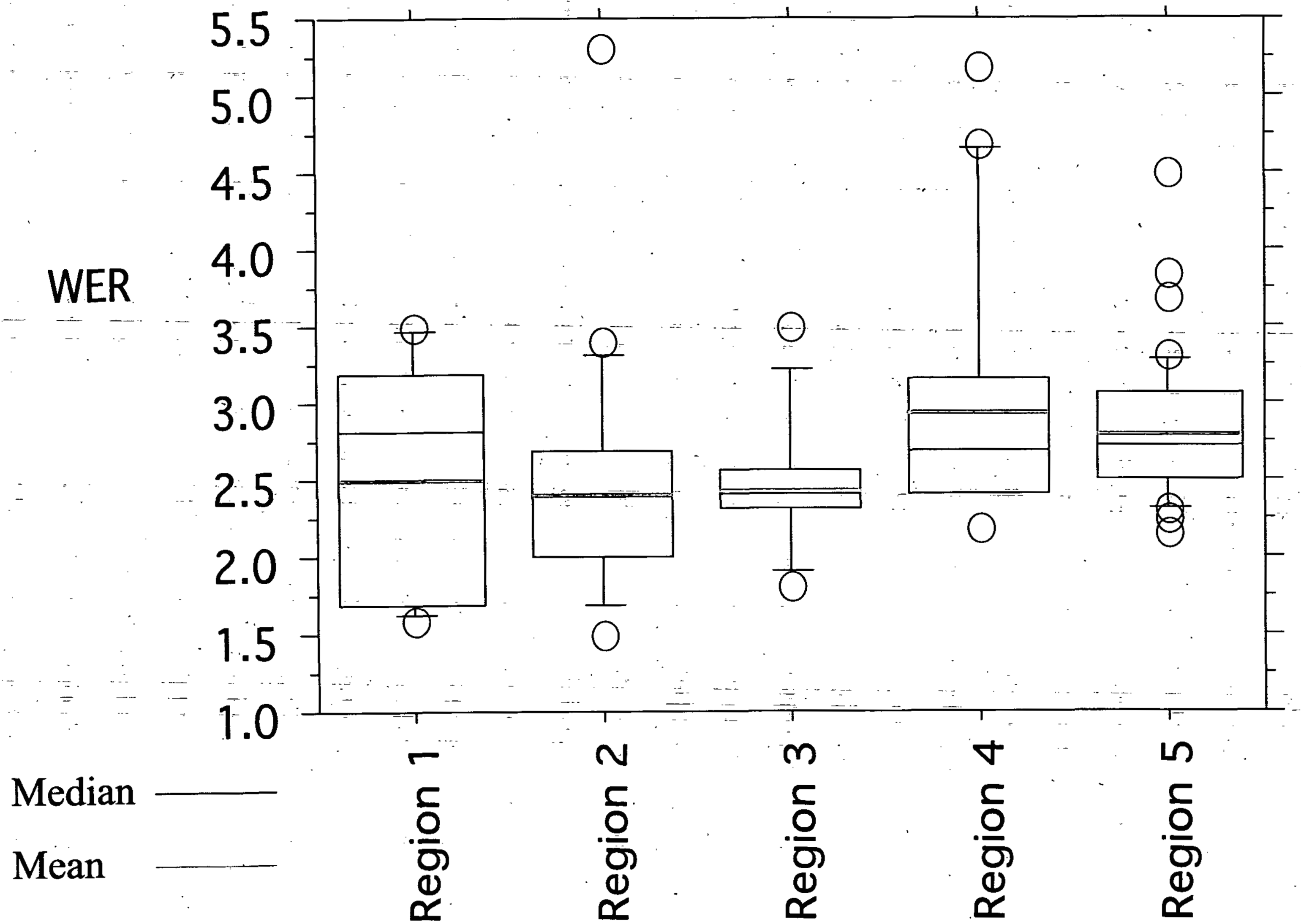


Figure 5. Bay Regions 1-3 Copper Concentrations; Toxicity Values; Potential Triggers and Site-Specific Objective

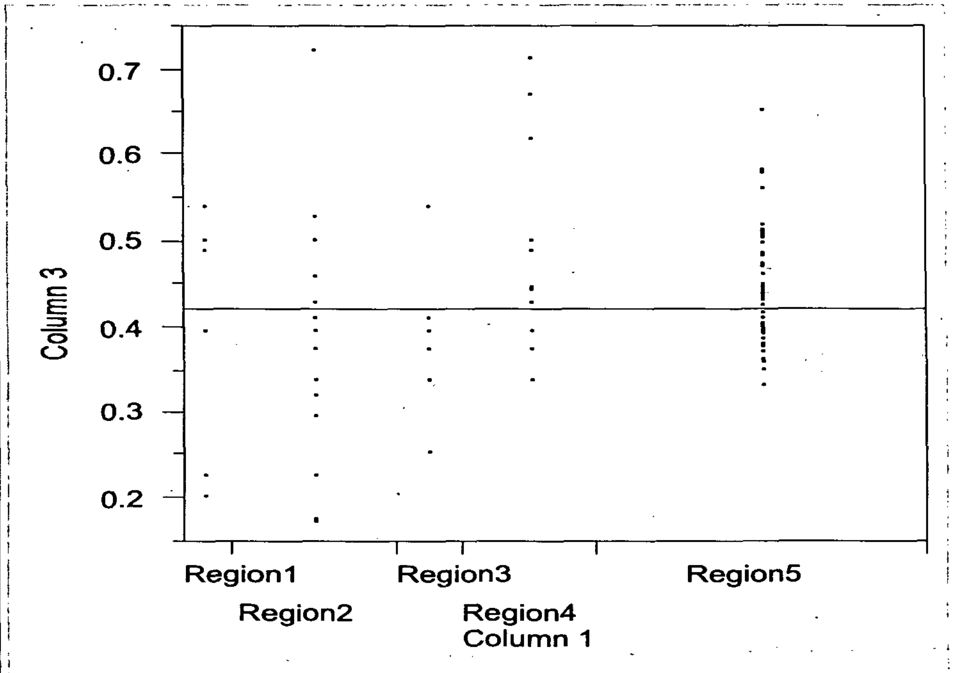


Geometric Mean WERs by Bay Region



ANOVA of Mean log WERs by Bay Region

Column 3 By Column 1



Oneway Anova

Summary of Fit

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	4	0.09099623	0.022749	2.4028
Error	85	0.80476062	0.009468	Prob>F
C Total	89	0.89575685	0.010065	0.0560

Legend

Height = 95% Confidence Interval

Width = n

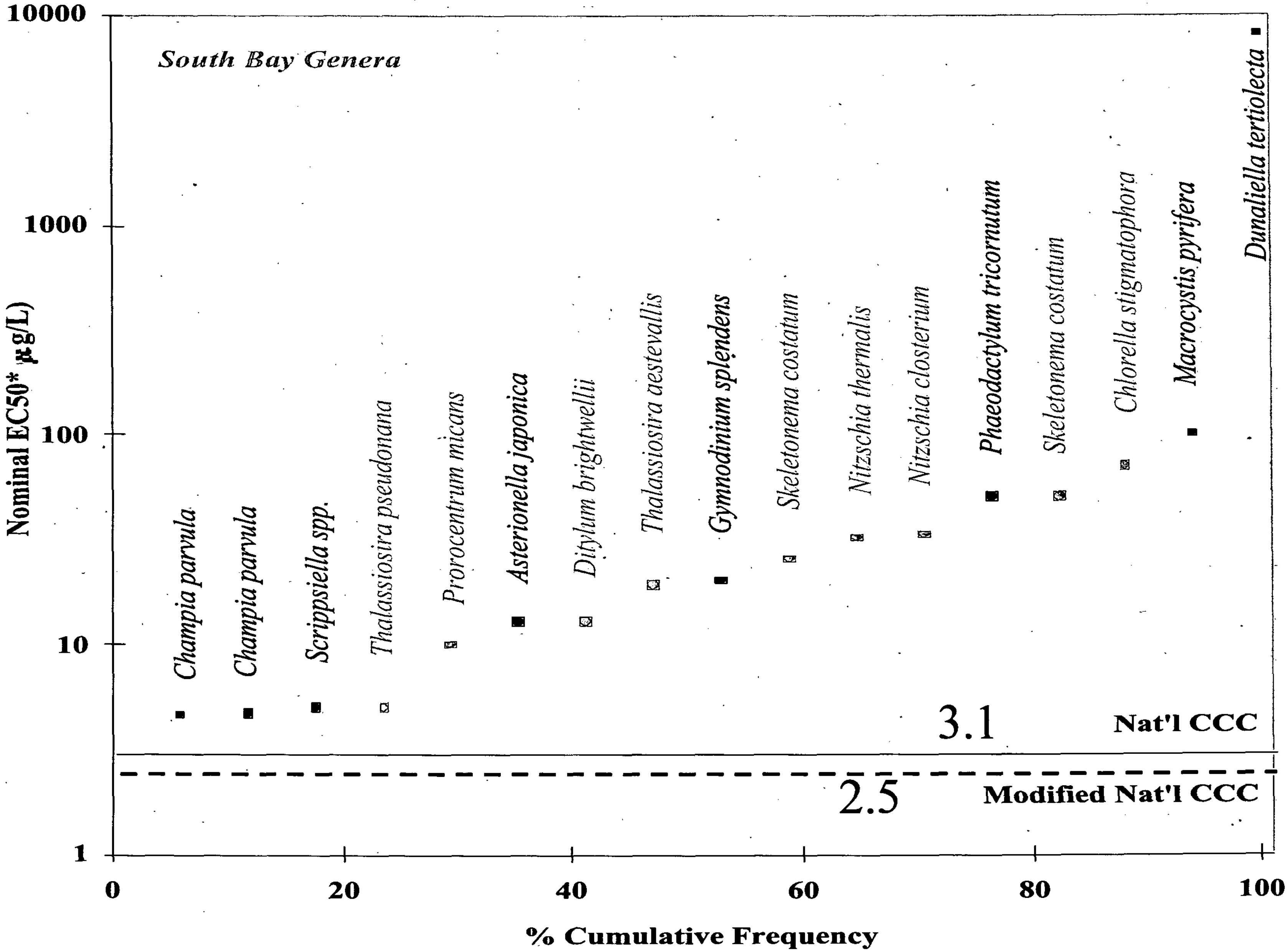
Horizontal Lines = Mean of Logs +/- 1s

Black dots = Individual WERs

Protection of Plants

- Evaluate Primary Production (surveys of species abundance and composition)
- Evaluate factors affecting phytoplankton (light, nutrients, grazing, hydrodynamics, etc.)
- Evaluate current research (e.g. Dr. Bruland speciation results)
- Can evidence of impacts to phytoplankton be linked to copper?
- EPA Final Plant Value - Value obtained by selecting the lowest result from a test with an important aquatic plant species in which the concentration of test material was measured and the endpoint was biologically important (EPA Office of Water). The Final Plant Value must be obtained from a chronic test using vascular plants or a macrophyte such as Champia (Dave Hansen, personal communication)

Sensitivities of saltwater plants to copper



WER studies with Algae

- Unicellular Algae
  - Regional Board Study with *Thalassiosira* sp.
    - Dissolved Copper WER = 2.3
    - Total Copper WER = 6.1
- Multicellular Algae
  - NY/NJ Harbor Study with *Champia* sp.
    - Dissolved Copper WER = 2.17
- Both Studies produced higher WERs for algae than for animals

Development of a S.F. Bay Site-Specific Chronic Criterion for Nickel

Using the EPA Recalculation Procedure and Modification of the EPA Nickel Saltwater Acute-To-Chronic Ratio

Environmental Services Department
City of San Jose
June 3, 2004

Background

- The City of San Jose's NPDES nickel limit dropped from 100 µg/l in 1989 to 8.3 µg/l in 1993.
- Regional Board implemented San Francisco Bay nickel WQC of 8.3 µg/l (1994).
- City of San Jose performed site-specific studies in 1989 & recalculation on nickel (1996). These studies were of limited usefulness but helped point out data gaps (chronic and ACR data)

Result of Initial Recalculation

- National & San Francisco Bay saltwater nickel CCC of 10.2 μg/l proposed following the recalculation procedure (with corrections and additions to the 1986 EPA database for nickel)
- Current Nickel Final ACR based on 2 freshwater and 1 saltwater species (FACR=17.99)

Introduction to ACR Study

- EPA establishes acute and chronic aquatic life protection for pollutants using toxicity data
- Chronic values are most often calculated from acute data employing an acute-to-chronic ratio (ACR)
- Few chronic saltwater values are available for nickel toxicity
- This study presents acute and chronic nickel toxicity data for 3 West Coast saltwater species

Acute-to-Chronic Ratio

- Acute endpoint divided by the chronic endpoint of the same test material under the same test conditions

Current Acute-to-Chronic Values

Pimephales promelas (Fathead minnow)	35.58
Daphnia magna (Water flea)	29.86
Americamysis bahia (Mysid shrimp)	5.478
Final ACR	17.99

ACR Study Objectives

- Produce acute & chronic nickel toxicity data on 3 West Coast saltwater species
- Use flow-through conditions
- Verify (<u>measure</u>) concentrations in test water
- Recalculate a Final ACR for nickel
- Evaluate SF Bay site-specific Ni criteria

Summary statistics for *Atherinops affinis*, (topsmelt)

Species	Endpoints	Values
Atherinops affinis	Acute Endpoint: 96-h Survival	
	Acute Value, LC50 (µg/L):	26,560
	Most Sensitive Chronic Endpoint: 40-d Survival	
	Lower Chronic Limit (µg/L):	3,240
	Upper Chronic Limit (µg/L):	5,630
	Chronic Value (geo. mean of upper and lower limits, µg/L):	4,270
	Acute-to-Chronic Ratio:	6.22

Summary statistics for *Haliotis rufescens*, (red abalone)

Species	Endpoints	Values
Haliotis rufescens	Acute Endpoint: 48-h Development	
	Acute Value, EC50 (μg/L):	145.46
	Most Sensitive Chronic Endpoint: 20-d Juvenile Growth	
	Lower Chronic Limit (μg/L):	21.5
	Upper Chronic Limit (μg/L):	32.5
	Chronic Value (geo. mean of upper and lower limits, μg/L):	26.43
	Acute -to- Chronic Ratio:	5.50

Summary statistics for *Mysidopsis intii* (mysid Shrimp)

Species	Endpoints	Values
Mysidopsis intii	Acute Endpoint: 96-h Survival	
	<u>Acute Value</u>, LC50 (µg/L):	148.60
	Most Sensitive Chronic Endpoint: 28-d Survival	
	Lower Chronic Limit (µg/L):	10.0
	Upper Chronic Limit (µg/L):	48.8
	<u>Chronic Value</u> (geo. mean of upper and lower limits, µg/L):	22.09
	<u>Acute</u>-to-<u>Chronic</u> Ratio:	6.73

Re-Recalculation: Applying current acute toxicity data to saltwater nickel re-calculation

National Water Quality Criterion			San Francisco Bay Site-Specific WQC		
Rank #	Species	GMAV	Rank #	Species	GMAV
4	*Mysidopsis (bigelowi & intii)*	306.9	4	*Mercenaria mercenaria*	310
3	*Mercenaria mercenaria*	310	3	*Heteromysis formosa*	151.7
2	*Heteromysis formosa*	151.7	2	*Mysidopsis intii*	148.6
1	*Haliotis rufescens*	145.5	1	*Haliotis rufescens*	145.5

Re-calculation of national and site-specific nickel FAVs and CMCs

	EPA 1986 National Ni WQC	Revised National Ni WQC	SF Bay Site-Specific Ni WQC
Number GMAVs in dataset	20	26	24
Final Acute Value	149.2	145.5	124.8
Criterion Maximum Concentration	74.6	72.8	62.4

Application of ACRs in re-calculations of saltwater Final ACR and CCC

Acute-to-Chronic Ratios (ACRs); Saltwater Only				
Species	Species Mean ACR	Calculated FACR	Revised Nat'l CCC	SF Bay Site-Specific CCC
Americamysis bahia (Mysidopsis bahia)	5.478			
Atherinops affinis	6.22			
Mysidopsis intii	6.73			
Haliotis rufescens	5.50	5.959	24.42	20.94

Re-calculations of Final ACRs (combined) and CCCs

Acute-to-Chronic Ratios (ACRs); Combined Freshwater & Saltwater				
Species	Species Mean ACR	Calculated FACR	Revised Nat'l CCC	SF Bay Site-Specific CCC
Pimephales promelas	35.58			
Daphnia magna	29.86			
Americamysis bahia (Mysidopsis bahia)	5.478	17.99	8.293	9.805
Atherinops affinis	6.22			
Mysidopsis intii	6.73			
Haliotis rufescens	5.50	10.50	13.86	11.89

Conclusions

- **ACRs for saltwater species are significantly lower than those for freshwater species**
- **Chronic nickel Water Quality Criterion is highly dependent on the Final ACR**
- **A national CCC would be 24.42 and 13.86 ppb, respectively, based on saltwater and combined saltwater/freshwater ACRs**
- **S.F. Bay Site-Specific CCCs would be 20.94 and 11.89, respectively, based on saltwater and combined saltwater/freshwater ACRs**

Nickel SSO is Conservative

- EPA (Dr. Thursby) July 28, 1998 commented that "…the data from the present study could be used to make a case that saltwater and freshwater ACRs may be different. This could substantially lower the FACR for the calculation of a nickel site-specific (objective) for South San Francisco Bay."
- Recalculated Nickel SSO lower than re-calculated national criterion

Adopted Chronic Criterion

- Water Board approved a site-specific objective for the South Bay of 11.9 ppb
- This SSO is applicable to the entire S.F. Bay

Application to S.F. Bay NDB?

- Water Board (Richard Looker) comments on NDB SIP Ni Justification - "From what is presented here, there is not enough for me to use to demonstrate that the SSO for nickel is a necessity. The arguments about triggering RPA and avoiding listings are not strong either.
- EPA (Alexis Strauss) comment on Mercury: "Aquatic Life standards for toxic pollutants are generally applied with an allowable exceedance frequency of no greater than once in any three year period (see 40 CFR 131.36(c)(2) at Table 4 Notes 1 and 2, 40 CFR 131.38(c)(2), and Technical Support Document for Water Quality-based Toxics Control, EPA 1991."

Application to S.F. Bay?

- During Event 2 of the NDB Cu/Ni Study, station BD15 (Petaluma River) had a dissolved nickel concentration of 17.2 ppb.
- Given a 3-year averaging period, isn't this likely to happen again?
- Isn't avoidance of a 303(d) listing sufficient reason to adopt an appropriate SSO for nickel for S.F. Bay NDB?
- Adopting a marine ACR would set the Nickel SSO at 20.94 ppb, above 17.2 ppb found at BD15.

Nickel ACR Report:

www.ci.san-jose.ca.us/esd/pub_res.htm

Robert Musial   Nov. 02, 2006

File Folder #842

SF Bay, Lower – Delist for Nickel
In Response To Bay Area Clean Water Agencies
October 20, 2006 Letter

Action Taken

- SF Bay, Lower has been De-listed for Nickel. A determination has been made and a fact sheet to that effect has been developed using the information found at the SF Estuary Institute website.
- SF Bay, South – Do Not List for Nickel. A determination has been made and a fact sheet to that effect has been developed using the information found at the SF Estuary Institute website.
- At this time no change has been made to the information/response regarding the initial comments contained in the Response To Comments database

PROPOSED 2006 CWA SECTION 303(d) LIST OF WATER QUALITY LIMITED SEGMENTS

SAN FRANCISCO BAY REGIONAL BOARD

SWRCB DRAFT 303(d) LIST RELEASE DATE: SEPTEMBER 15, 2006

REGION	TYPE	NAME	CALWATER WATERSHED	POLLUTANT/STRESSOR	POTENTIAL SOURCES	ESTIMATED SIZE AFFECTED	PROPOSED TMDL COMPLETION
				DDT		92274 Acres	2008
				This listing was made by USEPA.			
					Nonpoint Source		
				Dieldrin		92274 Acres	2008
				This listing was made by USEPA.			
					Nonpoint Source		
				Dioxin Compounds (including 2,3,7,8-TCDD)		92274 Acres	2019
				The specific compounds are 2,3,7,8-TCDD, 1,2,3,7,8-PeCDD, 1,2,3,4,7,8-HxCDD, 1,2,3,6,7,8-HxCDD, 1,2,3,7,8,9-HxCDD, 1,2,3,4,6,7,8-HpCDD, and OCDD. This listing was made by USEPA.			
					Atmospheric Deposition		
				Exotic Species		92274 Acres	2019
				Disrupt natural benthos; change pollutant availability in food chain; disrupt food availability to native species.			
					Ballast Water		
				Furan Compounds		92274 Acres	2019
				The specific compounds are 2,3,7,8-TCDF, 1,2,3,7,8-PeCDF, 2,3,4,7,8-PeCDF, 1,2,3,4,7,8-HxCDF, 1,2,3,6, 7,8,-HxCDF, 1,2,3,7,8,9-HxCDF, 2,3,4,6,7,8-HxCDF, 1,2,3,4,6,7,8-HpCDF, 1,2,3,4,7,8,9-HpCDF, and OCDF. This listing was made by USEPA.			
					Atmospheric Deposition		
				Mercury		92274 Acres	2006
				Current data indicate fish consumption and wildlife consumption impacted uses: health consumption advisory in effect for multiple fish species including striped bass and shark. Major source is historic: gold mining sediments and local mercury mining; most significant ongoing source is erosion and drainage from abandoned mines; moderate to low level inputs from point sources: water quality objective exceedances. Elevated sediment levels and elevated tissue levels.			
					Industrial Point Sources		
					Municipal Point Sources		
					Resource Extraction		
					Atmospheric Deposition		
					Natural Sources		
					Nonpoint Source		
				Nickel		92274 Acres	2019
				This listing was made by USEPA.			
					Source Unknown		
				PCBs (Polychlorinated biphenyls)		92274 Acres	2006
				This listing covers non dioxin-like PCBs.Interim health advisory for fish; uncertainty regarding water column concentration data.			
					Unknown Nonpoint Source		

REGION	TYPE	NAME	CALWATER WATERSHED	POLLUTANT/STRESSOR	POTENTIAL SOURCES	ESTIMATED SIZE AFFECTED	PROPOSED TMDL COMPLETION
				PCBs (Polychlorinated biphenyls) (dioxin-like)		**92274 Acres**	**2019**
				The specific dioxin like compounds are 3,4,4,5-TCB (81), 3,3,3,3-TCB (77), 3,3,4,4,5-PeCB (126), 3,3,4,4,4,4-HxCB (169), 2,3,3,4,4-PeCB (105), 2,3,4,4,5-PeCB (114), 2,3,4,4,5-PeCB (118), 2,3,4,4,5-PeCB (123), 2,3,3,4,4,5-HxCB (156), 2,3,3,4,4,5-HxCB (157), 2,3,4,4,5,5,-HxCB (167), 2,3,3,4,4,5,5-HpCB (189). This listing was made by USEPA.	**Unknown Nonpoint Source**		
2	**B**	**San Francisco Bay, South**	**20510000**				
				Chlordane		**9204 Acres**	**2008**
				This listing was made by USEPA.	**Nonpoint Source**		
				DDT		**9204 Acres**	**2008**
				This listing was made by USEPA.	**Nonpoint Source**		
				Dieldrin		**9204 Acres**	**2008**
				This listing was made by USEPA.	**Nonpoint Source**		
				Dioxin Compounds (including 2,3,7,8-TCDD)		**9204 Acres**	**2019**
				The specific compounds are 2,3,7,8-TCDD, 1,2,3,7,8-PeCDD, 1,2,3,4,7,8-HxCDD, 1,2,3,6,7,8-HxCDD, 1,2,3,7,8,9-HxCDD, 1,2,3,4,6,7,8-HpCDD, and OCDD. This listing was made by USEPA.	**Atmospheric Deposition**		
				Exotic Species		**9204 Acres**	**2019**
				Disrupt natural benthos; change pollutant availability in food chain; disrupt food availability to native species.	**Ballast Water**		
				Furan Compounds		**9204 Acres**	**2019**
				The specific compounds are 2,3,7,8-TCDF, 1,2,3,7,8-PeCDF, 2,3,4,7,8-PeCDF, 1,2,3,4,7,8-HxCDF, 1,2,3,6,7,8-HxCDF, 1,2,3,7,8,9-HxCDF, 2,3,4,6,7,8-HxCDF, 1,2,3,4,6,7,8-HpCDF, 1,2,3,4,7,8,9-HpCDF, and OCDF. This listing was made by USEPA.	**Atmospheric Deposition**		
				Mercury		**9204 Acres**	**2006**
				Current data indicate fish consumption and wildlife consumption impacted uses: health consumption advisory in effect for multiple fish species including striped bass and shark. Major source is historic: gold mining sediments and local mercury mining; most significant ongoing source is erosion and drainage from abandoned mines; moderate to low level inputs frompoint sources: water quality objective exceedances. Elevated sediment level and elevated tissue levels.	**Industrial Point Sources** **Municipal Point Sources** **Resource Extraction** **Atmospheric Deposition** **Natural Sources** **Nonpoint Source**		

REGION	TYPE	NAME	CALWATER WATERSHED	POLLUTANT/STRESSOR	POTENTIAL SOURCES	ESTIMATED SIZE AFFECTED	PROPOSED TMDL COMPLETION
				PCBs (Polychlorinated biphenyls)		9204 Acres	2006
				This listing covers non dioxin-like PCBs.Interim health advisory for fish; uncertainty regarding water column concentration data.			
					Unknown Nonpoint Source		
				PCBs (Polychlorinated biphenyls) (dioxin-like)		9204 Acres	2019
				The specific dioxin like compounds are 3,4,4,5-TCB (81), 3,3,3,3-TCB (77), 3,3,4,4,5-PeCB (126), 3,3,4,4,4,4-HxCB (169), 2,3,3,4,4-PeCB (105), 2,3,4,4,5-PeCB (114), 2,3,4,4,5-PeCB (118), 2,3,4,4,5-PeCB (123), 2,3,3,4,4,5-HxCB (156), 2,3,3,4,4,5-HxCB (157), 2,3,4,4,5,5,-HxCB (167), 2,3,3,4,4,5,5-HpCB (189). This listing was made by USEPA.			
					Unknown Nonpoint Source		
				Selenium		9204 Acres	2019
				A formal health advisory has been issued by OEHHA for benthic-feeding ducks in South San Francisco Bay. This health advisory clearly establishes that water contact recreation beneficial use (REC-1) is not fully supported and standards are not fully met.			
					Agriculture		
					Domestic Use of Ground Water		
2	R	San Francisquito Creek	20550040				
				Diazinon		12 Miles	2005
				This listing was made by USEPA.			
					Urban Runoff/Storm Sewers		
				Sedimentation/Siltation		12 Miles	2008
				Impairment to steelhead habitat.			
					Nonpoint Source		
2	R	San Gregorio Creek	20230014				
				Coliform Bacteria		11 Miles	2019
					Nonpoint Source		
				Sedimentation/Siltation		11 Miles	2019
				Impairment to steelhead habitat.			
					Nonpoint Source		
2	B	San Leandro Bay (part of SF Bay, Central)	20420040				
				Chlordane		588 Acres	2008
				This listing was made by USEPA.			
					Nonpoint Source		
				Dieldrin		588 Acres	2008
				This listing was made by USEPA.			
					Nonpoint Source		

REGION	TYPE	NAME	CALWATER WATERSHED	POLLUTANT/STRESSOR	POTENTIAL SOURCES	TMDL PRIORITY	ESTIMATED SIZE AFFECTED	PROPOSED TMDL COMPLETION
				Furan Compounds		**Low**	**70992 Acres**	
				The specific compounds are 2,3,7,8-TCDF, 1,2,3,7,8-PeCDF, 2,3,4,7,8-PeCDF, 1,2,3,4,7,8-HxCDF, 1,2,3,6,7,8-HxCDF, 1,2,3,7,8,9-HxCDF, 2,3,4,6,7,8-HxCDF, 1,2,3,4,6,7,8-HpCDF, 1,2,3,4,7,8,9-HpCDF, and OCDF. This listing was made by USEPA.				
					Atmospheric Deposition			
				Mercury		**High**	**70992 Acres**	**2003**
				Current data indicate fish consumption and wildlife consumption impacted uses: health consumption advisory in effect for multiple fish species including striped bass and shark. Major source is historic: gold mining sediments and local mercury mining; most significant ongoing source is erosion and drainage from abandoned mines; moderate to low level inputs from point sources.				
					Industrial Point Sources			
					Municipal Point Sources			
					Resource Extraction			
					Atmospheric Deposition			
					Natural Sources			
					Nonpoint Source			
				PCBs		**High**	**70992 Acres**	**2004**
				This listing covers non dioxin-like PCBs.Interim health advisory for fish; uncertainty regarding water column concentration data.				
					Unknown Nonpoint Source			
				PCBs (dioxin-like)		**Low**	**70992 Acres**	
				The specific dioxin like compounds are 3,4,4,5-TCB (81), 3,3,3,3-TCB (77), 3,3,4,4,5-PeCB (126), 3,3,4,4,4,4-HxCB (169), 2,3,3,4,4-PeCB (105), 2,3,4,4,5-PeCB (114), 2,3,4,4,5-PeCB (118), 2,3,4,4,5-PeCB (123), 2,3,3,4,4,5-HxCB (156), 2,3,3,4,4,5-HxCB (157), 2,3,4,4,5,5,-HxCB (167), 2,3,3,4,4,5,5-HpCB (189). This listing was made by USEPA.				
					Unknown Nonpoint Source			
				Selenium		**Low**	**70992 Acres**	
				Affected use is one branch of the food chain; most sensitive indicator is hatchability in nesting diving birds, significant contributions from oil refineries (control program in place) and agriculture (carried downstream by rivers); exotic species may have made food chain more susceptible to accumulation of selenium; health consumption advisory in effect for scaup and scoter (diving ducks); low TMDL priority because Individual Control Strategy in place.				
					Industrial Point Sources			
					Agriculture			
					Natural Sources			
					Exotic Species			
2	**B**	**San Francisco Bay, Lower**	**20410010**					
				Chlordane		**Low**	**79293 Acres**	
				This listing was made by USEPA.				
					Nonpoint Source			
				DDT		**Low**	**79293 Acres**	
				This listing was made by USEPA.				
					Nonpoint Source			

REGION	TYPE	NAME	CALWATER WATERSHED	POLLUTANT/STRESSOR	POTENTIAL SOURCES	TMDL PRIORITY	ESTIMATED SIZE AFFECTED	PROPOSED TMDL COMPLETION
				Diazinon		**Low**	**79293 Acres**	
				Diazinon levels cause water column toxicity. Two patterns: pulses through riverine systems linked to agricultural application in late winter and pulse from residential land use areas linked to homeowner pesticide use in late spring, early summer. Chlorpyrifos may also be the cause of toxicity; more data needed, however.				
					Nonpoint Source			
				Dieldrin		**Low**	**79293 Acres**	
				This listing was made by USEPA.				
					Nonpoint Source			
				Dioxin Compounds		**Low**	**79293 Acres**	
				The specific compounds are 2,3,7,8-TCDD, 1,2,3,7,8-PeCDD, 1,2,3,4,7,8-HxCDD, 1,2,3,6,7,8-HxCDD, 1,2,3,7,8,9-HxCDD, 1,2,3,4,6,7,8-HpCDD, and OCDD. This listing was made by USEPA.				
					Atmospheric Deposition			
				Exotic Species		**Medium**	**79293 Acres**	
				Disrupt natural benthos; change pollutant availability in food chain; disrupt food availability to native species.				
					Ballast Water			
				Furan Compounds		**Low**	**79293 Acres**	
				The specific compounds are 2,3,7,8-TCDF, 1,2,3,7,8-PeCDF, 2,3,4,7,8-PeCDF, 1,2,3,4,7,8-HxCDF, 1,2,3,6, 7,8,-HxCDF, 1,2,3,7,8,9-HxCDF, 2,3,4,6,7,8-HxCDF, 1,2,3,4,6,7,8-HpCDF, 1,2,3,4,7,8,9-HpCDF, and OCDF. This listing was made by USEPA.				
					Atmospheric Deposition			
				Mercury		**High**	**79293 Acres**	**2003**
				Current data indicate fish consumption and wildlife consumption impacted uses: health consumption advisory in effect for multiple fish species including striped bass and shark. Major source is historic: gold mining sediments and local mercury mining; most significant ongoing source is erosion and drainage from abandoned mines; moderate to low level inputs from point sources: water quality objective exceedances. Elevated sediment levels and elevated tissue levels.				
					Industrial Point Sources			
					Municipal Point Sources			
					Resource Extraction			
					Atmospheric Deposition			
					Natural Sources			
					Nonpoint Source			
				Nickel		**Low**	**79293 Acres**	
				This listing was made by USEPA.				
					Source Unknown			
				PCBs		**High**	**79293 Acres**	**2004**
				This listing covers non dioxin-like PCBs.Interim health advisory for fish; uncertainty regarding water column concentration data.				
					Unknown Nonpoint Source			
				PCBs (dioxin-like)		**Low**	**79293 Acres**	
				The specific dioxin like compounds are 3,4,4,5-TCB (81), 3,3,3,3-TCB (77), 3,3,4,4,5-PeCB (126), 3,3,4,4,4,4-HxCB (169), 2,3,3,4,4-PeCB (105), 2,3,4,4,5-PeCB (114), 2,3,4,4,5-PeCB (118), 2,3,4,4,5-PeCB (123), 2,3,3,4,4,5-HxCB (156), 2,3,3,4,4,5-HxCB (157), 2,3,4,4,5,5,-HxCB (167), 2,3,3,4,4,5,5-HpCB (189). This listing was made by USEPA.				
					Unknown Nonpoint Source			

REGION	TYPE	NAME	CALWATER WATERSHED	POLLUTANT/STRESSOR	POTENTIAL SOURCES	TMDL PRIORITY	ESTIMATED SIZE AFFECTED	PROPOSED TMDL COMPLETION
2	B	San Francisco Bay, South	20510000					
				Chlordane		Low	21669 Acres	
				This listing was made by USEPA.				
					Nonpoint Source			
				DDT		Low	21669 Acres	
				This listing was made by USEPA.				
					Nonpoint Source			
				Diazinon		Low	21669 Acres	
				Diazinon levels cause water column toxicity. Two patterns: pulses through riverine systems linked to agricultural application in late winter and pulse from residential land use areas linked to homeowner pesticide use in late spring, early summer. Chlorpyrifos may also be the cause of toxicity; more data needed, however.				
					Nonpoint Source			
				Dieldrin		Low	21669 Acres	
				This listing was made by USEPA.				
					Nonpoint Source			
				Dioxin Compounds		Low	21669 Acres	
				The specific compounds are 2,3,7,8-TCDD, 1,2,3,7,8-PeCDD, 1,2,3,4,7,8-HxCDD, 1,2,3,6,7,8-HxCDD, 1,2,3,7,8,9-HxCDD, 1,2,3,4,6,7,8-HpCDD, and OCDD. This listing was made by USEPA.				
					Atmospheric Deposition			
				Exotic Species		Medium	21669 Acres	
				Disrupt natural benthos; change pollutant availability in food chain; disrupt food availability to native species.				
					Ballast Water			
				Furan Compounds		Low	21669 Acres	
				The specific compounds are 2,3,7,8-TCDF, 1,2,3,7,8-PeCDF, 2,3,4,7,8-PeCDF, 1,2,3,4,7,8-HxCDF, 1,2,3,6,7,8-HxCDF, 1,2,3,7,8,9-HxCDF, 2,3,4,6,7,8-HxCDF, 1,2,3,4,6,7,8-HpCDF, 1,2,3,4,7,8,9-HpCDF, and OCDF. This listing was made by USEPA.				
					Atmospheric Deposition			
				Mercury		High	21669 Acres	2003
				Current data indicate fish consumption and wildlife consumption impacted uses: health consumption advisory in effect for multiple fish species including striped bass and shark. Major source is historic: gold mining sediments and local mercury mining; most significant ongoing source is erosion and drainage from abandoned mines; moderate to low level inputs from point sources: water quality objective exceedances. Elevated sediment level and elevated tissue levels.				
					Industrial Point Sources			
					Municipal Point Sources			
					Resource Extraction			
					Atmospheric Deposition			
					Natural Sources			
					Nonpoint Source			
				PCBs		High	21669 Acres	2004
				This listing covers non dioxin-like PCBs.Interim health advisory for fish; uncertainty regarding water column concentration data.				
					Unknown Nonpoint Source			

REGION	TYPE	NAME	CALWATER WATERSHED	POLLUTANT/STRESSOR	POTENTIAL SOURCES	TMDL PRIORITY	ESTIMATED SIZE AFFECTED	PROPOSED TMDL COMPLETION
				PCBs (dioxin-like)		**Low**	**21669 Acres**	
				The specific dioxin like compounds are 3,4,4,5-TCB (81), 3,3,3,3-TCB (77), 3,3,4,4,5-PeCB (126), 3,3,4,4,4,4-HxCB (169), 2,3,3,4,4-PeCB (105), 2,3,4,4,5-PeCB (114), 2,3,4,4,5-PeCB (118), 2,3,4,4,5-PeCB (123), 2,3,3,4,4,5-HxCB (156), 2,3,3,4,4,5-HxCB (157), 2,3,4,4,5,5,-HxCB (167), 2,3,3,4,4,5,5-HpCB (189). This listing was made by USEPA.				
					Unknown Nonpoint Source			
				Selenium		**Low**	**21669 Acres**	
				A formal health advisory has been issued by OEHHA for benthic-feeding ducks in South San Francisco Bay. This health advisory clearly establishes that water contact recreation beneficial use (REC-1) is not fully supported and standards are not fully met.				
					Agriculture			
					Domestic Use of Ground Water			
2	**R**	**San Francisquito Creek**	**20550040**					
				Diazinon		**High**	**12 Miles**	**2004**
				This listing was made by USEPA.				
					Urban Runoff/Storm Sewers			
				Sedimentation/Siltation		**Medium**	**12 Miles**	
				Impairment to steelhead habitat.				
					Nonpoint Source			
2	**R**	**San Gregorio Creek**	**20230014**					
				High Coliform Count		**Low**	**11 Miles**	
					Nonpoint Source			
				Sedimentation/Siltation		**Medium**	**11 Miles**	
				Impairment to steelhead habitat.				
					Nonpoint Source			
2	**B**	**San Leandro Bay (part of SF Bay, Central)**	**20420040**					
				Chlordane		**Low**	**588 Acres**	
				This listing was made by USEPA.				
					Nonpoint Source			
				DDT		**Low**	**588 Acres**	
				This listing was made by USEPA.				
					Nonpoint Source			
				DDT (sediment)		**Low**	**588 Acres**	
					Source Unknown			
				Diazinon		**Low**	**588 Acres**	
				Diazinon levels cause water column toxicity. Two patterns: pulses through riverine systems linked to agricultural application in late winter and pulse from residential land use areas linked to homeowner pesticide use in late spring, early summer. Chlorpyrifos may also be the cause of toxicity; more data needed, however.				
					Nonpoint Source			
				Dieldrin		**Low**	**588 Acres**	
				This listing was made by USEPA.				
					Nonpoint Source			

SFEI

SAN FRANCISCO BAY, SOUTH BAY (NICKEL DATA)

DATA USED IN RESPONSE TO BAY AREA CLEAN WATER AGENCIES LETTER OF OCT 20, 2006

70 SAMPLES

Ni

	Test Materi Matrix	Site Code	Cruise #	Sample Date		Result	MDL	Unit
1	ES_WATE WCD	BA30	1993-03	03/02/1993		3.42	0.01	ug/L
2	ES_WATE WCD	BA30	1993-05	05/24/1993	3	2.81	0.01	ug/L
3	ES_WATE WCD	BA30	1993-09	09/13/1993		2.73	0.01	ug/L
4	ES_WATE WCD	BA30	1994-01	01/31/1994		2.28	0.01	ug/L
5	ES_WATE WCD	BA30	1994-04	04/18/1994	3	2.68	0.01	ug/L
6	ES_WATE WCD	BA30	1994-08	08/15/1994		3.07	0.00	ug/L
7	ES_WATE WCD	BA30	1995-02	02/06/1995		3.25	0.00	ug/L
8	ES_WATE WCD	BA30	1995-04	04/24/1995	3	2.88	0.01	ug/L
9	ES_WATE WCD	BA30	1995-08	08/15/1995		3.35	0.00	ug/L
10	ES_WATE WCD	BA30	1996-02	02/05/1996		2.91	0.00	ug/L
11	ES_WATE WCD	BA30	1996-04	05/02/1996	3	2.25	0.00	ug/L
12	ES_WATE WCD	BA30	1996-07	07/29/1996		2.86	0.00	ug/L
13	ES_WATE WCD	BA30	1997-01	01/21/1997		2.93	0.00	ug/L
14	ES_WATE WCD	BA30	1997-04	04/16/1997	3	2.95	0.00	ug/L
15	ES_WATE WCD	BA30	1997-07	07/28/1997		2.57	0.01	ug/L
16	ES_WATE WCD	BA30	1998-02	01/28/1998		2.26	0.01	ug/L
17	ES_WATE WCD	BA30	1998-04	04/22/1998	3	2.40	0.01	ug/L
18	ES_WATE WCD	BA30	1998-07	07/21/1998		2.14	0.00	ug/L
19	ES_WATE WCD	BA30	1999-02	02/02/1999		2.34	0.00	ug/L
20	ES_WATE WCD	BA30	1999-04	04/12/1999	3	1.81	0.00	ug/L
21	ES_WATE WCD	BA30	1999-07	07/14/1999		2.96	0.01	ug/L
22	ES_WATE WCD	BA30	2000-02	02/01/2000	2	2.38	0.06	ug/L
23	ES_WATE WCD	BA30	2000-07	07/11/2000		2.79	0.06	ug/L
24	ES_WATE WCD	BA30	2001-02	02/07/2001	2	2.56	0.06	ug/L
25	ES_WATE WCD	BA30	2001-08	08/01/2001		2.70	0.06	ug/L
26	ES_WATE WCD	BA30	2003-08	08/05/2003	1	2.63	0.08	ug/L
27	ES_WATE WCD	BA40	1993-03	03/02/1993		3.20	0.01	ug/L
28	ES_WATE WCD	BA40	1993-05	05/24/1993	3	2.10	0.01	ug/L
29	ES_WATE WCD	BA40	1993-09	09/13/1993		2.37	0.01	ug/L
30	ES_WATE WCD	BA40	1994-01	02/02/1994		2.19	0.01	ug/L
31	ES_WATE WCD	BA40	1994-04	04/18/1994	3	2.68	0.01	ug/L
32	ES_WATE WCD	BA40	1994-08	08/16/1994		2.67	0.00	ug/L
33	ES_WATE WCD	BA40	1995-02	02/07/1995		2.70	0.00	ug/L
34	ES_WATE WCD	BA40	1995-04	04/24/1995	3	2.04	0.01	ug/L
35	ES_WATE WCD	BA40	1995-08	08/15/1995		1.97	0.00	ug/L
36	ES_WATE WCD	BA40	1996-02	02/06/1996		2.91	0.00	ug/L
37	ES_WATE WCD	BA40	1996-04	05/02/1996	3	1.94	0.00	ug/L
38	ES_WATE WCD	BA40	1996-07	07/29/1996		2.38	0.00	ug/L
39	ES_WATE WCD	BA40	1997-01	01/22/1997		1.76	0.00	ug/L
40	ES_WATE WCD	BA40	1997-04	04/16/1997	3	2.38	0.00	ug/L
41	ES_WATE WCD	BA40	1997-07	07/29/1997		2.32	0.01	ug/L
42	ES_WATE WCD	BA40	1998-02	01/27/1998		1.65	0.01	ug/L
43	ES_WATE WCD	BA40	1998-04	04/22/1998	3	1.66	0.01	ug/L
44	ES_WATE WCD	BA40	1998-07	07/20/1998		2.20	0.00	ug/L
45	ES_WATE WCD	BA40	1999-02	02/01/1999		2.06	0.00	ug/L
46	ES_WATE WCD	BA40	1999-04	04/12/1999	3	1.70	0.00	ug/L
47	ES_WATE WCD	BA40	1999-07	07/13/1999		1.93	0.01	ug/L
48	ES_WATE WCD	BA40	2000-02	02/01/2000	2	2.17	0.06	ug/L
49	ES_WATE WCD	BA40	2000-07	07/11/2000		1.82	0.06	ug/L
50	ES_WATE WCD	BA40	2001-02	02/06/2001	2 SAMPLES	2.31	0.06	ug/L

SEE NEXT PAGE

TAKEN FROM S.F. ESTUARY INSTITUTE (SFEI)

RMP STATUS & TRENDS MONITORING DATA

"S.F. SOUTH BAY" (303(d) LISTED AS S.F. BAY, LOWER)

51	ES_WATE WCD	BA40	2001-08	07/31/2001	2.53	0.06 ug/L
52	ES_WATE WCD	SB001W	2002-07	07/25/2002	1.74	0.00 ug/L
53	ES_WATE WCD	SB002W	2002-07	07/24/2002	2.28	0.00 ug/L
54	ES_WATE WCD	SB003W	2002-07	07/26/2002	1.74	0.00 ug/L
55	ES_WATE WCD	SB004W	2002-07	07/25/2002	1.93	0.00 ug/L
56	ES_WATE WCD	SB005W	2002-07	07/26/2002 10 IN JULY	1.88	0.00 ug/L
57	ES_WATE WCD	SB006W	2002-07	07/23/2002	2.39	0.00 ug/L
58	ES_WATE WCD	SB007W	2002-07	07/26/2002	2.13	0.00 ug/L
59	ES_WATE WCD	SB008W	2002-07	07/25/2002	1.78	0.00 ug/L
60	ES_WATE WCD	SB009W	2002-07	07/26/2002	1.62	0.00 ug/L
61	ES_WATE WCD	SB010W	2002-07	07/25/2002	2.08	0.00 ug/L
62	ES_WATE WCD	SB011W	2003-08	08/08/2003	1.55	0.08 ug/L
63	ES_WATE WCD	SB012W	2003-08	08/08/2003	0.87	0.08 ug/L
64	ES_WATE WCD	SB013W	2003-08	08/07/2003	1.86	0.08 ug/L
65	ES_WATE WCD	SB014W	2003-08	08/05/2003	2.03	0.08 ug/L
66	ES_WATE WCD	SB015W	2003-08	08/07/2003	1.68	0.08 ug/L
67	ES_WATE WCD	SB016W	2003-08	08/07/2003	1.67	0.08 ug/L
68	ES_WATE WCD	SB017W	2003-08	08/08/2003	1.66	0.08 ug/L
69	ES_WATE WCD	SB018W	2003-08	08/07/2003	1.93	0.08 ug/L
70	ES_WATE WCD	SB019W	2003-08	08/08/2003	1.84	0.08 ug/L

SAN FRANCISCO BAY, LOWER SO. BAY (NICKEL DATA)
S.F. ESTUARY INSTITUTE | RMP STATUS AND TRENDS MONITORING DATA

ID AS SOUTH BAY ON 303(d) LIST

Table 3-3: Marine[a] Water Quality Objectives for Toxic Pollutants for Surface Waters (all values in ug/l)

APPLICABLE TO S.F. BAY MARINE WATERS NORTH OF THE DUMBARTON BRIDGE.

Compound	4-day Average	1-hr Average	24-hr Average
Arsenic[b, c, d]	36	69	
Cadmium[b, c, d]	9.3	42	
Chromium VI[b, c, d, e]	50	1100	
Copper[c, d, f]			
Cyanide[g]			
Lead[b, c, d]	8.1	210	
Mercury[h]	0.025	2.1	
Nickel[b, c, d]	8.2	74	
Selenium[i]			
Silver[b, c, d]		1.9	
Tributyltin[j]			
Zinc[b, c, d]	81	90	
PAHs[k]			15

Notes:

a. Marine waters are those in which the salinity is equal to or greater than 10 parts per thousand 95% of the time, as set forth in Chapter 4 of the Basin Plan. Unless a site-specific objective has been adopted, these objectives shall apply to all marine waters except for the South Bay south of Dumbarton Bridge, where the California Toxics Rule (CTR) applies. For waters in which the salinity is between 1 and 10 parts per thousand, the applicable objectives are the more stringent of the freshwater (Table 3-4) or marine objectives.

b. Source: 40 CFR Part 131.38 (California Toxics Rule or CTR), May 18, 2000.

c. These objectives for metals are expressed in terms of the dissolved fraction of the metal in the water column.

d. According to the CTR, these objectives are expressed as a function of the water-effect ratio (WER), which is a measure of the toxicity of a pollutant in site water divided by the same measure of the toxicity of the same pollutant in laboratory dilution water. The 1-hr. and 4-day objectives = table value X WER. The table values assume a WER equal to one.

e. This objective may be met as total chromium.

f. Water quality objectives for copper were promulgated by the CTR and may be updated by U.S. EPA without amending the Basin Plan. Note: at the time of writing, the values are 3.1 ug/l (4-day average) and 4.8 ug/l (1-hr. average). The most recent version of the CTR should be consulted before applying these values.

g. Cyanide criteria were promulgated in the National Toxics Rule (NTR). The NTR criteria specifically apply to San Francisco Bay upstream to and including Suisun Bay and Sacramento-San Joaquin Delta. Note: at the time of writing, the values are 1.0 ug/l (4-day average) and 1.0 ug/l (1-hr. average).

h. Source: U.S. EPA Ambient Water Quality Criteria for Mercury (1984). The CTR human health criteria for mercury are also legally applicable to all waters of the San Francisco Bay Region.

i. Selenium criteria were promulgated for all San Francisco Bay/Delta waters in the National Toxics Rule (NTR). The NTR criteria specifically apply to San Francisco Bay upstream to and including Suisun Bay and Sacramento-San Joaquin Delta. Note: at the time of writing, the values are 5.0 ug/l (4-day average) and 20 ug/l (1-hr. average).

j. Tributyltin is a compound used as an antifouling ingredient in marine paints and toxic to aquatic life in low concentrations. U.S. EPA has published draft criteria for protection of aquatic life (Federal Register: December 27, 2002, Vol. 67, No. 249, Page 79090-79091). These criteria are cited for advisory purposes. The draft criteria may be revised.

k. The 24-hour average aquatic life protection objective for total PAHs is retained from the 1995 Basin Plan. Source: U.S. EPA 1980.

SFEI LOWER SO. BAY

SAN FRANCISCO BAY – NICKEL (SF BAY, ~~South~~)

DATA USED IN RESPONSE TO BAY AREA CLEAN WATER AGENCIES LETTER OF OCT 20, 2006

13 SAMPLING LOCATIONS.

	Test Material	Matrix	Site Code	Cruise #	Sample Date		Qual	Cu Result	MDL	Unit	Ni Result	MDL	Unit
1	ES_WATER	WCD	BA10	1994-01	02/01/1994			2.847	0.001	ug/L	3.70	0.01	ug/L
2	ES_WATER	WCD	BA10	1994-04	04/18/1994	3		4.890	0.005	ug/L	4.06	0.01	ug/L
3	ES_WATER	WCD	BA10	1994-08	08/16/1994			4.462	0.003	ug/L	4.63	0.00	ug/L
4	ES_WATER	WCD	BA10	1995-02	02/07/1995			3.032	0.007	ug/L	4.50	0.00	ug/L
5	ES_WATER	WCD	BA10	1995-04	04/24/1995	3		4.290	0.005	ug/L	4.74	0.01	ug/L
6	ES_WATER	WCD	BA10	1995-08	08/14/1995			4.130	0.001	ug/L	3.90	0.00	ug/L
7	ES_WATER	WCD	BA10	1996-02	02/06/1996			2.090	0.002	ug/L	3.17	0.00	ug/L
8	ES_WATER	WCD	BA10	1996-04	05/01/1996	3		3.270	0.003	ug/L	2.94	0.00	ug/L
9	ES_WATER	WCD	BA10	1996-07	07/30/1996			3.160	0.002	ug/L	6.56	0.00	ug/L
10	ES_WATER	WCD	BA10	1997-01	01/22/1997			1.608	0.002	ug/L	2.09	0.00	ug/L
11	ES_WATER	WCD	BA10	1997-04	04/17/1997	3		4.097	0.012	ug/L	4.93	0.00	ug/L
12	ES_WATER	WCD	BA10	1997-07	07/29/1997			3.107	0.014	ug/L	3.60	0.01	ug/L
13	ES_WATER	WCD	BA10	1998-02	01/28/1998			1.735	0.010	ug/L	2.28	0.01	ug/L
14	ES_WATER	WCD	BA10	1998-04	04/22/1998	3		2.463	0.012	ug/L	2.37	0.01	ug/L
15	ES_WATER	WCD	BA10	1998-07	07/20/1998			2.665	0.006	ug/L	2.68	0.00	ug/L
16	ES_WATER	WCD	BA10	1999-02	02/01/1999			1.556	0.009	ug/L	2.22	0.00	ug/L
17	ES_WATER	WCD	BA10	1999-04	04/13/1999	3		2.006	0.008	ug/L	1.98	0.00	ug/L
18	ES_WATER	WCD	BA10	1999-07	07/13/1999			3.219	0.005	ug/L	3.64	0.01	ug/L
19	ES_WATER	WCD	BA10	2000-02	02/02/2000	2		1.922	0.021	ug/L	2.46	0.06	ug/L
20	ES_WATER	WCD	BA10	2000-07	07/12/2000			3.197	0.021	ug/L	3.28	0.06	ug/L
21	ES_WATER	WCD	BA10	2001-02	02/07/2001	2		2.525	0.021	ug/L	2.83	0.06	ug/L
22	ES_WATER	WCD	BA10	2001-08	07/31/2001			3.604	0.021	ug/L	4.72	0.06	ug/L
23	ES_WATER	WCD	BA20	1993-03	03/02/1993			2.420	0.004	ug/L	3.56	0.01	ug/L
24	ES_WATER	WCD	BA20	1993-05	05/24/1993	3		3.250	0.004	ug/L	2.94	0.01	ug/L
25	ES_WATER	WCD	BA20	1993-09	09/13/1993			2.890	0.004	ug/L	2.79	0.01	ug/L
26	ES_WATER	WCD	BA20	1994-01	01/31/1994			2.480	0.001	ug/L	2.37	0.01	ug/L
27	ES_WATER	WCD	BA20	1994-04	04/19/1994	3		4.956	0.005	ug/L	3.50	0.01	ug/L
28	ES_WATER	WCD	BA20	1994-08	08/15/1994			3.845	0.003	ug/L	3.37	0.00	ug/L
29	ES_WATER	WCD	BA20	1995-02	02/06/1995			2.951	0.007	ug/L	3.49	0.00	ug/L
30	ES_WATER	WCD	BA20	1995-04	04/25/1995	3		2.888	0.005	ug/L	3.10	0.01	ug/L
31	ES_WATER	WCD	BA20	1995-08	08/14/1995			4.370	0.001	ug/L	4.41	0.00	ug/L
32	ES_WATER	WCD	BA20	1996-02	02/05/1996			1.950	0.002	ug/L	2.78	0.00	ug/L

DATA TAKEN FROM THE S.F. ESTUARY INSTITUTE – RMP STATUS & TRENDS MONITORING DATA

→ "S.F. LOWER SOUTH BAY" (303(d) LISTED AS S.F. BAY, SOUTH)

							Cu		Ni	
33	ES_WATER	WCD	BA20	1996-04	05/02/1996	3	2.500	0.003 ug/L	2.38	0.00 ug/L
34	ES_WATER	WCD	BA20	1996-07	07/29/1996		3.243	0.002 ug/L	3.04	0.00 ug/L
35	ES_WATER	WCD	BA20	1997-01	01/21/1997		1.821	0.002 ug/L	2.69	0.00 ug/L
36	ES_WATER	WCD	BA20	1997-04	04/16/1997	3	3.599	0.012 ug/L	3.69	0.00 ug/L
37	ES_WATER	WCD	BA20	1997-07	07/28/1997		3.189	0.014 ug/L	3.58	0.01 ug/L
38	ES_WATER	WCD	BA20	1998-02	01/27/1998		1.899	0.010 ug/L	2.45	0.01 ug/L
39	ES_WATER	WCD	BA20	1998-04	04/22/1998	3	2.899	0.012 ug/L	2.73	0.01 ug/L
40	ES_WATER	WCD	BA20	1998-07	07/20/1998		3.314	0.006 ug/L	3.11	0.00 ug/L
41	ES_WATER	WCD	BA20	1999-02	02/02/1999		1.486	0.009 ug/L	2.00	0.00 ug/L
42	ES_WATER	WCD	BA20	1999-04	04/13/1999	3	2.114	0.008 ug/L	2.11	0.00 ug/L
43	ES_WATER	WCD	BA20	1999-07	07/14/1999		2.659	0.005 ug/L	3.28	0.01 ug/L
44	ES_WATER	WCD	BA20	2000-02	02/02/2000	2	1.966	0.021 ug/L	2.51	0.06 ug/L
45	ES_WATER	WCD	BA20	2000-07	07/11/2000		3.125	0.021 ug/L	3.38	0.06 ug/L
46	ES_WATER	WCD	BA20	2001-02	02/07/2001	2	2.417	0.021 ug/L	2.62	0.06 ug/L
47	ES_WATER	WCD	BA20	2001-08	07/31/2001		3.520	0.021 ug/L	3.66	0.06 ug/L
48	ES_WATER	WCD	LSB001W	2002-07	07/24/2002		2.718	0.005 ug/L	2.30	0.00 ug/L
49	ES_WATER	WCD	LSB002W	2002-07	07/22/2002		3.302	0.005 ug/L	4.13	0.00 ug/L
50	ES_WATER	WCD	LSB003W	2002-07	07/24/2002		3.406	0.005 ug/L	3.16	0.00 ug/L
51	ES_WATER	WCD	LSB004W	2002-07	07/24/2002	6	2.986	0.005 ug/L	2.66	0.00 ug/L
52	ES_WATER	WCD	LSB005W	2002-07	07/23/2002		2.904	0.005 ug/L	2.34	0.00 ug/L
53	ES_WATER	WCD	LSB006W	2002-07	07/22/2002		3.207	0.005 ug/L	3.05	0.00 ug/L
54	ES_WATER	WCD	LSB007W	2003-08	08/05/2003	b	3.526	0.039 ug/L	2.60	0.08 ug/L
55	ES_WATER	WCD	LSB008W	2003-08	08/05/2003	b	3.883	0.039 ug/L	3.19	0.08 ug/L
56	ES_WATER	WCD	LSB009W	2003-08	08/06/2003	b	3.529	0.039 ug/L	2.61	0.08 ug/L
57	ES_WATER	WCD	LSB010W	2003-08	08/06/2003	b	3.509	0.039 ug/L	2.74	0.08 ug/L
58	ES_WATER	WCD	LSB011W	2003-08	08/06/2003	b	3.478	0.039 ug/L	2.71	0.08 ug/L

5

USED IN RESPONDING TO BAY AREA CLEAN WATER AGENCIES
OCT. 20, 2006 LETTER

Table 3-3A: Water Quality Objectives for Copper and Nickel in Lower South San Francisco Bay

Compound	4-day Average (CCC)[1] µg/l	1-hr Average (CMC)[2] µg/l	Extent of Applicability
Copper	6.9	10.8	Marine and Estuarine Waters Contiguous to SF Bay, South of Dumbarton Bridge
Nickel	11.9	62.4*	Marine and Estuarine Waters Contiguous to SF Bay, South of Dumbarton Bridge

*Handbook of WQS, 2nd ed. 1994 in Section 3.7.6 states that the CMC = Final AcuteValue/2; 62.4 is the Final Acute Value (resident species database)/2; so the site-specific CMC is lower than the California Toxics Rule value because we are using the resident species database instead of the National Species Database.

[1]Criteria Continuous Concentration

[2]Criteria Maximum Concentration

303(d) List
Response to Comments.
Where is demarcation
Inform Nancy to remove Nickel - Lower S.F. Bay

ACTIONS

De-List Nickel (Ni) from the 2002 S.F. Bay, Lower Listing
(Develop Fact Sheet)

Do Not List Nickel (Ni) on the 2006 S.F. Bay, South Listing
(Develop Fact Sheet).
Where is demarcation

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RMP: Home | Program Information | Meeting Minutes & Agendas | Status & Trends Monitoring | Pilot & Special Studies | Committees & Work Groups | Data Access | Documents | Glossary

RMP Status & Trends Monitoring Data

View and download Status and Trends data for San Francisco Estuary water, bottom sediment, and transplanted clam, mussel, and oyster tissue. More information (Questions/Comments)

Query Selection

Test Material

Collection Dates

Parameter Type

Regions

Display Query Results

Display Query Results

Test Material: Water Column Dissolved
Collection Date: All Years
Parameter Type: Trace Elements
Region: Lower South Bay

Download Excel WorkBook

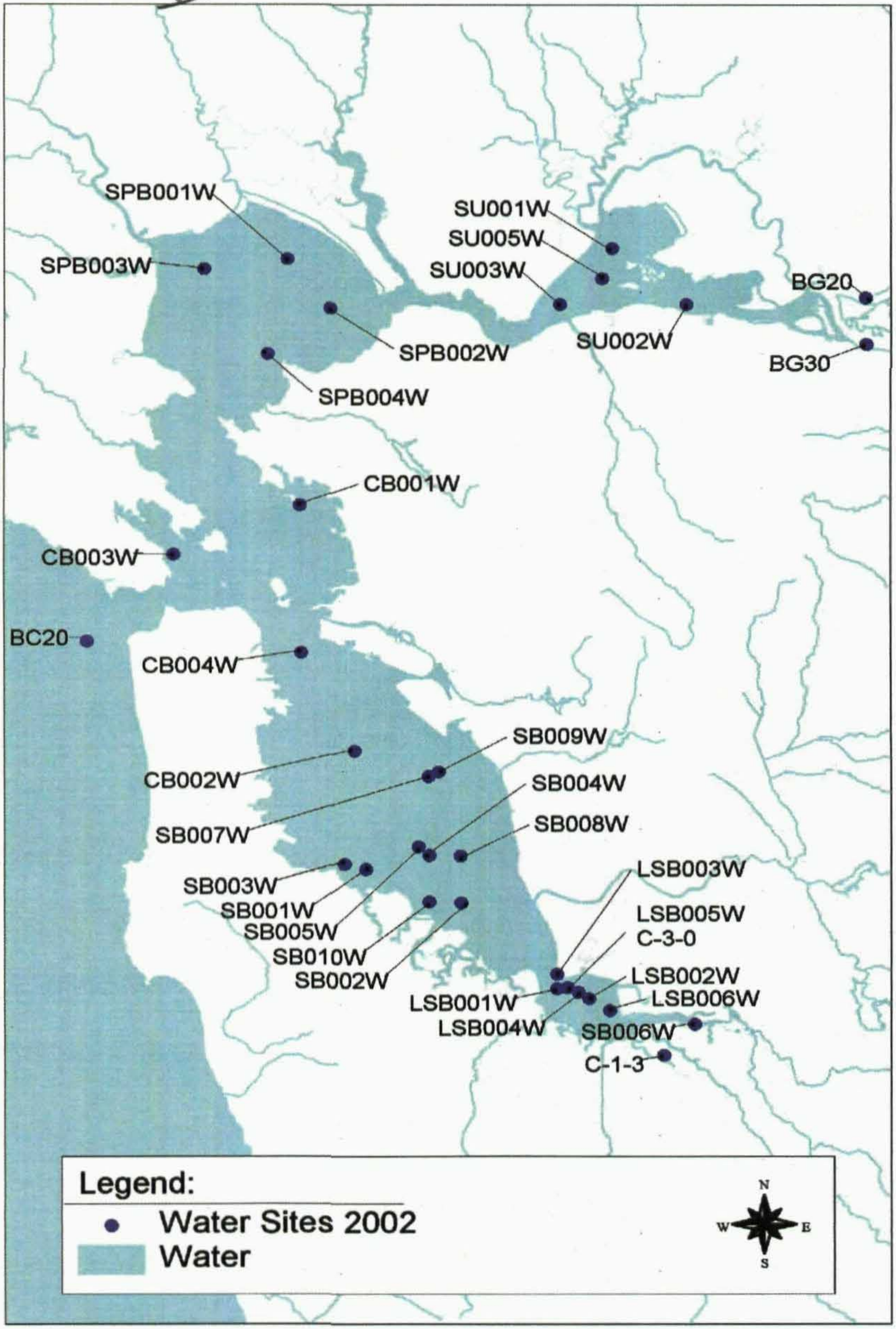
3.6 & 9.1 first pag.

1st step
Set v.d.o.f.)

How to get p stable

Table Take out Application
Spatial & temporal representation

SFEI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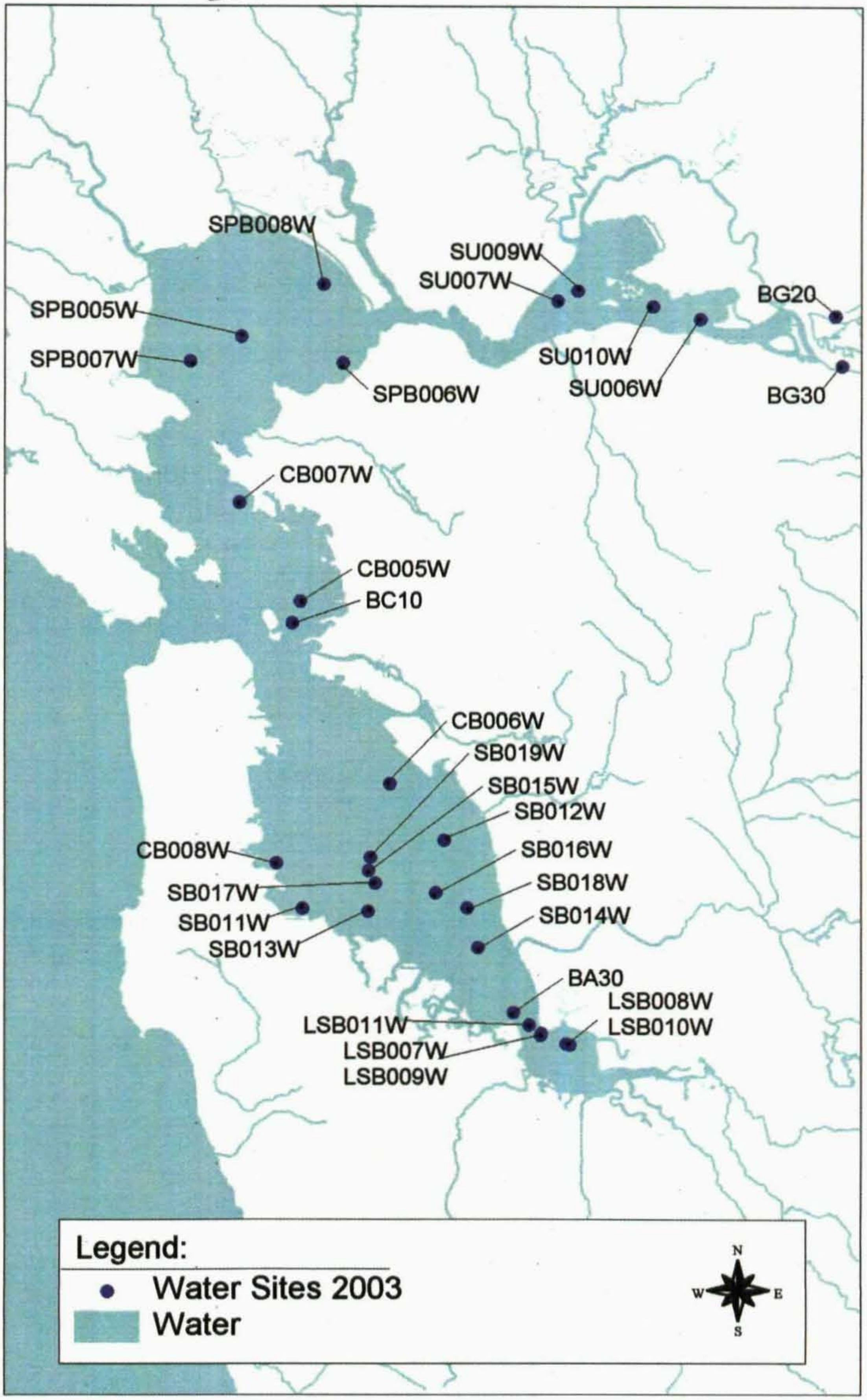
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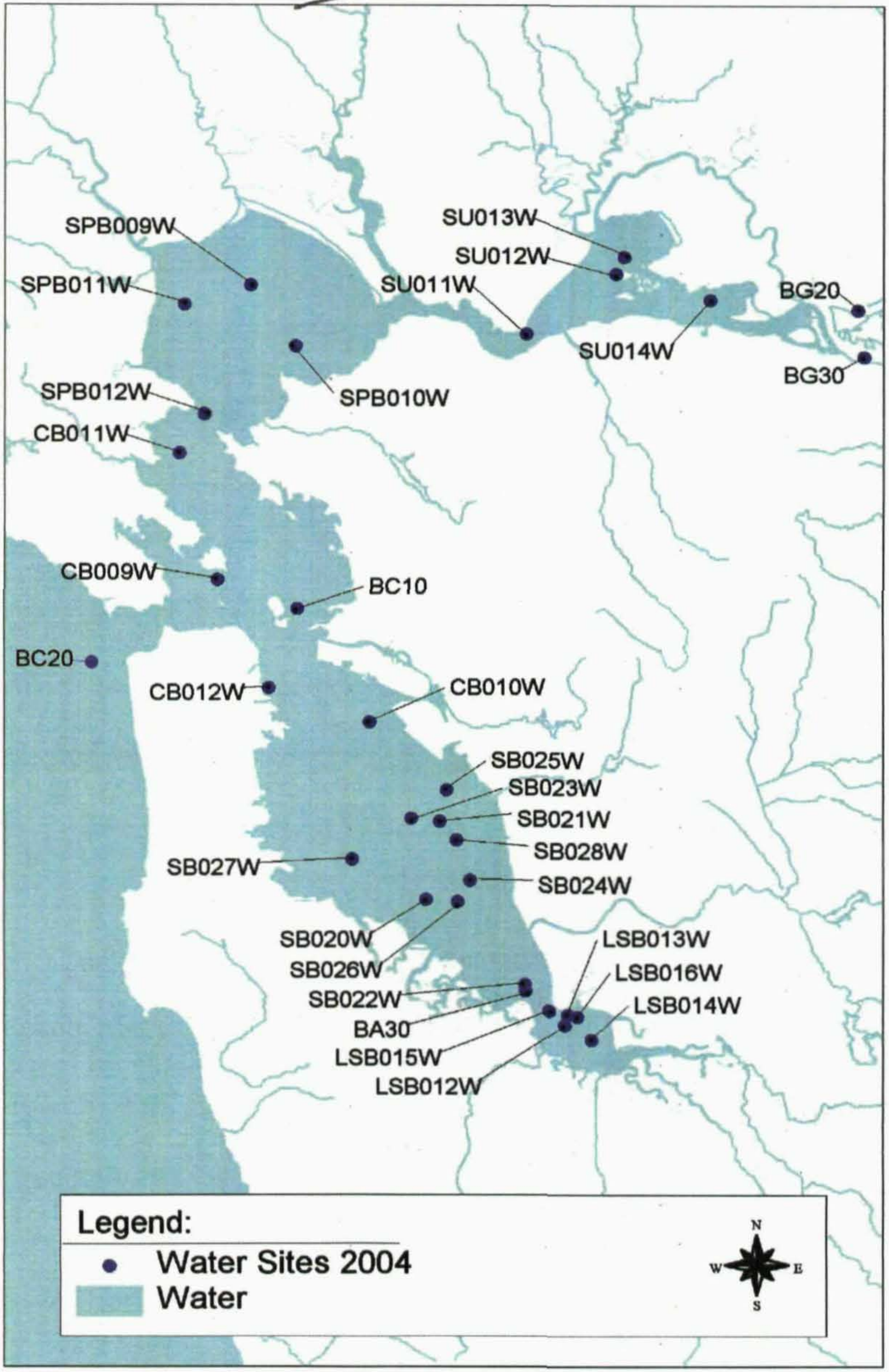

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BC20
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SB028W
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SB026W
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LSB016W
SB022W
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BA30
LSB015W
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Legend:
Water Sites 2004
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SFEI sampling locations in San Francisco Bay
1993 to 2001

SITE_CODE	CRUISE_TYPE	SITE_NAME	Lat in DD	long in DD	Datum
BA10	WATER	Coyote Creek	37.46868	122.0632	WGS-84
BA20	WATER	South Bay	37.49315	122.08792	WGS-84
BA30	WATER	Dumbarton Bridge	37.51375	122.13462	WGS-84
BA40	WATER	Redwood Creek	37.55878	122.20912	WGS-84
BB15	WATER	San Bruno Shoal	37.61477	122.28205	WGS-84
BB30	WATER	Oyster Point	37.6691	122.32862	WGS-84
BB70	WATER	Alameda	37.74225	122.32207	WGS-84
BC10	WATER	Yerba Buena Island	37.82158	122.3495	WGS-84
BC20	WATER	Golden Gate	37.8635	122.67333	WGS-84
BC30	WATER	Richardson Bay	37.8621	122.47868	WGS-84
BC41	WATER	Point Isabel	37.8869	122.34272	WGS-84
BC60	WATER	Red Rock	37.91765	122.43573	WGS-84
BD15	WATER	Petaluma River	38.11148	122.48655	WGS-84
BD20	WATER	San Pablo Bay	38.04823	122.42185	WGS-84
BD30	WATER	Pinole Point	38.02423	122.36262	WGS-84
BD40	WATER	Davis Point	38.05072	122.27768	WGS-84
BD50	WATER	Napa River	38.09672	122.26068	WGS-84
BF10	WATER	Pacheco Creek	38.0511	122.09898	WGS-84
BF20	WATER	Grizzly Bay	38.11588	122.03952	WGS-84
BF40	WATER	Honker Bay	38.06702	121.93437	WGS-84
BG20	WATER	Sacramento River	38.05978	121.8102	WGS-84
BG30	WATER	San Joaquin River	38.02062	121.80522	WGS-84
BW10	WATER	Standish Dam	37.45167	121.9215	WGS-84
BW15	WATER	Guadalupe River	37.42233	121.97417	WGS-84
C-1-3	WATER	Sunnyvale	37.44667	122.01067	WGS-84
C-3-0	WATER	San Jose	37.46417	122.02667	WGS-84

Region 2

Water Segment: San Francisco Bay, South SFEI - Lower South.

Pollutant: Nickel

Decision: Do Not List

Weight of Evidence: This pollutant is being considered for placement on the section 303(d) list under section 3.1 of the Listing Policy. One line of evidence is available in the administrative record to assess this pollutant.

Based on the readily available data and information, the weight of evidence indicates that there is insufficient justification in favor of placing this water segment-pollutant combination on the section 303(d) list in the Water Quality Limited Segments category.

This conclusion is based on the staff findings that:
1. The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
2. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
3. None of the 58 samples exceeded the Regional Board water quality control plan site-specific objectives and in turn does not exceed the allowable frequency listed in Table 3.1 of the Listing Policy.
4. Pursuant to section 3.11 of the Listing Policy, no additional data and information are available indicating that standards are not met.

SWRCB Staff Recommendation: After review of the available data and information, State Water Board staff concludes that the water body-pollutant combination should not be placed on the section 303(d) list because applicable water quality standards are not exceeded.

Lines of Evidence:

Numeric Line of Evidence	Pollutant-Water
Beneficial Use:	ES - Estuarine Habitat
Matrix:	Water
Water Quality Objective/ Water Quality Criterion:	Regional Water Board site-specific water quality objectives 4-day Average Criteria Continuous Concentration (CCC) - 11.9µg/l 1-hour Average Criteria Maximum Concentration (CMC) - 62.4µg/l
Data Used to Assess Water Quality:	Taken from the San Francisco Bay Estuary institute (SFEI) - Regional Monitoring Program. None of 58 samples exceeded the site-specific water quality objective.
Spatial Representation:	13 sampling locations within the segment
Temporal Representation:	Samples were taken from 1993 to 2003 with three samples taken each year, on average. A total of 58 samples were taken during the aforementioned time period.

QA/QC Equivalent: SFEI RMP QA/QC program

Region 2

Water Segment: San Francisco Bay, Lower SEE I - SOUTH BAY.

Pollutant: Nickel

Decision: Delist

Weight of Evidence: This pollutant is being considered for delisting under sections 4.1 of the Listing Policy. Under section 4.1 a single line of evidence is necessary to assess listing status.

One line of evidence is available in the administrative record to assess this pollutant.

Based on the readily available data and information, the weight of evidence indicates that there is sufficient justification available in favor of removing this water segment-pollutant combination from the section 303(d) list in the Water Quality Limited Segments category.

This conclusion is based on the staff findings that:
1. The data used satisfies the data quality requirements of section 6.1.4 of the Policy.
2. The data used satisfies the data quantity requirements of section 6.1.5 of the Policy.
3. None of the 70 samples exceeded the water quality objective; therefore the allowable frequency listed in Table 4.1 of the Listing Policy was not exceeded.
4. Pursuant to section 4.11 of the Listing Policy, no additional data and information are available indicating that standards are met.

SWRCB Staff Recommendation: After review of the available data and information, State Water Board staff concludes that the water body-pollutant combination should be removed from the section 303(d) list because applicable water quality standards have not been exceeded. .

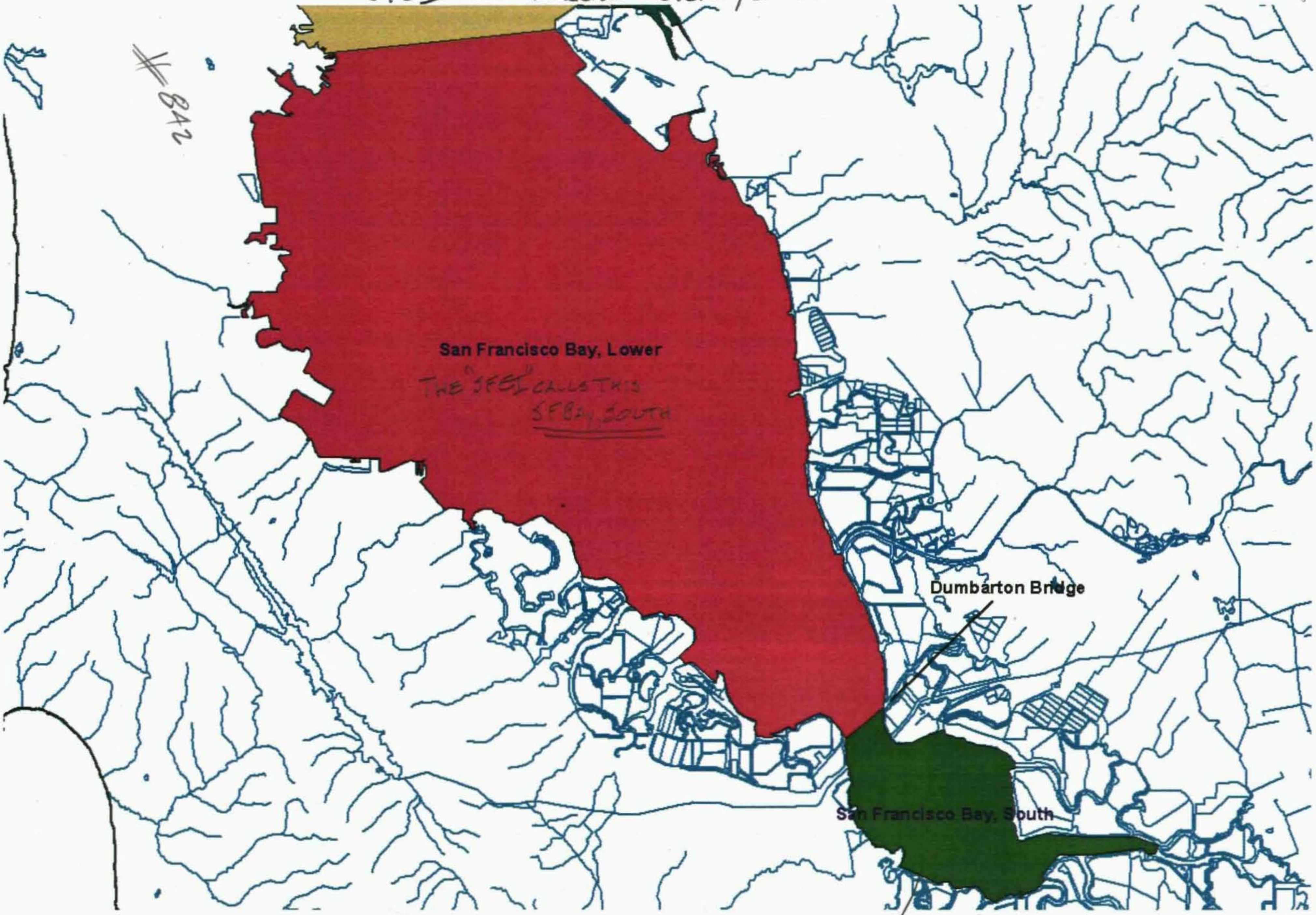
Different names for locations

Lines of Evidence:

Numeric Line of Evidence	Pollutant-Water
Beneficial Use:	ES - Estuarine Habitat
Matrix:	Water
Water Quality Objective/ Water Quality Criterion:	The Regional Water Board Basin Plan contains water quality objectives for nickel in San Francisco Bay - Lower of 8.2µg/L, 4-day average and, 74µg/L 1-hour average. These objectives were approved by USEPA in January 2005 and are contained in the Regional Board Basin Plan in Table 3-3.
Data Used to Assess Water Quality:	Taken from the San Francisco Bay Estuary Institute (SFEI) - Regional Monitoring Program (RMP). None of the 70 samples exceeded the site-specific water quality objective
Spatial Representation:	21 sampling locations
Temporal Representation:	Samples were taken from 1993 to 2003 with three samples taken each year, on average. A total of 70 samples were taken during the aforementioned time period.
QA/QC Equivalent:	SFEI RMP OA/QC program

SFEI - SAN FRANCISCO ESTUARY INSTITUTE

#842



SFEI CALLS THIS "LOWER SOUTH BAY"

SAN FRANCISCO ESTUARY INSTITUTE

RMP Status & Trends Monitoring Data

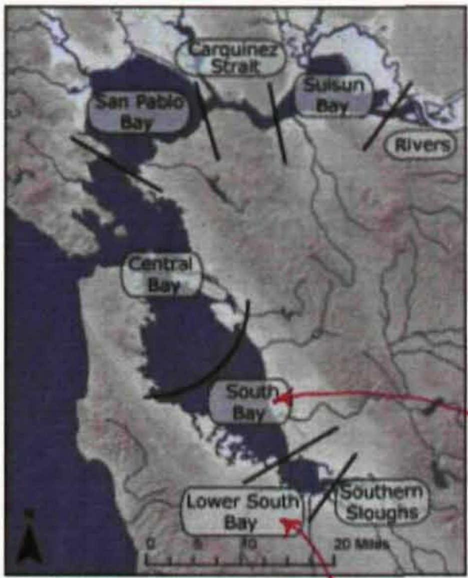
View and download Status and Trends data for San Francisco Estuary water, bottom sediment, and transplanted clam, mussel, and oyster tissue. More information (Questions/Comments)

Query Selection

- **Test Material**
- **Collection Dates**
- **Parameter Type**
- **Regions**
- **Display Query Results**

Regions

- [ ] All Regions
- [ ] Rivers
- [ ] Suisun Bay
- [ ] Carquinez Strait
- [ ] San Pablo Bay
- [ ] Central Bay
- [x] South Bay
- [ ] Lower South Bay
- [ ] Southern Sloughs



303d LISTED AS S.F. BAY LOWER

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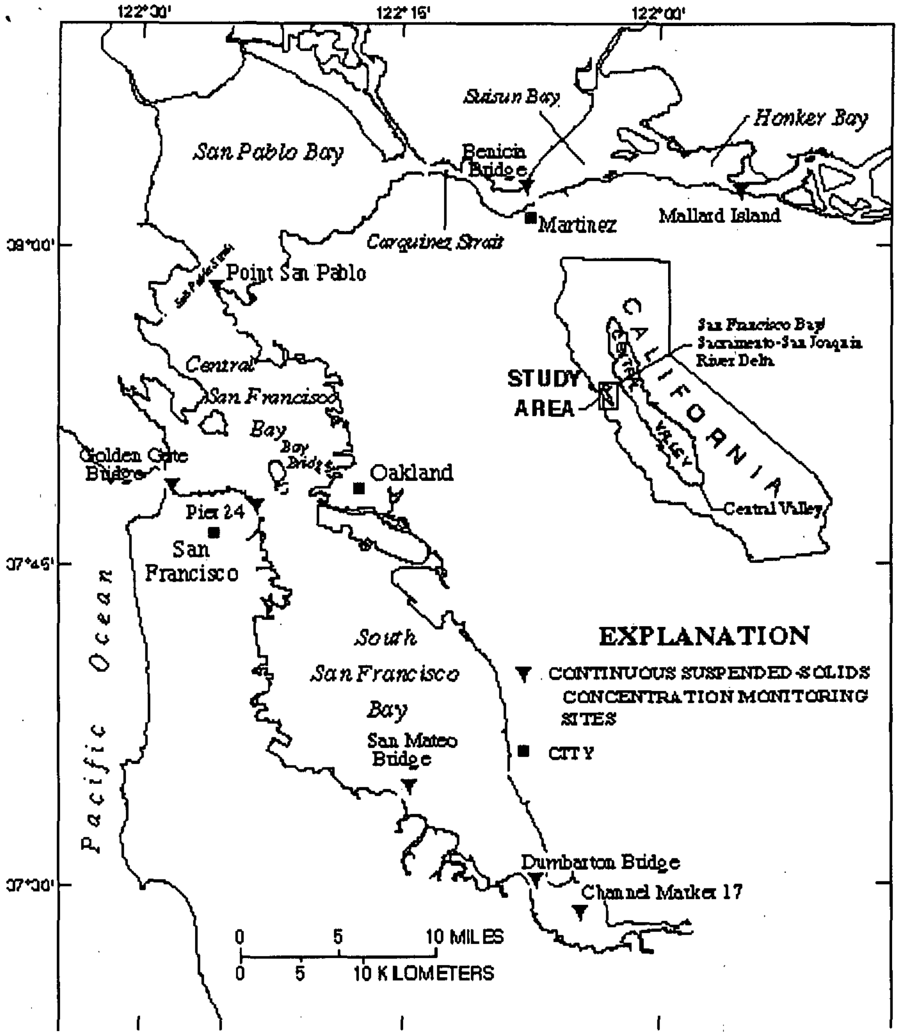
303d LISTED AS ~~[illegible]~~ SF BAY, SOUTH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Point San Pablo
Central San Francisco Bay
Golden Gate Bridge
Bay Bridge
Oakland
Pier 24
San Francisco
Pacific Ocean
South San Francisco Bay
San Mateo Bridge
Dumbarton Bridge
Channel Marker 17
STUDY AREA
CALIFORNIA
San Francisco Bay/ Sacramento-San Joaquin River Delta
Central Valley
EXPLANATION
CONTINUOUS SUSPENDED-SOLIDS CONCENTRATION MONITORING SITES
CITY
0 5 10 MILES
0 5 10 KILOMETERS

Bay Area Clean Water Agencies

Leading the Way to Protect Our Bay
A Joint Powers Public Agency

P.O. Box 24055, MS 702
Oakland, California 94623

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October 20, 2006

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OCT 2006
SWRCB
Executive Ofc.

Song Her
Clerk to the Board
State Water Resources Control Board
1001 I Street
Sacramento, CA 95814
commentletters@waterboards.ca.gov

SUBJECT: Proposed 2006 Federal Clean Water Act Section 303(d) List of Water Quality Limited Segments for California for Nickel

Dear Ms. Her:

The Bay Area Clean Water Agencies (BACWA) appreciates the opportunity to comment on the proposed 2006 Federal Clean Water Act Section 303(d) List of Water Quality Limited Segments for California. BACWA is an umbrella organization that represents nearly all Publicly Owned Treatment Works (POTWs) in the San Francisco Bay Area. BACWA's mission emphasizes the protection and enhancement of the natural resources of the San Francisco Bay Estuary. Our POTW community works daily to ensure that sanitary and industrial wastewater flows receive treatment that meet and often exceed water quality standards that protect the Bay's natural resources. The 2006 proposed 303(d) listing of impaired waterbodies lists the following segments of San Francisco Bay as impaired for nickel: Lower San Francisco Bay, San Pablo Bay, Suisun Bay, and the Sacramento San Joaquin Delta. It is BACWA's position that all these segments should be delisted for nickel.

During development of the 2002 303(d) list, both the San Francisco Regional Water Board (Regional Water Board) and the State Water Resources Control Board (State Board) supported delisting the San Francisco Bay north of the Dumbarton Bridge (NDB) based on a comparison of ambient data to the California Toxics Rule (CTR) 8.2 ug/L dissolved nickel water quality objective (WQO). However, USEPA in its July 23, 2003 final 2002 section 303(d) approval letter did not approve delisting nickel for Lower San Francisco Bay, San Pablo Bay, Suisun Bay, and the Sacramento/San Joaquin Delta. USEPA asserted that the applicable standard to assess the ambient data was the 7.1 ug/L nickel objective contained in the Basin Plan at that time. The 7.1 nickel WQO was exceeded in 102 of 467 ambient samples collected between March 1993 and April 2001. The CTR 8.2 ug /L WQO was only exceeded four times during that time frame, hence the reason for the Regional Water Board and State Board delisting recommendations (all four excursions were at mouth of the Petaluma River). USEPA did establish a low priority TMDL ranking for their nickel listing noting that "the State is in the process of developing site specific water quality standards for nickel that will likely be attained. Therefore it is most reasonable to proceed with water quality standards modifications that will likely obviate the need to complete a nickel TMDL for the Bay."

The Regional Water Board subsequently amended the Basin Plan on January 21, 2004 to update the WQOs (including nickel) from total metal concentrations to be identical to the CTR dissolved WQOs (except for cadmium). The State Board approved the Basin Plan amendment on July 22, 2004, the Office of Administrative Law on October 4, 2004, and USEPA on January 5, 2005. Therefore, the 8.2 ug/L nickel WQO in the Basin Plan has been fully approved. Using the same data and rationale submitted for the 2002 listing, all San Francisco Bay segments north of Dumbarton Bridge should be delisted for nickel.

In addition, nickel impairment in the San Francisco Bay has been extensively studied since it was first identified as a pollutant of concern. An abundance of technical work has been performed in San Francisco Bay in accordance with USEPA site-specific criteria guidance that has been used to justify the adoption of site-specific water quality objectives (SSO) for both copper and nickel in the Lower South Bay segment. In May 2002, the Regional Water Board adopted a Basin Plan amendment to establish site-specific objectives for copper and nickel in Lower South Bay. These objectives were approved by USEPA in January 2003.

Recent technical studies and ambient water column monitoring conducted in San Francisco Bay north of the Dumbarton Bridge have determined that aquatic life impairment due to water column levels of dissolved copper and nickel in San Francisco Bay is unlikely. (See Clean Estuary Partnership, *North of Dumbarton Bridge Copper and Nickel Site-Specific Objectives State Implementation Policy Justification Report* March 2005, *North of Dumbarton Bridge Copper and Nickel Conceptual Model and Impairment Assessment (CMIA) Report* -- March 2005, and *North of Dumbarton Bridge Copper and Nickel Site Specific Objective (SSO) Derivation* March 2005.) These technical studies documented that the 11.9 ug/L dissolved nickel SSO approved for the Lower South Bay was applicable to the entire San Francisco Bay. Using the results of these studies, the Regional Water Board is in the process of developing a Basin Plan amendment to adopt copper and nickel SSOs for the bay north of the Dumbarton Bridge.

BACWA submitted the above technical information with a request to delist nickel to the State Water Board in its comment letter dated January 31, 2006 regarding the September 2005 draft 303(d) list. This correspondence was identified as comment number 127 in the September 2006 Draft Final Staff Report Response to Comments Volume IV. BACWA respectfully requests reconsideration of the denial of our request for delisting nickel, as indicated in the response to comment number 127.3 on page 164 of the Response to Comments:

> "Because the actual data was not submitted with the comment communication, the data could not be evaluated; consequently a determination to delist, could not be conducted."

The Regional Water Board submitted their nickel delisting analysis, recommendations, and the supporting Regional Monitoring Program ambient San Francisco Bay nickel data as part of the 2002 303(d) list development (see attached February 26, 2002 memorandum from Loretta Barsamian, Executive Officer San Francisco Bay Regional Water Quality Control Board to Stan Martinson, Chief Division of Water Quality State Water Resources Control Board, Table 2 page 4). Therefore, BACWA believes that the information and data necessary for a delisting decision is already in the administrative record. However, BACWA has attached the above referenced memorandum to our comments for the administrative record.

Furthermore, the Staff Report under Faulty Listings (page 13) includes as one of the criteria for removal from the list if:

> "The evaluation guideline used originally would lead to improper conclusions regarding the status of the water segment."

As noted above, the 7.1 ug/L total metals nickel WQO in the 1995 Basin Plan cited by USEPA as the basis for their 2002 listing decision was replaced by the 8.2 ug/L dissolved nickel WQO in the 2004 amendments to the Basin Plan. Therefore it would be improper and lead to "improper conclusions" for the State Water Board to use the superseded 7.1 ug/L total metals WQO as the basis for the continued nickel listing of San Francisco Bay water segments.

The State Water Board September 15, 2006 proposed 2006 303(d) list tables currently carry forward the 2002 303(d) nickel listings for applicable Bay segments with the notation "This listing was made by USEPA" and "Source Unknown." Based on the above information and documentation in the existing 2002 303(d) listing administrative record, BACWA respectfully requests that the State Water Board remove nickel from the 2006 CWA Section 303(d) List of Water Quality Limited Segments for the Sacramento San Joaquin Delta, Lower San Francisco Bay, San Pablo Bay, and Suisun Bay.

BACWA appreciates the opportunity to provide these comments and thanks you for your consideration. If you have any questions, please call me at 510-547-1174.

Sincerely,

David R. Williams

David R. Williams, Chair
Bay Area Clean Water Agencies

Attachments - 4

MARCH 2005

848

Clean Estuary Partnership

North of Dumbarton Bridge Copper and Nickel Conceptual Model and Impairment Assessment Report

Prepared by:

EOA, Inc.

LARRY WALKER ASSOCIATES

LARRY WALKER ASSOCIATES

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GLOSSARY OF ACRONYMS

μg/L	Micrograms per liter, or parts per billion
ABAG	Association of Bay Area Governments
ACCWP	Alameda Countywide Clean Water Program
ACR	Acute-to-Chronic Ratio
AMEL	Average Monthly Effluent Limit
ASARCO	American Smelting and Refining Company
Ave.	Average
BACWA	Bay Area Clean Water Agencies
BAPPG	Bay Area Pollution Prevention Group
BASMAA	Bay Area Stormwater Management Agencies Association
BM&M	Bay Modeling and Monitoring
BMP	Best Management Practice
BOD	Biological Oxygen Demand
BPP	Brake Pad Partnership
CAP	Copper Action Plan
CB	Copper Baseline
CCC	Criterion Continuous Concentration (chronic)
CCCWP	Contra Costa Clean Water Program
CEP	Clean Estuary Program
CFR	Code of Federal Regulations
cm	Centimeter
CMC	Criterion Maximum Concentration (acute)
CMR	Conceptual Model Report
CMIA	Conceptual Model Impairment Assessment
COMM	Ocean, Commercial, and Sportsfishing Beneficial Use
CTR	California Toxics Rule
Cu	Copper
Cu^{2+}	Copper ion
CV	Coefficient of variation
CWA	Clean Water Act
CWF	Clean Water Fund
DHS	Department of Health Services
DTSC	Department of Toxic Substances Control
EC	Environmental Clearinghouse
ECA	Effluent Concentration Allowance
EMP	Environmental Monitoring Program
EOA	Eisenberg, Olivieri, and Associates
ERL	Effects Range-Low
ERM	Effects Range-Medium
ERS	Electronic Reporting System
EST	Estuarine Habitat Beneficial Use
FACR	Final Acute-to-Chronic Ratio
FAV	Final Acute Value
FSURMP	Fairfield Suisun Urban Runoff Management Program
ft	Feet
g/day	Grams per day
GAC	Granular Activated Carbon
HNO_3	Nitric Acid
IA	Impairment Assessment
IAR	Impairment Assessment Report
ICS	Industrial Control Strategies
IEP	Interagency Ecological Program
IPBL	Interim performance-based effluent limits
IQR	Inter-quartile Range

Kd	Partition coefficient
kg	Kilogram
L1, L2	Ligands
LC50	50% Lethal Concentration (concentration with kills half of the test species)
LGVSD	Las Gallinas Valley Sanitary District
LSB	Lower South Bay
LSSFB	Lower South San Francisco Bay
LTA	Long-term Average
LWA	Larry Walker Associates
M	Molar
m^3/s	Cubic meters per second
MAR	Marine Habitat Beneficial Use
MCSTOPPP	Marin County Stormwater Pollution Prevention Program
MDEL	Maximum Daily Effluent Limit
MEC	Maximum Effluent Concentration
MEP	Maximum Extent Practicable
mg/kg	Milligrams per kilogram
mg/L	Milligram per Liter
MGD	Million Gallons per Day
mi^2	Square miles
MIGR	Fish Migration Beneficial Use
MLML	Moss Landing Marine Laboratories
mm	Millimeter
MMWD	Marin Municipal Water District
MOA	Memorandum of Agreement
NAP	Nickel Action Plan
NDB	North of Dumbarton Bridge
Ni	Nickel
nM	Nano Molar
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
OAL	Office of Administrative Law
P2	Pollution Prevention
PAH	Polycyclic Aromatic Hydrocarbon
PCB	Polychlorinated Biphenyl
POTW	Publicly Owned Treatment Works
ppb	Parts per billion
psu	Practical salinity units
RMP	Regional Monitoring Program
RO	Reverse Osmosis
RWQCB	Regional Water Quality Control Board
SA	Salicylaldoxime
SCVURPPP	Santa Clara Valley Urban Runoff Pollution Prevention Program
SD	Sanitary District
SF	San Francisco
SFEI	San Francisco Estuary Institute
SFO	San Francisco Airport
SFSU	San Francisco state University
SHELL	Shellfish Harvesting Beneficial Use
SIP	Policy for Implementation of Toxics Standards for Inland Surface Waters, Enclosed Bays, and Estuaries of California; aka State Implementation Policy
SMAV	Species Mean Acute Value
SPWN	Fish Spawning Beneficial Use
SSO	Site-Specific Objective
STOPPP	San Mateo Stormwater Pollution Prevention Program
SWMP	Storm Water Management Plan

SWRCB	State Water Resources Control Board
TDC	Environmental Consulting Firm
TIE	Toxicity Identification Evaluation
TMDL	Total Maximum Daily Load
TOC	Total Organic Carbon
TSS	Total Suspended Solids
TWG	Technical Work Group
ug/g	Microgram per gram
US EPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WER	Water-Effects Ratio
WMI	Watershed Management Initiative
WQO	Water Quality Objective
WSPA	Western States Petroleum Agencies
WWTP	Wastewater Treatment Plant

EXECUTIVE SUMMARY

Introduction

This report includes an impairment assessment and a conceptual model for copper and nickel in San Francisco Bay:

- The impairment assessment summarizes existing data on copper and nickel in water, sediment, and biota and compares them to environmental standards. The assessment also documents ongoing and proposed source control measures for copper and nickel.
- The conceptual model describes the sources of copper and nickel to the Bay and the processes that determine concentrations and fate of these metals in the ecosystem. It uses available information to predict how the ecosystem would respond to management actions that reduce ongoing inputs of copper and nickel.

Copper and nickel were on the 1998 Clean Water Act Section 303(d) "impaired waters" list for San Francisco Bay. In the recently approved 2002 303(d) list, copper was removed and nickel was retained, with qualification. Copper and nickel have been of ongoing environmental concern in San Francisco Bay since the mid-1980's, because elevated water column concentrations may impair aquatic uses in the Bay by producing either acute or chronic toxicity in sensitive aquatic organisms.

San Francisco Bay is a dynamic tidal system. Water and sediment circulation patterns are especially complex as a result of the Bay's elongated shape, the large volume of fresh water (Delta outflow) that passes through its northern reach, its narrow connection to the Pacific Ocean at the Golden Gate, and the relatively low freshwater inputs from local tributaries, especially those in South San Francisco Bay. Ocean tides enter and leave the Bay twice a day. The volume between tidal elevations is called the *tidal prism*, approximately 25 percent of the total volume of the Bay. The Sacramento and San Joaquin Rivers convey the freshwater inflows to the North Bay and transport wet and dry weather runoff from the Central Valley to the Bay.

The toxicity of copper and nickel to aquatic organisms is dependent on site-specific factors such as pH, hardness, suspended solids, dissolved oxygen, dissolved carbon compounds, salinity, and concentrations of other organic and inorganic constituents. Additionally, new toxicity data has become available that should affect the national aquatic life criteria values. Because the national aquatic life criteria for copper and nickel that were adopted as water quality standards in the California Toxics Rule (CTR) may not be directly applicable to San Francisco Bay, USEPA has provided guidance outlining procedures that may be used to develop site-specific criteria for these metals [USEPA, 1994]. An abundance of work has been performed in San Francisco Bay in accordance with this USEPA guidance which can be used to justify the adoption of site-specific water quality objectives for copper and nickel. The original work on such objectives was performed in Lower South Bay, south of the Dumbarton Bridge (see Section 1 of the *Copper & Nickel North of the Dumbarton Bridge Step 1: Impairment Assessment Report, July 2002* for a summary of LSB work). In May 2002, the Regional Board adopted a Basin Plan amendment to establish site-specific objectives for copper and nickel in Lower South Bay, based on that work.

Additional technical work has been performed North of the Dumbarton Bridge (NDB), following the same technical approach and procedures used in the Lower South Bay. Results from that work indicates that site-specific objectives for copper and nickel are appropriate in the Bay NDB. That technical work and the resulting site-specific objectives for copper and nickel are summarized in this document and described in detail in a separate document (*North of Dumbarton Bridge, Copper and Nickel, Development of Site-specific Objectives*, [LWA/EOA, 2004]).

The following management questions have been raised by interested parties in the consideration of adoption of these site-specific objectives. These questions are addressed in the impairment assessment and conceptual model described in this document.

1. Will the adoption of site-specific objectives lead to increased loadings from point sources that will have a measurable impact on dissolved water column copper and nickel concentrations in SF Bay?
2. What implementation measures are needed to ensure that existing copper and nickel concentrations in the water column and surface sediments of the Bay will not increase significantly?
3. Does copper toxicity to sensitive invertebrates (as measured by a Water Effects Ratio) vary significantly over space or time in the Bay?
4. Do existing copper or nickel concentrations in surface sediments cause sediment toxicity in the Bay?
5. Will additional loadings of copper and nickel from point sources produce significant changes in sediment concentrations or sediment toxicity in the Bay?
6. Do existing dissolved copper or nickel concentrations cause phytoplankton toxicity in the Bay?

Impairment Assessment

In February 1989, the State Board designated the Lower South Bay as an impaired water body under Section 304(l) of the Clean Water Act, due to evidence of water quality impacts associated with seven metals based on total recoverable fractions: cadmium, copper, lead, mercury, nickel, selenium, and silver. The State Board identified the three municipal wastewater treatment plants and stormwater discharges into the Lower South Bay as point sources contributing to this impairment.

The 1996 San Francisco Bay Impaired Water Body (Clean Water Act Section 303(d)) listing identified the entire Bay as a high priority impaired water body. "Metals" (as a broad category) were noted as the pollutant of concern and municipal point sources, urban and storm runoff and surface mining were identified as the sources of metals.

In 1998, the RWQCB staff refined the broad listing of "metals" on the 1996 303(d) list to specifically identify mercury, copper, nickel and selenium as the metals of concern. The specific rationale used to support the listing for copper and nickel was "exceedance of the California Toxics Rule {draft at that time} dissolved criteria and National Toxic Rules total criteria, and elevated water and sediment tissue levels." The list identified sources as municipal point sources, urban runoff/storm sewers, atmospheric deposition, and other and was approved by USEPA in May 12, 1999.

Dissolved water quality objectives for copper and nickel in San Francisco Bay were adopted in the May 2000 California Toxics Rule [USEPA, 2000]. The CTR established each of these objectives as a specific numeric value times a WER value. If site-specific studies were not performed to establish a WER value, a default value of 1.0 was to be assumed.

Information was submitted by RWQCB staff to the SWRCB by memorandum dated February 26, 2002 citing the available Step 1 NDB copper water effect ratio (WER) data as support for a recommendation to de-list copper. Available ambient dissolved copper concentrations in the estuary never exceeded the most conservative copper objectives derived from the NDB site-specific WER values.

Based in part on the Step 1 NDB WER and related ambient concentration information for copper and nickel, the SWRCB approved on February 4, 2003 the 2002 303(d) list. The SWRCB list included the delisting of copper throughout the Bay and nickel throughout the Bay, except for nickel in the area around the mouth of the Petaluma River.

However, USEPA did not approve delisting nickel for Lower San Francisco Bay, San Pablo Bay, Suisun Bay, and the Sacramento/San Joaquin Delta because USEPA asserted that the applicable WQO was the Basin Plan 7.1 µg/L total metals nickel objective. The nickel total metals objective was exceeded 102 times since 1993 in those segments while the CTR 8.2 µg/L dissolved metals objective was only exceeded four times and only at the mouth of the Petaluma River. USEPA noted that "the State is in the process of developing site-specific water quality standards for nickel that will likely be attained. Therefore it is most reasonable to proceed with water quality standards modifications that will likely obviate the need to complete a nickel TMDL for the Bay."

Site-Specific Objectives

For copper the geometric mean final WERs (FWERs) were 2.670, 2.876, and 3.535, respectively, for the Dumbarton North, Dumbarton South and Coyote Creek stations in Lower South Bay (LSB). The range of chronic SSOs for the lower South Bay resulting from the Impairment Assessment was 5 to 12 µg/L dissolved copper. EPA reviewed this work and found that the species used were appropriate, the data valid and the conclusions reasonable [USEPA July 27, 1998].

Copper WER studies performed in San Francisco Bay North of Dumbarton Bridge have measured dissolved WER values ranging from 1.6 to 5.3. The mean WER value measured in all NDB samples was 2.7. A range of chronic copper SSOs of 6.8 to 8.4 µg/L was developed from the observed WER values NDB.

The nickel SSO adopted for the LSB is based on recalculation of the national criterion and is therefore a value applicable Bay-wide. Candidate nickel SSOs range from 11.9 µg/L to 20.9 µg/L.

The results of SSO studies and ambient water column monitoring NDB have established that aquatic life impairment due to water column levels of dissolved copper and nickel in San Francisco Bay is unlikely. Results of studies regarding phytoplankton and sediment quality indicate that copper and/or nickel are not likely to be causing impairment of phytoplankton or benthic communities in the Bay. Studies are ongoing to resolve uncertainties, regarding sediment toxicity, phytoplankton toxicity, and the impact of loadings on sediment concentrations. Additional studies are proposed to resolve uncertainties regarding the impact of load management alternatives on ambient copper and nickel levels in the Bay.

Conceptual Model

Available information regarding the sources, loadings, fate and transport, toxicity and ambient levels of copper and nickel in San Francisco Bay are summarized in the conceptual model portion of this document.

Sources and Pathways

The major sources and pathways of copper and nickel to San Francisco Bay are remobilization from in-Bay sediments, riverine inputs, urban and non-urban runoff, POTWs and industrial effluents, and atmospheric wet and dry deposition. Municipalities and industries have invested significant resources in the determination of sources of copper and nickel to wastewater and runoff. Those sources, and associated control measures, are identified in this document.

Loadings

Numerous estimates of loadings of copper and nickel to the Bay have been made. SFEI made the most recent estimate in 2000, which estimated local loads to the Bay of 74 tons per year for copper and 64 tons per year for nickel. SFEI estimated external loads from the Central Valley to be 270 and 410 tons per year for copper and nickel, respectively. The SFEI estimates do not account for re-mobilization of copper and nickel from Bay sediments, which is estimated to be an even larger source than Delta outflow from the Central Valley.

Mass loadings to San Pablo Bay and Lower South Bay were estimated by Rivera-Duarte and Flegal in 1997. SFEI summarized results from that study in its report on the Sources, Pathways and Loadings Workgroup published in 2001. The mass loading estimates indicated that benthic remobilization was a dominant source of loadings of both copper and nickel to the Bay, with riverine loadings next most important. For copper in San Pablo Bay, benthic remobilization is estimated to be 72% of the total loading, riverine and runoff is 26%, and POTWs and atmospheric deposition are each 1%. For nickel in San Pablo Bay, the respective loading percentages are 77%, 21%, 2% and <1%.

Fate and Transport

Copper and nickel partition between the dissolved and particulate phase in San Francisco Bay. Processes of sorption and desorption impact this partitioning. The ratio of adsorption to desorption is referred to as the partition coefficient (Kd). This coefficient depends on metal chemistry and site-specific factors, including salinity, suspended solids, and dissolved organic carbon.

Dissolved copper and nickel exist as inorganic complexes, organic complexes, colloids and free cationic species. The ionic forms of copper and nickel are most toxic to aquatic organisms, as they are the forms which most readily diffuse or are taken up across cell membranes. The complexation of dissolved copper has a direct effect on copper toxicity in San Francisco Bay. Complexation of nickel does not demonstrate a similar effect on nickel toxicity. Neither copper nor nickel bioaccumulate in organisms to a significant degree.

In the northern reach of the estuary, dissolved copper and nickel both have non-conservative excesses (in Bay sources). Copper excesses in the northern reach are relatively consistent during both wet and dry seasons, whereas dissolved nickel excesses are as much as ten-fold greater during the wet season. This difference is due to several coupled processes. These may include weathering of nickel-enriched serpentines, formation of soluble nickel-sulfide complexes, and episodic flushing of adjacent wetlands.

Ambient Conditions

Water column and sediment monitoring has been performed at numerous sites in San Francisco Bay NDB by the Regional Monitoring Program (RMP) since 1993. Plots and tables of these RMP ambient results are provided in this document.

Uncertainty in Conceptual Model that can be Addressed through Water Quality Modeling

The following areas of important ongoing uncertainty have been identified that can be significantly reduced through the use of mathematical hydrodynamic and water quality models of San Francisco Bay.

a. Incremental water quality impacts that may result at various locations in San Francisco Bay due to changes in (1) concentrations and/or (2) mass loadings from existing POTW and Industrial discharges of treated wastewater.

   Mathematical models can be used to address this issue by assessing the incremental effect of increased loadings from some or all sources on water quality at various locations in the Bay.

b. Incremental changes in surface sediment concentrations of copper and nickel that may result from increased loadings of copper and nickel from NPDES discharges.

   Mathematical models can be used to predict the change in surface sediment concentrations under the existing NPDES loading condition and various other loading scenarios.

c. The impact of the erosion of bedded sediments or exposed ore slag with high copper or nickel concentrations on Bay water quality.

   Mathematical models can be employed to assess the effect of significantly elevated areas of surface sediment concentration on dissolved copper and nickel concentrations around the Bay.

d. The relative magnitude and importance of different copper and nickel sources to Bay water quality.

Mathematical models can be used to calculate source loadings from all significant sources. The results from the ongoing Brake Pad Partnership modeling effort will assist greatly in the quantification of urban runoff loadings to the Bay.

1. INTRODUCTION

Section 303(d) of the federal Clean Water Act (CWA) requires states to compile lists of water bodies that do not meet water quality standards and to develop plans for achieving the standards. Copper and nickel were on the 1998 CWA 303(d) List for San Francisco Bay because of elevated water column concentrations. Copper was removed from the 303(d) list for San Francisco Bay in 2002 based on consideration of Water Effect Ratio-adjusted dissolved copper objectives and ambient data on dissolved copper levels in the Bay NDB. Nickel was retained on the 2002 303(d) list for the Bay NDB pending adoption of dissolved CTR objectives in the Basin Plan.

This report includes an impairment assessment and a conceptual model for copper and nickel in San Francisco Bay NDB:

- The impairment assessment summarizes existing data on copper and nickel in water, sediment, and biota and compares them to indicators of impairment.
- The conceptual model describes the sources of copper and nickel to the Bay and the processes that determine concentrations and fate of these metals in the ecosystem. It uses available information to predict how the ecosystem would respond to management actions that reduce ongoing inputs of copper and nickel and addresses uncertainties in these predictions.

This Introduction presents the regulatory background, describes San Francisco Bay and its beneficial uses, introduces the pollutants of concern, and presents the rationale for the current 303(d) listing.

1.1 Regulatory Background

The Clean Water Act provides protection to the surface waters of the United States. Section 101(a)(2) of the Act establishes a national goal of "water quality, which provides for the protection and propagation of fish, shellfish, and wildlife, and recreation in and on the water, wherever attainable." Section 303(c)(2)(a) requires that states develop water quality standards to protect human health and the aquatic environment, and Section 303(d) requires that states develop lists of waterbodies that do not meet those standards. U.S. Environmental Protection Agency (USEPA) regulations require that 303(d) lists be compiled every two years.

In California, Section 13001 of the California Water Code identifies the California State Water Resources Control Board (SWRCB) and Regional Water Quality Control Boards (RWQCBs) as the principal agencies responsible for controlling water quality. These boards are responsible for compiling the 303(d) list of impaired waterbodies. The lists are to be determined using state policy and USEPA guidelines and are subject to approval by USEPA.

1.2 San Francisco Bay and Beneficial Uses

1.2.1 Bay Description

The Bay/Delta estuary is one of the largest estuaries in North America. It comprises two distinct regions, San Francisco Bay and the Sacramento-San Joaquin Delta, and has a surface area of some 1,620 square miles.

The San Francisco Bay system is the largest coastal embayment on the Pacific Coast of the United States [Nichols and Pamatmat, 1988]. The watershed encompasses about 60,000 mi^2, or 40% of California [STB et al., 2000]. Its waters have a surface area of 470 mi^2 and are divided into several segments: Suisun Bay (including Grizzly and Honker Bays), Carquinez Strait, San Pablo Bay, and San Francisco Bay. As shown in **Table 1.1** below, the area, depth, and volume of each of these segments varies considerably.

Table 1.1. Bathymetric Data for San Francisco Bay

Region	Surface Area (mi^2)	Mean Depth (ft)	Mean Volume (acre-ft)
Suisun Bay	36	14	323,000
Carquinez Strait	12	29	223,000
San Pablo Bay	105	9	605,000
Central Bay	103	35	2,307,000
South Bay	214	11	1,507,000
Total >>>	*470*	*17*	*4,965,000*

Suisun Bay is a shallow embayment between Chipps Island, at the western boundary of the Delta, and the Benicia-Martinez Bridge; adjacent is Suisun Marsh, the largest brackish marsh in the United States. The narrow, 12-mile-long Carquinez Strait joins Suisun Bay with San Pablo Bay. San Pablo Bay is a large, open bay that extends from the Carquinez Strait to the San Pablo Strait near the Richmond-San Rafael Bridge. Adjacent to San Pablo Bay lies the northern part of San Francisco Bay, known informally as Central Bay; it is bounded by the San Pablo Strait to the north, the Golden Gate Bridge to the west, and the Oakland-San Francisco Bay Bridge to the south. The southern part of San Francisco Bay, known informally as South Bay, includes all Bay waters south of the Oakland-San Francisco Bay Bridge.

1.2.2 Tributaries

The Sacramento-San Joaquin Delta is a 1,150-square-mile, triangular-shaped region of land and water at the confluence of the Sacramento and San Joaquin rivers. Bounded by the city of Sacramento to the north, Vernalis to the south, and Chipps Island to the west, the Delta is divided into several segments [Gunther, 1987]. The northern Delta is dominated by waters of the Sacramento River, the southern Delta by waters of the San Joaquin River, and the eastern Delta by waters of the Cosumnes and Mokelumne rivers. The Delta's western segment is subject to the greatest tidal effects. The central Delta, surrounded by the other segments, includes many channels where waters from all four rivers mix. The Delta's rivers, sloughs, and excavated channels comprise a surface area of about 75 square miles.

Large volumes of freshwater are episodically introduced into the Bay through the Delta from the

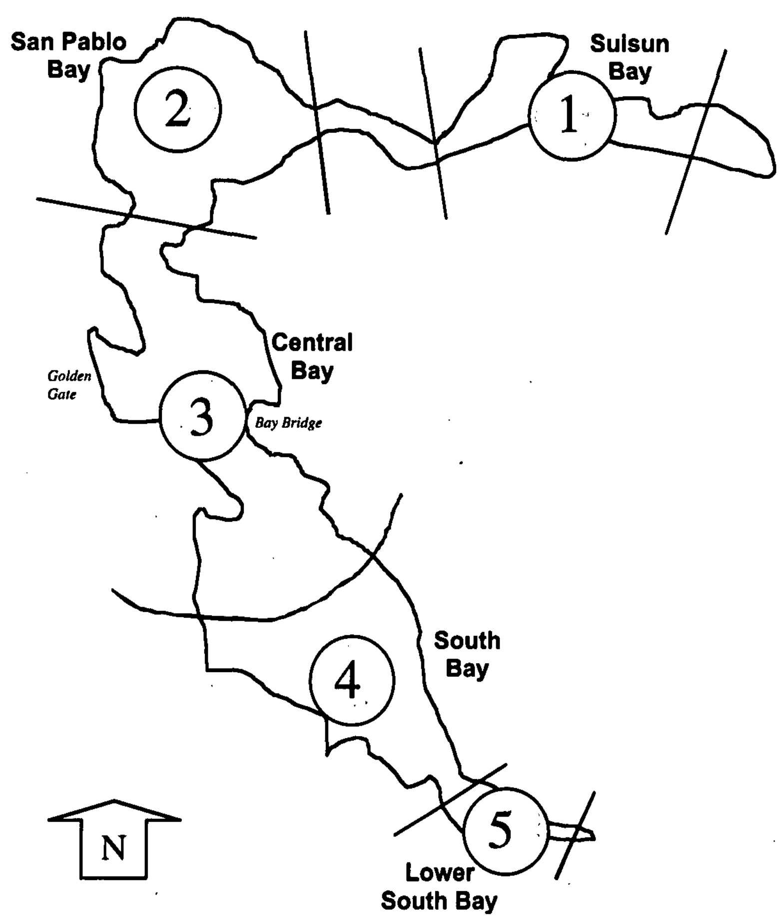
Sacramento and San Joaquin Rivers, at discharge rates ranging from less than 1,000 cubic meters per second (m^3/s) to greater than 10,000 m^3/s [Tetra Tech, 1999; DWR, 1998].

1.2.3 Tidal influence

San Francisco Bay is a dynamic tidal system. Water and sediment circulation patterns are especially complex as a result of the Bay's elongated shape, the large volume of water that passes through its northern reach, its narrow connection to the Pacific Ocean at the Golden Gate, and the relatively low freshwater inputs from local tributaries, especially those in South San Francisco Bay. Ocean tides enter and leave the Bay twice a day. Between high and low tides, changes in the surface of the water may be as much as 9 feet. The average range, 4 to 4-1/2 feet, moves 390 billion gallons of salt water through the Golden Gate. This volume between tidal elevations is called the *tidal prism* [US Army Corps of Engineers, 2001].

Also affecting the Bay's tidal system is the water flowing into the Bay from rivers and other sources. Runoff following rainstorms and snowmelt from the Sierras, travel through either the Sacramento or San Joaquin River to their final destination in the Bay.

Figure 1.1. Regions of San Francisco Bay Defined by Revised Regional Monitoring Program



1.2.4 Current and projected land uses and population

The San Francisco Bay area is bordered by nine counties (**Figure 1.2**). The project area includes portions of all nine counties (except for Santa Clara County) north of the Dumbarton Bridge and whose watersheds drain to San Francisco Bay. Information on land use and populations was gathered from the Regional Board's "Watershed Management Initiative Integrated Plan Chapter" [SWRCB, 2002] and ABAG's "Projections 2002" [ABAG, 2001]. A summary of this information is provided below.

The local drainage area to San Francisco Bay (i.e., exclusive of the Central Valley) encompasses 8550 square kilometers. Land uses in the drainage area are as follows: open space (56%), residential (21%), agricultural (13%), commercial (5%) and industrial (4%) [Davis *et al.*, 2000].

1.2.5 Projections for the Overall San Francisco Bay Area

1.2.5.1 Population

By 2025, the population of the San Francisco Bay area will exceed 8.22 million people, an increase of over 1.44 million from its current level of 6.78 million [ABAG, 2000]. Alameda County will grow by 270,500 people to 1.71 million, Contra Costa County will grow by 261,100 people to 1.18 million and Solano County will grow by 176,800 people to 571,000. In percentage terms, Solano and Napa Counties will see the highest growth during the forecast period. Solano County will add more than 45% and Napa County will add more than 32%, respectively.

1.2.5.2 Job Growth

It is estimated that the San Francisco Bay area will add approximately 1,180,000 jobs during the next twenty-five years. Alameda County will add over 262,500 jobs during this period, an increase of 37%. As a city, San Francisco will add the most jobs over the next 25 years, more than 162,000. In percentage terms, Solano and Sonoma Counties will see the highest growth during the forecast period. Both counties will add approximately 52%, respectively.

1.2.5.3 Land Available for Development

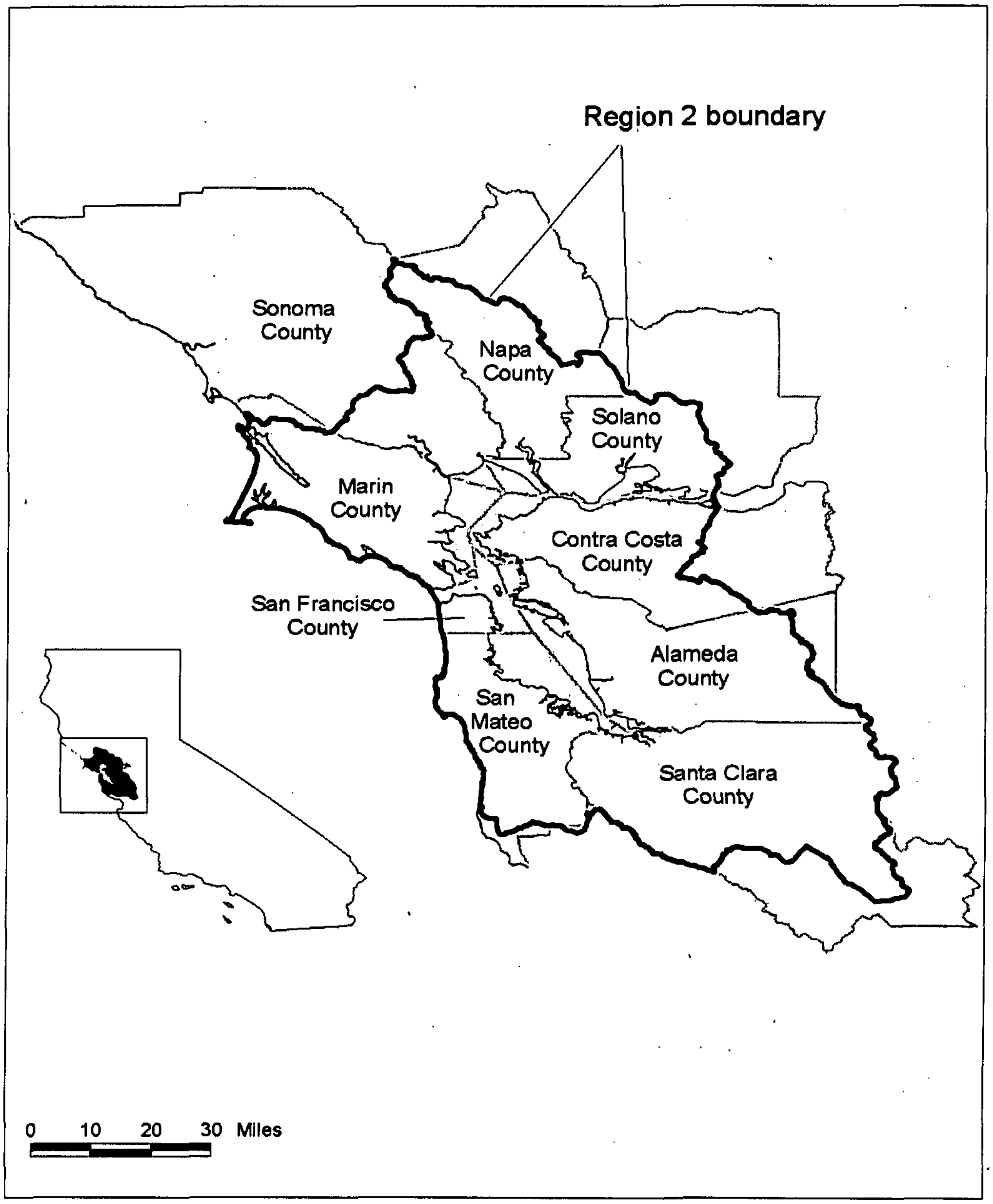
In 2000, about 17% of the region's total acreage was developed, or 752,000 acres. There are approximately 252,800 acres of land available for development in the San Francisco Bay area over the next twenty-five years. This is approximately 5.7% of the region's total area. About 192,700 acres are available for residential development and 57,400 for commercial or industrial development. The largest amount of land available for development is in Sonoma, Contra Costa, Alameda, and Santa Clara Counties. In percentage terms, San Francisco has the most with 52.6%, but only 15,700 acres. Contra Costa and Alameda Counties have the second and third most with 9.1% and 7.8%, respectively.

ABAG notes that the impact of potential growth is difficult to characterize because the nature of urban development is constantly changing. If for example the movement towards "smart growth" continues, ABAG's projections could be realized by developing or redeveloping fewer acres with higher densities than what is now planned.

1.2.6 Beneficial Uses

Chapter 2 of the 1995 Basin Plan lists designated beneficial uses for San Francisco Bay. The beneficial uses potentially impacted by copper or nickel toxicity to aquatic organisms in San Francisco Bay are estuarine habitat (EST), marine habitat (MAR), ocean, commercial and sportfishing (COMM), fish migration (MIGR), fish spawning (SPWN) and shellfish harvesting (SHELL). Detailed descriptions of these uses are provided in the Basin Plan.

Figure 1.2. San Francisco Bay Region



1.3 Copper and Nickel

Concern for copper and nickel toxicity in San Francisco Bay has existed since the mid-1980's, when USEPA aquatic life criteria for trace metals were promulgated and those numeric criteria were adopted as water quality objectives in the San Francisco Basin Plan. At the time of adoption, the USEPA criteria were interpreted as total recoverable values. Limited sampling in San Francisco Bay indicated that ambient levels of total recoverable copper and nickel exceeded the newly adopted Basin Plan objectives. Although the 1993 USEPA metals policy contained the recommendation to apply USEPA aquatic life criteria for trace metals, including copper and nickel, as dissolved values, reliable information on dissolved levels of metals in the Bay was just emerging, various parties were reluctant to accept the change from the total recoverable interpretation of objectives, and residual concern for these metals continued to exist.

Figures 1.3 and 1.4 depict the conceptual models of copper and nickel in San Francisco Bay. Sources of copper and nickel range from industrial, POTW, urban runoff, atmospheric deposition, tributaries, and the sediment bed, to name a few. The processes involving the sedment bed include resuspension and dissolution, erosion of buried sediments, and benthic flux of dissolved copper and nickel. Resuspension and dissolution occur as a function of the movement of the water over the sediments, which lifts the sediments and mixes them with the water column [Kimmer, 2003]. Erosion of buried sediments results when the water movement wears away rock, which may contain serpentinite formations or other metal containing geological structures. Benthic flux (sometimes referred to as internal recycling) represents the transport of dissolved chemical species between the water column and the underlying sediment. This transport is affected by oxidation reduction reactions, complexation and repartitioning, among other chemical processes [Topping *et al*, 2001].

Figure 1.3. Conceptual Model of Copper for San Francisco Bay

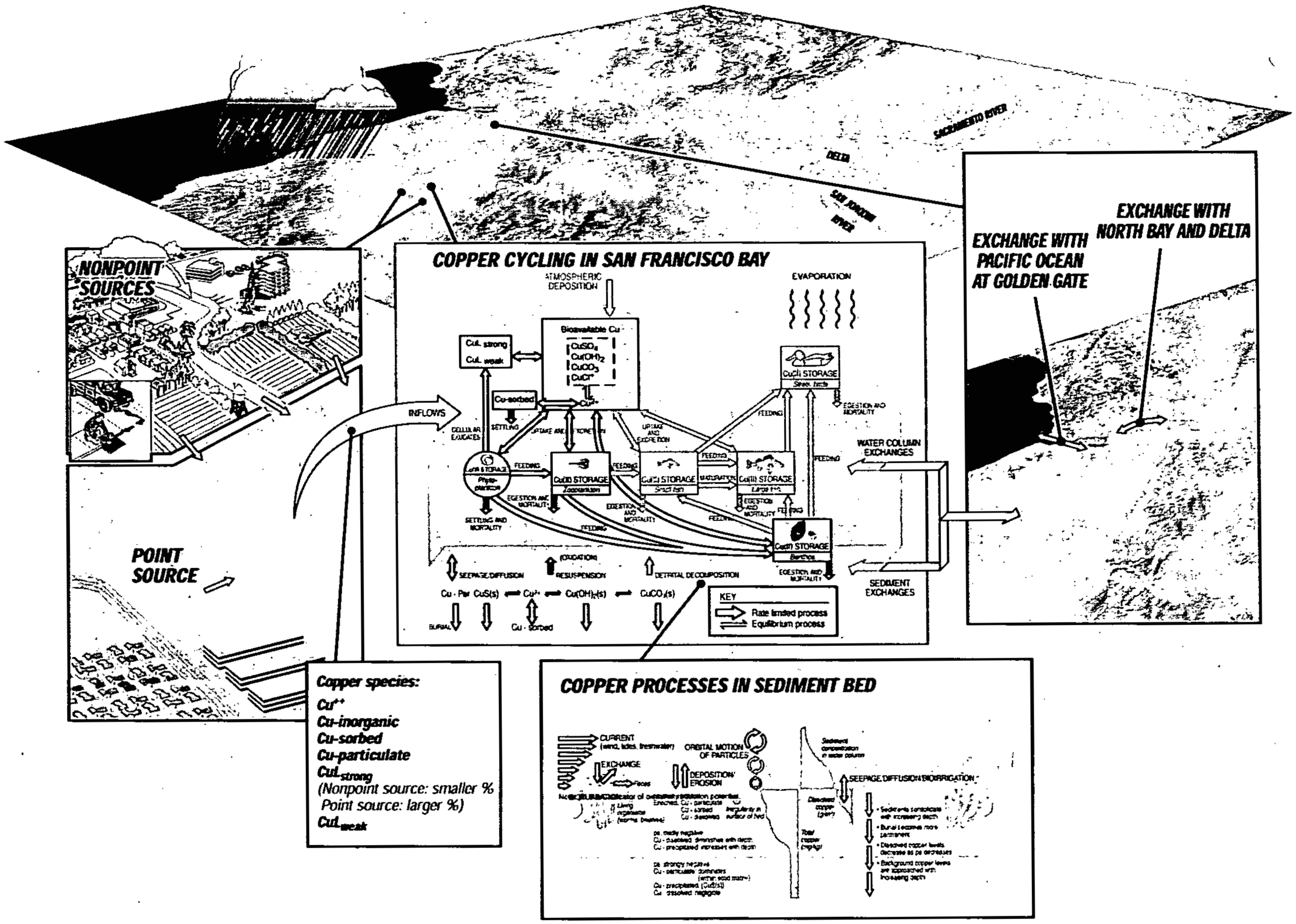


Figure derived from *Conceptual Model Report for Copper and Nickel in Lower South San Francisco Bay* (Tetra Tech, 1999)

Figure 1.4. Conceptual Model of Nickel for San Francisco Bay

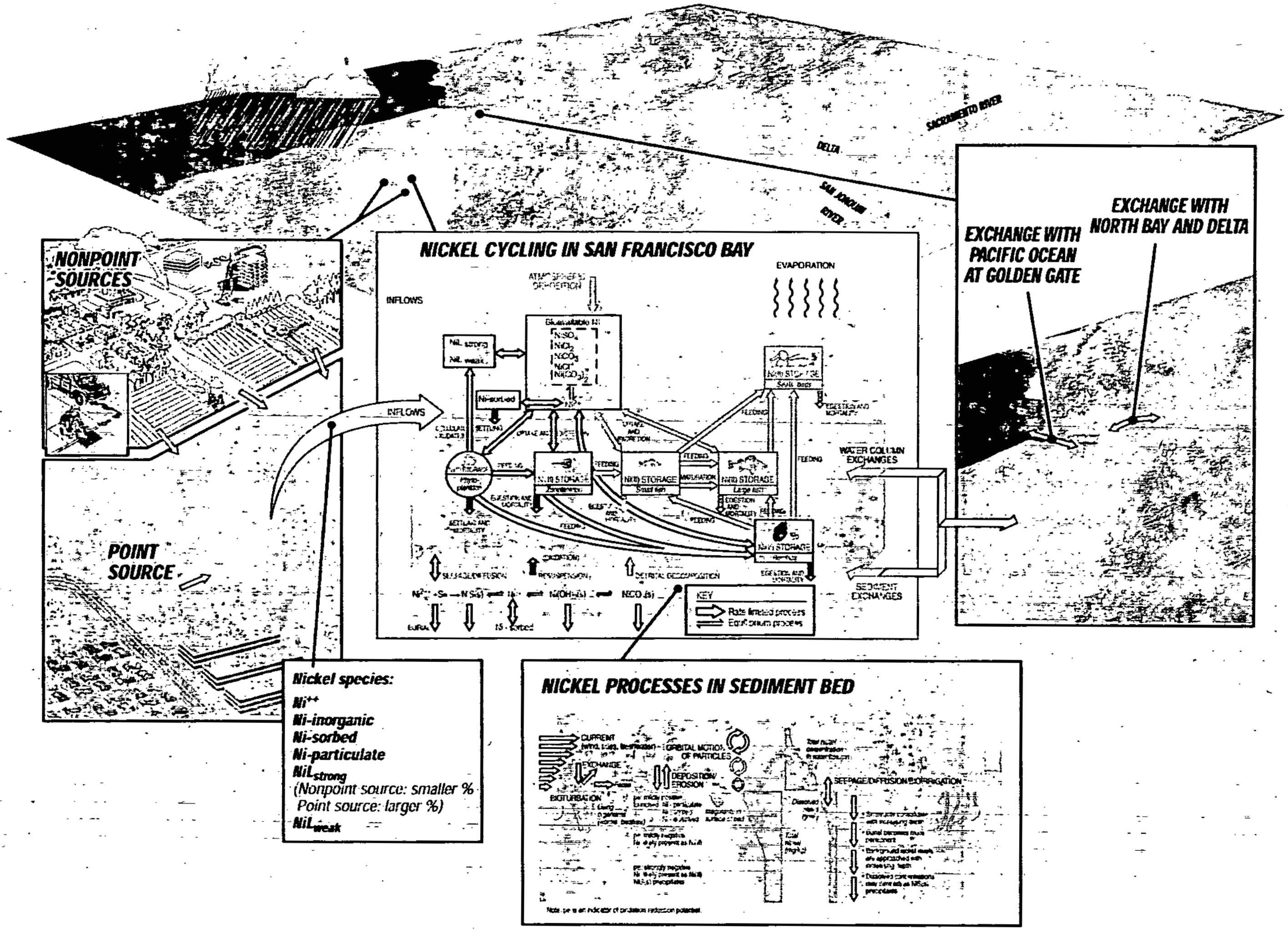


Figure derived from *Conceptual Model Report for Copper and Nickel in Lower South San Francisco Bay* (Tetra Tech, 1999)

1.4 Basis for the Impairment Listing

Section 304(l) of the federal Clean Water Act (as amended in 1987) required States to develop lists of water bodies impaired by toxic pollutant discharges, identify point sources and pollutants causing toxic impacts, and develop individual control strategies (ICS) for each point source identified. In February 1989, the State Board designated the Lower South Bay as an impaired water body under Section 304(l), due to evidence of water quality impacts associated with seven metals based on total recoverable fractions: cadmium, copper, lead, mercury, nickel, selenium, and silver. The State Board identified the three municipal wastewater treatment plants and stormwater discharges into the Lower South Bay as point sources contributing to this impairment. In June 1989, EPA Region IX approved the State's inclusion of the Lower South Bay and conditionally approved the three NPDES permits as ICSs for the municipal discharges.

The 1996 San Francisco Bay Impaired Water Body listing identified the Bay as a high priority impaired water body. Metals were noted as the pollutant of concern and municipal point sources, urban and storm runoff and surface mining were identified as the sources of pollutants. A detailed scientific analysis of the available data to support the listing was not conducted. The listing was essentially based on the analysis contained in the State Board's 304(l) listing.

An ad hoc workgroup made up of staff from the RWQCBs, the SWRCB, and USEPA developed and released guidelines (August 11, 1997) for use in California for conducting the 1998 listing to meet Section 303(d) requirements of the Clean Water Act. An updated listing for the Bay was prepared in early 1998 by the RWQCB staff. The RWQCB staff refined the broad listing of pollutant of concern noted as "metals" on the 1996 303(d) list to specifically identify mercury, copper, nickel and selenium as the metals of concern. The specific rationale used to support the listing for copper and nickel was "exceedance of the California Toxics Rule {draft at that time} dissolved criteria and National Toxic Rules total criteria, and elevated water and sediment tissue levels." The list identified sources as municipal point sources, urban runoff/storm sewers, atmospheric deposition, and other. The 1998 list was approved by USEPA May 12, 1999.

Regional Board staff began the process to update the 1998 list in early 2000 and issued a formal request for available information supporting changes to the list. At the time of this public solicitation of water quality information, the Step 1 water quality monitoring study of copper and nickel north of Dumbarton Bridge (NDB) conducted by the Bay Area Clean Water Agencies (BACWA), Bay Area Stormwater Management Agencies Association (BASMAA), and Western States Petroleum Association (WSPA) was underway.

On November 28, 2001, the Regional Board adopted a resolution allowing the Executive Officer to transmit the staff recommendations for changes to the 303(d) list of impaired waterbodies. The staff recommendations, documented in a staff report dated November 14, 2001, were based on water quality information readily available, including information solicited from individuals, organizations, and agencies on or before May 15, 2001. Data from the first two events of the NDB study were submitted to the RWQCB for use in this update on May 15, 2001. Information after May 15 could be used if a study was underway and staff was notified by May 15 of pending NDB information.

The RWQCB staff recommendations of November 14, 2001 included a recommendation to de-list copper in San Francisco Bay segments north of the Dumbarton Bridge. This was based on evaluation of ambient dissolved copper concentrations compared to the California Toxics Rule (CTR) water quality objective of 3.1 µg/L and a default WER of 1.0. The data evaluated spanned from 1993 to April 2001 and were collected by both the Regional Monitoring Program (RMP) and the NDB study.

Review of these data indicated that the CTR water quality objective for copper was consistently achieved except at the mouth of the Petaluma River. The staff report noted on page 32 "Regional Board staff recommends that targeted monitoring for copper and nickel continue to ensure that beneficial uses are protected, and to document any other sites in the estuary that may be exhibiting exceedances similar to the mouth of the Petaluma River. Based on the consistently high levels documented at the Petaluma River mouth, the RMP and special study spatial coverage is not adequate to conclude that unmonitored freshwater/saltwater interfaces or actively dredged river channels are meeting the water quality standards for copper and nickel." New information bore out this statement, since shoal monitoring in San Pablo Bay showed exceedances of 3.1 µg/L at two monitoring stations in June 2001. However, no exceedances of the criterion maximum concentration (CMC or acute criterion), which is 4.8 µg/L for dissolved copper, have been recorded in 466 samples since the RMP began in 1993.

Additional information was submitted by RWQCB staff to the SWRCB by memorandum dated February 26, 2002 citing the available Step 1 NDB water effect ratio (WER) data as further support for the original recommendation to de-list copper. That memo noted that both shallow and deep-water locations WERs were higher than 1.5 and usually above 2. The CTR allows the national criterion of 3.1 µg/L to be multiplied by the WERs developed in accordance with USEPA guidance to generate applicable thresholds of impairment. Accordingly, a site-specific objective for copper based on WERs does not have to be adopted in the Basin Plan before the State Board can de-list based on the available information and the CTR at 40 CFR 131.38 (b)(1), footnote i, and (c)(4)(i) and (iii).

Available ambient dissolved copper concentrations in the estuary never exceeded the most conservative WER-based objectives. This statement was also true for the mouth of the Petaluma River, and as such, RWQCB staff recommended that it also <u>not</u> be listed for copper. The two new data points from the San Pablo Bay shoals did not exceed the WER-based chronic objective, nor the acute objective of 4.8 µg/L, the latter of which should not be exceeded more than once in three years, according to USEPA guidance.

The WERs demonstrated that Bay waters consistently render copper less toxic than in clean laboratory waters, and justify a site-specific objective(s) for copper in San Francisco Bay segments that have concentrations close to or intermittently above 3.1 µg/L. Since the information was available to support a finding that the WER adjusted water quality standard for copper was met in the San Francisco Estuary north of the Dumbarton Bridge, but that numeric site-specific objectives were not established, the de-listing recommendation was accompanied by a recommendation to establish one or more site-specific objectives based on the latest scientific information. Also, as stated in the November 14, 2001 staff report, de-listing needed to be accompanied by commitments by dischargers to copper pollution prevention to meet the anti-degradation portion of the water quality standard.

Based in part on the Step 1 NDB WER and related ambient concentration information submitted to the RWQCB and SWRCB staff in 2002 as part of the 2002 303(d) list update process, the SWRCB approved on February 4, 2003 the 2002 303(d) list. The SWRCB list included the de-listing of copper throughout the Bay and nickel throughout the Bay, except for nickel in the area around the mouth of the Petaluma River. USEPA gave final approval on July 25, 2003 to the SWRCB 2002 303(d) list, including de-listing copper for the Bay north (and south) of the Dumbarton Bridge.

However, USEPA did not approve de-listing nickel for Lower San Francisco Bay, San Pablo Bay, Suisun Bay, and the Sacramento/San Joaquin Delta because USEPA asserted that the applicable WQO was the Basin Plan 7.1 μg/L total metals nickel objective. The nickel total metals objective was exceeded 102 times since 1993 in those segments while the CTR 8.2 μg/L dissolved metals objective was only exceeded four times and only at the mouth of the Petaluma River. USEPA established a low priority ranking for the nickel listing noting that "the State is in the process of developing site-specific water quality standards for nickel that will likely be attained. Therefore it is most reasonable to proceed with water quality standards modifications that will likely obviate the need to complete a nickel TMDL for the Bay."

On January 21, 2004, the RWQCB approved amendments to the Basin Plan that replaced the total metals water quality objectives with the CTR dissolved metals objectives. Once these amendments are deemed in effect (following SWRCB, OAL, and USEPA approval), USEPA could proceed with de-listing the Bay for nickel, except for the Petaluma River mouth, unless a NDB SSO has been adopted by then. The nickel SSO adopted for the LSB is based on recalculation of the national copper criterion and is therefore a value technically applicable Bay-wide.

1.5 Clean Estuary Partnership

This work is being performed under the direction and review of the Clean Estuary Partnership. The Clean Estuary Partnership (CEP) is a cooperative partnership, including three official partners:

- San Francisco Bay Regional Water Quality Control Board (RWQCB)
- Bay Area Stormwater Management Agencies Association (BASMAA)
- Bay Area Clean Water Agencies (BACWA)

The goal of the CEP is to facilitate efforts to improve water quality in San Francisco Bay. The CEP is working towards developing water quality management strategies, including TMDLs, which identify pollutant sources, assess impacts, and set forth actions that will lead to solutions. This report on copper and nickel is one of a series of impairment assessment and conceptual model reports being developed by the CEP. The impairment assessment reexamines the question of whether the Bay is impaired by copper and nickel. The conceptual model examines what we know about the inputs and fates of copper and nickel in the ecosystem. Together, the impairment assessment and conceptual model will be used to determine management actions that should be taken to maintain or lower the concentrations of copper and nickel in the Bay and additional data that are needed to make that decision.

2. IMPAIRMENT ASSESSMENT

The assessment of the degree to which uses of the San Francisco Bay north of the Dumbarton Bridge are impaired by levels of dissolved copper or nickel in the aquatic environment is presented in this section. The aquatic environmental compartments considered in this assessment include the water column and the surface sediments of San Francisco Bay.

From considerations of the impairment assessment work on copper and nickel in the Lower South Bay and from meetings and communications from interested parties NDB, the following set of management questions have emerged which form the basis for the impairment assessment for San Francisco Bay NDB are described in this section.

1. Will the adoption of site-specific objectives lead to increased loadings from point sources that will have a measurable impact on dissolved water column copper and nickel concentrations in SF Bay?
2. What implementation measures are needed to ensure that existing copper and nickel concentrations in the water column and surface sediments of the Bay will not increase significantly?
3. Does copper toxicity to sensitive invertebrates (as measured by a Water Effects Ratio) vary significantly over space or time in the Bay?
4. Do existing copper or nickel concentrations in surface sediments cause sediment toxicity in the Bay?
5. Will additional loadings of copper and nickel from point sources produce significant changes in sediment concentrations or sediment toxicity in the Bay?
6. Do existing dissolved copper or nickel concentrations cause phytoplankton toxicity in the Bay?

2.1 Water Quality

Copper and nickel toxicities are directly proportional to their free ionic concentrations. Free ionic concentrations of these metals are dependent on site-specific factors such as pH, hardness, suspended solids, dissolved oxygen (i.e., Redox state), dissolved carbon compounds, salinity, and other constituents. Because of the potential for spatial inaccuracies in the national aquatic-life criterion, USEPA has provided guidance concerning three procedures that may be used to convert a national water quality criterion into a site-specific criterion [USEPA, 1994]. One of these, the Indicator Species procedure, is based on the assumption that characteristics of ambient water may influence the bioavailability and toxicity of a pollutant. Under this procedure, acute toxicity in site water and laboratory water is determined in concurrent toxicity tests using either resident species or acceptable sensitive non-resident species, which can be used as surrogates for the resident species. The ratio of the ambient to the laboratory water toxicity values, deemed a water effects ratio (WER), can be used to convert a national concentration criterion for a pollutant to a site-specific concentration criterion (or site-specific objective (SSO) in California terminology).

Findings from prior SSO related studies in Lower South Bay identified in the San Jose WER report (p. 4-43) [City of San Jose, 1998] include:

- The toxicity of copper and nickel in Lower South Bay is less in ambient site-water than the national water quality criteria predict (i.e., Water Effect Ratio[1] values are significantly greater than 1.0);
- The amount of bioavailable copper and nickel in San Francisco Bay is reduced by the presence of water quality components, which make up the apparent complexing capacity of Lower South San Francisco Bay. These components can bind with copper and nickel, making them biologically unavailable (i.e., natural or anthropogenic organic ligands) or may compete for receptor sites on, or in, the organism (i.e., manganese and iron);
- The apparent complexing capacity is greatest in the extreme northern and southern portions of San Francisco Bay;
- The amount of bioavailable copper decreases from north to south in the Lower South Bay (i.e., mean WER values increase in the South Bay in a southward direction);
- Existing toxicological data indicate that the USEPA national aquatic life criteria for copper and nickel are over-protective of the beneficial uses of Lower San Francisco Bay; and
- The Lower South Bay results could justify multiple WER values (i.e., one for the northern end, one for the southern most reaches).

[1] A WER is the ratio of toxicity of a given pollutant in site water to toxicity in laboratory water. If the value of the water effect ratio exceeds 1.0, the site water reduces the toxic effects of the pollutant being tested.

2.1.1 USEPA Criteria Methodology

Because a national aquatic life criterion might be more or less protective than intended for the aquatic life in most bodies of water, EPA has provided guidance concerning three procedures that may be used to derive a site-specific criterion [USEPA, 1994]:

2.1.1.1 Recalculation Procedure

The Recalculation Procedure is intended to take into account relevant differences between the sensitivities of the aquatic organisms in the national dataset and the sensitivities of organisms that occur at the site. This procedure involves eliminating non-resident species from the national data set of aquatic species whose toxicity test results are used to compute the water quality criterion, and then recalculating a site-specific objective with the modified set of species.

2.1.1.2 Indicator Species Procedure

The Indicator Species procedure is based on the assumption that characteristics of ambient water may influence the bioavailability and toxicity of a pollutant. Acute toxicity in site water and laboratory water is determined in side-by-side toxicity tests using either resident species or acceptable sensitive non-resident species which are used as surrogates for the resident species. The Indicator Species Procedure allows for modification of the national criterion by using a site-specific multiplier that accounts for ambient water quality characteristics that may affect the bioavailability of the pollutant in question. As part of this procedure, a water effects ratio (WER) is determined using results from toxicity tests performed in ambient water and laboratory water.

A WER is the ratio of toxicity of a compound to an aquatic organism when the tests are performed using standard laboratory water versus the toxicity when the tests are performed using ambient water. A WER is expected to appropriately take into account the (a) site-specific toxicity of a compound and (b) interactions with other constituents of the site water that may either reduce or increase the toxicity of the compound in question. If the value of the water effect ratio exceeds 1.0, the pollutant is less toxic in the site water than in laboratory water. The difference in toxicity values, expressed as a WER, is used to convert a national water quality criterion for a pollutant to a site-specific water quality criterion.

2.1.1.3 Resident Species Procedure

This procedure is used to account for differences in resident species' sensitivity and differences in bioavailability and toxicity of a material due to the physical and chemical characteristics of the ambient water. The Resident Species Procedure allows for modification of the national criterion by concurrently testing resident species for chronic and acute toxicity in ambient site water.

2.1.2 Water Column-based Site-Specific Objectives for Copper and Nickel

2.1.2.1 Copper

For copper, the City of San Jose used the Indicator Species Procedure in its Impairment Assessment. The range of adjusted WERs for the two Dumbarton stations used to derive a LSB final dissolved copper WER and SSO was 2.2 to 4.5. The range of chronic SSOs for the lower South Bay resulting from the Impairment Assessment was 5 to 12 µg/L dissolved copper. EPA reviewed this work and found that the species used were appropriate, the data valid and the conclusions reasonable [USEPA July 27, 1998].

Copper WER studies performed in San Francisco Bay North of Dumbarton Bridge have measured dissolved WER values ranging from 1.6 to 5.3. The mean WER value measured in all NDB samples was 2.7. A range of chronic copper SSOs of 6.0 to 8.6 µg/L NDB was derived from the observed WER values using the pooled data for Regions 1, 2, 3 and for Regions 4 & 5 multiplied by either 3.1 µg/L (the CTR WQO) or 2.5 µg/L (the San Jose recalculated national WQO) [EOA/LWA, 2004].

2.1.2.2 Nickel

For nickel, a combination of the Recalculation procedure and modification of the EPA recommended Acute-to-Chronic Ratio (ACR) was used by San Jose to develop site-specific modifications to the national water quality criterion. In 1995, Watson, et al. (1996) recalculated the numeric nickel national water quality criterion using the procedure outlined by the USEPA (Carlson, et al. 1984). The corrections, additions, and deletions resulted in a proposed criterion of 10.2 µg/L using the most conservative approach. During this recalculation process, it became obvious that there were no recent chronic data that could be used to recalculate the Final Acute-to-Chronic Ratio (FACR).

The FACR derived in 1986 (17.99) was based on two freshwater and one marine species. There was a large difference between the freshwater and saltwater ACR values that contributed to the FACR. The ACR for the freshwater minnow, *Pimephales promelas*, was 35.58 and that for the waterflea, *Daphnia magna*, was 29.86. Only one marine species, the mysid shrimp, *Mysidopsis bahia* (since reclassified as *Americamysis bahia*), had verifiable chronic data which resulted in a single marine ACR value of 5.48.

In 1997, Watson, et al. (1999) designed and conducted acute and chronic flow-through bioassay tests on three marine species (topsmelt fish, *Atherinops affinis*; red abalone, *Haliotes rufescens*; and the mysid shrimp, *Mysidopsis intii*). The topsmelt is a native to Lower South San Francisco Bay, while the other two species are West Coast natives and commonly used surrogate resident species. Abalone and mysids were found to be far more sensitive to nickel than was topsmelt. Chronic values for abalone and mysids were similar (26.43 and 22.09 µg/L, respectively), and were lower than available literature values. The chronic value for the topsmelt was 4,270 µg/L.

The resultant acute-to-chronic ratios for all three marine species tested by San Jose were remarkably similar, ranging from 5.50 to 6.73. These values were in turn comparable to the ACR value previously reported for *M. bahia* of 5.48 (USEPA 1986). A FACR derived solely from a geometric mean of these four marine species ACRs would be 5.959. An alternative FACR of 10.50 was also developed, using a combination of the four marine ACRs plus two freshwater ACRs.

Watson, et al (1996, 1999) updated the national data-set by deleting non-native species, eliminating questionable data from the data set, adding additional saltwater acute and chronic test data to the dataset, and recalculating both new "proposed" national and site-specific criteria for nickel.

Since abalone is a commercially important species, the calculated Final Acute Value (FAV) that would normally be used for criteria derivation was replaced in the national dataset by the lower (more conservative) abalone Species Mean Acute Value (145.5 μg/L) in order to protect this species. Thus, the recalculated potential national and "South San Francisco Bay" site-specific FAVs were 145.5 μg/L and 124.8 μg/L, respectively. While the San Jose reports used the terminology "South San Francisco Bay " SSOs, the approach taken resulted in a range of SSO values applicable throughout the Bay and potentially to the West Coast. This report will use the "Resident Species" terminology for this SSO approach.

Using the two updated FACRs (marine and combined freshwater plus marine) and the two recalculated FAVs (national and resident species), four alternative SSOs can be derived using the Formula: FAV ÷ ACR = CCC

1) Recalculated National Criterion/Combined Freshwater and Marine ACR;
145.5 μg/L ÷ 10.50 = 13.86 μg/L

2) Recalculated National Criterion/Marine ACR
145.5 μg/L ÷ 5.959 = 24.42 μg/L

3) SF Bay Resident Species/Combined Freshwater and Marine ACR; and
124.8 μg/L ÷ 10.50 = 11.89 μg/L

4) SF Bay Resident Species/Marine ACR;
124.8 μg/L ÷ 5.959 = 20.94 μg/L

The chronic values of 22.09 and 26.43 ug /L for mysids and abalone, respectively indicate that all but option 2) (24.42 μg/L) of the above four potential nickel SSOs would be protective (in clean laboratory water) of the more sensitive mysid (and abalone) and, as such, be protective of the Beneficial Uses San Francisco Bay and North and South of the Dumbarton Bridge. It should be noted, however, that these SSO values are based on clean laboratory toxicity test results and do not include any of the ambient "apparent complexing capacity" present in the Bay that may be responsible for making nickel even less bioavailable to aquatic organisms.

EPA reviewed this San Jose work and found that the species and methodologies used were appropriate for developing site-specific modifications to the national water quality criterion for nickel. As such, no additional toxicity testing is required to derive a nickel SSO for other regions of the Bay. Use of the resident species dataset, while more conservative, would appear appropriate for establishing a NDB SSO, versus use of the recalculated national dataset.

Decisions are required as to whether it is more technically appropriate to use the four species marine ACR versus the combined freshwater/marine (used for the LSB) given the relative robustness of the marine ACR dataset.

2.1.3 Impairment Assessment using Site-Specific Objectives

Comparison of ambient dissolved copper and nickel concentrations in San Francisco Bay NDB with the ranges of site-specific objectives noted above indicates that the Bay would be in consistent compliance with those objectives. Using the site-specific objectives as indicators of the condition of aquatic life uses, the conclusion would be that such uses in the Bay NDB are not likely to be impaired by either copper or nickel. This finding would be consistent with the finding of the copper and nickel impairment assessment report and Basin Plan amendment for the Lower South Bay.

2.1.4 Uncertainty

The following areas of uncertainty were identified in the Lower South Bay studies and are applicable to the use of site-specific objectives as the basis for the impairment assessment in the Bay NDB.

- Use of single sensitive organisms (early life stage) in lab water
- Use of surrogate sensitive fish and invertebrate species to indicate toxicity to native species
- Phytoplankton toxicity
- Length of toxicity tests versus full life exposure
- Limited number of Nickel ACR values

Each of these areas of uncertainty were previously addressed in the impairment assessment report prepared for the Lower South Bay. That information is incorporated herein by reference. Additional information to resolve uncertainty regarding phytoplankton toxicity is provided in Section 2.5 of this document.

2.2 Sediment Quality

2.2.1 Sediment Concentrations

Average surface (top 5 cm) sediment copper concentrations for San Francisco Bay range from approximately 16 to 63 mg/kg dry weight, based on data collected by the Regional Monitoring Program over the period from 1993 through 2001. Highest copper levels in surface sediment (55 to 63 µg/L) occur in the northern areas (Napa River, Petaluma River, Grizzly Bay and Honker Bay) where the percent fines (< 63 um) are highest (greater than 90% fines). By contrast, lowest levels of copper in surface sediment (16 to 20 µg/L) have been measured at non-depositional sites (Sacramento River, Pacheco Creek, etc) where coarse sediments prevail (less than 20% fines) (see **Tables 3.5 & 3.6**).

Average surface sediment concentrations for nickel for the Bay range from 65 to 110 mg/kg dry weight (RMP data for 1993-2001). Nickel levels follow the pattern exhibited by copper, with highest concentrations in the same areas where fines exceed 90%. Nickel is strongly enriched in some geologic components of the northern Bay. Analysis of sediment cores by Hornberger *et al.*, 1999 and Luoma *et al.*, 1998 indicates that elevated concentrations of nickel in surface sediments in North San Francisco Bay were originated from natural geologic outputs, likely from nickel deposits in ultramafic rocks.

The ambient copper and nickel concentrations in surface sediments of San Francisco Bay are not at levels of concern. While no enforceable sediment quality objectives have been adopted in California, one common frame of reference for sediment quality evaluation is the effects-range numerical values produced by Long *et al.* for NOAA. Sediment quality guidelines [Long *et al.*, 1995; Long and Morgan, 1990] were used to evaluate if sediment concentrations were within ranges that have been previously associated with biological effects. Those guidelines were derived from a large national database and are currently the most widely used and accepted sediment effects guidelines available. In interpreting the guidelines, concentrations below the Effects Range-Low (ERL) are not typically associated with adverse effects, concentrations between the ERL and Effects Range-Median (ERM) are occasionally associated with adverse effects, and concentrations above the ERM are frequently associated with adverse effects [Long *et al.*, 1995].

The ERL and ERM values developed by Long, *et al.* for copper are 34 and 270. Comparing these values with observed surface sediment concentrations in San Francisco Bay NDB, approximately half of the sites sampled showed copper concentrations that exceeded the ERL value. The highest copper levels in surface sediments in the Bay NDB were in Honker Bay, where levels reached 63 mg/kg. This value was far below the ERM value of 270 mg/kg, a level at which effects are expected.

Effects-Range values for nickel are not considered to be very accurate predictors of effects [Long *et al.*, 1995] because of limited data. Therefore, similar comparisons of observed nickel data with Effects-Range values for nickel is not deemed to be useful.

2.2.2 Sediment Toxicity

Sediment toxicity is an area of uncertainty, based on the fact that average surficial sediment concentrations in San Francisco Bay NDB can range from 2 to 3 times higher than an average background concentration of 20 mg/kg. As stated in the Impairment Assessment Report (IAR) for Lower South Bay:

> *"There are currently no definitive methods that can be used to determine whether any observed sediment toxicity is caused by the presence of copper. Sediments are extremely complex and even though many of the components that make up the sediment are fairly well known, interactions between those components remain unclear at this time."*

No sediment special studies were recommended by the IAR for Lower South Bay because of the lack of any methodology that can be used to definitively assess the specific role that copper plays in any observed sediment toxicity.

Surface sediment samples have exhibited toxicity to test organisms at a number of sites throughout the Estuary. Since 1993, the RMP has seasonally evaluated the toxicity of sediments to mussel embryos and amphipods. For each seasonal sampling period since 1993, the proportion of sediment samples that were toxic to at least one test organism ranged from 33% to 100%, with no clear overall trend, but with clear seasonal differences. As with water toxicity, sediment toxicity is more frequent in the Estuary during the wet season than in the dry season, suggesting stormwater runoff may be an important source of constituents that cause sediment toxicity. This pattern is particularly clear for amphipods. For example, 51% of the winter samples tested between 1993 and 1999 were toxic to amphipods, while only 16% of the summer samples were toxic during this period.

Sediment from specific locations in the Estuary has been most frequently toxic to amphipods and mussel embryos. Samples from Grizzly Bay, the mouth of the Napa River, Redwood Creek, and the South Bay have often been toxic to amphipods. Samples collected in the northern Estuary (Grizzly Bay and the Sacramento and San Joaquin Rivers) have often been toxic to mussel embryos. Grizzly Bay sediment is contaminated by a complex mixture of moderate concentrations of trace metals and trace organic compounds.

Initial analyses to identify the causes of observed sediment toxicity have yielded a variety of answers, in large part due to the complex mixtures of chemicals involved. Comparisons of the chemical data to toxicity test data indicated that amphipod mortality and reductions in normal mussel embryo development may have been related to various chemicals in sediments [Thompson *et al.*, 1999; Anderson *et al.*; 2001; Phillips *et al.*, 2000].

Causes of sediment toxicity have been further investigated using toxicity identification evaluations (TIEs). TIEs are laboratory procedures designed to characterize the class of chemicals causing toxicity, then identify and confirm specific chemicals responsible for toxicity. TIE procedures developed by the U.S. EPA and novel techniques developed as part of RMP special studies have shown that divalent metals may have contributed to inhibited bivalve embryo development and caused amphipod mortality in sediment samples from the Grizzly Bay station [Phillips *et al.*, 2000, Anderson *et al.*, 2001]. However, the TIE findings were not conclusive regarding the contribution of copper to observed sediment toxicity effects. (See City of San Jose comments on the Phillips *et al.* (2000) paper in Attachment 1 to their May 18, 2004 comment letter included in **Appendix A.**)

The source of toxicity in Grizzly Bay sediment samples is clearly unknown. There are a number of issues that would require more investigation to link observed toxicity to copper, if such a link exists. It is therefore recommended that the results from TIE testing should only be used to develop a more definitive test procedure to confirm the suggested toxicant. Chemical specific data must also be used to verify the source of toxicity conclusively. Pollutants should be positively identified using statistical testing of biological endpoints that can be compared to chemical specific toxicological data (taken from EPA criteria documents or other sources) for the pollutant believed to be associated with observed toxicity.

2.2.3 Plans to Resolve Uncertainty

Sediment toxicity is likely to persist for many years to come, considering the continuing toxicity observed in the RMP. Additional special studies are planned to further examine whether water and sediment toxicity tests used in the RMP are accurate predictors of impacts on the Estuary's aquatic and benthic communities. Because the amphipod (*Eohaustorius estuarius*) used in the

RMP is not a resident of the Estuary, there has been some debate regarding its ecological relevance. Sensitivity of selected resident organisms to key chemicals of concern will be compared to sensitivity of this amphipod species. Similar tests are planned to evaluate the water test species. Information from these experiments will confirm whether the current species employed are adequately sensitive to represent and ensure the protection of the Estuary ecosystem. Determination of the causes of sediment toxicity observed in monitoring will ultimately require evidence from numerical analysis of monitoring data and manipulative experiments. Such experiments will include continued toxicity identification evaluations (TIEs), laboratory and/or *in situ* sediment spiking and dose-response tests at concentrations shown to be associated with toxicity [SFEI, 2003].

2.3 Benthic Macroinvertebrates

Community analysis of benthic macroinvertebrates is a useful indicator for overall ecosystem health, but is typically not a valuable indicator for assessment of impairment by single stressors. Many of the stressors and pollutants in the Bay co-vary – as a result, it is difficult to attribute or identify an impact to a single pollutant or stressor. The best use of this indicator would be to confirm impacts that were predicted by indicators that had a tighter linkage to copper and nickel. The IAR for Lower South Bay concluded that community analysis of benthic macroinvertebrates was not a useful indicator for the assessment of copper and nickel impairment.

The USEPA aquatic life criteria are calculated to be protective of sensitive invertebrates and fish. Therefore, as described elsewhere in this report, the water column-based site-specific objectives for copper and nickel directly account for toxicity to sensitive benthic invertebrate species (e.g. copper sensitivity to *Mytilus edulis* and nickel sensitivity to mysids).

2.4 Fish and Shellfish

The USEPA water column-based aquatic life criteria for copper and nickel directly account for toxicity to sensitive fish and shellfish species. Of the four most sensitive species to copper (which govern the copper criteria value), one (summer flounder, *Paralichthys dentatus*) is a fish species: This sensitive fish species has an acute LC50 value of 12.7 μg/L dissolved copper, while the most sensitive fish (chronic) has a chronic toxicity value of 5.9 μg/L. By comparison, the acute toxicity value for the most sensitive invertebrate species (mussel, *Mytilus edulis*) is roughly 8 μg/L. Maximum ambient levels of dissolved copper NDB are four-fold and two-fold lower than the acute and chronic toxicity values for these sensitive fish in clean laboratory water, respectively. At these ambient levels, impairment of fish species in San Francisco Bay by copper is unlikely.

For nickel, none of the four most sensitive species in the USEPA criteria toxicological data set are fish. In fact, the most sensitive fish species in the USEPA data set (Atlantic silverside, *Menidia menidia*) has an acute LC50 value of 7958 μg/L nickel. With ambient levels of dissolved nickel NDB typically less than 4 μg/L, no impairment of fish species by nickel is likely in San Francisco Bay.

2.5 Copper Toxicity to Phytoplankton

Certain phytoplankton species are very sensitive to concentrations of free ionic copper. Therefore, phytoplankton have been an important consideration in prior copper impairment assessments (IA) of Lower South San Francisco Bay (LSB). Many of the IA conclusions, findings, and uncertainties associated with phytoplankton toxicity in the LSB are applicable to the Bay north of Dumbarton Bridge (NDB). This section summarizes the findings of the prior IA regarding phytoplankton and the results of studies undertaken to address the issue of whether phytoplankton are being adversely impacted by ambient levels of copper in the Bay.

2.5.1 San Jose SSO Report (Lower South Bay)

The City of San Jose, in their report "*Development of a Site-Specific Water Quality Criterion for Copper in South San Francisco* Bay" [City of San Jose, 1998] summarized the available toxicity values for various nationally and locally present phytoplankton. The report described the limitations of currently available phytoplankton laboratory toxicity testing methods and the rationale why phytoplankton were not used for developing the LSB Water Effect Ratios (pp. 50-53 Protection of South Bay Plant Life).

2.5.2 Draft Impairment Assessment Report (Lower South Bay)

In July 1999, the Copper Nickel TMDL Work Group (TWG) of the Santa Clara Basin Watershed Management Initiative (WMI) provided initial comments on the draft *Impairment Assessment Report for Copper and Nickel in Lower South San Francisco Bay* [May 1999] (IAR). Comments on phytoplankton toxicity were the most numerous, with 21 out of 57 comments were either directly or indirectly (i.e., copper speciation and phytoplankton community structure) related to phytoplankton toxicity.

In response to these concerns, additional literature was compiled and the available data re-evaluated in an issue paper in July 1999. The Assessment Team compared the findings of this re-evaluation to the project's established Indicator Evaluation Criteria (Table 2-1, IAR, May 1999). These criteria were developed early in the South Bay impairment assessment process to evaluate the applicability of individual environmental measurements as indicators of beneficial use impairment. Based on several factors, ranging from feasibility issues to the ability to interpret test results, phytoplankton were judged <u>not</u> to be an acceptable indicator for the impairment assessment.

Special studies were proposed in the draft IAR to address some of the uncertainties that affect the ability to interpret phytoplankton study results (as well as other relevant laboratory and field results).

2.5.3 Conceptual Model Report (Lower South Bay)

The "*Conceptual Model Report for Copper and Nickel in Lower South San Francisco Bay*" [Tetra Tech, 1999] (CMR) stated that additional data should be collected to further assess the speciation of copper and nickel in the Bay. The presence of ionic forms of these metals was deemed to be important to the assessment of potential impacts on phytoplankton.

At the time the CMR and IAR were being prepared, there were relatively few measurements in San Francisco Bay of free ionic copper and complexing ligand types and concentrations. Work by Bruland *et al.* [1992] provided initial information to indicate that significant complexation occurs in the Bay. The recommendation was to conduct additional speciation measurements and to compare the free ionic copper concentrations to the known threshold toxicity levels (10^{-11} M or 6 x 10^{-5} µg/L) of sensitive phytoplankton in seawater having little or no complexing capacity and low concentrations of competing ions (i.e. zinc, manganese, and iron). Free ionic copper concentrations at or above these levels would be an indication that the potential for impairment to phytoplankton productivity exists.

2.5.4 Final Impairment Assessment Report (Lower South Bay)

The final "*Impairment Assessment Report for Copper and Nickel in Lower South San Francisco Bay*" [Tetra Tech, 2000a] (IAR) found that the weight of available evidence supported the conclusion that impairment of beneficial uses due to copper and nickel was unlikely. The IAR also found that uncertainties remained regarding the scientific information upon which that conclusion was based. The IAR summarized the key uncertainties and potential special studies to reduce the associated level of uncertainty (Section 5.3 Uncertainties and Special Studies). Two of the three areas of uncertainty cited in the IAR were similar to those identified in the CMR and included 1) toxicity of copper to phytoplankton and 2) biogeochemical processes influencing copper and nickel speciation relative to bioavailability.

The Final IAR included information on phytoplankton community structure, species abundance, the feasibility of conducting laboratory bioassays to directly measure copper toxicity, and whether existing dissolved copper levels were toxic to phytoplankton. Articles were cited which indicated that certain marine species of phytoplankton, in particular species of cyanobacteria, were highly sensitive to copper. Additionally, some studies in San Francisco Bay had suggested that cyanobacteria were not commonly found in the Bay. Based on these studies, some South Bay stakeholders had questioned whether existing dissolved copper concentrations were causing toxicity to these species.

Prior to the release of the final South Bay Impairment Assessment Report, two papers regarding the occurrence of the cyanobacteria *Synechococcus* sp. in San Francisco Bay were published. Both papers[2], which were included in the South Bay Impairment Assessment Report Appendices, showed that cyanobacteria were a "persistent component of the San Francisco Bay phytoplankton in all the estuarine habitats" in 1998 and 1999.

After receiving this information, the Copper and Nickel TMDL Work Group requested the Technical Review Committee to examine the information and comment on its significance to findings of the South Bay Impairment Assessment Report. The Technical Review Committee's response lent additional support to the overall finding that impairment to the beneficial uses due to ambient copper concentrations is unlikely.

[2] Ning, X., J. E. Cloern and B. E. Cole. 2000. Spatial and temporal variability of picocyanobacteria *Synechococcus* sp. in San Francisco Bay. Limnology and Oceanography; Palenik, B. and A. R. Flegal, 1999. Cyanobacterial populations in San Francisco Bay. Regional Monitoring Program for Trace Substances, Technical Report. (http://www.sfei.org/rmp/reports/cyanobacterial.html)

The final conclusion reached in the South Bay IAR was that ambient levels of dissolved copper in South Bay (which are the highest levels in the Bay) were not adversely affecting phytoplankton populations in the South Bay. The South Bay IAR was reviewed by SWRCB peer reviewers, Dr. Alex Horne and Dr. David Jenkins. Dr. Horne concluded that the IAR "reflects good science and a thorough external reviewing of the complex physical, chemical, biological and regulatory problems of assessing impairment of beneficial uses...". Professor Horne strongly supported the recommendation of the IAR that the 303(d) list should be updated to de-list copper and nickel as stressors for Lower South San Francisco Bay.

2.5.5 San Jose Phytoplankton Study

Issues identified in the South Bay Impairment Assessment study included (a) whether copper-sensitive phytoplankton species are important to the San Francisco Bay ecosystem, (b) whether copper-sensitive species are present in the Bay; and (c) the fact that USEPA criteria development is not driven by the consideration of phytoplankton toxicity. These issues are also relevant to the consideration of copper and nickel impairment in San Francisco Bay north of the Dumbarton Bridge.

The City of San Jose agreed to pursue additional studies of phytoplankton distribution and abundance. In cooperation with the Regional Board and local scientific experts, the City designed a project to develop bioassessment techniques for South San Francisco Bay's plankton community.

In 2001 San Jose began a project to develop and conduct a pilot monitoring program of the plankton of the South San Francisco Bay (i.e., south of the San Mateo Bridge) to provide guidelines for long-term monitoring, and recommendations of indicators of ecosystem condition. The project had two phases: (a) development of a monitoring plan including potential indicators of ecosystem condition; and (b) field work to test and further refine the monitoring plan and proposed indicators. The biological, physical, and habitat information collected in this study were intended to aid in the understanding of the effects of natural variability on plankton community composition in the South Bay.

In physically dynamic environments such as San Francisco Bay, the effects of natural variability (i.e., physical changes in the environment, such as salinity, temperature, seasonal runoff, etc.) on phytoplankton community structure must be understood in order to appropriately evaluate effects from other sources.

Results were presented in a report titled "*Plankton Communities in South San Francisco Bay: Historical Data Analysis and Pilot Monitoring, Phase I Draft Report*" prepared by the Romberg Tiburon Center for Environmental Studies, San Francisco State University dated May 1, 2003. A brief summary of the report's findings and conclusions are presented below.

The Phase I monitoring found nutrient and chlorophyll levels in South San Francisco Bay compared well with USGS data for Station 36 sampled five times between 1992 and 1999. Picocyanobacteria (among the most sensitive phytoplankton to copper) were still present and varied a great deal. For example, average cyanobacteria measured by the study in August 2002 (0.40E07 and 0.38E07 cells/L) were an order of magnitude lower than previously published values of Ning *et al.* [2000] for August 1998. However, May 2002 abundance values for cyanobacteria (15.5E07 & 13.1E07 cells/L) were consistent with those reported for May 1998 for South S.F. Bay (15.4E07 cells/L) by Ning *et al.* [2000]. Enumeration of phytoplankton samples collected seven times from August 2001 to February 2003 indicated the usual presence of diatoms, large and small (5 mm) flagellates, dinoflagellates, and cyanobacteria.

The Phase I study confirmed the presence of sensitive phytoplankton species in South San Francisco Bay. This study found that "Regardless of site or season, the [Cu^{2+}] values throughout San Francisco Bay did not exceed 1E^{-13} M, suitably below the toxicity limit for sensitive aquatic organisms [Buck & Bruland, 2003].

The study review of extant data was not able to further develop or link any of the proposed variables to specific indicators of ecosystem health. Further, the study did not link pollutant data to ecosystem health, a major project objective. The merits of the study were discussed among the interested parties (Regional Board, City, SFSU). That discussion concluded that it was not likely that indicators of ecosystem health could be linked to anthropogenic effects or to specific pollutant data in the foreseeable future. Therefore, the study was concluded.

2.5.6 CALFED Open Water Processes White Paper

One of the investigators in the San Jose/RTC project, Dr. Wim Kimmerer prepared a draft White Paper for the CALFED Ecosystem Restoration Program titled "*Open Water Processes of the San Francisco Estuary*" [Kimmer, 2003]. The document contains a comprehensive literature review and discussion of phytoplankton, particularly in the context of primary productivity in the Bay. It covers the multitude of complex factors that affect phytoplankton growth, species composition, and the timing and location of blooms. These include light and nutrient limitation, grazing, hydrodynamic effects, and the impact of the Delta and the Pacific Ocean. Copper is not mentioned as a factor influencing phytoplankton dynamics in the Bay. The White Paper lists the following eight key uncertainties regarding phytoplankton primary production, none of which include copper toxicity:

- How do phytoplankton and higher plants interact, especially in the Delta?
- How will changes in sediment supplies to the water column affect primary production?
- How have biomass and primary production changed as a result of *P. amurensis* and *Corbicula fluminea*?
- How do stratification and shoal-channel exchange influence bloom dynamics in Suisun, San Pablo, and Central Bays?
- What is the effect of losses to export pumping and agricultural diversions on phytoplankton?
- What are the effects of barriers in the Delta on phytoplankton?
- What is the influence of the coastal ocean on phytoplankton?
- What is the role of benthic microalgae in estuarine primary production?

2.5.7 USGS

The USGS in Menlo Park is continuing a long-term study of hydrography and phytoplankton in San Francisco Bay. The Principal Investigator is Dr. Jim Cloern. The objectives of this study are

(1) to track seasonal changes in basic water quality and habitat parameters that influence biological communities and the role of phytoplankton in the distribution and reactivity of trace elements and (2) to provide a depth-integrated picture of salinity, temperature, chlorophyll and suspended sediment distribution for modeling purposes. This study continues its measurement program in support of the RMP, with monthly water sampling to map the spatial distributions of basic water quality parameters along the entire Bay-Delta system. Measurements include salinity, temperature and dissolved oxygen, which influence the chemical form and solubility of some trace contaminants, and suspended sediments and phytoplankton biomass, which influence the partitioning of reactive contaminants between dissolved and particulate forms. This basic information is required to follow the seasonal changes in water quality and estuarine habitat as they influence biological communities and the distribution-reactivity of trace contaminants.

This study has documented the presence of a highly complex and at times rapidly varying phytoplankton community throughout the Bay as measured by chlorophyll concentrations. Some species composition data are compiled but reportedly information on the small cyanobacteria such as *Synechococcus* is limited since different microscopic techniques are required. RMP staff are coordinating with Jim Cloern to identify USGS plans and schedule for compiling and reporting on historic Bay-wide species composition and abundance information.

2.5.8 Basin Plan SSO Amendment Staff Report

The RWQCB "*Staff Report on Proposed Site-Specific Water Quality Objectives and Water Quality Attainment Strategy for Copper and Nickel for San Francisco Bay South of the Dumbarton Bridge*" [RWQCB, 2002]. Response to Comments noted that "virtually all information about systems as complex as Lower South SF Bay will have associated uncertainty. This does not mean that decisions cannot be reasonably made based on the strength and weight of available evidence." The IAR, CMR, and other reports had generally identified the same basic areas of scientific uncertainty, varying slightly due to their differing focus and authorship. The Staff Report cited the following four areas of remaining uncertainty:

- Copper toxicity to phytoplankton;
- Copper and nickel cycling;
- Copper sediment toxicity; and
- Loading estimates.

The RWQCB obtained funding to have additional ambient copper speciation work conducted as this was determined to be the most direct means of addressing the copper toxicity issue (see Bruland study below).

2.5.9 Bruland Copper Speciation Study

The RWQCB contracted with Dr. Ken Bruland of the University of California, Santa Cruz during 2001 to evaluate copper speciation in San Francisco Bay. Trace metal clean techniques were employed in the collection of samples on four separate occasions from six sites throughout the Bay. The six sites sampled, from south to north, include: Dumbarton Bridge, Redwood Creek, San Bruno Shoals, Yerba Buena Island, San Pablo Bay, and Grizzly Bay. The sampling took place during June 2001, July – August 2001, January 2003 and March 2003. Results were reported in a May 2002 interim report and July 2003 draft final report.

The study found that in San Francisco Bay the total dissolved copper is strongly complexed by organic ligands. The study estimated the concentrations and conditional stability constants of two classes of ambient ligands complexing copper in the Bay: a strong L_1 class and an intermediate L_2 ligand class. These ligands complex greater than 99.9% of the total dissolved copper in San Francisco Bay and, in every case, the ligand concentrations exceed the dissolved copper concentrations. This tends to reduce copper toxicity by reducing free ionic copper concentrations.

Another factor that reduces copper toxicity is competitive uptake of other divalent cations, such as dissolved manganese(II). The highest dissolved manganese concentrations were documented in the far reaches of the Bay, at the Dumbarton Bridge and Grizzly Bay sites. The manganese values observed at the other sites were significantly lower, generally less than half the levels seen at Grizzly Bay and Dumbarton Bridge. In other waterbodies, dissolved manganese/copper ratios are good predictors of copper toxicity, so dissolved manganese needs to be considered when evaluating the potential for copper toxicity.

Ligand and dissolved copper concentrations were lowest at the Yerba Buena Island site and generally increased further away from the mouth of the Bay and into the farthest North and South Bay sites. In the January and March data, Grizzly Bay, the north-easternmost site, had significantly higher ligand concentrations than any of the remaining sites. Dumbarton Bridge, the southernmost site, had the second highest ligand concentrations.

Complimentary trends were observed for the free Cu^{2+} ion concentrations, with the highest $[Cu^{2+}]$ values at Yerba Buena Island, where there was the least excess of strong L_1 ligands. The lowest $[Cu^{2+}]$ values were observed at the Grizzly Bay site, and the second lowest at Dumbarton Bridge. Regardless, at every site sampled and over all of the different sampling periods, $[Cu^{2+}]$ never exceeded 10^{-13} M, which is low enough to be nontoxic to the residing phytoplankton community. It was extrapolated from the results that if ambient dissolved copper concentrations were to increase from the current ~3.4 µg/L range to the site-specific LSB SSO of 6.9 µg/L, or approximately 108 nM, the $[Cu^{2+}]$ (free ionic copper concentration) would reach 10^{-11} M, the previously identified toxicity threshold for sensitive phytoplankton in open oceanic type seawater [Buck & Bruland, 2003].

The report concluded that strong copper-complexing ligands dominate the chemical speciation of dissolved copper in San Francisco Bay. The concentrations of these ambient organic ligands exceeds the total dissolved copper concentrations at every site, and it is these ligands which complex greater than 99.9% of the dissolved copper. This strong organic complexation of the copper results in very low free hydrated Cu^{2+} ion concentrations. Across all sites and seasons, the $[Cu^{2+}]$ values throughout San Francisco Bay did not exceed 10^{-13} M, the reported toxicity limit for sensitive aquatic organisms in oceanic systems.

In summary, these measurements, made during 2001-2003, found free ionic copper concentrations to be a factor of 100 below the threshold toxicity values for sensitive phytoplankton.

2.5.10 CVRWQCB Algae Toxicity Study

In August 2002, the Central Valley RWQCB published results of a CALFED funded study to identify the causes of algae toxicity in the Sacramento and San Joaquin River Watersheds and the Delta titled "Algae Toxicity Study Monitoring Results: 2000-2001." As noted in the report, "the cause of toxicity to algae is infrequently identified because the laboratory control is unsuitable for comparison with ambient samples and standard toxicity identification evaluation (TIE) methods are limited for use in algae toxicity tests." The study investigated alternative TIE methods, primarily using solid phase (C8) extraction in an attempt to develop better protocols to evaluate causes of toxicity. The investigation focused on organics, since herbicides (primarily diuron) appeared to be the most prevalent source of toxicity. Work is continuing on further development of the algae TIE methodology and on how phytotoxicity relates to instream impacts. The potential relevance of this project depends on its success in developing TIE methodologies that can accurately differentiate and assess impacts of water column concentrations of copper, versus other constituents, on phytoplankton toxicity.

During the Lower South Bay SSO development process, San Jose staff evaluated the potential problems (confounding factors, extrapolation to the field, and salient endpoint to regulate) associated with algal toxicity testing. (See comments in Attachment 2 to City of San Jose letter dated May 18, 2004 in **Appendix A**).

2.5.11 SCVURPPP Copper Action Plans-Phytoplankton Uncertainties and Studies

The South Bay Copper Action Plan (CAP) (June 2000) includes several baseline activities (CB-17, CB-18) to "track and encourage" activities and research intended to reduce the scientific uncertainties associated with the impairment assessment and conceptual model reports' conclusions. These copper baseline activities from the Copper Action Plan are included among the full suite of 21 baseline CAP activities in Appendix B of the Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP) NPDES Permit Number CAS029718, Order Number 01-024 dated February 21, 2001 [SCVURPPP, 2001].

Since 2001, SCVURPPP has been tracking activities and research intended to reduce the scientific uncertainties associated with the South Bay Impairment Assessment and Conceptual Models Reports' conclusions. Many of these uncertainty reduction activities are applicable to assessing potential copper impacts on a Bay-wide basis rather than just in Lower South San Francisco Bay. "Track and encourage" activities are included in the annual Copper/Nickel Work Plans prepared and submitted to the Regional Board each March 1^{st}. Actions accomplished are summarized in the Annual Report submitted each September 15^{th}.

The copper baseline activities relevant to phytoplankton uncertainties and studies and a brief description of their linkage to copper are described below:

- CB-17 (1): Phytoplankton species toxicity and prevalence- ambient concentrations could influence phytoplankton species composition, abundance and spatial distribution;
- CB-17 (2): Measures to assess cycling and fluxes between water column, phytoplankton, sediment and benthos - improve understanding of mechanisms and

flux rates impacting water column concentrations of total, dissolved, and free ionic copper;

- CB-17 (4): Bio-assessment tools to track presence of copper sensitive taxa in Lower South Bay- independent indicator of whether ambient concentrations are adversely impacting biota.
- CB-17 (5): Assess feasibility of phytoplankton bioassays to measure toxicity- ambient free ionic copper (not complexed with organic ligands) is form toxic to phytoplankton;
- CB-18 (3): Determine Cu-L_1 and L_2 complex concentrations (copper speciation); and
- CB-18 (4): Investigate algal uptake/toxicity with competing metals- algae may preferentially uptake substances (e.g., Manganese), which may reduce the net toxicity of ambient copper concentrations.

The San Jose/RTC study provided additional information relative to CB-17 (1) further documenting the prevalence of sensitive phytoplankton in the LSB. The on-going USGS work will continue to provide related information throughout the Bay on this topic. The San Jose/RTC study concluded that CB-17 (4) was not feasible to accomplish. The results of the Bruland copper speciation work appear to adequately address CB-18 (3) and in the process reduce, and possibly eliminate the need for additional effort on CB-17 (2), CB-17 (5), and CB-18 (4).

2.5.12 Future Tracking of CAP Uncertainty Reduction Activities

In addition to the above CAP baseline activities, SCVURPPP has initiated efforts in 2004 to help develop and implement a program to more comprehensively identify, track, and encourage investigations being conducted by others in the Bay-Delta region that will provide information useful to improving the understanding of copper/nickel impacts throughout the Bay.

The RMP itself is conducting monitoring and special studies of relevance to copper such as attempting to develop improved sediment toxicity testing methods, ambient and sediment toxicity testing, and projects conducted by their various workgroups. The RMP is a member of the Interagency Ecological Program (IEP), which in turn has members or associations with many of the agencies and researchers conducting studies in the Bay-Delta region of relevance to CAP issues such as phytoplankton monitoring. The RMP has tasks in its current workplan directed towards improved data integration from other entities, and improved data dissemination.

The IEP is undergoing a comprehensive programmatic review with a final draft synthesis report from its Science Advisory Group expected in early 2003. One recommendation was that IEP Environmental Monitoring Program (EMP) data be "more rapidly and reliably turned into more useful products through increases human intellectual investment." The Bay-Delta Science Consortium (that includes most IEP members as well as several local universities and non-profit organizations) has an overall goal to "enhance cooperation and collaboration among researchers working in the Bay-Delta." As noted in the Winter 2002 IEP Newsletter, "CALFED intends to allocate one million dollars per year for the next few years to the Consortium to help sponsor activities that will help increase collaboration and cooperation." The Consortium also indicated their intent to sponsor an on-line technical journal and to "investigate ways of sharing digital information among the many data holders and increasing its utility for synthetic analyses."

A significant amount of basic and applied research has been undertaken in the region investigating Cu/Ni processes in various segments of the Bay. Much of this work is scattered about in various reports both off-line, and on-line located at websites for particular research institutions, scientific journals, stakeholder groups, and agencies. Although many of these efforts already cite and cross-reference each other, compiling these various data sources together at one location would benefit any parties interested in research on Cu/Ni processes in the region.

To assist in the tracking of information related to the CAP baseline "uncertainty" activities, SCVURPPP in March 2004 contracted with the San Francisco Estuary Institute (SFEI) to develop a website that links organizations, research, reports, and contact people for regional "track and encourage" activities and related items of interest.

Information sought will fall under three general categories: reports supporting copper TMDL efforts, academic basic research/peer reviewed literature, and institutional research reports. For the initial design, information will be organized by topic. The general topic areas will be as follows:

- Environmental Distribution
- Sources and Loads
- Transport Processes
- Chemical Processes
- Bioavailability and Effects
- Comprehensive Studies

Within the general topics, each of the specific Uncertainty Reduction Baseline Activities included in the most recent fiscal year Copper/Nickel Action Plan Workplan will be listed. Information relevant to each baseline activity will be cited and a brief synthesis provided, and updated annually, assessing the current level of uncertainty associated with each baseline activity topic.

The FY 04-05 C/NAP Workplan includes the following uncertainty reduction baseline activities:

- CB-17 (1): Phytoplankton species toxicity and prevalence
- CB-17 (2): Measures to assess cycling and fluxes between water column, phytoplankton, sediments, and benthos
- CB-17 (3): Measures to assess wet season tributary loading and loading uncertainty
- CB-17 (4): Bioassessment tools to track presence of copper sensitive taxa
- CB-17 (5): Assess feasibility of phytoplankton bioassays to measure toxicity
- CB-18 (1): Investigate flushing time estimates for different wet weather conditions
- CB-18 (2): Investigate location of northern boundary conditions
- CB-18 (3): Determine Cu-L_1 and L_2 complex concentrations (copper speciation)
- CB-18 (4): Investigate algal uptake/toxicity with competing metals
- CB-20: Measures to revise the Conceptual Model Report

SCVURPPP is providing limited seed money and in-kind assistance to RMP/SFEI to initiate this project during calendar year 2004. Since this is a project of Bay-wide benefit, stakeholders will need to identify how to integrate this into existing RMP activities or to identify other funding sources to operate and maintain the website after 2004. While the initial SFEI website effort is focused on copper, it could serve as a template and be expanded to address other constituents of concern as a potential way to access other sources of funding.

2.6 Wildlife Health Concerns

Both copper and nickel are of concern in San Francisco Bay due to concerns regarding possible effects on early life stage aquatic organisms. Neither of these metals has a strong inclination to bioaccumulate or to biomagnify in aquatic ecosystems to levels of concern to upper trophic organisms (e.g. fish eating birds or mammals). Impacts of copper and nickel concentrations on sensitive species of birds and mammals were addressed in the Lower South San Francisco Bay Impairment Assessment Report [Tetra Tech, 2000a] and were not found to be of significant concern. Therefore, impairment of wildlife by copper or nickel is unlikely in San Francisco Bay NDB and will not be addressed in this report.

2.7 Control Programs

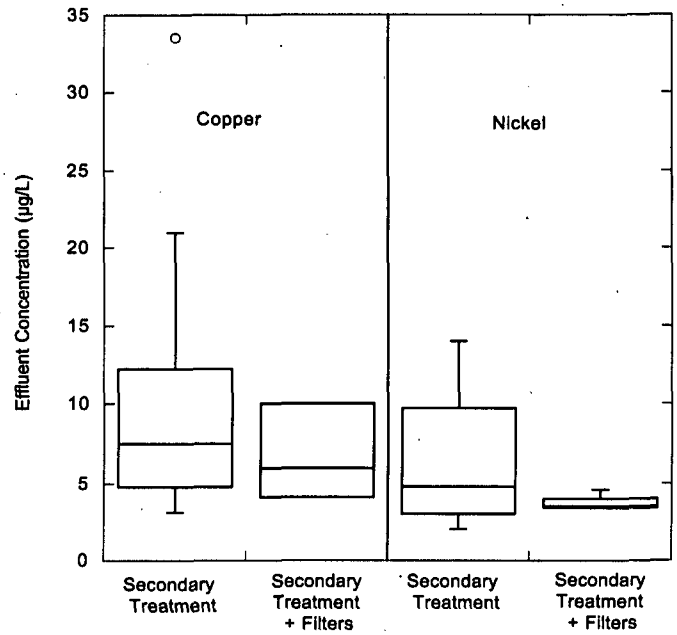
Ongoing control programs for copper and nickel from POTWs and urban stormwater are addressed in this section. These programs have been implemented in an effort to reduce effluent concentrations through source control activities. In the Lower South Bay, these control actions were a product of a working hypothesis that ambient water column concentrations will be affected by reductions in POTW and urban runoff loadings. Lower South Bay public agencies have implemented a Copper Action Plan (CAP) and a Nickel Action Plan (NAP) to ensure that control measures continue to be implemented. The benefit of these programs to ambient water quality protection is an area of uncertainty that may be addressed through use of sophisticated water quality modeling tools. (See further discussion of Action Plans in **Appendix C**).

Copper and nickel loadings from POTWs are reduced significantly through treatment. The Action Plans for North of the Dumbarton Bridge are concerned primarily with (1) development of water quality monitoring triggers and (2) development of effective source control programs. A major difference from the LSSFB is that there is a considerably larger number of municipal, industrial, and stormwater entities contributing to copper and nickel loading to the Bay north of the Dumbarton Bridge. Another difference is that not all of the actions identified for the LSSFB are appropriate for the North Bay. Finally, the presumption is that the majority of effort will be focused on copper, with knowledge that such efforts will have a collateral benefit in reducing nickel at similar sources.

2.7.1 Municipal

Pollution prevention activities targeting copper and nickel sources have been conducted by several Bay Area POTWs beginning in the early 1990's. In some cases, these activities have resulted in reductions in influent copper concentrations. Annual average copper and nickel concentrations from 2000 shown in **Figure 2.1**, demonstrate the current range of effluent levels for several Bay Area POTWs north of the Dumbarton Bridge.

Figure 2.1. Annual Average Bay Area POTW Effluent Concentrations for 2000 (12 secondary plants & 5 secondary with filters)



To assess the range and extent of ongoing copper and nickel source control activities in the Bay Area, questionnaires were sent to pollution prevention program coordinators at 39 publicly owned treatment works (POTWs) requesting information concerning historical pretreatment and pollution prevention (P2) programs targeting copper and nickel. Respondents provided information on the sources that had been targeted, the types of programs that had been implemented for these sources, and the results of efforts to measure the effectiveness of these programs in achieving copper and nickel reductions. The POTW responses were compiled and summarized in the Activity Investigation Memo, dated January 14, 2003. This Memo was included as an appendix to the June 6, 2003 Draft "Copper & Nickel North of the Dumbarton Bridge Development of Action Plans" report. Results of the P2 work were updated in September 2003 and are summarized in **Appendix C** of this report.

2.8 Impairment Summary

Impairment of aquatic life uses is the primary concern related to copper and nickel levels in San Francisco Bay NDB. The above impairment assessment addressed three primary indicators to assess potential impairment of aquatic organisms in San Francisco Bay: (1) site-specific water column criteria based on USEPA guidance, (2) surface sediment concentrations and toxicity, and (3) phytoplankton. The overriding conclusion from the impairment assessment is that impairment of aquatic life uses NDB in San Francisco Bay is unlikely. Remaining uncertainties regarding this finding are diminishing. Mathematical modeling of San Francisco Bay using available sophisticated hydrodynamic and water quality models is recommended to assist in the development and evaluation of effectiveness of management measures and in the further reduction of remaining uncertainties.

The following areas of uncertainty in the copper and nickel impairment assessment were identified and addressed in detail in the IAR for the Lower South Bay. Further consideration of these areas of uncertainty was not performed for this assessment.

- Use of single sensitive organisms (early life stage) in lab water
- Use of surrogate sensitive fish and invertebrate species to indicate toxicity to native species
- Length of toxicity tests versus full life exposure
- Limited number of Nickel ACR values

Three areas of uncertainty that have been addressed in detail in this assessment are:

- Impact of copper and nickel on phytoplankton toxicity
- Linkage of copper and nickel to observed sediment toxicity
- Impact and need for municipal and industrial source control activities to control ambient copper and nickel levels in San Francisco Bay NDB

3. CONCEPTUAL MODEL

3.1 Background

In this section, current knowledge regarding the sources, loads, distribution, transport and behavior of copper and nickel in San Francisco Bay NDB are described. This information is important to the understanding and implementation of appropriate management activities for copper and nickel.

3.2 Regional Studies

Major regional studies of copper and nickel have been performed in San Francisco Bay. These studies include:

- Conceptual Model in Lower South Bay
- Impairment Assessment in Lower South Bay

- WER Technical Study NDB
- RMP Sources and Loadings Studies
- USGS Studies

At the national level, copper toxicity has been extensively studied. Findings from those studies have been used to support the impairment assessment and conceptual model information contained in this document.

3.3 Sources & Loads to the Bay

Numerous estimates of loadings of copper and nickel to the Bay have been made. SFEI made the most recent estimate in 2000, which estimated local loads to the Bay of 74 tons per year for copper and 64 tons per year for nickel. SFEI estimated external loads from the Central Valley to be 270 and 410 tons per year for copper and nickel, respectively. The SFEI estimates do not account for re-mobilization of copper and nickel from Bay sediments, which is estimated to be an even larger source than Delta outflow from the Central Valley.

Mass loadings to San Pablo Bay and Lower South Bay have been estimated in 1997 [Rivera-Duarte & Flegal, 1997]. SFEI summarized results from that study in its report on the Sources, Pathways and Loadings Workgroup published in 2001 [Davis *et al.*, 2001]. The mass loading estimates indicated that benthic remobilization was a dominant source of loadings of both copper and nickel to the Bay, with riverine loadings next most important. For copper in San Pablo Bay, benthic remobilization is estimated to be 72% of the total loading, riverine and runoff is 26%, and POTWs and atmospheric deposition are each 1%. For nickel in San Pablo Bay, the respective loading percentages are 77%, 21%, 2% and <1%.

3.3.1 Municipal & Industrial Point Sources

Effluent dissolved copper and nickel data and flows were obtained for 57 dischargers to San Francisco Bay North of the Dumbarton Bridge. This data was used to estimate loadings of copper and nickel to the Bay from municipal and industrial sources.

The locations of all municipal and industrial dischargers to San Francisco Bay are located on the map in **Figure 3.1**. Average daily flows and dissolved copper and nickel summary statistics for each discharger are also provided below.

Figure 3.1. San Francisco Bay Sampling Locations and Point Source Discharges

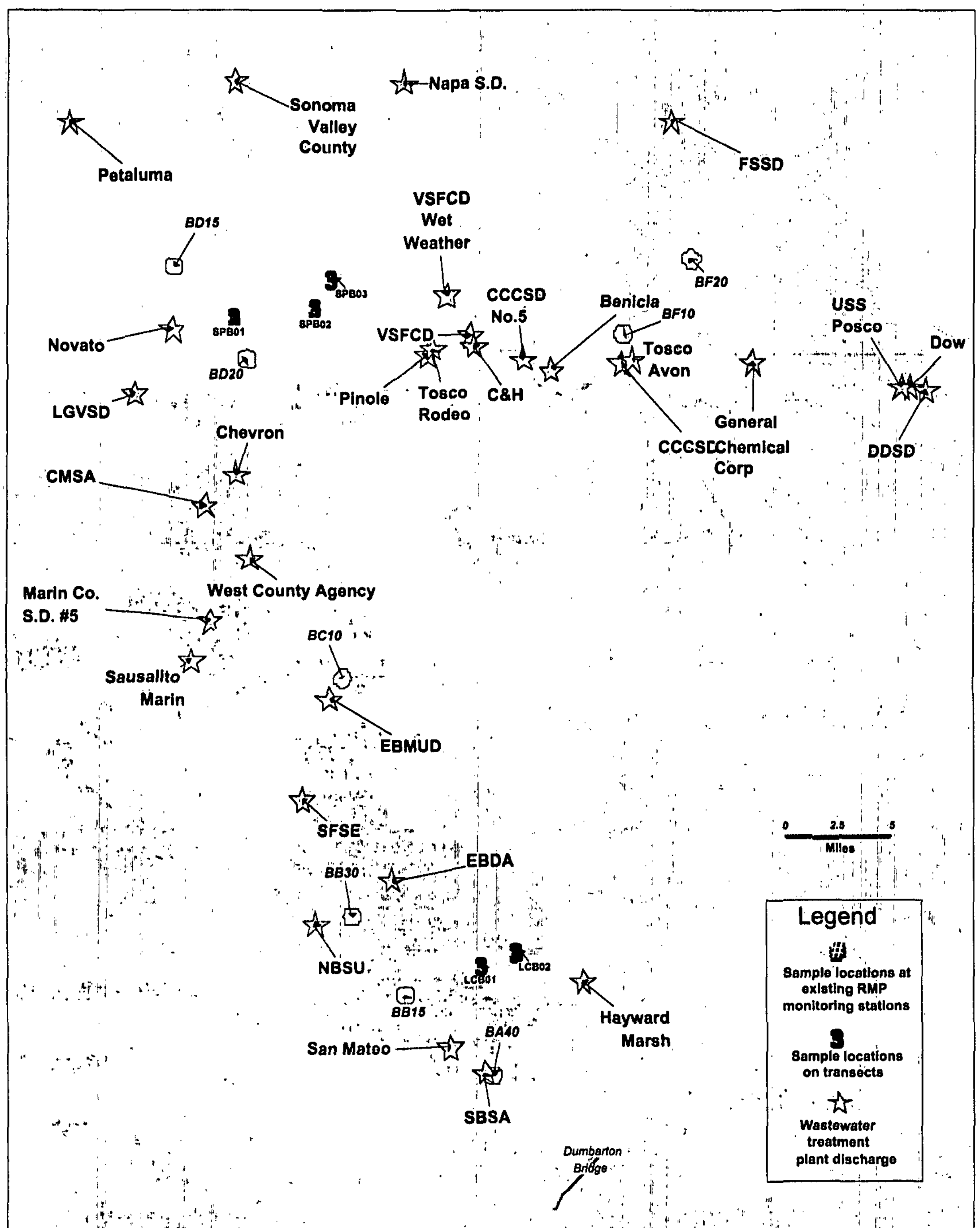


Table 3.1. Dischargers Categorized by Average Effluent Flow

Discharger	Ave. Flow MGD	Plant Size
Morton Permit	0.027	<1 MGD
GWF E 3rd St (Site I) Permit	0.043	
GWF Nichols Rd (Site V) Permit	0.047	
General Electric Company	0.052	
Rhodia Basic Chemicals Permit	0.109	
Dow Chemical Company Permit	0.26	
General Chemical Permit	0.32	
US Navy Treasure Island Permit	0.417	
S.F.Airport, Industrial	0.69	
Tiburon Treatment Plant Permit	0.706	
S.F. Airport, Water Quality Control Plant	0.75	
Rodeo Sanitary District Permit	0.76	
ConocoPhillips (at Rodeo)	1.49	1-10 MGD
Sausalito-Marin Sanitary District Permit	1.67	
SAM Permit	1.71	
Millbrae	1.86	
Mt. View Sanitary District	1.96	
Novato: Novato Plant	2.01	
Valero Benicia Refinery	2.07	
City of Benicia	3.02	
Sewerage Agency of Southern Marin Permit	3.11	
Pinole-Hercules	3.2	
Novato Sanitary District Permit: Overall	3.25	
Sonoma Valley Permit	3.32	
Las Gallinas Valley SD Permit	3.34	
Pacifica Calera Creek	3.59	
Burlingame	4.02	
Tesoro Golden Eagle Refinery	4.22	
Novato: Ignacio Plant	4.49	
EBDA: San Leandro	5.45	
Martinez Refining Company	5.98	
Chevron Richmond Refinery	6.32	
North San Mateo	6.83	
Petaluma Permit	7.3	
USS - Posco	7.6	
West County/Richmond Permit	8.87	
South San Francisco & San Bruno	9.91	
Delta Diablo Sanitation District	9.94	
Central Marin	10.43	10-30 MGD
Dublin San Ramon Services District Permit	10.52	
Sunnyvale	12.73	
San Mateo City	12.81	
EBDA: Hayward	13.07	
Vallejo San & Flood Control District	14.02	
EBDA: Castro Valley	15.37	
San Francisco Oceanside	16.38	
Fairfield-Suisun Sewer District	16.57	
South Bay System Authority	16.91	
San Francisco City & County Bayside (wet)	22.75	
Palo Alto	25.1	
EBDA: Overall	27.56	
EBDA: Union SD	29.1	
Central Contra Costa	43.89	40-75 MGD
San Francisco City & County Southeast	71.17	
EBMUD	73.49	
EBDA: E-001	74.96	
San Jose & Santa Clara	110.16	> 100 MGD

Table 3.2. Daily Maximum Effluent Copper (2001 – 2003)

Discharger	Concentration [µg/L] Min	Max	Median	Mean	SD	n
City of Benicia	1.9	27.0	6.1	6.8	3.8	53
Burlingame	4.4	38.0	8.0	9.8	7.4	34
Central Contra Costa	2.0	11.0	6.7	6.6	1.7	27
Central Marin	1.4	4.5	2.7	2.8	0.8	32
Chevron Richmond Refinery	1.0	15.0	2.2	3.5	3.4	24
ConocoPhillips (at Rodeo)	1.8	20.0	6.4	6.7	4.0	32
Delta Diablo Sanitation District	2.5	16.0	7.5	7.6	2.1	65
Dow Chemical Company Permit	4.1	25.0	10.0	12.2	6.9	29
Dublin San Ramon Services District Permit	21.0	80.0	40.0	44.2	16.3	35
EBDA:	3.8	50.0	12.3	13.9	7.0	142
E-001	3.8	18.3	12.5	12.3	2.9	27
Castro Valley	3.9	19.0	9.6	9.7	3.2	28
Hayward	14.8	50.0	22.2	24.1	7.7	28
San Leandro	3.9	16.3	8.4	9.1	3.3	28
Union SD	8.1	24.7	14.5	14.3	4.0	31
EBMUD	3.0	25.9	9.0	10.1	5.0	50
Fairfield-Suisun Sewer District	2.2	9.0	4.2	4.4	1.4	57
General Chemical Permit	0.0	5.0	5.0	3.7	2.2	11
General Electric Company	5.0	10.0	10.0	8.3	2.4	8
GWF E 3rd St (Site I) Permit	12.2	32.8	21.8	21.9	4.3	40
GWF Nichols Rd (Site V) Permit	13.6	28.0	19.9	20.0	3.8	39
Las Gallinas Valley SD Permit	8.0	25.0	11.0	12.6	4.9	10
Martinez Refining Company	2.0	12.0	5.0	5.4	2.2	32
Millbrae	5.0	14.0	8.0	8.8	2.3	35
Morton Permit	1.9	30.5	5.0	10.6	13.3	4
Mt. View Sanitary District	2.5	8.3	4.7	5.0	1.4	31
North San Mateo	10.0	100.0	11.0	22.5	31.4	8
Novato Sanitary District Permit:	5.2	11.0	8.1	8.1	4.1	2
Ignacio Plant	5.2	5.2	5.2	5.2	5.2	1
Novato Plant	11.0	11.0	11.0	11.0	11.0	1
Pacifica Calera Creek	2.8	9.3	5.3	5.6	1.7	30
Palo Alto	3.3	11.5	6.3	6.4	1.4	139
Petaluma Permit	1.7	6.0	3.7	3.6	1.2	15
Pinole-Hercules	1.4	9.0	4.1	4.6	1.9	31
Rhodia Basic Chemicals Permit	1.0	22.0	11.0	10.7	6.0	30
Rodeo Sanitary District Permit	0.0	5.0	3.4	3.2	1.3	23
S.F. Airport, Water Quality Control Plant	1.2	14.8	6.7	7.0	3.6	32
S.F.Airport, Industrial	0.3	24.5	4.8	5.5	4.2	34
SAM Permit	15.3	15.3	15.3	15.3	0.0	1
San Francisco City & County Southeast	6.3	23.8	12.8	13.7	4.2	100
San Francisco City & County Bayside (wet)	28.5	64.3	50.2	48.2	13.8	10
San Francisco Oceanside	5.5	23.9	15.3	16.0	4.2	30
San Jose & Santa Clara	1.2	6.7	3.2	3.3	1.1	170
San Mateo City	3.2	14.0	5.6	6.0	2.2	30
Sausalito-Marin Sanitary District Permit	0.0	16.0	11.0	11.2	2.8	29
Sewerage Agency of Southern Marin Permit	8.3	24.0	16.0	15.5	3.6	29
Sonoma Valley Permit	2.9	12.0	7.7	7.7	1.7	57
South Bay System Authority	4.0	16.0	9.7	10.1	2.9	37
South San Francisco & San Bruno	4.6	32.7	10.3	10.6	4.8	32
Sunnyvale	0.5	4.8	1.7	1.9	1.0	121
Tesoro Golden Eagle Refinery	1.3	20.0	4.0	4.6	2.8	122
Tiburon Treatment Plant Permit	5.2	30.0	20.0	18.2	6.2	16
US Navy Treasure Island Permit	8.2	23.1	10.8	12.5	3.9	29
USS - Posco	2.0	4.7	2.5	2.7	0.8	32
Valero Benicia Refinery	1.4	13.0	8.0	7.6	2.7	68
Vallejo San & Flood Control District	3.6	11.8	6.3	6.4	1.6	40
West County/Richmond Permit	5.0	11.0	7.0	7.4	1.9	11

Table 3.3. Daily Maximum Effluent Nickel (2001 – 2003)

	Concentration [µg/L]					
Discharger	Min	Max	Median	Mean	SD	n
City of Benicia	2.8	8.5	4.4	4.7	1.2	51
Burlingame	0.3	6.6	3.2	3.5	1.2	34
Central Contra Costa	0.5	3.2	1.6	1.6	0.7	27
Central Marin	3.1	7.2	4.1	4.2	0.8	32
Chevron Richmond Refinery	3.0	26.0	19.1	18.9	4.7	24
ConocoPhillips (at Rodeo)	1.1	13.0	3.0	3.3	2.1	32
Delta Diablo Sanitation District	3.8	14.0	8.0	8.3	2.7	28
Dow Chemical Company Permit	2.7	40.0	10.0	17.1	16.0	29
Dublin San Ramon Services District Permit	2.0	5.1	2.8	2.9	0.8	30
EBDA:	5.0	93.0	5.4	7.5	7.9	139
E-001	5.0	19.0	5.3	6.6	2.9	27
Castro Valley	5.0	5.0	5.0	5.0	0.0	28
Hayward	5.4	93.0	8.6	12.5	16.2	28
San Leandro	5.0	9.1	5.0	5.6	1.0	28
Union SD	5.0	14.0	6.4	7.7	2.9	28
EBMUD	5.0	16.0	6.7	7.2	2.4	50
Fairfield-Suisun Sewer District	1.5	6.6	3.8	3.9	1.0	57
General Chemical Permit	2.6	5.5	5.0	4.8	0.9	8
GWF E 3rd St (Site I) Permit	7.9	58.4	15.2	16.8	7.6	48
GWF Nichols Rd (Site V) Permit	7.0	92.9	9.7	12.7	16.1	27
Las Gallinas Valley SD Permit	4.2	8.2	4.8	5.5	1.4	10
Martinez Refining Company	10.0	38.0	19.0	20.4	7.7	32
Millbrae	2.6	6.5	3.5	3.6	0.7	48
Morton Permit	1.0	13.0	10.0	8.5	5.2	4
Mt. View Sanitary District	1.7	5.9	3.9	3.7	1.1	20
North San Mateo	50.0	50.0	50.0	50.0	0.0	9
Novato Sanitary District Permit:	2.2	2.3	2.3	2.3	0.1	2
Ignacio Plant	2.2	2.2	2.2	2.2	0.0	1
Novato Plant	2.3	2.3	2.3	2.3	0.0	1
Pacifica Calera Creek	2.1	5.4	3.2	3.2	0.8	30
Palo Alto	2.8	6.0	4.0	4.2	0.8	32
Petaluma Permit	3.0	6.8	4.1	4.3	1.0	15
Pinole-Hercules	1.6	7.0	4.3	4.4	1.1	24
Rhodia Basic Chemicals Permit	7.2	37.0	20.4	20.4	10.1	10
Rodeo Sanitary District Permit	2.2	6.0	3.1	3.6	1.2	9
S.F. Airport, Water Quality Control Plant	0.3	5.4	2.3	2.5	0.9	32
S.F.Airport, Industrial	0.5	30.0	5.4	6.5	6.0	32
SAM Permit	3.1	3.1	3.1	3.1	0.0	1
San Francisco City & County Southeast	0.5	17.0	3.7	4.1	1.8	101
San Francisco City & County Bayside (wet)	2.4	6.6	5.1	4.7	1.5	10
San Francisco Oceanside	1.1	5.0	2.3	2.4	0.7	30
San Jose & Santa Clara	4.0	10.0	6.0	6.3	1.3	170
San Mateo City	2.8	17.0	4.2	5.1	3.1	30
Sausalito-Marin Sanitary District Permit	0.0	7.3	4.3	4.3	1.6	29
Sewerage Agency of Southern Marin Permit	3.0	5.2	4.3	4.3	0.6	14
Sonoma Valley Permit	1.0	6.0	2.6	3.0	1.4	9
South Bay System Authority	4.0	11.0	5.4	5.7	1.4	37
South San Francisco & San Bruno	3.7	17.1	5.2	6.7	3.5	32
Sunnyvale	1.0	5.7	2.0	2.1	0.9	83
Tesoro Golden Eagle Refinery	10.0	87.0	14.0	16.5	7.9	122
Tiburon Treatment Plant Permit	2.0	10.0	10.0	6.9	4.2	5
US Navy Treasure Island Permit	1.2	5.7	2.2	2.5	1.1	29
USS - Posco	2.0	4.7	2.5	2.7	0.8	32
Valero Benicia Refinery	3.3	100.0	10.0	12.3	9.9	135
Vallejo San & Flood Control District	2.3	3.6	2.9	2.9	0.4	38
West County/Richmond Permit	5.0	11.0	6.9	7.3	2.3	11

3.3.2 Watershed Sources

Located at the mouth of the Sacramento/San Joaquin River Delta, the San Francisco Bay watershed encompasses about 60,000 mi^2 (155,400 km^2), or 40% of California [STB *et al.*, 2000]. Copper and nickel contributions in the Central Valley watershed impact the Bay as the waters of the Sacramento and San Joaquin Rivers are conveyed into the North Bay. For this analysis, these sources to the Bay are expressed as "riverine sources". These riverine sources are comprised of component sources, which include urban and agricultural runoff, erosion of native soils, atmospheric deposition, treated wastewater discharges, and others. Analysis of these component sources in the upper watershed is not within the scope of this document.

3.3.2.1 Urban runoff estimates

Urban runoff occurs year round. However, significant loadings of most constituents, including copper and nickel, occur during wet weather urban runoff flow events. Wet weather urban runoff is a component of stormwater runoff, which has been assessed by SFEI in a report titled *Contaminant Loads from Stormwater to Coastal Waters in the San Francisco Bay Region*, [Davis *et al.*, 2000]. In that report, estimated loads to San Francisco Bay from stormwater runoff ranged from 36 to 110 tons per year for copper, with a best estimate of 66 tons per year. Estimated nickel loads were from 27 to 78 tons per year, with a best estimate of 49 tons per year. In comparison to local loads to the Bay from wastewater effluent, atmospheric deposition and dredging, storm runoff was estimated to be the dominant source of both copper (89% of total) and nickel (76% of total). For copper, the report estimated urban runoff to contribute 60% of the total storm runoff load to the Bay, indicating that urban runoff was estimated to be over half the total local load of copper to the Bay.

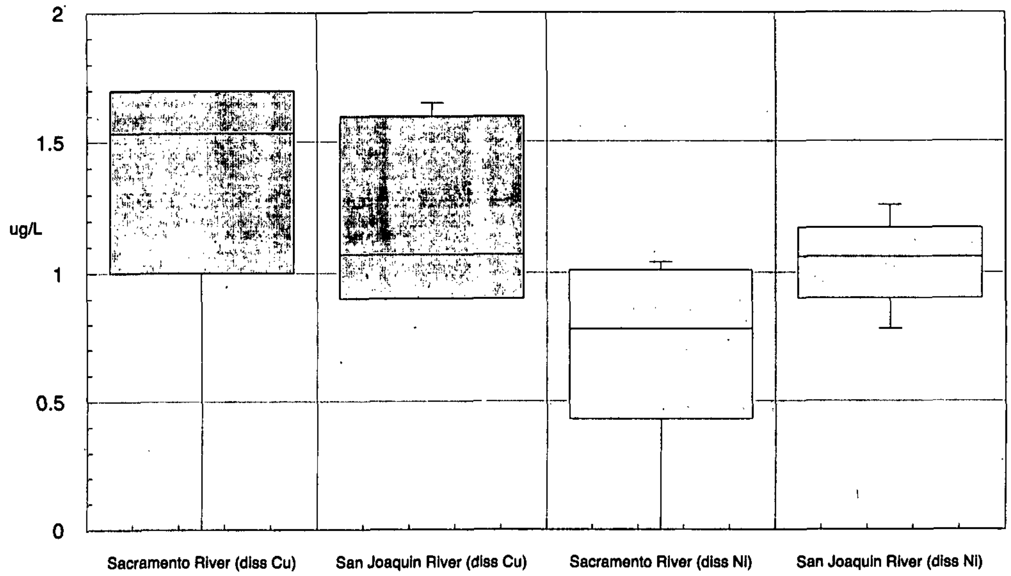
The report indicated that the estimated aggregate local loads of copper (74 tons per year) and nickel (64 tons per year) were small in comparison to loads of total copper and nickel from the Central Valley (less than 25%). Most of the load from the Central Valley is particulate bound, based on a comparison of total load estimates with estimates of dissolved copper and nickel loads to the Bay in Delta outflow.

In a March 2004 report titled *Copper Sources in Urban Runoff and Shoreline Activities* prepared by TDC Environmental, estimates for the sources of copper in urban runoff and shoreline activity inputs to San Francisco Bay were presented [TDC, 2004]. The significant sources of copper in urban runoff were estimated to be, in ranked order, vehicle brake pads, air emissions, copper-containing pesticides, soil erosion, architectural copper, industrial copper use, domestic water discharges, and vehicle fluid leaks. The significant sources of copper from shoreline activities were identified as marine antifouling coatings and copper algaecides applied to surface waters. The report noted that these estimates of source contributions had a certain degree of uncertainty associated with them.

3.3.2.2 Riverine inputs

The Sacramento and San Joaquin Rivers flow into Northern San Francisco Bay at the eastern end of Honker Bay. Concentrations of dissolved copper and nickel from these sources are presented in the box plots below **(Figure 3.2)**.

Figure 3.2. Dissolved Copper and Nickel in Sacramento and San Joaquin Rivers (1993 – 1994) [SFEI, 2001]



Annual riverine loads of copper and nickel are determined by the freshwater inflow volumes from each river to San Francisco Bay. Riverine flow volumes vary significantly from year to year, depending largely on the rainfall patterns occurring in the Central Valley. Annual average flow from the Sacramento-San Joaquin Delta to the Bay is 21.1 million acre-feet (26,000 million cubic meters). In the period 1981 to 2000, maximum and minimum annual riverine flows have ranged from 4.1 to 64.9 million acre-feet per year [McKee *et al.*, 2002]. The Napa River and Petaluma River contribute small increments to the total riverine flow volume.

Average annual riverine loads of dissolved copper and nickel to the Bay are approximately 107 and 71 kg/yr, respectively. During maximum observed flow years, these riverine dissolved loadings have increased to 329 kg/yr for copper and 219 kg/yr for nickel.

3.3.3 Atmospheric Deposition

The global releases of metals into the atmosphere from combustion, industry, and natural sources result in atmospheric loadings in San Francisco Bay. Pollutants released hundreds or thousands of miles away are deposited directly in the Bay during rainstorms. Load estimates from atmospheric deposition of copper and nickel to the San Francisco estuary are presented in **Table 3.4**, below.

Table 3.4. Atmospheric Deposition to North and Central San Francisco Bay (1999 – 2000) [Tsai *et al.*, 2001].

	Dry Deposition		Wet Deposition	
(kg/yr)	Copper	Nickel	Copper	Nickel
North Bay	490 (±280)	300 (±170)	240	82
Central Bay	270 (±210)	140 (±76)	270	83

3.3.4 Erosion of Buried Sediment

Nickel-rich serpentinite formations in the San Francisco Bay area are eroded, transported and accumulated in estuarine sediments, providing a natural source of nickel [Topping *et al.*, 2001]. Although the relative areal coverage of these formations may not seem pronounced, the spatial distribution of serpentinite throughout the watersheds surrounding the Bay suggest the complexity and potential importance of these multiple sources.

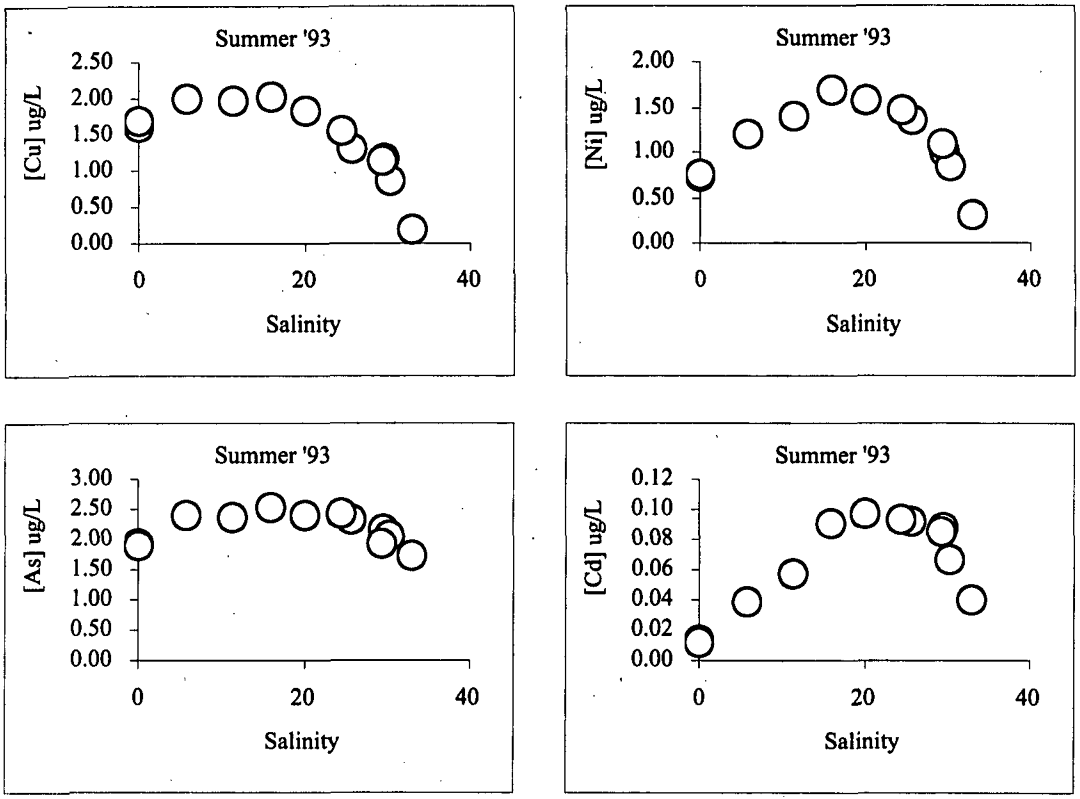
The importance of this process to ambient nickel levels in the Bay was examined in the Lower South Bay. Using data from twenty-eight unique core incubations, spanning two years and three Lower South Bay sites, the average benthic flux load was 39 kg-Ni/day, with a 95% confidence interval of 11 kg-Ni/day. This estimate is much larger than the major municipal point-source input of ~3 kg-Ni/day by the San Jose/ Santa Clara Water Pollution Control Plant for 1999 [Topping *et al.*, 2001]. The flux estimates are of similar magnitude to non-point source stormwater run-off estimates for the surrounding watersheds (~56 kg-Ni/day) [Davis *et al.*, 2000]. This value is derived by combining seven different sub-watersheds, or hydrologic units as defined by the authors. These units include significant rivers such as Guadalupe River, Coyote Creek, Alameda Creek and San Francisquito Creek. It should be noted that while other elements, such as copper, exhibited temporal variability in flux direction (both into and out of the sediment), nickel flux was consistently positive. That is, 27 of the 28 unique core incubations indicated a flux out of the sediment, into the overlying water column.

Since these results indicate that the magnitude of the measured benthic-flux of nickel is significant relative to major fresh-water inputs, metal remobilization from the sediment is an important consideration in determining realistic responses to future load-allocation strategies for nickel into the estuary. Data suggests that benthic interaction with the overlying water column is one of the primary processes regulating dissolved-nickel concentrations in the South Bay.

3.3.5 In-Bay Hot Spots (The Selby Smelter Site)

A smelting and refining plant, known as the Selby Smelter, operated on the shores of San Pablo Bay near Davis Point from 1886 through 1970. The plant primarily produced lead, but refined other metals. Smelter operations produced massive piles of ore slag, which were disposed in tidal and sub-tidal waters of San Pablo Bay. Beginning in 1989, remedial actions were undertaken by responsible parties to contain and cap solid waste piles, remove contaminated sediments by dredging, and contain surface waters. The site is currently undergoing additional remedial investigations and feasibility studies, with a report scheduled for completion 12/31/2005. According to the Department of Toxic Substances Control (DTSC), one of the primary areas to be addressed by further investigation activities is the metals mass loading from the site into San Pablo Bay (DTSC CALSITES Database, Site ID #07330031 – ASARCO).

Figure 3.3. Salinity Distributions



The downward concavity in the salinity distributions of dissolved copper, nickel, arsenic, and cadmium in the northern reach of San Francisco Bay indicates internal inputs. The distributions shown have been consistently observed in every summer cruise of the RMP since the program began in 1993.

The question of metals mass loading from the Selby Site posed by DTSC is extremely important, given that observed distributions of dissolved trace elements in the northern reach indicate substantial inputs. Preliminary assessments indicate that dissolved copper and nickel loadings in the order of 100 – 400 kg per day are required to explain the distributions shown in **Figure 3.3** [Abu-Saba, 1998]. The fact that arsenic and cadmium have similar patterns could indicate pollutant mobilization from ore slag. The mechanism for this could be tidal pumping through exposed slag along the shoreline, or erosion of exposed slag coupled to dissolution within Bay waters.

There are alternative processes that could explain the observed internal inputs in the northern reach, including benthic remobilization and desorption from suspended sediments as fresh water mixes with salt, so the available evidence does not provide a definitive link to the Selby site. Resolving whether or not the observed internal inputs of copper and nickel could be reduced or eliminated through additional remedial measures at this site (e.g., hydraulic containment) is an important management question.

3.3.6 Describe types and magnitude of other sources of each metal

3.3.6.1 Future Loading from Sediment

A USGS study collected sediment cores from four locations in northern San Francisco Bay. In addition, cores were also collected at one 'control' location (Tomales Bay) to assess historical trends of copper in Bay sediments. Metals were analyzed in sediments fraction less than 64 um in size.

Data show that baseline concentrations of copper ranged from 23.7 ± 1.2 ug/g to 41.4 ± 2.4 ug/g. Maximum concentrations of copper in the cores were less than 3 times the baseline [Hornberger *et al.*, 1999]. It was concluded that copper is only moderately enriched in Bay sediments. The enrichment factor (concentration in horizon / baseline value) is similar to southern California coastal waters and less than sediments near the head of Narragansett Bay (where there is extreme contamination). The results of tests for copper in San Francisco Bay cores can be found in **Figure 3.4.**

It was determined that concentrations of nickel in Bay sediments are greater than the mean crustal content, and greater than concentrations found in many other coastal sediments. Erosion of ultramafic rock formations in the watershed appears to be the predominant source [Hornberger *et al.*, 1999]. The results of tests for nickel in San Francisco Bay cores can be found in **Figure 3.5.**

Figure 3.4. San Francisco Bay Sediment Core Copper Data

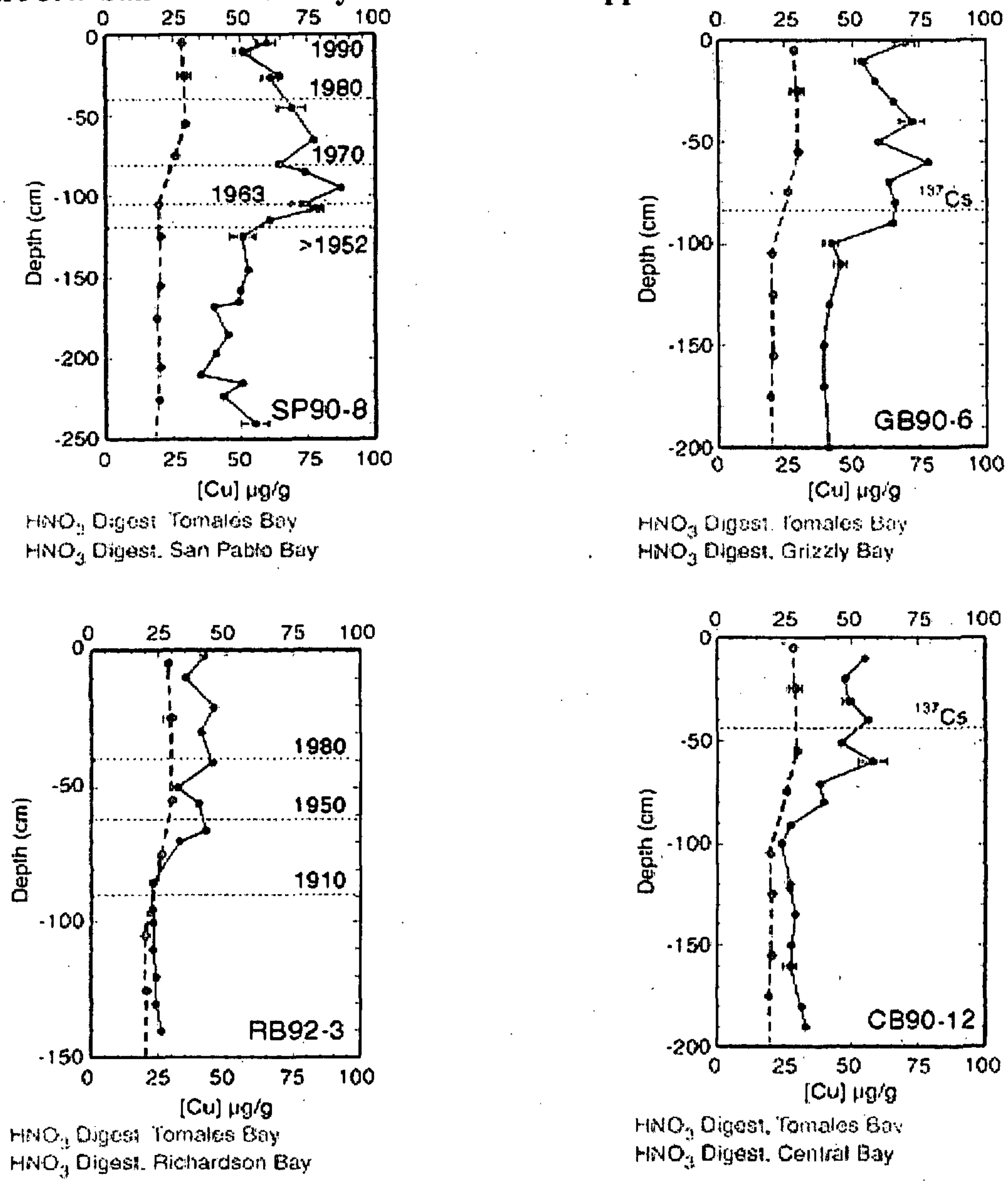
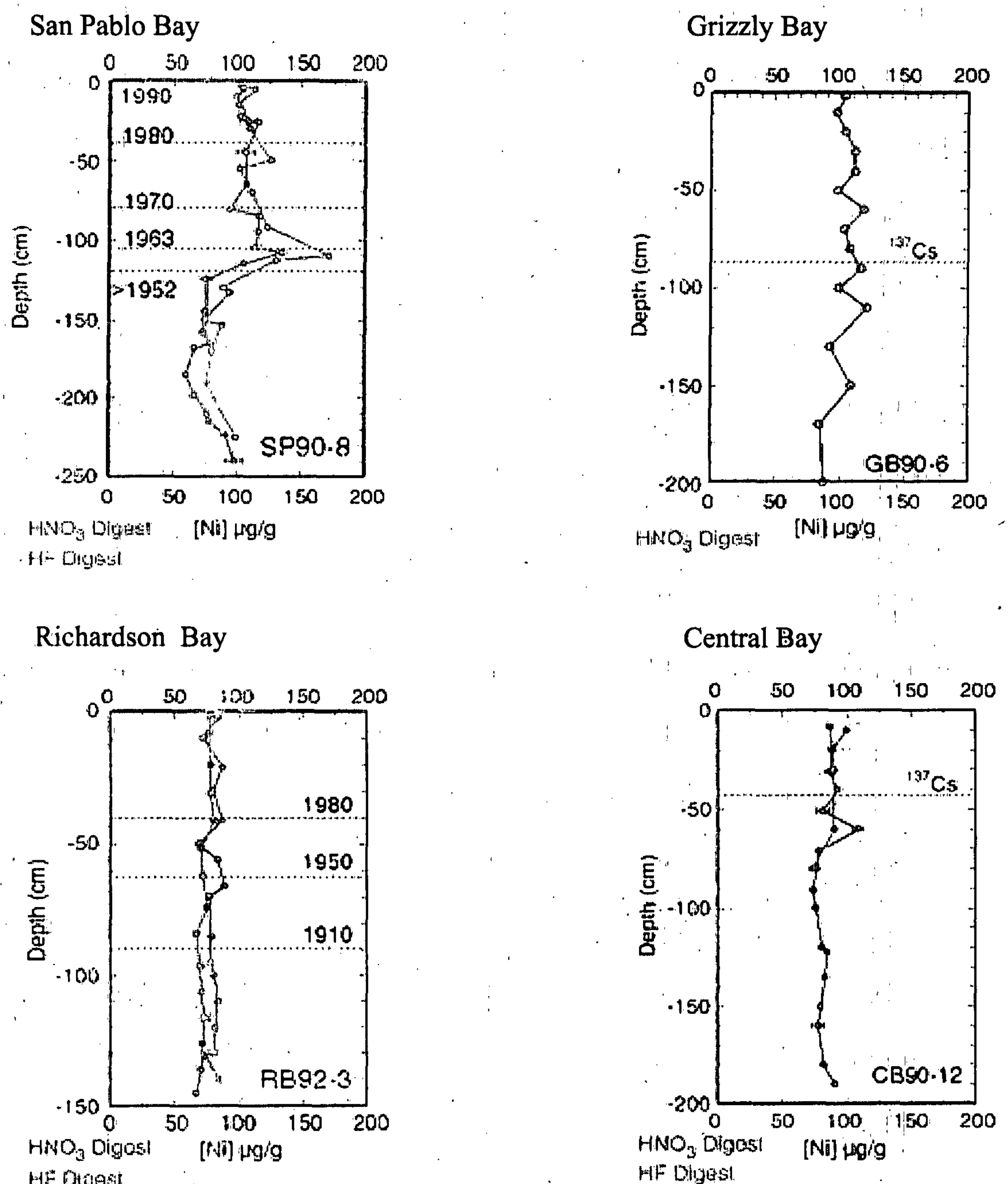


Figure 3.5. San Francisco Bay Sediment Core Nickel Data



Sediment copper and nickel concentrations vary throughout the San Francisco Bay with an overall average of approximately 40 mg Cu/kg sediment and 85 mg Ni/kg sediment. **Table 3.5** reports the mean and standard deviations for sediment copper and Ni concentrations from 1993-1999 at eight of the sites sampled in this study. Also included in **Table 3.5** is the percent of fine grains found in the sediment at each site. Metals tend to attach to finer grains, so this parameter is very important when studying metal concentrations in sediments.

Table 3.5. Sediment Copper and Nickel Concentrations in San Francisco Bay Based on Data collected 1993-2001 (mg/kg sediment) [sorted by % fines]

Location		Mean Cu	σ	Mean Ni	σ	% Fines (<63um)
BC60	Red Rock	16.1	10.5	72.0	16.1	13.1
BG20	Sacramento River	23.2	7.8	85.5	14.2	19.3
BD41	Davis Point	20.1	5.8	72.7	10.0	19.4
BF10	Pacheco Creek	20.0	3.9	73.8	9.8	20.4
BC21	Horseshoe Bay	25.1	6.6	64.5	9.0	43.9
BG30	San Joaquin River	33.5	10.3	70.3	12.7	47.6
BB30	Oyster Point	33.2	5.3	74.9	13.5	63.5
BC11	Yerba Buena Island	36.0	6.6	69.4	14.2	69.1
BB15	San Bruno Shoal	37.5	7.8	79.2	19.9	74.6
BD31	Pinole Point	51.2	10.6	96.6	16.1	75.3
BB70	Alameda	42.1	4.6	86.0	15.2	76.0
BC32	Richardson Bay	34.8	8.2	76.2	15.9	79.5
BA41	Redwood Creek	40.9	7.9	82.3	21.3	80.8
BD22	San Pablo Bay	49.1	4.1	84.6	9.7	84.2
BC41	Point Isabel	40.9	4.2	84.7	14.3	86.3
BA30	Dumbarton Bridge	41.7	5.0	87.2	18.5	90.5
BD50	Napa River	62.0	6.5	101.7	15.5	91.3
BF40	Honker Bay	62.7	8.5	110.1	19.0	94.9
BD15	Petaluma River	55.3	5.3	107.1	20.5	95.9
BF21	Grizzly Bay	59.1	7.4	105.1	18.5	98.3

Table 3.6. Average Grain Sizes in North and Central San Francisco Bay Sediments

Station Code		% Fines (<63μm)	% Clay (<4μm)	% Silt (4μm-63μm)	% Sand (63μm-2mm)	% Gravel+Shell (>2mm)
BA30	Dumbarton Bridge	90.5	59.9	30.4	8.1	1.4
BA41	Redwood Creek	80.8	56.4	24.6	12.6	6.5
BB15	San Bruno Shoal	74.6	50.6	24.1	22.4	2.9
BB30	Oyster Point	63.5	42.6	21.0	32.6	3.6
BB70	Alameda	76.0	50.1	26.0	24.1	0.0
BC11	Yerba Buena Island	69.1	46.8	22.1	26.8	4.3
BC21	Horseshoe Bay	43.9	25.4	18.4	54.0	2.1
BC32	Richardson Bay	79.5	40.8	38.9	20.3	0.1
BC41	Point Isabel	86.3	51.4	34.9	13.8	0.1
BC60	Red Rock	13.1	8.7	4.1	82.9	4.1
BD15	Petaluma River	95.9	63.3	32.5	3.7	0.4
BD22	San Pablo Bay	84.2	52.0	32.2	15.2	0.5
BD31	Pinole Point	75.3	49.8	25.4	24.3	0.3
BD41	Davis Point	19.4	12.6	6.9	79.4	1.2
BD50	Napa River	91.3	66.2	25.1	5.6	3.1
BF10	Pacheco Creek	20.4	13.1	7.2	78.4	1.3
BF21	Grizzly Bay	98.3	62.5	35.8	1.8	0.1
BF40	Honker Bay	94.9	57.9	37.0	4.9	0.0
BG20	Sacramento River	19.3	11.5	7.8	80.6	0.1
BG30	San Joaquin River	47.6	24.8	22.8	52.3	0.0

Box plots of copper and nickel in San Francisco Bay sediments, north of the Dumbarton Bridge can be found in **Figures 3.10 & 3.12.**

A conceptual model study of the Lower South San Francisco Bay (Lower Bay) was conducted by Tetra Tech in 1999. Many of the conclusions of that report can be applied generally to the rest of San Francisco Bay. This study found that the two largest sources of copper and nickel to the Lower Bay are sediment exchange during resuspension and nonpoint source loads from tributaries [Tetra Tech, 1999]. These sources account for approximately 80-90% of the total copper and nickel loads to the Lower South Bay.

3.4 Chemistry, fate, transformations and transport of each metal

3.4.1 Describe state of knowledge regarding fate and transport for each metal

3.4.1.1 Sediment Transport Processes

Sediment transport is important to the cycling of copper and nickel in San Francisco Bay, since sediment re-mobilization is acknowledged to be one of the largest sources of these metals. The particle size distribution of suspended sediments is smaller than the particle size distribution of sediments in the bed. This affects the fate and transport of the adsorbed metals, since they associate more strongly and therefore have higher concentrations on the smaller clay or silt particles. A fraction of the sediments that erode from the watershed appear to be deposited in streambeds in the flatlands, and may enter the Bay during subsequent storm events.

3.4.1.2 Copper and Nickel Cycling

Copper and nickel cycling is important in San Francisco Bay because it plays a major role in both the fate and toxicity of the metal loads entering the estuary. The conceptual model of cycling involves chemical speciation of the metals and the chemical, physical, and biological processes that influence their fate, concentrations, and interactions between chemical forms. The species considered are the free metal ions; inorganic complexes with chlorides, hydroxides, carbonates, and sulfates; organic complexes with strong and weak ligands; and adsorbed forms and other particulate forms. Speciation is very important since only free metal ions and labile inorganic complexes are bioavailable for uptake. Therefore, these are also the forms that determine toxicity.

Only a small fraction of the total copper and nickel in the water column occurs in these forms. Much of the dissolved copper and nickel is complexed with organic ligands, and particulate forms also represent a significant fraction of the total metal concentrations. The free ions and inorganic complexes have been estimated to range from 8 - 20 % of the total dissolved copper and 50 - 66 % of the total dissolved nickel in South San Francisco Bay [Donat *et al.*, 1994]. However, this distribution could change as metal loads or ligand loads to the estuary change, or if other changes occur in the Bay that effect the internal cycling of the metals. Therefore, it is important to understand the processes that control the transformations between different chemical forms of the metals, since these will determine the speciation and concentrations of the metals as loads or internal cycling processes change in the future.

3.4.1.3 Speciation Processes

Complexation and adsorption are the main processes that control copper and nickel speciation. Inorganic complexation reactions are fast, and can be considered as equilibrium processes. Seasonal salinity variations have the largest effect on these reactions, since salinity determines the concentrations of the inorganic ligands that complex with the metals. Organic complexation and sorption reactions are slower, and are considered to be kinetically limited. These kinetic relationships make the organic complexes and sorbed species unavailable for uptake, as well as influencing their fate and transport in the estuary.

Adsorption processes are believed to depend on free metal ion concentrations. Organic complexation reactions depend on the relative concentrations of organic ligands and dissolved metals.

3.4.1.4 Biological Cycling

Organisms influence biogeochemical cycling through uptake and excretion processes, incorporation into biological tissues, production of organic detrital material containing the metals, and subsequent metals release during decomposition and mineralization. Uptake removes dissolved metals from the water column and incorporates them in the biota, while excretion returns metals back to the water in soluble forms. However, this biological processing can change the form and bioavailability of the metals. Free metal ions and weak inorganic complexes are the forms that are most readily assimilated from the water, while excreted forms may be complexed with organic ligands that are much less available for uptake. In addition, phytoplankton excrete cellular exudates that chelate copper ions, effectively reducing copper bioavailability and toxicity.

Particulate organic detrital copper and nickel are produced through food web processing. Following accumulation of the metals in the biota, processes such as phytoplankton settling, plankton mortality, and egestion generate organic detrital metals that settle and deposit the metals in the sediments. These metals are released as soluble forms to the water column and sediment porewaters as the organic material decomposes. Solubilization of the metals by benthic animals feeding on phytoplankton and detritus could also be an important process, as could benthic bioturbation/irrigation effects on sediment release.

3.4.1.5 Food Web Accumulation

Accumulation of copper and nickel in the aquatic food web depends on uptake from two routes of exposure, water and food. Accumulation can be calculated from the metal uptake rates from water; metal assimilation efficiencies from food; metal elimination rates from the organisms; organism growth rates, consumption rates, and dietary preferences; and metal concentrations in food items. The uptake and elimination rates must consider the effects of metal regulation by the organisms, at least for copper. A steady-state approach can be used to estimate total metal concentrations in different organisms and relative contributions from water and food. Alternatively, a dynamic food web model can be constructed to predict metal concentrations throughout the food web in response to changing exposure conditions, for example, from seasonal variations in the loading and cycling of the metals, or to future projected conditions in the South Bay. Currently, copper and nickel measurements in aquatic organisms in San Francisco Bay are limited to benthic bivalves.

Copper and nickel partition between the dissolved and particulate phase in San Francisco Bay. Processes of sorption and desorption impact this partitioning. The ratio of adsorption to desorption is referred to as the partition coefficient (K_d). This coefficient depends on metal chemistry and site-specific factors, including salinity, suspended solids, and dissolved organic carbon.

Dissolved copper and nickel exist as inorganic complexes, organic complexes, colloids and free cationic species. The ionic forms of copper and nickel are most toxic to aquatic organisms, as they are the forms, which most readily diffuse or are taken up across cell membranes. The complexation of dissolved copper has a direct effect on copper toxicity in San Francisco Bay. Complexation of nickel is neither observed nor expected to effect nickel toxicity in the Bay. Neither copper nor nickel bioaccumulate in organisms to a significant degree.

In the northern reach of the estuary, dissolved copper and nickel both have non-conservative excesses. Copper excesses in the northern reach are relatively consistent during both wet and dry seasons, whereas dissolved nickel excesses are as much as ten-fold greater during the wet season. This difference is due to several coupled processes. These include weathering of nickel-enriched serpentines, formation of soluble nickel-sulfide complexes, and episodic flushing of adjacent wetlands.

- Copper and nickel are enriched near Petaluma River mouth
- Copper distributions are similar year-round.
- Nickel, in contrast, shows a ten-fold increase during winter (high-flow season).
- Internal inputs amount to 100-400 kg per day, orders of magnitude greater than combined municipal / industrial discharges (10-20 kg per day).
- Sedimentary diagenesis in marshes, wetlands, mudflats is a likely source - metals are released from dissolution of oxide surfaces in suboxic sediments (e.g., Rivera Duarte and Flegal, 1997).
- Nickel also has a substantial watershed source, probably originating from nickel-rich ultramafic minerals common to California (e.g., serpentines).
- Copper has a substantial internal input that is tenfold greater than municipal and industrial discharges to the region

3.4.1.6 Schematic – Copper Model

Figure 3.6. Conceptual Model of Copper for San Francisco Bay

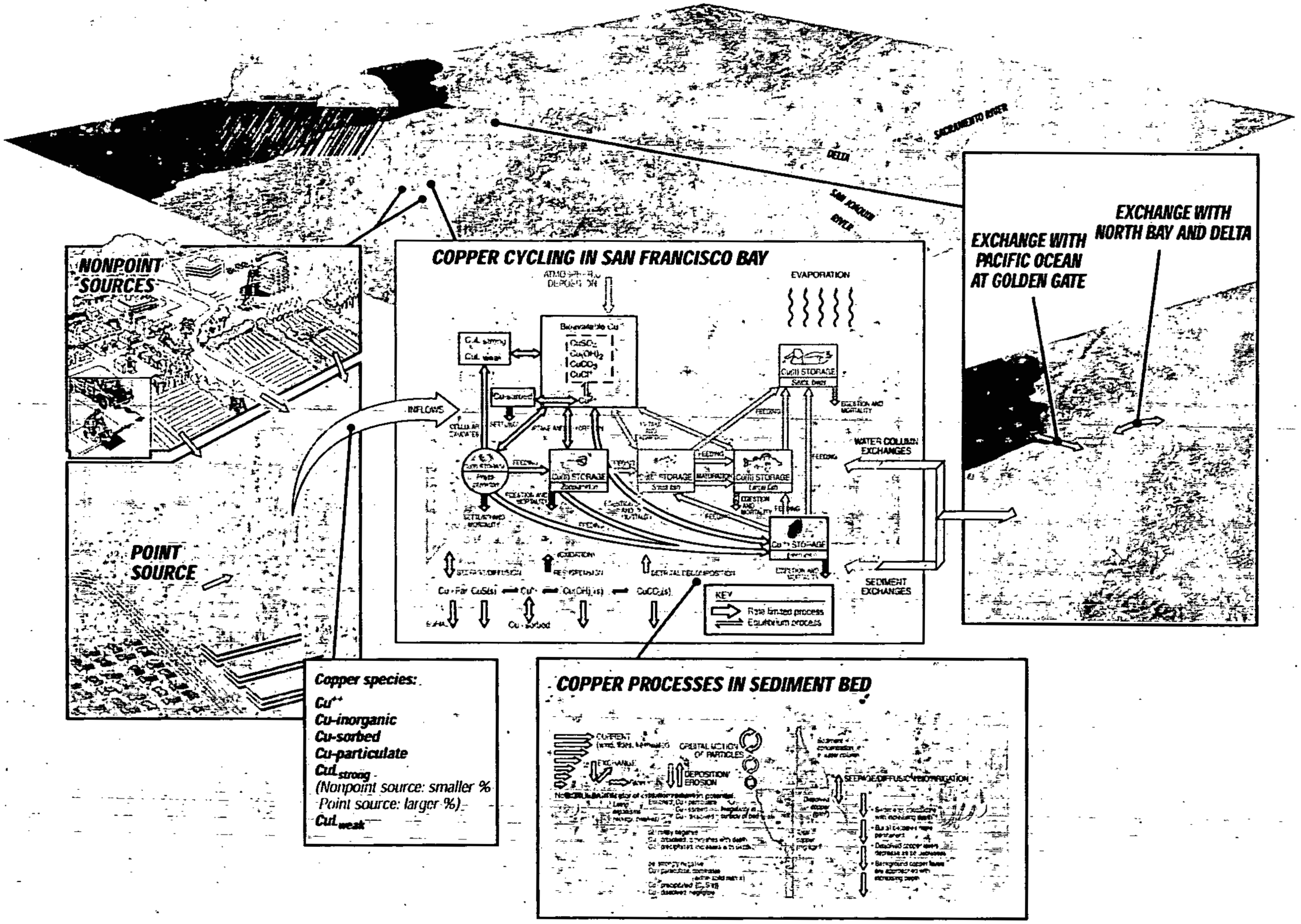


Figure derived from *Conceptual Model Report for Copper and Nickel in Lower South San Francisco Bay* (Tetra Tech, 1999)

3.4.1.7 Schematic – Nickel Model

Figure 3.7. Conceptual Model of Nickel for San Francisco Bay

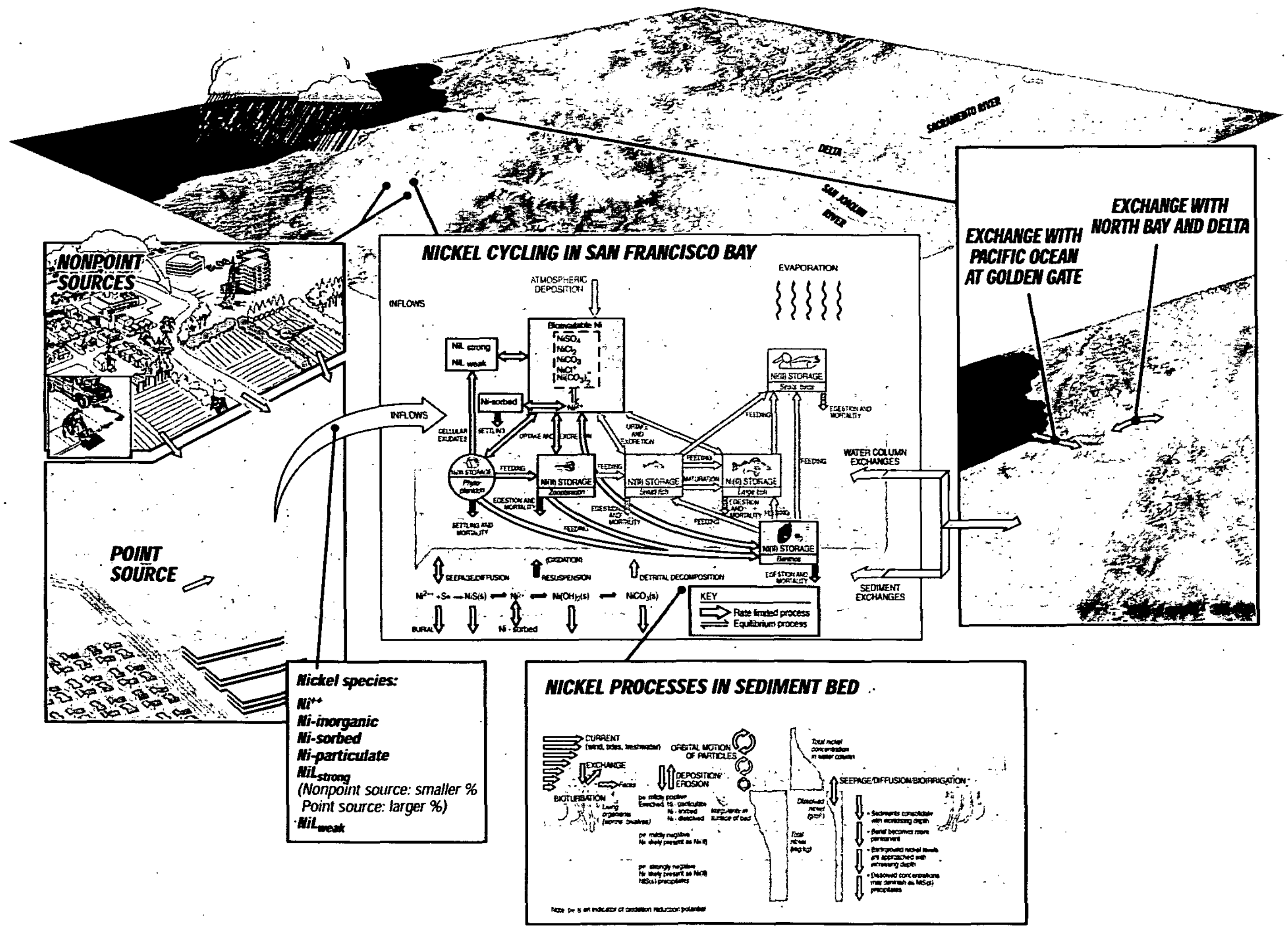


Figure derived from *Conceptual Model Report for Copper and Nickel in Lower South San Francisco Bay* (Tetra Tech, 1999)

3.4.2 Mechanism of toxicity of copper and nickel

Copper toxicity is related to uptake of free ionic copper concentrations [Sunda *et al*, 1988]. Complexation of copper by organic ligands or competitive uptake of dissolved manganese at binding sites in aquatic organisms substantially reduces copper toxicity [Bruland *et al.*, 1992]. This reduction in copper toxicity through complexation is a phenomenon driving the observed Water Effect Ratio results (greater than 1.0) in San Francisco Bay.

Mechanisms of nickel toxicity are varied and complex (USEPA, 1986). Significant effects occur at cell membranes and in membranous tissues (e.g. gills). Nickel does not exhibit the same reduction in toxicity as copper due to complexation. As a result, Water Effect Ratios for nickel in San Francisco Bay have approximated 1.0.

3.4.3 Effects of current inputs of copper and nickel on surface sediment concentrations

The influence of current source inputs of copper and nickel on surface sediment concentrations in San Francisco Bay is an area of ongoing uncertainty. Review of Bay-wide copper and nickel concentrations in surface sediments over time does not indicate identifiable trends, despite reductions in each of these metals in POTW discharges.

The concern has been raised that increasing the water quality objectives for copper and nickel, and a subsequent increase in NPDES effluent limits for copper and nickel concentrations, will produce an increase in the loading of these metals to the sediments in the Bay. Further, the concern exists that such loadings will increase concentrations of copper and nickel in surface sediments, may enhance sediment toxicity and will create a long-term effect on water column concentrations of copper and nickel.

To begin, it has not been established that increasing copper and nickel effluent limits will increase the concentrations of copper and nickel discharged into the Bay, since NPDES treatment facilities typically cannot manipulate treatment operations or effluent concentrations to precisely match effluent concentrations for individual trace constituents. Typical practice in the Bay area is to optimize treatment plant operation at a best achievable level and to maintain a "cushion" below effluent limits to provide reliability in the achievement of those permit requirements.

Second, changes in effluent limits will only impact those sources that are currently restricted by NPDES permits. Changes in loadings to sediment would need to be evaluated in comparison to the total current loading, considering all sources.

If, for the sake of argument, copper and nickel loads from NPDES sources are assumed to increase in response to changes in effluent limits, analytical tools now exist to examine the effects of this change on ambient sediment and water column concentrations. A mathematical model of hydrodynamics, sediment transport and water quality in San Francisco Bay (MIKE 21) has been developed for use in the evaluation of the San Francisco Airport expansion. This model addresses the impact of various sources on water and sediment quality in the Bay. The model includes mechanistic relationships between sediment and water column that are necessary to address the impact of varied loadings on surface sediment quality. The model has been externally peer reviewed and accepted for use by federal agencies, including NOAA and the Federal

Aviation Board. This tool can be used, under varying source load scenarios, to directly assess the incremental changes in sediment and water quality of concern.

As described above, the current approach to ensuring that copper and nickel loads to the Bay do not become a problem would be to periodically monitor selected areas of the Bay. If copper or nickel levels in water column (or in sediments) increase significantly, if the increase is correlated to increases in NPDES loadings, and if there is potential for toxicity problems in water or sediment due to increased sediment copper and nickel concentrations, NPDES sources will need to implement source control alternatives. The action levels to trigger such activity NDB have been described above.

3.4.4 Effect of Sediment Concentrations on Ambient Water Column Levels

The transport of sediment into, within, and out of the Bay is an important component of the copper and nickel cycling process because both copper and nickel are adsorbed to the surfaces of, or embedded within the matrix of, solid particles. Large net loading of copper and nickel into the water column are thought to originate as particulates from the bed and then a net desorption occurs that acts as an internal source of dissolved copper. The overall process of sediment cycling is referred to as the sediment budget.

Solids that enter the Bay from freshwater inflows are subject to flocculation, since the salinity of the Bay is typically high enough to destabilize the solid particles (salinities typically range from 5 to 35 psu). Once in the Bay, the solids are subjected to gravitational forces and depositional shear stresses that tend to cause them to settle to the bed, as well as hydrodynamic forces such as erosional shear stresses that tend to keep the solids suspended [McDonald and Cheng, 1996].

Redox conditions are lower in the sediments, producing different chemical reactions than occur in the water column. Soluble fluxes between the water column and sediments are low compared to other sources of the metals. However, sediment resuspension and desorption may release large quantities of dissolved copper and nickel to the water column, making this a major source of dissolved metals.

Again, as described above, available mathematical modeling tools can provide answers regarding the relative impact of sediment concentrations on dissolved levels of copper and nickel in the Bay.

3.5 Mass loading budget for Municipal and Industrial sources for each metal

Load estimates for each municipal and industrial discharger to San Francisco Bay are presented in **Tables 3.7 & 3.8**, below. Loads were estimated using the average maximum daily metals concentrations, along with the average daily effluent flow.

3.5.1 POTW Data

Municipal discharger copper and nickel mean effluent concentrations and loads are presented in **Table 3.7.**

Table 3.7. POTW Effluent Copper and Nickel Concentrations and Loads (2001-2003)

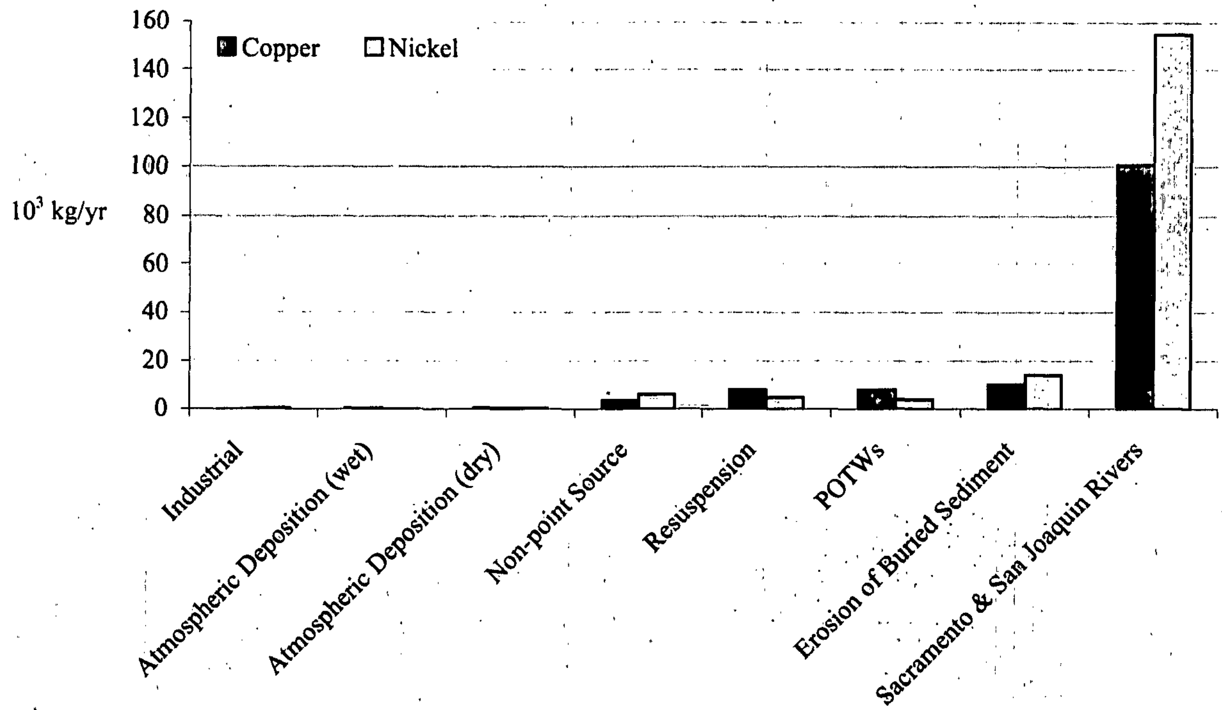
Discharger	Ave. Flow MGD	Mean Cu µg/L	Cu Load g/day	Mean Ni µg/L	Ni Load g/day
City of Benicia	3.02	6.8	78.0	4.7	53.4
Burlingame	4.02	9.8	149.7	3.5	53.1
Central Contra Costa	43.89	6.6	1091.5	1.6	262.7
Central Marin	10.43	2.8	110.5	4.2	165.8
Delta Diablo Sanitation District	9.94	7.6	285.3	8.3	310.8
Dublin San Ramon Services District Permit	10.52	44.2	1758.3	2.9	115.7
EBDA:	27.56	13.9	1452.9	7.5	780.1
E-001	74.96	12.3	3498.8	6.6	1863.1
Castro Valley	15.37	9.7	565.5	5.0	290.9
Hayward	13.07	24.1	1192.0	12.5	620.3
San Leandro	5.45	9.1	188.2	5.6	115.2
Union SD	29.1	14.3	1572.3	7.7	844.6
EBMUD	73.49	9.9	2743.0	6.6	1821.9
Fairfield-Suisun Sewer District	16.57	4.4	274.6	3.9	242.6
Las Gallinas Valley SD Permit	3.34	12.6	159.7	5.5	69.8
Millbrae	1.86	8.8	62.2	3.6	25.5
Mt. View Sanitary District	1.96	5.0	37.2	3.7	27.5
North San Mateo	6.83	22.5	581.7	50.0	1292.6
Novato Sanitary District Permit:	3.25	8.1	99.6	2.3	27.7
Ignacio Plant	4.49	5.2	88.4	2.2	37.4
Novato Plant	2.01	11.0	83.7	2.3	17.1
Pacifica Calera Creek	3.59	5.6	75.8	3.2	43.5
Palo Alto	25.1	6.4	609.2	4.2	394.3
Petaluma Permit	7.3	3.6	99.1	4.3	119.7
Pinole-Hercules	3.2	4.6	55.8	4.4	52.9
Rodeo Sanitary District Permit	0.76	3.2	9.1	3.6	10.3
S.F. Airport, Water Quality Control Plant	0.75	7.0	19.7	2.5	7.1
San Francisco City & County Southeast	71.17	13.7	3695.5	4.1	1099.9
San Francisco City & County Bayside (wet)	22.75	48.2	4146.1	4.7	405.1
San Francisco Oceanside	16.38	16.0	994.9	2.4	150.0
San Jose & Santa Clara	110.16	3.3	1362.2	6.3	2629.3
San Mateo City	12.81	6.0	291.6	5.1	248.1
Sausalito-Marin Sanitary District Permit	1.67	11.2	70.5	4.3	27.1
Sewerage Agency of Southern Marin Permit	3.11	15.5	183.0	4.3	50.9
Sonoma Valley Permit	3.32	7.7	96.7	3.0	38.0
South Bay System Authority	16.91	10.1	643.5	5.7	363.3
South San Francisco & San Bruno	9.91	10.6	398.5	6.7	251.5
Sunnyvale	12.73	1.9	92.0	2.1	102.1
Tiburon Treatment Plant Permit	0.706	18.2	48.5	6.9	18.5
US Navy Treasure Island Permit	0.417	12.5	19.7	2.5	3.9
Vallejo San & Flood Control District	14.02	6.4	341.1	2.9	153.3
West County/Richmond Permit	8.87	7.4	248.5	7.3	245.7

3.5.2 Industrial effluent data

Table 3.8. Industrial Effluent Copper and Nickel Concentrations and Loads (2001-2003)

Discharger	Ave. Flow	Mean Cu	Cu Load	Mean Ni	Ni Load
	MGD	µg/L	g/day	µg/L	g/day
Chevron Richmond Refinery	6.32	3.5	83.1	18.9	451.8
ConocoPhillips (at Rodeo)	1.49	6.7	37.7	3.3	18.7
Dow Chemical Company Permit	0.26	8.8	8.7	10.9	10.7
General Chemical Permit	0.32	3.7	4.5	4.8	5.8
General Electric Company	0.052	8.3	1.6	4.8	0.9
GWF E 3rd St (Site I) Permit	0.043	21.9	3.6	16.8	2.7
GWF Nichols Rd (Site V) Permit	0.047	20.0	3.6	12.7	2.3
Martinez Refining Company	5.98	5.4	122.6	20.4	462.6
Morton Permit	0.027	10.6	1.1	8.5	0.9
Rhodia Basic Chemicals Permit	0.109	10.7	4.4	20.4	8.4
S.F.Airport, Industrial	0.69	5.5	14.5	6.5	17.1
SAM Permit	1.71	15.3	99.0	3.1	20.1
Tesoro Golden Eagle Refinery	4.22	4.6	74.1	16.5	262.9
USS – Posco	7.6	2.7	78.9	2.7	78.9
Valero Benicia Refinery	2.07	7.6	59.3	12.3	96.5

Figure 3.8. Total Mass Budget



	(kg/yr)	
	Copper	Nickel
Industrial	218	526
Atmospheric Deposition (wet)	510	165
Atmospheric Deposition (dry)	760	440
Non-point Source	3800	6100
Resuspension	8000	5000
POTWs	8170	4257
Erosion of Buried Sediment	~10000	14235
Sacramento & San Joaquin Rivers	100990	155129

3.6 Ambient Copper and Nickel Conditions

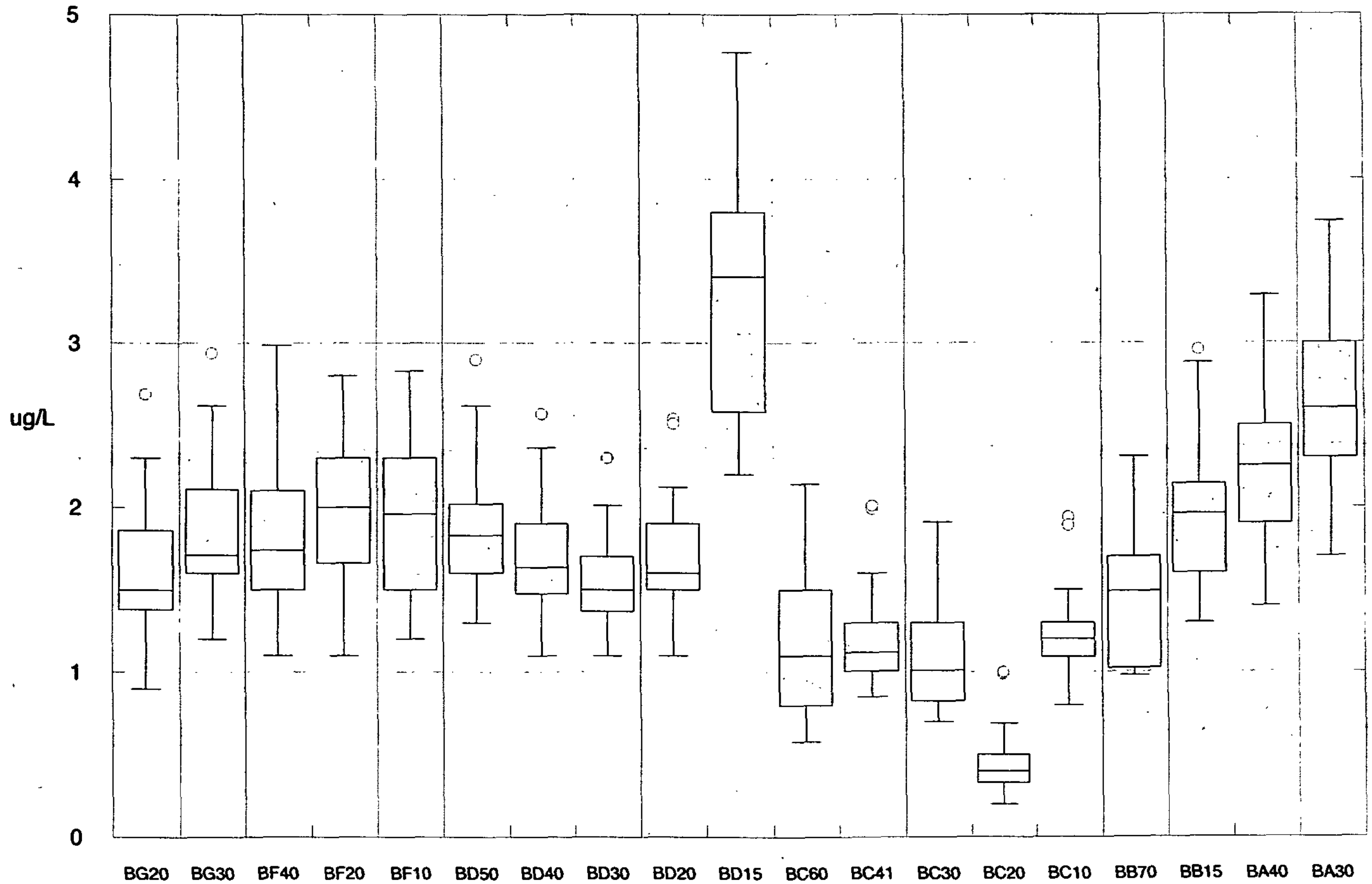
Ambient data were collected from 1993 – 2001 by the San Francisco Estuary Institute's Regional Monitoring Program and as part of the Copper and Nickel North of Dumbarton Bridge study. Water column and sediment data are presented in the box plots below.

The plots present the median, the 25th percentile, the 75th percentile, extreme values and outliers. The lower and upper boundaries of the box represent the 25th and 75th percentiles, respectively. The horizontal line inside the box represents the median. The length of the box corresponds to the inter-quartile range (IQR), which is the difference between the 75th and 25th percentiles. The whiskers indicate the general spread of the data, up to 1.5 times the IQR. Outliers (>1.5 times the IQR) are identified as circles outside the whiskers.

3.6.1 Water Column and Sediment Data

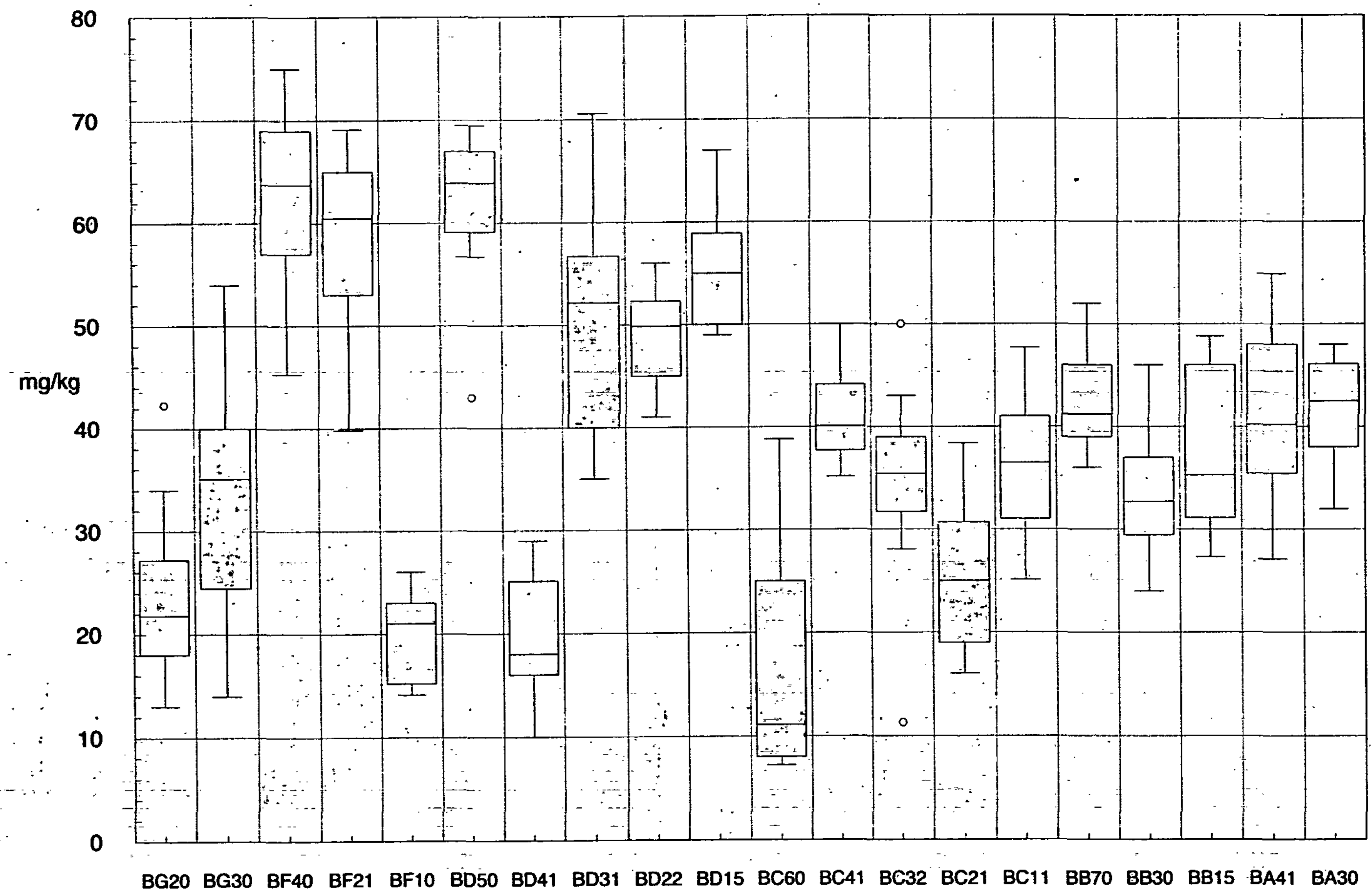
Variations in the copper concentrations in Bay waters are exhibited in **Figure 3.9**. The BC20 station represents the Golden Gate Bridge samples, and the lowest concentrations of dissolved copper in the Bay (ocean water). The Petaluma River station (BD15) represents the highest concentrations, and is discussed in further detail later in this section. To the left of BC20 in **Figure 3.9**, concentrations increase somewhat steadily to Grizzly Bay (BF20), excluding BD15 and begin to decrease at the Sacramento and San Joaquin River mouths. To the right of BC20, concentrations of dissolved copper increase steadily as stations move toward the Dumbarton Bridge.

Figure 3.9. Dissolved Copper in San Francisco Bay Water North of the Dumbarton Bridge (1993 – 2001) [SFEI, 2001a]



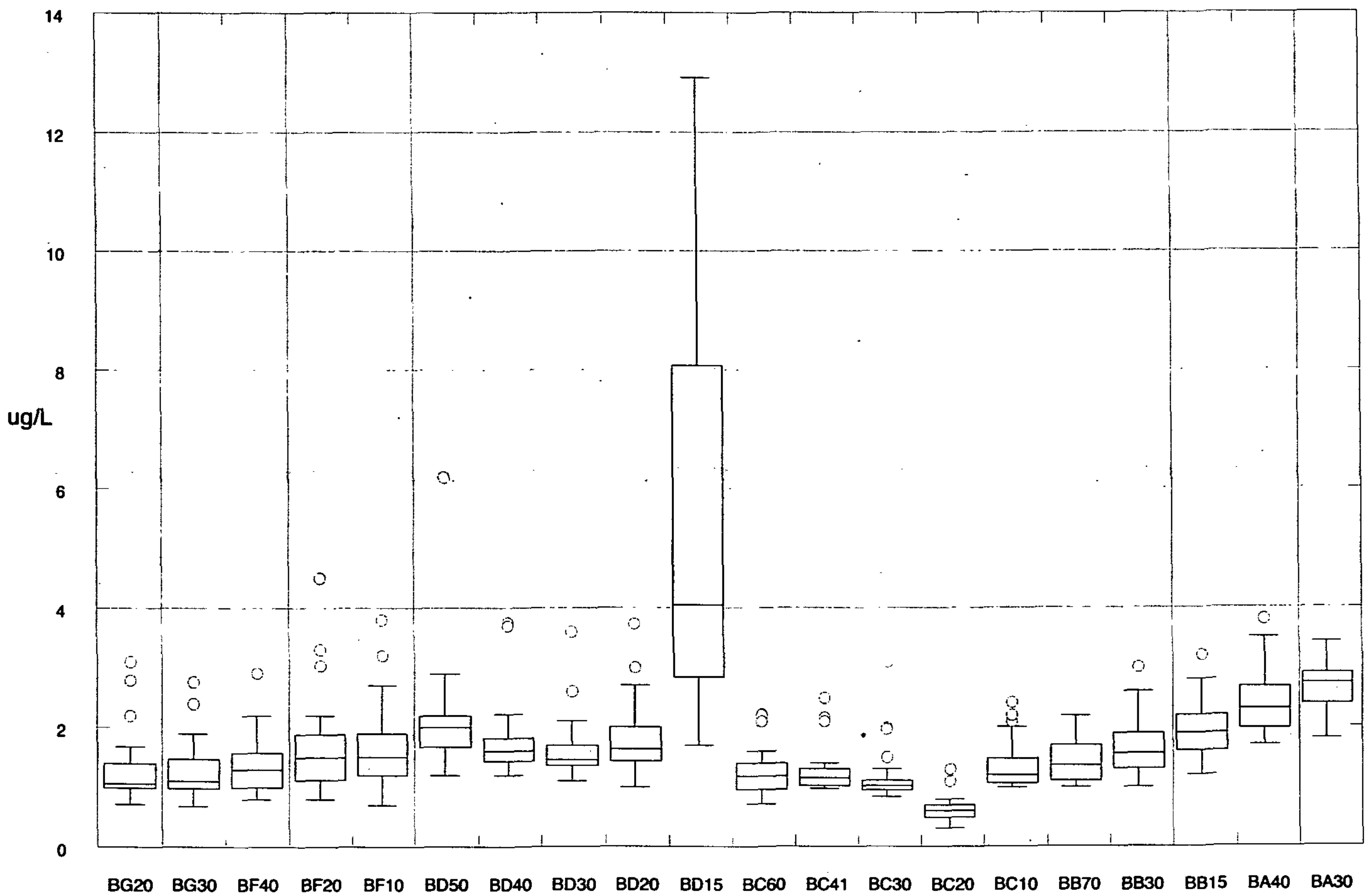
Variations in copper concentrations in Bay sediments are exhibited in **Figure 3.10**. These concentrations are likely a function of the types of sediments found in each area. For instance coarse sands at BG20 and BG30 correlate with lower binding of metals, while the fine grain sediments at BF40 and BF21 correlate with high metals concentrations.

Figure 3.10. Dissolved Copper in San Francisco Bay Sediment North of the Dumbarton Bridge (1993 – 2001) [SFEI, 2001a]



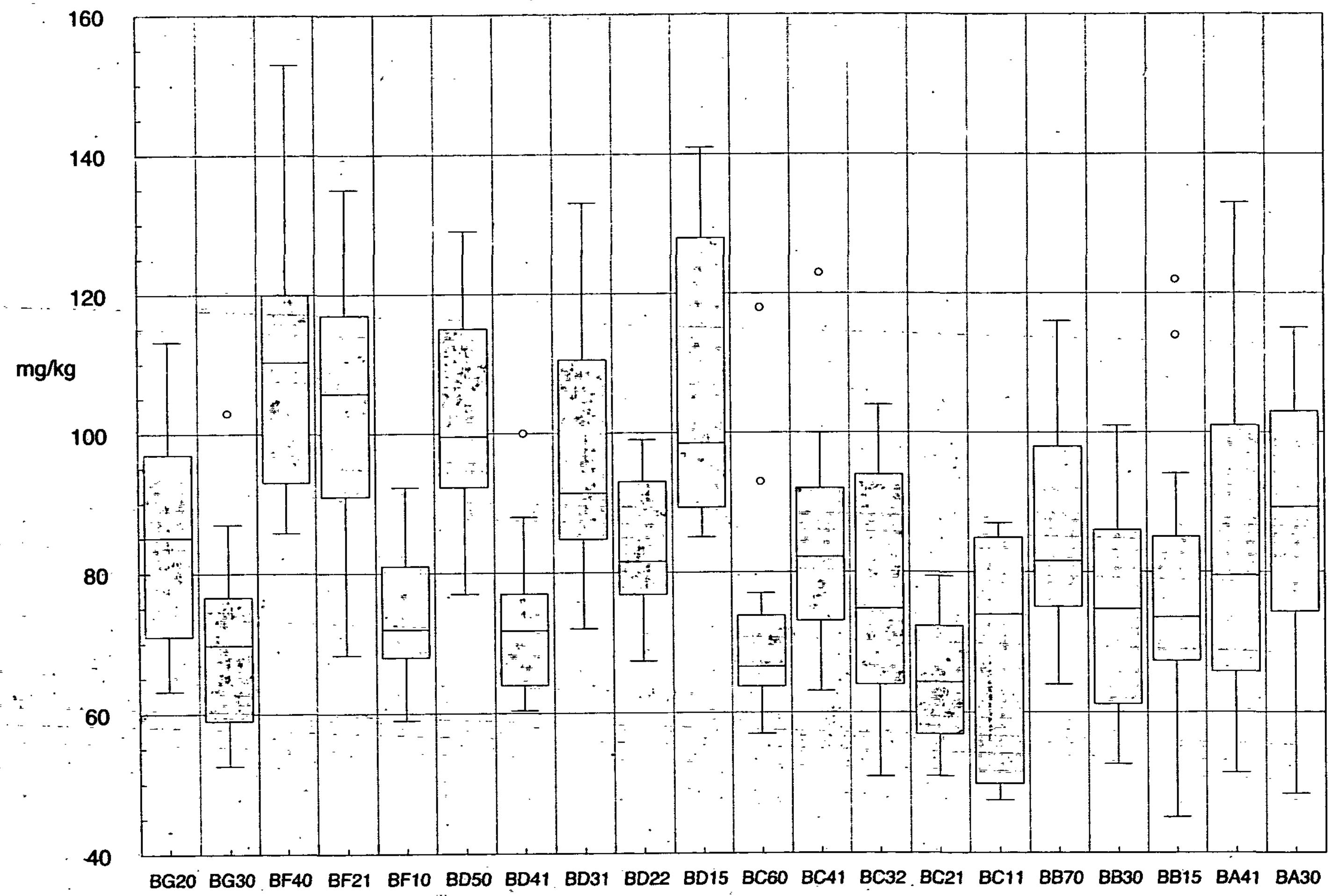
Variations in dissolved nickel concentrations in Bay waters are exhibited in **Figure 3.11**. The BC20 station represents the Golden Gate Bridge samples, and the lowest concentrations of dissolved nickel in the Bay (ocean water). The Petaluma River station (BD15) represents the highest concentrations, and is discussed in further detail later in this section. To the left of BC20 in **Figure 3.11**, concentrations increase somewhat steadily to the Napa River stations (BD50) {excluding BD15} and then decrease toward the Sacramento and San Joaquin River mouths. To the right of BC20, concentrations of dissolved nickel increase steadily as stations move toward the Dumbarton Bridge.

Figure 3.11. Dissolved Nickel in San Francisco Bay Water North of the Dumbarton Bridge (1993 – 2001) [SFEI, 2001a]



Variations in nickel concentrations in Bay sediments are exhibited in **Figure 3.12**. These concentrations are likely a function of the types of sediments found in each area. For instance, coarse sands at BG20 and BG30 correlate with lower binding of metals, while the fine grain sediments at BF40 and BF21 correlate with high metals concentrations.

Figure 3.12. Dissolved Nickel in San Francisco Bay Sediment North of the Dumbarton Bridge (1993 – 2001) [SFEI, 2001a]



3.6.2 Sediment Dynamics

Many contaminants of greatest concern in San Francisco Bay, are primarily associated with sediment particles rather than dissolved in water. Therefore, the movement and fate of sediment determines the movement and fate of many contaminants in the Bay.

Through study of suspended sediment dynamics, the RMP is developing a better understanding of trends and patterns of contaminants and how the Bay will respond to management actions during the next several decades. Recent RMP efforts to develop predictive models of contaminant fate in the Bay have highlighted the fundamental importance of understanding sediment dynamics. Sediment movement in the Bay is determined by tides, wind, and freshwater inflow. Tides flood and ebb twice a day, wind typically is strongest in the afternoon, and freshwater inflow is greatest during the winter rainy season.

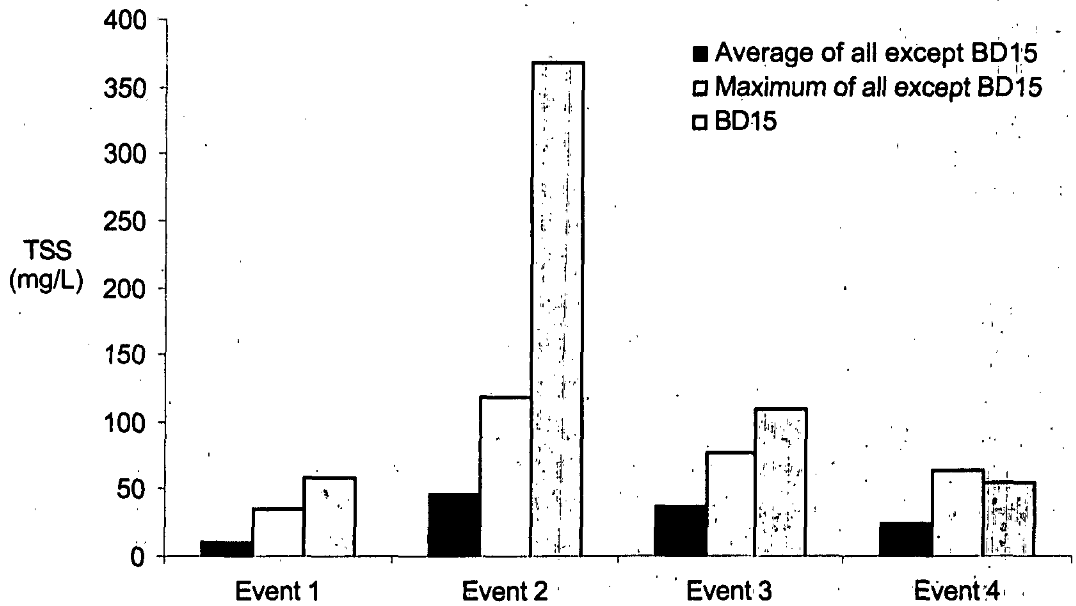
3.6.3 Sediment Transport Explains Contaminant Distribution: Petaluma River

The RMP consistently has measured high concentrations of contaminants in the mouth of the Petaluma River, which drains into northern San Pablo Bay [RMP, 2002]. Sediment transport between the Petaluma River and San Pablo Bay creates high suspended sediment concentrations, which largely explains the area's high concentrations of contaminants. The USGS and the University of California at Davis collected continuous hydrodynamic and suspended sediment concentration data in the Petaluma River from January 1999–August 1999, and from September 2000–March 2001 [Barad et al., 2001]. The geometry and tidal currents in the area create a process of sediment erosion and deposition that repeats with each tidal cycle (about every 12.4 hours). As water flows seaward on ebb tides, the tidal currents apply force to the riverbed. An upstream deposit of sediment on the bed of the Petaluma River is eroded and mixed into the water column. As this suspended sediment mass moves downstream, very high suspended sediment concentration are present (>500 mg/L). Once the suspended sediment mass reaches San Pablo Bay, the slack tide and broad area allow sediment to drop out of the water, forming a downstream sediment deposit. As water begins flowing landward immediately after the tide turns from slack to flood, the downstream sediment deposit is re-suspended and transported upstream. This to and fro process then repeats, with the same sediment mass oscillating back and forth between the Petaluma River and San Pablo Bay. Sediment effectively is trapped within this area, except during large flows in the Petaluma River. This process accounts for the high concentrations of suspended sediment concentration and contaminants in RMP samples collected at the mouth of the Petaluma River.

As was be seen in the plots above (**Figures 3.9 & 3.11**), site BD15 stands out from the other sites as having higher metal concentrations. The highest observed dissolved nickel concentration of 17.2 μg/L occurred during Event 2 at site BD15. The associated total nickel concentration was 47.6 μg/L. Fine grain size as a result of upstream erosion sources and marsh resuspension may contribute to high natural nickel concentrations in this part of San Francisco Bay.

The 2003 Pulse of the Estuary provides a detailed discussion of sediment transport of contaminants at the Petaluma River mouth [SFEI, 2003]. **Figure 3.13** illustrates the elevated TSS at site BD15 compared to the other twelve sites monitored. The BD15 suspended solids were greater than the average and maximum TSS concentrations at all of the other sites, except for site SPB03 during Event 4. Elevated total copper and nickel concentrations appear at least partially linked to the elevated suspended solids (at BD15). Higher concentrations of complexing ligands may be responsible at least in part to the higher dissolved metals concentrations also observed.

Figure 3.13. Suspended Solids (mg/L) at BD15



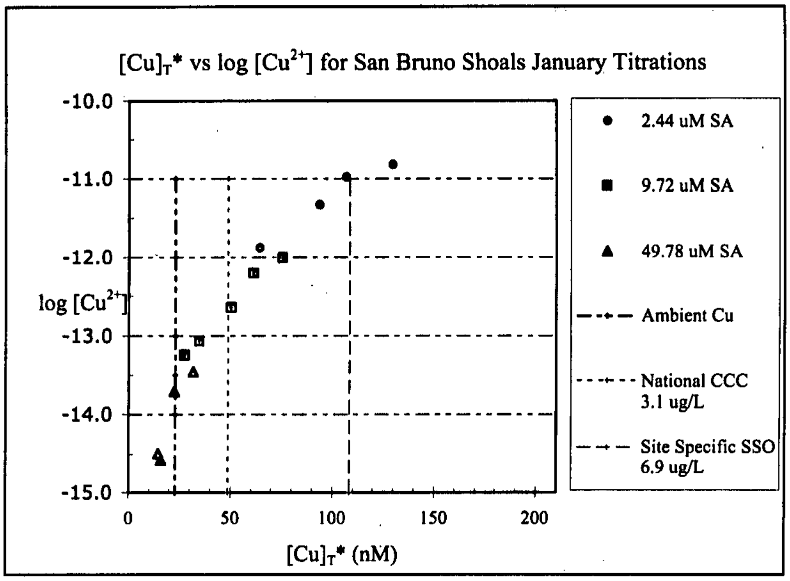
3.6.4 RWQCB Speciation Study Results

Buck and Bruland [2003] performed a study on copper speciation in San Francisco Bay. Total dissolved copper concentrations and the chemical speciation of the dissolved copper were determined at six sites throughout San Francisco Bay (Dumbarton Bridge, Redwood Creek, San Bruno Shoals, Yerba Buena Island, San Pablo Bay, and Grizzly Bay) during January and March 2003 to compliment data sets from previous summertime samplings. Overall, the data from the winter months correlates well with the summer month data. The highest [Cu^{2+}] values were found at Yerba Buena Island, where there was the least excess of strong L_1 ligands. The lowest [Cu^{2+}] values were observed at the Grizzly Bay site, and the second lowest at Dumbarton Bridge.

Throughout San Francisco Bay the total dissolved copper is strongly complexed by natural ligands in solution. Results indicate that the strong copper-binding ligand concentrations (organic ligands) exceed the dissolved copper concentrations at each site, and that in every case the dissolved copper is greater than 99.9% complexed by the natural L_1 strong ligand class. This strong organic complexation of the copper results in very low free hydrated Cu^{2+} ion concentrations. Regardless of site or season, the [Cu^{2+}] values throughout San Francisco Bay did not exceed 10^{-13} M, suitably below the toxicity limit for aquatic organisms [Brand et al., 1986]. Thus, the strong copper-binding ligands appear to effectively buffer the free Cu^{2+} at low concentrations and supports the finding that San Francisco Bay is not likely impaired by the existing levels of dissolved copper in the water column.

The method for determining speciation incorporates salicylaldoxime (SA) as the added ligand, which forms an electroactive $Cu(SA)_2^0$ complex. Using this method, one can predict the $[Cu^{2+}]$ resulting from an increase in the $[Cu^*_T]$ to, for example, national guidelines (see **Figure 3.14** below). At the site-specific SSO guideline of 6.9 µg/L, or approximately 108 nM, results from the South Bay sites predict that the $[Cu^{2+}]$ will reach 10^{-11} M, which approaches the threshold value for copper toxicity to phytoplankton.

Figure 3.14. Copper Speciation Study Results



A $[Cu^*_T]$ versus $[Cu^{2+}]$ plot for San Bruno Shoals January titrations at three unique analytical windows (2.44uM, 9.72uM, 49.78uM) was used to determine the carrying capacity of the ligand pool. The carrying capacity of the ligand pool describes to what level of total dissolved copper the water will tolerate before the free Cu^{2+} concentrations exceed the toxicity threshold of the phytoplankton community. In the above plot it can be seen that at the ambient dissolved copper concentration, $[Cu_{amb}]$, the $[Cu^{2+}]$ is $10^{-13.5}$ M. It can also be seen that the $[Cu^{2+}]$ would exceed 10^{-11} M at a $[Cu_T]$ of 108 nM (or 6.9 µg/L). This observation supports the results of the site-specific toxicity studies done in South San Francisco Bay, which proposed the level of 6.9 µg/L as the toxicity threshold for this region. It is important to note, however, that exceeding this dissolved copper level may lead to toxic conditions for phytoplankton, as the free Cu^{2+} concentrations exceeds 10^{-11} M.

3.6.5 Describe dissolved to total relationships (translators)

The relationship between dissolved and total concentrations of copper and nickel in San Francisco Bay NDB has been reviewed extensively in a separate CEP report (*North of Dumbarton Bridge, Copper and Nickel Development and Selection of Final Translators*, EOA/LWA, 2004).

The key finding in that report is that choices exist regarding the adoption of acute (90th percentile) and chronic (median) translator values for use in NPDES permitting. These values may be adopted for Central Bay, for North Bay, or as single values for the entire Bay. As was done in the Lower South Bay, the report recommends that the final selection of translator values be considered jointly with the determinations regarding site-specific objectives values for copper and nickel NDB.

3.7 Summarize other key elements and findings in the conceptual model report for copper and nickel for South Bay

The "*Conceptual Model Report for Copper and Nickel in Lower South San Francisco Bay*" [Tetra Tech, 1999] (CMR) stated the following:

> ***The highest priority should be to quantify the speciation of copper and nickel*** *and the cycling processes that influence speciation, since this determines bioavailability, uptake, and toxicity to aquatic organisms.* ***If*** *it is determined that the potential exists for the impairment of beneficial uses due to copper or nickel concentrations in Lower South San Francisco Bay, then steps should be taken to better quantify the sources of these metals. Four key areas have been identified for future studies: 1) biogeochemical processes influencing chemical speciation, 2) effects of speciation and competing metals on phytoplankton uptake and toxicity, 3) resuspension fluxes and other sediment-water interactions, and 4) wet season tributary loads* (emphasis added).

As stated previously, speciation studies have been performed NDB which have provided greater understanding regarding the concentrations of important chemical forms (free ionic, strongly and weakly complexed) and the probable impact of these conditions on aquatic toxicity. Other areas of emphasis identified in the LSB effort are discussed below.

3.8 Uncertainties

Several processes have been identified that would be important to the development of the SSOs for copper and nickel, but for which there is either a lack of sufficient information or a high degree of uncertainty. These processes may be the focus of future studies, if deemed necessary. The major sources of uncertainties are summarized below, followed by recommendations for future studies to reduce these uncertainties.

3.8.1 Key Questions regarding Copper and Nickel in San Francisco Bay

3.8.1.1 Copper and nickel management questions

As identified in the impairment assessment portion of this report, several major management questions exist which are fundamental to Regional Board actions in the adoption and implementation of site-specific objectives for copper and nickel. Two of these questions have particular connection with the conceptual models for copper and nickel.

1. Will the adoption of site-specific objectives lead to increased loadings from point sources that will have a measurable impact on dissolved water column copper and nickel concentrations in SF Bay?

   This question has been described previously and relates to several factors, including the change in effluent limitations resulting from adoption of site-specific objectives, the sensitivity of effluent quality changes at NPDES treatment facilities to relaxed effluent limitations, the magnitude of NPDES source loadings from a Bay-wide or subembayment standpoint, and the effect of changes in copper and nickel loadings from the existing baseline condition resulting from such changes in effluent quality.

At least a portion of these uncertainties can be resolved through use of water quality modeling, as described later.

2. What implementation measures are needed to ensure that existing copper and nickel concentrations in the water column and surface sediments of the Bay will not increase significantly?

This question is a follow-up to the previous question. If increased NPDES inputs of copper and nickel resulting from relaxed effluent limits are determined to have a significant effect on ambient conditions in the Bay, additional controls will be needed to minimize such increased inputs. The effectiveness of various control measures in reducing NPDES inputs must be understood to enable prioritization and implementation of appropriate control measures. Again, water quality modeling will be useful in the resolution this question, as described later. In addition to these primary management questions, a number of technical uncertainties remain. The need to address these areas of uncertainty will be a determination to be made by the CEP after review of this document.

3.8.1.2 Sedimentation/Resuspension Dynamics

Interactions between the sediments and water column are important, both because metals released through resuspension and porewater diffusion are significant sources of metals to the water column and because external metal loads accumulate in the sediments and produce exposure through the benthic food web. Unfortunately, limited information is available on the sedimentation dynamics of the Bay.

A detailed sediment budget has not been developed. The magnitude, seasonal variations, and year-to-year variations of external sediment loads from the watersheds are highly uncertain due to limited data. Information on the temporal variations in sedimentation and resuspension fluxes is also sparse. No information is available on the exchange of sediments between the shoals and the channel. Understanding the differences in the sedimentation and resuspension dynamics between the shallow shoal areas and the deeper channel areas is important for quantifying resuspension fluxes and metals release to the water. Sediment rheology parameters such as erodability have also not been measured. Sediment transport processes and sediment exchange with other areas of the Bay have not been well quantified.

3.8.1.3 Adsorption/Desorption Kinetics

Desorption of copper and nickel during sediment resuspension is an important source of dissolved metals to the water column, yet very limited information is available on the rate constants for the adsorption and desorption reactions. These rates will vary depending on the size and nature of the suspended particles, so the particle size distributions of both suspended particles and sediments also need to be quantified.

3.8.1.4 Limited Sediment Core Data

Information on copper and nickel concentrations in sediments and sediment porewaters is limited to only a few cores and sampling dates. More data are necessary to better determine metal release fluxes due to resuspension and porewater diffusion, and to estimate the long-term sediment recovery from the previously higher historical loadings.

3.8.1.5 Nonpoint Source Tributary Loads

Wet season tributary loads of copper and nickel are currently the largest external sources, but their magnitudes and temporal variations have high uncertainties. The streams have not been regularly monitored for metals and suspended particle concentrations, so the loadings are based on simulation model predictions [URS Greiner Woodward Clyde, 1998]. The resulting estimates are uncertain because the data used in the model have a high degree of variability, land-use data from the late 1980's were used, limited data were available for metal concentrations in runoff from open space and industrial land uses, large correction factors were required during model calibration, and several simplifying assumptions were used in the model (e.g., metal concentrations in runoff are independent of flow rates and antecedent conditions) [URS Greiner Woodward Clyde, 1998]. The Sources, Pathways and Loadings work group of the Regional Monitoring Program, in cooperation with the Clean Estuary Partnership, is undertaking studies to improve the methodologies for estimation of wet season loadings from small and large tributaries (McKee and Leatherbarrow, 2003). This effort includes high flow monitoring studies at Mallard Island and on the Guadalupe River that may provide useful tools for estimation of wet season copper and nickel tributary loads.

3.8.1.6 Food Web Transfer

With the exception of bivalves, copper and nickel have not been measured in higher trophic level organisms such as zooplankton and fish in San Francisco Bay. This makes it difficult to estimate food web transfer of the metals and the relative contributions of water versus food uptake. Limited information is available in the literature on copper and nickel uptake rates from water, assimilation efficiencies from food, and depuration rates. Much less information is available for nickel than for copper. Most of the available data are for different species than those in San Francisco Bay. Although information from other species can be used to estimate uptake and accumulation of copper and nickel in South San Francisco Bay organisms, these estimates would be speculative without some measurements of copper and nickel concentrations in the target organisms and their key food sources. Although tissue concentration data are available for benthic bivalves, no data are available for their major food sources (phytoplankton, organic detritus).

3.8.1.7 Limited Information on Nickel

Much less is known about the cycling, bioavailability, uptake, accumulation, and toxicity of nickel than of copper. This is true of the literature in general, as well as for studies conducted specifically in San Francisco Bay.

3.8.1.8 Limited Wet Season Data

Less information is available for wet season cycling and transport processes than for the dry season. Most of the existing transport studies have focused on dry season conditions. The effects of seasonal variations in Delta outflows and flushing effects on the fate of copper and nickel in the Bay are uncertain.

3.8.2 Approaches to Resolve Uncertainty

3.8.2.1 Areas of Uncertainty that can be Addressed through Water Quality Modeling

The following areas of ongoing uncertainty have been identified, which can be significantly reduced through the use of mathematical hydrodynamic and water quality models (e.g. MIKE 21).

a. Incremental water quality impacts that may result at various locations in San Francisco Bay due to changes in (1) concentrations and/or (2) mass loadings from existing POTW and Industrial discharges of treated wastewater. This is important to the Regional Board's assessment of the effect of adopting site-specific water objectives for copper and nickel for San Francisco Bay. Water quality objectives are used in the determination of numeric effluent limitations. Concern exists that an increase in the water quality objectives for copper and nickel to higher allowable water column concentrations in the Bay will result in higher effluent limits and, thereafter, higher concentrations in NPDES effluents. Concern also exists that such increases in effluent concentrations will produce higher concentrations of dissolved copper and nickel in the Bay. The Regional Board must address a potential change in ambient water quality as a result of adoption of SSOs for copper and nickel to determine consistency with state and federal anti-degradation policies. In the South Bay, this issue was addressed through implementation of the ambient monitoring/ambient trigger approach. This empirical approach linked enhanced source control at NPDES discharges to results of Bay monitoring. The working hypothesis for this program was that control of mass loadings from NPDES discharges (POTWS and urban runoff) was key to control of ambient water quality.

   The mathematical model can address this issue by replicating existing ambient water quality conditions with existing NPDES loadings, Delta outflow, etc. and then increasing or reducing the loadings from some or all sources to assess incremental changes in water quality at various locations in the Bay.

b. Incremental changes in surface sediment concentrations of copper and nickel that may result from increased loadings of copper and nickel from NPDES discharges, as described above. The concern is that incremental increases in mass loads from NPDES dischargers will increase the mass of copper and nickel in surface sediments, resulting in increases in concentration.

   The mathematical model can predict the change in surface sediment concentrations under the existing NPDES loading condition and various other loading scenarios. The *model can also address the resulting interactions between surface sediments and water column concentrations.*

c. The impact of the erosion of bedded sediments on Bay water quality. Available sediment cores indicate that elevated levels of copper and nickel exist at specific locations in the Bay. The Selby Slag disposal area is an example of one such area. If erosion of Bay sediments occurs in these areas, concern exists that exposure of sediments with elevated concentrations will cause and increase in ambient dissolved copper and nickel water column concentrations.

   The mathematical model can be employed to assess the effect of significantly elevated areas of surface sediment concentration on dissolved copper and nickel concentrations around the Bay.

d. The relative magnitude and importance of copper and nickel sources to Bay water quality. While the mass loadings of copper and nickel in POTWs and industrial treated effluents are accurately quantified, the mass loadings from urban runoff, atmospheric deposition, riverine sources and in-Bay sediments are not.

   The mathematical model simulates source loadings based on available data for all significant sources. The sensitivity of Bay water quality at any location to changes in other significant sources (apart from NPDES discharges) is a direct result that can be obtained from the model. The results from the ongoing Brake Pad Partnership modeling effort will assist greatly in the quantification of urban runoff loadings to the Bay.

3.8.2.2 Resuspension Fluxes and Other Sediment-Water Interactions

One of the largest sources of both dissolved and particulate copper and nickel is estimated to be resuspension from the sediments. Although external loads are highest during the wet season, water column concentrations of both dissolved and particulate copper and nickel are highest during the dry season. The dry season is also the windy season, when resuspension rates are highest. During sediment resuspension, desorption can release significant quantities of dissolved metals to the water column. Mass balance analyses of dry season loadings, inventories, and residence times in the water column of the Lower South Bay indicate that desorption during resuspension could be a major source of dissolved copper and nickel during the dry season. The other loadings cannot account for the currently observed dissolved metal concentrations in the water column. This internal source is also the most difficult to quantify, and therefore has the highest uncertainty and the least amount of information available. Decomposition and mineralization of settled phytoplankton could also be an important sediment source, as could remineralization of suspended particles during benthic grazing and benthic bioturbation/ irrigation effects on sediment release. Therefore, studies to better quantify copper and nickel release during resuspension and biological effects on sediment cycling may be warranted.

Of related importance are studies to quantify the accumulation of metals into the sediments. Since the sediments are a main repository of both historical and continuing loads, and since they continue to reintroduce copper and nickel into the water column through resuspension, sediment diffusion, and biological cycling, it would be useful to get a better understanding of the movement of copper and nickel into the sediments from existing external loading sources.

It may be appropriate to convene an expert panel to develop ideas for further studies to quantify these processes. Laboratory experiments could be conducted to estimate desorption fluxes using surficial sediments and water collected from the Bay. Since the metal concentrations adsorbed to particles appear to vary with particle size, additional information to establish these relationships, along with particle size distributions in the Bay, could be established through field and/or laboratory studies. This information should be used in conjunction with model analyses to estimate the resuspension and other sediment exchange fluxes, since it is not practical to obtain direct estimates from field studies. Studies by Moss Landing Marine Laboratories (MLML) of soluble metal fluxes from Bay sediments could be used to refine the current estimates of these fluxes. Analysis of historical bathymetry changes along with geochemical studies of sediment cores could provide additional information on metal accumulation in sediments.

3.8.2.3 Wet Season Tributary Loads

Wet season tributary runoff loads are the most important of the external load sources, both in terms of magnitude and in terms of potential for load reductions by watershed management or stormwater treatment. The existing load estimates also have a fair amount of uncertainty associated with them, and they could be refined using more current or projected land use information, more recent and complete runoff loading data, and more advanced models than were available when the original estimates were made. Therefore, wet season loads should continue to be the primary focus of additional work on refining external load estimates. POTW loads have already been substantially reduced and the load estimates are well characterized through frequent monitoring. Atmospheric loads are uncertain, but are very small compared to other sources and therefore do not merit additional work. Sediment diffusion loads appear to be small relative to resuspension loads. However, these estimates were based on limited data, and they should be refined in conjunction with the other sediment studies recommended above. Even though the wet season tributary loads occur during the period when water column concentrations of copper and nickel are at their lowest, they are still the largest external source, and therefore probably contribute significantly to the sediment inventories, which in turn contribute to the water column through resuspension during the dry season.

3.8.2.4 Track and Encourage

The Copper Action Plan (CAP) developed as part of the Lower South San Francisco Bay copper and nickel studies includes efforts to "track and encourage" activities and research intended to reduce the scientific uncertainties associated with the impairment assessment and conceptual model reports' conclusions [Tetra Tech, 2000b]. Many of these uncertainty reduction activities are applicable to assessing potential copper impacts throughout the Bay NDB.

The Santa Clara Valley Urban Runoff Program has contracted with both SFEI and the Clean Water Fund (CWF) to develop web-based clearinghouses for "uncertainty" studies and pollution prevention studies, respectively, for copper and nickel. The SFEI effort is scheduled to be completed at the end of 2004. The CWF effort on pollution prevention studies is scheduled to be completed in mid 2005. The Brake Pad Partnership is also establishing a website to address copper issues, pending receipt of Proposition 13 grant funding.

3.8.2.5 Coordination

SCVURPPP, as one of its South Bay CAP activities, has developed a prototype Copper P2 Clearinghouse website. The site contains pages describing about 15 copper sources with links to documents and other sites with information on potential control measures for both POTWs and stormwater programs. It incorporates the latest information from, and is intended to be a complementary resource to the Pollution Prevention Menus project report and the Copper Sources in Urban Runoff and Shoreline Activities report. It was released in December 2004. The website has been designed as a bay-wide resource and is recommended to be continued as such.

3.8.2.6 Compile Regional Research Documents

A significant amount of basic and applied research has been undertaken in the region investigating copper and nickel processes and effects in various segments of the Bay. Much of this work is scattered about in various reports both off-line, and on-line located at websites for particular research institutions, scientific journals, stakeholder groups, and agencies. Although many of these efforts already cite and cross-reference each other, compiling these various data sources together at one location would benefit any parties interested in research on Cu/Ni processes in the region.

SCVURPPP contracted with SFEI to develop a prototype website that groups technical uncertainties into six categories (see below) and provides links to documents and other sites with applicable information.

- Environmental Distribution
- Sources and Loads
- Transport Processes
- Chemical Processes
- Bioavailability and Effects
- Comprehensive Studies

Most of these uncertainties apply to issues and phenomena bay-wide such as copper speciation and sediment toxicity. The intent is to use the site as a vehicle for keeping track of new information bearing on the identified scientific uncertainties and on potentially newly identified uncertainties. It was released in December 2004. The website has been designed as a bay-wide resource and is recommended to be continued as such.

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Appendix A

City of San Jose Comment Letter,
May 18, 2004

Note:
Requested changes in the attached letter were made to the body of the report.

Dear Mr. Hardin:

The City of San José (City) appreciates the opportunity to submit comments on the April 2004, Clean Estuary Partnership's *North of Dumbarton Bridge Copper and Nickel Conceptual Model and Impairment Assessment Report (Draft Report).*

Based on the City's previous experience with the copper and nickel impairment assessment and conceptual model development for the South Bay, the CMIA's should include the following three elements:

1. estimated loadings, mass balances, and inventories of the pollutants;
2. description of processes thought to be most important in controlling the pollutant, and;
3. a discussion of pollutant cycling effects on uptake and toxicity to aquatic organisms.

The Draft Report reasonably discusses the first two elements above with one important exception. The processes controlling existing in-Bay inventories of copper and nickel and the role of new inputs to the system are not completely understood. However, this should not be a critical information gap since dissolved copper and nickel concentrations in the Bay have remained uniform over the past decade, despite significant efforts to reduce point and non-point source contributions. Finally, the report does a good job in describing copper speciation and the dominant role of the ionic species in copper toxicity to Bay organisms. The report presents technical data and information so that an individual unacquainted with the subject matter can understand the issues and includes all of the elements described above. In addition, the report thoroughly discusses the data uncertainties, and requisite next steps.

The Draft Report recommends significant additional modeling to reduce uncertainties. The City does not support further numerical modeling as part of this project since ambient concentrations of copper and nickel have remained uniform in the Bay. CEP funding is very limited, and other pollutants where impairment is likely should be the priority. A Water Quality Attainment Strategy (WQAS) along with ambient monitoring such as required for the Lower South Bay, provides adequate assurances that beneficial uses are protected. Additional numerical modeling may be appropriate at a later date if increasing ambient concentrations are documented

The Draft Report often alludes to the Lower South Bay (LSB) Site-Specific Objective (SSO) development process without summarizing its findings. This may be an inconvenience to readers who may not have that document available to them. Such references to the LSB work should include summaries of approaches, processes, results, and conclusions. One example of this is the useful graphic of the conceptual model for copper and nickel developed for the LSB effort. However, the copy of this model used in the Draft Report is small and difficult to read. It is suggested that it be enlarged so that readers can review its contents.

Response: *Reference was made to Section1 of the July 2002* Copper & Nickel North of the Dumbarton Bridge Step 1: Impairment Assessment Report*, which summarizes the LSB work. Additionally, the conceptual model figures were made larger in this report.*

Copper & Nickel: Impairment Unlikely

City staff concludes that the Draft Report demonstrates that impairment of the Bay due to copper and nickel is unlikely. With the exception of dissolved nickel concentrations at the BD15 site (mouth of Petaluma River), water column measurements for copper and nickel North of the Dumbarton Bridge (NDB) are well below potential Site-Specific Objectives for these metals. In addition, sediment copper concentrations are well below ERM criteria (Long *et al.* 1995) which are indicative of sediments expected to exhibit toxicity.

City staff has the following additional comments on the Draft Report.

Impairment Assessment Specific Comments:

- Page iii

  "For copper in Lower South Bay, observed WER values ranged from 2.7 to 3.5 based on measured dissolved copper."

  Page 12

  "For copper, the City of San Jose used the Indicator Species Procedure in its Impairment Assessment. Observed WER values ranged from 2.5 to 5.2 based on measured dissolved copper."

  Comment:

  The numbers quoted on p. iii are a range of station means rather than a range of WER values. The "adjusted" (-14%) geometric **mean** Final WERs (FWERs) were 2.670, 2.876, and 3.535, respectively, for the Dumbarton North, Dumbarton South and Coyote Creek stations in Lower South Bay (LSB).

  Response: *Text replaced with "For copper, the geometric mean Final WERs (FWERs) were 2.670, 2.876, and 3.535, respectively, for the Dumbarton North, Dumbarton South and Coyote Creek stations in Lower South Bay (LSB)."*

  The range of 2.5 – 5.2 cited on p. 12 is for the unadjusted (observed) WER values for the two Dumbarton Bridge stations. These values were not used directly in the LSB calculations. The range of adjusted WERs for the two Dumbarton stations used to derive a LSB Final WER and SSO was 2.2 to 4.5.

  Response: *Text replaced with "The range of adjusted WERs for the two Dumbarton stations used to derive a LSB Final dissolved copper WER and SSO was 2.2 to 4.5.*

- Page 11, footnote 1

"a WER is the ratio of toxicity of a given pollutant in laboratory water to toxicity in site water."

Comment: This statement transposed the words "laboratory" and "site". In the "ratio", site water results are the numerator and lab water results are the denominator (the lab water is the standard denominator).

Response: *Footnote has been edited appropriately.*

- Page 12

"A recommended range of chronic copper SSOs of 6.8 to 8.4 NDB has been developed from the observed WER values [EOA/LWA 2004]."

Comment:

The numbers 6.8 and 8.4 do not represent a range at all. Rather, they are both derived using the arithmetic mean for all 13 NDB sites multiplied by either 3.1 (the "CTR SSO") or 2.5 (the "Recalc SSO"). In a comment letter dated 4/1/2004 concerning the NDB SSO report, the City recommended the development and evaluation of Final WERs by Bay Region. Using a modified national criterion of 2.5 (referred to as "Recalc SSO" in the report) and the Bay regional WERs recommended in the City's letter, City staff calculated a range of NDB SSOs of 6.0 (Region 2) to 7.3 (Region 4). This represents an appropriate range of FWERs for the Bay NDB.

Response: *Range has been edited to 6.0 to 8.6, for Regions 1-2-3, and Region 4. This range incorporates both the current 3.1 µg/L and the recalculated 2.5 µg/L criterion.*

P. 17

"Causes of sediment toxicity have been further investigated using toxicity identification evaluations (TIEs)...However, the TIE findings were not conclusive regarding the contribution of copper to observed sediment toxicity effects."

"It is therefore recommended that the results from TIE testing should only be used to develop a more definitive test procedure to confirm the suggested toxicant. Chemical specific data must also be used to verify the source of toxicity conclusively"

Comment:

City staff agrees with these statements. The SFEI sponsored Phillips *et al.* (2000) TIE paper implicating copper is a working example of flawed science and why confirmatory Phase III TIEs are needed.[3] Papers such as Phillips et al. (2000) need greater peer review, evaluation,

[3] The City's comments on the Phillips *et al.* (2000) paper are included as Attachment 1.

and oversight prior to publication. The overstatement of the data in the conclusions is subjective and does not serve the needs of this report.

Response: *Included Phillips et al. paper and San Jose's comments in Appendix A of this report, and referenced this addition in the body of the report.*

- P. 24

"Regardless of site or season, the [Cu2+] values throughout San Francisco Bay did not exceed 10^{-13} M, suitably below the toxicity limit for aquatic organisms."

Comment:

Since this is a direct quote from Buck and Bruland (2003), please cite the work and put the statement in quotation marks. It is important that the reader understands that this is the conclusion of Drs. Buck and Bruland.

Response: *Clarified reference and changed sentence so that it was not a direct quote.*

- P. 24, Section 2.5.10 CVRWQCB Algae Toxicity Study

This section discusses problems with algal toxicity tests and TIE methods in a study funded by CALFED. During the Lower South Bay SSO development process, City staff evaluated the potential problems (confounding factors, extrapolation to the field, and salient endpoint to regulate) associated with algal toxicity testing. Those comments are included as Attachment 2.

Response: *Added the following text "During the Lower South Bay SSO development process, San Jose staff evaluated the potential problems (confounding factors, extrapolation to the field, and salient endpoint to regulate) associated with algal toxicity testing (see comments in Attachment 2 to City of San Jose letter dated May 18, 2004 in Appendix A).*

- Page 46, Table 2.3

Table 2.3 Trigger Levels Relating to the Ideal Sampling Scheme (µg/L)

		Region 1	*Region 2*	*Region 3*	*Region 4*
Copper µg/L	*increment*	*0.82*	*1.29*	*0.79*	*0.79*
	concentration	*2.87*	*3.47*	*2.23*	*3.16*
Nickel µg/L	*increment*	*0.80*	*1.18*	*0.76*	*1.22*
	concentration	*2.16*	*3.26*	*2.18*	*3.55*

"It is assumed that RMP sampling will provide 12 samples in Region 2 and 8 samples in Region 4, to provide a 99% level of power in the monitoring effort."

Comment:

The report should note that some power (ability to detect a statistical difference) is lost in using an n of 8 for Region 4 compared to using an n of 12, as is recommended for Region 2. The report should note what the added cost would be to sample Region 4 twelve times so that the power analysis for each Bay Region would be based on the same n.

Power analysis indicates the increase in copper (or nickel) that can be statistically detected. This is not likely an increase that is ecologically or biologically significant. A biologically significant endpoint is the SSO itself.

Response: *Added the following text "Some power (ability to detect a statistical difference) is lost in using an n of 8 for Region 4 compared to using an n of 12, as is recommended in Region 4 (Draft Development of Action Plans, EOA/LWA, June 2003, Appendix 3). Power analysis results simply indicate the incremental increase in ambient copper (or nickel) concentrations that can be statistically detected at a given level of significance (in this case 99%). This level of increase is not likely one that is ecologically or biologically significant. A biologically significant endpoint is the SSO itself."*

<u>**Conceptual Model Specific Comments:**</u>

- P. 75

  "Elevated copper and nickel concentrations appear at least partially linked to the elevated suspended solids" (at BD15).

  Comment:

  High TSS values at BD15 explain the higher total metals concentrations often observed at that station. Please explain in the report the reason (i.e. source of complexing ligands) for the higher dissolved metals concentrations also observed at that station.

  Response: *Added the following text "Higher concentrations of complexing ligands may be responsible at least in part to the higher dissolved metals concentrations also observed."*

- P. 77

  Concerning acute and chronic translators, the report asserts that *"These values may be adopted for Central Bay, for North Bay, or as single values for the entire Bay. As was done in the Lower South Bay, the report recommends that the final selection of translator values be considered jointly with the determinations regarding site-specific objectives values for copper and nickel NDB."*

  Comment:

The City supports the derivation of regional translators for Bay Regions 1-4. It may be appropriate to combine chronic (median) translators for Bay Regions 3 & 4 (Central Bay) since they are similar (0.72 & 0.76). It may not be appropriate to combine median translators for Bay Regions 1 (San Pablo Bay) & 2 (Suisun Bay) into one North Bay translator since translators for these two regions are not entirely similar (0.35 & 0.44) and since these Bay regions are separate embayments.

The City supports the application of a single SSO of 6.9 to Bay Regions 4 & 5. The City also supports combining SSOs for Bay Regions 1-3 into a single SSO. Since the derived translators for Bay Regions 4 (NDB) & 5 (Lower South Bay) are 0.76 and 0.53, respectively, there is little likelihood that only one or two translators and one or two SSOs will be appropriate for the entire Bay (Regions 1-5). The focus should be on the best available science not just on the most simplistic regulatory approach. As recommended in the report, there is no reason why these two decisions (translators and SSOs) cannot be considered jointly.

Response: *These issues will be dealt with in the translator report and the Basin Plan Amendment process.*

San José comments on the Phillips *et al.* (2000) paper

Title: Causes of Sediment Toxicity to *Mytilus galloprovincialis* in San Francisco Bay, California

This paper presents some critical information and results characterizing the persistent toxicity associated with Grizzly Bay sediments. Sediment toxicity at this station and its underlying causes appears to be variable, complex, and enigmatic. The paper helps to clarify the role of copper in the persistent toxicity observed at this station. There is concern, however, that the role of copper in the sediment toxicity at this station may have been overstated in the paper's conclusions. The following remarks describe some of these concerns.

The paper describes results of TIE manipulations done on three Grizzly Bay sediment samples. Three of the paper's conclusions (restated below) are critically reviewed with regard to the TIE results obtained for the three samples.

Conclusion 1, stated in the Abstract: "TIE results and chemical analyses of elutriate samples suggested that divalent metals were responsible for the observed toxicity."

Conclusion 2, stated in the Discussion section: "Chemical analyses of three elutriate samples demonstrated copper concentrations were within the range toxic to bivalves."

Conclusion 3, stated in the Discussion section: "Although metal concentrations in Grizzly Bay samples were measured above *M. galloprovincialis* tolerance limits only in the third TIE, it is possible that low concentrations of metals might be working additively or synergistically to cause toxicity."

Comment 1: Regarding Conclusion 1, divalent metals may have been responsible for **some** of the observed toxicity. It could be argued that the toxicity that was not ameliorated by EDTA or cation column was as (or more) significant than the toxicity actually removed by those treatments. For example, 54%, 67%, and 32% of the toxicity in samples 1-3, respectively, was not removed by EDTA or Cation column. None of the observed toxicity in the 100% elutriate samples was removed by any of the treatments.

Comment 2: Conclusions 2 and 3 are overstated. All three samples showed significant toxicity in an elutriate concentration in which the copper concentration was clearly not "within the range" or "above…tolerance limits…" for *M. galloprovincialis*. Copper was measured at 2.5, 0.23, and 8.7 μg/L, respectively, in the three (100%) elutriate samples. Therefore, copper levels in the 50% elutriate concentrations were 1.25, 0.12, and 4.4 μg/L, respectively. All three concentrations are well below the current EPA Final Acute Value (EC50) of 9.625 μg/L for *M. galloprovincialis*, below the author's EC50 of 7.8 μg/L cited in Table 2, and below the author's (MPSL unpublished data cited in RMP contribution # 43) LOEC of 5.6 μg/L for this species. Notwithstanding the reduction in sample 2 toxicity by EDTA, it would be unreasonable and misleading to describe the effect of 0.12 μg/L copper as potentially "synergistic" since the mean oceanic concentration of copper in the North Pacific Ocean is 150 ng/kg (approx. 0.15 μg/L, Bruland 1980). Further, in sample 3, there appears to be a significant effect in the 6.25% elutriate sample (the author does not say). The concentration of copper in that sample would have been 0.5 μg/L.

Comment 3: The source of toxicity in Grizzly Bay sediment samples is clearly enigmatic. There are several issues that require more investigation before the role of copper can be clearly understood. The increase in toxicity following an upward pH adjustment to sample 2 is one example. As the author mentions, this anomaly requires additional investigation. The results with C18 column treatment is also quite puzzling since one would expect some organic pollutant contamination at the Grizzly Bay station and since C18 is known to remove some divalent cation toxicity (e.g. zinc). It is helpful to keep in mind that the TIE manipulations may not address all of the potential toxicity sources. In fact, it may not address any of them. For example, the author states in RMP contribution # 43 that "Toxicity was not significantly mitigated in any of the TIE manipulations performed on the San Joaquin River sample." Does this mean that there was no "organic" contaminant and no "divalent cation" toxicity in the sample?

This paper increases our understanding of Grizzly Bay sediment toxicity. However, there is much more that we need to know and characterize before we can adequately assess the role of copper in toxicity of elutriate samples from that station.

San José comments on the potential problems associated with algal toxicity tests

Confounding Factors:
The confounding factors (EDTA, filtration, nutrient additions, cultured vs. wild stock, species selection) in conducting copper toxicity tests with algae are summarized below.

- In summary, the chief confounding factor is the 0.22 µm-pore-size filtration (rather drastic) required for sterilizing the test medium prior to use. This removes an unknown amount of binding capacity, may alter the site water chemistry in unknown ways (adsorb toxicity-ameliorating ions?) and may add some toxicity (membrane filters may contain toxic substances even following a rinsing procedure).
- EDTA can be omitted from saltwater tests. EDTA is a confounding factor for freshwater algal tests.
- Nutrient additions chemically alter the site water. These should be kept to a minimum. Can exponential growth be obtained without the addition of nitrogen and phosphorus?
- Species maintained in the laboratory for many years may respond very differently from wild populations of the same species.
- Surrogates don't express natural population responses and tests with single species can produce results very different from that of mixed cultures or natural assemblages.

Extrapolation to the Field:
A major criticism of the use of toxicity testing in NPDES permitting is that it may not be a good predictor of in situ effects. This concern is greater for plants than for animals due to their greater sensitivity and variability in their response to physical and chemical factors. The laboratory variables which make extrapolation of the results of algal tests to the field difficult include: nutrient additions, duration, species selection, and the actual physical characteristics of the testing situation.

- The rapid log-phase growth required in typical algal toxicity tests might simulate natural bloom conditions but it would certainly not simulate natural background phytoplankton densities. Natural background densities are usually several degrees of magnitude below densities of laboratory (test) cultures. One would expect the response of phytoplankton in the field at lower nutrient levels and densities to be very different from that of lab test cultures.
- Lab results vary with the amount and type of added nutrients. For example, Walsh et al. (1987) found that EC50s of three algal species for several organic compounds varied with the growth media used. He concluded that responses to toxicants in different media are the results of interactions between algae, growth medium, toxicant and solvent carrier. Which nutrient enrichment best simulates field conditions? None?
- Algal tests are usually conducted for 96 hours. When this result is applied (extrapolated) to the field, there is no time limitation. Walsh (1983) found that EC50 values for five species of algae exposed to various pesticides were lowest (i.e. greatest toxicity was exhibited) after 48 h of exposure and that after 96 h of exposure the maximum growth rates of treated cultures had recovered compared to control cultures. If phytoplankton are impaired at 48 hrs but not

at 96 hrs, does this fit the regulatory definition of impairment? Which test duration is the best one to extrapolate the results to the field?

- If algal/copper toxicity test results are affected by temperature, which temperature should be chosen? 15°C? 20°C? 25°C? The possible choices are the average site temperature or the temperature at which the test species show the greatest sensitivity.
- Algal/copper toxicity test results are certainly dependent upon the quantity and quality of light. Which field condition (overcast, high turbidity, full sunlight) should be simulated in the lab?
- In contrast, none of these physical parameters (temperature, light, turbidity) in the ranges encountered in the lab or field would be expected to affect the results of Mytilus (animal) embryo/larval development tests. Thus, some extrapolation problems are peculiar to plant responses.

Salient Endpoint to Regulate:

Using the latest techniques, several endpoints including oxygen production, carbon dioxide consumption, cell ion transport, flagellar motility, and culture growth can be chosen to evaluate toxicity. Toxicity testing usually measures culture growth, specific growth rate or biomass as measured by final cell densities or chlorophyll *a* content. The endpoint usually reported for short-term algal toxicity tests is an EC50 based on growth.

Which endpoint best evaluates whether South Bay phytoplankton are impaired due to copper? Our definition of impairment might be different from that used for animals for the following reasons:

- With few exceptions, toxicological responses in animals are irreversible. A *Mytilus* larva that has developed abnormally due to copper will die. Algal responses, except at very high copper concentrations (ppm) are not algicidal (causing death of the organism). In algae, growth may be arrested, cells may encyst or lose their flagella, but they likely will live to grow another day.
- Growth in unicellular algae is very rapid and populations can recover much more rapidly than animal species.
- A chronic endpoint can be measured in animals. The only true chronic test for marine algae is *Champia,* a multicellular macrophyte for which an EPA testing protocol exists (tests with unicellular algae are not considered true chronic tests).
- Autotrophs are affected by a myriad of physical (and chemical) variables that have little effect on hererotrophs. This makes algal toxicological responses more variable than animal responses.
- When a population of animals dies or its growth is inhibited, it is unlikely that another less sensitive species will immediately fill the same niche. When the population of a given species of phytoplankton declines, a less sensitive species will likely fill the same niche.

In the final analysis, a sound scientific approach to regulating copper in the South Bay based on phytoplankton responses must answer the following questions.

- What is an acceptable endpoint to regulate in phytoplankton? EC50? EC25? EC10?

- Which species should be regulated? The most sensitive? The least sensitive? The most abundant? The least abundant? The most ecologically important?
- If the beneficial uses of "estuarine habitat" and "fisheries" are protected, is there still "impairment" because a single phytoplankton species is sensitive to copper below the SSO?

Literature Cited

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Appendix B

Multibox Contaminant Transport Model Development

Note:
The model discussed below may assist in efforts to resolve uncertainty relating to loading and sediment. This model is also referenced in the Response to Comments in Appendix D.

CONCEPTUAL SCOPE OF WORK
[CEP TC Meeting 10/13/04 Attachment 3]

MULTIBOX CONTAMINANT TRANSPORT MODEL DEVELOPMENT

October 5, 2004

The Clean Estuary Partnership's Technical Memorandum on the *Use of Conceptual and Numerical Models to Guide TMDL Development and Implementation in San Francisco Bay* (CEP, 2004) described the role of computer modeling to achieve a better understanding of the basic ecosystem processes that control pollutant fate and transport and to support water quality management activities. This Conceptual Scope of Work describes a multiyear, systematic plan, building on model-development efforts already underway, to construct a basic mechanistic model that will advance our understanding of contaminant behavior in the estuary and will make an essential contribution to the existing water quality management toolbox.

The goals of this project include (1) developing a better tool for predicting future contaminant concentrations and testing potential management actions, (2) clarify uncertainty of existing model predictions; (3) identifying key areas where field work can be done to reduce the uncertainties; (4) develop unambiguous documentation regarding the model for future professionals working on these issues as part of adaptive implementation. The CEP Technical Memorandum on Modeling (CEP, 2004) described four levels of computer models that are developed to support water quality management activities. This document describes the development of a Level 2 model: a multibox model that provides the first step in the development of a predictive methodology. The multibox model represents physical and chemical processes the affect the fate, transport and residence times of pollutants in the estuary. The representation of these processes is based on empirical relationships derived from the existing knowledge. The construction of this multibox model will provide the opportunity to perturb the system, evaluate the response, and gauge uncertainty associated with predicted outcomes.

1. Introduction and Background

The San Francisco Bay Regional Water Quality Control Board (Water Board) is in the process of developing a Total Maximum Daily Load (TMDL) for several contaminants in San Francisco Bay whose predominant source, because of accumulation from past discharges/releases to the Bay, is the sediment and whose environmental transport is dominated by sediment processes. For example, efforts are underway by the Water Board to determine what concentrations of PCBs in the sediments of the Bay are required to achieve acceptable human-health and ecological risk levels and to establish a sediment-based approach to regulating PCBs in San Francisco Bay. Similar efforts are underway to understand and to predict the behavior of mercury, legacy pesticides, dioxins, PAHs and PBDEs.

Understanding the ecological significance of changes in sediment and water-column concentrations of contaminants in response to alternative management actions and the ability to achieve these changes is a critical information need. Some of the key management questions associated with the evaluation and development of alternative TMDL implementation strategies are:

- *How much will concentrations of a pollutant in the sediment and water column change in response to a given percentage reduction in inflowing load?*
- *How will beneficial uses (related to concentrations in biota) be affected by changes in the sediment and water column concentration?*
- *Are there differences in the effectiveness of alternative loading reduction strategies?*
- *How long will it take for the responses to become apparent?*

These questions are central to any TMDL analysis, and data collection alone cannot provide the information necessary to make the required predictions. Modeling, based on proper calibration and evaluation of uncertainty, is therefore a vital part of a TMDL (NRC, 2001). Models can be used to integrate our knowledge on environmental system components to estimate chemical transport and fate processes in the Bay, allowing us to predict concentrations and effects on beneficial use in response to different management actions.

Numerous coordinated efforts are underway to build better predictive capabilities to support a wide range of water quality management activities. The Regional Monitoring Program (RMP) has initiated work on the development of a multi-box mass budget model to improve the understanding of the long term fate of PCBs in San Francisco Bay. This model builds on the results of a single box model of PCB transport and cycling in the Bay (Davis, 2004). The multibox model development by RMP is coupled to the U.S. Geological Survey's development of a sediment-transport model (Lionberger and Schoellhamer, 2003) and a tidally averaged salinity box model of San Francisco Bay previously developed by Uncles and Peterson (1995). The Bay is represented by 51 segments composed of 2 layers representing the channel and shallows. Calculations are made using a daily time step. Sediment dynamics have been parameterized, calibrated, and validated using extensive suspended sediment concentration data collected for the RMP over the past 10 years and changes in bathymetry observed from 1950 to 1990. PCB fluxes into and out of each box are calculated primarily using equations developed previously for a one-box model of the Bay. Improvements being incorporated in this version of the model include a more realistic treatment of sediment mixing and sediment erosion and deposition.

Also underway is the development of a San Francisco Bay PCB Food-Web Model (Gobas and Wilcockson, 2003) to estimate the concentrations of PCBs in a set of indicator species as a result of PCB contamination in sediments and water in the Bay. The food-web model can be used to determine what concentrations of PCBs in the sediment and water need to be reached to achieve an acceptable level of risk to wildlife and humans living in the Bay area.

2. Statement of Work

This Conceptual Scope of Work lays out a multiyear process for the development of predictive modeling tools that can be used to guide data collection efforts, enhance our understanding of pollutant fate and transort in the Bay, and provide a quantitative basis for the regulatory decision making process. Phase 1 of the multiyear process begins with documentation and rigorous evaluation of the existing modeling tools. Most of the modeling efforts to date have been focused on efforts to aid the PCB TMDL development. Phase 2 of the project will begin with the application of the SFEI Version 1 of the multibox model to the assessment of fate and transport processes of other contaminants in the Bay (e.g., Hg, Cu, legacy pesticides, dioxins, PAHs, PBDEs). These contaminants are the subject of TMDL development, the TMDL implementation phase, or are chemicals with a significant amount of relevant information. Phase 2 of the project also includes the collection of new sediment data, especially sediment cores, that are needed to obtain a better understanding of sediment dynamics in the Bay. These sediment data will also be critical to the validation of the multibox model. Finally, Phase 2 includes a reassessment of the multibox model and the development of specific plans of action for enhancing the model further and extending its applicability.

This work will provide a foundation for modeling the fate of persistent, particle-associated contaminants in the Bay in support of both RMP monitoring and TMDL development and implementation for years to come.

Phase 1 – Model Documentation and Testing

Task 1. Prepare Documentation for USGS Sediment and Water Transport Model and Augment Model Output

USGS has developed, calibrated and validated a tidally averaged sediment transport model of San Francisco Bay (Lionberger and Schoellhamer, 2003). This model provides a basis for the PCB multibox model. However, the efforts of USGS have been focused on model development and testing. The model documentation is not adequate to permit wide use of the model. The first task will be the preparation of the model documentation. The product of this task is a USGS report with the tentative outline provided in Table 1.

Table 1. Proposed Outline for USGS Model Documentation

A tidally-averaged sediment transport model for San Francisco Bay, California
1) Abstract
2) Introduction
    a) Tidally averaged
    b) Uses box model approach (well-mixed)
    c) Daily time step, simulates over decadal time scale
3) Purpose and Scope
    a) Why use the UP model?
    b) PCB and sediment budgets
4) Acknowledgments
5) Description of the study area
6) UP Salinity model
    a) Model domain an discretization
        i) 51-with averaged segments
        ii) Each segment composed of two layers
    b) Required Input data
        i) Tide data at the GG
        ii) Coastal salinity
        iii) Delta outflow
        iv) Tributary flows
        v) Evaporation, Precipitation
    c) Salinity boundary Conditions
        i) Lower layer at the GG
        ii) Zero at the Delta and for tributary inputs
        iii) Left free in SB
    d) Applications: literature review
7) Sediment transport
    a) Required Input data
        i) Mallard Island SSC
        ii) Daily average wind speed
        iii) Tributary loads
    b) SSC boundary Conditions
        i) Mallard Island
        ii) Pacific Ocean
        iii) Tributaries
    c) Algorithm
        i) Advection/dispersion
        ii) Tributaries
        iii) Erosion/deposition
        iv) Bed Model
    d) Calibration to SSC
        i) Results at PSP and DMB
        ii) Comparison to bathymetry
    e) Calibration to bathymetry
    f) Sensitivity analysis
        i) Adjust coefficients 10%
            (1) Percent change SSC
            (2) Percent change sedimentation
8) Display of model results: tables, graphics, and animation
9) Conclusions

Task 2. Create Graphic Output

It is important that the results of computer models can be communicated to a wide audience. The purpose of this task is to provide graphical output for SFEI's version 1.0 of the Multibox PCB Model. The following are some of the graphics and animation that are being considered:

- Graphical presentations of simulation results that provide geographical reference points, e.g., aerial views of different parts of the bay, including the whole bay; cross-sections of different locations in the bay, etc.

- Presentation of time variable loadings that are considered in the model from all sources, e.g., total mass emission rates/total loading variations over time, with options of showing the results of major parts of the bay.
- Representations of mass in the bay and sediments (active layer and below), spatially segregated and composites as desired. These masses are time variable as the bay responds to clean up efforts.
- Animation of model results showing concentrations through selected time intervals of key variables, e.g., PCBs and salinity, throughout the bay in each box and by sediment layers.

Task 3. Conduct Initial Testing of SFEI PCB Model (Version 1.0) and Conduct Sensitivity Analyses

The product of SFEI's Version 1.0 of the PCB Multibox Model will be documentation of the model and initial testing and a draft report that will go out for peer review. Task 3 will be conducted in two parts. In part one, the model verification and calibration efforts by SFEI will be independently reviewed. In part two, sensitivity analyses will be conducted to identify the parameters and processes that that are most important in determining the model outcome. The sensitivity analysis results will be used to address the uncertainties in our understanding of the system as well as the performance of the model.

The review process will be documented in sufficient detail that it can be independently replicated. Some of the elements of this subtask are:

- Review model test case I/O, the model code, the compiled version, and draft documentation prepared (user manual, technical support manual, test results, etc.).
- Review the theoretical equations and verify that the theoretical equations are formulated and solved correctly.
- Test key parts of the model: salinity distribution, sediment transport, and PCB transport.
- Using realistic data sets, check the model's general behavior, and anticipated responses to changes in forcing, parameter values, etc.

The product of Part 1 of this task will include the results of all tests, procedures, and outcomes. If problems, or anomalous behaviors are noted, the reviewers will meet with the developers to see if these issues can be resolved before the testing is completed.

The variability of computer model results provides a measure of the uncertainty that exists in our understanding of the environmental processes simulated. Excluding measurement errors or the mis-specification of the model structure, the observed variability in model output is primarily the result of the variation in a subset of the most important parameters. Parameter sensitivity is used to refer to the variation in output of a mathematical model with respect to changes in the values of the model's input parameters. Sensitivity analysis therefore involves the determination of the change in the response of a model to changes in individual model parameters and specifications.

The results of a sensitivity analysis are used to identify the magnitude of the contribution of individual parameters to the observed variation in the predicted endpoint.

Sensitivity analyses, using Monte Carlo simulation methods, will be conducted as Part 2 of this task. The results will provide an improved understanding of the simulated system and serves as a guide for designing field surveys and laboratory experiments that will increase our knowledge of important natural processes. A better understanding of model uncertainty will also lead to improved credibility of projections and enhance the ability to produce realistic values of state variables for use in regulatory decision making and planning. The initial focus of the sensitivity analyses will focus on sediment erodability and mixing processes, areas already identified by the model developers to be of special concern. The examination of the model sensitivity to variations in contaminant profiles is also a primary objective. The results of these analyses will contribute to the efforts planned in Phase 2 of the project. A technical memorandum will be prepared to summarize the results of Task 3.

Phase 2 - Field Data Collection, Further Model Test, and Program Planning

Task 4. Conduct Sediment Sampling and Testing

The RMP's Contaminant Fate Work Group (CFWG) recommended improvements in the collection of field data (particularly cores) to determine the distribution of contaminants with depth, the erodability profile of sediments, and the rate of mixing of surface sediments with deeper sediments. This task will be conducted in two parts. The first part of the task will be to prioritize remaining information gaps using existing data and to design the most effective sediment sampling program to obtain data necessary to support modeling efforts and regulatory management decisions. Existing data on spatial variability (both horizontally and vertically) will be used to select the location and variables measured in a sediment-core sampling program.

Preliminary estimates using erosion rates (0.5 cm/yr) and average concentrations of PCBs (~10 ppb) at depth within the middle range seen in some areas of the Bay would lead to PCB inputs of ~70 kg/yr (for the whole Bay), roughly equal to the overall loss rate estimated from the one box model. As a result, even without external loads, continued erosion of sediments at that concentration would lead to no change in surface sediment concentrations so long as that concentration is found in the eroding sediment bed. Maximum concentrations in deeply buried sediments (~50 cm depth) have measured up to 35 ppb and might provide comparable PCB loads even at much lower erosion rates. Thus more extensive data on contaminant concentrations with depth are needed, as loads from legacy deposits in the Bay exposed through erosion could easily swamp all other new inputs.

It is proposed that the initial sample collection and analysis of sediment cores be conducted in the South Bay because:

1) It is one area with sediment contaminant concentrations typically higher than the Bay average
2) Shallow water depths in many areas expose sediments to erosion/deposition and mixing

forces

3) There is less previous information on sediment mixing and contaminant profiles than in north and central SF Bay, for which there are at least one core each with high quality contaminant profiles (metals and organics from USGS) and measurements of mixing/deposition processes at a large number of sites (USACE dredge disposal tracer studies)
4) there may be opportunity for cost-sharing (or at least joint data interpretation) with data collection for the South Bay Salt Pond project.

Because in the short term it is impossible to representatively sample with just a few sites in a segment, the highest priority is to constrain the range of possible contribution from contaminated sediments within the system. We propose initially collecting a small number of cores at locations within the segment exhibiting the highest erosion rates. These sites are preferred because depositional sites with high pollutants at depth would be expected to progressively pose less risk as sediments are buried beyond the mixed and biologically active zone. Sites selected would preferably be in areas found with above average surface concentrations in previous sampling, as high surface concentrations would indicate either continued loading from a nearby source (an thus possibly long term historical loading from the same source), or vertical or lateral mixing from more contaminated sediments in proximity. A smaller number of sites with lower or average surface concentrations should be sampled as well, as mixing may not yet have reintroduced more contaminated deeper sediments to the surface mixed layer, but may pose a risk in the future as the mixed layer encroaches on the buried deposits.

Based on the results from the analysis of the initial set of sediment cores, additional sampling will be conducted to further reduce our gaps in knowledge concerning contaminant profiles in other portions of the Bay. A multi-year sampling and analysis effort is planned. Interim reports will be prepared each year.

Task 5. Apply SFEI Multibox Model to Other Pollutants

In addition to PCBs there are other contaminants of concern for which a sufficient database exists to calibrate and test the multibox model. A single box model has been previously used to model copper concentrations in the sediments and water column of the South Bay. The comparison of the single and multiple box model approaches would provide a quick indication of the benefits of extending the spatial coverage of the model. Likewise, a single box model was used to estimate the response time of the Bay to significant reductions in mercury loading. Examination of the differences in the predictions of the single- and multibox models would be instructive. A technical memorandum will be prepared to summarize the results of Task 5.

Task 6. Plan Next Generation of Sediment and Pollutant Transport Models

The results of the multibox-model testing linked with the analysis of the sediment core samples will provide a sound and well-structured examination of model performance. The final report will assess the efficacy of the multibox model as a primary tool for establishing loading limits in the TMDL process and in the evaluation of the projected rates of recovery associated with specific load reductions. The final report will also provide recommended enhancements in existing models and a guide for the expected benefits of more complex models to the overall goal of effective management of the water quality and beneficial uses of the estuary.

Schedule and Deliverables

The following milestones reflect planned activities. The first milestone, the Detailed Scope of Work, will provide explicit links between milestones and the six tasks described above. The contractor will work closely with the CEP Program Coordinator to identify required technical support for management of modeling efforts.

Milestone	Start Date	End Date
Detailed Scope of Work	10-14-04	11-19-04
Task 1. Prepare Documentation for USGS Sediment Transport Model and Augment Model Output		
• Draft Report	10-14-04	03-31-05
• Final Published Report	03-31-05	09-30-05
Task 2. Create Graphic Output	10-25-04	02-28-05
Task 3. Conduct Initial Testing of SFEI PCB Model and Conduct Uncertainty Analyses	11-19-04	05-06-05
Task 4. Conduct Sediment Sampling and Testing	10-01-05	09-28-07
Task 5. Apply SFEI Multibox Model to Other Pollutants	05-05-05	04-09-06
Task 6. Plan Next Generation of Sediment and Pollutant Transport Models	10-01-07	02-30-08

Budget

The task budgets are estimated values. The actual values will depend on the direction provided by the CEP Program Coordinator and the Technical Committee. A more detailed budget will be prepared for the Detailed Scope of Work. The estimated budget is presented by task and by year.

Task	Estimated Budget
Detailed Scope of Work	$ 10,000.
1. Prepare Documentation for USGS Sediment Transport Model	$ 40,000.
2. Create Graphic Output	$ 20,000.
3. Conduct Testing and Uncertainty Analysis	$ 55,000.
4. Conduct Sediment Sampling and Testing	$220,000.
5. Apply SFEI Multibox Model to Other Pollutants.	$120,000
6. Plan Next Generation of Models	$ 35,000.
Total Estimated Cost	$500,000.

Fiscal Year		Estimated Budget
2005	Detailed Scope of Work, Tasks 1 – 3.	$125,000
2006	Task 4 Planning and Initial Sediment Core Sampling and Analysis, Task 5 Part 1	$170,000.
2007	Task 4 Additional Sampling and Analysis. Task 5 Part 2	$170,000.
2008	Task 6	$ 35,000.

Recommended Contractor: SFEI and Tetra Tech, Inc.

Alternative Contractor:

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Appendix C

Action Plan Information

Information regarding POTW size, source categories addressed and control strategies utilized is highlighted below for the 39 POTW respondents:

# of POTWs in each size range	
< 5 mgd	8
5-20 mgd	17
> 20 mgd	6
no P2	8

Source Categories Being Addressed
Industrial
Commercial
Residential
Corrosion
Stormwater (onsite only)

Control Strategies Utilized
Source identification/quantification
Permitting
Zero discharge facilities
BMPs
Outreach/education
Participation in the BAPPG
Recognition programs
Legislative controls
Other methods than listed above

Source control activities conducted throughout the Bay Area correspond well with the actions included in the South Bay CAP/NAP. POTW source control activities that could be or have been implemented in other parts of the Bay Area include:

- CB-1 (1): Outreach regarding residential vehicle washing
- CB-1 (2): BMPs for vehicle/equipment washing for new development and redevelopment
- CB-1 (3): Mobile surface cleaner training and certification
- CB-2: Tracking copper sulfate usage in water supply reservoirs
- CB-9: Track corrosion control opportunities
- CB-12: Outreach regarding copper discharges from pools and spas
- CB-13/NB-3: Track Pretreatment Program efforts and POTW loadings
- CB-14/NB-4: Track and encourage water recycling efforts
- CB-19/NB-6: Track industrial virtual closed-loop wastewater efficiency measures

It should be noted that some of these measures like BMPs for vehicle washing or pool and spa discharges are often implemented by stormwater programs. However, because discharges from these activities are often redirected to the sanitary sewer, POTW pollution prevention programs have also developed programs targeting these sources.

Of the 39 POTWs discharging to the San Francisco Bay area, 8 were small (i.e., <5 MGD). These agencies had not identified copper or nickel as problem constituents and, therefore, had not conducted copper or nickel P2 programs. The other 31 POTWs had conducted some level of copper source control activities. Much less activity occurred to specifically target nickel sources, although some of the copper source control activities would indirectly address nickel as well (e.g., some commercial and industrial sources such as vehicle service facilities, metal plating, carwashes). Nickel-specific source control activities were most likely to target industrial sources. Five POTWs reported such activities targeting industrial and commercial nickel sources. Three of these POTWs (all >20 MGD) reported influent reductions in nickel associated with source control activities. There was no obvious correlation between POTW size and the types of source control actions taken. Size and available resources would be more likely to influence the total number of source control actions taken or the time frame over which actions were implemented.

A POTW with more resources may implement several control measures simultaneously while a smaller POTW with less resources would be more likely to implement control measures one at a time. Another factor that will influence the source control actions taken is which sources are identified as the largest. For copper, there are several possible source categories (e.g., corrosion, metal finishers, vehicle service facilities) and the water supply and makeup of the service area will determine which source is the largest in each service area.

With respect to copper source control, the source categories most likely to be addressed included:

- Corrosion of copper plumbing
- Commercial sources (i.e., vehicle service facilities, printers)
- Industrial sources (i.e., metal finishers, electroplaters)
- Residential sources (i.e, copper sulfate root control products, pools and spas)

Greater than 90% of the 31 POTWs had conducted source control activities targeting vehicle service facilities, root control products, and pools and spas. All three of these sources were targets of Bay Area Pollution Prevention Group (BAPPG) projects, which may explain the high percentage of agencies working with these sources. More than half the POTWs had targeted corrosion, industry, and printers.

Of the 31 POTWs with pollution prevention programs, 12 reported observed influent or effluent reductions attributable to source control efforts. These reductions were attributed to a variety of factors with most of the larger reductions attributed to pH control of the water supply to reduce corrosion.

In general, corrosion of copper plumbing was identified as the largest source of copper to wastewater treatment plant influent. For example, the three South Bay POTWs (Palo Alto, San Jose, and Sunnyvale) have estimated that corrosion accounts for 30-58% of the copper loading in their respective influents. Five POTWs attributed reductions in influent or effluent copper levels to reduced corrosivity of the water supply through pH adjustment. Other efforts that were reported to contribute to measurable impacts on influent or effluent copper levels include industrial source control and P2 programs targeting vehicle service facilities and printers. Two POTWS attributed reductions to industrial source control and two POTWs attributed reductions to commercial source control actions. The remaining 3 of 12 POTWs reporting influent or effluent reductions did not attribute reductions to a specific source control actions. While several POTWs reporting conducting source control activities targeting residential sources, measurable reductions were not attributed to these actions. Outreach regarding residential source control served more to raise awareness regarding water pollution issues than to effect measurable reductions.

Baseline actions that maintain existing source control efforts and implement additional program as needed are discussed below. In addition, Phase 1 actions that would be conducted should the identified triggers be met are also discussed. It should be noted that the specific Baseline and Phase 1 programs developed will vary from POTW to POTW depending on which sources are determined to be the most significant and the resources available to the POTW. Some general guidelines in developing the program are discussed below. In addition, the actions described in

Appendix 4 will also provide guidance on the types of actions that can be taken. More detailed guidance for developing effective source control programs is being developed by BACWA through the P2 Menus Project. Under this project, comprehensive lists of source control actions are being developed for several constituents. In addition, guidance will be developed on choosing the actions that will be most effective.

Baseline actions

Most agencies are conducting copper source control programs targeting their largest sources. Actions implemented under the Baseline condition should be those actions most likely to achieve measurable reductions or maintain reductions achieved previously. Therefore, the initial Baseline actions (**Table 2.1**) should be to determine if corrosion is a significant source and to determine the other significant sources of copper contributing to the POTW's influent. Based on this evaluation a POTW should develop a plan to implement source control measures that are consistent with its resources and that targets the largest source categories. In addition, a periodic update or evaluation of ongoing control measures should be conducted to determine if the measure is being implemented properly or if it is still necessary. For example, a program where vehicle service BMPs were distributed to businesses should be evaluated periodically to determine if the businesses are continuing to implement the BMPs. Additionally, a review of influent and effluent data trends should be completed every 5 years to evaluate the effectiveness of source control activities.

Agencies should assess the feasibility of achieving reductions through corrosion control by determining average influent copper levels and water supply pH. For agencies with elevated effluent copper concentrations, discussions should be initiated with the service area's water purveyor to investigate the feasibility of implementing pH adjustment or other form of corrosion control of the water supply.

Permitted industries, particularly metal finishers, should have copper effluent limits and P2 requirements in their permits. In addition, vehicle service facilities have been identified as a source of copper, nickel, other trace metals and other priority pollutants (e.g., PAHs). Outreach materials and BMPs are readily available for vehicle service facilities. Therefore, implementing an outreach and education program directed at this category is a straightforward project requiring minimal resources for most POTWs. Materials are also available for other source categories including printers, pools and spas, and plumbing activities. These materials would facilitate implementation or updating of programs for other sources determined to be significant.

Phase I Actions

If the ambient water quality monitoring trigger is exceeded, additional actions targeting corrosion and vehicle service facilities may need to be undertaken. In addition, other sources could be investigated for reduction potential. Additional sources to investigate could include printers, copper-containing pesticides, pools and spas, cooling towers and heating and cooling facilities. Programs that were voluntary under the Baseline condition should be upgraded to regulatory (**Table 2.2**).

Water supply corrosion control should be pursued more aggressively. It should be noted that this option may not be under the direct control of the POTW. The cooperation of the water purveyor is critical should this source be found to be significant.

Additional actions should also be considered. Incentives for vehicle service facilities to become zero-dischargers could be included in a regulatory program. In addition, agencies may consider evaluating laundry graywater as a copper source and developing approaches to reducing copper loadings from this source.

Industrial

Direct discharges to surface waters from the industrial sector are closely regulated through the NPDES program, making source control and pollution prevention important aspects of their operations. In general, nickel and copper levels in the effluent from direct industrial dischargers to San Francisco Bay are below permit limits. Therefore, source control targeting these constituents has not been a major element of the dischargers source control program. Even so, industry conducted source investigations for metals in the early 1990s, identified copper and nickel sources and conducted source control actions needed.

The primary source of copper to Bay Area industrial dischargers has been identified as the water supply. Other sources include corrosion in heat exchangers, trace copper contaminants in the ferric chloride used in the selenium precipitation process, and domestic waste within the refinery. Efforts to reduce copper include optimizing solids separation processes, adding Granular Activated Carbon Units in the treatment process, switching to a ferric chloride product with less heavy metal contamination, optimization of process conditions to minimize corrosion, and increasing cooling tower water cycles.

Nickel sources were identified as water supply, corrosion in heat exchangers, nickel catalysts, byproduct of Flexicoking Process, and trace contaminant in ferric chloride. Efforts to reduce nickel discharges included some of the same actions listed above for copper including optimizing solids separation processes, adding Granular Activated Carbon Units in the treatment process, process optimization to minimize corrosion, and increasing cooling tower water cycles. In addition, specific nickel reduction efforts included optimization of the Flexicoking process and segregation of wash waters contacting nickel catalysts. Despite these efforts, nickel effluent levels have not changed significantly.

Table B1. Baseline Actions

Baseline Number	Description	Lead Party	Implementation Mechanism
B-1	Assess corrosion control potential	POTWs	Investigate previous studies on corrosion control. Evaluate influent data to determine if copper levels are indicative of corrosion (i.e., >100 µg/L). Evaluate water supply pH to determine if pH is indicative of corrosivity (i.e., <8).
B-2	Evaluate other copper sources	POTWs	Conduct source identification studies by either scaling source loading estimates from other communities to fit POTW service area or conduct trunkline monitoring to determine largest influent copper sources.
B-3	Pursue source control actions for 1-3 largest copper sources depending on POTW resources. Actions to choose from include B-3a-g.	POTWs	
B-3a	Require copper source control at permitted industries	POTWs	Include requirements in permit for pretreatment and/or BMPs
B-3b	Conduct outreach to commercial establishments	POTWs	Distribute BMPs and conduct site visits to determine if BMPs are implemented properly.
B-3c	Conduct vehicle washing outreach to businesses	POTWs	Distribute BMPs and conduct site visits to determine if BMPs are implemented properly.
B-3d	Conduct vehicle washing outreach to residents	POTWs	Newspaper ads, radio, newsletters, direct mail
B-3e	Implement mobile cleaner BMPs	POTWs	Conduct training sessions and workshops. Provide incentives for mobile cleaners to become certified.
B-3f	Track copper sulfate use by water suppliers	POTWs	Report copper in source water concentrations monthly/annually using low level detection limits.
B-3g	Control copper in stormwater from industrial sources	POTWs	Meet with industrial facilities to discuss performance improvements
B-4	Track pretreatment program and recycling P2 efforts.	POTWs	Monitoring and inspections reports can be used to track reductions achieved through these programs.

B-5	Follow up Quantification studies	POTWs	Estimate effectiveness of copper source control/pollution prevention measures and resulting source loadings
B-6	Data reports *NOTE: B-6 is not really targeting a wastewater related source*	POTWs	Collect and report influent, effluent and source data as applicable for use in periodic updates of source identification and program effectiveness evaluation
B-7	Conduct follow-up activities to assess and update ongoing source control actions	POTWs	Periodic review of ongoing programs should be conducted. For example, Return site visits to commercial establishments or follow-up monitoring should be conducted every 2-3 years to determine if BMPs are being properly implemented.

Table 2.2. Phase I Actions

Phase I Number	Description	Lead Party	Implementation Mechanism
I-1	Identify additional sources beyond those for which programs were developed in Baseline	POTWs	Perform literature research and conduct monitoring as necessary
I-2	Develop voluntary BMP based programs for additional sources	POTWs	Conduct outreach and education for residential sources and conduct site visits for commercial sources.
I-3	Upgrade all voluntary programs to regulatory	POTWs	Include regulations in permit
I-4	Aggressively pursue corrosion control	POTWs/Water Purveyor	Work with purveyors to implement pH control
I-5	Offer incentives to zero-dischargers	POTWs	Provide monetary or other rewards for zero-discharge
I-6	Evaluate laundry graywater as copper source	POTWs	Perform literature research and conduct monitoring as necessary
I-7	Pursue modifications to regulations for lead and copper in drinking water to more actively trigger corrosion control programs for drinking water systems based on impacts to POTWs.	POTWs/DHS	This would require a cooperative regional effort to work with DHS to accomplish these modifications.

Municipal Stormwater Program Copper Control Activities

Overview

Municipal stormwater programs in the Bay area conduct a variety of activities that are directly and/or indirectly targeted at reducing copper in municipal stormwater runoff. A survey of the major programs was conducted in spring 2003 (updated early 2004) to characterize the range of activities being conducted. An overall survey goal was to provide information to assist in identifying reasonable and appropriate baseline copper control measures to be included in Copper Action Plans being considered for stormwater agencies north of the Dumbarton Bridge.

Detailed survey results are contained in an Appendix to the BACWA sponsored report titled *Copper & Nickel North of the Dumbarton Bridge, Development of Action Plans* (EOA/LWA, 2004b].

From the survey, programs were grouped into four categories. First are the so-called "second generation" programs. These programs implement general programmatic measures aimed at reducing pollutants in general, rather than copper in particular.

Next are the "third generation" programs. These programs have specific Provisions in their NPDES permits requiring them to develop and implement pollutant reduction plans for several pollutants of concern, including copper. The subsequent category includes the wide range of copper control baseline activities being conducted by the Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP) and Co-permittees pursuant to the June 2000 Copper Action Plan (CAP).

The last category includes a discussion of the activities being taken to develop a next-generation "focused" or "streamlined" CAP, pursuant to the adaptive management process built into the CAP. As part of this effort, a CEP funded project is underway to develop updated information on the most important copper sources in stormwater and on the most effective potential control activities. One possible outcome may be a single Bay-wide CAP with a menu of prioritized control measures.

Stormwater Permit History

Unlike NPDES permits issued to publicly owned treatment works (POTWs), municipal stormwater NPDES permits within the San Francisco Bay Region do not contain numerical effluent limits. Instead, municipalities are required to implement Storm Water Management Plans (SWMPs). These SWMPs include stormwater control measures necessary to demonstrate control of pollutants in stormwater to the maximum extent practicable (MEP) and measures to effectively prohibit non-stormwater discharges into municipal storm drain systems and watercourses.

The SWMP serves as the framework for identification, assignment and implementation of control measures and best management practices during the term of the permit. Best management practices (BMPs) are practical ways to significantly reduce potential discharges of pollutants to nearby storm drains and watercourses. In addition, SWMPs include performance standards that represent the baseline level of effort required to implement activities that constitute MEP based on current technical knowledge, available resources and local conditions. Through a continuous improvement process, the Permittees are expected to modify and improve their performance standards to achieve reduction of pollutants in stormwater to MEP.

Each San Francisco Bay region stormwater agency (excluding Vallejo Sanitation and Flood Control District) is an association of cities, towns and/or other governmental agencies which share a common NPDES permit to discharge stormwater to San Francisco Bay. In addition, each Program (excluding Vallejo Sanitation and Flood Control District and Fairfield Suisun Urban Runoff Management Program) is organized, coordinated and implemented based upon a mutual Memorandum of Agreement (MOA) signed by the participating public agencies. The MOA defines roles and responsibilities of all Permittees. Each Program (excluding Vallejo Sanitation and Flood Control District and Fairfield Suisun Urban Runoff Management Program) has a Management Committee that is responsible for making Program decisions. The Management Committee consists of one designated voting member from each Permittee. Fairfield Suisun Urban Runoff Management Program has a Program Oversight and New Development Committee responsible for making Program decisions.

In June 1990, the Regional Water Quality Control Board (Regional Board) issued the SCVURPPP its first NPDES permit. Permit provisions recognized that the Program had already accomplished significant work considered equivalent to specific municipal stormwater permitting requirements promulgated by EPA in October 1990.

The first five-year NPDES stormwater permits ("first generation") were subsequently issued in the early to mid 1990's for the other four Phase I agencies requiring similar stormwater management activities and SWMPs (e.g., Alameda Countywide Clean Water Program (ACCWP), Contra Costa Clean Water Program (CCCWP), San Mateo Countywide Stormwater Pollution Prevention Program (STOPPP), Fairfield Suisun Urban Runoff Management Program (FSURMP)).

In 1995, the SCVURPPP developed and submitted a second SWMP (SCVURPPP refers to their SWMP as an Urban Runoff Management Plan) as part of the five-year NPDES permit cycle. The SWMP included a *Revised Metals Control Measures Plan* to reduce copper, nickel and seven other metals in stormwater. The second five-year NPDES permit ("second generation") adopted in 1995 required SCVURPPP to develop model performance standards for various stormwater control measures and to incorporate them into their SWMP.

The second five-year NPDES permits ("second generation") were adopted for the three of the other four Phase I stormwater agencies (excluding FSURMP) in 1997 – 1999. These required monitoring for pollutants of concern (e.g., metals) in stormwater discharges and identification of potential sources, but not reduction measures. In October 1999, FSURMP submitted a complete permit reapplication package. This package, which included a Storm Water Management Plan for FY 1999-2000 to FY 2004-2005, provided a description of FSURMP's efforts to target urban runoff pollutants of concern. Copper, nickel and other metals were identified as pollutants of concern. Standard task controls/programs for each pollutant were also identified. FSURMP did not have a "second generation" permit.

The third five-year NPDES permits ("third generation") issued so far [SCVURPPP, 2001] require Permittees to implement control programs for pollutants that have the reasonable potential to cause or contribute to exceedances of water quality standards. Specific control programs include copper, nickel, mercury, pesticides, PCBs, dioxins and sediments. SCVURPPP is also required to continue to implement the 2000 Copper and Nickel Action Plans.

Second Generation Stormwater NPDES Programs (CCCWP, STOPPP) and Non-NPDES (MCSTOPPP) with General Pollutant Reduction Activities

<u>Stormwater NPDES Programs with General Pollutant Reduction Activities</u>

Programs now operating under their second-five year NPDES permits ("second generation") are not required to conduct specific copper control activities. Instead, Programs were required to develop monitoring programs to assess existing or potential impacts on beneficial uses caused by pollutants of concern (e.g., metals) in stormwater discharges, to identify potential sources of pollutants of concern found in stormwater discharges, etc. The two current "second generation" NPDES permits include:

- Contra Costa Clean Water Program
- San Mateo Countywide Stormwater Pollution Prevention Program

Both Programs have similar approaches to controlling pollutants in stormwater that are organized around several core programmatic activities as outlined in their individual Storm Water Management Plans. These activities are aimed at reducing pollutants in general (versus copper specifically) from reaching and contaminating stormwater runoff. The six core activities include the following:

- Illicit Discharge Controls
- Industrial/Commercial Business Controls
- Municipal Government Maintenance Activities
- New Development and Redevelopment Activities
- Watershed Awareness and Collaborative Activities
- Public Information and Participation

These six activities, while not necessarily directly targeting copper may result in indirect reductions in copper in stormwater runoff. For example, street sweeping and storm drain and inlet cleaning can reduce copper to the extent it captures and removes copper-containing brake pad debris. In addition, controlling pollutants from new and redevelopment activities, pre and post-construction, can reduce copper in stormwater to the extent that erosion and copper-containing sediments are prevented from reaching waterways. Since stormwater programs are based on the implementation of best management practices to reduce pollutants to MEP, these practices are practical and cost-effective methods to significantly reduce potential discharges of pollutants to nearby storm drains and waterways.

<u>Stormwater Non-NPDES Programs with General Pollutant Reduction Activities</u>

The Marin County Stormwater Pollution Prevention Program (MCSTOPPP) is in the process of receiving its first Phase II permit. Phase II permits do not require the implementation of pollutant reduction plans for copper or other specific pollutants of concern. While it has not been operating under an NPDES permit, MCSTOPPP has been performing essentially the same programmatic activities as the "second generation" NPDES permittees (with the same likely impacts on reducing copper in stormwater runoff).

Third Generation NPDES Permits with Pollutant Reduction Plans

The third-five year NPDES permits ("third generation") require the stormwater agencies to implement control programs for pollutants that have the reasonable potential to cause or contribute to exceedances of water quality standards. The first stormwater agency within the San Francisco Bay Region required to implement pollutant reduction plans was the Santa Clara Valley Urban Runoff Pollution Prevention Program. This requirement was part of their NPDES Permit reissued on February 21, 2001. A full description of their copper reduction plans is provided in the next section.

The second stormwater agency in the Bay area required to implement pollutant reduction plans was the Alameda Countywide Clean Water Program (ACCWP). This requirement was part of their reissued Municipal Stormwater Discharge NPDES Permit (Order R2-2003-0021) adopted on February 19, 2003. Provision C.10 required the Permittees to develop and implement programs to control discharges of copper and other pollutants of concern. In addition, Provision C.10 required the Permittees to refine the Pollutant Reduction Plans to incorporate specific activities and to provide detailed descriptions of the planned activities by fiscal year. Provision C.10.a does not require specific additional activities related to controlling the discharge of copper. It does require a refinement of the Copper Pollutant Reduction Plan and a description of activities by fiscal year.

Information prepared for the SCVURPPP in 1994 had estimated the largest single source of copper in stormwater to be wear debris from automobile brake pads. Other potentially significant sources included copper algaecides, building materials, swimming pool discharges and erosion of native soils. Based in part on this information, the major tasks included within the ACCWP Copper Pollutant Reduction Plan were:

- Participating in the Brake Pad Partnership (BPP);
- Monitoring copper in stormwater discharges;
- Evaluating the significance of potential sources copper other than brake pad wear debris;
- Municipal maintenance activities; and
- Public education and outreach to businesses.

The copper reduction measures selected by the ACCWP target the largest source of copper discharged to the Bay (brake pad debris) and include on an extensive business outreach and inspection program. The incorporation of public education and outreach programs by stormwater agencies within the San Francisco Bay region has been shown to change behaviors that adversely affect water quality and to increase the public's understanding of and appreciation for the Bay.

Fairfield Suisun Urban Runoff Management Program (FSURMP) NPDES permit was reissued in April 2003. This NPDES permit included specific permit requirements to develop pollutant reduction plans (PRP) for several pollutants, including copper, by November 2003. The PRP was to include control actions which include/relate to new/redevelopment and monitoring. This requirement is similar to the requirements found in a "third generation" permit. However, FSURMP's current permit is their second NPDES permit. In addition, FSURMP was to refine a list of tasks targeted to control copper by providing more detailed descriptions of activities. The CCCWP and SMSTOPPP NPDES permits are scheduled for reissuance in July 2004 and will likely include similar PRP and copper control measure requirements.

SCVURPPP and CAP/NAP

<u>*Copper Action Plan*</u>
In June 2000, the final Copper Action Plan (CAP) was developed for SCVURPPP. The final CAP contained specific baseline actions to be implemented by various entities. The complete list of CAP actions applicable to the Co-permittees was incorporated by the RWQCB into the Program's NPDES Permit Number CAS029718, Order Number 01-024, dated February 21, 2001, (see Appendix B of permit).

The overall purpose of the CAP was to serve as a non-degradation plan to ensure that: existing water quality is maintained; beneficial uses are protected; and that exceedances of the site-specific water quality objectives for copper did not occur in the Lower South San Francisco Bay. The CAP included current control measures/actions being used to minimize copper releases to the Bay; ambient monitoring "triggers" that would initiate additional measures/actions; actions necessary to address uncertainty; and a proactive framework for addressing increases to future copper concentrations in LSSFB, if they occur.

Each action was assigned a priority level that determined what condition and the order in which the action was to be conducted. More specifically, these "baseline" actions included programmatic actions by public agencies; special studies that track and address specific technical areas of uncertainty identified in the *Impairment Assessment Report* and the *Copper Conceptual Model Report*; and planning-type studies to track, evaluate, and/or develop additional indicators to use and future potential indicators and triggers (i.e., indicators for growth, development, or increased use or discharge of copper in the watershed).

These baseline activities were selected through an extensive stakeholder process from the array of potential copper reducing activities that had been considered in the South Bay since the late 1980's. Some selected baseline activities are unique due to the South Bay location and environment. Other watershed and planning type activities were unique for the South Bay due to the existence of the Santa Clara Valley Watershed Management Initiative (WMI) and its various programs. Some activities were selected to develop the additional information needed to evaluate the extent to which they may, or may not be effective in reducing sources of copper or better evaluating the potential impacts of copper loading on the Bay. A listing of each baseline activity is provided below.

The CAP also required the monitoring of municipal wastewater copper loading and dissolved copper in Lower South San Francisco Bay during the dry season. If the mean dissolved copper concentrations measured at certain specified stations increases from ambient (typically ~3.2 µg/L) to 4.0 µg/L or higher (Phase I Trigger Level), Phase I actions would be triggered to further control copper discharges. If the mean dissolved copper concentration increases to 4.4 µg/L (Phase II Trigger Level), Phase II actions would be triggered. If dischargers into the Lower

South San Francisco Bay demonstrate that the increases in copper concentrations are due to factors beyond their control, the CAP states that the Regional Board will consider eliminating or postponing actions required under Phase I or Phase II of the CAP.

Implementation of Copper/Nickel Baseline Activities

The majority of copper baseline (CB) actions have been implemented by SCVURPPP at the Program level (except for several assigned to San Jose, Sunnyvale and Palo Alto). Baseline actions conducted or proposed to be conducted are included in the SCVURPPP Annual Reports and Work Plans, respectively. They include the following 21 copper and 7 nickel baseline actions:

- CB-2: Water supplier copper sulfate use;
- CB-4 (1): Quantification studies of copper in vehicle brake pads;
- CB-4 (2): Quantification studies of brake pad copper debris fate and transport;
- CB-4 (3): Potential copper sources, loadings and impact indicators;
- CB-4 (4): Issue paper on feasibility of monitoring brake pad copper fate and transport;
- CB-5: Local support for Brake Pad Partnership (BPP);
- CB-9: Continue current efforts and track corrosion control opportunities;
- CB-10/NB-2: Measures associated with utilizing the Sediment Characteristics and Contamination Environmental Indicator;
- CB-13-NB-3: Track POTW pretreatment program efforts and POTW loadings;
- CB-14/NB-4: Track and encourage water recycling efforts;
- CB-15/NB-5: Measures to evaluate effectiveness of Performance Standards and identify cost- effective modifications to reduce discharges of copper (see NB-1, CB-3 and CB-11);
- CB-16: Measures to establish an Environmental Clearinghouse;
- CB-17 (1): Phytoplankton species toxicity and prevalence;
- CB-17 (2): Measures to assess cycling and fluxes between water column, phytoplankton, sediment and benthos;
- CB-17 (3): Measures to assess wet season tributary loading and loading uncertainty;
- CB-17 (4): Bio-assessment tools to track presence of copper sensitive taxa in Lower South Bay;
- CB-17 (5): Assess feasibility of phytoplankton bioassays to measure toxicity;
- CB-18 (1): Investigate flushing time estimates for different wet weather conditions;
- CB-18 (2): Investigate location of northern boundary conditions;
- CB-18 (3): Determine Cu-L_1 and L_2 complex concentrations (copper speciation);
- CB-18 (4): Investigate algal uptake/toxicity with competing metals;
- CB-19/NB-6: Track industrial virtual closed-loop wastewater efficiency measures as part of POTW source control programs;
- CB-20: Measures to revise the Copper Conceptual Model Report findings; and
- NB-7: Measures to establish a watershed model linked to process oriented Bay model.

The Regional Board also expects Co-permittees to implement appropriate actions at the local level. SCVURPPP has identified copper control activities that are feasible to implement to varying degrees at the Co-permittee level, based on the size, urbanization, etc. of a given Co-permittee's service area. These activities include the following:

- CB-1: Measures to reduce copper discharges from vehicle washing operations;
- CB-3: Measures to control copper in discharges of stormwater in targeted industrial sources;
- CB-6, 7: Measures to reduce traffic congestion/promote alternative transportation;
- CB-8: Measures to classify and assess watersheds and improve institutional arrangements for watershed protection;
- CB-11: Measures to improve street sweeping controls and stormwater system operation and Maintenance;
- CB-12: Measures to control copper discharges from pools and spas;
- CB-21: Measures to discourage architectural use of copper; and
- NB-1: Measures to control nickel discharges from construction sites (sediment).

Individual Co-permittees include measures to address each of these activities, as applicable in their Work Plans. In addition, the SCVURPPP and certain Co-permittees as appropriate will continue to prepare a Copper/Nickel Work Plan as part of the SCVURPPP draft Work Plan submitted March 1 of each year.

Next Generation CAP

The Copper Action Plan developed for the Lower South San Francisco Bay was designed to incorporate lessons learned from implemented action items and from scientific and technical information from other sources. The update will be completed every five years, as part of the NPDES permitting process, and regular review of conditions in LSSFB. The review, which is conducted by a temporary work group, using a collaborative, stakeholder based adaptive management process. The updated CAP would be evaluated within the context of the technical products used in its development, including the TMDL loading analysis, conceptual model and impairment assessment. If revisions were found to be needed prior to the five-year update, the CAP provided that the Regional Board could amend the CAP through Co-permittees annual Work Plans or other regulatory actions. The first major review/update of the CAP since it was adopted in June 2000 began in mid-2003 with revisions to the baseline activity reporting table format.

The Santa Clara Basin Watershed Management Initiative Bay Modeling and Monitoring (BM&M) workgroup has agreed that further efforts at fine-tuning the CAP baseline activities may not be a productive use of stakeholder's time due to certain inherent problems with the current CAP/NAP language. Instead, together with Regional Board staff they are working towards an approach that will streamline the current CAP to focus on activities that will remove the largest amount of copper.

To assist in the identification of key baseline copper control activities that are most effective in removing copper, the Clean Estuary Partnership (CEP) is currently funding a project to update information on copper sources in Bay Area urban runoff. This project is part of the North of

Dumbarton Cu/Ni site-specific objective (SSO) project. Updated copper source information will be compiled, based on scientific literature, reliable technical reports and other information from the South Bay. The project will produce a short technical report with updated copper source, control, and quantification information. The report will develop a prioritized list of potential stormwater copper source control measures that will remove the largest amount of copper per effort expended. A menu of these prioritized activities could form the nucleus for a "next generation", potentially Bay-wide CAP. The activities and approach included in the ACCWP Copper Pollutant Reduction Plan represent one potential vision of what parts of a next generation CAP might look like.

Regional Board staff has indicated a desire to work towards a single Bay-wide CAP. One potential approach would be to develop the baseline activity language for the North Bay Cu/Ni Action Plans and then to incorporate the language directly (or perhaps by reference) into the appropriate North Bay stormwater permits. Next, following the prior South Bay approach, the Basin Plan would be amended to include both the North Bay SSOs and references to the "next generation" CAP/NAP in the implementation section. Concurrently, the existing Basin Plan language regarding the South Bay CAP/NAP activities would also be amended to be consistent with the North Bay language and CAP/NAP approach.

An overarching goal of a revised CAP would be to facilitate a more intensive effort on a smaller number of the most effective copper control actions, implemented with on-going input from Regional Board staff. The development and implementation of a Bay-wide CAP would be one means to help to ensure a reasonable and equitable level of participation among all stormwater programs within the Bay.

Ambient water quality triggers and monitoring

The Action Plans for North of the Dumbarton Bridge are concerned primarily with (1) development of water quality monitoring triggers and (2) development of an effective source control program. The presumption is that the majority of source control effort will be focused on copper, with knowledge that such efforts will have a collateral benefit in reducing nickel at similar sources. The intent of the North Bay Action Plans was to utilize the South Bay Action Plans [Tetra Tech, 2000b,c], thereby creating templates for use by the North Bay entities. It was found that municipal and industrial dischargers have existing copper control program information that could be readily adapted into the South Bay templates.

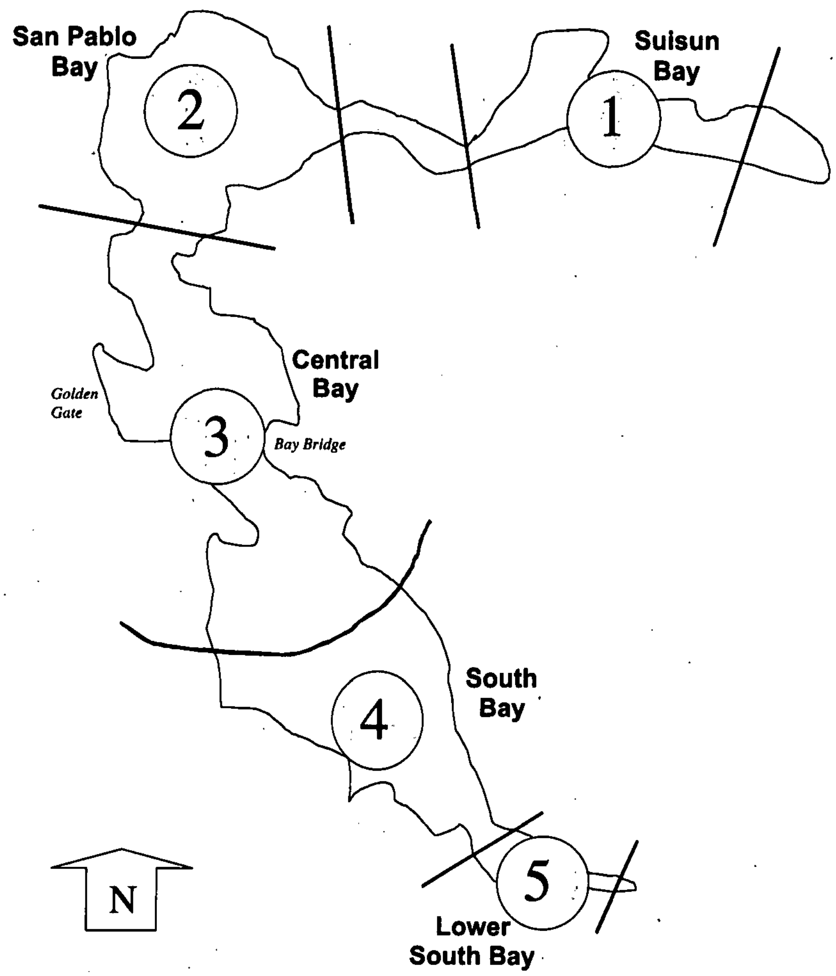
Municipal, industrial and stormwater copper and nickel sources were investigated to determine feasible baseline and subsequent actions for controlling discharges to the North Bay if loadings from these sources are found to be significant. Previous pollution prevention and source control work in these areas was incorporated for this effort.

Trigger Development

The next step in developing the Action Plans was preparing a plan to monitor dissolved copper and dissolved nickel concentrations in the Bay north of the Dumbarton Bridge. The 2002 revised Regional Monitoring Program (RMP) monitoring approach [SFEI, 2001b], with fixed stations plus randomized stations by Bay segment (see map below), was reviewed with RMP staff to confirm that the sites provide adequate shallow and deepwater spatial coverage for tracking ambient copper concentrations (this was partly how sites were selected during the RMP redesign). Additionally, LSSFB trigger development was reviewed prior to the development of triggers north of the Dumbarton Bridge.

Multiple trigger concentrations were determined using a power analysis (one-sided t-test of means with an alpha value of 0.05) on previous dissolved copper and dissolved nickel water quality data collected north of the Dumbarton Bridge.

Figure 2.2. Regions of San Francisco Bay Defined by Revised Regional Monitoring Program



Trigger Program

Ambient water quality trigger levels were established for dissolved copper and dissolved nickel in each of the four Bay regions north of the Dumbarton Bridge using the statistical methods described above (see **Table 2.3**).

Table 2.3. Trigger Levels Relating to the Ideal Sampling Scheme (µg/L)

		Region 1	Region 2	Region 3	Region 4
Copper (µg/L)	increment	0.82	1.29	0.79	0.79
	concentration	2.87	3.47	2.23	3.16
Nickel (µg/L)	increment	0.80	1.18	0.76	1.22
	concentration	2.16	3.26	2.18	3.55

To properly test the established indicators, concentrations of copper in the Bay north of the Dumbarton Bridge will be monitored during the dry season. The monitoring plan for LSSFB included monthly monitoring at each of the identified trigger stations. The proposed monitoring in the Bay north of the Dumbarton Bridge will utilize results obtained by the RMP monitoring. The proposed option is to sample for triggers in regions 2 and 4 only, as these are the two regions with the highest (most sensitive) copper and nickel concentrations and it is judged that changes in these areas will be indicative of changes in the Bay NDB. It is assumed that RMP sampling will provide 12 samples in Region 2 and 8 samples in Region 4, to provide a 99% level of power in the monitoring effort. Some power (ability to detect a statistical difference) is lost in using an n of 8 for Region 4 compared to using an n of 12, as is recommended for Region 2. It would cost an additional ($910) to sample an n of 12 in Region 4 (*Draft Development of Action Plans, EOA/LWA, June 2003, Appendix 3*).

Power analysis results simply indicate the incremental increase in ambient copper (or nickel) concentrations that can be statistically detected at a given level of significance (in this case 99%). This level of increase is not likely one that is ecologically or biologically significant. A biologically significant endpoint is the SSO itself.

Response actions have been described above to address situations where the trigger levels are activated. In addition, point source monitoring and cumulative load tracking is necessary on an annual basis to report and assess the relationship, if any, between increases in ambient concentrations and point source loads. It is proposed that the Regional Board's Electronic Reporting System be used to obtain the effluent data from NPDES dischargers for use in this tracking activity.

Appendix D

Response to Comments

Copper-Nickel CMIA Review – Richard Looker – April 19, 2004

1) Generally, did the report follow the prescribed outline in terms of coverage, tone, level of detail, graphics? *Is this report supposed to adhere to the outline since it was in process prior to those guidelines being established? Generally yes, the report has the content. For impairment assessment, I think it is all there. For CM, it is there, but the order is a bit odd. I think. I will give specific comments later.*

2) Regarding the Impairment Assessment Section:

a. Was there a clear statement of the relevant water quality standards and whether or not they are met in the Bay? *Yes*

b. Was there a clear statement of the beneficial uses threatened? *Yes*

c. Was there a clear statement of the basis of impairment? *Yes*

d. Was there a clear discussion of indicators of impairment and values of those indicators in the Bay? *Yes*

3) **Impairment unlikely:** The evidence clearly supports the judgment that the contaminant is not causing a negative impact to beneficial uses. This finding includes some uncertainty.

e. Based on your reading of the Impairment Assessment section, which level of certainty is most applicable for the contaminant (refer to discussion above)? Please give a brief explanation of why you chose this level of certainty. *I choose Impairment Unlikely. The reasons are the same as why that level was chosen for the south of Dumbarton project. The weight of evidence points to "no impairment", but there are uncertainties and some possible avenues to explore for impairment (sediment and phytoplankton) that are still unresolved.*

f. Are there specific problems with tone or miscellaneous editorial problems that you would prefer be corrected in the final draft? *Yes, quite a few:*

4) Pg. iii : "CTR established each of these objectives as numeric value times a WER" (error, WER only applies to copper).

San José Response: *San Jose staff believe the author of the CMIA was only stating that the EPA WER procedure was officially promulgated first with the National Toxics Rule (1992, Amended 1995) and recently with the California Toxics Rule. In this latter rule (see footnote "i" to the water quality criteria table in the CTR), the WER applies to some ten metals (arsenic, cadmium, chromium III, chromium VI, copper, lead nickel, selenium, silver and zinc). While the WER procedure applies to all these metals, the NDB study participants (and the state) are developing a state-approved WER for copper only. While a WER is not being developed in the present case for nickel, the "CTR established each of these objectives (copper & nickel) as numeric value*

(EPA criteria) times a WER." Staff does not perceive an "error" was made in this statement by the CMIA authors.

5) Pg. v:" Complexation of nickel is neither observed nor expected to effect nickel toxicity." I think this is incorrect. Please refer to Sedlak et al. 1997 *Strongly Complexed Cu and Ni in wastewater effluents and surface runoff.* ES&T 31(10): 3010-3016

Response: *Text changed to " Complexation of nickel does not demonstrate a similar effect on nickel toxicity."*

6) Page v: what is non-conservative excess?

Response: *Non-conservative excess refers to the idea that there are in Bay sources (such as benthic remobilization from the Selby Slag site (see Section 3.3.5).*

7) Page 1 of REL comments: Pg. 18; "...the water column-based site-specific objectives for copper and nickel directly account for toxicity to sensitive benthic invertebrates." REL Comment: Not necessarily. You are establishing water column dissolved values that are likely lower than pore water concentrations. Those (presumably) higher pore water concentrations could be a problem through sediment toxicity.

San José Response: *Critical life stages of many benthic invertebrates are protected by the dissolved copper criteria. Larvae of mussels, oysters, sea urchins, clams, and scallops develop in the water column. Forty-four genera are represented in the draft EPA copper criteria document (2003). Most of these animals have critical (larval) life stages that develop in the water column. Three of these (mussels, oysters, sea urchins) are among the four-most-sensitive genera from which the Final Acute Value (FAV) for copper is derived. The FAV is lowered from 10.39 to 9.625 ppb to protect Mytilus sp. The tests with Mytilus sp. were conducted with sensitive life stages (embryos), which develop in the water column. Of the 44 genera listed in the EPA database, those most likely to be affected by pore water are animals with developing young in close contact with the sediment. These are:*

Above Benthos: Crabs – GMAV = 41.06 – 502.8 ppb
Polychaete worms – GMAV = 100.6 – 136.9 ppb
Sand Shrimp - GMAV = 816.3 ppb
Within Benthos: Amphipods – GMAV = 209.5 – 502.8 ppb
Polychaete worms – GMAV = 318.3 ppb
Nematode – GMAV = 217.9 ppb

Crab tests are performed on larval stages and a site-specific objective of 6.9 ppb (for example) is likely protective of the Dungeness crab, which has an acute value of 41.06 ppb, especially since its larvae are planktonic. The greatest unknown is amphipods, since there are no test procedures *for developing young. However, adult amphipods are not very sensitive to copper (GMAV = 209.5 – 502.8 ppb).*

g. Are there big problems in terms of presentation or interpretation of data that must be resolved before we go any further with this report?

8) Pg. iii: Be careful about using term like "recommended range of SSOs". This implies there is some scientific reason why these were recommended. This is not the case and the discussion should not be limited to that range.

Response: *Deleted the word recommended.*

9) Pg. iv: I cannot accept this implication of benthic remobilization as having nothing to do with anthropogenic inputs. There is almost no mention in the report that the sediments are a bigger source than they otherwise would be because they are enriched by human inputs. Please discuss more fully the concept that anthropogenic inputs can contribute to dissolved concentrations either directly or indirectly as those inputs are stored in the sediments from future release. In this way, the sediment source is correctly viewed as being composed as a background component and a component that would not be there were it not for historical and ongoing loading. There is almost no mention of this possibility at all. The sediments are characterized as dwarfing ongoing inputs and this is a disingenuous characterization of the story in my opinion.

Response: *The importance of ongoing loadings cannot be understated, however there is a lot of uncertainty on the concept of "anthropogenic inputs contributing to dissolved concentrations either directly or indirectly. The sediment source is correctly viewed as being composed as a background component and a component that would not be there were it not for historical and ongoing loading." This uncertainty will be addressed in the multibox modeling exercise and can be addressed using the MIKE (URS) model. SFEI has been funded by the CEP to improve the model regarding sediments impact in San Francisco Bay. (See Appendix B).*

10) Pg iv: you say that "results of studies regarding phytoplankton and sediment quality indicate that copper and/or nickel are not likely to be causing impairment of phytoplankton or benthic communities in the Bay". I think that this statement is probably a fair statement for phytoplankton, but the evidence presented for sediment toxicity on p. 17 makes the statement for sediment misleading. I do not think you can make the claim for sediment. The jury is still out.

San José Response: *The City agrees with the statement that phytoplankton impairment is no longer an issue due to the speciation results published by Buck and Bruland (2003) and because we now know that sensitive phytoplankton (picocyanobacteria) are commonly found in the Bay. The paper (in preparation) by Buck and Bruland (4/12/04 version) states that: "Regardless of site or season, the [Cu^{2+}] values throughout San Francisco Bay did not exceed 10^{-13} M, suitably below the toxicity limit for aquatic organisms....the data from Lessin et al. (unpubl.) in summer 2001, from Beck et al. (2002) in April 2000, and from this study in January and March 2003, all support the conclusion that copper speciation in San Francisco Bay is dominated by a strong L1* *ligand class that maintains free [Cu^{2+}] to levels easily tolerated by the ambient phytoplankton communities." (bold added). Clearly, there is no longer uncertainty with regard to the effect of Bay copper concentrations on phytoplankton in the Bay.*

The City agrees with the CMIA authors that much (if not all) of the work done to link observed sediment toxicity to copper has been poorly done (e.g. Phillips et al. 2000). Technically speaking, the Phillips et al. study (2000) did not establish a meaningful link to copper or to any other single toxicant. Unless or until Phase III, confirmatory TIEs are done (these and intermediate evaluations are expensive) any "demonstrated linkage" will be poor at best. One evaluation reported by Phillips et al. (2000), linked copper to sediment elutriate toxicity even though none of the toxicity in the 100% elutriate samples was ameliorated by manipulations designed to remove copper (i.e. EDTA addition and cation exchange treatment). In the same study, the authors described the effect of 0.12 µg/L copper as potentially "synergistic."

This is unreasonable and misleading since the mean oceanic concentration of copper in the North Pacific Ocean in 150 ng/kg (approximately 0.15 µg/L; Bruland 1980). The discussion of copper-related sediment toxicity on p. 17 does not contradict the statement on p. iv (quoted above by REL) but concludes that "the source of toxicity in Grizzly Bay sediment samples is clearly unknown." The City agrees with this conclusion.

11) Pg. 30 - : Way too much info on the Action Plans. This was a distraction to me. The only part that seems to fit was information about the origin of copper and nickel found in WW effluent and UR. I do not need this information in the CMIA report.

Response: *Information on Action Plans has been moved to Appendix C.*

h. Is there a clear statement of the relevant data gaps? Do you agree with those findings? *Pretty good treatment here on the relevant uncertainties.*

*Regarding the Conceptual Model Section:

Analogous to the discussion above about level of certainty in the impairment finding, there are three categories for level of support for findings about the conceptual model:

The conceptual model findings are well supported with existing data and these data are cited and presented clearly.

The findings are based on limited data with the data gaps clearly identified

The findings are based on seriously insufficient data or on nothing

12) a. Is the system adequately described? What is the state of certainty regarding the findings (which category from above) made regarding the system description? *Findings are based on a level of certainty somewhere between adequate data and limited data. There are reasonably*

ample data for some things like ambient conditions and the toxicity studies. However, the loading information is poor. The information about the significance of sources is poor (e.g. how do CV watershed inputs impact ambient conditions compared to local trib loading).

Response: *Information on loadings continues to be developed. New reports and models can assist in determining more accurate and complete loading estimates. The goal of this report was to outline some of the major areas believed to contribute copper and nickel to the water column of San Francisco Bay.*

13) b. Are all relevant sources included, and what is the level of certainty regarding the findings? *Yes, high level of uncertainty regarding sources it seems.*

Response: *See response to 12).*

14) c. Is the significance of each source or load described and what is the level of certainty regarding these findings? *The significance of each source is only described in terms of gross magnitude, but not significance. For example, CV inputs are big, but they may just shoot through. This sort of hydrodynamic consideration is only touched upon briefly. So, level of uncertainty for these findings is high.*

Response: *There are two things that have to be considered when evaluating the significance of a source:*

1) to what degree does the source maintain or increase the concentration of copper and nickel in Bay sediments;
2) to what degree does the source maintain or increase dissolved, free ionic copper and nickel concentrations in Bay waters?

We care about sediment concentrations because the sediments serve as a long-term reservoir for metals – simple equilibrium considerations tell you that when copper concentrations in sediments increase, desorption rates of copper from those sediments will increase, elevating dissolved copper concentrations. Also, metals in sediments have the potential for direct effects on benthic organisms, which is going to be addressed through the State's Sediment Quality Objectives guidance. This is why one of the goals of the copper action plan is to ensure that metal concentrations in Bay sediments do not increase over time, and why we have to evaluate effects on the long term metal concentration in sediments when we talk about the significance of a source. From that standpoint, it is appropriate to simply look at the gross magnitude of the source in a simple box-model active layer approach to talk about its significance.

POTWs remove particles, so in effluent dominated waterbodies (like the receiving water sloughs of lower South Bay), you see a shift towards dissolved metals. However, the recent work of Sedlak et al, and Bruland before that, showed that copper and nickel discharge from POTWs is strongly complexed by organic ligands, so POTWs don't turn out to be significant sources of free ionic copper.

From reviewing RMP data, plus recent translator studies carried out on the margins (Sonoma Creek, Napa River), it becomes apparent that the most significant factor affecting dissolved copper and nickel in the Bay is mobilization from particles at interfacial areas – lower south Bay, Carquinez straits, the Napa River, anywhere fresh water mixes with salt water in a turbidity maximum zone seems to be associated with a localized peak in dissolved copper concentrations.

To summarize: the gross magnitude of a source is a good predicter of it's significance, as long as you normalize it to the sediment load of the source. Metal loads that result from large volumes of sediment with moderate to low metal concentrations (e.g., erosion from open spaces) aren't as much of a concern as metal loads that result from erosion of solid material with high metal concentrations (like the submerged slag pile off of Davis Point). Beyond that, the significant factor that drives dissolved metal concentrations isn't really the nature of the metal source. The question is where in the estuary are metals mobilized from sediments into the dissolved phase, and how do sources affect the baseline concentration of metals in sediments that are transported into these mobilizing zones.

15) d. Are the relevant fate/transport/transformations/effects described clearly, and what is the level of certainty regarding any findings made? *No, these processes are not described adequately. I think that the beginning of conceptual model should take care of this. There are some confusing passages about processes that I will discuss later. The chemistry and biological effects are ok, but the transport and physical cycling is not clearly presented.*

Response: *See response to 14).*

16) e. Are there specific problems with tone or miscellaneous editorial problems that you would prefer be corrected in the final draft? *Yes.*

Response: *Comment noted. Edits have been made.*

17) Pg 55: in section titled "erosion of bed sediment" you talk about benthic flux load. I think this is a confusing section because you have not identified and defined the major processes. I think it could be a terminology problem here. In the past, I have seen three processes involving sediments: 1) resuspension of sediments and dissolution, 2) erosion of buried (previously unavailable) sediments containing metals, and 3) benthic flux of dissolved copper. Please define the processes up front and perhaps include a picture early on to help the reader.

Response: *Conceptual model figures have been moved to Section 1.3, as well as an introduction to resuspension of sediments and dissolution, erosion of buried sediments containing metals, and benthic flux of dissolved copper.*

18) Pg. 64: Do the first and last bullets contradict each other?

Response:. *Bullets have been edited to state the findings more clearly.*

19) Pg. 64: perhaps should have started the CM with figures like this and then explained the processes contained in them.

Response: *Figures have been moved up to Section 1.3..*

20) Pg. 66: Why no mention of UR loadings in the discussion of effects of current inputs of copper and nickel on surface sediment concentrations?

Response: *A lot of loadings from urban runoff are already particulate bound. A load might look big but if it is not dissolved, there may be no adverse impact on aquatic life. The question can then be posed as to whether the particulate bound metals might be remobilized in the benthic layer. It is known that copper and nickel are in urban runoff, which adds to the pounds of these metals in surface sediments (if they are in particulate form). The degree to which these affect surface sediment concentrations is not well understood. The Multibox Model (Appendix B) and the Brakepad Partnership work will both address this concern.*

21) Pg. 70: Uncertainties in loading numbers?

Response: *There are very high uncertainties in the loading numbers, some of which are discussed in Section 3.3. Estimates of copper and nickel loading vary from day-to-day and year-to-year. For example, a high rainfall year increases the flow (and potentially loading) in the Rivers that empty into the Bay. Additionally, wet deposition will vary during increased or decreased rainfall years. Dry deposition estimates have error bars of 50-80%. POTW and industrial loads were calculated using average daily maximum copper and nickel values, so will be variation from these means in addition to the plants being spread out around the Bay.*

f. Are there big problems in terms of presentation or interpretation of data that must be resolved before we go any further with this report?

22) There was no mention of the anthropogenic impact on sediment concentrations. It is as if that copper and nickel magically got there or is just background. This is not the case. Copper and nickel inputs likely stay in the estuary a long time (~ years) so they are a major part of what later is viewed as merely a legacy sediment problem.

Response: *See response to 12) and 14).*

23) Pg. 77: You failed to mention or show the titrations/results from Central Bay stations. The conclusion from the Central Bay titrations is that you reach the phytoplankton toxicity threshold well below 6.9 µg/L. Please present a more thorough picture of these data. There are some areas where 6.9 µg/L will not be unambiguously protective of phytoplankton according to the Bruland results.

San José Response: *Predicting the impact of copper on Bay phytoplankton has been the subject of much recent experimentation and debate. The work of Dr. Bruland and his co-workers has dramatically increased our understanding of the potential toxicity of copper to phytoplankton. It is important to review phytoplankton protection as part of the SSO process. However, it may not be prudent to regulate on phytoplankton as discussed in the City comments on the NDB Cu/Ni CMIA report (confounding factors, extrapolation to the field, salient endpoint to regulate, and whether you should regulate on primary production in general or on a single algal species). In addition, the recent history of the scientific debate over this issue points out the shortcomings of attempting to "predict" Bay phytoplankton responses to ambient copper concentrations. That history and some further considerations are summarized below.*

At the South Bay Copper Impairment Assessment Workshop, Dr. Bruland suggested that South Bay [Cu^{2+}] was sufficiently high to impact diatoms. He hypothesized that the co-occurrence of other ions (e.g. Mn^{2+} and Zn^{2+}) was the reason why South Bay diatom blooms did not appear to be affected by copper. He suggested that cyanobacteria were not in the South Bay because they are much more sensitive than diatoms.

Subsequent communications with USGS and further studies revealed that cyanobacteria are routinely found in South Bay.

The 4/12/04 Kristin Buck & Ken Bruland draft paper entitled "Copper Speciation in San Francisco Bay" concluded that "Regardless of site or season, the [Cu2+] values throughout San Francisco Bay did not exceed 10^{-13} M, suitably below the toxicity limit for aquatic organisms." Table 1 of that paper shows the range of concentrations for the January and March 2003 samplings to be from $10^{-13.3}$ M at Yerba Buena Island and San Bruno Shoals to $10^{-15.5}$ M at Grizzly Bay. This appeared to contradict the original [Cu^{2+}] prediction that suggested cyanobacteria would be affected.

It is helpful to review the titration results of Buck & Bruland (2004). For example, they seem to indicate that the 6.9 ppb SSO established for South Bay is protective. However, there are other factors that should be considered in addition to the titration graphs and the [Cu^{2+}] in the Bay. These include competition by other ions and source and fate of ligands in the Bay.

In addition to [Cu^{2+}] in the Bay, one must also evaluate the role of [Mn^{2+}] and [Zn^{2+}]. The role of ion interactions in ameliorating the toxicity of copper to phytoplankton is not well understood. However, these ions appear to be a significant factor.

The role of organic ligands (L1 and L2) in copper speciation is well known (Buck & Bruland 2004). However, the source and fate of the ligand populations in the Bay is not well understood. The copper speciation work of Buck & Bruland (2004) indicated that the Bay could assimilate more copper and still be protective of Bay phytoplankton.

Many algae produce exudates in order to regulate the amount of available metal in their environment. This affects both plant and animal populations. The Copper Project Report (Buck, Bruland, and Hurst) dated 3/18/04, reported that the South Bay ligand sources "may be due to either industrial inputs or biological activity." The report also noted that there was an observed *decrease in ligand concentrations during the March 2003 sampling despite the presence of a very large diatom bloom. The report concluded that there "is no real motivation for the biology (phytoplankton) to produce additional ligands" since "the free copper concentrations observed in the bay are not at toxic levels to any ambient microorganisms" (diatoms). These statements suggest a further assimilative capacity in the Bay due to excess ligands and the ability of algae to produce additional ligands to regulate [Cu^{2+}] in the Bay.*

The Regional Board Study determined acute algal WERs for Thalassiosira Pseudonana using 13 samples from six locations throughout S.F. Bay. Mean WERs for total and dissolved copper, respectively, were 6.1 and 2.3. Filtering site water may drastically alter its assimilative capacity for copper, rendering it more sensitive. However, EPA laboratory waters for algal testing are filtered through 0.45 micron pore-size filters as a matter of procedure. Thus, the 2.3 dissolved copper WER for T. Pseudonana may be underestimated as indicated by the mean WER for total copper of 6.1.

The Guidelines For Deriving Numerical National Water Quality Criteria For The Protection Of Aquatic Organisms And Their Uses (EPA 1985) indicates that "the Final Plant Value should be obtained by selecting the lowest result from a test with an important aquatic plant species in which the concentrations of test material were measured and the endpoint was biologically important." The only true chronic test with algae is Champia, an east coast red macrophyte species (Dave Hansen, personal communication). It is primary production in general that ought to be protected rather than individual phytoplankton species, which ecologically may be responding to a variety of natural pressures (competition, nutrients, light, grazing).

24) Pg. 83 top of page "…it would be **useful** to get a better understanding of the movement of copper and nickel into the sediments from existing external loading sources". I would say essential. I think this is the only place in the report where you raise this issue, and it is barely a mention and it is on the second to last page. To me, this is an important issue that needs to be clearly presented for consideration. The previous box modeling from the LSSFB work was flawed in that it did not consider this issue and it used hydraulic residence times instead of particle residence times. Thus, you cannot rely on those modeling results or that framework for this report.

Response: *SFEI has been funded by the CEP to prepare a multibox model for understanding sediment impact in San Francisco Bay (see Appendix B).*

25) g. Is there a clear statement of the relevant data gaps? Do you agree with those findings? *Not really a separate statement of data gaps for the CM section. I think the presentation was pretty clear in the IA portion. It is possible that the CM could have pointed out a few more, but not sure at this point.*

Response: *Comment noted.*

e. Next Steps

Did the report make suggestions for appropriate next project steps and provide reasonable support for those suggestions? Do you agree with the suggestions based on your evaluation of the material presented in the Impairment Assessment and Conceptual Model sections? If not, what next steps do you feel are appropriate and why? *This section did not appear. It could be because the suggested outline predated development of this report.*

Response: *Section predated development of report. We're already doing the recommendations.*