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Clean Estuary Partnership

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

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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 Metal*s 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

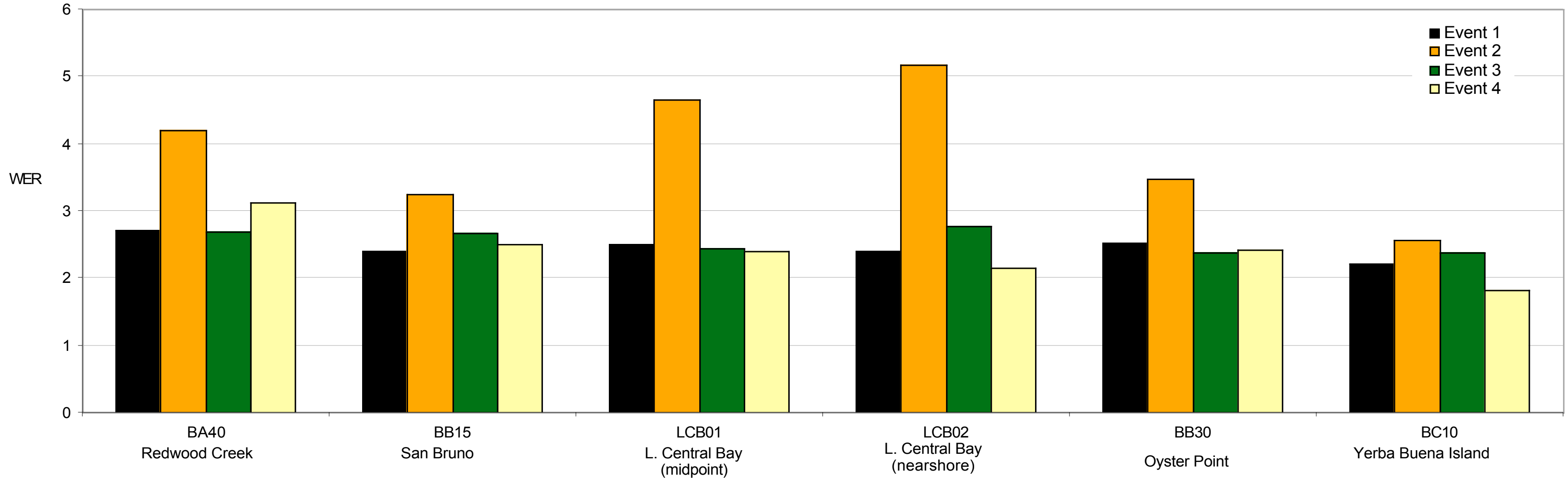
Station		Event 1	Event 2	Event 3	Event 4
Central Bay	BA40	2.7	4.2	2.7	3.1
	BB15	2.4	3.2	2.7	2.5
	LCB01	2.5	4.7	2.4	2.4
	LCB02	2.4	5.2	2.8	2.2
	BB30	2.5	3.5	2.4	2.4
	BC10	2.2	2.6	2.4	1.8
North Bay	BD20	2.2	2.6	2.0	1.5
	SPB01	2.0	2.6	2.9	2.0
	BD15	2.7	5.3	3.4	2.4
	SPB02	1.7	3.2	2.4	2.2
	SPB03	1.7	2.5	2.7	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)



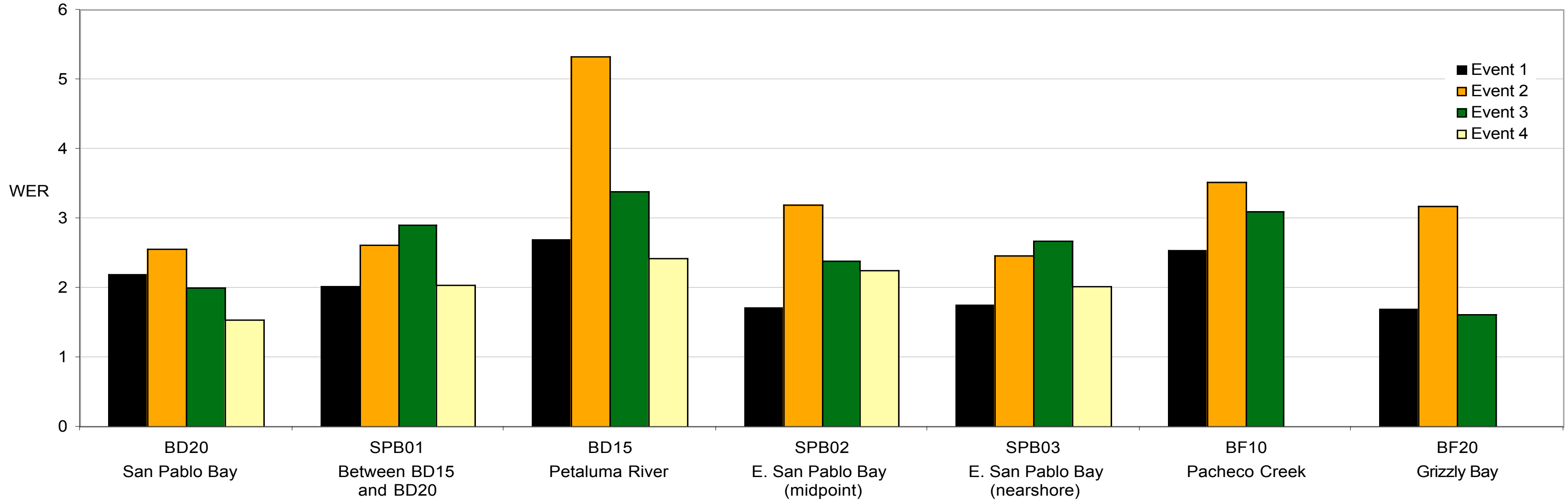


Figure 2a. Dissolved Copper WER Results by Sampling Station

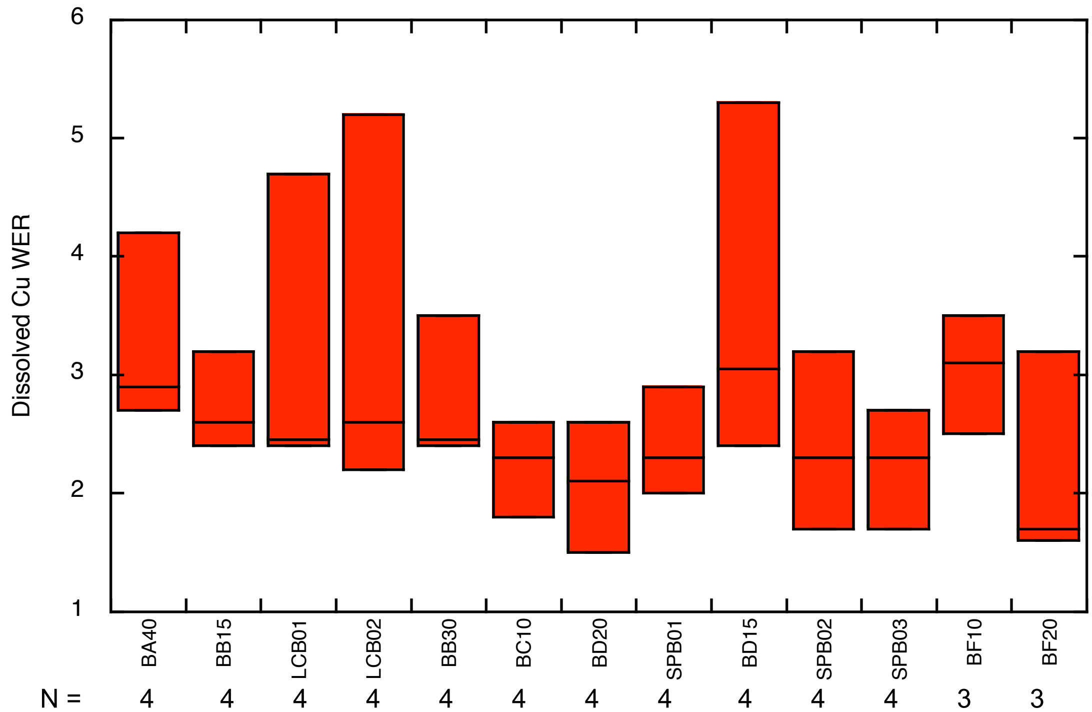
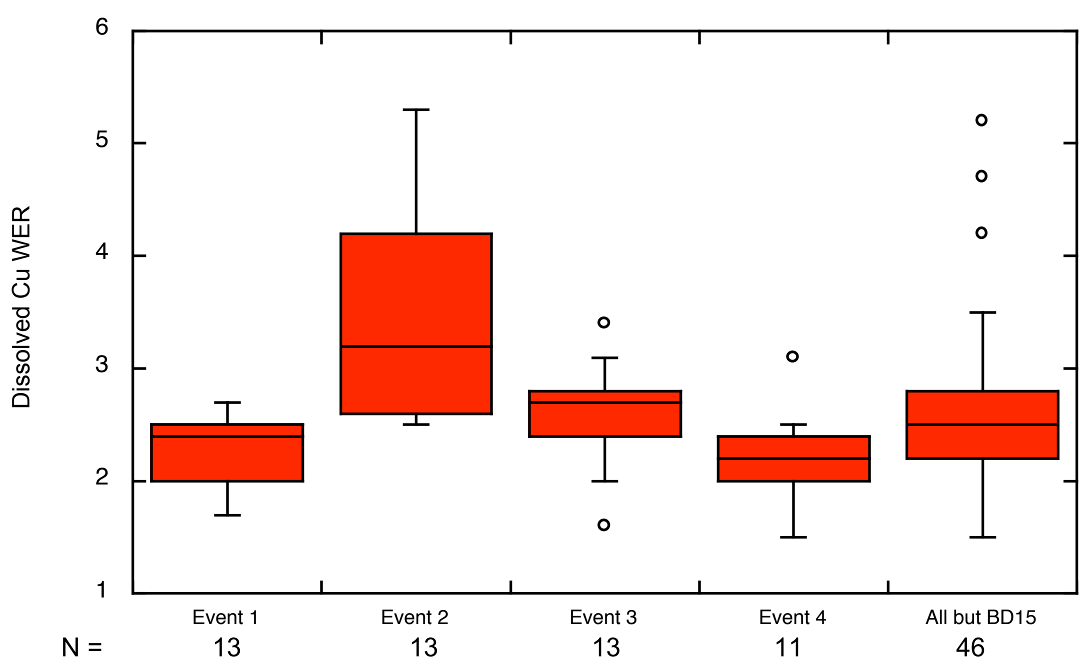


Figure 2b. Dissolved Copper WER Results by Event



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 5th 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
90^{th} Percentile	4.0	3.3	3.5	3.4	3.3	3.5
5^{th} 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 95^{th} % 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

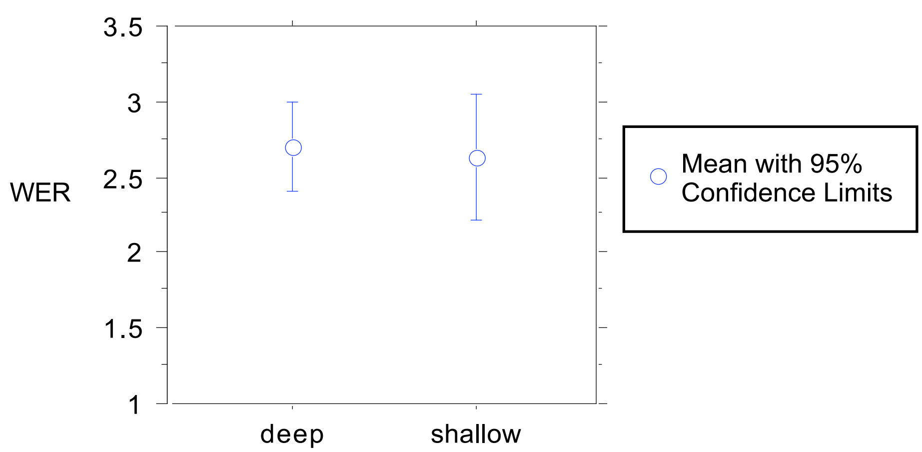


Figure 4. Mean WERs: Deep versus Shallow for Each Event

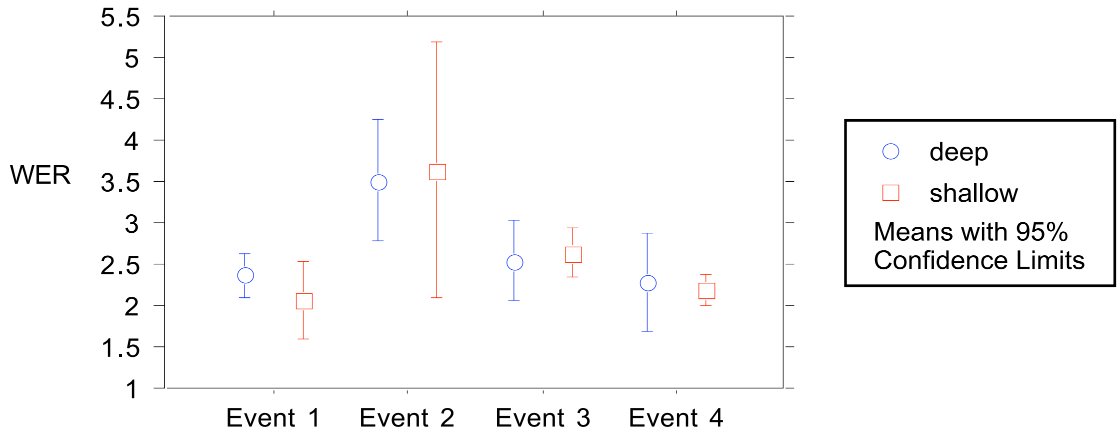
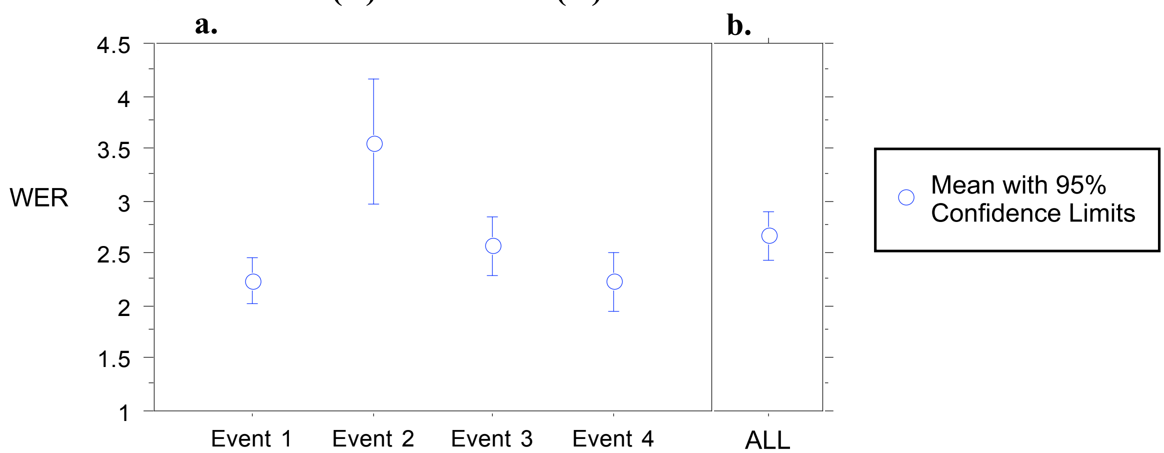


Figure 5. Mean WERs: Event (a.) and Overall (b.)



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	
BB30	LCB01
BB15	LCB02
BA40	

Central Bay
BC10

San Pablo Bay	
BD15	LCB01
BD20	LCB02
	LCB03

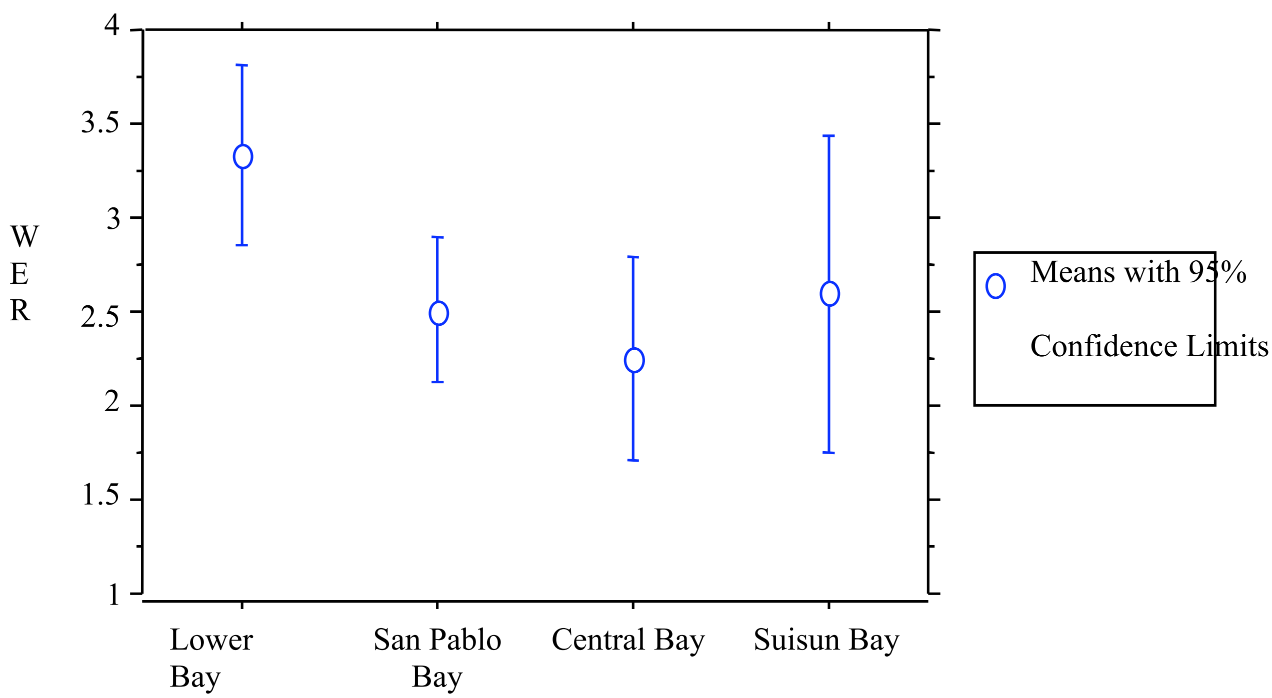
Suisun Bay
BF10
BF20

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
5th 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
90th 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

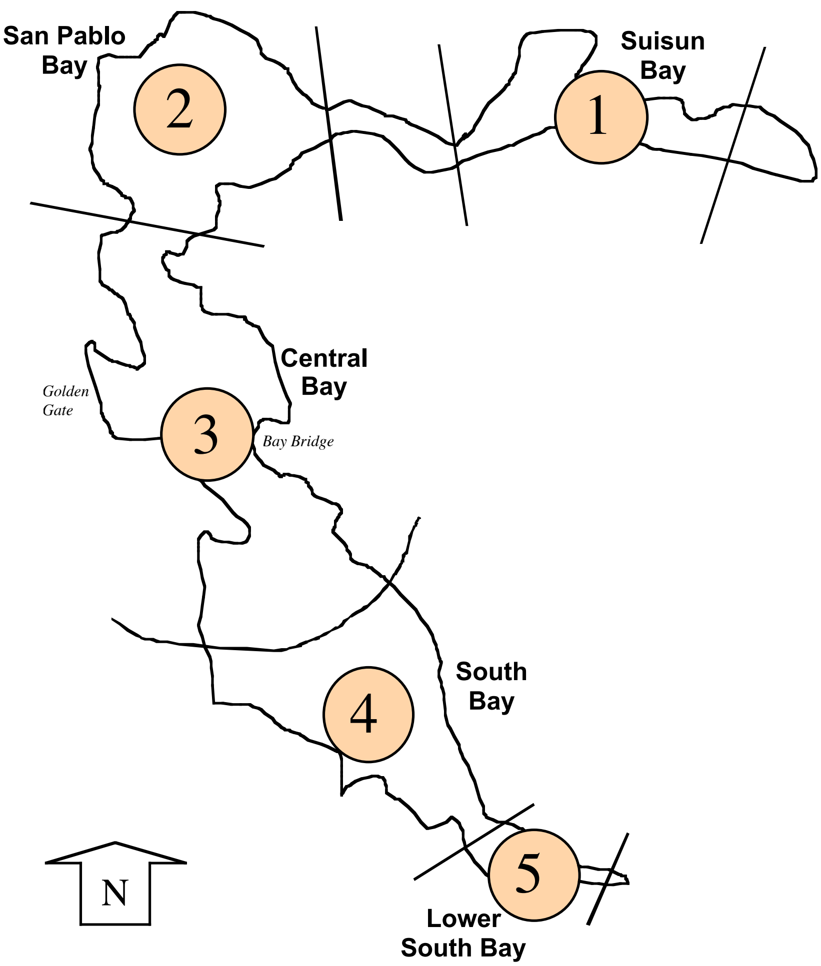
The low end of All Sites range is close to the Lower South Bay SSO value of 6.9 µg/L. The copper speciation results (Bruland 2003) provide an independent line of evidence that a SSO value in that range could be considered protective bay-wide. The report calculated that if the concentration of dissolved 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.

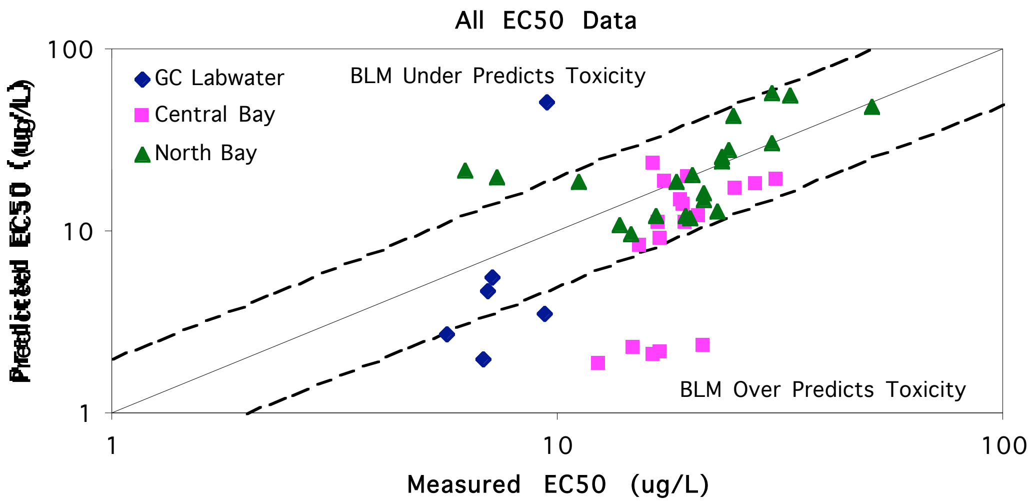
Previous comparisons of BLM predictions with measured toxicity data have established plus or minus a factor of 2 as a standard comparison indicating good agreement between predicated and measured values (Santore et al., 2001). Comparison of measured and predicted EC50 values in these results initially 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.

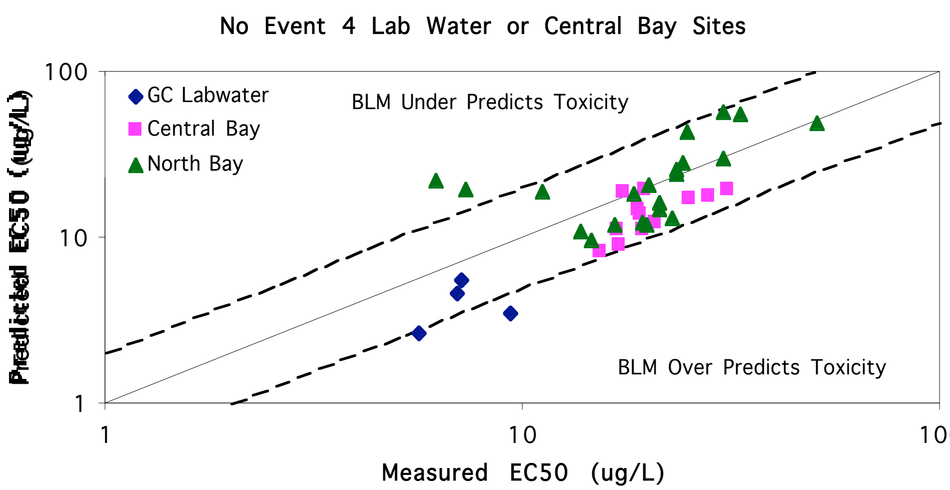
All of these samples with very low or high DOC concentrations were also cases where the BLM predictions based on those reported DOC concentrations did not match well with measured values. When these suspect TOC samples are censored, the comparison of predicted and measured Cu EC50s improves dramatically (**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.

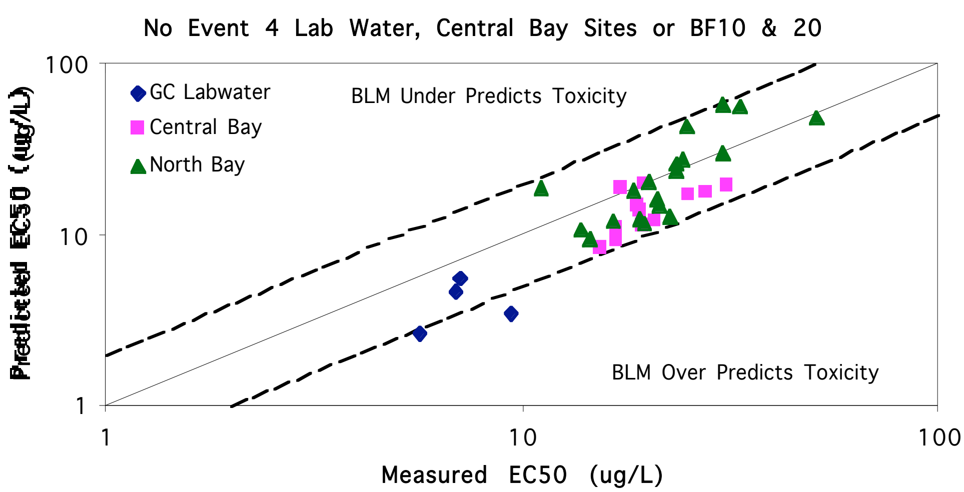
There does appear to be a systematic bias in the model results showing predictions that are too low at DOC concentrations below 4.0 mg C/L, and too high at DOC concentrations above this value. In general, the Cu BLM applied to estuarine data appears to predict too strong an impact of DOC on copper toxicity. 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 90^{th} 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).

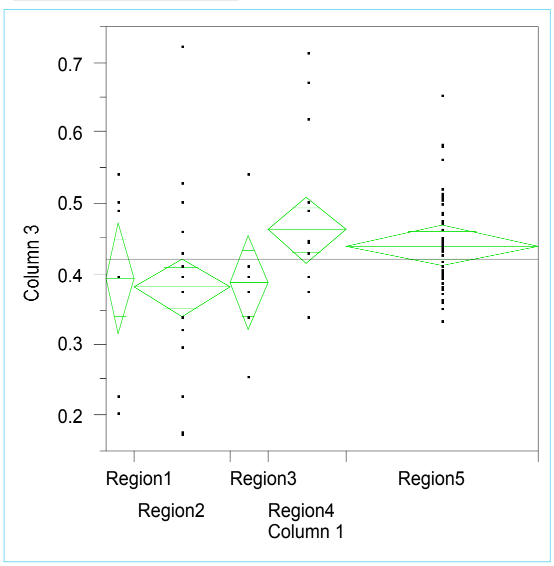
Table 1. Mean Water-Effect Ratios* by Bay Region

	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.*

City of San José Comment: 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.

City of San José Comment: 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:
  - 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.
- 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

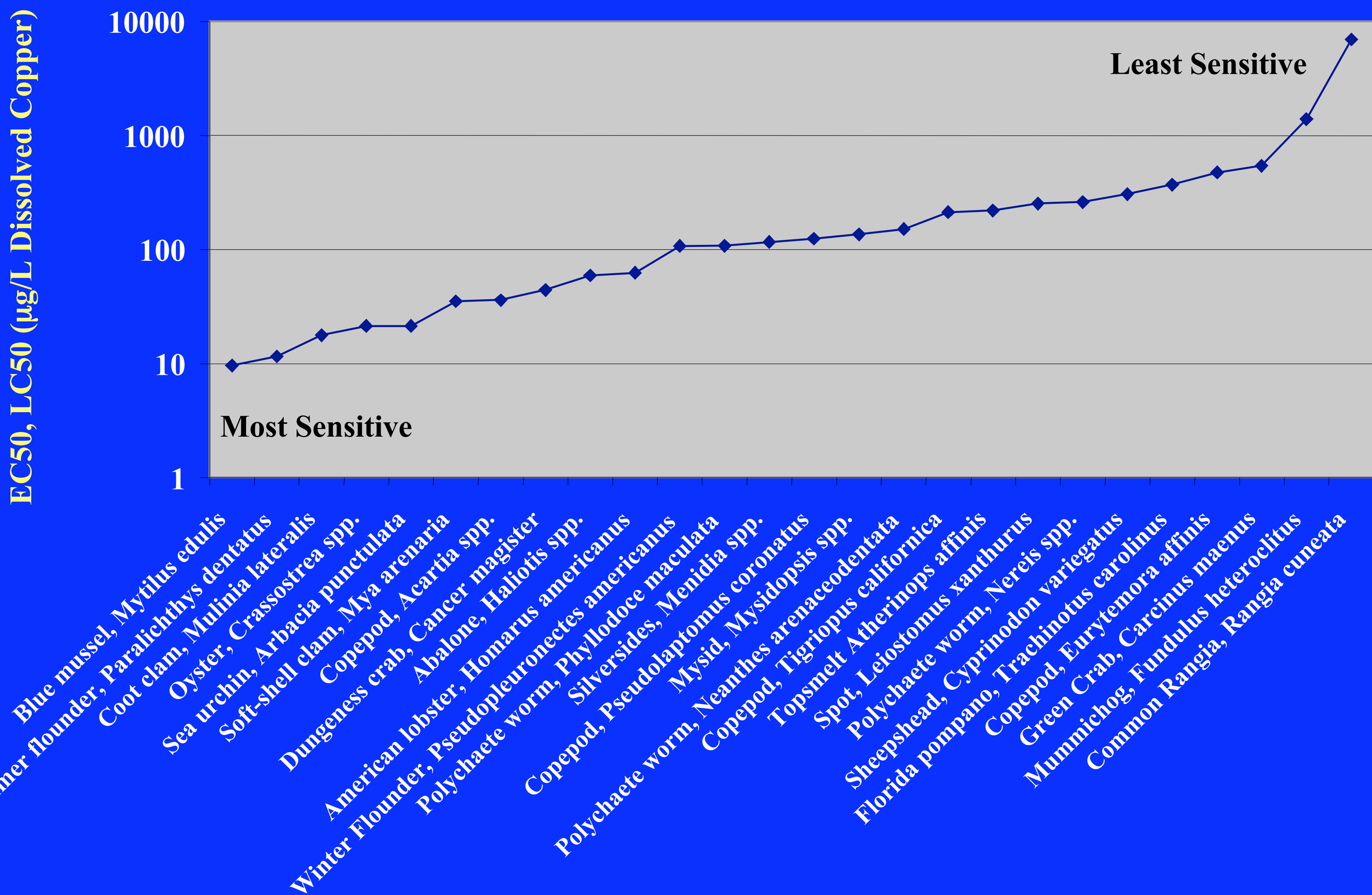
EPA 1995 Saltwater Copper Addendum

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)

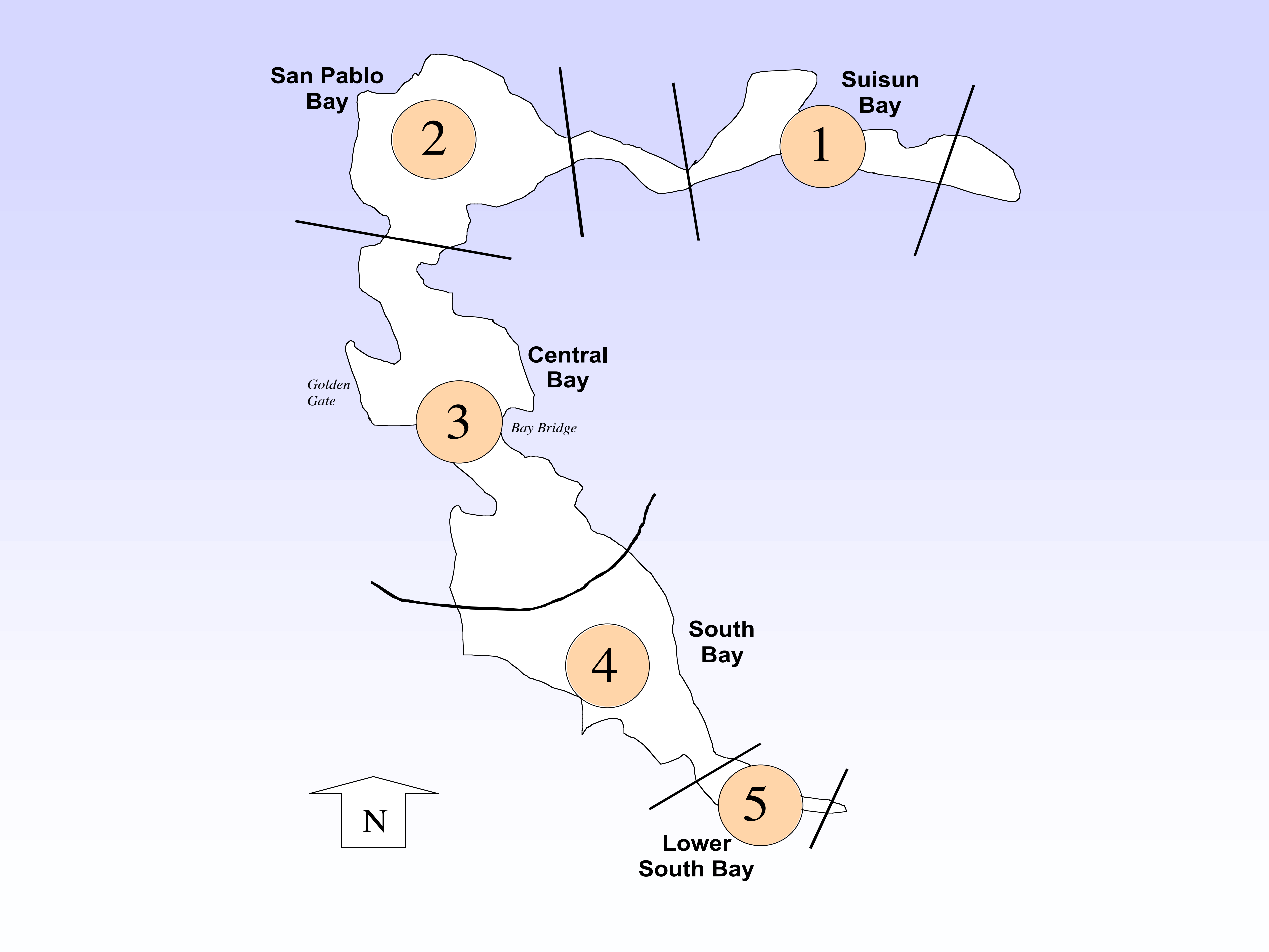


Sensitivity Revisited

- 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

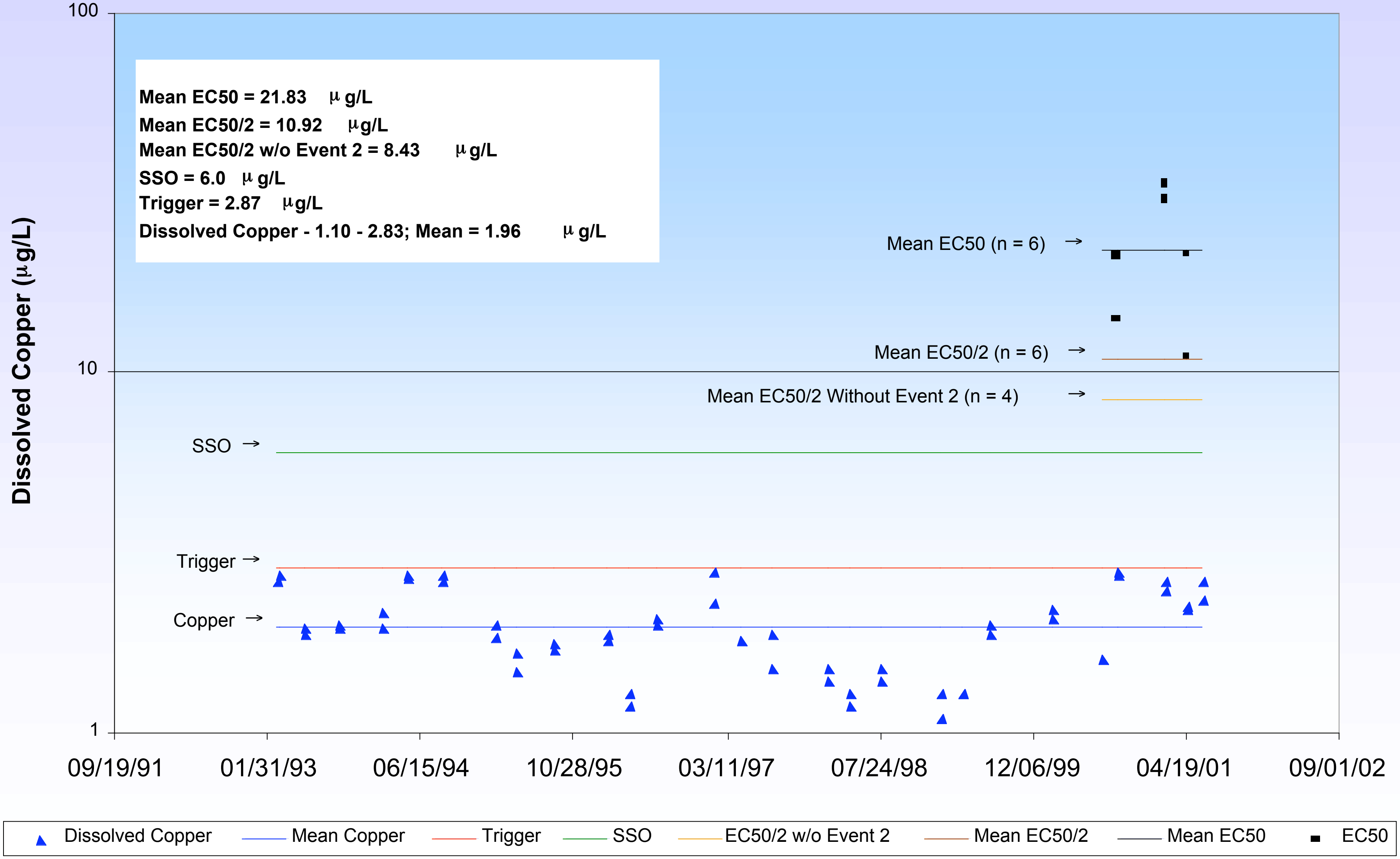


Figure 2. Bay Region 2 Copper Concentrations; Toxicity Values; Potential Trigger and Site-Specific Objective

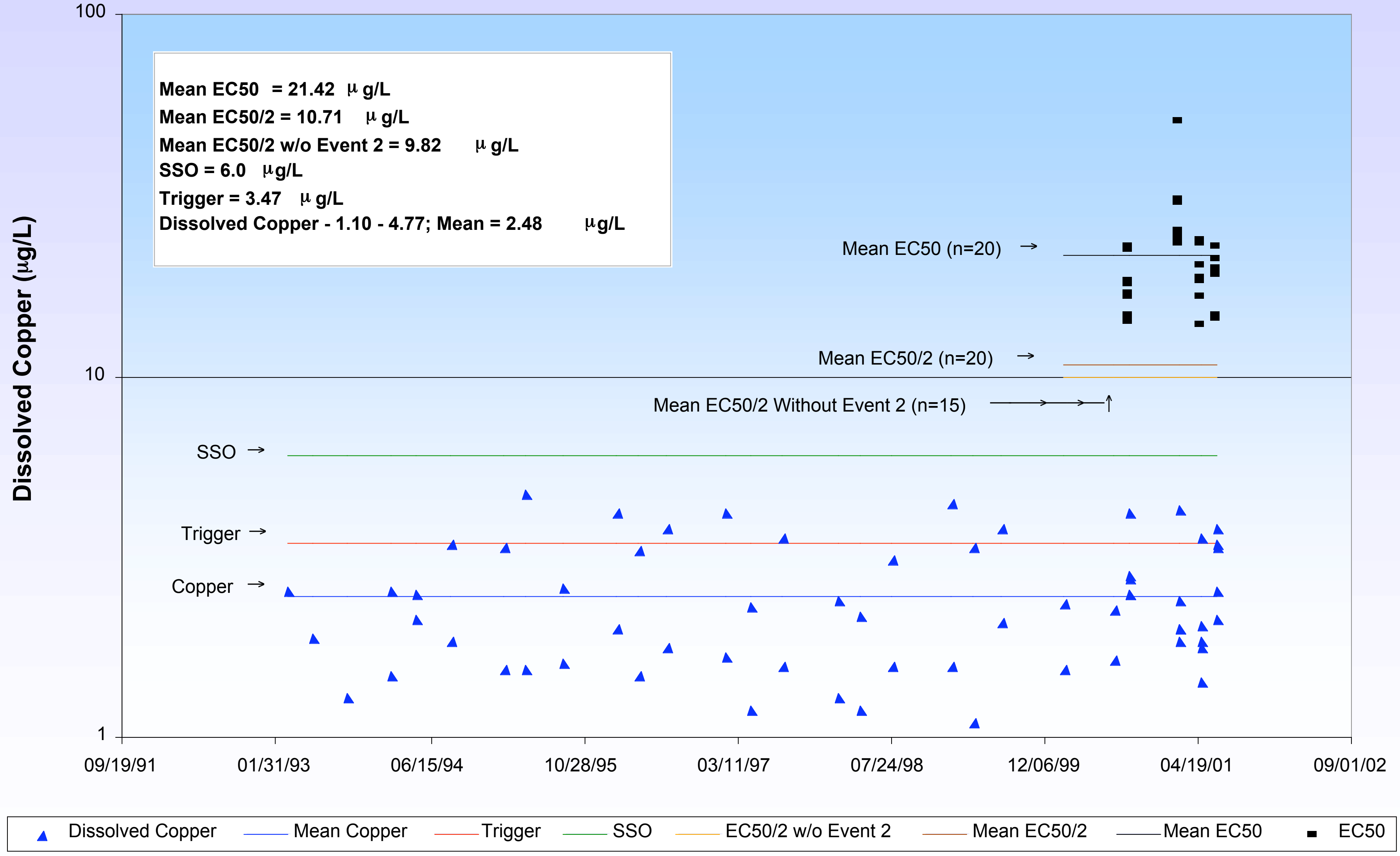


Figure 3. Bay Region 3 Copper Concentrations; Toxicity Values; Potential Trigger and Site-Specific Objective

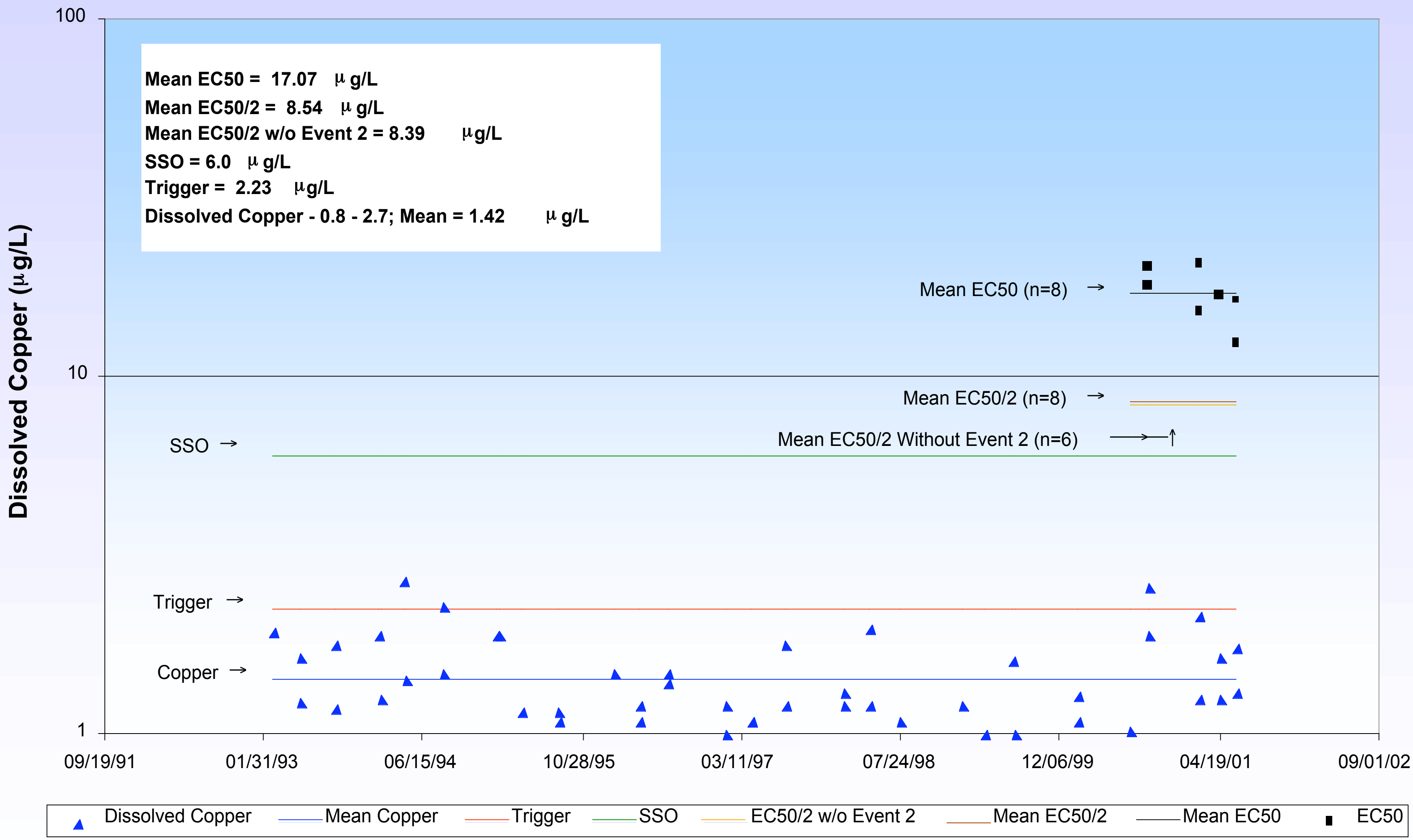


Figure 4. Bay Region 4 Copper Concentrations; Toxicity Values; Potential Trigger and Site-Specific Objective

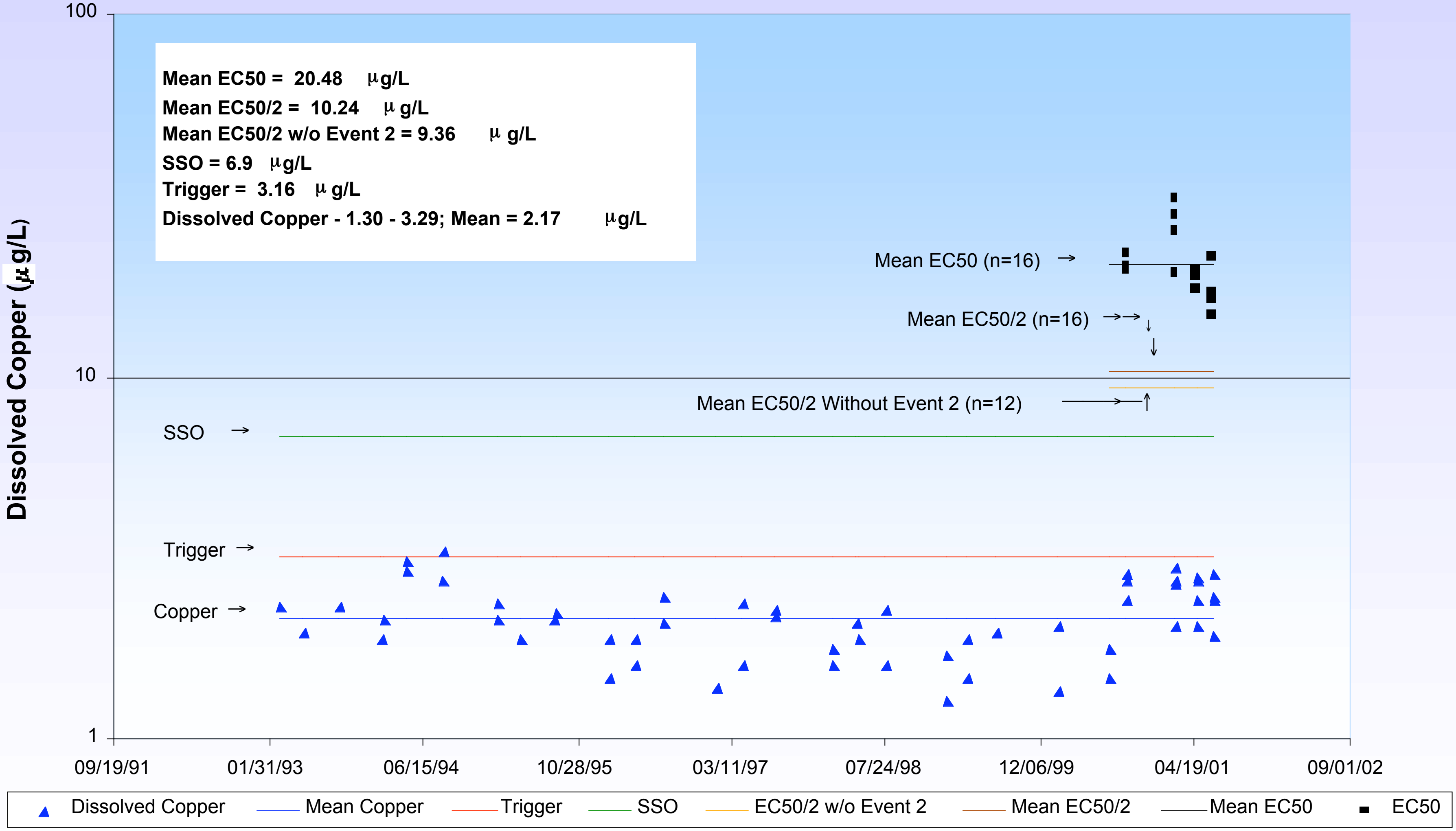
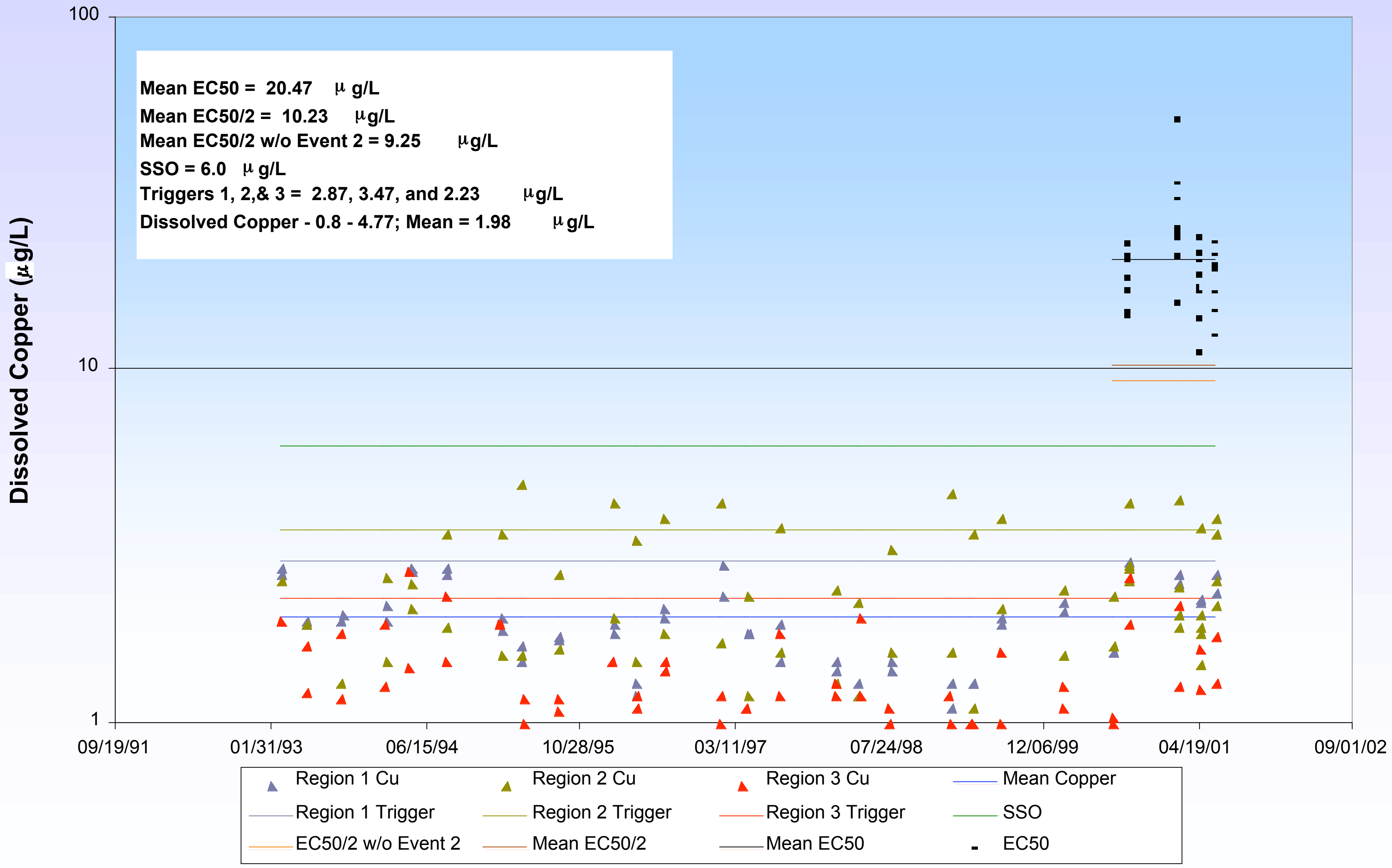
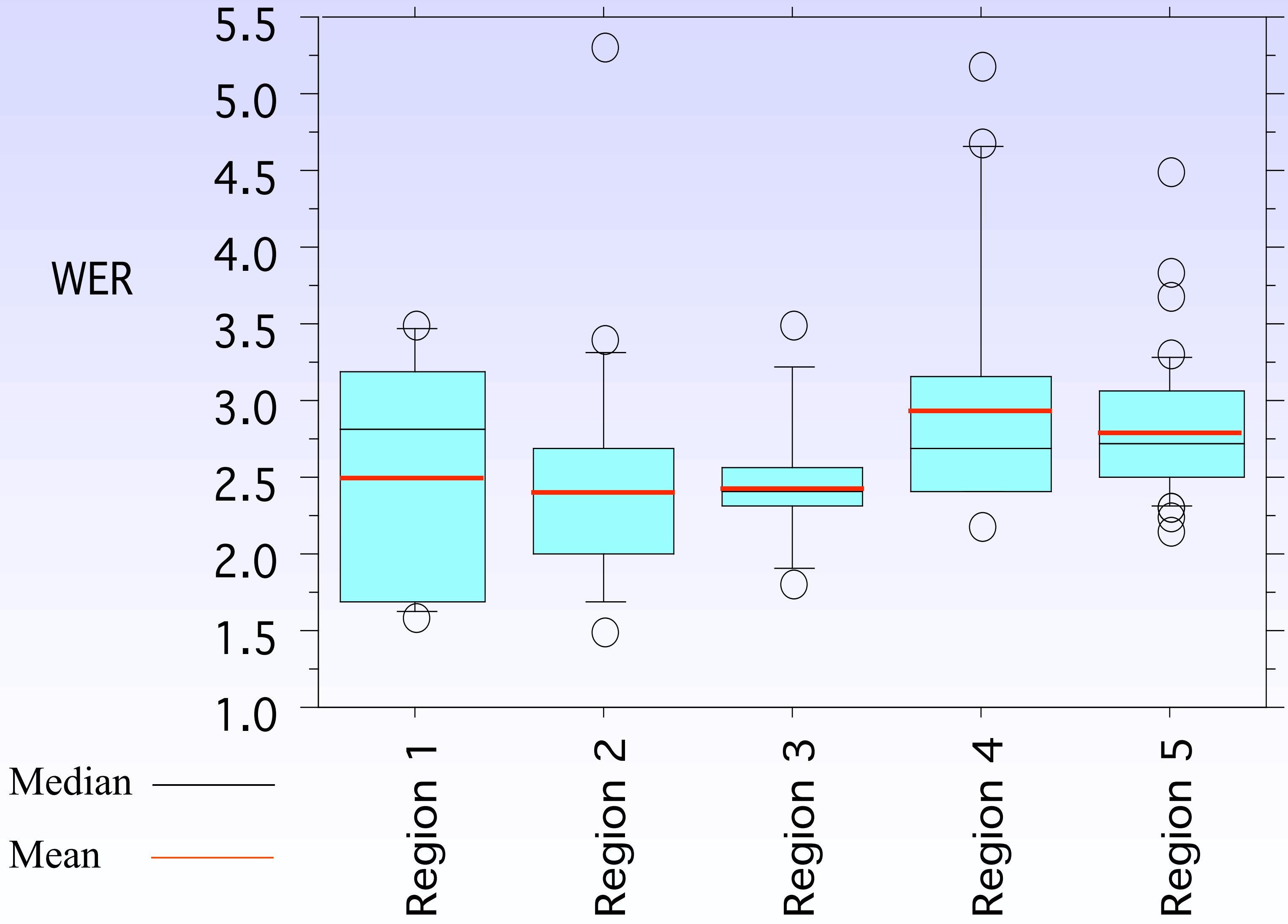


Figure 5. Bay Regions 1-3 Copper Concentrations; Toxicity Values; Potential Triggers and Site-Specific Objective

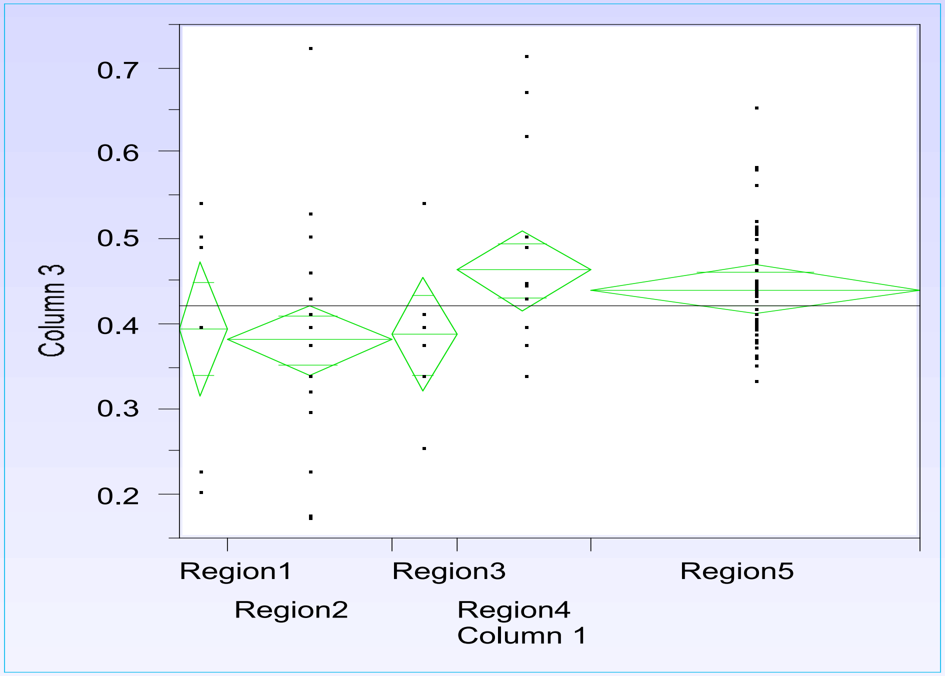


Geometric Mean WERs by Bay Region



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

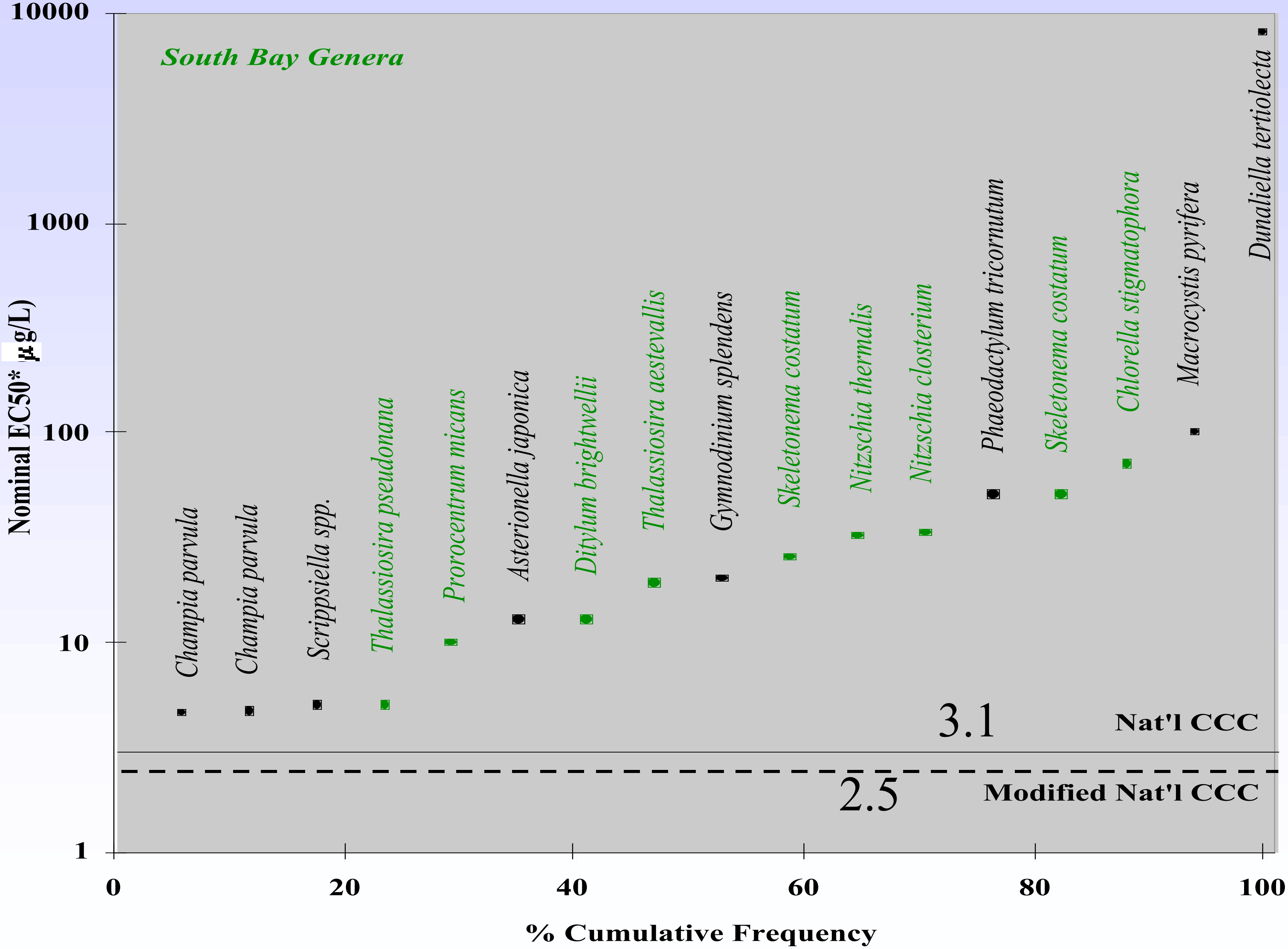
Horizontal Lines = Mean of Logs +/- 1s

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 (measure) 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**	
	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			
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