STAFF REPORT

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PROPOSED AMENDMENTS TO THE WATER QUALITY CONTROL PLAN TO INCORPORATE WATER EFFECT RATIOS (WERs) FOR COPPER IN LOWER CALLEGUAS CREEK AND MUGU LAGOON (CALLEGUAS CREEK WATERSHED, VENTURA COUNTY)

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I. SUMMARY OF PROPOSED ACTION

Action

Regional Board staff proposes an amendment to the Basin Plan to incorporate water-effect ratios (WERs) [1] that would modify the copper water quality objectives for lower Calleguas Creek and Mugu Lagoon in the Calleguas Creek Watershed in Ventura County. The WERs would be applied as multipliers to the copper water quality criteria contained in the federal California Toxics Rule (CTR) codified in 40 CFR 131.38. The CTR establishes a mathematical function to calculate criteria for metals, using thresholds for copper (criteria), a water-effect ratio (WER) multiplier and other variables. The WER has a default value of 1.0 unless a study is conducted consistent with US EPA's WER guidance and adopted by the Regional Board. If approved, the WER would modify the current acute (one-hour average) and chronic (4-day average) copper objectives set to protect aquatic life for this subset of inland surface waters. The goal of this amendment is to take into account site specific conditions in these two waterbodies, which have been shown to reduce the toxicity of copper to aquatic life, to modify the water quality objectives for copper applicable to these waters such that the objectives as protective of the aquatic life in these waterbodies as the criteria set forth in the CTR. Methods to develop the WERs are set forth in US EPA's guidance (US EPA 1994, US EPA 2001). The proposed changes are based on toxicity tests using the saltwater species *Mytilus edulis*, commonly called blue mussels. Other copper WER studies have been conducted in California; some of these are summarized for comparison in Appendix D.

Reports

The proposed basin plan amendment is based on the Technical Report, "Calleguas Creek Watershed Copper Water-Effects Ratio (WER) Study" (LWA WER Study), prepared by Larry Walker Associates (LWA) on behalf of the Calleguas Creek Watershed Management Plan, a stakeholder group in the Calleguas Creek Watershed. The technical report prepared by LWA contains a detailed description of the scientific background and data collection and analysis that support the proposed Basin Plan amendment. The technical report is distinguished from this staff report in that it does not necessarily present the recommendation of Regional Board staff. The final consultants' report on recommended water-effect ratios for copper (Larry Walker Associates, 2005) is included as Appendix 3 to this staff report, and other reference documents are cited as appropriate.

The purpose of this staff report is to:

1. provide a summary of the key components and results of the LWA WER study;
2. describe the main issues that were raised by reviewers of the LWA WER study (including those raised by Regional Board staff, Heal the Bay, a peer reviewer hired by the stakeholder group, and the State Board assigned peer reviewer);
3. present Regional Board staff's proposed amendment and describe the alternatives considered; and

[1] A water-effect ratio is a measure of the toxicity of a material obtained in site water from a particular waterbody divided by the same measure of the toxicity of the same material obtained simultaneously in a laboratory dilution water.

4. consider the factors set forth in Water Code section 13241.

Regional Board staff reviewed US EPA and State Water Resources Control Board guidance and water quality criteria relevant to the proposed amendments. Regional Board staff did not perform or contract for any water quality sampling or other field or laboratory studies as part of this project.

Target Waterbodies

See Table 1 for a description of the waterbodies for which WERs were developed and Figure 1 for a map of the same waterbodies.

Table 1 – Reaches in the Calleguas Creek Watershed Affected by the Water-effect Ratios

Reach Names as identified in Metals TMDL	Reach Names listed in 303(d) List and Consent Decree	Geographic Description	Notes
1 Mugu Lagoon	Mugu Lagoon	Lagoon fed by Calleguas Creek	Salinity of water samples for this study ranged from 4.7 to 31.5 ppt; contiguous with Pacific Ocean
2 Lower Calleguas Creek	Calleguas Creek Reach 1 and Reach 2 (Estuary to Potrero Road)	Downstream (south) of Potrero Road	Salinity of water samples for this study ranged from 0.3 to 1.4 ppt; tidal influence; concrete lined; tile drains; Oxnard Plain

Figure 1. Monitoring and Wastewater Treatment Plant Discharge Locations applicable to LWA WER Study

II. IMPETUS FOR PROPOSED AMENDMENT

Purpose of a Water-Effect Ratio

The toxicity of a metal to aquatic life can be influenced by a variety of physical and chemical characteristics of both the site water and the metal itself. If there is a difference in toxicity due to the site water and it is not taken into account, the aquatic life criterion for the waterbody will be more or less protective than intended by EPA's "Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses," which were designed to be protective of conditions throughout the United States. Because of the potential for site-specific conditions to vary from the conditions used to derive the national aquatic life criterion, US EPA has provided guidance concerning three procedures that may be used to convert a national criterion into a site-specific criterion (US EPA, 1994). In instances where the chemistry of local water is different from laboratory test water, such as those used to establish California Toxic Rule (CTR) criteria, the appropriate procedure to use is the water-effect ratio (WER) method. A WER is a means to account for a difference between the toxicity of copper in laboratory test water and its toxicity in local waterbodies. A WER of 1.0 indicates equivalence between local waters and laboratory dilution water, while a WER of greater (*or less*) than 1.0 indicates lower (*or higher*) toxicity in local waters than in laboratory dilution waters.

After a WER is determined for a site, the applicable criteria are calculated by multiplying the criteria from the CTR by the WER. Most WERs are expected to be equal to or greater than 1.0, but some might be less than 1.0. If a WER is greater than 1.0, then the chemistry of the site water makes the metal less toxic than that metal would be in lab water and therefore the objective will be higher (less stringent). Conversely, if a WER is less than 1.0 then the chemistry of the site water makes the metal more toxic than the metal would be in lab water and therefore the objective will be lower (more stringent). (US EPA, 1994)

Rationale for Developing a Water-Effect Ratio

Bioavailability and toxicity of copper are dependent on site-specific factors such as pH, hardness, suspended solids, dissolved oxygen (i.e., Redox state), dissolved carbon compounds, salinity, and other constituents. Beyond the headwaters, many of the waterbodies in Los Angeles and Ventura Counties are dominated by effluent from publicly owned treatment works (POTWs), particularly during the prevailing dry weather conditions in Southern California. Characteristics of these waterbodies, such as high hardness and ionic composition, vary from conditions in other waterbodies where there is significant flow from sources other than POTW discharges. These differences in water chemistry illustrate that developing and implementing a WER for these waterbodies may be appropriate.

It is in the interest of the Regional Board and stakeholders to establish the most appropriate objective for a waterbody. The 303(d) list of impaired water bodies identifies Mugu Lagoon and lower Calleguas Creek as impaired due to levels of copper that exceed CTR criteria. Before implementing additional controls for copper, stakeholders wanted to ensure that the national criteria were appropriate for these waterbodies, given site specific conditions, by conducting a WER study.

303(d) List and the Calleguas Creek Metals and Selenium Total Maximum Daily Load

In accordance with Section 303(d) of the Clean Water Act (CWA), 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. Three of fourteen reaches in the Calleguas Creek Watershed (CCW) in southern Ventura County are identified on the 2002 Clean Water Act Section 303(d) list of water-quality limited segments as impaired due to elevated levels of metals and selenium in water. Mugu Lagoon was listed on the 1998 303(d) list due to levels of copper that exceeded Basin Plan total recoverable metals objectives and/or United States Environmental Protection Agency (US EPA) national criteria. Lower Calleguas Creek was listed for dissolved copper in 2002. These exceedances were the basis for the concern that copper was impairing aquatic life uses in the Lagoon and Creek, resulting in either acute or chronic toxicity in sensitive aquatic organisms. The consent decree[2], which requires development of total maximum daily loads (TMDLs) for impaired waterbodies in the Los Angeles Region, includes Mugu Lagoon (Reach 1) for total copper and lower Calleguas Creek (Reach 2) for dissolved copper in TMDL analytical unit 2.

The 303(d) listings, which were approved by the State Water Resources Control Board in February 2003 and US EPA in July 2003, require the development of TMDLs to establish the maximum amount of pollutants a water body can receive without exceeding water quality standards. The Calleguas Creek Watershed Metals and Selenium TMDL addresses the requirements prescribed by Section 303(d) of the Clean Water Act (40 CFR 130.2 and 130.7) and US EPA guidance (US EPA, 1991). The Regional Board adopted the TMDL on June 8, 2006. The State Board, OAL and US EPA must still approve the TMDL before the regulatory provisions of the TMDL become effective. The WER is an outgrowth of the TMDL and is being developed to address the copper impairments in Mugu Lagoon and lower Calleguas Creek as part of a comprehensive strategy to addressing metals impairments in the Calleguas Creek watershed.

III. STAKEHOLDER / TAC PROCESS

The Calleguas Creek Watershed Management Plan (CCWMP) is a stakeholder led watershed management group, which was formed in 1996. The CCWMP includes broad participation from Federal, State and County agencies, municipalities, POTWs, water purveyors, groundwater management agencies, and agricultural and environmental groups. In 2001, the CCWMP proposed to the US EPA and Regional Board that they assume a key role in the development of the water quality plans for the Calleguas Creek watershed, including the development of the Calleguas Creek Metals and Selenium TMDL and the Copper WER.

The Work Plan for the “Calleguas Creek Watershed Copper Water-Effects Ratio (WER) Study” was developed during 2003 by the CCWMP. Larry Walker Associates wrote the Work Plan for the CCWMP. The Work Plan was reviewed by Technical Advisory Committee (TAC) member Russ Flegal of the University of California Santa Cruz; Technical Working Group member Sam Unger of the Los Angeles Regional Water Quality Control Board; and Lucie McGovern of the City of Camarillo. This approach to review is consistent with US EPA’s WER guidance (US EPA, 1994), which recommends that a multi-disciplinary “design team” with site-specific knowledge be used.

The workplan for this study called for a technical review panel consisting of three experts in the field of toxicity, ecology and chemistry to review of the work plan and subsequent deliverables for this study, written by LWA. The members of the technical review panel (hereafter called the technical advisory committee (TAC)) can be found in Table 1, Appendix C. When Regional Board staff began to seek review of the LWA technical report, “Calleguas Creek Watershed Water-Effects Ratio (WER) Study,” Regional Board staff was told that Charles Delos (US EPA), Russ Flegal (UC Santa Cruz) and Dave Hansen (private consultant) were the likely TAC to review the work. Of the three reviewers, the only TAC member to complete a review of the

[2] Heal the Bay, Inc., Santa Monica Baykeeper, Inc., and Terry Tamminen, Plaintiffs V. Carol Browner, Administrator of the United States Environmental Protection Agency, Felicia Marcus, Regional Administrator of the United States Environmental Protection Agency, Region IX, and the United States Environmental Protection Agency. United States District Court for the Northern District of California. March 23, 1999.

report was Dave Hansen. Regional Board staff considered and utilized the key comments made by Dave Hansen.

Health and Safety Code Section 57004 mandates external scientific peer review to determine whether the scientific portions of proposed rule are based upon sound scientific knowledge, methods, and practices. In accordance with this statute, on May 25, 2006 the chief of the Toxicology and Peer Review Section of the Division of Water Quality, State Water Resources Control Board, sent a letter to Regional Board staff informing staff that Dr. James Moffett, a senior scientist from Woods Hole Oceanographic Institution, Marine Chemistry and Geochemistry Department had been assigned to be the external peer reviewer for the proposed amendment to adopt water effect ratios for copper in lower Calleguas Creek and Mugu Lagoon. On June 22, 2006, Regional Board staff sent a formal request for review to Dr. Moffett along with the scientific documents and supporting documents for his review. On July 25, 2006, Dr. Moffett emailed his comments in a short report (see Appendix F).

"Regional projects" must conduct a CEQA scoping meeting (section 21083.9 of Public Resources Code). CEQA Scoping meetings are designed to identify the "scope and content" of the environmental documents, including the range of actions, alternatives, mitigation measures, and significant effects to be analyzed (CCR § 15083). Notice of a CEQA scoping meeting for the project was sent to approximately 270 persons. The meeting was held on February 23, 2006. No significant comments were received at this meeting.

IV. OVERVIEW OF EXISTING WATER QUALITY STANDARDS

Regional Water Quality Control Plan

Water quality standards in California include designated beneficial uses, narrative and numeric water quality objectives (equivalent to the federal term "criteria") for protection of designated uses, and an anti-degradation policy. The Regional Water Quality Control Plan (Basin Plan) as amended contains the beneficial uses and water quality objectives for the Los Angeles region, including the Calleguas Creek watershed. The Basin Plan contains narrative objectives for toxicity. The Plan states that "All waters shall be maintained free of toxic substances in concentrations that are toxic to, or that produce detrimental physiological responses in human, plant, animal, or aquatic life."

California Toxics Rule (CTR) Water Quality Criteria

Federal water quality standards under section 303 of the Clean Water Act consist of designated uses and criteria to protect those uses. (40 C.F.R. 131.3(i).) Designated uses are tantamount to "beneficial uses" under state law, and federal criteria are water quality objectives under state law. In addition to objectives set forth in the Basin Plan, federally promulgated criteria applicable to California waters are also part of the California water quality standards.

On May 18, 2000, the US EPA promulgated numeric criteria for certain "priority pollutants" for the State of California. Collectively, the criteria are part of the California Toxics Rule (CTR), codified as 40 CFR section 131.38. The CTR establishes the numeric water quality objectives for various toxic pollutants. These objectives apply "without exception" to all inland surface waters within the State of California, including the Los Angeles region. (40 C.F.R. 131.38(d)(1)-(2).) The CTR numeric criteria for priority toxic pollutants were promulgated for the protection of aquatic life and human health. The aquatic life criteria include one-hour average (acute) and four-day average (chronic) concentrations of these chemicals to which aquatic life can be exposed without harmful effect. The human health criteria are typically applied as 30-day average concentrations for consumption of organisms and water or consumption of organisms only. The CTR criteria for copper set to protect aquatic life are shown in Table 2 below.

Table 2 - California Toxics Rule Water Quality Criteria for Copper

Compound	Freshwater CMC[3] ug/L	Freshwater CCC[4] ug/L	Saltwater CMC ug/L	Saltwater CCC ug/L
Copper	13 (1,2,3)	9.0 (1,2,3)	4.8 (2,3)	3.1 (2, 3)

Notes:

1. Freshwater aquatic life criteria for metals are expressed as a function of total hardness (mg/L) in the water body. Values displayed above correspond to a hardness of 100 mg/L. Criteria will increase or decrease as site-specific hardness increases or decreases.
2. Criterion for this metal is expressed as a function of the water-effect ratio (WER).
3. The freshwater and saltwater criteria for metals are expressed in terms of the dissolved fraction of the metal in the water column.

In the CTR, the US EPA has provided for the adjustment of these water quality objectives through the application by States of the WER procedure. The WER is applied as a multiplier to the copper water quality criteria. The WER has a default value of 1.0 unless a study is conducted consistent with US EPA's WER guidance and adopted by the Regional Board, establishing the ratio that represents the difference between toxicity in laboratory test water and toxicity in a specific water body based on ambient conditions.

Antidegradation

The state's Antidegradation Policy is contained in State Board Resolution 68-16, Statement of Policy with Respect to Maintaining High Quality Water in California. The Antidegradation Policy states that water quality in surface and ground waters of California must be maintained unless it is demonstrated that a change will be consistent with the maximum benefit of the people of the state, not unreasonably affect present and anticipated beneficial use of such water, and not result in water quality less than that prescribed in water quality plans and policies. In addition to meeting the state Antidegradation Policy, any actions that may result in a reduction of water quality of a water of the United States are subject to the federal Antidegradation Policy provisions contained in 40 CFR 131.12, which only allows for a reduction in water quality if existing beneficial uses are maintained and that the lowering of water quality is necessary to accommodate important economic and social development in the area.

V. WATER-EFFECT RATIOS STUDY

A water effect ratio, or WER, is the ratio of the toxicity of a chemical in site water to that chemical's toxicity in laboratory test water.

$$\text{WER} = \frac{\text{Site Water Copper EC}_{50}}{\text{Lab Water Copper EC}_{50}}$$

The procedure involves conducting a minimum of three sets of side-by-side toxicity tests using both laboratory and site water. The "effect level" of the test in the site water is divided by the "effect level" for the

[3] CMC = Criterion Maximum Concentration

[4] CCC = Criterion Continuous Concentration

laboratory water to derive the WER. The “effect level” used in this study was the effect concentration 50 (EC_{50}). The EC_{50} is the statistically derived concentration of a substance in an environmental medium expected to produce a certain effect in 50% of test organisms in a given population under a defined set of conditions. Typically, the resultant final WER is then used to modify an existing water quality objective by multiplying the objective by the WER to derive the modified objective.

The following is a summary of the “Calleguas Creek Watershed Copper Water-Effects Ratio (WER) Study” (2005) by Larry Walker Associates. The full study is included as Appendix 3.

STUDY DESIGN

EPA Guidance

The methods in the LWA WER Study generally follow the US EPA’s direction for the development of WERs contained in “Interim Guidance on Determination and Use of Water-Effect Ratios for Metals” (1994 Interim Guidance) (US EPA 1994). Another guidance document, “Streamlined Water-Effect Ratio Procedure for Discharges of Copper” (2001 Streamlined Procedure) (US EPA 2001) was deemed less appropriate for this study by Larry Walker Associates. The 1994 WER guidance was used as the basis for the analysis because not all of the criteria for using the Streamlined Method were met.

Test Organisms

Several factors must be considered when selecting test species to use in a WER Study. These include the salinity of the site water and the sensitivity of test species for the pollutant of concern, among other factors.

Based on these considerations, two test species were initially identified in the work plan, and used in the LWA WER Study. *Ceriodaphnia dubia* (commonly known as water flea), a freshwater aquatic invertebrate and approved US EPA test organism for freshwater toxicity testing, was used as a test species for the first two sample events on August 28, 2003 and January 28, 2004. *Mytilus edulis*, a marine bivalve with the common name of blue mussel or common mussel, was used as a test species for all four sample events: 8/26/03, 1/27/04, 3/1/04, and 4/15/06. *Mytilus edulis* is a routinely used US EPA toxicity test organism for saline environments.

The two waterbodies of focus, Mugu Lagoon and lower Calleguas Creek, are brackish to saline. The CTR states that for brackish waterbodies (those with salinities between 1 and 10 ppt more than 5% of the time) the more stringent of the freshwater and saltwater criteria apply. In the case of copper, the saltwater criteria are the more stringent. Therefore the saltwater criteria apply to both lower Calleguas Creek and Mugu Lagoon. Therefore, the saltwater species, *Mytilus edulis* is an appropriate test species to use in site water tests to set the WER.

Additionally, *Mytilus edulis* is recognized as a sensitive test species. It was the most acutely sensitive test species used in the development of the draft national copper criteria for acute conditions. In November 2003, US EPA published the 2003 Draft Update of Ambient Water Quality Criteria for Copper. Embryo-larval life-stages of bivalve mollusc genera represent the first two of the four most sensitive genera, including the genera *Mytilus*.

Sample Locations and Dates

There were a total of five sampling stations used to characterize the waterbody segments of focus. Three were located in Mugu Lagoon and two were located in lower Calleguas Creek. Lower Calleguas Creek is identified in the TMDL as Reach 2 of the creek; it extends from the estuary upstream to Potrero Road. Sampling primarily occurred from August 2003 to March 2004, with one additional sample event in April of 2006. See below for a schedule of the sample events.

Table 3 - Sampling Locations and Dates

<table>
<tr><th>Station Code</th><th>Site Location</th><th>Event 1</th><th>Event 2</th><th>Event 3</th><th>Event 4*</th></tr>
<tr><td></td><td></td><td>Dry</td><td>Dry</td><td>Wet</td><td>Wet</td></tr>
<tr><td>1-WER-A</td><td>Mugu Lagoon at 11th Street Bridge</td><td rowspan="4">8/26/03</td><td rowspan="6">1/27/04</td><td rowspan="6">3/1/04</td><td rowspan="4">---</td></tr>
<tr><td>1-WER-B</td><td>Central Mugu Lagoon</td></tr>
<tr><td>1-WER-C</td><td>Mugu Lagoon at Mouth</td></tr>
<tr><td>1-WER-D</td><td>Mugu Lagoon at Laguna Road Bridge</td></tr>
<tr><td>2-WER-A</td><td>Calleguas Creek at Potrero Road</td><td rowspan="2">8/27/03</td><td rowspan="2">4/15/06</td></tr>
<tr><td>2-WER-B</td><td>Calleguas Creek above Mugu Lagoon</td></tr>
</table>

*A fourth event was conducted for only Lower Calleguas Creek, to further characterize copper toxicity in the Creek during wet weather.

- Event 1 - Dry weather during late summer (August), low flows and calm conditions.
- Event 2 - Dry weather during winter (January), medium flows and somewhat calm conditions.
- Event 3 - Wet weather during winter (March), increased flows and turbid conditions following a storm event.
- Event 4 - Wet weather during winter (April), increased flows and turbid conditions during a storm event, Lower Calleguas Creek sites only.

Laboratory Methods

Upon arrival at the laboratory, water quality of the raw sample water was measured. Measurements included temperature, pH, total organic carbon (TOC), dissolved organic carbon (DOC), total suspended solids (TSS), total and dissolved copper, alkalinity, hardness, and salinity of the sample water in the lab. Samples were stored at 4+/- 2 °C. Toxicity tests were initiated within 24-36 hours of sample collection.

Previous work indicated that a salinity of below 25 ppt adversely affects the saltwater test species, *Mytilus edulis.* Site waters with a salinity of <28 ppt were salinity adjusted to the selected range by adding GP-2 salts (a synthetic sea salt) to ensure test species survival.

STUDY RESULTS: CALCULATION OF fWERS

Individual WERs were calculated and can be seen in Table 22 of the LWA Report (Appendix 3) entitled "Total and dissolved copper EC50 determinations for site water and lab water" (using *M. edulis*). For each location, individual WERs were calculated for each of the events by dividing the site water LC_{50} by the adjusted lab water LC_{50}. An LC_{50} value is the concentration of a material in the environment that will kill (is lethal to) 50% of the test organisms. An LC_{50} is a type of EC_{50} where the effect is mortality. To calculate the final WER or fWER the adjusted geometric mean was taken of the individual WERs from the weather condition that was most critical (dry weather for the lagoon and wet weather for the creek). To be environmentally conservative, two individual WER values (Event 3, sites 1-WER-A and 1-WER-B) were excluded from the geometric mean calculation because they were notably higher than the rest of the individual WERs by a magnitude of ~2. Therefore, they were considered to be outliers. The final WERs are presented below.

Table 4 - Final WERs (fWERs) by Waterbody & Site

Test	Location	Critical Weather Condition	Geometric Mean
Mytilus edulis	Mugu Lagoon	Dry	1.51
	Lower Calleguas Creek	Wet	3.69

The fWER will be used as multipliers to modify the existing CTR objectives to obtain the modified objectives for lower Calleguas Creek and Mugu Lagoon. This calculation is shown below:

Modified Objective = CTR criterion[5] * Final WER

Table 5 - Final WERs and Modified Objectives for Mugu Lagoon and Lower Calleguas Creek.

Reach	Final WER	Modified Chronic Objective (ug/L)	Modified Acute Objective (ug/L)
Mugu Lagoon	1.51	4.68	7.25
Lower Calleguas Creek	3.69	11.4	17.7

VI. ANALYSIS OF ALTERNATIVES

Alternatives for the creek and lagoon WERs are discussed separately below. They are addressed separately because they are different waterbody types and this has implications for the way their respective fWERs are calculated. Most importantly, the critical weather condition (the weather condition producing the lowest WER) for the two waterbodies varies. The critical condition for the lagoon is dry weather and the

[5] CTR chronic criterion (CCC) is 3.1 ug/L and the CTR acute criterion (CMC) is 4.8 ug/L.

critical condition for the creek is wet weather. In addition, in 1994 Interim Guidance, different methodologies apply for calculating the fWER (method one applies to the creek and method two applies to the lagoon).

The Regional Board considered several alternatives for developing WERs for Mugu Lagoon and lower Calleguas Creek, respectively.

ALTERNATIVES ANALYSIS FOR MUGU LAGOON

Regional Board staff considered three alternatives for calculating the fWER for the lagoon:

- Alternative 1: A single WER based on the geometric mean of the individual dry weather WERs from the most sensitive site within the lagoon
- Alternative 2: Two WERs, one for the upper lagoon and one for the lower lagoon, based on the geometric mean of the upper sites' dry-weather individual WERs and the geometric mean of the lower sites' dry-weather individual WERs
- Alternative 3: A single WER based on the geometric mean of all dry weather individual WERs, except for the two excluded individual WERs.

Table 6 - Lagoon Data Considered

Site ID	Site location	Dry Weather – 8/26/03	Dry Weather – 1/27/04
1-WER-A	Upper site	1.68	~~2.8*~~
1-WER-B	Upper site	1.36	~~2.75*~~
1-WER-C	Lower site	1.26	1.31
1-WER-D	Lower site	1.71	1.83

* Outliers excluded from analysis based on recommendation of TAC member.

Under Alternative 1, the fWER would be 1.28, based on the geometric mean of the individual WERs for the two dry weather events at the most sensitive site (1-WER-C). This approach is consistent with the 1994 Interim Guidance, which gives decision-makers the alternative, for large waterbodies, to choose the geometric mean of the individual WERs from the most sensitive site(s) where there is variability in water chemistry (e.g. dissolved oxygen, salinity, hardness, total suspended solids) within the waterbody. This alternative is not recommended by staff, recognizing that the upper lagoon and lower lagoon are different from one another in terms of water circulation and chemistry (e.g. dissolved oxygen, salinity, hardness, total suspended solids) but that each sites in the upper lagoon were not so variable from one another and sites in the lower lagoon were not so variable from one another. Also, Regional Board staff determined that using the individual WERs from the most sensitive site in the lower lagoon might be overprotective of the upper sites. This led Regional Board staff to consider an upper and a lower fWER which is described in Alternative 2 below.

Under Alternative 2, two separate WERs would be calculated, one for the upper lagoon and one for the lower lagoon. Only one critical weather event (dry weather for the lagoon) and two individual WERs are available to calculate the fWER for the upper lagoon because two data points were excluded as outliers. [6,7] The WER for the upper lagoon would be 1.51. The WER for the lower lagoon using all four individual WERs for the lower sites is coincidently also 1.51. However, Regional Board staff concluded that the data are inadequate to develop a fWER unique to the upper lagoon at this time. Therefore, Alternative 3 was pursued - a single WER is calculated for the entire lagoon taking the geometric mean of the six non-excluded WERs listed above (these data are shaded in Table 6).

Alternative 3 is recommended by Regional Board staff. Under Alternative 1, the final WER is derived from the most sensitive site in the entire lagoon. The stakeholders requested that an alternative that would establish separate WERs for the upper and lower lagoon also be evaluated. This is reasonable, since it appears that the lower and upper lagoon may vary from one another in terms of water chemistry (e.g. dissolved oxygen, salinity, hardness, total suspended solids). However, there were insufficient data to calculate a fWER for the upper lagoon based on the current data set. Therefore, Regional Board staff recommends the third alternative, which would include all the dry weather data in the fWER calculation except the outlier data points. Regional Board staff concludes that a final WER of 1.51 would be protective of the most sensitive areas of the lagoon.

Regional Board staff wanted to explore whether there was a real difference in the toxicological effect resulting from a WER of 1.28 versus 1.51. Therefore Regional Board staff explored the difference in the toxicological response to a change in concentration of 1 ppb Cu. It was concluded that this change has a relatively small effect on the toxicological response of a sensitive organism such as mussel embryos. For example, spiked water tests with copper indicate that a 10% change in mussel (*Mytilus galloprovincialis)* embryo development (e.g. from ~40% abnormal to ~50% abnormal) is associated with an increase of about 1 ppb Cu. This is a worst case scenario because the chosen concentration was at the EC50. These data indicate that a dramatic change in impacts to resident fauna would not be expected by the increasing the fWER from 1.28 (Alternative 1) to 1.51 (Alternative 3).

In addition, in consulting the ambient water quality criteria document for Copper, Regional Board staff calculated the percent change in copper associated with the different WER alternatives, and then related that change with the impact that percent change in copper concentration would have on the percentage of species protected by the higher water quality criterion. The change in allowable copper concentration from Alternative 1 (1.28) to Alternative 3 (1.51) did not change the percentage of species affected by the concentration of copper.

Table 7 - Calculation Alternatives for Final WER for Mugu Lagoon

	Alternative 1	**Alternative 2**	**Alternative 3**
Upper Lagoon	1.28	1.51	1.51
Lower Lagoon		1.51	

[6] The 1994 Interim Guidance requires a minimum of 3 WER measurements considered to develop the final WER.

[7] Initially, technical advisory committee (TAC) member Dave Hansen recommended excluding one of the two upper dry weather events due to the concern that salts added to these samples or chemistry unique to these samples confounded the test results. Later these individual WERs were excluded because, although the issue of the salts was resolved, they were significantly higher than other individual WERs and therefore identified as outliers.

LOWER CALLEGUAS CREEK (Reach 2)

Using the data shown in Table 8, Regional Board staff considered three alternatives for the creek:

- Alternative 1: A single WER based on the geometric mean of *all the events* (wet and dry weather) at all creek stations
- Alternative 2: A single WER based on the geometric mean of *all dry weather* individual WERs at all creek stations
- Alternative 3: A single WER based on the geometric mean of *all wet weather* individual WERs at all creek stations

Regional Board staff originally concluded that the amount of sampling was inadequate to allow a fWER to be determined that is unique to the creek, since the critical condition for the creek appeared to be wet weather. The only WERs available for calculating the fWER were based on one sample event during the critical condition (wet weather for the creek) at two sample locations. Therefore, another wet weather event was conducted on April 14, 2006.

Table 8 - Creek Data Considered

Creek Stations	Wet Weather Event - 3/01/04	Wet Weather Event - 4/14/06
2-WER-A	3.40	4.20
2-WER-B	3.39	3.84

Under Alternative 1, a fWER would be calculated by taking the geometric mean of all the events (wet and dry weather) at all creek stations. This alternative is not recommended by staff because the data indicate that wet weather is the critical condition for the creek. In order to be protective of the creek, Regional Board staff recommends that the final WER for the creek be determined using data from the wet weather sampling events.

Under Alternative 2, a fWER would be calculated by taking the geometric mean of all dry weather events at all creek stations. Regional Board staff does not recommend Alternative 2 for the same reasons as Alternative 1.

Under Alternative 3, a fWER would be calculated by taking the geometric mean of all wet weather events at all creek stations. The most conservative and appropriate of the three alternatives is Alternative 3, since it uses data from the most critical weather condition. **Alternative 3 is recommended by Regional Board staff.**

Table 9 - Calculation Alternatives for Final WER for Calleguas Creek

Alternative 1	Alternative 2	Alternative 3
Geometric Mean (all individual WERs)	Geometric Mean (all individual dry weather WERs)	Geometric Mean (all individual wet weather WERs)
3.97	4.28	3.69

VII. SIGNIFICANT SCIENTIFIC ISSUES

Most Appropriate EPA Guidance: US EPA 1994 Interim Guidance vs. US EPA 2001 Streamlined Procedure

There are two US EPA guidance documents that could have been used in the LWA WER Study -- the 2001 Streamlined Water-Effect Ratio Procedure for Discharges of Copper or the 1994 Interim Guidance on Determination and Use of Water-Effect Ratios for Metals. The two guidance documents are applicable in different situations and have different requirements. Larry Walker Associates relied upon the 1994 "Interim Guidance on Determination and Use of Water-Effect Ratios for Metals." Regional Board staff determined that LWA chose the most applicable guidance and followed the minimum requirements of this guidance. The "Streamlined Water-Effect Ratio Procedure for Discharges of Copper" is recommended only for situations where copper concentrations are elevated primarily by continuous point source effluents. This is not the case in the Calleguas Creek watershed. The "Interim Guidance on Determination and Use of Water-Effect Ratios for Metals" has broader applicability and is appropriate in watersheds with multiple point and nonpoint source discharges.

Most Appropriate Test Organisms: *Ceriodaphnia dubia* vs. *Mytilus edulis*

To more adequately characterize conditions, Regional Board staff and Heal the Bay thought that two test species should be used in the Creek and the Lagoon. As discussed in the 1994 Interim Guidance, a secondary test should be conducted with a species that is taxonomically different than the first test species. (p. 21) Conducting tests on multiple species will account for species variation and sensitivity. Larry Walker Associates used two test species, *Ceriadaphnia dubi*a and *Mytilus edulis*, in the initial sample events.

WERs calculated using *Ceriodaphnia dubi*a in the Creek were 1.9 times higher on average for the two sites than the WERs calculated using *Mytilus edulis*. [8] Dr. James Moffett, the external peer reviewer for this project, commented that the observed trends of higher WERs using *Ceriodaphnia dubia* as compared to *Mytilus edulis* is not what is usually expected. He offered a potential explanation that the addition of salts to creek water when testing *M. edulis* could have removed some of the copper binding agents, which may result in WERs derived from *M. edulis* that are overly conservative (low). However, to fully understand the difference between the WERs using *C. dubia* and *M. edulis* in the creek water samples further testing would be needed and this was not elected.

Therefore, LWA decided that they would base the fWERs on the data from the more sensitive saltwater species, *M. edulis*. In addition to resulting in the most conservative WERs, this is most appropriate since the CTR specifies that where brackish conditions (salinities between 1 and 10 parts per thousand (ppt)) prevail more than 5% of the time, the more stringent criteria should apply. The more stringent criteria in this case are the saltwater copper criteria. Therefore, it is appropriate to use the data from the saltwater test species *M. edulis* to calculate the fWER.

[8] Median EC50 values calculated for the two Creek sampling sites are 1.9 using *M. edulis* and 3.2 using *C. dubia*. Median WER values calculated for the two Creek sampling sites are 4.4 using *M. edulis* and 8.4 using *C. dubia*.

Critical Weather Condition

As shown in Appendix C, Table 12, analysis of dry versus wet weather WERs in the lagoon and creek illustrates that dry weather produces the lowest site EC_{50}s for the lagoon and therefore the lowest WER, while wet weather produces the lowest site EC_{50}s and therefore the lowest WER for the creek. Therefore, to be protective under all weather conditions, the individual WERs calculated for the critical conditions must be used to calculate the fWER for the lagoon and the fWER for the creek.

Data Adequacy

During the review process of the LWA technical report, Regional Board staff was concerned that data collected in the WER Study were insufficient to develop an appropriate WER for Calleguas Creek and Mugu Lagoon. The first draft of this study included three sampling events under varied seasonal conditions: two dry weather events and one wet-weather event. The board requested an additional sample event at the two creek sites during the critical wet-weather condition, so that two wet weather events (the critical weather condition for the creek) would be available to calculate the fWER for the creek.

Standard parameters such as hardness and TSS were tested during these events to determine if the toxicity tests were conducted under "typical conditions" (see Appendix C). There was concern that the WER needs to be calculated from data that is representative of situations where copper is most bioavailable. The data points collected at each sampling location were collected under conditions considered typical, but it is very hard to obtain fully representative data without a large number of samples. Larry Walker Associates did satisfy the minimum requirements of the US EPA 1994 Interim Guidance and therefore Regional Board staff concluded that while additional data would give greater confidence in the results, the data were adequate to develop fWERs. In addition, future monitoring will be conducted to ensure the fWERs are protective of the beneficial uses.

Potential Interference from Addition of GP-2 Salts

Regional Board staff was originally concerned that the calculation of the appropriate WER for low salinity sites and times was uncertain because data from these tests suggest that a lower biological availability of copper in low **salinity** sites may be a result of the effect of the added GP-2 salts. Absent tests that demonstrated the role of the added salt, it was thought that the WERs derived for site waters where salinity adjustment was necessary could not be used. To use this data, it was important to demonstrate that added salt did not affect the availability of copper in low salinity waters. Three experts in the field (Dave Hansen, Steve Bay and Jeff Cosifas) were convened on a conference call to determine whether the GP-2 salts may have confounded the results. After a thorough discussion, it was concluded that the GP-2 salts were not an issue. This decision was rendered after studies were made available that showed that under similar conditions GP-2 salts did not affect the bioavailability of the copper in the site water where they were added.

Effect of Creek on Lagoon

Dr. James Moffett commented that while he does not think the WER for the creek is too large, he is concerned that a higher criteria in the creek may result in more Cu entering the lagoon. He expressed that ultimately a waste load allocation model rather than a site specific criterion for the creek, may limit allowable discharges. Regional Board staff expressed that regional monitoring plans would address this issue. The monitoring plan would show if the targets of the TMDL are being met, and if excessive loadings are found, the WER or TMDL can be reconsidered.

Biotic Ligand Model

Dr. James Moffett commented that the biotic ligand model (BLM) was mentioned in Larry Walker Associates' report as a side project funded by the Copper Development Association, but not in the staff report. He expressed that data used in that model might be useful in unraveling some of the seasonal variability and wondered why it was not discussed. In response to this comment, LWA explained that during the time of this study, it was determined that the BLM wasn't accurate for marine water at this stage of development. However, studies demonstrated that copper toxicity to *M. edulis* is inversely proportional to the concentration of DOC in the site water. In fact, analytical chemistry data collected as part of this project were used to validate this model. A comparison of model-predicted copper EC50 values to the *M. edulis* copper EC50 values reported in this study were in agreement, indicating that the site water characteristics (i.e., DOC) were driving the decrease in copper toxicity to *M. edulis*.

VIII. RECOMMENDED ALTERNATIVE

Regional Board staff recommends that the Board adopt the WERs given in Alternative 3 for both lower Calleguas Creek and Mugu Lagoon as described above. A fWER of **1.51 for the Mugu Lagoon** is obtained by taking the geometric mean of all dry weather individual WERs, except for the two excluded individual WERs. A fWER of **3.69 for lower Calleguas Creek (Reach 2)** is obtained by calculating the geometric mean of all wet weather events at all creek stations.

IX. PROPOSED CHANGES TO REGIONAL WATER QUALITY CONTROL PLAN

The following language will be added to Chapter 3, Water Quality Objectives of the Basin Plan, as a new section (in alphabetical order):

Priority Pollutants

The California Toxics Rule (CTR), located at 40 CFR 131.38, contains federally promulgated water quality objectives applicable to California waters for 126 priority pollutants for the protection of aquatic life and human health.

Implementation Provisions

The water quality objectives for metals contained in the CTR are expressed as a function of a water-effect ratio (WER). [9] In the CTR, the US EPA has provided for the adjustment of these water quality objectives through the application by States of the WER procedure. The WER has a default value of 1.0 unless a site-specific WER is approved. To use a WER other than the default of 1.0, a study must be conducted, establishing the ratio that represents the difference between toxicity in laboratory test water and toxicity in a specific water body based on ambient conditions. The study must be consistent with US EPA procedures on deriving WERs and must be adopted by the Regional Board.

Additional receiving water monitoring shall be required of dischargers subject to site-specific WER(s) to evaluate whether objectives, as modified by the WER(s), are as protective of beneficial uses as the CTR

[9] There are two exceptions where the criteria are not a function of a WER. The freshwater criteria for selenium are not a function of a WER. The freshwater and saltwater criteria for mercury are not a function of a WER.

objectives are intended to be. This additional monitoring shall be required through the discharger's NPDES permit monitoring and reporting program. If additional monitoring indicates a change in the chemical characteristics of the water body or toxicity, the Regional Board may reconsider the site-specific WER(s).

Copper

For the following water bodies, the copper water quality objectives contained in the CTR shall be modified using the site-specific WERs set forth below.

Table 10 - Site-specific Water-Effect Ratios for Copper

Waterbody Name	**Reach Name**	**Description of Reach/Area**	**Water-Effect Ratio**
Mugu Lagoon	Reach 1	Lagoon fed by Calleguas Creek	1.51
Lower Calleguas Creek	Reach 2	Downstream (south) of Potrero Road to the lagoon	3.69

X. EFFECT OF WERs ON WATER QUALITY OBJECTIVES AND COMPARISON TO EXISTING WATER QUALITY OBJECTIVES

Comparison of Modified Objectives and Current Basin Plan Objectives

The proposed water-effect ratio(s) will result in modified copper objectives that are higher (less stringent) than the current objectives set forth in the CTR.

Table 11 - Comparison of Modified Versus Current Basin Plan Acute Objectives

Reach	Final WER	Acute CTR objective (ug/L)	Modified Acute objective (ug/L)
Mugu Lagoon	1.51	4.8	7.25
Lower Calleguas Creek	3.69	4.8	17.7

Table 12 - Comparison of Modified Versus Current Basin Plan Chronic Objectives

Reach	Final WER	Chronic CTR Objective (ug/L)	Modified Chronic Objective (ug/L)
Mugu Lagoon	1.51	3.1	4.68
Lower Calleguas Creek	3.69	3.1	11.4

XI. IMPLEMENTATION OF COPPER WERs

The Basin Plan authorizes the use of compliance schedules in NPDES permits for effluent limits and receiving water limits to achieve new, revised or newly interpreted water quality standards, where justified. However, the modified objectives would be less stringent than the current objectives, therefore, a compliance schedule for the modified objectives will most likely not be necessary.

Potential Means of Compliance

The California Water Code (Section 13360) prohibits Regional Boards from specifying the means of compliance with their orders. However, the California Environmental Quality Act (Sections 21159 and 21159.4) requires Regional Boards, when adopting requirements for the installation of new pollution control equipment or new performance standards for pollution control, to analyze reasonable means of compliance with the new regulations, including general consideration of environmental impacts, alternatives, and mitigation measures. The following is a summary of potential means of compliance with the performance standards that would be established by the proposed Basin Plan amendments. Environmental impacts, alternatives, and mitigation measures are addressed in a separate draft environmental document (CEQA Checklist) for the proposed amendments.

The POTWs discharging to these waterbodies are expected to be the primary parties involved in compliance with the revised objectives. If approved, the copper WERs would be reflected in revised effluent and receiving water limitations for the affected POTWs and waterbody reaches, subject to antidegradation and antibacksliding requirements. It is not foreseeable that the amendment would instigate new or different compliance measures other than those required to comply with the current objectives. Therefore, the additional economic cost of this amendment should negligible.

Future Monitoring

Additional receiving water monitoring by dischargers subject to site-specific WER(s) is essential to evaluate whether the copper objectives, as modified by the WER(s), are as protective of beneficial uses as the CTR objectives are intended to be. This additional monitoring should be required through the discharger's NPDES permit monitoring and reporting program. If additional monitoring indicates a change in the chemical characteristics of the water body or toxicity, the Regional Board may reconsider the site-specific WER(s).

To the extent possible, proposed monitoring and reporting requirements should be coordinated with any Executive Officer approved Calleguas Creek Watershed TMDL Monitoring Plan (CCWTMP). The Calleguas Creek Watershed TMDL Monitoring Plan (CCWTMP) will be designed to monitor and evaluate implementation of the TMDL, potentially refining the understanding of current metals and selenium loads. The goals of the CCWTMP include:

1. To determine compliance with copper, nickel, selenium and mercury numeric targets.
2. To determine compliance with waste load and load allocations for copper, nickel, selenium and mercury at receiving water sites and at POTW discharges.
3. To monitor the effect of implementation actions by urban, POTW, and agricultural dischargers on in-stream water quality.
4. To implement the CCWTMP in a manner consistent with other TMDL implementation plans and regulatory actions within the CCW.

In stream water column samples will be collected quarterly for analysis of water column toxicity, general water quality constituents (GWQC), and copper, nickel, mercury, selenium and zinc. In-stream water column samples will generally be collected at the base of Calleguas Creek and in Mugu Lagoon until numeric targets are consistently met at these points. Sediment and land-use monitoring will also be conducted.

A monitoring report will be prepared annually within six months after completion of the final event of the sampling year. An adaptive management approach to the CCWTMP will be adopted as it may be necessary to modify aspects of the CCWTMP.

Downstream Protection

Implementation actions to achieve applicable copper objectives in Calleguas Creek must also result in compliance with downstream objectives in Mugu Lagoon. Regional Board regulations prohibit the violation of water quality objectives assigned to any water body segment. Therefore, if copper levels in downstream reaches (Mugu Lagoon) violate water quality objectives, the party responsible for the exceedance will be held accountable.

XII. WATER CODE SECTION 13241 CONSIDERATIONS

Because this amendment establishes a policy affecting the application of existing standards for lower Calleguas Creek and Mugu Lagoon, it is a modification to applicable water quality objectives and is therefore subject to Water Code section 13241. The Regional Board has conducted a review of the factors described in section 13241.

Past, present and probable future beneficial uses. See Table 12 at the end of this section for a listing of the beneficial uses of the watershed. Additionally, see Chapter 2 of the Basin Plan, which identifies the definitions of the designated beneficial uses for waterbodies in the Los Angeles Region. The goal of this amendment is to take into account site specific conditions in these two waterbodies, which have been shown to reduce the toxicity of copper to aquatic life, to modify the water quality objectives for copper applicable to these waters such that the objectives will be fully protective, but not unnecessarily so, of the aquatic life in these waterbodies. The WER procedure, developed by the US EPA and used by Larry Walker Associates as the basis for the proposed modifications, is designed to ensure that any modified water quality objectives are as protective of aquatic life as the national criteria. The US EPA document, "Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses", sets forth procedures to ensure that US EPA's recommended national criteria are protective of 95% of species. The WER procedure is designed to achieve this same standard of protection for local water quality objectives, while taking into account site specific characteristics of the waterbody. Additionally, the WER study used the most sensitive saltwater species, *M. edulis*, to ensure protection of all other aquatic organisms in these two waterbodies. Therefore, past, present and probable future beneficial uses should be as protected by the modified objectives as by the CTR criteria for copper.

Environmental characteristics of the hydrographic unit under consideration, including the quality of water available thereto. See Appendix B, attached hereto, for information on the "Water Quality in Calleguas Creek with respect to Copper." The environmental characteristics of the relevant hydrographic unit under consideration are also described in Chapters 1 through 3 of the Basin Plan. The toxicity of a metal to aquatic life is influenced by a variety of physical and chemical characteristics of both the site water and the metal itself. Bioavailability and toxicity of copper are dependent on site-specific factors such as pH, hardness, suspended solids, dissolved oxygen (i.e., Redox state), dissolved carbon compounds, salinity, and other constituents. If there is a difference in toxicity due to the local site water and it is not taken into account, the aquatic life criteria for the waterbody will be more or less protective than intended by US EPA's "Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses," which were designed to be protective of 95% of aquatic species based on conditions throughout the United States.

Because of the potential for site-specific conditions to vary from the conditions used to derive the national aquatic life criteria, US EPA has provided guidance concerning three procedures that may be used to modify national criteria to account for site-specific characteristics (US EPA, 1994). In the CTR specifically, the US EPA has provided for the adjustment of water quality for metals through the application by States of the WER procedure.

Beyond the headwaters, many of the waterbodies in Los Angeles and Ventura County are dominated by effluent from publicly owned treatment works (POTWs), particularly during the prevailing dry weather conditions in Southern California. Characteristics of these waterbodies, such as high hardness and ionic composition, vary from conditions in other waterbodies where there is significant flow from sources other than POTW discharges. These differences in water chemistry illustrate that developing and implementing a WER for these waterbodies may be appropriate.

Water quality conditions that could reasonably be achieved through the coordinated control of all factors which affect water quality in the area. The environmental setting of the Calleguas Creek watershed and environmental factors affecting water quality and beneficial uses in these watersheds are discussed in Appendix B to this report. Regional Board staff uses existing water quality standards contained in Chapters 2 and 3 of the Basin Plan as the baseline or benchmark for water quality conditions that could reasonable be achieved through the coordinated control of all factors that affect water quality in the affected waters, and no additional analysis beyond that set forth is required.

Economic considerations. The POTWs discharging to these waterbodies are expected to be the primary parties involved in compliance with the revised objectives. Because the WERs would modify objectives to values that are higher than the current objectives applicable to the waterbodies, this amendment should not necessitate any facility upgrades or modifications to treatment processes. Therefore, the economic cost of this amendment should negligible in terms of the cost to the regulated community.

Additionally, there should be no cost to the environment in terms of environmental degradation, since the WER procedure used as the basis for the proposed modifications is designed to result in modified objectives that are as protective of aquatic life as the CTR criteria. Therefore, while the proposed modified objectives are higher than the current CTR criteria for copper, the change would not result in any decrease in protection below the national standard of 95% of all species.

Need for developing housing within the region. The adoption of WERs for copper is not expected to affect the development of housing in Ventura County. The modified objectives are not so low as to require additional treatment that may then result in increased county or municipal costs that would be transferred as increased cost to homeowners. In addition, the modified objectives are not so high as to result in increased pollution which may make the area undesirable for new housing development. Rather the modified objectives would result in an appropriate level of protection to support a healthy aquatic environment.

Need to develop and use recycled water. The difference in the allowable copper concentrations between waterbodies with or without a WER is not significant enough to impact the development or use of recycled water because recycled water requires specified minimum water quality treatment technologies depending on the end goal of the recycled water. The concentrations required by both objectives (CTR versus those modified by the proposed WERs) are both acceptable for application of the specified treatment technologies.

Table 13 - Beneficial Uses of Affected Waterbodies in the Calleguas Creek Watershed

WATERSHED[a]	Hydro Unit No.	MUN	IND	PROC	AGR	GWR	FRSH	NAV	POW	REC1	REC2	COMM	AQUA	WARM	COLD	SAL	EST	MAR	WILD	BIOL	RARE	MIGR	SPWN	SHELL	WET[b]
Mugu Lagoon [c]	403.11							E		Pn	E	Ed					E	E	Eo	E	Ee,p	Ef	Ef	Ed	E
Calleguas Creek Estuary [c]	403.11							P		Pn	E	E					E		E		Ee,p	Ef	Ef		E
Calleguas Creek	403.11	P*			E	E	E			E	E			E	E				E		Ep				E

E: Existing beneficial use
P: Potential beneficial use
I: Intermittent beneficial use
E, P, and I shall be protected as required.

e One or more rare species utilize all ocean, bays, estuaries and coastal wetlands for foraging and/or nesting

d Limited public access precludes full utilization

f Aquatic organisms utilize all bays, estuaries, lagoons and coastal wetlands, to a certain extent, for spawning and early development. This may include migration into areas which are heavily influenced by freshwater inputs.

n area is currently under control f the navy; swimming is prohibited

p habitat of the Clapper Rail

q Whenever flow conditions are suitable.

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Appendix A – Copper Chemistry and Sources

Copper Chemistry

Due to the complex interactions of copper with numerous other chemical species normally found in natural waters, the amounts of the various copper compounds and complexes that actually exist in solution will depend on the pH, temperature, alkalinity, and the concentrations of bicarbonate, sulfide, and organic ligands. Generally, ionic copper is more soluble in low pH, acidic waters and less soluble in high pH, alkaline waters.

Field and laboratory studies by Thomas and Grill (1977) indicate that copper adsorbed to sediments and particulates in freshwater may be released as soluble copper when it comes in contact with seawater in estuarine environments.

Copper, which occurs in natural waters primarily as the divalent cupric ion in free and complexed forms (Callahan, et al. 1979) is a minor nutrient for both plants and animals at low concentrations but is toxic to aquatic life at concentrations only slightly higher.

Sources of Copper

Copper is ubiquitous in the rocks and minerals of the earth's crust. In nature, copper occurs usually as sulfides and oxides and occasionally as metallic copper. Weathering and solution of these natural copper minerals results in background levels of copper in natural surface waters at concentrations generally well below 20 µg/l. Concentrations of 1 to 10 µg/l are usually reported for unpolluted surface waters in the United States (Boyle, 1979). Higher concentrations of copper are usually from anthropogenic sources.

Concentrations in the vicinity of municipal and industrial effluents, particularly from smelting, refining, or metal plating industries, may be much higher than 10 µg/l (Harrison and Bishop, 1984; Hutchinson, 1979). These sources include corrosion of brass and copper pipe by acidic waters, industrial effluents and fallout, sewage treatment plant effluents, and the use of copper compounds as aquatic algicides. Potential industrial copper pollution sources number in the tens of thousands in the United States. However, the major industrial sources include the smelting and refining industries, copper wire mills, coal burning industries, and iron and steel producing industries. Copper may enter natural waters either directly from these sources or by atmospheric fallout of air pollutants produced by these industries. Precipitation of atmospheric fallout may be a significant source of copper to the aquatic environment in industrial and mining areas.

Appendix B – Environmental Setting

ENVIRONMENTAL SETTING

Calleguas Creek and its tributaries are located in southeast Ventura County and a small portion of western Los Angeles County. Calleguas Creek drains an area of approximately 343 square miles from the Santa Susana Pass in the east to Mugu Lagoon in the southwest. The main surface water system drains from the mountains in the northeast part of the watershed toward the southwest where it flows through the Oxnard Plain before emptying into the Pacific Ocean through Mugu Lagoon. The watershed, which is elongated along an east-west axis, is about thirty miles long and fourteen miles wide. The Santa Susana Mountains, South Mountain, and Oak Ridge form the northern boundary of the watershed; the southern boundary is formed by the Simi Hills and Santa Monica Mountains.

Land uses in the Calleguas Creek watershed include agriculture, high and low density residential, commercial, industrial, open space, and a Naval Air Base located around Mugu Lagoon. The watershed includes the cities of Simi Valley, Moorpark, Thousand Oaks, and Camarillo. Most of the agriculture is located in the middle and lower watershed with the major urban areas (Thousand Oaks and Simi Valley) located in the upper watershed. The current land use in the watershed is approximately 26% agriculture, 24% urban, and 50% open space. Patches of high quality riparian habitat are present along the length of Calleguas Creek and its tributaries.

Climate and Hydrology

The climate in the watershed is typical of the southern California coastal region. Summers are relatively warm and dry, and winters are mild and wet. Eighty-five percent of the rainfall occurs between November and March, with most of the precipitation occurring during just a few major storms. Annual rainfall in Ventura County averages 15 inches and varies from 13 inches on the Oxnard Plain to a maximum of 20 inches in the higher elevations (USDA, 1995). Storm events concentrated in the wet-weather months produce runoff usually ranging in duration from one-half day to several days. Discharge during runoff from storm events is commonly 10 to 100 times greater than at other times. Storm events and the resulting high stream flows are highly seasonal, grouped heavily in the months of November through February, with an occasional major storm as early as September and as late as April. Rainfall is rare in other months, and major storm flows historically have not been observed outside the wet-weather season.

Surface Waters

The main surface water system drains from the mountains toward the southwest, where it flows through the Oxnard Plain before emptying to the Pacific Ocean through Mugu Lagoon. Dry weather surface water flow in the Calleguas Creek watershed is primarily composed of groundwater, municipal wastewater, urban nonstorm water discharges, and agricultural runoff. In the upper reaches of the watershed, upstream of any wastewater discharges, groundwater discharge from shallow surface aquifers provides a constant base flow. Additionally, urban non-stormwater runoff and groundwater extraction for construction dewatering or remediation of contaminated aquifers contribute to the base flow. Stream flow in the upper portion of the watershed is minimal, except during and immediately after rainfall. Flow in Calleguas Creek is described as “storm-peaking” and is typical of smaller watersheds in coastal southern California. “Storm-peaking” refers to peak discharges limited to a wet weather season and concentrated into a few days after short-term, discrete storm events, when flow commonly is two to three orders of magnitude greater than non-storm flow.

The Calleguas Creek Watershed is generally characterized by three major subwatersheds: Arroyo Simi / Las Posas in the northeast, Conejo Creek in the south, and Revolon Slough in the west. Additionally, the lower watershed (including Mugu Lagoon) is drained by several minor agricultural drains in the Oxnard plain. Subwatersheds of the CCW are depicted in Figure 1 along with reach names.

Calleguas Creek

Calleguas Creek runs along the eastern side of Oxnard Plain to Mugu Lagoon. From the headwaters in the hills north of Camarillo to the confluence with the Arroyo Las Posas through to the confluence with Conejo Creek, Calleguas Creek is typically dry due to rapid infiltration and evaporation. During wet weather storm events, the stretch of Calleguas Creek provides a conduit for transporting storm flows from the upper CCW to the Pacific Ocean. The Camrosa WRP is located near California State University, Channel Islands. The Camrosa WRP only discharges to the creek during extreme storm events. Calleguas Creek is tidally influenced from Mugu Lagoon to approximately Potrero Road (this fact has implications on the test species chosen to develop the WER covered by this amendment).

Water Quality in Calleguas Creek with respect to Copper (Excerpts from Draft Final Technical Report - Calleguas Creek Watershed Metals and Selenium TMDL, March 29, 2006, prepared by LWA)

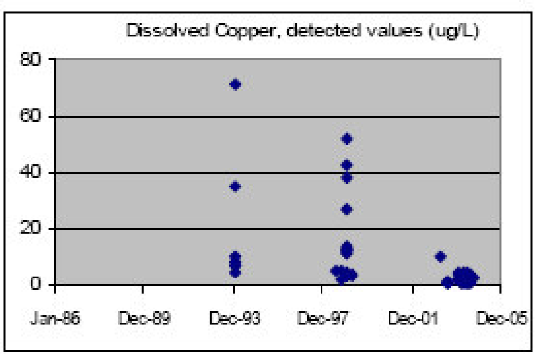
Mugu Lagoon is on the 2002 303(d) list for total copper, total mercury, total nickel, and total zinc. In addition, water quality data have indicated the presence of selenium. The Table below presents relevant summary statistics for water quality data collected in Reach 1.

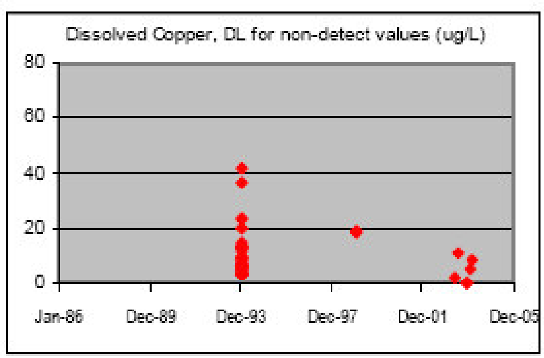
Summary Statistics for Relevant Water Quality Data in Reach 1 (ug/L)

Constituent	n	% Detected	Criteria Used	Mean	Standard Deviation	Median	Maximum Detected Value	% Above Criteria [1]
Dissolved Copper	47	85%	3.1	2.1	1.8	1.5	10.3	28%
Total Mercury	46	87%	0.051	0.01	0.02	0.002	0.13	2%
Dissolved Nickel	47	96%	8.2	3.0	2.3	2.2	11.4	4%
Total Selenium	48	85%	71	1.4	2.2	0.55	13.4	0%
Dissolved Zinc	47	100%	81	7.5	6.7	5.5	31	0%

1 Only detected values that exceed criteria are used in calculation of "% Above Criteria." The actual number of exceedances could be higher because not all samples were tested at detection limits below numeric targets.

Concentration of Metals and Selenium Verses Time in Mugu Lagoon





Calleguas Creek Reach 2 (Calleguas Creek South)
Calleguas Creek South is listed on the 2002 303(d) list for dissolved copper. In addition, water quality data have indicated the presence of mercury, nickel, selenium, and zinc; as shown below.

Summary Statistics for Relevant Water Quality Data in Reach 2 (ug/L)

Constituent	n	% Detected	Criteria Used [1]	Mean	Standard Deviation	Median	Maximum Detected Value	% Above Criteria [2]
Dissolved Copper	19	79%	3.1	3.8	1.4	3.6	8.67	47%
Total Mercury	23	74%	0.051	0.05	0.158	0.005	0.700	13%
Dissolved Nickel	19	100%	8.2	8.3	4.1	7.6	22.2	47%
Total Selenium	24	58%	5	3.3	3.5	2.1	13.6	25%
Dissolved Zinc	19	100%	81	14.8	6.8	13.2	30.1	0%

1 The lower of freshwater and saltwater criteria were used per the CTR requirement that the lower of the two criteria apply in waterbodies with salinities between 1 and 10 ppt.
2 Only detected values that exceed criteria are used in calculation of "% Above Criteria." The actual number of exceedances could be higher because not all samples were tested at detection limits below numeric targets.

Estimated Loading Contributions by Land Use Type

Runoff data categorized according to land use (land-use runoff data) and data from point source discharges (discharge data) are available from several sources, as shown in the Table below. This information is used to gain an understanding about the relative contributions of metals and selenium from various pathways and sources.

Summary of Land-Use Runoff and Discharge Data.

Data Source	Begin Date	End Date	Urban Land Use Sites	Agricultural Land Use Sites	Groundwater Discharge	POTW
205(J) Non Point Source Study	Nov-98	May-99	x	x		
Ventura County WPD	Feb-92	--	x	x		
Calleguas Creek Characterization Study(LWA, 1999)	Aug-98	May-99	x	x	x	x
Camrosa WRF	Dec-95	Dec-02				x
Camarillo WRP	Aug-98	--				x
Hill Canyon WWTP	Feb-94	--				x
Moorpark WWTP	Sep-97	--				x
Olsen Road WRP	Aug-93	May-99				x
Simi Valley WQCP	Dec-93	--				x
TMDL Work Plan Monitoring (LWA, 2004a)	Feb-04	Aug-04	x			

Estimated Total Copper Loading in CCW by Land Use Type (Lbs/Yr).

Year	Urban	Ag	Groundwater	POTW	Simi Wells	Open Space	Total
1993	3,247	2,009	172	494	40	11	5,971
1994	68,316	210,502	313	508	37	13,355	293,033
1995	4,456	4,713	201	485	37	130	10,022
1996	7,372	26,077	215	489	38	138	34,329
1997	151,112	423,949	329	575	38	75,892	651,895
1998	1,933	252	156	469	28	2	2,841
1999	5,834	9,361	161	522	37	85	16,000
2000	24,147	55,460	210	521	33	839	81,208
2001	2,285	406	135	542	34	7	3,409
2002	23,579	37,529	174	540	35	496	62,353
2003	8,786	9,631	120	537	34	164	19,273
average	27,370	70,899	199	516	36	8,284	107,303
% of Total	26%	66%	0%	0%	0%	8%	100%

Estimated Dissolved Copper Loading in CCW by Land Use Type (Lbs/Yr).

Year	Urban	Ag	Groundwater	POTW	Simi Wells	Open Space	Total
1993	5	1.22	171.54	493.67	39.75	0.05	711.13
1994	84	72.3	312.94	508.12	37.41	47.08	1061.71
1995	8	3.01	201.19	485.15	36.72	0.69	734.52
1996	19	15.87	215.32	489.36	37.77	1.08	777.94
1997	124	104.45	329.39	574.64	37.86	116.02	1285.97
1998	2	0.12	155.81	468.89	28.45	0.01	655.29
1999	15	6.41	160.87	522.36	37.34	0.45	742.35
2000	47	29.53	209.88	520.5	32.76	5.98	845.27
2001	1	0.31	134.63	541.71	34.02	0.01	712.02
2002	42	17.16	173.81	539.86	34.98	3.19	811.28
2003	11	4.75	120.17	537.06	33.79	0.44	706.73
average	32	23	199	516	36	16	822
% of Total	4%	3%	24%	63%	4%	2%	100%

In the loading estimate tables presented above, the category 'Urban' is calculated as the sum of the following: residential, commercial, and industrial areas; plus runoff which lands on impervious surfaces and flows directly to drain systems (i.e. driveways and roads are included, but rooftops are not because most water landing on a rooftop usually runs off into the yard). The category 'Groundwater' represents seepage/exfiltration of groundwater into surface waters in the watershed. The category 'Simi Well' is based on monitoring data from five dewatering wells in Simi Valley, which discharge pumped groundwater to the storm drain system for the purpose of lowering the local water table. Although runoff from 'Open Space' has not been monitored explicitly, one monitoring site drains a lightly developed portion of Tapo Canyon which is considered representative of undeveloped open space.

Appendix C – Calleguas Creek Watershed Copper Water-Effects Ratio (WER) Study. June 8, 2006. Larry Walker Associates.

JUNE 8, 2006

Calleguas Creek Watershed Copper **Water-Effects Ratio** (WER) Study

Prepared by:
Larry Walker Associates

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GLOSSARY OF ACRONYMS

AMEL	Average Monthly Effluent Limit
BLM	Biotic Ligand Model
CCC	Criterion Continuous Concentration
CD A	Copper Development Association
CEQA cfs	California Environmental Quality Act
CMC CSJ	cubic feet per second (measure of flow)
Cu	Criterion Maximum Concentration
Cu'	City of San Jose
CU2+	Copper
CV	Complexed Copper
CWA DFG	Free Copper Ion
DIC	Coefficient of Variance
DO	Clean Water Act
DOC EC50	Department of Fish and Game
EO FACR	Dissolved Inorganic Carbon
FB	Dissolved Oxygen
FDPE GPS	Dissolved Organic Carbon
HDPE	50% Effect Concentration
ICP.MS LB	Executive Officer
LC50 LOEC	Final Acute-Chronic Ratio
LWA MDEL	Field Blank
mg/L	Fluorocarbon-lined High-Density Polyethylene Global
Mn	Positioning System
MSD neat	High Density Polyethylene
water ng/L	Inductively Coupled Plasma - Mass Spectrometer Laboratory
Ni	Blank
NOEC	50% Lethal Concentration
NPDES	Lowest Observable Effect Concentration.
OBS	Larry Walker Associates
PB	Maximum Daily Effluent Limit
PER POTW	milligrams per liter (aka: ppm)
	Manganese
	Minimum Significant Difference
	Site or Lab water without salinity adjustment nanograms per
	liter (aka: ppt)
	Nickel
	No Observable Effect Concentration
	National Pollutant Discharge Elimination System Optical
	Backscatterance
	Procedure Blank
	Pacific EcoRisk Environmental Consulting and Testing Publici
	v Owned Treatment Works

ppb	parts per billion
ppm ppt	parts per. million
QA/QC	parts per thousand (salinity)
RPD	Quality Assurance/Quality Control
RWQCB	Relative Percent Difference
SOP	Regional Water Quality Control Board (Los Angeles Region)
SSO	Standard Operating Procedures
SWRCB	Site-Specific Objective
TAC	State Water Resource Control Board
TMDL	Technical Advisory Committee
TOC	Total Maximum Daily Load
TSS	Total Organic Carbon
ug/L	Total Suspended Solids
USEPA	micrograms per liter (aka: ppb, parts per billion)
USGS	United States Environmental Protection Agency
WER	United States Geological Survey
WQO	Water-Effect Ratio
WWTP	Water Quality Objective
	Wastewater Treatment Plant

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INTRODUCTION

Background

.In accordance with Section 303(d) of the Clean Water Act (CWA), 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. Mugu Lagoon (Lagoon) and Lower Calleguas Creek (Creek) were listed on the 1998 303(d) list for California due to levels of copper which exceeded 1986 Basin Plan total recoverable metals objectives and/or United States Environmental Protection Agency (USEPA) national criteria. These exceedances were the basis for a concern that copper was impairing aquatic uses in the Lagoon and Creek by producing either acute or chronic toxicity in sensitive aquatic organisms.

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

The California Toxics Rule (CTR) defines the chronic criterion for dissolved copper as 3.1 ug/L for marine water and 9.0 ug/L (at hardness of 100 mg/L) for freshwater, *multiplied by* a *Water-Effect Ratio or WER* (40 CFR 131.38 (b) and (c)(4)(i) and (iii)). The default value for theWER is 1.0 unless a WER has been developed using methods as set forth in US EPA's WER guidance (US EPA, 1994[1]). EPA has, in effect, . streamlined SSOs for trace metals given this CTR adopted wording.

Study Purpose and Approach

The purpose of this study is to develop a WER for copper using methods set forth in the US EPA's guidance. The WER is being developed as part of a comprehensive approach to addressing metals impairments in the Calleguas Creek watershed. The WER study was designed to work in conjunction with the metals TMDL for the watershed to develop an effective implementation strategy for copper. The Work . Plan and Sampling & Analysis Plan were developed during 2003 through a .stakeholder process that included regulators. dischargers, researchers, and environmental advocates. In particular, the Work Plan was reviewed by Technical Advisory Committee member Russ Flegal of the University of California Santa Cruz, Technical Working Group member Sam Unger of the Los Angeles Regional Water Quality Control Board, and Lucie McGovern of the City of Camarillo. This approach is consistent with the WER guidance manual (USEPA, 1994) that recommends that a multi-disciplinary "design team" with site~specific knowledge be used. The guidance also recommends including the regulatory authority on the team from

[1] US EPA, 1994. Interim Guidance on Determination and Use of Water-Effect Ratios, USEPA Office of Water, EPA-823-B-94 .001, February 1994.

the beginning. Local RWQCB and EPA staff with knowledge of the Calleguas Creek Watershed have been active participants since the beginning.

The final Work Plan ("Calleguas Creek Watershed Metals TMDL Work Plan [2003])" included in Appendix 1 summarizes the rationale for selecting the sampling sites, monitoring and analytical procedures, and *QA/QC* protocols.

The primary purpose of the study outlined in the Work Plan was to collect data to improve understanding of the aquatic toxicity of copper in the Lagoon and Creek. The study included (a) the collection of water column data to broaden the knowledge regarding spatial and temporal variability of ambient concentrations of copper and associated chemical parameters and (b) the collection of copper toxicity data for a sensitive saltwater species *(Mytilus edulis)* in the Lagoon and Creek as well as for a sensitive freshwater species *(Ceriodaphnia dubia)* in the Creek to allow calculation of WERs for these reaches. Both saltwater and freshwater species were studied in Lower Calleguas Creek water due to the tidal influence in this zone. Performing toxicity tests on both. species allowed the most sensitive and conservative WERs to be 'developed. The .study was designed to help provide a scientific basis for site-specific objectives, the copper TMDL, and future 303(d) lists.

This study was intended to:

(1) provide technically sound analytical data (i.e., accurate, reproducible, etc.),
(2) provide data which impartially characterizes chemical and toxicological conditions at various locations in the Lagoon,
(3) provide data that wi!! be useful in the evaluation of possible copper impairment in the water column of Mugu Lagoon and Lower Calleguas Creek, and
(4) provide data that will be useful in the development of site-specific water quality objectives (WQO) for copper in the Lagoon and Creek, through the use of water-effect ratios.

Sampling sites were selected to provide representative spatial coverage of the Lagoon and Reach 2 of Calleguas Creek (Figure 1). The sampling schedule captured both wet and dry season conditions, with two sampling events conducted for dry weather, one event under wet conditions in the Lagoon, and two events under wet conditions in Calleguas Creek. Sample runs included four Lagoon sample sites and two Creek ,sample sites sampled each event, during outgoing tidal conditions.

The WER guidance recommends that data from one sampling event be analyzed prior to the next sampling event, with the goal of improving the sampling design as the study progresses. Following the first sampling event, the data was evaluated to help determine any change in direction. No changes were made in study design, as the original sites appeared to capture any variability in the Lagoon and Creek.

Related Analyses

The primary emphasis of this study was on the development of WERs for copper and on characterizing ambient total and dissolved copper. Additional analyses for various conventional water quality parameters (total suspended solids (TSS), total organic carbon (TOC), dissolved organic carbon (DOC), salinity) were also conducted for each site during each of the events in the study. This information wi!! be used to augment existing data, and to aid in the interpretation of t?xicity test results.

Biotic Ligand Model

Some constituents not included in previous monitoring efforts in the Watershed were added to this study to provide information useful to the national effort to develop a Biotic Ligand Model (BLM). The BLM was created to evaluate bioavailability and toxicity of metals that have been discharged into surface water. The model takes into consideration several water quality parameters, including hardness, DOC, chloride, pH, and alkalinity. The USEPAis currently reviewing the BLM as a potentially less resource intensive option to WER studies for the development of site-specific criteria. The Water Environment Research Foundation (WERF) is working closely with the USEPA in the development of this model. At this stage, the model has been developed and is being calibrated and beta-tested for copper and silver. Water quality constituents required as inputs into the model were collected as part of this study in the hopes of providing useful data to BLM researchers and to ensure the data set collected could be used in the BLM at a later date. This BLM work was funded and coordinated by the Copper Development Association (CDA) and results will be reported independently.

Technical Working Group & Technical Review Committee

A Technical Working Group (TWG) was established to review documents and provide input on decisions pertaining to the metals TMDL work. The TWG members are listed below:

- Carolyn Greene ~ City of Thousand Oa.ks
- Damon Wing - Ventura Coastkeeper
- John Bejhan - City of Simi Valley
- Morgan Wehtje - Department of Fish and Game
- Rick Farris - US Fish & Wildlife Service
- Sally Coleman - Ventura County Watershed Protection District
- Sam Unger - Los Angeles Regional Water Quality Control Board
- Steve Granade - US Navy

As part of this project, a Technical Advisory Committee (TAC) was convened to provide an independent outside critique of the project design and results. A list of T AC members proposed for review of the technical documents is provided in Table 1.

Table 1. Technical Advisory Committee Members

Area of Expertise	T AC Member
Modelina	
Regulatory/TMDL Process/Standards	William Walker.
Toxicity	
- Metals	Russ Flegal, UC Santa Cruz
- Pesticides	Ronald Tieerderma, UC Davis
Habijat	
- Wetlands	Eric Stein, SCCWRP
- Riparian	Michael Josselyn, WRA
Bioaccumulation/Risk Assessment	David Sedlak, UC Berkelev
Agriculture	
- Standards	Donald Suarez, USDA-ARS George E Brown Jr. Salinity Laboratory
- BMP implementation	Stephen Grattan, UC Davis
Bacteria	Stan lev Grant, UC Irvine
Treatment Technology Expertise	Michael Stenstrom, UCLA

Acknowledgements

This project has been a broad, stakeholder based effort from its beginnings. The project was developed as part of the Calleguas Creek Watershed Management Plan that includes the following groups.

General Purpose Agencies
City of Camarillo
City of Moorpark
.city of Simi Valley
City of Thousand Oaks
County of Ventura
Ventura County Flood Control District

Other Property Owners/Business Organizations
Business Industry Association .
Naval Base Ventura County
Ventura County Economic Development Association
Ventura County Farm Bureau

Agencies/Organ izations
California Coastal Conservancy
California Department of Water Resources
California Native Plant Society
California Wildlife Conservation Board Caltrans
Environmental Defense Center
Natural Resources Conservation Service Santa
Monica Mountains Conservancy Burfrider
Foundation
Ventura County Resource Conservation District

Water/Wastewatei' Management Agencies
Berylwood Mutual Water Company
Calleguas Municipal Water District
Camarillo Sanitary District
Camrosa Water District
Fox Canyon Groundwater Management Agency
Pleasant Valley County Water District
United Water Conservation District
Ventura County Waterworks Districts: 1, 8, 19.
Zone Mutual Water Company
Ventura County Association of Water Agencies

Recreational and Open Space Entities California
Department of Parks & Recreation Conejo
Valley Park & Recreation District Pleasant
Valley Park & Recreation District Rancho Simi
Valley Recreation & Park District

Federal and State Agencies
California Coastal Conservancy
CA Department of Fish and Game
Regional Water Quality Control Board- Los Angeles
US Army Corps of Engineers
US Environmental Protection Agency
US Fish and Wildlife Service

RWQCB staff approved the Metals TMDL Work Plan and associated WER Sampling & Analysis Plan and are actively participating in work being conducted under the Work Plan.

SAMPLING PROCEDURES

Environmental Setting

Calleguas Creek and its tributaries are located in southeast Ventura County and a small portion of western Los Angeles County. Calleguas Creek drains an area of approximately 343 square miles from the Santa Susana Pass in the east to Mugu Lagoon in the southwest. The main surface water system drains from the mountains in the northeast part of the watershed toward the southwest where it flows through the Oxnard Plain before emptying into the Pacific Ocean through Mugu Lagoon. The watershed, which is elongated . along an east-west axis, is about thirty miles long and fourteen miles wide. The Santa Susana Mountains, South Mountain, and Oak Ridge form the northern boundary of the watershed; the southern boundary is formed by the Simi Hills and Santa Monica Mountains.

Land uses in the Calleguas Creek watershed include agriculture, high and low density residential, commercial, industrial, open space, and a Naval Air Base located around Mugu Lagoon. The watershed includes the cities of Simi Valley, Moorpark, Thousand Oaks, and Camarillo. Most of the agriculture is located in the middle and lower watershed with the major urban areas (Thousand Oaks and Simi Valley) . located in the upper watershed. The current land use in the watershed is approximately 26% agriculture, 24% urban, and 50% open space. Patches of high quality riparian habitat are present along the length of Calleguas Creek and its tributaries.

The Calleguas Creek Watershed is generally characterized by three major subwatersheds: Arroyo Simi/Las Posas in the northeast, Conejo Creek in the south, and Revolon Slough in the west. Additionally, the lower watershed including Mugu Lagoon is also drained by several minor agricultural drains in the Oxnard plain. The three major subwatersheds are described below in more detail.

. Conejo Creek Subwatershed

Conejo Creek and its tributaries (Arroyo Conejo and Arroyo Santa Rosa) drain the southern portion of the watershed. Flow in the southern portion of the watershed originates in the City of Thousand Oaks and flows through the east side of the City of Camarillo before joining Calleguas Creek upstream of the California State University Channel Islands. The subwatershed supports significant residential and agricultural land uses. The streams and channels of the Conejo Creek subwatershed are described below, in order from uppermost to lower.

. *Calfeguas Creek*

Calleguas Creek runs along the eastern side of Oxnard Plain to Mugu Lagoon. From the headwaters in the hills north of Camarillo to the confluence with the Arroyo Las Posas through to the confluence with Conejo Creek, Calleguas Creek is typically dry due to rapid infiltration and evaporation. During wet weather storm events, the stretch of Calleguas Creek provides a conduit for transporting storm flows from the upper CCW to the Pacific Ocean. The Camrosa WRP is located near California State University, Channel Islands. The Camrosa WRP only discharges to the creek during extreme storm events. Calleguas Creek is tidally influenced from Mugu Lagoon to approximately Potrero Road.

Revolon Slough Subwatershed

Revolon Slough drains the agricultural/and in the western portion of the watershed (Oxnard Plain). The slough does not pass through any urban areas, but does receive drainage from tributaries which drain urban areas. Revolon Slough starts as Beardsley Wash in the hills north of Camarillo. The wash is a rip-rapped channel for most of its length and combines with Revolon Slough at Central Avenue in Camarillo. The slough is conerete lined just upstream of Central Avenue and remains lined for approximately 4 miles to Wood Road. From there, the slough is soft bottomed with rip-rapped sides. The lower mile to mile and a half ofthe slough to above Las Posas Road appears to be tidally influenced by inflows from Mugu Lagoon. Revolon Slough flows into Mugu Lagoon in a channel that runs parallel to Calleguas Creek. The flows from Revolon Slough and Calleguas Creek only converge in the Lagoon. In addition to Revolon Slough, a number of agricultural drains (Oxnard Drain, Mugu Drain, and Duck Pond Drain) serve as conveyances for agricultural and industrial drainage water to the Calleguas Creek estuary and Mugu Lagoon.

Mugu Lagoon

Mugu Lagoon, an estuary at the mouth of Calleguas Creek, supports a diverse wildlife population including migratory birds and endangered species. The Point Mugu Naval Air Weapons Station directly impacts Mugu Lagoon as do the substantial agricultural activities in the Oxnard Plain. The Lagoon consists of approximately 287 acres of open water, 128 acres of tidal flats, 40 acres of tidal creeks, 944 acres of tidal marsh and 77 acres of salt pan (California Resources Agency, 1997). The Lagoon is comprised of a central basin which receives the flow from Revolon Slough and Calleguas Creek, and two arms (eastern and western) that receive some drainage from agricultural and industrial drains. In addition, multiple drainage ditches drain into the Lagoon. Two of these ditches, Oxnard drainage ditches 2 and 3, discharge urban and agricultural runoff originating beyond the Naval Station's boundaries into the central and western portion of the Lagoon. The remaining ditches discharge urban and industrial runoff originating on the Station.

The salinity in the Lagoon is generally between 31 and 33 parts per thousand (ppt) (Granade, 2001). The central basin of the Lagoon has a maximum tidal range of approximately -1.1 to 7 feet (as compared to mean sea level) with smaller ranges in the eastern and western arms of the Lagoon. The western arm of the Lagoon receives less tidal volume because of a bridge culvert that restricts the flows in that area. The velocity of water traveling through the narrow mouth of the Lagoon is approximately 5-6 knots, which is a high velocity for a Lagoon (Grigorian, 2001). The mouth of the Lagoon never closes, apparently as a result of a large canyon present at the mouth of Calleguas Creek. The canyon prevents ocean sand from building up to a high enough level to close the mouth and likely accounts for the high velocities in the Lagoon (Grigorian, 2001).

Sampling Locations

Sampling was conducted at four Mugu Lagoon (Reach 1) stations and two Lower Calleguas Creek (Reach 2) stations (Figure 1). Sites were ,selected with the intent of providing spatial coverage and representing different hydrodynamic segments of Mugu Lagoon and Lower Calleguas Creek. Mugu Lagoon is located within the Naval Air Weapons Station at Point Mugu, making access to some areas of the Lagoon for sample collection difficult and/or impossible. In addition, the Lagoon serves as the pupping and nesting grounds for harbor seals, clapper rails, snowy plovers and least terns. Access to areas of the Lagoon where pupping and nesting is occurring is limited from February to July, and in some areas this extends into September. High flows in the Lagoon immediately following a storm event made sampling via boat .unsafe and inaccessible during these times.

Site identification nomenclature utilized the following information:

Reach - Study - Site in that Reach

For example, for the first site sampled in Reach 1 (Mugu Lagoon) during the WER study, the name "1WER-A" was used, with additional sites being "-8," "_C," and "-D." In Lower Calleguas Creek (Reach 2) where two different species were tested, the following notations were added to distinguish between species:

M .e. ;;; *Mytilus edulis* C.d.;;;
Ceriodaphnia dubia

Throughout the remainder of this report, where it is necessary to distinguish between species tested, the notations identified above will be added after the "Site in that Reach" letter. For instance, "2-WER-A-M.e." identifies samples collected at Site A in Lower Calleguas Creek for Mytilus edulis toxicity testing during the WER study.

0 -WER **Location of Sampling Stations for Water Effects Ratio Study**

~ Reaches ~ POTW

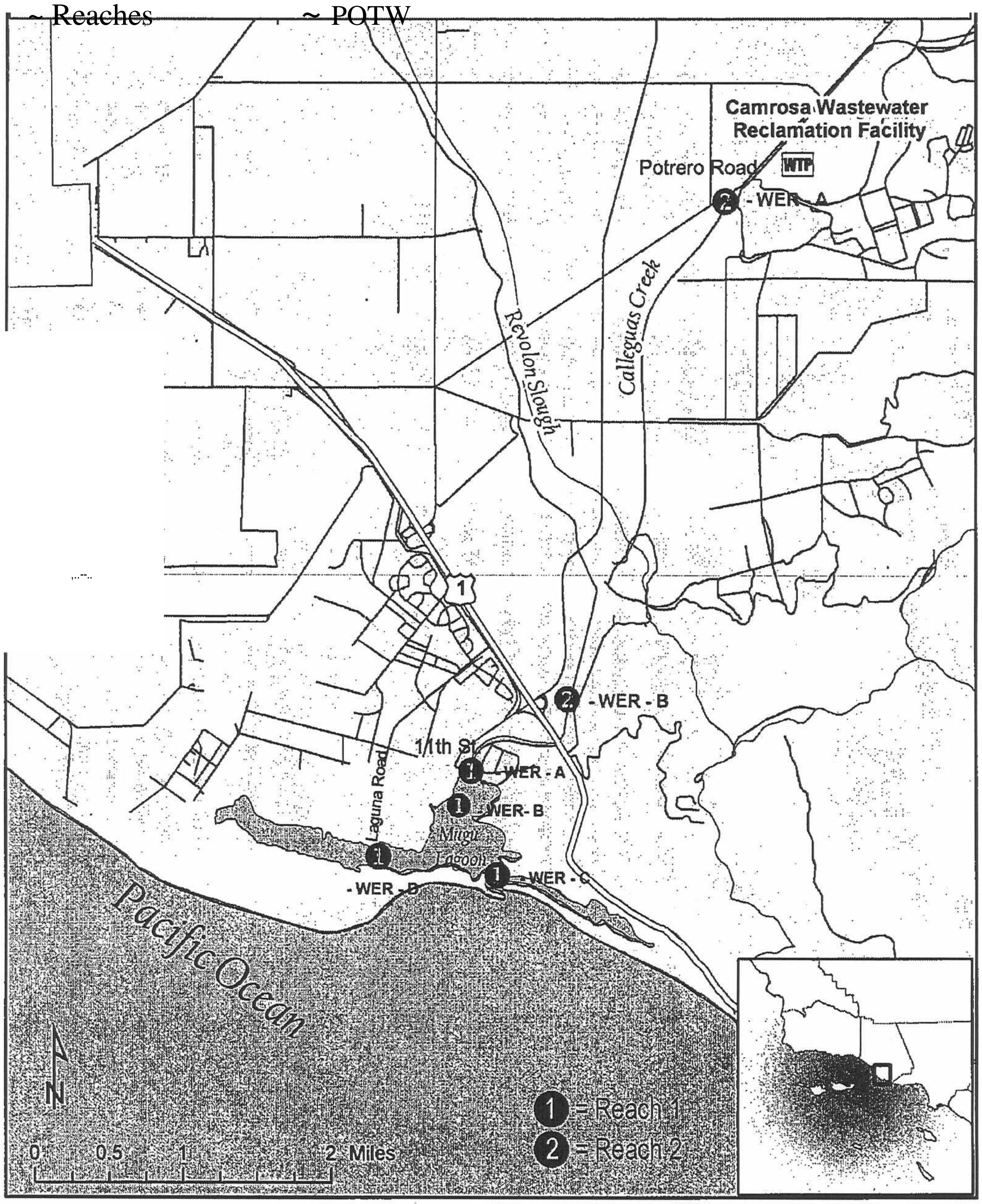

Figure 1. Map of Monitoring and Wastewater Treatment Plant Discharge Locations

Sampling Period and Site Water Collection

Sampling Period

USEPA guidance states that the selection of the number and timing of sampling events should take into account seasonal considerations and should result in at least three WERs determined with the primary test species (in this case, *Mytilus edufis* and *Ceriodaphnia dubia)* (USEPA 1994). In accordance with this guidance, four separate sets of surface-water measurements were included to assess ambient conditions and to calculate saltwater and freshwater copper WERs. The selected frequency also represented a balancing of temporal coverage with the need for extensive spatial coverage to address representative areas of the Lagoon and Creek.

Sampling events were conducted from August 2003 to March 2004, with an additional wet weather event in April 2006 (Table 2). The goal of the sampling and toxicity testing was to produce three successful[2] WER events (two from the dry season and one from the wet season). Based on the results of the wet season event in Lower Calleguas Creek, another wet event was added in April 2006 to further characterize copper toxicity during the wet season. The rationale behind the sampling period was to capture the dominant hydrological conditions observed during the year. The actual selection of sample dates was determined by a balancing of multiple criteria including favorable tidal conditions, coordination with analytical labs, availability of test organisms, and sampling boat and crew availability. Sampling conditions for each of the events included the following:

- Dry weather during late summer (August), low flows and calm conditions.
- Dry weather during winter (January), medium flows and somewhat calm conditions.
- Wet weather during winter (March), increased flows and turbid conditions following a storm event.
- Wet weather during winter (April), increased flows and turbid conditions during a storm event, Lower Calleguas Creek sites only.

Table 2. Sampling Locations and Dates

Station Code	Site Location	Event 1	Event 2	Event 3	Event 4*
1-WER-A	Mugu Lagoon at 11th Street Bridge				
1-WER-B	Central Mugu Lagoon	8/26/03			--
1-WER-C	Mugu Lagoon at Mouth		1/27/04	3/1/04	
1-WER-D	Mugu Lagoon at Laguna Road Bridge				
2-WER-A	Calleguas Creek at Potrero Road	8/27/03			4/15/06
2-WER-B	Calleguas Creek above Mugu Lagoon				

*A fourth event was sampled for only Lower Calleguas Creek to further characterize copper toxicity in the Creek during wet weather.

2 Samples were obtained and preponderance of test results were acceptable per *QAIQC* measures.

Site Water Collection

All samples were collected as grab samples from bridges, a boat or by wading into the sampling stream. In general, samples were taken at approximately mid-stream, mid-depth at the location of greatest flow (where feasible). Clean, powder-free nitrile gloves were worn for collection of all samples.

Upon arrival at the sampling stations, weather conditions, time, and station depth were recorded onto field logs. Using 'clean hands' techniques, samples were collected by direct submersion or using a peristaltic pump with appropriately cleaned tubing. Approximately 500 mL were collected into the cubitainer, the cubitainer was then capped and shaken to pre-rinse (repeated 3 times). The cubitainer was then filled with -site water, sealed, and placed on ice.

Clean techniques (EPA Method 1669[3]) were used throughout all phases of the sampling and laboratory analytical work, including equipment preparation, water collection, sample handling and storage, and testing. Site water was collected in 5-gallon containers. All containers were acid-rinsed, with the exception of the scintillation vials used for the WER testing. The scintillation vials were rinsed with ultra pure water rather than acid due to associated toxicity of acid residue. Mugu Lagoon site water was collected at slack high tide to minimize TSS and DOC. In Lower Calleguas Creek, samples were collected to minimize tidal .influences. After sampling, site water was placed in ice chests, on wet ice, until reaching the appropriate laboratories.

Upon arrival at the laboratory, water quality of the raw water was measured. Measurements included temperature, pH, total organic carbon (TOC) , dissolved organic carbon (DOC), total suspended solids (TSS), total and dissolved copper, alkalinity, hardness, and salinity {see Appendix 4}. Samples were stored at 4 :t 2°C. Site water samples were used in the toxicity tests within 24-36 hours of collection.

Routine water quality characteristics (temperature, pH, dissolved oxygen (DO) and salinity) for each event 'were measured in the field. Clean sampling techniques were used for all fieldwork (USEPA, 1995a). All tubing and sample containers used for the collection of ambient water samples were cleaned following USEPA guidelines (Le., Alconox@, organic solvent, acid and de-ionized water). Methanol was used as the organic solvent, and its use was followed by a minimum of four 01 rinses. Methanol was used on field sampling tubing and containers, and, basically, all laboratory glassware and plastic-ware.

LABORATORY PROCEDURES

Site Water Preparation and Salinity Adjustment

Previous work has indicated that a salinity of below 25 parts per thousand (ppt) adversely affects the saltwater test species, *Mytilus edulis.* As a result, a toxicity test salinity of 30 :t 2 ppt was chosen. Site waters with a salinity <28 ppt were salinity adjusted to the selected range by adding GP-2 salts (a synthetic sea salt). Test solutions were mixed on a mechanical stir-plate (using a Teflon stir-bar) until the GP-2 salts were dissolved. The target salinity was confirmed by measuring an aliquot of water with a conductivity meter.

[3] USEPA. April 1995. Method 1669: Sampling Ambient Water for Trace Metals at EPA Water Quality Criteria Levels. EPA 821-R95-634.

Although the Lower Calleguas Creek has relatively low salinity, the saltwater CTR criteria apply to this reach. As stated in the CTR, the more stringent of the freshwater and saltwater criteria apply if the salinity of the reach is between 1 and 10 ppt more than 5% of the time. Because the Lower Calleguas Creek is tidally influenced and the salinity is between 1 and 10 ppt more than 5% of the time, the more stringent saltwater copper criteria apply. Therefore *Mytilus edulis* testing was conducted on this reach and the samples adjusted to the salinity necessary to test this species.

Synthetic Sea Salt Preparation

Synthetic sea salts were prepared as described in ASTM E-724-98: *Standard Guide for Conducting Static Acute Toxicity Tests Starting with Embryos* of *Four Species* of *Saltwater Bivalve Molluscs.* Reagent grade chemicals were combined in a one-gallon plastic container in the order provided in Table 3. The amount of salt prepared for each event varied by need. After the addition of each chemical, the container was shaken vigorously. Fresh synthetic seawater salts were prepared for each testing event.

Table 3. Synthetic Seawater Salt Preparation

Chemical	Amount (mg)	Amount (mg/L)
NaF	3	0.79
SrC12*6H20	20	5.28
NaSi03*9H201	39.4	10.41
H3B03	30	7.93
KBr	100	26.42
NaHC03	200	52.84
KCI	700	184.94
CaCl2*2H20	1470	388.38
Na2S04	4000	1057
NaCl	23500	6209
MgC12*6H20	10780	2848
Total	40842.4	10791

'Substitution in place of Na2Si03*H20 (20 mg)

Laboratory Dilution Water Preparation and Salinity Adjustment

Dilution water used in the laboratory water and reference toxicant tests for the saltwater tests was 1 !-1m sand-filtered natural seawater obtained from the Granite Canyon Marine Laboratory in Carmel, California. Seawater was collected into an appropriately cleaned and labeled 5-gallon FDPE container from a continuously running seawater source. After collection and temporary storage of the samples on wet ice in ice chests, the water was transported overnight to the Pacific EcoRisk (PER) laboratory. Upon receipt at 'PER, the laboratory water was logged in and placed in cold storage at 4°C:!: 2°C until testing was initiated. Prior to the preparation of test solutions, an aliquot of lab water was filtered (0.45 !-1m) and adjusted (with reverse osmosis, 18.1 MQ de-ionized water) to the test salinity of 30 :!: 2 ppt.

The quality of seawater obtained from Granite Canyon Marine Laboratory met all laboratory standards. Granite Canyon seawater has been used since 1984 by the California Marine Bioassay Project to develop sensitive methods for testing discharges into California marine waters (USEPA, 1995b). These methods include the development of tests for abalone *(Haliotis rufescens),* topsmelt *(Atherinops affinis),* giant kelp *'(Macrocystic pyrifera)* and mysids *(Holmesimysis costata).*

Dilution water used in the laboratory water and reference toxicant tests for the freshwater tests consisted of EPA synthetic freshwater at a hardness of 220 *mg/L,* prepared just prior to test initiation. This hardness was selected as a conservative estimate of Lower Calleguas Creek ambient hardness, which ranged from 371 - 485 *mg/L* during the freshwater toxicity testing events. .

Copper Spiking and Test Solution Preparation

To bracket the expected EC50 value and obtain partial effects results for *Mytilus edulis* and *Ceriodaphnia dubia* development, nominal test copper concentrations were selected. Table 4 and Table 5 provide nominal (Le., calculated) test copper concentrations used in this study. Each toxicity test had between seven and ten concentrations of copper. Test concentrations were prepared by spiking one-liter aliquots of the laboratory and site waters with a certified commercial copper nitrate standard (obtained from Inorganic Ventures of Lakewood, New Jersey). A two-liter volume of test solution was prepared for solutions used as "duplicates". Prior to analysis, test solutions were allowed to sit for approximately three hours. This allowed ,copper partitioning to reach equilibrium with site water constituents and is consistent with WER guidance.

Table 4. Nominal total copper additions to site water and lab water for *Mytilus edu/is* tests

Site	Nominal Test Concentrations (Total Cu ug/L)
Mugu Lagoon Sites	*100,70,49,34,24,17,12,8,6,0* 34,24,17,12,8,6,4,0
Lab Water 2-WER-	500,350,245,172,120,84,59,41,29 and 0
A-M.e. 2-WER-B-	1000,700,490,343,240, 168, 118,82,58,40 and 0
M.e. Lab Water2	100,70,49,34,24,17,12,8,6,4, and 0

Table 5. Nominal total copper additions to site waters and lab water for *Ceriodaphnia* tests.

Site 2-WER-A-	Nominal Test Concentrations (Total Cu ug/L)'
C.d. 2-WER-B-	*500,350,245,* 172, 120,84,59,41,29 and 0
C.d. Lab	1000,700,490,343,240, 168, 118,82, 58,40 and 0
Water1 Lab	100,50,35,24, 17,12,8,6,4, and 0
Water2	100,70,49,34,24,17,12,8,6,4, and 0

Toxicity Testing Procedure

Saltwater

Mytifus edulis is the ideal organism for use in saltwater WER studies with copper. When deriving a site 'specific criterion, it is critical to use a test species that is sensitive at Criterion Continuous Concentrations (CCC) or Criterion Maximum Concentrations (CMC). The concentrations that affected *Mytilus eeJulis* approximate the criteria concentrations. *Mytilus edulis* is the most appropriate species to use both as a surrogate for brackish water species and to set a site-specific criterion for copper for a number of important reasons:

- The CTR saltwater criterion for copper is determined exclusively by *Mytilus edulis.* Since it is used exclusively to set the current national criterion, it is appropriate to use it exclusively to set a site-specific criterion for the Lagoon and Creek.

- It is the most sensitive species in the national saltwater database. It therefore is not only a good surrogate for invertebrate species (which tend to be more sensitive to copper than vertebrates) and not only a good surrogate for 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 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 *Mytilus edulis* (genus mean acute value (GMAV) of 14.48 ug/L for the genus *Daphnia,* 9.92, ug/L for *Ceriodaphnia* and 9.625 ug/L for *Mytilus edulis).*

The *Mytilus edulis* toxicity test used for this study followed the guidelines, established by the USEPA manual (USEPA, 1995b). A summary of test conditions and acceptability criteria used in *Mytilus edulis* toxicity testing is provided in Appendix 6.

'The adult, reproductive mussels were obtained from a commercial supplier (Carlsbad Aquafarms, Carlsbad, CA). Upon receipt and prior to spawning, the adult bivalves were stored in filtered seawater at a temperature of 15°C :t 1°C. Bivalve embryos were generated from gravid *Mytilus edulis.* To induce spawning, the gravid adults were placed into clean Bodega Bay seawater (0.45 !-1m-filtered) at 20°C. This increase in temperature induced the bivalves to release sperm and eggs. When an individual bivalve was observed releasing sperm or eggs, it was transferred to a separate container for isolation and collection of gametes. To evaluate viability and quality, gametes were examined microscopically. The highest quality gametes were then used to prepare freshly-fertilized embryos by mixing a solution of sperm (at the .appropriate concentration) to an aliquot of the best quality eggs. The resulting embryos were examined approximately one hour after fertilization to ensure viability.

Toxicity t~sting required the use of five replicates at each treatment level. Each replicate consisted of a 20mL glass scintillation vial containing 10 mL of appropriate test solution. To initiate the test, approximately 150 to 300 embryos at or beyond the two-celled stage were inoculated into each test scintillation vial. Initial embryo density numbers were not used to calculate endpoints but to verify that the controls were behaving normally (Le., adequate survival). Additional replicates were established to determine initial embryo density, successful embryo development (i.e., to allow monitoring of the test conditions without affecting actual test replicates) and final water quality characteristics. Water quality vials contained 20 mL of test solution at the 'same embryo density as the test vials. Test and observation/monitoring vials were then placed into a temperature-controlled water bath at 15°C::!: 1°C under a 16L: 80 photoperiod.

After 48 hrs, the "observation" vials were examined to ensure that 2: 90% of the surviving embryos achieved normal development to the "D-hinge" stage. If normal embryo development was confirmed, the test was terminated by adding 0.5 mL of 5% glutaraldehyde. At test termination, the water quality vials at each treatment level were composited and analyzed for salinity, D.O., and pH. Each preserved test vial was subsequently examined microscopically to determine the percent of embryos exhibiting normal .development. .

To determine any developmental impairment or toxicity, the percent normal development results (for each treatment level) were compared to the control treatment results. Determinations of the No Observable Effect Concentration (NOEC), Lowest Observable Effect Concentration (LOEC) and key Effect Concentration (EC) point estimates were made using the CETIS@ statistical package (Version 1.023, TidePool Scientific, McKinleyville, CA). EC50 values were calculated using either the Maximum Likelihood Probit or Trimmed Spearman-Karber Method. After an initial statistical evaluation using nominal copper .concentrations was conducted, specific copper concentrations test treatments were selected and measured for total and dissolved copper. Test response data were reanalyzed to determine EC50 point estimates based on measured copper concentrations.

Freshwater

The acute survival test with *Ceriodaphnia dubia* was performed only on the two water samples for which the ambient salinity was below a threshold value of 2,000 + 500 IJS/cm conductivity (Lower Calleguas Creek stations).

-The range-finding tests for *Ceriodaphnia* consisted of acute (48-hr) exposures to test solutions that were prepared by spiking the site waters and "Lab" water with copper from a commercial CuN03 standard at concentrations of 10, 50, 100,200,500, and 1000 ug/L Cu. "New" water quality characteristics (pH, D.O., and conductivity) were measured for each test solution prior to use in these tests.

There were 2 replicates for each test treatment, each replicate consisting of 60-mL of test solution in a 100mL HOPE beaker; a third "water quality" replicate was similarly established for measurement of test solution water quality characteristics. Neonate *Ceriodaphnia* «24 hrs old), from in-house laboratory .cultures, were used to start these acute tests, which were initiated by allocating 10 *Ceriodaphnia.* into each of the replicate cups. The cups containing the test treatments were placed in a temperature-controlled water bath so as to maintain the water temperature.in each replicate cup at 20°C, under fluorescent lighting on a 16L:8D photoperlod~ Routine water quality characteristics (pH and D.O.) of the test waters were measured each day and at the end of the test in the water quality replicate. After 48 hrs, the tests were terminated and the number of live neonates in each replicate cup was determined.

The survival data for the treatments for each site water were analyzed to determine key concentration-response endpoints (e.g., EC50 values); all statistical analyses were performed using the CETIS@ statistical 'package. The results of these range-finding tests were then used to determine the nominal definitive test copper concentrations based upon identification of copper concentrations that would be expected to bracket the potential range of *Ceriodaphnia dubia* acute survival EC50 values.

The control treatment for each of the two site waters consisted of an aliquot of the site water without any added copper. Nominal definitive test copper concentrations (Table 5) were selected based on the results of the copper range-finding tests performed on site waters and Lab waters so as to bracket the expected range of *Ceriodaphnia dubia* acute survival EC50 values. Test solutions at these concentrations were .prepared by spiking 1.O-L aliquots of the site waters and Lab water with copper from a commercial CuN03 standard. Test solutions were allowed to sit for approximately 3 hours prior to test initiation to allow for copper partitioning to reach equilibrium with the site water constituents. Initial test water quality characteristics (pH, D.O., and salinity) were determined for each treatment test solution prior to use in the tests.

There were 4 replicates for each test treatment, each replicate consisting of 60-mL of test solution in a 100mL HOPE beaker; an additional "water quality" replicate was similarly established for measurement of test solution water quality characteristics. These acute tests were initiated by allocating 5 neonate *Ceriodaphnia* . « 24 hrs old), from in-house laboratory cultures, into each of the replicate beakers. The test replicates were then placed in a foam board which floated in a temperature-controlled water bath so as to maintain the water temperature in each replicate cup at 20°C, under fluorescent lighting on a 16L:8D photoperiod.

Routine water quality characteristics (pH and DO) of each of the test treatment test solutions were measured in the water quality replicate each day and at the end of the test. After 48 hrs,the tests were terminated and the number of live neonates in each replicate cup was determined. The survival data for each test treatment were analyzed and compared to the appropriate Control treatment to determine key 'concentration-response endpoints (e.g., EC50 values); all statistical analyses were performed using the CETIS@ statistical package.

Secondary and Supportive Testing

In this study, a secondary freshwater and saltwater aquatic test species were not used to verify WER results obtained from *Mytilus edulis* and *Ceriodaphnia dubie.* It was determined to be unnecessary in large part because *Mytilus edulis* is the same (and most sensitive) species used to set the USEPA saltwater .quality objective for copper. Likewise, the Streamlined Water~Effect Ratio Procedure for Copper recognizes that daphnids are quite sensitive to copper and have been the most useful organisms for freshwater WER studies (USEPA, 2001). Other species for which approved toxicity tests exist would be less sensitive to copper resulting in less applicable WERs. In addition, Cu WER studies using only one species have been completed and approved in other areas. Additionally, the Streamlined Water-Effect Ratio Procedure for Copper (USEPA, 2001) requires the testing of only one species and states "the 1994 Interim Procedure recommendation for a test with a second species has been dropped, because the additional test has not been found to have value."

.Reference Toxicant Testing

To confirm that the *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. The control water used for reference toxicant testing consisted of 0.45 j..Jm filtered seawater from Bodega Bay at 30 ppt. Test solutions were prepared by spiking the control water with copper (as CUCI2) at copper concentrations of 1.25,2.5,5,10,15 and 20 ug/L.

. To confirm that the *Ceriodaphnia dubia* 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. The control water used for reference toxicant testing consisted of 80% Arrowhead and 20% Evian commercial spring waters. Test solutions were prepared by spiking the control water with copper (as CUCI2) at copper concentrations of 4, 8, 16, 32, and 64 ug/L. Test results were used to determine EC50 endpoints to compare to the ongoing laboratory reference toxicant database to ensure that test result responses were consistent with previous test results. Statistical analyses were performed using the CETIS@ statistical package. .

Collection of Site water and Test Solutions

Prior to analysis, the following samples were collected for chemical analyses: samples of each test solution, "neat" (Le., without salinity adjustment) ambient site waters and lab water. Samples undergoing copper analyses were collected by directly pouring an aliquot (800 mL to 850 mL) of test solution into a uniquelylabeled and pre-cleaned one-liter HOPE bottle. Collected samples were sealed, placed on ice and shipped to CRG Marine Laboratory in Torrance, California for analysis.

. Samples of the."neat" ambient site waters and lab water were similarly collected for analyses of dissolved manganese. Additional samples of salinity-adjusted ambient site and lab waters were collected for analyses of selected major ions and other parameters associated with the bioavailability and/or toxicity of copper. Collected samples were sealed, placed on ice and shipped to CRG Marine Laboratory for ancillary analysis. .

Collection of Site Waters and Test Solutions for Chemical Analyses

,Immediately prior to test initiation and again at test termination, samples of each test solution were collected for copper analysis. These samples were collected into labeled, pre-cleaned 250-mL HOPE bottles (supplied by the analytical lab), which were sealed and placed within an insulated cooler. At this time, 1-L samples of each of the two site waters and of the "Lab" water were similarly collected for analysis of TSS, TOC, DOC, hardness, alkalinity and ammonia. These samples were immediately shipped via overnight delivery, on ice and under chain of custody, to the analytical laboratory (CRG Laboratories, Inc).

Measurement of Toxicity Test Solutions for Total and Dissolved Copper

'Once toxicity testing was completed, guidance found in the USEPA Memorandum *Interim Guidance on the Determination and Use of Water Effect Ratios for Metals* was used to select test solutions for chemical analysis (USEPA, 1994). Rather than measuring all test solutions, this guidance recommends measuring test solutions (for initial and final dissolved copper) that are used in determining the endpoint. This study followed the USEPA recommendation of measuring only values used in determining the endpoint but with one modification. WE~ calculations were based on EC50s calculated using initial copper concentrations as opposed to a time-weighted average of initial and final values. This is a more conservative approach given that a proportionately greater copper recovery is expected in site water than in lab water when measured at ,the test conclusion (San Jose, 1998). This is most likely due to the lab water experiencing a greater loss d copper to glassware, as opposed to the site water that has more constituents that can coat the glass and prevent copper loss. The net effect of using the weighted average instead of the initial concentrations would have a disproportionately lower lab water EC50 that in' turn would produce a disproportionately higher WER. Thus it is more conservative to analyze only the initial concentrations. Initial and final results were measured for one station's tests during the first sampling event for comparison.

Chemical Analysis of Water Samples and Test Solutions

. Spiked samples were delivered to the analytical laboratory in <24 hours. Samples were handled in this manner so that all of the filtration, preservation, and other sample handling after spiking could be conducted in the analytical laboratory's clean room facilities and using their equipment and distilled acid.

Upon arrival at CRG Marine Laboratory, all samples for copper analyses were split. One of the split aliquots was then filtered (0.45 ~m) and placed into a separate pre-cleaned HDPE bottle. Both aliquots (filtered and unfiltered) were preserved with ultra-pure HN03. "Neaf' (unadjusted salinity) waters. salinity-adjusted ambient site waters, lab water and selected test solutions were ,analyzed for copper (total and dissolved).
. Copper analyses were performed using USEPA Method 200.8.

Additional samples of salinity-adjusted ambient site and lab waters were analyzed for selected major ions and other parameters associated with the bioavailability and/or toxicity of copper and nickel. In addition, Pacific EcoRisk performed pH and salinity measurements of the test solutions. Most of these constituents were included to support a parallel study using these data as input into the Biotic Ligand Model (BLM).

Table 6. Summary of Measured Parameters and Analytical Methods

Analyte	Laboratory	Method	Holding Timea	MDL
Total Suspended Solids (TSS)	CRG	SM 2540-D	7 days	0.1 mg
Total Organic Carbon (TOC)	CRG	EPA 415.1	28 days	0.5mg
Dissolved Organic Carbon (DOC)	CRG	EPA 415.1	24 hrs (filter), 28 days	0.5mg
Total Dissolved Solids (TDS)	CRG	SM 2540-C	7 days	0.1 mg
Ammonia	CRG	SM 4500-NH3 F	28 days	0.01 m.
Chloride	CRG	SM 4500-CI E	28 days	0.01 m
Total Hardness as CaC03	CRG	SM 2340-8	180 days	1 mg/L
Dissolved Alkalinity	CRG	EPA 310.2	14 days	1 mg/L
Dissolved Calcium (Ca)	CRG	EPA 1640/200.8	24 hrs (filter), 180 days	0.5 mg
Dissolved Magnesium (Mg)	CRG.	EPA 1640/200.8	24 hrs (filter), 180 days	5 mg/L
Dissolved Sodium (Na)	CRG	EPA 1640/200.8	24 hrs (filter), 180 days	5 mg/L
Dissolved Potassium (K)	CRG	EPA 1640/200.8	24 hrs (filter), 180 days	5 mg/L
Dissolved Sulfate (S04)	CRG	SM 4500-S04 F	24 hrs (filter), 28 days	0.01 m
Total Recoverable Copper	CRG	EPA 1640/200.8	180 days	0.005/(
Dissolved Copper	CRG	EPA 1640/200.8	48 hrs (filter), 180 days	0.005/!

aHolding times are from date/time of sample collection.

QUALITY ASSURANCE/QUALITY CONTROL

Quality control/quality assurance *(QNQC)* practices were maintained during all facets of this study (sampling, testing, chemical analysis). This is evidenced by the high quality, low variability results obtained in compliance with the individual lab's *QNQC* criteria. *QNQC* data is provided in Appendix 3.

T.he laboratories used, CRG Marine Laboratory and Pacific Ecorisk are NELAP/NELAC certified, and in addition, they are also certified in California.

Synthetic Sea Salts

Artificial sea salts were added to. site water due to the fact that site waters were either collected from a freshwater environment (Creek) or from areas in the Lagoon that were significantly effected by freshwater inputs into the Lagoon. With respect to *Mytilus* test salinity requirements, this species can not be tested at salinities much lower than 30 ppt, thus requiring the use of artificial sea salts in test experimental design. During non-storm conditions (Events 1 and 2), the presence of freshwater inputs resulted in an increased site water dissolved organic carbon (DOC) concentration relative to areas of the Lagoon which were not significantly impacted by freshwater inputs. This pattern was similarly observed and exacerbated during storm conditions (Events 3 and 4). Studies have demonstrated that copper toxicity to *Mytilus* is inversely proportional to the concentration of DOC in the site water (Arnold et al., 2006). In fact, analytical chemistry data collected as part of this project were used to validate this model. A comparison of model-predicted copper EC50 values to the *Mytilus* copper EC50 values reported in this study were in agreement, indicating that the site water characteristics (Le. DOC) were driving the decrease in copper toxicity to *Mytilus.* GP-2 sea salt is made from reagent grade salts and as a result does not contribute DOC to the site water matrix. rhis is substantiated by work performed by Arnold et al. (in press) that evaluated the potential for DOC contribution to test media by artificial sea salts; GP-2 sea salt was evaluated as part of this study. Results of that study indicated that GP-2 salts would not contribute DOC to test media.

Upstream inputs of DOC from Calleguas Creek (freshwater) appears to be driving the bioavailability of copper in the *Mytilus* toxicity tests and thus resulting in higher EC50 concentrations; toxicity testing with *Ceriodaphnia dubia* for this study also support this conclusion.

Chemistry QAIQC

Extensive *QNQC* requirements were designed into this study as part of the agreements with the contract laboratories that performed the physical, chemical, and biological analyses. This *QNQC* analysis summarizes the acceptability of data generated during the sampling events. Holding times, analytical accuracy and precision, potential contamination, and conformance to data acceptability criteria were reviewed. Questionable raw data, results or missing data were identified and referred back to the originating lab for further investigation and qualification as appropriate.

Analytical chemistry accuracy and precision were monitored throughout the sampling events of this study using blanks, duplicates and spikes. 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. The potential for contamination of environmental samples was investigated through the collection and analysis of lab, field, method, filtered, and procedure blanks to determine if contamination arose at the various stages of sampling and analysis.

Analytical results, toxicity test results, and *QAIQC* results from each sampling event were compared with *QAIQC* parameters. Limited QAIQC evaluation of hardne~s, Mg, TOC and TSS values was performed given that precision of these parameters was less critical to the interpretation of results.

Chemistry Data Quality

Holding Times

The USEPA analytical holding time guidelines require metals sample filtration' and preservation within 48 hours of sampling and analysis within 6 months. These guidelines were consistently met. A few samples (alkalinity, TDS, TSS) were analyzed outside of the recommended holding times, so th~se samples were qualified (Appendix 2) as "estimated" values. These qualifications did not affect the WER Falculations.

Precision

Laboratory duplicate samples were analyzed and did not require any data qualifications. I

Accuracy

Percent recoveries of external reference standard measurements and matrix-spike duplicates were deemed acceptable when measured values were between 75% - 125% of the certired concentration values. One sample (TOC) was qualified as "high bias" because the recovery was greater than 125%. This indicates that the concentration of TOC reported for that sample may be higher than ~he actual sample concentration. This qualification did not affect the subsequent WER analyses and calculations.

Toxicity Test QAIQC

Test acceptability requirements set forth in the USEPA Short Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to West Coast Marine and Estuarine Organisms (USEPA, 1995b) and WER test guidance (USEPA, 1994) were used in the assessment of toxicity *gata.*

Standard Test ConditionsITest Acceptability Criteria

The toxicity testing of the ambient site waters with *Mytilus sp.* and *Ceriodaphnia dubia* incorporated standard QA procedures to ensure that the test results were valid, including the use ofl negative controls, positive controls, test replicates, and measurement of water quality during testing. The~e QA procedures are consistent with methods described in the USEPA guidelines. Water samples for lhe toxicity testing were shipped/stored at ~ °C and were used within the 36 hour holding time period. AI~I measurements of routine water quality characteristics were performed as described in the PER Standard Operating Procedures. 1

Lab Water Quality and Holding Times

Table 7 provides sample collection dates and respective test initiations.

Table 7. Copper WER Study Sample Collection and Test Initiation Dates

Event	L r oca Ion	Site Water Collection Date	Lab Water Collection Date	Test Initiation Datea
	Lagoon	8/26/03	*8/261038*	8/27/03
Event 1	Creek	8/27/03	8/28/03F	8/28/03
E t 2	Lagoon	1/27/04	1/26/048	1/28/04
	ven Creek	1/27/04	1/27/04F	1/28/04
E t 3	Lagoon	3/01/04	2/26/048	3/02/04b
	ven Creek	3/01/04	3/02/04F	3/02/04b
Event 4	Creek	4/15/06	4/14/068	4/15/06

a - Typically, tests were initiated on the day following site water collection.
b - Freshwater toxicity tests were conducted but the analytical laboratory mistakenly did not run the copper analyses. S - Saltwater
F - Freshwater

Sea Salt Controls

A "sea salt" control with the maximum salinity addition (salting from zero to 30 :t 2 ppt) was used for each event to evaluate the affects of synthetic sea salts on embryo development. Salt controls were compared to lab control water to test statistical significance. Test results indicated that the addition of sea salts did not effect normal development. A summary of synthetic sea salt control results is provided in Table 8. In addition, initial test water quality characteristics (pH, D.O., and salinity) were determined for each treatment test solution prior to testing.

Table 8. Summary Results for Synthetic Sea Salt Control

Treatment	Mean Normal Development (%)
GP2 Control (Event 1)	91.3
GP2 Control (Event 2)	91.6
GP2 Control (Event 3)	98.0
GP2 Control (Event 4)	98.8

Initial versus Final Copper Concentrations

The CCW Study followed the initial versus final copper test sample analysis protocols established during previous studies (San Francisco Bay, New York Harbor) given the fact that these protocols had been peer reviewed and approved by both the San Francisco Bay Technical Review Committees and EPA specialists.

The 1994 WER guidance conservatively recommends that both initial and final copper measurements be made on all concentrations used in determining the EC50 endpoint. Based on previous results, in this study, only initial total and dissolved copper measurements were made for selected concentrations and the control. Subsequent statistical analyses and EC50 calculations were based on measured copper concentrations at the beginning of the test, rather than on a time-weighted average of initial and final . v!:1lues.

In the San Jose Copper WER study, for example, in which both initial and final copper values were measured for many samples. data showed that laboratory water loses more copper (proportionally) than site water (Appendix 5). This difference in percent lost results in the calculation of a higher WER (Le., laboratory water, the denominator in the equation, has a smaller value). Therefore, using the final copper concentration, or an average of initial and final, will result in a higher WER value for all samples. Using the initial copper concentration is thus a conservative approach to EC50 and WER calculations. A site-specific copper study conducted in the New York/New Jersey Harbor, analyzed both initial and. final copper concentrations and then calculated the mean of the two values. The results of this study found that initial measurements of copper produced more conservative WERs because site water copper concentrations increased from initial to final, while lab water concentrations stayed virtually the same.

Initial and final copper concentrations were measured during one event of the CCW work to verify this conservative assumption. Site data (Table 9) showed a slight average increase in copper from initial to final. Lab water results showed that for spiked samples, there was a decrease in copper concentration in the final samples. Therefore, if there is an average increase in copper concentrations in site water and decrease in lab water concentrations, using the initial copper concentration will be a more conservative option as it will produce lower WER values.

Table 9. Copper concentrations in site water and lab water (ug/L) before and after toxicity testing.

Nominal	Dissolved		Total	
Spike	Initial	Final	Initial	Final
Site Water:				
0	2.13	3.54	2.92	3.36
172	125	132	141	143
245	171	180	191	196
350	210	231	263	264
Lab Water:				
0	1.11	1.92	1.34	1.59
17	14.4	14.3	14.8	12.8

ffased on the San Francisco Bay and New York/New Jersey data and conclusions, along with initial and final concentrations measured in this study, it was determined that using only initial copper concentrations would be a reasonable and conservative approach for calculating the EC50s used in the WER calculations.

Comparison to Standard Parameters

Per the 1994 WER Guidance, standard parameters collected in Mugu Lagoon and Lower Calleguas Creek during the four events were compared to long term average and median concentrations of these same parameters (Table 10, Table 11). These comparisons indicate that conventional parameters were within the expected range for the sites, based on historic data. Additionally, probability plots were created to illustrate the trends of historic hardness and TSS data (Figure 2, Figure 3, Figure 4, and Figure 5).

Table 10. Comparison of Event Hardness to Average Hardness (mglL)

	Event 1-	Event 2	Event 3	Event 4
1-WER-A	6120	3550		
1-WER-B	5990	3170		
1-WER-C	6310	5550	1800	
1-WER-D	5980	5020	3670	
Reach 1 Average*		3134 *mg/L*		
Reach 1 Median*		2044 *mg/L*		
Reach 1 Range*t		1029 - 7650 *mg/L*		
2-WER-A	264	272	306	156
2-WER-B	451	400	371	157
Reach 2 Average*		534		
Reach 2 Median*		480		
Reach 2 Range*t		146 - 643 *mg/L*		

*Reach averages, medians and ranges incorporate data from 1986 - 2004.
tRanges were calculated using the mean :t2 standard deviations.

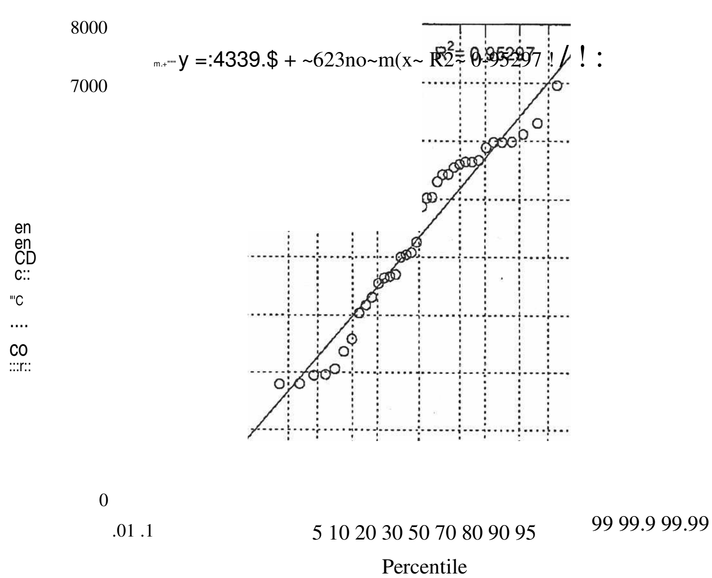

Figure 2. Probability Plot for Reach 1 Hardness

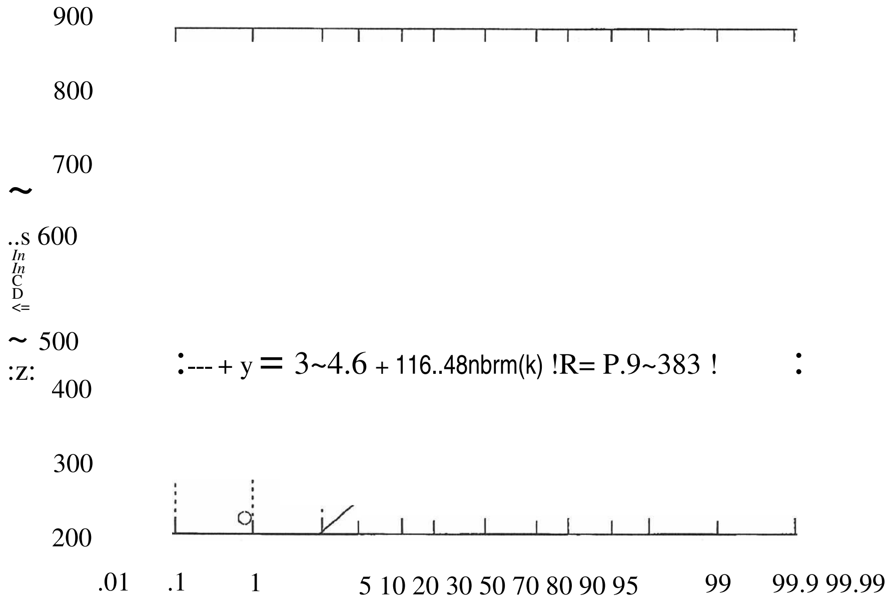

Figure 3. Probability Plot for Reach 2

Hardness

Table 11. Comparison of EventTSS to Average TSS (mg/L)

	Event 1	Event 2	Event 3	Event 4
1-WER-A	6.0	13	78	
1-WER-B	6.1	9.5	-	
1-WER-C	8.4	9.8	19	
1-WER-D	12	6.1	41	
Reach 1 Average*		77 *mg/L*		
Reach 1 Median*		12 *mg/L*		952
Reach 1 Range*t		-0 - 629 mg/L		900
2-WER-A	5.7	43	222	
2-WER-B	4.0	14	41	
Reach 2 Average*		104 *mg/L*		
Reach 2 Median*		29 *mg/L*		
Reach 2 Range*t		0 - 574 mg/L		

*Reach averages, medians and ranges incorporate data from 2003 - 2004. tRanges were calculated using the mean :1:2 standard deviations. A "0" was included where -280 resulted in a negative number.

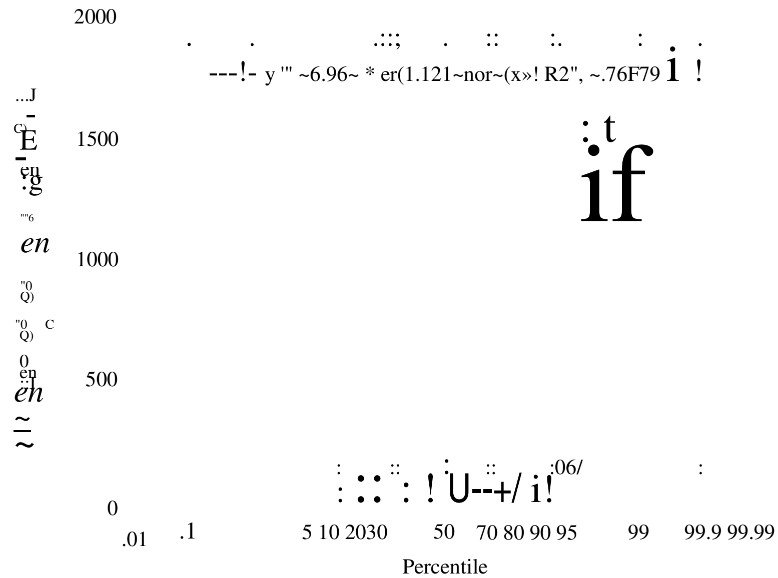

Figure 4. Probability Plot for Reach 1 Total Suspended Solids

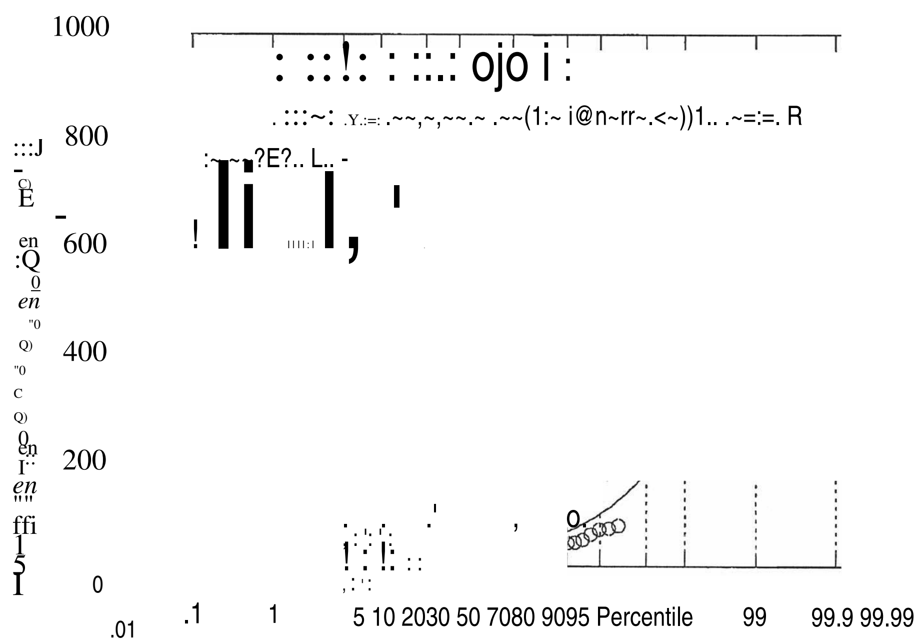

Figure 5. Probability Plot for Reach 2 Total Suspended Solids

QA/QC Conclusions

The results from all sampling events are complete with sufficient QA data to support the validity of the reported chemical and toxicological data. Only the minor QA issues discussed above were identified. None of these issues impacted the calculation of the WERs.

RESULTS

Tables of results for all measured parameters are located in Appendix 2. Concentration-response plots for all *Mytilus, Ceriodaphnia,.* and lab water toxicity tests are presented below. The "% Effect' on the y-axis represents the percentage of test organisms that were not adversely affected. All of the curves show the expected effect that as the organisms are exposed to increasing copper concentrations, adverse effects are observed.

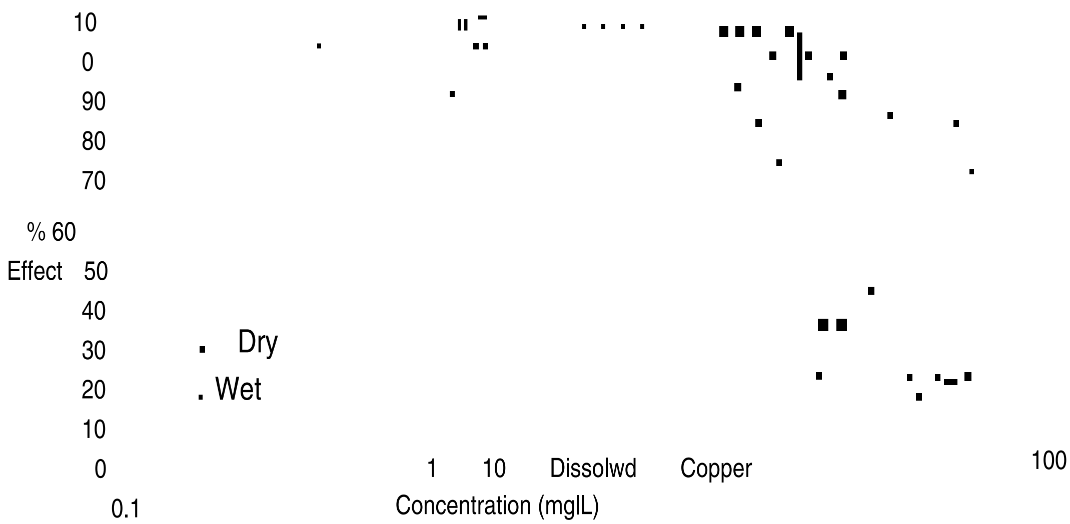

Figure 6. Concentration-response curves for *Mytilus* tests in Mugu Lagoon

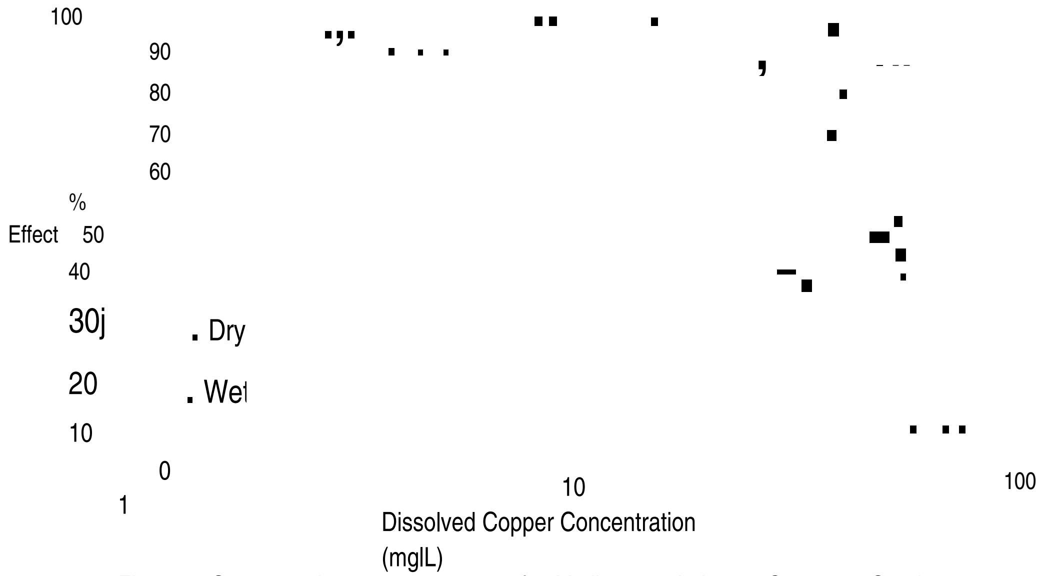

Figure 7. Concentration-response curves for *Mytilus* tests in Lower Calleguas Creek

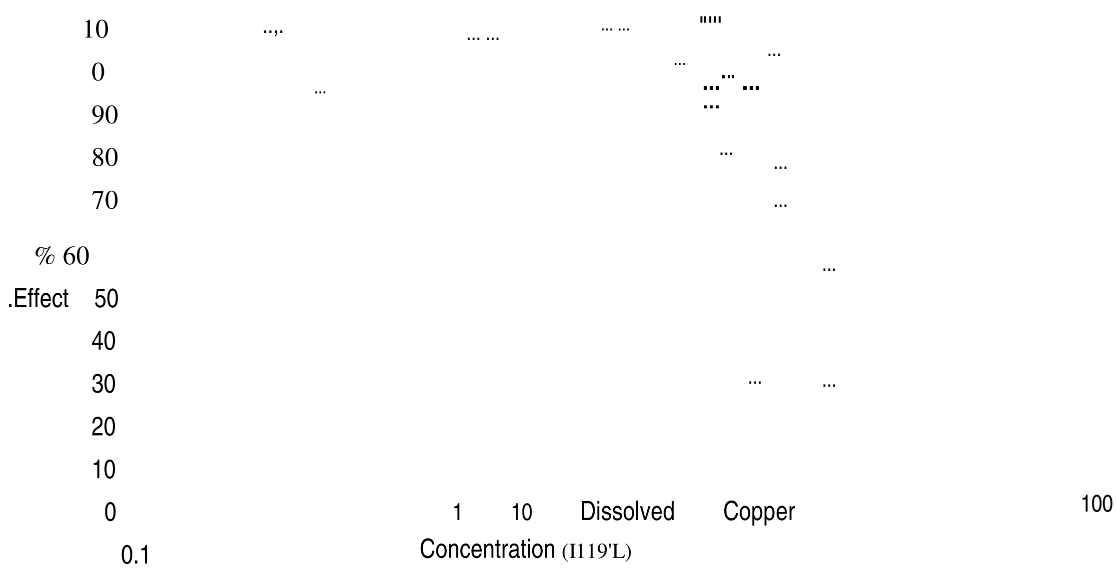

Figure 8. Concentration-response curves for *Mytilus* lab water tests

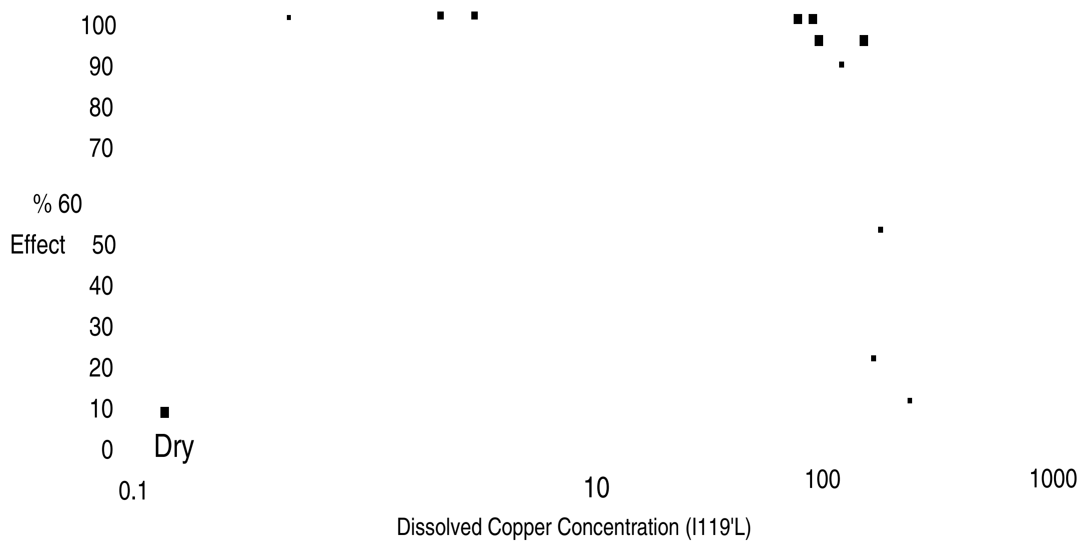

Figure 9. Concentration-response curves for *Ceriodaphnia* tests in Lower Calleguas Creek

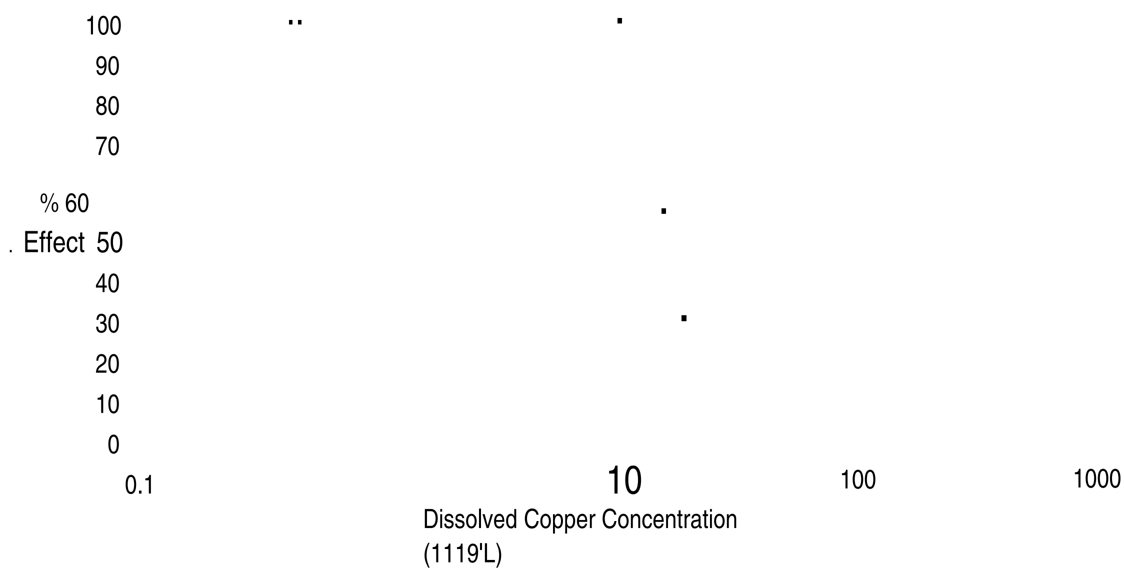

Figure 10. Concentration-response curves for *Ceriodaphnia* lab

water tests

Table 12. Total and dissolved copper EC50 determinations for site water and lab water (*Mytilus* tests).

Site	Date Initiated*	Dissolved Copper EC50, ug/L (95% confidence limits)	Dissolved Copper WER	Salinity (ppt)
1-WER-A	*8/27103*	19.6 (19.3-19.8)	1.68	31.1
1-WER-B	8/27/03	15.9 (15.8-16.0)	1.36	31.0
1-WER-C	8/27/03	14.7 (14.2-15.0)	1.26	30.0
1-WER-D	*8/27103*	20.0 (19.5-20.6)	1.71	31.5
"Lab" Water	8/27/03	11.7 (11.5-11.8)		
2-WER-A-M.e.	8/28/03	52.9 (49.5-58.7)	4.49	0.5
2-WER-B-M.e.	8/28/03	48.2 (45.6-49.5)	4.08	1.4
"Lab" Water	8/28/03	11.8 (11.5-12.0)		
1-WER-A	1/28/04	34.4 (34.0-34.8)	2.80	17.5
1-WER-B	1/28/04	33.8 (33.4-34.0)	2.75	15.8
1-WER-C	1/28/04	16.1 (15.3-17.2)	1.31	31.6
1-WER-D	1/28/04	22.5 (16.2-30.6)	1.83	27.5
2-WER-A-M.e.	1/28/04	59.4 (54.3-62.6)	4.83	1.0
2-WER-B-M.e.	1/28/04	54.0 (49.6-57.9)	4.39	1.2
"Lab" Water,	1/28/04	12.3 (11.5-13.0)		
1-WER-A	3/2/04	56.8 (55.7-57.8)	4.03	4.7
1-WER-C	3/2/04	41.6 (40.9-42.3)	2.95	7.2
1-WER-D	3/2/04	54.4 (53.8-55.2)	3.86	22.8
2-WER-A-M.e.	3/2/04	47.9 (45.9-50.4)	3.40	0.5
2-WER-8-M.e.	3/2/04	>47.8 (---)	3.39	0.7
"Lab"Water	3/2/04	14.1 (12.5-16.1)		
2-WER-A-M.e.	4/15/06	31.6 (31.2-32.0)	4.20	0.3
2-WER-B-M.e.	4/15/06	28.9 (28.6-29.3)	3.84	0.3
"Lab" Water	4/15/06	7.53 (7.31-7.76)		

*The dates in the above table represent the day the toxicity tests were initiated. Typically, samples were collected and shipped overnight to Pacific Ecorisk, who initiated the toxicity tests upon arrival.

Note: The species mean acute value (SMA V) for *Myti/us* is 9.625 uglL for dissolved copper. The SMA V is the geometric mean of the results of all acceptable acute toxicity tests for the most sensitive life stage of the species.

Table 13. Total and dissolved copper EC50 determinations for site water and lab water *(Ceriodaphnia* tests).

Site	Date Initiated"	Dissolved Copper EC50, ug/L (95% confidence limits)	Dissolved Copper WER
2-WER-A-C.d.	8/28/03	150 (139-161)	8.93
2-WER-B-C.d.	8/28/03	179 (161-197)	10.6
"Lab" Water	8/28/03	16.8 (15.2-18.4)	
2-WER-A-C.d.	1/28/04	175 (168-178)	6.81
2-WER-B-C.d.	1/28/04	183 (174-186)	7.12
"Lab" Water	1/28/04	25.7 (25.7-25.7)	

"The dates in the above table represent the day the toxicity tests were initiated. Typically,
samples were collected and shipped overnight to Pacific Ecorisk, who initiated the toxicity tests upon arrival.
Note: The species mean acute value (SMA V) for *Ceriodaphnia* is 22.1 ug/L for dissolved copper, at a hardness of 100 *mg/L.* The SMA V is the geometric mean of the results of all acceptable acute toxicity tests for the most sensitive life stage of the species.

Summary Statistics

Summary statistics for dissolved copper concentrations and dissolved copper EC50s and WERs are presented in this section. Table 14 and Table 15 present the dissolved copper data measured in ambient samples collected in both Mugu Lagoon and Lower Calleguas Creek. Tables 16, 17, 18, and 19 present EC50 values for Mugu Lagoon and Lower Calleguas Creek. Tables 20 and 21 summarize WER results for Mugu Lagoon and Lower Calleguas Creek *(Mytilus* and *Ceriodaphnia).* Summaries are provided for each event, as well as all events combined. Results are not reported for *Ceriodaphnia* for Event 3 because although toxicity samples were collected, the analytical laboratory mistakenly did not run the copper analyses.

Table 14. Dissolved copper ambient concentrations (ug/L) in Mugu Lagoon.

Site	Event 1	Event 2	Event 3	All Events
1-WER-A	0.69	4.32	3.74	ave = 2.92
1-WER-B	0.99	3.79	---	ave = 2.39
1-WER-C	0.68	1.85	3.57	ave = 2.03
1-WER-D	0.60	1.90	1.72	ave = 1.41
number	4	4	3	11
minimum	0.60	1.85	1.72	0.60
maximum	0.99	4.32	3.74	4.32
a. mean	0.74	2.97	3.01	2.17
g. mean	0.73	2.75	2.84	1.71
90th Percentile	0.90	4.16	3.71	3.79
. 5th Percentile	0.61	1.86	1.91	0.64
median	0.69	2.85	3.57	1.85
std. deviation	0.17	1.28	1.12	1.43

Table 15. Dissolved copper ambient concentrations (ug/L) in Lower Calleguas Creek.

Site	Event 1	Event 2	Event 3	Event 4	All Events
2-WER-A	6.54	4.04	2.77	2.48	ave = 3.96
. 2-WER-B	8.67	4.01	2.7	2.4	ave = 4.45
number	2	2	2	2	8
minimum	6.54	4.01	2.70	2.4	2.40
maximum	8.67	4.04	2.77	2.48	8.67
a. mean	7.61	4.03	2.74	2.44	4.20
g. mean	7.53	4.02	2.73	2.44	3.77
90th Percentile	8.46	4.04	2.76	2.47	7.18
5th Percentile	6.65	4.01	2.70	2.40	2.43
median	7.61	4.03	2.74	2.44	3.39
std. deviation	1.51	0.02	0.05	0.06	2.27

Dissolved copper EC50 values and WERs summary statistics are provided below. Dissolved copper EC50 values were used to calculate the WERs for each station and event:

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

Table 16. Dissolved copper EC50 values (ug/L) and summary statistics in Mugu Lagoon.

Site	Event 1	Event 2	Event 3	All Events
Lab Water	11.7	12.3	14.1	ave = 12.7
1-WER-A	19.6	34.4	56.8	ave = 36.9
1-WER-B	15.9	33.8	---	ave = 24.9
1-WER-C	14.7	16.1	41.6	ave = 24.1
1-WER-D	20.0	22.5	54.4	ave = 32.3
number	4	4	3	11
minimum	14.7	16.1	41.6	14.7
maximum	20.0	34.4	56.8	56.8
a. mean	17.5	.26.7	50.9	30.0
g. mean	17.4	25.5	50.5	26.7
90th Percentile	19.9	34.2	56.3	54.4
5th Percentile	14.9	17.1	42.9	15.3
median	17.7	28.1	54.4	22.5
std. deviation	2.65	8.94	8.17	15.4

Table 17. Dissolved copper EC50 values (ug/L) and summary statistics in Lower Calleguas Creek *(Mytilus).*

Site	Event 1	Event 2	Event 3	Event 4	All Events
Lab Water	11.7	12.3	14.1	7.53	ave = 11.4
2-WER-A-M.e.	53.0	59.4	47.9	31.6	ave = 48.0
2-WER-B-M.e.	48.2	54.0	47.8	28.9	ave = 44.7
number	2	2	2	2	8
minimum	48.2	54.0	47.8	28.9	28.9
maximum	53.0	59.4	47.9	31.6	59.4
a. mean	50.6	56.7	47.8	30.3	46.4
g. mean	50.5	56.6	47.8	30.2	45.1
90th Percentile	52.5	58.9	47.9	31.3	55.6
5th Percentile	48.4	54.2	47.8	29.0	29.8
median	50.6	56.7	47.8	30.3	48.1
std. deviation	3.39	3.82	0.07	1.9	10.7

Table 18. Dissolved copper EC50 values (ug/L) and summary statistics in Lower Calleguas Creek *(Ceriodaphnia).*

Site	Event 1	Event 2	All Events
Lab Water	16.8	25.7	ave = 21.3
2-WER-A-C.d.	150	175	ave = 163
2-WER-B-C.d.	179	183	ave = 181
number	2	2	4
minimum	150	175	150
maximum	179	183	183
a. mean	164	179	172
g. mean	163	179	171
90th Percentile	176	182	182
5th Percentile	151	175	154
median	164	179	177
std. deviation	20.5	5.66	14.9

Table 19. Dissolved copperWER values and summary statistics in Mugu Lagoon.

Site	Event 1	Event 2	Event 3	All Events
1-WER-A	1.68	2.80	4.03	ave = 2.8
1-WER-B	1.36	2.75	--	ave = 2.1
1-WER-C	1.26	1.31	2.95	ave = 1.8
1-WER-D	1.71	1.83	3.86	ave = 2.5
number	4	4	3	11
minimum	1.26	1.31	2.95	1.26
maximum	1.71	2.80	4.03	4.03
a. mean	1.50	2.17	3.61	2.32
g. mean	1.49	2.07	3.58	2.13
90th Percentile	1.70	2.78	3.99	3.86
5th Percentile	1.27	1.39	3.04	, 1.28
median	1.52	2.29	3.86	1.83
std. deviation	0.23	0.73	0.58	1.01

Table 20. Dissolved copper WER values and summary statistics in Lower Calleguas Creek *(Myti/us).*

Site	Event 1	Event 2	Event 3	Event 4	All Events
2-WER-A-M.e.	4.49	4.83	3.40	4.20	ave = 4.2
2-WER-B-M.e.	4.08	4.39	3.39	3.84	ave = 3.9
number	2	2	2	2	8
minimum	4.08	4.39	3.39	3.84	3.39
maximum	4.49	4.83	3.40	4.20	4.83
a. mean	4.29	4.61	3.39	4.02	4.08
g. mean	4.28	4.60	3.39	4.02	4.05
90th Percentile	4.45	4.79	3.40	4.16	4.59
5th Percentile	4.11	4.41	3.39	3.86	3.39
median	4.29	4.61	3.39	4.02	4.14
std. deviation	0.29	0.31	0.01	0.25	0.51

Table 21. Dissolved copper WER values and summary statistics in Lower Calleguas Creek *(Ceriodaphnia).*

Site	Event 1	Event 2	All Events
2-WER-A-C.d.	8.93	6.81	ave = 7.87
2-WER-B-C.d.	10.7	7.12	ave = 8.89
number	2	2	4
minimum	8.93	6.81	6.81
maximum	10.6	7.12	10.6
a. mean	9.79	6.96	8.38
g. mean	9.75	6.96	8.24
90th Percentile	10.5	7.09	10.1
5th Percentile	9.01	6.82	6.86
median	9.79	6.96	8.02
std. deviation	1.22	0.22	1.78

An aspect of spatial variability not directly addressed by WER measurements involves evaluating whether the measured ambi~nt copper concentrations are exceeding toxicity threshold values. 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" (USEPA, 1994).

$$\frac{\text{Measured Copper (ug/L)}}{\text{3.1 ug/L * Copper WER}}$$

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 ug/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 (USEPA, 1994}." A table of these values using the data collected during this study shows that all such quotients are less than 1.0 (Table 22), and are therefore acceptable.

Table 22. Sample Specific WER Approach Results

Site	Event 1	Event 2	Event 3	Event 4
1-WER-A	0.13	0.50	0.30	
1-WER-B	0.23	0.44	---	
1-WER-C	0.17	0.46	0.38	
1-WER-D	0.11	0.33	0.14	
2-WER-A-M.e.	0.47	0.27	0.26	.0.19
2-WER-B-M.e.	0.69	0.29	0.26	0.20

CALCULATION OF RECOMMENDED WER AND SSO

The EPA has developed two guidance documents to assist in the development of WERs for copper. The 1994 WER guidance contains two different methods for developing WERs for all metals. The Streamlined Water-Effect Ratio Procedure for Discharges of Copper provides guidance for developing WERs for copper downstream of POTW discharges. Each of the methods is designed to address different waterbody types and discharge conditions. For the purposes of calculating the recommended WERs, the 1994 WER guidance was used as the basis for the analysis because not all of the criteria for using the Streamlined Method were met. For Mugu Lagoon, Method 2 in the 1994 WER guidance is the only applicable method.. For Calleguas Creek, either Method 1 or Method 2 could apply for calculating the WER.

The 1994 WER guidance, Method 1, includes a specific calculation method that is basically the calculation of an adjusted geometric mean of the dry weather samples. Additional analysis is included to account for different flow conditions, but the calculations are based on the assumption that samples were collected directly downstream of a POTW discharge. In the case of Calleguas Creek, there are no porw discharges to the reach for which the WERs were being developed. Therefore, all of the specific calculations outlined in Method 1 could not be directly applied. Additionally, concerns have been raised about potential differences between dry and wet weather samples that are not specifically addressed in the WER guidance.

Method 2 provides less specific guidance about how to calculate the final WERs, but suggests that "a WER is determined for each sample, and the final WER (FWER) is calculated as the geometric mean of some or all of the WERs" (USEPA, 1994). Additionally, the *Streamlined WER Procedure* (though not used as the basis for the study) also specifies that the final WER be calculated as the geometric mean of two (or more) sample WERs.

Because all three WER calculation methods include a discussion of geometric means as possible calculation methods, geometric means were determined to be the most appropriate calculation method for the final WERs. This calculation approach was developed in conjunction with the T AC and Regional Board staff. The geometric mean is a measure of the central tendency of a data set that minimizes the effects of extreme values. The equation for the geometric mean is:

Geometric mean = ~Y1 * Y2 * Y3 * '''Yo

An example of the geometric mean calculation for site 2-WER-A and 2-WER-B for *Myiilus,* using the WERs calculated at the Lower Calleguas Creek sites during the dry weather events is as follows:

Geometric meanMytilUSL_CollegwoCnlek = V 4.49 * 4.08 * 4.83 * 4.39 == 4.44

To address concerns that dry and wet weather conditions produce different WERs, the geometric mean of the dry weather WERs and wet weather WERs were calculated separately. To ensure that the selected final WER was protective for all conditions, the lower of the dry and wet weather geometric mean WERs for each reach was selected as the final WER. In Mugu Lagoon, the dry weather results differed based on the degree of freshwater influence on the Lagoon. The sample results indicate that when the freshwater flows were more significant, the WERs in the reaches closest to the freshwater inputs were higher than during o.ther times. Therefore, to provide a conservative estimate of the dry weather WER, the geometric mean of the dry weather WERs in the Lagoon were calculated without the higher dry weather WERs from periods with more significant freshwater flows.

As can be seen in Table 18 and Table 21, the EC50and calculated WER values from results of *Ceriodaphnia* tests are much greater than those calculated using *Mytilus* test data. Therefore. to take a conservative approach, only *Mytilus* results are used in subsequent calculations of WERs and site-specific objectives (SSOs).

The wet and dry weather WERs are presented Table 23.

Table 23. Dissolved copper WER geometric mean values.

Test	Location	Weather	Geometric Mean
Mytilus edulis	Mugu Lagoon	Dry	1.51'
		Wet	3.58
	Lower Calleguas Creek	Dry	4.44
		Wet	3.69

* To provide a conservative estimate of the dry weather WER, the geometric mean was calculated using only those samples which did not require the addition of GP-2 salts. The results indicate that when the freshwater flows were more significant, the WERs in the areas of the Lagoon closest to the freshwater inputs were higher than during other times. The samples used for this calculations included Event 1, Sites A, 8, C, D and Event 2, Sites C, D.

Based on the results in Table 23, the dry weather WER is the lowest WER for Mugu Lagoon and the wet weather WER is the lowest value for Lower Calleguas Creek. Therefore. the recommended WERs are 1.51 for Mugu Lagoon and 3.69 for Lower Calleguas Creek.

In addition to Mugu Lagoon and Lower Calleguas Creek, the saltwater criteria also applies to Revolon Slough because the salinity of the reach is between 1 and 10 ppt more than 5% of the time. The CTR requires that the lower of the saltwater and freshwater CTR criteria be applied in those situations. The WER for Mugu Lagoon effectively adjusts the saltwater criteria for the most sensitive area of the watershed. Because Revolon Slough flows directly into Mugu Lagoon and the criteria are driven by this connection, the WER developed for the Lagoon will be applied to Revolon Slough as well. As shown by the results of the Lower Calleguas Creek sampling, the WER in waterbodies with lower salinities is higher than in the Lagoon so it is conservative to apply the Lagoon WER to Revolon Slough.

The recommended SSOs are determined by multiplying the CTR saltwater chronic and acute criteria by the final WERs as shown in the equations below:

$SSO_{general} =$ CTR criterion * Final WER

$SSO_{chronic} =$ 3.1 ug/L * Final WER SSO ~cute

= 4.8 ug/L * Final WER

For example:

$$SSOChronic_{MuguLagoon} = 3.1\ ug/L * 1.51 = 4.68\ ug/L$$

The final recommended WERs and SSOs are shown in Table 24.

Table 24. Recommended WERs and SSOs for Mugu Lagoon, Revolon Slough and Lower Calleguas Creek.

Reach	Final WER	Chronic SS01 (ug/L)	Acute SS01
Mugu Lagoon	1.51	4.68	7.25
Lower Calleguas Creek	3.69	11.4	17.7
Revolon Slough	1.51	4.68	7.25

1 The Saltwater criterion is applied to Mugu Lagoon, Revolon Slough and Lower Calleguas Creek. Mugu Lagoon salinities are >1 Oppt all of the time, and Lower Calleguas Creek and Revolon Slough salinities are most typically between 1-1 Oppt, indicating that the more stringent of the saltwater and freshwater criteria should be applied. For copper, the saltwater criterion is more stringent than the freshwater.

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Appendix D – Other Copper WERs in California

Development of the Site-Specific Objective Range for Copper in Lower South San Francisco Bay

The development of site-specific objectives for copper in the Lower South SF Bay involved combining the recalculation procedure and the indicator species procedure.

1. **Recalculation Procedure** – The recalculation procedure allows modification of the national criterion by correcting, adding or removing data from the national toxicity database.

2. **Indicator Species Procedure** – This procedure allows modifications of the national criterion by using a site-specific multiplier, called a water-effect ratio, to account for ambient water quality characteristics affecting the bioavailability of metals like copper and nickel.

The most defensible options were chosen for the toxicity database, WER value, and ACR for copper, and these options yielded the recommended acute (10.8 µg/L) and chronic (6.9 µg/L) site-specific objective values for dissolved copper. The WER for lower South San Francisco Bay was set at 2.25. The resulting WER falls within the range of WERs recommended for Mugu Lagoon (1.51) and the lower Calleguas Creek (3.69). The development of site-specific objectives for copper in the Lower South SF Bay involved combining the recalculation procedure and the indicator species procedure. Two WERs were considered: a two-station-based WER and a three-station-based WER.

Water Quality Objectives for Copper in Lower South San Francisco Bay

Compound	WER	4-day Average (CCC)[1]	1-hr Average (CMC)[2]	Extent of Applicability
Copper	2.25	6.9	10.8	Marine and Estuarine Waters Contiguous to SF Bay, South of Dumbarton Bridge

Los Angeles River Copper Water-Effect Ratio Study

The purpose of this study, sponsored by the cities of Los Angeles and Burbank, is to determine the Water-Effect Ratio (WER) for copper in the Los Angeles River downstream of the discharges of each of three municipal tertiary wastewater treatment plants. The WER would modify national water quality criteria for copper based on observed toxicity in the LA River itself, rather than in laboratory dilution water. This study is underway at this time. Preliminary WERs reported by the consultant, Larry Walker Associates, are between 3.6 to 6.1. These preliminary WERs have not been fully reviewed by the study sponsors, technical advisory committee or the Regional Board at this time.

Appendix E - Resumes of Expert Reviewers: Bay, Hansen and Moffett

STEVEN M. SA V, Principal Scientist

EDUCA TION:

B.S.,.Marine Biology, California State University, Long Beach, 1976
M.S. Biology, California State University, Long Beach, 1982

AREAS OF EXPERTISE:

The design of research and interpretation of data to understand the relationship between sediment contamination and biological effects is Mr. Bay's primary research focus. As the director of SCCWRP's Toxicology Laboratory, Mr. Bay directs research to develop sediment toxicity test methods having improved sensitivity and ecological relevance. His current research includes projects to assess and improve the performance of sediment Toxicity Identification Evaluation (TIE) methods and to use TIE methods in TMDL development in southern California bays and estuaries. Mr. Bay works closely with California environmental management agencies to develop methods for sediment quality assessment. Current activities in this area include a five-year project to develop sediment quality objectives for the California Water Resources Control Board and a multi-year effort to assist the San Diego Regional Water Quality Control Board in developing guidel,ines for sediment quality assessment and cleanup in San Diego Bay. As Special Studies Manager for the Los Angeles Basin Contaminated Sediments Task Force, Mr. Bay is coordinating several multi-year research projects related to the disposal and effects of contaminated dredge material and is also assisting state and federal agencies in developing a long-term strategy for the management of contaminated sediments in southern California.

Mr. Bay's diverse experience and training includes invertebrate taxonomy, field biology, animal culture, physiology, and radioisotope techniques. These skills have resulted in many creative and innovative projects, including some of the first toxicity investigations of Southern California receiving waters and sediments using marine species and studies of PCB bioaccumulation and structure-activity relationships. His research and advisory activities have had a significant influence on marine toxicity testing at many levels, including the development and review of marine toxicity test methods for California regulatory programs, and standardization of west coast effluent test methods for the U.S. EPA. He participated in the recent Pellston workshop on porewater toxicity method and has also been invited to participate in the August 2002 Pellston workshop on the use of sediment quality guidelines.

PROFESSIONAL EXPERIENCE:

Principal Scientist, Southern California Coastal Water Research Project. Westminster, CA. 1980-Present.
Biologist, US Army Corps of Engineers. Los Angeles, CA. 1980.
Instructor, Fullerton College. Fullerton, CA. 1978
Teaching Assistant, California State University, Long Beach. Long Beach, CA. 1977-1979.
Research Assistant, Reish Marine Studies Inc. Los Alamitos, CA. 1977-1978.
Research Assistant, University of Southern California. Los Angeles, CA. 1976-1977.

PROFESSIONAL APPOINTMENTS:

Chair, Joint Task Group for Echinoderm Fertilization and Development Test section of Standard Methods - American Water Works Association Vice President- Santa Monica Bay Restoration Commission Technical Advisory Committee Management Committee and Special Studies Coordinator - Contaminated Sediments Task
. Force, Los Angeles Basin
Outreach Subcommittee Chair - Society for Environmental Toxicology and Chemistry, Education Committee
Reviewer - Environmental Science and Technology, Environmental Toxicology and Chemistry, Water Environment Research

HONORS AND AWARDS:

Los Angeles Regional Water Quality Control Board Water Quality Award for research", 2002
Southern California Toxicity Assessment Group Award for Outstanding Contribution, 1995
Kenneth L. Johnson Award for Outstanding Graduate Research - California State University Long Beach, 1982.
Summa Cum Laude - California State University Long Beach, 1976.
President's Honor List - California State University Long Beach, 1972-1976.

PROFESSIONAL SOCIETIES:

Society for Environmental Toxicology and Chemistry

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David J. Hansen

Mr. David J. Hansen has provided technical input to the U.S. Environmental Protection Agency`s water quality criteria and sediment quality criteria programs for over 25 years. This has included the publication of the *Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Life and their Uses, The Technical Basis for Establishing Sediment Quality Criteria for Non-ionic Chemicals by using Equilibrium Partitioning, Guidelines for Deriving Site-Specific Sediment Quality Criteria for the Protection of Benthic Organisms, Interim Guidance on the Determination and Use of Water-Effect Ratios for Metals,* all of EPA`s sediment quality criteria documents, and the saltwater portions of almost all of EPA`s water quality criteria documents. As an employee of HydroQual Inc., Mr. Hansen is lead author on the document *Cadmium, Copper, Lead, Nickel, Silver and Zinc: Proposed Sediment Quality Criteria for the Protection of Benthic Organisms: Technical Basis and Implementation.* He is authoring the "Criteria Derivation" section of the sediment quality criteria document for mixtures of polycyclic aromatic hydrocarbons. Mr Hansen has prepared responses to public comments on WQC, SQC and guidance documents.

Prior to Mr. Hansen`s retirement from the U. S. Environmental Protection Agency in January 1997, he served as the Technical Program Manager of the Water Quality and Sediment Quality Criteria Research Programs at the Narragansett Laboratory. He developed and prioritized research programs, allocated resources, created experimental designs, authored WQC and SQC documents, and published and presented the research accomplishments of both programs. Mr. Hansen provided Technical Assistance to EPA Regions and Program Offices, states, foreign institutions, and other scientists.

The major emphasis of Mr. Hansen`s research has been the development of technical bases for extrapolation from laboratory toxicity tests to accurate predictions of concentrations of substances acceptable to marine organisms. His research has developed (1) testing methods to quantify the effects of substances on marine organisms; (2) comprehensive databases required for extrapolations used in effects assessments; and (3) hazard assessment strategies to permit derivation of water quality criteria and sediment quality criteria protective of marine ecosystems.

Mr. Hansen`s most recent research dealt with development of a technical basis for deriving numerical, chemical-specific sediment quality criteria generic across sediment types. His research focused on the two principal technical issues which must be resolved if SQC are to be developed; (1) to provide a scientific basis for normalizing sediment concentration to that which is biologically available and (2) to select a concentration appropriate for benthic protection. His research examined the applicability of WQC as the effects concentration for establishing SQC for nonionic organic chemicals by use of the equilibrium partitioning approach. His research has utilized biological testing to demonstrate the role of acid volatile sulfide (AVS) and interstitial water metals concentrations in controlling the bioavailability of metals in sediments. Results from this research demonstrates that AVS is the principal sediment phase controlling the availability of individual metals (Ag, Cd, Cu, Ni, Pb, and Zn) and metals mixtures and led to the completion of SQC documents for non-ionic organic chemicals and metals.

CURRICULUM VITAE

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Education:

B.Sc. (Hons.): Chemistry, University of Otago, Dunedin, New Zealand (1981).
Ph.D. Chemical Oceanography, University of Miami (1986). Thesis title: "The Photochemistry of Copper Complexes in Seawater".

ProCessional Experience:

Teaching Assistant (Chemistry Laboratory), University of Otago (1980).
Research Assistant and Teaching Assistant, University of Miami (1981 - 1986). .
Postdoctoral Scholar, Department of Marine Chemistry and Geochemistry, Woods Hole Oceanographic Institution (1986 - December 1987).
Postdoctoral Investigator, Department of Marine Chemistry and Geochemistry, Woods Hole Oceanographic Institution (December 1987 - December 1988).
Assistant Scientist, Department of Marine Chemistry and Geochemistry, Woods Hole Oceanographic Institution (December 1988 - January 1993).
Associate Scientist, Department of Marine Chemistry and Geochemistry, Woods Hole Oceanographic Instltution (January 1993 to December 1996).
Associate Scientist w/Tenure, Department of Marine Chemistry and Geochemistry, Woods Hole Oceanographic Institution (December 1996 to December 2001).
Senior Scientist (December 2001 to present).

Awards:

Woods Hole Oceanographic Institution Postdoctoral Award (1986).
University of Miami Smith Prize (1987).
Office of Naval Research Young Investigator Award (1989.)

ProCessional Affiliations:

American Geophysical Union (1982 - Present)
American Chemical Society (1995 - Present)
American Society of Limnology and Oceanography (1996 - Present)

Research Interests:

Photochemistry of natural waters
Speciation and redox chemistry of trace elements in natural waters, with emphasis on transport processes and catalytic processes.
Metal-phytoplankton interactions; characterization of biologically produced chelators
Effects of protozoans on chemical fate
Bacterially mediated metal precipitation reactions

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n - updated 2/18/03

Appendix F
External Peer Review Comments from Dr. James Moffett

External Review of the Proposed Site Specific Criteria for L. Calleguas Creek and Mugu Lagoon

James W. Moffett, Woods Hole Oceanographic Institution

Summary Statement

The revised criteria are based on a well thought-out and executed work plan, given the complexity of these two receiving waters. The study convinced me that adoption of the new criteria will not adversely affect the aquatic ecosystems in either receiving water. In the following report, I will raise several issues that probably should have been considered in the original study, and will argue that the WER in Calleguas Creek may well be higher than the adopted value. However, given that the study adhered to EPA guidelines in adopting the most conservative finding, these considerations don't detract from my basic conclusion.

Report

Development of revised criteria for these receiving waters was particularly complicated because the WERs showed seasonal variation, were significantly different between the creek and the lagoon, and one was a freshwater system whilst the other was saline. Larry Walker Associates used good judgment in using the EPA Interim Guidelines (1994) rather than the Streamlined guidelines in this complex system. I am familiar with Pacific Eco-Risk from previous work. They are competent and thorough toxicologists.

The decision to use two organisms, following these guidelines, was also sound. However, I am troubled by the reasoning behind the use of the *Mytilus*, rather than the *Ceriodaphnia* data for the creek WERs. *Mytilus* is more Cu sensitive, yet the WER for *Ceriodaphnia* is higher, at odds with the usual trends. I think a possible explanation is that the addition of salts to the creek water is removing some of the Cu binding agents. This could occur if Ca and/or Mg are competing with Cu for binding sites, or if a "salting out" effect removes binding agents by flocculation. Therefore, a WER derived using *Mytilus* may be overly conservative if some binding agents have been removed. The effects of salts were considered in the work plan - but only their effect on artificially inflating the WER.

The seasonal variability in WERs led to a need for additional testing and these conformed to the EPA interim guidelines. However, given the potential economic importance of even small differences in WER values, I am surprised more funds were not used to make additional measurements, to obtain a more statistically defendable WER.

While I do not think that the WER for the creek is too large (I argued above that this WER might be too low), I am nevertheless concerned that a higher criteria in the creek may result in more Cu entering the lagoon. Ultimately, a waste load allocation model rather than a site specific criterion for the creek, may limit allowable discharges. I think this should be addressed and included in recommendations.

A final issue is that the biotic ligand model (BLM) was mentioned in Larry Walker Associates' report as a side project funded by the Copper Development association, but not in the staff report. Data used in that model might be useful in unraveling some of the seasonal variability. Why was it not discussed?