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Copper Management Strategy Development Resources, Final

submitted to

CLEAN ESTUARY PARTNERSHIP

prepared by

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PREFACE

This document was prepared for the Clean Estuary Partnership to support Technical Task 4.11, Basin Planning Assistance for Cu/Ni North of the Dumbarton Bridge, Sub-task 4.0, Basin Plan Amendment Assistance: Copper Management Strategy Development. Views or information expressed in this report may not necessarily reflect those of the funding agencies.

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COPPER MANAGEMENT STRATEGY DEVELOPMENT RESOURCES
Final

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1.0 INTRODUCTION

The purpose of this document is to support development of the stormwater related sections of the Copper Management Strategy (CMS) for San Francisco Bay North of the Dumbarton Bridge. It contains information to support development of the CMS.

This information and this format are intended to support stakeholder discussion of the CMS. Finalization of the CMS and its elements will involve discussions both internal to and external to the Clean Estuary Partnership that are beyond the scope of this document. *This is an information document—not a regulatory or policy document*. *This document does not set priorities among copper sources or among available control measures for each copper source.* Prioritization involves many considerations—including practical and policy considerations—that are specific to individual stakeholders.

In accordance with the scope of work, this document:

- Briefly describes the nature of the copper source.
- Identifies potential non-monitoring leading indicators for assessing the significance of the source and the effectiveness of control programs.
- Identifies control measures available to urban runoff programs to address the source, considering potential roles for other entities and regional activities.
- Identifies activity and effectiveness metrics for control measures.
    - An activity metric is a measure of the level of effort expended in addressing a source category. The activity metric should bear a relationship to the prospects of success.
    - An effectiveness metric is a measure of the effect that the action is having. Examples could be a measure of a behavior change, a load reduction, or a change in an environmental concentration or some combination.
- Lays out a sequence and time frame for implementation of control measures.

The information in this document is based on the recommendations of the report *Copper Sources in Urban Runoff and Shoreline Activities* (Copper Sources Report) (TDC Environmental 2004). The Copper Sources report provided copper source load estimates for urban runoff and shoreline activities (see Tables 1 and 2 on the next page), estimated the relative degree of uncertainty in each estimate, reviewed available control measures for each copper source, and identified priority for investigation of sources and control measures. Indicators and metrics included in the annual *Copper Action Plan Report*, prepared by the City of Palo Alto (Palo Alto 2005), have also been considered in this report. Using information from the Copper Sources Report, this report reflects existing control strategies used in urban runoff programs in the San Francisco Bay Area and elsewhere.

Available management strategies addressing copper sources are described in the following sections:

2.0 Architectural Copper	5.0 Marine Antifouling Coatings
3.0 Copper Pesticides	6.0 Existing Permit Requirements
4.0 Vehicle Brake Pads	7.0 Public Outreach

Table 1. Summary of Copper Sources in Urban Runoff
(Pounds of Copper per Year Discharged to San Francisco Bay)

Copper Source	Load Estimate	Uncertainty[a]
Architectural copper	4,500	Moderate-High
Copper pesticides *Estimate includes:* *Landscaping* *Wood preservatives* *Pool, spa, and fountain algaecides*	<8,000 – <10,000 *1,200 to 2,500* *1,400 to 2,800* *<5,000*	High
Vehicle brake pads *Estimate includes:* *Original equipment pads* *Replacement brake pads* *Brake pads on heavy-duty trucks, off-road vehicles, rail cars, and motorcycles*	>10,000 *10,000* *?* *?*	High
Industrial copper use	3,300	Moderate
Deposition of copper air emissions *Estimate includes:* *Diesel and gasoline fuel combustion* *Industrial facilities* *Residential wood burning and forest fires* *Unknown*	8,800[b] *3 – 60* *130* *110* *>8,000*	Low to Moderate
Soil erosion *Estimate includes:* *Construction* *Hydromodification*	7,000 *2,600* *<5,000*	Moderate
Copper in domestic water discharged to storm drains	3,000	Moderate-High
Vehicle fluid leaks and dumping	600	Moderate-High

[a]Uncertainty is defined as follows: Low indicates that the estimate has an error within 50%; Moderate indicates that the estimate has an error up to 2 fold; Moderate-high indicates that the estimate has an error up to 5 fold; High indicates an error up to 10 fold.
[b]May overlap with vehicle brake pad estimate.
Source: TDC Environmental, *Copper Sources in Urban Runoff and Shoreline Activities*, prepared for the Clean Estuary Partnership, 2004.

Table 2. Summary of Shoreline Copper Sources
(Pounds of Copper per Year Released to San Francisco Bay)

Copper Source	Load Estimate	Uncertainty
Marine antifouling coatings	20,000	Moderate-High
Copper algaecides applied surface waters	4,000	High

Source: TDC Environmental, *Copper Sources in Urban Runoff and Shoreline Activities*, prepared for the Clean Estuary Partnership, 2004.

2.0 ARCHITECTURAL COPPER

The major types of architectural copper features are roofs, gutters, and copper-treated composite shingles. While all copper pieces start with a shiny metal appearance, if left untreated, the copper will develop a patina, oxidizing to shades of green and brown as it ages. Factory or field copper oxidation treatments are often used to give the copper a desired patina immediately. Oxidation forms compounds that are soluble in water to varying degrees; these are incrementally washed off in runoff. Copper metal exposed to air continues to oxidize and incrementally wash off throughout its service life, which may extend for 100 years or longer.

Some composite roofing shingles are made with copper granules to retard moss and mildew growth. Like the copper in pure copper roofs, the copper granules will age, oxidize, and be subject to runoff when it rains.

Use of copper architectural features is relatively infrequent in the San Francisco Bay Area. The current best estimate of the frequency of copper architectural material use is:[1]

- Copper roofs—0.05% of residential structures and 0.3% of industrial commercial structures.
- Copper gutters—present on all structures with copper roofs plus another 0.01% of residential structures.
- Composite roofing shingles with copper biocides—0.03% of residential structures (use on other structures is believed to be negligible).[2]

The Copper Sources Report estimated that architectural copper annually releases about 4,500 pounds per year of copper. Of this amount, more than 90% is estimated to be released from copper roofs, about 5% from copper gutters, and about 1% from copper biocides in composite roofing shingles. This load estimate has a moderate-high uncertainty, due to uncertainty in architectural copper surface areas in the Bay Area, copper release rates, copper losses between building discharge points and surface waters, and the omission of possible discharges from patina treatments and cleaning solutions from the estimates.

Based on the relative importance of estimated load from the major types of architectural copper, the discussion below focuses on structures with copper roofs, as these structures and their gutters (which are usually copper) comprise more than 98% of the estimated load. Other structures (those without copper roofs that have copper gutters and those with copper-containing composite roofing shingles) comprise less than 2% of estimated copper releases.

2.1 CONTROL MEASURES

The Copper Sources Report described the control measures available to address architectural copper. This section briefly describes each option; describes how the option could be implemented in an effective manner (considering whether entities other than urban runoff programs that could play a role in implementing the control measure and generally how they can be engaged and whether regional actions would be appropriate); identifies important implementation issues; and identifies appropriate activity metrics and effectiveness metrics.

[1] Barron, T. S., *Architectural Uses of Copper: An Evaluation of Stormwater Pollution Loads and BMPs*, prepared for the Palo Alto Regional Water Quality Control Plant, November 2000, revised March 2001.
[2] Use may be increasing, as these products are relatively new in California market.

Strategy AC-1: Targeted Public Education

Education of architects, planners, and the public has the potential to reduce architectural copper use.[3]

Effective Implementation Design

Educational programs are most effective when designed in a targeted manner using information from previous, related programs.[4] In this case, the two key target audiences are (1) businesses or individuals applying for permits for projects involving installation of copper roofs and (2) architects.[5] Reaching these audiences would be most effectively accomplished in collaboration with partners.

Permit applicants for copper roofs can be identified when they approach a municipality to initiate a permitting process. The initial contact may occur in one of two ways: (1) to obtain a permit for installation of a copper roof (e.g., a re-roofing job), generally from a Building Division (2) to obtain approvals for building construction (this usually requires a site plan and architectural review), generally from a Planning Division. An effective education program for permit applicants would require partnering with building and planning staff within each municipality.[6] While partnerships would need to be developed locally, educational materials may be most cost-effectively developed regionally.

Architects must be licensed by the California Architects Board to practice in California. This state board could be of assistance, but has relatively limited resources. The more likely partner for an education program is the American Institute of Architects (AIA). There are at least four AIA chapters in the Bay Area, which provide continuing education, convene professional meetings, and distribute newsletters. Since architects are highly trained professionals, outreach would need to involve well-designed, highly credible materials and messengers. Developing—and perhaps implementing—an educational program for architects would likely be more cost-effective at the regional level than at the local level.

Implementation issues

A highly targeted, well-designed education program for copper architecture could achieve behavior change rates in the 10-15% range.[7] Since the uncertainty in tracking mechanisms is probably at least 10-15%, education programs by themselves are unlikely to have a measurable effect on the installation rate for copper roofs. Nevertheless, education is an important step along the road toward regulating a pollutant source:

- Education programs make affected parties aware of the link between a pollutant source and a water quality threat.

[3] Educating copper roof installers about best management practices for wastewater management is also feasible; see Strategy AC-3.
[4] For example, outreach to designers about copper plumbing.
[5] Consideration should be given to including non-architect designers in educational programs if they are found to specify a meaningful fraction of copper roof installations.
[6] Urban runoff programs have already been working to develop such partnerships to implement other elements of their permits (e.g., new development requirements), but these relationships have proven challenging for many municipalities.
[7] Less targeted programs would have lower rates. See Larry Walker Associates, *Tools to Measure Source Control Program Effectiveness*, prepared for the Water Environment Research Foundation, Project #98-WSM-2, 1999.

- Voluntary actions resulting from an education program provide helpful examples that the requested change is feasible (or occasionally prove that a change is infeasible).
- Agencies that operate education programs can clarify the technical and policy issues that need to be faced prior to initiating a regulatory program.

If a regulatory program is implemented, an education program can usually be downsized or eliminated.

Activity metric

Activity metrics would need to be developed when the outreach program was designed, as they should relate specifically to the program design. Examples of activity metrics include number of architects attending presentations and number of brochures distributed by Planning/Building Divisions. Caution must be exercised in evaluating activity metrics for public education, as metrics rarely relate to the actions actually taken by the target audience.

Effectiveness metric

Measuring the number of things that are <u>not</u> done (i.e., the number of copper roofs that are not installed) is exceptionally difficult. It would be rare that the selection of an alternative roof in response to an education program could be documented. Colloquial reports, while interesting, are not sufficiently reliable as a metric to merit the cost of collecting them from each municipality. While various metrics are theoretically possible (i.e., surveys, comparison to controls), the cost would be relatively high and the maximum value measured is unlikely to be significant. Adequate evaluation should be available from the leading indicator (see Section 2.2).

<u>Strategy AC-2: Regulate Copper Roof Runoff</u>

Occasionally, copper architectural materials may be clear-coated to maintain a desired hue (typically a penny-colored brown). In theory, all architectural copper features could be coated in a manner that would maintain the copper's appearance, but would prevent release of copper to the environment. In practice, the efficacy of such coatings has not been demonstrated, particularly for copper with a green patina layer. Treatment of roof runoff for copper removal is also possible. Voluntary implementation would be unlikely to be successful due to the cost for roof owners and the need for urban runoff agencies to ensure that the coating or runoff treatment system is maintained.

Effective Implementation Design

Each municipality would need to pass an ordinance regulating runoff from copper roofs. Requirements for coating and roof runoff treatment would need to be implemented in coordination with municipal building permit issuance. The program would need to specify treatment performance requirements, maintenance frequencies, inspection authorities, reporting requirements, and penalties.[8] Funding would be needed to manage the program, which could potentially be fee-based.[9] Regulatory requirements would likely need to focus on new installations, as requirements for existing copper roofs would pose both political and logistical challenges.

[8] Requirements for collection and management of copper-containing wastewater from cleaning and treatment should be integrated into any regulatory program (see Strategy AC-3).
[9] Fees that provide full cost recovery could be perceived as relatively high.

Implementation issues

Runoff treatment systems have significant technical downsides—they require management and maintenance. Runoff treatment systems have incomplete copper removal. Without maintenance, performance of runoff treatment systems can fall to near zero over a period of a few years. Costs for treatment include building owner costs for installation and maintenance, and municipal costs to ensure that treatment systems meet performance standards. The coating option is likely to be less costly for both roof owners and municipalities than runoff treatment, but would still entail meaningful owner costs for applying and renewing the coating and municipal costs to ensure the coatings are renewed. Municipalities would also incur one-time costs to adopt a local ordinance regulating copper roof runoff and to set up the new regulatory program to implement the requirements. (To reduce these costs, regional development of a model ordinance is recommended in Section 2.3). Implementing such controls for certain types of buildings (e.g., single-family homes) would likely be impractical.

While coating has the theoretical potential to essentially eliminate copper discharges, questions remain regarding the practicality, efficacy, and maintenance requirements for copper roof coatings. (A study to address these questions is recommended in Section 2.3, below). Coatings may have other negative impacts—for example, some coatings contain chemicals that post worker safety risks or contribute to air quality problems. If coating copper is practical and effective, it offers a more complicated—but perhaps politically less difficult—alternative to completely prohibiting architectural copper use.

Activity metric

Activity could be measured by counting the number of copper roofs installed with coatings or treatment.

Effectiveness metric

Using literature values for coating and treatment system efficacy in combination with the proposed activity metric, an effectiveness metric can be calculated. Since system performance tends to decline between maintenance events, it may be necessary to adjust the metric to account for actual maintenance frequencies. If treatment system regulations require sampling to prove system efficacy, these data could be used to develop a more accurate estimate of treatment efficacy. Note that this metric would only indicate the increase in copper releases (unless regulatory requirements were applied to existing roofs).

Strategy AC-3: Collecting Copper Wastewater During Construction

Cleaning and treating copper architectural features (particularly patina treatments) creates corrosive waste solutions that may contain relatively high concentrations of copper. These treatments occur when a roof is installed. Solutions could be collected, tested to determine their waste classification, and managed according to accepted best management practices for wastewater from building surface cleaning activities.[10]

Effective Implementation Design

This measure could be implemented through either enhanced enforcement or targeted outreach. Enhancing implementation of existing wastewater management requirements would entail coordination with municipal building

[10] Bay Area Stormwater Management Agencies Association (BASMAA), Best Management Practices for Surface Cleaning, 2000.

permit issuance. Most municipalities already have the legal authority necessary to require proper wastewater management, but have not targeted copper roof treatment waste for enforcement. Since municipal wastewater treatment plants vary in their criteria for acceptance of copper-containing wastewater, if procedures addressing this specific topic were not worked out when the Bay Area Stormwater Management Agencies Association (BASMAA) surface cleaning program was implemented, municipality-specific procedures could need to be developed to provide specific guidance to roof installers about how wastewater would need to be managed.

Since copper roof installers consist of a relatively small group of specialized roofing companies, an effective education program could support or serve as an alternative to enhanced enforcement. An effective education program would involve one-on-one contacts with firm owners and/or managers to educate them about proper waste solution management and the regulatory consequences of improper management. Due to the regional nature of these businesses and the need to ensure that educators can provide complete and reliable information to installers, this program would be most cost-effectively developed and implemented regionally. Local implementation issues for multiple municipalities would need to be addressed.

The quantitative benefits of this measure have not been estimated (due to lack of data on the discharges) and thus are not included in the load estimates in Table 1. Reductions would involve one-time "slug" discharges.[11]

Implementation issues

Since most of the issues were worked out when BASMAA implemented the surface cleaning program, implementing this strategy would be generally less difficult and costly than implementing the other identified strategies (however, there may be some exceptions). Because a roof installer education program would be backed by existing regulatory requirements, its behavior change rate would likely be higher than success rates for typical education programs (perhaps as high as 50%).[12] Implementation of an enhanced regulatory program would require an effective partnership with municipal building permit divisions, particularly with regard to enforcement of the requirements.[13]

Activity metric

Activity could be measured by counting the number of copper roofs installed that were subject to wastewater management requirements during construction.

Effectiveness metric

Proper management should eliminate this load, which means that the activity metric could also serve as an effectiveness metric. Alternatively, load reductions could potentially be estimated on the basis of copper concentration and wastewater volumes. Copper loads could be grossly estimated (no literature values were identified) or they could be estimated on the basis of data compiled from roof installers (regional compilation would be necessary to achieve a

[11] In the absence of additional information, it would be reasonable to assume that current loads are somewhat less than the total annual load from architectural copper, based on the copper treatment process, its one-time nature, and that some of this wastewater is probably not currently discharged to storm drains.
[12] Based on similar programs; see Larry Walker Associates, *Tools to Measure Source Control Program Effectiveness*, prepared for the Water Environment Research Foundation, Project #98-WSM-2, 1999.
[13] As noted previously, developing these partnerships have proven challenging.

sufficient size data set within a reasonable period of time). (Note that if non-compliance rates are high, these metrics would overestimate effectiveness.)

Strategy AC-4: Prohibiting Architectural Copper Use

Local governments have the authority to regulate the use of building materials. For example, the City of Palo Alto has an ordinance prohibiting the use of copper for new roofs and gutters (including composite roofing shingles with copper biocides).

Effective Implementation Design

Each municipality would need to pass an ordinance addressing architectural copper use. Like the Palo Alto ordinance, which includes provisions to protect historic buildings, it is likely that municipal ordinances would need to include certain exemptions in response to local policy issues. Implementation would entail partnering with building and planning divisions to ensure the requirements were implemented during building permitting and design review.

Implementation issues

Prohibiting installation of copper architectural features would eliminate new copper releases from architectural copper (except to the extent that exemptions are provided in local ordinances). Municipalities would incur one-time costs for ordinance development and minor ongoing costs for implementation. (To reduce ordinance development costs, regional development of a model ordinance is recommended in Section 2.3). While prohibiting architectural copper use is technically feasible, completely eliminating the opportunity to use copper may be politically unpalatable in some communities. To address this concern, use limitations could potentially be structured to allow installation with coating and/or treatment measures; however, offering these options would significantly increase implementation cost (see above). Although regulatory bans are among the most cost-effective pollutant source controls, municipalities would incur one-time costs for developing and adopting the ordinance and ongoing costs for enforcing it.

Activity metric

Since ordinance adoption would effectively eliminate additional copper roofs, a one-time activity metric to record adoption is appropriate.

Effectiveness metric

No metric is needed—a prohibition would essentially eliminate increases in the architectural copper load. Estimating the amount of load prevented would be difficult, as the current annual installation rate for copper roofs is unknown.

2.2 LEADING INDICATORS

Leading indicators are actions that can be tracked and used to assess the change in significance of a pollutant source (trends). These differ from effectiveness metrics, which evaluate the response to a specific control measure. Leading indicators should track actions that occur prior to environmental impacts.[14] Ideal leading indicators involve information that can be easily collected and compiled. Ideal leading indicators correlate with the magnitude of the pollutant source and/or effectiveness of addressing the source.

The amount of copper washed off copper roofs is proportional to the roof area. Therefore, good leading indicators for copper roofs will be proportional to roof area. Possible indicators and their pros and cons are listed in Table 3. Continuous tracking of

[14] Water quality monitoring is not a leading indicator, but rather a trailing indicator indicating the environmental response to a pollutant management action.

Table 3. Potential Leading Indicators for Architectural Copper Use

Potential Indicator	Comments	Recommended?
1. Number of permits issued for installation of copper roofs	Can be tracked on the basis of building permits. Should be possible to use a statistical sampling method to track, rather than asking every municipality to record every roof. Since copper roof installation rates are variable and often involve clusters of buildings, sample size would need to be relatively large to ensure that it is representative. Tracking is imperfect (some roofs are installed without permits despite the requirement that projects of this size obtain permits). Because roof sizes vary, correlates with increase in roof area but does not quantify that increase. Only reflects increase in roofing stock.	✓Yes
2. Area of new copper roofs installed	Similar to above indicator, but would require tracking of the area of each installed roof. Would require more data management than #1.	No. Management costs exceed indicator's value.
3. Percent of new roofs installed that are copper	Similar to #1, but would also entail recording all building permits that include roofs. Data challenges similar to #2.	No. Management costs exceed indicator's value.
4. Change in copper roof area	Can be tracked using high-resolution aerial photographs. 100% coverage would not be necessary—a sampling method could be used (see sample size caveat in #1). Commercially purchased aerial photos at the necessary resolution can be quite expensive ($70 for 10 acres).	No, unless aerial high-resolution aerial photos can be obtained at very low cost.
5. Sales of copper roofing material	Not feasible to track. Unlikely to be able to obtain such data for a reasonable price due to the nature of the marketplace (national) and confidential nature of sales data.	No. Not feasible.
6. Copper roofing contractor sales survey	Can be tracked by conducting a local market survey for copper roofing installers. Probably necessary to pay installers to participate in survey and to keep individual installer reports confidential. Data likely to be not entirely quantitative. Data could not be readily verified. Might not be feasible—could be difficult to obtain a meaningful sample size (particularly if survey is linked to copper roof control programs). If agency staff time costs are considered, could be least expensive option.	Yes, if feasible (best alternative to #1).
7. Number of copper roofs removed	Not feasible to track. Building and demolition permits generally do not indicate composition of existing roof. Since copper roofs have long lifetimes (100+ years), removal from service will be relatively rare.	No. Not feasible.
8. Roofing materials market forecasts	Forecasts of roofing materials markets can be purchased from market research firms (for example, http://freedonia.ecnext.com/coms2/summary_0285-32036_ITM). Such market reports can be expensive (thousands), but sometimes sections can be purchased for reasonable prices ($100 or less). Market reports usually do not cover regions as small as the San Francisco Bay area, so they would not reflect effectiveness of local control measures.	No. Unlikely to reflect local control measures and could be expensive.

indicators is not necessary as long as recent indicator data are available to support management decisions. For some indicators, properly designed representative samples can be used. For municipalities that have prohibited installation of copper roofs, no tracking would be necessary since no increase in copper roof area would occur.

Since copper roofs have very long service lifetimes (100+ years), in the near term copper roof area is much more likely to increase (reflecting new installations) than decrease (reflecting removal or demolition of the building). For all practical purposes, an indicator reflecting roof installation would be sufficient to track trends in copper roof area.

2.3 IMPLEMENTATION SEQUENCE AND TIME FRAME

Table 4 (on the next page) and Figure 1 (on page 12) lay out an appropriate initial implementation sequence and time frame for implementation of a copper management strategy for architectural copper. To ensure all elements are addressed, both Table 4 and Figure 1 envision maximum implementation of the strategy (partial implementation is also feasible; see below). Figure 1 clarifies that two parallel implementation approaches exist; jumping from one approach to another is possible. The time frames in Table 4 and Figure 1 recognize that some of these strategies require action from every Bay Area municipality that issues building permits—with at least 85 municipalities, this is no small task.

While full implementation would provide the most complete control of this urban runoff copper source, less than full implementation is entirely feasible, as long as the effectiveness level is judged acceptable (see descriptions above for effectiveness estimates for individual strategies). If partial implementation is selected, implementation of Strategy AC-1 is recommended prior to implementation of Strategies AC-2 or AC-4 (see the description of Strategy AC-1 in Section 2.1).

Available Copper Load Reduction

The strategies identified would only serve to slow the increase in copper quantities in urban runoff from architectural copper. This means that *even full implementation of the strategy would not reduce the quantity of copper in urban runoff from architectural copper*.

Post-Implementation Actions

Post-implementation reviews would evaluate progress and effectiveness of the strategy and identify appropriate modifications. For example, modifications could increase effectiveness, reduce costs by eliminating unnecessary activities, or modify strategies in response to newly identified issues. Reviews are recommended at the following times:

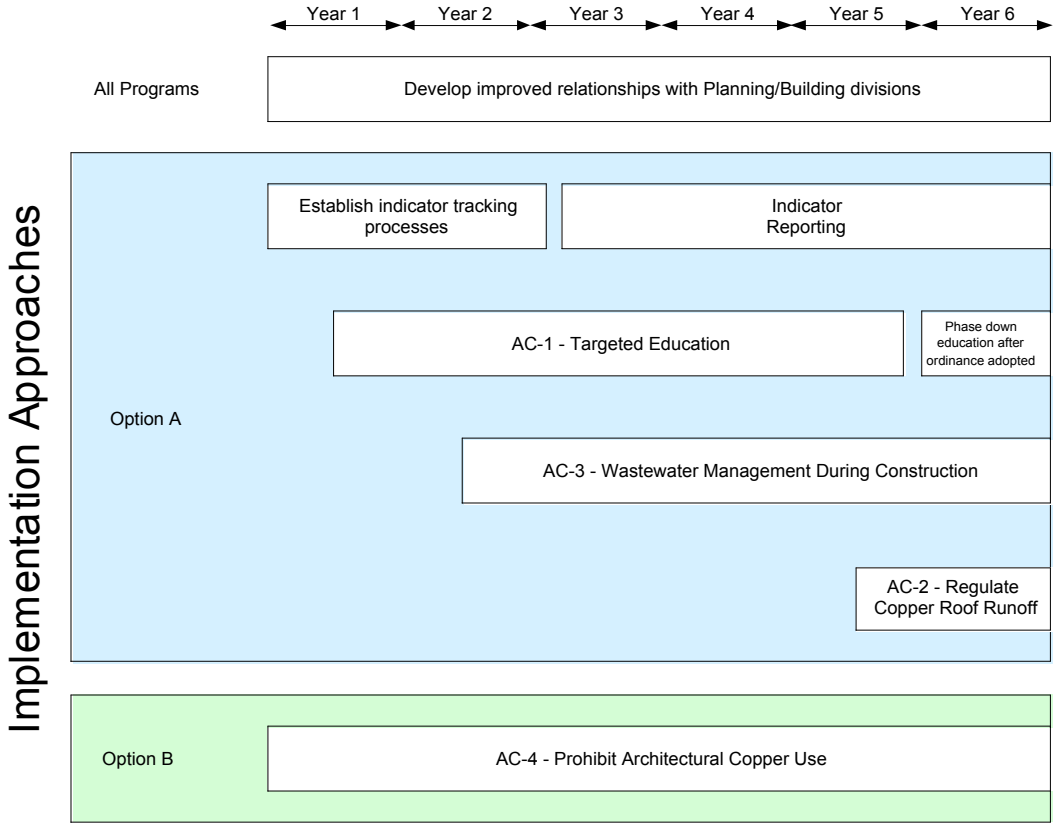
- About Year 4 – after completing the investigation in Action #5. This review can provide information (e.g., results of investigation, lessons from education program) to support development of model ordinance language.
- About year 10 – after the report documenting long-term testing to determine maintenance requirements for coatings (assuming this study is conducted). This review can identify adjustments needed based on lessons learned from the regulatory program.
- Every 5 years thereafter – Long-term reviews should consider the need for and frequency for continued tracking of various indicators.

The recommended time periods are flexible. Combining the review process with reviews of other CMS elements would be most efficient.

Table 4. Potential Framework for Implementation of All Architectural Copper Strategies

Action	Implementing Agency	Time Frame
1. Develop improved relationships with municipal Planning/Building divisions (necessary for successful implementation of actions below)	Individual municipalities	Start: Already being implemented for other reasons Implementation: ongoing
2. Establish tracking and reporting of the leading indicator and for activity and effectiveness metrics as strategies are implemented	Tracking—Individual municipalities Reporting—Regional preferred (may not be practical for metrics)	Start: Tracking established within 2 years; begin reports in year 3 Implementation: ongoing (every 1-2 years recommended initially); end if copper roofs are prohibited
3. Implement Strategy AC-1, conduct targeted outreach & education about copper roofs	Individual municipalities with regional support	Start: Begin implementing within 1 year Implementation: ongoing; end or downscale if copper roofs are regulated or prohibited
4. Implement Strategy AC-3, requirements for management of wastewater from copper roof installation	Individual municipalities	Start: Implement within 2 years Implementation: ongoing; end if copper roofs are prohibited
5. Investigate the practicality, efficacy, and maintenance requirements for copper roof coatings; if initial results are promising, continue testing to determine long-term maintenance requirements	One regional study	One-Time Task: Initial literature review within 1 year; initial study report within 3 years; continued testing to determine maintenance requirements may require 7-10 years
6. Develop model ordinance language for Strategy AC-4, Prohibiting Architectural Copper Use and Strategy AC-2, Regulate Copper Roof Runoff (provide options such that AC-2, AC-4, or a combination could be selected)	Regional model to serve as a resource for individual municipalities	One-Time Task: Complete within 4 years
7. Adopt ordinances to implement Strategy AC-4, Prohibiting Architectural Copper Use and/or Strategy AC-2, Regulate Copper Roof Runoff	Individual municipalities	Start: Progress report in year 5; complete adoption by year 6 Implementation: ongoing

Figure 1. Potential Framework for Implementation of All Architectural Copper Strategies



3.0 COPPER PESTICIDES

Copper-containing pesticides are widely used to control fungi, mildew, algae, and roots. As of February, 2004, there were 19 copper-containing pesticide active ingredients in products registered for sale in California. Primary uses are as algaecides, marine antifouling paint biocides, root killers, wood preservatives, and agricultural and garden fungicides.[15] In the San Francisco Bay area, municipalities have sought to reduce the use of copper-containing pesticides through a variety of efforts including public outreach to reduce copper algaecide use in swimming pools, spas, and fountains, and working with the California Department of Pesticide Regulation (DPR) to secure a 1995 prohibition on the sale and use of copper root control products in the Bay Area. Even so, copper pesticides are used in the Bay Area for a variety of applications.

The copper-containing pesticide use in the Bay Area can be divided into 3 categories: Landscaping fungicides, Wood preservatives, and Pool, Spa and Fountain Algaecides. Marine antifouling paint, which is also technically a pesticide, is addressed in Section 5. Copper-based root control products are assumed not to be used—in compliance with the state prohibition. Algaecides applications to surface waters in urban areas (e.g., to reservoirs and lagoons) are considered in Section 6, because they are regulated by the Aquatic Pesticide General Permit program managed by the State and Regional Water Boards.

[15] TDC Environmental. *Copper Sources in Urban Runoff and Shoreline Activities*. Information Update. Prepared for the Clean Estuary Partnership. November 2004.

The Copper Sources Report estimated that copper-containing pesticide use in the Bay Area amounted to approximately 650,000 lbs of copper annually. It was estimated that the release of copper to San Francisco Bay area urban runoff from landscaping fungicide use was 1,200 to 2,500 pounds per year. Release to Bay Area urban runoff of copper from wood preservative use was estimated as 1,400 to 2,800 pounds annually and from non-regulated algaecide use (i.e., applications to pools, spas, and fountains) was estimated as <5,000 pounds annually. This load estimate has a high uncertainty, due to uncertainty in statewide sales data extrapolations to the Bay Area, pesticide washoff rates, inaccuracies in DPR databases and assumptions regarding relative importance of various pesticide uses, proportion of copper pesticides used for pools, and copper release rates from pools.

The discussion below evaluates control measures for algaecides, landscaping pesticide use, and wood preservatives. Of these copper pesticide uses, pool, spa, and fountain uses appear to be the most significant copper source; however, this conclusion should be viewed cautiously, as the uncertainties in the available load estimates are greater than the differences among the loads.

3.1 CONTROL MEASURES

The Copper Sources Report described the control measures available to address copper pesticide use. The discussion below refers to these measures and is divided into control measures addressing pool, spa, and fountain algaecides, landscaping pesticides, and wood preservatives. This section briefly describes each option; describes how the option could be implemented in an effective manner (considering whether there are entities other than urban runoff programs that could play a role in implementing the control measure and generally how they can be engaged and whether regional actions would be appropriate); identifies important implementation issues; and identifies appropriate activity metrics and effectiveness metrics.

The control measures are selected based on the significance of the source and the potential for measurable reductions to be achieved by targeting a given source. The pool, spa, and fountain algaecides and the wood preservatives are anticipated to provide greater reduction potential for copper in urban runoff due to available alternatives and potential significance of the loading contributions for these sources. Landscaping pesticides are anticipated to offer a smaller reduction potential due to the expected lack of feasible safe alternatives. Therefore, the selected source control measures are more limited in scope for this source.

Pool, Spa, and Fountain Algaecides

Because the load estimate associated with the use of pool, spa, and fountain algaecides developed for the Copper Sources Report is highly uncertain and the estimated load is moderate, the relative importance of this source is not fully understood. A study to refine load estimates is recommended in Section 3.3 below. The refined load estimate should be used to determine whether implementing additional control strategies is warranted and if strategies are warranted, which strategies should be implemented.

Alternatives to copper algaecides are commonly available and widely implemented and promoted in California. They include improved maintenance practices that prevent algae from growing (i.e., maintaining proper biocide levels, maintaining water filtration and circulation and products containing polymeric quaternary amine compounds).

Strategy CP-1: Targeted Public Education

Education of pool service companies and pool owners has the potential to reduce discharges from the use of copper based algaecides. This strategy relies on voluntary actions by pool service companies and pool owners.

Effective Implementation Design

Educational programs are most effective when designed to target specific audiences using messages that resonate with that audience and using methods that target the specific audience. For outreach on pool algaecides, the key target audiences would be pool cleaning services, public swimming pool managers, pool product retailers and private pool owners. Initial efforts could focus on the businesses (i.e., cleaning services, pool managers, retailers) with outreach to private pool owners as a follow-up activity. Outreach materials have been developed by some Bay Area communities that target pool owners & pool companies and explain the issue of copper and water pollution and how use of algaecides in swimming pools, fountains, and spas contribute to copper discharges to local water bodies. These materials could be updated and modified to be used regionally. If practical non-copper alternatives are offered and practices directing discharges to the sanitary sewer that are easy to implement are recommended, some behavior change is also possible. An effective education program would involve direct contacts with firm owners and/or managers to educate them about proper waste solution management and the regulatory consequences of improper management. Due to the regional nature of these businesses and the need to ensure that educators can provide complete and reliable information to installers, this program would be most cost-effectively developed and implemented regionally. Local implementation issues for multiple municipalities would need to be addressed. Adding a certification element to this program may help to increase participation by the businesses.

As a second element of this outreach program, working with retailers to place education materials and signage where pool chemicals are sold increases the likelihood of copper reducing practices being adopted by private pool owners. A recognition program for retailers that place the educational materials in their stores will increase the effectiveness of this part of the program.

Implementation Issues

A highly targeted, well-designed education program for swimming pool algaecides could achieve behavior change rates in the 10-15% range.[16] Since the uncertainty in tracking mechanisms is probably at least 10-15%, education programs that rely on voluntary actions by themselves are unlikely to have a measurable effect on the reduction in use of copper based pool algaecides. Nevertheless, education is an important step along the road toward regulating a pollutant source:

- Education programs make affected parties aware of the link between a pollutant source and a water quality threat.

[16] Less targeted programs would have lower rates. See Larry Walker Associates, *Tools to Measure Source Control Program Effectiveness*, prepared for the Water Environment Research Foundation, Project #98-WSM-2, 1999.

- Voluntary actions resulting from an education program provide helpful examples that the requested change is feasible (or occasionally prove that a change is infeasible).
- Agencies that operate education programs can clarify the technical and policy issues that need to be faced prior to initiating a regulatory program.

The effectiveness of such a program may be improved by enlisting the help of pool service companies. Adding a certification program or recognition program for companies that recommend the use of non-copper algaecides or who provide services to redirect backwash flow to the sanitary sewer may increase the rate at which pool owners adopt the recommended practices. If a regulatory program is implemented, an education program can usually be downsized or eliminated.

Other issues include ease of redirecting discharges to the sanitary sewer and Publicly Owned Treatment Works (POTW) policies regarding acceptance of swimming pool discharges. In general, POTWs will accept filter backwash but their criteria varies for acceptance of discharges associated with draining of swimming pools. If procedures addressing this specific topic were not worked out for a previous pool education program, municipality-specific procedures may need to be developed to provide specific guidance to pool maintenance firms and pool owners about how pool emptying would need to be managed.

Activity metrics

Activity metrics would need to be developed when the outreach program was designed, as they should relate specifically to the program design. Measurement of activity implementation of an outreach program can include the number of brochures distributed, the number of pool service company employees attending workshops, number of articles or advertisements placed, number of retail establishments displaying outreach materials, or the number of brochures taken from a retail display. If materials include a phone number or website, tracking the number of calls or website hits can also be a measure of activity.

Effectiveness metrics

Again, the effectiveness metric would best be designed in concert with the design of the education program. To determine if recommended practices are being adopted, surveys or random site inspections could be conducted for both private pool owners and for pool service companies. Low rates of implementation may be observed due to the voluntary nature of the program. Adequate evaluation should be available from the leading indicator (see Section 3.2).

If pool chemicals sold in local hardware stores are targeted, shelf surveys that track what is available for sale may be useful. Shelf surveys would require that a baseline survey is conducted prior to starting an outreach program so that reductions could be measured.

<u>Strategy CP-2: Require Specific Management Practices for Pool, Spa, and Fountain Discharges</u>

Ordinance modifications and permit programs could be used to require that certain management practices be implemented to reduce copper discharges from swimming pools, spas, and fountains.

Effective Implementation Design

Regulatory authority to require actions of commercial and industrial facilities exists in most municipalities. In most municipalities, this authority does not extend to residents. Specific management practices could be required of pool service companies and swimming pools, spas, and fountains operated by businesses, non-profit organizations, or public agencies. The specific management practices would focus on requiring discharges to be directed to the sanitary sewer (or otherwise not to the storm drain in the case of filter backwash) and permission to be obtained from the POTW for pool emptying. It may be possible to offer the alternative of certifying that copper algaecides have not been used in the pool or that copper concentrations are below a certain threshold.[17] Educational materials explaining the requirements would be needed as would outreach to the regulated community. Input from pool service companies and public and private pool, spa, and fountain facility managers should be sought during development of requirements to ensure that requirements are achievable.

Implementation Issues

Regulating fixed facilities (e.g., municipal and fitness club swimming pools and spas, fountains at private businesses) would be relatively straightforward since they could be inspected to assess physical facilities and to evaluate management practices and most would have facility managers who could be responsible for ensuring compliance. Inspections would involve costs (e.g., staff time). Costs would be proportional to the number of fixed facilities in the municipality. It might be politically challenging to use fees to recover costs associated with regulating this class of facilities.

Given the regional and mobile nature of the pool service business, finding dischargers presents a significant practical challenge. A regulatory program addressing pool service companies would need to be supplemented by public education efforts to be more effective.

Regulation would only reduce discharges from a portion of pools, spas, and fountains, because many private pool owners conduct their own maintenance and do not use a service. A regulatory program also requires that a municipality have adequate resources and staff to enforce the program through inspections, permitting and compliance actions.

Regulatory programs are far more effective than voluntary programs if they are enforced. Regulatory programs can achieve 90% or greater compliance. Determining compliance for pool service companies may also be challenging. It would require verifying that the pools that are being served by the companies are set up to discharge properly. It may be possible to verify compliance based on reported algaecide use.

Activity metrics

The primary measures of implementation of a regulatory program would be to track the number of businesses contacted, the number of permits issued, or the number of inspections.

[17] This option may require careful structuring because other constituents in pool, spa, and fountain water may pose hazards to water quality, such as chlorine and the biocide polyhexamethylene biguanadine (PHMB), which does not readily evaporate or decompose.

Effectiveness metrics

Compliance rates are the primary metric to determine the effectiveness of a regulatory program. As noted above, there are challenges associated with determining compliance for pool service company management of private pools. Assessing compliance could be accomplished by random inspections of pool service events or inspection of pools to see if the proper connections and equipment are available to allow discharge to the sanitary sewer and to see if copper algaecides are in use.

Strategy CP-3: Require Installation of Appropriate Sewer Discharge Connections for Pools, Spas, and Fountains

Pools, spas, and fountains are occasionally emptied, usually for cleaning and repair. Swimming pools and spas also have routine discharges of wastewater generated from backwashing their filter systems. Requiring that pool and spa filter backwash discharge to the sewer and that pools, spas, and fountains have a conveniently located sewer discharge connection location (generally an indirect connection or a sewer cleanout) would prevent copper discharges to the storm drain.

Effective Implementation Design

Each municipality would need to adopt an ordinance to modify its building and plumbing codes to require sewer discharge connections to be available for pools, spas, and fountains. Implementation would entail partnering with Building and Planning divisions to ensure the requirements were implemented during pool, spa, and fountain permitting and design review. Regulatory requirements would likely need to focus on new installations, as retroactively implementing requirement for existing pools, spas, and fountains would pose both political and logistical challenges.

Implementation Issues

Because pool, spa, and fountain discharges would be redirected to the sanitary sewer, this program would need to be developed in coordination with the local POTW to ensure compatibility with the POTW's policies regarding acceptance of wastewater. Local sewer system managers would also need to be involved, as sizing and design of the connection for emptying the entire pool, spa, or fountain, would need to prevent flows large enough to impair sewer system operation.

This action is probably only feasible for new construction and remodeling. It would primarily serve to prevent increases in copper discharges rather than result in significant reductions.

Activity metrics

Since ordinance adoption would effectively eliminate additional copper discharges from pools, spas, and fountains, a one-time activity metric to record adoption is appropriate.

Effectiveness metrics

No metric is needed—a convenient sewer connection would essentially eliminate increases in the pool, spa, and fountain copper load. Estimating the amount of load prevented would be difficult, as the current annual installation rate for pools, spas, and fountains is unknown.

Landscaping Pesticides

Copper-containing pesticides are used to control fungus growth on lawns and in gardens. Copper-containing pesticides are considered among the least harmful of the available fungus control pesticides, because they are safer for humans and are allowable under organic food standards. Since it is not clear that increased use of alternative fungicides would not be harmful for human health, an evaluation of alternatives is recommended in Section 3.3 prior to implementation of any control strategy for landscaping fungicides. The expected lack of safe alternatives is anticipated to limit the reduction potential for this source regardless of the control measure implemented.

Strategy LP-1: Public Education and Outreach

Educating the general public regarding the potential impact of copper containing lawn fungicides and providing information on alternative practices may have the potential to reduce use of these pesticides. However, a less toxic alternative would have to be identified to make this program effective.

Effective Implementation Design

As noted above, public outreach is most effective when it has a targeted message and reaches the appropriate audience. Abundant resources are available regarding less toxic pest management and information regarding fungus has been developed. Many municipalities have public education programs targeting pesticide use and have identified good vehicles for communicating these messages including working with lawn and garden retailers to train them to assist customers and working with master gardeners programs to the same end. Adding messages regarding copper containing pesticides to existing programs will facilitate the development of a successful program. Fact sheets or brochures containing information on recommended practices would be developed. Links to websites or phone numbers would be included in all outreach materials to allow residents to obtain more detailed information. However, to be effective, a safe alternative must be identified. Practices that prevent fungal growth reducing the need for fungicides may be promising if they are determined to be feasible. If safe practices or products are identified, incorporating this outreach message into an existing regional program may enhance the effectiveness of the program. For example, the *Our Water, Our World* program works with retailers to promote less toxic pest control alternatives. Working through this program may be worthwhile.

Implementation Issues

Public outreach is more effective for creating awareness than for changing behavior (see CP-1, above). In addition, to be effective, ongoing programs over several years are necessary which may require a significant investment of resources. Most chemical alternatives to copper landscaping pesticides are more toxic to humans. Unless a safe alternative is identified, this strategy is unlikely to achieve significant reductions.

Activity metrics

Activity metrics would need to be developed when the outreach program was designed, as they should relate specifically to the program design. Measurement of activity implementation of an outreach program can include the number of

brochures distributed, number of workshops conducted, or number of people attending a workshop or public event.

Effectiveness metrics

Effectiveness of education programs would need to be measured through surveys, since local pesticide sales data are not available. Phone or mail surveys can be used to assess general awareness of impacts of copper pesticides and awareness of alternatives. Intercept surveys or card surveys conducted at lawn and garden stores may be useful in assessing behavior changes in addition to awareness. Shelf surveys may be used to assess behavior by tracking availability of copper and non-copper pesticides.

Wood Preservatives

Most wood preservatives intended for outdoor use contain copper—the primary alternatives (creosote and pentachlorophenol) have limited allowable uses due to the environmental and human health hazards they pose. Concentrations of copper in preserved wood recently increased with the phase out of most allowable urban uses of chromated copper arsenate (CCA), as alternative preservatives rely solely on copper compounds for their functionality. The primary control measure is use of non-wood construction materials. Non-wood construction materials are not drop-in substitutes—they may not be feasible or appropriate in all applications, and some (e.g., recycled plastic lumber) may pose risks to aquatic ecosystems. Guidelines for substitution would need to be developed to ensure that substitutes function appropriately and do not create new environmental problems. Treated wood products used in and near water (i.e., creek and marine uses) have greater potential to discharge copper directly to water than wood products used in commercial and residential applications. Therefore, control strategies should focus on uses in and near water.

Strategy WP-1: Minimize Municipal Copper Wood Preservative Use Near and In Water

Use of alternatives to treated wood in construction at public marinas, along shorelines (e.g., shoring), across creeks, and other locations near water bodies will reduce the amount of copper released to surface water from wood preservatives.

Effective Implementation Design

Guidelines for selection of and use of non-wood alternatives for the various specific applications of copper-treated wood need to be developed, as recommended in Section 3.3. Municipalities can incorporate these guidelines into their design specifications for new public projects and major maintenance of public facilities in or near water (e.g., public marinas, waterfront shoring, bridges, and creek and waterfront landscaping). Specific design, maintenance, and purchasing policies would need to be developed. Staff would need to be trained regarding acceptable materials and maintenance requirements.

Implementation Issues

Guidelines for selection and use of non-wood alternatives would need to be developed in association with Public Works departments, Parks departments, recreation departments, marina facility managers, and agencies that regulate creek and shoreline activities (e.g., flood control districts, Bay Conservation and Development Commission).

This program would be associated with construction of new facilities and major maintenance of existing facilities. Because major maintenance intervals are long

(treated wood has a lifetime of 15-20 years), implementation of this measure would be gradual. Alternative materials may be more costly, less aesthetically pleasing, or technically infeasible for certain applications, which would make it unlikely that all copper treated wood could be replaced with alternatives. Copper reductions achieved through this strategy would be gradual and would rely on feasible replacement materials being available.

Activity metrics

A one-time metric would be appropriate to record adoption of a municipal policy regarding use of treated wood in and near water. Because change is necessarily gradual, it would be worthwhile to periodically evaluate how the policy is being implemented.

Effectiveness metrics

Effectiveness could be measured based on the amount of copper-treated wood materials being installed each year in and near water. Alternatively, effectiveness could be measured by an inventory of treated wood use in and near water. A baseline assessment of the amount of treated wood or an inventory of treated wood use locations in and near water in a municipality would be necessary to facilitate measuring effectiveness.

Strategy WP-2: Minimize Private Copper Wood Preservative Use Near and In Water

Use of non-wood materials in privately owned marinas and other locations near water bodies will reduce the amount of copper discharged from wood preservatives.

Effective Implementation Design

Guidelines for selection of and use of non-wood alternatives for the various specific applications of copper-treated wood need to be developed, as recommended in Section 3.3. Policies and practices developed for publicly owned facilities could be used as a model for this program. Outreach to privately owned marinas to promote the use of non-wood materials during remodeling and repair activities would be included in this program. Contractors would also need to be trained regarding use of non-wood materials. This could first be implemented voluntarily and then by regulation in the building code if necessary. Using regulatory approaches to require privately owned marinas to take certain actions is an approach that can be taken depending on the priority of this source. Regulatory programs are much more effective than voluntary programs.

Implementation Issues

Guidelines for selection, use and maintenance of non-wood alternatives would be developed based on previously developed municipal policies or would need to take into consideration requirements of local agencies that regulate creek and shoreline activities.

This program would be associated with construction of new facilities and major maintenance of existing facilities. Because major maintenance intervals are long (treated wood has a lifetime of 15-20 years), implementation of this measure would be gradual. Alternative materials may be more costly, less aesthetically pleasing, or technically infeasible for certain applications, which would make it unlikely that all copper treated wood could be replaced with alternatives. Copper reductions achieved through this strategy would be gradual and would rely on feasible replacement materials being available.

Activity metrics

Activity could be measured by the number of marinas contacted and provided with information regarding the impact of wood preservatives and promoting the use of alternative materials. Under a regulatory program, activity would also be monitored based on the number of permits issued.

Effectiveness metrics

Effectiveness could be measured based on the amount of copper-treated wood materials being installed each year in and near water. Alternatively, effectiveness could be measured by an inventory of treated wood use in and near water. A baseline assessment of the amount of treated wood or an inventory of treated wood use locations in and near water in a municipality would be necessary to facilitate measuring effectiveness. Selected permit owners could be audited as another effectiveness assessment measure.

All Pesticides

Strategy P-1: Ask DPR to Regulate Copper-Containing Pesticides

Only the California Department of Pesticide Regulation has the authority to regulate pesticides in California. Municipalities and the Regional Water Board could request that DPR restrict use of copper-containing pesticides in the San Francisco Bay area. DPR has already put such restrictions in place for copper-based root control products, which cannot be used in the 9 San Francisco Bay area counties. Given the relative magnitude of the potential copper load and the cost of alternative control measures, regulation would be most cost-effective for controlling copper-based pool, spa, and fountain algaecides.

Effective Implementation Design

DPR generally requires quantitative information about the water quality and/or permit compliance problems associated with a pesticide (including quantification of the pesticide's relative contribution to the problem) before it will consider restricting a pesticide's sales and use. A request for DPR action is most likely to be successful if it is made jointly by water quality agencies and is supported by appropriate scientific information.

Implementation Issues

It is uncertain whether DPR would consider such a request to be of a high enough priority to invest the necessary staff time to go through the regulatory process. If the request is made jointly with the Regional Water Board (preferably including the State Water Board) and with other regions of the state it would have an increased chance of success.

DPR may not have the modeling tools and other resources necessary to make the required legal case for regulatory controls. DPR's budget has not historically allocated funds to evaluate or implement regulatory requests by water quality agencies. Water quality agencies may need to be ready to provide information and scientific support to DPR to help its staff complete its regulatory process.

Activity metrics

Since a request to DPR would be a one-time event, no activity metric is appropriate.

Effectiveness metrics

Load reduction estimates would probably need to be created to support any regulatory decision by DPR. These would be an appropriate effectiveness metric. Since any regulatory action would likely be permanent, a one-time estimate would be sufficient.

3.2 LEADING INDICATORS

Leading indicators are actions that can be tracked and used to assess the change in significance of a pollutant source (trends). These differ from effectiveness metrics, which evaluate the response to a specific control measure. Leading indicators should track actions that occur prior to environmental impacts.[18] Ideal leading indicators involve information that can be easily collected and compiled. Ideal leading indicators correlate with the magnitude of the pollutant source and/or effectiveness of addressing the source.

The amount of copper pesticides washed off into urban runoff would be proportional to the amount of copper used in urban applications (recognizing that different uses have different copper wash-off fractions). Therefore, good leading indicators for copper pesticides will be proportional to pesticide uses and will consider wash-off fractions. Possible indicators and their pros and cons are listed in Table 5 (on the next page). Year-to-year variations in pesticide use are common for copper-containing pesticides, as weather is an important factor in the decision to use many of them. This means that annual tracking of indicators and evaluation of multi-year data sets is necessary to support management decisions.

For some indicators, properly designed representative samples can be used. Reported pesticide usage can be tracked on a county-wide basis. Breaking it down into smaller jurisdictions may not be possible. However, municipalities can track their own usage (i.e., publicly owned pools, public open spaces, parks, and other landscaping, and publicly owned marinas). In addition, municipalities can conduct shelf surveys perhaps working with the Our Water Our World program to determine the amount of pesticides available for sale.

3.3 IMPLEMENTATION SEQUENCE AND TIME FRAME

Table 6 (on pages 24-25) and Figure 2 (on page 26) lay out a potential initial implementation sequence and time frame for implementation of a copper management strategy for copper pesticides. The basis for the time frames relates to the estimated time it takes to initiate a certain program. After the program is started, the time frames were relative to how long it could take to complete and evaluate results of the first action before moving on to the next action. To ensure all elements are addressed, both Table 6 and Figure 2 envision maximum implementation of the strategy (partial implementation is also feasible; see below). The time frames in Table 6 and Figure 2 recognize that some of these strategies require action from every Bay Area municipality—with at least 85 municipalities, this is no small task.

While full implementation of the actions listed below in Table 6 would provide the most complete control of this urban runoff copper source, less than full implementation is entirely feasible, as long as the effectiveness level is judged acceptable (see descriptions above for effectiveness estimates for individual strategies). Assessing load estimates and/or determining if feasible alternatives are available are important steps in

[18] Water quality monitoring is not a leading indicator, but rather a trailing indicator indicating the environmental response to a pollutant management action.

the development of most strategies. The order of implementation is based on the need to develop some background information prior to implementing certain strategies and then implementing control measures based on their potential to achieve reductions. Landscape pesticide strategies are expected to meet with limited success in achieving reductions and may pose challenges due to expected limitations of available alternatives. Therefore, it is recommended that they are implemented only if needed after seeing the results of other strategies. DPR regulation of copper pesticides would be difficult to obtain; it is included as a fall-back plan, as it would likely only be possible if all measures under local control are first exhausted. If partial implementation is selected, strategies targeting municipal sources (e.g., publicly owned pools, publicly owned marinas, public parks and open spaces) could be implemented first to serve as role models for subsequent programs targeting commercial businesses and the general public.

Table 5. Potential Leading Indicators for Copper Pesticide Use

Potential Indicator	Comments	Recommended?
1. Copper load to Bay, estimated on the basis of statewide sales, local reported use, and estimated wash-off fraction.	Similar to method used to generate Copper Source report. Can be updated with current information. Relatively inexpensive. Data reported to DPR are relatively accurate and readily available. Professional use is reported only on a county-wide basis. Requires extrapolation of statewide sales data to estimate non-reported uses (of the uses covered by this strategy, only professional application of copper landscaping pesticides require reporting); does not reflect local or regional actions affecting retail sales. Cannot be used to assess the progress of an individual municipality.	✓Yes. Shows trends. Would need to be supported by other indicators of local non-reported use.
2. Shelf surveys for copper containing pesticides	Surveys of copper pesticides and copper-treated wood products available for sale at retail outlets provide an indicator of copper pesticide use, particularly non-reported uses. However, does not provide sales or use data, may not account for internet purchasing or purchasing across jurisdictions.	✓Yes. Only way to explore effects of regional & local control measures.
3. Quantity of copper pesticide use estimated on the basis of statewide sales and local reported use.	Data reported to DPR are relatively accurate and readily available. Professional use is reported only on a county-wide basis. Requires extrapolation of statewide sales data to estimate non-reported uses (of the uses covered by this strategy, only professional application of copper landscaping pesticides require reporting); does not reflect local or regional actions affecting retail sales. Cannot be used to assess the progress of an individual municipality.	No. Does not reflect relative importance of various pesticide application locations.
4. Quantity of pesticides used by municipal staff	Should be straightforward to track as municipalities keep records of pesticide use. May require significant data management.	No. Only covers a small portion of copper pesticide use.
5. Copper pesticides sales	Only available for free on a statewide basis. Unlikely to be able to obtain local data for a reasonable price due to the confidential nature of sales data.	No. Not feasible.

Table 6. Potential Framework for Implementation of All Copper Pesticide Strategies

Action	Implementing Agency	Time Frame*
1. Refine pool algaecide loading estimates	One regional study	Start: In 1st year of program Implementation: Complete by year 2. Completed early in program because it informs later strategies.
2. Assess feasibility of alternatives to wood preservatives	One regional study	Start: In 3rd year of program Implementation: Complete by year 5. Completed early in program because it informs later strategies.
3. Establish tracking and reporting of the leading indicator and for activity and effectiveness metrics as strategies are implemented	Tracking—Individual municipalities Reporting—Regional preferred (may not be practical for metrics)	Start: Tracking established within 2 years; begin reports in year 3 Implementation: ongoing (every 1-2 years recommended initially); end regulatory controls are adopted for all copper pesticides.
4. Implement Strategy CP-1, conducting targeted outreach & education about pool, spa & fountain pesticides	Individual municipalities with regional support	Start: After load estimate has been refined, if this is still indicated to be a significant source. The sequence of implementation of this and Strategy WP-2 should be set based on updated load estimates generated by Action #1. Implementation: Outreach should be coordinated with other outreach efforts so as not to introduce too many new concepts at once.
5. Implement strategies WP-1 targeting municipal activities for marinas	Individual municipalities	Start: After feasible alternatives have been identified. Implementation: Ongoing.
6. Implement Strategies WP-2 to conduct targeted outreach & education about wood preservatives	Individual municipalities with regional support	Start: After feasible alternatives have been identified and municipal programs have been implemented. The sequence of implementation of this and Strategy CP-1 should be set based on updated load estimates. Implementation: Outreach should be conducted in a phased approach so as not to introduce too many new concepts at once.
7. Implement Strategies CP-2, requirements for directing pool discharges to sanitary sewers	Individual municipalities	Start: Approximately 1year after public outreach is established Implementation: ongoing
8. Develop model ordinance language for Strategy CP-3	Regional model to serve as a resource for individual municipalities	One-Time Task: Complete within 4 years depending on success of voluntary programs and priority of source

Table 6 Cont'd. Potential Framework for Implementation of All Copper Pesticide Strategies

Action	Implementing Agency	Time Frame*
9. Adopt ordinance to implement Strategies CP-3	Individual municipalities	Start: If success level of voluntary programs and priority of source are determined to warrant regulation, complete progress report in year 5, complete adoption by year 6 Implementation: ongoing
10. Assess feasibility and safety of alternatives to landscape fungicides	One regional study	Start: Initiate if additional strategies are deemed necessary based on results of algaecide and wood preservative control measures.
11. Implement Strategy LP-1 to conduct targeted outreach & education about landscape fungicides	Individual municipalities with regional support	Start: After feasible and safe alternatives have been identified. Do not initiate if feasible & safe alternative are not found. Implementation: Outreach should be conducted in conjunction with existing pesticide education programs.
12. Work with DPR to regulate use of copper containing pesticides	Regional action.	Start: Initiate if additional strategies are deemed necessary. Implementation: One-time action.

***Time frames based on time to develop and implement a new program or to implement and evaluate a program before moving on to the next task.**

Available Copper Load Reduction

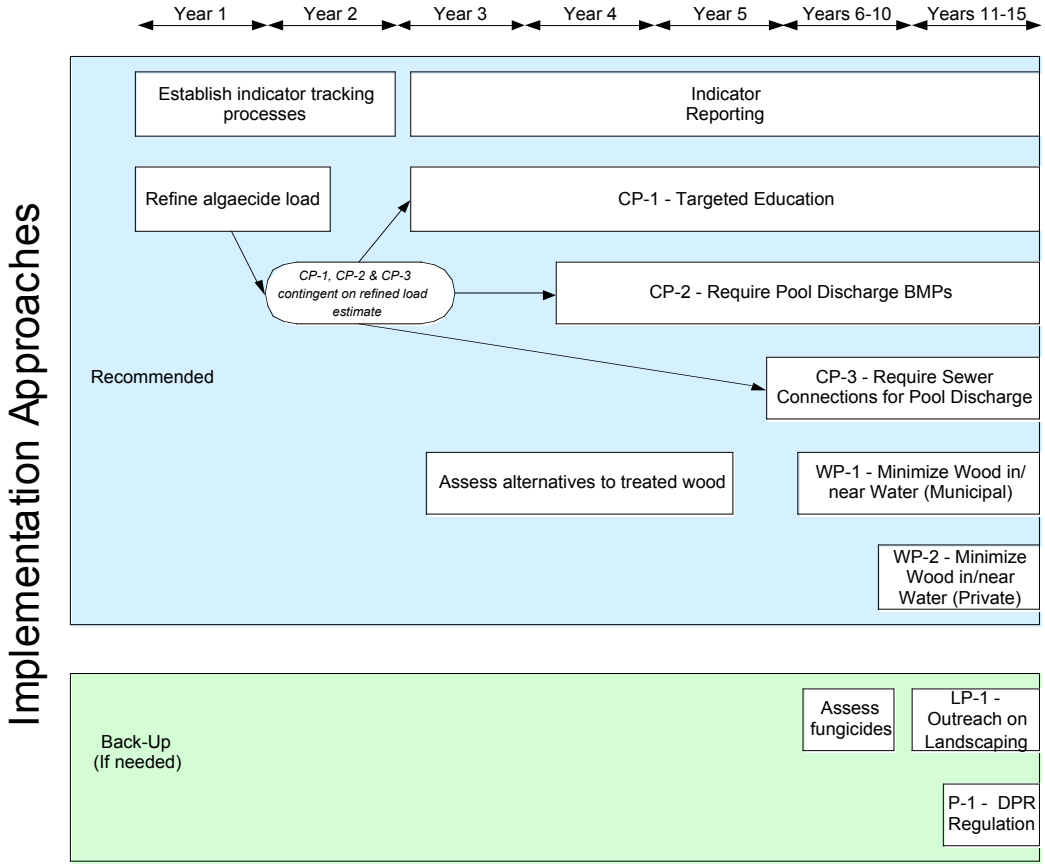
For pool algaecides, it is possible to avoid any increase in the load with code changes, or to try to reduce the load through various measures. Redirecting discharges from pools to the sanitary sewer will eliminate copper algaecides as a source to urban runoff but will still result in some copper being discharged to water bodies. Wastewater treatment plants have copper removal efficiencies in the 80-95% range. For landscaping pesticides, it may not be possible to achieve a reduction unless a safe alternative is identified. For wood preservatives, non-wood alternatives exist that are feasible for many applications, but it is unlikely that a 100% reduction would be achieved because there are applications where wood will remain the preferred approach. The greatest reduction could be achieved through regulation by DPR of copper pesticide use. However, obstacles to implementation make this likely only as a last resort.

Post-Implementation Actions

Post-implementation reviews would evaluate progress and effectiveness of the strategy and identify appropriate modifications. For example, modifications could increase effectiveness, reduce costs by eliminating unnecessary activities, or modify strategies in response to newly identified issues. Reviews are recommended at the following times:

- About Year 2 – after completing assessment of loading estimates and alternatives to treated wood to determine the relative priority of pool algaecides and wood preservatives as copper sources. Decide whether copper load from pools, spas, and fountains merits control strategy implementation by comparing to the load estimates for other copper sources (see Table 1).

Figure 2. Potential Framework for Implementation of All Copper Pesticide Strategies



- About Year 5 – after completing the investigation in Action #2 in Table 6. This review can provide information (e.g., results of investigation, lessons from education program) to support development of model ordinance language. In addition, results of public outreach programs will be useful for determining the need for more regulatory approaches.
- Every 5 years thereafter – Long-term reviews should consider the need for and frequency for continued tracking of various indicators and the need to move from voluntary to more regulatory approaches. Long term reviews should also consider the need for additional actions (i.e., specifically actions 10 – 12 in Table 6) as well as the elimination of actions that are not effective or no longer warranted based on updated information and data collection.

The recommended time periods are flexible. Combining the review process with reviews of other CMS elements would be most efficient.

4.0 VEHICLE BRAKE PADS

San Francisco Bay Area drivers use their brakes millions of times a day, each time releasing small amounts of brake wear debris to the environment. In 1993, the Santa Clara Valley Nonpoint Source Pollution Control Program retained Woodward-Clyde to investigate the potential that vehicle brake wear debris contained water pollutants. The resulting report[19] identified vehicle brake pads as a potentially significant source of copper in urban runoff, sparking Santa Clara Valley water quality agencies' interest in vehicle brake pads, and eventually leading to the formation of a partnership with the brake pad industry and other interested stakeholders to explore the issue.

The Brake Pad Partnership (BPP) is currently conducting investigations that will lead to a reliable estimate of the contribution of vehicle brake pads to copper levels in San Francisco Bay. The approach of the BPP is to characterize brake wear debris and to conduct environmental transport and fate modeling to predict how copper released from brake pads enters the Bay and affects both the short-term and long-term concentrations of copper in the Bay. Results of these studies, which involve air, watershed, and Bay modeling, are anticipated in late 2006.

Since the BPP estimates are not yet complete, the Copper Sources Report estimated copper releases from vehicle brake pads by estimating brake pad copper releases in the watershed, and then estimating the fraction of copper released that is washed off in runoff. The best available data on brake pad copper content is from the BPP. As part of the BPP, U.S. brake pad manufacturers have developed a procedure for reporting on the amount of copper used in brake pads on new vehicles ("original equipment" brake pads) each year. Reporting began in 1998; data are currently available through vehicle model year 2002 (see Table 7). Although these data are not intended for use in copper load calculations, they are the most comprehensive and reliable data available regarding the copper content of automotive brake pads.

Table 7. Copper Use in Brake Pads on the 20 Best Selling Domestic Light Duty Vehicles, Model Years 1998-2004

Model Year	1998	1999	2000	2001	2002	2003	2004
Copper per vehicle (kg)	0.0402	0.0517	0.0564	0.0561	0.0766	0.0769	0.0650
Copper per vehicle (lb)	0.0886	0.114	0.124	0.124	0.169	0.169	0.143

Source: Brake Pad Partnership, *Copper Use Monitoring Program Results for Model Years 1998-2004*, January 2006.

Using the BPP data, the Copper Sources Report estimated that vehicle brake pads release more than 10,000 pounds per year of copper. This load estimate has a high uncertainty and likely understates brake pad copper releases, due to the unavailability of copper data for replacement brake pads or brake pads used on heavy-duty trucks, off-road vehicles, rail cars, and motorcycles. Additionally, the estimate of the portion of vehicle brake wear debris washed from urban surfaces used to generate this load estimate is highly uncertain because it was based on preliminary results of U.S. EPA modeling of copper runoff in Castro Valley.

4.1 CONTROL MEASURES

The Copper Sources Report described the control measures available to address vehicle brake pads. This section briefly describes each of the options; describes how

[19] Woodward-Clyde Consultants, *Contribution of Heavy Metals to Storm Water From Automotive Disc Brake Pad Wear*, prepared for the Santa Clara Valley Nonpoint Source Pollution Control Program, October 1994.

the option could be implemented in an effective manner (considering whether entities other than urban runoff programs that could play a role in implementing the control measure and generally how they can be engaged and whether regional actions would be appropriate); identifies important implementation issues; and identifies appropriate activity metrics and effectiveness metrics.

Several theoretically possible control measures (including two options identified in the Copper Sources Report–street sweeping and reducing vehicle miles traveled–have been determined to be unlikely to result in meaningful reduction in copper releases from brake pads.

- Street sweeping. As described in the Copper Sources Report, street sweepers are relatively inefficient in collecting fine particles. Brake Pad Partnership research data show that brake pad wear debris is comprised of extremely fine particles, averaging about 2.7 µm in diameter. Because of its tiny particle size, brake wear debris is distributed throughout urban areas, including impervious and pervious areas; it does not just fall on roads, as had been assumed previously. Therefore, street sweeping is not an effective control measure for brake pad wear debris.
- Reducing vehicle miles traveled (VMT). Due to population increases and land use patterns, the significant regional efforts toward reducing vehicle miles traveled in the Bay Area have been successful in moderating the increase in VMT, but not in reducing it. Data from these efforts show that measures within the control of water quality agencies (e.g., public outreach) would not be effective at reducing VMT, and therefore would not be effective at reducing copper releases from vehicle brake pads. This report assumes that air quality and transportation agencies will continue their long-term efforts to control VMT.
- Car washing. The amount of copper from brake pad wear debris that is released to the environment during vehicle washing outdoors is relatively minor (less than 5% of total releases).[20] This copper is also released during normal driving, rain events, and washing at commercial carwashes. Therefore, public outreach pertaining to vehicle washing would not be an effective control measure for brake pad wear debris.

The following strategies are believed to be the most effective options for controlling copper from brake pad wear debris.

Strategy BP-1: Participate in the Brake Pad Partnership

This strategy calls for continued participation in the Brake Pad Partnership, through the conclusion of the partnership's ongoing studies and final decision-making process. The BPP is a voluntary partnership effort involving stakeholders from the brake pad industry, environmental organizations, and state, federal, and local government agencies. The main focus of the BPP is to examine the link between brake pad wear debris and surface water quality impairment. If the Partnership concludes that copper from brake pads is a significant source of water quality impairment, manufacturers have committed to voluntarily introducing new, lower copper products within five years.[21]

[20] Inferred from data on residential car washing behavior and estimated release to car washes from Process Profiles, *Copper Released from Brake Lining Wear in the San Francisco Bay Area*, prepared for the Brake Pad Partnership, 2006.
[21] http://www.suscon.org/brakepad/

Effective Implementation Design

Implementation will involve continued active participation in BPP meetings, providing information to the BPP about Bay Area and other California problems with copper in surface waters, making timely decisions on the basis of the outcome of the BPP's scientific studies at project-concluding decision points, and advocating (as appropriate based on the BPP's scientific findings) for a partnership outcome that meets Bay Area water quality compliance needs for brake pad copper.

Implementation issues

Implementation is dependent on the outcome of ongoing study results and cooperation between participating entities. New brake pad materials must meet safety standards, and there is concern regarding vehicle manufacturer acceptance of new pad formulations.[22] Additionally, although alternative brake pads may be offered to the vehicle manufacturers, vehicle manufacturers are not obligated to purchase low copper or copper free brake pads. If the outcome of the BPP is that brake pad manufacturers do agree to offer lower copper products, Bay Area agencies may need to develop strategies to promote their acceptance by vehicle manufacturers.

The BPP does not currently cover replacement brake pads, or brake pads used on heavy-duty trucks, off-road vehicles, rail cars, and motorcycles. If BPP research shows that these brake pad categories are significant sources of environmentally important copper, methods for achieving desired copper reductions through or outside of the BPP will need to be considered.

Activity metric

Activity for this strategy could be measured by tracking progress on the BPP grant funded studies and final project deliberations.

Effectiveness metric

For original equipment brake pads, effectiveness can be measured by tracking the amount of copper in brake pads reported by the brake pad manufacturers. Since this metric does not address replacement brake pads, or brake pads used on heavy-duty trucks, off-road vehicles, rail cars, and motorcycles, a more complete metric will be needed if these other brake pad types prove to be significant sources of environmentally important copper. Another method of tracking effectiveness would be to collect tunnel air measurements or air deposition measurements. This type of testing is expensive, but could potentially be implemented every few years through partnerships with air quality agencies to track the release of copper from brake pads.

Strategy BP-2: Seek Regulation of Brake Pad Copper Content

This strategy would entail efforts to have an appropriate agency regulate the copper content of vehicle brake pads. A specific plan of action would need to be developed if this strategy is implemented, based on a legal review of options and a timely political analysis of the legislative bodies that could be approached.

[22] Moran, K. D., BASMAA representative on BPP Steering Committee, personal communication, March 2005.

Effective Implementation Design

Since Federal law generally prohibits local regulation of products like vehicle brake pads, if brake pad copper content is to be regulated, regulation by a State or Federal agency would probably be required. New State or Federal law would probably be necessary to enact such regulation.[23] A legal review should be completed to identify specific, feasible options for brake pad copper content regulation that do not create brake safety liability for the regulating agency or municipalities. Likely options for this strategy include legislation to regulate brake pad copper content directly or a law that provides an appropriate agency with necessary regulatory authority to control brake pad copper content as needed to protect surface water quality. Regulation under an existing authority may be possible. For instance, there is some possibility that the California Air Resources Board could use its authority to regulate motor vehicle emissions to reduce brake pad copper content. A regulatory program should be capable of achieving reductions necessary to meet Bay Area water quality compliance needs for brake pad copper.

Implementation issues

Opposition (particularly from brake pad manufacturers) is likely. A strong case—based on good scientific information and reasonable policies—would be necessary to overcome opposition. The development of the action plan would need to consider what options are viable politically. The regulatory program would need to consider the environmental impacts of the reformulated brake pad materials, because the manufacturers' voluntary promise to incorporate the BPP's evaluation approach into their product development processes to avoid using potentially harmful ingredients would not be applicable to a regulatory program.

The cost to the regulatory agency would need to be addressed. Costly new regulatory programs are often rejected by lawmakers. Unfunded activities are difficult for agencies to implement.

Activity metric

Activity for this strategy could be measured by tracking progress on the implementation of the plan of action. Since adoption of a law or regulation would effectively control copper content in brake pads, a final one-time activity metric to record adoption is appropriate.

Effectiveness metric

No metric is needed—a law or regulation would probably reduce or eliminate the copper load from brake pads. Estimating the amount of load prevented would be possible but could be difficult, depending on how the regulation was designed. Post-implementation monitoring of the leading indicator (see Section 4.2) may be sufficient to provide a quantitative estimate of effectiveness.

[23] Catherine C. Engberg. *The Regulation and Manufacture of Brake Pads: The Feasibility of Reformulation to Reduce the Copper Load to the San Francisco Bay.* Prepared for the Palo Alto Regional Water Quality Control Plant July 1995. http://www.cityofpaloalto.org/public-works/documents/cb-brkrpt.pdf. Information obtained by the authors subsequent to completion of this report indicates that unlikely that any of the agencies identified in this report have regulatory authority over brake pad composition.

Strategy BP-3: Urban Runoff Treatment Controls

Various alternatives are available for capturing and treating copper in urban runoff. The California Stormwater Quality Association (CASQA) Stormwater Best Management Practice Handbooks[24] describe various measures that are capable of reducing copper concentrations in urban runoff, including porous pavement, detention ponds, and vegetation-based methods (like grassy swales). Requirements are already in place to treat runoff from new development.[25] These requirements address (but do not completely eliminate) increases in copper from new vehicles and new impervious surfaces in the Bay Area. Current requirements do not address runoff from existing areas. Runoff from existing areas may possibly be treated in the future to address other pollutants of concern in targeted areas.

Effective Implementation Design

The design would depend on the goal of the program. For example, if additional copper increases are to be prevented, it is theoretically possible to require new development projects to be "copper runoff neutral". Since few runoff treatment systems can reduce copper content in runoff to pre-development levels, it would likely be necessary to require new developments to obtain offsetting reductions from other copper runoff sources (e.g., installing runoff treatment systems for an appropriate area of existing development).

If copper reductions are deemed necessary and cannot be achieved through other means, treatment of runoff from existing development would need to be considered. This would entail substantial financial, legal, and technical challenges since much of existing development in the Bay Area is dense—and much of the available land in the downstream part of urban watersheds is environmentally sensitive (e.g., wetlands bordering San Francisco Bay). To capture and treat urban runoff from existing development, both region-wide and community specific approaches would need to be identified. In addition to determining financially and technically feasible approaches, the design would need to ensure that systems perform appropriately, by specifying treatment performance requirements, maintenance frequencies, inspection authorities, reporting requirements, and penalties.

Implementation issues

Treating all urban runoff in the Bay Area is almost certainly financially and technically infeasible under current conditions. A growing portion of urban runoff will be treated in response to other permit requirements (e.g., for new development and redevelopment). Treatment may also be implemented in targeted areas to address other pollutants of concern. If properly designed, these treatment systems could reduce copper loads (but would likely only treat a small fraction of the San Francisco Bay watershed's urban runoff). Prior to implementing any substantial new requirement for runoff treatment (particularly if it involves treating runoff from existing development), agencies would need to develop widespread community support and be able to present a strong case about the need for such measures to community leaders.

[24] California Stormwater Quality Association. Stormwater Best Management Practice Handbook. Municipal. January 2003.

[25] These are often referred to as the "C.3. requirements" because they are in that section of Bay Area urban runoff agency NPDES permits.

Runoff treatment systems have significant technical downsides—they require management and maintenance. Typical runoff treatment systems have incomplete copper removal; removal of dissolved copper is even more difficult than removal of total copper.[26] Without maintenance, performance of runoff treatment systems can fall to near zero over a period of a few years. Costs for treatment include costs for installation and maintenance, and costs to ensure that treatment systems meet performance standards. Installing runoff treatment devices for existing developments poses potentially significant retrofitting costs. Vegetation-based systems and infiltration methods, which are among the more efficient for removal of dissolved and fine particulate metals,[27] are among the lower cost end treatment systems to install and operate,[28] but may be difficult to implement due to limited land availability and soil types in the Bay Area. Because treating runoff occurs subsequent to the broad dispersion of fine copper-containing particles from brake pads into the environment, treating the runoff that carries the deposited copper to the Bay is an inefficient way of keeping the copper that is released from brake pads out of the Bay.

Activity metric

Activity could be measured by counting the number treatment devices installed. Ongoing methods of tracking of the implementation of runoff treatment requirements for new development should be evaluated for possible use as activity metrics for this strategy.

Effectiveness metric

The percent of total urbanized area where runoff flows through treatment systems could be tracked. While this indicator would show treatment system coverage, estimating copper reduction effectiveness would require estimates of copper reduction due to the treatment. Performance data from the literature could be used initially; however, because system performance tends to decline between maintenance events, it may be necessary to adjust the copper removal estimate to account for actual maintenance frequencies. If treatment system regulations require sampling to prove system efficacy, these data could be used to develop a more accurate estimate of treatment efficacy. Ongoing methods of tracking of the implementation of runoff treatment requirements for new development should be evaluated for possible use as effectiveness metrics for this strategy.

4.2 LEADING INDICATORS

Leading indicators are actions that can be tracked and used to assess the change in significance of a pollutant source (trends). These differ from effectiveness metrics, which evaluate the response to a specific control measure. Leading indicators should track actions that occur prior to environmental impacts.[29] Ideal leading indicators involve information that can be easily collected and compiled. Ideal leading indicators correlate with the magnitude of the pollutant source and/or effectiveness of addressing the source.

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[26] Winer, R. *Stormwater Treatment Practice Pollutant Removal Performance Database, for Stormwater Treatment Practices, 2nd Edition*, Center for Watershed Protection, 2000.
[27] *Ibid*.
[28] California Department of Transportation, *BMP Retrofit Pilot Program Final Report*, Report ID CTSW-RT-01-050, January 2004.
[29] Water quality monitoring is not a leading indicator, but rather a trailing indicator describing the environmental effects of a source.

Possible indicators for vehicle brake pad copper load and their pros and cons are listed in Table 8. Continuous tracking of indicators is not necessary as long as recent indicator data are available to support management decisions. For some indicators, properly designed representative samples can be used.

Brake pad manufacturers have agreed to report the copper content of original equipment brake pads to the BPP. This information serves as an indicator of how much copper can be expected to be released from original equipment brake pads. This indicator does not necessarily reflect copper use in replacement brake pads, or brake pads used on heavy-duty trucks, off-road vehicles, rail cars, and motorcycles. If BPP research shows that these brake pad categories are significant sources of environmentally important copper, an indicator that includes all types of brake pads will need to be considered; options for such indicators are presented in Table 8 (on the next page).

If voluntary programs such as that conceived by the BPP are to be relied on, verification of market changes by continued tracking of indicators will be necessary (Note that the BPP agreement does not include a promise from automobile companies to purchase lower copper brake pads). Continued tracking after the implementation period would probably be unnecessary if copper content in new and replacement vehicle brake pads was mandated by law or regulation.

4.3 IMPLEMENTATION SEQUENCE AND TIME FRAME

Table 9 (on page 35) and Figure 3 (on page 36) lay out a potential initial implementation sequence and time frame for implementation of a copper management strategy for vehicle brake pads. The basis for the time frames relates to the estimated time it takes to initiate a certain program. After the program is started, the time frames were relative to how long it could take to complete and evaluate results of the first action before moving on to the next action. To ensure all elements are addressed, both Table 9 and Figure 3 envision maximum implementation of the strategy (partial implementation is also feasible; see below). Although it would be theoretically possible to implement some identified strategies in parallel, sequential implementation is recommended because strategy BP-1 is more cost-effective than BP-2, and BP-2 is substantially more cost-effective than BP-3. BP-1 and BP-2 cannot be implemented in parallel, as implementation of BP-2 would probably terminate the Brake Pad Partnership. Strategy BP-1 is recommended as the primary strategy; Strategies BP-2 and BP-3 are recommended for consideration for sequential implementation as fall-back plans, should BP-1 (and subsequently BP-2) not achieve needed reductions.

When evaluating time frames for implementation of Strategies BP-1 and BP-2, it is important to recognize the time lags between agreements (or requirements) to reduce copper use in brake pads and achieving the actual reduction in releases to the environment. The time frames are longest for brake pads on new vehicles. Automobile manufacturers specify brake pad materials several years before a new vehicle design is brought to market. While subsequent changes in pad material do occur, it is not uncommon for the same pad material to be used for the lifetime of the specific design of that vehicle model (which may be several years). Based on this information and the commitment that brake pad manufacturers made to the BPP, if the outcome of the BPP is an agreement by manufacturers to reduce copper use in original equipment brake pads, and this agreement is achieved in 2007, lower copper or copper-free brake pads would appear on new cars starting in about 2012. Since copper brake pads have a service lifetime of approximately 3-4 years and reduced copper pad formulations would phase in as vehicle models are redesigned, reductions would phase in over the following

decade (2012 – 2022). Time frames for reductions in copper levels in replacement pads could be shorter.

Table 8. Potential Leading Indicators for Use of Copper in Brake Pads

Potential Indicator	Comments	Recommended?
1. Original equipment brake pad copper content	Reported to the BPP annually. Report does not include replacement brake pads, or brake pads used on heavy-duty trucks, off-road vehicles, rail cars, and motorcycles.	✓Yes
2. Air emission or deposition samples	Air emission or deposition samples could be collected around urban areas to track the release of copper from brake pads into the environment. (Brake pads are the primary source of copper in Bay Area vehicle emissions and in air deposition). Tunnel air emissions studies were used to estimate copper releases from brake pads; such studies are conducted on an irregular basis by air quality researchers in locations like the Caldecott tunnel. Alternatively, air deposition measurements could be performed similar to measurements performed by the BPP in Castro Valley.	Yes, if replacement and other pad types are determined to be significant copper sources and the industry or the BPP do not offer an alternative tracking mechanism. Air deposition sampling and tunnel studies are expensive and difficult to implement. However, if collaboration with researchers or air quality agencies is possible, useful information could be gained at relatively low cost.
3. Vehicle manufacturer environmental specifications	Vehicle manufacturers provide specifications to brake pad manufacturers regarding what materials are prohibited in their brake pads. These specifications could be obtained for all major manufacturers.	Yes, if the BPP copper use reporting program terminates. The BPP program provides more complete information.
4. Brake pad replacement	Information regarding the replacement of brake pads can provide information regarding wear rates as well as copper content of "in use" brake pads by monitoring what materials are used in replacement pads.	No. There are too many types of brake pads, with unknown or varying copper content. It would be nearly impossible to create a representative sample.
5. Analytical testing for copper content of replacement brake pads	Replacement brake pads could be purchased and sampled to determine copper content. These data could be used to supplement copper use reports from manufacturers of original equipment brake pads.	No. There are many types of brake pad formulations and sales data are not public, rendering creation of a representative sample impossible. It is costly to obtain a representative brake wear debris sample from a brake pad in the laboratory.
6. Vehicle type purchasing trends	Tracking of the sales of different vehicle types can be related to the amount of copper that may be released to the environment.	No. There is no longer a considerable difference in copper content of brake pads from different vehicle types or manufacturers.
7. Awareness of issues	Surveys can be conducted to assess general awareness of issues associated with copper brake pads and available alternatives for brake pad materials and car washing. However, awareness does not translate directly to behavior changes.	No. The public has little control over the copper content of brake pads being put on their vehicles. Likewise, brake pads are not likely a major consideration in vehicle purchases.

Table 9. Potential Framework for Implementation of All Brake Pad Strategies

Action	Implementing Agency	Time Frame*
1. Establish tracking and reporting of the leading indicator and for activity and effectiveness metrics as strategies are implemented	Tracking—Regional Reporting—Regional	Start: Tracking of BPP indicator already in progress. If other types of brake pads are found to be significant copper sources, establish tracking plans within 2 years; begin first measurements in year 3. Implementation: Reports every 3-5 years recommended); end if copper-containing brake pads become obsolete.
2. Implement Strategy BP-1, continued participation in Brake Pad Partnership	Regional	Start: Already ongoing Implementation: Through completion of BPP studies and final decision-making process (~2007)
3. Introduce low copper or copper-free brake original equipment brake pads to vehicle manufacturer.	Brake pad manufacturers	Start: By about 2012, dependent on BPP outcome. Implementation: ongoing
4. Implement Strategy BP-2, seek regulation of brake pad copper content	Regional (Statewide preferred)	Start: Immediately upon making the determination that the outcome of the BPP is insufficient. Implementation: First year--complete legal and political analyses and develop action plan. Ongoing—implement Action Plan. Implementation should be re-evaluated and possibly abandoned if not successful within 5-10 years.
5. Implement Strategy BP-3, urban runoff treatment controls and establish activity and effectiveness metrics	Individual municipalities	Start: Implement if BPP does not produce needed outcome and efforts to seek regulation of brake pads are determined to be unproductive. Implementation: ongoing

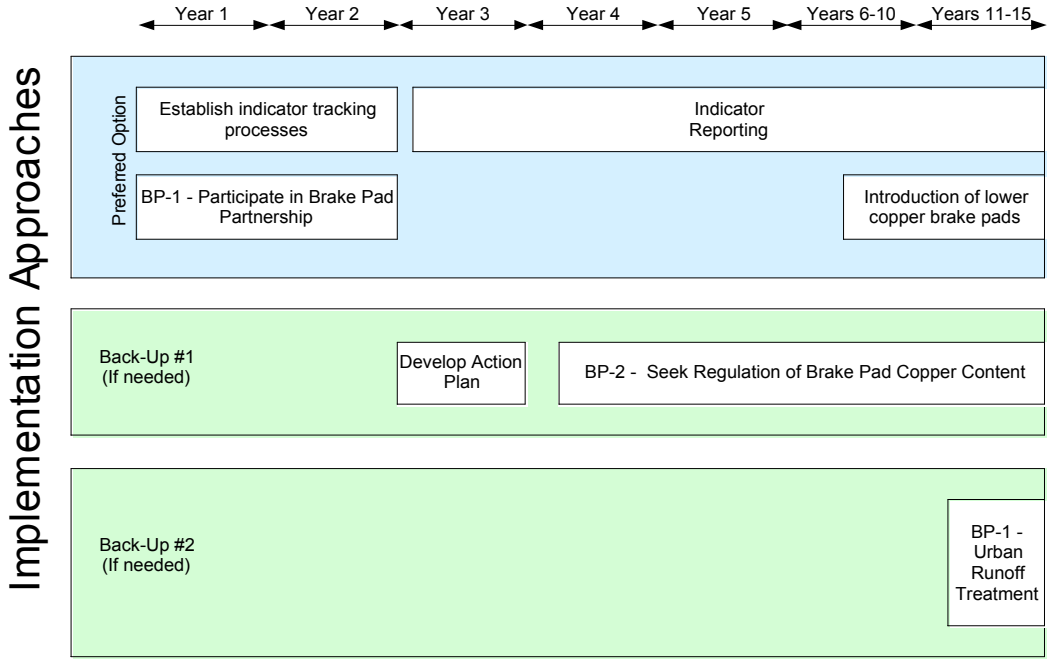
***Time frames based on time to develop and implement a new program or to implement and evaluate a program before moving on to the next task.**

Available Copper Load Reduction

The preferred strategy and the primary fall-back plan above would serve to reduce copper quantities in urban runoff from vehicle brake pads. The specific amount of the reduction is not known, but should be capable of achieving reductions necessary to meet Bay Area water quality compliance needs for brake pad copper. The reduction level can be influenced by Bay Area water quality agencies' actions and decisions. For instance, even if the BPP results in introduction of low or no copper original equipment brake pads, Option B may still be necessary to regulate the copper content of brake pads (such as replacement pads), or if voluntary reductions are not taking place.

In contrast, the second fall-back strategy identified above would have variable potential outcome and might not be capable of achieving necessary reductions. Due to technical constraints (including limited availability of land for treatment and inefficient removal of copper in runoff treatment systems) Strategy BP-3 offers the lowest potential reduction at the highest financial cost.

Figure 3. Potential Framework for Implementation of All Brake Pad Strategies



Post-Implementation Actions

Post-implementation reviews would evaluate progress and effectiveness of the strategy and identify appropriate modifications. For example, modifications could increase effectiveness, reduce costs by eliminating unnecessary activities, or modify strategies in response to newly identified issues. Reviews are recommended at the following times:

- After Year 1 – Determine if replacement brake pads, and brake pads used on heavy-duty trucks, off-road vehicles, rail cars, and motorcycles are significant copper sources; if so, plan for implementation of a leading indicator that covers all brake pad copper emissions (e.g., air emissions or deposition monitoring; see Table 9).
- After Year 2 – A review of the outcome of the Brake Pad Partnership should be completed to determine if the outcome is sufficient to ensure achievement of required reductions. If the outcome is insufficient, work on Strategy BP-2 should be initiated.
- After Year 5 – If the outcome of the BPP is satisfactory, this review should determine whether implementation of the agreement arising from the outcome is successful. If not, reopening the BPP or fall-back plans (Strategy BP-2) should be considered. If the outcome of the BPP was not satisfactory, the status of efforts on Strategy BP-2 should be evaluated and adjustments made as appropriate.
- After Year 10 – If the outcome of the BPP was not satisfactory and Strategy BP-2 is being implemented, the status of efforts should be evaluated. If BP-2 is not successful, available water quality data should be re-evaluated to determine whether Strategy BP-3 needs to be implemented, and if so, what the appropriate implementation design would entail.

- Every 5 years thereafter – Long-term reviews should consider the need for and frequency for continued tracking of various indicators.

The recommended time periods are flexible. Combining the review process with reviews of other CMS elements would be most efficient.

5.0 MARINE ANTIFOULING COATINGS

Paints applied to boats and ships to control unwanted "fouling" growth[30] on their hulls often contain copper-based biocides. When the use of tributyltin in marine coatings was phased out in the late 1980s, copper-based biocides—long used on recreational boats—became the primary antifouling coating option for recreational boats.

In the Bay north of the Dumbarton Bridge, there are major ports, industrial piers, and dozens of marinas. Thousands of boats are berthed in the Bay; recreational boaters put thousands of additional boats into the Bay for short-term use. Larger vessels include about 2,000 shipping vessels that dock in Bay ports each year, hundreds of commercial ships involved in trade and tourism, and hundreds of government-owned vessels to manage aquatic safety and resources. Boats and ships coated with copper-containing biocides may release copper directly into the Bay during storage, operation, and in-water maintenance. On-shore maintenance activities have the potential to release copper into urban runoff.

5.1 CONTROL MEASURES

The Copper Sources Report described the control measures available to address copper in marine antifouling paint. The discussion below refers to these measures. This section briefly describes each option; describes how the option could be implemented in an effective manner (considering whether regional actions would be appropriate); identifies important implementation issues; and identifies appropriate activity metrics and effectiveness metrics.

Currently there are no regional control measures in place to limit copper releases from marine antifouling paint in the San Francisco Bay Area. In response to issues raised in a San Diego Regional Water Board TMDL, DPR and the State Water Resources Control Board are working together to explore the relationship between marine antifouling paints and copper levels in surface waters. To facilitate exploration of this issue, the Interagency Coordinating Committee (IACC), an existing working group composed of 28 State agencies involved in implementing California's Nonpoint Source Pollution Control Program, has created the Copper Antifouling Paint Sub-Workgroup of its Marina and Recreational Boating Workgroup. The purpose of the subgroup is to assess the degree and geographical distribution of copper pollution caused by copper antifouling paints in California's aquatic environments. The San Francisco Bay Regional Water Board is participating in this work group.

<u>Strategy AF-1: Department of Pesticide Regulation of Marine Antifouling Coatings.</u>

To date, no California agency has prohibited use of copper marine antifouling coatings. DPR has the authority to restrict use of marine antifouling coatings. Recognizing that the situation that occurred in the San Diego TMDL may not be unique, DPR is implementing a strategy to determine the appropriate regulatory approach to biocides in marine antifouling coatings, including copper. Key elements of the DPR strategy include

[30] Growth of seaweed, barnacles and other organisms. The presence of such growth on the hull reduces boat speeds and increases motor boat fuel consumption.

completion of a monitoring study to evaluate the extent and magnitude of water quality impacts from marine antifouling paint ingredients (primarily copper) on California surface waters and sediments and coordination for development of safer alternative fouling control practices.

DPR has announced that it anticipates initiating a regulatory process called "re-evaluation" in 2006. This regulatory authority allows DPR to require specific information from makers of marine antifouling coatings.[31] To address the potential for regulatory action on copper-based marine antifouling coatings to switch users to another toxic coating, DPR intends to include most or all biocide-based marine antifouling coatings in its re-evaluation and (to the extent financially feasible) to address biocide alternatives in its marina monitoring study.

Based on information from its own monitoring, information obtained from manufacturers through re-evaluation, U.S. EPA's regulatory actions (if any), Water Board regulatory changes (if any), voluntary commitments by manufacturers (if any) and any other relevant available evidence, DPR intends to determine its appropriate regulatory action some time after the end of 2006. (DPR may also pursue non-regulatory actions). DPR has said that it intends to provide a timely response to the State Water Board's request for feedback by November 2007 (a deadline set when the State Water Board adopted the San Diego Region's Shelter Island Yacht Basin TMDL).

Effective Implementation Design

DPR generally requires quantitative information about the water quality and/or permit compliance problems associated with a pesticide (including quantification of the pesticide's relative contribution to the problem) before it will consider restricting a pesticide's sales and use. DPR's marine antifouling paint strategy is designed to provide it with the type of information it believes necessary to make appropriate regulatory decisions.

Implementation Issues

There is a chance that the DPR re-evaluation will not occur, that it will not be concluded in a timely manner, or that its outcome will not generate regulatory action by DPR that minimizes copper releases to San Francisco Bay from marine antifouling coatings and ensures that marine antifouling coatings do not cause water quality impairment. To address this, the State Water Board included in the resolution approving the San Diego Regional Water Board's Shelter Island Yacht Basin TMDL a commitment to address marine antifouling paint itself. If after two years (2007-2008), DPR (or U.S. EPA through its re-registration program) has not taken action to adequately address the impacts of copper-based marine antifouling coatings on water quality, the State Water Board intends to work with all coastal Regional Water Boards (including the San Francisco Bay Region) to

[31] Mechanically, a re-evaluation consists of the following steps. First, DPR develops a data requirement to present to marine antifouling paint manufacturers. DPR then works with manufacturers to complete acceptable studies to answer the questions listed in the data requirement. Normally, the data requirement calls for manufacturers to develop specific ways to prevent water quality problems. The results of the work done by the manufacturers are studies that must be approved by DPR. DPR then decides based on the studies and any other available information what regulatory action, if any, is appropriate. For example, studies could suggest specific changes to how marine antifouling coatings are used. These types of changes would typically be implemented through changes in product label language. However, it may not be possible to avoid water quality problems without severely limiting or prohibiting use of the certain biocides in marine antifouling coatings. In this case, DPR would need to consider a variety of factors, including the alternatives available and the economic and other reasons that the biocide might be necessary, in making its decision about potential regulatory controls.

develop a state policy for water quality control to address water quality impairments in coastal marinas from copper-based marine antifouling coatings.

Activity metrics

Tracking of manufacturer responses and the results of special studies being performed during the re-evaluation by DPR and manufacturers would provide a measure of activity. DPR issues semi-annual status reports on re-evaluations that are in progress; these reports would provide a suitable mechanism for tracking activity.

Effectiveness metrics

Effectiveness should be measured at the end of the re-evaluation or after Water Board action in lieu of DPR action. The appropriate effectiveness metric would depend on the design of the regulatory program. For example, if DPR or U.S. EPA prohibited all use of copper-based marine antifouling coatings or if manufacturers voluntarily withdrew them from the market, no metric would be necessary. If, on the other hand, Water Board authorities have to be used, metrics associated with the implementation of those authorities would need to be selected.

Strategy AF-2: Targeted Public Education for Alternative Marine Antifouling Coatings

Boats may be stored in the water or on shore. Only those boats that are stored in the water typically have antifouling coatings. These boats account for only a small fraction (perhaps 10-15%) of registered boats. Education of boaters and boat repair facility (boatyard) operators has the potential to reduce use of copper-based marine antifouling coatings. This strategy relies on voluntary actions by boaters and boatyards. Even if DPR proceeds with regulatory action to control water pollution from marine antifouling coatings, this strategy would be needed to assist with a timely and effective transition to less polluting alternatives.

Effective Implementation Design

Educational programs are most effective when designed to target specific audiences using messages that resonate with that audience and using methods that target the specific audience. For outreach on marine antifouling coatings, the key target audiences would be boaters and boatyard owners.

An effective education program would involve direct contacts with boaters and boatyard owners to educate them about alternative coatings. Due to the regional nature of these businesses and the need to ensure that educators can provide complete and reliable information to those involved with hull coating, this program would be most cost-effectively developed and implemented regionally. Many potential partners are already working with Bay Area boaters and boatyards (see the IACC Copper Antifouling Paint Sub-Workgroup participant list).[32] Three examples of specific opportunities for partnerships in the Bay Area include:

- The San Francisco Estuary Project's (SFEP's) Boater Education Program has worked with boaters and marinas since the early 1990s to develop and implement an education and outreach program to protect Bay water quality. The program has focused on marine waste management, encouraging

[32] Available on the workgroup web site http://www.cdpr.ca.gov/docs/sw/caps.htm.

boaters to use pump out and dump stations rather than discharging directly into San Francisco Bay and the Delta.

- The California Department of Toxic Substances Control (DTSC) is initiating a pollution prevention program for marine vehicle service and repair. This program, which plans to focus on hazardous waste generation and management, will be developing invaluable information (e.g., lists of boatyards) and networks. DTSC intends for its Berkeley office to be involved in implementing this program in the Bay Area.
- The Clean Marinas Program is a voluntary recognition program operated by California marina owners, operators, and yacht clubs. The program promotes implementation of best management practices that are intended to protect water quality. Several Bay Area marinas have achieved clean marina certification.[33]

It may also be possible to partner with the San Diego-based University of California Cooperative Extension Sea Grant program, which has been conducting pilot projects and education on non-toxic marine antifouling coatings in Southern California. Coordination with members of the Copper Antifouling Paint Sub-Workgroup the IACC Marina and Recreational Boating Workgroup is recommended.

An education program addressing marinas may also be useful. Although most marinas do not normally conduct boat maintenance,[34] they can influence boat owners via requirements for leasing slips for boat storage. Marinas would be most likely to assist with voluntary programs if they could foresee future regulatory pressures to improve water quality.

Implementation Issues

A highly targeted, well-designed education program for copper marine antifouling coatings could achieve behavior change rates in the 10-15% range.[35] Since the uncertainty in tracking mechanisms is probably at least 10-15%, education programs by themselves are unlikely to have a measurable effect on the amount of copper released to San Francisco Bay from marine antifouling coatings. Nevertheless, education is an important step along the road toward regulating a pollutant source:

- Education programs make affected parties aware of the link between a pollutant source and a water quality threat.
- Voluntary actions resulting from an education program provide helpful examples demonstrating that the requested change is feasible (or occasionally prove that a change is infeasible).
- Agencies that operate education programs can clarify the technical and policy issues that need to be faced prior to initiating a regulatory program.

[33] For more information, see http://cleanmarinascalifornia.org/.
[34] According to a survey completed by DTSC, marine vehicle servicing or repair occurs at fewer than 10% of California marinas. (See DTSC OPPTD, *Pollution Prevention Report and Two-Year Workplan 2006-2008*, June 2006).
[35] Less targeted programs would have lower rates. See Larry Walker Associates, *Tools to Measure Source Control Program Effectiveness*, prepared for the Water Environment Research Foundation, Project #98-WSM-2, 1999.

If a regulatory program is implemented, an education program can usually be downsized or eliminated.

Due to the lack of San Francisco Bay-specific information on copper loss from marine antifouling coatings, boat owners and boatyard managers may reasonably question the importance of this copper source. Although the Copper Sources Report recommended a region-specific investigation of the copper load from marine antifouling coatings and related issues, such an investigation may not be necessary depending on the outcome of a study currently being conducted by DPR with funding from the State Water Board. This DPR study (which was mentioned above) will include more than a dozen Bay Area marinas in its evaluation of the extent and magnitude of water quality impacts from marine antifouling paint ingredients. The results of the DPR study, which are expected in early 2007, should be evaluated to determine if additional Bay Area specific work is needed to establish the need for (or lack of need for) changes in marine antifouling coatings.

Many alternatives to copper-based marine antifouling coatings exist; however, some alternatives are not practical, effective, or desirable. Although the focus has been on non-toxic alternatives to copper-based marine antifouling coatings, a number of toxic alternatives also exist. California registered marine antifouling biocides that are of particular concern with regards to water quality are Irgarol® and zinc pyrithione.[36] Prior to implementing this strategy, a review of alternatives should be conducted to determine which strategies are most likely to be practical and effective and least likely to have adverse environmental or human health consequences.

This strategy involves the use of antifouling coatings that are relatively new and currently considered "unproven" in the industry. To address this issue, pilot projects are recommended as the first step in implementing this strategy. Local pilot projects can demonstrate how alternative materials perform in Bay waters and how effective they are against Bay fouling species. Long-term testing of coatings under different operating conditions (i.e. heavy boat use versus extended moored periods) would be useful. Obtaining cost data is important, because cost of antifouling coating installation and maintenance is important to boat owners.[37] Government agencies that own water-stored boats and/or private entities connected to resource protection would be the most likely partners in pilot projects. Prior to implementing pilot projects, appropriate alternative coatings should be selected based on the review recommended above.

Before most of the currently available non-toxic marine antifouling coatings can be used, the current coating must be fully removed. Coating removal is time consuming and expensive; it is normally completed by professionals at boatyards. Due to this cost, boat owners have been reluctant to consider switching to alternative coatings until their current coating has reached the end of its useful lifetime. Although antifouling paint recoating typically occurs every 2-3 years, paint stripping only typically is completed about once every 15 years.[38]

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[36] TDC Environmental, *Pesticides in Urban Surface Water: Annual Research and Monitoring Update 2005*, prepared for the San Francisco Estuary Project, 2005.

[37] Johnson, L. T., and J. A. Miller, University of California Cooperative Extension—Sea Grant Program, "Nontoxic Antifouling Strategies Economic Incentives Study." UCSGEP-SD Fact Sheet 04-1 May 2004.

[38] See the Johnson and Miller reference cited above.

The effectiveness of such a program may be improved by enlisting the help of marinas. A certification program or recognition program for marinas that recommend or require the use of alternative anti-fouling coatings may increase the rate at which boat owners and boatyards adopt the recommended practices. If a voluntary incentive program is planned, the potential for cooperation with the Clean Marinas Program should be explored.

Activity metrics

Activity metrics would need to be developed when the outreach program was designed, as they should relate specifically to the program design. Measurement of activity implementation of an outreach program can include the number of brochures distributed, number of articles or advertisements placed, the number of boat and boatyard owners attending workshops, the number of boats involved in pilot projects, or the number of brochures taken from a display.

Effectiveness metrics

The effectiveness metric would best be designed in concert with the design of the education program. To determine if recommended practices are being adopted, surveys or random site inspections could be conducted at boatyards. Low rates of implementation may be observed due to the voluntary nature of the program.

Strategy AF-3: Hull Cleaning Best Management Practices

Marine antifouling coatings rely on slow release of a biocide impregnated in the coating to prevent fouling growth on the hull. Of the two formulation types, ordinary "hard" copper-containing antifouling paints must be cleaned often enough to remove early stages of fouling growth before it becomes established on the boat's hull. Unless the boat is removed from the water, the only practical cleaning method is to send divers underwater to remove any fouling growth from the hull. Vigorous cleaning dislodges some of the antifouling coating, releasing copper into the water.

Educational programs could be used to encourage that best management practices be implemented during hull cleaning to reduce copper discharges from antifouling coatings. Management practices that minimize copper release during hull cleaning have been developed by the University of California Extension Sea Grant program as well as by other U.S. coastal agencies.[39] Because available data indicate that only a relatively small fraction of copper releases from marine antifouling coatings occur during hull cleaning, this measure is recommended as a contingency measure. Implementing this measure may, however, be a useful step in obtaining boat owner cooperation with efforts to promote voluntary use of non-toxic alternative antifouling coatings (see Strategy AF-2).

Effective Implementation Design

For outreach on hull cleaning practices, the key target audiences would be boaters and underwater hull cleaning services. An effective education program would involve direct contacts with boat owners and underwater hull cleaning services to educate them about cleaning practices. Due to the regional nature of these businesses and the need to ensure that educators can provide complete and reliable information to boaters and hull cleaners, this program would be most cost-effectively developed and implemented regionally.

[39] See for example the U.C. Sea Grant Program Underwater Hull Cleaner's Best Management Practices, available on the Internet at http://seagrant.ucdavis.edu/underwater.htm.

An education program addressing marinas may also be useful. Although most marinas do not normally conduct boat maintenance,[40] they can influence boat owners via requirements for leasing slips for boat storage or by helping connect boat owners to hull cleaning services. Marinas would be most likely to assist with voluntary programs if they could foresee future regulatory pressures to improve water quality.

Implementation Issues

Since boat owners hire contractors for hull cleaning, it is difficult for them to ensure that appropriate management practices are actually being implemented when their boat hulls are being cleaned. Contract specifications and certification programs could help owners to ensure that management practices are being implemented.[41]

Although modifying underwater hull cleaning practices to minimize copper release is possible, data from San Diego suggest that even with relatively frequent underwater cleanings, modified procedures are likely have little impact on copper loads.[42]

Activity metrics

Activity metrics would need to be developed when the outreach program was designed, as they should relate specifically to the program design. Measurement of activity implementation of an outreach program can include the number of brochures distributed, the number of boat owners and hull cleaning service employees attending workshops, or the number of brochures taken from a display.

Effectiveness metrics

The effectiveness metric would best be designed in concert with the design of the education program. A survey of hull cleaning service companies could be one measure of the effectiveness of outreach programs. Low rates of implementation may be observed due to the voluntary nature of the program.

5.2 LEADING INDICATORS

Leading indicators are actions that can be tracked and used to assess the change in significance of a pollutant source (trends). These differ from effectiveness metrics, which evaluate the response to a specific control measure. Leading indicators should track actions that occur prior to environmental impacts.[43] Ideal leading indicators involve information that can be easily collected and compiled. Ideal leading indicators correlate with the magnitude of the pollutant source and/or effectiveness of addressing the source.

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[40] According to a survey completed by DTSC, marine vehicle servicing or repair occurs at fewer than 10% of California marinas. (See DTSC OPPTD, *Pollution Prevention Report and Two-Year Workplan 2006-2008*, June 2006.)

[41] See for example the U.C. Sea Grant Program's recommendations for boat owners "Selecting a Service Provider" available on the Internet: http://seagrant.ucdavis.edu/topside.htm.

[42] *Schiff, K. C; Diehl, D.; Valkirs, A*. Copper Emissions from Antifouling Paint on Recreational Vessels*, Technical Report 405, Southern California Coastal Water Research Projec*t, June 2003; *Carson, R.; Damon, M.; Johnson, L.; Miller, J.* Transitioning to Non-Metal Antifouling Paints on Marine Recreational Boats in San Diego Bay*, Final Report, prepared for the California Department of Boating and Waterways pursuant to California Senate Bill 315 of 2001*, 2002.

[43] Water quality monitoring is not a leading indicator, but rather a trailing indicator indicating the environmental response to a pollutant management action.

The amount of copper entering the Bay from antifouling paints would be proportional to the amount of copper antifouling paints used on boats in the San Francisco Bay. Possible indicators and their pros and cons are listed in Table 10 (on the next page). Evaluation of multi-year data sets is necessary to support management decisions. Year-to-year variations in marine antifouling coating use are likely, as weather is an important factor in recreational boating. This means that annual tracking of indicators and evaluation of multi-year data sets is necessary to support management decisions.

5.3 IMPLEMENTATION SEQUENCE AND TIME FRAME

Table 11 (on page 46) and Figure 4 (on page 47) lay out a potential initial implementation sequence and time frame for implementation of a copper management strategy for copper-based marine antifouling coatings. The basis for the time frames relates to the estimated time it takes to initiate a certain program. This timeline also gives coating companies time to research and develop new coatings and time for independent parties to evaluate the coatings in different geographic conditions and under different circumstances. After the program is started, the time frames are relative to how long it could take to complete and evaluate results of the first action before moving on to the next action. To ensure all elements are addressed, both Table 11 and Figure 4 envision maximum implementation of the strategy.

While full implementation of the actions listed in Table 11 would provide the most complete control of this copper source, less than full implementation is entirely feasible, as long as the effectiveness level is judged acceptable (see descriptions above for effectiveness estimates for individual strategies). Assessing load estimates and/or determining if feasible alternatives are available are important steps in the development of most strategies. The order of implementation is based on the need to develop some background information prior to implementing certain strategies and then implementing control measures based on their potential to achieve reductions.

Table 10. Potential Leading Indicators for Copper Marine Antifouling Coatings

Potential Indicator	Comments	Recommended?
1. Quantity of copper antifouling coating use estimated on the basis of non-reported cuprous oxide use.[44]	Data reported to DPR are relatively accurate and readily available. Requires extrapolation of statewide sales data, so does not reflect local or regional actions.	✓Yes. Shows trends. Would need to be supported by other indicators of local use if statewide regulatory action is not implemented.
2. Boatyard surveys for use of alternative antifouling coatings.	Surveys of antifouling products used by boatyards provide an indicator of penetration of alternatives in the Bay Area market. However, does not provide reliable quantitative data.	✓Yes. Only way to explore effects of regional control measures.
3. Marine antifouling coating sales.	Unlikely to be able to obtain local data for a reasonable price due to the confidential nature of sales data. Although statewide data are submitted to DPR, they are considered trade secret and thus normally must be kept confidential.	No. Probably not feasible.
4. Number of boats coated with copper-based paint.	Maintain records of all boats that are coated (including make, size, quantity of paint used, etc).	No. Not feasible, as this is not a practice requiring a permit.
5. Number of boats with copper-based coating removed and replaced with alternatives.	Maintain records of all boats that have their antifouling coating removed.	No. Not feasible, as this is not a practice requiring a permit.

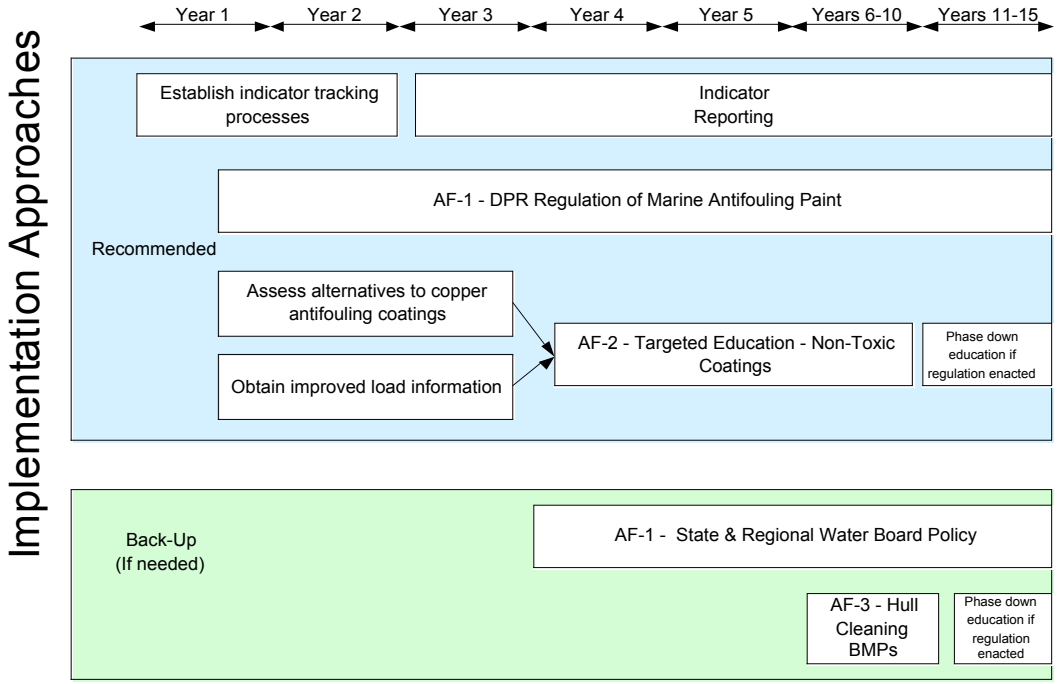
[44] Methodology described in City of Palo Alto Regional Water Quality Control Plant, *Copper Action Plan Report*, 2006.

Table 11. Potential Framework for Implementation of All Copper Marine Antifouling Coating Strategies

Action	Implementing Agency	Time Frame*
1. Begin DPR re-evaluation of antifouling coatings	DPR	Start: By Fall 2006. Implementation: Complete re-evaluation by year 5. Regulatory action would follow completion of re-evaluation; implementation of regulations would be ongoing.
2. Develop local antifouling coating load contribution estimates, if necessary	One regional study	Start: In 1st year of program, evaluate results of DPR marina monitoring study and determine if additional local data are needed. Implementation: If additional local data are needed, design and complete study by year 3. Completed early in program because it informs and assists with implementation of later strategies.
3. Review alternatives to copper-based antifouling coatings	One regional or statewide study	Start: In 1st year of program (exact timing could be modified to accommodate a statewide coordination opportunity). Implementation: Complete by year 3. Review will determine which alternatives are most likely to be practical and effective and least likely to have adverse environmental or human health consequences.
4. Establish tracking and reporting of the leading indicator and for activity and effectiveness metrics as strategies are implemented	Tracking—Regional Reporting—Regional preferred (may not be practical for metrics)	Start: Tracking established within 2 years; begin reports in year 3. Implementation: Ongoing; end if regulatory controls judged adequate by the Water Board are adopted for copper antifouling coatings.
5. Implement Strategy AF-2, conducting targeted outreach & education about non-toxic alternative antifouling coatings	One regional program	Start: After review of alternatives, assuming one or more promising alternatives are identified. Implementation: Start pilot projects in year 3; time start of outreach based on pilot project schedule. May take up to 20 years to fully implement alternatives.
6. Implement Strategy AF-3, conducting targeted outreach & education about hull cleaning BMPs	One regional program	Start: If additional strategies are deemed necessary. Implementation: Ongoing; end if adequate regulatory controls are adopted for copper –based marine antifouling coatings.
7. Develop and implement statewide policy regarding copper antifouling coatings	State and coastal Regional Water Boards	Start: If DPR's November 2007 response to the State Water Board (or subsequent regulatory action) does not adequately address the impacts of copper-based marine antifouling coatings on water quality. Implementation: Ongoing.

***Time frames based on time to develop and implement a new program or to implement and evaluate a program before moving on to the next task.**

Figure 4. Potential Framework for Implementation of All Copper Marine Antifouling Coating Strategies



Available Copper Load Reduction

Replacing current copper-based antifouling coatings with non-toxic alternatives could provide a substantial reduction in copper loading to the Bay from this source, as each replacement would eliminate that boat's entire contribution to the copper load. Reductions from implementation of underwater hull cleaning best management practices would be relatively small, since they would reduce—but not eliminate—the relatively small load contribution from hull cleaning (see above). The greatest reduction could be achieved through regulation of copper-based antifouling coatings.

Post-Implementation Actions

Post-implementation reviews would evaluate progress and effectiveness of the strategy (based in part on evaluation of the leading indicator and activity and effectiveness metrics) and identify appropriate modifications. For example, modifications could increase effectiveness, reduce costs by eliminating unnecessary activities, or modify strategies in response to newly identified issues. Reviews are recommended at the following times:

- About Year 2 – after DPR feedback to the State Water Board on its activities (due in November 2007), obtaining improved load information, and completing an assessment of alternative antifouling coatings. Even if regulatory action is imminent, moving forward with the first step of the education and outreach program (pilot projects) using recommendations based on results of the alternatives assessment is recommended to encourage and smooth the transition to safer alternatives. If a joint State and Regional Water Board decision on policy development has not been made, it should be made at this time.

- About Year 5 – in concert with five year reviews of other program elements. Review regulatory status and determine if fall-back regulatory action or the hull cleaning educational program is warranted. Determine whether the antifouling coating targeted education program should be modified (or terminated if no longer necessary due to regulations).
- Every 5 years thereafter – Long-term reviews should consider the need for and frequency for continued tracking of various indicators and the need to modify regulatory approaches. Long term reviews should also consider the need for additional actions (e.g., to address large commercial ships, which may have antifouling coatings applied outside of California) as well as the elimination of actions that are not effective or no longer warranted based on updated information and data collection.

The recommended time periods are flexible. Combining the review process with reviews of other CMS elements would be most efficient.

6.0 EXISTING PERMIT REQUIREMENTS

The Copper Sources Report identified several potentially significant copper sources that are already controlled by permits issued by the State Water Board. These are summarized below.

- Industrial Activities. Industry has long been a focus of environmental regulatory programs, including both wastewater pretreatment and stormwater permit programs. Any industrial facility in one of 10 broad categories of industrial activities must participate in the State Water Board's industrial stormwater permit program. Boat maintenance facilities, marinas, and other water transportation facilities are included in SIC code 44 (Water Transportation) and are part of the Transportation category covered by the State General Industrial Permit. According to the State General Industrial Permit, any facility in this category that has vehicle maintenance shops or equipment cleaning operations is subject to the requirements of the permit. About 1,500 industrial facilities in the San Francisco Bay Area are currently active participants in the program. Using industrial stormwater monitoring data, the Copper Sources Report estimated that about 3,300 pounds of copper are discharged annually in industrial runoff; this estimate has a moderate uncertainty, primarily because it involved extrapolation to create a regional estimate from Santa Clara County data.
- Soil Erosion. Each year, hundreds of construction sites cover thousands of acres of San Francisco Bay Area land, digging up the soil to build new homes, businesses, industries, and infrastructure. In order to prevent releases of soil and other pollutants into stormwater runoff, the State Water Board requires all construction sites 1 acre and larger to participate in the construction stormwater permit program. There were about 700 active construction sites in the San Francisco Bay Area in 2003. Construction of new impervious surfaces in Bay Area watersheds also changes the quantity and timing of runoff flows in urban creeks. These changes can accelerate erosion of stream banks—potentially contributing significantly to sediment loads in runoff. Recent new development related amendments to urban runoff agency permits require development of hydromodification management plans to protect beneficial uses in Bay Area creeks. Using previous estimates of the copper content of eroded soil, the Copper Sources report estimated soil erosion discharges at about 7,000 pounds

of copper per year (about two-thirds from hydromodification and one third from construction sites). This estimate has a moderate uncertainty.

- Copper Algaecides Applied to Surface Waters. For decades, copper has been used to control algae growth in reservoirs, lagoons, and drainage channels. In response to a 2001 Federal court decision, the State Water Board initiated a program to regulate applications of pesticides to surface waters. A study of the environmental effects of aquatic pesticide applications conducted by the San Francisco Estuary Institute found that dissolved copper from aquatic pesticide applications caused lethal and sublethal toxicity in juvenile trout for at least 24 hours after application, toxicity in *Ceriodaphnia dubia* (water flea) for at least a week after application, and may relate to increased sediment copper concentrations (though results on sediment toxicity were inconclusive).[45] The presence of the permit requirements has increased incentives for applicators (who are primarily public agencies) to reduce use of aquatic pesticides and to transition to alternative pesticides or to non-pesticide control methods for aquatic weeds and algae. The Copper Sources Report estimated that about 4,000 pounds of copper were applied to shoreline water bodies. This estimate, which was based on an incomplete database of reports to DPR and uncompiled reports to the State Water Board was judged highly uncertain.

Existing permit requirements for construction and industrial stormwater runoff, aquatic pest management, and hydromodification management planning address these copper sources. Implementation of these permit requirements is intended to ensure that these activities do not cause or contribute to exceedance of water quality standards in receiving waters. If these activities are found to be causing or significantly contributing to copper water quality standard exceedances, they may be modified as necessary. Given the basis of these permit requirements and the State and Regional Water Board's authority to modify the permits if necessary, additional copper management strategies for these copper sources are not necessary.

7.0 PUBLIC OUTREACH

The previous sections describe specific control strategies that are available to prevent and minimize discharges from the largest sources of copper in urban runoff and release from Bay shoreline activities. Other minor copper sources exist (for example, vehicle fluid leaks and dumping, domestic water discharged to storm drains). Copper may also be conveyed to surface waters by improper discharges (e.g., from car washing). These copper sources and conveyances can be addressed through public outreach programs, as appropriate within the context of other public outreach priorities.

All municipal stormwater management programs are required by their NPDES permits to operate public information and participation (PI/P) programs. The goals of these programs include changing behaviors that adversely affect water quality. Several of the control strategies identified in previous sections would be implemented in conjunction with the required PI/P programs. Public outreach for minor copper sources is not a top priority; however, there may be opportunities to address these sources in conjunction with programs addressing other pollutant sources. Opportunities to address minor copper sources and conveyances should be considered when setting program priorities each year.

[45] Siemering, G., *Aquatic Pesticide Monitoring Program, Phase 2 (2003) Monitoring Project Report*, prepared by the San Francisco Estuary Institute for the State Water Resources Control Board, February 2004.