

# **Copper Released from Non-Brake Sources in the San Francisco Bay Area**

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# Copper Released from Non-Brake Sources in the San Francisco Bay Area

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# Copper Released from Non-Brake Sources in the San Francisco Bay Area

## Executive Summary

Many human activities result in the release of copper to the environment. The results presented in this report are part of a larger effort whose purpose is to gain a better understanding of the sources of elevated copper concentrations in the San Francisco Bay. The overall effort includes assessing the magnitude of copper released in the Bay area, followed by modeling of the environmental fate and transport of these estimated releases. In this report, estimated releases of non-brake sources of copper for use in the modeling effort, along with the methodology for preparing those estimates, are presented. Copper releases from brake lining wear are the subject of a separate report.

Estimates of releases of copper to surface waters and storm drains in the Bay area sub-watersheds in 2003 are summarized in Table ES-1. An estimated 6,900 kg of copper were released to surface waters and storm drains in the Bay area in 2003. This category of releases includes releases of copper from

- agricultural uses of algaecides in water areas,
- algaecide uses in rights of way (nonagricultural), public health, and recreational areas,
- pool, spa, and fountain algaecides that are discharged to storm drains,
- industrial runoff,
- domestic water discharged to storm drains, and
- architectural uses of copper.

Table ES-1 shows that there is no single dominant source of this category of releases. The sub-watersheds with the largest releases are the Pacheco Creek watershed and the Coyote Hills Slough watershed.

Table ES-2 shows the estimated releases of copper that occurred directly to Bay waters in 2003. Total estimated releases in this category in 2003 were 11,000 kg. This category of releases includes releases of copper from

- antifouling coatings on boats berthed in the Bay, and
- copper-based algaecides used to treat shoreline waters.

The larger of these two sources of releases is the antifouling coatings, with more than 80% of total releases.

Air releases of copper in the Bay area include releases from brake lining materials (the subject of another report) and industrial air releases. Eleven facilities reported air releases of copper in the Toxic Chemical Release Inventory in 2003. These releases, which total 359 kg for the nine counties in the Bay area, are summarized in Table ES-3. The largest single reporter is San Francisco Drydock Inc., which reported nearly 200 kg of copper released to air in 2003.

Table ES-4 summarizes releases of copper to permeable surfaces in the Bay area sub-watersheds in 2003. These releases total 200,000 kg. This category of releases includes releases of copper from

- non-algaecidal agricultural uses of copper-based pesticides,
- urban land applications of copper-based pesticides,
- pressure-treated lumber, and
- fertilizers.

The largest contributor to this category is copper pesticides applied to urban land, followed by copper leached from pressure-treated lumber. The sub-watersheds with the largest releases are the Coyote Hills Slough watershed and the San Francisquito Creek watershed.

Section 1 of this report is an introduction. Section 2 presents the estimation methodology and results for calculating releases of copper from various sources. This section begins with a discussion of themes relevant to estimating releases from all categories of sources, followed by subsections on architectural copper, copper in pesticides, copper in fertilizers, copper released from industrial operations, and copper in domestic water discharged to storm drains. Section 3 provides a brief discussion of sources not included in this inventory, and Section 4 is a list of references.

Table ES-1 Estimates of copper released to storm drains and surface waters in the Bay area sub-watersheds in 2003.

Watershed	Copper in Algaecides Applied to Agricultural Water Areas, kg/y	Copper in Algaecides Used in Nonagricultural Rights of Way, Recreation Areas, and Public Health, kg/y	Copper Released from Pool, Spa, and Fountain Algaecides, kg/y	Copper Released in Industrial Runoff, kg/y	Copper in Domestic Water Discharged to Storm Drains, kg/y	Architectural Releases of Copper, kg/y	<b>Total Copper Released to Surface Waters and Storm Drains, kg/y</b>	Standard Uncertainty, kg/y
Alameda Creek	0	54	95	68	22	78	<b>317</b>	92
Calabazas Creek	0	0	150	42	35	69	<b>296</b>	116
Castro Valley	0	0	15	3	4	6	<b>28</b>	12
Cerrito Creek	0	95	105	50	24	59	<b>334</b>	114
Colma Creek	0	0	34	5	8	10	<b>58</b>	26
Corte Madera Creek	0	0	54	22	13	34	<b>123</b>	43
Coyote Creek	0	0	246	134	57	149	<b>587</b>	199
Coyote Hills Slough	0	26	378	243	88	260	<b>994</b>	314
Fremont Bayside	0	1	80	72	19	75	<b>247</b>	72
Montezuma Slough	0	2	75	73	17	77	<b>244</b>	69
Napa River	0	278	88	55	20	64	<b>505</b>	238
North Napa River	0	73	11	5	3	7	<b>98</b>	60
North Sonoma Creek	0	1	4	1	1	2	<b>9</b>	3
Novato Creek	96	0	35	17	8	25	<b>181</b>	62
Pacheco Creek	0	520	203	104	47	152	<b>1,027</b>	455
Petaluma River	11	9	30	21	7	23	<b>101</b>	27
San Francisquito Creek	0	0	308	174	71	221	<b>774</b>	252
San Lorenzo Creek	0	0	15	4	3	7	<b>30</b>	12
San Pablo Bay	0	185	73	51	17	62	<b>387</b>	163
Seal Slough	0	0	187	122	43	144	<b>496</b>	156
Sonoma Creek	0	4	14	6	3	8	<b>36</b>	12
Upper San Francisquito Creek	0	0	5	3	1	8	<b>17</b>	5
West Corte Madera Creek	0	0	11	1	3	4	<b>19</b>	8
<b>TOTAL</b>	<b>107</b>	<b>1,249</b>	<b>2,216</b>	<b>1,275</b>	<b>514</b>	<b>1,544</b>	<b>6,904</b>	<b>757</b>

Table ES-2 Estimated copper released directly to Bay waters in 2003.

Source	Estimate, kg/y	Standard Uncertainty, kg/y
Copper in algae/corals released to shoreline surface waters	1,862	101
Copper releases from antifouling coatings	9,000	3,210
Total	10,862	3,212

Table ES-3 Air emissions of copper reported in the Toxic Chemical Release Inventory in the 9-county region in 2003 (US EPA, 2005b).

Facility	City	Facility- Reported Latitude	Facility- Reported Longitude	Preferred Latitude	Preferred Longitude	Reported Release, kg/y	Standard Uncertainty, kg/y
Isola USA Corp	Fremont	372024	1242236	37.469698	121.918306	4	1
Titan PCB West Inc	Fremont	373028	1215650	37.508333	121.936111	114	38
New United Motor Manufacturing Inc	Fremont	372924	1215630	37.484722	121.941667	5	2
Pressure Cast Products Corp	Oakland	374620	1221259	37.772222	122.216389	2	1
Communications & Power Industries Inc Eimac Div	San Carlos	373052	1201604	37.514444	122.267778	20	7
San Francisco Drydock Inc	San Francisco	374540	1222245	37.761111	122.379167	195	64
South Bay Circuits Inc	San Jose	371653	1215038	37.281389	121.843889	5	2
Viko Technology Inc Adaptive Circuits Div	San Jose	372146	1215314	37.366667	121.851667	2	1
ECS Refining	Santa Clara	372140	1225640	37.3615	121.9382	9	3
Pycon Inc	Santa Clara	373330	1215929	37.383822	121.955817	2	1
Sprig Circuits Inc	Vacaville	382100	1220000	38.417222	121.970833	1	0.3
Total						359	

Table ES-4 Copper released to permeable surfaces in the Bay area sub-watersheds in 2003.

Watershed	Copper in Pesticides Applied to Urban Land, kg/y	Copper in Pesticides Applied to Agricultural Land, kg/y	Copper Released from Pressure-Treated Wood, kg/y	Copper Applied in Fertilizers, kg/y	<b>Total Copper Released to Permeable Surfaces, kg/y</b>	Standard Uncertainty, kg/y
Alameda Creek	4,510	107	3,090	644	<b>8,351</b>	2,751
Calabazas Creek	7,138	20	4,890	101	<b>12,149</b>	4,294
Castro Valley	719	0	493	4	<b>1,215</b>	433
Cerrito Creek	5,007	0	3,431	26	<b>8,464</b>	3,012
Colma Creek	1,633	0	1,119	9	<b>2,760</b>	982
Corte Madera Creek	2,570	0	1,761	13	<b>4,344</b>	1,546
Coyote Creek	11,726	291	8,034	1,003	<b>21,056</b>	7,089
Coyote Hills Slough	17,975	8	12,316	152	<b>30,451</b>	10,813
Fremont Bayside	3,807	12	2,608	103	<b>6,529</b>	2,291
Montezuma Slough	3,547	897	2,430	1,441	<b>8,316</b>	2,426
Napa River	4,177	1,895	2,862	1,114	<b>10,049</b>	2,853
North Napa River	513	4,636	352	2,678	<b>8,180</b>	3,320
North Sonoma Creek	204	894	140	343	<b>1,580</b>	586
Novato Creek	1,654	94	1,134	11	<b>2,893</b>	997
Pacheco Creek	9,673	30	6,628	115	<b>16,447</b>	5,819
Petaluma River	1,426	613	977	238	<b>3,253</b>	943
San Francisquito Creek	14,664	17	10,047	130	<b>24,858</b>	8,821
San Lorenzo Creek	713	0	488	4	<b>1,205</b>	429
San Pablo Bay	3,464	11	2,374	42	<b>5,891</b>	2,084
Seal Slough	8,898	0	6,096	46	<b>15,040</b>	5,352
Sonoma Creek	674	2,239	462	860	<b>4,235</b>	1,490
Upper San Francisquito Creek	229	15	157	32	<b>432</b>	140
West Corte Madera Creek	522	0	358	3	<b>882</b>	314
<b>TOTAL</b>	<b>105,442</b>	<b>11,780</b>	<b>72,247</b>	<b>9,111</b>	<b>198,580</b>	<b>19,634</b>

# 1 Introduction

Many human activities result in the release of copper to the environment. The results presented in this report are part of a larger effort whose purpose is to gain a better understanding of the sources of elevated copper concentrations in the San Francisco Bay. The overall effort includes assessing the magnitude of copper released in the Bay area, followed by modeling of the environmental fate and transport of these estimated releases. In this report, estimated releases of non-brake sources of copper for use in the modeling effort, along with the methodology for preparing those estimates, are presented. Copper releases from brake lining wear are the subject of a separate report.

This report contains separate release estimates for the following categories of releases of copper:

- architectural copper
- copper in pesticides
- copper in fertilizer
- copper releases from industrial operations (including releases in runoff)
- copper in domestic water discharged to storm drains

These categories of releases are taken from “Copper Sources in Urban Runoff and Shoreline Activities” (hereafter referred to as the urban runoff report) prepared by TDC Environmental for the Clean Estuary Partnership in November of 2004. Sources estimated to contribute less than one thousand pounds of copper per year in urban runoff (those from fuel combustion, wood burning, and vehicle fluid leaks) are not included in this report. Also, copper released from soil erosion will be calculated by the runoff model and was not estimated. An estimate of copper releases from fertilizer use was developed.

In many cases, approaches for estimating releases that are described in the urban runoff report were adopted in this study. A report titled "Work Plans for Estimating Non-Brake Releases of Copper in the San Francisco Bay Area Watershed" contains supplementary information about the release inventory methodology pursued in the creation of the estimated releases presented in this report.

## 2 Estimates for Individual Categories of Releases

Some of the strategies for developing release estimates apply to all or most of the release categories. These commonalities are presented in this section.

### *Multimedia Estimates*

Multimedia emission estimates of copper are given in this report, so that releases to land, water, and air are identified separately. Direct releases to storm drains and to surface waters were inventoried separately from releases to pervious surfaces. Releases were estimated for the more than 20 sub-watersheds that lie within the greater Bay watershed.

### *Study Area*

Figure 2-1 shows the counties and sub-watersheds within the greater San Francisco Bay area watershed. San Francisco County drains almost exclusively to the ocean as opposed to the Bay and is not generally included in the inventories presented in this report. An exception is made for air emissions of copper in San Francisco County, as they have a high potential for transport to the Bay or to portions of the Bay area that drain to the Bay. Also, a very small portion of Santa Cruz County falls within the watershed. This area is neglected for purposes of creating the copper release inventories. Thus, the 9-county region that is referred to in this report when discussing air emissions includes the following counties: San Francisco, San Mateo, Santa Clara, Alameda, Contra Costa, Solano, Napa, Sonoma, and Marin Counties. The 8-county region that is referred to when discussing point source and land releases includes all of those counties except for San Francisco County.

### *General Methodology*

Information that can be used to estimate releases is almost without exception available for areas bordered by political boundaries as opposed to physical ones such as watersheds. Data for estimating emissions were gathered with the highest geographic resolution possible. For some categories of releases, the data are county-based; for others, they are state- or nationally-based. Emissions for the portion of the county (or state or country) within the watershed were then parceled out based on population, land use, or some other appropriate factor.

Population counts and other weighting factors such as land use areas for each sub-watershed area by county, for the counties, and for the state were provided by URS Corporation, a member of the Bay modeling team. Tables 2-1 through 2-6 include some of the data that were needed to estimate releases by sub-watershed.

A number of assumptions were made in order to conduct the inventories of copper releases. These assumptions are stated in the report. In cases where there is more than one source of data for a given value, the value judged to be superior in terms of factors including peer-review of the reference, geography, sample size, and timeliness was used. If several values are available in different references that are determined to be of equal quality, a value that is representative of all of them was chosen.

Standard uncertainties were estimated for each of the values obtained, following the strategies outlined in NIST, 2005. In a few cases, a standard deviation of a sample was calculated and used as the standard uncertainty. However, in most cases, it was possible to determine only a potential range of possible values for a given variable, where the true value was equally likely to be anywhere in the range (a uniform distribution). In these cases, the point value was calculated to be the midpoint of the range and the standard uncertainty is equal to half of the range divided by the square root of three. (Half of the range divided by the square root of three corresponds to the square root of the variance, or the second central moment, of a uniform distribution, and the square root of the variance is, by definition, the standard deviation in statistical terms.)

Developing an estimated standard uncertainty for each variable was onerous, but it is necessary so that the uncertainties in each intermediate value can be combined in order to develop a sense for the standard uncertainty in the final calculated results. One way to estimate the standard uncertainty in a value that is calculated using the function  $f(x_1, x_2, \dots, x_n)$  is to apply the Kline-McClintock equation to that function. The Kline-McClintock equation is the first term in the Taylor series approximation for the propagation of uncertainty and can be used when variables are not co-related. It is

$$u_R = \sqrt{\left(u_1 \frac{\partial f}{\partial x_1}\right)^2 + \left(u_2 \frac{\partial f}{\partial x_2}\right)^2 + \dots + \left(u_n \frac{\partial f}{\partial x_n}\right)^2},$$

where  $u$  is uncertainty,  $R$  is the resulting value, and  $n$  is the number of variables in the function. The Kline-McClintock equation was used to estimate the uncertainty in calculated results for this project.

Standard uncertainties are also useful in that they can be used to provide a range of values that apply to a desired confidence interval. For a 95% confidence interval, the range of values provided for the final result are 95% likely to contain the true (actual) value. This 95% confidence interval would be described as a point value plus or minus two times the standard uncertainty for that value. A 67% confidence interval is one that includes the point value plus or minus the standard uncertainty. (This assumes that the probability distribution characterized by a function's result and its standard uncertainty is approximately normal, and the uncertainty result is a reliable estimate of the standard deviation of the result.)

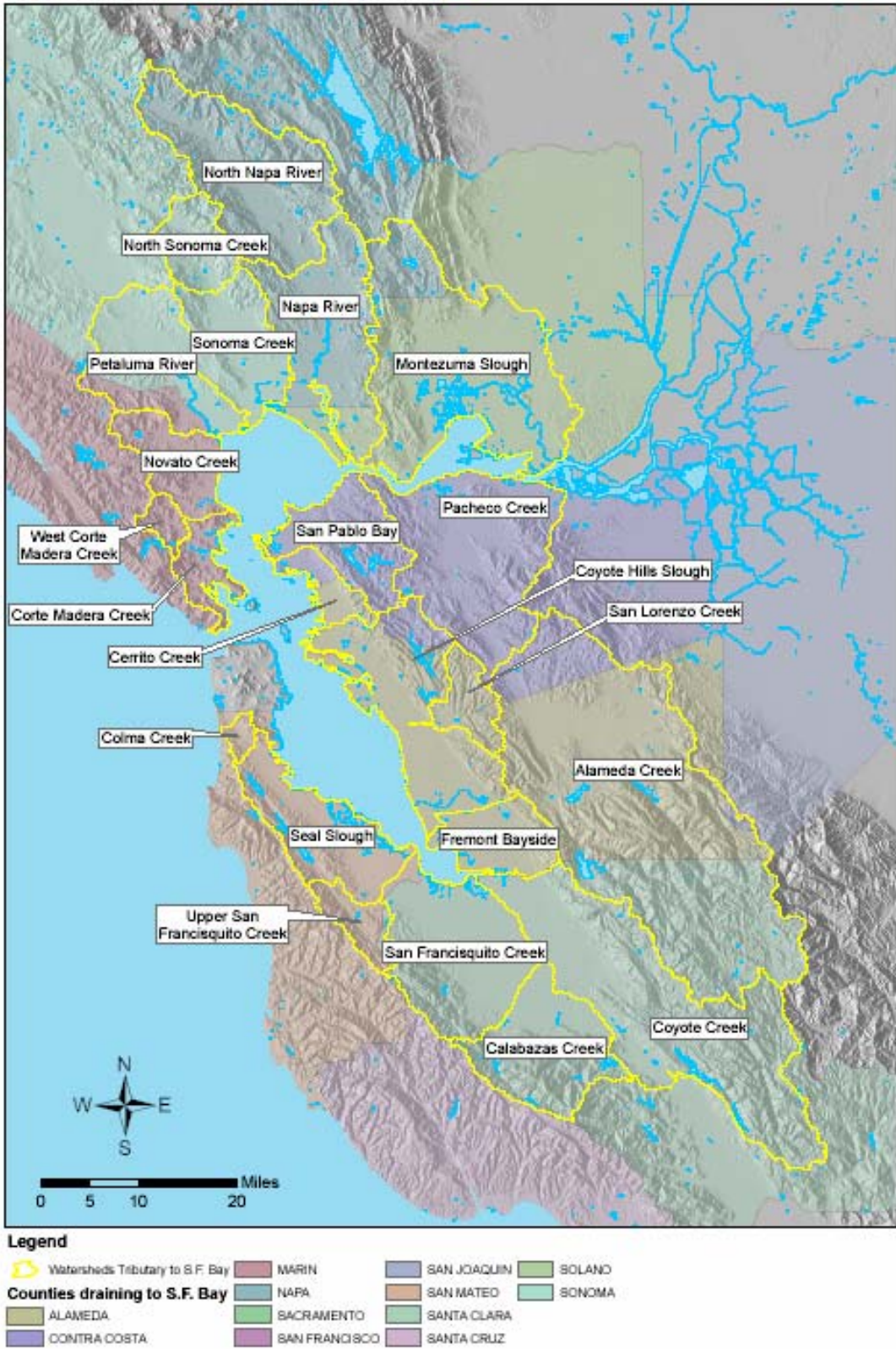


Figure 2-1 Sub-watersheds in the greater San Francisco Bay area watershed (URS, 2005).

Table 2-1. Data used to assign releases to the San Francisco Bay area watershed.

Area	Population (% in watershed)	Area, m <sup>2</sup> (% in watershed)	Area by Land Use Category, m <sup>2</sup>		
			Agricultural (% in watershed)	Residential (% in watershed)	Commercial/ Industrial/ Transportation (% in watershed)
United States	290,809,777 (2%)	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
California	33,871,648 (15%)	409,874,161,860 (2%)	31,725,542,200 (1%)	9,173,708,900 (18%)	3,017,909,600 (12%)
Alameda County	1,443,741 (100%)	1,953,699,152 (90%)	32,377,500 (81%)	370,398,100 (100%)	111,510,000 (100%)
Contra Costa County	948,816 (83%)	1,964,595,501 (59%)	146,006,100 (4%)	390,201,000 (87%)	64,098,900 (83%)
Marin County	247,289 (95%)	1,412,412,634 (30%)	126,900 (93%)	111,232,200 (93%)	12,347,100 (95%)
Napa County	124,279 (98%)	2,041,071,836 (54%)	151,664,800 (96%)	36,727,200 (95%)	7,490,700 (98%)
San Francisco County	776,733 (0%)	127,205,702 (0%)	0 (0%)	84,504,600 (0%)	20,382,300 (0%)
San Mateo County	707,161 (80%)	1,194,501,487 (38%)	10,487,700 (11%)	234,374,500 (83%)	43,065,000 (87%)
Santa Clara County	1,682,585 (95%)	3,377,679,385 (71%)	150,470,900 (27%)	528,315,700 (95%)	105,190,000 (92%)
Solano County	394,542 (71%)	2,300,256,594 (38%)	611,600,200 (8%)	128,275,600 (74%)	38,932,200 (76%)
Sonoma County	458,614 (24%)	4,118,178,208 (18%)	234,120,500 (23%)	122,115,900 (28%)	24,449,400 (28%)
8-County area	6,007,027 (85%)	18,362,394,797 (49%)	1,336,854,600 (24%)	1,921,640,200 (87%)	407,083,300 (87%)
9-County area	6,783,760 (76%)	18,489,600,499 (48%)	1,336,854,600 (24%)	2,006,144,800 (83%)	427,465,600 (83%)
San Francisco Bay area watershed	5,135,779 (100%)	8,913,383,406 (100%)	324,270,900 (100%)	1,672,962,300 (100%)	354,911,400 (100%)

Table 2-2. Population by sub-watershed.

Sub-watershed	POPULATION, 2000									
	Sonoma	Solano	Santa Clara	San Mateo	San Francisco	Napa	Marin	Contra Costa	Alameda	TOTAL
Alameda Creek	0	0	223	0	0	0	0	48,103	171,322	219,648
Calabazas Creek	0	0	347,650	0	0	0	0	0	0	347,650
Castro Valley	0	0	0	0	0	0	0	0	35,023	35,023
Cerrito Creek	0	0	0	0	0	0	0	85,046	158,852	243,897
Colma Creek	0	0	0	79,525	0	0	0	0	0	79,525
Corte Madera Creek	0	0	0	0	0	0	125,179	0	0	125,179
Coyote Creek	0	0	571,147	0	0	0	0	0	0	571,147
Coyote Hills Slough	0	0	0	0	0	0	0	18,285	857,207	875,492
Fremont Bayside	0	0	1,749	0	0	0	0	0	183,665	185,414
Montezuma Slough	0	172,236	0	0	0	520	0	0	0	172,755
Napa River	2	107,613	0	0	0	95,852	0	0	0	203,467
North Napa River	8	0	0	0	0	24,997	0	0	0	25,005
North Sonoma Creek	9,927	0	0	0	0	2	0	0	0	9,929
Novato Creek	0	0	0	0	0	0	80,582	0	0	80,582
Pacheco Creek	0	0	0	0	0	0	0	471,163	2	471,165
Petaluma River	66,505	0	0	0	0	0	2,946	0	0	69,451
San Francisquito Creek	0	0	669,727	44,512	0	0	0	0	0	714,239
San Lorenzo Creek	0	0	0	0	0	0	0	2	34,716	34,718
San Pablo Bay	0	0	0	0	0	0	0	167,549	1,179	168,728
Seal Slough	0	0	0	433,373	0	0	0	0	0	433,373
Sonoma Creek	32,834	0	0	0	0	1	0	0	0	32,835
Upper San Francisquito Creek	0	0	147	10,998	0	0	0	0	0	11,144
West Corte Madera Creek	0	0	0	0	0	0	25,414	0	0	25,414
City of San Francisco					776,733					776,733
WATERSHED TOTAL	109,275	279,849	1,590,642	568,407	0	121,372	234,121	790,147	1,441,965	5,135,779
COUNTY TOTAL	458,614	394,542	1,682,585	707,161	776,733	124,279	247,289	948,816	1,443,741	6,783,760

Table 2-3. Land area by sub-watershed.

Sub-watershed	AREA (m <sup>2</sup> )								
	Sonoma	Solano	Santa Clara	San Mateo	Napa	Marin	Contra Costa	Alameda	TOTAL
Alameda Creek	0	0	569,667,660	0	0	0	156,839,820	923,910,443	1,650,417,923
Calabazas Creek	0	0	368,720,232	0	0	0	0	0	369,367,983
Castro Valley	0	0	0	0	0	0	0	14,236,851	14,236,851
Cerrito Creek	0	0	0	0	0	0	38,683,529	52,795,508	91,479,037
Colma Creek	0	0	0	27,281,791	0	0	0	0	27,281,791
Corte Madera Creek	0	0	0	0	0	113,110,758	0	0	113,136,276
Coyote Creek	0	0	966,384,393	0	0	0	0	0	966,384,393
Coyote Hills Slough	0	0	0	0	0	0	53,391,891	466,575,698	520,087,677
Fremont Bayside	0	0	2,216,535	0	0	0	0	191,618,628	193,835,164
Montezuma Slough	0	773,412,422	0	0	123,046,394	0	0	0	896,458,817
Napa River	973,992	96,218,658	0	0	415,235,611	0	0	0	512,428,261
North Napa River	855,776	0	0	0	565,375,144	0	0	0	566,230,920
North Sonoma Creek	151,776,894	0	0	0	165,608	0	0	0	151,942,501
Novato Creek	0	0	0	0	0	185,472,023	0	0	185,472,023
Pacheco Creek	0	0	0	0	0	0	653,816,114	270,654	654,086,768
Petaluma River	298,210,466	0	0	0	0	84,043,122	0	0	382,253,589
San Francisquito Creek	0	0	484,864,703	16,416,015	0	0	0	0	501,538,211
San Lorenzo Creek	0	0	0	0	0	0	826,636	102,221,067	103,047,703
San Pablo Bay	0	0	0	0	0	0	261,468,003	781,737	262,249,740
Seal Slough	0	0	0	328,199,584	0	0	0	0	328,199,584
Sonoma Creek	278,867,641	35,347	0	0	197,270	0	0	0	279,100,257
Upper San Francisquito Creek	0	0	13,138,177	84,666,471	0	0	0	0	97,804,648
West Corte Madera Creek	0	0	0	0	0	47,394,139	0	0	47,394,139
WATERSHED TOTAL	730,684,768	869,666,427	2,404,991,700	456,563,861	1,104,020,027	430,020,043	1,165,025,994	1,752,410,586	8,914,434,258

Table 2-4. Agricultural land use in the sub-watersheds.

Sub-watershed	AGRICULTURAL AREA (m <sup>2</sup> )								
	Sonoma	Solano	Santa Clara	San Mateo	Napa	Marin	Contra Costa	Alameda	TOTAL
Alameda Creek	0	0	279,000	0	0	0	2,452,500	20,766,600	23,498,100
Calabazas Creek	0	0	2,449,800	0	0	0	0	0	2,449,800
Castro Valley	0	0	0	0	0	0	0	0	0
Cerrito Creek	0	0	0	0	0	0	0	0	0
Colma Creek	0	0	0	18,900	0	0	0	0	18,900
Corte Madera Creek	0	0	0	0	0	0	0	0	0
Coyote Creek	0	0	35,693,100	0	0	0	0	0	35,693,100
Coyote Hills Slough	0	0	0	0	0	0	13,500	2,277,000	2,290,500
Fremont Bayside	0	0	43,200	0	0	0	0	3,111,300	3,154,500
Montezuma Slough	0	50,537,700	0	0	3,296,700	0	0	0	53,834,400
Napa River	68,400	2,700	0	0	41,262,300	0	0	0	41,333,400
North Napa River	20,700	0	0	0	101,182,500	0	0	0	101,203,200
North Sonoma Creek	12,925,800	0	0	0	3,600	0	0	0	12,929,400
Novato Creek	0	0	0	0	0	105,300	0	0	105,300
Pacheco Creek	0	0	0	0	0	0	2,490,300	0	2,490,300
Petaluma River	8,700,300	0	0	0	0	12,600	0	0	8,712,900
San Francisquito Creek	0	0	2,068,200	900	0	0	0	0	2,069,100
San Lorenzo Creek	0	0	0	0	0	0	0	0	0
San Pablo Bay	0	0	0	0	0	0	917,100	0	917,100
Seal Slough	0	0	0	10,800	0	0	0	0	10,800
Sonoma Creek	32,362,200	0	0	0	27,900	0	0	0	32,390,100
Upper San Francisquito Creek	0	0	12,600	1,157,400	0	0	0	0	1,170,000
West Corte Madera Creek	0	0	0	0	0	0	0	0	0
WATERSHED TOTAL	54,077,400	50,540,400	40,545,900	1,188,000	145,773,000	117,900	5,873,400	26,154,900	324,270,900
COUNTY TOTAL	234,120,500	611,600,200	150,470,900	10,487,700	151,664,800	126,900	146,006,100	32,377,500	1,336,854,600

Table 2-5. Residential land use in the sub-watersheds.

Sub-watershed	RESIDENTIAL/URBAN AREA (m <sup>2</sup> )								
	Sonoma	Solano	Santa Clara	San Mateo	Napa	Marin	Contra Costa	Alameda	TOTAL
Alameda Creek	0	0	218,700	0	0	0	15,110,100	61,531,200	76,860,000
Calabazas Creek	0	0	113,288,400	0	0	0	0	0	113,350,500
Castro Valley	0	0	0	0	0	0	0	10,795,500	10,795,500
Cerrito Creek	0	0	0	0	0	0	26,065,800	33,708,600	59,774,400
Colma Creek	0	0	0	18,446,400	0	0	0	0	18,446,400
Corte Madera Creek	0	0	0	0	0	52,890,300	0	0	52,891,200
Coyote Creek	0	0	134,801,100	0	0	0	0	0	134,801,100
Coyote Hills Slough	0	0	0	0	0	0	10,377,900	197,658,900	208,096,200
Fremont Bayside	0	0	444,600	0	0	0	0	56,329,200	56,773,800
Montezuma Slough	0	58,060,800	0	0	213,300	0	0	0	58,274,100
Napa River	18,900	36,740,700	0	0	27,042,300	0	0	0	63,801,900
North Napa River	0	0	0	0	7,751,700	0	0	0	7,751,700
North Sonoma Creek	4,214,700	0	0	0	0	0	0	0	4,214,700
Novato Creek	0	0	0	0	0	36,290,700	0	0	36,290,700
Pacheco Creek	0	0	0	0	0	0	220,281,300	0	220,281,300
Petaluma River	16,563,600	0	0	0	0	2,474,100	0	0	19,037,700
San Francisquito Creek	0	0	251,110,800	10,549,800	0	0	0	0	261,662,400
San Lorenzo Creek	0	0	0	0	0	0	0	10,795,500	10,795,500
San Pablo Bay	0	0	0	0	0	0	66,592,800	471,600	67,064,400
Seal Slough	0	0	0	148,028,400	0	0	0	0	148,028,400
Sonoma Creek	13,039,200	0	0	0	0	0	0	0	13,039,200
Upper San Francisquito Creek	0	0	1,071,900	17,729,100	0	0	0	0	18,801,000
West Corte Madera Creek	0	0	0	0	0	12,254,400	0	0	12,254,400
WATERSHED TOTAL	33,836,400	94,801,500	500,935,500	194,753,700	35,007,300	103,909,500	338,427,900	371,290,500	1,673,086,500

Table 2-6. Industrial/commercial/transportation land use in the sub-watersheds.

Sub-watershed	INDUSTRIAL AREA (m <sup>2</sup> )								
	Sonoma	Solano	Santa Clara	San Mateo	Napa	Marin	Contra Costa	Alameda	TOTAL
Alameda Creek	0	0	5,400	0	0	0	2,484,000	16,370,100	18,859,500
Calabazas Creek	0	0	11,700,000	0	0	0	0	0	11,700,900
Castro Valley	0	0	0	0	0	0	0	824,400	824,400
Cerrito Creek	0	0	0	0	0	0	7,659,900	6,318,000	13,977,900
Colma Creek	0	0	0	1,484,100	0	0	0	0	1,484,100
Corte Madera Creek	0	0	0	0	0	6,138,900	0	0	6,142,500
Coyote Creek	0	0	37,251,900	0	0	0	0	0	37,251,900
Coyote Hills Slough	0	0	0	0	0	0	145,800	67,490,100	67,643,100
Fremont Bayside	0	0	189,900	0	0	0	0	19,807,200	19,997,100
Montezuma Slough	0	20,430,000	0	0	0	0	0	0	20,430,000
Napa River	16,200	9,293,400	0	0	5,892,300	0	0	0	15,201,900
North Napa River	0	0	0	0	1,423,800	0	0	0	1,423,800
North Sonoma Creek	185,400	0	0	0	0	0	0	0	185,400
Novato Creek	0	0	0	0	0	4,762,800	0	0	4,762,800
Pacheco Creek	0	0	0	0	0	0	29,088,000	0	29,088,000
Petaluma River	5,178,600	0	0	0	0	632,700	0	0	5,811,300
San Francisquito Creek	0	0	47,007,900	1,398,600	0	0	0	0	48,406,500
San Lorenzo Creek	0	0	0	0	0	0	0	1,208,700	1,208,700
San Pablo Bay	0	0	0	0	0	0	14,125,500	900	14,126,400
Seal Slough	0	0	0	33,879,600	0	0	0	0	33,879,600
Sonoma Creek	1,541,700	0	0	0	0	0	0	0	1,541,700
Upper San Francisquito Creek	0	0	177,300	582,300	0	0	0	0	759,600
West Corte Madera Creek	0	0	0	0	0	216,000	0	0	216,000
WATERSHED TOTAL	6,921,900	29,723,400	96,332,400	37,344,600	7,316,100	11,750,400	53,503,200	112,019,400	354,923,100

## **2.1 Architectural Copper**

Releases from this category were estimated using the approach taken in the urban runoff report. Using this methodology, the surface area of copper roofs, composite shingles containing copper biocide, and copper gutters is calculated and then multiplied by factors that identify the amount of copper released per unit of surface area for each type of material.

Values used to estimate architectural release of copper are summarized in Table 2.1-1. The emission factor selected for estimating releases of copper from copper roofs is  $1.8 \text{ g/m}^2/\text{y}$ . This factor is based on the concentration of copper in runoff from a roof exposed to marine conditions (He et al, 2001) and the rainfall rate in the Bay area. It is intended to reflect the elevated levels of chloride ions that are found in the San Francisco Bay area (National Atmospheric Deposition Program, 2005). The potential range of release rates was assumed to be 1.0 to  $2.6 \text{ g/m}^2/\text{y}$  so that the standard uncertainty in this value  $0.5 \text{ g/m}^2/\text{y}$ .

The emission factor selected for estimating releases of copper from composite shingles with copper biocide is  $0.2 \text{ g/m}^2/\text{yr}$ . This is based on field tests of seven rainfall events in Palo Alto (Barron, 2001). The standard uncertainty in this value is the standard deviation of the average values for the seven rainfall events and is  $0.1 \text{ g/m}^2/\text{y}$ .

The emission factor selected for estimating releases of copper from copper gutters is based on a study of gutters of varying ages in the Palo Alto area in the late 1990s (Uribe and Associates, 1999). The point value for the emission factor from this study is  $4 \text{ g/m}^2/\text{y}$ . It was assumed that the actual value for the release rates has a 100% likelihood of falling between 2 and  $6 \text{ g/m}^2/\text{y}$ , so that the standard uncertainty is  $1 \text{ g/m}^2/\text{y}$ .

The surface area of each sub-watershed that is devoted to residential and industrial/commercial/transportation structures was used to determine the copper releases. Not shown in Table 2.1-1 is the standard uncertainty in the surface area of each sub-watershed that is devoted to the two types of land use, which was assumed to be 3% of the land use area.

The estimated standard uncertainty in the fraction of surface area occupied by each type of architectural feature is taken as half of the point value divided by the square root of three.

It was assumed that all of the releases of architectural copper are released directly to runoff, even for residential applications. They were estimated as a point source for the purposes of modeling because they are almost always hard-piped to storm drains.

Estimates of copper released in runoff from architectural features are given in Table 2.1-2. The total estimated release of copper from architectural features in the greater Bay area watershed is 1500 kg/y, and the sub-watersheds with the highest releases are the Coyote Hills Slough watershed and the San Francisquito Creek watershed.

Table 2.1-1 Architectural features that release copper.

Architectural Feature	Fraction That Is Roof	Standard Uncertainty in Fraction That Is Roof	Fraction of Roof That Is Gutter	Standard Uncertainty in Fraction of Roof That Is Gutter	Fraction That Is Copper	Standard Uncertainty in Fraction That Is Copper	Emission Factor, kg/m <sup>2</sup> /y	Standard Uncertainty in Emission Factor, kg/m <sup>2</sup> /y
Residential copper roofs	0.3	0.03			0.0005	0.0001	0.0018	0.0005
Residential roofs with copper-impregnated composite shingles	0.3	0.03			0.0003	0.00009	0.0002	0.0001
Residential copper gutters	0.3	0.03	0.0325	0.009	0.0006	0.0002	0.004	0.001
Industrial/commercial/transportation copper roofs	0.5	0.03			0.003	0.0009	0.0018	0.0005
Industrial/commercial/transportation copper gutters	0.5	0.03	0.0325	0.009	0.003	0.0009	0.004	0.001

Table 2.1-2 Estimates of architectural releases of copper in the Bay area by sub-watershed.

Watershed	Architectural Releases of Copper, kg/y	Standard Uncertainty in Architectural Releases of Copper, kg/y
Alameda Creek	78	25
Calabazas Creek	69	21
Castro Valley	6	2
Cerrito Creek	59	19
Colma Creek	10	3
Corte Madera Creek	34	10
Coyote Creek	149	48
Coyote Hills Slough	260	84
Fremont Bayside	75	25
Montezuma Slough	77	25
Napa River	64	20
North Napa River	7	2
North Sonoma Creek	2	1
Novato Creek	25	8
Pacheco Creek	152	47
Petaluma River	23	7
San Francisquito Creek	221	69
San Lorenzo Creek	7	2
San Pablo Bay	62	19
Seal Slough	144	45
Sonoma Creek	8	3
Upper San Francisquito Creek	8	3
West Corte Madera Creek	4	1
TOTAL	1,544	



## **2.2 Copper in Pesticides**

Pesticide use reports are available statewide (CA DPR, 2005a) and by county (CA DPR, not dated, various counties) and pesticide sales data are available statewide (CA DPR, 2005b). Data in these reports are generally given in terms of active ingredient.

In the pesticide sales reports, sales are disclosed only for pesticides that have three or more registrants. Eight copper-based pesticides in California have reported use with no reported sales. The sales for these pesticides can be estimated either based on their sales history or based on their labeling information, coupled with information on usage. Unfortunately, sales of some retail products sold at “big box” stores are inadequately disclosed (CA DPR, 2004). These stores dominate sales of pesticides to consumers. Estimated consumer sales were adjusted upwards by a factor of 20% in order to correct for unreported sales (Brank, 2005). This was taken as the midpoint of a range from 0-40%. The standard uncertainty in this correction factor is 10%.

Use is also known to be under-reported. Reported uses were adjusted upwards by 10% of reported usage to correct for under-reporting. This correction factor is taken from a study by the California Department of Pesticide Regulation, where it was found that about 90% of the sales were reported used over a five-year period for a group of pesticides whose usage was required to be entirely reported (Wilhoit, 2005). For calculating the standard uncertainty, it was assumed that 67% of pesticides fall within a range of 80-100% fully reported, so that the standard uncertainty in the correction factor is 10%.

Note that all currently registered copper-based pesticide products appear in the California use and/or sales reports.

Pesticide use reporting applies to agricultural use and to use by licensed professional pesticide applicators. The difference between adjusted sales and adjusted reported use can be assumed to include everything else, including the amount of active ingredient applied by commercial, institutional, and household consumers.

### **2.2a Pesticides Applied to Land in Urban Areas**

Estimates for this category were made by assuming that copper-based pesticides sold in California that are not used in agriculture, for pressure treating wood, as algaecides, as antifouling coatings, or as root killer are applied to land in urban areas. It is assumed that adjusted reported uses in agriculture and pressure treated wood are adequate estimates of those uses. Algaecide and antifouling coating uses as well as root killer uses are not necessarily required to be reported and must be estimated.

A statewide estimate of cuprous oxide use in antifouling paints for boats can be made by assuming that any unreported uses of cuprous oxide are used in antifouling coatings (paints). Adjusted reported sales of this pesticide in California were 1,800,000 lb copper in 2003, while adjusted reported use on boats and piers is approximately 6,100 lb Cu/yr. Other adjusted reported uses of this active ingredient, most of which are agricultural, totaled 310,000 lb copper.

Thus, use of cuprous oxide in antifouling coatings on boats and piers was estimated to be 1,500,000 lb Cu, which is 240 times larger than adjusted reported use.

Sales are not reported for cuprous thiocyanate because there is only one registrant. In order to estimate use of this active ingredient, it was assumed that the use of cuprous thiocyanate as an antifouling coating is reported at the same rate as the use of cuprous oxide as an antifouling coating. Adjusted reported statewide use of cuprous thiocyanate for boats and piers was 6.5 lb copper in 2003. Multiplying this value by 240 yields an estimate of 1,500 lb Cu/yr.

Copper hydroxide is registered for antifouling paint use, but is used for that purpose in only two products where it is present in low concentrations (TDC, 2004). Therefore, its use as a marine antifouling coating was neglected.

The reported uses of the six copper pesticides that are applied to water along with reported uses that preclude algaecide applications can be used to arrive at statewide estimates of the amount of these pesticides that are used as algaecides. These six pesticides are copper, copper carbonate (basic), copper ethanolamine complexes (mixed), copper ethylenediamine complex, copper sulfate (pentahydrate), and copper triethanolamine complex. Many uses of these pesticides are not reported, and some of the uses are reported in categories that may or may not be algaecide applications. Thus, the fraction of each pesticide used as an algaecide can only be found in terms of a fairly wide range.

Table 2.2-1 shows this range, along with the estimated statewide use of these compounds as algaecides and their adjusted reported uses to water. Footnotes for Table 2.2-1 explain calculations for each column that is not taken directly from adjusted reported use values. For the purposes of estimating releases of copper-based pesticides to urban land, only the column titled "Estimated Use as Algaecide" is used. The uncertainty in these values is large, mostly because the range of possible use as algaecide is large. It is calculated based on the standard uncertainty in the fraction of pesticide used as algaecide as well as the standard uncertainty in sales.

Finally, the use of copper in copper sulfate (pentahydrate) as a root killer must be estimated. The sale of root killer products containing this compound have been banned in the nine counties surrounding the bays but are still allowed in the remainder of California. Use of these products as root killer can be estimated by using the reduction in sewer copper in Palo Alto after the ban on sales of root killer products containing this active ingredient was instituted. A reduction of 370 lb of copper per year was observed for a population base of 226,300 (Moran, 2005). The population of California outside of the nine-county Bay area is 26,637,987, so the statewide estimated use of copper for root control in products containing copper sulfate (pentahydrate) is 44,000 lb Cu/yr.

Table 2.2-2 shows the statewide values for reported sales and use of copper-containing pesticides. The second-to-the-last column in this table represents estimated copper in copper pesticides applied to urban land. Uncertainty in the estimated statewide use of antifouling paints, treated lumber, and root killer is insignificant compared to the uncertainty in adjusted sales, agricultural uses, and (especially) algaecide uses and are not included in the calculated standard uncertainty for urban land uses. Because of the way antifouling coating use is estimated, the

uncertainty in urban land applications of cuprous oxide and cuprous thiocyanate is based on the uncertainty in total adjusted reported usage, adjusted reported agricultural usage, and adjusted reported usage on boats/piers. The final column of Table 2.2-2 gives the standard uncertainty for urban land applications of copper in copper-based pesticides in California.

The ratio of population in each sub-watershed to total state population was applied to statewide estimates of copper based-pesticides on urban land from Table 2.2-2 in order to determine the portion of copper in unreported copper pesticides that is used in urban areas in each sub-watershed. Results, along with their standard uncertainties, are given in Table 2.2-3. The standard uncertainties in Table 2.2-3 includes the uncertainty in basing sub-watershed releases on population ratios. This uncertainty is based on a range of half the population to 1.5 times the population of the sub-watersheds.

In the greater Bay area watershed, an estimated 110,000 kg of copper in pesticides were applied to urban land in 2003. The sub-watersheds with the largest estimated copper releases from this source are the Coyote Hills Slough watershed and the San Francisquito Creek watershed. All of the releases in Table 2.2-3 are assumed to be to permeable surfaces.

## 2.2b Agricultural Applications

The next step in estimating copper releases from copper-containing pesticides in the watershed is to estimate agricultural applications of copper pesticides within each sub-watershed. Copper use reports for the eight counties in the watershed were used. Adjusted usage values (excluding use as algaecide, if any) are shown in Table 2.2-4. The portion of agricultural area in each county that falls within each sub-watershed was used to assign agricultural releases to the sub-watersheds.

Results for the sub-watersheds are given in Table 2.2-5. The standard uncertainties in these values were estimated as half of the range from zero to twice as much as the average application per unit of agricultural land, divided by the square root of three. All of these releases are assumed to be applied to permeable surfaces. Three sub-watersheds (Napa River, North Napa River, and Sonoma Creek) account for three-quarters of the copper loading in the greater watershed from this source.

## 2.2c Algaecide Treatment of Surface Waters

The pesticides in this category are the same as those listed in Table 2.2-1. Reported usage in industrial water was not included in this category, because it is assumed that those uses are captured in the section on industrial runoff and industrial releases to surface waters.

Adjusted reported agricultural water area uses of copper-based algaecides in the 8-county region are given in Table 2.2-6. Uses of algaecides in agricultural water areas will be treated as point sources to surface water and were apportioned amongst the sub-watersheds based on agricultural land use area. Estimates by sub-watershed are given in Table 2.2-7. The estimated copper released in algaecide treatments of agricultural surface waters in the greater San Francisco Bay watershed was 107 kg in 2003. Only two of the sub-watersheds in the greater Bay area

watershed had estimated releases to agricultural water areas greater than 0.5 kg in 2003. They are the Novato Creek watershed and the Petaluma River watershed. For uses in agricultural water areas, the uncertainty in the adjustment factor (which accounts for under-reporting) can be neglected because it is far outweighed by the uncertainty associated with apportioning the values among the sub-watersheds. This apportioning uncertainty is estimated as half of the range from zero to twice as much as the average application per unit of agricultural land, divided by the square root of three.

Use of copper-based algaecides in nonagricultural water areas in the eight-county area is assumed to occur entirely within the watershed and along the shoreline of the bays in the watershed. Values are given in Table 2.2-8. The total estimated releases to the shorelines of the three bays in the San Francisco Bay watershed were 1,862 kg in 2003. Four of the counties had no reported uses of copper-based algaecides in nonagricultural water areas in 2003. They are Alameda, Contra Costa, Napa, and Marin Counties. Also, estimated shoreline releases in Santa Clara County are quite small. The standard uncertainty in the estimates in Table 2.2-8 is based on the uncertainty in the correction factor for usage reporting.

Estimates for those portions of adjusted reported uses of algaecides in rights of way (nonagricultural), public health, and recreation area categories were taken as the midpoint of a range from zero to total adjusted reported use in these categories. Table 2.2-6 gives county-specific estimates of these releases, which will be modeled as point sources to surface water. These values were apportioned amongst the sub-watersheds based on population. Results are given in Table 2.2-9. The total estimated releases of copper from algaecide uses in rights of way (nonagricultural), public health, and recreation areas were 1,249 kg in 2003. The sub-watersheds with the largest estimated releases of copper in this category are the Pacheco Creek watershed and the Napa River watershed. The uncertainty in county-specific estimates is based on half of the possible range (from zero to 100% of adjusted reported usage) divided by the square root of three. In order to obtain the uncertainty in the release estimates, this uncertainty was combined with the uncertainty in apportioning the releases by population, which was taken as half of the range of half the population to 1.5 times the population of each sub-watershed, divided by the square root of three. The uncertainty in the magnitude of these releases is quite large.

## 2.2d Wood Preservatives

This category includes copper that is released (leached) from pressure-treated lumber. The amount of treated lumber that is used in California is not necessarily related to the amount of treatment applied in California. Therefore, treated lumber releases are based on total copper applied to treated lumber in the nation adjusted by the fraction of the nation's population that is in each sub-watershed.

Each year in the United States, approximately 13 million cubic meters of wood are treated with water-based preservatives, most of which contain copper. If the copper concentration in treated wood is on the order of 1 kg/m<sup>3</sup> (CDA, 2003), then approximately 13 million kilograms or 29 million pounds of copper are applied to treated wood in the United States each year.

Only a portion of the copper used to treat lumber is released during product use. Loss rates depend on the type of preservative used, the type of wood, the surface area of the wood, and environmental factors including acidity, exposure to moisture, temperature, and salinity. Researchers have estimated that it would take about 180 years to leach all the copper from CCA-treated wood posts and pilings submerged in water (Rice et al., 2002). Of the 29 million pounds of copper applied to treated wood in the United States each year, it is assumed that a range from 2 to 22 million pounds per year is released.

Point values and standard uncertainties used to calculate releases of copper are given in Table 2.2-10. The uncertainty in apportioning nationwide releases of copper to the sub-watersheds based on population is based on a range of half the population to 1.5 times the population.

Results are given in Table 2.2-11. The estimated copper released from pressure-treated lumber in 2003 in the greater San Francisco Bay watershed is 70,000 kg/y. The sub-watersheds with the largest estimated releases are the Coyote Hills Slough watershed and the San Francisquito Creek watershed. This category of releases will be assumed to occur entirely to permeable surfaces.

## 2.2e Antifouling Coatings

Antifouling coatings (paints) are designed to deter growth of aquatic life on submerged boat and structure surfaces. Table 2.2-2 shows that the statewide estimate of the copper portion of the coatings used in 2003 is 1,500,000 lb. However, along with the pesticides used in treated lumber and unlike most other pesticides, all of the copper in these coatings is not released directly to the environment. Instead, it leaches out of the coating over time in a process that does not go to completion.

The copper released from antifouling coatings was estimated by using an emission factor of 1.8 lb Cu/boat/yr. This emission factor is based on values obtained in a number of studies whose results vary over a range of approximately 1.3 lb Cu/boat/yr to 2.3 lb Cu/boat/yr (CA RWQCB, 2005). Half of this range divided by the square root of three is the estimate of the standard uncertainty in this emission factor. The uncertainty in the number of boats berthed in the bays is estimated as half of the range from 10,000 to 12,000 (TDC Environmental, 2004) divided by the square root of three. Values used to calculate releases of copper from this source along with estimated releases of copper from antifouling coatings to the Bay waters are summarized in Table 2.2-12.

## 2.2f Pool, Spa, and Fountain Algaecides

The final two columns in Table 2.2-1 are estimated use of copper-based algaecides in pools, spas, and fountains in California along with their associated standard uncertainty. This table shows that the estimate for pool, spa, and fountain use, which is based on possible fractions of use of these compounds as algaecides, is highly uncertain. The fraction of California's population in each sub-watershed was used to estimate the total pool, spa, and fountain algaecide used in each sub-watershed.

In arriving at estimated releases of this source of copper to storm drains, it was assumed that 5% of the use of these algaecides is released to storm drains rather than being sewerred or trapped in filter media that is subsequently disposed of in a landfill. The standard uncertainty in the fraction released to storm drains is 3%.

Table 2.2-13 gives estimates of copper released to storm drains from pool, spa, and fountain algaecides in the Bay area in 2003. Total estimated releases are 2,216 kg/y. The sub-watersheds with the highest releases from this source are the Coyote Hills Slough watershed and the San Francisquito Creek watershed. The uncertainties in the estimates presented in this table include the uncertainty in the use estimate along with the uncertainty in the fraction that is released as a point source to storm drains and the error in assuming that swimming pools, spas, and fountains are uniform throughout California on a per capita basis. The uncertainty in basing values on sub-watershed population is assumed to reflect a range from half the sub-watershed population to 1.5 times the sub-watershed population.

Table 2.2-1 Estimated applications of copper-based algaecides in California in 2003. Values are in pounds of copper.

Pesticide	Range of Possible Use as Algaecide <sup>a</sup> , %	Estimated Use as Algaecide <sup>b</sup>	Adjusted Reported Agricultural Use in Water Area	Estimated Algaecide Use for Rights-of-Way, Regulatory Pest Control, Recreation Areas, and Public Health	Adjusted Reported Non-Agricultural Use in Water Area	Adjusted Reported Use in Industrial Water	Estimated Use as Pool, Spa, and Fountain Algaecide <sup>c</sup>	Standard Uncertainty in Estimated Use as Pool, Spa, and Fountain Algaecide
Copper	0-80	165,364	259	52	0	0	165,053	93,737
Copper carbonate, basic	0-100	4,458	322	1,402	0	104	2,629	1,177
Copper ethanolamine complexes, mixed	0-100	114,148	1,229	4,003	711	15	108,187	60,437
Copper ethylenediamine complex <sup>d</sup>	40-100	3,634	1,970	699	45	0	518	299
Copper sulfate (pentahydrate)	0-50	476,871	15,533	42,790	49,617	1,152	366,464	205,213
Copper triethanolamine complex	0-100	70	0	0	0	0	70	40
<b>TOTAL</b>		<b>764,545</b>	<b>19,314</b>	<b>48,946</b>	<b>50,372</b>	<b>1,271</b>	<b>642,921</b>	<b>233,566</b>

<sup>a</sup> The lower bound in this column represents reported uses to water; the upper bound is based on reporting in usage categories that preclude use as an algaecide.

<sup>b</sup> Total algaecide use is adjusted reported sales multiplied by the midpoint of the range of possible use as algaecide.

<sup>c</sup> Pool, spa, and fountain algaecide use is estimated by subtracting adjusted reported agricultural and non-agricultural applications to water areas, industrial water use, and estimated other algaecide uses from total estimated algaecide use. Use of copper algaecides in drinking water reservoirs, which is unreported, is small and not expected to be important.

<sup>d</sup> Copper ethylenediamine complex had no reported sales. Its sales were estimated to be equal to adjusted reported use, as labeling information on products containing this active ingredient indicated that all use should be reported.

Table 2.2-2 Estimated urban land application of copper-containing pesticides in California in 2003. Values are in pounds of copper.

Chemical	Adjusted Sales	Adjusted Use in Agriculture, Excluding Application to Water Areas	Estimated Use as Marine Antifouling Coating	Estimated Use as Algacide	Adjusted Use for Pressure-Treating Lumber	Estimated Use as Root Killer	Estimated Release to Urban Land	Standard Uncertainty In Release To Urban Land
Copper	414,717	84,236	0	165,364	0	0	165,375	111,565
Copper 8-quinolinoleate <sup>1</sup>	98	0	0	0	0	0	98	14
Copper ammonium carbonate <sup>2</sup>	3	0	0	0	0	0	3	0
Copper ammonium complex	16,302	4,529	0	0	0	0	11,773	2,080
Copper carbonate, basic <sup>3</sup>	8,716	26	0	4,458	200	0	4,354	2,603
Copper ethanolamine complexes, mixed	226,341	0	3	114,148	0	0	113,419	73,256
Copper ethylenediamine complex <sup>2</sup>	5,252	0	0	3,634	0	0	3,589	1,209
Copper hydroxide	2,823,913	2,080,643	0	0	0	0	743,270	381,922
Copper naphthenate	19,288	0	0	0	0	0	19,288	2,445
Copper octanoate	68	0	0	0	0	0	68	9
Copper oxide (ic) <sup>2</sup>	79,889	0	0	0	77,143	0	2,747	9,587
Copper oxide (ous)	1,758,864	307,555	1,450,881	0	0	0	428	39,968
Copper oxychloride	87,187	63,385	0	0	0	0	23,802	11,754
Copper oxychloride sulfate <sup>2</sup>	283,829	283,829	0	0	0	0	0	42,730
Copper salts of fatty and rosin acids <sup>2</sup>	1,286	1,285	0	0	0	0	0	194
Copper sulfate (basic)	620,584	561,387	0	0	0	0	59,197	89,527
Copper sulfate (pentahydrate) <sup>4</sup>	1,866,483	979,245	0	476,871	0	43,553	382,347	340,540
Cuprous thiocyanate <sup>5</sup>	1,632	0	1,544	0	0	0	88	9
Copper triethanolamine complex	139	0	0	70	0	0	70	46
Total	8,214,592	4,366,121	1,452,428	764,545	77,343	43,553	1,529,916	539,752

<sup>1</sup>Reported sales of copper 8-quinolinoleate were 455 lb active ingredient in 2001, or 80 lb of copper. This value is used to estimate 2003 sales of this product (in any event, this is not a high-volume pesticide).

<sup>2</sup>Because labeling information indicates that all usage is reported and because sales of these active ingredients are not reported, total adjusted statewide reported uses or total statewide estimated uses are used to estimate sales of these products.

<sup>3</sup>Copper carbonate sales estimated using ratio of sales (8,136 lb copper) to total reported usage (4,490 lb copper) from 2002 and applying to 2003 reported usage (4,905 lb copper).

<sup>4</sup>Corrected for 533 pounds of nonagricultural water area usage that were reported for copper sulfate (basic) but that should have been reported for copper sulfate (pentahydrate).

<sup>5</sup>Adjusted sales for boat/pier usage estimated as 240 multiplied by adjusted reported use on boat/pier (this is the ratio of estimated cuprous oxide use on boats to reported cuprous oxide use on boats).

Table 2.2-3 Estimates of copper in pesticides applied to urban land in the Bay area sub-watersheds in 2003.

Watershed	Copper in Pesticides Applied to Urban Land, kg/y	Standard Uncertainty in Copper in Pesticides Applied to Urban Land, kg/y
Alameda Creek	4,510	2,056
Calabazas Creek	7,138	3,254
Castro Valley	719	328
Cerrito Creek	5,007	2,283
Colma Creek	1,633	744
Corte Madera Creek	2,570	1,172
Coyote Creek	11,726	5,345
Coyote Hills Slough	17,975	8,194
Fremont Bayside	3,807	1,735
Montezuma Slough	3,547	1,617
Napa River	4,177	1,904
North Napa River	513	234
North Sonoma Creek	204	93
Novato Creek	1,654	754
Pacheco Creek	9,673	4,410
Petaluma River	1,426	650
San Francisquito Creek	14,664	6,685
San Lorenzo Creek	713	325
San Pablo Bay	3,464	1,579
Seal Slough	8,898	4,056
Sonoma Creek	674	307
Upper San Francisquito Creek	229	104
West Corte Madera Creek	522	238
TOTAL	105,442	

Table 2.2-4 Reported agricultural use of copper-containing pesticides in the watershed counties, 2003.

Species	Adjusted Reported Agricultural Usage, lb Cu								TOTAL
	San Mateo	Santa Clara	Alameda	Contra Costa	Solano	Napa	Sonoma	Marin	
Copper								18	18
Copper ammonium complex				0			68	1	70
Copper hydroxide	256	3,431	74	13,075	279	2,673	19,312	23,204	62,306
Copper oxide (ous)		92		449			388	2,750	3,679
Copper oxychloride			149				57	441	647
Copper oxychloride sulfate		256		1,758		23		8,962	10,999
Copper salts of fatty and rosin acids	3	39		2	4		18	95	161
Copper sulfate (basic)		18	26			1	27	144	215
Copper sulfate (pentahydrate)		22		0	5	6		2	35
Total	259	3,857	249	15,285	288	2,703	19,870	35,618	78,128

Table 2.2-5 Estimates of copper in pesticides applied to agricultural land in the Bay area sub-watersheds in 2003.

Watershed	Copper in Pesticides Applied to Agricultural Land, kg/y	Standard Uncertainty in Copper in Pesticides Applied to Agricultural Land, kg/y
Alameda Creek	107	62
Calabazas Creek	20	12
Castro Valley	0	0
Cerrito Creek	0	0
Colma Creek	0	0
Corte Madera Creek	0	0
Coyote Creek	291	168
Coyote Hills Slough	8	5
Fremont Bayside	12	7
Montezuma Slough	897	518
Napa River	1,895	1,094
North Napa River	4,636	2,677
North Sonoma Creek	894	516
Novato Creek	94	54
Pacheco Creek	30	17
Petaluma River	613	354
San Francisquito Creek	17	10
San Lorenzo Creek	0	0
San Pablo Bay	11	6
Seal Slough	0	0
Sonoma Creek	2,239	1,293
Upper San Francisquito Creek	15	8
West Corte Madera Creek	0	0
TOTAL	11,780	

Table 2.2-6 Releases of copper-based algaecides to surface waters in the 8-county area in 2003. Values are in pounds of copper.

County	Use in Nonagricultural Rights of Way, Recreation Areas, and Public Health			Adjusted Reported Use in Agricultural Water Area
	Total Adjusted Reported Usage for Six Algaecides	Estimated Use as Algaecide	Uncertainty in Estimated Use as Algaecide	
Alameda	45	22	13	0
Santa Clara	0	0	0	0
San Mateo	0	0	0	0
Contra Costa	4,603	2,302	832	2
Solano	0	0	0	0
Sonoma	276	138	77	0
Napa	1,586	793	340	0
Marin	3	1	1	254
TOTAL	6,513	3,256	902	256

Table 2.2-7 Estimates of copper in algaecides applied to agricultural water areas in the Bay area sub-watersheds in 2003.

Watershed	Copper in Algaecides Applied to Agricultural Water Areas, kg/y	Standard Uncertainty in Copper in Algaecides Applied to Agricultural Water Areas, kg/y
Alameda Creek	0	0
Calabazas Creek	0	0
Castro Valley	0	0
Cerrito Creek	0	0
Colma Creek	0	0
Corte Madera Creek	0	0
Coyote Creek	0	0
Coyote Hills Slough	0	0
Fremont Bayside	0	0
Montezuma Slough	0	0
Napa River	0	0
North Napa River	0	0
North Sonoma Creek	0	0
Novato Creek	96	55
Pacheco Creek	0	0
Petaluma River	11	7
San Francisquito Creek	0	0
San Lorenzo Creek	0	0
San Pablo Bay	0	0
Seal Slough	0	0
Sonoma Creek	0	0
Upper San Francisquito Creek	0	0
West Corte Madera Creek	0	0
TOTAL	107	

Table 2.2-8 Estimates of copper in algaecides released to shoreline surface waters in the Bay area counties in 2003.

County	Copper in Algaecides Released to Shoreline Surface Waters, kg/y	Standard Uncertainty in Copper in Algaecides Released to Shoreline Surface Waters, kg/y
Alameda	0	0
Santa Clara	5.0	0.5
San Mateo	583	53
Contra Costa	0	0
Solano	847	77
Sonoma	427	39
Napa	0	0
Marin	0	0
TOTAL	1,862	

Table 2.2-9 Estimates of copper in algaecides used in nonagricultural rights of way, recreation areas, and public health in the Bay area sub-watersheds in 2003.

Watershed	Copper in Algaecides Used in Nonagricultural Rights of Way, Recreation Areas, and Public Health, kg/y	Standard Uncertainty in Copper in Algaecides Used in Nonagricultural Rights of Way, Recreation Areas, and Public Health, kg/y
Alameda Creek	54	43
Calabazas Creek	0	0
Castro Valley	0	0
Cerrito Creek	95	77
Colma Creek	0	0
Corte Madera Creek	0	0
Coyote Creek	0	0
Coyote Hills Slough	26	17
Fremont Bayside	1	1
Montezuma Slough	2	1
Napa River	278	227
North Napa River	73	59
North Sonoma Creek	1	1
Novato Creek	0	0
Pacheco Creek	520	424
Petaluma River	9	7
San Francisquito Creek	0	0
San Lorenzo Creek	0	0
San Pablo Bay	185	151
Seal Slough	0	0
Sonoma Creek	4	4
Upper San Francisquito Creek	0	0
West Corte Madera Creek	0	0
TOTAL	1,249	

Table 2.2-10 Values used to calculate copper releases from pressure-treated wood.

Variable	Value	Standard Uncertainty
Copper released nationwide, kg/y	5,454,545	2,624,319
Fraction not susceptible to runoff	0.25	0.09

Table 2.2-11 Estimates of copper released from pressure-treated wood in the Bay area sub-watersheds in 2003.

Watershed	Copper Released from Pressure-Treated Wood, kg/y	Standard Uncertainty in Copper Released from Pressure-Treated Wood, kg/y
Alameda Creek	3,090	1,770
Calabazas Creek	4,890	2,801
Castro Valley	493	282
Cerrito Creek	3,431	1,965
Colma Creek	1,119	641
Corte Madera Creek	1,761	1,009
Coyote Creek	8,034	4,602
Coyote Hills Slough	12,316	7,055
Fremont Bayside	2,608	1,494
Montezuma Slough	2,430	1,392
Napa River	2,862	1,640
North Napa River	352	201
North Sonoma Creek	140	80
Novato Creek	1,134	649
Pacheco Creek	6,628	3,797
Petaluma River	977	560
San Francisquito Creek	10,047	5,756
San Lorenzo Creek	488	280
San Pablo Bay	2,374	1,360
Seal Slough	6,096	3,492
Sonoma Creek	462	265
Upper San Francisquito Creek	157	90
West Corte Madera Creek	358	205
TOTAL	72,247	

Table 2.2-12 Values used to calculate copper releases from antifouling coatings along with estimates of copper released from antifouling coatings to the Bay in 2003.

Variable	Value	Standard Uncertainty
Emission factor, kg Cu/boat/y	0.8	0.3
Number of boats	11,000	577
Estimated releases to Bay, kg/y	9,000	3,210

Table 2.2-13 Estimates of copper released from copper-based algaecides used in pools, spas, and fountains in the Bay area sub-watersheds in 2003.

Watershed	Copper Released from Pool, Spa, and Fountain Algaecides, kg/y	Standard Uncertainty in Copper Released from Pool, Spa, and Fountain Algaecides, kg/y
Alameda Creek	95	70
Calabazas Creek	150	111
Castro Valley	15	11
Cerrito Creek	105	78
Colma Creek	34	25
Corte Madera Creek	54	40
Coyote Creek	246	182
Coyote Hills Slough	378	280
Fremont Bayside	80	59
Montezuma Slough	75	55
Napa River	88	65
North Napa River	11	8
North Sonoma Creek	4	3
Novato Creek	35	26
Pacheco Creek	203	151
Petaluma River	30	22
San Francisquito Creek	308	228
San Lorenzo Creek	15	11
San Pablo Bay	73	54
Seal Slough	187	138
Sonoma Creek	14	10
Upper San Francisquito Creek	5	4
West Corte Madera Creek	11	8
TOTAL	2,216	

## **2.3 Copper in Fertilizers**

Approximately 10% of the 54 million tons of commercial fertilizers used in the United States in 1996 were used in California (US EPA, 1999). Table 2.3-1 shows farm and non-farm fertilizer application by broad category of fertilizer in California in 1996. The standard uncertainty in these values is estimated to be half of the value divided by the square root of three. This estimate is meant to include errors in the data and in the gap between the year that the data represent and the year 2003.

The amount of copper in fertilizer varies from 0% to 39 g/kg. The average concentration of copper in fertilizer by fertilizer category is shown in Table 2.3-1. As this table shows, the uncertainty in these averages is large.

Farm uses of fertilizer were assigned to the sub-watersheds based on the ratio of the agricultural land use in the sub-watershed to the agricultural land use in California. Non-farm uses were assigned to sub-watersheds based on population. The uncertainties in apportioning according to land use fraction and population are estimated as half of a range of 0.5 to 1.5 of land use or population, whichever is appropriate, divided by the square root of three.

In some agricultural applications, fertilizers are tilled into the soil after application and are not entirely available for incorporation into runoff. The fraction available for runoff in agricultural applications was based on a range from 50-100%, and uncertainty is half of this range divided by the square root of three.

The amount of copper that is applied in fertilizers in the Bay area watersheds, along with the standard uncertainty in these values, is given in Table 2.3-2. The sub-watersheds with the largest applications of copper are the Montezuma Slough watershed and the North Napa River watershed. These applications are to permeable surfaces.

Table 2.3-1 Values used to calculate copper loading from fertilizer use.

Fertilizer Type	Application Type	Fertilizer Applied in California in 1996, kg <sup>1</sup>	Standard Uncertainty in Fertilizer Applied, kg	Average Copper Concentration, mg/kg <sup>2</sup>	Standard Uncertainty in Average Concentration, mg/kg <sup>3</sup>	Copper Applied in Fertilizer in California, kg/y	Standard Uncertainty in Copper Applied, kg/y
Multinutrient	Farm	1,162,687,000	335,638,826	4	4	4,644	4,367
Multinutrient	Non-farm	316,487,000	91,361,927	4	4	1,264	1,189
N	Farm	1,706,091,000	492,506,049	4	4	6,824	7,103
N	Non-farm	0	0	4	4	0	0
P <sub>2</sub> O <sub>5</sub>	Farm	223,074,000	64,395,917	49	47	10,933	10,927
P <sub>2</sub> O <sub>5</sub>	Non-farm	0	0	49	47	0	0
K <sub>2</sub> O	Farm	130,149,000	37,570,780	0.3	0.3	39	42
K <sub>2</sub> O	Non-farm	0	0	0.3	0.3	0	0
Organic	Farm	78,781,000	22,742,116	114	117	8,996	9,580
Organic	Non-farm	0	0	114	117	0	0
Secondary and micronutrient <sup>4</sup>	Farm	1,593,276,000	459,939,164	649	405	1,033,697	711,086
Secondary and micronutrient <sup>4</sup>	Non-farm	3,520,000	1,016,136	649	405	2,284	1,571
Liming	Farm	621,915,000	179,531,396	86	39	53,196	28,714
Liming	Non-farm	0	0	86	39	0	0
TOTAL	Farm	5,515,973,000				1,118,330	711,863
TOTAL	Non-farm	320,007,000				3,548	1,970

<sup>1</sup> From US EPA, 1999.

<sup>2</sup> Derived from data in US EPA, 1999. Data on copper concentrations in non-farm fertilizers are not available; copper concentrations found in farm fertilizers was used for non-farm applications. Concentrations for P<sub>2</sub>O<sub>5</sub> include concentrations of rock phosphates and TSP.

<sup>3</sup> Standard deviation in population-weighted averages from various data sources except for N, where there was only one concentration measured, and K<sub>2</sub>O, where data on only one population was available. The values in this column are an attempt to estimate the standard deviations for the average concentration of copper in populations of fertilizers, not the standard deviation in the copper concentration of a population of individual fertilizers.

<sup>4</sup> Eliminated two samples with very high copper concentrations (19,400 mg/kg and 39,000 mg/kg) when obtaining average concentration and standard uncertainty in average concentration for this group of fertilizers.

Table 2.3-2 Estimates of copper applied in fertilizers in the Bay area sub-watersheds.

Watershed	Copper Applied in Fertilizers, kg/y	Standard Uncertainty in Copper Applied in Fertilizers, kg/y
Alameda Creek	644	451
Calabazas Creek	101	52
Castro Valley	4	2
Cerrito Creek	26	16
Colma Creek	9	5
Corte Madera Creek	13	8
Coyote Creek	1,003	685
Coyote Hills Slough	152	72
Fremont Bayside	103	62
Montezuma Slough	1,441	1,032
Napa River	1,114	792
North Napa River	2,678	1,940
North Sonoma Creek	343	248
Novato Creek	11	6
Pacheco Creek	115	57
Petaluma River	238	167
San Francisquito Creek	130	61
San Lorenzo Creek	4	2
San Pablo Bay	42	21
Seal Slough	46	28
Sonoma Creek	860	621
Upper San Francisquito Creek	32	22
West Corte Madera Creek	3	2
TOTAL	9,111	

## **2.4 Copper Releases from Industrial Operations**

### **2.4a Industrial Runoff and Industrial Releases to Surface Waters**

Industrial runoff releases are a point source because they go directly to storm water drains. The methodology from the urban runoff report was used to estimate copper contributions from this source. This approach extrapolates copper released in industrial runoff as measured in a study in Santa Clara County to the Bay area sub-watersheds based on industrial acreage within each sub-watershed. Copper in industrial runoff in the Santa Clara County study was found to be 0.04 lb Cu/industrial acre/yr (derived from Grotte, 1996; SCVURP, 1997).

The uncertainty in the urban runoff result includes uncertainty in the monitoring data that the emission factor is based on, uncertainty in land use values, and uncertainty in extrapolating the monitored sites to all industrial sites.

The monitoring data this value is based on was collected nearly a decade ago and the uncertainty in this value must reflect this, along with the inherent uncertainty in applying monitored data to long-term estimates of releases. This uncertainty was estimated as half of a range from 0.02 to 0.06 lb Cu/industrial acre/yr divided by the square root of three.

Land use values for industrial uses in the sub-watersheds include transportation and commercial uses. Transportation and commercial land use would not be expected to have copper runoff concentration levels as high as the average industrial site. Industrial land use area in Santa Clara County is 18,835 acres; combined commercial/transportation/industrial acreage for the county is 25,980 acres. Industrial land use area in the 9-county region is 89,266 acres while combined commercial/transportation/industrial land use is 105,575 acres. Thus, in Santa Clara County, industrial land use area is 72.5% of combined industrial/commercial/ transportation land use area and in the 9-county region industrial land use area is 84.6% of combined industrial/commercial/transportation land use area. It will be assumed that this factor has a 100% likelihood of falling between 60% and 100%, so that a factor of 80% will be used to adjust the combined land usage value downwards to be more representative of industrial land use area. The standard uncertainty in this value is half of the range divided by the square root of three.

The uncertainty in extrapolating monitored sites to all industrial sites is based on half of a range of half of industrial acreage within each sub-watershed to 1.5 times the industrial acreage, divided by the square root of three.

Point values and standard uncertainties for copper in industrial runoff are given by sub-watershed in Table 2.4-1. The uncertainty associated with applying data from monitored sites to all industrial sites and the uncertainty in the emission factor of 0.04 lb/acre/yr contribute equally to the standard uncertainty in the values of Table 2.4-1. The uncertainty in adjusting industrial/commercial/transportation land use to include only industrial land use is less important. Note that these releases are direct to storm drains.

The Toxic Chemical Release Inventory (TRI) is a database containing facility-reported release data for many chemicals. One of the reported chemicals is copper, either as elemental copper or

copper in copper compounds. TRI-reported releases capture only a subset of industrial releases. Facilities are not required to report copper releases to the TRI unless they fall into manufacturing and certain other industrial classifications, have more than ten employees, and either process more than 25,000 lb/yr of copper or “otherwise use” more than 10,000 lb/yr of copper. Also, TRI reporting requirements apply only if copper is present in any facility stream at a concentration greater than 1%, regardless of the total amount of copper emitted. TRI data include information on receiving streams and facility location, along with the percentage of releases that are in storm water. In 2002, TRI-reported releases to surface waters in the 8-county region were 320 lb (US EPA, 2005). In 2003, these reported releases dropped to 39 pounds.

Three refineries that reported no copper releases to water in 2003 reported a total of 247 pounds in 2002. These refineries are ConocoPhillips San Francisco Refinery, Chevron Products Co Richmond Refinery, and Shell Oil Products US Martinez Refinery. Valero Refining Co California Benicia Refinery reported 20 pounds released to water in 2002 and one pound in 2003. Other than these four refineries, facilities in the 8-county region are fairly consistent in their reporting of copper discharges to surface waters over this two-year period.

It is felt that because TRI-reported releases in the 8-county region are minimal, the effort of determining how much of the 39 pounds that are reported as released to surface waters in 2003 is entrained in storm water (and should not be included because it would result in double-counting of industrial releases of storm water) is not worthwhile.

#### 2.4b Industrial Air Emissions

TRI-reported air emissions of copper from 17 facilities in the 9-county region were 776 kg in 2002. This is several times larger than the value of 186 kg copper from 53 facilities reported by the Bay Area Air Quality Management District (BAAQMD) for 2001. However, TRI-reported releases dropped to 359 kg/y in 2003. Seven facilities that reported air releases of copper in 2002 did not report such releases in 2003. These facilities include four refineries (Chevron Products Co Richmond Refinery, ConocoPhillips San Francisco Refinery, Shell Oil Products US Martinez Refinery, and Valero Refining Co California Benicia Refinery) that together reported air releases of 194 kg of copper in 2002, and Waukesha Electric Systems Inc, a facility that reported 114 kg of copper released to air in 2002. The single largest reporter for both years is San Francisco Drydock Inc.

Part of the explanation for the discrepancy between the BAAQMD data and the TRI data is due to differences in reporting requirements. For example, only facilities releasing more than 1000 kg/y of copper are required to report releases to the BAAQMD. As discussed in the previous subsection of this report, TRI-reported releases also capture only a subset of industrial releases. Thus, the number of facilities emitting copper to air is likely far larger than either the TRI or the BAAQMD database include. However, offsetting this potential for under-reporting is that many of the simplest emission estimation methodologies are conservative and result in estimated emissions that are larger than actual emissions.

Table 2.4-2 summarizes the 2002 TRI air emission data. This information will not be used in modeling of copper emissions to air, but comparing it to 2003 data provides insight into the

potential for uncertainty in the values. Of the 17 facilities that reported copper releases to air in 2002, four were refineries, one was an organic chemical manufacturer, one was a secondary nonferrous metals manufacturer, one was a maker of aluminum die-cast parts, one was a non-electronic transformer manufacturer, one was a commercial lighting fixture manufacturer, one was an electron tube manufacturer, four made cathode ray television picture tubes, one made electronic components not elsewhere classified, one made motor vehicles and car bodies, and one was a ship building and repair facility. Clearly, not all facilities in these industrial classification categories are reporting releases of copper to air.

Table 2.4-3 gives 2003 TRI air emission data for copper, including information on the latitude and longitude of reporting companies. The latitude and longitude data can be used to accommodate these releases spatially during modeling. Some of these facilities may fall outside of the greater watershed boundary.

BAAQMD data is not available by facility or facility address. Thus, it is impossible to know what BAAQMD values are duplicated by TRI reporting or what sub-watersheds to assign the BAAQMD releases to.

A comparison of 2001 TRI data on air releases for the Great Lakes states and 2001 air toxics data published by the Great Lakes Commission (GLC) sheds some light on the uncertainty in industrial air emissions. This comparison suggests that in the aggregate, TRI-reported releases for the industry categories listed in Table 2.4-2 range from twice as high as GLC air toxics data to a third of GLC air toxics data.

It was hoped that data on county business patterns might allow a second means of estimating industrial air emissions of copper in the Bay area by assuming emissions per employee in the Great Lakes states are roughly the same as they are in California for some industry categories. The Great Lakes air toxics and TRI data are collected by Standard Industrial Classification (SIC) code. However, since 1998, county business patterns have been collected not by SIC code but by NAICS code, and there is no one-to-one correspondence between the two classification systems for many industry categories. Employment trends in the Great Lakes region are too volatile to apply four-year old data on employees and hope to achieve anything meaningful. Also, the Great Lakes air toxics data do not clearly include a universal set of reporting facilities for copper.

TRI-reported values for the year 2003, as presented in Table 2.4-3, will be used as point estimates of industrial copper emissions to air. The standard uncertainty in these values is assumed to be 33% of the point value.

Table 2.4-1 Estimates for copper released in industrial runoff in the Bay area sub-watersheds.

Watershed	Copper Released in Industrial Runoff, kg/y	Standard Uncertainty, kg/y
Alameda Creek	68	28
Calabazas Creek	42	17
Castro Valley	3	1
Cerrito Creek	50	21
Colma Creek	5	2
Corte Madera Creek	22	9
Coyote Creek	134	55
Coyote Hills Slough	243	101
Fremont Bayside	72	30
Montezuma Slough	73	30
Napa River	55	23
North Napa River	5	2
North Sonoma Creek	1	0.3
Novato Creek	17	7
Pacheco Creek	104	43
Petaluma River	21	9
San Francisquito Creek	174	72
San Lorenzo Creek	4	2
San Pablo Bay	51	21
Seal Slough	122	50
Sonoma Creek	6	2
Upper San Francisquito Creek	3	1
West Corte Madera Creek	1	0.3
TOTAL	1,275	

Table 2.4-2 TRI-reported air emissions of copper in the 9-county region in 2002 (for comparison with 2003 TRI-reported releases) (US EPA, 2005a).

Facility Name	SIC Code Description	Reported Air Emissions, kg/y
Shell Chemical Co. Martinez Catalyst Plant	Industrial organic chemicals nec	0.01
Chevron Products Co Richmond Refinery	Petroleum refining	32
ConocoPhillips San Francisco Refinery	Petroleum refining	114
Shell Oil Products US Martinez Refinery	Petroleum refining	47
Valero Refining Co California Benicia Refinery	Petroleum refining	0
ECS Refining	Secondary nonferrous metals	6
Pressure Cast Products Corp	Aluminum die-castings (1987)	2
Waukesha Electric Sys. Inc.	Transformers except electronic	114
Shaper Lighting	Commercial lighting fixtures	1
Communications & Power Industries Inc Eimac Div	Electron tubes	27
Pycon Inc	Cathode ray television picture tubes (disc. 1987 3671)	2
South Bay Circuits Inc	Cathode ray television picture tubes (disc. 1987 3671)	116
Sprig Circuits Inc	Cathode ray television picture tubes (disc. 1987 3671)	1
Viko Technology Inc Adaptive Circuits Div	Cathode ray television picture tubes (disc. 1987 3671)	2
Isola USA Corp	Electronic components nec	2
New United Motor Manufacturing Inc	Motor vehicles and car bodies	114
San Francisco Drydock Inc	Ship building and repairing	195
TOTAL		776

Table 2.4-3 TRI-reported air emissions of copper in the 9-county region in 2003 (US EPA, 2005b)

Facility	City	Facility-Reported Latitude	Facility-Reported Longitude	Preferred Latitude	Preferred Longitude	Reported Release, kg/y	Standard Uncertainty, kg/y
Isola USA Corp	Fremont	372024	1242236	37.469698	121.918306	4	1
Titan PCB West Inc	Fremont	373028	1215650	37.508333	121.936111	114	38
New United Motor Manufacturing Inc	Fremont	372924	1215630	37.484722	121.941667	5	2
Pressure Cast Products Corp	Oakland	374620	1221259	37.772222	122.216389	2	1
Communications & Power Industries Inc Eimac Div	San Carlos	373052	1201604	37.514444	122.267778	20	7
San Francisco Drydock Inc	San Francisco	374540	1222245	37.761111	122.379167	195	64
South Bay Circuits Inc	San Jose	371653	1215038	37.281389	121.843889	5	2
Viko Technology Inc Adaptive Circuits Div	San Jose	372146	1215314	37.366667	121.851667	2	1
ECS Refining	Santa Clara	372140	1225640	37.3615	121.9382	9	3
Pycon Inc	Santa Clara	373330	1215929	37.383822	121.955817	2	1
Sprig Circuits Inc	Vacaville	382100	1220000	38.417222	121.970833	1	0.3
Total						359	

## **2.5 Copper in Domestic Water Discharged to Storm Drains**

This source consists of domestic water that contains copper because it has passed through copper pipes. An example of these discharges is domestic water that is lost to storm drains during irrigation. The methodology from the urban runoff report was used for estimating these releases. This approach is to extrapolate copper discharged to storm drains as measured in a study in Santa Clara County to the Bay area based on population. Copper in domestic water in the Santa Clara County study was found to be 0.0004 lb Cu/person/yr (derived from TDC Environmental, 2004).

Note that this methodology is expected to produce an upper bound estimate because it is based on tap water concentrations of copper. It is likely that domestic water discharges to storm drains pass through less copper piping than tap water does. In fact, in many cases, irrigation water passes through no copper piping. A lower bound for the emission factor was assumed to be an order of magnitude smaller, or 0.00004 lb Cu/person/yr. The midpoint of this range (0.0002 lb Cu/person/yr) was used to produce the estimate of copper released to storm drains from domestic water discharges, and the standard uncertainty is half of the range divided by the square root of three, or 0.0001 lb Cu/person/yr. The uncertainty in extrapolating this to all domestic water discharges within the Bay area is assumed to be relatively negligible.

Table 2.5-1 provides estimates of copper in domestic water discharged to storm drains in 2003 for the sub-watersheds, along with the standard uncertainty in these estimates. These releases are direct to storm drains. They total 514 kg in the greater Bay area watershed.

Table 2.5-1 Estimates for copper in domestic water discharged to storm drains in the Bay area sub-watersheds.

Watershed	Copper in Domestic Water Discharged to Storm Drains, kg/y	Standard Uncertainty, kg/y
Alameda Creek	22	10
Calabazas Creek	35	16
Castro Valley	4	2
Cerrito Creek	24	12
Colma Creek	8	4
Corte Madera Creek	13	6
Coyote Creek	57	27
Coyote Hills Slough	88	41
Fremont Bayside	19	9
Montezuma Slough	17	8
Napa River	20	10
North Napa River	3	1
North Sonoma Creek	1	0.5
Novato Creek	8	4
Pacheco Creek	47	22
Petaluma River	7	3
San Francisquito Creek	71	34
San Lorenzo Creek	3	2
San Pablo Bay	17	8
Seal Slough	43	20
Sonoma Creek	3	2
Upper San Francisquito Creek	1	1
West Corte Madera Creek	3	1
TOTAL	514	

### 3 Sources Not Included in this Inventory

Release estimates for sources whose contribution to copper in urban runoff to the Bay were estimated to be minimal in the urban runoff report were not developed. These sources include fuel combustion, which was estimated to release 10 to 200 lb/yr of copper to air in the nine Bay area counties each year (TDC Environmental, 2004). Another source that falls into this category is wood burning, which was estimated to release 340 lb/yr of copper to air in the nine Bay area counties (TDC Environmental, 2004). The final source identified as minor in the urban runoff report is vehicle fluid leaks. An estimated 600 lb/yr of copper is released due to vehicle fluid leaks (mostly coolant dumping, but some coolant leaks as well) in the nine-county Bay area (TDC Environmental, 2004).

Also, copper released from soil erosion will be calculated by the runoff model and was not estimated.

Copper runoff from landfills was not inventoried because modern landfills are regulated under the Resource Conservation and Recovery Act (RCRA) and landfill leachate is managed and treated either on-site or routed to sewer. Old landfills in the Bay area are regulated under programs for closed landfills and have been controlled since the 1980s. Demolition debris that was dumped around the edges of the city after the Loma Prieta earthquake is now covered and paved, and is surrounded by engineered fill.

There is a potential for copper to be released from the exposed copper that provides power to electrically powered public transit systems, either as mechanically abraded particles or as very small particulate matter that is generated when arcing occurs between the contacts. The only location in the Bay area where public transit relies on exposed overhead copper wires is a small area in San Francisco where runoff drains to sewer and is treated before discharge.

Copper releases from electrically powered public transit systems were not inventoried because they are expected to be small. BART has not conducted any studies of the losses of copper from its conducting surfaces, and to the author's knowledge, no such studies exist in the literature. Also, BART is required to treat the wash off water from their trains before discharging it to the sewer, so copper that adheres to the trains is removed and treated before discharge.

Copper losses from the brake lining materials of electrically powered public transit systems are also expected to be small. The manufacturer of the brake pads used for BART trains has indicated that the copper/brass content of the pads is less than one percent by weight (Kahr, 2004).

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