Mercury Management by Bay Area Wastewater Treatment Plants

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Mercury Management by Bay Area Wastewater Treatment Plants

Approaches, costs, and benefits of alternative scenarios for implementing the San Francisco Bay TMDL mercury in municipal and industrial National Pollutant Discharge Elimination System (NPDES) permits.

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Executive Summary

This report summarizes the approaches and feasibility of mercury management strategies for Bay Area wastewater treatment plants. It begins with an assessment of current mercury loads, predicts future (2025 A.D) loads based on population growth, and then evaluates the costs and benefits of different load management strategies. In addition to mercury load management strategies, factors affecting the feasibility of capturing and treating stormwater and managing mercury methylation in shallow waters are also discussed.

The current mercury load to the Bay from wastewater treatment plants is 15 +/- 3 kg/yr, (13 kg from municipal facilities, 2 kg from industries). This amounts to approximately 1 - 2% of the total mercury load entering the Bay (1200 kg / yr). Based on growth projections for the Bay Area, this load is predicted to increase to 17 kg/yr by the year 2025, absent any new mercury load reduction measures.

Implementation of pollution prevention and source control projects could reduce the future load from 17 kg/yr to 11 - 16.5 kg/yr, at a cost of $8 million - $25 million/yr. This represents an upper limit for both the costs and expected benefits of pollution prevention and source control, as these programs are already substantially implemented throughout the Bay Area. Combining pollution prevention with limited (Stage 1) increases in water reclamation would limit the future load to 10 –14 kg/yr, at a cost of $87 – 104 million/yr. More extensive water reclamation (Stage 2) would limit the future load to 8 – 12 kg/yr, at an annualized cost of $247 - $267 million. Upgrading all existing secondary plants (including industrial facilities) to include filtration would constrain the future mercury load to < 7 kg/yr, at a cost of $167 - $404 million/yr, and installation of reverse osmosis treatment on all Bay Area wastewater facilities would reduce the future mercury load to < 3 kg/yr at a cost of $917 – 934 million/yr.

The feasibility of capturing and treating stormwater is very site-specific, depending on the ability to match catchments with highly polluted sediments with nearby excess treatment capacity. For mercury alone, the approach may not produce significant load reductions: in an example from an industrial catchment in Oakland, the projected load reduction for a significant engineering project would amount to 0.1 - 0.4 kg/yr of mercury, while consuming up to 6 mgd of capacity and requiring storage of 2.2 billion gallons. The feasibility of such a project could be enhanced if additional stormwater pollutant loads, such as PCBs or legacy pesticides, were considered. However, there are substantial technical and public policy barriers to blending urban runoff with sewage.

Strategies to reduce conversion of mercury to methylmercury may ultimately be more effective at reducing mercury concentrations in Bay fish. The final section discusses the need for an assessment of which mercury sources are most readily “methylated,” how dissolved oxygen management could affect methylation rates, and whether other aspects of treatment plant operation, such as nitrification or the choice of flocculant, can affect mercury methylation in receiving waters.

1. Background

The Clean Estuary Partnership, in support of the Regional Board's development of a Total Maximum Daily Load and Implementation Plan for mercury in San Francisco Bay, has authorized production of this report to answer specific questions regarding mercury management alternatives for municipal and industrial wastewater treatment plants. In order to provide reasonable assurance that wastewater discharges of mercury do not impair beneficial uses such as fishing and wildlife habitat, the Regional Board needs to know:

1) What is the current mercury load discharged to the Bay from wastewater?
2) In the absence of significant infrastructural and programmatic changes, how much will that load increase as a result of increased effluent flow due to population growth over time?
3) What benefit would additional infrastructural and / or programmatic mercury control measures have on the mercury load from wastewater discharges?
4) What are the expected costs of infrastructural and programmatic mercury control measures?
5) What additional management actions are possible that might reduce the conversion of mercury to methylmercury in receiving waters?

From the initial public review of the draft mercury strategy for managing mercury in the northern reach (Taylor, 1998), to the Mercury TMDL preliminary project report (Abu-Saba and Tang, 2000), to the Mercury TMDL final project report (Looker and Johnson, 2003), two important findings have emerged regarding mercury management alternatives for wastewater. First, it is clear that the mercury load to the Bay is dominated by watershed sources, such as mining-impacted watersheds and atmospheric deposition. The latest assessments quantify mercury loads from wastewater as 14.7 kg/ yr, compared to 1220 kg per year from all sources. Second, mercury management needs to address mercury bioaccumulation, because the beneficial uses impaired by mercury are related to mercury concentrations in fish. For mercury, this means looking for ways to reduce the formation of methylmercury in receiving waters, because this is the form that accumulates in fish. This report discusses management of mercury loads from wastewater in the context of those two findings.

Section 2 documents the approach to calculating wastewater loads from municipal and industrial treatment plants. This information was directly relied upon in the development of the Mercury TMDL final project report. A periodic update of Section 2 would be a useful mechanism for the Regional Board to track individual and aggregate mercury loads over time, providing reasonable assurance that the TMDL load allocation for wastewater is attained.

Section 3 analyzes the effect of population growth on the mercury load from wastewater, in the absence of any new infrastructural or programmatic mercury controls (i.e., the “no-action” alternative). Section 4 combines the information from Sections 2 and 3, along with cost and load reduction estimates, to summarize the costs and expected benefits for different load management scenarios. This analysis is important to fulfill the Porter-Cologne requirement (Sec. 13241 and 13242) to consider the need for communities to grow and develop new housing when the Regional Board adopts plans to implement water quality standards.

Section 5 describes site-specific factors that need to be considered to evaluate the feasibility of routing urban stormwater through municipal pollution control plants in order to control mercury loads. Section 6 describes monitoring and infrastructural approaches approaches to managing mercury methylation in receiving waters.

The last two sections are adaptive management components of TMDL implementation for wastewater treatment plants. While there is a relatively high degree of certainty about current and future mercury loads from wastewater, and the costs associated with managing those loads, there is a great deal of uncertainty as to whether the benefits of treating stormwater are commensurate with the economic and societal costs, and the extent to which decisions about the operation of wastewater treatment plants can affect mercury methylation in receiving waters. Sections 5 and 6 describe some of the key factors to be considered to resolve these questions.

2. Updated mercury annual load estimates and annual average effluent concentrations for municipal and industrial wastewater treatment facilities

2.1 Purpose

Establish current baseline loading from municipal and industrial wastewater point sources for use in the mercury TMDL and wasteload allocation analysis.

2.2 Background

Loads were originally estimated in the Mercury TMDL preliminary project report (Abu-Saba and Tang, 2000). Estimates of mercury load from wastewater treatment facilities as outlined in that report ranged from 25 to 63 kilograms per year. It was acknowledged that those estimates were based on a limited set of reliable mercury effluent concentration data. For a number of the treatment facilities considered in that analysis, available data had been collected using an inadequate USEPA analytical method with a method detection limit of 200 nanograms per liter (ng/l). Such data have been shown to significantly overestimate actual mercury concentrations in treated effluent.

Recognizing this deficiency, the Regional Board required that all Bay area facilities begin collecting mercury data using a newly adopted USEPA analytical method (Method 1631) in January 2000 (SFRWQCB, 1999). The detection limit for the new analytical method was less than 1 ng/l. A preliminary report and statistical analysis using all available method 1631 mercury data for Bay area treatment plants was compiled by Regional Board staff (SFRWQCB, 2001). In that report, data distributions for secondary and advanced treatment facilities were developed. In support of the mercury TMDL that will be considered by the Regional Board, an updated estimate of mercury annual loadings based on a larger data set of Method 1631 data is desired. Thus, using data provided by the Bay Area pollution control plants and statistical tools developed by Regional Board staff (SFRWQCB, 2001), this type of regional update can be implemented from time to time (i.e., every five years) to provide reasonable assurance that the load allocation for wastewater is attained.

2.3 Approach

Treated wastewater flow data for the period January 1999 through June 2002 and mercury concentration data for the period January 2000 through June 2002 were obtained from the Regional Board electronic reporting database for individual treatment facilities. Those data were used to calculate an updated estimate of annual mercury loads from municipal and industrial treatment facilities. The important assumptions used in making the calculations are as follows:

Monthly mercury measurements were averaged to form a single average mercury concentration for each facility. For those facilities that did not have data, values of 15.3 ng/l, 5.4 ng/l, and 25 ng/l were used for secondary, advanced (tertiary), and industrial treatment plants, respectively. The default value of 15.3 ng/l is derived from the median value of the mercury concentrations in the available January 2000 to June 2002 data set for secondary treatment facilities. The default value of 5.4 ng/l is the mercury concentration for tertiary treatment facilities based on an assumed removal of 65% of the mercury in secondary effluent.

The total monthly flow volumes were summed and divided by the number of days that the flow was monitored to obtain an average daily flow rate. This value was then used to estimate the total annual flow discharged to the Bay from each facility. For treatment facilities that did not have data, the flows from the 2001 Regional Board staff report were used. It is assumed that the flow data reported to the Regional Board reflect the volume of treated wastewater discharged to the Bay.

Most of the data gaps that occurred were for smaller treatment facilities, which have minor impacts on the total mercury load to the Bay. An exception is the C&H Sugar/Crockett-Valona treatment facility, for which reliable flow and mercury concentration data were unavailable.

2.4 Results

Using the calculation methods described above, the updated average annual estimates of existing mercury loadings to the Bay from municipal and industrial wastewater treatment facilities are as follows:

Existing annual mercury loading from municipal facilities:	12.7 kg/yr
Existing annual mercury loading from industrial facilities:	2.1 kg/yr
Total existing annual mercury loading from wastewater treatment facilities:	14.8 kg/yr (+/- 3.3)

Spreadsheets showing the data used in the derivation of these estimates are summarized in Table 1 and Table 2.

2.5 References

Abu-Saba, K.E., and L.W. Tang, 2000. *Watershed Management of Mercury in San Francisco Bay: a TMDL report to USEPA*. SFRWQCB staff report presented to the Regional Board in a public hearing, June 20, 2000. Available from the SFRWQCB, Oakland, CA. www.swrcb.ca.gov/rwqbc2.

Katen, K. 2001. *Statistical Analysis of Pooled Data from Regionwide Ultraclean Mercury Sampling for Municipal Dischargers*. SFRWQCB staff report presented in a public hearing June 11, available at www.swrcb.ca.gov/rwqcb2.

Lam, Johnson, SFRWQCB, personal communication, August 2002. NPDES electronic data summaries.

Looker, R.E., and Johnson, B.J. 2003. *Mercury in San Francisco Bay: TMDL project report*. SFRWQCB Draft staff report presented to stakeholders in a public workshop on July 2, 2003. Available at www.swrcb.ca.gov/rwqcb2

SFRWQCB, 1999. August 4, 1999 letter from Lawrence Kolb, acting Executive Officer, to all NPDES permit holders with self-monitoring requirements. Letter invokes Regional Boards authority to require monitoring information as set forth in Section 13267 of the California Water Code.

Taylor, K.A. *Defining the mercury problem in the northern reaches of San Francisco Bay and designing appropriate regulatory approaches.* SFRWQCB draft staff report presented to the SFRWQCB in a public hearing December, 1998.

Facility	Treatment	Annual Effluent flow (L x 10^9)	Flow-weighted mean [Hg] (ng/L)	Annual mercury load (kg)
San Jose/Santa Clara WPCP – 23	Advanced	165 +/- 13	3 +/- 1	0.5 +/- 0.1
East Bay MUD – 9	Secondary	107 +/- 24	30 +/- 14	3.2 +/- 1.7
EBDA, East Bay Dischargers Authority – 8	Secondary	106 +/- 10	19 +/- 9	2.0 +/- 0.9
City & Co. of S.F., Southeast – 21	Secondary	109 +/- 26	13 +/- 14	1.4 +/- 1.6
Central Contra Costa S.D – 6	Secondary	62 +/- 8	28 +/- 8	1.7 +/- 0.6
City of Palo Alto – 19	Advanced	37 +/- 3	7 +/- 3	0.2 +/- 0.1
So. Bayside System Authority – 29	Advanced	27 +/- 4	16 +/- 8	0.4 +/- 0.2
West County Agency – 34	Secondary	23 +/- 2	15 +/- 6	0.3 +/- 0.1
City of Sunnyvale – 32	Advanced	22 +/- 13	4 +/- 2	0.1 +/- 0.1
Napa S.D. – 15	Advanced	17 +/- 2	5 +/- 3	0.1 +/- 0.0
Delta Diablo S.D. – 7	Secondary	18 +/- 2	12 +/- 2	0.2 +/- 0.0
City of San Mateo – 24	Advanced	19 +/- 3	13 +/- 12	0.3 +/- 0.2
Fairfield Suisun Sewer Dist. – 10	Advanced	23 +/- 4	7 +/- 6	0.2 +/- 0.1
Vallejo Sanitation & Flood Cont. – 33	Secondary	21 +/- 6	19 +/- 6	0.4 +/- 0.2
City of Livermore (LAVWMA – EBDA)	Secondary	9 +/- 1	8 +/- 8	0.1 +/- 0.1
Dublin-San Ramon (LAVWMA –EBDA)	Secondary	15 +/- 3	32 +/- 45	0.5 +/- 0.7
Central Marin Sanitation A.G. – 5	Secondary	15 +/- 6	6 +/- 3	0.1 +/- 0.1
So. S.F./ San Bruno WQCP – 30	Secondary	14 +/- 1	17 +/- 6	0.2 +/- 0.1
City of Petaluma – 20	Secondary	8 +/- 3	5 +/- 2	0.04 +/- 0.03
Novato S.D. – 17	Advanced	8 +/- 1	5 +/- 6	0.04 +/- 0.05
City of Burlingame – 2	Secondary	6 +/- 1	9 +/- 5	0.05 +/- 0.03
Sewerage Agency of So. Marin – 27	Secondary	5 +/- 2	21 +/- 6	0.10 +/- 0.05
Sonoma Valley County S.D. – 28	Secondary	5 +/- 2	5 +/- 1	0.02 +/- 0.01
City of Pinole-Hercules – 11	Secondary	4 +/- 1	6 +/- 4	0.02 +/- 0.01
City of Benicia – 1	Secondary	4 +/- 1	15 +/- 11	0.07 +/- 0.05
City of Millbrae – 2	Secondary	3 +/- 0	16 +/- 15	0.04 +/- 0.04
Las Gallinas Valley S.D. – 12	Secondary	5 +/- 2	52 +/- 20	0.26 +/- 0.13
Mt. View S.D. – 14	Secondary	3 +/- 1	9 +/- 6	0.03 +/- 0.02
Sausalito-Marin City S.D. – 25	Advanced	2 +/- 1	23 +/- 9	0.05 +/- 0.02
City & Co. of S.F., Int. Airport - 2	Secondary	1 +/- 1	24 +/- 20	0.03 +/- 0.03
Marin Co. S.D. #5/Tiburon – 13	Secondary	1 +/- 0	6 +/- 5	0.01 +/- 0.01
Rodeo S.D. – 11	Secondary	1 +/- 0	16 +/- 27	0.02 +/- 0.03
City of Calistoga – 3	Advanced	1 +/- 0	5 +/- 6	0.01 +/- 0.01
Town of Yountville – 35	Advanced	0 +/- 0	5 +/- 6	0.00 +/- 0.00
City of St. Helena – 31	Secondary	0 +/- 0	15 +/- 6	0.01 +/- 0.00
			Total	12.7 +/- 2.7

Table 1: Summary of current flows, concentrations and loads for municipal pollution control plants. Numbers next to each facility name refer to map locations in Basin Plan (Figure 1).

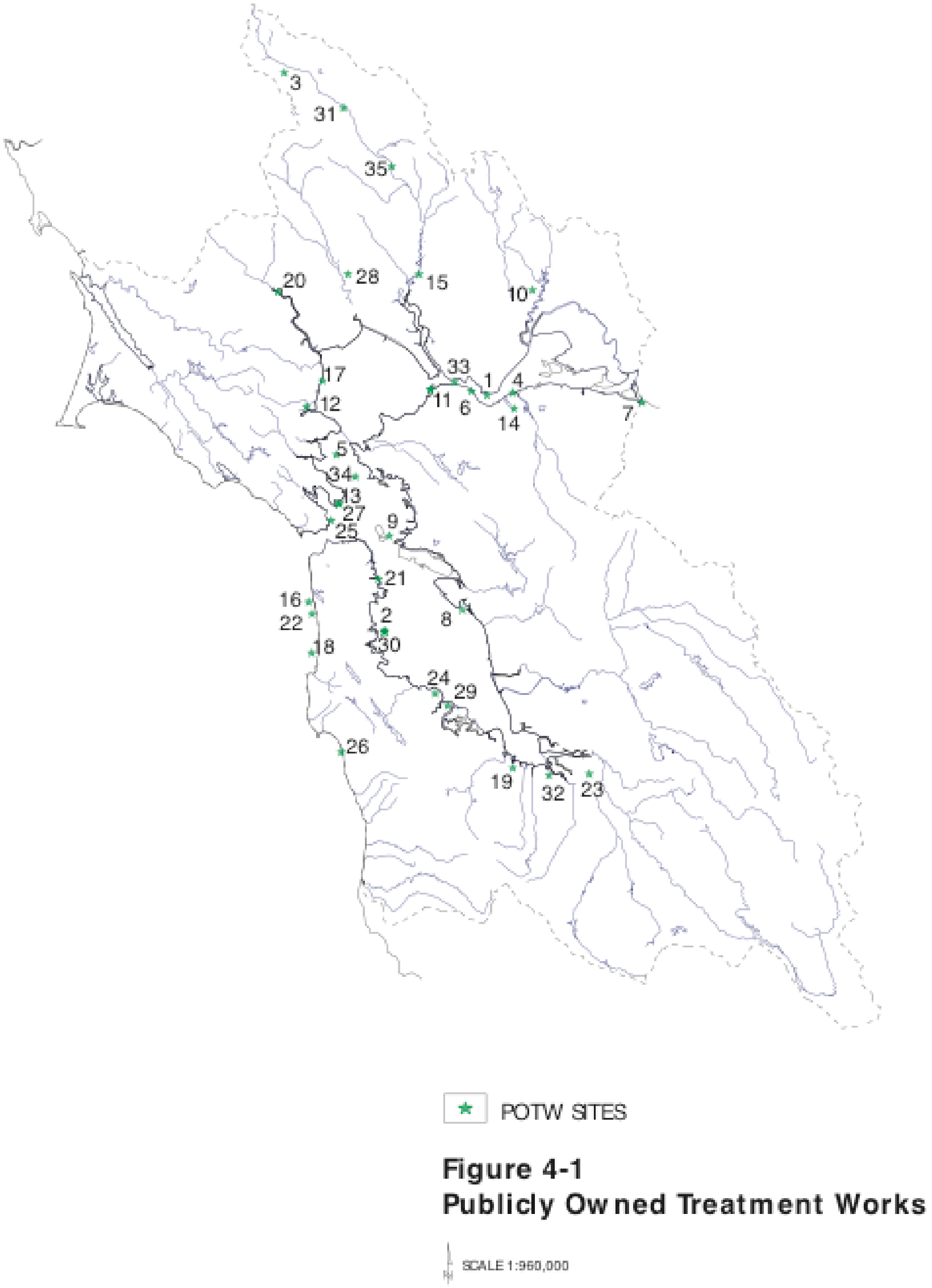

Figure 1: Locations of publicly owned treatment works. Figure taken from San Francisco Bay Basin Plan.

Facility	Treatment	Total Annual Effluent flow (L x 10^9)	**Flow-weighted average mercury concentration (ng/L)**	**Annual mercury load (kg)**
C&H Sugar Co. – 2	Activated sludge	34 +/- 3	25 +/- 10	0.8 +/- 0.3
Chevron U.S.A. – 3	Activated sludge/wetland	9 +/- 4	66 +/- 43	0.6 +/- 0.5
Equilon Enterprises LLC. – 8	Activated sludge/carbon	8 +/- 1	11 +/- 17	0.1 +/- 0.1
Tosco Corp. Avon Refinery -12 (Tesoro Golden Eagle Refinery)		6 +/- 3	7 +/- 4	0.04 +/- 0.03
Dow Chemical Co. – 4	Neutralization/activated carbon	0 +/- 0	30 +/- 69	0.01 +/- 0.02
Exxon	Activated sludge/carbon	3 +/- 0	13 +/- 8	0.03 +/- 0.02
Tosco Corp. Rodeo Refinery –11	Pond/RBC/carbon	3 +/- 1	30 +/- 34	0.09 +/- 0.10
San Francisco Int. Airport	Physical/chemical	1 +/- 0	18 +/- 15	0.02 +/- 0.02
General Chemical Corp. Bay Point Works – 1	Neutralization/pond	1 +/- 1	335 +/- 279	0.2 +/- 0.3
Rhone Poulenc Basic Chemical Co. – 9	Neutralization/pond	0 +/- 0	48 +/- 90	0.01 +/- 0.01
Zeneca Agricultural Products – 10	Activated carbon/pond	0 +/- 0	25 +/- 10	0.0 +/- 0.0
USS Posco – 13	Physical/chemical	11 +/- 3	3 +/- 3	0.04 +/- 0.04
U.S. Navy Treasure Island		1 +/- 3	23 +/- 11	0.02 +/- 0.06
			Total	2.1 +/- 0.7

Table 2: Summary of current flows, concentrations, and loads for industrial pollution control plants. Numbers next to facility ID refers to map location in Basin Plan (Figure 2). Loads in this table sum to 2.0 kg/ye, but written in as 2.1 kg/yr to be consistent with TMDL Project Report (Looker and Johnson, 2003).

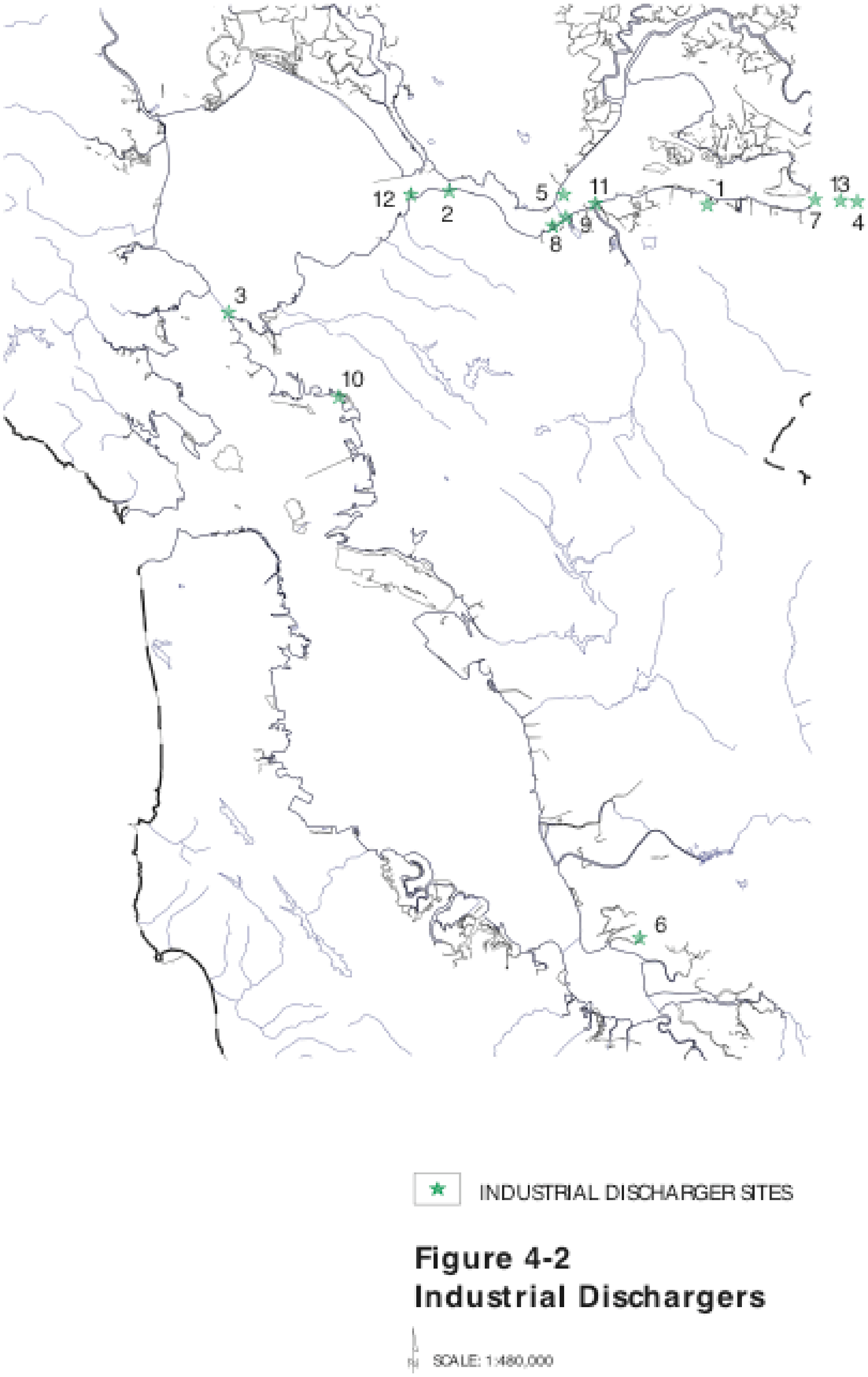

Figure 2: Locations of Industrial Dischargers to San Francisco Bay. Map taken from San Francisco Bay Basin Plan.

3. Effect of growth and development on average annual mercury loads from municipal and industrial wastewater treatment facilities

3.1 Purpose

Estimate future treated wastewater flows and associated mercury loadings at Bay area treatment facilities.

3.2 Background

The existing population of the San Francisco Bay area is approximately 6 million. Projected population growth will occur in communities with available undeveloped land and strong economic foundations. "Smart Growth" plans may also encourage increases in population densities near job and transit centers. Consequently, the magnitude and rate of growth at each Bay area treatment facility will be variable.

Regional population growth estimates are available through the Association of Bay Area Governments (ABAG). These estimates indicate expected population growth in Bay area cities and counties through the year 2025.

3.3 Approach

The population estimates for individual cities were apportioned to the corresponding individual treatment facilities based on service area information taken from individual NPDES permits. Percentage increases in population to the year 2025 were calculated for each facility. An overall projected growth rate was determined for each treatment facility (Table 3).

The assumed growth rates (expressed as a percentage) were used to estimate future (2025) flow increases at each facility. Projected increases in mercury load were calculated, using the existing mercury concentration and the estimated future flow. A spreadsheet showing these calculations is attached.

3.4 Results

The existing municipal and industrial treated wastewater flow and mercury loadings to the bay are estimated to be 692 mgd and 14.8 kilograms per year, respectively. Projected future (year 2025) baseline flow and baseline mercury loadings are estimated to be 800 mgd and 16.9 kilograms per year, respectively. Year 2025 flow and load estimates at individual treatment facilities are shown in Table 4. These estimates are used as a baseline for comparison with load reduction alternatives in the next section.

3.5 References

Association of Bay Area Governments (ABAG). *Projections 2002: Forecasts for the San Francisco Bay Area to the Year 2025.* Oakland: J.T. Litho (Printer) Dec. 2001. 286 pages.

SFRWQCB, 1998 – Present. Adopted NPDES permits for the treatment facilities considered in this analysis.

Table 3:

Projected population growth, by facility service area. Growth projections are estimates for purposes of projecting future wastewater discharge scenarios in this report. The growth estimates do not imply that local governments have adopted them in their master plans.

	2000 Census Population	2025 Est. Population	Growth between 2000 and 2025
City of Benicia (Benicia Wastewater Treatment Plant) –1			
BENICIA	26865	30,000	12%
Total	26865	30,000	11.7%
City of Burlingame (Burlingame Wastewater Treatment Plant) – 2			
BURLINGAME	28158	32,400	15%
OTHER	9000	11,400	27%
Total	37158	43,800	17.9%
City of Calistoga (Dunaweal Wastewater Treatment Plant) –3			
CALISTOGA	5190	6,800	31%
Total	5190	6,800	31.0%
Central Contra Costa SD (Central Contra Costa Wastewater Treatment Plant) –4			
CONCORD	121780	138,500	14%
DANVILLE	41715	45,500	9%
LAFAYETTE	23908	27,100	13%
MORAGA	16290	18,100	11%
ORINDA	17599	19,600	11%
PLEASANT HILL	32837	37,500	14%
WALNUT CREEK	64296	71,800	12%
CLAYTON	10762	13,500	25%
MARTINEZ	11900	13,500	13%
OTHER	80000	107,000	34%
Total	421087	492,100	16.9%
Central Marin Sanitation Agency (San Rafael SD, Sanitary District 1-2, Larkspur) –5			
SAN RAFAEL	56063	65,500	17%
ROSS	2329	2,480	6%
LARKSPUR	12014	13,300	11%
CORTE MADERA	9100	9,900	9%
Total	79506	91,180	14.7%

	2000 Census Population	2025 Est. Population	Growth between 2000 and 2025
Delta Diablo Sanitary District –7			
ANTIOCH	90532	117,500	30%
PITTSBURG	56769	85,100	50%
Total	147301	202,600	37.5%
East Bay Dischargers Authority –8			
HAYWARD	140030	160,300	14%
SAN LEANDRO	79452	87,600	10%
UNION CITY	66869	84,700	27%
NEWARK	42471	53,400	26%
FREMONT	203413	233,200	15%
Total	532235	619,200	16.3%
EBMUD –9			
ALAMEDA	72259	80,600	12%
ALBANY	16444	18,000	9%
BERKELEY	102743	111,600	9%
EMERYVILLE	6882	11,200	63%
OAKLAND	399484	449,500	13%
PIEDMONT	10952	11,300	3%
EL CERRITO	23171	24,700	7%
OTHER	6000	7,400	23%
Total	637935	706,900	10.8%
Fairfield Suisun - 10			
FAIRFIELD	96178	135,700	41%
SUISUN CITY	26118	35,300	35%
Total	122296	171,000	39.8%
Las Gallinas – 11			
OTHER	28000	30700	9.6%
Total	28000	30700	9.6%

	2000 Census Population	2025 Est. Population	Growth between 2000 and 2025
Livermore-Amador Valley Water Management Agency –8			
LIVERMORE	73345	99,400	36%
PLEASANTON	63654	83,600	31%
DUBLIN	29973	63,100	111%
SAN RAMON*	44722	82,500	84%
Total	211694	328,600	55.2%
Millbrae (Water Pollution Control Plant) – 2			
MILLBRAE	20718	23,100	11%
Total	20718	23,100	11.5%
Mt. View Sanitary District – 14			
MARTINEZ	24000	27,200	13%
Total	24000	27,200	13.3%
Napa (Soscol Water Recycling Facility) – 15			
AMERICAN CANYON	9774	14,200	45%
NAPA	72585	98,100	35%
Total	82359	112,300	36.4%
Novato (Novato and Ignacio Plants) – 17			
NOVATO	47630	59,900	26%
Total	47630	59,900	25.8%
Palo Alto (Palo Alto Regional Water Quality Control Plant) - 19			
PALO ALTO	58598	67,500	15%
MOUNTAIN VIEW	70708	80,700	14%
LOS ALTOS	27693	29,700	7%
LOS ALTOS HILLS	7902	8,900	13%
MENLO PARK	30785	33,900	10%
EAST PALO ALTO	29506	38,200	29%
Total	225192	258,900	15.0%

	2000 Census	2025 Est.	Growth between
	Population	Population	2000 and 2025
	2000 Census	2025 Est.	Growth between
Petaluma – 20			
PETALUMA	54548	64,200	18%
Total	54548	64,200	17.7%
Pinole Hercules (Pinole-Hercules Water Pollution Control Plant) – 11			
PINOLE	19039	21,400	12%
HERCULES	19488	26,100	34%
Total	38527	47,500	23.3%
Rodeo – 11			
OTHER	8500	11,400	34.1%
Total	8500	11,400	34.1%
St. Helena 31			
ST. HELENA	5950	7,900	33%
Total	5950	7,900	32.8%
SF – SE – 21			
BRISBANE	3597	5,480	52%
SAN FRANCISCO	776733	815,200	5%
Total	780330	820,680	5.2%
SF-Bayside			
Total			
SFO (San Francisco International Airport Water Quality Control Plant) – 2			
Total			
SD No. 5 Marin – 13			
BELVEDERE	2125	2,260	6%
TIBURON	8666	9,200	6%
Total	10791	11,460	6.2%

	2000 Census Population	2025 Est. Population	Growth between 2000 and 2025
San Jose (San Jose/Santa Clara Water Pollution Control Plant) - 23			
CAMPBELL	38138	41,700	9%
CUPERTINO	50546	64,500	28%
LOS GATOS	28592	32,500	14%
MILPITAS	62698	86,200	37%
MONTE SERENO	3483	4,400	26%
SAN JOSE	894943	1,096,200	22%
SANTA CLARA	102361	134,000	31%
SARATOGA	29843	33,600	13%
Total	1210604	1,493,100	23.3%
San Mateo (City of San Mateo Water Quality Control Plant) – 24			
SAN MATEO	92482	108,300	17%
FOSTER CITY	28803	33,000	15%
HILLSBOROUGH	10825	11,800	9%
Total	132110	153,100	15.9%
Sausalito Marin 25			
SAUSALITO	7330	7,900	8%
OTHER	11000	12,100	10%
Total	18330	20,000	9.1%
SASM – 27			
MILL VALLEY	13600	14,500	7%
OTHER	12000	13,100	9%
Total	25600	27,600	7.8%
Sonoma Co - 28			
SONOMA	9128	11,900	30%
OTHER	28000	36,900	32%
Total	37128	48,800	31.4%

	2000 Census Population	2025 Est. Population	Growth between 2000 and 2025
SBSA – 29			
REDWOOD CITY	75402	85,300	13%
BELMONT	25123	28,000	11%
SAN CARLOS	27718	29,700	7%
ATHERTON	7194	8,000	11%
PORTOLA VALLEY	4462	5,300	19%
WOODSIDE	5352	6,000	12%
OTHER	50000	63,400	27%
Total	195251	225,700	15.6%
So SF San Bruno – 30			
SAN BRUNO	40165	44,700	11%
SOUTH SAN FRANCISCO	60552	68,500	13%
Total	100717	113,200	12.4%
Sunnyvale (Sunnyvale Water Pollution Control Plant – 32			
SUNNYVALE	131760	150,100	14%
Total	131760	150,100	13.9%
Vallejo Sanitation and Flood Control - 33			
VALLEJO	116760	143,600	23%
Total	116760	143,600	23.0%
West County Agency – 34			
SAN PABLO	30215	32,200	7%
RICHMOND	99216	112,200	13%
OTHER	20000	26,800	34%
Total	149431	171,200	14.6%
Yountville - 35			
YOUNTVILLE	2916	3,400	17%
Total	2916	3,400	16.6%

Facility	Treatment	Total Annual Effluent flow (L x 10^9)	**Flow-weighted average mercury concentration (ng/L)**	**Annual mercury load (kg)**
San Jose/Santa Clara WPCP	Advanced	204 +/- 16	3 +/- 1	0.6 +/- 0.2
East Bay MUD	Secondary	119 +/- 26	30 +/- 14	3.5 +/- 1.9
EBDA, East Bay Dischargers Authority	Secondary	123 +/- 11	19 +/- 9	2.3 +/- 1.1
City & Co. of S.F., Southeast	Secondary	115 +/- 27	13 +/- 14	1.5 +/- 1.6
Central Contra Costa S.D	Secondary	73 +/- 10	28 +/- 8	2.0 +/- 0.7
City of Palo Alto	Advanced	42 +/- 4	7 +/- 3	0.3 +/- 0.1
So. Bayside System Authority	Advanced	31 +/- 5	16 +/- 8	0.5 +/- 0.3
West County Agency	Secondary	26 +/- 3	15 +/- 6	0.4 +/- 0.2
City of Sunnyvale	Advanced	25 +/- 15	4 +/- 2	0.1 +/- 0.1
Napa S.D.	Advanced	22 +/- 3	5 +/- 3	0.1 +/- 0.1
Delta Diablo S.D.	Secondary	25 +/- 3	12 +/- 2	0.3 +/- 0.1
City of San Mateo	Advanced	22 +/- 4	13 +/- 12	0.3 +/- 0.3
Fairfield Suisun Sewer Dist.	Advanced	32 +/- 6	7 +/- 6	0.2 +/- 0.2
Vallejo Sanitation & Flood Cont.	Secondary	26 +/- 7	19 +/- 6	0.5 +/- 0.2
City of Livermore (LAVWMA – EBDA)	Secondary	13 +/- 1	8 +/- 8	0.1 +/- 0.1
Dublin - San Ramon (LAVWMA – EBDA)	Secondary	25 /- 5	32 +/- 45	0.8 +/- 1.1
Central Marin Sanitation A.G.	Secondary	17 +/- 7	6 +/- 3	0.1 +/- 0.1
So. S.F./ San Bruno WQCP	Secondary	16 +/- 2	17 +/- 6	0.3 +/- 0.1
City of Petaluma	Secondary	10 +/- 4	5 +/- 2	0.0 +/- 0.0
Novato S.D.	Advanced	10 +/- 1	5 +/- 6	0.1 +/- 0.1
City of Burlingame	Secondary	7 +/- 1	9 +/- 5	0.06 +/- 0.03
Sewerage Agency of So. Marin	Secondary	5 +/- 2	21 +/- 6	0.10 +/- 0.05
Sonoma Valley County S.D.	Secondary	7 +/- 3	5 +/- 1	0.03 +/- 0.02
City of Pinole-Hercules	Secondary	5 +/- 1	6 +/- 4	0.03 +/- 0.02
City of Benicia	Secondary	5 +/- 1	15 +/- 11	0.07 +/- 0.05
City of Millbrae	Secondary	3 +/- 1	16 +/- 15	0.05 +/- 0.05
Las Gallinas Valley S.D.	Secondary	6 +/- 2	52 +/- 20	0.29 +/- 0.14
Mt. View S.D.	Secondary	3 +/- 1	9 +/- 6	0.03 +/- 0.02
Sausalito-Marin City S.D.	Advanced	2 +/- 1	23 +/- 9	0.06 +/- 0.03
City & Co. of S.F., Int. Airport	Secondary	1 +/- 1	24 +/- 20	0.03 +/- 0.03
Marin Co. S.D. #5/Tiburon	Secondary	1 +/- 0	6 +/- 5	0.01 +/- 0.01
Rodeo S.D.	Secondary	2 +/- 0	16 +/- 27	0.03 +/- 0.04
City of Calistoga	Advanced	1 +/- 0	5 +/- 6	0.01 +/- 0.01
Town of Yountville	Advanced	1 +/- 0	5 +/- 6	0.00 +/- 0.00
City of St. Helena	Secondary	1 +/- 0	15 +/- 6	0.01 +/- 0.00
			Total	14.8 +/- 3.1

Table 4: Projected POTW mercury loads in 2025 if effluent concentrations remain unchanged.

4. Technological and programmatic options to manage mercury loads from municipal and industrial wastewater treatment facilities

4.1 Purpose

Quantify the costs and benefits of various mercury load management strategies that could be applied to wastewater treatment facilities in the Bay area.

4.2 Background

As part of the Basin Plan amendment process, the Regional Board considers the economic impact of proposed implementation plans and alternatives to satisfy its obligations under the California Water Code and CEQA. The following analysis has been prepared to provide assistance to Regional Board staff in understanding and quantifying the cost of infrastructural and programmatic approaches to managing mercury loads from wastewater treatment plants.

The range of options for mercury load reduction by wastewater treatment entities considered in this analysis is as follows:

<u>Additional wastewater treatment</u> - Treatment-based load reduction options include (1) filtration at existing secondary treatment plants and (2) reverse osmosis following filtration.

<u>Additional water recycling</u> – Recycling is currently practiced at a number of Bay area municipal facilities. The estimated annual recycled water volume is 20,000 acre-feet (BARWRP, 1999). The estimated avoided mercury load to the Bay due to the existing recycling effort is in the range from 0.1 to 0.4 kilograms per year (based on mercury concentrations ranging from 5.4 ng/l to 15.3 ng/l and an annual volume of 6520 million gallons (=20,000 acre-feet)). Potential future recycling uses include residential irrigation, irrigation of parks, golf courses and cemeteries, commercial and industrial uses, agricultural irrigation, stream flow augmentation, groundwater recharge and potable impoundment augmentation. A major planning study to evaluate future water demands and water recycling opportunities for the Bay area was completed by the San Francisco Bay Area Regional Water Recycling Program (BARWRP) in 1999 (San Francisco Bay Area Water Recycling Program, 1999). That study identified a two-stage program for future water recycling projects in the Bay area region.

<u>Additional pollution prevention/source control</u> - Municipal agencies have implemented pollution prevention and source control programs for mercury. Primary emphasis in those programs has been on dental offices, hospitals/medical clinics and household products. This analysis uses a previous study (AMSA, 2002) to estimate anticipated costs and load reduction benefits of implementing pollution prevention to the maximum extent practicable in the service areas of all Bay Area pollution control plants.

4.3 Approach

Cost estimates and load reduction estimates were identified for the above options, where possible. The methods used in deriving these estimates are described below.

<u>Additional wastewater treatment:</u> Unit costs for filtration, reverse osmosis, and filtration plus RO were derived from cost estimates contained in 1993 National Research Council publication titled *Managing Wastewater in Coastal Urban Areas* (NRC 1993). The following annual unit costs (expressed as $ million per year per mgd) were derived from the information provided in the NRC publication and are used to estimate costs in this analysis:

Filtration	0.18 – 0.65
Filtration plus RO	1.20

These costs are derived from annualized capital and annual operation and maintenance costs and are indexed to a 2001 construction cost index of 6342. The source document for these costs included costs with an estimated 1991 construction cost index of 4835.

These costs were checked against unit costs derived from a recent wastewater master plan report (Carollo, 2001). Carollo estimated the reverse osmosis cost based on the use of microfiltration (MF) rather than dual media filtration ahead of the RO process. The Carollo MF/RO unit cost, adjusted to an cost index of 6342, was $1.15 million per year per mgd, a close match to the unit cost (1.20) stated above. The Carollo unit cost for filtration was $0.65 million per year per mgd, significantly higher than the unit cost (0.18) cited in NRC, 1993. The $0.18 million per year per mgd is considered as the lower bound and $0.65 million per year per mgd as the upper bound for filtration costs.

The estimated mercury load reductions resulting from the additional treatment options described above are based on assumed removal efficiencies. For filtration, the assumed mercury removal efficiency was calculated from the median effluent concentration values for secondary (13.6 ng/l) versus advanced treatment (4.8 ng/l) taken from the June 2001 Regional Board staff report. Mercury removal efficiencies for reverse osmosis were calculated assuming a final RO effluent concentration of 2 ng/l. Final effluent concentrations were calculated for each facility based on the following assumed treatment efficiencies:

Filtration	65 % removal of Hg from secondary effluent
Reverse Osmosis	60 % removal of Hg from filtered secondary effluent

<u>Additional recycling:</u> The estimated cost for future recycling projects are based on information regarding recycling volumes and recycling costs contained in the San Francisco Bay Area Regional Water Recycling Program (BARWRP) report dated 1999. Costs developed in that report included treatment, distribution and on-site costs at the place of use. Assumed treatment prior to recycling was to meet Title 22 recycled water

requirements (secondary treatment plus filtration and enhanced disinfection) for most uses. In the BARWRP report, where TDS levels in effluent exceed 900 mg/l and recycled use included irrigation of agricultural crops, it was assumed that RO would be required.

The two stages of regional recycling projects identified in the BARWRP report were (1) 125,000 acre-feet per year (consisting primarily of service with Title 22 recycled water to commercial users, industrial users, parks, gold courses and cemeteries) and (2) 240,000 acre-feet per year (serving an expanded list of users and requiring RO treatment for a portion of the volume). The stage 1 program would include recycling projects at 22 municipal treatment facilities discharging to the Bay. The stage 2 program would involve increased recycled water supply from 17 of those 22 facilities. The estimated annual costs for these two stages are $79 million per year and $239 million per year, respectively.

The estimated mercury load reduction associated with implementation of these recycled water projects is calculated for each treatment facility based on recycled volume estimates provided in the BARWRP report.

<u>Additional source control:</u> The estimated annual cost range for mercury source control programs at a typical municipal facilitiy is $250,000 to $700,000 (AMSA, 2001). This reflects, the staff time to implement programs and the disposal costs of recovered mercury, and the cost of “take-backs.” To derive a conservative, upper estimate of the cost of maximizing pollution prevention and source control programs, the AMSA estmatit of $250,000 - $700,000 per facility was multiplied by the 34 POTWs, resulting in a total cost of $8 million - $25 million for pollution prevention and source control.

Over the past ten years in the SF Bay area, waste minimization, pollution prevention and source control programs have been implemented by wastewater agencies for a number of pollutants, including mercury. For mercury, pollution prevention and source control activities have focused on dental offices, hospitals and household products. However, the effectiveness of these efforts in reducing effluent concentrations (and loads) has not been well documented at most facilities. The same can be said at the national level. To address this question, the Association of Metropolitan Sanitation Agencies (AMSA) commissioned a national study of municipal treatment plants that have collected influent and effluent mercury data of sufficient quality and quantity to enable evaluation. In particular, each of the facilities included in the AMSA study has implemented USEPA Method 1631 to achieve suitable low detection limit mercury analysis on effluent.

The AMSA report employed two methods to estimate effluent concentrations as a result of source control. The first method assumed that effluent concentrations would decrease by the same percentage as predicted for influent. That is, by the first method, if source control reduced influent concentrations by 25 percent, it was assumed that effluent concentrations would decrease by 25 percent. This represents the absolute upper bound on the benefit of mercury source control. The second method (a probability-based approach) used actual data relationships between influent and effluent in predicting effluent concentrations.

Results from the both methods are used to establish a range. If effluent concentrations are directly proportional to influent concentrations, then the expected effluent load reduction due to increased source control and pollution prevention would be 26% – 33 %. On the other hand, based on actual measured plant performance, the AMSA report projects that reductions in effluent load reductions of mercury after implementation of pollution prevention and source control is 2% to 3%. Since this is based on actual data, the best guess is that actual reductions in effluent concentrations will be closer to 2%, rather than 33%.

Additional benefits of pollution prevention and source control include projected influent load reductions of 26% to 33%. This results in a decreased quantity of mercury in the biosolids for the facility, which will result in a decrease in loadings to landfills and may result in a decreased loading to the atmosphere (where incinerators are employed for biosolids volume reduction, depending part on the efficiency of capture of mercury in the air pollution control equipment on the incinerator). The risk reduction benefit of decreased mercury loadings to biosolids, incinerators, and landfills has not been quantified.

For both projected costs and projected load reductions, it should be recognized that pollution prevention and source control have already been substantially implemented throughout the Bay Area. Therefore, new costs may be substantially less than $8 – 25 million. If so, then the benefit of expected additional load reductions would also be commensurately lower, because the load reductions would have already been realized.

4.4 Results

Addition of filtration to Bay area municipal facilities which do not currently have filtration is estimated to cost an additional $80 – 300 million per year to address projected 2025 flows (723 mgd). The addition of filtration would drop the projected annual mercury loading from 14.8 to 6.3 kilograms per year for municipal effluent. For industrial facilities, filtration would cost an additional $14 – 60 million per year and would reduce the industrial loading from 2.0 to 0.7 kilograms per year. The projected total annual mercury loading from wastewater treatment facilities with filters in place would be 7.0 kilograms per year at an additional annual cost of $94 - 380 million.

Addition of filtration and reverse osmosis to Bay area municipal facilities would cost an additional $817 million per year to address projected 2025 flows. The estimated municipal mercury loading following the addition of filtration and RO would be 2.5 kilograms per year. The annual mercury loading from industrial wastewater treated through filters and RO is estimated to be 0.3 kilograms per year, at a cost of $92 million per year. The projected total annual mercury loading from wastewater after addition of filters and RO on a Bay-wide basis would be 2.8 kilograms per year. The estimated cost of this treatment would be $909 million per year.

Implementation of major additional water recycling facilities in the Bay area is estimated to cost between $79 and $239 million per year. The reduction in 2025 mercury loading resulting from such recycling efforts would range from 2.2 to 3.6 kilograms per year, depending on the magnitude of the recycling project. Resulting future mercury loadings to the Bay would be approximately 8 to 14 kilograms per year after implementation of the recycling programs. The range reflects the different degrees of recycling (Stage 1 vs. Stage 2) and the uncertainty of the response to pollution prevention programs.

The estimated annual cost for additional mercury pollution prevention and source control activity in the Bay area is in the range from $8 to $25 million. Based on an expected reduction of 2% - 33% in effluent concentrations, the future mercury load in 2025 would be 11.3 – 16.6 kg/yr from all wastewater treatment facilities.

The cost and mercury load reduction estimates for treatment of storm water in wastewater treatment facilities require site-specific study, as described in Section 5. A summary matrix of load reduction costs and benefits for the above options is provided in Table 5.

4.5 References

Association of Metropolitan Sewerage Agencies. 2002. *Mercury Source Control and Pollution Prevention Program Evaluation.* Prepared by Larry Walker Associates for AMSA under USEPA Grant Assistance ID No. CX827577-01-0. March.

National Research Council. 1993. *Managing Wastewater in Coastal Urban Areas*. National Academy Press. Washington, D.C.

San Francisco Bay Regional Water Quality Control Board: adopted NPDES permits for the treatment facilities considered in this analysis (1998 – present).

San Francisco Bay Area Regional Water Recycling Program. 1999. *Recycled Water Master Plan*. December. Available from RMC Engineering, Walnut Creek, CA, www.rmcengr.com.

Carollo Engineers. 2001. *Sacramento Regional Wastewater Treatment Plant – 2020 Master Plan. Final Draft Summary Report*. Prepared for Sacramento Regional County Sanitation District. November.

Scenario	Total Mercury Load (kg/year)	Additional annualized capital and operating costs over current expenditures ($ millions)	Additional Benefits, considerations
2002	15 +/- 3	0	Baseline
A: No Action – 2025	17 +/- 3	0	Resources not spent on mercury can be spent on other pollutants. Pollution prevention and source control already substantially implemented.
B: Pollution prevention (P2)	11 – 16.5	8 – 25	Potential benefits of additional P2: further reduction in influent mercury leads to reduction of mercury in sludge, helps move towards overall reduction of anthropogenic mercury use and release.
C1: Pollution Prevention + Reclamation Stage 1	9 –14	87 - 104	P2 as Scenario B; reduction of other pollutant loads, increased water resources available for water supply, Delta outflow.
C2: Pollution Prevention + Reclamation Stage 2	8 – 12	247 - 264	P2 as Scenario B; reduction of other pollutant loads, increased water resources available for water supply, Delta outflow.
D: Pollution prevention + Reclamation Stage 1 +Tertiary (filtered) Baywide	<7	167 – 404	P2, Reclamation as Scenario C1, 50 to 65 percent reduction of other pollutants associated with particulate phase
E: Reverse Osmosis Baywide	<3	917 - 934	Over 700 mgd of high-quality water available. Significant energy use requirements, treatment and disposal of 140 mgd brine stream

Table 5: Cost benefit summary of mercury load management alternatives for POTWs

5. Feasibility of using excess treatment capacity to reduce urban runoff mercury loads at strategic locations

5.1 Purpose

Identify the key factors to be considered in assessing the feasibility of connecting urban runoff facilities to wastewater treatment facilities to reduce mercury (and other pollutant) loading to SF Bay.

5.2 Background

A concept has been identified to connect portions of urban storm drain systems to wastewater treatment plants as a method of reducing mercury loadings to SF Bay. This practice has been employed in Southern California as a method to reduce coliform contamination of beaches. In those examples, the approach has been to route dry weather urban runoff (which contains high coliform levels) to wastewater treatment plants that have available treatment capacity to accommodate those dry season flows. Typically those treatment plants discharge through ocean outfalls that provide dilution in the range from 100 to 200 to one. The NPDES permits for those treatment facilities are written to provide dilution credit for the actual dilution that occurs.

Mercury in urban runoff is primarily associated with suspended sediments. Therefore, highest mercury loads will occur where high mercury concentrations in sediments and high suspended sediment levels occur. Elevated mercury concentrations in sediments must be identified through monitoring at specific locations. Suspended sediment concentrations are typically significantly elevated during early season, first flush storm events. Therefore, as opposed to the treatment of dry season urban runoff flows to control coliform bacteria, treatment of first flush storm flows in areas where mercury sediment levels are high is likely to have the greatest benefit in terms mercury load reduction. Treatment of dry season urban runoff is not expected to reduce significant suspended sediment or mercury quantities.

The connection of urban runoff flows to wastewater treatment plants is an unconventional practice in most Bay Area communities. Wastewater collection and treatment systems have been designed to exclude urban runoff flows in those communities. Excess treatment capacity in existing facilities has been constructed to accommodate future wastewater flows, without consideration of storm-related contributions, aside from allowances for infiltration and inflow to the wastewater collection system. An exception exists in the City of San Francisco, where special conveyance, storage and treatment facilities have been constructed to handle both urban runoff and wastewater flows in a combined sewer system.

Due to the fundamental change in utility design associated with the connection of urban runoff flows to wastewater treatment facilities, a number of complex, site specific factors must be considered prior to implementing this concept, as described below.

5.3 Approach

The factors to be considered in a feasibility analysis for this concept should include the following:

The concept of "available excess treatment capacity" in existing wastewater treatment facilities needs to be defined and quantified from the perspective of treating first flush storm flows. Treatment capacity analyses involve the assessment of hydraulic (flow) capacity, as well as treatment (solids removal, solids handling disinfection) capacity. Excess capacity which exists today will ultimately be utilized, i.e. it is a commodity which declines over time, depending on the growth rate in the community. The time required to plan, design and construct the next increment of capacity will influence determination of "available excess capacity" at a given facility.

A table of existing average dry weather flows versus design flows should be developed as a preliminary screening effort to identify candidate Bay area treatment facilities for storm water treatment. Areas with elevated mercury concentrations in suspended storm water sediment should be identified using mercury monitoring data from urban runoff programs or other available sources. The mercury monitoring data should be summarized for each identified area. Monitoring data for other pollutants of concern (e.g. PCBs) should also be summarized.

An analysis of "available excess capacity" should be performed at those treatment facilities which (a) are identified in the initial screening effort as potentially having excess capacity and (b) are located in proximity to an area with elevated mercury concentrations in storm water. The analysis should quantify, for planning purposes, the "available excess capacity" at the selected treatment facilities and the "shelf life" for that capacity. Individual projects should be evaluated at a planning level for each of the identified treatment facilities. Project level analysis include connection facilities between the storm system and the treatment system (storage, pumps, conveyance piping and controls) which is largely a function of distance, operating costs to treat storm flows through the wastewater facility (power, chemicals), and costs to replace the capacity used for storm water treatment. Project level analysis should also include a compliance analysis with the existing NPDES permit for the facility to evaluate the ability to achieve 85 percent removal of BOD and suspended solids, effluent limits for conventional and toxic pollutants, and bypass prohibitions.

The potential benefits of each project should be estimated in terms of mercury (and other pollutant) load reductions. The calculation method for the annual load reduction requires the following information:

- The volume of storm water treated on an annual basis.
- The percent removal of suspended solids through the treatment process (85 percent through secondary, 95 percent removal through filtered secondary)
- The average suspended solids concentration in the storm flow to be treated

- The average mercury (and other pollutant) concentration on suspended sediment in the storm flow.

A funding mechanism and funding arrangements between the wastewater and storm water agencies must be developed and adopted. Agreements must be reached regarding the payment for the front-end costs to perform studies and engineering analysis required for the feasibility assessment.

Finally, while blending urban stormwater with municipal sewage has the potential to reduce multiple pollutant loads (e.g., PCBs and chlorinated pesticides), this could also have the unintended consequence of increasing the pollutant concentrations of biosolids. This is potentially a concern for proper biosolids management (Committee on Toxicants and Pathogens in Biosolids Applied to Land, 2002).

5.4 Results

The concept only has application on a site-specific basis, where a treatment facility with excess capacity is located near an area with elevated mercury in sediments. The typical project emerging from the original concept would be facilities to connect a storm system to a wastewater treatment facility to treat first flush storm flows. The project would typically include storage, pumps, pipelines and control systems. An alternative would be for the storm water agency to build separate wet weather treatment facilities (e.g. screening, sedimentation, disinfection) to handle storm flows from areas with high mercury concentrations.

Individual projects may have multi-pollutant benefits in special cases where sediments in runoff are elevated for multiple pollutants. Where multi-pollutant benefits would not occur, it is doubtful that the achievable reduction in mercury loading will offset the cost for facilities to implement the concept.

As an example, the hypothetical scenario of an industrialized catchment can be considered. Sediments collected from a catch basin at the Ettie Street puming station in West Oakland have approximately 1 ppm mercury and 3 ppm PCBs (Gunther et al., 2002). The catchment is estimated to produce between 0.04 and 0.1 million kilograms of sediment per year. Therefore, effectively capturing this sediment could potentially reduce mercury loads to the Bay by 0.04 – 0.1 kg per year, and PCB loads by 0.1 to 0.3 kg per year. If the stormwater carrying this sediment has an average TSS of 10 mg/L, this would mean that approximately 10^{10} liters of water would have to be treated – approximately 2200 million gallons. 2200 million gallons is a significant volume of water to treat – the nearest facility (EBMUD) has a dry-weather capacity of 75 million gallons per day, and less than that during wet weather. Treatment of 2200 million gallons over a month would use 60 million gallons per day of that capacity. Treatment of an extra 2200 million gallons over a period of a year would use an extra 6 million gallons per day of capacity, so the feasibility of treating stormwater would be enhanced by construction of storage facilities. A detailed feasibility assessment for this example should examine the cost of designing and constructing sufficient storage capacity (i.e., up to 2,000,000 gallons), pumps and pipes to transport the water approximately three miles, the cost of permitting and public review, and any changes to the biosolids management plan that might result.

Four general trends in the feasibility of improving water quality by capturing urban stormwater emerge from this example:

1) Feasibility of treating urban stormwater increases with increasing pollutant concentrations in sediments;
2) Feasibility also increases with increasing TSS levels in stormwater;
3) Feasibility decreases with increasing distance to the nearest facility; and
4) Feasibility increases with increasing wet-weather capacity.
5) Discreet, targeted water quality improvement systems may be more feasible than blending urban runoff with sewage.

5.5 References

Committee on Toxicants and Pathogens in Biosolids Applied to Land, 2002. Biosolids Applied to Land: Advancing Standards and Practices, National Research Coucil, Washington, D.C.

Gunther, A.J., Salop, P., Abu-Saba, K.E. and Feng, A., 2002. Characterization of PCB, Mercury, PAH, and Chlorinated Pesticide Concentrations in Drainages of Western Alameda County, CA, Livermore, CA.

Orange County Sanitation District, 2003. “Answer to questions about Urban Runoff Diversions.” Fact Sheet available at www.ocsd.com.

Personal Communication. 2002. Charles Weir. East Bay Dischargers Authority. August.

Personal Communication. 2002. Khalil Abu-Saba. Applied Marine Sciences. August. Technical memorandum #2, CEP Project # HG-IP-1; 8/28/02.

6. Feasibility of managing mercury methylation in receiving waters

6.1 Purpose

Provide guidance for adaptive approaches to investigate linkages between design and operational choices of pollution control plants and mercury methylation in receiving waters.

6.2 Background

The conversion of mercury to methylmercury ("methylation") is a key linkage between mercury loads and impairment of beneficial uses. Given that, and the fact that mercury loads from pollution control plants are less than 2% of total loads to the Bay, it is likely that management strategies to reduce methylation rates in the Bay may be more important than management strategies to reduce or control mercury loads from wastewater.

Mercury methylation in receiving waters happens when bacteria, especially sulfate reducing bacteria, assimilate inorganic mercury. Sulfate reducing bacteria thrive under low oxygen conditions, because they use sulfate as a terminal electron acceptor in their respiration of organic matter. Therefore, some typical environmental factors that affect mercury methylation are:

1) How readily inorganic mercury is assimilated by bacteria (the "bioavailability");
2) The amount of sulfate available; and
3) Dissolved oxygen concentrations.

Pilot projects to evaluate the feasibility of managing mercury methylation should focus on how choices about the operation of wastewater treatment facilities affect these and other factors controlling mercury methylation.

For example, a methylmercury receiving water monitoring study conducted as a provision of the Fairfield-Suisun Sewer District (FSSD) NPDES permit (SFRWQCB, 1998) is a example of one such pilot study. The results from that study showed a linkage between low dissolved oxygen (DO) and enhanced methylation efficiency (Figure 3). Given the ability of sulfate reducing bacteria to thrive under low oxygen conditions, this finding was not surprising. An additional finding was that the linkage was present in both effluent receiving water and reference sloughs, suggesting that in this case, there was no detectable difference in the "bioavailability" of mercury in wastewater compared to ambient mercury.

Depressed DO in the vicinity of FSSD occurs because of decreased flow and the seasonal die-off of vegetation in the surrounding marshes. Discharge from FSSD actually enhances DO in the receiving water+. Thus, planning decisions made for other reasons have also created a potential benefit for mercury management by reducing mercury methylation rates.

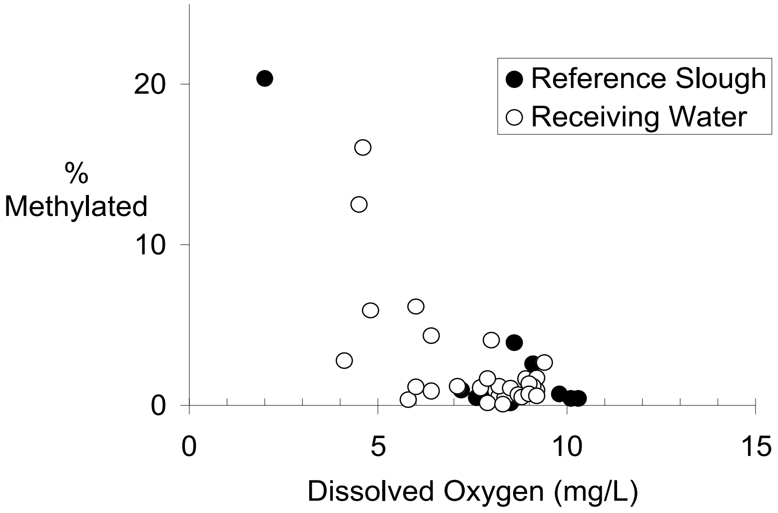

Figure 3: Fraction of mercury as methylmercury in the surface water of sloughs along the northern reach of San Francisco Bay plotted vs. dissolved oxygen. Note the general trend of increasing mercury methylation with decreasing dissolved oxygen. Data from NPDES receiving water study conducted by Fairfield Suisun Sewer district, courtesy Larry Bahr (Senior Environmental Scientist). Methylmercury measurements made by Dr. R.P. Mason, University of Maryland Chesapeake Biological Laboratories

6.3 Results

Several key questions need to be answered to determine the feasibility of affecting mercury methylation rates in Bay waters through operational decisions at POTWs. A key uncertainty is whether the bioavailability of mercury in POTW effluent is significantly greater or less than mercury in other sources. Knowing the answer to this would help resolve the importance and possible benefits, in terms of reduced mercury risk, to controlling mercury loads under the different scenarios presented in Table 5. As mentioned above, a preliminary study does not show a difference in the methylation efficiency of mercury in effluent receiving waters compared to a reference slough (Figure 3), but this could be explored in more detail and with a more regional scope.

Another question is whether dissolved oxygen management is an effective tool for reducing methylmercury concentrations in water. If so nitrification facilities that reduce ammonia levels in effluent may reduce mercury methylation in specific shallow water discharge situations by increasing DO levels. Assuming a unit cost of $ 0.2 million / yr /

mgd (NRC, 1993), the cost to provide nitrification facilities serving 44 mgd would be approximately $7.5 million / yr, and could provide ancillary habitat benefits of elevated DO and reduced ammonia. The validity of this hypothesis and the relative benefit to reducing methylmercury in fish must be ascertained before nitrification is mandated for such purpose.

Noting from the example above that discharge from FSSD helps maintain near-field DO, it is also possible that reclaimed water could be used to maintain flushing of shallow sloughs, thereby maintaining adequate DO levels and reducing mercury methylation rates. This emphasizes the importance of a regionally coordinated approach that combines treatment, reclamation, and receiving water monitoring to provide multiple environmental and resource conservation benefits.

Many treatment plants use alum (potassium aluminum sulfate) as a flocculant. Sulfate is an important factor affecting mercury methylation rates (Henry et al, 1992). In other ecosystems, it has been shown that there is an optimum sulfate concentration for enhanced mercury methylation, corresponding to sulfate concentrations typical of brackish waters. Thus, in effluent dominated freshwater marshes, it is possible that an alternative to alum as a flocculant might be desirable.

Answering these and similar questions involves several steps:

1) Development of a conceptual model;
2) Framing questions to test the conceptual model;
3) Conducting monitoring studies to answer the questions;
4) Revising the conceptual model according to the results of the monitoring studies;
5) Development and implementation of pilot projects based on the revised conceptual model to test adaptive management hypotheses;
6) Monitoring to verify the benefits of the pilot project;
7) Full-scale implementation of resulting actions of merit from the pilot projects.

The CEP has established a process for executing steps 1-4 above through development and implementation of its annual work plan. The draft year-two work plan includes resources for refinement of the mercury conceptual model and developing peer-reviewed study plans based on management questions. Resources to answer this kind of basic research question may exceed resources available to Bay Area local governments, so the CEP (or individual agencies that are part of the CEP) may need to seek outside funding to conduct monitoring and implement pilot projects if they desire to pursue management strategies that address mercury methylation.

6.4 References

San Francisco Bay Regional Water Quality Control Board, 1998. NPDES permit adopted for the Fairfield-Suisun Sewer District.

Gilmour, C.C., Henry, E.A., and Mitchel, R. 1992. Sulfate stimulation of mercury methylation in freshwater sediments. Environmental Science and Technology 26: 2281 – 2287.