Appendix I. Calculation of the Water Column Targets

This appendix provides the equations and calculations used to derive the water column targets from the Mercury Water Quality Objectives. The water column targets would be used to derive an effluent limitation that will be used in permits for discharges that contain mercury. Bioaccumulation factors are one means to derive a water column target. The results derived using bioaccumulation factors (Sections I.1 through Section I.3 and Section I.6) are compared with the results from other models later in this appendix (Section I.4 and Section I.5). Conclusions and recommendations are at the end of this appendix (Section I.8).

I.1 Bioaccumulation Factors

A *bioaccumulation factor* (BAF) is a number used to estimate the methylmercury concentration in water that corresponds to the methylmercury concentration in fish. More specifically, the BAF is the ratio (in Liters (L) per (/) kilogram (kg)-tissue) of the concentration of a substance in tissue to its concentration in the ambient water. The BAF is calculated as:

$$\text{BAF} = \frac{C_{tissue}}{C_{water}} \quad (1)$$

where:

C_{tissue} = Concentration of the chemical in wet tissue

C_{water} = Concentration of chemical in water

In situations where both the organism and its food are exposed to the substance, the ratio does not change substantially over time. Equation 1 can be rearranged to equation 2, and used to calculate a water concentration from the fish tissue concentration.

$$\frac{C_{fish\ tissue}}{\text{BAF}} = C_{water} \quad (2)$$

<u>I.1.1 U.S. EPA Bioaccumulation Factors</u>

U.S. EPA calculated the BAFs shown in Table I-1 for two ecosystem types based on national data. Since the Sport Fish Water Quality Objective is for trophic level 4 fish, the BAFs for trophic level 4 will be used in the calculations (for a description of trophic levels see Section 4.2 of the Staff Report). U.S. EPA first calculated separate values for river-like ecosystems (lotic), lake-like ecosystems (lentic) and estuarine ecosystems because methylmercury bioaccumulates to different degrees in the different ecosystems. Slower moving anoxic waters with high organic matter content (some lakes, reservoirs, estuaries) tend to generate the most methylmercury, while fast moving well aerated waters (rivers) tend to have less methylmercury bioaccumulation.

The U.S. EPA calculated the BAFs from multiple studies. First, a BAF was calculated for each study. Then the various BAF were combined using a geometric mean to calculate the final

BAFs (see U.S. EPA 2001 for more details). Figure 1, below, shows the uncertainly in the BAFs as represented by the 5th to the 95th percentile of the log normal distribution.

I.1.2. California BAF

A BAF was derived for California by Science Applications International Corporations (SAIC) using California specific data, from the State Water Board. This California BAF is described and compared to the U.S. EPA national BAF in a report by Sanborn and Brodberg (Sanborn and Brodberg 2006). The California BAF (for tropic level 4 fish) is shown below in Figure I-1 in comparison with U.S. EPA BAFs. In brief, the California BAF was similar to the national values that U.S. EPA calculated, but the California value is not as high quality due to data limitations, as described below.

The use of SAIC's original California BAF was not recommended because the California BAF was not as robust as the draft national BAF (Sanborn and Brodberg 2006). The California BAF was based on limited data and the data selection procedure was less rigorous than U.S. EPA's procedures. U.S. EPA only used water and biota data from the same water body and the same study to calculate a water body-specific BAF. Individual BAFs were then combined for the final BAF. Conversely, for SAIC's California BAF, all water column data were pooled to calculate a statewide average water concentration, and all fish data were pooled to calculate a statewide average fish mercury concentration. Then these two values were used to calculate the BAF. Sanborn and Brodberg described that this approach oversimplifies the data.

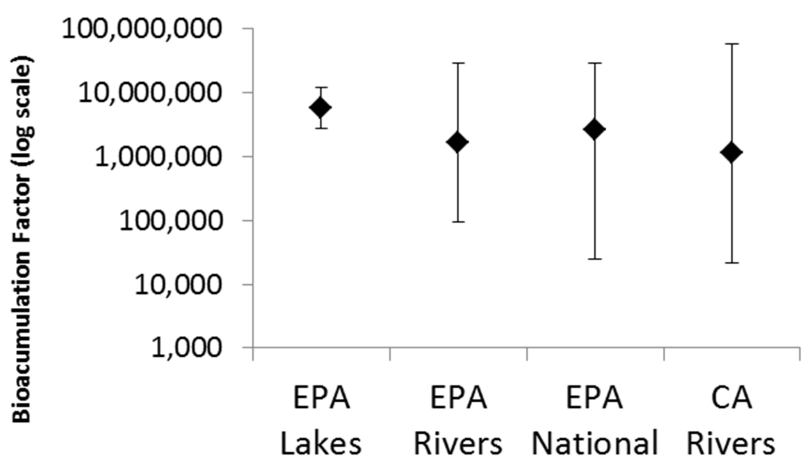

Figure I-1. Comparison of National and California Bioaccumulation Factors. Data points (diamond symbols) are geometric means from Table 31 in Sanborn and Brodberg 2006 and Table A-8, in Appendix A of U.S. EPA 2001. Vertical bars extend from the 5th to the 95th percentile of the log normal distribution.

Sanborn and Brodberg recalculated the California BAF, using the approach U.S. EPA used to calculate BAFs. Sanborn and Brodberg first calculated BAFs for each water body, then combined the water body-specific BAFs into one statewide value. Due to data limitations, there was only one final value for river systems for the California data set, and there was not enough data to calculate BAFs for lakes. Most of the California data were from the Sacramento-San Joaquin River watershed, which provided limited representation of the state as a whole. Sanborn and Brodberg also tested how well the U.S. EPA values predicted bioaccumulation in California. Sanborn and Brodberg found that U.S. EPA BAFs predicted California values well. Figure 1 shows how the U.S. EPA and California BAFs for rivers are very similar.

Sanborn and Brodberg recalculated BAFs using both geometric and arithmetic means. Sanborn and Brodberg preferred the use of arithmetic means because the BAFs are larger and therefore more protective (Sanborn and Brodberg 2006). In this appendix only BAFs calculated with geometric means are used, following U.S. EPA methodology. Also, using geometric means enables a better comparison to the U.S. EPA BAFs since U.S. EPA used only geometric means. The geometric mean equates to the 50^{th} percentile of the log normal distribution.

Geometric means can be preferable over arithmetic means when the data span multiple orders of magnitude. In this case, the geometric mean provides a better representation of where the values are clustering. For example, the geometric mean of the data set: 1,1,1,10, and 1,000 is 6. This geometric mean of 6 is much closer to 1 (where the data are clustering) than the arithmetic mean of 203.

Based on the similarity of the U.S. EPA and California values, and on the limitations of the California values, Sanborn and Brodberg recommended the U.S. BAFs as an option to derive a water column target for California (Sanborn and Brodberg 2006), either alone or in combination with the California values. (A third recommendation was to collect more data to derive more representative values.)

Table I-1: Bioaccumulation Factors (BAFs) for Dissolved Methylmercury

	U.S. EPA National BAFs						California
	BAF_2		BAF_3		BAF_4		BAF_4
	Lakes	Rivers	Lakes	Rivers	Lakes	Rivers	Rivers
Separate based on ecosystem type	130,000	110,000	1,100,000	520,000	5,700,000	1,200,000	1,100,000
Combined: Draft National BAFs	120,000		680,000		2,700,000		NA

BAFx corresponds to trophic level X. (Data from Table A-8, A-9 in U.S. EPA 2001 are expressed to two significant figures, in accordance with the U.S. EPA final BAFs in Table A-9.)

I.1.3 California Bays BAFs

Mercury BAFs for California bays and harbors were calculated from fish and water samples collected in northern California, including locations in Humboldt Bay, Bodega Bay, San Francisco Bay Area, and Morro Bay, and southern California, including locations in LA Harbor, Newport Bay, Mission Bay, San Diego Bay (Stephenson et al. 2009). Mercury BAFs were calculated by dividing the mean mercury concentration in fish by the mean total aqueous methylmercury value. Values calculated using geometric means are shown in Table I-2. Conversely, the U.S. EPA calculated their BAFs using dissolved concentrations of methylmercury, not total methylmercury.

Table I-2 Bioaccumulation Factors (BAFs) for Total Methylmercury for California Bays

	Trophic Level 3~4 BAF
Southern California Bays	3,250,000
Northern California Bays	6,010,000
Geometric Mean	4,419,559

The study authors also attempted to use linear regression to derive a relationship between mercury concentrations in water and in fish tissue, in which tissue concentrations are normalized to a standard length then plotted against ambient water concentrations for each location in the study (Stephenson et al. 2009). The authors found a lack of correlation between site-specific aqueous methylmercury and tissue concentrations in the higher trophic level species. The authors explained that unlike freshwater BAFs, a marine or estuarine BAF will be considerably more variable due to the processes that occur in these types of systems. One consideration is tidal flux and the tidal prism. Every ebb and flood of the tidal cycle can greatly diminish the ability to accurately characterize a contaminant's aqueous concentration. Another consideration is that the larger, higher trophic level species of fish are not limited in space.

Additionally, the prey fish that higher trophic level fish consume may fluctuate as different species move in and out of the harbor or estuary depending on water conditions. Estuarine systems are, by definition, regions where freshwater meets the sea. In California, many of the bays and harbors have some source of freshwater input (typically the lower course of a river) and could be considered estuarine. These systems are highly dynamic mixing zones (Stephenson et al. 2009).

I.1.4 Other California site-specific BAFs

Site-specific mercury BAFs calculated as part of established mercury Total Maximum Daily Load (TMDLs) are included in Table I-6, in Section I-5. Also, Alpers et al. calculated an overall BAF for Camp far West Reservoir from data from 2001 – 2003 (Alpers et al. 2008). The BAF for trophic level 4 fish was 10,000,000, which is almost two times larger than the U.S. EPA national BAF for lakes of 5,700,000. This is not surprising since the anoxic bottom of a reservoir is a prime area for methylmercury production. The Camp Far West Reservoir BAF is somewhat higher than found in other California reservoirs, namely Guadalupe Reservoir (Kuwabara et al. 2005, see Table I-6 below). This BAF was not used in any of the calculations since it was from only one water body.

I.2 Translators

Mercury in the water column can be measured as different forms, such as total mercury (organic and inorganic), dissolved (filtered) methylmercury and total methylmercury. A *translator* is a value used to convert between the different forms of mercury in the water column. The U.S. EPA BAF and equation 2 provides a water column concentration in the form of dissolved methylmercury (not total mercury). However, it may be appropriate to set a regulatory water concentration limitation in the form of total mercury. This is because inorganic mercury can be converted to methylmercury.

U.S. EPA derived translators to convert between concentrations of dissolved methylmercury ($MeHg_{dissolved}$) and total (unfiltered) concentrations of methylmercury ($MeHg_{total}$) and to convert between total mercury (Hg_{total}) and the dissolved concentrations of methylmercury ($MeHg_{dissolved}$), shown in Table I-3. Also, Sanborn and Brodberg, calculated translators for rivers for California (Table I-3) and found that they were not significantly different from the U.S. EPA translators for rivers (Sanborn and Brodberg 2006). U.S. EPA translators for estuaries are based on a very limited data set that included only two sites.

The bay BAF study provided data that could be used to calculate translators (Stephenson et al.2009). For each sampling station, the geometric mean total methylmercury concentration was divided by the geomantic mean total mercury concentration, to derived translators to convert from total methylmercury to total mercury. The translators for each station were combined into a regional geometric mean for northern or southern California (values shown in Table I-3).

Table I-3. Mercury Translators for Mercury in Water for Lakes, Rivers, and Estuaries

	$MeHg_{dissolved}/Hg_{total}$	$MeHg_{dissolved}/MeHg_{total}$	$MeHg_{total}/Hg_{total}$
Lakes[1]	0.032	0.61	NA
Rivers[1]	0.014	0.49	NA
Estuaries[1]	0.19*	0.61*	NA
Geomean of Lakes & Rivers[1]	0.021	0.55	NA
California Rivers Translator[2]	0.015	0.51	NA
Northern California Bays[3]	NA	NA	0.030
Southern California Bays[3]	NA	NA	0.015
Geomean of Bays[3]	NA	NA	0.021

[1]Data from Table A-10 in U.S. EPA 2001. [2]Data from Table 32 Sanborn and Brodberg 2006. [3]Derived from data from Stephen son et al. 2009. *Based on data from only two sites. NA means not available.

I.3 Water Column Concentrations Derived from Bioaccumulation Factors (BAFs)

The BAFs (Table I-1) and translators (Table I-3) were used to calculate the equivalent concentrations of dissolved methylmercury, total methylmercury, and total mercury that correspond to the Sport Fish Water Quality Objective (0.2 mg/kg), shown in Table I-4. First, equation 2 was used to calculate a water concentration from the fish tissue concentration. An example calculation using the U.S. EPA combined lakes and rivers BAF (2,700,000) is shown below:

$$\frac{C_{fish\ tissue}}{\mathrm{BAF}} = C_{water} \tag{2}$$

$$\frac{0.2\ \mathrm{mg/kg\ \ MeHg}}{2{,}700{,}000} \times \frac{1{,}000{,}000\ ng}{1\ mg} \times \frac{1kg}{1L} = 0.074\ \ ng/L\ \ MeHg_{dissolved}$$

Next, the concentration of dissolved methylmercury was converted to total mercury using the corresponding translator from Table I-2. For example, to calculate the total mercury concentration that corresponds to 0.074 ng/L (nanograms per liter) methylmercury (for lakes and rivers combined):

$$\frac{0.074\ \mathrm{ng/l\ MeHg}_{dissolved}}{0.021\ \mathrm{ng/l\ MeHg}_{dissolved}/\mathrm{Hg}_{total}} = 4\ \mathrm{ng/L}$$

Similarly, another translator was used to derive the corresponding concentration of total methylmercury. The resulting concentrations of total mercury and total methylmercury that correspond to the water quality objective are shown in Table I-4.

Table I-4. Corresponding Water Column Concentrations for the Mercury Sport Fish Water Quality Objective

Matrix	U.S. EPA BAFs				California BAF
	Lakes	Rivers	Estuaries	Lakes & Rivers	Rivers
Trophic Level 4 Fish Tissue (mg/kg)	0.2	0.2	0.2	0.2	0.2
$MeHg_{dissolved}$ (ng/L)	0.04	0.2	NA	0.07	0.2
$MeHg_{total}$ (ng/L)	0.06	0.3	0.1*	0.1	0.4
Hg_{total} (ng/L)	1	12	0.4*	4	12

* derived from the lakes and rivers dissolved MeHg concentration of 0.074 ng/L (also shown in this table) since there was no BAF for estuaries.

Using the California rivers BAF and translator calculated by Sanborn and Brodberg (BAF of 1,100,000, translator for $MeHg_{dissolved}/Hg_{total}$ of 0.015) the resulting total mercury water column values is 12.1 ng/L. This is not significantly different than the value derived with the U.S. EPA values for rivers of 11.9 ng/L (results round to two significant figures that are shown in Table I-4).

The bay BAF study provided data that was used to calculate translators (Stephenson et al. 2009). The translator is somewhat different than those used for the U.S. EPA and California Rivers BAFs, since the bay BAF was designed to convert the fish tissue concentration to a concentration of *total* methylmercury, not *dissolved* methylmercury. The bay BAF and bay translators were used to calculate corresponding mercury concentrations for bays (Table I-5). The resulting water column concentrations for bays are close to the values for lakes and the values for lakes and rivers (combined), derived with the U.S. EPA and California BAFs.

Table I-5. Corresponding Water Column Concentrations for California Bays

	Northern California Bays	Southern California Bays	Geometric Mean
Trophic Level 3~4 BAF	6010000	3250000	4419559
Fish Tissue (mg/kg)	0.2	0.2	0.2
$MeHg_{total}$ (ng/L)	0.033	0.062	0.045
Hg_{total} (ng/L)	1.1	4.1	2.2

I.4 Other Models

Besides BAFs, other models, such as regression analysis, can be used to derive a relationship between the concentrations of mercury in fish to the mercury concentration in the water column. Table I-6 lists examples used in California. An example with national data by Brumbaugh et al. (Brumbaugh et al. 2001) is described in this section.

The U.S. Geological Survey analyzed mercury fish tissue data from 106 sites (mostly streams) across the U.S and developed a model using linear regression. A methylmercury concentration of 0.12 ng/L in water (non-filtered samples) was associated with a fish fillet mercury concentration of 0.3 mg/kg wet weight for age-3 fish when all species were considered. For age-3 largemouth bass (250 mm), a methylmercury concentration of 0.058 ng/L in water was associated with the 0.3 mg/kg fillet concentration in fish (Brumbaugh et al. 2001). Using the equation provided by Brumbaugh, in order to achieve the Sport Fish Water Quality Objective (0.2 mg/kg) in age-3 bass, the average aqueous methylmercury concentration would need to be 0.02 ng/L. This concentration is more than ten times lower than the methylmercury concentration derived from the U.S. EPA BAF for rivers and streams (0.3 ng/L MeHg, from Table I-4). This suggests that the water column concentrations derived with U.S. EPA BAF for rivers and streams maybe underprotective of many streams.

I.5 Comparison to TMDL Water Column Targets

In several established mercury/methylmercury TMDLs, water column targets were calculated with site-specific data (Table I-6). The targets can be compared to the target derived in this appendix. These TMDLs were based on targets or site-specific objectives that set a similar level of protection as the Sport Fish Water Quality Objective in the Provisions (see Section 3 of the Staff Report for more information on the TMDLs). Many of the water column targets in Table I-6 are roughly close (within an order of magnitude) to the water column target derived for lakes and rivers combined using the U.S. EPA draft national BAF (0.1 ng/L total methylmercury, shown in Table I-4).

Table I-6. Water Column Mercury or Methylmercury Targets from California TMDLs and Criteria

Water body, citation	Water Column targets (and sediment targets)	Calculation method
San Francisco Bay, San Francisco Bay Water Board 2006	No water column target	
Walker Creek, Soulajule Reservoir, and tributaries, San Francisco Bay Water Board 2008	0.04 ng/L **dissolved methylmercury** for Soulajule Reservoir. (Also 0.2-0.5 mg/kg total mercury in suspended sediment.)	U.S. EPA's national TL3 BAF of 1,300,000
Guadalupe Reservoir, San Francisco Bay Water Board 2008	1.5 ng/L **total methylmercury** as a hypolimnion seasonal maximum. (Also 0.2 mg/kg Hg in suspended sediment.)	TL3 BAF of 31,923, calculated with site specific data from the reservoir bottom (hypolimnion).
Clear lake, Central Valley Water Board 2002	No water column target (0.8-16 mg/kg dry weight sediment)	
Cache Creek, Central Valley Water Board 2005	0.14 ng/L **total methylmercury**	Linear regression of TL3 and TL4 fish tissue and water concentrations (site-specific)
Bear Creek, Central Valley Water Board 2004	0.06 ng/L **total methylmercury**	Linear regression using fish tissue and water concentrations (site-specific)
Harley Gulch, Central Valley Water Board 2004	0.09 ng/L **total methylmercury**	Site specific BAF of 570,000 for TL2/3 fish
Sacramento-San Joaquin Delta & Yolo Bypass, Central Valley Water Board 2010	0.06 ng/L **total methylmercury**	Linear regression of largemouth bass tissue and water concentrations (site-specific)
Sulfur Creek, Central Valley Water Board 2007	1,800 ng/L **total mercury** during low flow. High flow: 35 mg/kg total mercury in suspended sediment.	Estimated natural background
LA Lakes TMDL, U.S. EPA 2012	0.081 ng/L **dissolved methylmercury**	U.S. EPA national TL4 BAF of 2,700,000
Statewide, California Toxics Rule, 40 C.F.R. §131.38	51 ng/L or 50 ng/L **total mercury**	BCF* in California Toxics Rule of 7342.6

*BCF is a bioconcentration factor, which only accounts for direct absorption from water into organisms. A BCF does not account for accumulation up the food chain like a BAF.

However, none of these targets from TMDLs were used as the effluent limitation for municipal wastewater treatment plants and industrial dischargers (individual NPDES non-storm water permittees). Many of the TMDLs do not include wastewater and industrial dischargers, with the exception of mines. The only mercury/methylmercury TMDLs that include wastewater and industrial dischargers were for the San Francisco Bay, Sacramento-San Joaquin Delta & Yolo Bypass (listed above), and Calleguas Creek (Los Angeles Water Board 2006). As in the San Francisco Bay mercury TMDL, the Calleguas Creek TMDL did not translate the water quality objective into a water column concentration.

The water column targets from mercury/methylmercury TMDLs may have been derived with a site-specific BAF, regression analysis or other method (as listed in Table I-6). The methods used to calculate water column targets shown in Table I-6 generally depended on how much site specific data existed. A large amount of site-specific data enabled generation of linear models to extrapolate the water column targets or site-specific BAFs. In absence of much site-specific data, U.S. EPA's BAFs were often used.

The BAFs used in the TMDLs (listed in Table I-6) cannot be combined into one California BAF because they are based on fish from different trophic levels and some sites are exceptional. For example, Sulfur Creek is an area naturally very high in mercury. The other water column targets range from 0.06 - 0.14 ng/L for total methylmercury, except for Guadalupe Reservoir, which is 1.5 ng/L. The Guadalupe Reservoir target is much higher because the reservoir hypolimnium concentrations of methylmercury were used, which tended to be about 10 times higher than surface water concentrations. The Guadalupe Reservoir is also an exceptional case since it is extremely rich in mercury. It is located in the most productive mercury mining area in North America.

I.6 Translating the Subsistence Objectives

Water quality objectives are also being considered for tribal subsistence fishing and subsistence fishing by other communities (see Staff Report, Section 6.4 and 6.5). Table I-7 and Table I-8 show how these objectives can also be converted into water column concentrations using the U.S. EPA's BAFs and the California BAF and translators as in Sections I.3.

For tribal subsistence, the default application of the objective (0.04 mg/kg) is to 30% trophic level 4 and 70% trophic level 3 fish. Appendix H shows this is equivalent to 0.03 mg/kg in TL3 and 0.06 in TL4 fish (i.e. 70% of 0.03 mg/kg + 30% of 0.06 mg/kg = 0.04 mg/kg in the overall diet). This composition may be modified based on site-specific evidence. The subsistence objective for non-tribal subsistence fishing communities would need to be implemented on a case-by–case basis. The water column concentration should be calculated using procedures similar to the procedures shown in this appendix. Example water column concentrations are shown in Table I-8, which were calculated by applying an example water quality objective (0.05 mg/kg) to trophic level 4 fish.

Table I-7. Corresponding Water Column Concentrations for the Tribal Subsistence Mercury Objective by Ecosystem Type

	U.S. EPA BAFs				California BAF
	Lakes	Rivers	Estuaries	Lakes & Rivers	Rivers
Trophic Level 4 Fish tissue (mg/kg)	0.06	0.06	0.06	0.06	0.06
$MeHg_{dissolved}$ (ng/L)	0.010	0.050	NA	0.022	0.055
$MeHg_{total}$ (ng/L)	0.019	0.10	0.040*	0.040	0.11
Hg_{total} (ng/L)	0.33	3.6	0.12*	1.1	3.6

* derived from the lakes and rivers dissolved MeHg concentration of 0.026 ng/L (also shown in this table) since there was no BAF for estuaries.

Table I-8. Example Water Column Concentrations for the Subsistence fishing Mercury Objective by Ecosystem Type

	U.S. EPA BAFs				California BAF
	Lakes	Rivers	Estuaries	Lakes & Rivers	Rivers
Trophic Level 4 Fish tissue (mg/kg)	0.05	0.05	0.05	0.05	0.05
$MeHg_{dissolved}$ (ng/L)	0.0087	0.042	NA	0.019	0.045
$MeHg_{total}$ (ng/L)	0.016	0.085	0.034*	0.034	0.089
Hg_{total} (ng/L)	0.27	3.0	0.10*	0.88	3.0

* derived from the lakes and rivers dissolved MeHg concentration of 0.019 ng/L (also shown in this table) since there was no BAF for estuaries.

I.7 Uncertainties in BAFs

Three different approaches were used by U.S. EPA to estimate methylmercury BAFs for use in deriving national 304(a) ambient water quality criteria for mercury. All three approaches resulted in BAFs with central tendency point estimates in agreement with one another (see U.S. EPA 2001 for details). U.S. EPA acknowledged that there is at least an order of magnitude in the variability of the individual BAF estimates for a given trophic level, which leads to uncertainty in the overall central tendency estimate. This is further reflected in the range of 90 percent (5th and 95th percentiles) confidence intervals (Figure I-1).

U.S. EPA recognized that the approach taken to derive mercury BAFs collapses a very complicated non-linear process, which is affected by numerous physical, chemical, and biological factors, into a rather simplistic linear process. U.S. EPA also recognized that uncertainty exists in applying a national BAF to all water bodies of the United States. Therefore, U.S. EPA encourages and provided guidance for states, territories, authorized tribes, and other stakeholders to derive site-specific field-measured BAFs when possible (U.S. EPA 2000, U.S. EPA 2010). In addition, should stakeholders believe some other type of model may better predict mercury bioaccumulation on a site-specific basis they are encouraged to use one, provided it is scientifically justifiable and clearly documented with sufficient data. Additionally, Stephenson et al. described how there is more uncertainty associated with BAFs for bays and estuaries (Section I.1.3, Stephenson et al. 2009)

I.8 Recommendations

To calculate a water column target for methylmercury objectives, site-specific models for every water body would be ideal, but are impractical. A California specific BAF (or other model) would be the next preferred alternative, although the existing California BAF, shown in Figure I-1, is not as robust as the U.S. EPA BAF as discussed above. To generate a California BAF (or other model) of comparable quality to the U.S. EPA BAFs would require significant time and resources. Generally, the Water Board's monitoring programs have not collected fish mercury data and water samples simultaneously, so new data would need to be collected throughout the state. The best options available are the existing BAFs. The water column concentration resulting from the U.S. EPA BAFs were similar to the value for California, providing assurance that these values are fairly representative, despite the uncertainties described in Section I.7.

Although U.S. EPA derived separate lakes (lentic) and rivers (lotic) BAFs and translators, the use of one value for the whole state would be ideal for statewide consistency. Using a different translation depending on the water body type would be complicated since not all water bodies will fit neatly into one of the two categories (lakes vs. rivers), and one type of water body may be adjacent or upstream of another. Additionally, the BAF values for the lakes and rivers are not so different from each other. Figure I-1 shows that the range of values in the lakes and rivers categories overlaps. The use of a single BAF and translator for the whole state would make permitting less complex and promote statewide consistency.

To obtain one statewide water column target, the combined U.S. EPA BAF value for lakes and rivers was used. A water column target based on this approach would be 0.1 ng/L total methylmercury or 4 ng/L total mercury (Table I-4). This combined approach may be the most appropriate since most discharges will flow through multiple water body types. Estuaries likely require a lower concentration of methylmercury and rivers flow through estuaries before reaching the ocean. This approach offers more protection for downstream waters. Additionally, this value (0.1 ng/L of total methylmercury), agrees best with the water column targets derived for many mercury TMDLs in California: the Delta (0.06 ng/L), Cache creek (0.14 ng/L), Bear creek (0.09 ng/L), Harley Gulch (0.09 ng/L), LA Lakes (0.081 ng/L), and Soulajule Reservoir (0.04 ng/L) as shown in Table I-6.

On the other hand, the resulting water column target is to be used for effluent limitations for discharges from municipal wastewater treatment plants and industrial dischargers, most of which discharge into rivers or streams (see Appendix N), for which BAFs suggest less stringent requirements are needed. Only about 1% of wastewater and industrial discharges flow directly into reservoirs in the state and none flow into natural lakes. (Also another project is being developed to address impaired reservoirs, see Section 1.6 of the Staff Report.) Only about 7% of discharges flow into a water body that may be considered an estuary (see Appendix N).

Therefore, the second option is to use water column targets based on water body type. Using both California and U.S. EPA BAFs, the water column target based on rivers and streams would be 0.3 ng/L total methylmercury or 12 ng/L total mercury (Table I-4 and Section I.3). Since most discharges flow into rivers, streams or creeks, this would be the water column target applicable for most discharges. Discharges to lakes and reservoirs would almost entirely be addressed by a separate project, but could be calculated on a case-by case basis until the project is adopted. For slow moving waters, such as a bay or estuary that has slow moving water or a marsh, then a different water column translation would be needed. Site-specific information or the water column target from the combined U.S. EPA BAF (0.1 ng/L total methylmercury, or 4 ng/l total mercury) would be used for such situations. The advantage of this option is that most dischargers are not subject to requirements that may be over stringent, since most discharges flow into rivers, stream, or creeks. The other advantage is that the water column target for rivers, which would be most wildly used, is well supported by both national and California data.

The BAFs for Bays were not used to derive water column targets for the Provisions since they were added to the Staff Report subsequent to the scientific peer review. Also, these values are similar to the recommended water column targets; in fact the southern California bay BAF resulted in the same total mercury concentration (4 ng/L) as the U.S EPA combined data set for lakes and rivers (4 ng/L). Additionally, the authors noted that there may be greater uncertainty in the bay BAFs relating to the dynamic nature of bays and estuaries (Section I.1.3). These values could be used for site-specific water column target or with additional data these bay BAFs may be used in the future.

The recommended water column targets based on the Sport Fish Water Quality Objective (0.2 mg/kg in trophic level 4 fish, 150-500) should also be protective of wildlife since the Sport Fish Water Quality Objective is consistent with achieving the Prey Fish Water Quality Objective (0.05 mg/kg in fish, 50-150 mm) (see Section K.6.1 through Section K.6.6 of Appendix K). The water column targets are, on the whole, likely consistent with the California Least Tern Prey Fish Objective as well, since the Sport Fish Objective's fish tissue concentration value may be consistent with the California Least Tern Objective (0.03 mg/kg in fish less than 50 mm). However, data are not available to confirm that the Sport Fish Objective will protect the tern. That is why a separate objective is needed for the tern. Also, there is only a limited amount of data available on mercury levels in prey fish, so it seems unlikely that a robust water column target could be derived based on the two prey fish water quality objectives. The uncertainly in the BAF likely outweighs the differences between the Sport Fish Water Quality Objective and the two prey fish objectives.

For waters where the Tribal Subsistence Water Quality Objective or the Subsistence Fishing Water Quality Objective applies, different water column target may be needed. One of the values calculated in Section I.6 may be appropriate, although these objectives may be modified if adopted as a site-specific water quality objective or implemented as a narrative water quality objective. At this time the tribal subsistence fishing or subsistence fishing beneficial uses are not designated to any water body, since the uses themselves are not yet established.

References

Alpers CN, Stewart A., Saiki MK, Marvin-DiPasquale MC, Topping BR, Rider KM, Gallanthine SK, Kester CA, Rye, RO, Antweiler RC, De Wild JF. 2008. Environmental Factors Affecting Mercury in Camp Far West Reservoir, California, 2001–03: U.S. Geological Survey Scientific Investigations Report 2006-5008, 358 p. http://pubs.usgs.gov/sir/2006/5008/

Brumbaugh WG, Krabbenhoft DP, Helsel DR, Wiener JG, Echols KR. 2001. A National Pilot Study of Mercury Contamination of Aquatic Ecosystems Along Multiple Gradients: Bioaccumulation in Fish. USGS/BRD/BSR-2001-0009.

Central Valley Water Board (Central Valley Regional Water Quality Control Board). 2002. Amendments to the Water Quality Control Plan for the Sacramento River and San Joaquin River Basins for the Control of Mercury in Clear Lake (Lake County). Staff Report and Functional Equivalent Document. Final Report, December 2002. Rancho Cordova, CA.

Central Valley Water Board (Central Valley Regional Water Quality Control Board). 2004. Cache Creek, Bear Creek, and Harley Gulch TMDL for Mercury. Staff Report, November 2004. Rancho Cordova, CA.

Central Valley Water Board (Central Valley Regional Water Quality Control Board). 2005. Amendments to the Water Quality Control Plan for the Sacramento River and San Joaquin River Basins For The Control of Mercury in Cache Creek, Bear Creek, Sulphur Creek, and Harley Gulch. Staff Report, October 2005. Rancho Cordova, CA.

Central Valley Water Board (Central Valley Regional Water Quality Control Board). 2007. Sulphur Creek TMDL for Mercury. Final Staff report, January 2007. Rancho Cordova, CA.

Central Valley Water Board (Central Valley Regional Water Quality Control Board). 2010. Sacramento – San Joaquin Delta Estuary TMDL for Methylmercury. Staff Report, April 2010. Rancho Cordova, CA.

Kuwabara JS, Topping BR, Moon GE, Husby P, Lincoff A, Carter JL, Croteau MN. 2005. Mercury Accumulation by Lower Trophic-Level Organisms in Lentic Systems within the Guadalupe River Watershed, California: U.S. Geological Survey Scientific Investigations Report 2005-5037, 59 p. Also available at http://pubs.usgs.gov/sir/2005/5037/

Los Angeles Water Board (Los Angeles Regional Water Quality Control Board). 2006. Proposed Amendment to Water Quality Control Plan – Los Angeles Region, to Incorporate TMDL for Metals and Selenium in Calleguas Creek, its Tributaries and Mugu Lagoon. June 2006.

San Francisco Bay Water Board (San Francisco Bay Regional Water Quality Control Board). 2006. Mercury in San Francisco Bay. Adopted Basin Plan Amendment and Final Staff Report for Revised Total Maximum Daily Load (TMDL) and Mercury Water Quality Objectives. August 2006. San Francisco, California.

San Francisco Bay Water Board (San Francisco Bay Regional Water Quality Control Board). 2008. Guadalupe River Watershed Mercury Total Maximum Daily Load Project Basin Plan Amendment and Staff Report. October 2008. San Francisco, California.

San Francisco Bay Water Board (San Francisco Bay Regional Water Quality Control Board). 2008. Total Maximum Daily Load For Mercury In the Walker Creek Watershed Staff Report. With Minor Revisions, April 4, 2008. San Francisco, California.

Sanborn JR, Brodberg RK. 2006. Evaluation of Bioaccumulation factors and translators for methylmercury. Office of Environmental Health Hazard Assessment (OEHHA). March 2006.

Stephenson M, Negrey J, Hughes B. 2009. Spatial and temporal trends of methyl mercury in California bays and harbors: A bioaccumulation approach to assess fish and water quality. Prepared for: The State Water Resources Control Board, Division of Water Quality.

U.S. EPA (U.S. Environmental Protection Agency). 2000. Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health. EPA-822-B-00-004. October 2000. Office of Water, Office of Science and Technology, Washington, DC.

U.S. EPA (U.S. Environmental Protection Agency). 2001. Water Quality Criteria for the Protection of Human Health: Methylmercury. EPA-823-R-01-001. January 2002. Office of Water, Washington, DC.

U.S. EPA (U.S. Environmental Protection Agency). 2010. Guidance for Implementing the January 2001 Methylmercury Water Quality Criterion. EPA823-R-10-001 April 2010. Office of Water. Washington D.C.

U.S. EPA (U.S. Environmental Protection Agency). 2012. Los Angeles Area Lakes Total Maximum Daily Loads for Nitrogen Phosphorus, Mercury, Trash, Organochlorine Pesticides and PCBs. March 2012. San Francisco California. U.S. EPA Region IX.