Appendix 6F1

Mercury and Methylmercury Supplemental Analysis

This appendix describes the approach, data, assumptions, and analysis results of a supplemental sensitivity analysis for the Sites Reservoir Project Environmental Impact Report/Environmental Impact Statement (EIR/EIS) analysis of mercury and methylmercury. This supplemental analysis evaluates and validates data assumptions in Appendix 6F, *Mercury and Methylmercury*.

6F1-1 Objectives

Specific objectives for this supplemental analysis were to determine how alternative mercury input concentrations to the Sites Reservoir from the Sacramento River at Red Bluff and Hamilton City would change the estimated concentration of mercury and methylmercury that could occur in the reservoir and whether these changes would affect the impact determinations for mercury and methylmercury. This supplemental analysis was conducted to assess Project alternatives relative to the No Project Alternative.

6F1-1.1 Sensitivity Assessment Approach

Mercury and methylmercury surface water concentrations from the Sacramento River at Red Bluff and Hamilton City were used to estimate mercury concentrations in source water to the Sites Reservoir. These inflows could occur during most months of the year (i.e., September through June) and there are not statistically significant differences between concentrations during these months and all months for total mercury (t-test, $p>0.05$) or total methylmercury (t-test, $p>0.05$). The relationships between Sacramento River flow and mercury ($r^2=0.018$) or methylmercury ($r^2=0.052$) are also weak and are not statistically significant (**Figure 6F1-1** and **Figure 6F1-3**). Thus, all data (from all months of the year) were used to assess inflow concentrations from the Sacramento River to the Sites Reservoir in Appendix 6F.

Alternatively, the period of peak diversions from the Sacramento River to the Sites Reservoir are expected to occur from November through May. There are not statistically significant differences between concentrations during these months and all months for total mercury (t-test, $p>0.05$) or total methylmercury (t-test, $p>0.05$). The relationships between Sacramento River flow and mercury ($r^2=0.020$) or methylmercury ($r^2=0.066$) are also weak and are not statistically significant during these months (**Figure 6F1-2** and **Figure 6F1-4**). Nonetheless, the sensitivity analysis below calculated inflow concentrations that would occur with data limited to this November through May period of peak inflows to Sites Reservoir. Data and assumptions were the same as those reported in Appendix 6F. Quantitative analyses were conducted using the same methodology described in Appendix 6F. Qualitative analyses in Appendix 6F would not change and are not reiterated below. Assessment findings summaries are provided below.

6F1-2 Analysis Results and Discussion

This section discusses the results of the supplemental data analysis and its interpretation for making EIR/EIS impact determinations/effect determinations in each spatial domain.

6F1-2.1 Sites Reservoir Project Footprint

Water that would enter Sites Reservoir from the Sacramento River from the Red Bluff and Hamilton City diversion locations from November through May have geometric mean total mercury concentrations of 1.4 and 2.1 ng/L, respectively, and the 75th percentile concentrations are 1.9 and 3.5 ng/L. Geometric mean methylmercury concentrations in the Sacramento River from November through May are 0.045 ng/L and 0.072 ng/L at Red Bluff and Hamilton City, respectively, and the 75th percentile concentrations are 0.060 and 0.096 ng/L. CALSIM modeled data indicate that 73% of flow to Sites Reservoir would originate from Sacramento River diversions at Red Bluff and 27% from Hamilton City on an annual average basis. Based on these proportional flows, reasonable estimates of concentrations expected to enter the Sites Reservoir are from 1.6 to 2.3 ng/L total mercury and from 0.05 to 0.07 ng/L methylmercury based on the geometric mean and 75th percentile source water concentrations.

Estimated Long-Term Average Reservoir Mercury Concentrations

Total mercury concentrations in Sites Reservoir over the long term (i.e., 10 or more years after initial filling) are expected to range between the geometric mean and 75th percentile concentrations entering the reservoir from Sacramento River diversions. Thus, the expected long-term average total mercury concentration is 1.6 ng/L and a reasonable worst-case average total mercury concentration is 2.3 ng/L (**Table 6F1-1**).

An estimate of the long-term expected average methylmercury concentration in Sites Reservoir is twice the methylmercury concentration determined for average imports from the Sacramento River (i.e., two times 0.05 ng/L). This estimate of 0.10 ng/L accounts for methylmercury generation within the reservoir and is consistent with the range of methylmercury concentrations in nearby reservoirs (Appendix 6F, Table 6F-8).

Likewise, an estimate of the reasonable worst-case long-term methylmercury concentration of 0.14 ng/L is twice the 75th percentile of inflow concentrations (i.e., two times 0.07 ng/L). The term “reasonable worst-case” is not necessarily the maximum concentration that could occur at Sites Reservoir. Rather, it refers to an estimated upper bound of the expected average concentration based on the published literature and expected site-specific conditions.

There is inherent uncertainty associated with these estimated concentrations, and they may be conservative. For example, the Indian Valley Reservoir mean methylmercury concentration (0.09 ng/L) and maximum methylmercury concentration (0.19 ng/L), to which the estimated long-term average expected and worst-case methylmercury concentrations for Sites Reservoir are comparable, is from a watershed naturally enriched with mercury. The Sites Reservoir watershed and Sacramento River source water watershed are not enriched with mercury to the same level as the watershed for Indian Valley Reservoir (Chapter 12, *Geology and Soils*).

Estimated Short-Term Average Reservoir Mercury Concentrations

Both mercury and methylmercury concentrations are expected to be higher in the short term (i.e., over the first 10 years after filling) than in the long term due to mercury released from inundated

soils and methylmercury generation fueled by initial stores of organic carbon (Hall et al. 2005, State Water Resources Control Board 2017b). Thus, a reasonable estimate of expected average concentrations in the short term after filling (i.e., within 1–10 years) is that they will be twice the long-term average expected concentrations (Hall et al. 2005; State Water Resources Control Board 2017b). The expected short-term average total mercury concentration is therefore 3.2 ng/L (twice the long-term expected average concentration of 1.6 ng/L). Likewise, 4.6 ng/L is an estimated short-term reasonable worst-case average concentration for total mercury (twice the long-term reasonable worst-case average concentration of 2.3 ng/L). The short-term average methylmercury concentration is expected to be about 0.20 ng/L, and the reasonable worst-case short-term average methylmercury concentration is approximately 0.28 ng/L. A summary of estimated mercury and methylmercury concentrations in Sites Reservoir following filling is provided in Table 6F1-1 based on both November through May inflow concentrations and the inflow concentrations based on all Sacramento River data in Appendix 6F.

Assessment Summary for the Sites Reservoir Footprint

The assessment summary for the Sites Reservoir footprint does not change from that described in Appendix 6F when considering reservoir inflow concentrations of mercury and methylmercury from the Sacramento River from November through May. The summary bullets from Appendix 6F are restated below.

- Expected concentrations of total mercury do not exceed the California Toxics Rule (CTR) criterion of 50 ng/L and they would be within the ranges of mean total mercury concentrations found at other nearby reservoirs.
- Fish tissue methylmercury concentrations in the Sites Reservoir under each of the Project alternatives are expected be within the range observed at other nearby reservoirs and lakes where median tissue methylmercury normalized to 350 mm largemouth bass concentrations are approximately 0.47 mg/kg and exceed the 0.20 mg/kg ww sport fish objectives (State Water Resources Control Board 2017a).

6F1-2.2 Colusa Basin Drain

Total mercury discharges from the Project are not expected to exceed 4.6 ng/L, and the Project alternatives would not measurably increase long-term average concentrations in the Colusa Basin Drain (4.5 ng/L; Appendix 6F, Table 6F-4) relative to the No Project Alternative. Moreover, the Project would not cause exceedances of the lowest CTR criterion.

Mean methylmercury concentrations in the Colusa Basin Drain at Knights Landing were 0.17 ng/L prior to 1998 and 0.13 ng/L from 2000–2007 (Appendix 6F, Table 6F-6). These concentrations, representing the No Project Alternative, are greater than the long-term average expected methylmercury concentration (0.10 ng/L) and similar to the long-term reasonable worst-case methylmercury concentration (0.14 ng/L) estimated for Sites Reservoir. However, the expected short-term and reasonable worst-case short-term methylmercury concentrations that could be released from the Sites Reservoir (0.20 and 0.28 ng/L, respectively) would exceed long-term average concentrations in the Colusa Basin Drain.

Assessment Summary for the Colusa Basin Drain

The assessment summary for the Colusa Basin Drain does not change from that described in Appendix 6F when considering reservoir inflow concentrations of mercury and methylmercury

from the Sacramento River from November through May. The summary bullets from Appendix 6F are restated below.

- Surface water concentrations of total mercury in the Colusa Basin Drain (also applicable to the Tehama-Colusa Canal and Glenn-Colusa Irrigation District Main Canal) are expected to be reduced by the Project alternatives, relative to the No Project Alternative, and will not cause exceedances of the CTR criterion of 50 ng/L.
- In the short-term after initial reservoir inundation (i.e., 1–10 years), and under reasonable worst-cast conditions, average methylmercury concentrations may increase in the Colusa Basin Drain from about 0.13 ng/L up to about 0.28 ng/L due to the Project alternatives, relative to the No Project Alternative.
- Fish tissue methylmercury concentrations in the Colusa Basin Drain currently approach the California sport fish objective and may increase by a measurable amount under each of the Project alternatives, relative to the No Project Alternative, during the release period, at least over the short-term (i.e., <10 years). Therefore, the alternatives could potentially cause exceedances of the sport fish objective that would result in increased risk for adverse effects to humans and wildlife that consume Colusa Basin Drain fish during these years and months.
- The Colusa Basin Drain is included in the Section 303(d) list as impaired by mercury (State Water Resources Control Board 2017c). The Project alternatives may result in further increases in drain water column and fish tissue mercury concentrations when Sites Reservoir releases would be greatest (generally during May through November of drier years), such that impairments to WARM, COLD, and WILD beneficial uses could be made discernably worse.

6F1-2.3 Yolo Bypass

Total mercury concentrations in the Yolo Bypass were reported by the Central Valley Regional Water Quality Control Board (RWQCB) (2010) to have a mean concentration of 73.2 ng/L (Appendix 6F, Table 6F-4), which exceeds the lowest CTR surface water criterion of 50 ng/L. Exports from Sites Reservoir entering the Yolo Bypass, with a short-term reasonable worst-case total mercury concentration of 4.6 ng/L, would be less than these average concentration in the bypass. Likewise, exports from the Project with a short-term reasonable worst-case methylmercury average concentration of 0.28 ng/L would be less than the mean concentration in the Yolo Bypass of 0.35 ng/L (Appendix 6F, Table 6F-6).

Assessment Summary for the Yolo Bypass

The assessment summary for the Yolo Bypass does not change from that described in Appendix 6F when considering reservoir inflow concentrations of mercury and methylmercury from the Sacramento River from November through May. The summary bullets from Appendix 6F are restated below.

- Surface water concentrations of total mercury in the Yolo Bypass are not expected to substantially increase due to the Project alternatives, relative to the No Project Alternative, and will not cause exceedances of the lowest CTR criterion of 50 ng/L.
- Surface water concentrations of methylmercury are not expected to substantially increase in the Yolo Bypass due to the Project alternatives, relative to the No Project Alternative.

- Fish tissue methylmercury concentrations in the Yolo Bypass exceed the Central Valley RWQCB methylmercury total maximum daily load (TMDL) objectives. The Project alternatives are not expected to cause measurable increases in fish tissue mercury concentration relative to the No Project Alternative.
- The Yolo Bypass is included in the Section 303(d) list as impaired by mercury (State Water Resources Control Board 2017c). Mercury in water and fish tissues within the bypass are not expected to be further degraded on a long-term basis due to the Project alternatives, relative to levels of the No Project Alternative.

6F1-2.4 Delta

Sites Reservoir releases would be substantially diluted by the Sacramento River when they reach the Delta Sites. Thus, even the conservative reasonable worst-case short-term total mercury concentration of 4.6 ng/L, based on November through May input concentrations, would not increase the average total mercury concentration entering the Delta from the Sacramento River of 4.5 ng/L (Appendix 6F, Table 6F-4). Whereas, methylmercury releases from Sites Reservoir ranging from 0.10 to 0.28 ng/L, based on November through May input concentrations, could cause slight increases Sacramento River methylmercury concentrations at Freeport above the long-term average concentration of 0.069 ng/L (Appendix 6F, Table 6F-6). Potential impacts associated with these methylmercury concentrations entering the Delta are discussed as part of the supplemental quantitative analysis below.

Modeled Long-Term Average Water Column and Fish Tissues

Surface water methylmercury concentrations at Freeport for each Project alternative and the No Project Alternative based on CALSIM model output data are shown in **Figure 6F1-5**. Using these modeled surface water methylmercury concentrations at Freeport, tissue methylmercury concentrations in 350 mm largemouth bass were calculated with the Central Valley RWQCB TMDL model (2010). Fish tissue methylmercury concentrations at Freeport from these calculations are presented in **Figure 6F1-6**.

The predicted No Project Alternative methylmercury concentration in 350 mm largemouth bass is 0.26 mg/kg ww based on an exposure concentration of 0.069 ng/L, the long-term geometric mean methylmercury concentration at Freeport. Water column methylmercury at Freeport is estimated to increase by no more than 5% (to about 0.072 ng/L) from the alternatives, on a long-term average basis, relative to the No Project Alternative. The resulting long-term average fish tissue methylmercury concentrations calculated with the Central Valley RWQCB TMDL model (2010) would not increase by more than about 8% (to about 0.28 mg/kg ww) due to the Project alternatives, relative to the No Project Alternative (Figure 6F1-6). These potential changes associated with Project alternatives do not differ substantially, and likely not measurably, from the No Project Alternative. Consequently, the Project alternatives are not expected to result in long-term differences in water column or fish tissue methylmercury concentrations at Freeport, relative to the No Project Alternative, that would be measurable by a typical field monitoring program.

Reasonable Worst-Case Water Column and Fish Tissues

The preceding analysis is based upon changes in long-term annual average concentrations in the Sacramento River at Freeport. This reflects long-term trends but does not capture the conditions

that could occur during drought or extended drought conditions. Sites Reservoir exports to the Delta, or intended for the south Delta pumping facilities, would be greatest during the summer and fall months of Dry and Critically Dry Water Years when Sacramento River flows are relatively low. To account for these flow conditions, surface water and fish tissue methylmercury concentrations were modeled using the mean monthly flows in the Sacramento River at Freeport and exports from the Sites Reservoir in May through November of Dry and Critically Dry Water Years. While this 7-month period is sufficiently long that fish tissue methylmercury concentrations could overcome the lag-effect and be affected by changes in surface water methylmercury concentrations, the effect could be transient and fish tissue concentrations would return to lower concentrations when Sacramento River flows increase, relative to Sites Reservoir exports, and surface water mercury concentrations decrease.

Results of this supplemental sensitivity analysis for the Sacramento River at Freeport under low-flow conditions are illustrated in Figures 6F1-7 and 6F1-8 for surface water and fish tissue methylmercury, respectively. All Project alternatives would increase surface water methylmercury concentrations at Freeport to some degree during summer and fall months of Dry and Critically Dry Water Years. These increases would range from approximately 3% above the No Project Alterative when Sites Reservoir releases have the long-term expected methylmercury concentration of 0.10 ng/L, to a 23% increase above the No Project Alterative with the short-term reasonable worst-case methylmercury concentration of 0.28 ng/L. Likewise, fish tissue methylmercury concentrations could increase by about 5% above the No Project Alterative when Sites Reservoir releases have the long-term expected methylmercury concentration of 0.10 ng/L, and up to about 40% above the No Project Alterative when Sites Reservoir releases have the short-term reasonable worst-case methylmercury concentration of 0.28 ng/L.

Assessment Summary for the Delta

The assessment summary for the Sites Reservoir footprint does not change from that described in Appendix 6F when considering reservoir inflow concentrations of mercury and methylmercury from the Sacramento River from November through May. The summary bullets from Appendix 6F are restated below.

- Surface water concentrations of total mercury in the Delta associated with the Project alternatives are expected to be consistent with or below Delta total mercury concentrations under the No Project Alternative and the Project will not cause exceedances of the lowest CTR criterion of 50 ng/L.
- Surface water and fish tissue concentrations of methylmercury in the Delta associated with Project alternatives are not expected to result in measurable differences in the long-term average concentrations, relative to the No Project Alternative.
- Surface water concentrations of methylmercury in the north Delta may increase due to the Project alternatives, relative to the No Project Alternative, in Dry and Critically Dry Water Years during periods of peak releases. Such increases may result in measurable increases in the body burdens of methylmercury in fish which could potentially increase risks of adverse effects on humans and wildlife that consume Delta fish during these periods.
- Fish tissue methylmercury concentrations in the Delta currently exceed the Central Valley RWQCB methylmercury TMDL objectives. The Project alternatives may cause measurable degradation of water quality with respect to methylmercury concentrations in fish, relative to

the No Project Alternative in the north Delta, in Dry and Critically Dry Water Years during periods of peak releases, potentially causing exceedances of the methylmercury TMDL fish tissue objectives to occur more frequently and/or by greater magnitudes during these periods.

- The Delta is included in the Section 303(d) list as impaired by mercury (State Water Resources Control Board 2017c). Water quality may be degraded by measurable levels of mercury or methylmercury on a long-term basis in the north Delta due to the Project alternatives, relative to the No Project Alternative, such that impairments to WARM, COLD, WILD, and COMM beneficial uses could be made discernably worse.

6F1-3 References

Central Valley Regional Water Quality Control Board (Central Valley RWQCB). 2010. *Sacramento–San Joaquin Delta Estuary TMDL for Methylmercury*. Final Staff Report. April. Prepared by Wood, M., C. Foe, J. Cooke, and S. Louie. Available: https://www.waterboards.ca.gov/rwqcb5/water_issues/tmdl/central_valley_projects/delta_hg/archived_delta_hg_info/april_2010_hg_tmdl_hearing/apr2010_tmdl_staffrpt_final.pdf.

Hall, B. D., V. L. St. Louis, K. R. Rolfhus, R. A. Bodaly, K. G. Beaty, M. J. Paterson, and K. A. Peech Cherewyk. 2005. Impacts of Reservoir Creation on the Biogeochemical Cycling of Methyl Mercury and Total Mercury in Boreal Upland Forests. *Ecosystems* 8:248–266. DOI: 10.1007/s10021-003-0094-3.

State Water Resources Control Board. 2017a. *Appendix A: Final Staff Report: Part 2 of the Water Quality Control Plan for Inland Surface Waters, Enclosed Bays, and Estuaries of California – Tribal and Subsistence Fishing Beneficial Uses and Mercury Provisions*. Available: https://www.waterboards.ca.gov/water_issues/programs/mercury/docs/hg_prov_final.pdf.

State Water Resources Control Board. 2017b. *Draft Staff Report for Scientific Peer Review for the Amendment to the Water Quality Control Plan for Inland Surface Waters, Enclosed Bays, and Estuaries of California, Mercury Reservoir Provisions - Mercury TMDL and Implementation Program for Reservoirs*. Available: https://www.waterboards.ca.gov/water_issues/programs/mercury/reservoirs/.

State Water Resources Control Board. 2017c. *2014 and 2016 California Integrated Report (Clean Water Act Section 303(d) List and 305(b) Report)*. Available: https://www.waterboards.ca.gov/water_issues/programs/tmdl/integrated2014_2016.shtml.

Table 6F1-1. Estimated Concentrations of Total Mercury and Methylmercury in Sites Reservoir.

Estimated Concentration	Based on source water concentrations in the Sacramento River (all data 1999–2016)		Based on average source water concentrations in the Sacramento River (November–May* 1999–2016)	
	Short-Term (1–10 years after filling) (ng/L)	Long-Term Average (>10 years after filling) (ng/L)	Short-Term (1–10 years after filling) (ng/L)*	Long-Term Average (>10 years after filling) (ng/L)
Expected Total Mercury	2.8	1.4	3.2	1.6
Reasonable Worst-case Total Mercury	3.6	1.8	4.6	2.3
Expected Methylmercury	0.16	0.08	0.20	0.10
Reasonable Worst-case Methylmercury	0.24	0.12	0.28	0.14

* Primary months with Sacramento River flows expected to fill Sites Reservoir.

L = liter; ng = nanograms.

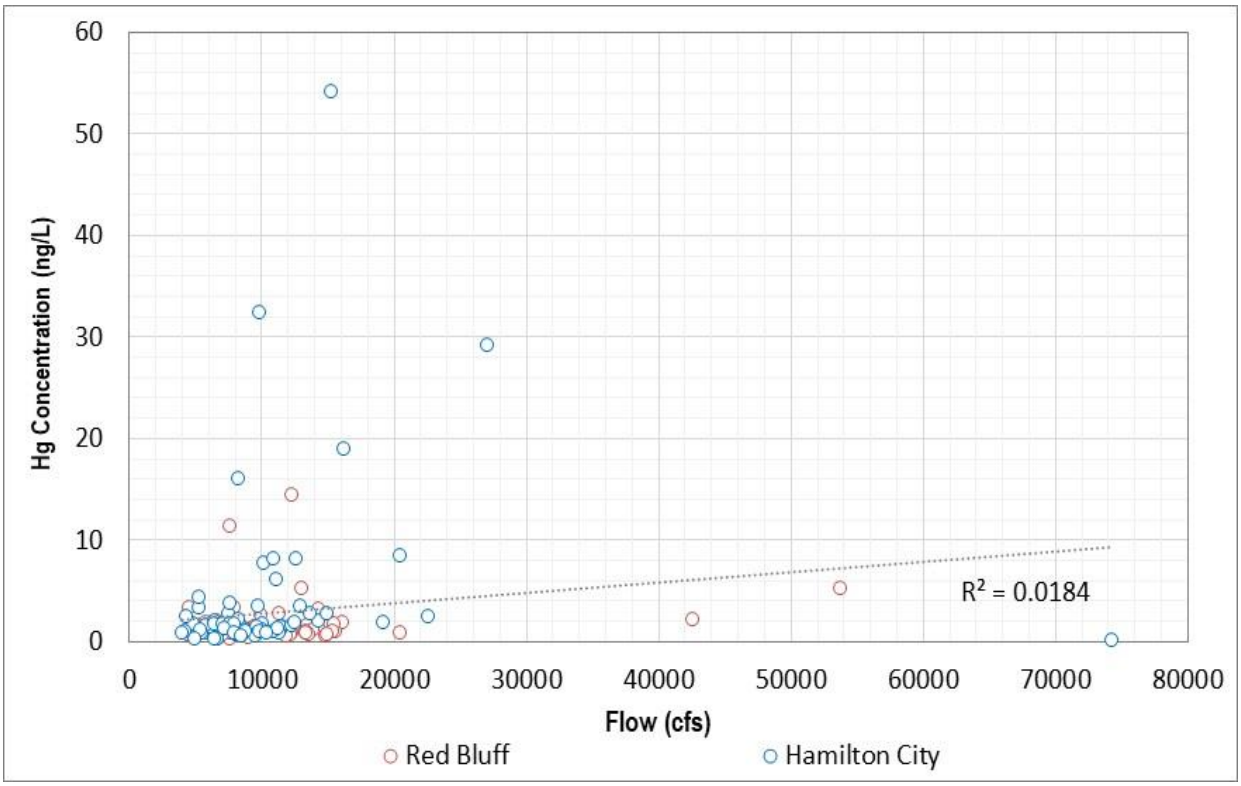

Figure 6F1-1. Total Mercury vs. Flow in the Sacramento River at Hamilton City and Red Bluff (1999–2016).

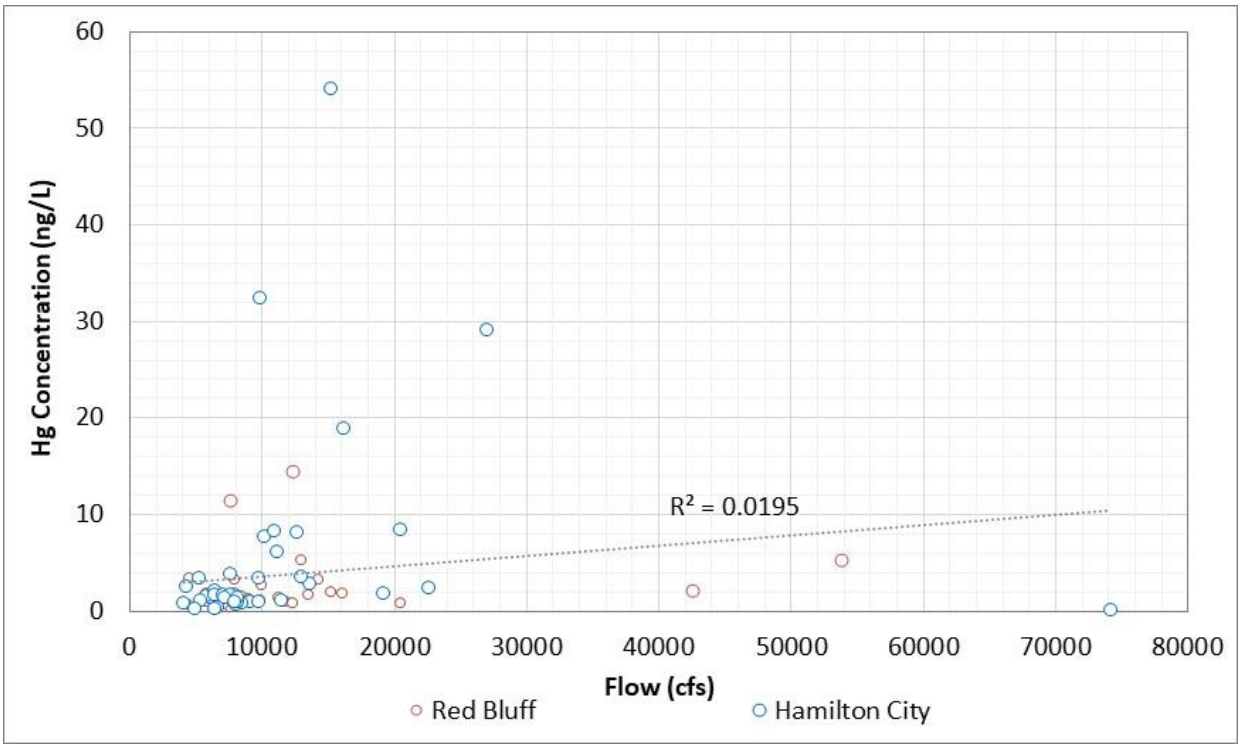

Figure 6F1-2. Total Mercury vs. Flow in the Sacramento River at Hamilton City and Red Bluff (November–May, 1999–2016).

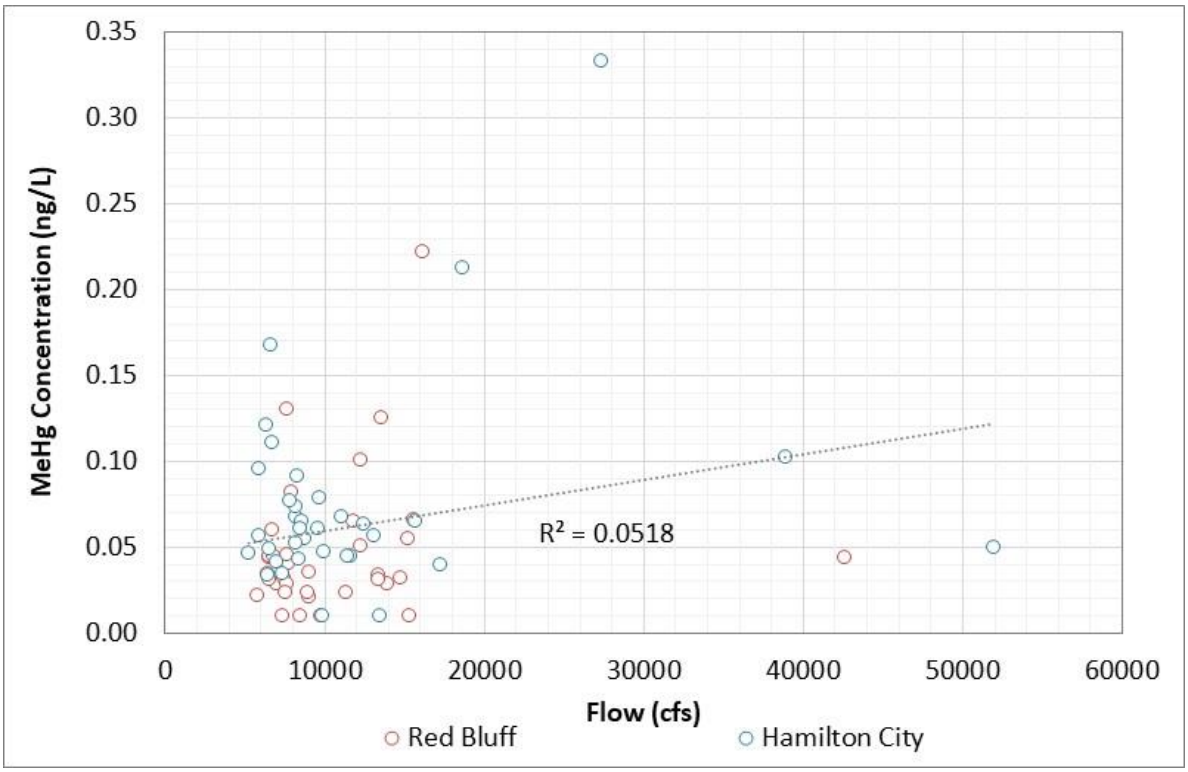

Figure 6F1-3. Methylmercury vs. Flow—Sacramento River at Hamilton City and Red Bluff (2000–2007).

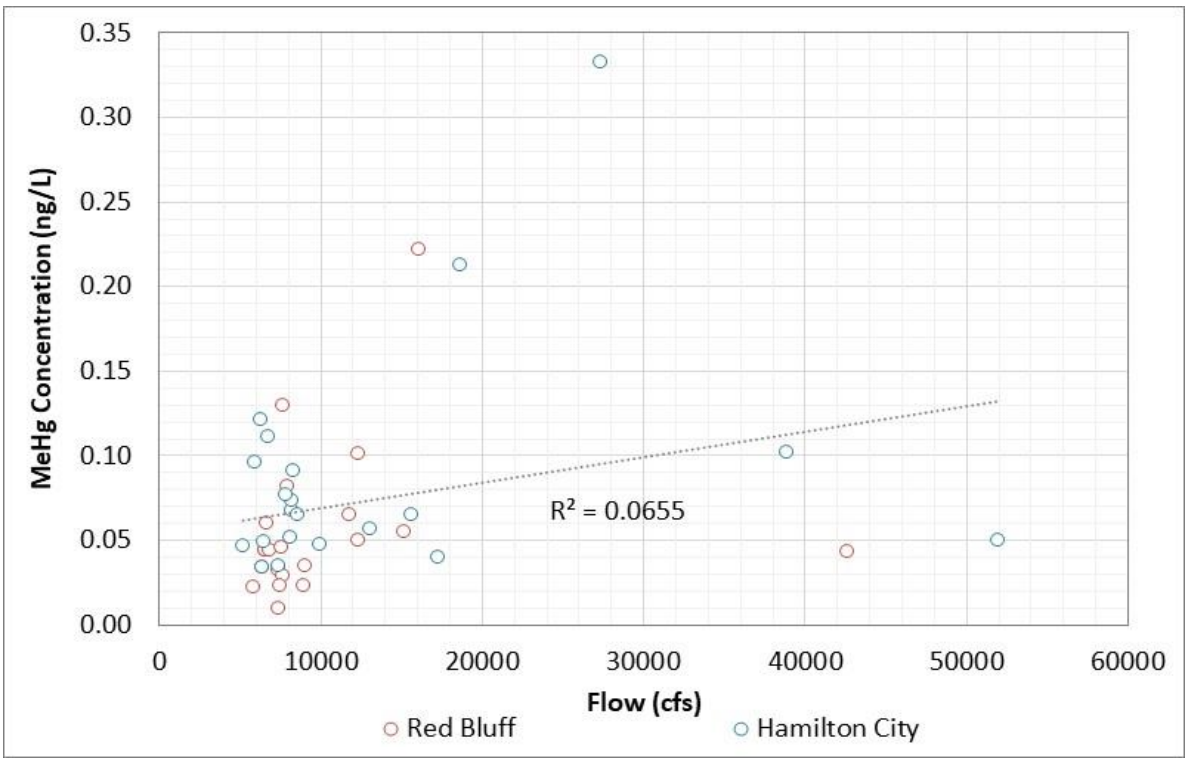

Figure 6F1-4. Methylmercury vs. Flow—Sacramento River at Hamilton City and Red Bluff (November–May 2000–2007).

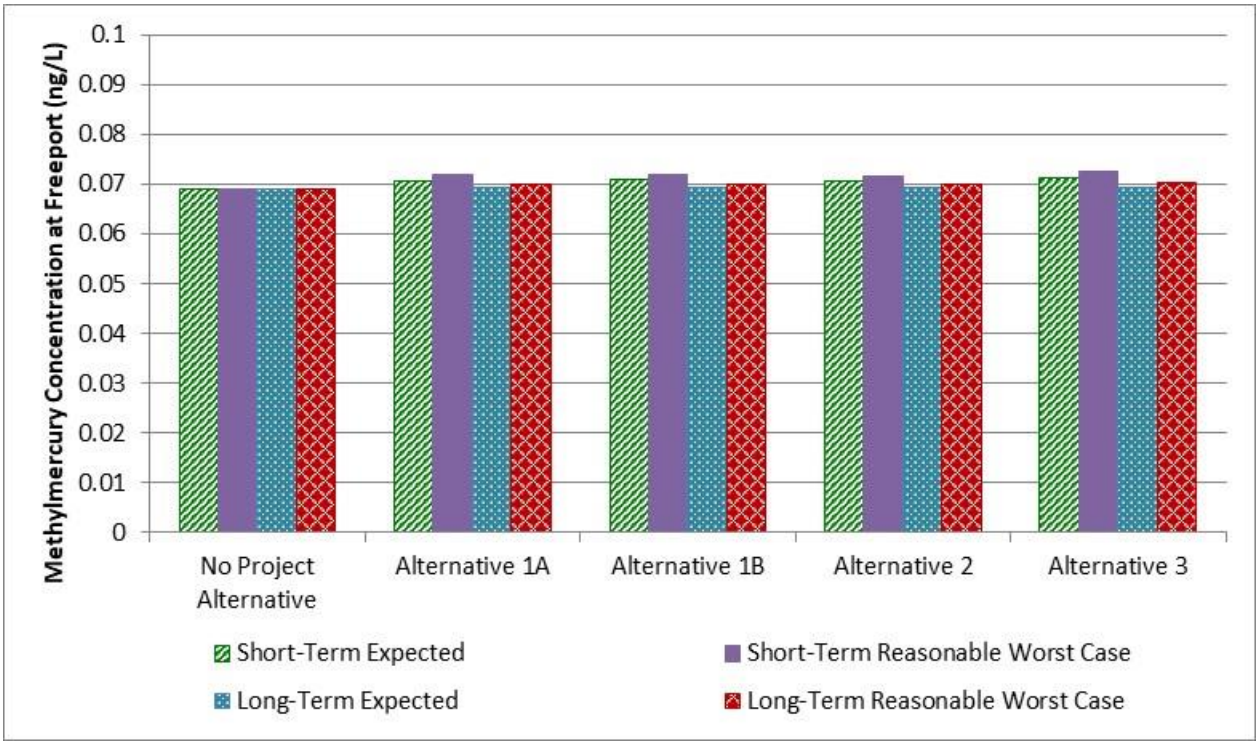

Figure 6F1-5. Estimated Surface Water Methylmercury Concentrations at Freeport for Alternatives and the No Project Alternative for Annual Average Flows with Sites Reservoir Mercury Concentration Estimates Based on November–May Inflows.

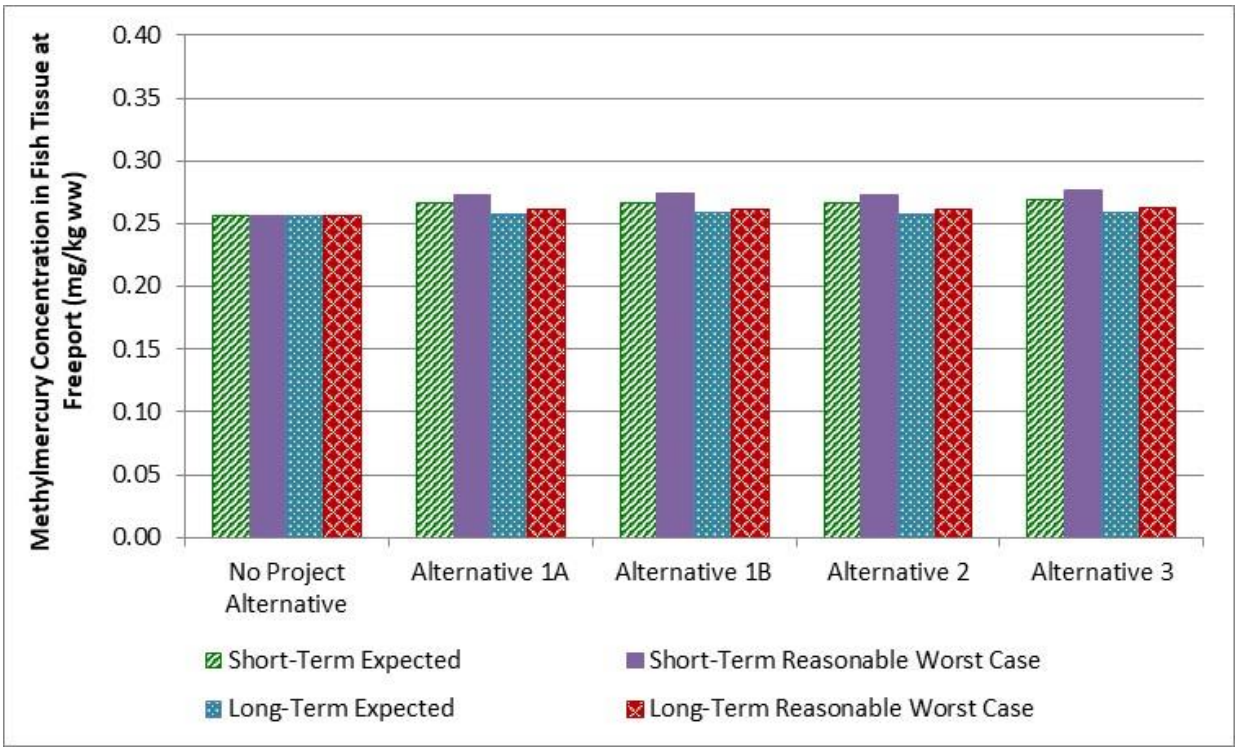

Figure 6F1-6. Estimated Fish Tissue Methylmercury Concentrations at Freeport for Alternatives and the No Project Alternative for Annual Average Flows with Sites Reservoir Mercury Concentration Estimates Based on November–May Inflows.

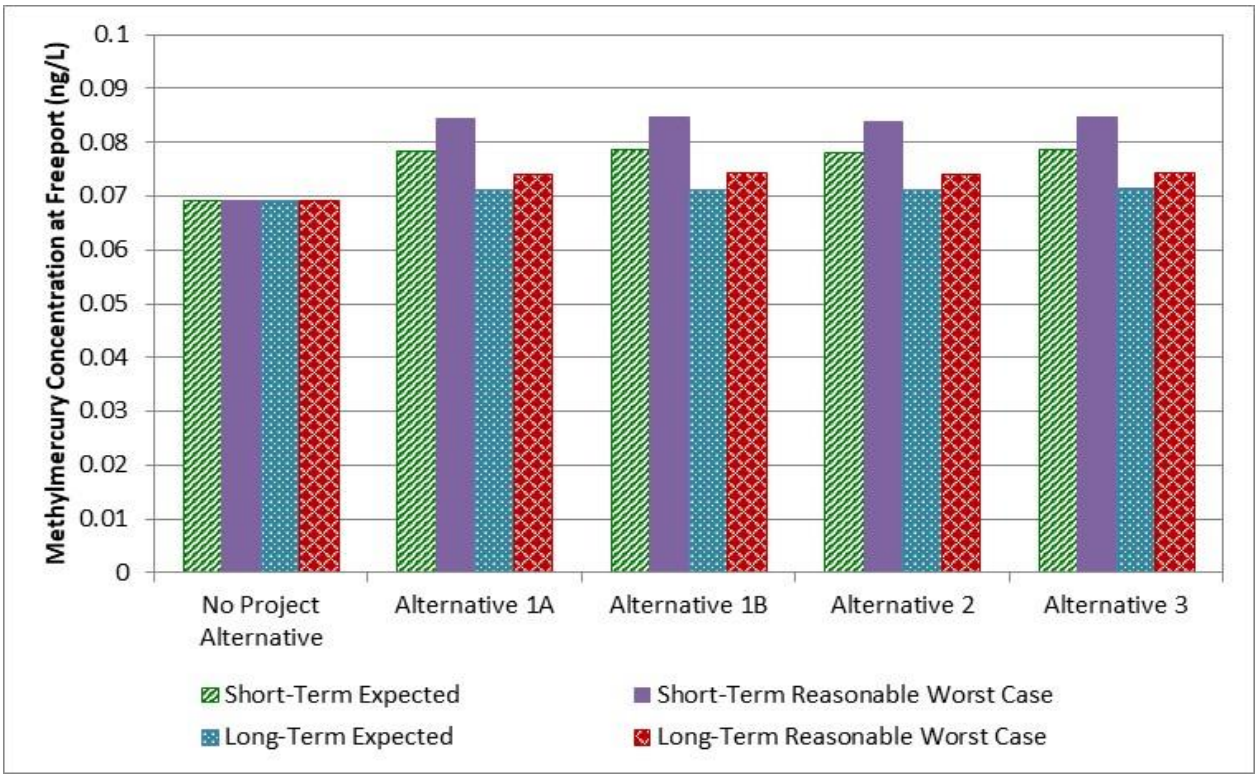

Figure 6F1-7. Estimated Surface Water Methylmercury Concentrations at Freeport for Alternatives and the No Project Alternative for Mean Monthly Flows in May–November of Dry and Critically Dry Water Years with Sites Reservoir Mercury Concentration Estimates Based on November–May Inflows.

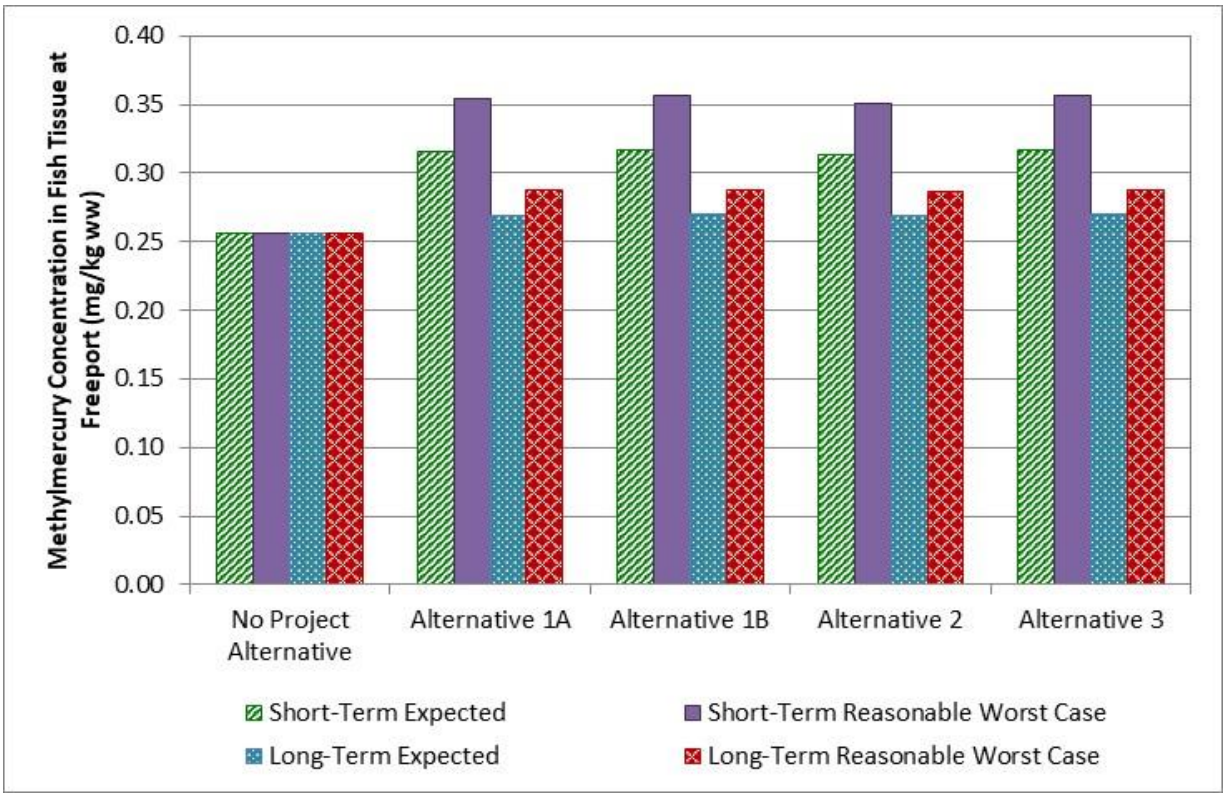

Figure 6F1-8. Estimated Fish Tissue Methylmercury Concentrations at Freeport for Alternatives and the No Project Alternative for Mean Monthly Flows in May–November of Dry and Critically Dry Water Years with Sites Reservoir Mercury Concentration Estimates Based on November–May Inflows.