Appendix 6E Water Quality Data

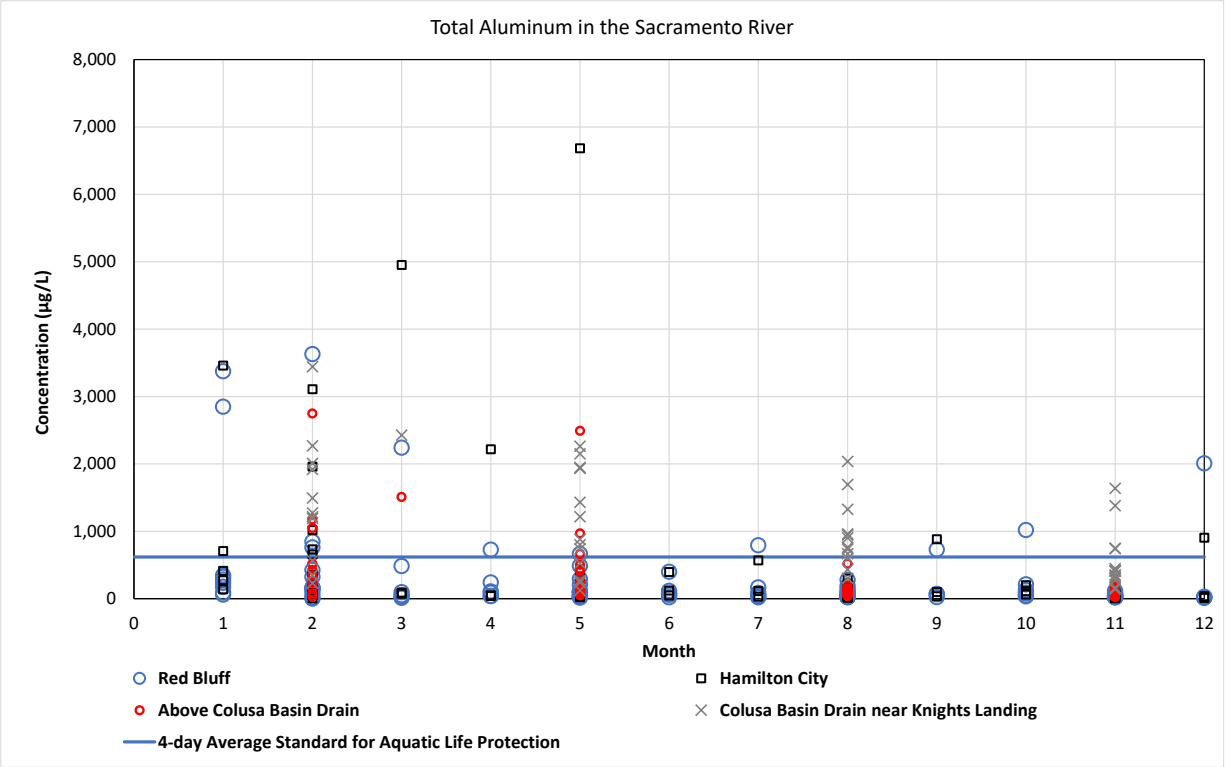

Figure 6E-1. Measured Total Aluminum in the Sacramento River and Colusa Basin Drain

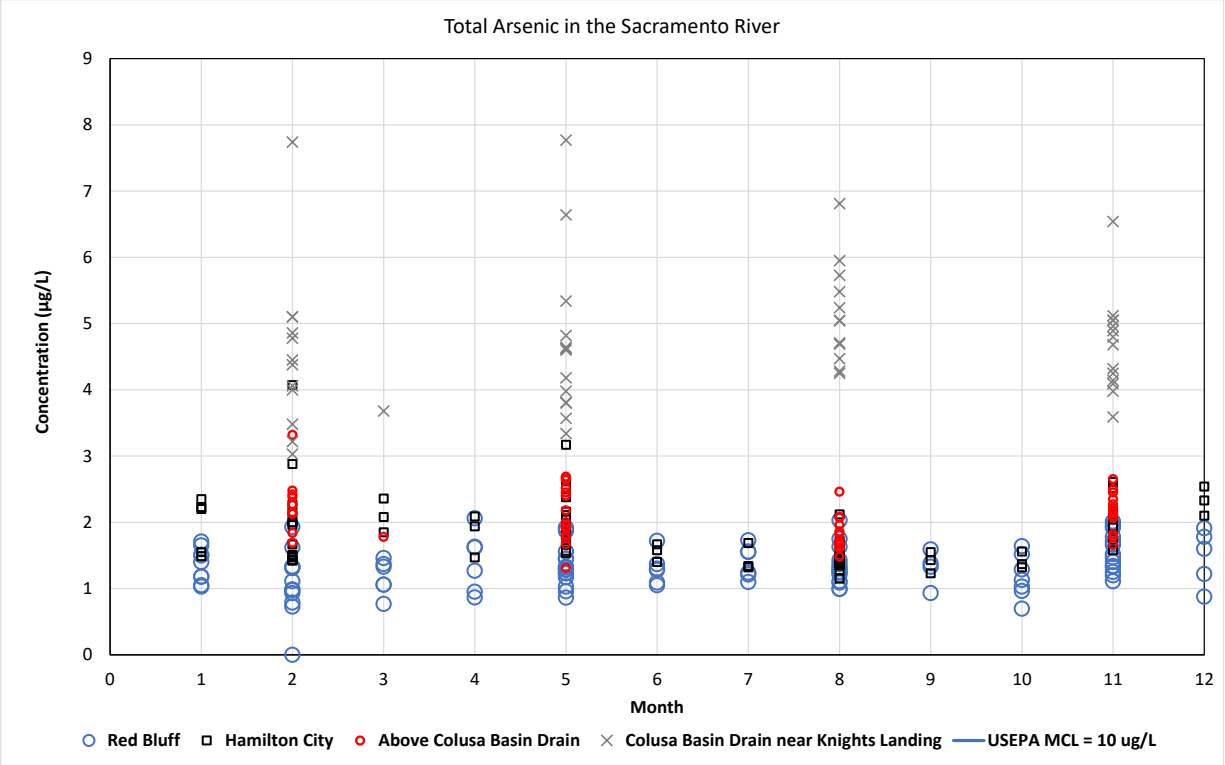

Figure 6E-2. Measured Total Arsenic in the Sacramento River and Colusa Basin Drain

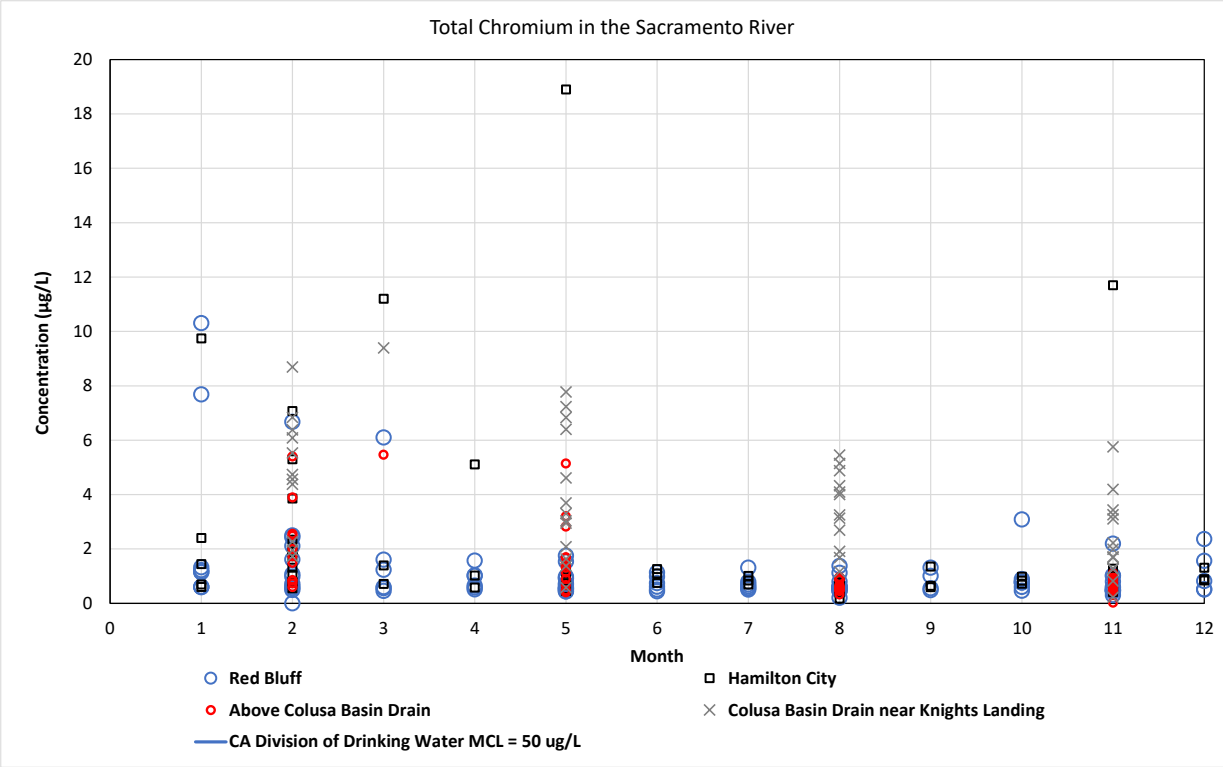

Figure 6E-3. Measured Total Chromium in the Sacramento River and Colusa Basin Drain

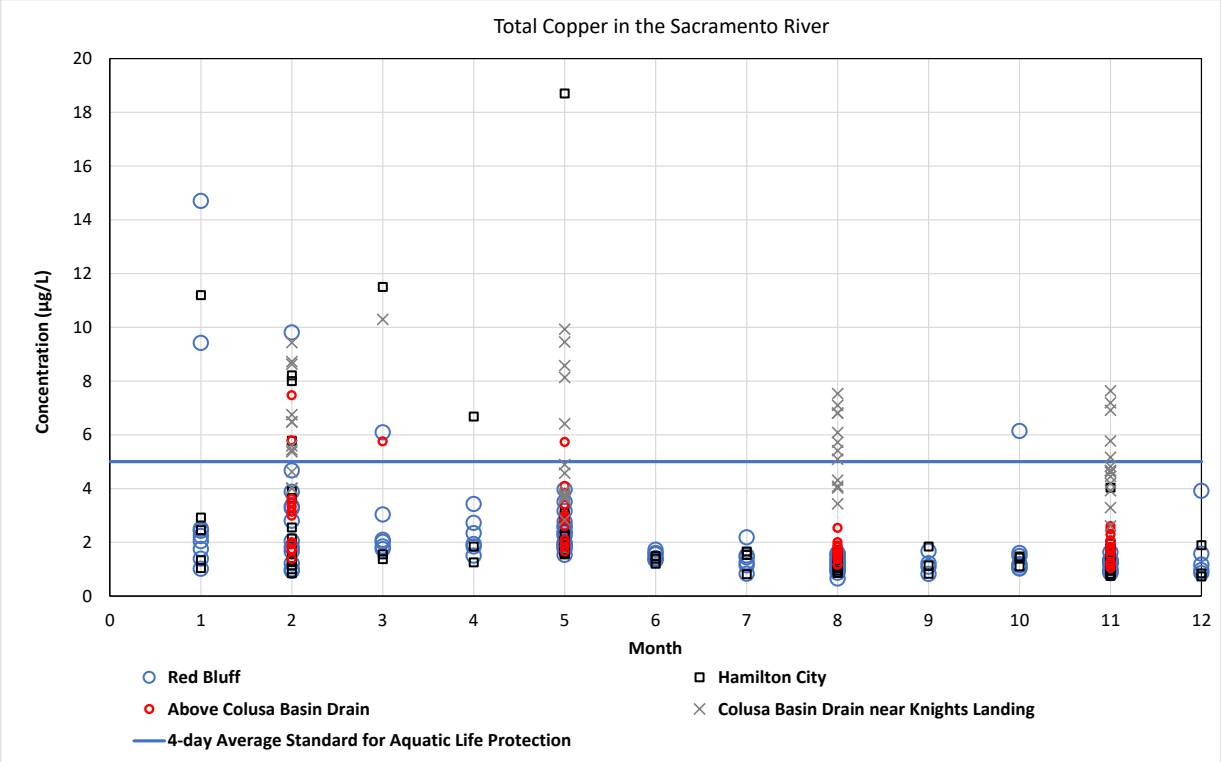

Figure 6E-4. Measured Total Copper in the Sacramento River and Colusa Basin Drain

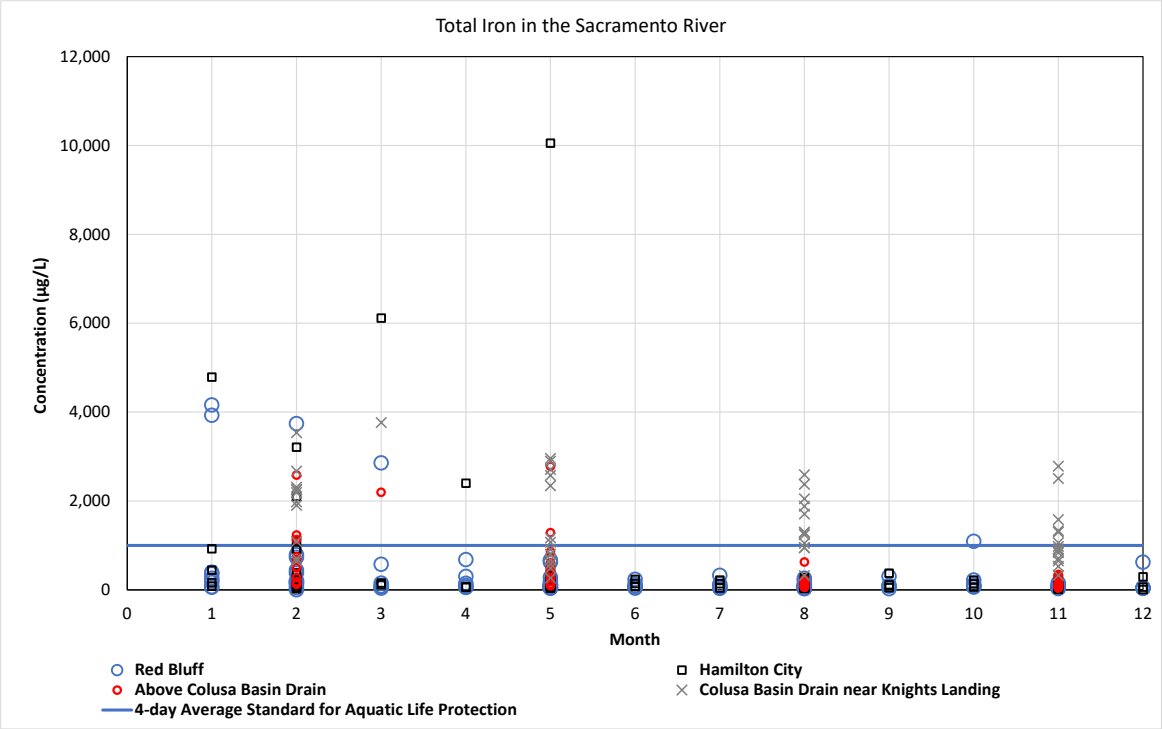

Figure 6E-5. Measured Total Iron in the Sacramento River and Colusa Basin Drain

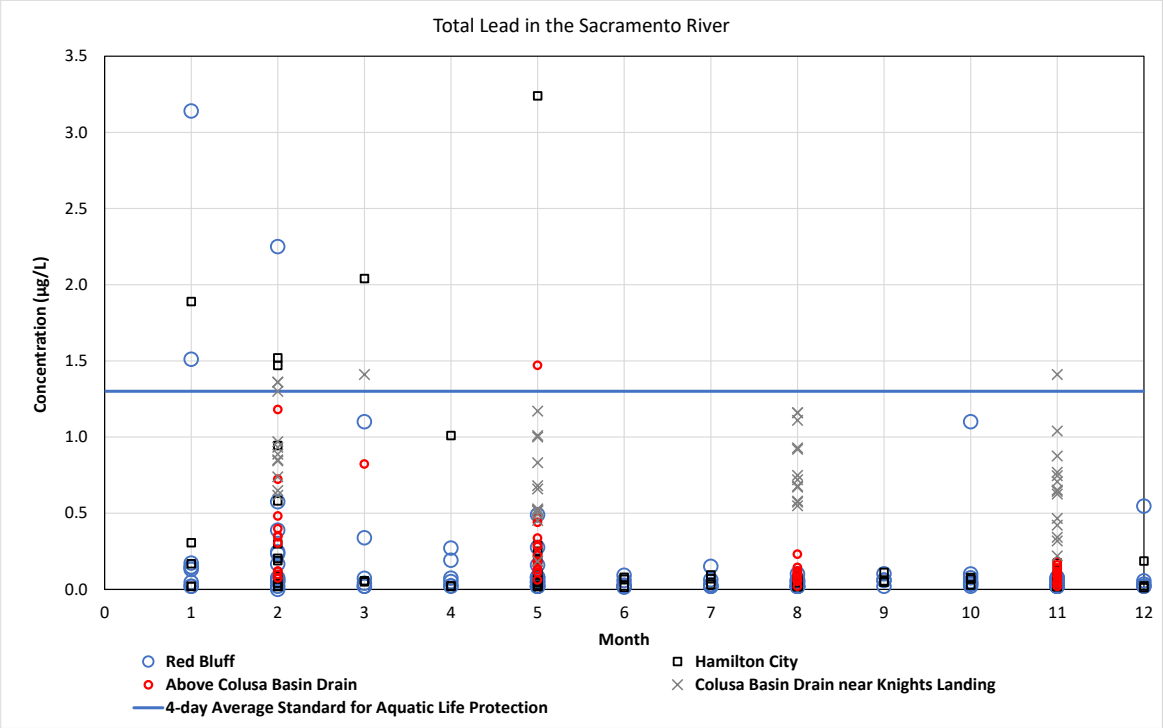

Figure 6E-6. Measured Total Lead in the Sacramento River and Colusa Basin Drain

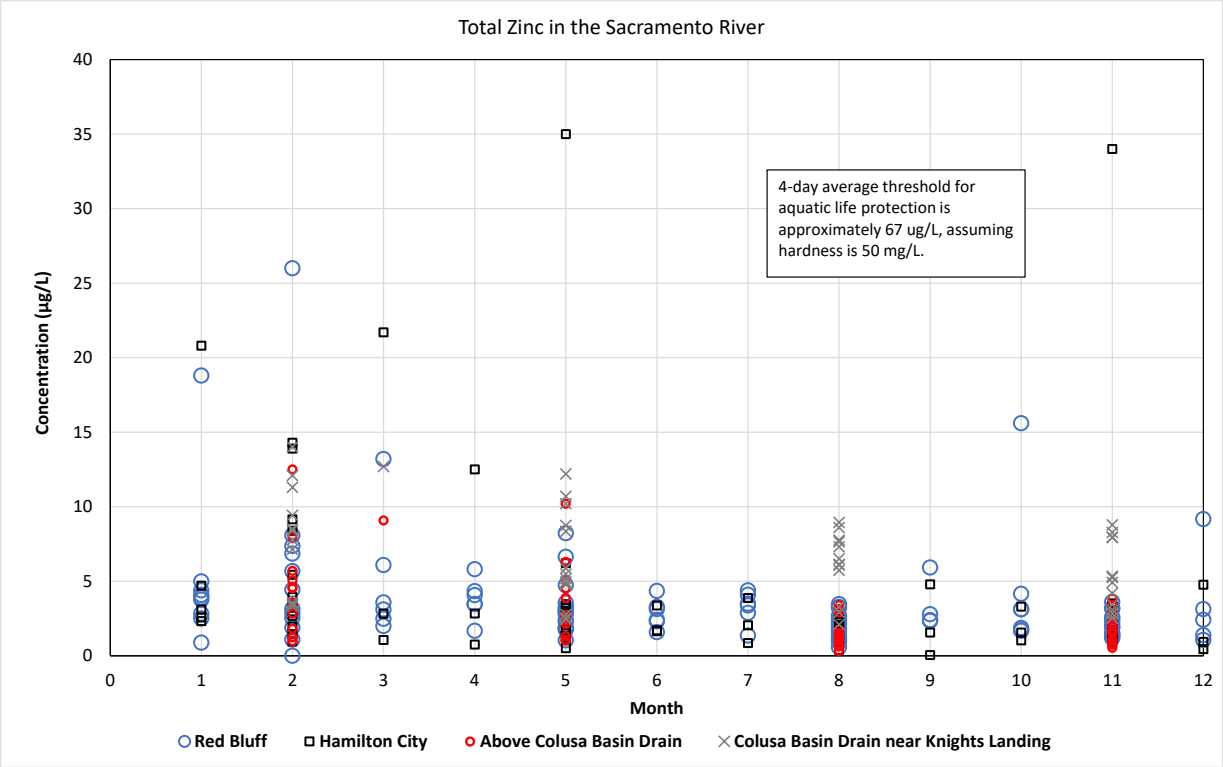

Figure 6E-9. Measured Total Zinc in the Sacramento River and Colusa Basin Drain

Table 6E-7. Metal Concentrations (µg/L) Reported from Groundwater 15 Wells in the Sites Reservoir Inundation Area during 2005

Metal/Metalloid	Count	Minimum	Average	Maximum
Dissolved Aluminum	15	0.5	3.02	15.2
Total Aluminum	15	0.57	12.04	89
Dissolved Arsenic	15	0.259	0.68	2.02
Total Arsenic	15	0.284	0.80	2.63
Dissolved Cadmium	15	0.0045	0.02	0.081
Total Cadmium	15	0.0045	0.05	0.165
Dissolved Chromium	15	0.06	2.61	5.6
Total Chromium	15	0.65	3.31	7.14
Dissolved Copper	15	0.14	2.70	11.1
Total Copper	15	0.21	3.37	16.2
Dissolved Iron	15	1.59	7.28	41
Total Iron	15	0.54	80.72	388
Dissolved Lead	15	0.0045	0.12	0.52
Total Lead	15	0.0135	0.27	1.85
Dissolved Manganese	15	0.06	17.77	107
Total Manganese	15	0.09	20.64	125
Dissolved Nickel	15	0.1	1.04	4.01
Total Nickel	15	0.13	1.26	4.02
Dissolved Selenium	15	1.01	4.55	25.3
Total Selenium	15	1.32	5.03	25.6
Dissolved Silver	15	0.001	0.00	0.014
Total Silver	15	0.0025	0.01	0.026
Dissolved Zinc	15	0.04	112.48	737
Total Zinc	15	0.129	115.19	748

Source: California Department of Water Resources 2007.
Note: Values less than detection limits were assumed to equal half the detection limit.
µg/L = micrograms per liter

6E.4 Metals Data Versus Flow

The following graphs were created to evaluate the relationship between flow and total metal concentrations. Flow in the Sacramento River at Keswick (U.S. Geological Survey [USGS] Station 11370500) was used to represent magnitude of flow and the ratio of flow in the Sacramento River at Keswick to flow in the Sacramento River at Bend Bridge (USGS station 11377100) was used to indicate the amount of runoff from local tributaries (with a lower number indicating more runoff from local tributaries). The first graph below shows the relationship between these two metrics.

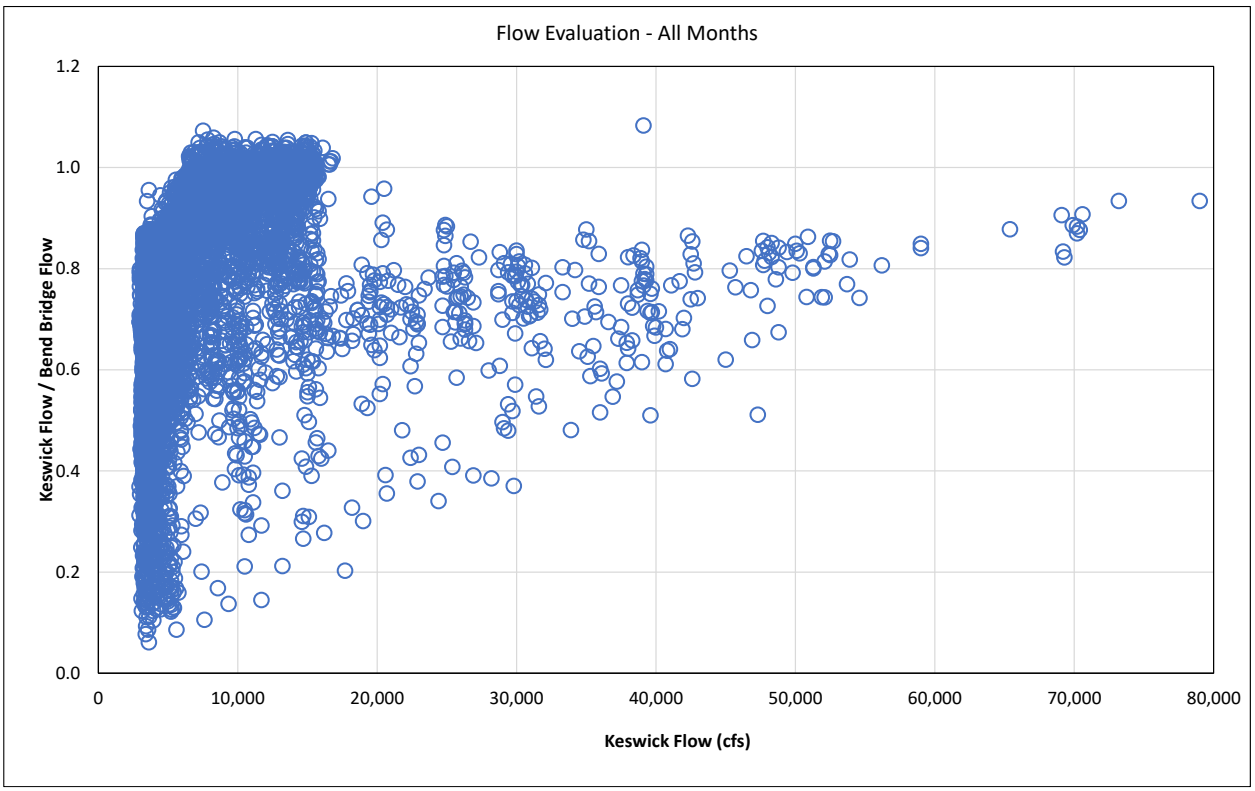

Figure 6E-10. Relationship between Measured Sacramento River Flow at Keswick and an Indicator of Local Runoff (Keswick Flow/Sacramento River flow at Bend Bridge)

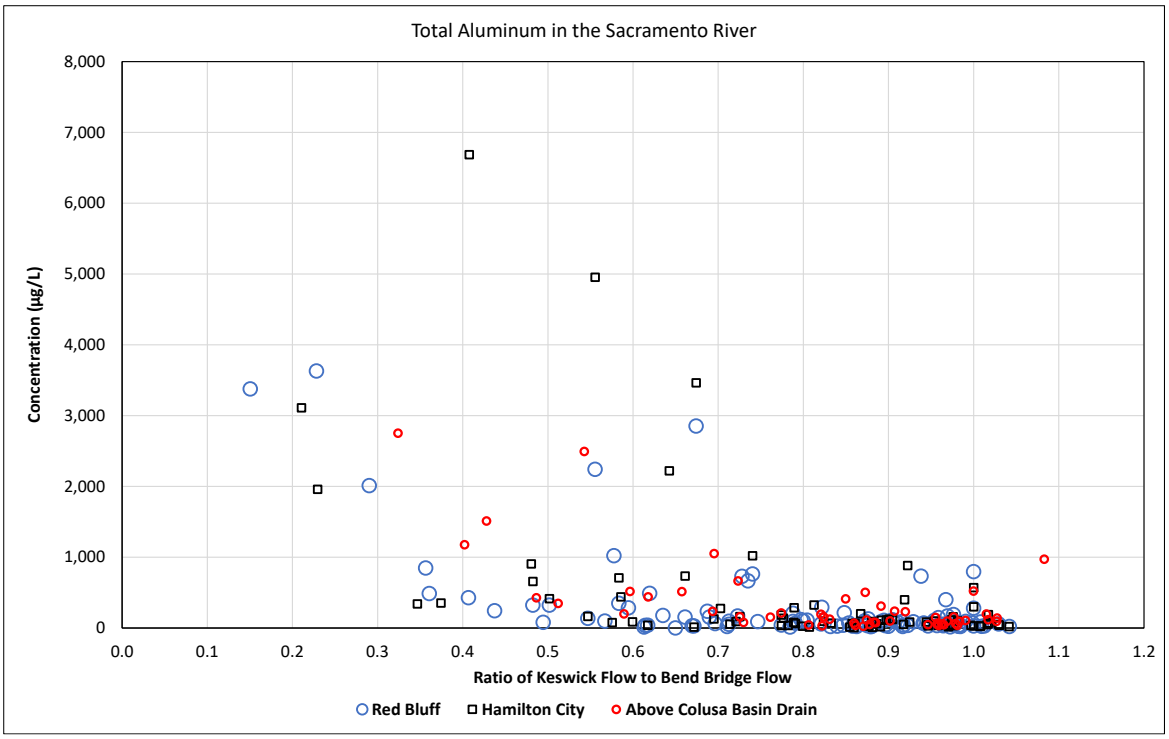

Figure 6E-11. Relationship between Indicator of Local Runoff and Concentration of Measured Total Aluminum in the Sacramento River

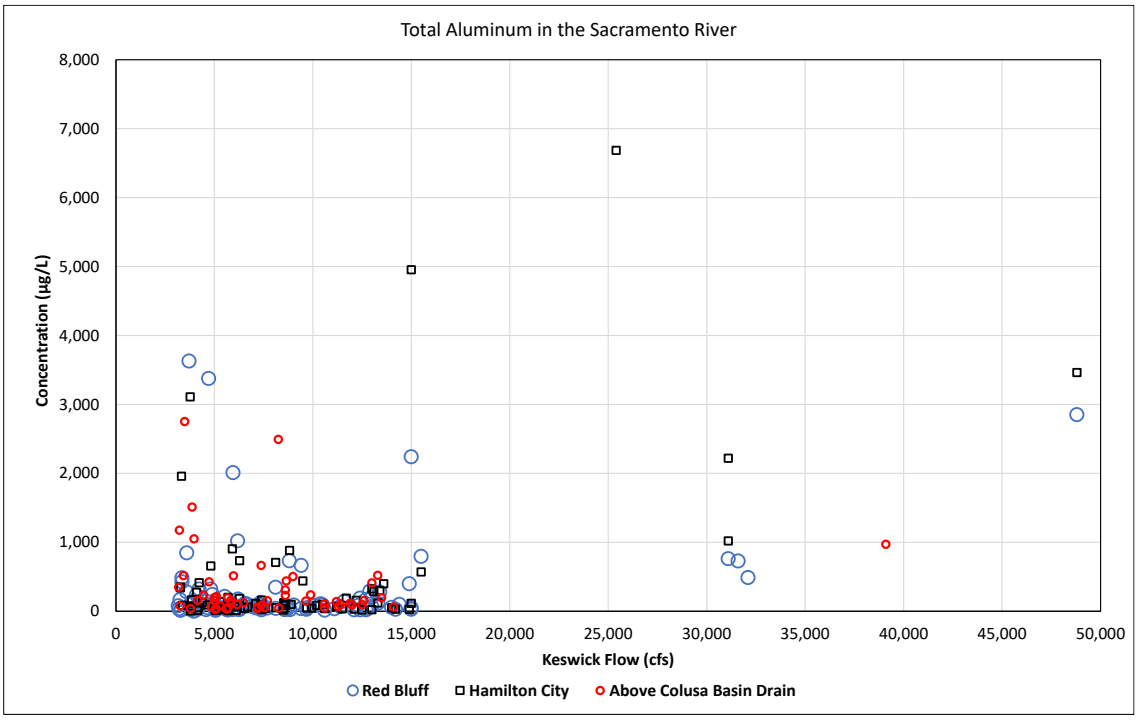

Figure 6E-12. Relationship between Flow in the Sacramento River at Keswick and Measured Concentration of Total Aluminum in the Sacramento River

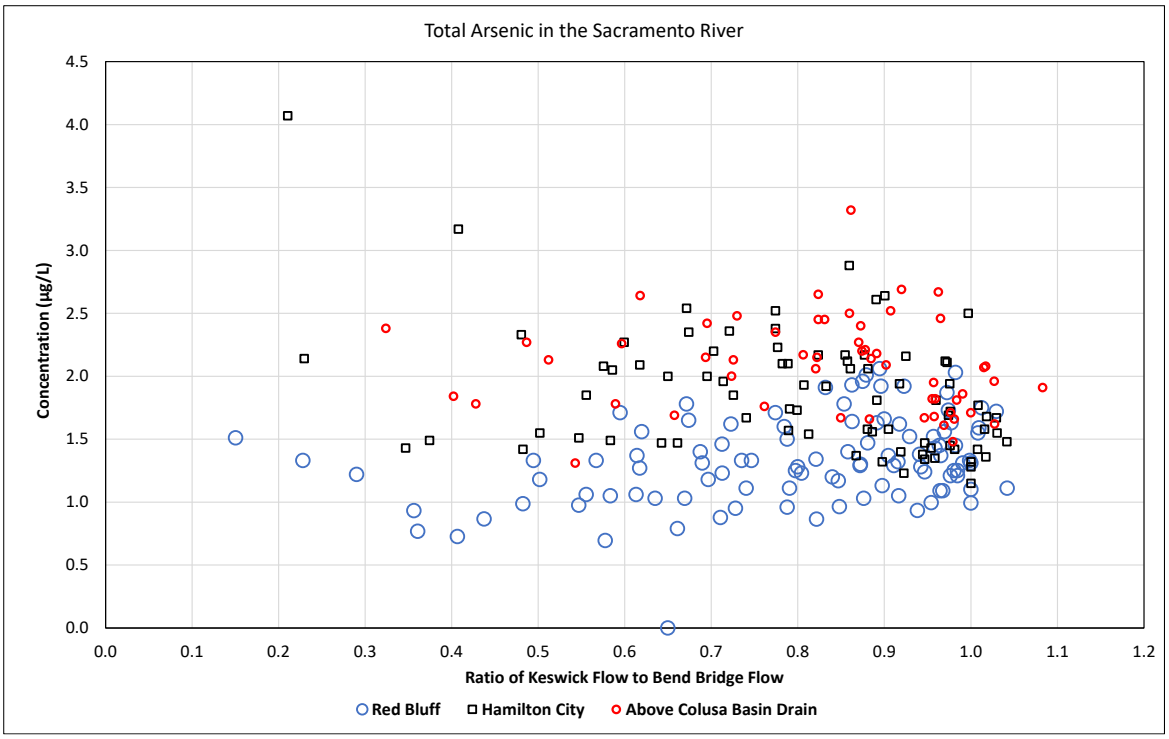

Figure 6E-13. Relationship between Indicator of Local Runoff and Concentration of Measured Total Arsenic in the Sacramento River

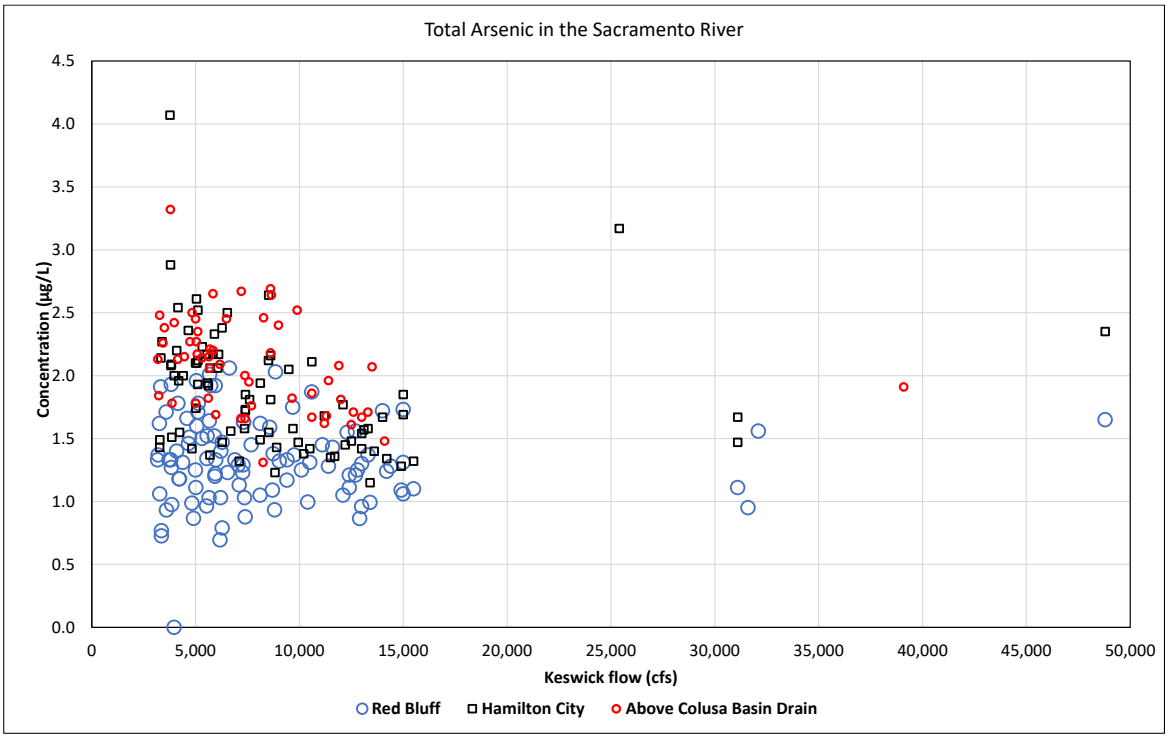

Figure 6E-14. Relationship between Flow in the Sacramento River at Keswick and Measured Concentration of Total Arsenic in the Sacramento River

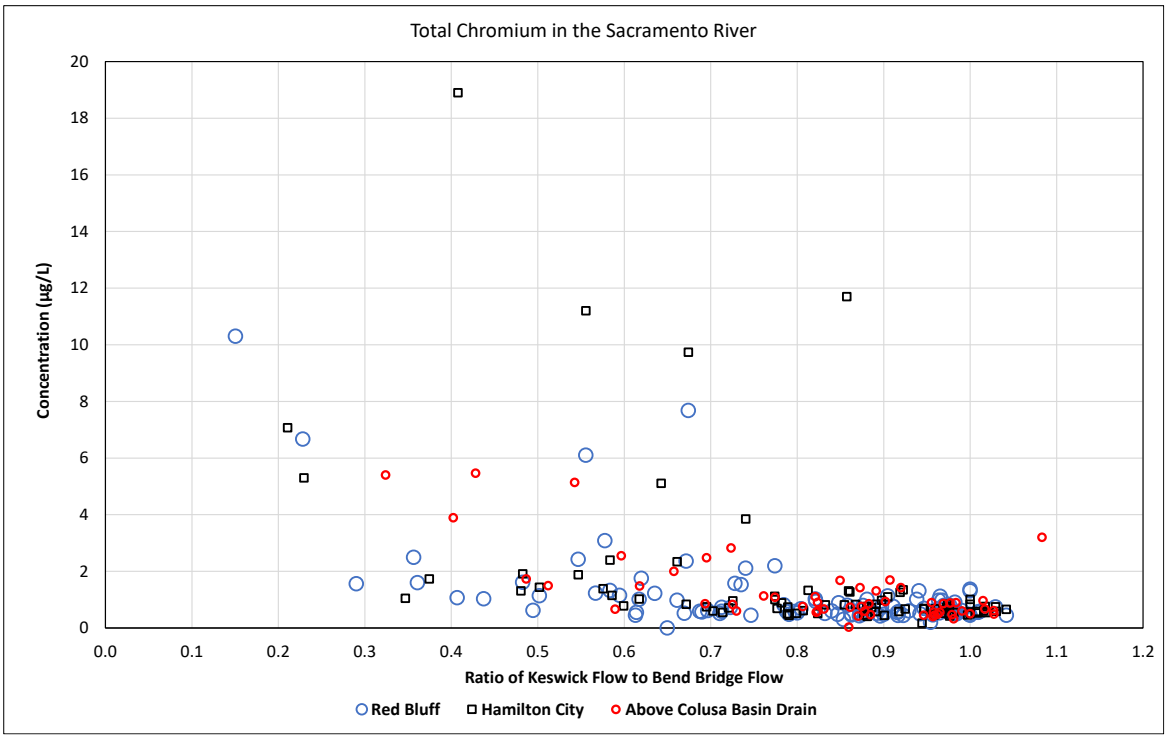

Figure 6E-15. Relationship between Indicator of Local Runoff and Concentration of Measured Total Aluminum in the Sacramento River

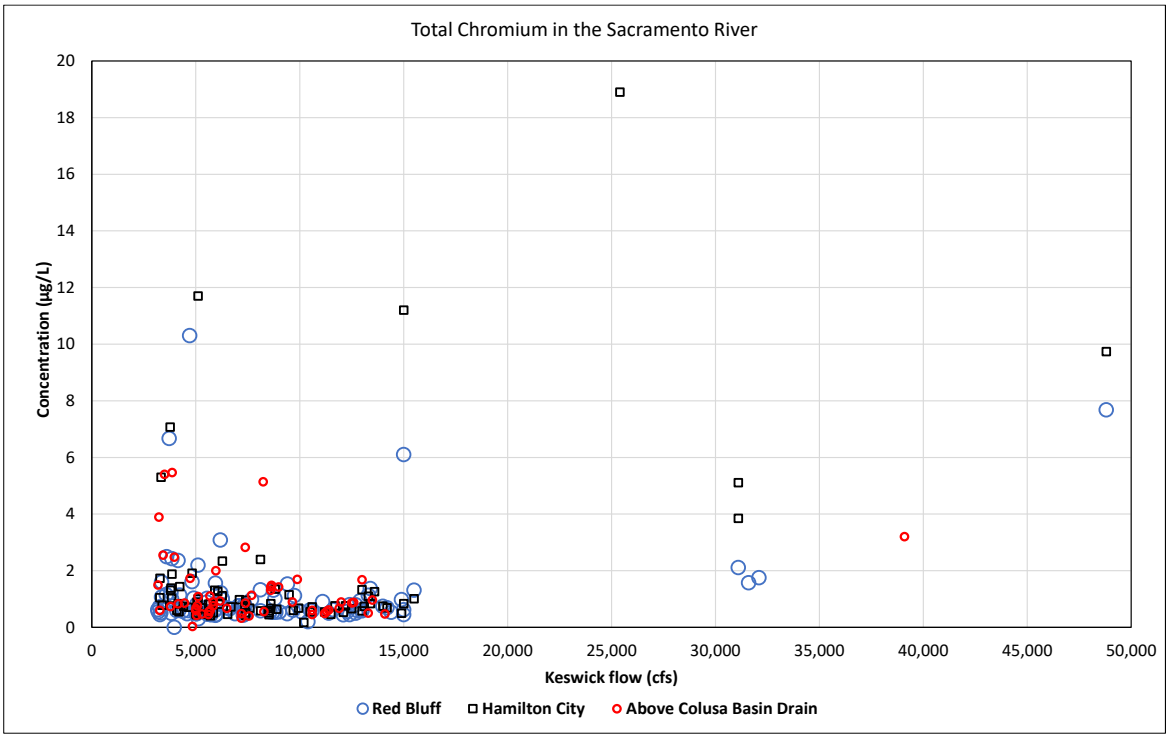

Figure 6E-16. Relationship between Flow in the Sacramento River at Keswick and Measured Concentration of Total Chromium in the Sacramento River

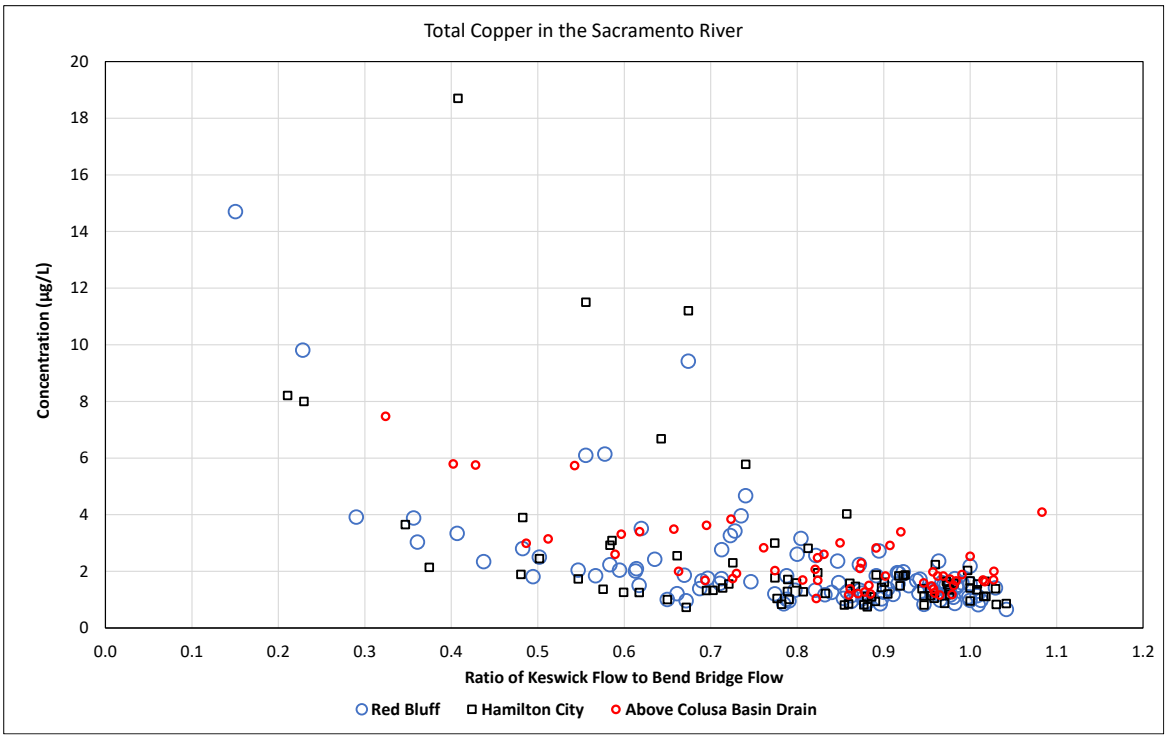

Figure 6E-17. Relationship between Indicator of Local Runoff and Concentration of Measured Total Copper in the Sacramento River

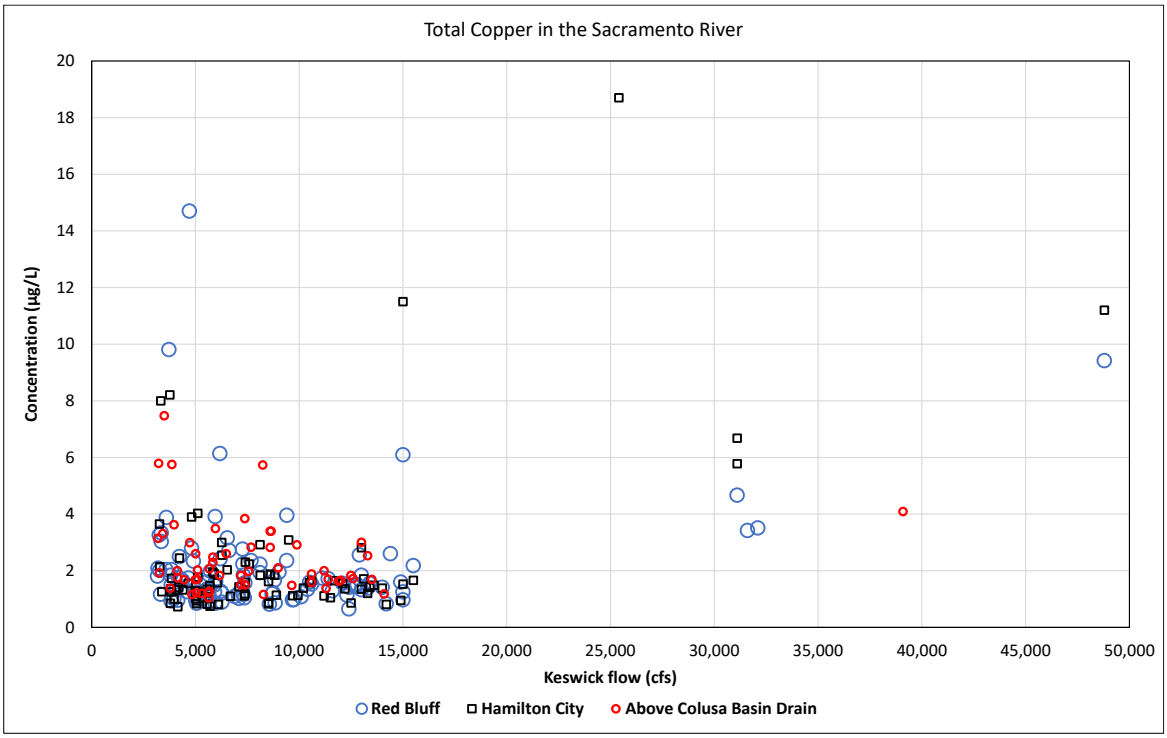

Figure 6E-18. Relationship between Flow in the Sacramento River at Keswick and Measured Concentration of Total Copper in the Sacramento River

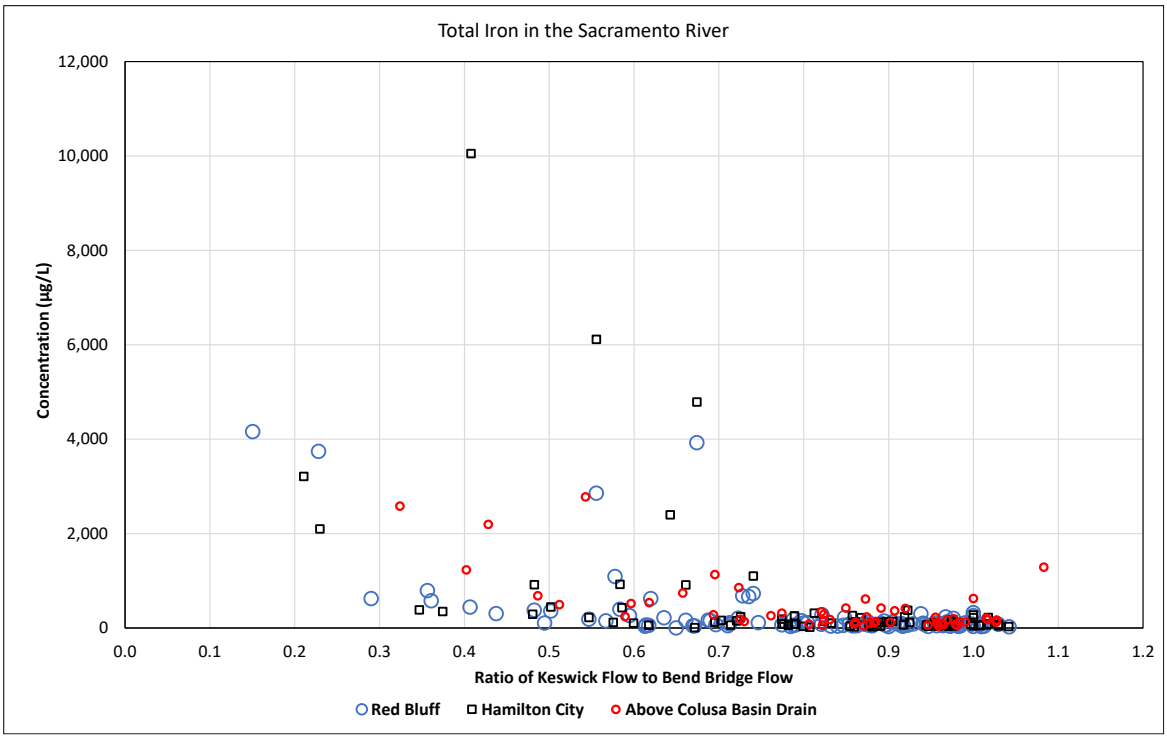

Figure 6E-19. Relationship between Indicator of Local Runoff and Concentration of Measured Total Iron in the Sacramento River

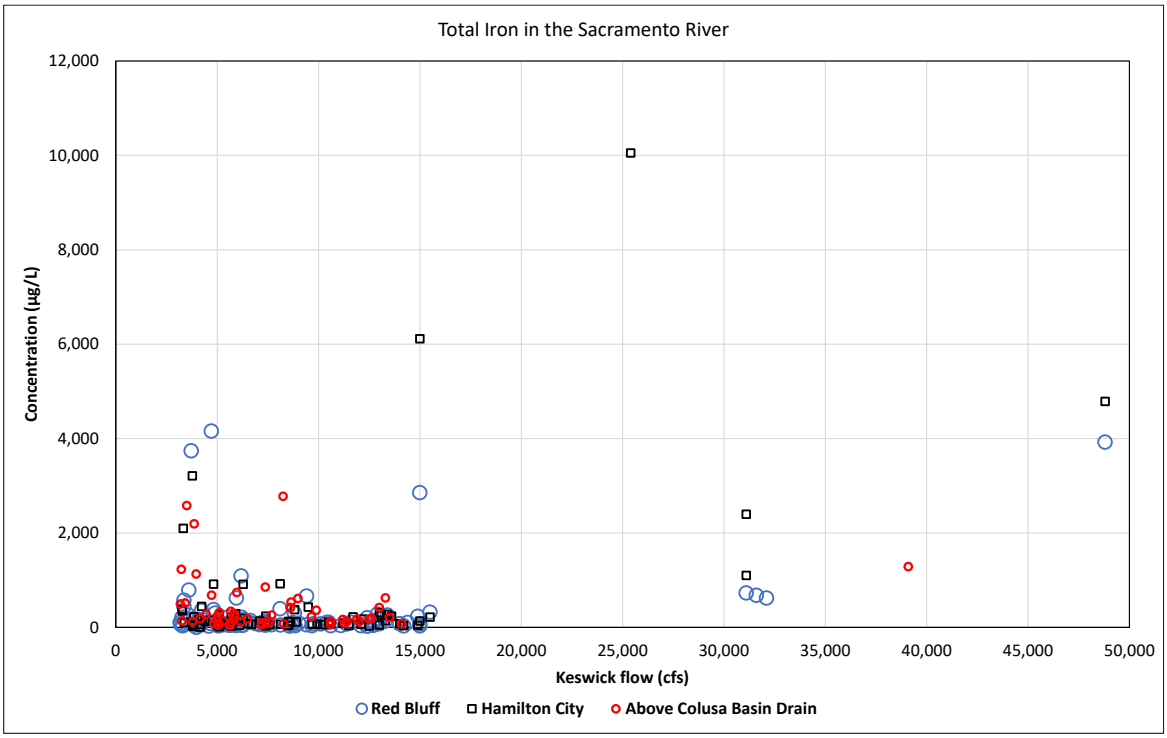

Figure 6E-20. Relationship between Flow in the Sacramento River at Keswick and Measured Concentration of Total Iron in the Sacramento River

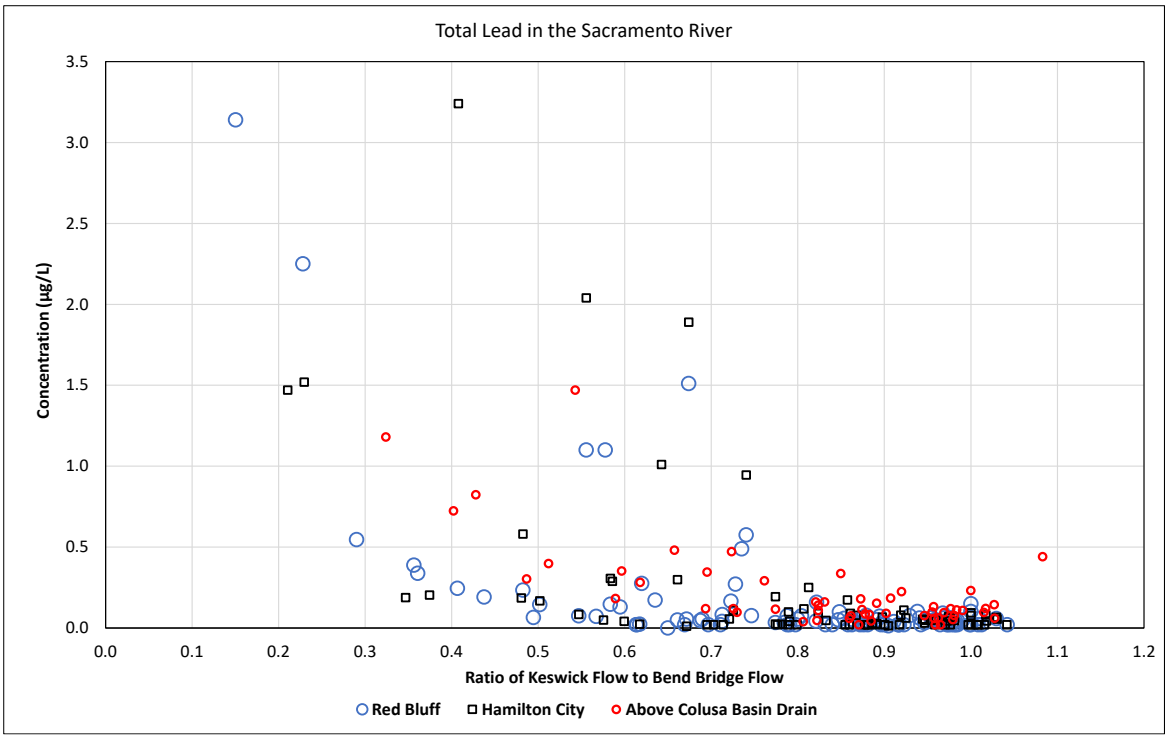

Figure 6E-21. Relationship between Indicator of Local Runoff and Concentration of Measured Total Lead in the Sacramento River

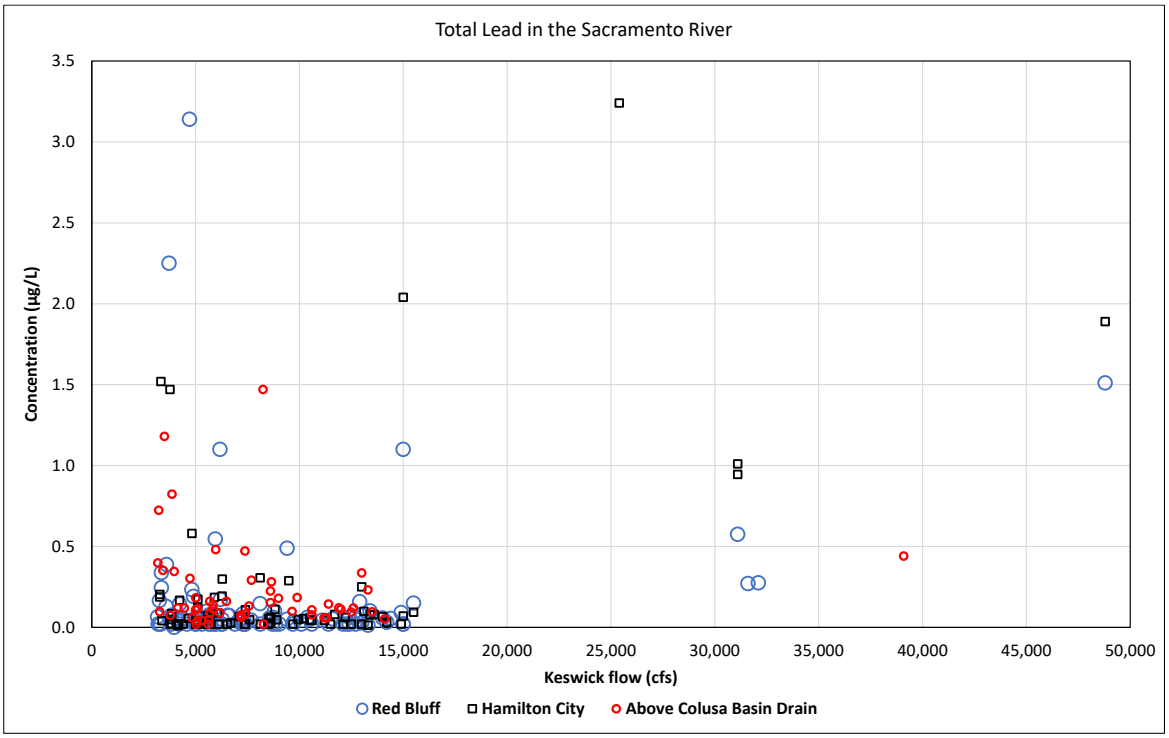

Figure 6E-22. Relationship between Flow in the Sacramento River at Keswick and Measured Concentration of Total Lead in the Sacramento River

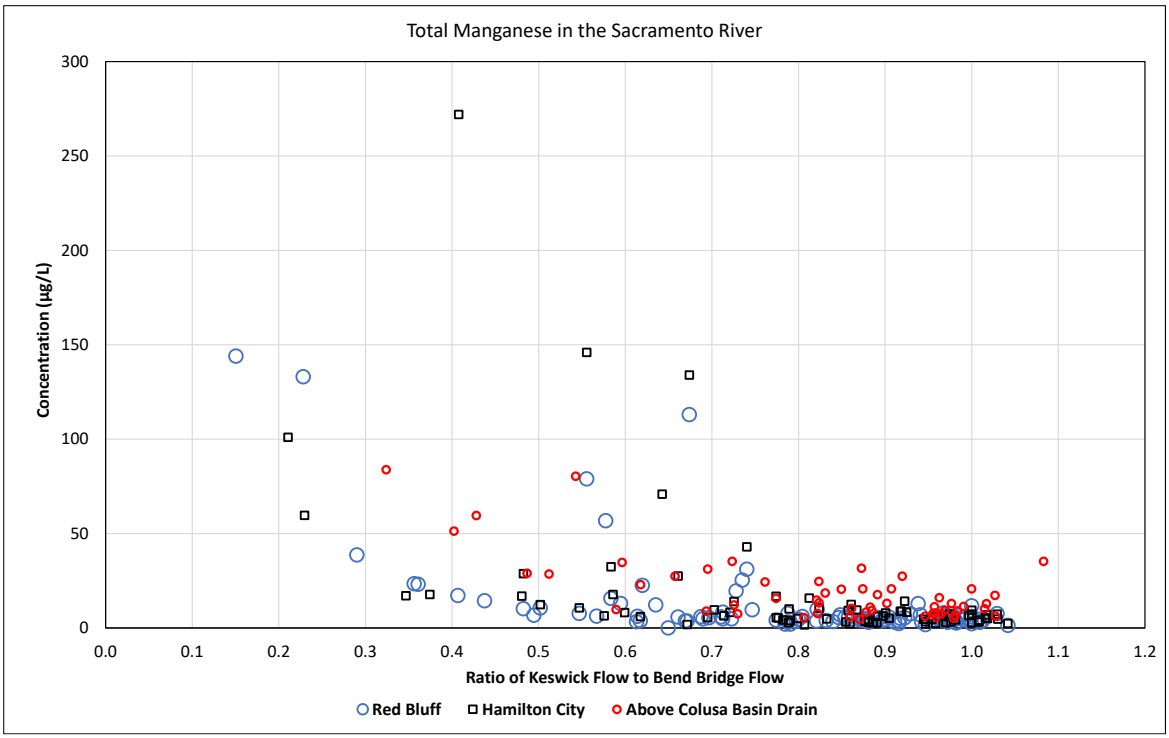

Figure 6E-23. Relationship between Indicator of Local Runoff and Concentration of Measured Total Manganese in the Sacramento River

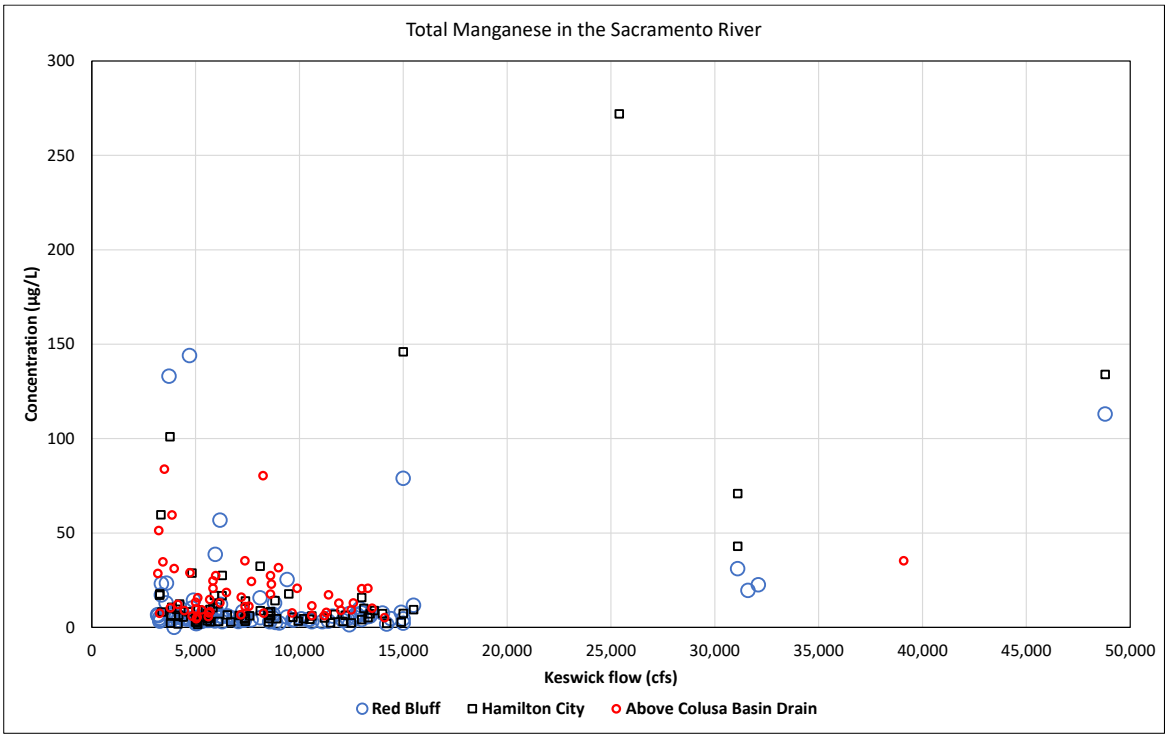

Figure 6E-24. Relationship between Flow in the Sacramento River at Keswick and Measured Concentration of Total Manganese in the Sacramento River

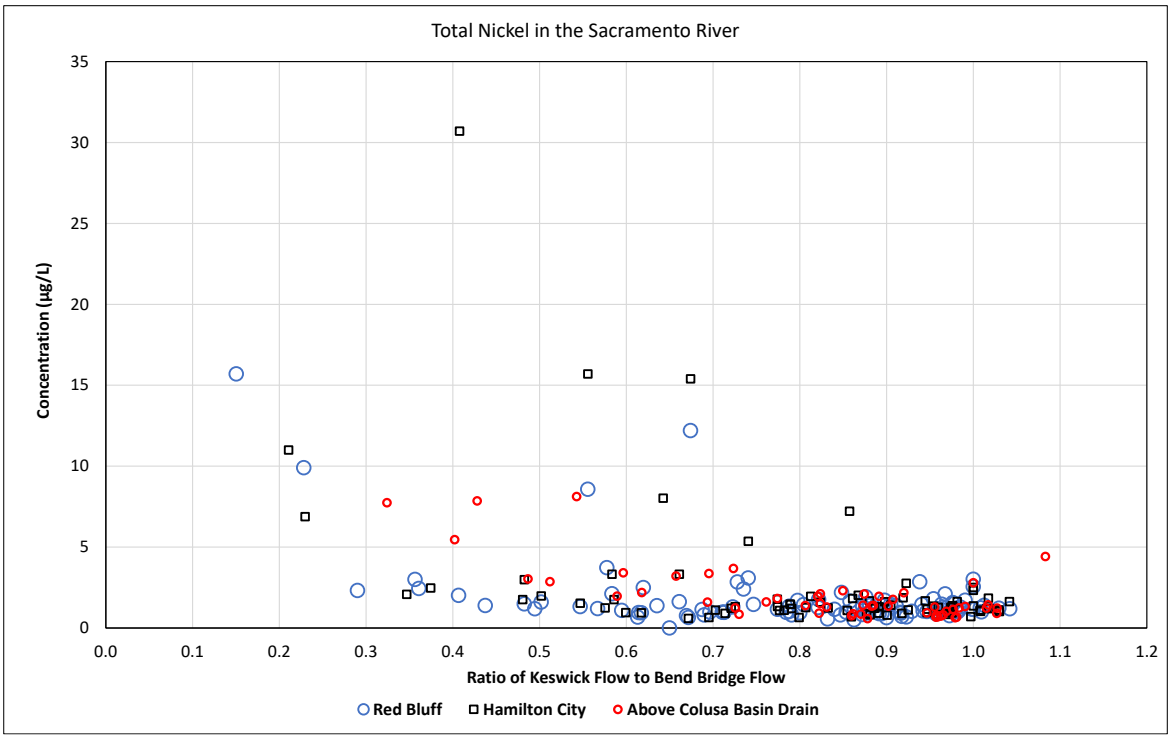

Figure 6E-25. Relationship between Indicator of Local Runoff and Concentration of Measured Total Nickel in the Sacramento River

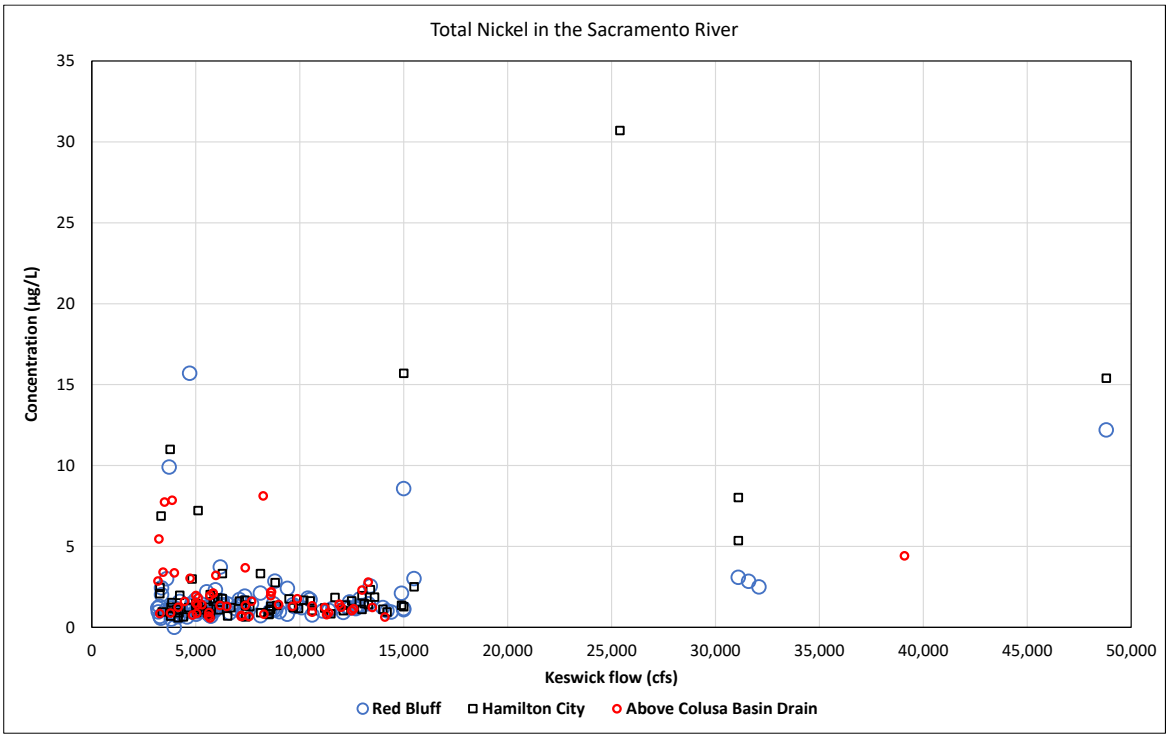

Figure 6E-26. Relationship between Flow in the Sacramento River at Keswick and Measured Concentration of Total Nickel in the Sacramento River

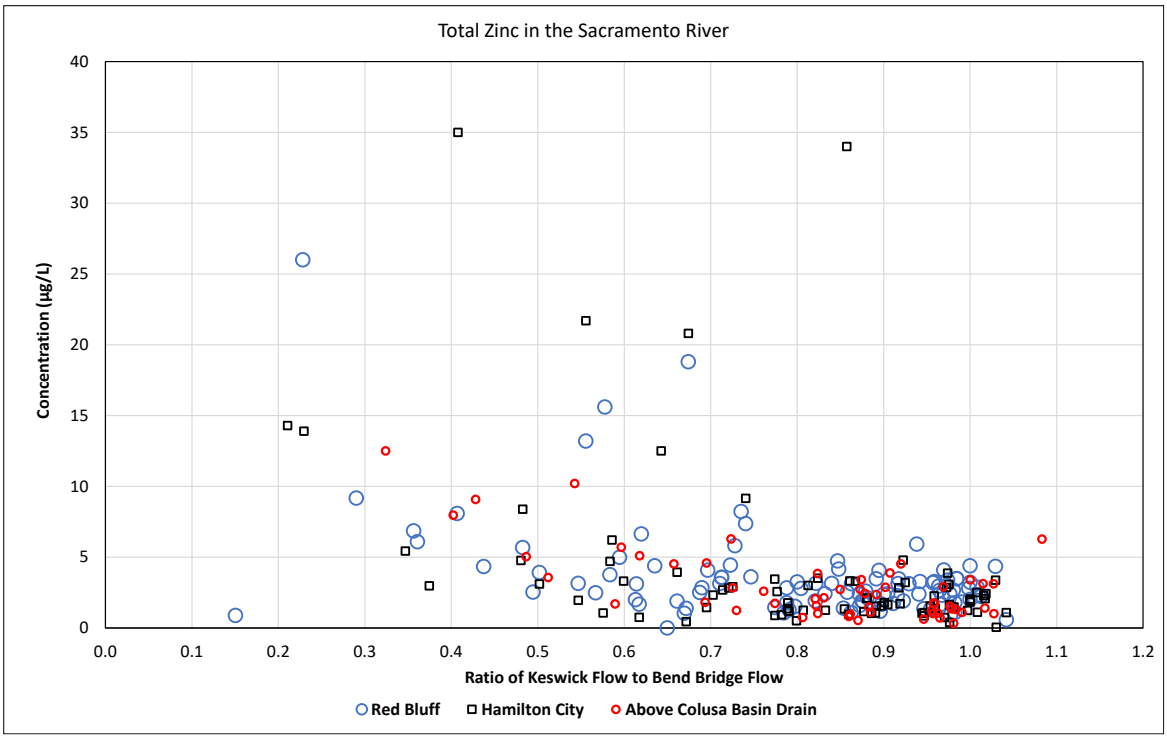

Figure 6E-27. Relationship between Indicator of Local Runoff and Concentration of Measured Total Zinc in the Sacramento River

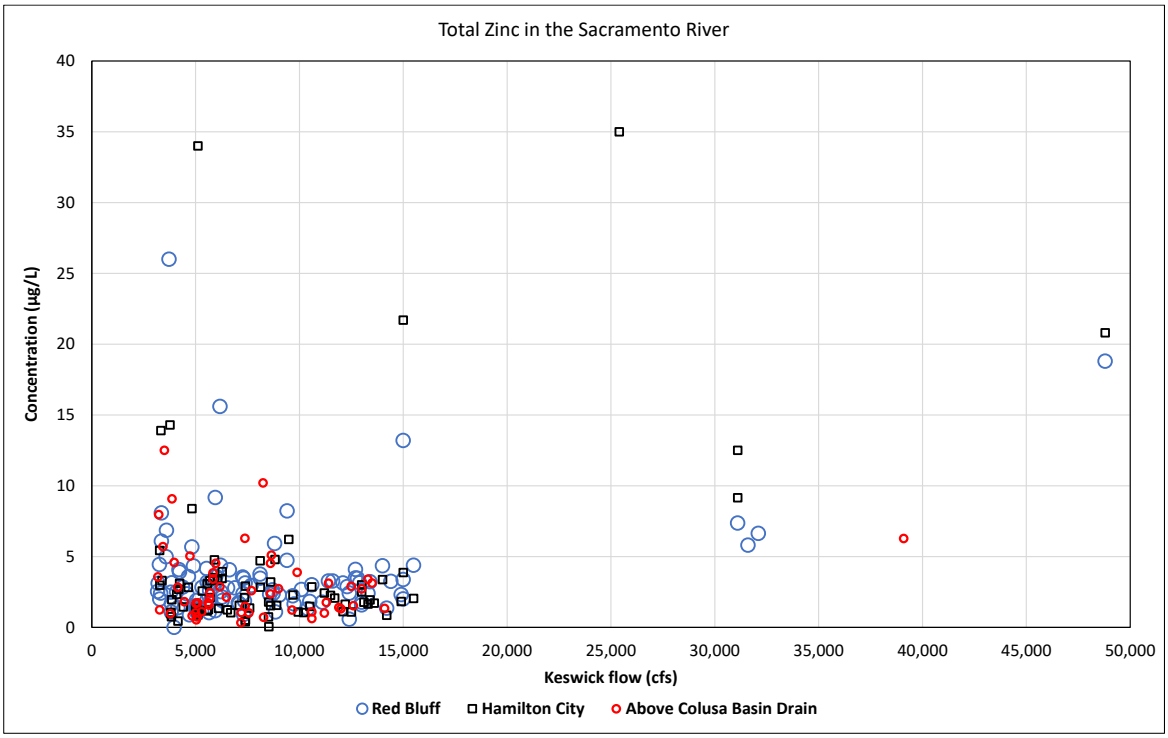

Figure 6E-28. Relationship between Flow in the Sacramento River at Keswick and Measured Concentration of Total Zinc in the Sacramento River

6E.5 Pesticide Data by Month

The graphs below show pesticide data from California Department of Pesticide Regulation's Surface Water Database (SURF), which combines data from multiple sources. Data were downloaded for the period of record from four stations:

- Sacramento River near Hamilton City – Station 04_2
- Sacramento River at Colusa – Station 06_4
- CBD above Knights Landing – Station 57_2, and
- Yolo Bypass Toe Drain near Babel Slough – Station 57_58

The measurements are shown by month in order to show seasonal trends.

Pesticides selected for graphing are those that have been detected in the Central Valley and that have a moderate number of measurements. These include azinphos-methyl, bifenthrin, carbofuran, chlorpyrifos, diazinon, malathion, proponil, and thiobencarb. Additional pesticides considered in the evaluation included chlordane, DDT, dichlorvos, dieldrin, and pyrethroids other than bifenthrin. The SURF database either had no data for these pesticides in the Sacramento River between Knights Landing and Red Bluff (stations at Colusa and near Hamilton City) or all values at these stations were less than detection limits.

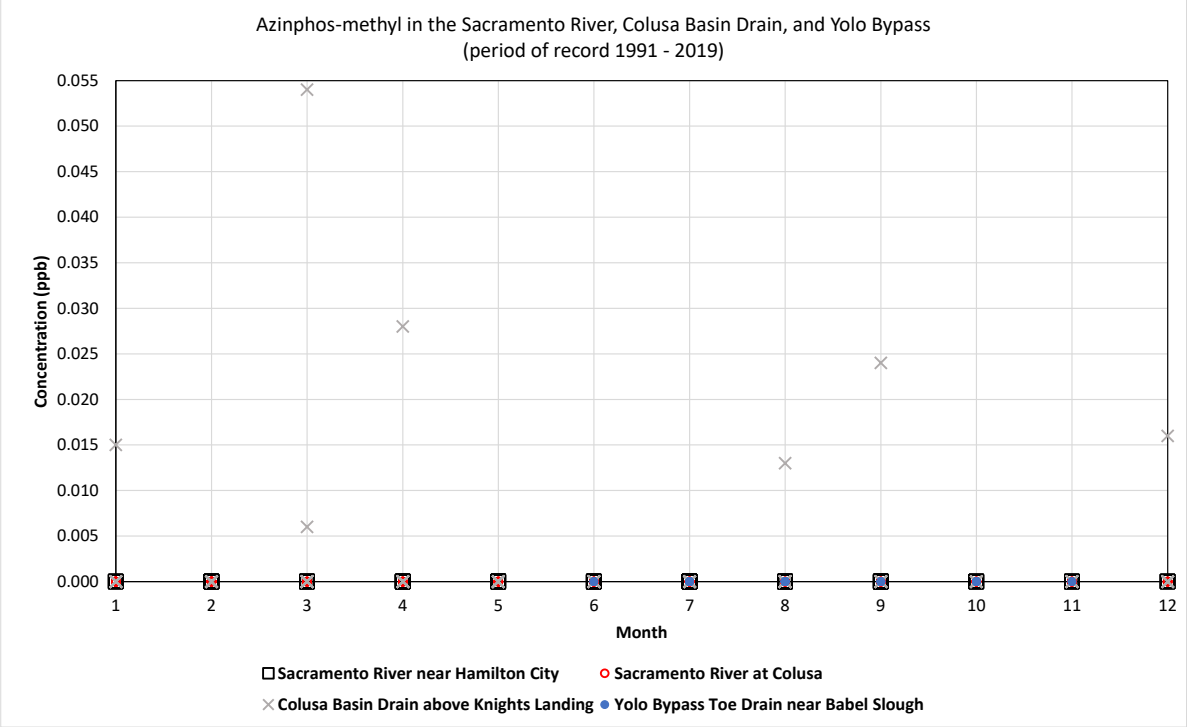

Figure 6E-29. Measured Azinphos-methyl in the Sacramento River, Colusa Basin Drain, and the Yolo Bypass

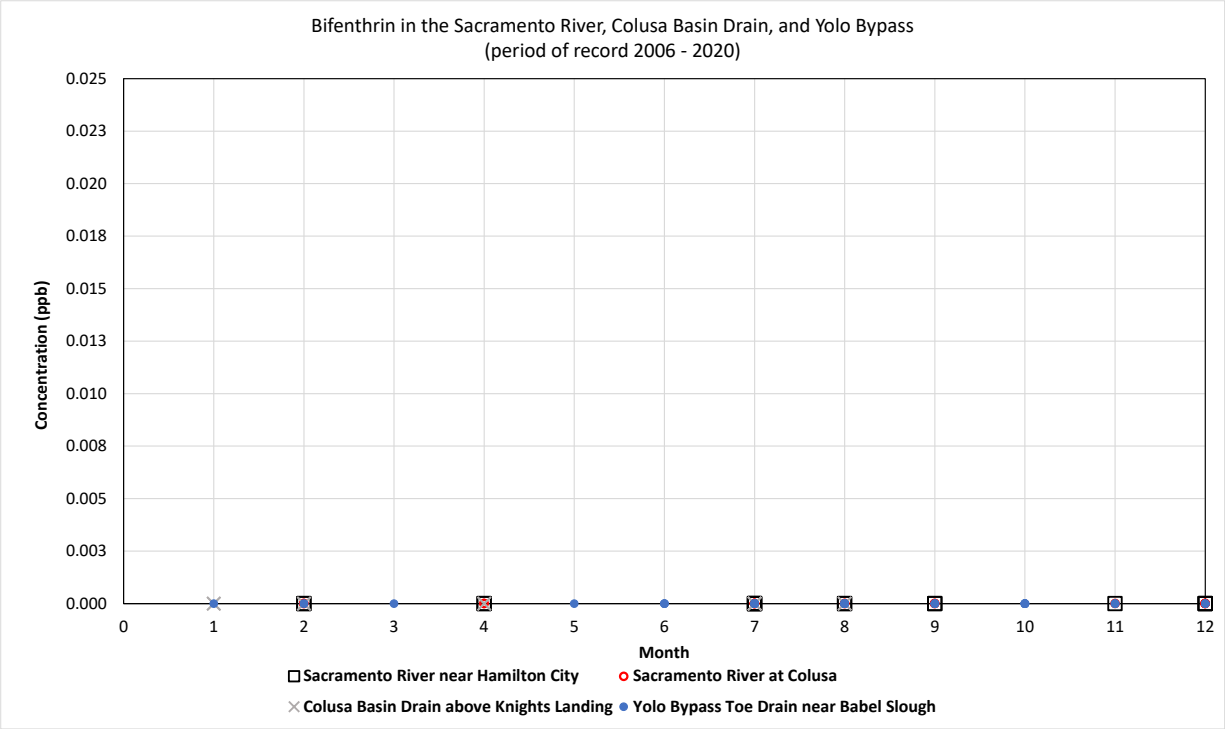

Figure 6E-30. Measured Bifenthrin in the Sacramento River, Colusa Basin Drain, and the Yolo Bypass

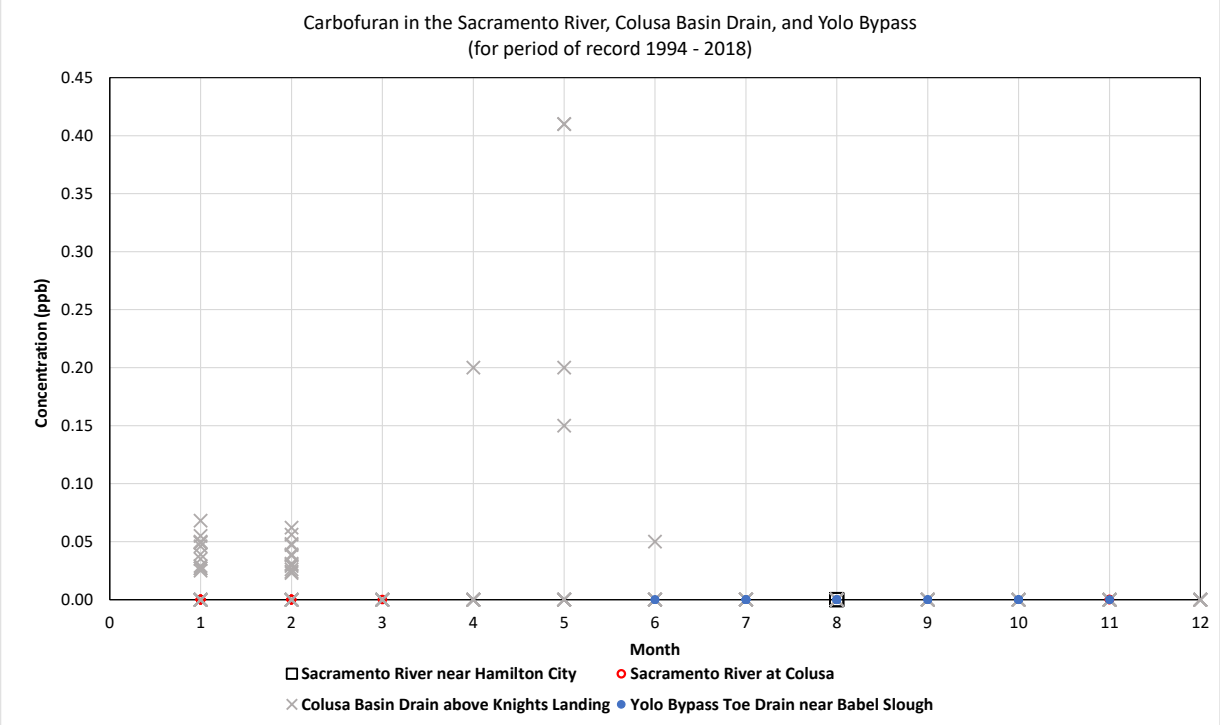

Figure 6E-31. Measured Carbofuran in the Sacramento River, Colusa Basin Drain, and the Yolo Bypass

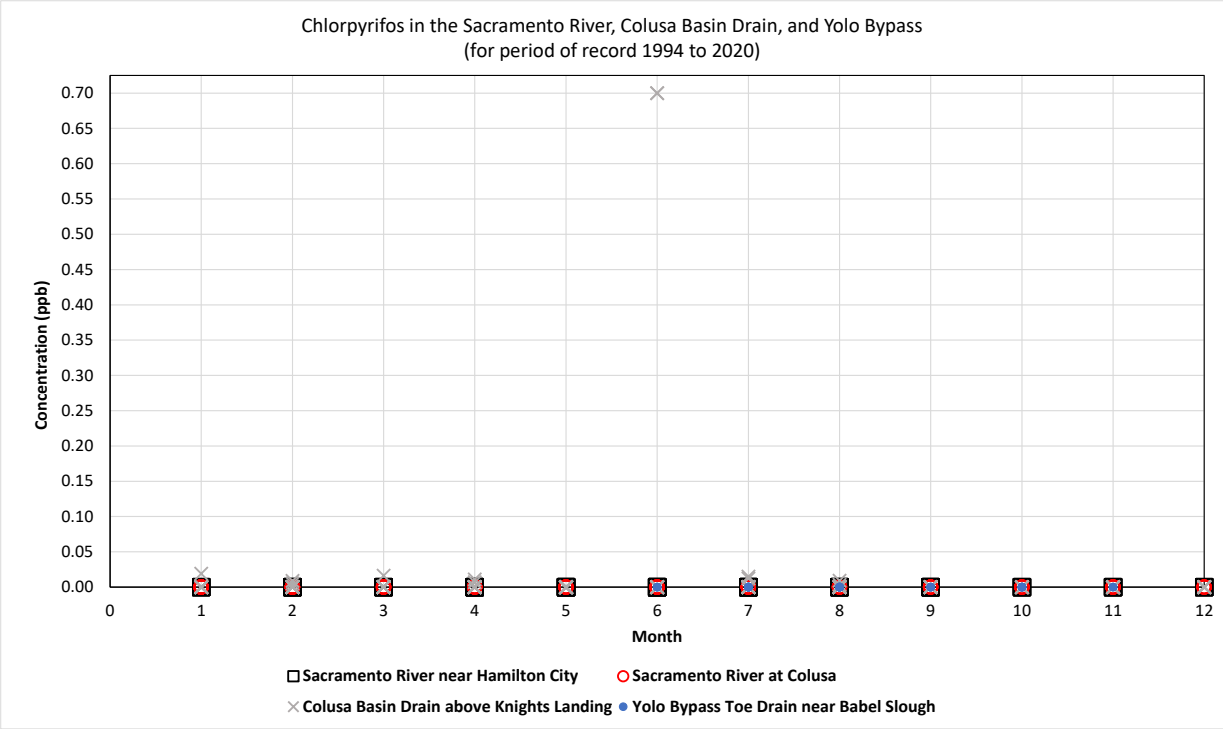

Figure 6E-32. Measured Chlorpyrifos in the Sacramento River, Colusa Basin Drain, and the Yolo Bypass

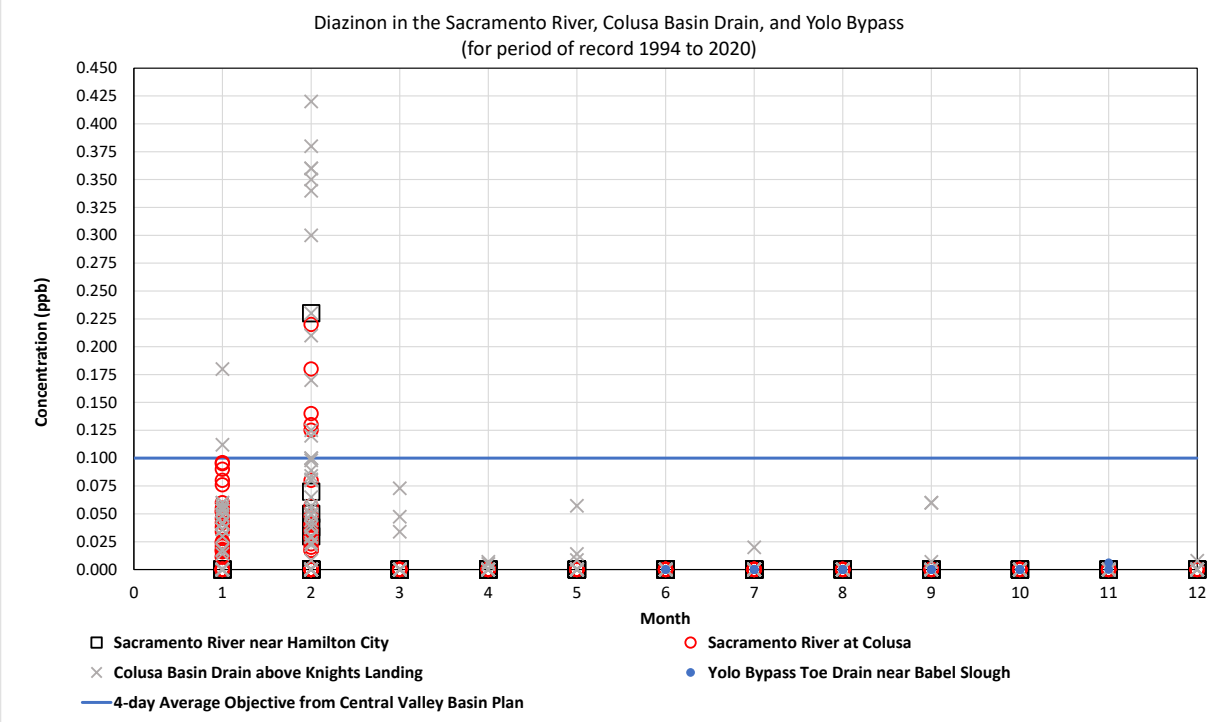

Figure 6E-33. Measured Diazinon in the Sacramento River, Colusa Basin Drain, and the Yolo Bypass

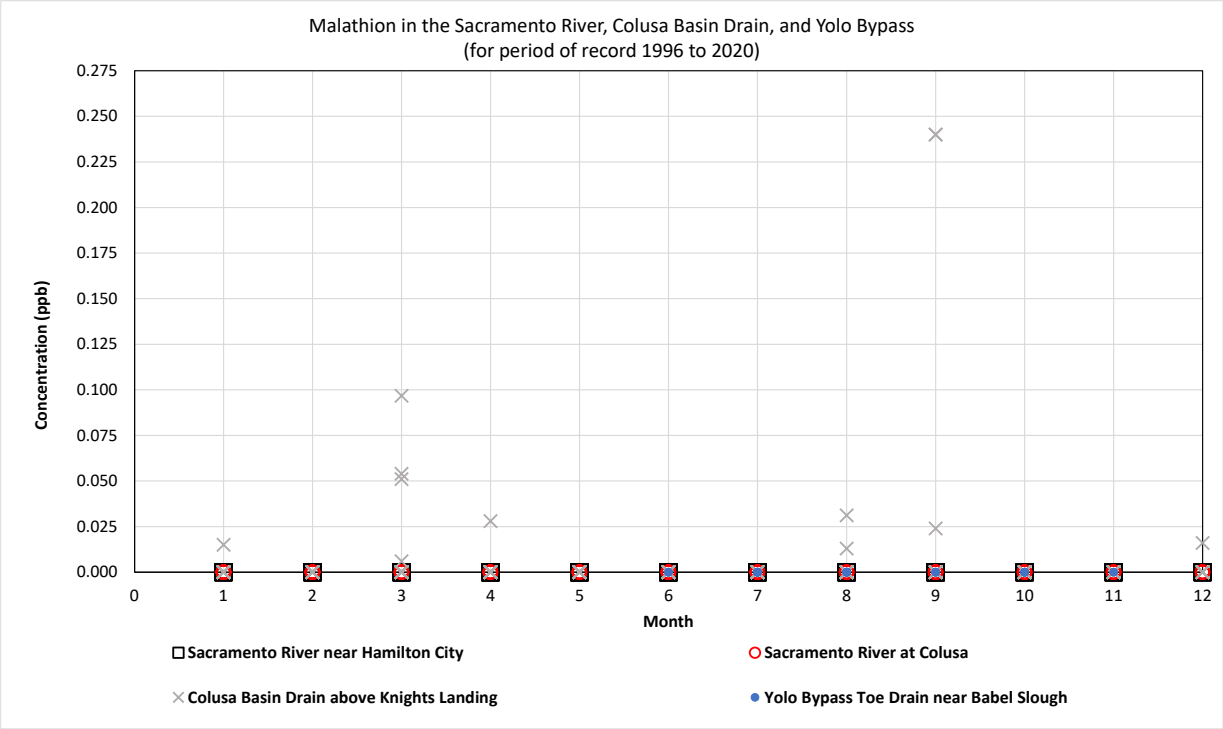

Figure 6E-34. Measured Malathion in the Sacramento River, Colusa Basin Drain, and the Yolo Bypass

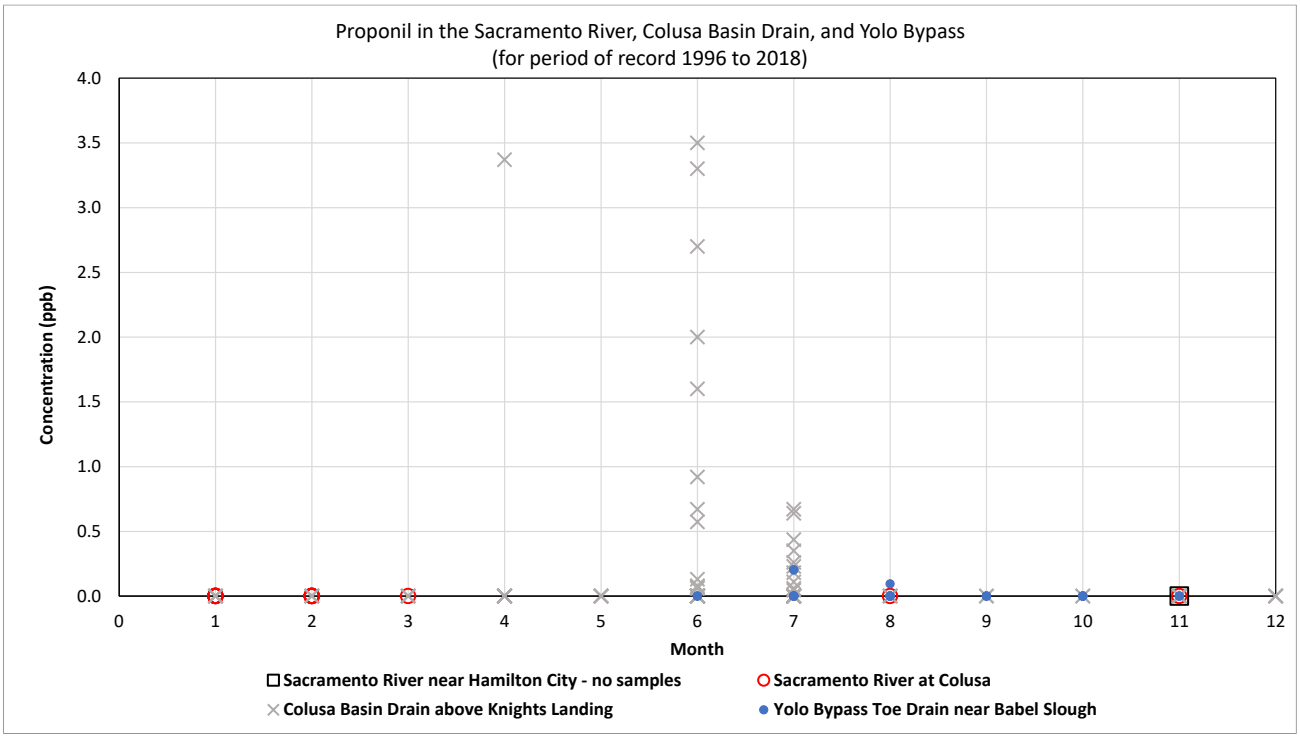

Figure 6E-35. Measured Proponil in the Sacramento River, Colusa Basin Drain, and the Yolo Bypass

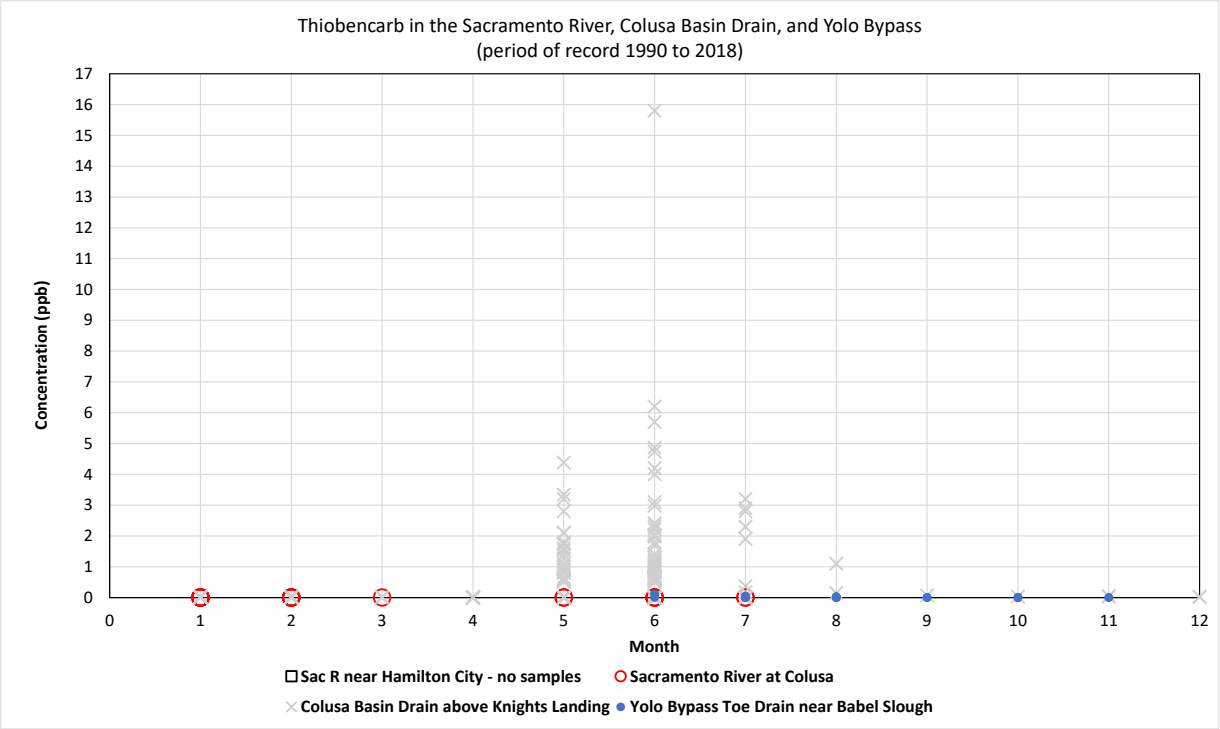

Figure 6E-36. Measured Thiobencarb in the Sacramento River, Colusa Basin Drain, and the Yolo Bypass

6E.6 Nutrients Data by Month

The graphs below show nutrient data from the DWR Water Data Library for measurements of total concentration (i.e., not filtered) taken during 2000 through 2020 at four stations:

- Sacramento River below Red Bluff - Station A0275890
- Sacramento River at Hamilton City - Station A0263000
- Sacramento River above Colusa Basin Drain - Station A0223002, and
- Colusa Basin Drain near Knights Landing - Station A0294710

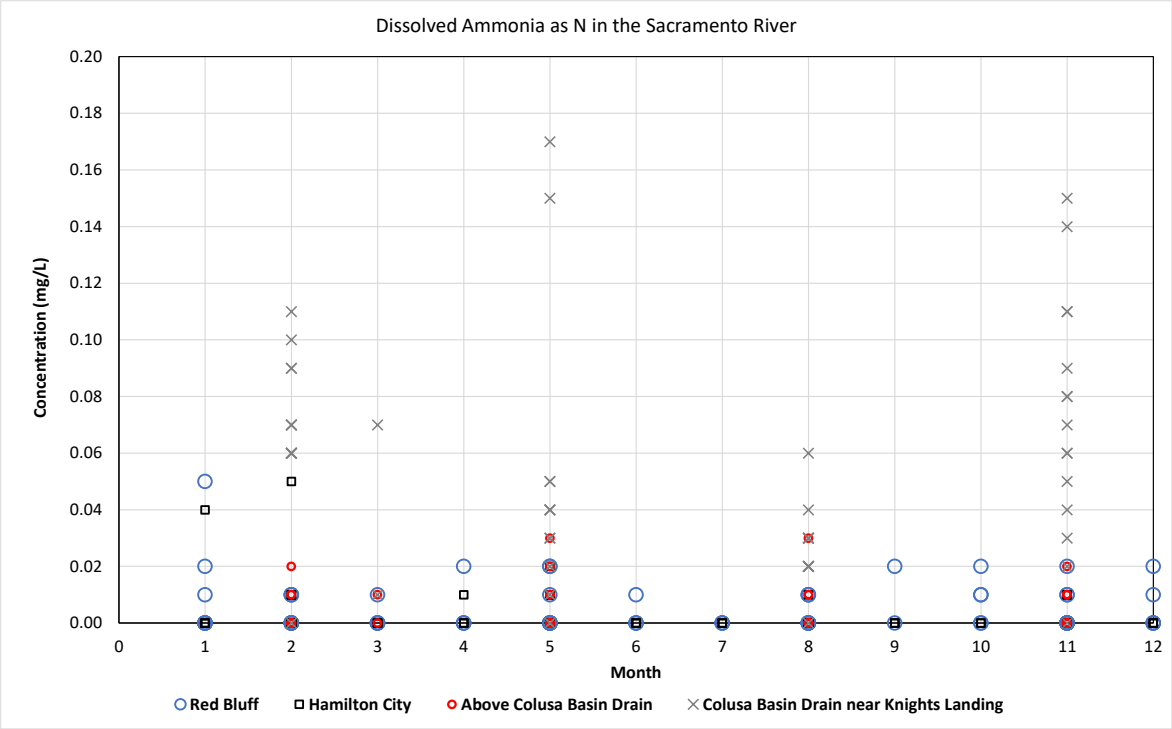

Figure 6E-37. Measured Dissolved Ammonia as Nitrogen in the Sacramento River and Colusa Basin Drain

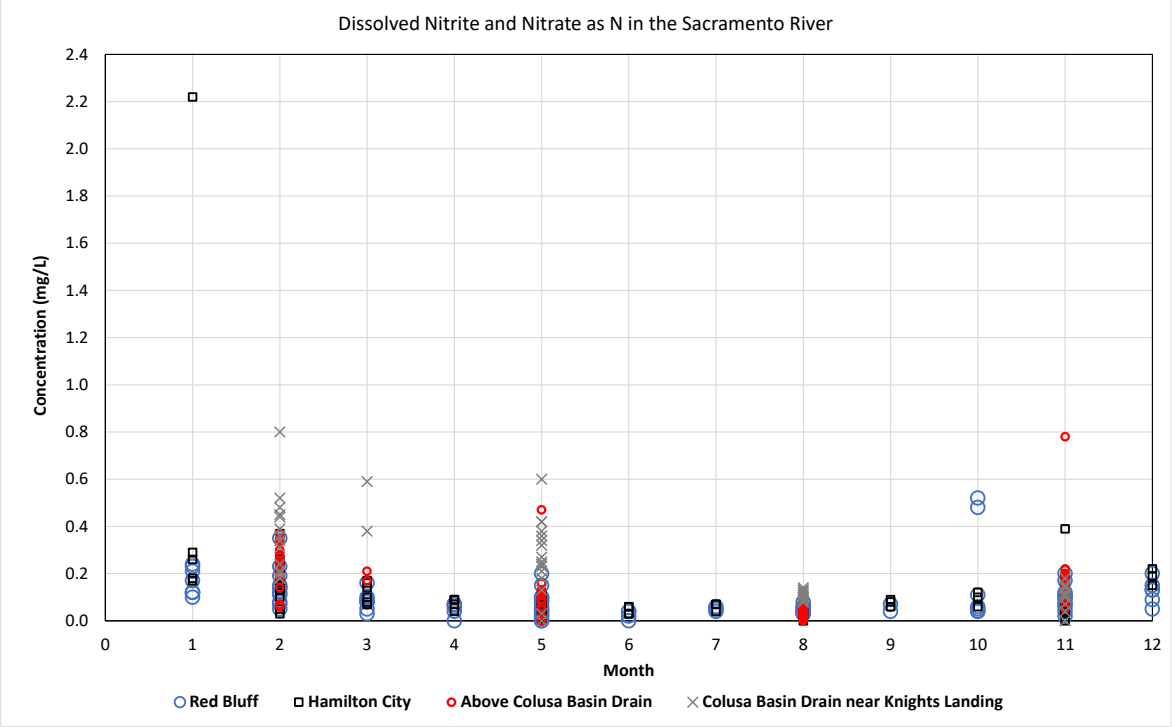

Figure 6E-38. Measured Dissolved Nitrite and Nitrate as Nitrogen in the Sacramento River and Colusa Basin Drain

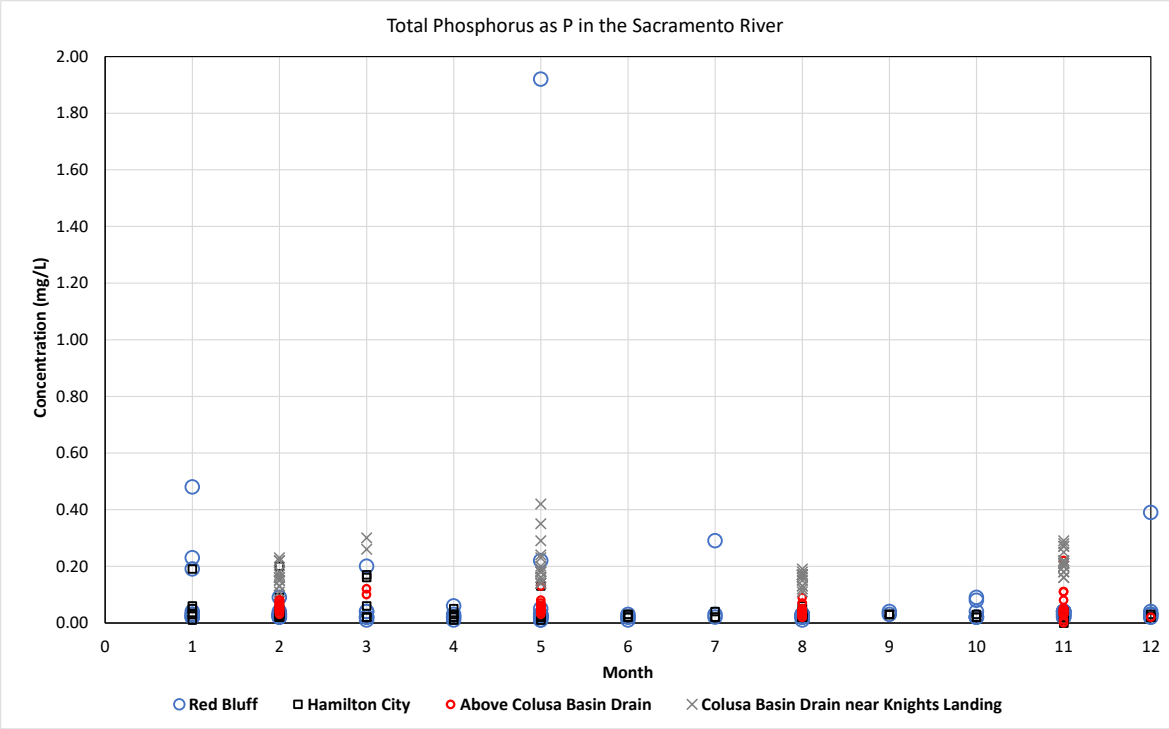

Figure 6E-39. Measured Total Phosphorus as Phosphorus in the Sacramento River and Colusa Basin Drain

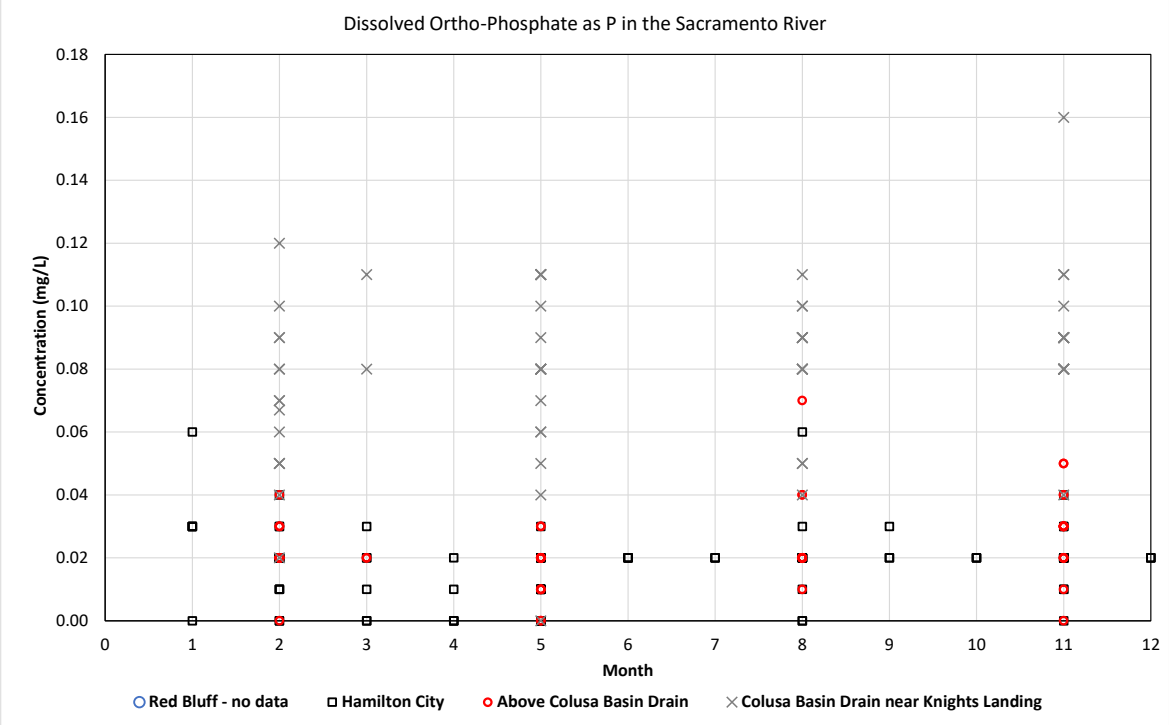

Figure 6E-40. Measured Dissolved Ortho Phosphate as Phosphorus in the Sacramento River and Colusa Basin Drain

6E.7 Metals Analysis for Aluminum, Copper, Iron, and Lead

Quantitative assessment was performed for total concentrations of four metals: aluminum, copper, iron, and lead. These four metals are of greatest concern based on what the measured data show for seasonal changes in concentration and concentrations above standards (graphs in Section 6E.2, *Metals Data by Month*).

6E.7.1. Equations for Estimating Inflow Concentrations Assuming No Settling of Suspended Sediment

Total concentrations measured in the Sacramento River at Red Bluff and Hamilton City (Sections 6E.2 and 6E.3, *Metals Data Tables*) were used to develop equations for estimating total metal concentration entering Sites Reservoir assuming no settling of suspended sediment. These data were paired with the daily average flow measured in the Sacramento River at Keswick and Bend Bridge. The data used in the evaluation were restricted to the November–May period of higher flows and concentrations to better focus on the range of flows that may occur when Sacramento River water would be diverted to Sites Reservoir.

A metric of the following form was developed to combine the indicators of flow and local runoff:

Metric = A*max(0,1-KWK/BND-B) + KWK

Where:

KWK = Sacramento River flow at Keswick in cfs

BND = Sacramento River flow at Bend Bridge in cfs

A and B were selected to balance the ratio metric (KWK/BND) with the flow metric and to optimize ability to estimate concentration.

An exponential trendline was fitted to the metric data to estimate concentration as a function of the metric. In some cases, the fitted equation was modified to estimate the higher concentrations more conservatively by slightly increasing the estimated values. The resulting equation has this form:

[Inflow] = C*e^(D*Metric)

Where:

[Inflow] = Estimated total metal concentration entering Sites Reservoir assuming no settling of suspended sediment

C and D are determined by fitting the equation to the data, and

e = Euler's number ≈ 2.718282

And, the maximum value was limited to double the highest measured concentration

Table 6E-8. Parameters for Estimating Total Concentrations of Aluminum, Copper, Iron, and Lead in Water Diverted to Sites Reservoir Storage

Metal	A	B	C	D	Value of R-Squared Prior to Equation Adjustments
Aluminum	70,000	0.1	17.44	0.000095	0.71
Copper	70,000	0.3	1.06	0.000053	0.69
Iron	70,000	0.1	28	0.000090	0.71
Lead	80,000	0	0.009	0.000077	0.67

6E.7.2. Graphs Showing Performance of Equations for Estimating Inflow Concentration Assuming No Settling of Suspended Sediment

There is much scatter in the values at the higher concentrations. The calculations capture the range of values that may occur, which is the purpose of these calculations.

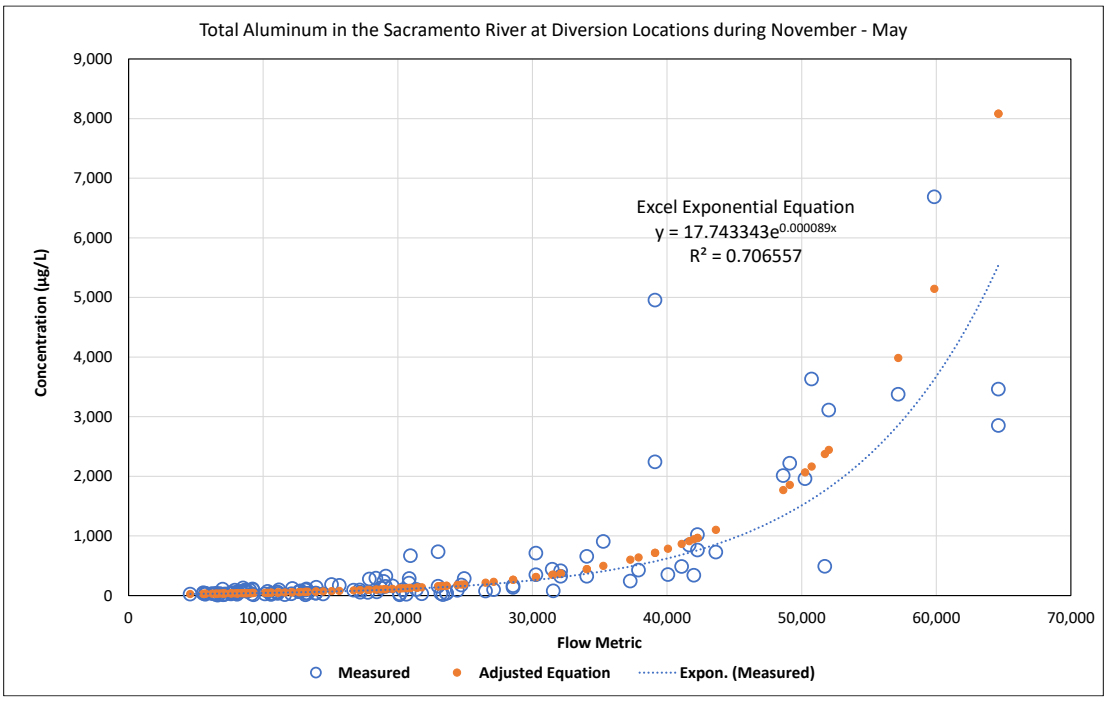

Figure 6E-41. Regression for Estimating Total Aluminum Concentration in Water Diverted to Sites Reservoir Storage as a Function of the Flow Metric

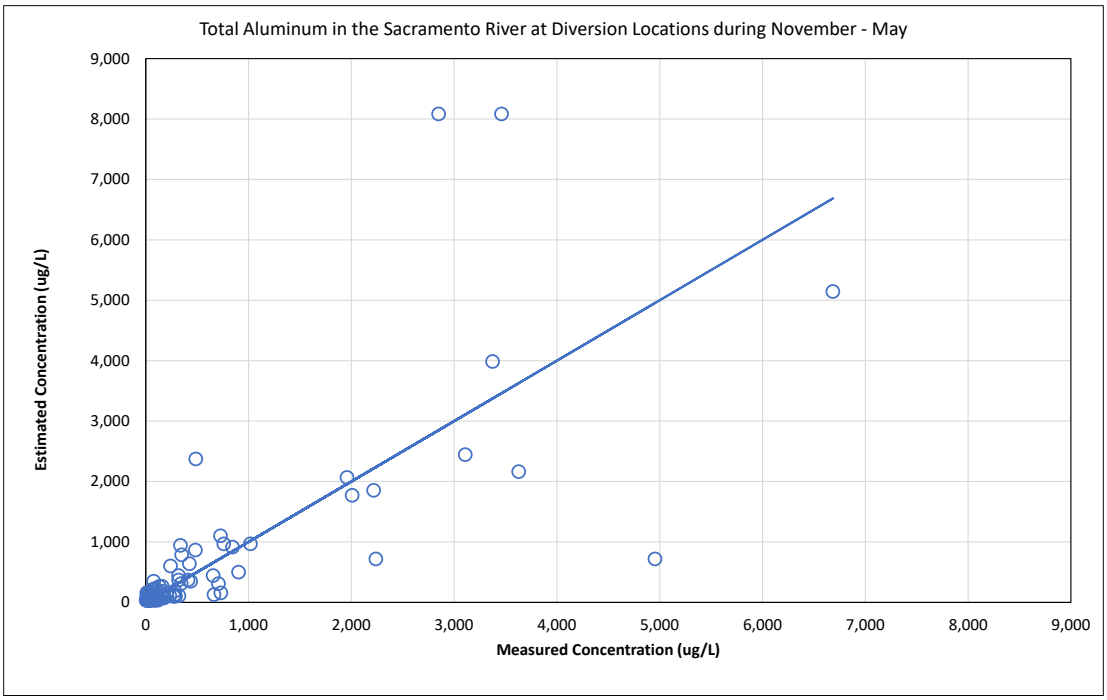

Figure 6E-42. Evaluation of the Performance of the Equation for Estimating Total Aluminum Concentration in the Water Diverted to Sites Reservoir Storage as a Function of the Flow Metric, Measured versus Estimated Values

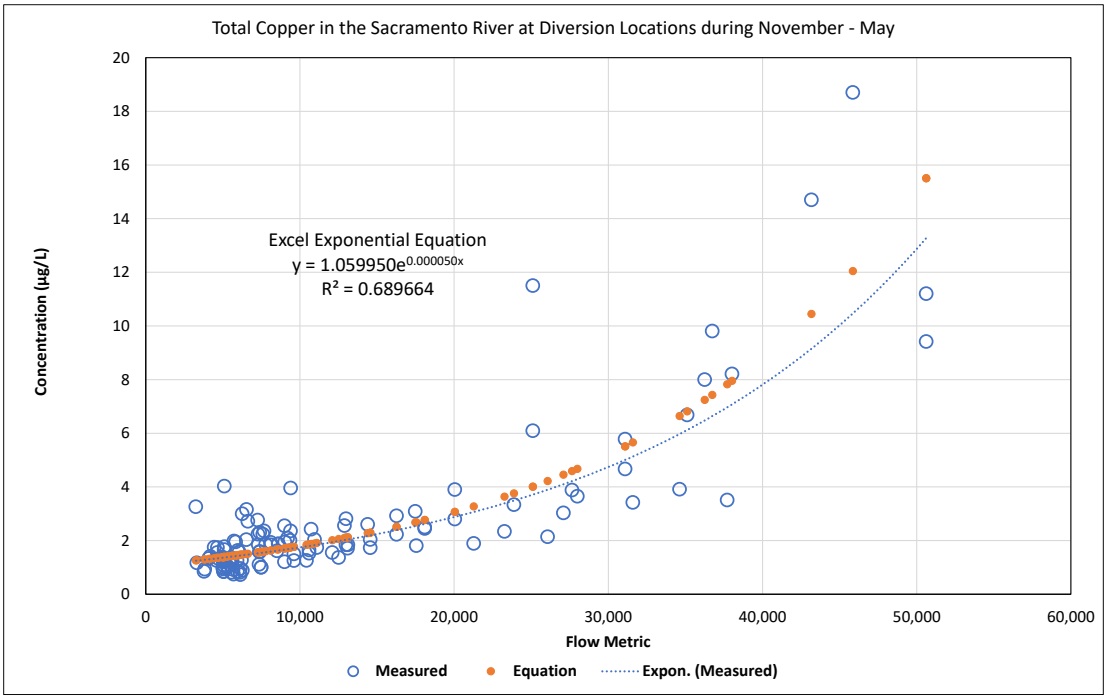

Figure 6E-43. Regression for Estimating Total Copper Concentration in Water Diverted to Sites Reservoir Storage as a Function of the Flow Metric

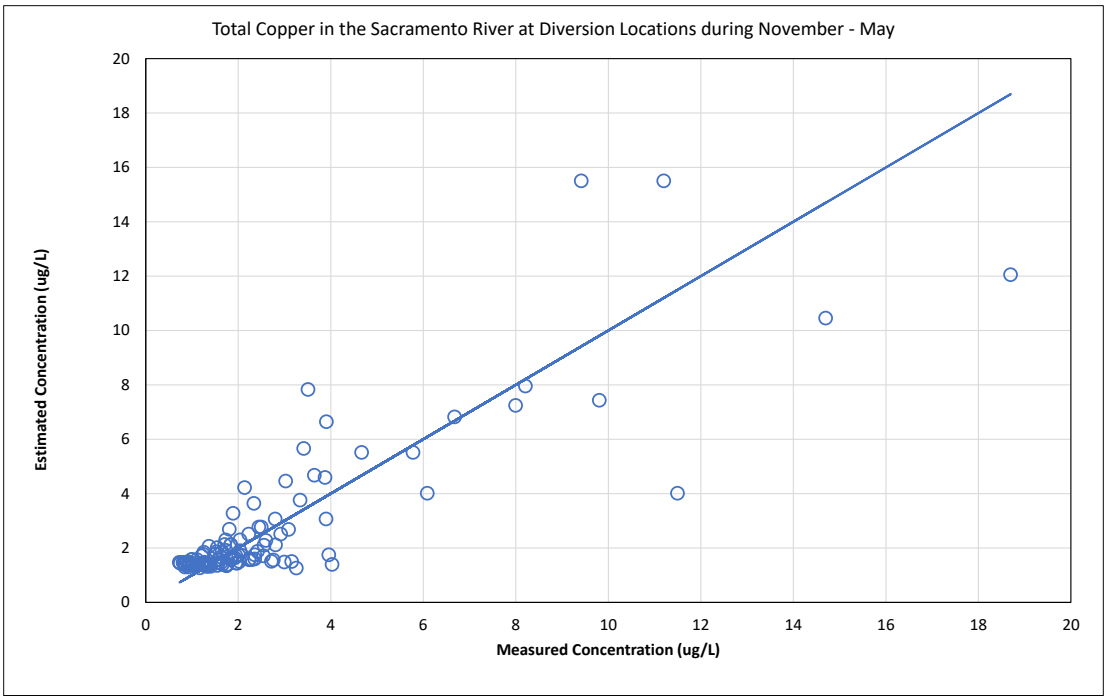

Figure 6E-44. Evaluation of the Performance of the Equation for Estimating Total Copper Concentration in the Water Diverted to Sites Reservoir Storage as a Function of the Flow Metric, Measured versus Estimated Values

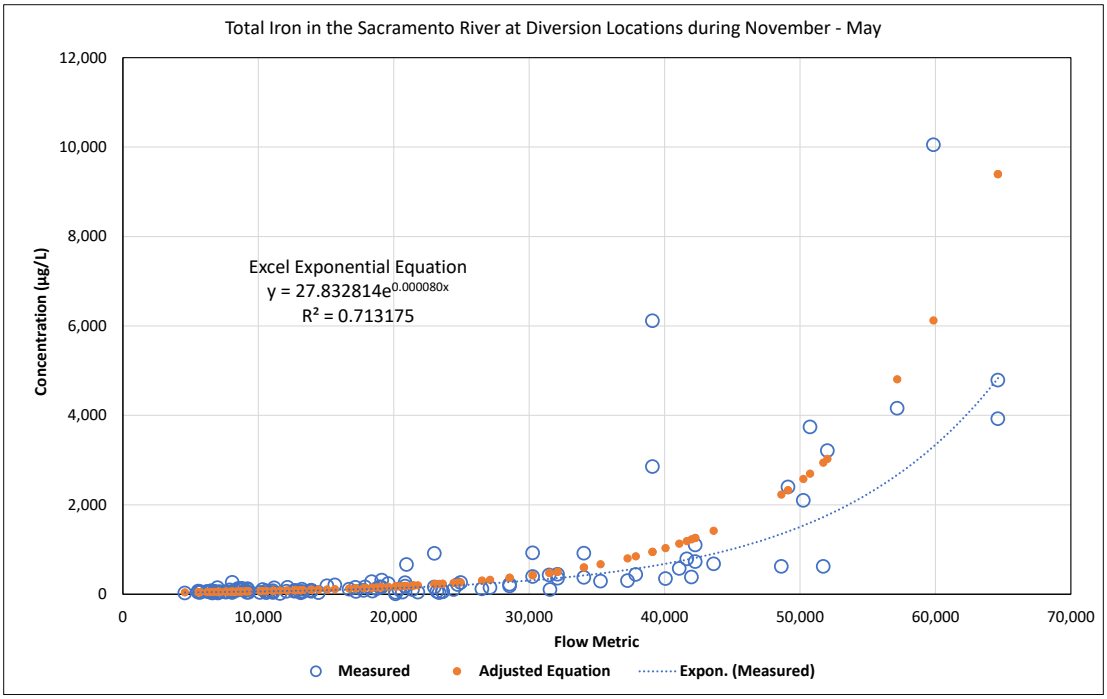

Figure 6E-45. Regression for Estimating Total Iron Concentration in Water Diverted to Sites Reservoir Storage as a Function of the Flow Metric

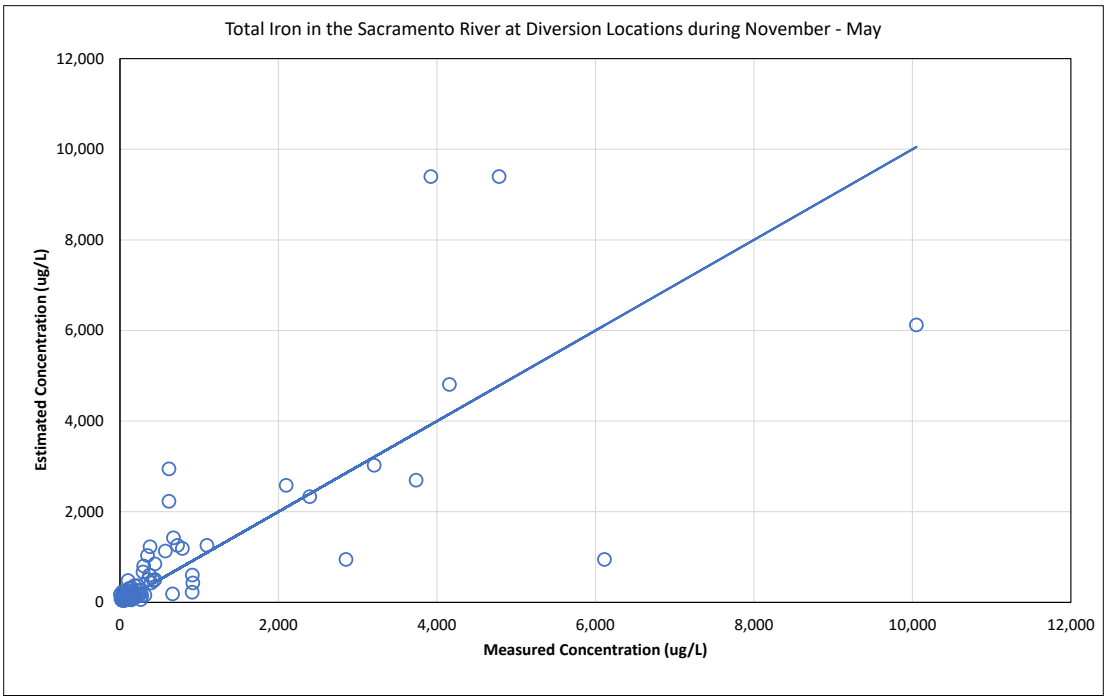

Figure 6E-46. Evaluation of the Performance of the Equation for Estimating Total Iron Concentration in the Water Diverted to Sites Reservoir Storage as a Function of the Flow Metric, Measured versus Estimated Values

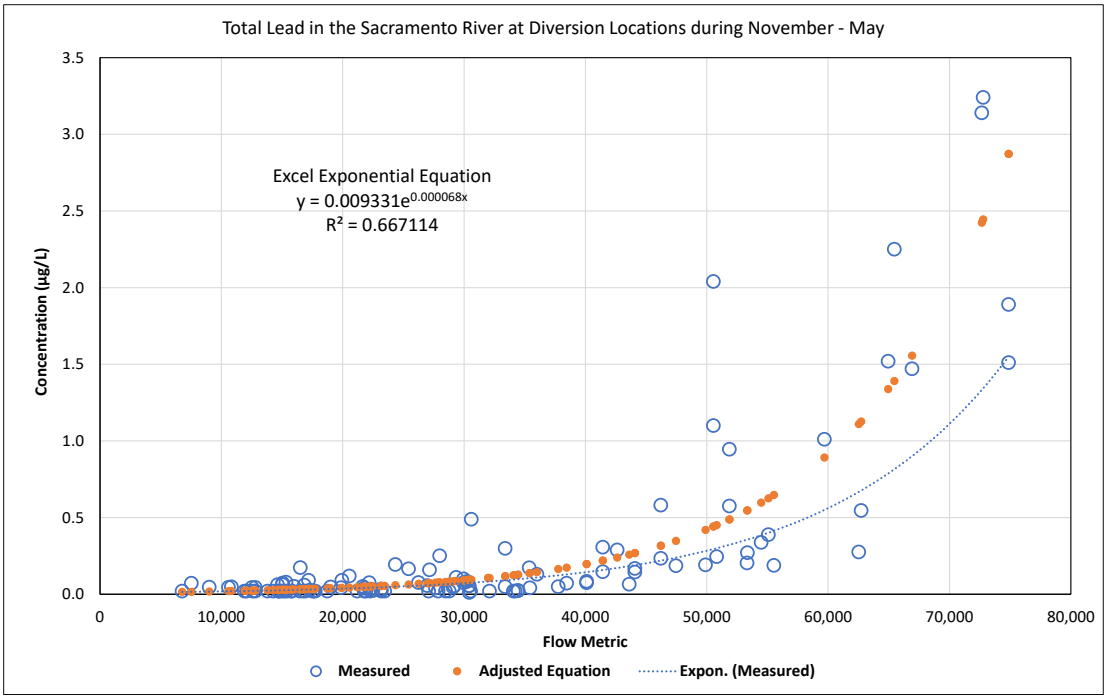

Figure 6E-47. Regression for Estimating Total Lead Concentration in Water Diverted to Sites Reservoir Storage as a Function of the Flow Metric

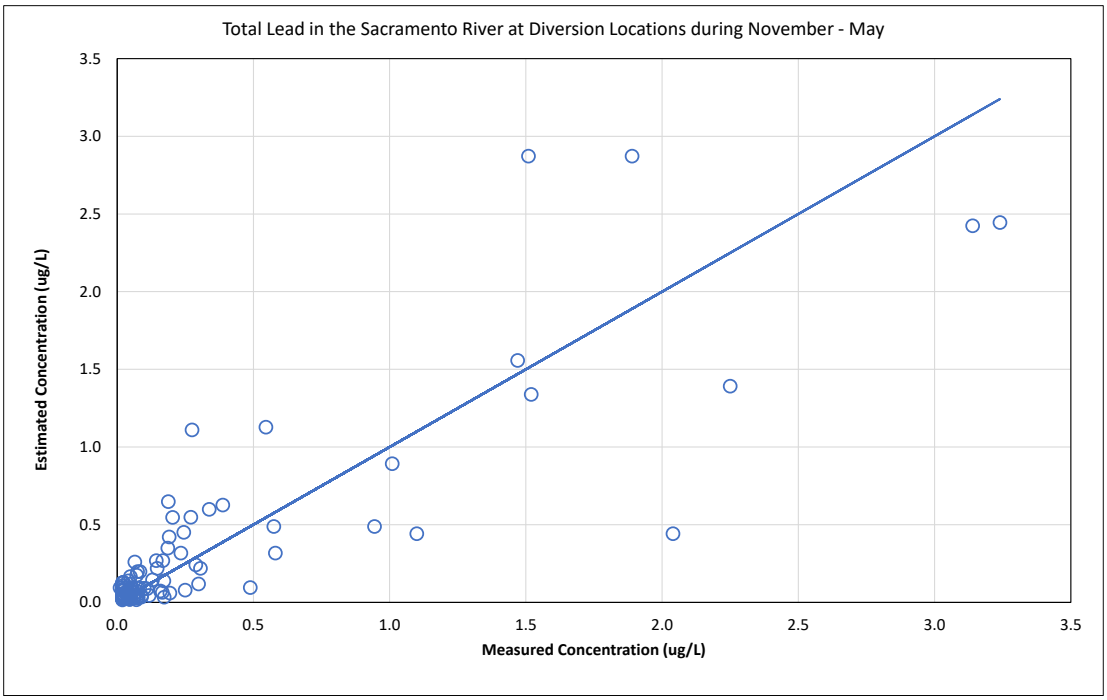

Figure 6E-48. Evaluation of the Performance of the Equation for Estimating Total Lead Concentration in the Water Diverted to Sites Reservoir Storage as a Function of the Flow Metric, Measured versus Estimated Values

6E.7.3. Procedure for Evaluating Effect of Settling of Suspended Sediment

To approximate potential concentration of total metal in Sites Reservoir after settling of sediment, additional calculations were made based on the assumption that once total concentrations are high (above the 80th percentile of measured values). Most of the difference between the measured total and dissolved concentrations is due to sediment that would settle in the canals, regulating reservoirs, or Sites Reservoir. This approximated value could be an underestimate but serves to illustrate the substantial effect that sediment settling can have on metal concentrations. To implement this conservative estimate of settling, a second set of inflow concentrations to estimate inflow concentration after settling was created. If the estimated total concentration was less than the 80th percentile value, it was unmodified; if it was greater, the new inflow concentration was estimated as:

(total concentration – 80th percentile value) * ratio + 80th percentile value

Where:

80th percentile value = 80th percentile of measurements collected from the Sacramento River at Red Bluff and Hamilton City during November – May (i.e., the same measured values used to create the equations for estimating Sites Reservoir inflow concentrations).

ratio = 80th percentile of dissolved concentrations / 80th percentile of total concentrations.

The figure below shows how this estimation process affects estimated metals concentrations using aluminum as an example. All of the concentrations below the 80th percentile are unaffected. Concentrations above the 80th percentile increase as a fraction of the total concentration. Most of the concentrations are below the 80th percentile, but the spread of the higher concentrations, some of which are outside of the graph, dominates what is seen on the graph.

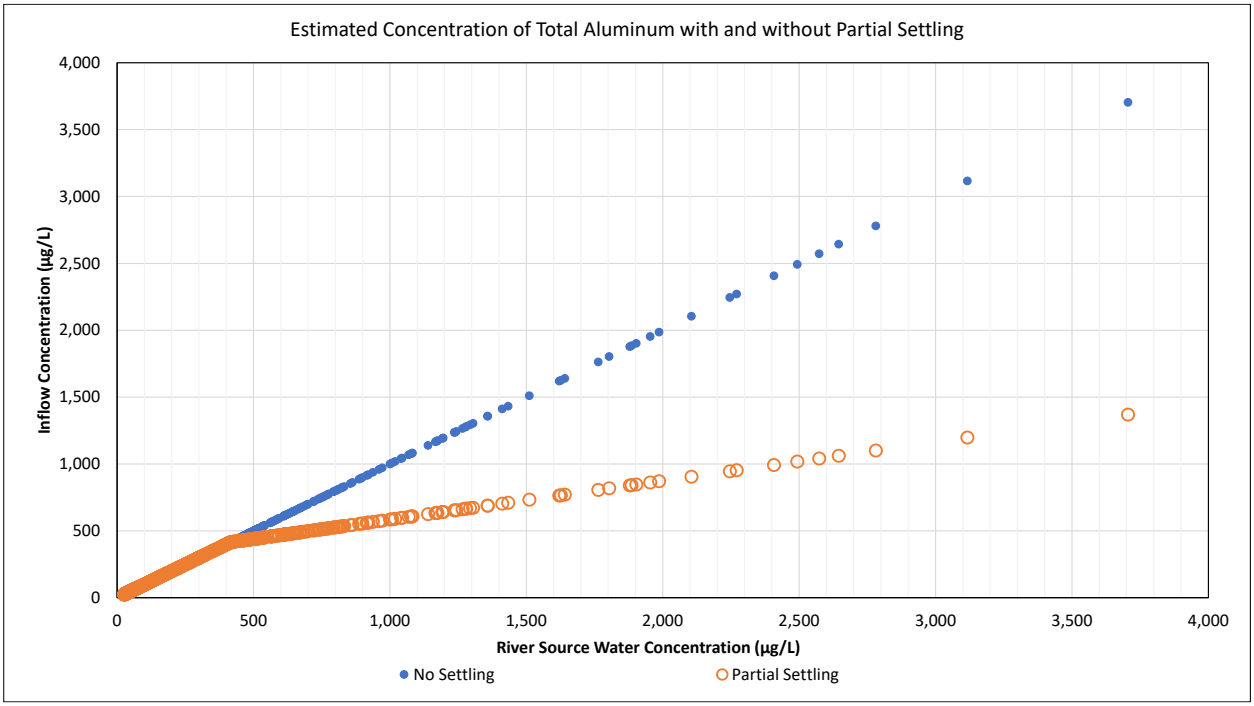

Figure 6E-49. Estimated Total Concentration of Aluminum Before and After Settling of Suspended Sediment

6E.7.4. Estimated Metals Concentration in Sites Reservoir and the Sacramento River Downstream of the Sites Discharge

These figures show estimated total concentrations entering Sites Reservoir, estimated concentrations in Sites Reservoir with and without settling, and anticipated effects of Sites discharges on concentrations in the Sacramento River. Estimated concentrations in the Sacramento River upstream of the Sites discharge location were based on measured values for the Sacramento River above CBD and the Sacramento River at Hamilton City during May–September. Because releases to the Sacramento River would occur after settling of suspended sediment, these graphs show concentrations assuming settling of suspended sediment. Two types of results for concentrations in the Sacramento River downstream of the Sites discharge are shown:

- Median river concentrations mixed with Sites Reservoir concentrations. This represents typical river concentrations mixed with Sites concentrations.

- 95th percentile river concentrations mixed with Sites Reservoir concentrations. This represents high river concentrations mixed with Sites concentrations.

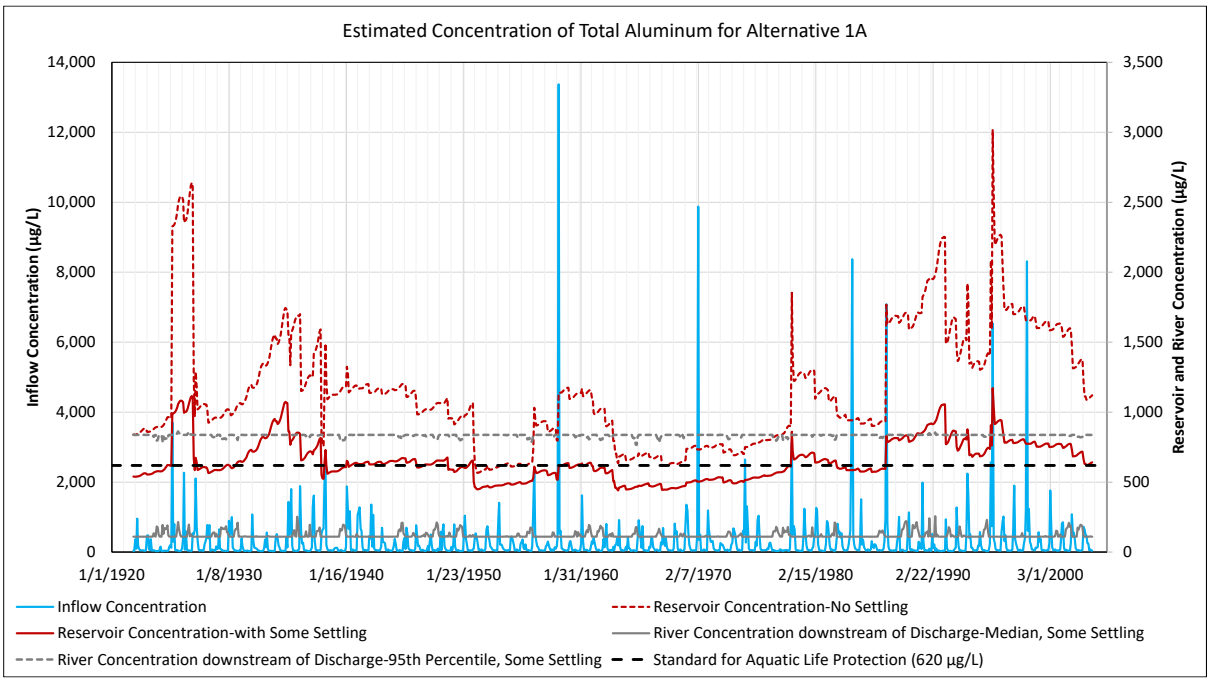

Figure 6E-50. Estimated Total Aluminum Concentration in Inflow to Sites Reservoir, in Sites Reservoir, and in the Sacramento River at the Sites Discharge Location for Alternative 1A

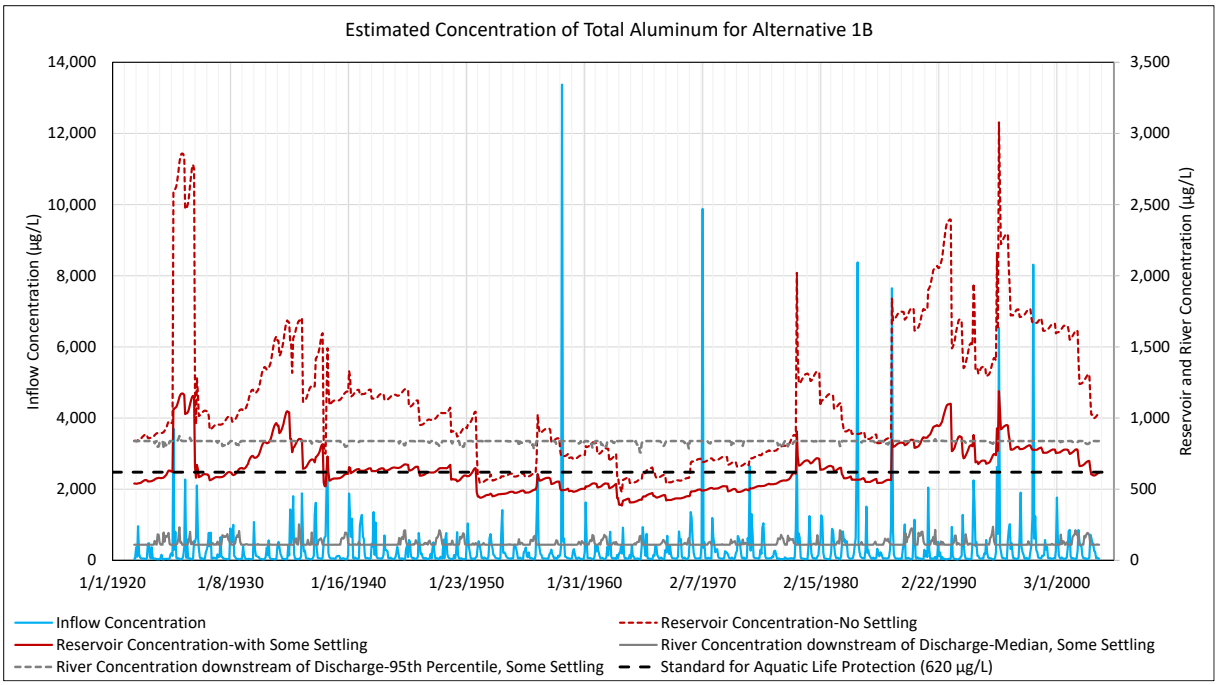

Figure 6E-51. Estimated Total Aluminum Concentration in Inflow to Sites Reservoir, in Sites Reservoir, and in the Sacramento River at the Sites Discharge Location for Alternative 1B

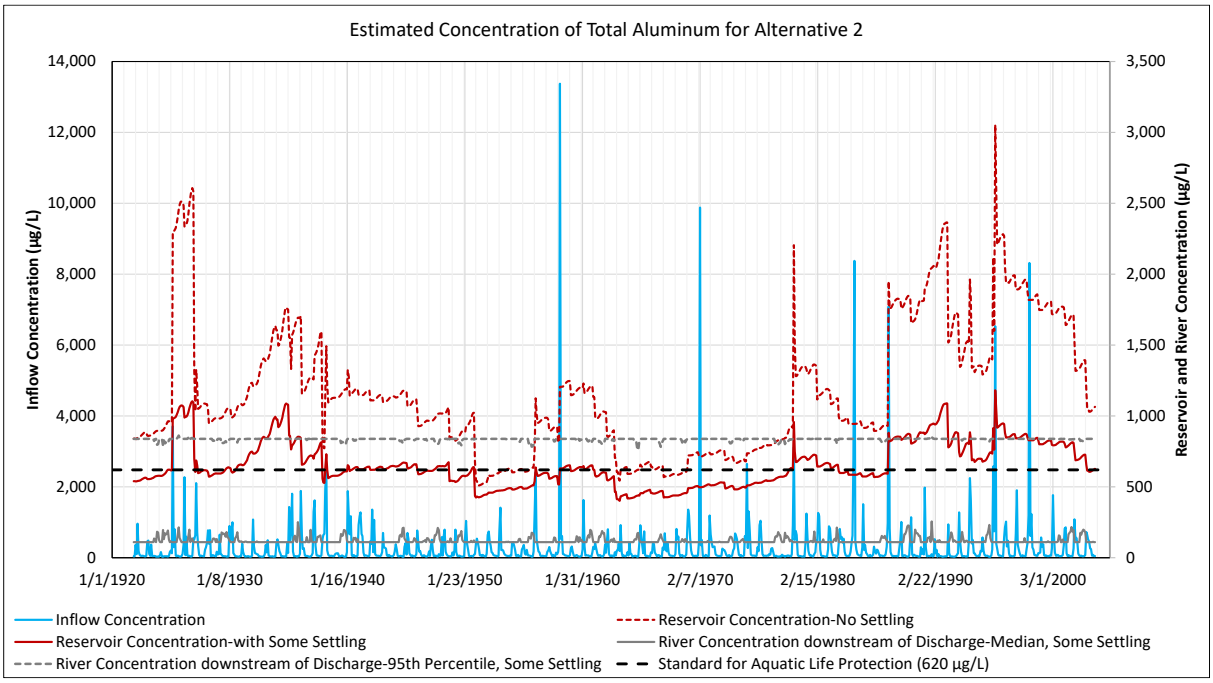

Figure 6E-52. Estimated Total Aluminum Concentration in Inflow to Sites Reservoir, in Sites Reservoir, and in the Sacramento River at the Sites Discharge Location for Alternative 2

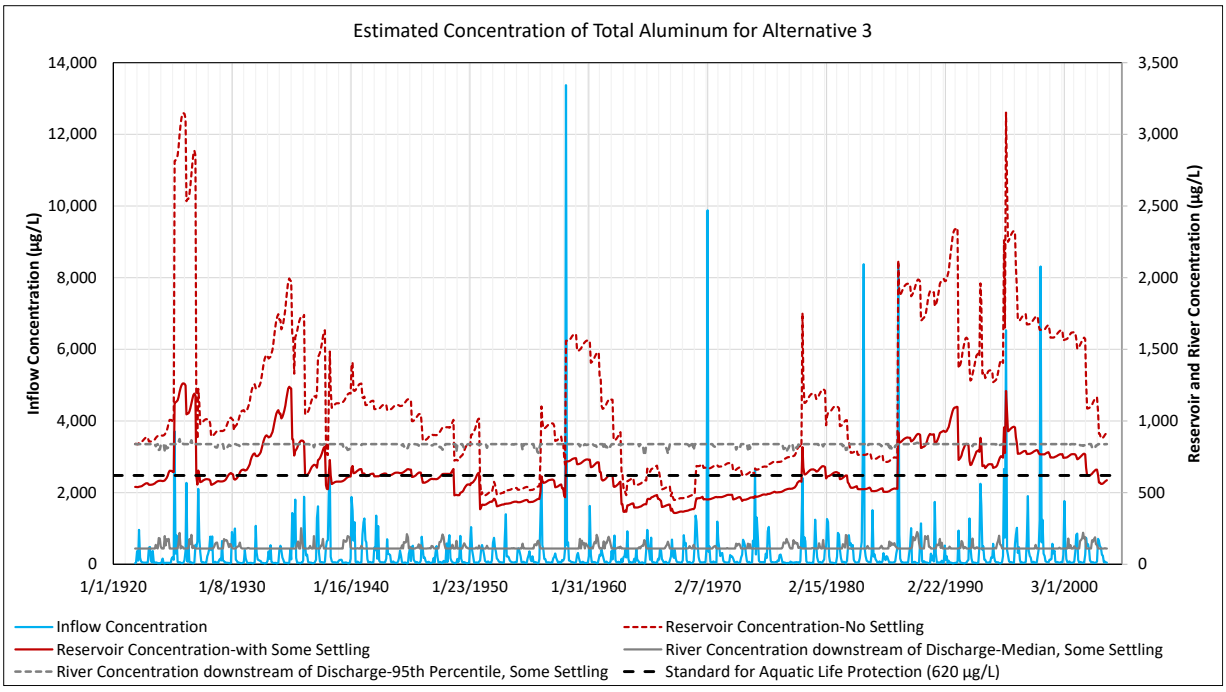

Figure 6E-53. Estimated Total Aluminum Concentration in Inflow to Sites Reservoir, in Sites Reservoir, and in the Sacramento River at the Sites Discharge Location for Alternative 3

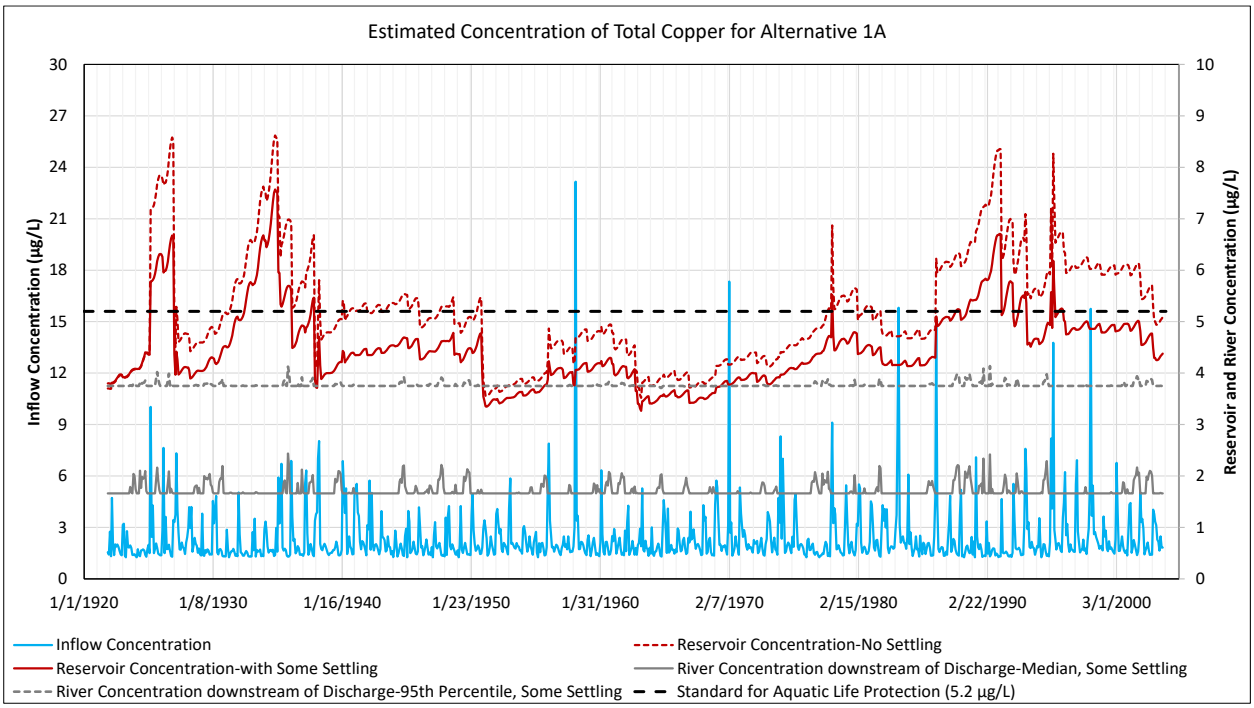

Figure 6E-54. Estimated Total Copper Concentration in Inflow to Sites Reservoir, in Sites Reservoir, and in the Sacramento River at the Sites Discharge Location for Alternative 1A

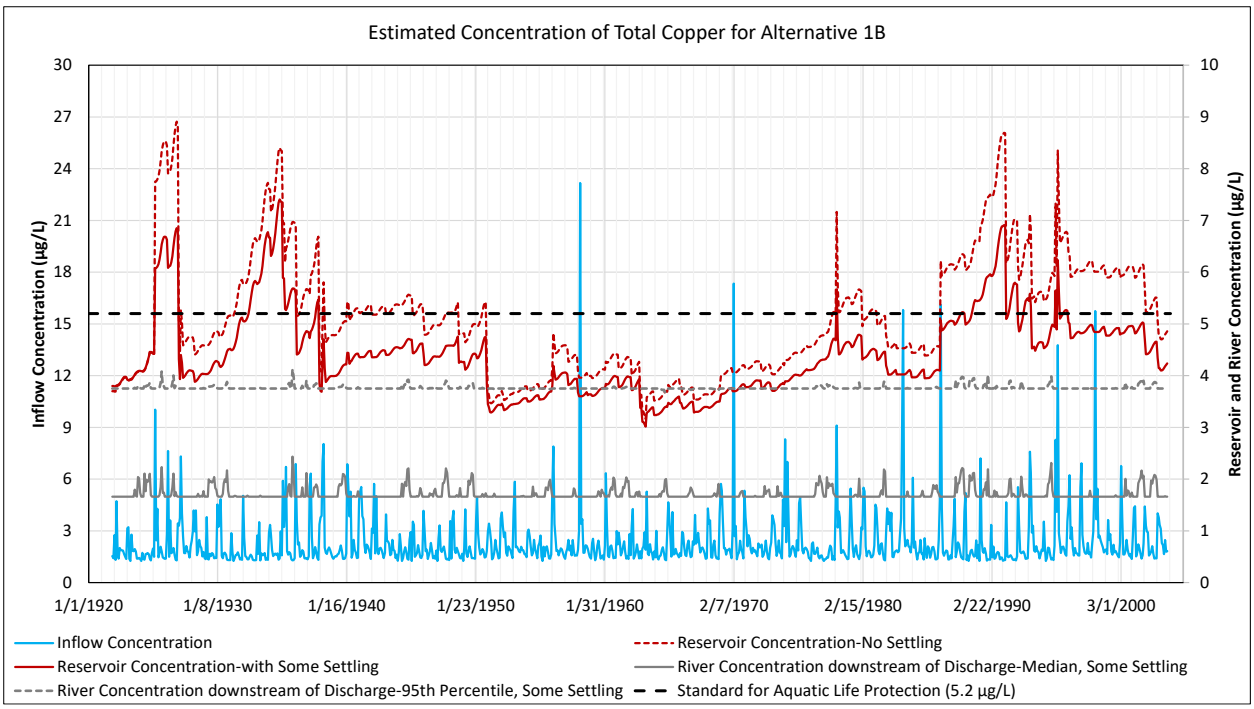

Figure 6E-55. Estimated Total Copper Concentration in Inflow to Sites Reservoir, in Sites Reservoir, and in the Sacramento River at the Sites Discharge Location for Alternative 1B

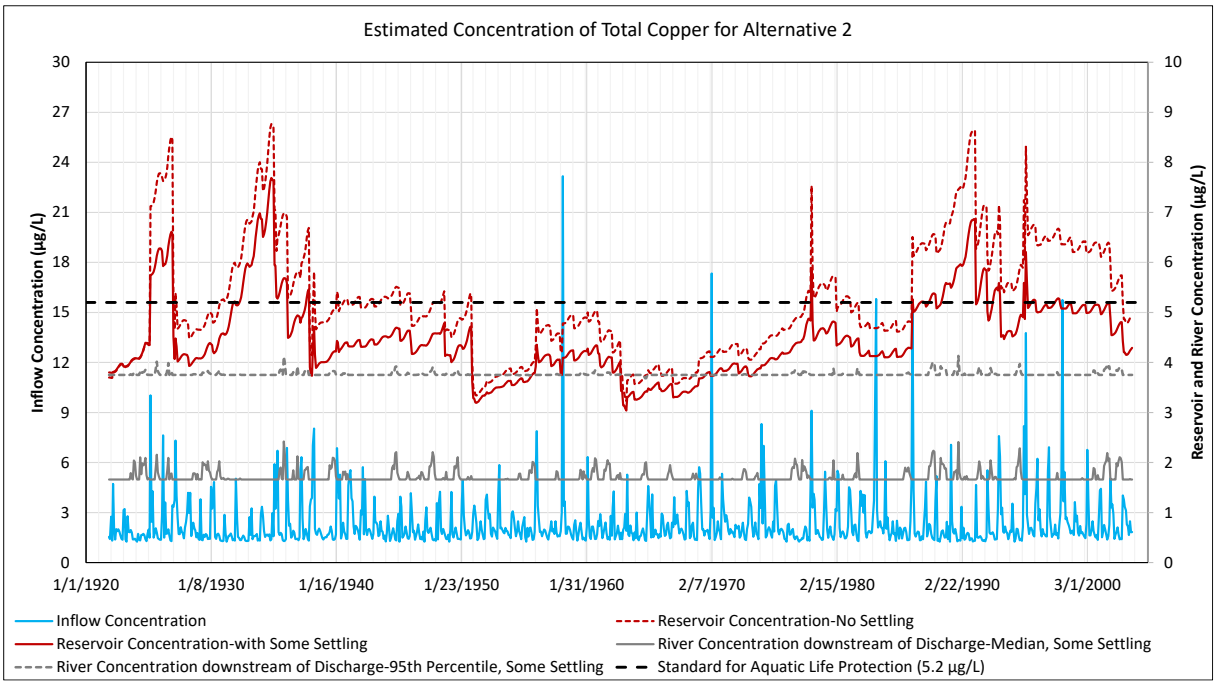

Figure 6E-56. Estimated Total Copper Concentration in Inflow to Sites Reservoir, in Sites Reservoir, and in the Sacramento River at the Sites Discharge Location for Alternative 2

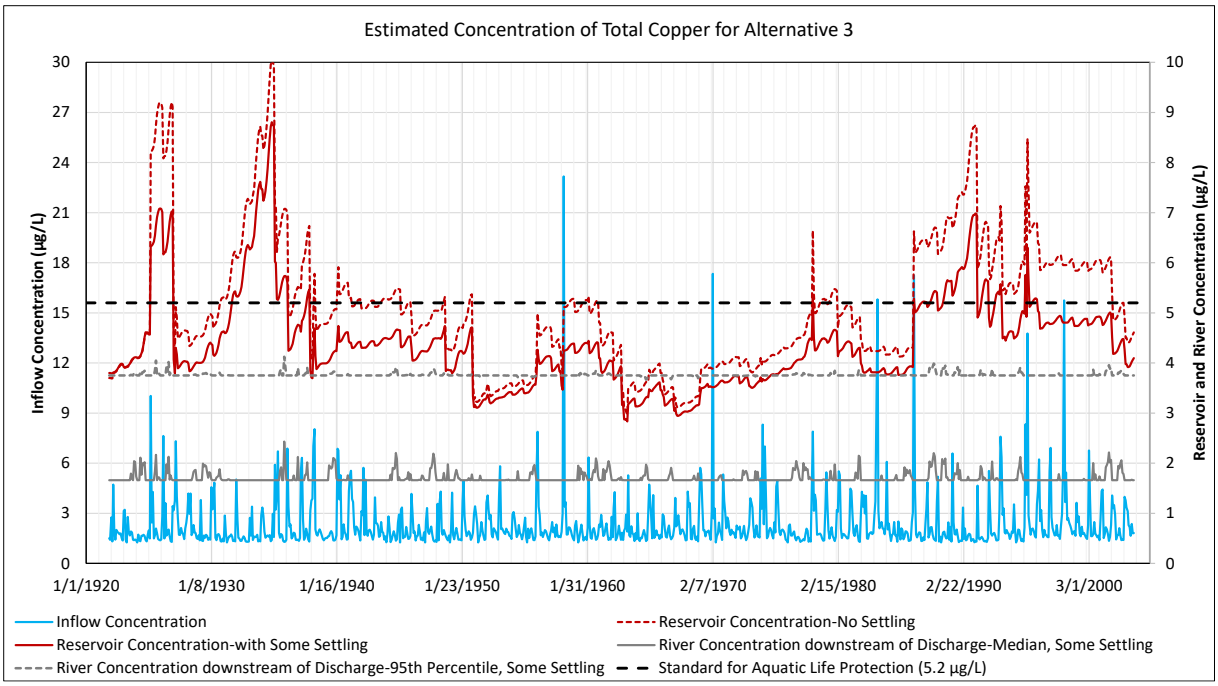

Figure 6E-57. Estimated Total Copper Concentration in Inflow to Sites Reservoir, in Sites Reservoir, and in the Sacramento River at the Sites Discharge Location for Alternative 3

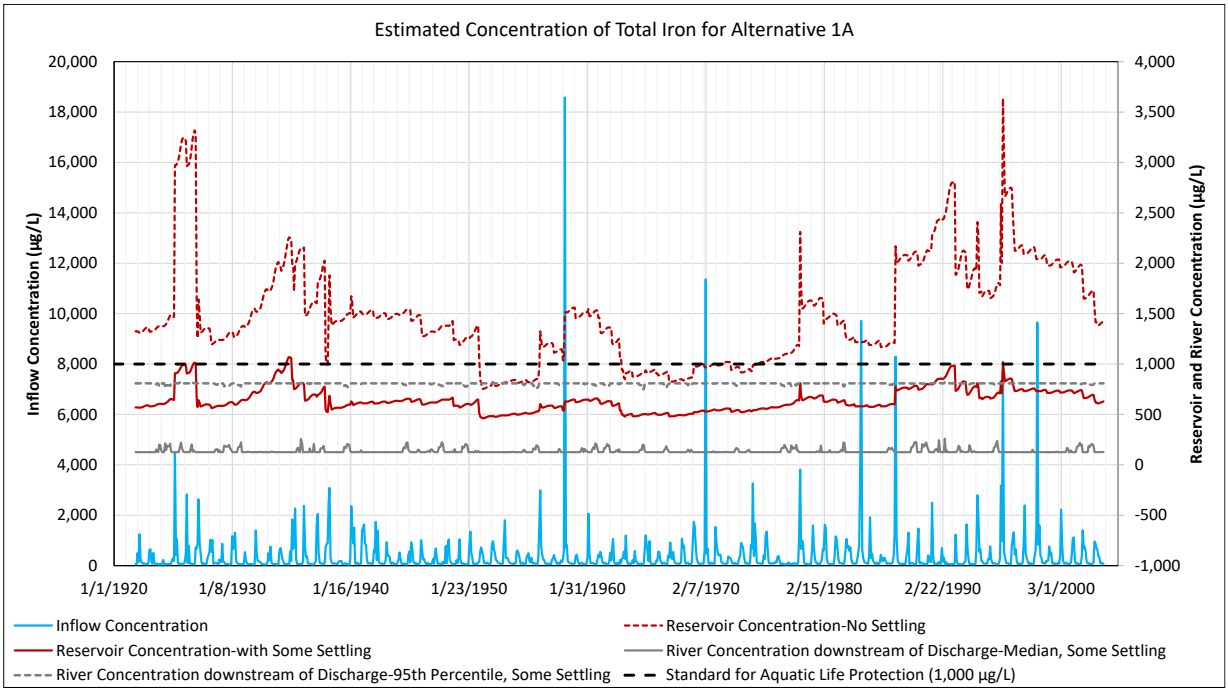

Figure 6E-58. Estimated Total Iron Concentration in Inflow to Sites Reservoir, in Sites Reservoir, and in the Sacramento River at the Sites Discharge Location for Alternative 1A

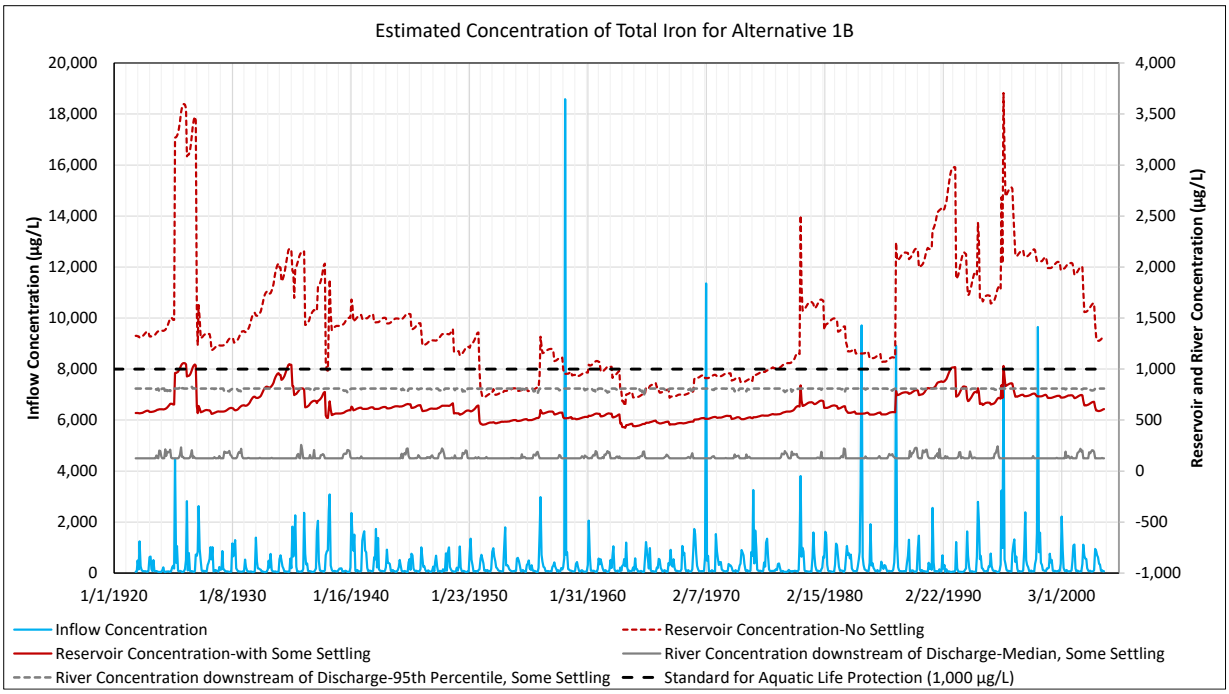

Figure 6E-59. Estimated Total Iron Concentration in Inflow to Sites Reservoir, in Sites Reservoir, and in the Sacramento River at the Sites Discharge Location for Alternative 1B

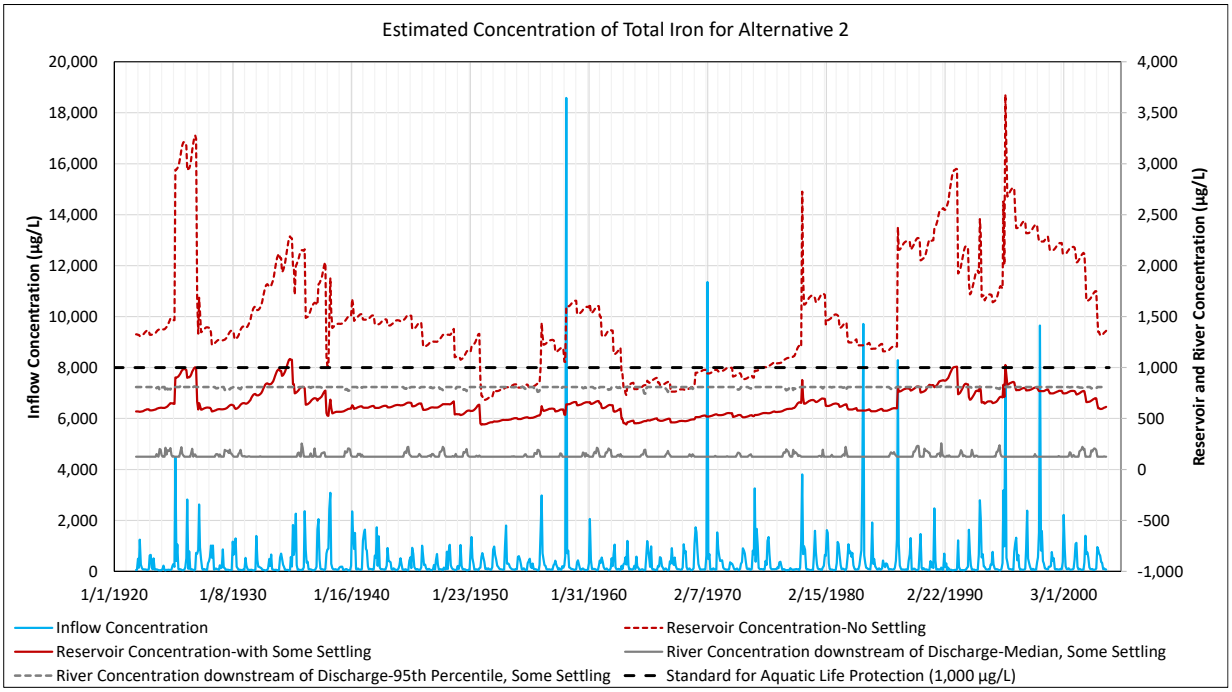

Figure 6E-60. Estimated Total Iron Concentration in Inflow to Sites Reservoir, in Sites Reservoir, and in the Sacramento River at the Sites Discharge Location for Alternative 2

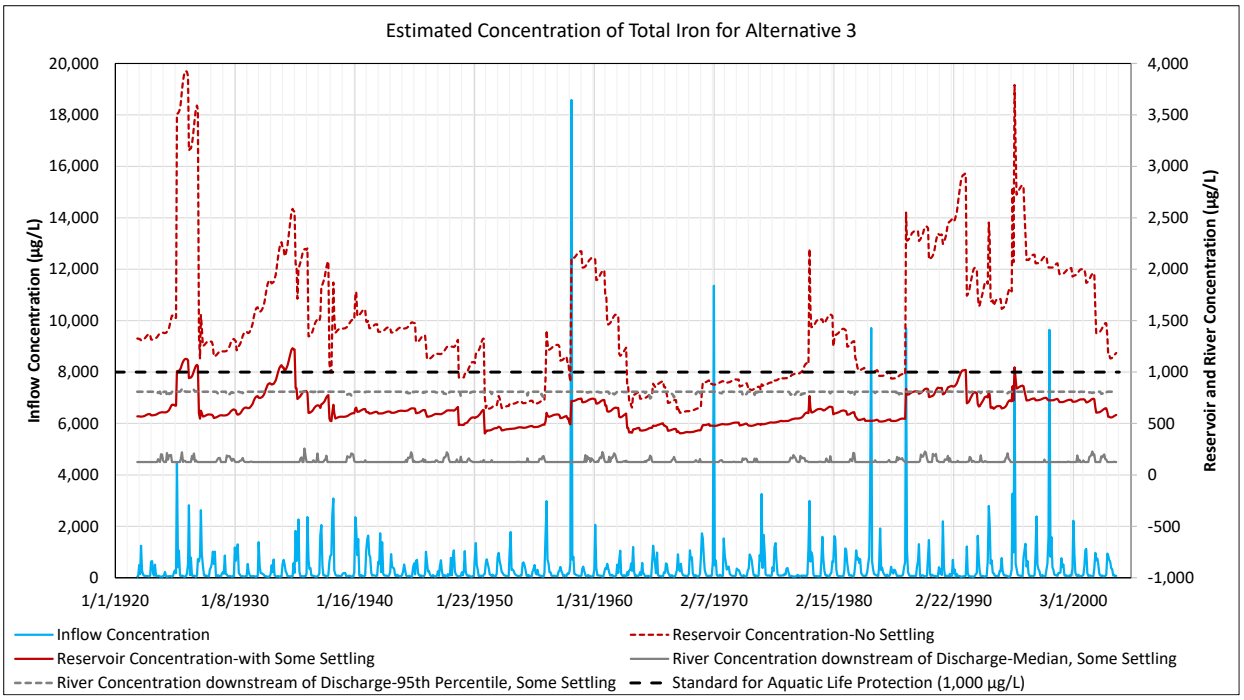

Figure 6E-61. Estimated Total Iron Concentration in Inflow to Sites Reservoir, in Sites Reservoir, and in the Sacramento River at the Sites Discharge Location for Alternative 3

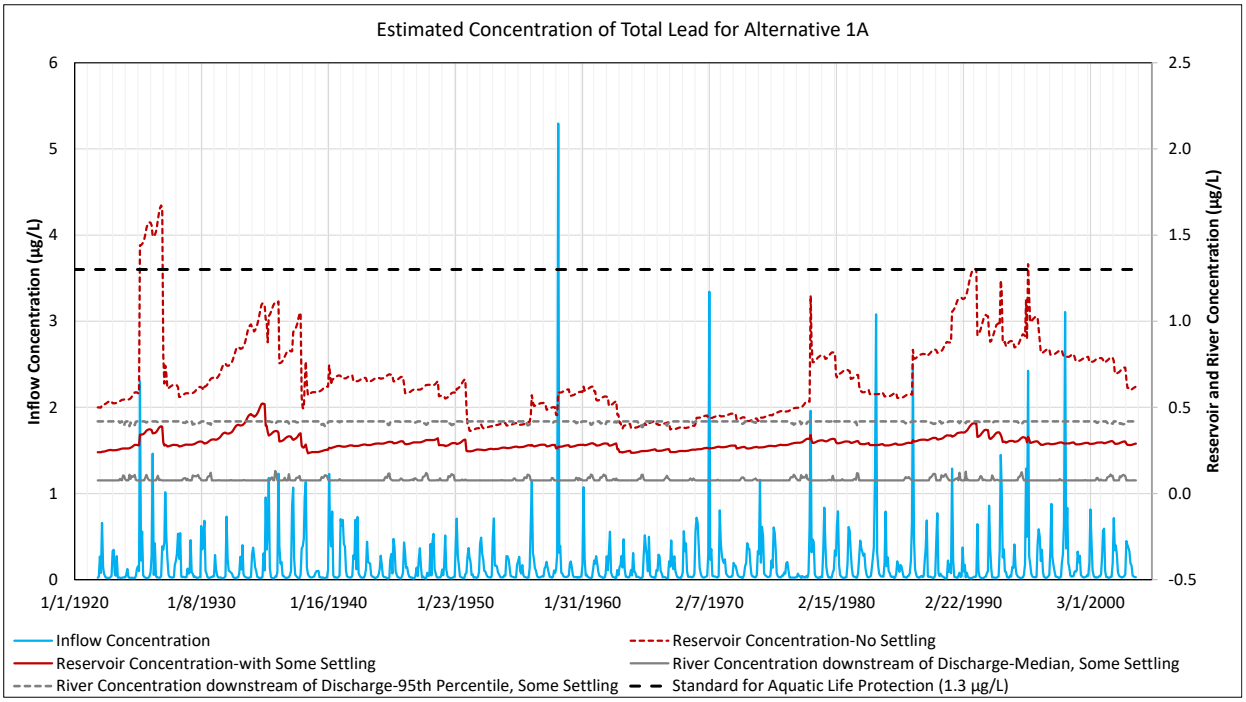

Figure 6E-62. Estimated Total Lead Concentration in Inflow to Sites Reservoir, in Sites Reservoir, and in the Sacramento River at the Sites Discharge Location for Alternative 1A

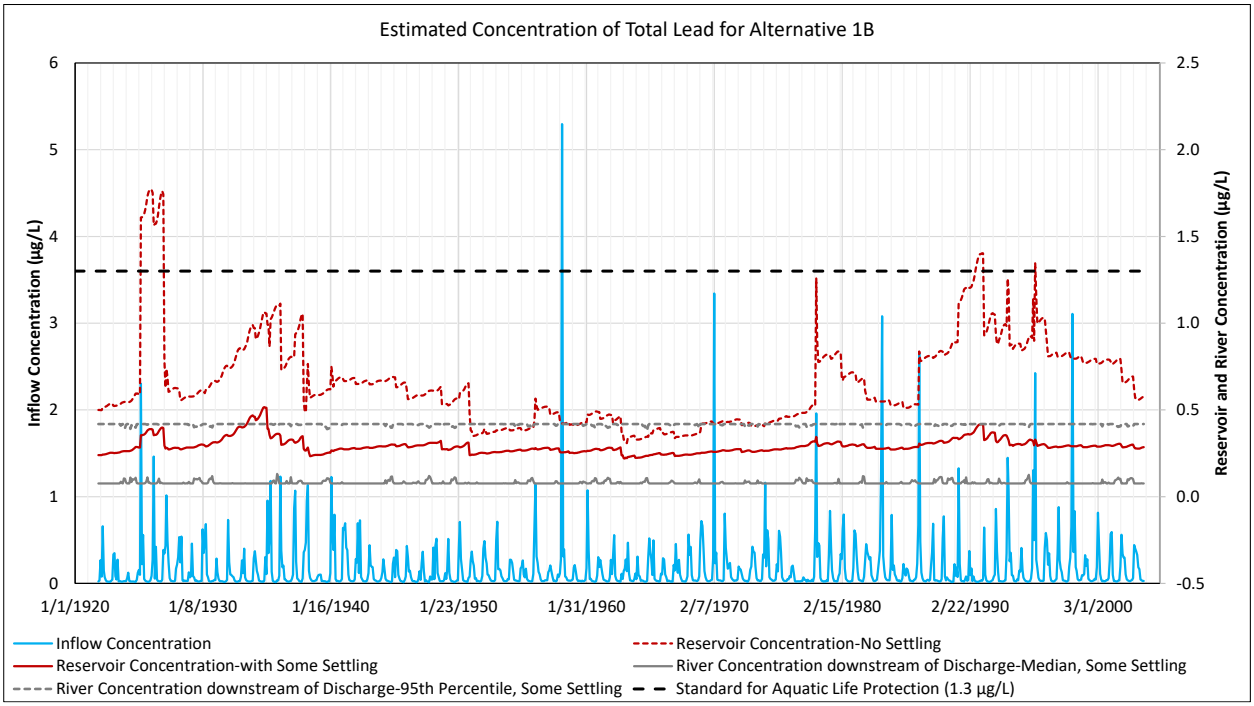

Figure 6E-63. Estimated Total Lead Concentration in Inflow to Sites Reservoir, in Sites Reservoir, and in the Sacramento River at the Sites Discharge Location for Alternative 1B

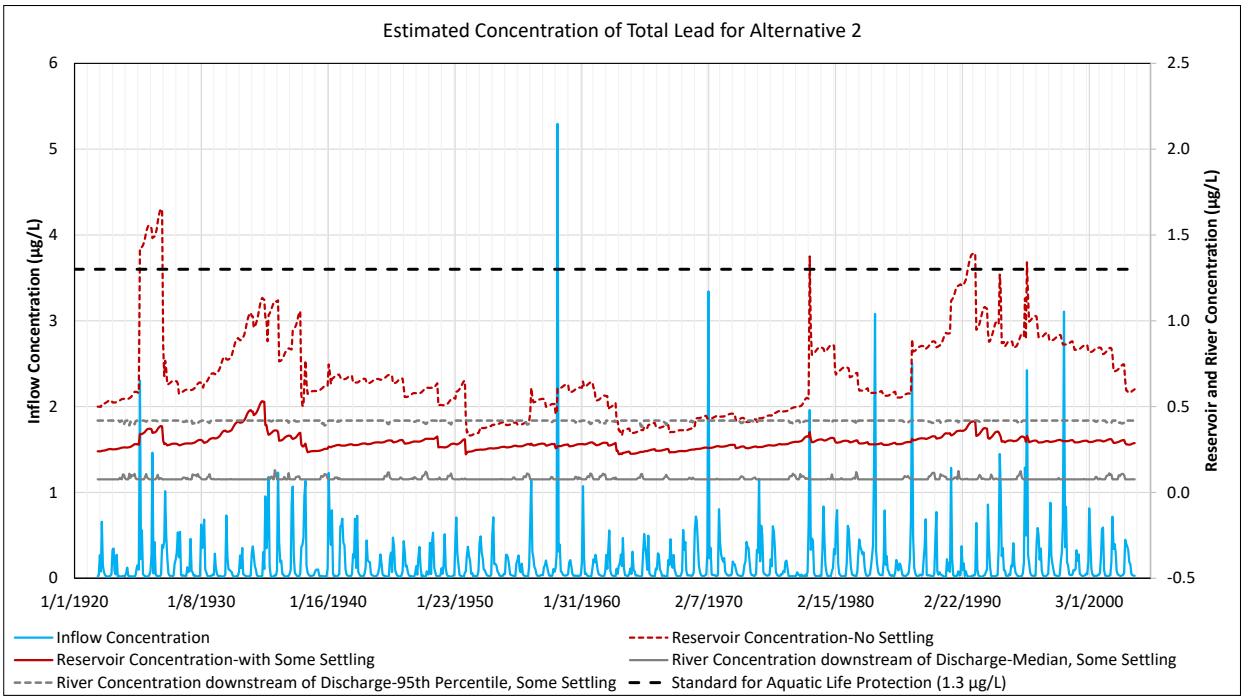

Figure 6E-64. Estimated Total Lead Concentration in Inflow to Sites Reservoir, in Sites Reservoir, and in the Sacramento River at the Sites Discharge Location for Alternative 2

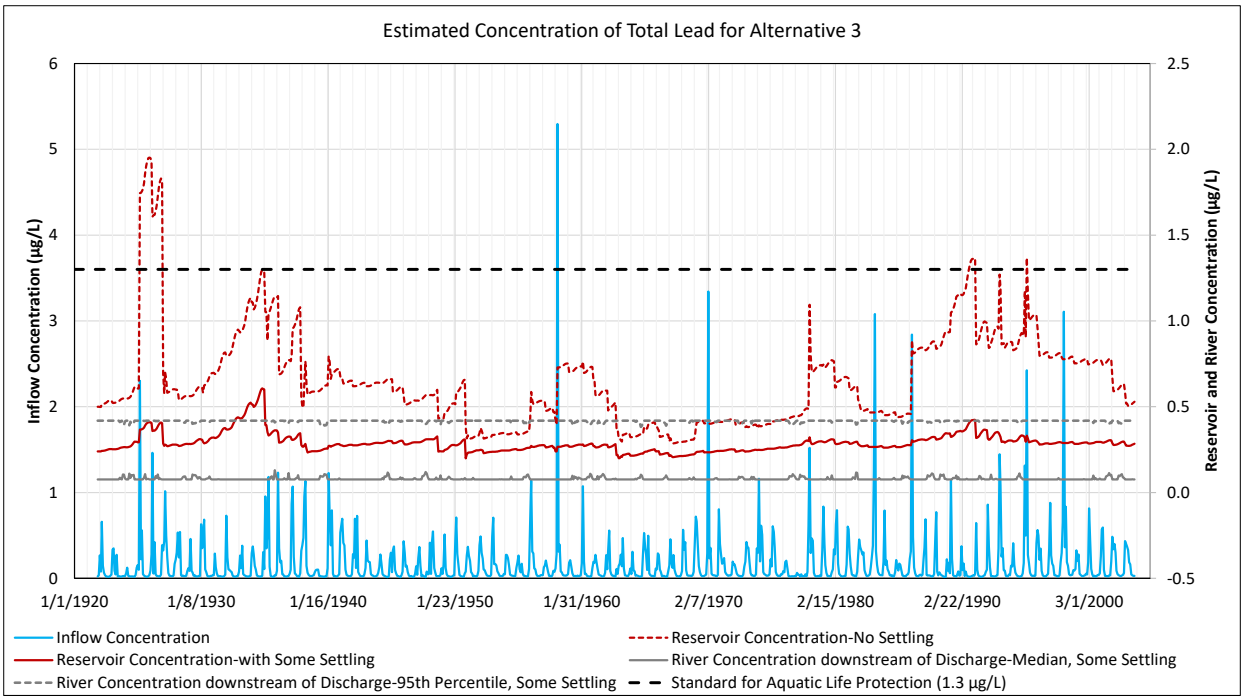

Figure 6E-65. Estimated Total Lead Concentration in Inflow to Sites Reservoir, in Sites Reservoir, and in the Sacramento River at the Sites Discharge Location for Alternative 3

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