Contra Costa Clean Water Program

Methylmercury Control Study Progress Report

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FINAL

Submitted to:

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EXECUTIVE SUMMARY

The Contra Costa Clean Water Program (CCCWP) began implementation of a Methylmercury Control Study in 2012 to fulfill requirements of the Central Valley Municipal Regional Stormwater Discharge Permit (Order No. R5-2010-010). A Methylmercury Control Study Work Plan (Amec, 2013) was prepared to 1) evaluate the effectiveness of existing Best Management Practices (BMPs) for the control of methylmercury; 2) evaluate additional or enhanced BMPs, as needed, to reduce mercury and methylmercury discharges to the Delta; and 3) determine the feasibility of meeting methylmercury waste load allocations.

The Central Valley Regional Valley Water Quality Control Board (CVRWQCB) has established a water column concentration goal of 0.06 ng/L total methylmercury. If the average total methylmercury concentration in a water body exceeds 0.06 ng/L, follow-up actions are required by the CVRWQCB to investigate causes within a water source, and to determine reasonable and foreseeable means of attaining 0.06 ng/L.

This progress report presents preliminary findings of the Methylmercury Control Study Work Plan from spring 2012 through spring 2015. Watershed characterization of methylmercury concentrations in eastern portions of the County is referred to as Phase 1; evaluation of potential control measures (e.g., structural BMPs) is referred to as Phase 2. A final report to the CVRWQCB is required by October 2018.

Following are summary findings to date for the Methylmercury Control Study overall:

- The preliminary data from Phase 1 and Phase 2 are fulfilling the goals of the Methylmercury Control Study:
    - Determine the effectiveness of methylmercury (MeHg) control measures applied to urban stormwater;
    - Use the results to evaluate the feasibility of attaining numeric targets established by the Sacramento – San Joaquin Delta Estuary TMDL for Methylmercury (Delta Mercury TMDL); and
    - Propose likely methylmercury load reductions attainable through reasonable and foreseeable control measures applied to urban stormwater discharges.
- The data confirm that background methylmercury concentrations in sediments make attaining the Total Maximum Daily Load (TMDL) target of 0.06 ng/L in surface waters infeasible.
- Contra Costa Clean Water Program staff intends to complete and submit the final methylmercury control study report on time in the 2018 program annual report.
- As additional BMP effectiveness and upper Marsh Creek watershed process information is developed through future BMP design innovations and watershed assessments, it can be reported on a five-year permit renewal cycle through the submittal of a Report of Waste Discharge.

Phase 1 – Watershed Characterization

Summary Findings

- The watershed survey did not reveal significant watershed sources of elevated methylmercury during the wet and dry events sampled.
- The lowest methylmercury concentrations measured were in lower Marsh Creek, where flow is primarily highly treated effluent from the Brentwood Wastewater Treatment Plant.

Data Gaps and Next Steps

- Future watershed monitoring for mercury will be limited to characterizing upper watershed flows from Marsh Creek where only a single sample has been collected thus far, owing to low rainfall amounts during much of the study period.
- As rainfalls allow, collect up to 2 additional sample sets at Site M2 (Lower Marsh Creek) during upper-watershed discharge (when the Marsh Creek reservoir is discharging to Lower Marsh Creek).

Phase 2 – BMP Evaluation

Summary Findings

- Treating stormwater by low impact development (LID) to promote infiltration and reduce suspended sediments in discharged stormwater is the most reasonable and foreseeable means of reducing methylmercury loads from urban stormwater.
- The non-traditional LID application in Richmond that was assessed in this study is not designed for infiltration – it only passes water through the root zones of plants to reduce suspended sediment concentrations and may not provide as much treatment as traditional LID applications (i.e., detention and infiltration structures).
- Some features of the Richmond biofiltration cells assessed in this study increased methylmercury; we are currently evaluating why.
- No matter how much progress is made over the next two years, there will likely be additional uncertainties and unanswered questions about optimizing LID designs and upper Marsh Creek watershed processes.

Data Gaps and Next Steps

- The remainder of the Phase 2 study will focus on evaluation of more traditional LID applications, as described in the Contra Costa County C.3 Design Guidance, that promote detention and infiltration. These types of BMPs have not yet been assessed in this study.
- The goal of the remaining Phase 2 Best Management Practice effectiveness evaluation effort is to characterize the methylmercury concentration in discharges from traditional LID devices.
- The final study report will also describe methylmercury load reduction benefits resulting from infiltration.

1.0 INTRODUCTION

Contra Costa Clean Water Program represents the 21 municipal agencies within Contra Costa County and are regulated by the State of California through two National Pollutant Discharge Elimination System (NPDES) stormwater discharge permits: the San Francisco Bay and Central Valley Regional Water Quality Control Board Municipal Regional Permits (MRPs). CCCWP is tasked with fulfilling the stormwater mandates of each of these two MRPs.

CCCWP began implementation of a Methylmercury Control Study in 2012 to fulfill requirements of Provision C.11 of the Central Valley MRP (Order No. R5-2010-010). A Methylmercury Control Study Work Plan (Amec, 2013) was prepared in response to Provision C.11 and was designed to 1) evaluate the effectiveness of existing BMPs for the control of methylmercury; 2) evaluate additional or enhanced BMPs, as needed, to reduce mercury and methylmercury discharges to the Delta; and 3) determine the feasibility of meeting methylmercury waste load allocations.

Methylmercury wasteload allocations were established for all dischargers to the Delta by the CVRWQCB through the Sacramento-San Joaquin Delta Estuary TMDL for Methylmercury (Delta Mercury TMDL). The Delta Mercury TMDL is intended to bring mercury concentrations in fish down to levels considered to be protective of people and wildlife who consume fish from the Delta. The Delta Mercury TMDL translates reduced levels of mercury in fish to a water column target of 0.06 nanograms per liter (ng/L) unfiltered methylmercury per liter of water. In essence, through its TMDL policy, CVRWQCB maintains that if all waters of the Delta were to attain a concentration of 0.06 ng/L, fish within the Delta would have a protective level of methylmercury.

The 0.06 ng/L implementation goal was used to establish wasteload allocations for dischargers and load allocations for tributaries and nonpoint sources. The concentration goal of 0.06 ng/L is multiplied by expected flows to establish load and wasteload allocations. For highly variable flows that result from tributaries and urban runoff or any given source of water flowing to the Delta, if the average methylmercury concentration exceeds 0.06 ng/L, follow-up actions are required by the CVRWQCB to investigate causes within that water source, and to determine reasonable and foreseeable means of attaining 0.06 ng/L.

This progress report presents preliminary findings of the Methylmercury Control Study Work Plan from spring 2012 through spring 2015. The Central Valley Permit defines the initial watershed characterization Phase of the Control Study as Phase 1, and the evaluation of potential control measures (e.g., structural BMPs) as Phase 2. A final report to the CVRWQCB will be submitted by October 2018.

1.1 Study Site Locations

Phase 1 sampling was performed at the following locations, as specified in Work Plan Table 4.

- Marsh Creek, upstream and downstream of the Brentwood WWTP
- Sand Creek, tributary to Marsh Creek
- Deer Creek, tributary to Marsh Creek
- Dry Creek, tributary to Marsh Creek

- West Antioch Creek, lower watershed
- East Antioch Creek, upstream and downstream of Lake Alhambra

Phase 2 sampling was conducted at two adjacent pilot biofiltration BMPs on Cutting Boulevard in the City of Richmond (LAU3 and LAU4). These BMPs were selected in part because monitoring costs were shared with a concurrent water quality study implemented at the same location. The concurrent BMP study was an EPA grant-funded study administered by BASMAA called Clean Watersheds for a Clean Bay (CW4CB).

LAU3 BMP is a biofiltration strip located between the roadway shoulder and the sidewalk on westbound Cutting Boulevard just west of 1st Street. This biofiltration strip is planted with native grass species and a standard soil mixture. Beneath the soil layer is an underdrain pipe that conveys filtered stormwater to the nearby MS4.

LAU4 BMP is adjacent to LAU3, and is identical in every way except 1) the soil mixture includes biochar, and 2) the underdrain outlet to the MS4 is slightly lower in elevation than at LAU3. The elevation difference may be significant in that the underdrain systems from LAU3 and LAU4 are tidally influenced, but the LAU4 underdrain remains periodically submerged at high-tide water for longer durations than at LAU3. This may have a confounding effect on effectiveness evaluation for methylmercury discharges since retention of water can enhance mercury methylation within an underdrain system.

1.2 Rainfall Characteristics During 2014-2015 Season

Most of Phase 1 and all of Phase 2 sampling took place during the 2014-2015 storm season which was an atypical rainfall season within Contra Costa County. The wet-weather season (October 1 through April 30) was characterized by long antecedent dry periods between storms and relatively low rainfall intensity. These atypical conditions can lead to collection of atypical data. For example, long antecedent dry periods can cause the accumulation of greater amounts of certain pollutants in urban areas (e.g., mercury by atmospheric dry deposition); whereas relatively low intensity rainfall do not scour drainage areas as much as high-intensity rainfall, and can lead to lower suspended sediment concentrations and thus lower sediment-bound pollutants (e.g., mercury).

2.0 METHODS

CCCWP's monitoring contractor, ADH Environmental (ADH), implemented the Control Study sampling under the direction of CCCWP. The following two subsections describe field and laboratory methods that were used in the implementation of the Work Plan.

2.1 Field Methods

Phase 1 water sampling was performed at eight stream locations in eastern Contra Costa County following clean-hands/dirty-hands grab sampling protocols (EPA Method 1669) for low-level mercury analysis (EPA Method 1631E). Phase 1 sampling was performed during dry and wet weather periods. Wet weather samples were collected during elevated stream stages near storm peak discharge.

Phase 2 stormwater samples were collected at the influent and effluent points of each of two BMP biofiltration cells in the City of Richmond. Influent samples were pumped from the curb and gutter conveyance on the north side of Cutting Boulevard, and effluent samples were pumped from the terminus of each biofiltration cell underdrain outfall within the City's municipal storm sewer system. Samples were drawn with non-contaminating peristaltic pumps fitted with solid fluorinated ethylene propylene (Teflon®) semi-rigid tubing and styrene ethylene butylene (C-Flex®) pump-roller tubing. All wetted surfaces of the tubing were cleaned with non-ionic detergent and hydrochloric acid prior to use. Clean sets of tubing were used at each sampling point and for every sampling event. Additionally, all tubing was thoroughly rinsed by pumping site water through each tubing assembly before each round of sample collection. Clean-hands/dirty-hands protocols were used for the collection of all mercury and methylmercury samples.

2.2 Laboratory Methods

Caltest Analytical Laboratory of Napa, California, performed all analytical testing. Table 1 presents the study's analytical test types, methods, reporting limits and holding times.

Table 1. Analytical Tests, Methods, Reporting Limits and Holding Times

Analytical Test	Method	Reporting Limit	Holding Time
Total (Unfiltered) Mercury	EPA 1631E	0.5 ng/L	90 days
Total (Unfiltered) Methylmercury	EPA 1631E	0.05 ng/L	90 days
Suspended Sediment Concentration	ASTM D3977-97B	3 mg/L	7 days

3.0 QUALITY ASSURANCE / QUALITY CONTROL ANALYSIS

This study analyzed data from samples collected in Contra Costa County during dry and wet weather events during water year 2015, as well as wet-weather samples collected in water years 2012 and 2013. The latter data set was found to be acceptable under the Measurement Quality Objectives (MQOs) of the Quality Assurance Project Plan, Regional Monitoring Coalition Pollutants of Concern Loads Monitoring Program (RMC, 2011). The QA/QC acceptance of these data was detailed in the Regional Monitoring Coalition Pollutants of Concern Loads Monitoring Reports for water years 2012 and 2013 (SFEI, 2014).

The samples analyzed during water year 2015 followed MQOs of the Contra Costa Clean Water Program Methylmercury Control Study Work Plan (Amec, 2013). These samples all met quality objectives with the exception of those flagged samples shown in Table 2. Given that all the quality control issues described in Table 2 show that all issues were of minor consequence, the data from these samples are of acceptable quality and have been included in the data set analyzed in this progress report.

Table 2. Quality Control Issues with 2014-2015 Methylmercury Samples at Locations Around Marsh Creek, Lake Alhambra, and Cutting Boulevard, Richmond

Field/Lab Sample ID	Sampling Period	Issue	Analysis
A33-201501141219-D1	Phase 1, Dry 1 (01/14/15)	RPDs for all analytes for field duplicate outside of acceptable limits of 25%; RPDs ranged from 50 to 110%	This is not an unexpected result for 1) field duplicates sampled sequentially, and 2) low concentration of parent sample
626078	Phase 1, Storm 1 (02/08/15)	SSC detected in laboratory blank at 3.2 mg/L	All field sample results in same analytical batch had levels of SSC over ten times the blank result; the field results are acceptable
M6-201502261250-D2	Phase 1, Dry 2 (02/26/15)	RPD for SSC for field duplicate for site M4 outside of acceptable limit of 25%; RPD was 48%	This is not an unexpected result for 1) field duplicates sampled sequentially, and 2) low concentration of parent sample
637559	Phase 1, Storm 3 (04/25/15)	Percent recovery of this matrix spike sample was not calculated due to the high native concentration in the sample selected for MS/MSD vs. lab spike concentration	An LCS sample and another MS/MSD pair in the same analytical batch had acceptable levels of percent recovery, indicating the entire batch was in control; this result is acceptable
615175	Phase 2, Storm 1 (11/22/14)	SSC detected in laboratory blank at 2.9 mg/L. (just less than the RL of 3.0)	Field samples LAU3-I-SSC-02, LAU3-I-SSC-03, LAU3-E-SSC-01, LAU3-E-SSC-02, LAU3-E-SSC-03 results all less than 10 times the blank level detection; results marked as estimates

4.0 RESULTS AND DISCUSSION

Phase 1 samples were collected from spring of 2012 through spring of 2015 and met or exceeded the completeness requirements of the Methylmercury Control Study Work Plan. Tables 3 and 4 indicate the number of target samples versus the number of achieved samples and show the percent completeness for each type of sample (100 percent or greater in all cases).

Table 3. Phase 1 Dry Weather Sampling Locations and Achieved vs. Target Frequency of Sample Collection

Location Code	Site Description	Latitude (Deg. N)	Longitude (Deg. W)	Achieved Number of Dry Weather Sampling Events	Target Number of Dry Weather Sampling Events	Percent Completeness (%)
A1	West Antioch Creek above tidal influence	38.01019	-121.82345	2	2	100
A2	East Antioch Creek discharge from Lake Alhambra tide gate	38.01061	-121.79678	3	3	100
A3	East Antioch Creek upstream of Lake Alhambra	38.00641	-121.78762	3	3	100
M1	Marsh Creek downstream of Brentwood WWTP	37.96394	-121.68361	2	2	100
M2	Marsh Creek POC Long-Term monitoring station*	37.96257	-121.68788	2	2	100
M3	Sand Creek (tributary to Marsh Creek)	37.93815	-121.70772	2	2	100
M4	Deer Creek (tributary to Marsh Creek)	37.93641	-121.70916	2	2	100
M5	Dry Creek (tributary to Marsh Creek)	37.92294	-121.71494	2	2	100

* This site is described as "Marsh Creek at fish ladder, upstream of Brentwood WWTP" in the Methylmercury Control Study Work Plan.

Table 4. Phase 1 Wet Weather Sampling Locations and Achieved vs. Target Frequency of Sample Collection

Location Code	Site Description	Latitude (Deg. N)	Longitude (Deg. W)	Achieved Number of Wet Weather Sampling Events	Target Number of Wet Weather Sampling Events	Percent Completeness (%)
A1	West Antioch Creek above tidal influence	38.01019	-121.82345	2	2	100
A2	East Antioch Creek discharge from Lake Alhambra tide gate	38.01061	-121.79678	3	3	100
A3	East Antioch Creek upstream of Lake Alhambra	38.00641	-121.78762	3	3	100
M2	Marsh Creek POC Long-Term monitoring station*	37.96257	-121.68788	16	3	>100

* This site is described as "Marsh Creek at fish ladder, upstream of Brentwood WWTP" in the Methylmercury Control Study Work Plan.

Phase 2 samples were collected from fall of 2014 through winter of 2015 and nearly met the completeness requirements of the Methylmercury Control Study Phase 2 Scope of Work. Table 5 indicates the number of target samples versus the number of achieved samples and shows the percent completeness for Phase 2 sampling (96 percent overall). Just one target pair of influent and effluent samples from LAU 4 were not collected due to insufficient rainfall during the study period.

Table 5. Phase 2 Wet Weather Achieved vs. Target Frequency of Sample Collection

Number of Storms	Number of Bioretention Test Areas	Number of Grab Sample Pairs Per Storm	Number of Samples Per Grab Sample Pair	Achieved Number of Sample Suites	Target number of Sample Suites	Percent Completeness (%)
4	2	3	2	46	48	96

Tabular results of Phase 1 and Phase 2 initial assessments are presented in Tables 6 and 7, respectively.

Table 6. Phase 1 Watershed Characterization Initial Assessments Monitoring Results Summary

Site ID	Wet or Dry Weather	Date	Time	SSC (mg/L)	Total Hg (ng/L)	Total MeHg (ng/L)	MeHg to Hg Ratio (%)
A1	Dry	01/14/15	1300	3.3	2.1	0.06	2.9
A1	Wet	02/08/15	1200	164	27	0.21	0.8
A1	Dry	02/26/15	1350	12	2.2	0.07	3.2
A1	Wet	04/07/15	1000	104	24	0.47	2.0
A2	Dry	01/14/15	1245	4	2	0.05	2.5
A2	Wet	02/08/15	1145	41	22	0.11	0.5
A2	Dry	02/26/15	1330	7.1	1.6	0.05	3.1
A2	Wet	04/07/15	0935	22	8.6	0.11	1.3
A2	Wet	04/25/15	0705	10	5.5	0.13	2.4
A2	Dry	06/09/15	1530	16	3.0	0.08	2.7
A3	Dry	01/14/15	1215	38	9.8	0.24	2.4
A3	Wet	02/08/15	1115	42	12	0.08	0.7
A3	Dry	02/26/15	1300	77	13	0.12	0.9
A3	Wet	04/07/15	0915	32	7.4	0.08	1.1
A3	Wet	04/25/15	0650	16	2.9	0.05	1.7
A3	Dry	06/09/15	1600	7.6	2.7	0.13	4.8
M1	Dry	01/14/15	1130	ND	0.9	ND	NA
M1	Dry	02/26/15	1220	4.7	1.1	ND	NA

Table 6. Phase 1 Watershed Characterization Initial Assessments Monitoring Results Summary

Site ID	Wet or Dry Weather	Date	Time	SSC (mg/L)	Total Hg (ng/L)	Total MeHg (ng/L)	MeHg to Hg Ratio (%)
M2	Wet	03/16/12	2247	180	32.4	0.19	0.6
M2	Wet	03/16/12	2337	260	36.7	0.24	0.7
M2	Wet	03/17/12	0839	61	9.41	0.08	0.9
M2	Wet	03/17/12	0131	130	17.4	0.17	1.0
M2	Wet	11/30/12	0343	29	11	0.10	0.9
M2	Wet	11/30/12	1640	108	12	0.12	1.0
M2	Wet	11/30/12	1155	241	25	0.24	1.0
M2	Wet	12/01/12	0950	25	6.9	0.07	1.0
M2	Wet	12/22/12	1500	66	9.9	0.14	1.4
M2	Wet	12/22/12	1153	205	19	0.22	1.2
M2	Wet	12/22/12	0858	223	39	0.38	1.0
M2	Wet	12/22/12	2124	464	91	0.66	0.7
M2	Wet	04/04/13	1326	14	9.8	0.15	1.5
M2	Wet	04/04/13	1051	50	11	0.25	2.3
M2	Wet	04/04/13	0711	242	35	1.10	3.1
M2	Wet	04/04/13	0738	288	43	1.20	2.8
M2	Dry	05/30/13	1400	3.3	1.9	0.09	4.7
M2	Dry	12/05/13	1310	ND	1.1	ND	NA
M3	Dry	01/14/15	1030	7.5	1.4	0.03 J	2.1
M3	Dry	02/26/15	1130	17	1.8	0.04 J	2.2
M4	Dry	01/14/15	1017	7.7	3	0.04 J	1.3
M4	Dry	02/26/15	1150	11	3.4	0.047 J	1.4
M5	Dry	01/14/15	0942	3.7	1.1	ND	NA
M5	Dry	02/26/15	1100	35	2	0.04 J	2.0

SSC = Suspended sediment concentration
A1 = West Antioch Creek above tidal influence
A2 = East Antioch Creek, discharge from Lake Alhambra tide gate
A3 = East Antioch Creek, upstream of Lake Alhambra
M1 = Marsh Creek, downstream of Brentwood WWTP
M2 = Marsh Creek at fish ladder, upstream of Brentwood WWTP
M3 = Sand Creek, tributary to Marsh Creek
M4 = Deer Creek, tributary to Marsh Creek
M5 = Dry Creek, tributary to Marsh Creek
J = Estimated value: measurement falls between the MDL and the MRL.
ND = Analyte not detected above the MDL
NA = Not applicable

Table 7. Phase 2 Evaluation of Potential Control Measures Initial Assessments Monitoring Results Summary

Site ID	Wet or Dry Weather	Date	Time	SSC (mg/L)	Total Hg (ng/L)	Total MeHg (ng/L)	MeHg to Hg Ratio (%)
LAU3-I	Wet	11/22/14	0530	36	28	0.11	0.4
LAU3-I	Wet	11/22/14	0600	<29	20	0.11	0.6
LAU3-I	Wet	11/22/14	0645	<13	11	0.07	0.6
LAU3-I	Wet	12/02/14	1045	49	43	0.11	0.3
LAU3-I	Wet	12/02/14	1130	125	130	0.18	0.1
LAU3-I	Wet	12/02/14	1230	89	110	0.19	0.2
LAU3-I	Wet	12/15/14	0100	11	32	0.15	0.5
LAU3-I	Wet	12/15/14	0300	40	8.5	0.14	1.6
LAU3-I	Wet	12/15/14	2330	52	41	0.20	0.5
LAU3-I	Wet	02/06/15	1105	70	86	0.23	0.3
LAU3-I	Wet	02/06/15	1615	111	120	0.16	0.1
LAU3-I	Wet	02/06/15	1700	353	380	0.17	0.04
LAU3-E	Wet	11/22/14	0535	<16	29	2.60	9.0
LAU3-E	Wet	11/22/14	0605	<17	35	2.70	7.7
LAU3-E	Wet	11/22/14	0650	<23	41	3.30	8.0
LAU3-E	Wet	12/02/14	1050	34	66	2.80	4.2
LAU3-E	Wet	12/02/14	1140	31	61	2.60	4.3
LAU3-E	Wet	12/02/14	1240	30	57	2.40	4.2
LAU3-E	Wet	12/15/14	0115	9.4	41	3.00	7.3
LAU3-E	Wet	12/15/14	0310	28	58	2.00	3.4
LAU3-E	Wet	12/15/14	2345	10	42	2.70	6.4
LAU3-E	Wet	02/06/15	1105	206	400	3.00	0.8
LAU3-E	Wet	02/06/15	1625	61	75	1.90	2.5
LAU3-E	Wet	02/06/15	1705	74	73	1.90	2.6
LAU4-I	Wet	12/02/14	1050	83	87	0.22	0.3
LAU4-I	Wet	12/02/14	1140	62	63	0.19	0.3
LAU4-I	Wet	12/02/14	1520	135	160	0.46	0.3
LAU4-I	Wet	12/15/14	0005	4.2	6.6	0.18	2.7
LAU4-I	Wet	12/15/14	0150	13	5	0.12	2.4
LAU4-I	Wet	12/15/14	0320	8.4	6.3	0.11	1.7
LAU4-I	Wet	02/06/15	1555	94	93	0.21	0.2

Table 7. Phase 2 Evaluation of Potential Control Measures Initial Assessments Monitoring Results Summary

Site ID	Wet or Dry Weather	Date	Time	SSC (mg/L)	Total Hg (ng/L)	Total MeHg (ng/L)	MeHg to Hg Ratio (%)
LAU4-I	Wet	02/06/15	1643	34	85	0.07	0.1
LAU4-I	Wet	02/06/15	1737	15	23	0.14	0.6
LAU4-E	Wet	12/02/14	1055	21	39	0.41	1.1
LAU4-E	Wet	12/02/14	1150	23	40	0.35	0.9
LAU4-E	Wet	12/02/14	1530	17	33	0.41	1.2
LAU4-E	Wet	12/15/14	0030	4	11	0.07	0.6
LAU4-E	Wet	12/15/14	0205	4.3	16	0.07	0.4
LAU4-E	Wet	12/15/14	0330	8.4	22	0.09	0.4
LAU4-E	Wet	02/06/15	1610	30	65	0.19	0.3
LAU4-E	Wet	02/06/15	1657	31	53	0.19	0.4
LAU4-E	Wet	02/06/15	1746	31	50	0.21	0.4

SSC = Suspended sediment concentration
LAU3-I = Influent, Biofiltration cell #3 at First Street and Cutting Blvd. in City of Richmond
LAU3-E = Effluent, Biofiltration cell #3 at First Street and Cutting Blvd. in City of Richmond
LAU4-I = Influent, Biofiltration cell #4 at First Street and Cutting Blvd. in City of Richmond
LAU4-E = Effluent, Biofiltration cell #4 at First Street and Cutting Blvd. in City of Richmond
< = result is an estimate due to possible contamination

Figures 1 and 2 present the levels of total SSC and total mercury in the Phase 1 and Phase 2 initial assessments. These graphs show that SSC and total mercury tend to co-occur in all sampled locations.

Figures 3 and 4 present the levels of total SSC and total methylmercury in Phases 1 and 2 initial assessments. These figures show that methylmercury typically occurred well over the CVRWQCB TMDL limit of 0.06 ng/L (represented by a horizontal dashed line). Further, methylmercury occurred in much higher concentrations in the effluent of Cutting Boulevard Station LAU3 than at other study locations.

Figure 5 is a box-and-whiskers plot (i.e., box plot) showing the distributions of total methylmercury during Phase 1 dry and wet sampling periods, and Phase 2 influent and effluent flows. With the exception of Phase 1 dry period sampling, this figure shows nearly all of the samples of total methylmercury were above the TMDL limit of 0.06 ng/L. During the Phase 1 dry period sampling, about half of the samples were above the TMDL limit.

Initial data observations indicate the following findings:

- The goal of the study is to explore factors affecting methylmercury concentrations in stormwater discharges and surface waters, and apply that information to determine effective control measures. The study results thus far appear to be useful for evaluating the following null hypothesis and its alternate hypothesis, as proposed in the approved study plan:

  - H_0 (null hypothesis) – The variability of methylmercury concentrations in discharges from the Contra Costa County MS4 system is explained entirely by variability of SSC.
  - H_A (alternate hypothesis) – The variability of methylmercury concentrations in discharges from the Contra Costa County MS4 system is explained by both variability of SSC and enhanced methylation efficiency found within areas with standing or slow moving water.

- The regression of methylmercury vs. SSC for all stormwater and surface water samples analyzed shows that about half (51%) of the variability in methylmercury concentrations is explained by variability in suspended sediment concentrations (Figure 6).
  - This tends to support the alternate hypothesis, which is that half of the variability is explained by other factors (e.g., net methylation rates).
  - Particle size distribution is likely another factor that affects methylmercury in water.
- The data define a background condition of methylmercury in storm-borne suspended sediments of Contra Costa County watersheds that is consistent with background conditions established in a national study (Krabbbenhoft et al., 1999) – about 2 ng MeHg/g of suspended sediment.
- The presence of 2 ng/g methylmercury in suspended sediment as a natural background condition reduces the feasibility of achieving the TMDL target of 0.06 ng/L methylmercury in surface waters having any reasonable, foreseeable, natural concentration of suspended sediments (i.e., > 30 mg suspended sediment /L water).
- The slope of the regression line across all watersheds shows an average mercury concentration of 1.7 +/- 0.04 ng/g (from the 95% confidence interval; Figure 6).
  - This means, in general, storm-borne sediments from this study have approximately 1.7 ng (1.7 billionth of a gram) of methylmercury per gram of suspended sediment (i.e., about 2 parts per billion [ppb]).
  - 2 ppb methylmercury can be expected as normal, natural background in any watershed sediment. A national study of methylmercury across multiple watersheds showed that areas of enhanced methylation – such as wetlands – typically have ten times this amount of methylmercury in sediments (e.g., 10 ppb; Krabbenhoft et al., 1999)
  - Thus, 2 ppb of methylmercury can be defined as the natural background in any watershed, including Contra Costa County watersheds.
- The presence of this concentration of methylmercury in storm-borne sediments as a background condition reduces the feasibility of achieving the 0.06 ng/L methylmercury TMDL target in surface waters.
- Outliers to the regression that define background methylmercury concentrations in Contra Costa County watersheds identify areas of enhanced methylation. Figure 6 shows that Phase 2 effluent samples lay well above the regression line, as do two samples from Marsh Creek.

- Thus far, the most significant outliers to the background regression line are in discharges from the underdrains of biofiltration cells used to treat stormwater at Cutting Boulevard in the City of Richmond (LAU3 and LAU4 effluent), where substantial mercury methylation appears to take place in the root zones of plants. Not all of the basin outflows showed elevated methylmercury. There are at least two possible explanations for this, and they are not mutually exclusive:
    - Differences in the media – presence / absence of biochar
    - Differences in elevation – both root zones may be tidally influenced; however, the basin bottoms are at different elevations, and may therefore be subject to different wetting / drying cycles
- The watershed survey did not reveal significant sources of elevated methylmercury during the wet and dry events sampled:
    - Lake Alhambra, at the base of the East Antioch Creek watershed, appears to provide a net reduction in total mercury and methylmercury by causing a net reduction in suspended sediments during wet and dry weather.
    - CCCWP still lacks new data from Upper Marsh Creek watershed flows owing to dry weather conditions during the study period; available data from upper watershed flow is a single pair of methylmercury and SSC measurements from 2012.
    - There may be some evidence for elevated methylmercury vs. suspended sediments during first flush events in Marsh Creek and West Antioch Creek, but the increase is still relatively moderate (i.e., 5 ng MeHg /g suspended sediment). Significant methylation is indicated by watersheds having 10 ng MeHg/g sediment or more (Krabbenhoft et al., 1999).
- The lowest methylmercury concentrations measured in the entire study were during dry weather in lower Marsh Creek, where the flow is primarily from highly treated effluent from the Brentwood Wastewater Treatment Plant.
- Total mercury in suspended sediments is substantially higher in Richmond stormwater compared to eastern Contra Costa County creeks (Figure 7). This may simply be a result of relatively more coarse suspended sediment in high energy creek flow as compared to stormwater, or may be a result of greater amounts of local mercury deposition associated with industrial activity in Richmond.

Figure 1. Phase 1 Initial Assessment – SSC and Total Hg

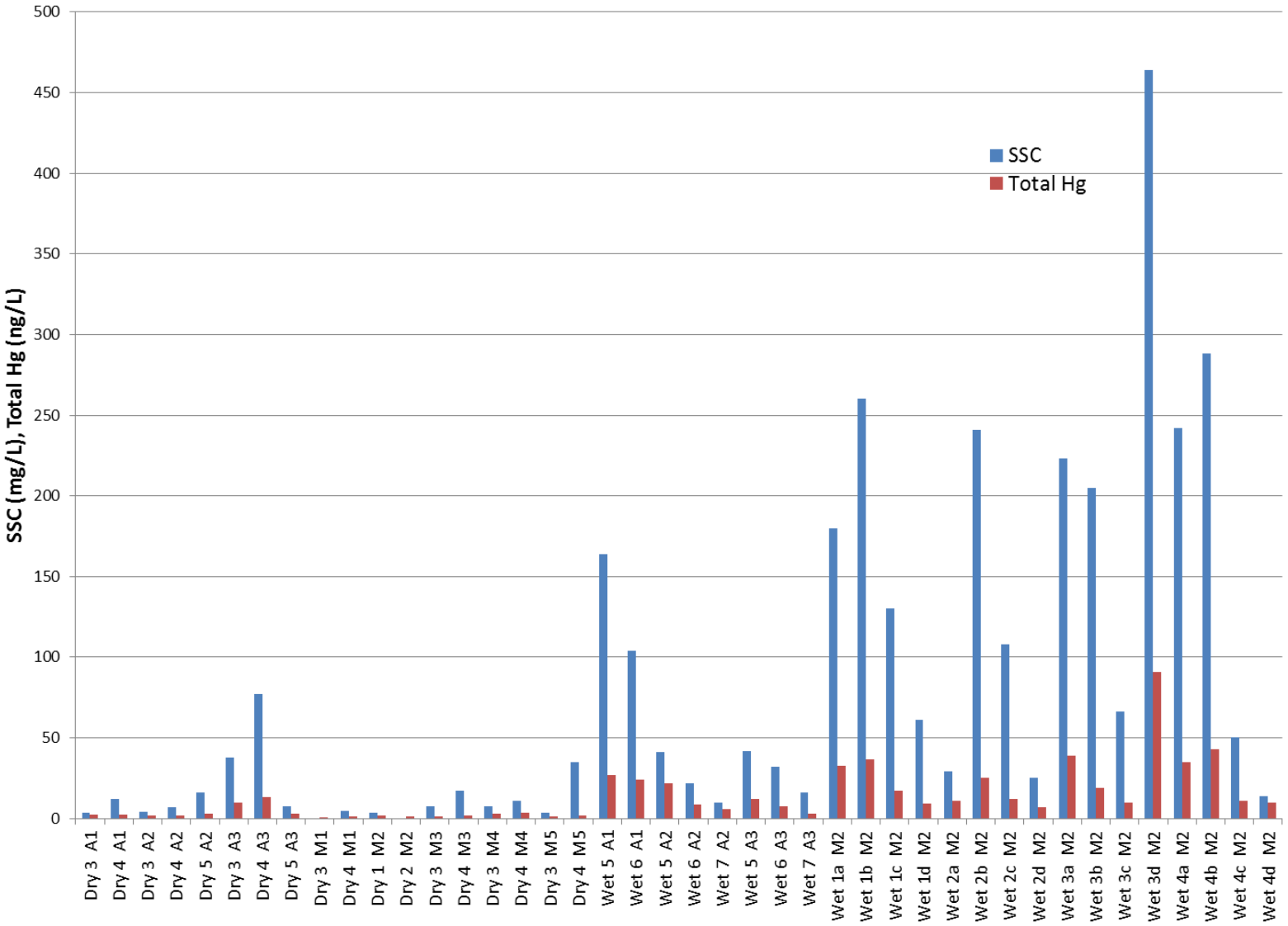


Figure 2. Phase 2 Initial Assessment – SSC and Total Hg

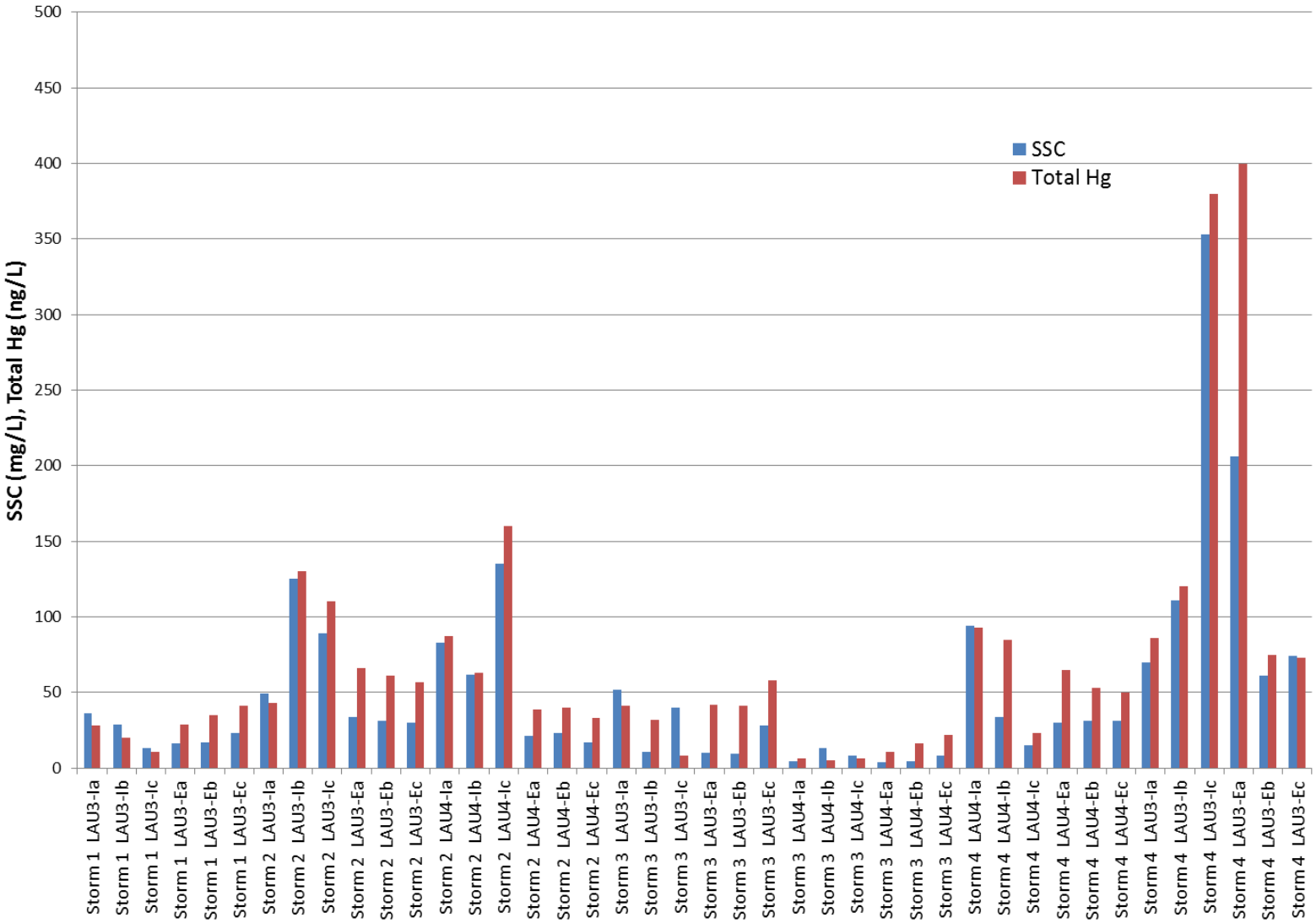


Figure 3. Phase 1 Initial Assessment – SSC and Total Methylmercury

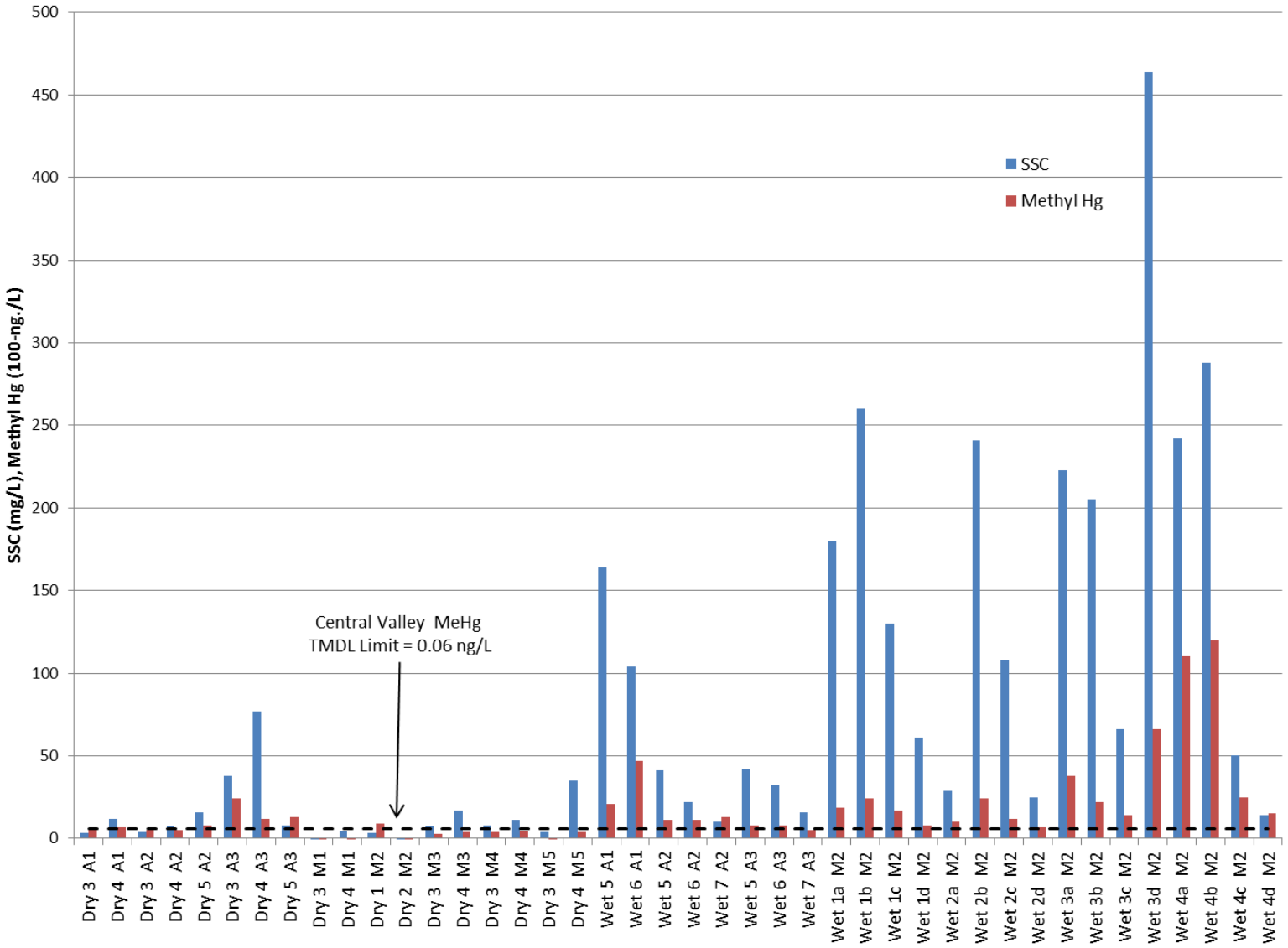


Figure 4. Phase 2 Initial Assessment – SSC and Total Methylmercury

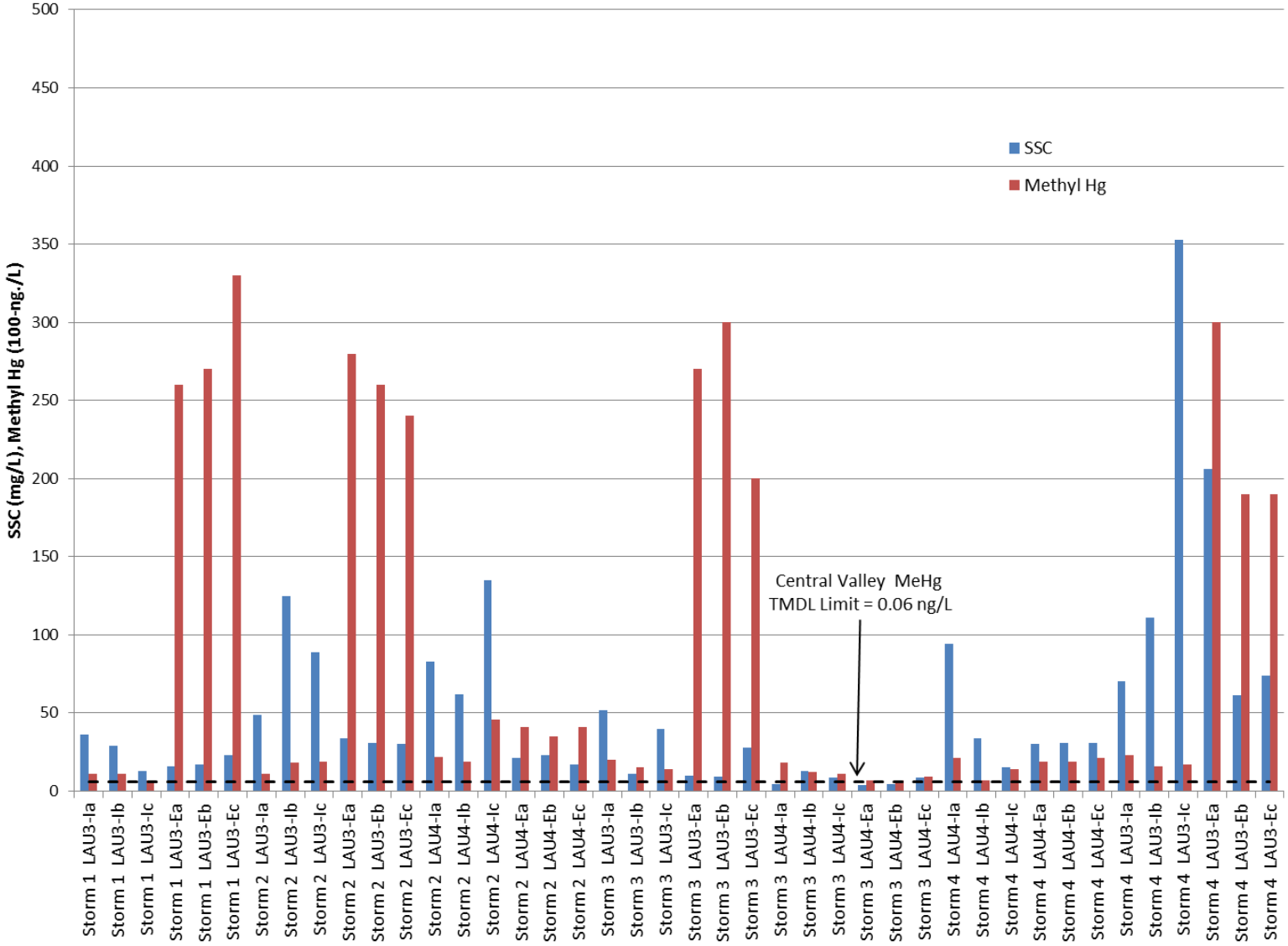
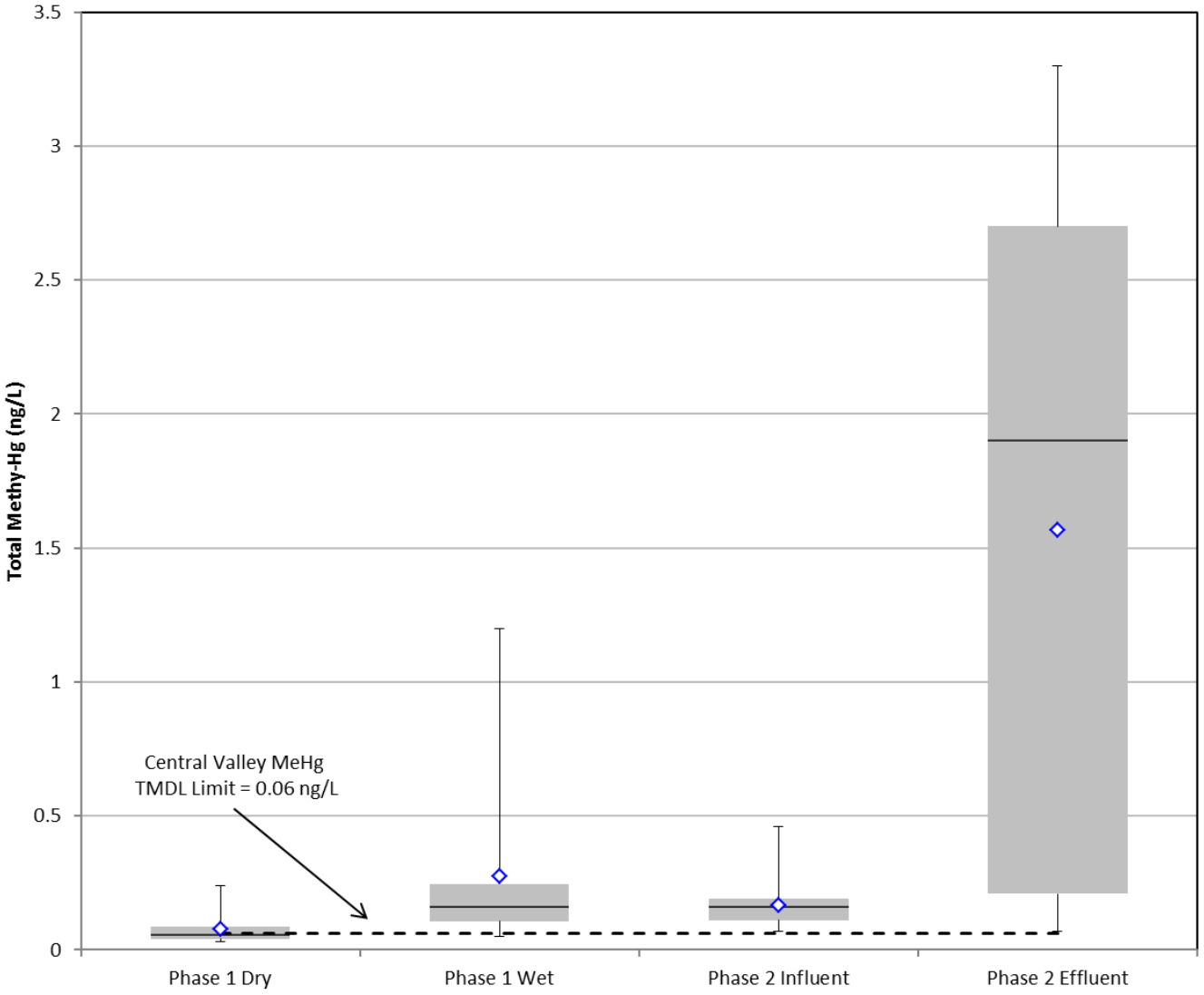


Figure 5. Phase 1 and Phase 2 Initial Assessments Total Methylmercury Box-and-Whiskers Diagram



The grey boxes indicate the range between the first and third quartiles (25th and 75th percentiles), the solid black line indicates the median (50th percentile), the open diamond indicates the mean, and the ends of the whiskers indicate the minimum and maximum values of the distributions of the total methylmercury samples.

Figure 6. Methylmercury vs. Suspended Sediment Concentrations

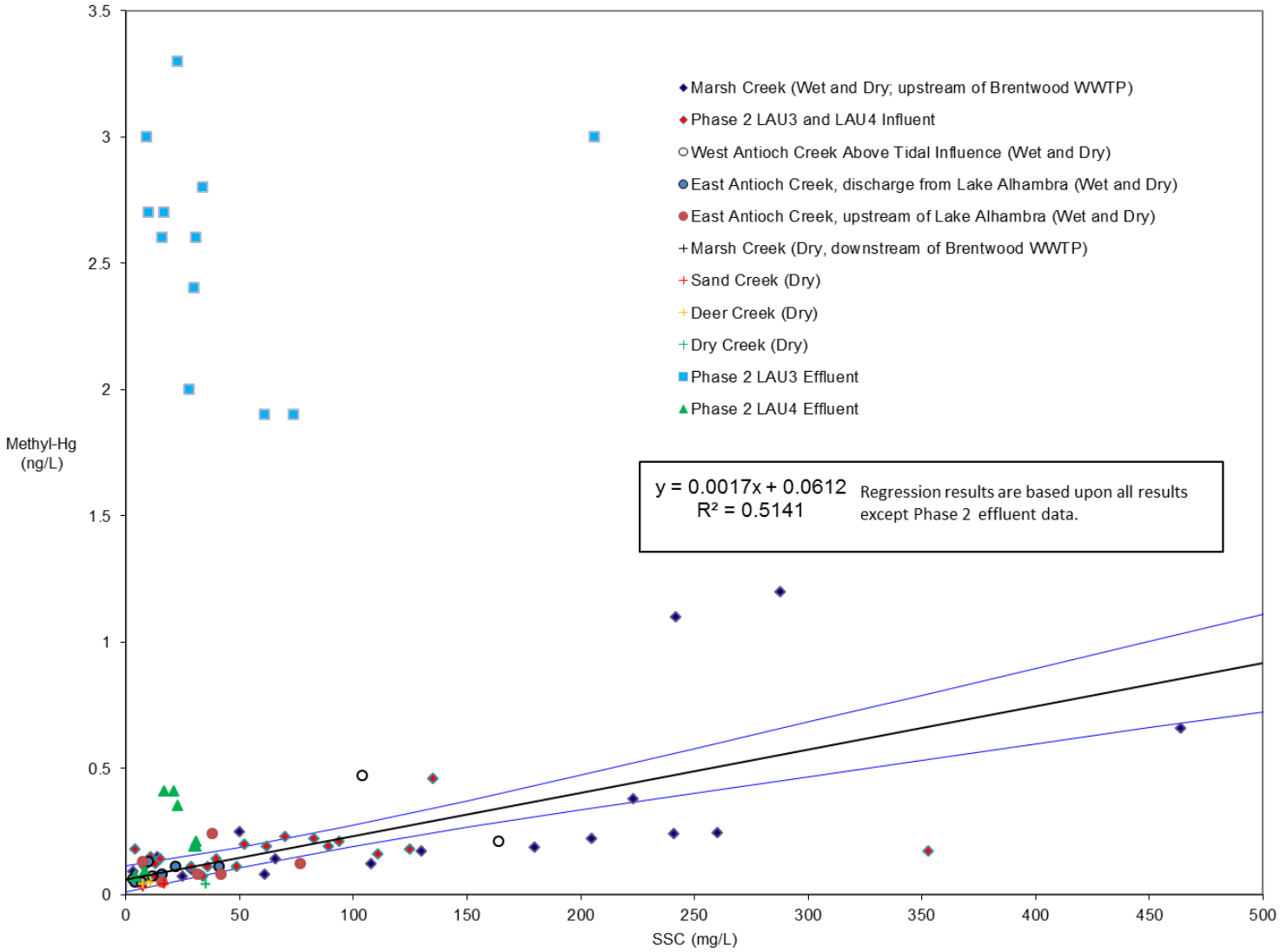
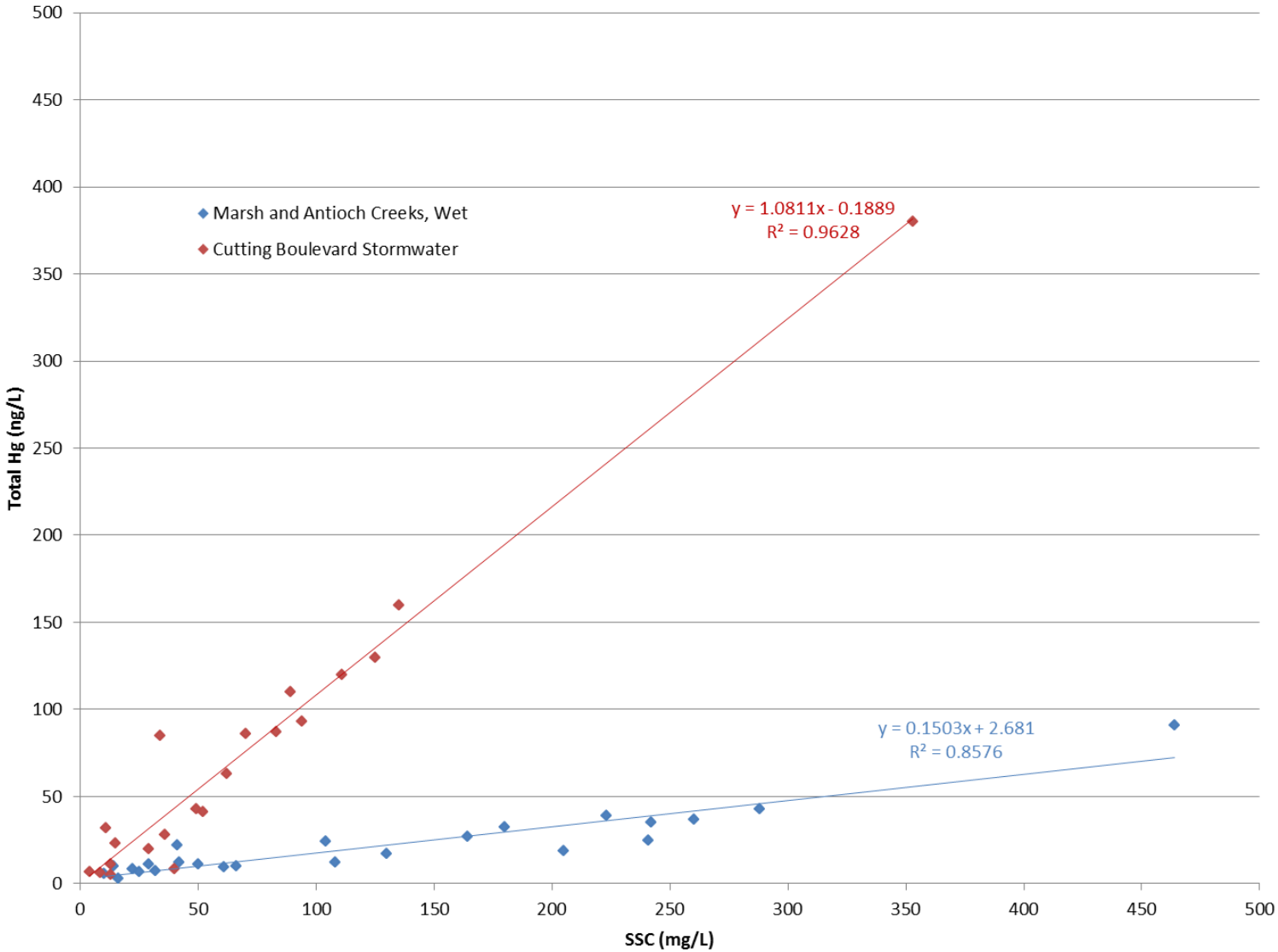


Figure 7. Total Mercury vs. SSC



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LIST OF ACRYONYMS AND ABBREVIATIONS

ADH	ADH Environmental
AMEC	Amec Foster Wheeler, Inc.
BASMAA	Bay Area Stormwater Management Agencies Association
BMP	Best management practice
CCCWP	Contra Costa Clean Water Program
CVRWQCB	Central Valley Regional Water Quality Control Board
CW4CB	Clean Watersheds for a Clean Bay
EPA	United States Environmental Protection Agency
ID	Identifier
J	Estimated value
LAU	Lauritzen Canal watershed
LCS	Laboratory control sample
MeHg	Methylmercury
MQO	Method quality objective
MRP	Municipal Regional Permit
MS	Matrix spike
MSD	Matrix spike duplicate
MS4	Municipal separate storm sewer system
NA	Not applicable
ND	Not detected
NPDES	National Pollutant Discharge Elimination System
POC	Pollutants of concern
QA/QC	Quality assurance / quality control
RMC	BASMAA Regional Monitoring Coalition
RPD	Relative percent difference
SFEI	San Francisco Estuary Institute
SSC	Suspended sediment concentration
TMDL	Total maximum daily load
WLA	Waste load allocation
WWTP	Waste water treatment plant
WY	Water year