OCTOBER 20, 2015

CITY OF STOCKTON
COUNTY OF SAN JOAQUIN

Methylmercury Control Study

Progress Report

prepared by

LARRY WALKER ASSOCIATES

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INTRODUCTION

The City of Stockton (City) and the County of San Joaquin (County) are named as National Pollutant Discharge Elimination System (NPDES) permitted urban runoff dischargers within the Delta Methylmercury Total Maximum Daily Load (TMDL). As a part of Phase I of the TMDL, the City and the County are required to conduct a Methylmercury Control Study (Control Study)[1]. Pursuant to their request[2] and the subsequent approval by the Central Valley Regional Water Quality Control Board (Regional Board)[3], the City and County have developed and are implementing a collaborative Control Study as described in their Methylmercury Control Study Workplan (Workplan), which was submitted to the Regional Board on April 22, 2013. The Technical Advisory Committee (TAC)[4] and Regional Board staff[5] provided comments on the Workplan in August 2013. The Workplan was subsequently revised to address the comments, and the final Workplan (**Appendix A**) was submitted to the Regional Board on October 2, 2013, and approved by the Executive Officer on November 7, 2013.

The Control Study focuses on evaluating the mercury and methylmercury removal performance of a detention basin within the Stockton Urbanized Area (SUA), along with examining the potential for methylmercury production within the basin. This Control Study Progress Report (Progress Report) presents the monitoring results from the first two monitoring years (2013-2014 and 2014-2015) and summarizes the next steps the City and County will take to complete the study.

BACKGROUND

TMDL Requirements

The City and Phase I NPDES municipal separate storm sewer systems (MS4) portion of the County[6] are located within the Central Delta and San Joaquin River Delta hydrologic subareas as illustrated in **Figure 1**.

A comparison of applicable TMDL allocations and loadings using City and County specific monitoring data and NPDES MS4 Phase I boundaries is provided in

Table 1**.** According to the City and County's calculations[7], a reduction in methylmercury loading from the MS4 is needed in the San Joaquin River subarea.

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[1] Central Valley Regional Water Quality Control Board. 2012. Amendments to the Water Quality Control Plan for the Sacramento River and San Joaquin River Basins for the Control of Methylmercury and Total Mercury in the Sacramento-San Joaquin River Delta Estuary. Rancho Cordova, CA. Available online: www.waterboards.ca.gov/rwqcb5/water_issues/tmdl/central_valley_projects/delta_hg/2011oct20/bpa_20oct2011_final.pdf

[2] As conveyed in the letter dated April 20, 2012 from the City and the County to Ms. Pamela Creedon, *Delta Methylmercury TMDL Phase I Control Study Organization* Letter.

[3] As conveyed in the letter dated May 2, 2012 from Ms. Pamela Creedon to the City and the County, *Extension of Methylmercury Control Study Workplan Due Date*.

[4] Delta MeHg Technical Advisory Committee Control Study Work Plan Review for Stockton & San Joaquin County, 31 May 2013, received by email August xx, 2013.

[5] Phone discussion between City and County staff, LWA staff, and Janis Cooke and Patrick Morris on August 16, 2013.

[6] The County contains both Phase I and Phase II permitted areas. The County Phase I NPDES permit area consists of the urbanized unincorporated areas adjacent to or surrounded by the City.

[7] Data and loading calculation methods are summarized fully in the City of Stockton and County of San Joaquin Baseline Mercury Monitoring Report, submitted to the Regional Board on December 1, 2011.

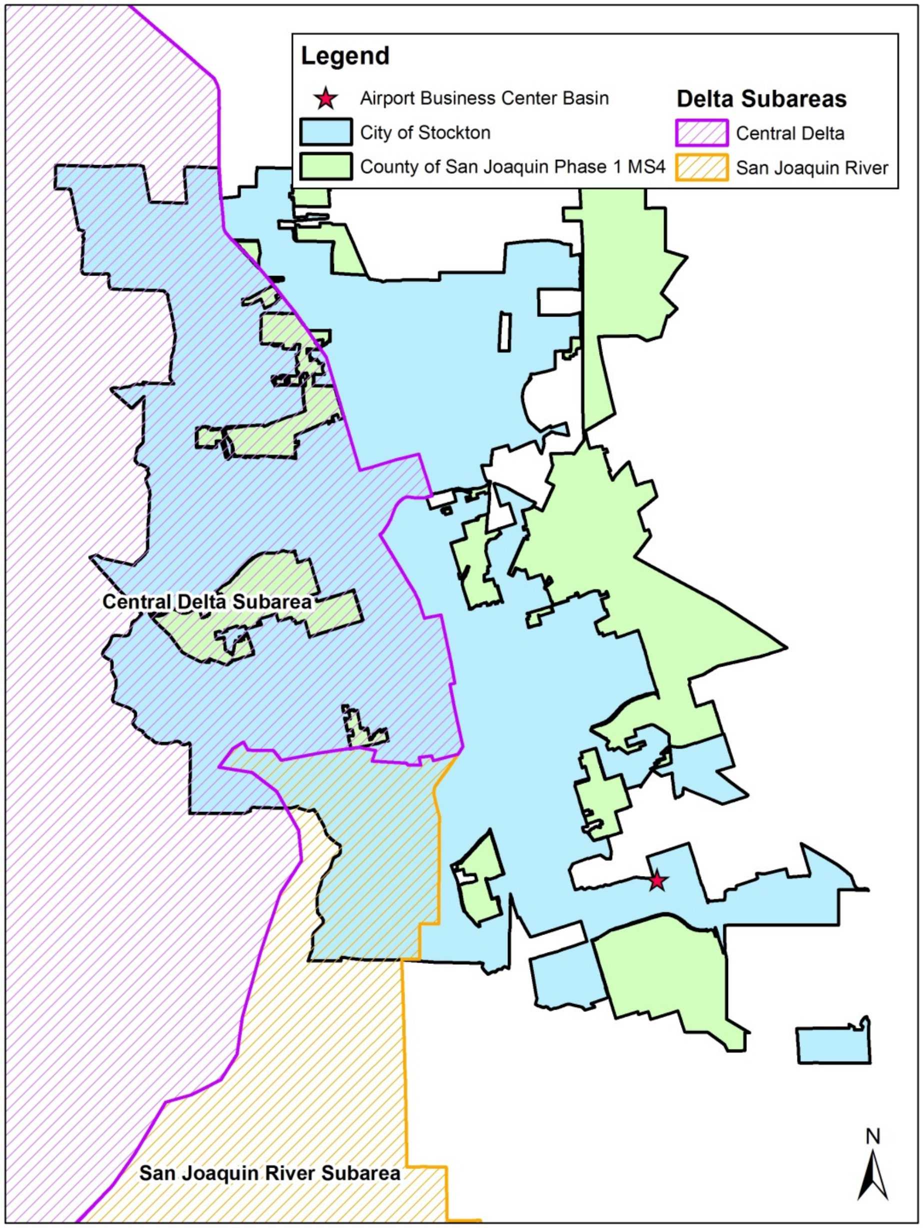

Figure 1. City and Phase I NPDES MS4 Portion of County Depicted in Context of Delta Hydrologic Subareas

Table 1. City and County-Specific Calculations of Existing Loading to Delta Subareas[8]

Subarea	Permittee	Phase I Acreage within Subarea[1]	MeHg Load (g/yr)[1]	MeHg WLA (g/yr)[2]	% Reduction Needed
Central Delta	County of San Joaquin	2,316	0.36	0.57	0%
	Stockton MS4	14,653	2.45	3.6	0%
San Joaquin River	County of San Joaquin	0	0	0.79	0%
	Stockton MS4	3,981	0.68	0.18	74%

Notes:

1. Calculation performed by the City, presented in the Workplan.
2. Presented in Tables 8.4.a and 8.4.e of the TMDL Staff Report

It should be noted that the City and County's methylmercury loads are de minimus in comparison to the total methylmercury loads in the Delta. **Table 2** shows the Delta methylmercury loads and wasteload allocations by sources, and **Figure 2** illustrates the relative contribution by source to the total loads and wasteload allocations. The City and County's methylmercury load represents a fraction of the 0.36% of current methylmercury loads and 0.44% total wasteload attributed to Phase I stormwater agencies. Thus, stormwater agency methylmercury load reductions will, ultimately, not be significant in reducing Delta methylmercury levels.

[8] Data and loading calculation methods are summarized fully in the City of Stockton and County of San Joaquin Baseline Mercury Monitoring Report, submitted to the Regional Board on December 1, 2011.

Table 2. Current Methylmercury Loads and Load and Wasteload Allocations to the Delta by Source Category[9]

Source Category	Percentage of Total Current Methylmercury Load	Percentage of Total LA or WLA
Agriculture	2.35%	2.6%
Atmospheric wet deposition	0.44%	0.79%
Open Water	16%	24%
Tributary Inputs	58%	50%
Urban (Nonpoint source)	0.02%	0.03%
Wetlands	18.9%	18.2%
NPDES Facilities	3.9%	3.7%
NPDES Facilities future growth	-----	0.42%
NPDES MS4	**0.36%**	**0.44%**

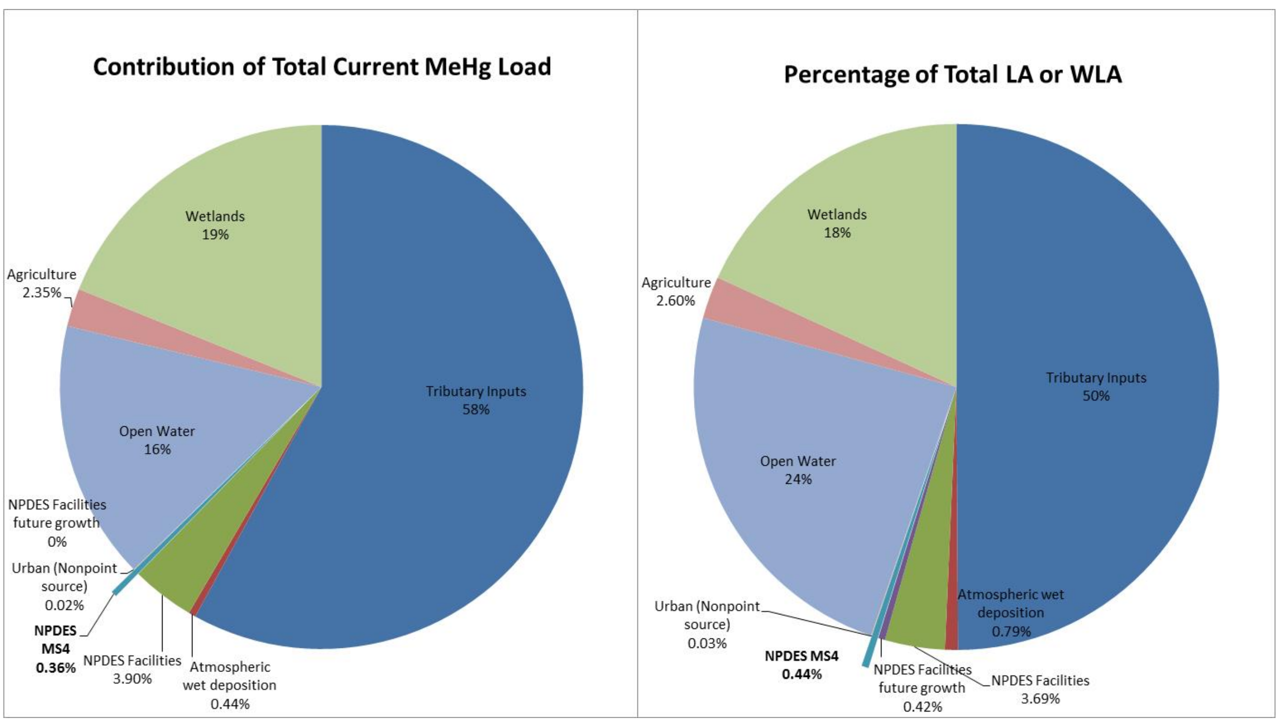

Figure 2. Contributions of Current Methylmercury Loads and Load and Wasteload Allocations to the Delta by Source Category

[9] Modified from Table 8.5 of the TMDL Staff Report.

Basin Overview

Since reductions in methylmercury are necessary in the San Joaquin River subarea, the City and County are evaluating a detention basin located in the urbanized area that drains to the San Joaquin subarea—the Airport Business Center Basin. Detention basins are a common Best Management Practice (BMP) in the Stockton Urbanized Area (SUA) for flood control and water quality purposes. There are currently eleven municipally-operated detention bases with the SUA.

The Airport Business Center Basin is located near the intersection of Pock Lane and Industrial Drive in the southeast portion of the City of Stockton and encompasses a total area of approximately 10.1 acres. The Basin has three gravity-fed storm drain inlets. The inlets drain industrial and residential developments as well as undeveloped areas. The Basin has one pump station outlet discharging into North Little Johns Creek (**Figure 3**). Basin design specifications are summarized in the Control Study Workplan.

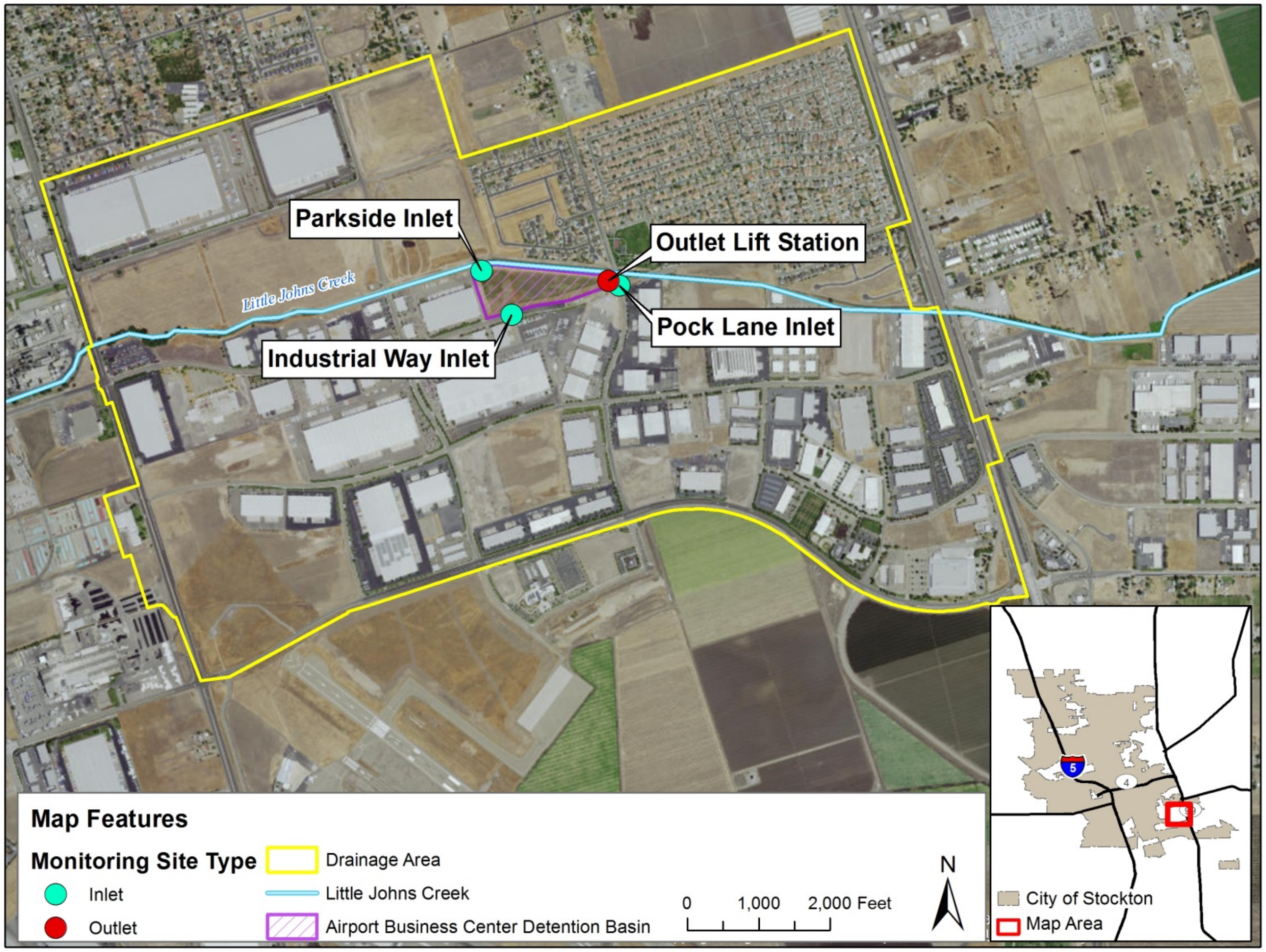

Figure 3. Airport Business Center Detention Basin Overview, showing Inlet and Outlet Monitoring Locations

Control Study Objectives

The control study objective is to evaluate the mercury and methylmercury removal effectiveness of the ABC Basin, along with the potential for methylmercury production in the basin.

The Control Study is testing the following hypothesis:

> Hypothesis: *The Airport Business Center Basin will reduce mercury and methylmercury loadings in the San Joaquin subarea. Sedimentation is the primary pollutant removal mechanism in detention basins, and as a result, detention basins will remove total mercury from the system, reducing the amount of mercury available for methylation.*

The data collected for the Control Study will be used to either support or reject the hypothesis. The information developed pursuant to this study will be applicable to other NPDES MS4 permittees including Sacramento and Contra Costa Counties in the Central Valley. In addition, the results will provide additional information on the mercury and methylmercury removal benefits associated with detention basins (with detention basin design taken into account).

MONITORING

During each study year, samples are collected during three wet weather events and one dry weather event. The dry weather event is dependent on sufficient dry weather flows to collect an inlet and outlet sample.

Samples were taken at the three Basin inlet points using composite samplers in manholes and at the outlet lift station during all events and sediment samples were obtained during dry weather events. The sampling locations are shown in **Figure 3**. Grab samples were taken for total mercury and methylmercury at each of the basin inlets, in order to compare with the composite sample results for those constituents.

Samples were analyzed for the constituents shown in **Table 3**. The events completed from October 1, 2013 through September 30, 2015, are summarized in **Table 4**. The summary of events notes the instances when composite samples could not be collected due to issues with composite sampler operation.

Table 3. Constituents Monitored for the Control Study

Constituent	Sample Type
Basin Influent and Effluent	
Specific conductance (EC)	Field Measurement
Dissolved Oxygen	
pH	
Temperature	
TDS	Composite Sample
TSS	
Turbidity	
Suspended Sediment Concentration	
Total phosphorus	
Total sulfate	
Total iron	
Total Mercury	Composite and Grab Samples
Methylmercury, total	
Methylmercury, dissolved	
Sediment	
Methylmercury, total	Sediment Grab Sample
Methylmercury, dissolved	

Table 4. Summary of Control Study Monitoring Completed during 2013-2014 and 2014-2015

Event	Date Completed	Storm Event Total Rainfall (inches)	INF-1 (Pock Lane)	INF-2 (Industrial Way)	INF-3 (Parkside)	Outlet	Sediment[1]	Notes
2013-2014 Monitoring Year								
SE1	2/7-8/2014	1.04	G	G	G	G		No composite samples were collected, as composite samplers failed to initiate sampling program.
SE2	2/26/2014	1.60	G,C	G,C	G	G,C		The sampler at the third influent location failed to initiate sampling program.
SE3	-------	-------	-------	-------	-------	-------		Not captured. Storms were not predicted with sufficient notice.
DW1	6/25/2014	-------	G,C	-------	-------	G,C	G	No flow at Industrial and Parkside inlets
2014-2015 Monitoring Year								
SE4	10/31/14	0.50	G	G,C	G,C	G,C		The sampler at the Pock Lane inlet location failed to initiate sampling program.
SE5	12/11/14	2.40	G,C	G,C	G,C	G,C		
SE6	2/6/15	1.40	G,C	G,C	G,C	G,C		
DW2	6/8/15	-------	G	G	G	G,C	G	Composite samples were not collected from inlet locations. • Insufficient flow at Pock Lane and Industrial Way inlets. • Sampler at Parkside Lane failed to initiate sampling

Notes:
[1]Sediment samples collected during dry weather events only.
G = Grab samples collected
C = Composite samples collected

PRELIMINARY RESULTS

Water quality data and Quality Assurance/Quality Control data for all completed events are provided in **Appendix B and C**, respectively. **Figure 4, Figure 5** and **Figure 6** show total mercury, total methylmercury, and dissolved methylmercury concentrations in the inlet and outlet locations from all 2013-2015 events.

The dry weather event sediment composite sample data are shown in **Table 5**. The sediment samples were collected at three representative locations within the basin, near each inlet location. Methylmercury concentrations were low in all sediment samples, at levels below the reporting limit.

While a full data analysis will not be performed until the Control Study monitoring is complete, the results to date suggest the following:

- It is anticipated that the basin decreases the total mercury load.
- Methylmercury concentrations are low overall, and are similar across all inlets and the outlet/effluent.
- Methylmercury is not detected in detention basin sediment.

For the final report, the City and County will include a statistical analysis of data for a full comparison of inlet/influent and outlet/effluent concentrations.

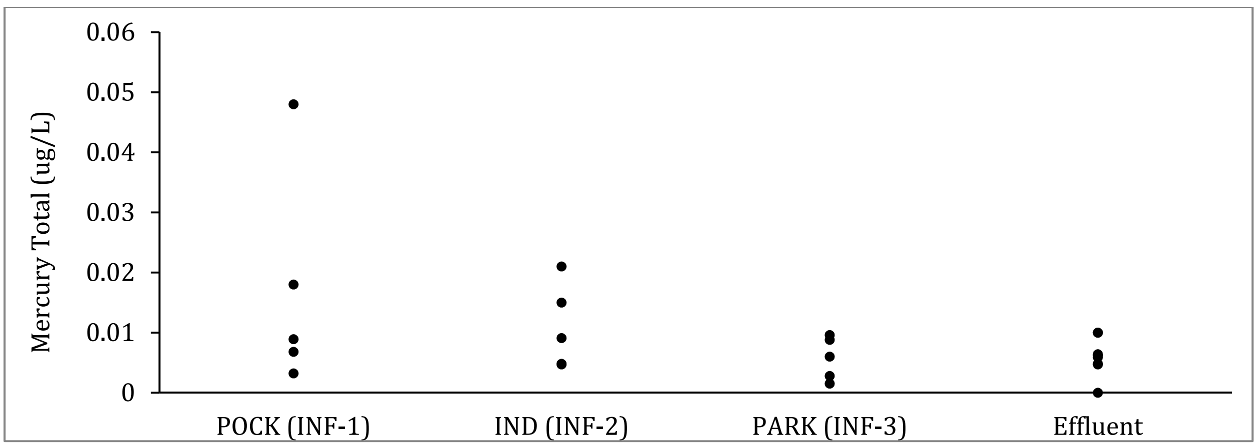

Figure 4. Total Mercury Concentrations from all 2013-2015 events

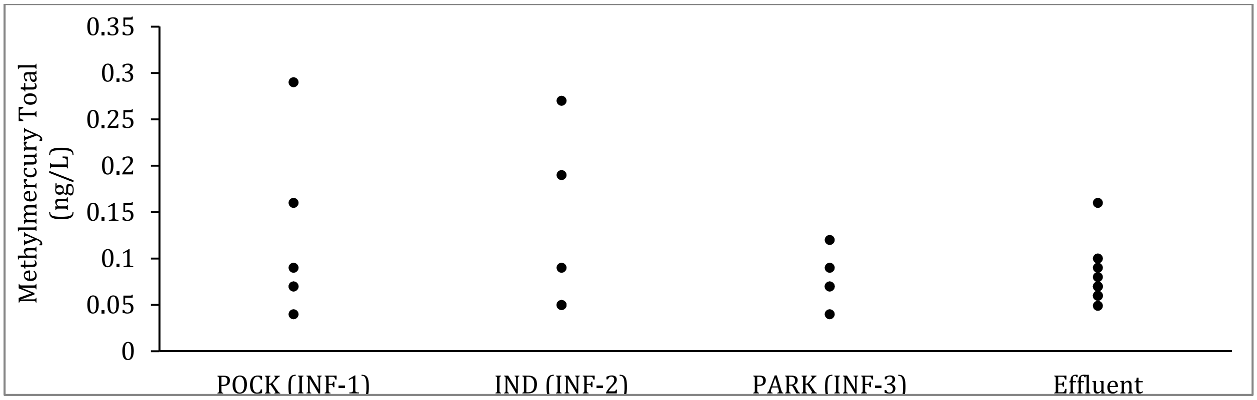

Figure 5. Total Methylmercury Concentrations from all 2013-2015 events

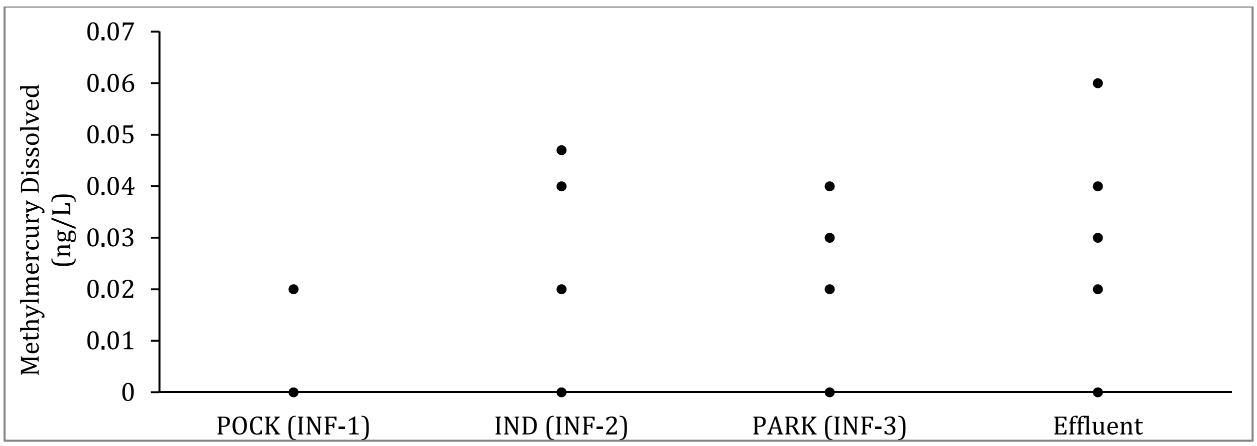

Figure 6. Dissolved Methylmercury Concentrations from all 2013-2015 events

Table 5. Dry Weather Event Sediment Composite data

Constituent	POCK (INF-1)	IND (INF-2)	PARK (INF-3)
DW1 -- 6/25/14			
Mercury, total (µg/kg)	56	29	20
Methylmercury, total (µg/kg)	0.06 [j]	0.03 [j]	< 0.03 [a]
DW2 -- 6/8/15			
Mercury, total (µg/kg)	36	45	52
Methylmercury, total (µg/kg)	0.09 [j]	0.06 [j]	0.04 [j]

[a] = Not detected, Analyte not detected at or above the listed Method Detection Limits (MDL).
[j] = Estimated value. Analyte detected at a level less than the Reporting Limit (RL) and greater than or equal to the Method Detection Limit (MDL).

Grab and Composite Mercury Sample Comparison

Grab samples were collected for mercury and methylmercury during all events. USEPA Methods 1631 and 1669 recommend grab sampling, since the USEPA was not able to demonstrate that composite sampling systems can collect mercury samples that are free from contamination, and not lose mercury to volatilization (USEPA, 2001). When possible, mercury was also analyzed from the composite samples in order to evaluate whether composite samples are subject to contamination, and whether grab samples are representative. A comparison of grab and composite mercury samples is shown in **Table 6.**

Generally, the concentrations of mercury and methylmercury are not consistently higher in either the grab or composite samples, and do not show unexpected variability given the low concentrations of mercury present. The variability between grab and composite total mercury results was high (approximately 75% different) in samples from the Pock Lane influent during two events, SE4 and SE5. In those cases, the levels were higher in the composite sample. It is possible that this difference can be attributable to grab sample timing. Overall, the sample results suggest that composite results are not biased high, and are representative of mercury concentrations.

Table 6. Evaluation of Composite Versus Grab Samples

Location	Event	Constituent	Grab Result	Composite Result	Percent Difference [c]
POCK (INF-1)	SE2	Mercury, total (µg/L)	0.018 [a]	0.016 [a]	11.8
		Methylmercury, total (ng/L)	0.16	0.13	20.7
		Methylmercury, dissolved (ng/L)	0.02 [j]	< 0.020 [b]	[d]
POCK (INF-1)	SE5	Mercury, total (µg/L)	0.0068	0.0054	23.0
		Methylmercury, total (ng/L)	0.07	0.06	15.4
		Methylmercury, dissolved (ng/L)	< 0.020 [b]	0.03 [j]	[d]
IND (INF-2)	SE4	Mercury, total (µg/L)	0.0091	0.021	79.1
		Methylmercury, total (ng/L)	0.09	0.20	75.9
		Methylmercury, dissolved (ng/L)	0.047 [j]	0.06	[d]
IND (INF-2)	SE5	Mercury, total (µg/L)	0.0048	0.0045	6.5
		Methylmercury, total (ng/L)	0.05	0.07	33.3
		Methylmercury, dissolved (ng/L)	0.02 [j]	0.02 [j]	[d]
PARK (INF-3)	SE5	Mercury, total (µg/L)	0.0028	0.0062	75.6
		Methylmercury, total (ng/L)	0.07	0.07	0.0
		Methylmercury, dissolved (ng/L)	0.02 [j]	< 0.020	[d]
Outlet	SE4	Mercury, total (µg/L)	0.010	0.010	0.0
		Methylmercury, total (ng/L)	0.08	0.09	11.8
		Methylmercury, dissolved (ng/L)	0.02 [j]	< 0.020 b	[d]
Outlet	SE5	Mercury, total (µg/L)	0.0062	0.0047	27.5
		Methylmercury, total (ng/L)	0.049 [j]	0.07	[d]
		Methylmercury, dissolved (ng/L)	< 0.020 b	0.02 [j]	[d]

[a] = Fraction denoted as "Trace" not "Total" on laboratory report.
[b] = Not detected, Analyte not detected at or above the listed Method Detection Limits (MDL).
[c] = absolute
[j] = Estimated value. Analyte detected at a level less than the Reporting Limit (RL) and greater than or equal to the Method Detection Limit (MDL). The user of this data should be aware that this data is of limited reliability; or estimated due to RPD failure.
[d] = Percent difference not calculated when result is either estimated or not detected.

NEXT STEPS

City and County Evaluations

The City and County will continue monitoring the ABC Basin for one more study year and follow the schedule shown in **Table 7.**

Table 7. Control Study Schedule

Task	Estimated Completion
~~Submit Control Study Work Plan to Regional Board~~	~~April 19, 2013~~
~~Regional Board and TAC Work Plan Review~~	~~May-July 2013~~
~~Finalize Work Plan~~	~~August-September 2013~~
~~Initiate Control Study Sampling~~	~~October 2013~~
• ~~First Year Monitoring~~	• ~~October 2013 – September 2014~~
• ~~Second Year Monitoring~~	• ~~October 2014 – September 2015~~
• Third Year Monitoring	• October 2015 – September 2016
~~Submit Control Study Progress Report~~	~~October 2015~~
Regional Board and TAC Progress Report Review	November 2015-January 2016
Complete Control Study Sampling	September 2016
Submit Control Study Final Report to Regional Board	October 2018

When data collection is complete, the City and County will evaluate the Control Study hypothesis that the ABC Basin will reduce mercury and methylmercury loadings in the San Joaquin Delta subarea. As part of the final evaluation, the City and County will assess the potential to comply with the WLA.

The City and County will confer and coordinate with the other MS4 urban stormwater Control Studies to compare results and identify potential control strategies to identify how to comply with the WLAs.

Delta-wide Assessments

In addition to the City and County specific evaluations described above, there are several other collaborative, Delta-wide assessments that may provide additional data and information for the Phase 1 Delta Mercury Control Program Review. To the extent that the City and County participates in these assessments, they will be described in the Control Study Final Report that is due October 20, 2018.

These efforts include the following:

- *Delta Regional Monitoring Program*

The Delta Regional Monitoring Program's (RMP) Monitoring Design Summary[10] describes the initial monitoring design for four priority constituents including mercury. Although mercury will not be monitored as a part of the 2015-2016 Workplan[11], the Steering Committee and Technical Advisory Committee will reconsider monitoring for 2016-2017. In addition, if Proposition 1 funds are received, monitoring may be conducted earlier. The City and County will continue to track the Delta RMP and encourage ambient mercury monitoring.

- *Open Water Workgroup – Delta-wide Mercury Modeling*
  The Open Water Workgroup is developing a modeling approach to test the impacts of different operational scenarios on the predicted MeHg levels in target fish populations. Depending on how the model is developed and implemented, it could be useful for predicting the effectiveness of various management scenario "bundles" in reducing MeHg concentrations in the Delta's waters and fish. The City and County will consider coordinating with the Workgroup to identify opportunities for collaboration.

- *Mercury Offsets Program*
  The Delta MeHg Control Program allows for the development of a mercury/ methylmercury offsets program. If an offset program is initiated, the City and County may identify opportunities for collaboration. The Regional Water Board will consider adoption of a mercury offset program on or before October 20, 2020.

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10 http://www.swrcb.ca.gov/centralvalley/water_issues/delta_water_quality/comprehensive_monitoring_program/2015_0616_deltarmp_design.pdf

11 http://www.swrcb.ca.gov/centralvalley/water_issues/delta_water_quality/comprehensive_monitoring_program/fy1516_delta_rmp_dtld_wrkpln.pdf

Appendix A. Control Study Workplan

APRIL 20, 2013 [revised SEPTEMBER 25, 2013]

CITY OF STOCKTON
COUNTY OF SAN JOAQUIN

Methylmercury Control Study Workplan

prepared by

LARRY WALKER ASSOCIATES

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1.0 Introduction

The City of Stockton (City) and the County of San Joaquin (County) are named as National Pollutant Discharge Elimination System (NPDES) permitted urban runoff dischargers within the Delta Methylmercury Total Maximum Daily Load (TMDL). As a part of Phase I of the TMDL, the City and the County are required to conduct a Methylmercury Control Study (Control Study)[1]. Pursuant to the request by the City and County[2] and the subsequent approval by the Central Valley Regional Water Quality Control Board (Regional Board)[3], the City and County are developing and implementing a collaborative Control Study.

The Control Study focuses on evaluating the mercury and methylmercury removal performance of a detention basin within the Stockton Urbanized Area (SUA), along with examining the potential for methylmercury production in the basin.

The City and the County submitted a preliminary concept proposal for the Control Study to the Regional Board in August 2012 and received comments and feedback from the Regional Board established Technical Advisory Committee (TAC). The comments received from the TAC and the responses to those comments are summarized and provided as **Attachment A**.

This Methylmercury Control Study Workplan (Workplan) is an expansion of the preliminary concept proposal and addresses comments received from the TAC. The Workplan provides an overview of the proposed study and addresses the seven required elements as identified within the Methylmercury Control Study Guidance,[4] as well as a Summary section identifying the next steps:

- Problem Statement (Section 2.0)
- Objectives (Section 3.0)
- Mechanisms Underlying the Study (Section 4.0)
- Proposed Control Measures (Section 5.0)
- Monitoring and Data Collection Plan (Section 6.0)
- Quality Assurance Procedures (Section 7.0)
- Project Evaluation and Data Sharing Plan (Section 8.0)

The requirements for each element of the Workplan, as identified within the Guidance Document, are included within the sections. In accordance with the Guidance Document, this

[1] Central Valley Regional Water Quality Control Board. 2012. Amendments to the Water Quality Control Plan for the Sacramento River and San Joaquin River Basins for the Control of Methylmercury and Total Mercury in the Sacramento-San Joaquin River Delta Estuary. Rancho Cordova, CA. Available online: www.waterboards.ca.gov/rwqcb5/water_issues/tmdl/central_valley_projects/delta_hg/2011oct20/bpa_20oct2011_final.pdf

[2] As conveyed in the letter dated April 20, 2012 from the City and the County to Ms. Pamela Creedon, *Delta Methylmercury TMDL Phase I Control Study Organization* Letter.

[3] As conveyed in the letter dated May 2, 2012 from Ms. Pamela Creedon to the City and the County, *Extension of Methylmercury Control Study Workplan Due Date*.

[4] Central Valley Regional Water Quality Control Board, 2012. Methylmercury Control Study Guidance for the Delta Methylmercury Control Program Implementation Phase I, May 15, 2012

Workplan was submitted to the Regional Board on April 22, 2013. The TAC[5] and Regional Board staff[6] provided comments on the Workplan during August 2013. The TAC comments and City and County responses are detailed in **Attachment B**. The City and County are submitting this revised Workplan to address the comments and feedback received.

[5] Delta MeHg Technical Advisory Committee Control Study Work Plan Review for Stockton & San Joaquin County, 31 May 2013, received by email August xx, 2013.

[6] Phone discussion between City and County staff, LWA staff, and Janis Cooke and Patrick Morris on August 16, 2013.

2.0 Problem Statement

> ***Guidance Document Requirement***
>
> *Identify the Delta hydrologic subarea that you are addressing, the percent reduction in methylmercury needed for that subarea, and whether the activity that will be addressed is an existing activity, a new project, or both. Briefly state how your management activity may affect methylmercury production and export.*

This section includes a description of the location of the City and County within the Delta hydrologic subareas, a discussion of the load reductions required for those subareas, and an overview of the Control Study approach.

The City and Phase I NPDES municipal separate storm sewer systems (MS4) portion of the County[7] are located within the Central Delta and San Joaquin River Delta hydrologic subareas as illustrated in **Figure 1**. The County Phase I NPDES permit area consists of the urbanized unincorporated areas adjacent to or surrounded by the City. The County includes the Cities of Escalon, Lathrop, Lodi, Manteca, Ripon, Stockton, and Tracy, and also contains Phase II NPDES permitted areas within the Mokelumne River Delta subarea and near the Sacramento River Delta subareas, which are shown in **Figure 2**. Although the Methylmercury TMDL Staff Report (TMDL Staff Report; Central Valley Regional Water Quality Control Board, 2010) estimated loads include both the Phase II NPDES MS4 portion of the County as well as the Phase I portions of the City and the County, NPDES MS4 Phase IIs are considered in compliance with their Delta Mercury and Methylmercury Control Requirements as long as they continue to implement their stormwater programs as indicated in the Statewide General Permit for Small Communities[8]. Thus, this Control Study is focused on the City and County Phase I NDPES MS4.

The TMDL Staff Report provides a current methylmercury estimated load, waste load allocation (WLA), and percent reduction needed for the City and County, as summarized in **Table 1**. The TMDL Staff Report estimated loads include the County Phase II areas in the Mokelumne and Sacramento River Delta Subareas. For the purposes of this Control Study and to evaluate the Phase I portion of the City and County, without including the Phase II areas, a revised calculation of City and County loadings was performed. The City and County performed mercury and methylmercury load calculations for the entire Stockton Urbanized Area as part of their Baseline Mercury Monitoring Report, using City and County specific monitoring data collected from 2008-2011[9]. The previously performed loading estimates were recalculated for each Delta subarea within the Stockton MS4, to provide separate estimates for the City and County's load contribution to the Central Delta and San Joaquin River Delta subareas. A comparison of applicable TMDL allocations and loadings using City and County specific monitoring data and NPDES MS4 Phase I boundaries is provided in **Table 2**. According to the City and County's calculations, a reduction in methylmercury loading from the Stockton MS4 is needed in the San Joaquin River subarea. For context, discharge from urban runoff accounts for less than one percent (<1%) of the methylmercury loading to the Delta, as shown in **Table 3**.

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[7] The County contains both Phase I and Phase II permitted areas.

[8] Letter from the California Regional Water Quality Control Board Central Valley Region, 17 November 2011. Subject: Delta Mercury Control Program Requirements for County of San Joaquin MS4 (CAS000004).

[9] Data and loading calculation methods are summarized fully in the City of Stockton and County of San Joaquin Baseline Mercury Monitoring Report, submitted to the Regional Board on December 1, 2011.

As detailed further below, this Control Study will study the impacts on methylmercury of an existing activity of the City and County's NPDES MS4 Phase I program. Detention basins are a common Best Management Practice (BMP) in the Stockton Urbanized Area (SUA) for flood control purposes, with eleven municipally-operated detention bases with the SUA. While little is known about detention basins' effect on methylmercury production and export, studies conducted in the Sacramento-area found that detention basins reduce both total mercury and methylmercury (Geosyntec, 2010 and Larry Walker Associates, 2011). The City and the County also previously studied the pollutant removal effectiveness of a detention basin, La Morada Basin, but study data did not indicate any trends in mercury or methylmercury removal (Larry Walker Associates, 2012). Those detention basin studies are briefly summarized in Section 4.0 of this Control Study Workplan.

The City and County expect Stockton-area detention basins to perform similarly to the Sacramento-area basins in that mercury and methylmercury will be reduced through sedimentation processes. Due to the reduction needed within the San Joaquin River subarea, the City and the County selected a City-owned basin that drains to this subarea, the Airport Business Center Basin, to meet the requirements of this Control Study. The location of the Airport Business Center Basin in relation to the San Joaquin River subarea is depicted in **Figure 1**.

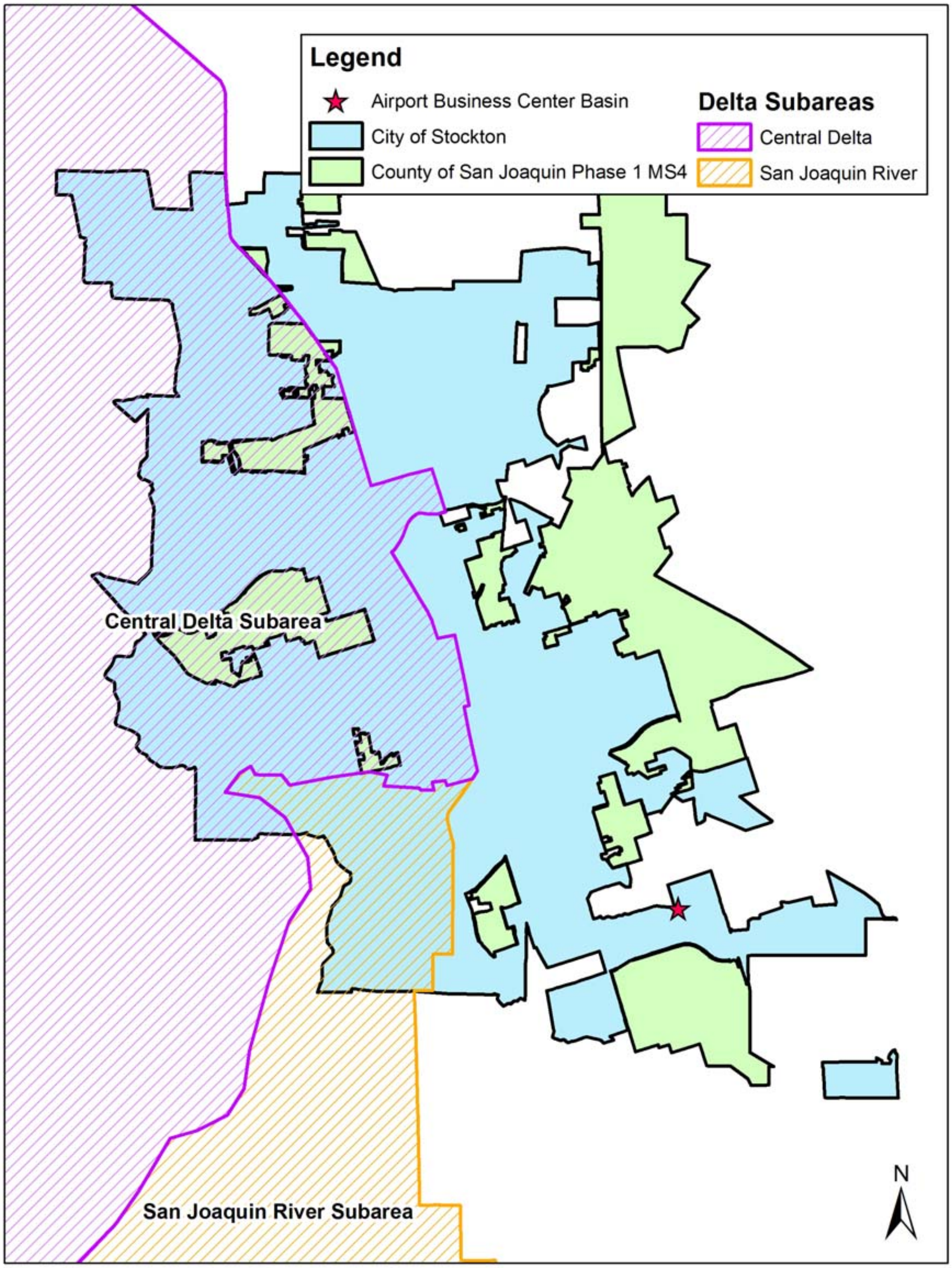

Figure 1. City and Phase I NPDES MS4 Portion of County Depicted in Context of Delta Hydrologic Subareas

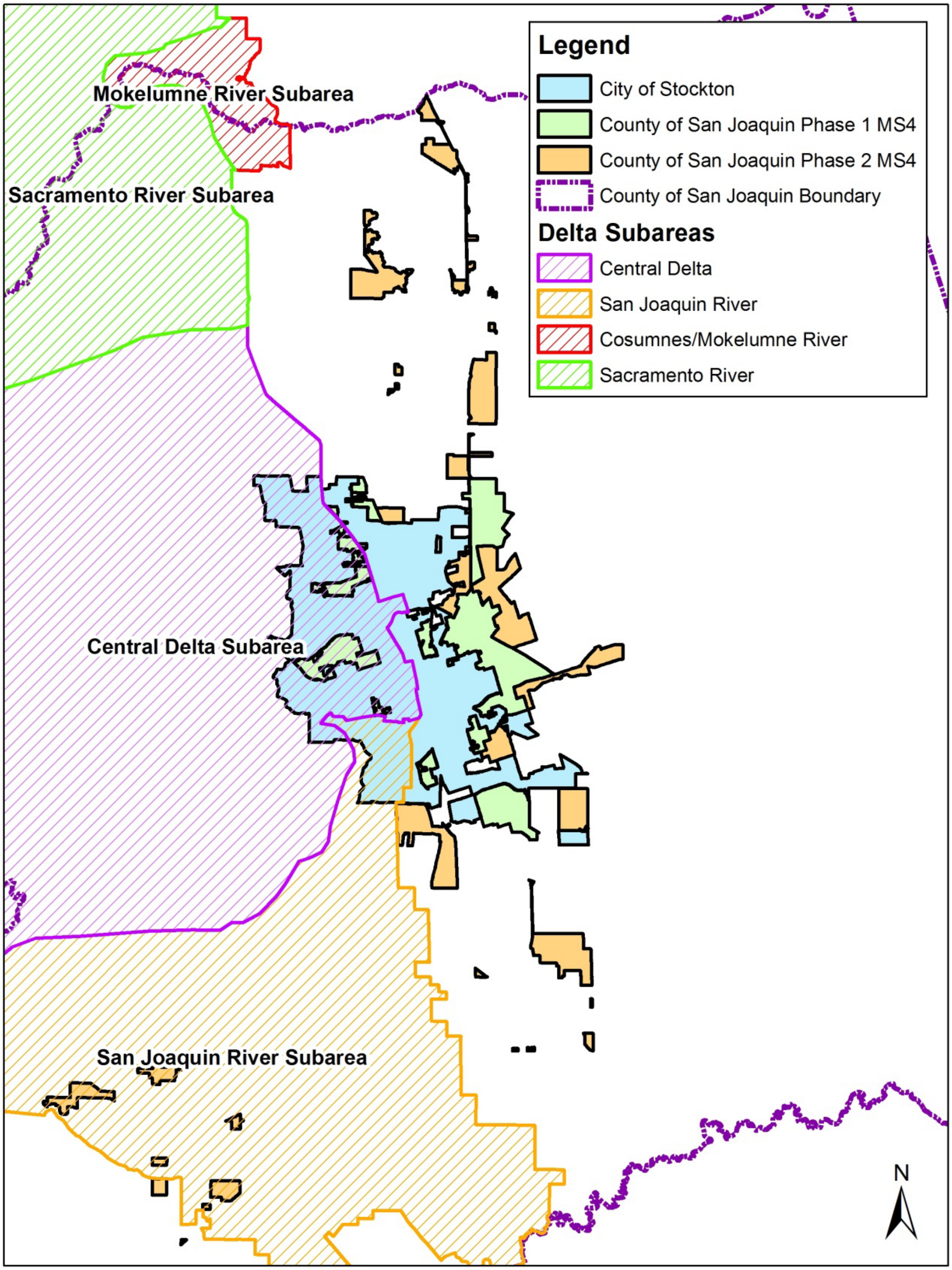

Figure 2. City of Stockton, Phase I and Phase II NPDES MS4 Portions of County Depicted in Context of Delta Hydrologic Subareas

Table 1. Comparison of Methylmercury TMDL Load Allocations to Existing Loads[10]

Subarea	Permittee	Existing MeHg Load (g/yr)	MeHg WLA (g/yr)	% Reduction Needed
Central Delta	County of San Joaquin	0.57	0.57	0%
	Stockton Area MS4	3.6	3.6	0%
Mokelumne River	County of San Joaquin	0.045	0.016	64%
Sacramento River	County of San Joaquin	0.19	0.11	42%
San Joaquin River	County of San Joaquin	2.2	0.79	64%
	Stockton Area MS4	0.50	0.18	64%

Table 2. City and County-Specific Calculations of Existing Loading to Delta Subareas[11]

Subarea	Permittee	Phase I Acreage within Subarea	MeHg Load (g/yr)	MeHg WLA (g/yr)	% Reduction Needed
Central Delta	County of San Joaquin	2,316	0.36	0.57	0%
	Stockton MS4	14,653	2.45	3.6	0%
San Joaquin River	County of San Joaquin	0	0	0.79	0%
	Stockton MS4	3,981	0.68	0.18	74%

[10] Modified from Table 8.4 of the TMDL Staff Report.

[11] Data and loading calculation methods are summarized fully in the City of Stockton and County of San Joaquin Baseline Mercury Monitoring Report, submitted to the Regional Board on December 1, 2011.

Table 3. Current Methylmercury Loads and Load and Wasteload Allocations to the Delta by Source Category[12]

Source Category	Percentage of Total Current Methylmercury Load	Percentage of Total LA or WLA
Agriculture	2.35%	2.6%
Atmospheric wet deposition	0.44%	0.79%
Open Water	16%	24%
Tributary Inputs	58%	50%
Urban (Nonpoint source)	0.02%	0.03%
Wetlands	18.9%	18.2%
NPDES Facilities	3.9%	3.7%
NPDES Facilities future growth	-----	0.42%
NPDES MS4	0.36%	0.44%

[12] Modified from Table 8.5 of the TMDL Staff Report.

3.0 Objectives

This section discusses the objectives of the Control Study, which includes both the study objective in the form of the study hypothesis that will be tested, and the control objective.

> ***Guidance Document Requirement***
>
> *To the extent possible, provide objectives that are specific, measurable, and relevant to the TMDL; for: 1) the study activity (i.e., experiments, evaluations, and/or modeling) that will be conducted and 2) application of the study results to your ultimate goal of methylmercury control.*
>
> a. *Study Objectives: What hypotheses do you plan to test with your study? Clearly state your hypotheses in a manner that focuses on the mechanism(s) by which your control measure may contribute to the Control objectives.*
>
> b. *Control Objective: Describe your total allocation responsibility. Demonstrate how your control measure could be applied, scaled up or combined with other control measures to achieve the methylmercury allocation.*

Study Objective

The study will examine the mercury and methylmercury removal effectiveness of a detention basin in the SUA, along with the potential for methylmercury production in the basin. It is anticipated that the Control Study will demonstrate that detention basins, in particular the Airport Business Center Basin, are an effective mechanism for reducing methylmercury loads.

The Control Study will test the following hypothesis:

Hypothesis: *The Airport Business Center Basin will reduce mercury and methylmercury loadings in the San Joaquin subarea. Sedimentation is the primary pollutant removal mechanism in detention basins, and as a result, detention basins will remove total mercury from the system, reducing the amount of mercury available for methylation.*

The data collected for the Control Study will be used to either support or reject the hypothesis. The information developed pursuant to this study will be applicable to other NPDES MS4 permittees including Sacramento and Contra Costa Counties in the Central Valley, and the results could be used to provide additional information on the mercury and methylmercury removal benefits associated with detention basins (with detention basin design taken into account). Results will be compared to previous studies on detention basins in the Sacramento and Stockton areas (see Section 4.0).

Control Objective

This study will help to inform how mercury and methylmercury loadings may be reduced in the SUA. The City and County's total waste load allocation responsibility are shown in **Table 2**. The required reduction is within the San Joaquin River Delta hydrologic subarea that receives drainage from the Airport Business Center Basin. In the event that the Airport Business Center Basin contributes to mercury export and/or methylation, the City and the County will consider options to alter the Basin to improve pollutant removal performance (e.g., determine if it is feasible to alter detention time or improve the ability of the Basin to retain a water quality design storm). The knowledge gained from the Control Study may be applied to further reduce methylmercury loads from the SUA using other detention basins in the SUA, or in the design of detention basins which are added to the SUA in future new development projects.

4.0 Mechanisms Underlying the Study

This section describes the underlying mechanisms to explain how the Control Study will achieve the Study and Control Objectives. An overview of detention basin mechanisms for mercury removal is provided, as well as a summary of other detention basin and mercury studies in the Central Valley.

> ***Guidance Document Requirement***
>
> *Provide a conceptual model or set of underlying assumptions to support your hypotheses and explain why or how your proposed control study will achieve the study and control objectives. To the extent that you can, describe factors affecting methylmercury within your source area, including seasonal dynamics. Reference sources include the Delta Regional Ecosystem Restoration Implementation Plan (DREIP) conceptual model and the NPDE Workgroup mercury synthesis. Summarize existing aqueous methylmercury concentrations and loads from your source.*

DETENTION BASIN MECHANISMS

Detention basins are used for both water quality purposes and for flood control. They improve stormwater quality by detaining water to allow particulate matter and associated pollutants to settle. Mercury binds to sediment, and detention basins remove total mercury by removing sediment with bound mercury. Because detention basins remove sediment and, therefore, the amount of inorganic mercury available to methylate, this study hypothesizes that the Airport Business Center Basin reduces the amount of methylmercury. However, there is very little information in the published literature about detention basin performance for methylmercury removal. It is likely that the design, operations, and hydrology of a detention basin are important in determining whether a detention basin becomes a sink or a source for methylmercury.

A study of stormwater pond-wetland systems in Minnesota found that stormwater wetlands export phosphorus, and that phosphorus export strongly correlates to an increase in methylmercury (Monson, 2007). The study results suggest that a BMP that removes phosphorus will minimize methylmercury release. Since detention basins remove pollutants through sedimentation, and thus remove particulate-bound phosphorus, it is possible that may correlate with a decrease in methylmercury production.

However, detention basins could also potentially contribute to methylmercury production. Detention basins may create an anaerobic environment during the wet season, thereby creating an environment conducive to methylation. Bacteria that process sulfate in the environment can take up mercury in its inorganic form, and through metabolic processes convert it to methylmercury. Factors such as dissolved oxygen, pH, nutrient, sulfide and sulfate concentrations affect methylation rates (USEPA, 1997). Sulfate and iron present in runoff may stimulate sulfate and iron-reducing bacteria that methylate mercury. It is possible that detention basins effective in removing sulfate and iron may create an environment less conducive to methylation.

In addition, detention basin design, operations and maintenance practices could contribute to methylation. According to Alpers, et al. (2008), wetting-drying cycles can contribute to methylmercury production. In particular, detention basins with limited open water and frequent wetting and drying may be problematic. In contrast, deep open-water basins (with little wetting and drying) could serve as a demethylation environment. Maintenance practices typically include inspection for erosion of pond banks or bottom, sediment accumulation, and debris accumulation in the basin and inlet and outlet points[13]. Methylation may be more likely to occur if excess sediment and debris are not removed according to maintenance schedules.

CENTRAL VALLEY DETENTION BASIN STUDIES

As previously mentioned, little is known about the pollutant removal effectiveness of detention basins as it relates to mercury and methylmercury. To illustrate, a search of the International Stormwater BMP Database (www.bmpdatabase.org) for methylmercury reveals only one study that examined a detention basin in Sacramento-area. The City of Stockton and County of San Joaquin have previously studied one detention basin within the SUA, La Morada Basin, as part of their stormwater monitoring program.

Brief summaries of the Sacramento area basin studies and La Morada Basin study are provided below, followed by an overview of these Central Valley detention basin studies.

Sacramento Stormwater Quality Partnership: Wet Detention Basin Effectiveness Study

A special study was conducted to assess the pollutant removal performance of a representative wet water quality detention basin.[14] The North Natomas Water Quality Basin 4 (Natomas Basin No. 4), which is located near the junction of Natomas Boulevard and Club Center Drive in the City of Sacramento, was selected for the study. The pollutant removal efficiency of Natomas Basin No. 4 is considered to rely primarily on settling of solid particles (i.e., fine (<63 µm) and coarse (>63 µm) particulates). Natomas Basin No. 4 has one inlet and one outlet (via pump station), and its drainage area is approximately 470 acres (primarily low-density, single family residential land use). Natomas Basin No. 4 has a permanent pool footprint of approximately 1.6 acres. The storm surcharge volume (i.e., volume that would be required to be pumped out of the basin at a rate that would meet the detention design criteria) (8 ac-ft) corresponds to an elevation of 4.2 feet and a footprint of approximately 4.5 acres.

Sampling began in the wet season of 2007-2008 and was completed in 2010. Positive efficiencies were estimated for metals associated with urban runoff. Total mercury measured from composite samples was reduced by approximately 36%. In addition, total mercury and methylmercury were analyzed from grab samples; the effectiveness estimate for the grab samples was 31.1% for total mercury and 12% for methylmercury, although the estimate for methylmercury was not significant. Thus, the basin appeared to be moderately effective in reducing the discharge of total mercury and does not appear to cause an increase in the discharge of methylmercury.

[13] USEPA Stormwater menu of BMPs:
http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=factsheet_results&view=specific&bmp=67

[14] Geosyntec Consultants, 2010. Wet Basin Effectiveness Study. Prepared for the Sacramento Stormwater Quality Partnership, August 2010.

Sacramento Stormwater Quality Partnership: Addendum to Wet Detention Basin Effectiveness Study

For this study, influent and effluent samples were collected from two wet water quality detention basins, Bear Hollow and Anatolia North, in the City and County of Sacramento in 2010-2011.[15] The Anatolia North watershed encompasses approximately 0.41 square miles of urban development draining to Wakita Creek, which eventually makes it way to the Sacramento River. The Anatolia North detention basin has two inlets and one outlet (via gravity). The Bear Hollow watershed is 0.87 square miles of urban development and drains into Morrison Creek, which is a tributary to the Sacramento River. The Bear Hollow detention basin has three inlets and one outlet (via pump station). Grab samples were collected from three wet and one dry weather events. For all four events, the inlets and outlets of each basin with sufficient system flow were monitored for methylmercury and total mercury.

The results for these two detention basins were compared to those for Natomas Basin No. 4 wet weather monitoring conducted from 2007 to 2010. Only the wet weather results from Anatolia North and Bear Hollow were used so that the efficiencies would be comparable to the Natomas detention basin. Total mercury and methylmercury were both reduced in all three detention basins, with slightly greater total mercury efficiency reduction. In Anatolia North and Bear Hollow, total mercury was reduced by 50% and 41%, respectively, compared to 31% at Natomas Basin No. 4. Methylmercury was reduced by 40% in Anatolia North and 11% in Bear Hollow, compared to 12% at Natomas Basin No. 4.

City of Stockton and County of San Joaquin: La Morada Detention Basin Study

Detention basin monitoring was designed to evaluate the effectiveness of La Morada Basin[16] in removing various constituents.[17] The basin drainageshed is primarily residential in land use and discharges to Mosher Slough. The drainageshed comprises three separate storm drain systems which have separate inlets to the detention basin; the basin has one outlet. The basin is a wet flood control basin designed for a ten-year storm with a depth of roughly 16 feet and a detention time of 24 hours. The La Morada Basin was selected for monitoring because it was one of the detention basins with the longest retention times in the SUA and it had been monitored during the second permit term (2002-2007). However, its retention time is still considered to be relatively short with regard to water quality purposes, and the basin was not designed as a water quality detention basin.

Influent and effluent water samples were monitored during two wet weather events during 2008-2009 and one wet weather event in 2010-2011[18] for several constituents, including total mercury and methylmercury. An analysis of these influent and effluent data revealed no consistent trends in mercury or methylmercury removal on an event basis. This is likely partially due to the fact

[15] Larry Walker Associates. 2011. Addendum to the Wet Detention Basin Effectiveness Study. Prepared for the Sacramento Stormwater Quality Partnership.

[16] The La Morada Basin was formerly called both Basin 2 and the San Joaquin Area Flood Control Agency (SJAFCA).

[17] Larry Walker Associates. 2012. City of Stockton and County of San Joaquin ROWD and Proposed SWMP. Prepared for the City of Stockton and County of San Joaquin.

[18] Only one wet weather event was monitored due to a lack of qualifying storm events.

that the basin is not designed for water quality, as well as the fact that the analysis was based on a small dataset (three events). Sediment sampling was also conducted in 2008-2009. Mercury was detected below the reporting limit in one sediment sample, at an estimated value of 11.0 µg/kg.

Overview of Central Valley Detention Basin Studies

An overview of the Central Valley detention basins and associated studies is provided in **Table 4.**

Table 4. Overview of Central Valley Detention Basin Studies (Wet Weather Events)

Basin Name	Detention Basin Type	Constituent	Sample Type	Influent n	Influent Median Concentration (ng/L)	Effluent n	Effluent Median Concentration (ng/L)	Removal Efficiency
Natomas Basin No. 4	Wet Water Quality	Mercury, total	Composite	9	5.90	9	3.80	36%
		Mercury, total	Grab	9	4.38	9	3.02	31%
		Methylmercury	Grab	9	0.125	9	0.11	12%
Anatolia North	Wet Water Quality	Mercury, total	Grab	3	4.54	3	2.25	50%
		Methylmercury	Grab	3	0.106	3	0.064	40%
Bear Hollow	Wet Water Quality	Mercury, total	Grab	3	9.46	3	5.54	41%
		Methylmercury	Grab	3	0.123	3	0.109	11%
La Morada Basin	Wet Flood Control	Mercury, total	Grab	9	7.70	3	5.00	N/A
		Methylmercury	Grab	9	0.123	3	0.128	N/A

Note:
N/A = Not evaluated due to small sample size and inconsistent removal trends (i.e., both removal and export occurred)

METHYLMERCURY IN THE STOCKTON AREA

The City and County's NPDES MS4 permit requires monitoring to characterize the concentrations and loads of methylmercury entering the Delta from Stockton urban runoff. Baseline characterization monitoring was conducted at ten locations from 2008-2011 for total mercury and methylmercury. A combination of discharge outfalls, major upstream tributaries, and downstream locations were monitored. Three wet weather events and two dry weather events were monitored each year for three years. General findings included:

- Total mercury concentrations were relatively low in both urban discharge and receiving waters, and were consistently below the CTR criterion of 0.05 µg/L.
- Generally, mercury concentrations were more variable and somewhat higher during wet weather events.
- There were no trends apparent between wet weather versus dry weather event total mercury concentrations.
- Methylmercury was detected in low concentrations at all locations during most sampling events. Methylmercury concentrations at all locations (including upstream) were generally higher than the TMDL implementation goal of 0.06 ng/L for unfiltered ambient water.
- For all monitoring years, methylmercury concentrations did not vary substantially among urban discharge and receiving water locations, or between the upstream location and locations within the urban area.

DATA GAPS ADRESSED BY THE CONTROL STUDY

The sections above describe the limited set of available information about the fate and transport of mercury in detention basins, and of concentrations and loads of mercury within the Stockton area. As mentioned previously, there is little information in the available literature about the function of detention basins with regard to methylmercury removal. Of the studies that are available, none have attempted to make a connection between design aspects (e.g., width-depth ratio) and methylation. These connections are not possible at this time due to small number of studies. However, once a larger body of studies and knowledge exists regarding detention basin methylmercury effectiveness, these connections may be possible.

The study of Airport Business Center Basin will help to fulfill data gaps in the following ways:

- The Airport Business Center Basin will provide a contrast to the Sacramento-area deep open-water basins and can add to the body of knowledge regarding wetting and drying cycles and methylation in detention basins.
- This study proposes to monitor for sulfate and iron in addition to total mercury and methylmercury, and will therefore help to determine if there is a relationship between methylmercury production and other elements that may be linked to microbial activity.
- This study also proposes to monitor for phosphorus and will therefore help to determine if the Airport Business Center Basin removes phosphorus and creates an environment less conducive to methylation.

As previously indicated, in the event that the Airport Business Center Basin contributes to mercury export and/or methylation, the City and the County will consider options to alter the basin to improve pollutant removal performance, including possibly improving the Basin's ability to detain or retain a greater portion of the water quality design storm (equates to about the 0.51 inch storm event for the Stockton area) to allow sedimentation processes to occur.

5.0 Proposed Control Measures

> ***Guidance Document Requirement***
>
> *Describe how the study will be designed to test the hypotheses and conceptual models as described in elements 2* [Section 3] *and 3* [Section 4.0) *above. Explain whether the measure is targeted research, a pilot project, or large in scope. If the project is targeted research, explain why the targeted research cannot be incorporated into a pilot project. If you are proposing a measure that is large in scope, describe the level of risk and how potential negative impacts could be managed or reversed.*

In order to test the hypothesis, the City and the County will collect samples from the influent and effluent of a detention basin in the SUA. Data obtained from this study will be compared with the results of the Sacramento detention basins and used to examine correlations between mercury, methylmercury and other constituents such as sulfate, iron and phosphorus.

As discussed previously, and indicated in **Table 2**, reductions in methylmercury are needed in the San Joaquin River subarea. As a result, the City and County are evaluating a detention basin located in the urbanized area that drains to the San Joaquin subarea—the Airport Business Center Basin. Studying a municipally-owned detention basin is necessary because it simplifies access and equipment installation issues.

The Airport Business Center Basin is located near the intersection of Pock Lane and Industrial Drive in the southeast portion of the City of Stockton and encompasses a total area of approximately 10.1 acres (**Figure 3**). The total area contributing flows into the Basin is approximately 1,446 acres (**Figure 4**). The Basin was designed to retain the 10-year 48-hour storm (a depth of 3.12 inches per Stockton standards), allowing the 10-year flow to enter the basin without creating street flooding. The Basin has a total available storage of 140.65 acre-ft, with the average basin bottom elevation set at -6.0 ft and a side slope of 2:1[19].

The Basin has three gravity-fed storm storm drain inlets. The inlets drain industrial and residential developments as well as undeveloped areas. The Basin has one pump station outlet discharging into North Little Johns Creek. The pump station is located at the east side of the Basin and includes three primary pumps and one standby pump (each with a power of 75HP and capacity of 8,600 gpm), as well as one low flow pump (with a power of 30HP and capacity of 1,800 gpm). The maximum flow rate which can be discharged into Little Johns Creek is 50 cubic feet per second. To achieve stormwater treatment, the Basin operates with an average low flow runoff residence time of 40 hours.

If possible, the study will identify recommendations to modify detention basin design to improve and/or maintain mercury and methylmercury reductions. The study may also help the City and County determine how operations and management of detention basins affect mercury and methylmercury removal effectiveness. Results from this study may provide useful information for the design of future detention basin that may be operated by the City and County as a result of new development.

This study is considered targeted research. The City and the County are not proposing a pilot project at this time, because as proposed, the study will contribute to a better understanding of detention basin removal effectiveness. It is in the interest of NPDES MS4 permittees to better

[19] Siegfried Engineering, Inc. 2001. Parkside Industrial Park Utility Master Plan. September.

understand how a commonly implemented BMP, such as a detention basin, can affect methylmercury loads.

Figure 3. Airport Business Center Basin Overview

Figure 4. Airport Business Center Basin Drainage Area

6.0 Monitoring and Data Collection Plan

The Airport Business Center Basin, located within the Stockton Urbanized Area that drains into the San Joaquin River subarea, will be monitored for the Control Study. Data has been previously collected regarding the effectiveness of detention basins in the Sacramento-area. It is the intent of this study to potentially build upon the Sacramento-area findings.

The monitoring and data collection plan is described in the following sections.

Guidance Document Requirement

Identify parameters and media that will be measured and over what frequency and duration. Describe how these measurements will be used to determine the effectiveness of the control measure(s). Describe the statistical approach you will use to evaluate the results and compare outcomes with the hypotheses. Studies to assess the effects of water management on methylmercury may largely rely on methylmercury data already collected.

DATA COLLECTION PERIOD

Data will be collected over three years, between October 2013 and September 2016. The monitoring plan will be reevaluated after the first year of monitoring. Control Study progress will be reported in the Control Study Progress Report, due in October 2015, and a Final Control Study Final Report will be submitted by October, 2018.

SAMPLE LOCATIONS AND FREQUENCY

During each study year, samples will be collected during three wet weather events and one dry weather event, as shown in **Table 4**. The sample size was selected based off of the accepted industry standard of ten storm events as a sufficient number of storm events to determine trends in BMP effectiveness[20]. The dry weather event will be dependent on sufficient dry weather flows to collect an inlet and outlet sample. Samples will be taken at the three Basin inlet points using composite samplers in manholes and at the outlet lift station during all events (shown in **Figure 5**), and sediment samples will be obtained during dry weather events.

Table 5. Control Study Monitoring Frequency

Monitoring Year	Number of Events	
	Wet Weather	Dry Weather
October 2013 - September 2014	3	1
October 2014 - September 2015	3	1
October 2015 - September 2016	3	1

[20] The number is derived, in part, from the Sacramento Stormwater Quality Partnership's minimum requirement for proprietary BMP effectiveness data: http://www.beriverfriendly.net/newdevelopment/propstormwatertreatdevice/

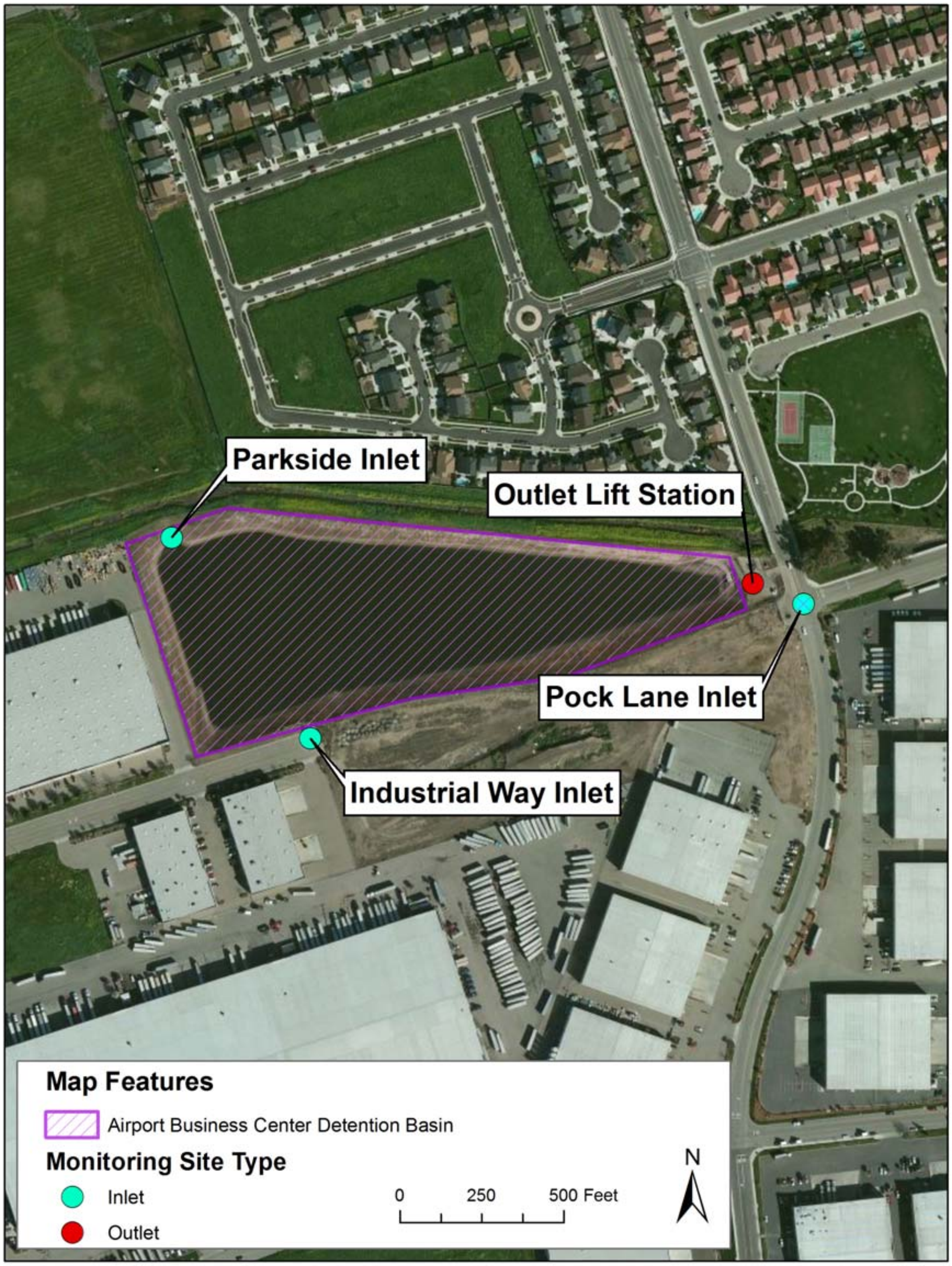

Figure 5. Location of Inlet and Outlet Locations for Airport Business Center Basin

MONITORED CONSTITUENTS

Composite and grab samples will be taken to evaluate water quality at the inlets and outlet of the Basin, and sediment samples will be collected to examine mercury and methylmercury content of detention basin sediments. Water quality constituents are summarized in **Figure 6,** and sediment sample constituents are summarized in **Table 6**. Sample analyses will be performed by a National Environmental Laboratory Accreditation Program (NELAP)-certified laboratory (to be determined) for the relevant methods. Because the analytical method and laboratory selection are critical steps in any monitoring program, all analyses must meet data quality objectives. The analytical method may change during the study if a different method is found to yield better results (better quality assurance/quality control results (QA/QC) and/or a lower detection limit).

Figure 6. Water Quality Constituents Monitored in Basin Influent and Effluent

Constituent	Bottle	Volume (mL)	Sample Type	Preservative	Holding Time	Method
Specific conductance (EC)	NA	NA	Field	None	ASAP	Field
Dissolved Oxygen	NA	NA	Field	None	ASAP	Field
pH	NA	50	Field	None	ASAP	Field
Temperature	NA	NA	Field	None	ASAP	Field
TDS	Sterilized PE	100	Composite	0-6˚C	7 days	EPA 160.1
TSS		100		0-6˚C	7 days	EPA 160.2
Turbidity		100		0-6˚C	48 hrs	EPA 180.1
Suspended Sediment Concentration	PE	125	Composite	None	7 days	ASTM Method D 3977-97[21]
Total phosphorus	PE	250	Composite	0-6˚C, H2SO4 to pH <2	28 days	EPA 365.3
Total sulfate	PE	250	Composite	0-6˚C	28 days	EPA 375.2
Total iron	PE	250	Composite	0-6˚C, preserve ASAP	6 months	Colorimetric
Total Mercury	Glass, double bagged	500	Grab	0-6˚C + HCl	48 hrs/ 90 days **	EPA 1631
Methylmercury, total		500	Grab	0-6˚C + HCl or H_2SO_4*		CVAFS
Methylmercury, dissolved		500	Grab	0-6˚C + HCl or H_2SO_4*	48 hrs/ 90 days ***	CVAFS

* Preserve with HCl if less than 10 ppth salinity OR preserve with H_2SO_4 if greater than 10 ppth salinity
** 48 hrs to preserve, 90 days once preserved
***24 hrs to filter (filter in lab), 48 hrs to preserve, and 90 days once preserved
PE=polyethylene

21 "Standard Test Method for Determining Sediment Concentration in Water Samples" (American Society for Testing and Materials, 2000)

Table 6. Sediment Sample Constituents

Constituent	Container	Volume (mL)	Preservative	Holding Time	EPA Method
Methylmercury	CWM[1]	250	0-6˚C + HCl or H_2SO_4*	48 hrs/ 90 days ***	CVAFS
Total mercury	CWM[1]	250	none	28 days	EPA 7471

1. CWM = clear wide-mouth glass jar with Teflon-lined lid

SAMPLE COLLECTION PROCEDURES

The following sections describe sample collection procedures for the constituents listed above.

Composite Sample Collection

In order to capture a more thorough picture of detention basin performance, composite samplers will be used to sample Basin inlet and outlet flows[22]. Flow composite samples, rather than time composite samples, are preferred when evaluating BMP effectiveness (Geosyntec and Wright Water Engineers, 2009). For this study, flow composite samples at the inlet and outlet locations will be taken at equal runoff volume increments over the duration of the storm event (at the inlets) and during Basin discharge (at the outlet). Composite sample volumes will be determined based on anticipated rainfall amounts and the required sample volume needed for constituent analyses, including quality control samples. Sampling procedures will be modified as needed following a trial run and based on observed field conditions.

Flow at the three inlet stations will be estimated as the product of measured velocity and area of the inlet pipes (assuming that the pipe is full of water). Flow measurements are desired for two purposes: (1) estimating pollutant loads, and (2) input to an automatic sampler for obtaining flow composite samples. The three inlet samples will be composited by the analytical laboratory based on flow in order to obtain one representative inlet sample for analysis.

During dry weather, samples will be taken over a 24 hour period. If flow velocities are below the threshold of the velocity sensor, approximately one hour time composite samples will be taken. At the outlet, the autosampler will be programmed to take a sample when water levels in the outlet channel start to decrease.

Grab Sample Collection

Grab samples will be collected for mercury and methylmercury samples. USEPA Methods 1631 and 1669 recommend grab sampling, since the USEPA was not able to demonstrate that composite sampling systems can collect mercury samples that are free from contamination, and not lose mercury to volatilization (USEPA, 2001). During the first sampling event, mercury will also be analyzed from the composite samples in order to evaluate whether composite samples are subject to contamination, and whether grab samples are representative.

[22] The feasibility of composite sampler installation at the basin inlet and outlet locations will be evaluated by the City and County, and alternate methods for sample collection may be proposed if installation is not practical.

One set of grab samples will be taken at each site during each event. It is desired that these grab samples be collected during peak flow. However, due to the difficulty in predicting the time of peak flow, grab sampling during peak flow may be problematic. Therefore, to the greatest extent possible, grab samples will be collected during the first portion of the storm event, at a time when flow rates are increasing and precipitation rates are decreasing. Grab samples for mercury and methylmercury will be collected at the inlet and outlet stations by operating the autosamplers in grab sample mode. Dissolved methylmercury will be analyzed in addition to total methylmercury from the grab samples in order to evaluate partitioning of methylmercury (i.e., if the Basin is removing particulate methylmercury but increasing the dissolved fraction).

Sediment Sampling

Sediment samples will be collected during the dry weather event and analyzed for mercury and methylmercury to examine the mercury content in sediment and characterize mercury partitioning. Sediment chemistry samples will be collected at three representative locations within the basin, with a global positioning system (GPS) device used to record the location of sampling.

Prior to sample collection, equipment will be laid out on plastic sheeting and surface vegetation will be removed from the sampling site. Surface soil samples will then be collected from the ground surface to six inches below ground surface. Dry sediment samples will be collected by loosening the soil with a clean stainless steel shovel and/or soil auger. A clean stainless steel scoop will then be used to place loose soil into the appropriate laboratory supplied container. Wet sediment samples will be collected using a clam-shell or dredge-type sampler. Glass sample bottles will be used (wide- mouth clear borosilicate for mercury) and bottles will be labeled, sealed in clean Ziploc bags, and immediately placed on ice in a cooler to await transport to the lab. The soil samples from each location will be composited (3:1) and the individual composites analyzed.

DATA EVALUATION

The performance of the Basin will be evaluated similarly to the Sacramento-area detention basin study. BMP performance will be analyzed using methods outlined by Geosyntec and Wright Water Engineers (2009). The operation of a BMP can be evaluated by any of the following terms:

- *Performance* – a measure of how well a BMP meets its goals for stormwater that the BMP is designed to treat.
- *Effectiveness* – a measure of how well a BMP meets its goals in relation to *all* stormwater flows.
- *Efficiency* – a measure of how well a BMP removes or controls pollutants.

This control study focuses on pollutant removal, and therefore study results will be evaluated in terms of efficiency. The "Event Mean Concentration" (EMC), obtained from the analysis of a flow-composite sample, is used in a common method to estimate efficiency according to the following equation:

Efficiency = (Influent EMC - Effluent EMC)/Influent EMC

The EMC multiplied by the influent or effluent volume equals the pollutant load, which is often key in evaluating receiving water impacts. Efficiency can also be evaluated in terms of loading, using the equation:

Percent Removal = (Influent Load - Effluent Load)/Influent Load

The recommended approach for computing the average efficiency of a BMP is to use the average of the pooled influent and effluent EMCs or loads (Geosyntec and Wright Water Engineers, 2009). This approach of using pooled data from the influent and effluent is more appropriate than using the averages for individual storms because they do not require an equal number of influent and effluent data pairs, and because they are not as sensitive to event-by-event performance variability. Average EMCs are generally preferred over loads due to uncertainties in flow measurements and limits in sample volumes – an event load assumes that the entire mass flux into and out of the Basin would be characterized by the sampling event. An average EMC is appropriate for evaluating influent and effluent data that is normally distributed; in cases where the data are not normally distributed, median EMCs are used. Efficiencies will be evaluated using an appropriate statistical test to determine if differences in mean or median EMCs are statistically different (described below).

In addition to evaluating the sampling data, an estimation of the contribution of mercury and methylmercury due to washoff from mercury accumulated on impervious surfaces will be performed using data available in the scientific literature.

STATISTICAL APPROACH

This section describes the statistical approaches that will be used for analysis of non-detect data and for influent and effluent comparisons.

Non-Detect Data

Non-detect data will be analyzed using the regression-on-order statistics (ROS) method (Helsel and Cohn, 1988). With this approach, the data above the analytical reporting limit are fit to a probability distribution and the data below the reporting limit are estimated based on their expected plotting position. Summary statistics can then be computed using the filled-in data set. This approach typically gives less biased results than simple substitution of half the reporting limit (RL). However, enough data above the detection limit must be available to adequately fit a theoretical probability distribution. Therefore, the ROS method will be used if the data set has greater than 20% detects, and greater than three detected values, based on recommendations from Helsel and Cohn (1988). One-half the RL will be used for constituent data sets that do not meet that criterion.

Statistical Analysis

Statistical methods will be used to evaluate differences between influent and effluent data, and determine if differences are significant. The Airport Business Center Basin has been observed to contain standing water during summer months, and thus it is likely that the sampled effluent may contain runoff from a previous storm or urban runoff. In order to assess the general performance of the Basin, and account for the "pooling" of influent from different events, combined data will be analyzed for sampling locations across events.

Statistical tests generally fall into two categories: parametric statistical tests and non-parametric tests. Parametric tests, such as the two-sample t-test, are appropriate for data sets where the influent and effluent data sets can be shown to follow a normal distribution. For data that do not follow a normal distribution, non-parametric tests, such as the Wilcoxin rank-sum test, are more appropriate. In this study, data will likely be analyzed using non-parametric tests for the following reasons:

- Many parametric methods can be biased for small sample sizes (e.g., less than 10 samples);
- If either influent or effluent data contain a high proportion of non-detects (i.e., greater than 15%), non-parametric methods may be more appropriate (Geosyntec and Wright Water, 2009).

7.0 Quality Assurance Procedures

The following section details quality assurance procedures for the Control Study.

> ***Guidance Document Requirement***
>
> *Contain or summarize and reference quality assurance procedures that cover all aspects of sample collection, handling, and analyses for all parameters that will be measured.*

CLEAN SAMPLING PRACTICES

"Clean sampling" techniques are required to collect and handle water samples in a way that do not result in contamination, loss or change in the chemical form of the analytes of interest. All samples will be collected in accordance with procedures detailed in EPA Method 1669 as follows:

- Samples are collected only into rigorously pre-cleaned sample bottles.
- At least two persons, wearing clean, powder-free nitrile gloves at all times, are required on a sampling crew.
- One person ("dirty hands") touches and opens only the outer bag of all double bagged items (such as sample bottles, tubing, strainers and lids), avoiding touching the inside of the bag.
- The other person ("clean hands") reaches into the outer bag, opens the inner bag, and removes the clean item (sample bottle, tubing, lid, strainer, etc.).
- After a sample is collected, or when a clean item must be re-bagged, it is done in the opposite order from which it was removed.
- Clean, powder-free nitrile gloves are changed whenever something not known to be clean has been touched.
- For this program, clean techniques must be employed whenever handling the composite bottles, Teflon lids, suction tubing, or strainers. During composite sample splitting, the metals bottles are also handled using clean techniques.

QUALITY CONTROL SAMPLES

Quality control (QC) samples will be collected during each monitoring event according to the schedule presented in **Table 7**, which combines the three wet weather and one dry weather events. Quality control sample results will be used for data evaluation and interpretation.

QC Sample Collection Schedule

Lab duplicate and matrix spike/matrix spike duplicate analyses will be performed on environmental samples. (i.e., not blanks). Field-generated quality control samples (field duplicates and field blanks) will be submitted "blind" to the laboratory. For the purposes of data evaluation and interpretation, quality control samples will be collected once during each monitoring event. The following samples will be analyzed at the frequency shown in **Table 7.**

- Field Blank (for total mercury)
- Matrix Spike / Matrix Duplicate (for total mercury and methylmercury)
- Field Duplicate (for all constituents)

Table 7. Quality Assurance and Quality Control Sample Collection Schedule

Location	WW1	WW2	WW3	DW1
Influent	FB	FD	MS/MD	
Effluent	FD	MS/MD	FB	
Sediment Chemistry				FD

FB = field blank; FD = field duplicate; MS/MD = matrix spike/matrix duplicate

Specific collection methods for each quality control sample type are described below.

Field Blank

Grab sample and composite sample field blanks shall be collected, using clean techniques, for the stations and events specified in **Table 7**. Grab sample field blanks shall be collected immediately prior to the collection of normal grab samples for total mercury and methylmercury. Grab sample field blanks shall be collected by pouring laboratory provided blank water directly into the sample bottle and using clean sampling techniques. Composite sample field blanks will be collected at the time that the final composite bottle is removed from the sampler. Blank water will be poured directly into the sample container.

MATRIX SPIKE/MATRIX SPIKE DUPLICATE

Matrix spike and matrix spike duplicate (MS/MSD) analyses shall be requested for total mercury and methylmercury samples for the stations and events specified in **Table 7**. No special sampling considerations are required.

FIELD DUPLICATE

Grab sample and composite sample field duplicates shall be collected at the stations and events specified in **Table 7** immediately following collection of normal grab samples.

8.0 Project Evaluation and Data Sharing Plan

This section provides an overview of how the results of this control study will be used to develop the Control Study Final Report and how Control Study data will be shared.

> ***Guidance Document Requirement***
>
> *Describe the information that will be gathered and how it will be used to evaluate the effectiveness of the management practices or actions.*

Evaluation Plan

The efforts outlined in this Control Study Workplan will be presented in the Control Study Progress Report, which is due October 2015. The results presented in the progress report will help to determine if any modifications to sample collection methods or data analysis are necessary for completion of the study. The progress report will provide an initial assessment of study progress (including a qualitative discussion of detention basin effectiveness); however, a thorough statistical evaluation will not be presented until the Control Study Final Report. The schedule for Control Study implementation is presented in **Table 8**.

Table 8. Control Study Schedule

Task	Estimated Completion
Submit Control Study Work Plan to Regional Board	April 19, 2013
Regional Board and TAC Work Plan Review	May-July 2013
Finalize Work Plan	August-September 2013
Initiate Control Study Sampling	October 2013
• First Year Monitoring	• October 2013 – September 2014
• Second Year Monitoring	• October 2014 – September 2015
• Third Year Monitoring	• October 2015 – September 2016
Submit Control Study Progress Report	October 2015
Regional Board and TAC Progress Report Review	November 2015-January 2016
Complete Control Study Sampling	September 2016
Submit Control Study Final Report to Regional Board	October 2018

The evaluation of the information collected during this Control Study and presented in the Control Study Final Report will include, but will not be limited to, the following:

- The City and County will evaluate the effectiveness of the Airport Business Center Basin in reducing methylmercury in its discharge.
- The City and County will evaluate the feasibility of potential alterations to Basin operations and/or design if removal is not sufficient. In combination, the City and County will evaluate whether alterations to the Basin would achieve compliance with the TMDL load allocations, and estimate the cost needed to alter the Basin operations to improve removal performance to meet load allocations;

- The City and County will identify potential environmental impacts of the control method; and
- The City and County will evaluate the overall feasibility of implementing the control method to comply with the load allocations.

The Control Study Final Report will identify recommendations, if appropriate, to modify detention basin design to improve and/or maintain mercury and methylmercury reductions. The study may also help the City and County determine how operations and management of detention basins affect mercury and methylmercury effectiveness.

Data Sharing Plan

Study results will be presented in the Control Study Final Report. Data from the study will be compiled in a format compatible with the California Data Exchange Network (CEDEN). Reporting procedures will be adjusted, as needed, if a common process for reporting and sharing data is identified by Regional Board staff. It is expected that the Control Study Results will potentially confirm and build upon findings regarding the effectiveness of detention basins based on data collected in the Sacramento-area, and therefore should be relevant to other Central Valley dischargers.

References

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Attachment A: TAC Comments and Responses to Comments – Preliminary Concept Proposal

City of Stockton and County of San Joaquin Methylmercury Control Study
Response to TAC Comments

No.	Comment	Response
OVERVIEW		
1	A more detailed description of possible Hg methylation, adsorption, and degradation in the detention basins is needed so as to better inform the study design as the current approach presumes sedimentation as the primary removal of Hg thereby limiting MeHg production.	A limited additional amount of information specific to detention basins was found, and added to Workplan text. If additional information is not available, this will be noted within the text.
2	Detention basins are presumed to reduce both total Hg and MeHg concentrations and no production or export of MeHg from the urbanized area is expected. They potentially overlook the underlying mechanism by which MeHg is produced and discharged into water bodies. Depending on its design, the detention basin could actually concentrate mercury in a methylating environment and possibly exacerbate the MeHg production.	The Workplan acknowledges that depending on design, detention basins could concentrate mercury in a methylating environment. Details on the design aspects (e.g., width to depth ratio) of the Charter Way Basin will be determined as an initial stage in the study.
3	Alternatively, reliance on “green infrastructure” urban planning that reduces urban runoff rates and transport through the use of pervious pavement, grass swales, and other bioremeditation type structures may be more fruitful towards reduction of MeHg formation and transport (from Monitoring and Data Collection Plan section).	Comment noted: at this time, it is preferable to monitor a dry detention basin until a monitorable green infrastructure BMP becomes available.
OBJECTIVES		
5	The study hypotheses….is overly general and fails to address the basic mechanisms affecting MeHg production and transport.	Hypothesis statement was modified.
MECHANISMS UNDERLYING THE STUDY		
6	Development of a high quality conceptual and numerical model of how detention basins in an urban or agricultural environment perform based on the results of recent peer reviewed science of MeHg in wetland environmental may be more useful towards developing detention basin control strategies (from Monitoring and Data Collection Plan section).	Comment noted: this will be a more fruitful task once there is a body of knowledge regarding detention basins and MeHg. Will note that this is as a "Future Area of Research" for others to potentially take on in the future.
7	There is evidence to suggest that detention basins with limited open water and frequent wetting and drying will be problematic in contrast to deep open-water basins with little shallow edge that wets and dries could serve as a demethylation environment.	The Workplan acknowledges this possibility.
8	...The data gaps should be identified and a detailed description of how the proposed efforts will fill these data gaps should be presented.	The Workplan identifies the data gaps.
MONITORING AND DATA COLLECTION PLAN		
11	A simple input-output monitoring study of a detention basin designed for water quality…with limited grab sampling is unlikely to satisfactorily capture the possible MeHg production or export (from Overview section on slides).	The Workplan includes sampling via automated sampler that can sample over the course of a storm event in order to collect additional data.
12	A complete water/mass balance is needed on the detention basin as well as initial soil conditions in terms of adsorbed Hg.	Will conduct study in an interative fashion and may add in components in future years that seem fruitful based on first year results. A water balance may be added into study in 2nd year depending on 1st year results. Effort may include a limited desktop water/mass balance that estimates the inputs and outputs of detention basin.

No.	Comment	Response
13	Suggest that they also collect water pond samples, pond water depth as time of sampling and detail the sampling frequency with respect to rainfall-runoff events.	Comment noted: Collecting pond samples during a rain event may present unsafe conditions for field crews. Will conduct study in an interative fashion and may add in components in future years that seem fruitful based on first year results. Permittees may investigate simple and inexpensive ways of estimating or documenting pond depth depending on 1st year results.
14	An integrated sampler should be used if continuous sampling is not possible during overflow events.	The Workplan proposes using an automated sampler that can sample over the course of a storm event.

Shading Key:

(green)	edit incorporated
(yellow)	some follow-up needed to see if implementing comment is feasible/easily done
(grey)	comment noted; may be appropriate for future area of research for others to take on in future

Attachment B: TAC Comments and Responses to Comments – Control Study Workplan (April 20, 2013)

City of Stockton and County of San Joaquin Methylmercury Control Study
Response to TAC Control Study Work Plan Review Comments

No.	Comment	Response	Addressed in Revised Workplan
RECOMMENDATIONS			
a.	Provide an inventory of other similar flood-control basins in the Delta regions to which results of this study may apply.	The City and County will provide detailed information on the ABC Basin, and will compile an inventory of available information on other detention basins operated by the City within the Stockton urbanized area. However, it is outside the scope of the City and County's study to compile information about detention basins throughout the Delta. The information provided on the ABC Basin will help other entities within the Delta to compare their detention basins with the ABC Basin with respect to basin design and operations.	No revision made.
b.	Develop all the design information and create a simple hydrologic model for the basin drainage area and run for various wet to dry water years to determine urban runoff capture potential and guide for sampling.	In switching to the ABC Basin, the City and County now have detailed information on detention basin design and operations. It is no longer necessary to create a hydrologic model for the basin drainage area in order to inform the initial Control Study sampling.	No revision made.
c.	Develop basin residence time – rainfall depth/intensity/duration relationship to help assess possible MeHg mechanism operations in basin.	Detailed design and operational information is available for the ABC Basin, which will be used in assessing the Control Study data.	No revision made.
d.	Consider developing study as evaluation of urban atmospheric deposition of MeHg or THg given near complete impermeable coverage of drainage area.	The wash-off fraction of Hg in urban runoff will be estimated using information available in the scientific literature.	p. 25
1 - PROBLEM STATEMENT			
1-1	The workplan outlines the urban areas of Stockton and San Joaquin County that contribute runoff to the Delta as well as identifying the MeHg load reductions desired for each entity. However, there is some confusion as to what this reduction is exactly. The last paragraph of page 2 explains how they performed calculations to determine the City's load reduction. Concluding sentence is not clear: "According to the City and County's calculations, a load reduction is needed in the San Joaquin River subarea." What does this mean? A reduction to what and from what? A comparison of Tables 1 and 2 suggest that the City of Stockton is to reduce loads by 74%.	Text modified to clarify that a reduction in methylmercury loading from the Stockton MS4 is needed in the San Joaquin River subarea.	p. 3
1-2	They note that the total WLAs are relatively small and that the urban areas contribute only a very small fraction of the total MeHg load to the Delta.	Comment noted.	No revision made.
2 - OBJECTIVES			
2-1	The study objective is straightfoward. . . though the hypothesis proposed is overly broad and not linked to particular mechanisms responsible for the MeHg retention by the basin	Hypothesis statement focuses on sedimentation as the primary mechanism for mercury removal in the basin.	p. 9
2-2	In terms of the control objective, the study results would presumably be applicable to other similar detention basins in the greater Sacramento region and should provide some insight into the relative performance of such basins vis-a-vis MeHg load reductions	Comment noted.	No revision made.

No.	Comment	Response	Addressed in Revised Workplan
2-3	The study would not, however, be broadly applicable or effective at advancing the control objective if this detention basin is not representative of most basins that exist or may be built. An inventory of basins and their characteristics (dimensions, hydrology, vegetation, etc.) in the Stockton or Delta region would help determine the applicability of this control study.	The City and County will provide detailed information on the ABC Basin, and will compile an inventory of available information on other detention basins operated by the City within the Stockton urbanized area. However, it is outside the scope of the City and County's study to compile information about detention basins throughout the Delta. The information provided on the ABC Basin will help other entities within the Delta to compare their detention basins with the ABC Basin with respect to basin design and operations.	No revision made.
3 - MECHANISMS UNDERLYING THE STUDY			
3-1	The workplan provides an overview of the likely mechanisms affecting MeHg retention/production in water basins based on both local studies and a reference from Minnesota indicating possible MeHg export with phosphorous from the basin. Three mechanisms are suggested to affect MeHg loading from the storage basin including, net volumetric reductions in urban runoff, Hg adsorption and settling as part of suspended and deposited sediment, possible MeHg production associated with sulfate in solution during anaerobic water column conditions and possible photo-demethylation in deep open basins.	Comment noted.	No revision made.
3-2	The first paragraph explaining detention basin mechanisms should explicitly state that mercury binds to sediment and that detention basins remove this mercury by removing these sediments. In a highly urban basin, how big are these sediments and how likely is a non-vegetated detention basin with a shore residence time likely to remove them.?	Text was revised accordingly.	p. 10
3-3	The project plan needs to separate the effects of volumetric flow reductions, methylation or volatilization related processes, and adsorption settling on final MeHg loads in the basin discharge. Possible surrogates for some of these parameters that may be of value include the basin hydraulic retention time (HRT) and daily redox conditions in the water column.	This would involve a complex effort in order to conduct a full contaminant evaluation, and may be considered in future study years if necessary, based on preliminary monitoring results.	No revision made.
3-4	Is there the possibility that monitoring of other divalent heavy metals may be of value as both wetland and column studies suggest that metals adsorption/retention might be similar (i.e. removal rates following an order of something similar to Sn>Cr>Cu>Pb>Zn>Fe ~ Hg)?	It would be possible to add additional metals to the analysis, but we do not understand how that additional monitoring would provide useful information to the study.	No revision made.
3-5	The general overview of the available local studies considering detention basin effects on MeHg retention/production is helpful towards indicating the relative dearth of information available. All of the studies had relatively few samples, and limited, if any information about the basin design capacities, depth of rain events resulting in discharge, HRTs, basin water depth at time of sampling/discharge etc. The proposed study of the Stockton Charter Way detention basin would certainly provide additional critical information needed to fill this data gap.	Comment noted.	No revision made.
3-6	This section should better emphasize that the design, operations, and hydrology of a detention basin are probably very important in determining whether a detention basin becomes a sink or source for MeHg.	Text was revised accordingly.	p. 10
3-7	More information on maintenance of basins and how these maintenance practices could alter fate and transport mechanisms would be useful.	Text was revised accordingly.	p. 10-11
4 - PROPOSED CONTROL MEASURES			

No.	Comment	Response	Addressed in Revised Workplan
4-1	The plan describes this project as a "targeted research" study directed at filling the data gap associated with MeHg removal/production by urban detention basins. As the Charter Way basin proposed for the study is a short retention time flood control basin, there may be limited broader applicability of the project results to basins designed for water quality control.	Comment noted.	No revision made.
4-2	The general overview of the available local studies considering detention basin effects on MeHg retention/production is helpful towards indicating the relative dearth of information available. All of the studies had relatively few samples, and limited, if any information about the basin design capacities, depth of rain events resulting in discharge, hydrologic residence times, basin water depth at time of sampling/discharge etc. The proposed study of the Stockton Charter Way detention basin could certainly provide additional critical information needed to fill this data gap.	Comment noted.	No revision made.
4-3	MeHg results of previous studies were all based on grab samples alone. Methylation is highly time dependent making grab samples less useful for accurately predicting efficacy for MeHg removal.	Comment noted.	No revision made.
4-4	After characterization of the Charter Way detention basin dimensions, volumetric capacity, infiltration rates and design storm, the workplan should consider developing a water balance for the 73-acre area and basin so as to help guide them in developing alternative infrastructure designs that improve the basin with respect to water quality control.	In switching to the ABC Basin, the City and County now have detailed information on detention basin design and operations, which could be used to inform potential detention basin improvements.	No revision made.
4-5	Based on Figure 4 indicating that nearly the entire 73-acre detention basin drainage area is impermeable as either rooftop or pavement, there exists the possibility that the basin inlet MeHg concentrations largely reflect atmospheric deposition processes and that given a variety of storms and antecedent moisture conditions that the study could capitalize on an opportunity to evaluate relative wash-off fractions of HgT and MeHg in urban runoff for the particular fractions and types of rooftop and pavement at the site.	The drainage area for the ABC Basin includes residential and undeveloped areas. The wash-off fraction of Hg in urban runoff will be estimated using information available in the scientific literature for the land use types in the drainage area.	p. 25
5 - MONITORING AND DATA COLLECTION PLAN			
5-1	The general sampling program and statistical analyses proposed are fairly adequate though it seems that the sampling frequency would be better advised by completion of water balance calculations and a simple hydrologic routing (travel time) modeling of the site. As noted above, in addition to gathering all the basic geometry and hydraulic characteristics of the basin, measurement of basin infiltration rates would be useful combined with determinations of HgT and MeHg concentrations in the sediment to complement those collected at the beginning of the study.	In switching to the ABC Basin, the City and County now have detailed information on detention basin design and operations. It is no longer necessary to create a hydrologic model for the basin drainage area in order to inform the initial Control Study sampling. The City has information on infiltration rates in the ABC Basin.	No revision made.
5-2	The discussion of performance, effectiveness and efficiency was relatively meaningless as are EMCs based on very limited sampling and uncertainty about the pdf's of the concentration data (i.e. whether normally distributed or not cannot be determined from only a handful of points).	While there are limited sampling events, EMCs are more useful for evaluating changes between influent and effluent than a comparison on an event to event basis, given the difference in timing between basin influent samples and discharge samples. We will provide a footnote in the Workplan to address this comment.	No revision made.

No.	Comment	Response	Addressed in Revised Workplan
5-3	In the statistical analyses, comparisons of inlet-outlet concentrations will depend on the residence times in the basin. The reference to "trends" (first sentence, 4th paragraph, p.24) is not clear, nor is the meaning of those trends relative to the project hypothesis.	The analysis is intended to determine if influent and effluent data are significantly different. The term "trends" was removed.	p. 25
5-4	Event-based monitoring, particularly with grab samples is problematic for MeHg, because methylation varies significantly with time and changing conditions. Sampling should consider: Provide more information on how these basins work. How long are these ponds discharging? Do they discharge after the event? What is the residence time? How often do they discharge and under what circumstances?	During the first year of sampling, composite samples for mercury can be taken and compared with grabs to determine if grabs are representative, and whether composite samples are clean from contamination. Operational information is available for the ABC Basin, and discharge timing is controlled by City staff. The Work Plan has been revised to include information about Basin operations.	p. 23
6 - QUALITY ASSURANCE PROCEDURES			
6-1	The QA/QC and related aspects of the workplan appear to be satisfactory.	Comment noted.	No revision made.
6-2	Section 6.0 states that "extensive data was collected regarding the effectiveness of detention basins in the Sacramento area." Extensive seems like an overstatement.	The sentence was revised accordingly.	p. 19
7 - PROJECT EVALUATION AND DATA SHARING PLAN			
7-1	As the workplan focuses only on a single flood-control detention basin of unknown design, there is a limited data/results sharing plan that should be accessible by the greater urban areas of the Sacramento region.	Comment noted.	No revision made.
7-2	If the study basins key characteristics (hydrology, dimensions, vegetation) are not representative of other basins, the study results could be of limited value.	Comment noted.	No revision made.
7-3	An inventory and analysis of the dimensions and characteristics of other basins could be useful both for determining the applicability of this study and the selection of other basins for study to broaden applicability. Perhaps study leaders could coordinate with the NPS workgroup which has plans to conduct studies at multiple managed wetlands of different dimensions, many of which are similar to detention basins	The City and County will provide detailed information on the ABC Basin, and will compile an inventory of available information on other detention basins operated by the City within the Stockton urbanized area. However, it is outside the scope of the City and County's study to compile information about detention basins throughout the Delta. The information provided on the ABC Basin will help other entities within the Delta to compare their detention basins with the ABC Basin with respect to basin design and operations.	No revision made.

Shading Key:

(green)	will incorporate edit
(yellow)	edit not incorporated; see notes for explanation
(white)	comment noted

Appendix B. Water Quality Monitoring Data

Tables B-1 – B-4 present composite data for both monitoring years.

Table B-1. Influent Composite Monitoring Data, 2013-2014

Event	SE1 [a]	SE2	SE3 [b]	DW1
Date	2/7-8/14	2/27/14		6/25/14
Time		11:15		15:15
Sample type		Composite [c]		Composite [e]
TDS (mg/L)		110		170
TSS (mg/L)		109		< 2 [f]
Turbidity (NTU)		38		2
SSC (mg/L)		117 [d]		< 2 [d, f]
Total Phosphorus (as P, mg/L)		0.41		0.12
Total Sulfate (as SO4, mg/L)		14		16
Total Iron (mg/L)		4.9		0.11
Mercury, total (µg/L)				0.0013
Methylmercury, total (ng/L)				0.046 [j]
Methylmercury, dissolved (ng/L)				< 0.020 [f]

[a] = No composite samples were collected as composite samplers failed to initiate sampling program.
[b] = Not captured, storms not predicted with sufficient notice.
[c] = Lab composite sample of Pock (INF-1) and IND (INF-2). PARK (INF-3) not included in composite due to insufficient sample in autosampler.
[d] = This analysis is not covered under Caltest's NELAP/CAL-ELAP Accreditations.
[e] = Lab composite sample of POCK (INF-1), IND (INF-2) and PARK (INF-3)
[f] = Not detected, Analyte not detected at or above the listed Method Detection Limits (MDL).
[j] = Estimated value. Analyte detected at a level less than the Reporting Limit (RL) and greater than or equal to the Method Detection Limit (MDL). The user of this data should be aware that this data is of limited reliability; or estimated due to RPD failure.

Table B-2. Effluent Composite Monitoring Data, 2013-2014

Event	SE1 [a]	SE2	SE3 [b]	DW1
Date	2/8/14	2/27/14		6/25/14
Time	11:20	10:50		15:45
Sample type	Grab	Composite [c]		Composite
TDS (mg/L)		22		150
TSS (mg/L)		45		< 2 [e]
Turbidity (NTU)		35		3
SSC (mg/L)		50 [d]		< 2 [d]
Total Phosphorus (as P, mg/L)		0.24		0.17
Total Sulfate (as SO4, mg/L)		2.7		13
Total Iron (mg/L)		2.1		0.25
Mercury, total (µg/L)	0.0059	0.0064		0.0015
Methylmercury, total (ng/L)	0.07	0.1		0.06
Methylmercury, dissolved (ng/L)	< 0.020 [e]	0.06		0.03 [j]

[a] = No composite samples were collected as composite samplers failed to initiate sampling program.
[b] = Not captured, storms not predicted with sufficient notice.
[c] = LJ-80(EFF) = composite sample from autosampler.
[d] = This analysis is not covered under Caltest's NELAP/CAL-ELAP Accreditations.
[e] = Not detected, Analyte not detected at or above the listed Method Detection Limits (MDL).
[j] = Estimated value. Analyte detected at a level less than the Reporting Limit (RL) and greater than or equal to the Method Detection Limit (MDL). The user of this data should be aware that this data is of limited reliability; or estimated due to RPD failure.

Table B-3. Influent Composite Monitoring Data, 2014-2015

Event	SE1 [a]	SE2	SE3	DW1 [b]
Date	11/1/14	12/12/14	2/6/2015	
Time	9:49	10:00	19:40	
Sample type	Composite	Composite	Composite	
TDS (mg/L)		33	47	
TSS (mg/L)		38	35	
Turbidity (NTU)		37	33	
SSC (mg/L)	141			
Total Phosphorus (as P, mg/L)		0.14	0.16	
Total Sulfate (as SO4, mg/L)		2.0	4.0	
Total Iron (mg/L)		1.9	1.5	
Mercury, total (µg/L)				
Methylmercury, total (ng/L)				
Methylmercury, dissolved (ng/L)				

[a] = Lab composite sample of IND (INF-2) and PARK (INF-3). POCK (INF-1) failed to initiate sampling program.
[b] = Composite samples were not collected from inlet locations. Insufficient flow at Pock (INF-1) and Industrial (INF-2) inlets. Sampler at Parkside (INF-3) failed to initiate sampling.

Table B-4. Effluent Composite Monitoring Data, 2014-2015

Event	SE1 [a]	SE2 [f]	SE3 [e]	DW1
Date	11/1/14	12/12/14	2/6/2015	6/8/15
Time	10:25	9:00	18:30	8:30
Sample type	Composite	Composite	Grab/Composite	Composite
TDS (mg/L)	77	44	49 [c]	330
TSS (mg/L)	51	42	73 [c]	23
Turbidity (NTU)	45	37	45 [c]	7.1
SSC (mg/L)	34	46	36 [g]	25 [d]
Total Phosphorus (as P, mg/L)	0.44	0.18	0.22 [c]	0.63
Total Sulfate (as SO4, mg/L)	6.0	1.6	3.7 [c]	270
Total Iron (mg/L)	2.5	2.0	2.5 [c]	0.75
Mercury, total (µg/L)	0.010	0.0047	0.0048 [g]	0.0024
Methylmercury, total (ng/L)	0.09	0.07	0.06 [g]	0.08
Methylmercury, dissolved (ng/L)	< 0.020 [b]	0.020 [j]	0.03 [j, g]	< 0.020 [b]

[a] = Quality Control listed as laboratory duplicate for all event samples.
[b] = Not detected, Analyte not detected at or above the listed Method Detection Limits (MDL).
[c] = Sample collected from composite sampler during device removal.
[d] = This analysis is not covered under Caltest's NELAP/CAL-ELAP Accreditations.
[e] = Sampled during two separate field visits. Grab samples collected 2/6/15 at 18:30. Composite samples collected 2/9/15 at 10:08. Composite samples collected during composite sampler removal.
[f] = Quality Control listed as field duplicate for all event samples.
[g] = Grab sample.
[j] = Estimated value. Analyte detected at a level less than the Reporting Limit (RL) and greater than or equal to the Method Detection Limit (MDL). The user of this data should be aware that this data is of limited reliability; or estimated due to RPD failure.

Tables B-5 – B-9 present wet weather grab data from for both monitoring years.

Table B-5. Event SE1 (2/8/14) Grab Data

Location	POCK (INF-1)	IND (INF-2)	PARK (INF-3)	Outlet
Time	11:45	12:15	12:30	11:20
Dissolved Oxygen (mg/L) [b]	10.10	10.80	10.27	12.31
pH [b]	7.08	7.39	7.36	6.85
EC (μS/cm) [b]	63	85	48	58
Temperature (°C) [b]	12.28	12.47	12.29	11.99
Mercury, total (μg/L)	0.0032	0.0047	0.0015	0.0059
Methylmercury, total (ng/L)	0.04 [j]	0.05 [j]	0.04 [j]	0.07
Methylmercury, dissolved (ng/L)	< 0.020 [a]	< 0.020 [a]	< 0.020 [a]	< 0.020 [a]

[a] = Not detected, Analyte not detected at or above the listed Method Detection Limits (MDL).
[b] = Field result.
[j] = Estimated value. Analyte detected at a level less than the Reporting Limit (RL) and greater than or equal to the Method Detection Limit (MDL). The user of this data should be aware that this data is of limited reliability; or estimated due to RPD failure.

Table B-6. Event SE2 (2/26/14) Grab Data

Location	POCK (INF-1)	IND (INF-2)	PARK (INF-3)	Outlet
Time	21:54	22:20	22:45	21:15
Dissolved Oxygen (mg/L) [b]	8.59	8.77	8.95	9.04
pH [b]	6.98	7.24	7.91	7.36
EC (μS/cm) [b]	109	61	58	13
Temperature (°C) [b]	14.57	13.86	13.80	14.22
Mercury, total (μg/L)	0.018 [a]	0.015 [a]	0.0096 [a]	0.020 [a]
Methylmercury, total (ng/L)	0.16	0.19	0.14	0.16
Methylmercury, dissolved (ng/L)	0.02 [j]	0.04 [j]	0.04 [j]	0.04 [j]

[a] = Fraction denoted as "Trace" not "Total" on laboratory report.
[b] = Field result
[j] = Estimated value. Analyte detected at a level less than the Reporting Limit (RL) and greater than or equal to the Method Detection Limit (MDL). The user of this data should be aware that this data is of limited reliability; or estimated due to RPD failure.

Table B-7. Event SE4 (10/31/14) Grab Data, Influent and Effluent

Event	POCK (INF-1)	IND (INF-2)	PARK (INF-3)	Outlet
Time	19:15	19:59	20:30	18:45
Dissolved Oxygen (mg/L) [b]	8.55	8.73	8.37	8.55
pH [b]	7.83	7.82	7.97	7.71
EC (μS/cm) [b]	81	142	59	71
Temperature (°C) [b]	17.67	17.26	17.04	17.09
SSC (mg/L)	170	15	20	156
Mercury, total (μg/L)	0.0089	0.0091	0.0060	0.010
Methylmercury, total (ng/L)	0.09	0.09	0.07	0.08
Methylmercury, dissolved (ng/L)	0.02 [j]	0.047 [j]	0.03 [j]	0.02 [j]

[b] = Field result.
[j] = Estimated value. Analyte detected at a level less than the Reporting Limit (RL) and greater than or equal to the Method Detection Limit (MDL). The user of this data should be aware that this data is of limited reliability; or estimated due to RPD failure.

Table B-8. Event SE5 (12/11/14) Grab Data, Influent and Effluent

Event	POCK (INF-1)	IND (INF-2)	PARK (INF-3)	Outlet
Time	14:45	15:10	15:18	14:30
Dissolved Oxygen (mg/L) [b]	9.85	8.79	8.48	8.83
pH [b]	8.24	8.18	8.18	7.81
EC (µS/cm) [b]	48	81	31	139
Temperature (°C) [b]	14.90	14.52	14.75	15.02
SSC (mg/L)	56	30	20	69
Mercury, total (µg/L)	0.0068	0.0048	0.0028	0.0062
Methylmercury, total (ng/L)	0.07	0.05	0.07	0.049 [j]
Methylmercury, dissolved (ng/L)	< 0.020 [a]	0.02 [j]	0.02 [j]	< 0.020 [a]

[a] = Not detected, Analyte not detected at or above the listed Method Detection Limits (MDL).
[b] = Field result.
[j] = Estimated value. Analyte detected at a level less than the Reporting Limit (RL) and greater than or equal to the Method Detection Limit (MDL). The user of this data should be aware that this data is of limited reliability; or estimated due to RPD failure.

Table B-9. Event SE6 (2/6/15) Grab Data, Influent and Effluent

Event	POCK (INF-1)	IND (INF-2)	PARK (INF-3)	Outlet
Time	18:45	19:15	19:40	18:30
Dissolved Oxygen (mg/L) [b]	9.33	9.22	8.79	11.07
pH [b]	7.43	7.60	7.51	7.85
EC (µS/cm) [b]	163	135	68	266
Temperature (°C) [b]	15.84	15.38	15.49	14.63
SSC (mg/L)	473	148	67	36
Mercury, total (µg/L)	0.048	0.021	0.0088	0.0048
Methylmercury, total (ng/L)	0.29	0.27	0.12	0.06
Methylmercury, dissolved (ng/L)	< 0.020 [a]	0.02 [j]	< 0.020 [a]	0.03 [j]

[a] = Not detected, Analyte not detected at or above the listed Method Detection Limits (MDL).
[b] = Field result.
[j] = Estimated value. Analyte detected at a level less than the Reporting Limit (RL) and greater than or equal to the Method Detection Limit (MDL). The user of this data should be aware that this data is of limited reliability; or estimated due to RPD failure.

Appendix C. Quality Assurance/Quality Control Data

Table C-1. Equipment Blank Results

Date	Event	Site Code	Type	Mercury, total (µg/L)			Methylmercury, total (ng/L)			Methylmercury, dissolved (ng/L)		
				EB	RL	Env	EB	RL	Env	EB	RL	Env
2/7-8/14	SE1	POCK (INF-1)	Grab	J0.0003	0.0005	0.0032	<0.02	0.05		<0.02	0.05	<0.02
		Effluent	Grab	--	--	0.0059	--	--	0.07	--	--	<0.02
2/26/14	SE2	POCK (INF-1)	Grab	J0.0004	0.0005	0.018	<0.02	0.05	0.16	<0.02	0.05	0.02
		Effluent	Comp	--	--	0.0064	--	--	0.1	--	--	0.06
			Grab	--	--	0.02	--	--	0.16	--	--	0.04

EB = Equipment Blank
Env = Environmental Sample
J = Estimated Value. Analyte detected at a level less than the RL and greater than or equal to the MDL.

Table C-2. Field Blank Results

Date	Event	Site Code	Type	Mercury, total (µg/L)			Methylmercury, total (ng/L)			Methylmercury, dissolved (ng/L)
				FB	RL	Env	FB	RL	Env	Env
2/7-8/14	SE1	POCK (INF-1)	Grab	<0.0002	0.0005	0.0032	J0.04	0.05		<0.02
		Effluent	Grab	--	--	0.0059	--	--	0.07	<0.02
2/26/14	SE2	POCK (INF-1)	Grab	<0.0002	0.0005	0.018	--	--	--	--
		Effluent	Comp	--	--	0.0064	--	--	--	--
			Grab	--	--	0.02	--	--		--
10/31/14	SE4	POCK (INF-1)	Grab	--	--	0.0089	--	--	--	--
		IND (INF-2)	Grab	<0.0002	0.0005	0.0091	--	--	--	--
		PARK (INF-3)	Grab	<0.0002	0.0005	0.006	--	--	--	--
		Effluent	Comp	--	--	0.01	--	--	--	--
			Grab	--	--	0.01	--	--	--	--
12/11/14	SE5	POCK (INF-1)	Grab	<0.0002	0.0005	0.0068	--	--	--	--
		IND (INF-2)	Grab	<0.0002	0.0005	0.0048	--	--	--	--
		PARK (INF-3)	Grab	<0.0002	0.0005	0.0028	--	--	--	--
		Effluent	Comp	--	--	0.0047	--	--	--	--
			Grab	--	--	0.0064	--	--	--	--

FB = Field Blank
Env = Environmental Sample
J = Estimated Value. Analyte detected at a level less than the RL and greater than or equal to the MDL.

Table C-3. Matrix Spikes/Matrix Spike Duplicates

Date	Event	Site Code	Type	Mercury, total (µg/L) MS	Mercury, total (µg/L) MSD	Methylmercury, total (ng/L) MS	Methylmercury, total (ng/L) MSD	Total Iron (mg/L) MS	Total Iron (mg/L) MSD
12/11/14	SE5	Effluent	Grab	0.029	0.029	--	--	--	--
2/6/2015	SE6	Effluent	Grab	0.024	0.024	1.3	1.3	--	--
				0.024	0.024	1.2	1.3	--	--
6/8/2015	DW2	POCK (INF-1)	Solid	49.6	55.9	--	--	--	--
		Effluent	Comp	--	--	--	--	11.3	11.6

MS = Matrix Spike
MSD = Matrix Spike Duplicate

Table C-4. Lab Duplicate Results

	Date	2/26/14		10/31/14		12/11/14	
	Event	SE2		SE4		SE5	
	Site Code	Effluent		Effluent		Effluent	
	Type	Comp	Grab	Comp	Grab	Comp	Grab
Mercury, total (µg/L)	LD	0.007	0.02	0.01	--	0.0043	--
	Env	0.0064	0.02	0.01	0.01	0.0047	0.0064
	RPD	9.0	0	0	0	8.9	39.3
Methylmercury, total (ng/L)	LD	0.07	0.16	0.09	--	0.047	--
	Env	0.1	0.16	0.09	0.08	0.07	0.08
	RPD	35.3	0	0	11.8	39.3	52.0
Methylmercury, dissolved (ng/L)	LD	<0.02	<0.02	0.03	--	<0.02	--
	Env	0.06	0.04	<0.02	0.02	0.02	0.02
	RPD	100	66.7	40	40	0	0
Total Iron (mg/L)	LD	2	--	2.6	--	1.8	--
	Env	2.1	--	2.5	--	2	--
	RPD	4.9	--	3.9	--	10.5	--
Total Sulfate (as SO4, mg/L)	LD	3	--	6	--	1.6	--
	Env	2.7	--	6	--	1.6	--
	RPD	10.5	--	0	--	0	--
TDS (mg/L)	LD	22	--	73	--	42	--
	Env	22	--	77	--	44	--
	RPD	0	--	5.3	--	4.7	--
Total Phosphorus (as P, mg/L)	LD	0.22	--	0.46	--	0.15	--
	Env	0.24	--	0.44	--	0.18	--
	RPD	8.7	--	4.4	--	18.2	--
TSS (mg/L)	LD	97	--	53	--	26	--
	Env	45	--	51	--	42	--
	RPD	73.2	--	3.8	--	47.1	--
Turbidity (NTU)	LD	36	--	50	--	38	--
	Env	35	--	45	--	37	--
	RPD	2.8	--	10.5	--	2.7	--
SSC (mg/L)	LD	--	--	68	--	44	--
	Env	--	--	34	156	46	66
	RPD	--	--	66.7	78.6	4.4	40

LD = Lab Duplicate
Env = Environmental Sample
RPD = Relative Percent Difference

Table C-5. Field Duplicate Results

	Date	2/7-8/14	2/26/14	6/25/14	10/31/14			12/11/14		2/6/15	6/8/15	
	Event	SE1	SE2	DW1	SE4			SE5		SE6	DW2	
	Site Code	Effluent	Effluent	POCK (INF-1)	POCK (INF-1)	Effluent		Effluent		IND (INF-2)	IND (INF-2)	Effluent
	Type	Grab	Grab	Solid	Grab	Comp	Grab	Comp	Grab	Grab	Solid	Comp
Mercury, total (µg/L)	FD	0.0051	0.022	59	<0.0002	--	0.011	--	0.0062	0.024	44	--
	Env	0.0059	0.02	56	0.0089	0.01	0.01	0.0047	0.0064	0.021	45	--
	RPD	14.5	9.5	5.2	191.2	9.5	9.5	27.5	3.2	13.3	2.2	--
Methylmercury, total (ng/L)	FD	0.04	0.14	0.07	--	--	0.09	--	0.049	0.25	0.08	--
	Env	0.07	0.16	0.06	--	0.09	0.08	0.07	0.08	0.27	0.06	--
	RPD	54.5	13.3	15.4	--	0	11.8	35.3	48.1	7.7	28.6	--
Methylmercury, dissolved (ng/L)	FD	<0.02	0.02	--	--	--	<0.02	--	<0.02	<0.02	--	--
	Env	<0.02	0.04	--	--	<0.02	0.02	0.02	0.02	0.02	--	--
	RPD	0	66.7	--	--	0	0	0	0	0	--	--
TDS (mg/L)	DUP	--	--	--	--	--	--	--	--	--	--	330
	Env	--	--	--	--	--	--	--	--	--	--	330
	RPD	--	--	--	--	--	--	--	--	--	--	0
SSC (mg/L)	FD	--	--	--	--	--	111	--	69	205	--	--
	Env	--	--	--	--	34	156	46	66	148	--	--
	RPD	--	--	--	--	106.2	33.7	40.0	4.4	32.3	--	--

FD = Field Duplicate
Env = Environmental Sample
RPD = Relative Percent Difference