APPENDIX A

BMP SITE RANKING ANALYSIS APPROACH

Ms. Cassandra Owens
Regional Water Quality Control Board
Los Angeles Region
320 West 4th St., Ste. 200
Los Angeles, CA 90013

June 22, 2011

Subject: SSFL Watershed 008 and 009 BMP Site Ranking Analysis Approach
The Boeing Company, Santa Susana Field Laboratory, Canoga Park, California
(Order No. R4-2010-0090; NPDES No. CA0001309, CI No. 6027)

Dear Ms. Owens:

The Santa Susana Field Laboratory (SSFL) Stormwater Expert Panel (Panel) was tasked by The Boeing Company (Boeing) and the Los Angeles Regional Water Quality Control Board (LARWQCB) with evaluating sites within the SSFL Outfall 008 and 009 watersheds for potential implementation of new Best Management Practices (BMPs)[1]. These BMPs may include source controls (such as removal of impacted surface soils), erosion and sediment controls (such as straw wattle and hydromulch, and instream measure such as bank stabilization and check dams), and/or treatment controls (such as sediment basins, media filters, and biofilters). The purpose of any new proposed BMPs would be to improve National Pollutant Discharge Elimination System (NPDES) permit (Order No. R4-2010-0090) compliance at Outfalls 008 and 009.

The purpose of this letter is to briefly summarize the Panel's proposed approach for ranking and selecting locations in these watersheds for new BMP implementation. This summary letter will be followed by the July Annual ISRA/BMP Report, which will include a detailed technical appendix that describes the BMP site ranking analysis methodology and results (i.e., recommended sites for new BMP implementation). This submittal follows the October 2010 BMP Plan for the Outfall 008 and 009 Watersheds (MWH et al, 2010a) and the December 2010 BMP and ISRA Performance Monitoring Sampling and Analysis Plan (MWH et al, 2010b). The December plan includes the Panel's and Geosyntec's BMP subarea monitoring recommendations, which resulted in new monitoring locations that were sampled during the 2010/11 wet season to provide stormwater quality data for use in this analysis.

[1] This is based on a requirement contained in the 2010 SSFL NPDES permit (Order No. R4-2010-0090), which states, "With input from the Expert Panel, the Discharger shall submit a workplan that describes and prioritizes BMPs, including measurable milestones and implementing Interim Source Removal Action (ISRA) and Engineered Natural Treatment Systems (ENTS) that will resolve exceedances from Outfalls 008 and 009. This workplan will describe the siting and phasing of BMPs."

Description of Proposed BMP Site Ranking Analysis Approach

The BMP site ranking analysis approach described here represents the final and most refined of several generations of alternative approaches that were iteratively developed and tested by the Panel and Geosyntec for the prioritization of potential BMP sites. This approach is based on the guiding principle that *only subareas that discharge stormwater runoff with NPDES pollutant of concern (POC) concentrations above NPDES permit limits and above site-specific background levels (when normalized to Total Suspended Solids [TSS])*[2] *should require additional water quality mitigation*. Furthermore, because stormwater quality is inherently variable, the Panel feels that the statistical approach should consider the number of samples (which reflects data uncertainty) as well as the percent of samples above these thresholds when ranking sites for new BMP needs. As a result of these overarching principles, the Panel's specific BMP site ranking analysis approach follows these basic steps:

1. Compare potential BMP subarea[3] monitoring results with site-specific stormwater background[4] data and NPDES permit limits;
2. Determine pollutant-specific "weighting factors" for each potential BMP subarea monitoring site based on this comparison (using a statistical methodology that accounts for sample size and number of results that are above both of these thresholds), with the highest weighting factors assigned to sites that most frequently exceed both of these thresholds;
3. Determine multi-pollutant ranking "scores" for each site based on the pollutant-specific weighting factors; and
4. Rank the potential BMP subarea monitoring sites based on these multi-pollutant ranking scores.

Once potential BMP subarea monitoring sites are ranked based on the above data analysis approach, specific BMP recommendations are developed for the highest scoring sites based on their monitoring results (e.g., effective treatment controls are developed if sites are scored high for metals and/or dioxins, or effective erosion and sediment controls are developed if sites are ranked high for TSS). Then during subsequent years, until the end of the BMP Plan coverage period, the analysis is repeated annually using monitoring data from the previous wet season to determine if any new sites should be added for BMP implementation.

[2] This principle follows previous SSFL stormwater background studies provided by the Expert Panel (SSFL Stormwater Expert Panel, 2010; SSFL Stormwater Expert Panel, 2009), and this particulate strength approach – or the normalizing of particulate phase pollutant concentrations to TSS (or pollutant particulate mass per mass of TSS) – is consistent with methods used in these reports.

[3] "Potential BMP subarea monitoring locations" are defined here as roughly 2 to 25 acre drainages areas with an outlet location for stormwater runoff sampling, and including land uses that include ISRA, RCRA Facility Investigation (RFI), and/or developed areas (i.e., roof or pavement) so that impacted runoff quality might be expected and/or treatment BMPs might be necessary, pending an evaluation of the monitoring results.

[4] "Stormwater background monitoring locations" are defined here as locations in these watersheds that represent stormwater runoff from unimpacted areas, or areas that do not include ISRA, RFI, or significant development, thereby representing site-specific background (or reference) stormwater quality.

A flow chart illustrating this general stepwise process is included as Attachment 1. The Outfall 008 and 009 watershed monitoring locations used for this BMP evaluation are shown in the map that is included as Attachment 2. For additional information on the selection of these potential BMP subarea and stormwater background monitoring locations, see the December 16, 2010 sampling recommendations memo from the Panel and Geosyntec (Geosyntec, 2010).

Consistency with the October 2010 BMP Plan and Panel's Previous White Papers

This final recommended BMP site ranking analysis approach was developed to be consistent with the Panel's general approach as described in the October 2010 BMP Plan (Preamble and Rationale section):

> "[…] the Expert Panel's primary recommendation is to target treatment systems to areas where either existing data and/or new data generated as part of this plan indicate that treatment may be required. This will be accomplished via review of existing outfall data, recently collected ISRA stormwater data, and other available data along with conducting additional subarea runoff sampling at potential BMP/ENTS locations within the Outfalls 008 and 009 watersheds to identify where treatment may be appropriate. *It is the Panel's recommendation that stormwater treatment controls be sited at those subareas where runoff concentrations are found to be above levels, to be established, that will be selected to differentiate between anthropogenic and natural sources. This recommendation will be made based on review and consideration of the Dioxins and Metals Reports that were prepared to identify stormwater concentrations that are indicative of anthropogenic or natural sources.* In the Expert Panel's opinion, exceedances of NPDES effluent limits at the outfalls will likely persist due to the presence of some pollutants (mostly metals and dioxins) within natural soils that enter the drainages through erosion and runoff processes, and because treatment systems cannot be permitted and built to capture the volumes and/or flow rates for all storms. However under the approach outlined in this BMP Plan, effective stormwater treatment controls will be implemented where appropriate (i.e., at locations where runoff concentrations are observed to be above stormwater concentrations that are indicative of natural sources), stormwater quality has and will continue to be improved via the source controls summarized above, and environmental impacts with construction of unnecessary treatment systems will be avoided."

Furthermore, this analysis approach builds upon the Panel's treatment control selection criteria from pages 3-3 and 3-4 of the October 2010 BMP Plan:

> "Treatment control BMPs will be selected in coordination with the Expert Panel as follows: (1) identify potential locations/subareas for treatment control implementation, including review of available water quality data, (2) monitor sub-area runoff from these areas, (3) assess subarea runoff water quality for need for treatment, (4) select potential BMPs, (5) evaluate hydrologic BMP Plan parameters as an input for flows for the BMP selection and sizing process, (6) evaluate constraints related to implementation of a BMP, such as available footprint, (7) design and implement treatment controls, and (8) monitor treatment control performance and design enhancements if increased performance is needed.
>
> "The following criteria will be used:
>
> - Implement treatment controls at potential BMP opportunity sites (i.e., where elevated concentrations in runoff is present) that are downstream of RFI and developed areas.

- Select and size treatment controls using methods similar to those employed previously for ENTS project and as described in previous Expert Panel reports (e.g., ENTS Alternatives Analysis, ENTS Hydrology Report, Design Storm White Paper, etc.).
- Select treatment controls that are suitable given unit processes that address the pollutant types and forms as identified in the subarea monitoring and data analysis results and the site conditions as listed below."

Results of BMP Site Ranking Analysis

As a result of the application of this BMP site ranking analysis approach, several new sites have been prioritized for BMP placement in the 008 and/or 009 watersheds. The prioritized sites will be evaluated for suitable and effective BMP alternatives, will be assessed for implementation feasibility, and will be summarized in the July report, along with their basis for selection. It is anticipated that as additional monitoring data is collected during future rain seasons, additional sites may be identified and recommended for BMP implementation during the annual evaluation.

Although this analysis focuses on the identification of sites that may require new treatment controls, the Panel continues to strongly recommend the rigorous application of erosion and sediment control practices and stream channel stabilization measures throughout the 008 and 009 watersheds. The Panel also continues to recommend the stabilization of roadways and the implementation of source controls, including source removal, such as through the successful ongoing ISRA program.

If you have any questions or comments on this proposed approach, please do not hesitate to contact us or Brandon Steets of Geosyntec. As noted previously, additional detail on the proposed BMP ranking analysis methodology will be provided in the ISRA/BMP Annual Report submittal in late July.

Sincerely,

Michael K Stenstrom

The Santa Susana Storm Water Expert Panel
Robert Gearheart, PhD, PE
Jonathan Jones, DWRE, PE
Michael Josselyn, PhD
Robert Pitt, PhD, PE
Michael Stenstrom, PhD, PE

Attachments:

1 - Summary Flow Chart for BMP Site Ranking Analysis Approach

2 - Locations used in BMP Site Ranking Analysis, Outfall 008/009 Watersheds

References:

Geosyntec Consultants, 2010. *BMP Subarea Sampling Recommendations for 008/009 BMP Work Plan*. December 16.

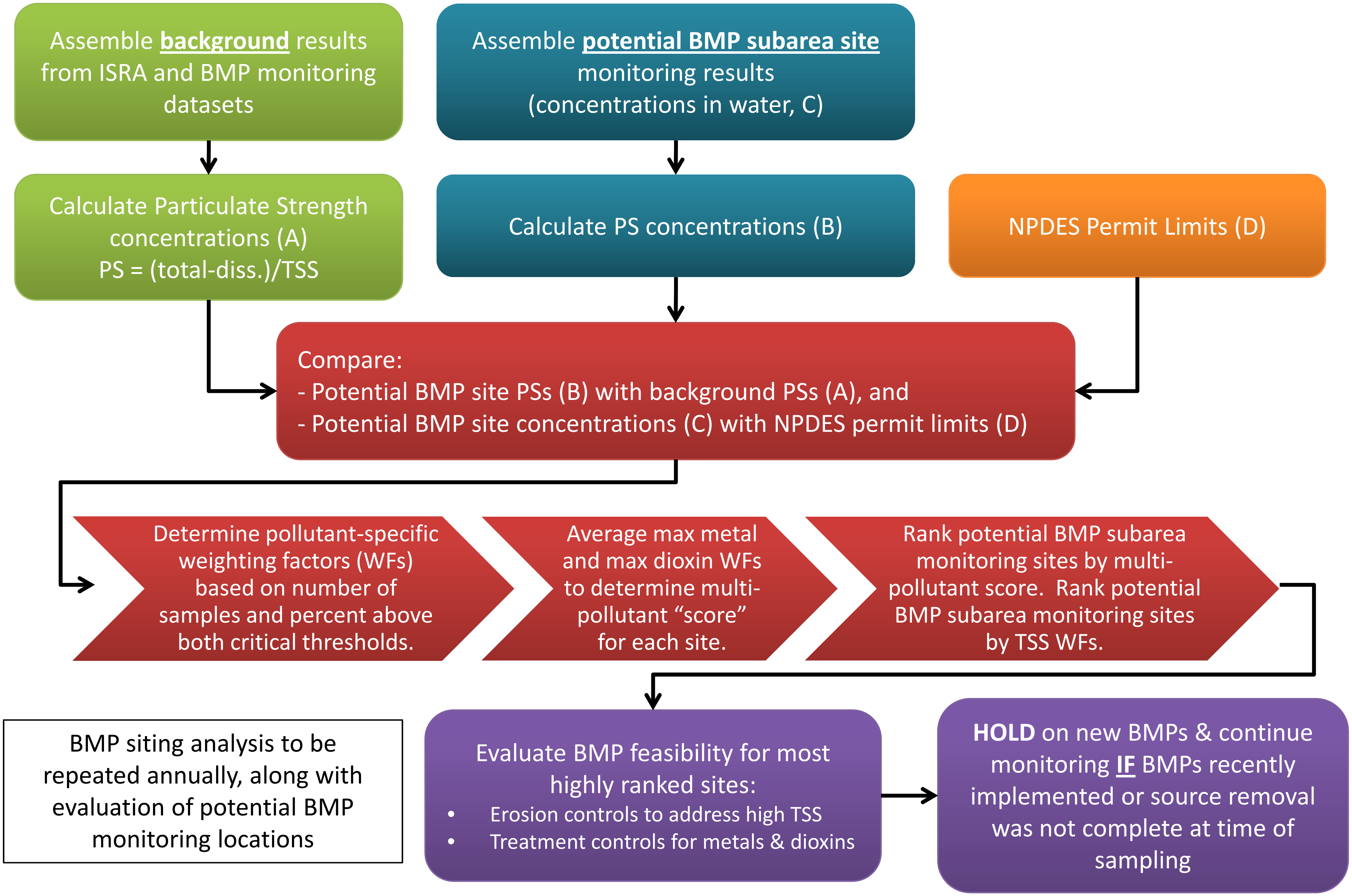
MWH et al, 2010a. *Best Management Practices (BMP) Plan – Outfalls 008 and 009 Watersheds.* Santa Susana Field Laboratory, Ventura County, California. October. http://www.boeing.com/aboutus/environment/santa_susana/water_quality/isra_10-10-19_BMPPlanOF008and009Watersheds.pdf

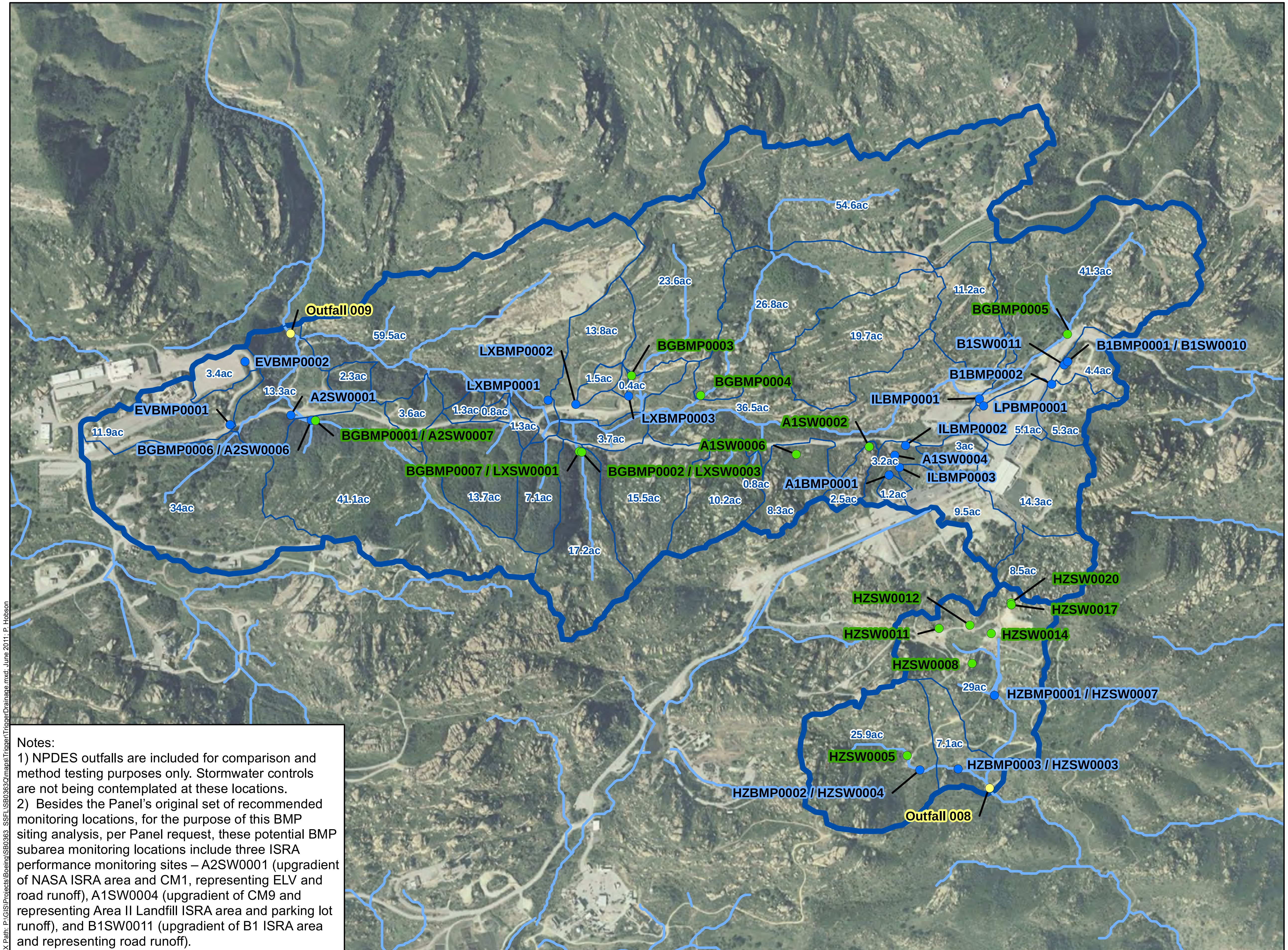
MWH, 2010b. *2010-2011 Best Management practices (BMP) and Interim Source removal Action (ISRA) Performance Monitoring Sampling and Analysis Plan for the 008/009 Watersheds*. December 21. http://www.boeing.com/aboutus/environment/santa_susana/water_quality/isra_101221_110693_BMPnISRA_PerfMntgPlan.pdf

SSFL Stormwater Expert Panel, 2010. *SSFL Stormwater Background Dioxin Report*. March 30. http://www.boeing.com/aboutus/environment/santa_susana/water_quality/tech_reports_100427_dioxins_background_report.pdf

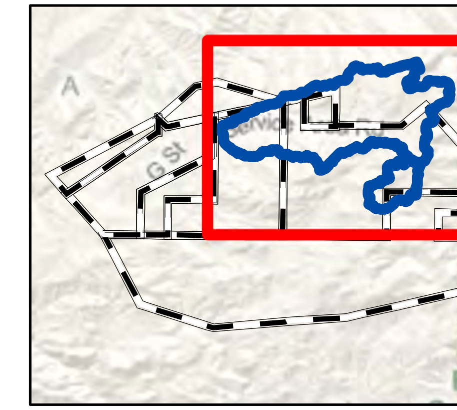
SSFL Stormwater Expert Panel, 2009. *Boeing SSFL Metals Background Report. Sources of Metals in SSFL Watersheds.* November 21. http://www.boeing.com/aboutus/environment/santa_susana/water_quality/tech_reports_100427_metals_background_report.pdf

Attachment 1. Summary Flowchart for BMP Site Ranking Analysis Approach





Notes:
1) NPDES outfalls are included for comparison and method testing purposes only. Stormwater controls are not being contemplated at these locations.
2) Besides the Panel's original set of recommended monitoring locations, for the purpose of this BMP siting analysis, per Panel request, these potential BMP subarea monitoring locations include three ISRA performance monitoring sites – A2SW0001 (upgradient of NASA ISRA area and CM1, representing ELV and road runoff), A1SW0004 (upgradient of CM9 and representing Area II Landfill ISRA area and parking lot runoff), and B1SW0011 (upgradient of B1 ISRA area and representing road runoff).



Legend

- Potential BMP subarea site (note 2)
- Stormwater background site
- Outfall monitoring sites
- Stream
- SWMM Subareas
- Outfall watershed boundary

Site Legend

Potential BMP subarea site
Stormwater background site
Outfalls

800 400 0 800
Feet

ATTACHMENT 2
Locations Used in Site Ranking Analysis Outfall 008/009 Watersheds
Santa Susana Field Laboratory
Ventura County, CA

Geosyntec consultants

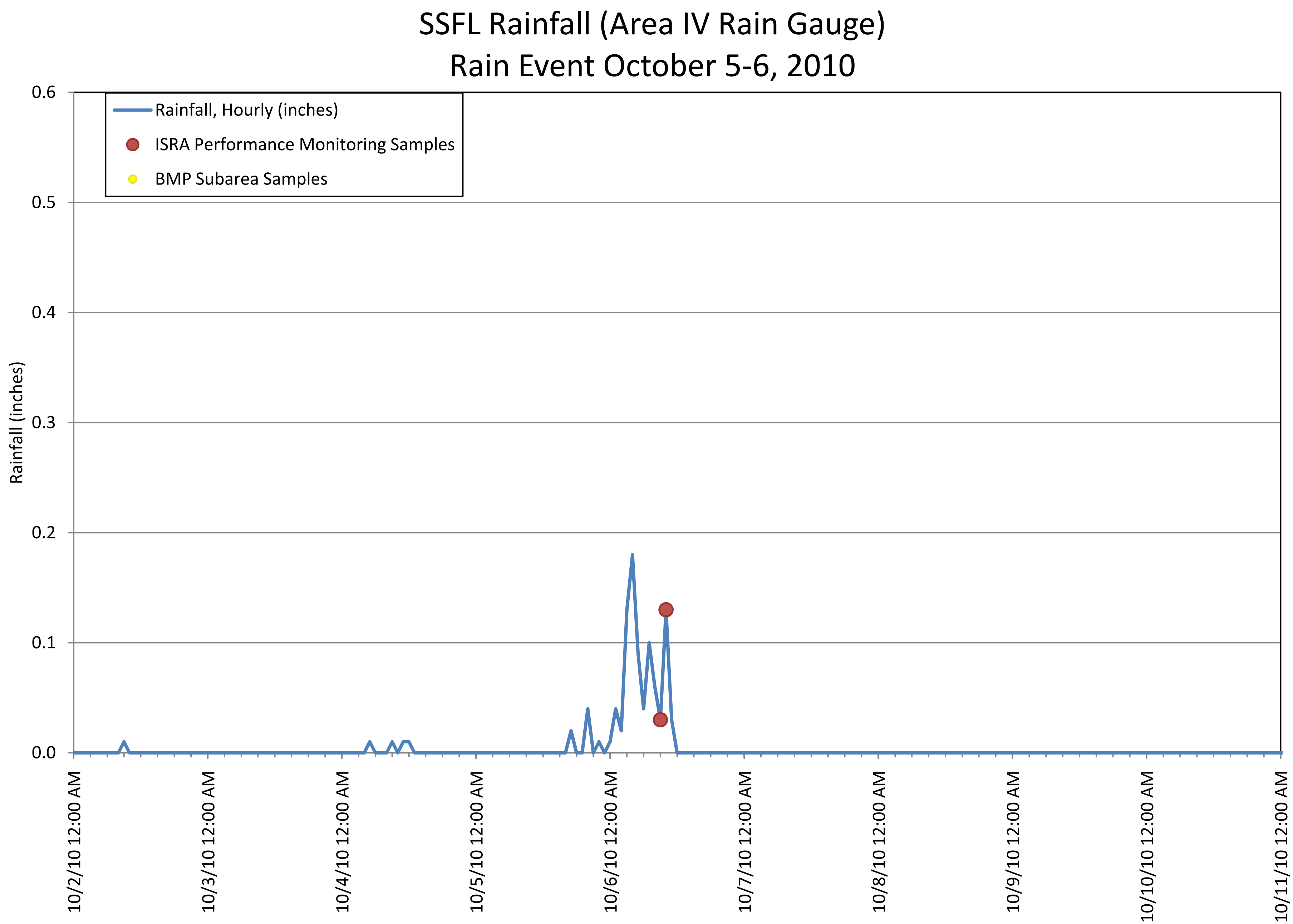
Portland, OR | June 2011

PDX Path: P:\GIS\Projects\Boeing\SB0363_SSFL\SB0363O\maps\TriggerTriggerDrainage.mxd; June 2011; P. Hobson

APPENDIX B

RAINFALL GRAPHS

Appendix B


SSFL Rainfall (Area IV Rain Gauge)
Rain Event October 5-6, 2010
Rainfall, Hourly (inches)
ISRA Performance Monitoring Samples
BMP Subarea Samples
Rainfall (inches)
0.6
0.5
0.4
0.3
0.2
0.1
0.0
10/2/10 12:00 AM
10/3/10 12:00 AM
10/4/10 12:00 AM
10/5/10 12:00 AM
10/6/10 12:00 AM
10/7/10 12:00 AM
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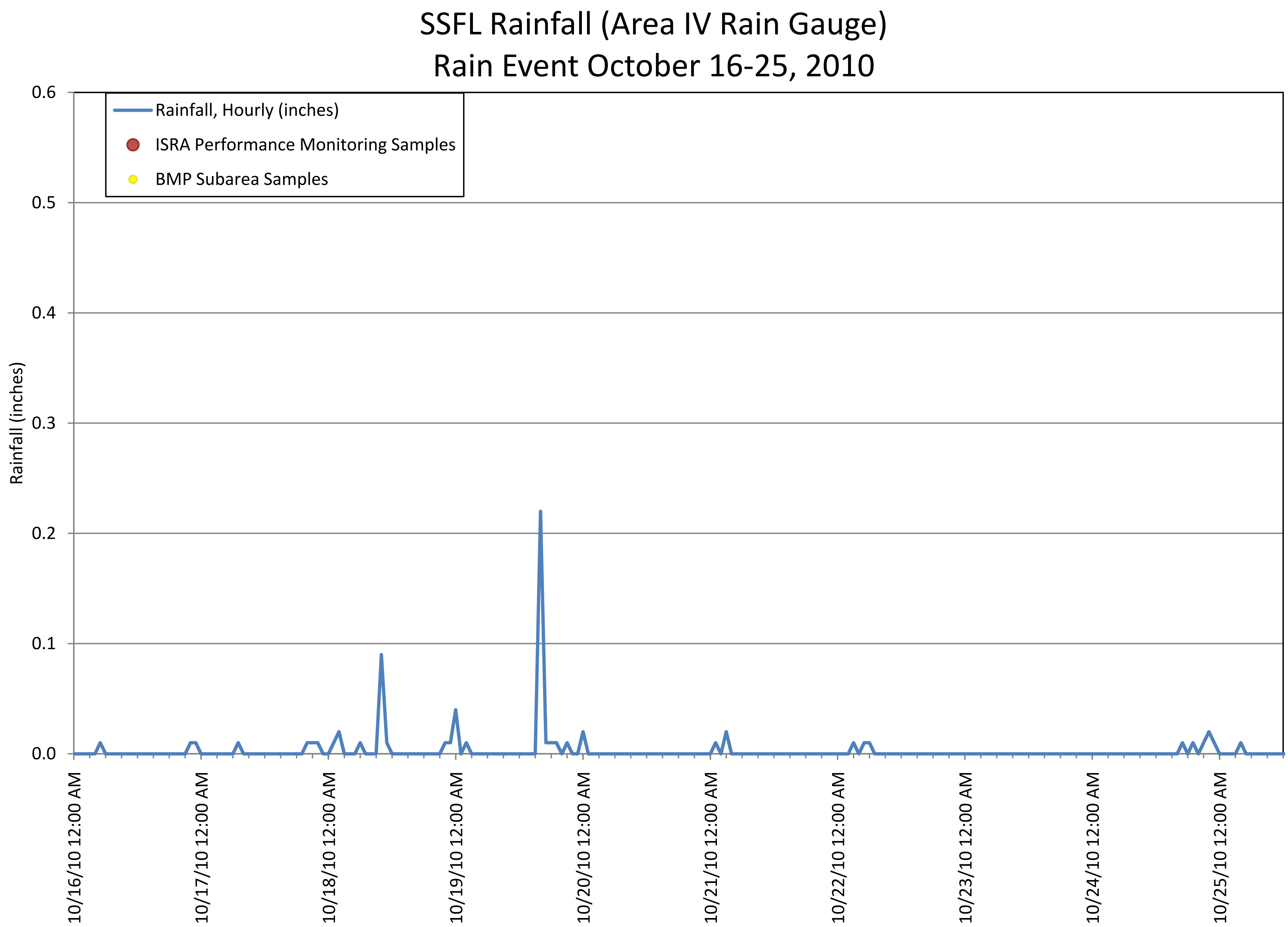
10/11/10 12:00 AM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Rain Event October 16-25, 2010
Rainfall (inches)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
Rainfall, Hourly (inches)
ISRA Performance Monitoring Samples
BMP Subarea Samples
10/16/10 12:00 AM
10/17/10 12:00 AM
10/18/10 12:00 AM
10/19/10 12:00 AM
10/20/10 12:00 AM
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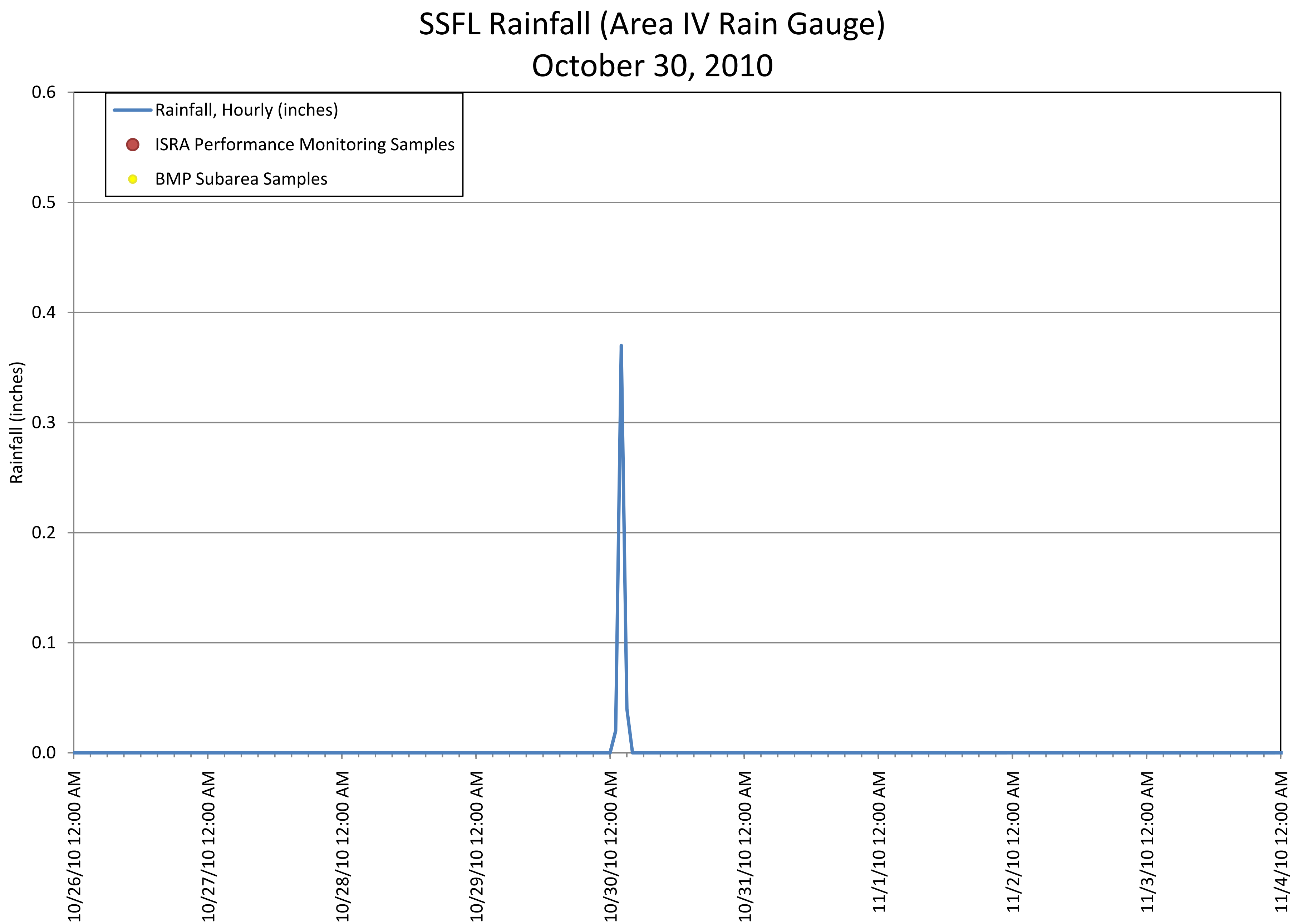
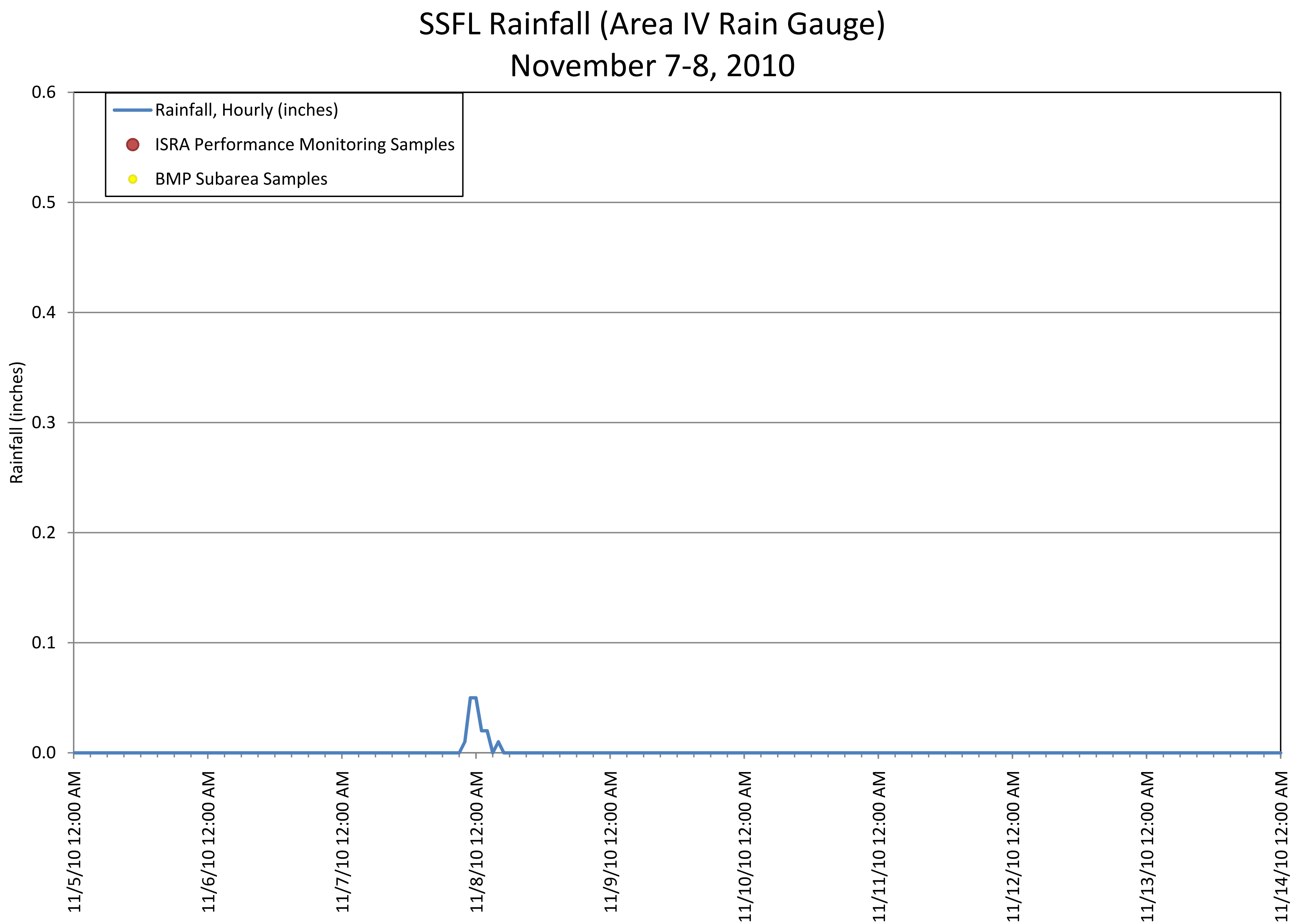
10/25/10 12:00 AM


SSFL Rainfall (Area IV Rain Gauge)
October 30, 2010
Rainfall, Hourly (inches)
ISRA Performance Monitoring Samples
BMP Subarea Samples
Rainfall (inches)
0.6
0.5
0.4
0.3
0.2
0.1
0.0
10/26/10 12:00 AM
10/27/10 12:00 AM
10/28/10 12:00 AM
10/29/10 12:00 AM
10/30/10 12:00 AM
10/31/10 12:00 AM
11/1/10 12:00 AM
11/2/10 12:00 AM
11/3/10 12:00 AM
11/4/10 12:00 AM

Appendix B


SSFL Rainfall (Area IV Rain Gauge)
November 7-8, 2010
Rainfall, Hourly (inches)
ISRA Performance Monitoring Samples
BMP Subarea Samples
Rainfall (inches)
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0.5
0.4
0.3
0.2
0.1
0.0
11/5/10 12:00 AM
11/6/10 12:00 AM
11/7/10 12:00 AM
11/8/10 12:00 AM
11/9/10 12:00 AM
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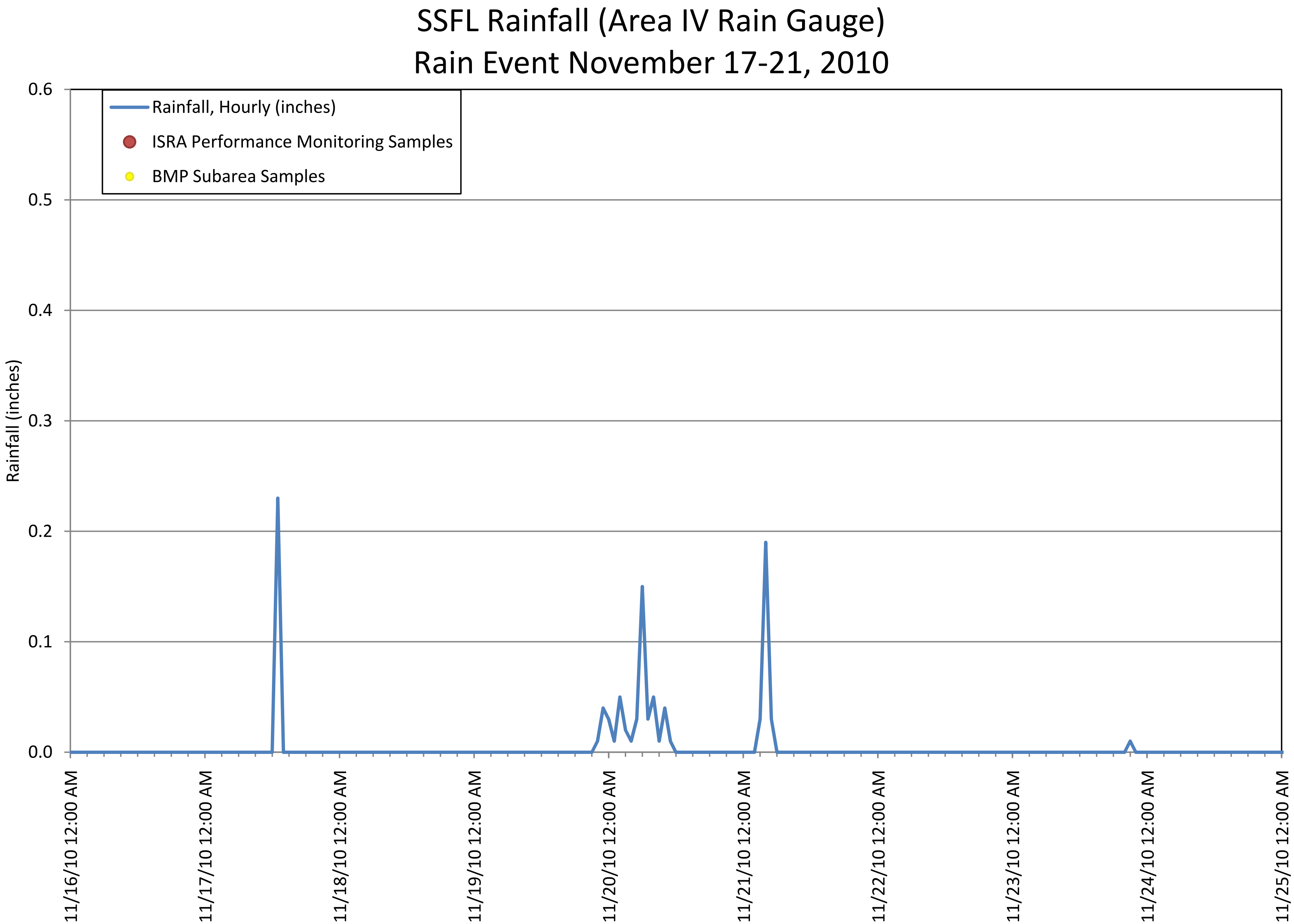
11/14/10 12:00 AM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Rain Event November 17-21, 2010
Rainfall, Hourly (inches)
ISRA Performance Monitoring Samples
BMP Subarea Samples
Rainfall (inches)
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0.5
0.4
0.3
0.2
0.1
0.0
11/16/10 12:00 AM
11/17/10 12:00 AM
11/18/10 12:00 AM
11/19/10 12:00 AM
11/20/10 12:00 AM
11/21/10 12:00 AM
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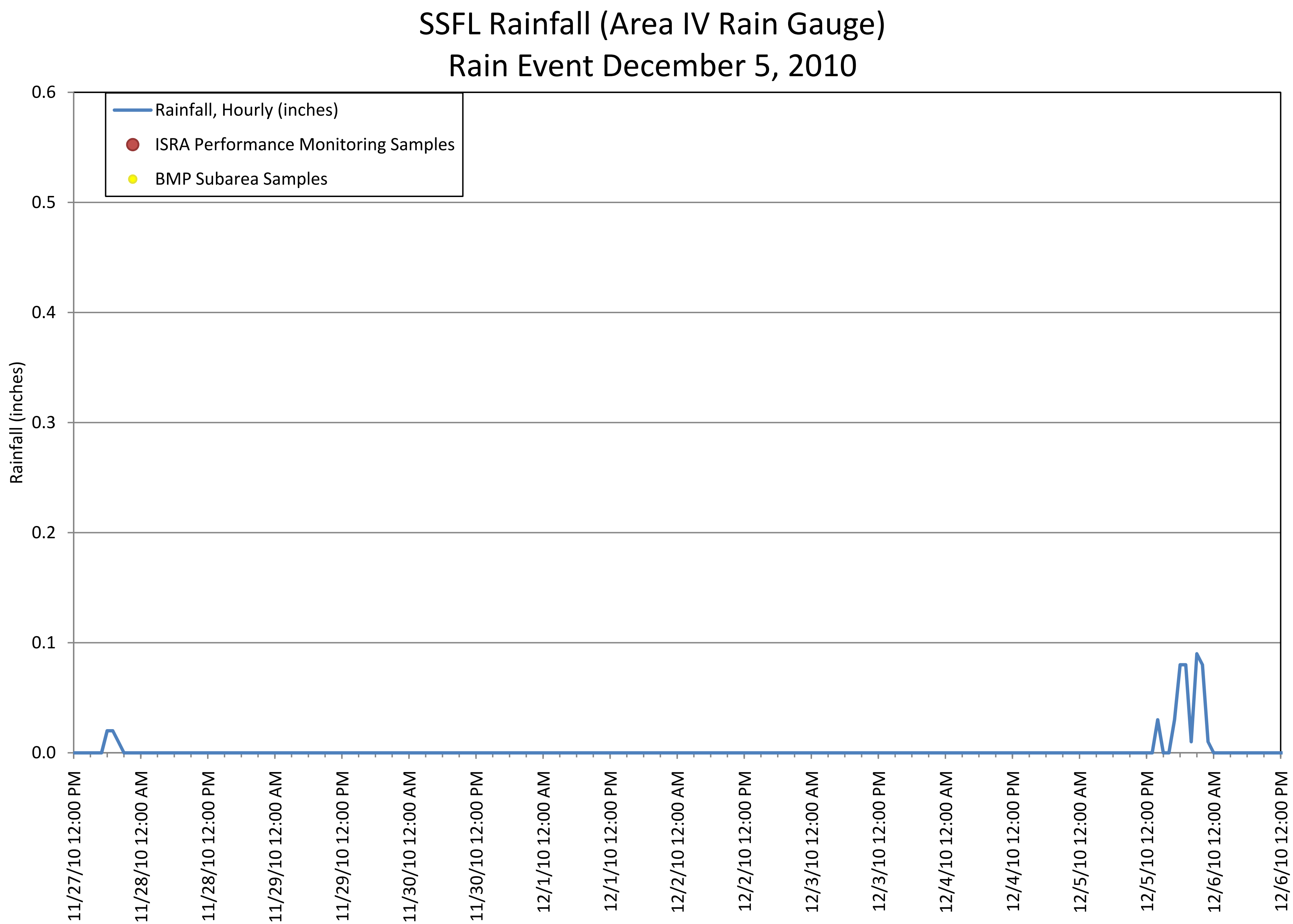
11/25/10 12:00 AM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Rain Event December 5, 2010
Rainfall, Hourly (inches)
ISRA Performance Monitoring Samples
BMP Subarea Samples
Rainfall (inches)
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0.5
0.4
0.3
0.2
0.1
0.0
11/27/10 12:00 PM
11/28/10 12:00 AM
11/28/10 12:00 PM
11/29/10 12:00 AM
11/29/10 12:00 PM
11/30/10 12:00 AM
11/30/10 12:00 PM
12/1/10 12:00 AM
12/1/10 12:00 PM
12/2/10 12:00 AM
12/2/10 12:00 PM
12/3/10 12:00 AM
12/3/10 12:00 PM
12/4/10 12:00 AM
12/4/10 12:00 PM
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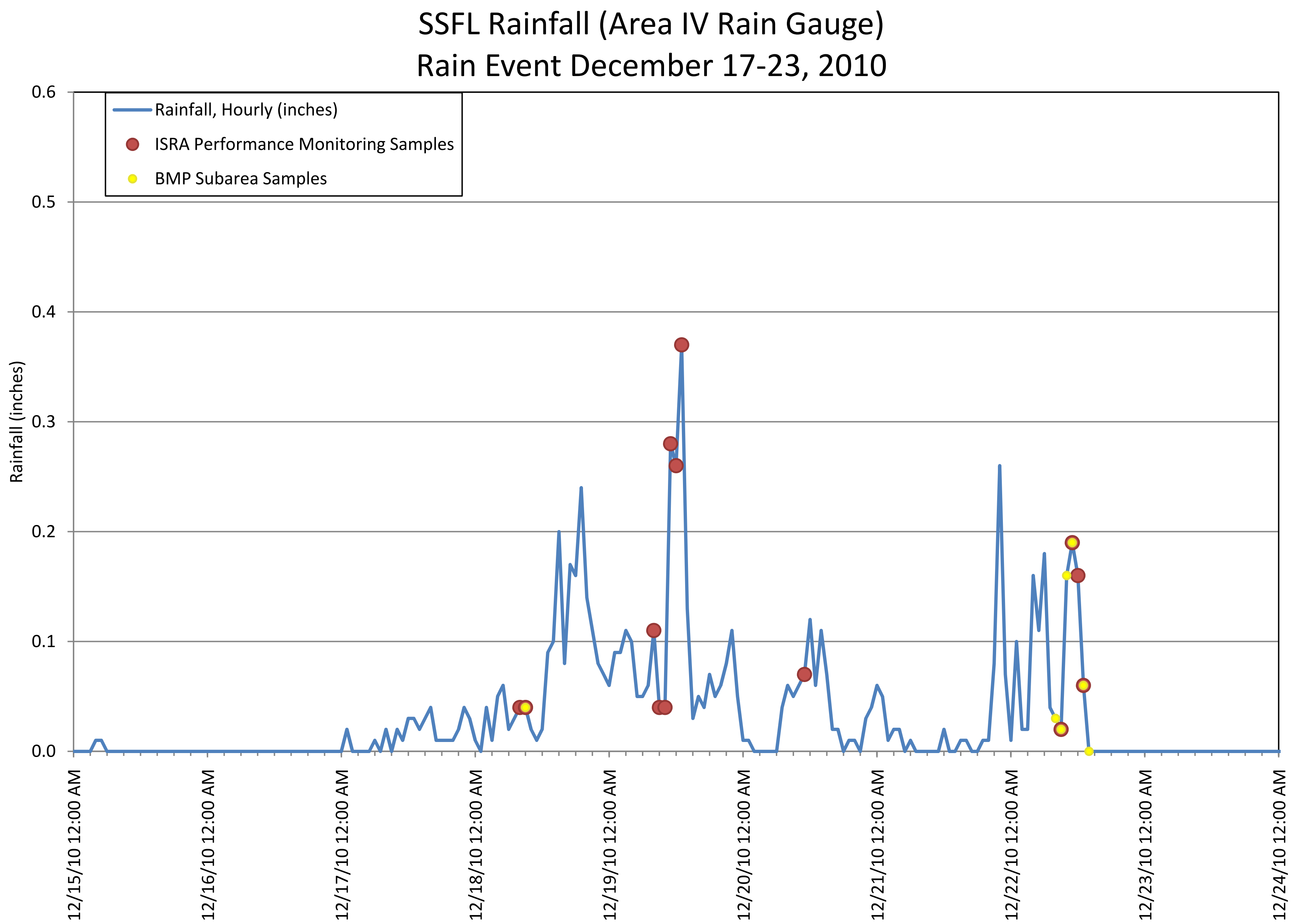
12/5/10 12:00 PM
12/6/10 12:00 AM
12/6/10 12:00 PM

Appendix B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Rain Event December 17-23, 2010
Rainfall (inches)
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0.5
0.4
0.3
0.2
0.1
0.0
Rainfall, Hourly (inches)
ISRA Performance Monitoring Samples
BMP Subarea Samples
12/15/10 12:00 AM
12/16/10 12:00 AM
12/17/10 12:00 AM
12/18/10 12:00 AM
12/19/10 12:00 AM
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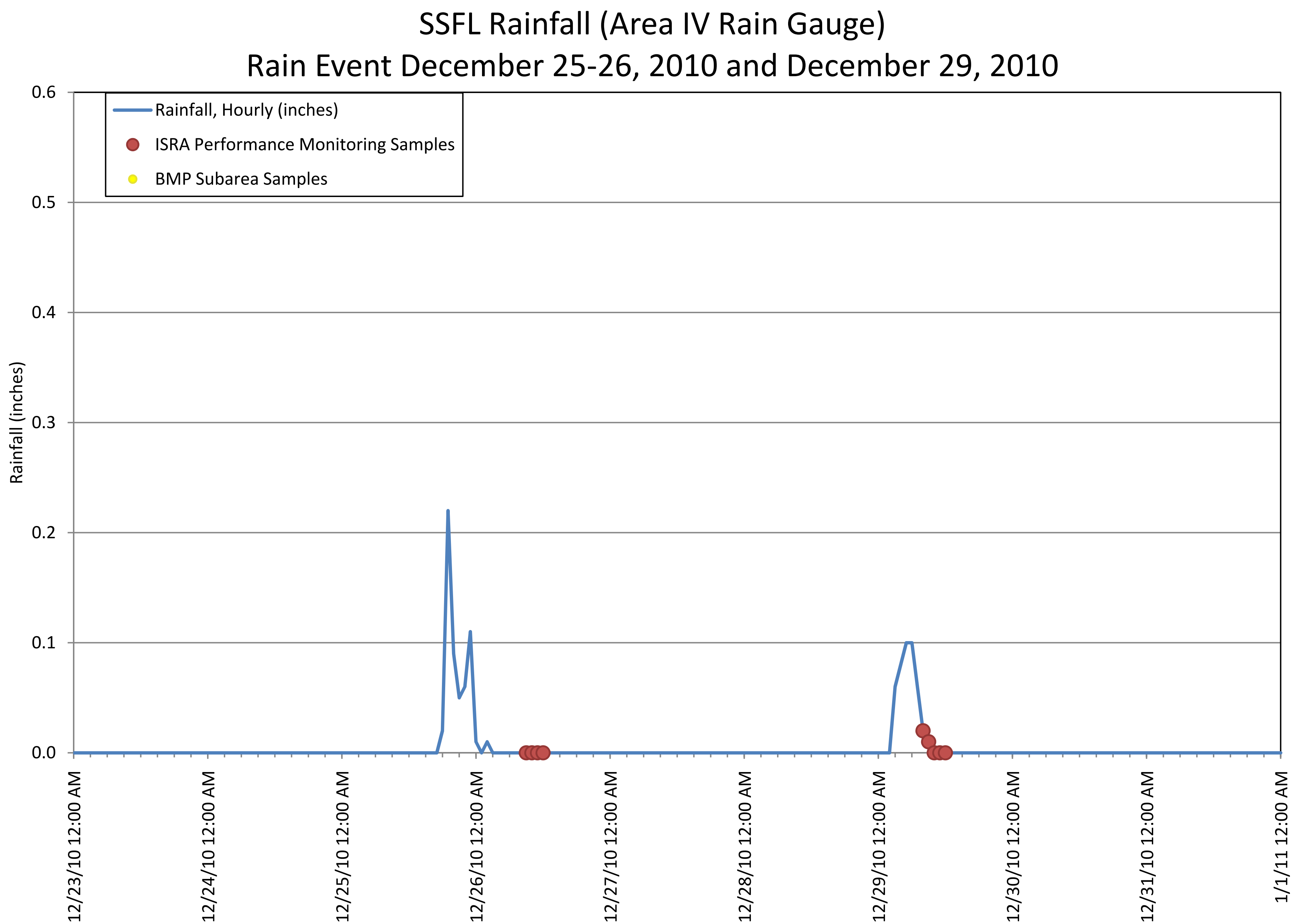
SSFL Rainfall (Area IV Rain Gauge)
Rain Event December 25-26, 2010 and December 29, 2010
Rainfall, Hourly (inches)
ISRA Performance Monitoring Samples
BMP Subarea Samples
Rainfall (inches)
0.6
0.5
0.4
0.3
0.2
0.1
0.0
12/23/10 12:00 AM
12/24/10 12:00 AM
12/25/10 12:00 AM
12/26/10 12:00 AM
12/27/10 12:00 AM
12/28/10 12:00 AM
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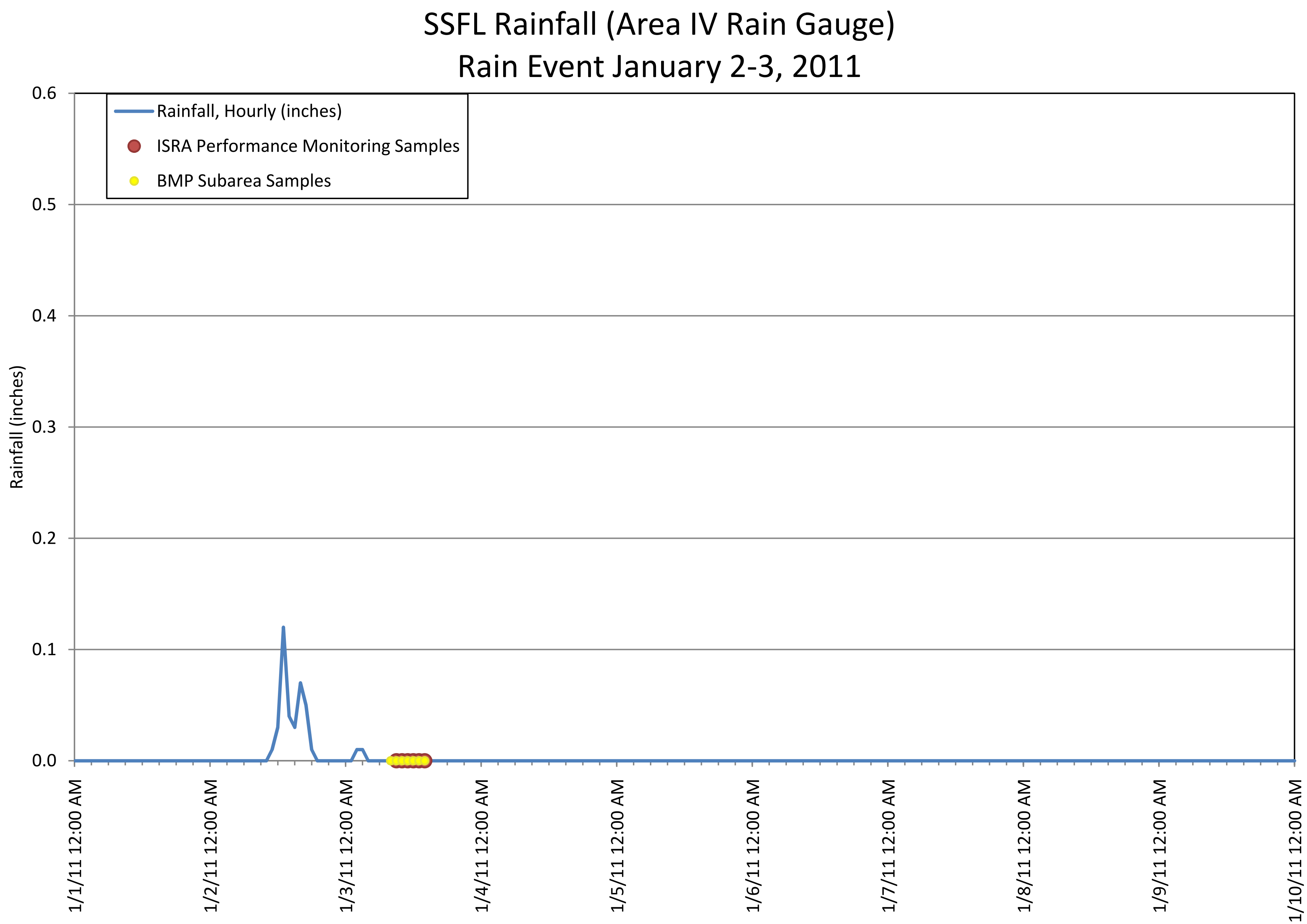
12/30/10 12:00 AM
12/31/10 12:00 AM
1/1/11 12:00 AM

Appendix B


SSFL Rainfall (Area IV Rain Gauge)
Rain Event January 2-3, 2011
Rainfall, Hourly (inches)
ISRA Performance Monitoring Samples
BMP Subarea Samples
Rainfall (inches)
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0.5
0.4
0.3
0.2
0.1
0.0
1/1/11 12:00 AM
1/2/11 12:00 AM
1/3/11 12:00 AM
1/4/11 12:00 AM
1/5/11 12:00 AM
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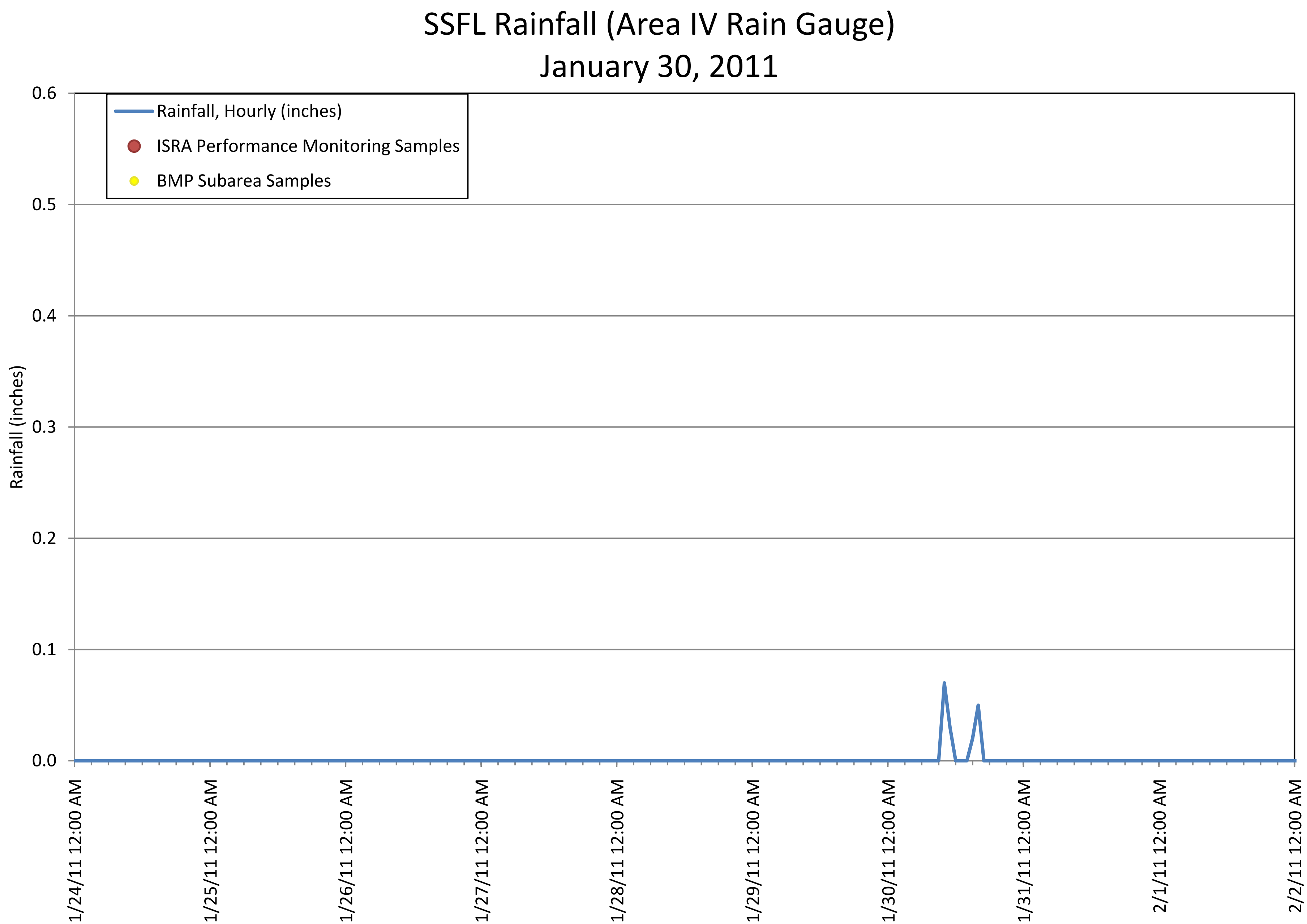
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January 30, 2011
Rainfall, Hourly (inches)
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BMP Subarea Samples
Rainfall (inches)
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0.2
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0.0
1/24/11 12:00 AM
1/25/11 12:00 AM
1/26/11 12:00 AM
1/27/11 12:00 AM
1/28/11 12:00 AM
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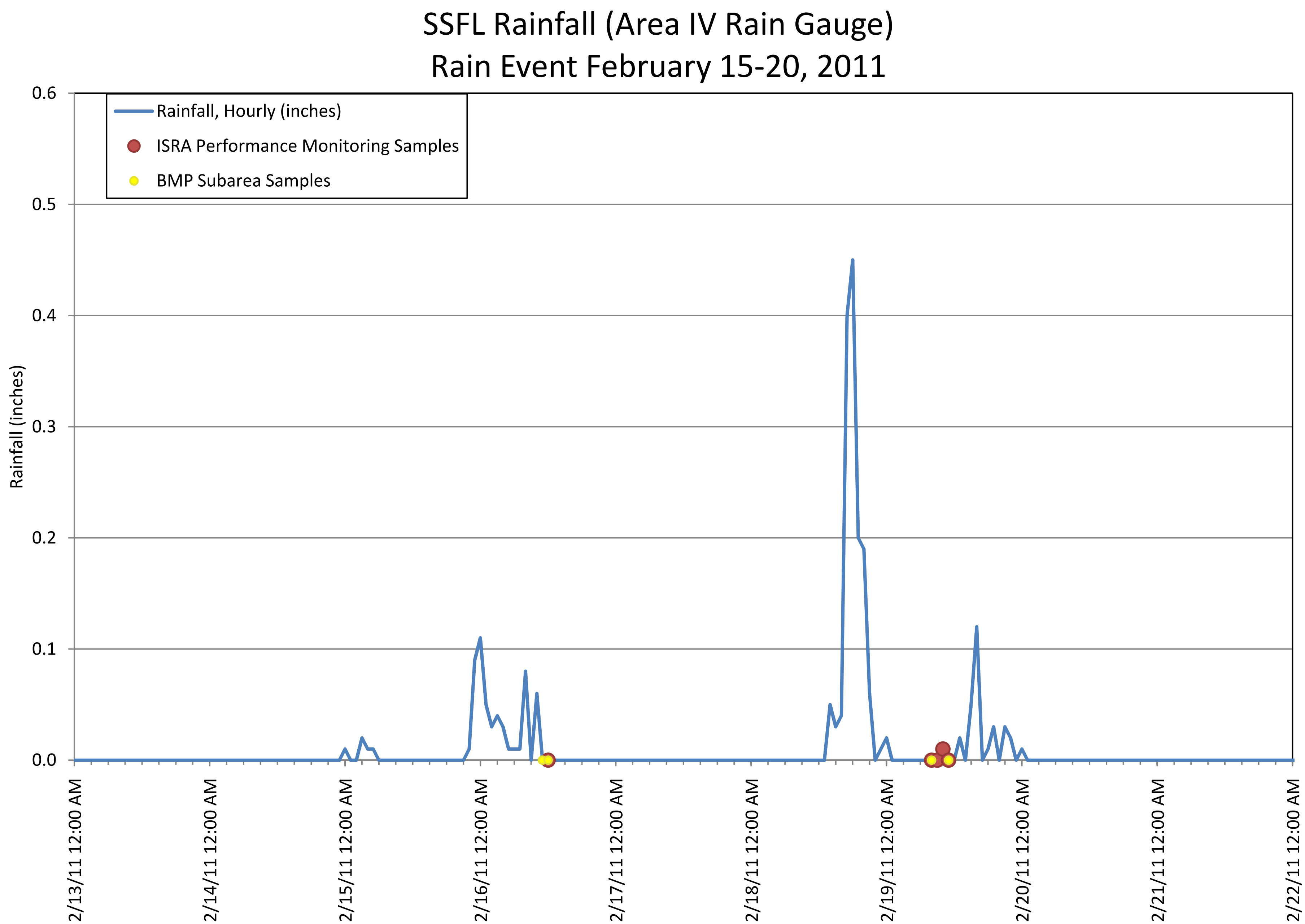
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Rain Event February 15-20, 2011
Rainfall, Hourly (inches)
ISRA Performance Monitoring Samples
BMP Subarea Samples
Rainfall (inches)
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0.5
0.4
0.3
0.2
0.1
0.0
2/13/11 12:00 AM
2/14/11 12:00 AM
2/15/11 12:00 AM
2/16/11 12:00 AM
2/17/11 12:00 AM
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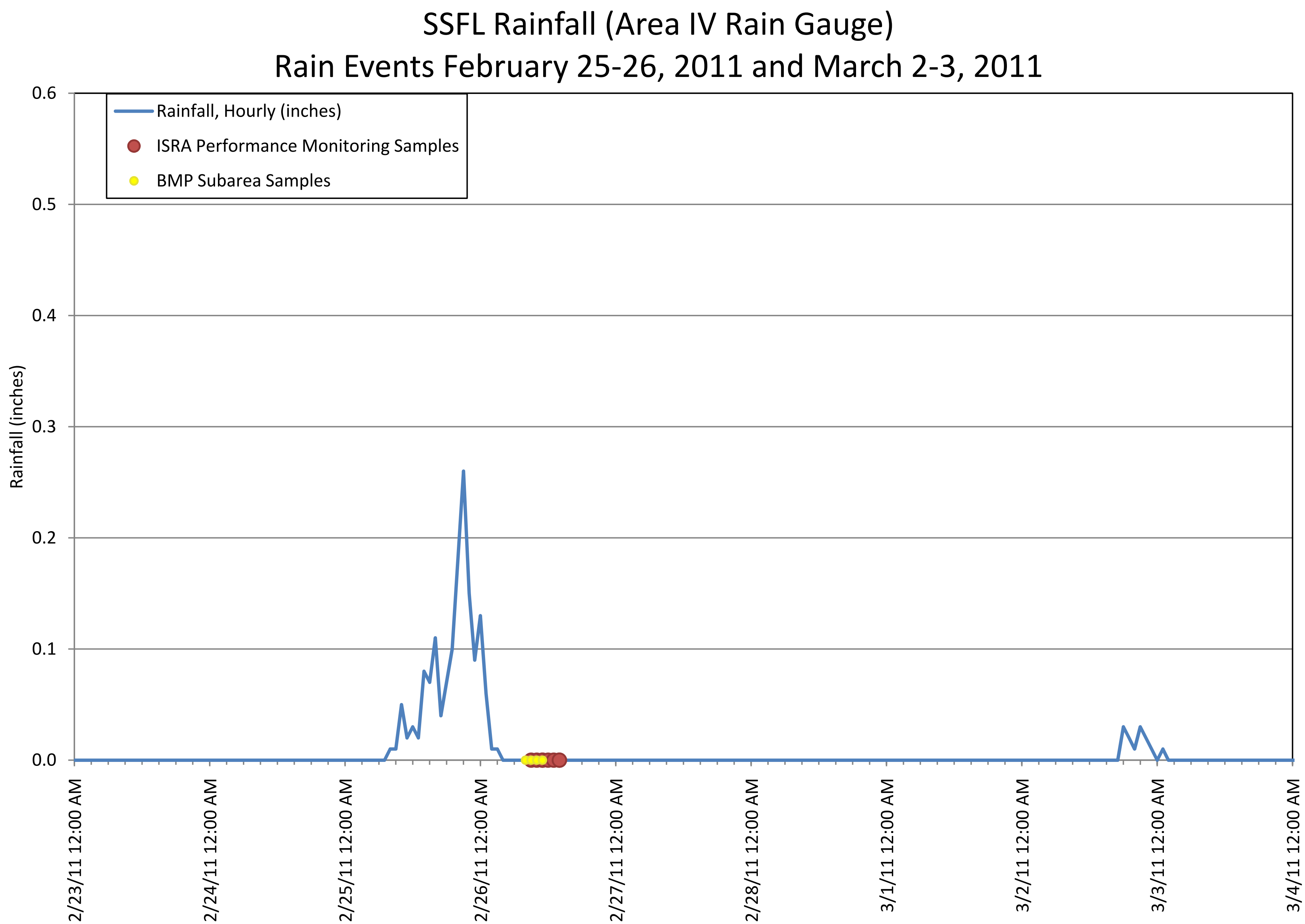
2/22/11 12:00 AM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Rainfall, Hourly (inches)
ISRA Performance Monitoring Samples
BMP Subarea Samples
Rainfall (inches)
0.6
0.5
0.4
0.3
0.2
0.1
0.0
2/23/11 12:00 AM
2/24/11 12:00 AM
2/25/11 12:00 AM
2/26/11 12:00 AM
2/27/11 12:00 AM
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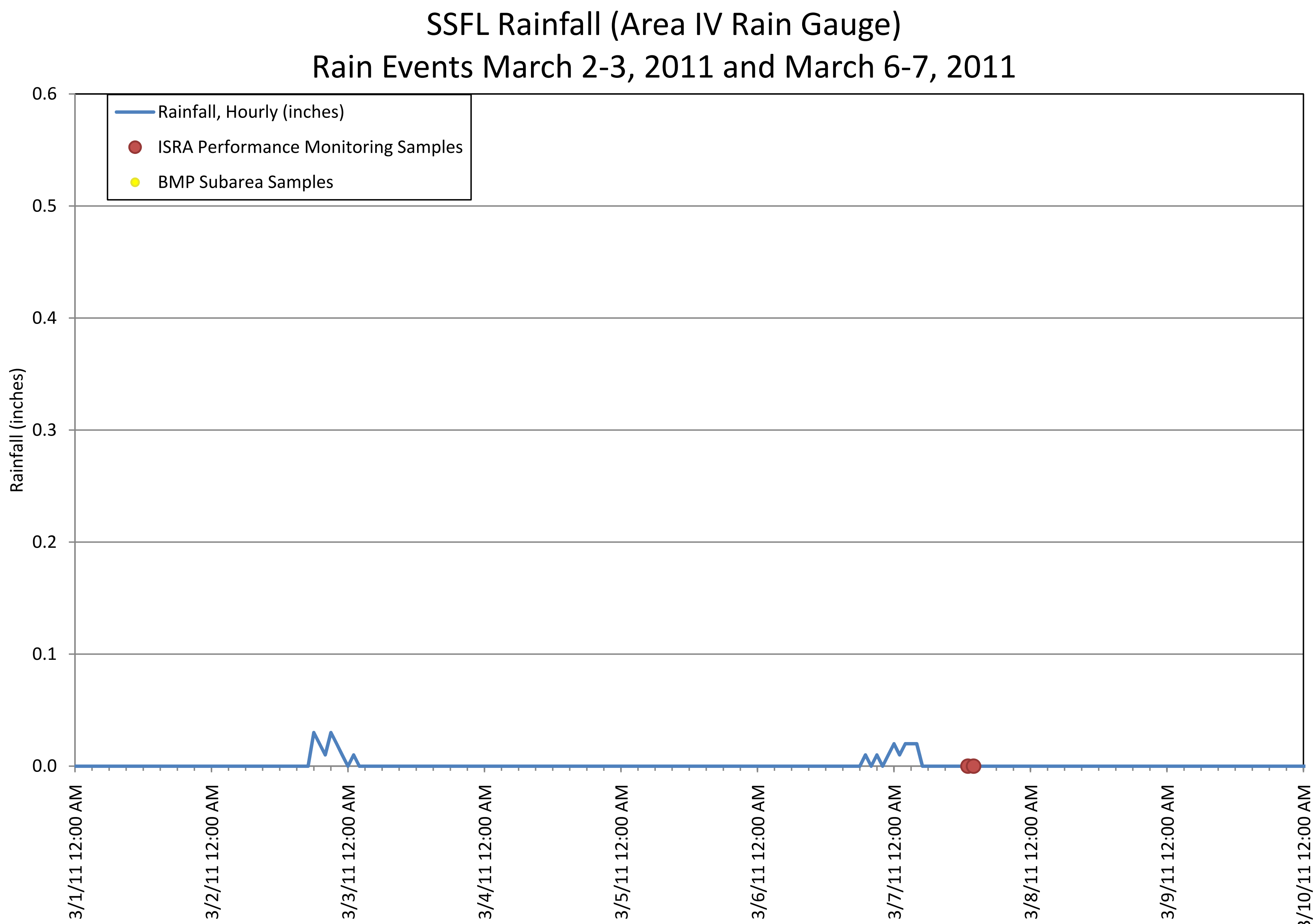
3/4/11 12:00 AM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Rain Events March 2-3, 2011 and March 6-7, 2011
Rainfall, Hourly (inches)
ISRA Performance Monitoring Samples
BMP Subarea Samples
Rainfall (inches)
0.6
0.5
0.4
0.3
0.2
0.1
0.0
3/1/11 12:00 AM
3/2/11 12:00 AM
3/3/11 12:00 AM
3/4/11 12:00 AM
3/5/11 12:00 AM
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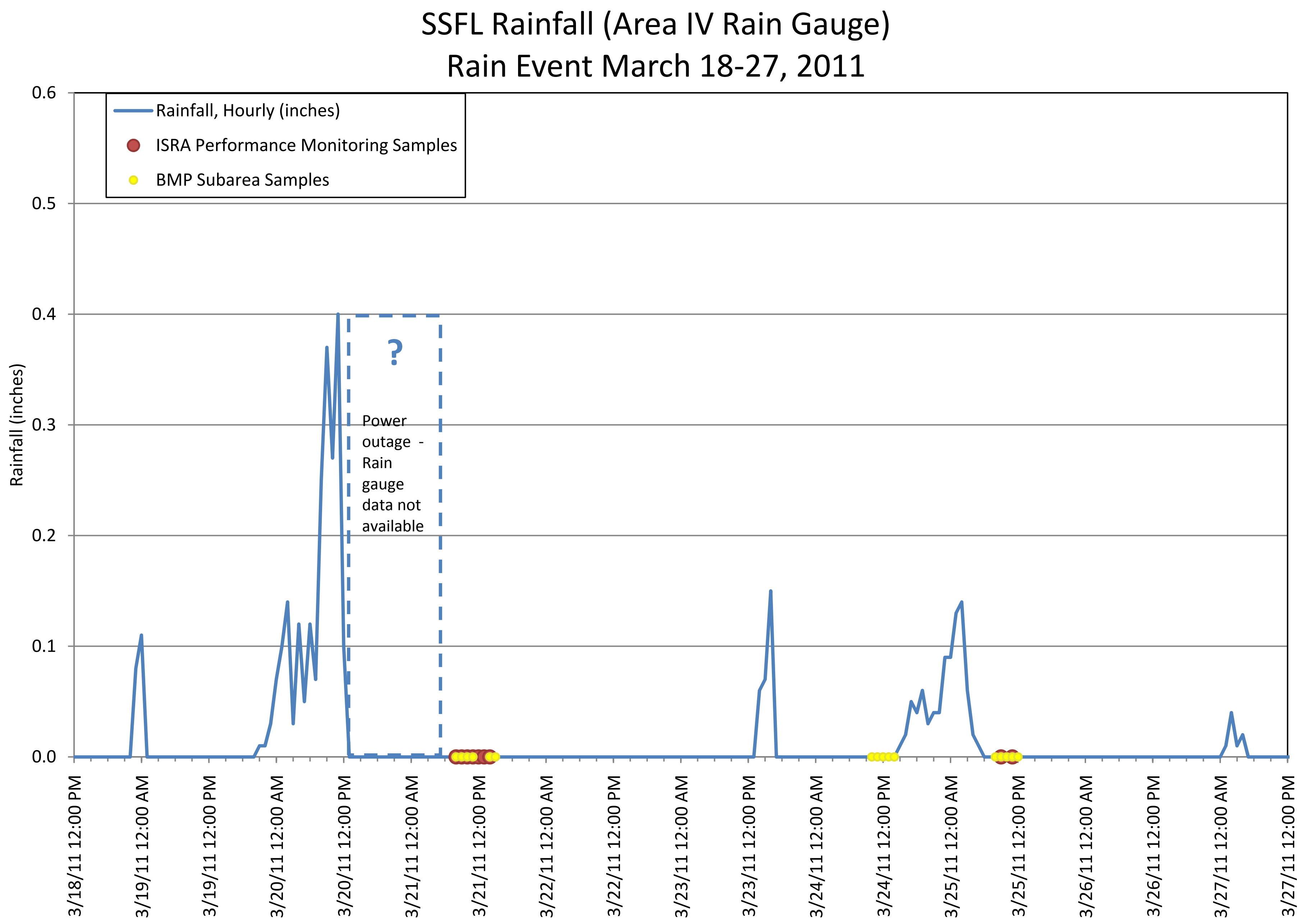
3/10/11 12:00 AM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Rain Event March 18-27, 2011
Rainfall (inches)
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Rainfall, Hourly (inches)
ISRA Performance Monitoring Samples
BMP Subarea Samples
?
Power outage - Rain gauge data not available
3/18/11 12:00 PM
3/19/11 12:00 AM
3/19/11 12:00 PM
3/20/11 12:00 AM
3/20/11 12:00 PM
3/21/11 12:00 AM
3/21/11 12:00 PM
3/22/11 12:00 AM
3/22/11 12:00 PM
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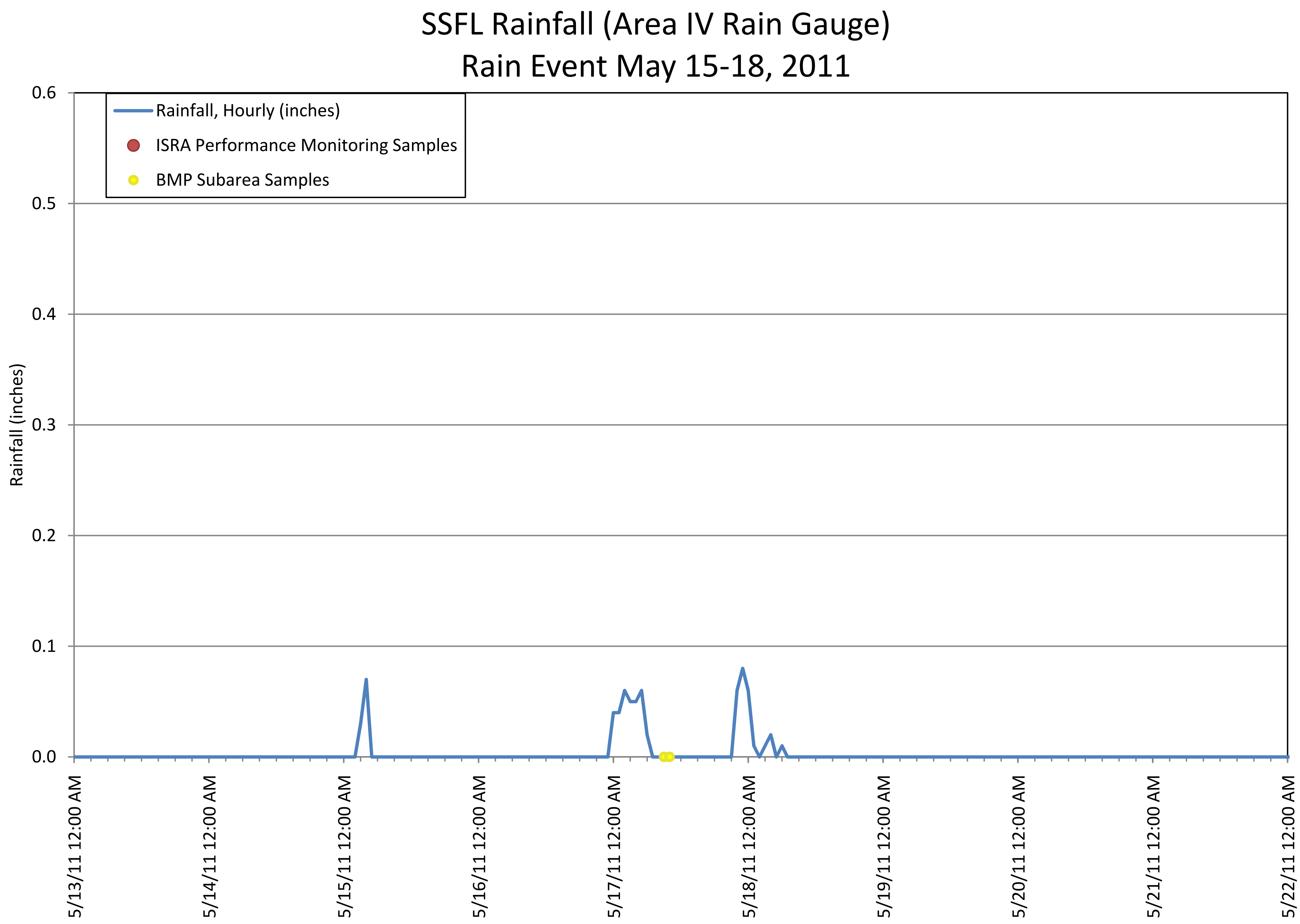

SSFL Rainfall (Area IV Rain Gauge)
Rain Event May 15-18, 2011
Rainfall, Hourly (inches)
ISRA Performance Monitoring Samples
BMP Subarea Samples
Rainfall (inches)
0.6
0.5
0.4
0.3
0.2
0.1
0.0
5/13/11 12:00 AM
5/14/11 12:00 AM
5/15/11 12:00 AM
5/16/11 12:00 AM
5/17/11 12:00 AM
5/18/11 12:00 AM
5/19/11 12:00 AM
5/20/11 12:00 AM
5/21/11 12:00 AM
5/22/11 12:00 AM

APPENDIX C

LABORATORY REPORTS AND DATA VALIDATION REPORTS

Table C-1
Laboratory Reports and Data Validation Reports
2010-2011 Rainy Season
Page 1 of 1

Sample Delivery Group	Sample Collection Date	Sample Type	Laboratory Name	Laboratory Report	Validation Report
ISRA Performance Monitoring					
ITJ0728	10/6/2010	Primary	TA-Irvine	Y	--
ITJ0730	10/6/2010	Primary	TA-Irvine	Y	--
ITL1882	12/18/2010	Primary	TA-Irvine	Y	--
ITL1892	12/19/2010	Primary	TA-Irvine	Y	Y
ITL2020	12/20/2010	Primary	TA-Irvine	Y	--
ITL2301	12/22/2010	Primary	TA-Irvine	Y	--
ITL2302	12/22/2010	Primary	TA-Irvine	Y	Y
ITL2484	12/26/2010	Primary	TA-Irvine	Y	--
ITL2684	12/29/2010	Primary	TA-Irvine	Y	Y
IUA0088	1/3/2011	Primary	TA-Irvine	Y	Y
IUA0089	1/3/2011	Primary	TA-Irvine	Y	Y
IUA0090	1/3/2011	Primary	TA-Irvine	Y	Y
IUB1746	2/16/2011	Primary & QA/QC	TA-Irvine	Y	Y
IUB1816	2/16/2011	Primary	TA-Irvine/ PTS	Y	--
IUB2138	2/19/2011	Primary & QA/QC	TA-Irvine	Y	Y
IUB2152	2/19/2011	Primary	TA-Irvine/ PTS	Y	--
IUB2824	2/26/2011	Primary & QA/QC	TA-Irvine	Y	Y
IUC0826	3/7/2011	Primary & QA/QC	TA-Irvine	Y	--
IUC2230	3/21/2011	Primary & QA/QC	TA-Irvine	Y	Y
IUC2923	3/25/2011	Primary	TA-Irvine/ PTS	Y	--
J48181	12/18/2010	RWQCB Split	ASL	Y	Y
J48222	12/22/2010	RWQCB Split	ASL	Y	--
J48255	12/26/2010	RWQCB Split	ASL	Y	--
J48308	12/29/2010	RWQCB Split	ASL	Y	Y
J48329	1/3/2011	RWQCB Split	ASL	Y	--
J48828	2/16/2011	RWQCB Split	ASL	Y	Y
J48869	12/22/2010	RWQCB Split	ASL	Y	--
J48890	2/19/2011	RWQCB Split	ASL	Y	Y
J48925	2/26/2011	RWQCB Split	ASL	Y	Y
J49052	3/7/2011	RWQCB Split	ASL	Y	--
J49228	3/21/2011	RWQCB Split	ASL	Y	Y
Treatment BMP Monitoring					
ITL1877	12/18/2010	Primary	TA-Irvine	Y	Y
ITL2299	12/22/2010	Primary	TA-Irvine	Y	Y
IUA0082	1/3/2011	Primary	TA-Irvine	Y	Y
IUB1806	2/16/2011	Primary	TA-Irvine	Y	--
IUB2151	2/19/2011	Primary	TA-Irvine	Y	Y
IUB2823	2/26/2011	Primary	TA-Irvine	Y	Y
IUC2229	3/21/2011	Primary	TA-Irvine	Y	Y
IUC2677	3/24/2011	Primary	TA-Irvine	Y	Y
IUC2679	3/24/2011	Primary	TA-Irvine	Y	Y
IUC2730	3/25/2011	Primary	TA-Irvine	Y	Y
IUE1774	5/17/2011	Primary	TA-Irvine	Y	Y

Notes

ASL - American Scientific Laboraties, LLC

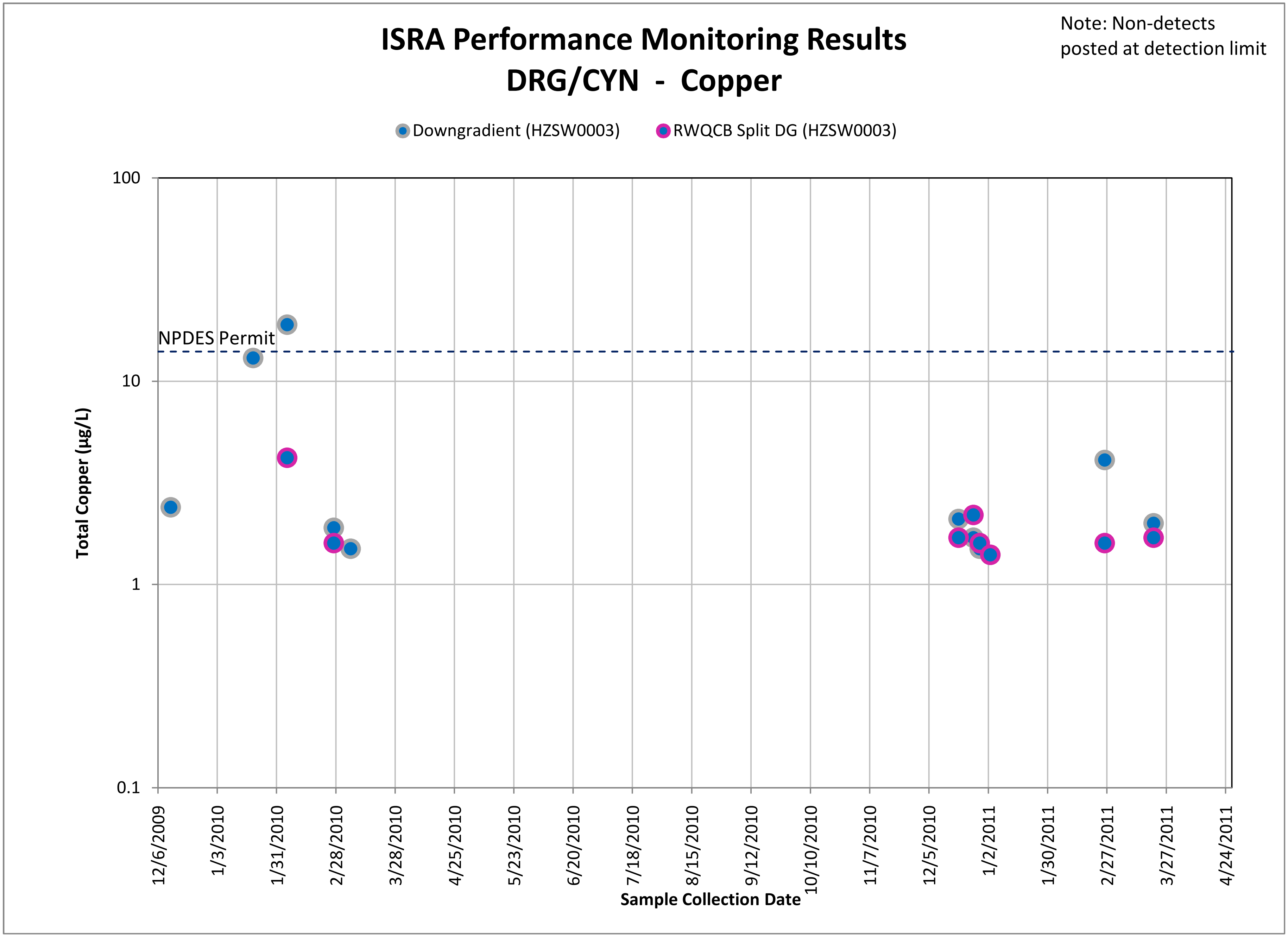
PTS - PTS Laboratories, Inc., Santa Fe Springs, California

TA-Irvine - Test America Laboratories, Irvine, California

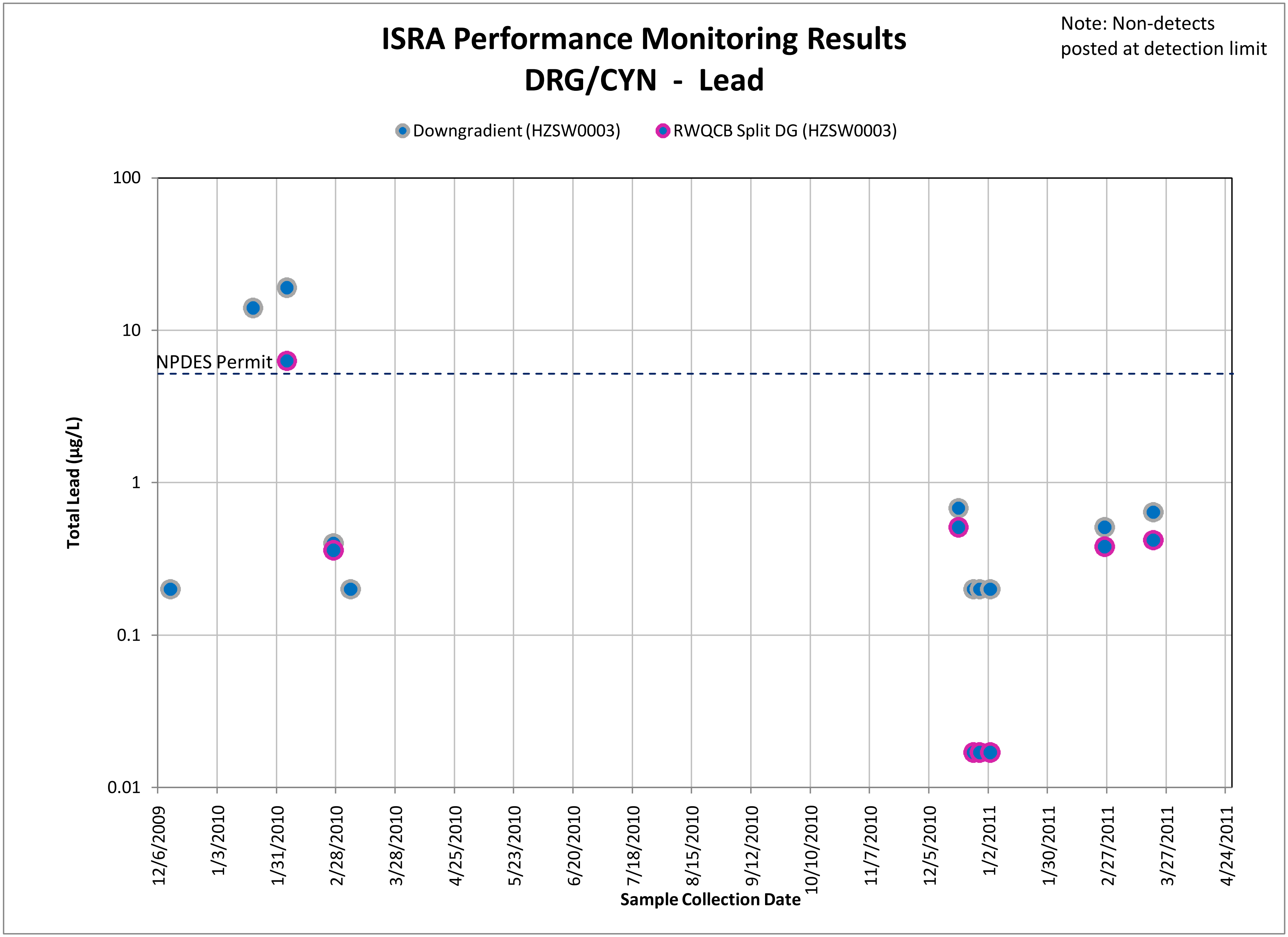
Please contact Debbie Taege at 818-466-8795 if you would like to receive a CD containing the Laboratory and Data Validation Reports listed in Table C-1. The reports are not posted on the Boeing External Website due to the large file size.

APPENDIX D-1

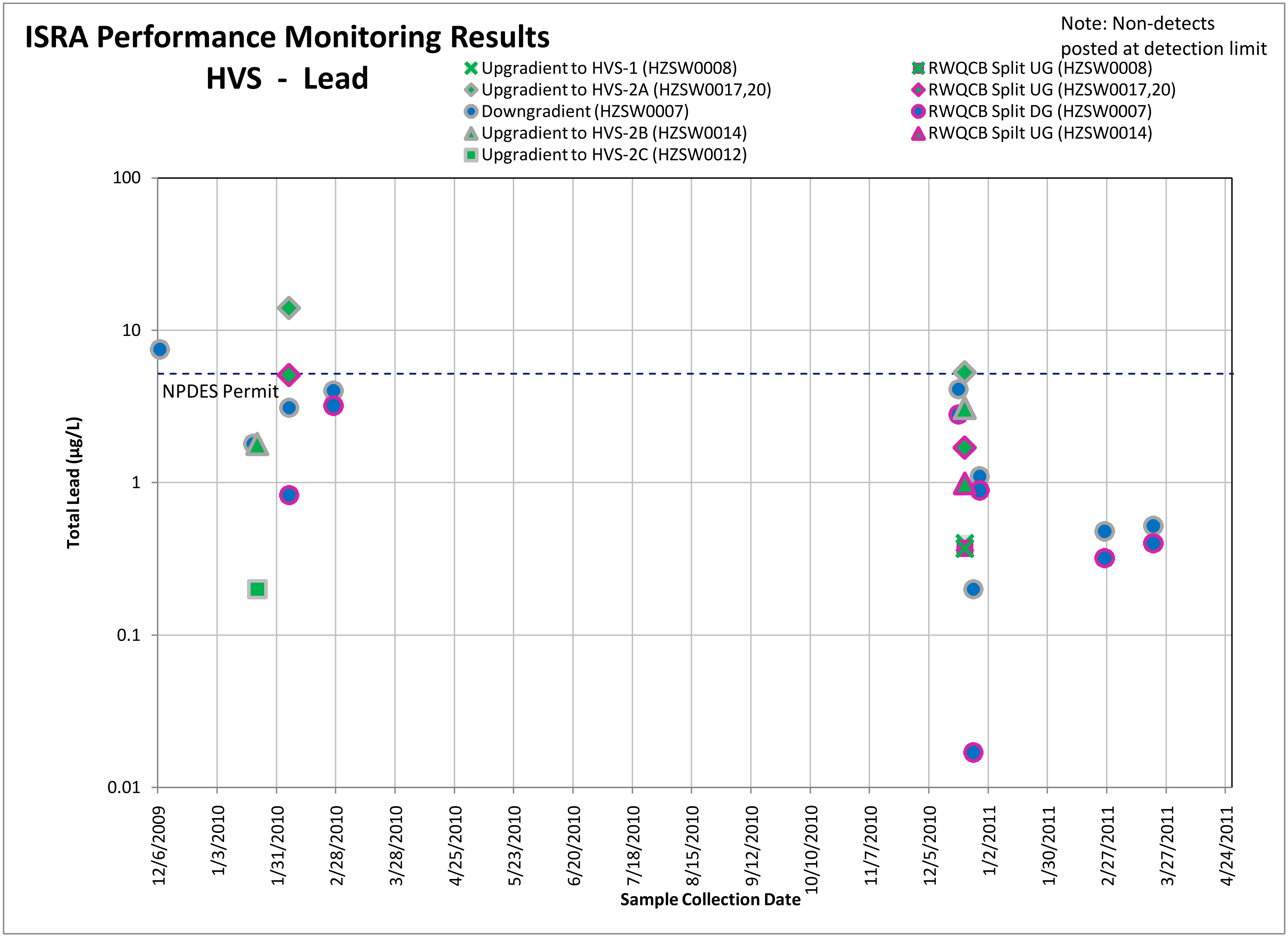
PERFORMANCE MONITORING DATA GRAPHS VS. TIME – DETECTIONS, BY DRAINAGE

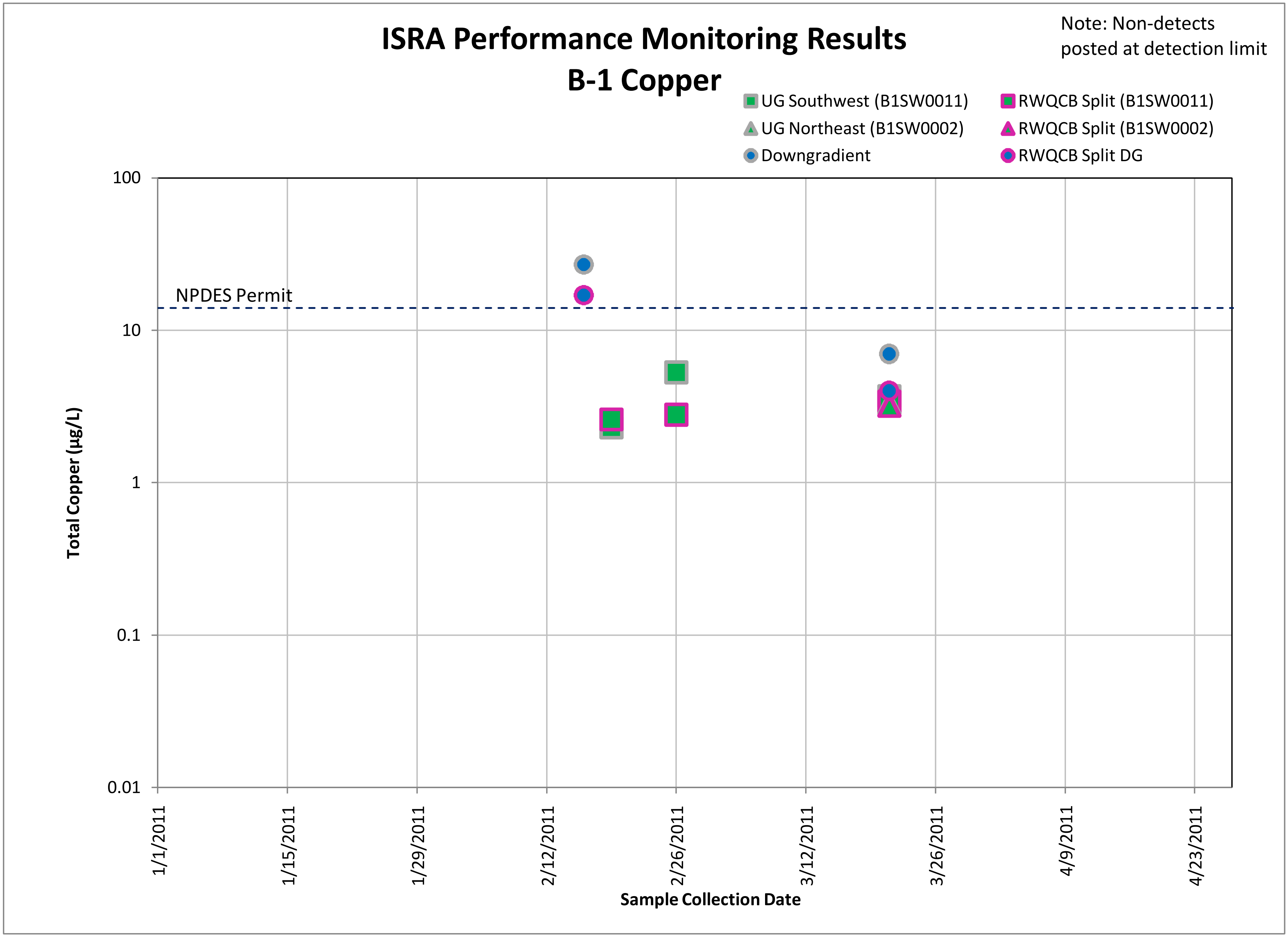


ISRA Performance Monitoring Results
DRG/CYN - Copper
Note: Non-detects posted at detection limit
Downgradient (HZSW0003)
RWQCB Split DG (HZSW0003)
NPDES Permit
100
10
1
0.1
Total Copper (µg/L)
12/6/2009
1/3/2010
1/31/2010
2/28/2010
3/28/2010
4/25/2010
5/23/2010
6/20/2010
7/18/2010
8/15/2010
9/12/2010
10/10/2010
11/7/2010
12/5/2010
1/2/2011
1/30/2011
2/27/2011
3/27/2011
4/24/2011
Sample Collection Date

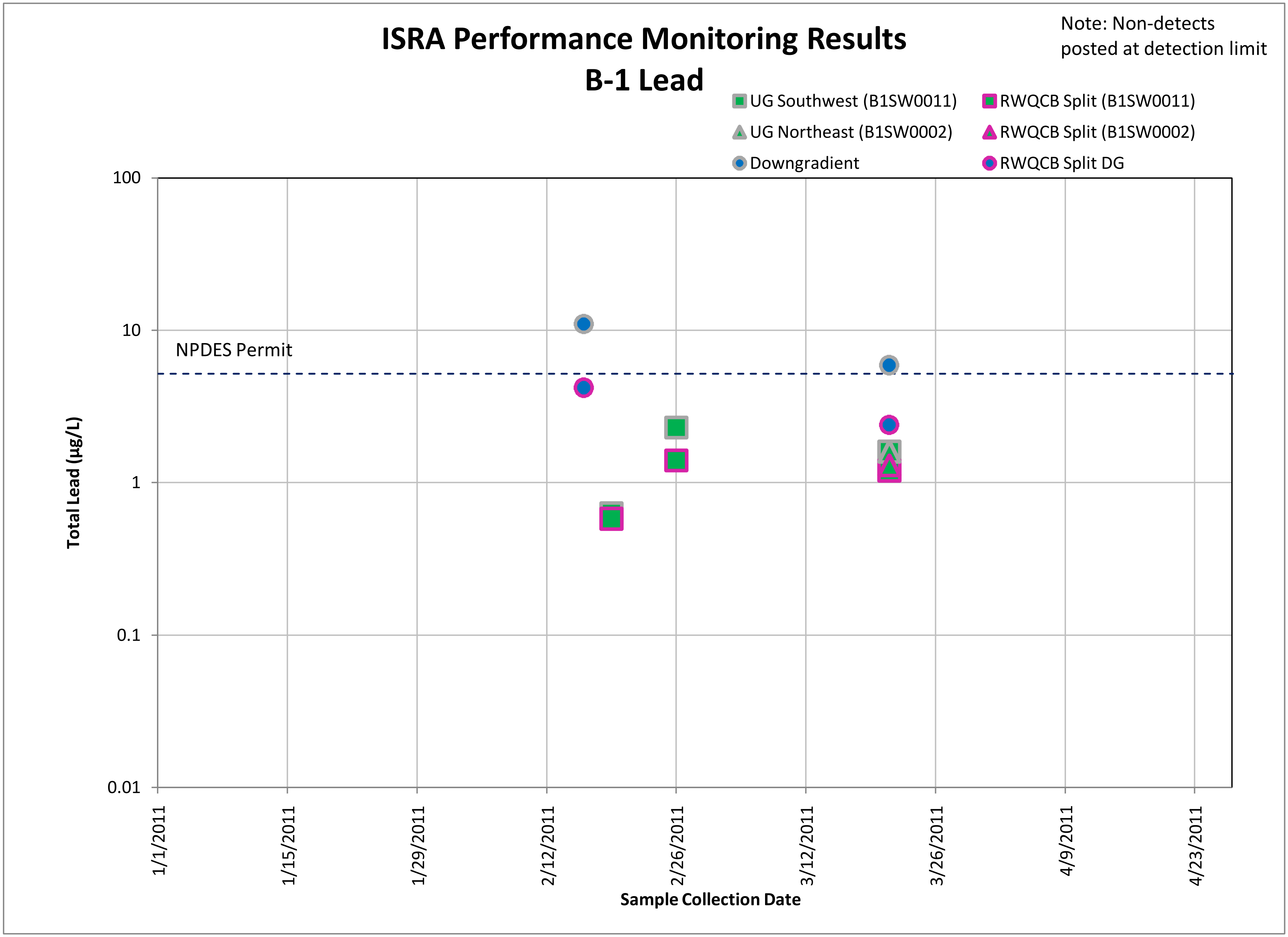


ISRA Performance Monitoring Results
DRG/CYN - Lead
Note: Non-detects posted at detection limit
Downgradient (HZSW0003)
RWQCB Split DG (HZSW0003)
Total Lead (µg/L)
100
10
1
0.1
0.01
NPDES Permit
12/6/2009
1/3/2010
1/31/2010
2/28/2010
3/28/2010
4/25/2010
5/23/2010
6/20/2010
7/18/2010
8/15/2010
9/12/2010
10/10/2010
11/7/2010
12/5/2010
1/2/2011
1/30/2011
2/27/2011
3/27/2011
4/24/2011
Sample Collection Date

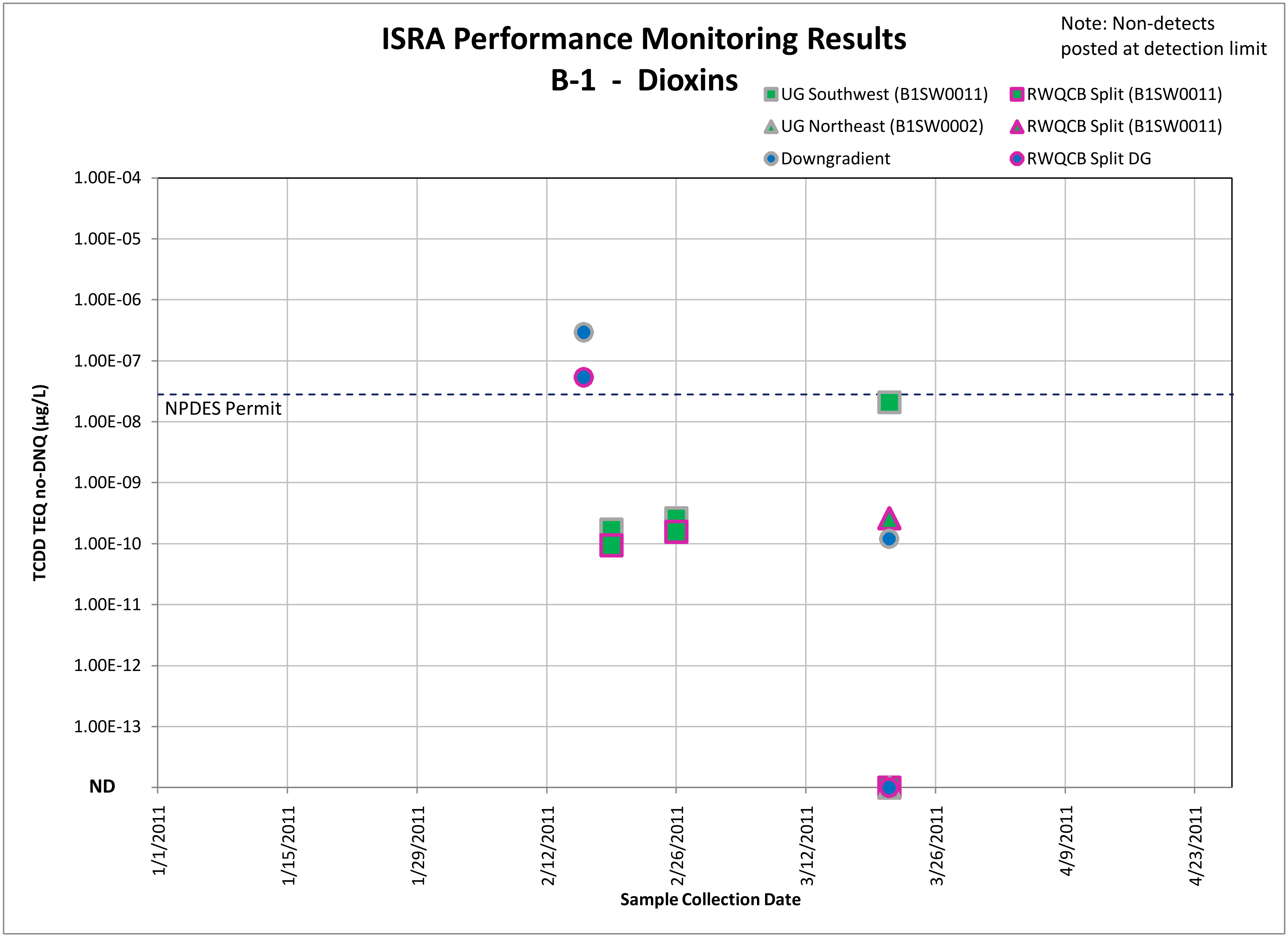

ISRA Performance Monitoring Results
HVS - Lead
Note: Non-detects posted at detection limit
Upgradient to HVS-1 (HZSW0008)
Upgradient to HVS-2A (HZSW0017,20)
Downgradient (HZSW0007)
Upgradient to HVS-2B (HZSW0014)
Upgradient to HVS-2C (HZSW0012)
RWQCB Split UG (HZSW0008)
RWQCB Split UG (HZSW0017,20)
RWQCB Split DG (HZSW0007)
RWQCB Spilt UG (HZSW0014)
NPDES Permit
Total Lead (µg/L)
100
10
1
0.1
0.01
12/6/2009
1/3/2010
1/31/2010
2/28/2010
3/28/2010
4/25/2010
5/23/2010
6/20/2010
7/18/2010
8/15/2010
9/12/2010
10/10/2010
11/7/2010
12/5/2010
1/2/2011
1/30/2011
2/27/2011
3/27/2011
4/24/2011
Sample Collection Date

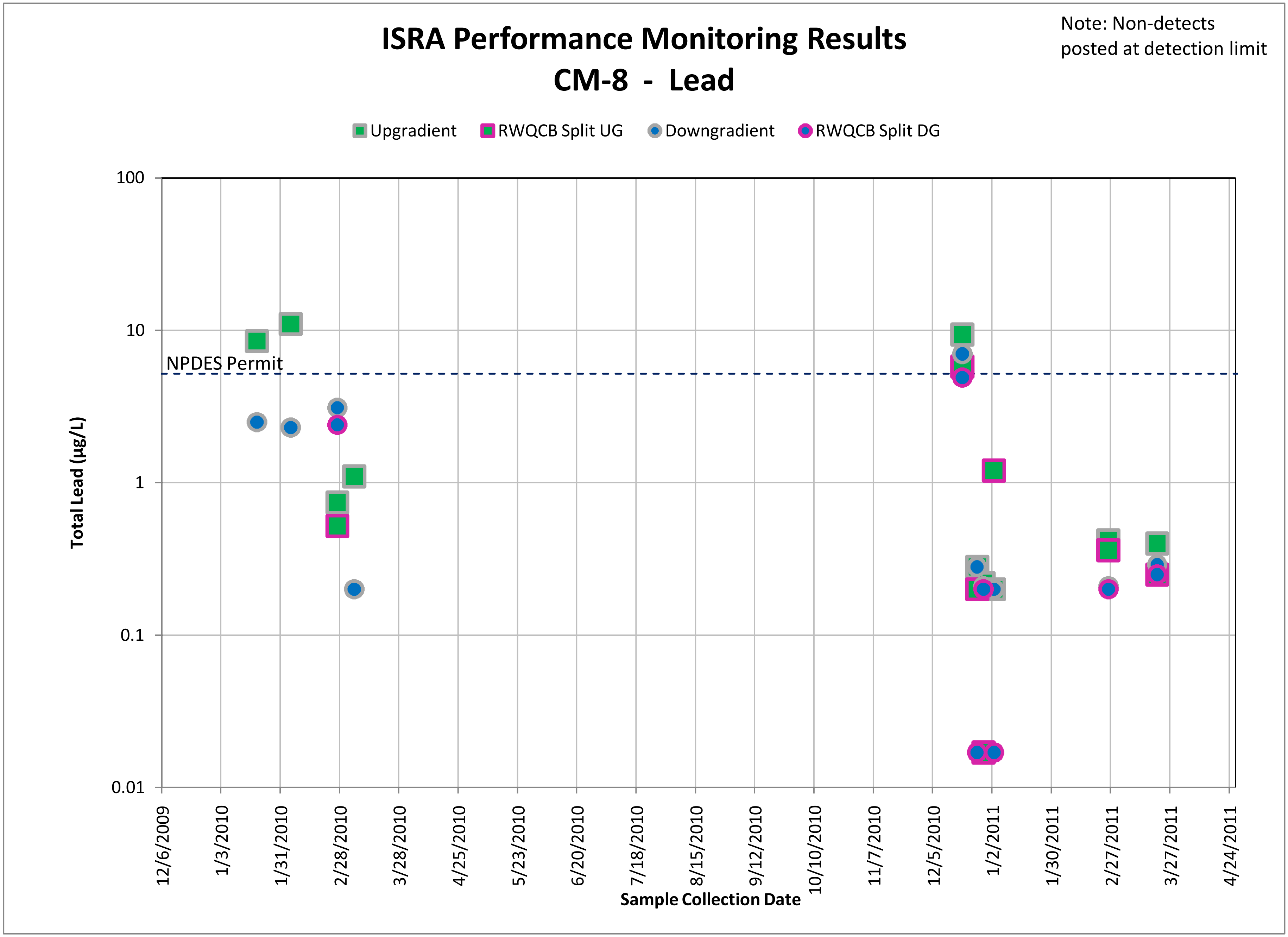


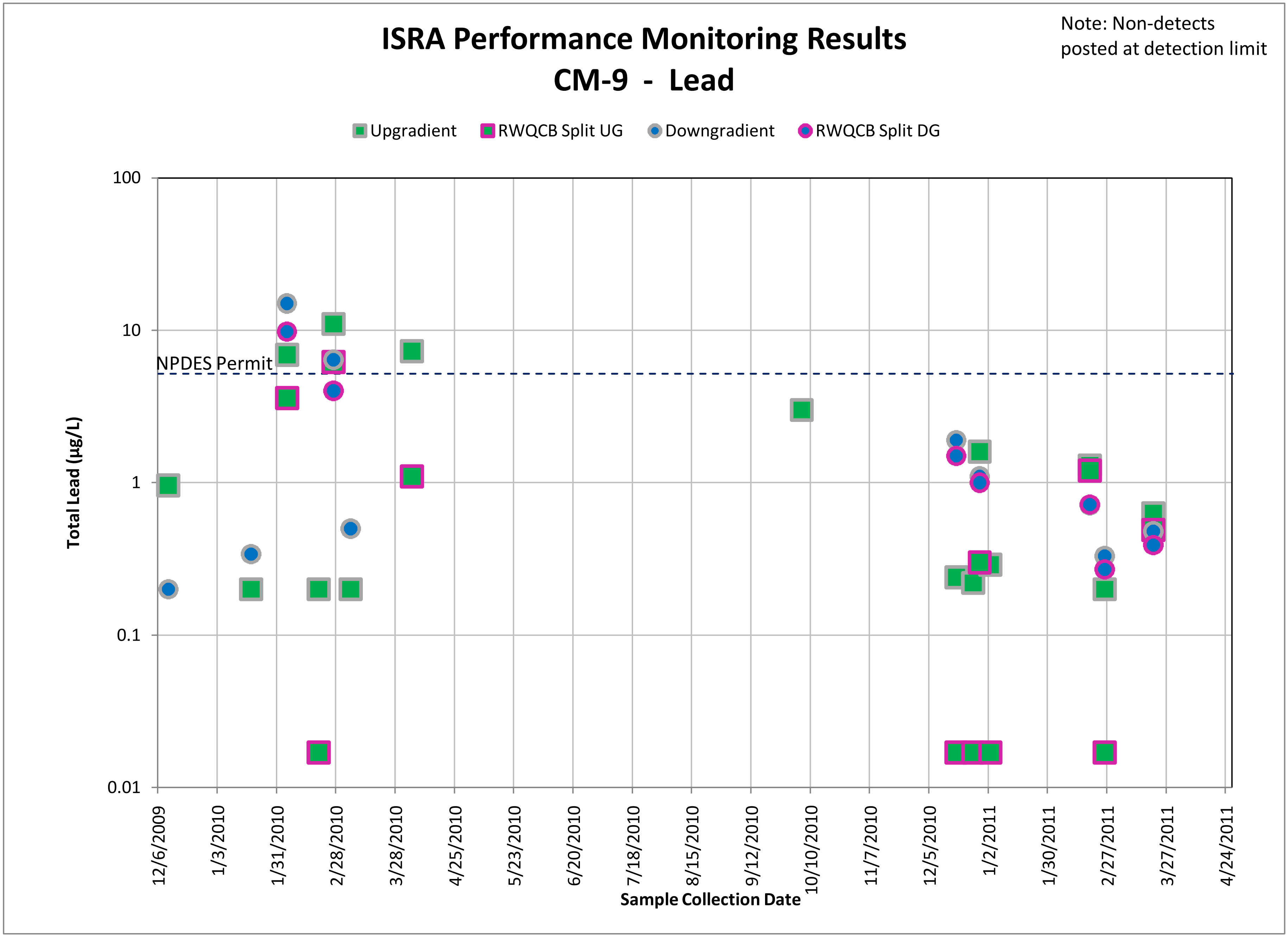
ISRA Performance Monitoring Results
B-1 Copper
Note: Non-detects posted at detection limit
UG Southwest (B1SW0011)
UG Northeast (B1SW0002)
Downgradient
RWQCB Split (B1SW0011)
RWQCB Split (B1SW0002)
RWQCB Split DG
NPDES Permit
Total Copper (µg/L)
100
10
1
0.1
0.01
1/1/2011
1/15/2011
1/29/2011
2/12/2011
2/26/2011
3/12/2011
3/26/2011
4/9/2011
4/23/2011
Sample Collection Date

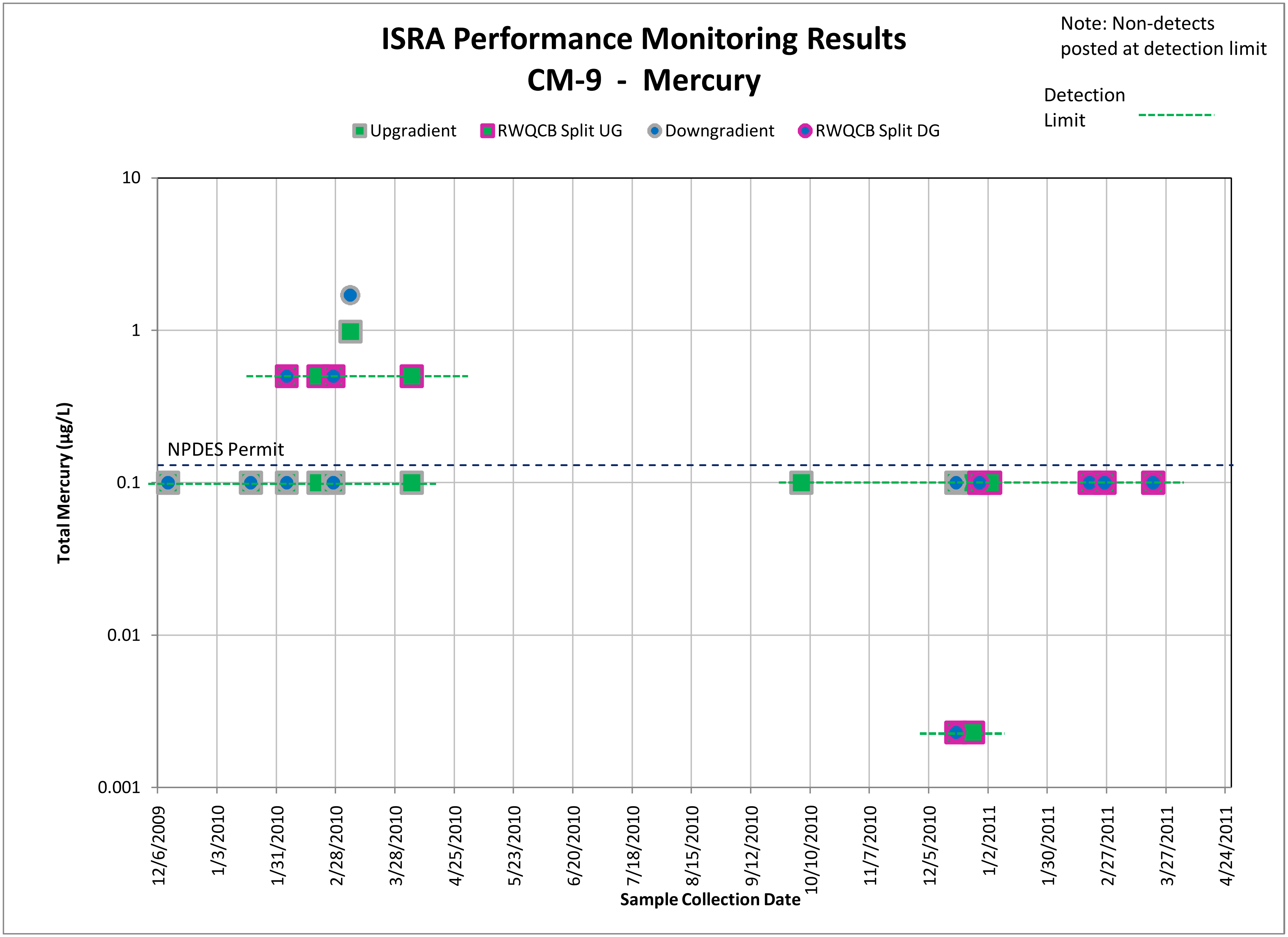


ISRA Performance Monitoring Results
B-1 Lead
Note: Non-detects posted at detection limit
UG Southwest (B1SW0011)
RWQCB Split (B1SW0011)
UG Northeast (B1SW0002)
RWQCB Split (B1SW0002)
Downgradient
RWQCB Split DG
NPDES Permit
Total Lead (µg/L)
100
10
1
0.1
0.01
1/1/2011
1/15/2011
1/29/2011
2/12/2011
2/26/2011
3/12/2011
3/26/2011
4/9/2011
4/23/2011
Sample Collection Date

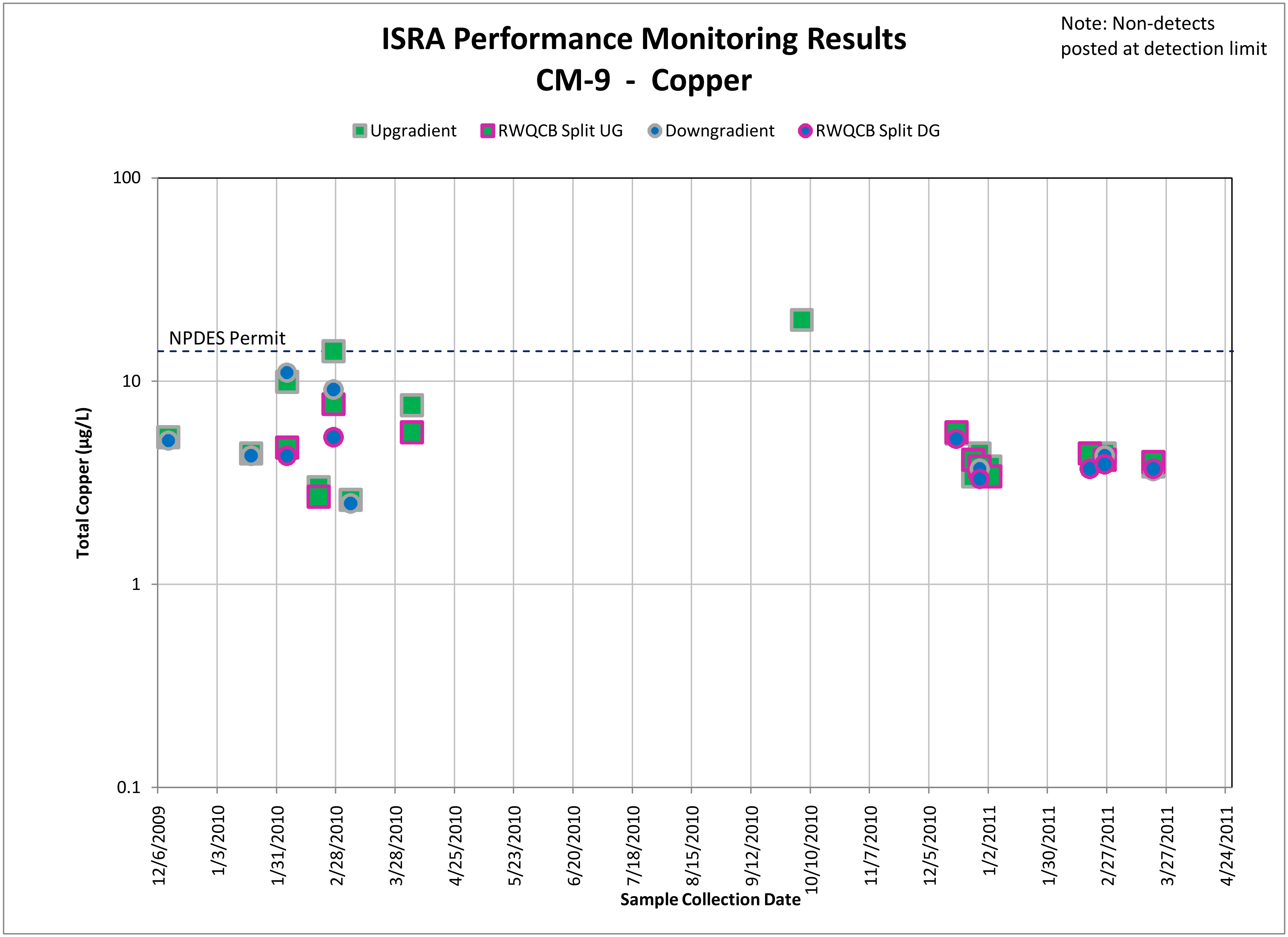

ISRA Performance Monitoring Results
B-1 - Dioxins
Note: Non-detects posted at detection limit
UG Southwest (B1SW0011)
UG Northeast (B1SW0002)
Downgradient
RWQCB Split (B1SW0011)
RWQCB Split (B1SW0011)
RWQCB Split DG
TCDD TEQ no-DNQ (µg/L)
1.00E-04
1.00E-05
1.00E-06
1.00E-07
1.00E-08
1.00E-09
1.00E-10
1.00E-11
1.00E-12
1.00E-13
ND
NPDES Permit
1/1/2011
1/15/2011
1/29/2011
2/12/2011
2/26/2011
3/12/2011
3/26/2011
4/9/2011
4/23/2011
Sample Collection Date


ISRA Performance Monitoring Results
CM-8 - Lead
Note: Non-detects posted at detection limit
Upgradient
RWQCB Split UG
Downgradient
RWQCB Split DG
NPDES Permit
Total Lead (µg/L)
100
10
1
0.1
0.01
12/6/2009
1/3/2010
1/31/2010
2/28/2010
3/28/2010
4/25/2010
5/23/2010
6/20/2010
7/18/2010
8/15/2010
9/12/2010
10/10/2010
11/7/2010
12/5/2010
1/2/2011
1/30/2011
2/27/2011
3/27/2011
4/24/2011
Sample Collection Date

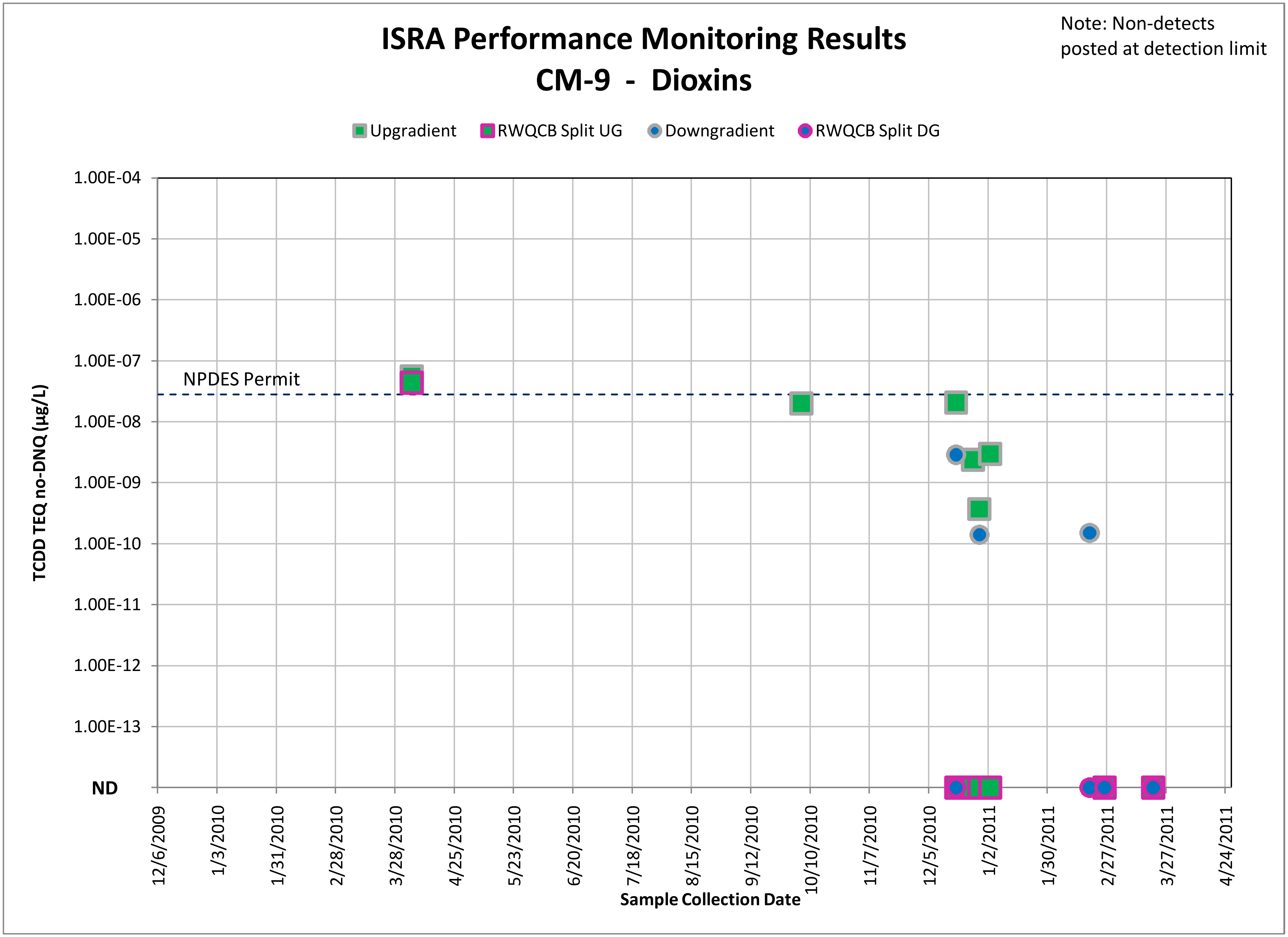

ISRA Performance Monitoring Results
CM-9 - Lead
Note: Non-detects posted at detection limit
Upgradient
RWQCB Split UG
Downgradient
RWQCB Split DG
NPDES Permit
Total Lead (µg/L)
100
10
1
0.1
0.01
12/6/2009
1/3/2010
1/31/2010
2/28/2010
3/28/2010
4/25/2010
5/23/2010
6/20/2010
7/18/2010
8/15/2010
9/12/2010
10/10/2010
11/7/2010
12/5/2010
1/2/2011
1/30/2011
2/27/2011
3/27/2011
4/24/2011
Sample Collection Date

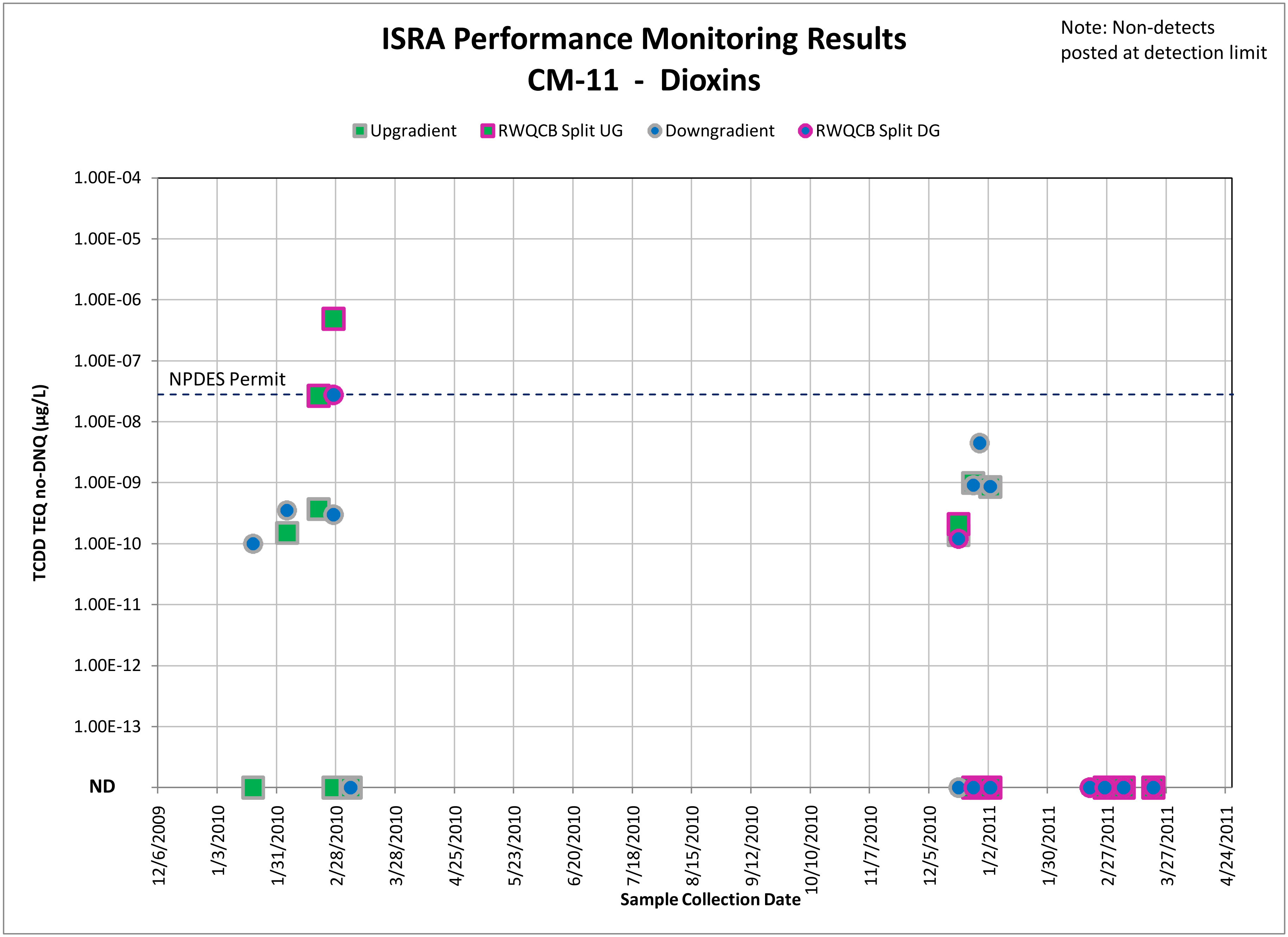


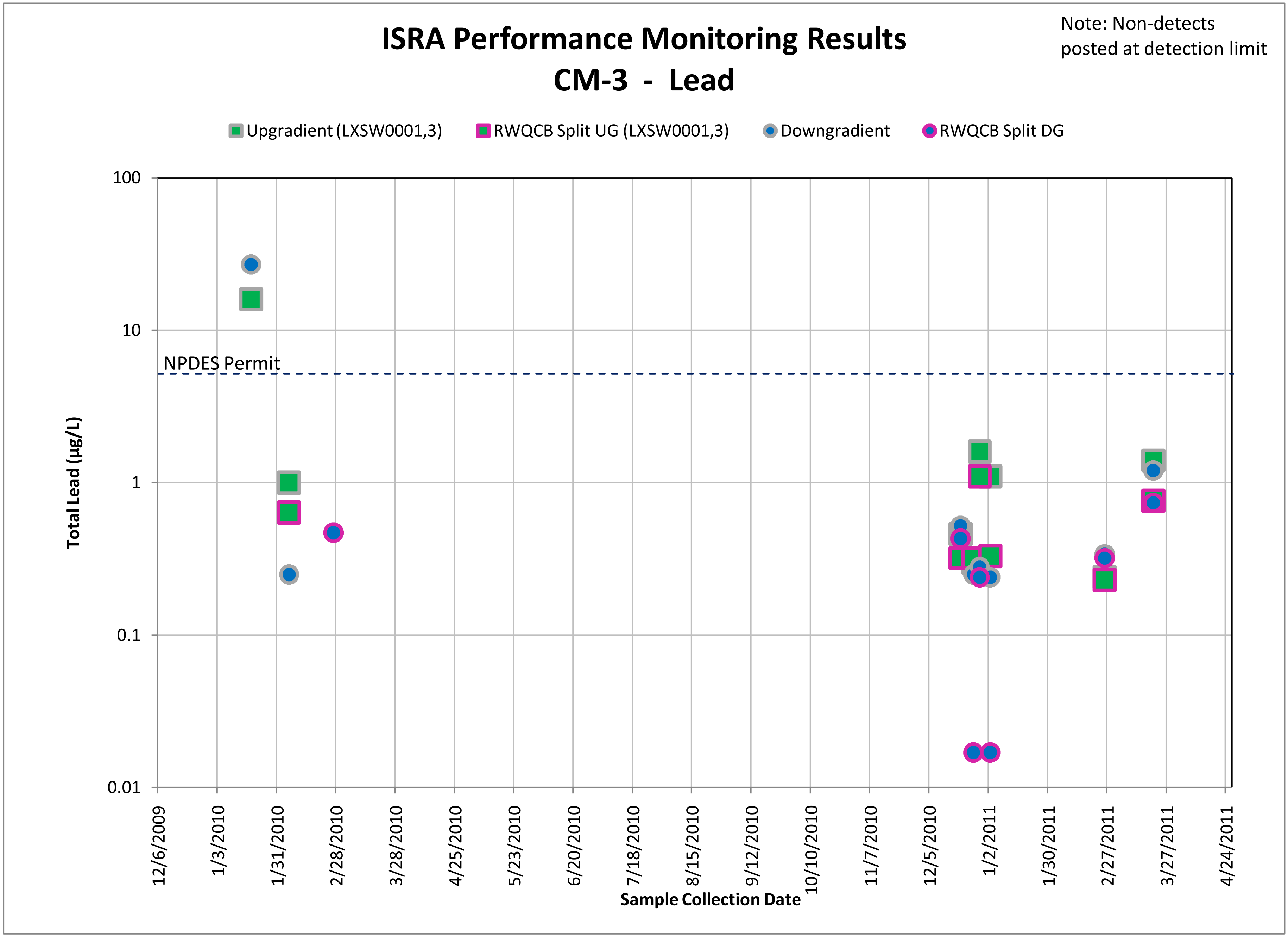
ISRA Performance Monitoring Results
CM-9 - Mercury
Note: Non-detects posted at detection limit
Detection Limit
Upgradient
RWQCB Split UG
Downgradient
RWQCB Split DG
NPDES Permit
Total Mercury (µg/L)
10
1
0.1
0.01
0.001
12/6/2009
1/3/2010
1/31/2010
2/28/2010
3/28/2010
4/25/2010
5/23/2010
6/20/2010
7/18/2010
8/15/2010
9/12/2010
10/10/2010
11/7/2010
12/5/2010
1/2/2011
1/30/2011
2/27/2011
3/27/2011
4/24/2011
Sample Collection Date



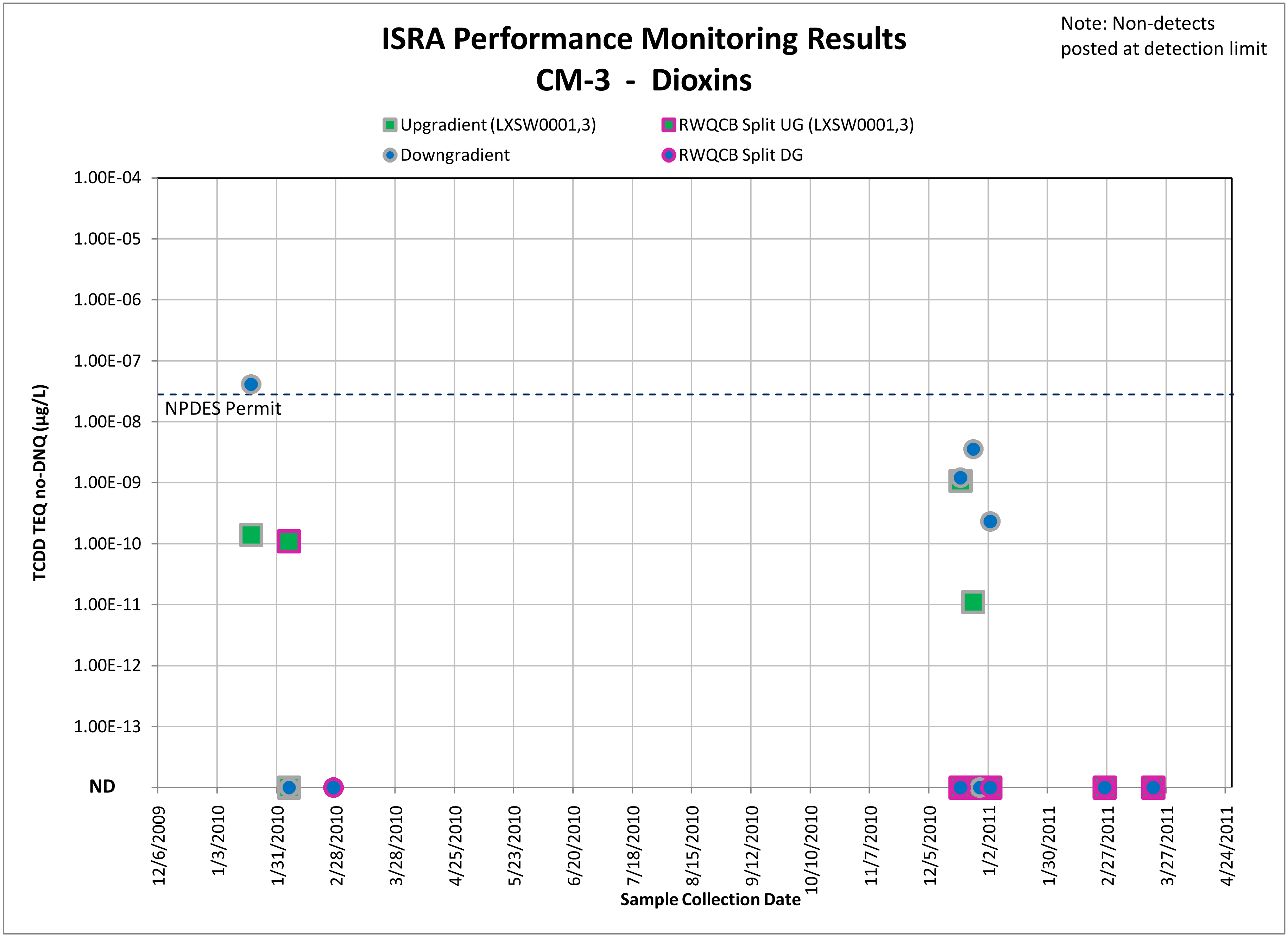
ISRA Performance Monitoring Results
CM-9 - Copper
Note: Non-detects posted at detection limit
Upgradient
RWQCB Split UG
Downgradient
RWQCB Split DG
NPDES Permit
Total Copper (µg/L)
100
10
1
0.1
12/6/2009
1/3/2010
1/31/2010
2/28/2010
3/28/2010
4/25/2010
5/23/2010
6/20/2010
7/18/2010
8/15/2010
9/12/2010
10/10/2010
11/7/2010
12/5/2010
1/2/2011
1/30/2011
2/27/2011
3/27/2011
4/24/2011
Sample Collection Date


ISRA Performance Monitoring Results
CM-9 - Dioxins
Note: Non-detects posted at detection limit
Upgradient
RWQCB Split UG
Downgradient
RWQCB Split DG
NPDES Permit
TCDD TEQ no-DNQ (µg/L)
1.00E-04
1.00E-05
1.00E-06
1.00E-07
1.00E-08
1.00E-09
1.00E-10
1.00E-11
1.00E-12
1.00E-13
ND
12/6/2009
1/3/2010
1/31/2010
2/28/2010
3/28/2010
4/25/2010
5/23/2010
6/20/2010
7/18/2010
8/15/2010
9/12/2010
10/10/2010
11/7/2010
12/5/2010
1/2/2011
1/30/2011
2/27/2011
3/27/2011
4/24/2011
Sample Collection Date

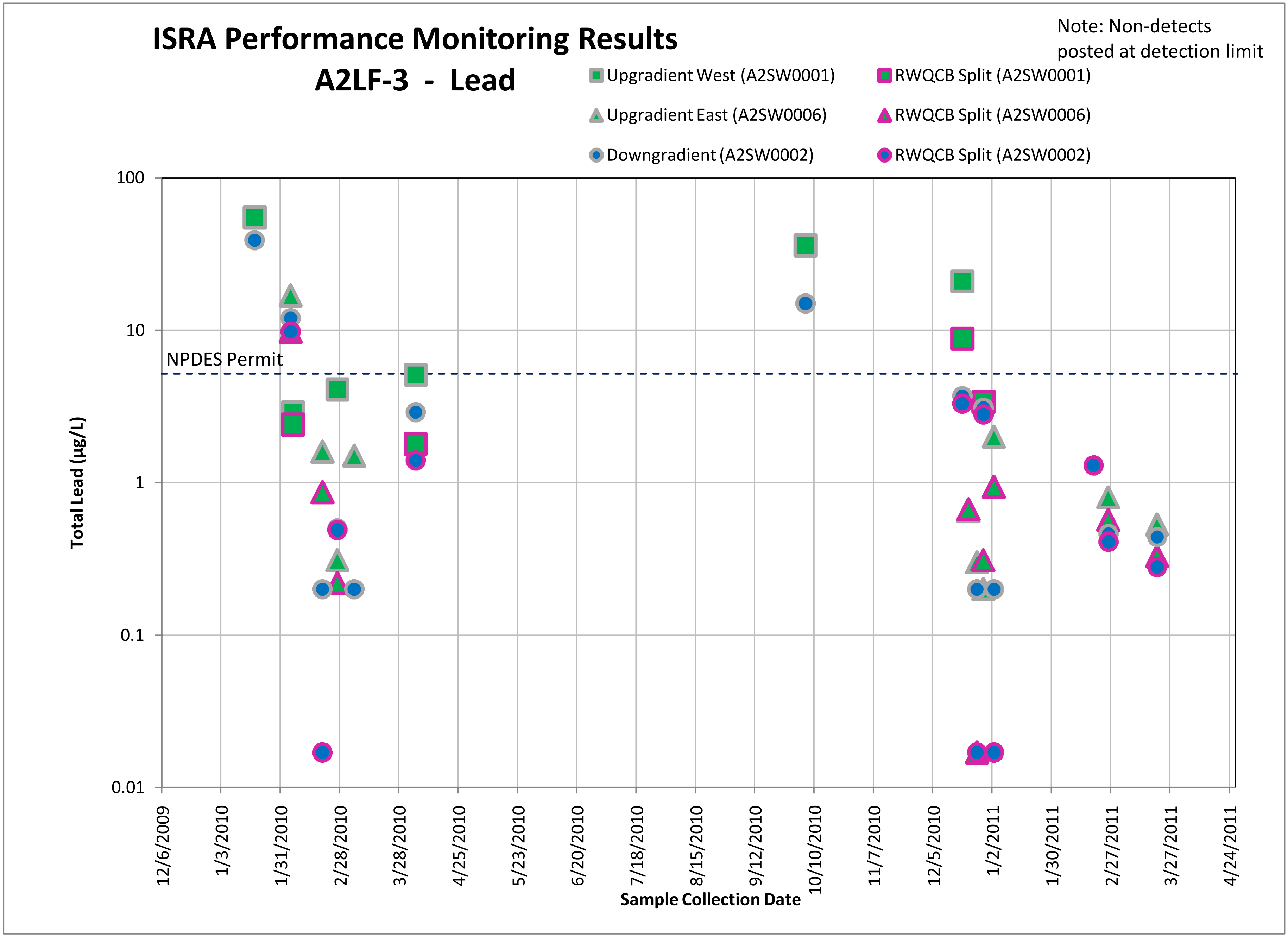

ISRA Performance Monitoring Results
CM-11 - Dioxins
Note: Non-detects posted at detection limit
Upgradient
RWQCB Split UG
Downgradient
RWQCB Split DG
TCDD TEQ no-DNQ (µg/L)
1.00E-04
1.00E-05
1.00E-06
1.00E-07
1.00E-08
1.00E-09
1.00E-10
1.00E-11
1.00E-12
1.00E-13
ND
NPDES Permit
12/6/2009
1/3/2010
1/31/2010
2/28/2010
3/28/2010
4/25/2010
5/23/2010
6/20/2010
7/18/2010
8/15/2010
9/12/2010
10/10/2010
11/7/2010
12/5/2010
1/2/2011
1/30/2011
2/27/2011
3/27/2011
4/24/2011
Sample Collection Date



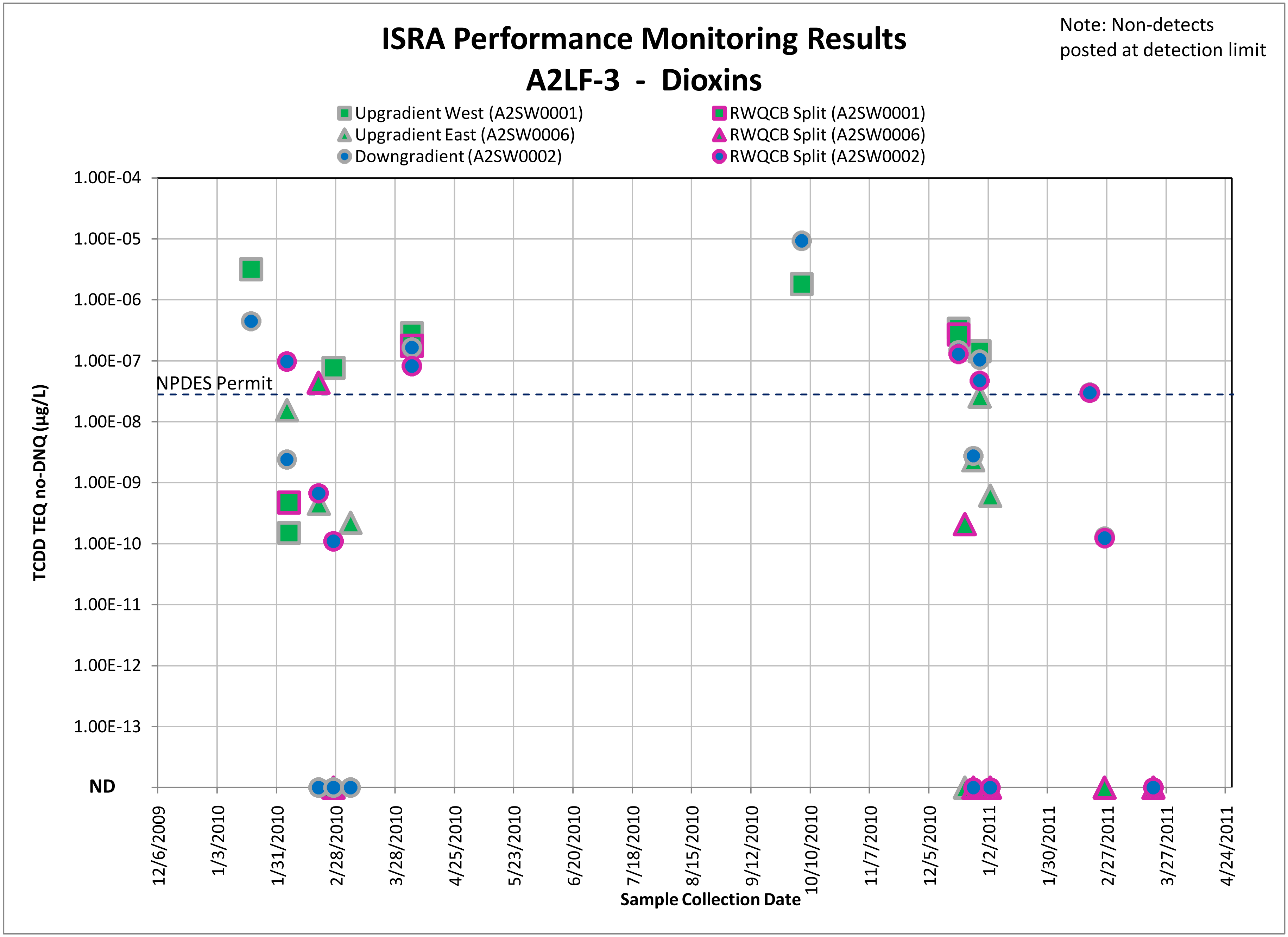
ISRA Performance Monitoring Results
CM-3 - Lead
Note: Non-detects posted at detection limit
Upgradient (LXSW0001,3)
RWQCB Split UG (LXSW0001,3)
Downgradient
RWQCB Split DG
NPDES Permit
Total Lead (µg/L)
100
10
1
0.1
0.01
Sample Collection Date
12/6/2009
1/3/2010
1/31/2010
2/28/2010
3/28/2010
4/25/2010
5/23/2010
6/20/2010
7/18/2010
8/15/2010
9/12/2010
10/10/2010
11/7/2010
12/5/2010
1/2/2011
1/30/2011
2/27/2011
3/27/2011
4/24/2011



ISRA Performance Monitoring Results
CM-3 - Dioxins
Note: Non-detects posted at detection limit
Upgradient (LXSW0001,3)
RWQCB Split UG (LXSW0001,3)
Downgradient
RWQCB Split DG
TCDD TEQ no-DNQ (µg/L)
1.00E-04
1.00E-05
1.00E-06
1.00E-07
1.00E-08
1.00E-09
1.00E-10
1.00E-11
1.00E-12
1.00E-13
ND
NPDES Permit
12/6/2009
1/3/2010
1/31/2010
2/28/2010
3/28/2010
4/25/2010
5/23/2010
6/20/2010
7/18/2010
8/15/2010
9/12/2010
10/10/2010
11/7/2010
12/5/2010
1/2/2011
1/30/2011
2/27/2011
3/27/2011
4/24/2011
Sample Collection Date



ISRA Performance Monitoring Results
A2LF-3 - Lead
Note: Non-detects posted at detection limit
Upgradient West (A2SW0001)
RWQCB Split (A2SW0001)
Upgradient East (A2SW0006)
RWQCB Split (A2SW0006)
Downgradient (A2SW0002)
RWQCB Split (A2SW0002)
NPDES Permit
Total Lead (µg/L)
100
10
1
0.1
0.01
12/6/2009
1/3/2010
1/31/2010
2/28/2010
3/28/2010
4/25/2010
5/23/2010
6/20/2010
7/18/2010
8/15/2010
9/12/2010
10/10/2010
11/7/2010
12/5/2010
1/2/2011
1/30/2011
2/27/2011
3/27/2011
4/24/2011
Sample Collection Date

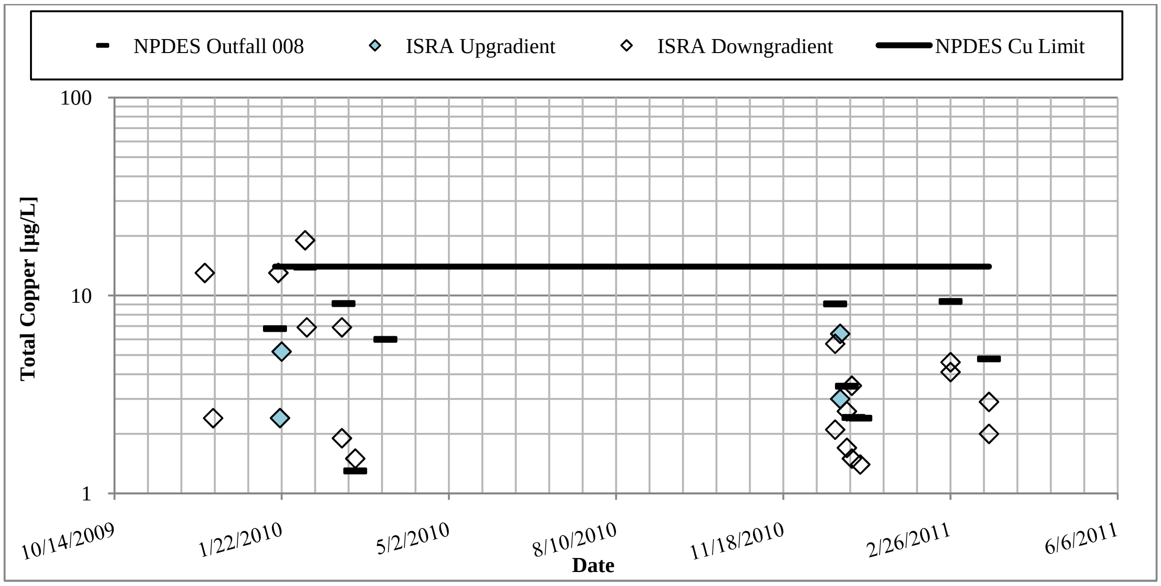

ISRA Performance Monitoring Results
A2LF-3 - Dioxins
Note: Non-detects posted at detection limit
Upgradient West (A2SW0001)
Upgradient East (A2SW0006)
Downgradient (A2SW0002)
RWQCB Split (A2SW0001)
RWQCB Split (A2SW0006)
RWQCB Split (A2SW0002)
NPDES Permit
TCDD TEQ no-DNQ (µg/L)
1.00E-04
1.00E-05
1.00E-06
1.00E-07
1.00E-08
1.00E-09
1.00E-10
1.00E-11
1.00E-12
1.00E-13
ND
12/6/2009
1/3/2010
1/31/2010
2/28/2010
3/28/2010
4/25/2010
5/23/2010
6/20/2010
7/18/2010
8/15/2010
9/12/2010
10/10/2010
11/7/2010
12/5/2010
1/2/2011
1/30/2011
2/27/2011
3/27/2011
4/24/2011
Sample Collection Date

APPENDIX D-2

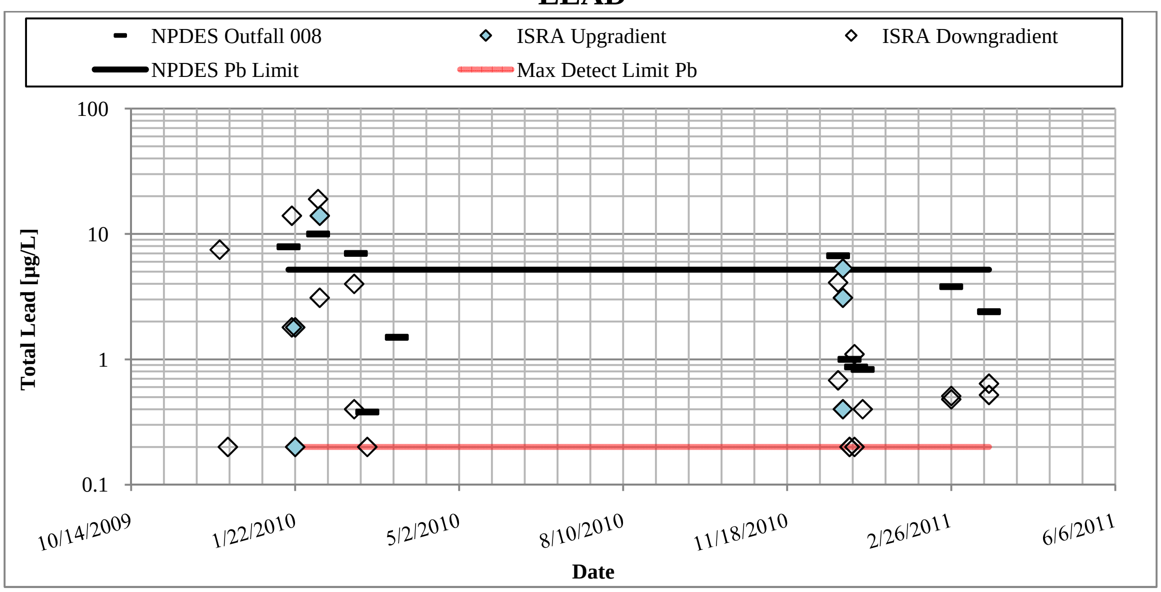
PERFORMANCE MONITORING DATA GRAPHS VS. TIME – BY OUTFALL

OUTFALL 008 TIME-SERIES CHARTS
ISRA PERFORMANCE MONITORING PROGRAM

COPPER

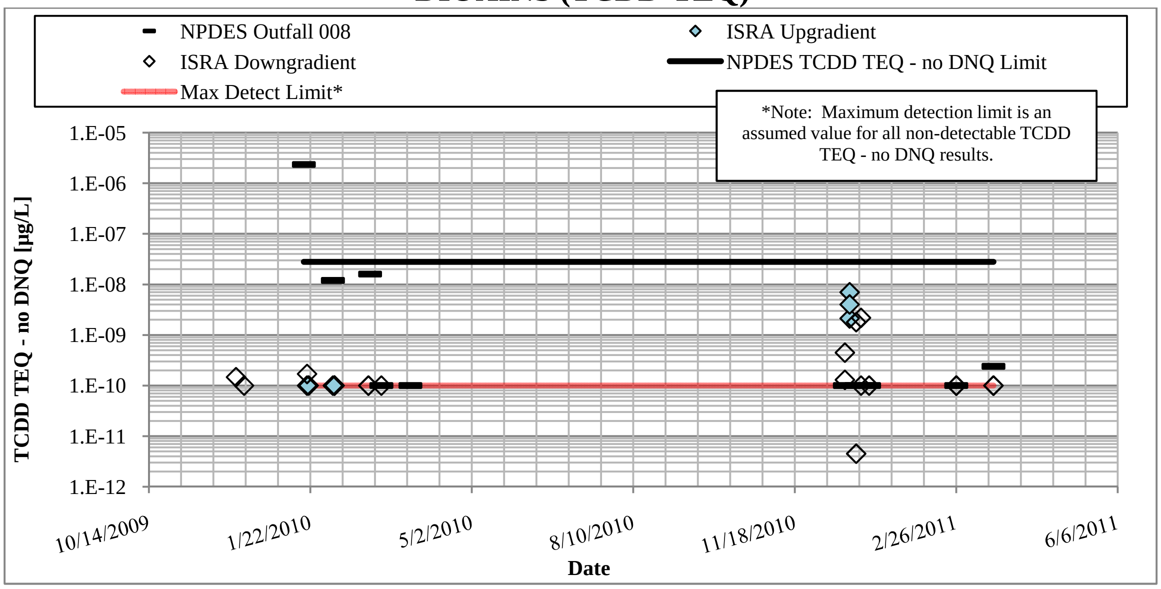


LEAD



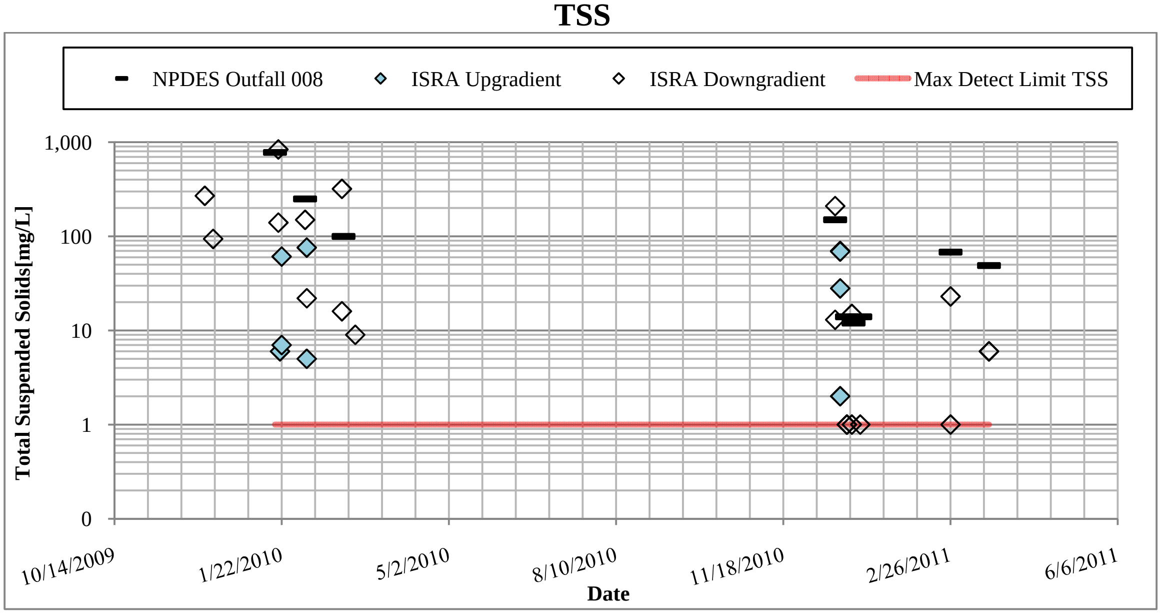
OUTFALL 008 TIME-SERIES CHARTS (CONTINUED)
ISRA PERFORMANCE MONITORING PROGRAM

DIOXINS (TCDD-TEQ)



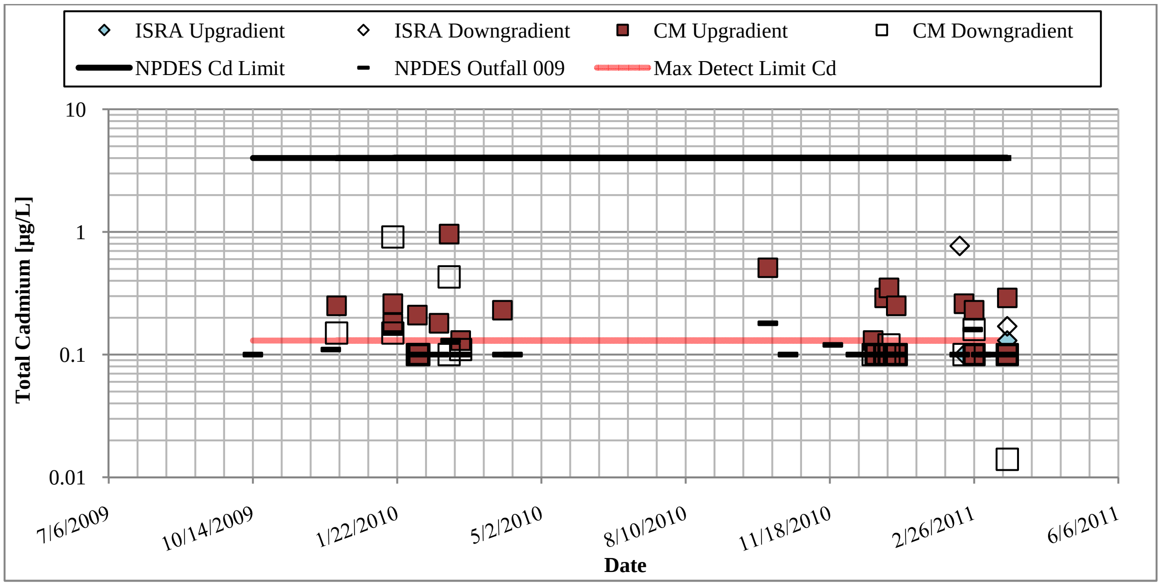
Note: Dioxin TEQ concentrations for NPDES samples collected during the 2010/2011 rainy season were calculated per the NPDES permit adopted on June 3, 2010 by multiplying each congener concentration by its respective TEF and BEF, and excluding congener DNQ results. Dioxin TEQ concentrations for NPDES samples collected prior to the 2010/2011 rainy season were calculated per pervious NPDES permits by multiplying each congener concentration by only its respective TEF, and excluding congener DNQ results.

TSS

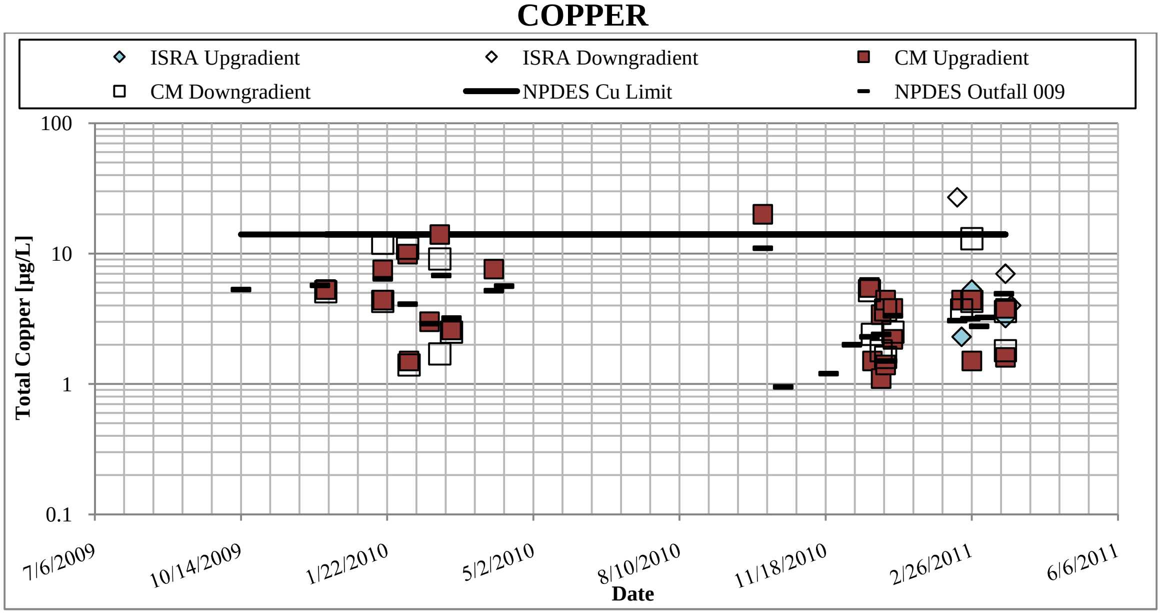


OUTFALL 009 TIME-SERIES CHARTS
ISRA PERFORMANCE MONITORING PROGRAM

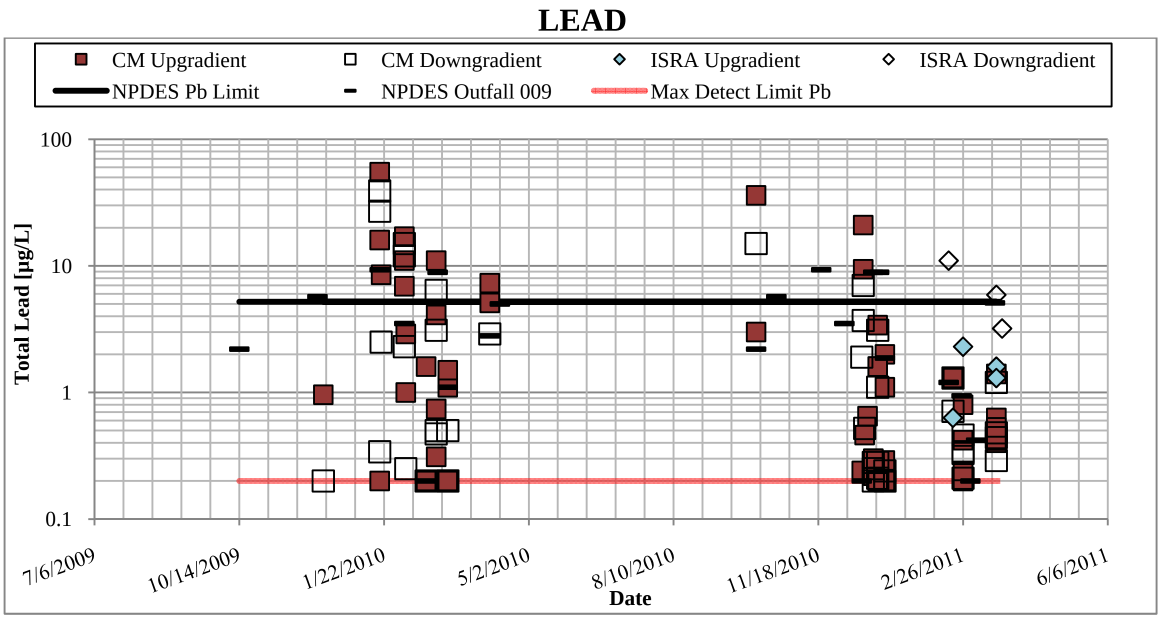
CADMIUM

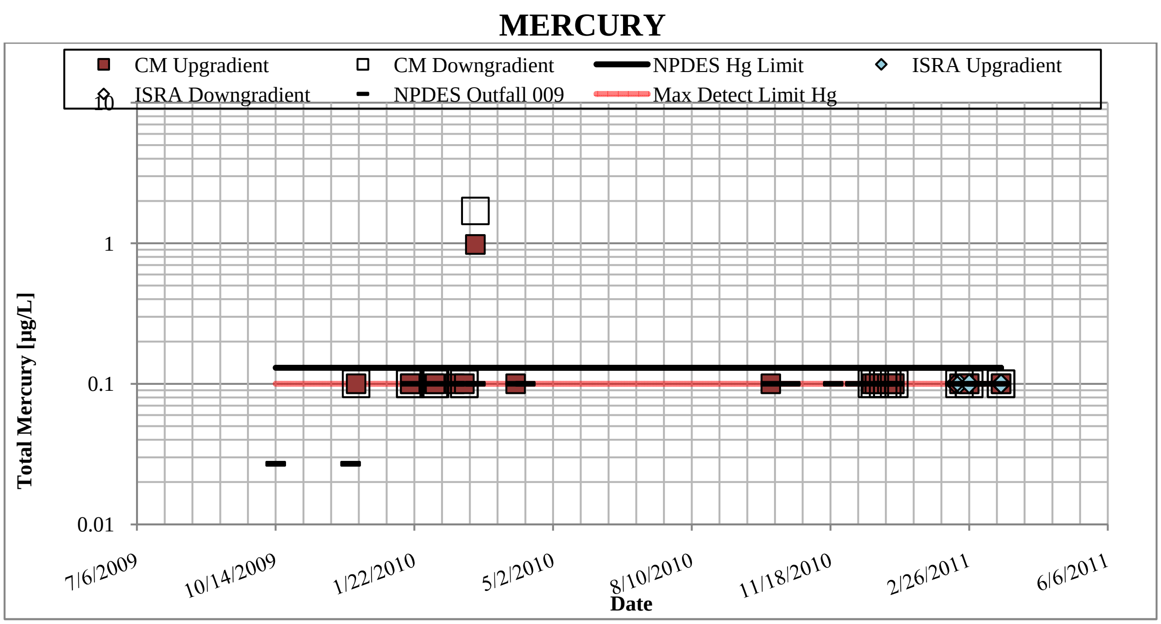


COPPER



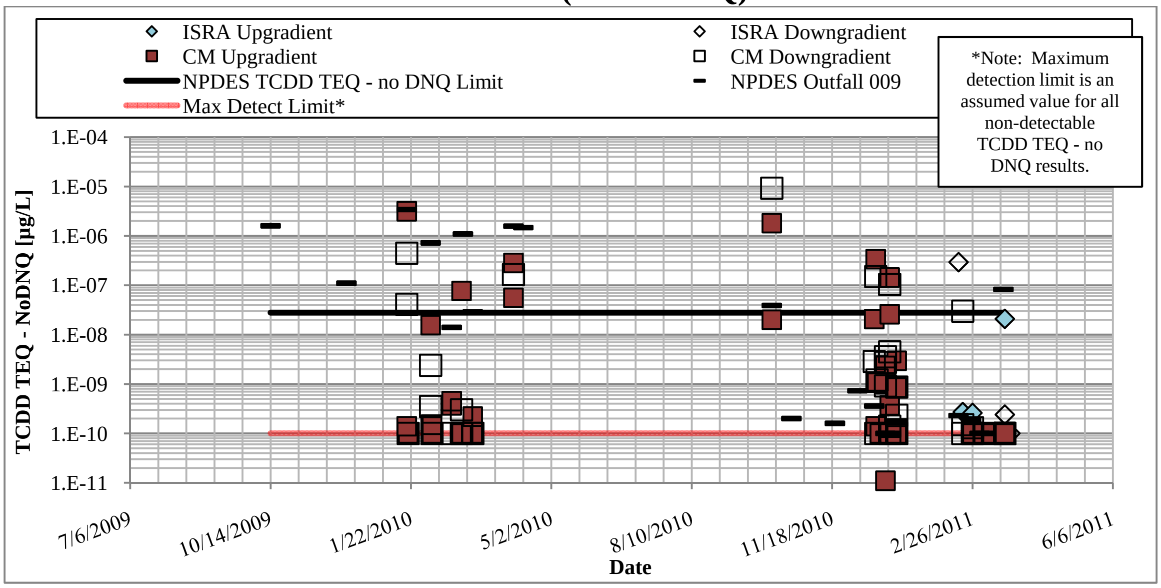
OUTFALL 009 TIME-SERIES CHARTS (CONTINUED)
ISRA PERFORMANCE MONITORING PROGRAM





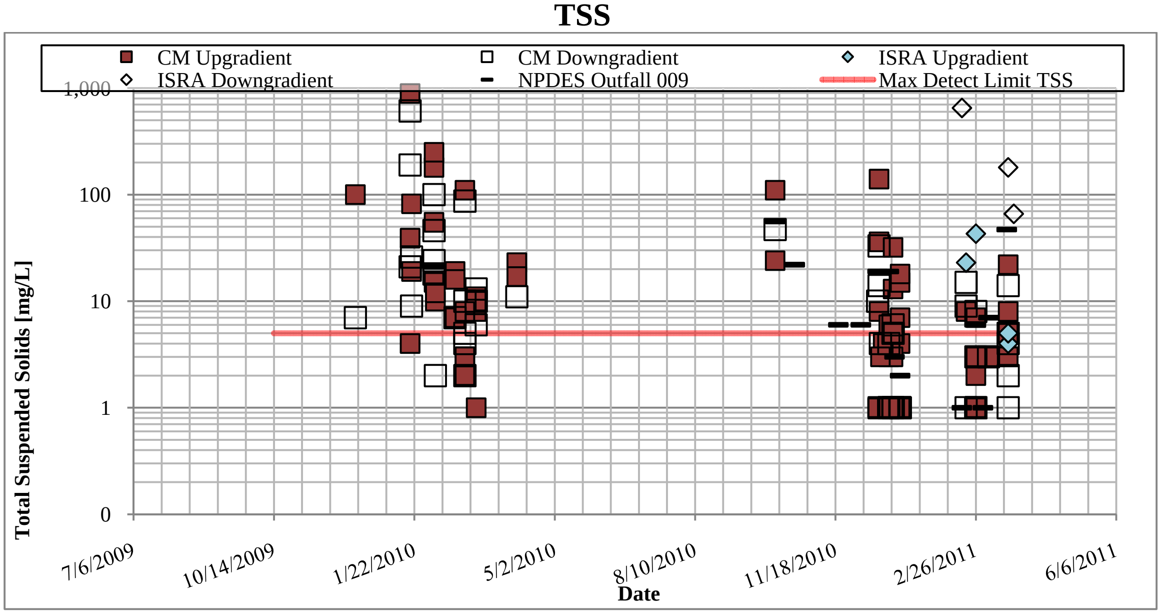
OUTFALL 009 TIME-SERIES CHARTS (CONTINUED)
ISRA PERFORMANCE MONITORING PROGRAM

DIOXINS (TCDD TEQ)



Note: Dioxin TEQ concentrations for NPDES samples collected during the 2010/2011 rainy season were calculated per the NPDES permit adopted on June 3, 2010 by multiplying each congener concentration by its respective TEF and BEF, and excluding congener DNQ results. Dioxin TEQ concentrations for NPDES samples collected prior to the 2010/2011 rainy season were calculated per pervious NPDES permits by multiplying each congener concentration by only its respective TEF, and excluding congener DNQ results.

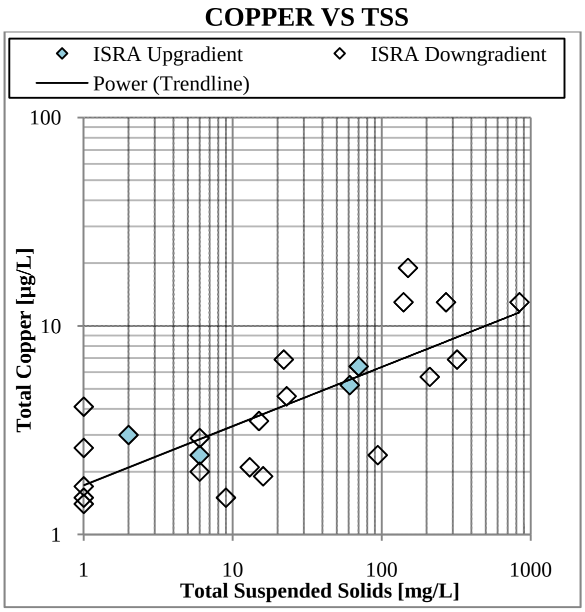
TSS

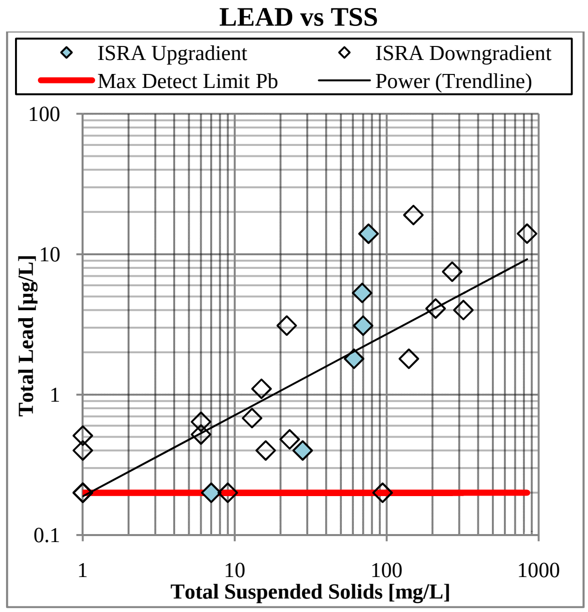


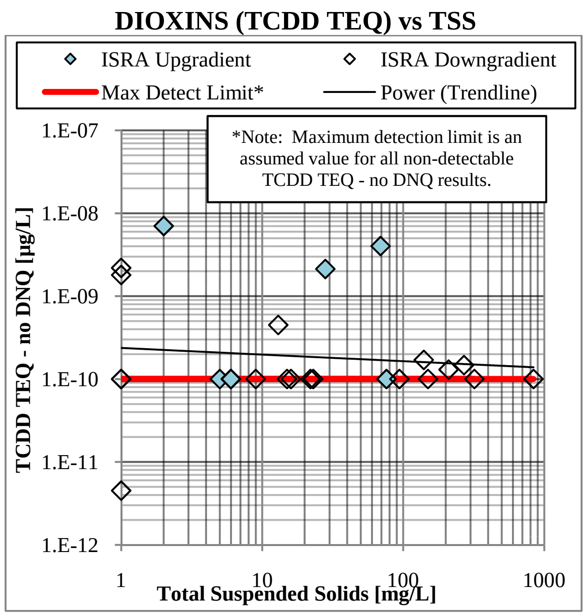
APPENDIX D-3

PERFORMANCE MONITORING DATA GRAPHS – COC CORRELATIONS

OUTFALL 008 CORRELATION CHARTS
ISRA PERFORMANCE MONITORING PROGRAM

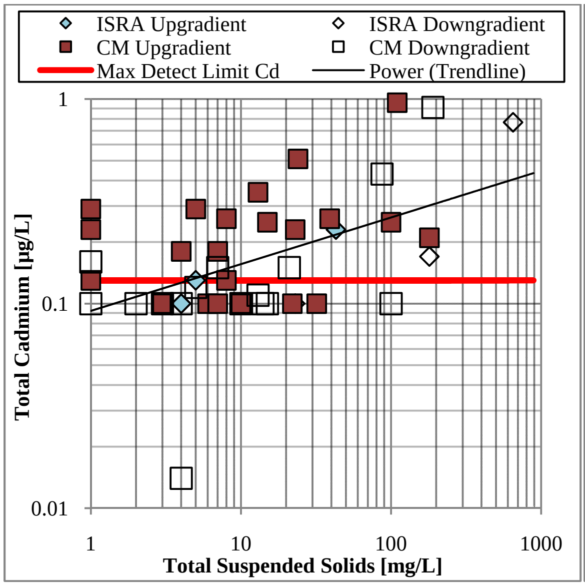




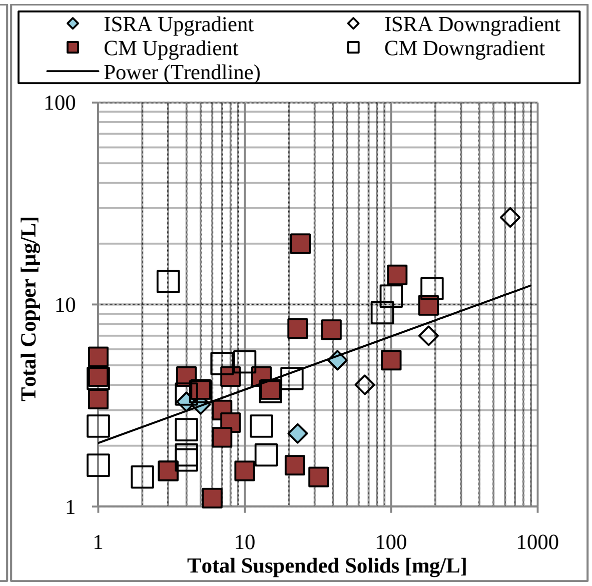


OUTFALL 009 CORRELATION CHARTS
ISRA PERFORMANCE MONITORING PROGRAM

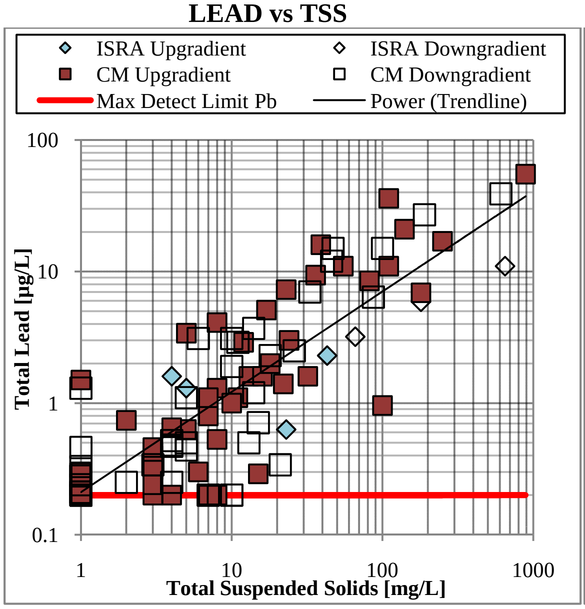
CADMIUM vs TSS



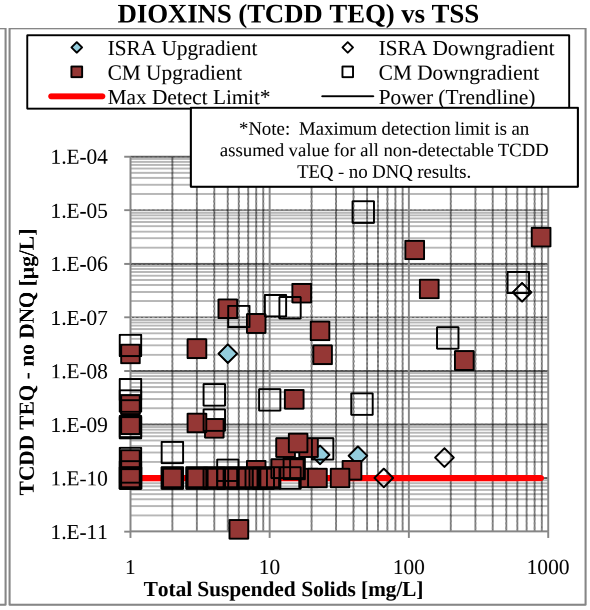
COPPER vs TSS



LEAD vs TSS



DIOXINS (TCDD TEQ) vs TSS



APPENDIX E

SAMPLE SPLIT EVALUATION

Memorandum

Date: 27 July 2011

To: The Boeing Company (Boeing), Santa Susana Field Laboratory

From: Geosyntec Consultants and the Stormwater Expert Panel

Subject: Sample Split Evaluation, Santa Susana Field Laboratory
Geosyntec Project: SB0363R

Background

The Boeing Company's (Boeing) Santa Susana Field Laboratory (SSFL) is located in the Simi Hills near the Los Angeles/Ventura County line. Part of Boeing's stormwater monitoring program includes sampling at Interim Source Removal Action (ISRA) and culvert modification (CM) monitoring locations[1]. Stormwater sampling at these locations began in December of 2009. Sample splits were analyzed as part of the stormwater monitoring quality control (QC) program since February of 2010. Splits are typically one sample divided into two subsamples (either in the field or at the laboratory), where one subsample (the "sample") would be analyzed at the project lab and the other subsample (the "split") would be analyzed at an independent lab (in this case, the RWQCB laboratory). Early in Boeing's sampling program, a replicate sample was collected by filling a secondary container (the split) after filling the primary container (the sample) at the time of sample collection in the field. Due to inherent difficulties when collecting the two samples containing sediment, or through user error, it is hypothesized that this method may not have resulted in the collection of a true split, or replicate sample. As such, a USGS-Dekaport (cone) splitter was implemented on February 16, 2011. The USGS developed this new sample splitter for use in the field to split a single collected sample into two or more identical samples. This was done after they found that prior methods resulted in errors, especially for surface water samples that contained significant amounts of solids.

The Dekaport splitter is a positive pour device that composites and splits the sample in one step, in a manner that largely compensates for the different settling rates of various sized sediments. Use of the Dekaport cone splitter was expected to improve analytical consistency between split samples containing significant concentrations of suspended sediments to which the SSFL NPDES Pollutants of Concern (POCs) sorb; at low sediment concentrations, analytical inconsistencies will still have to be attributed to variability in other laboratory or sampling procedures. Proper sampling procedures for this location and the new Dekaport sampling splitter

[1] Sample locations with paired data included in this analysis include B1-2, CM-1/A2LF-3, CM-11, CM-3, CM-8, CM-9/A1LF, CTLI, CYN-1/DRG-1, HVS, HVS-1, HVS-2A, HVS-2A/-2D, HVS-2B-1/-2, and HVS-3.

can be found in the document *Environmental Sampling of Dioxins and Other Low Solubility Pollutants at Parts-Per-Billion and Lower Concentrations: Field Protocols for Collecting SSFL ISRA Performance Samples and Obtaining Splits Using a Dekaport Cone Splitter* (WWE and Expert Panel, 2010).

Purpose

The purpose of this analysis is to evaluate the precision and accuracy of the sample and split results both before and after implementation of the Dekaport splitter. The reliability of the RWQCB laboratory, manual split results, and Dekaport split results are also evaluated through this analysis of split results.

Methodology

The accuracy and precision of the split sample results, before and after implementation of the Dekaport sampling splitter, have been evaluated for total suspended solids (TSS), TCDD dioxin (TEQ_noDNQ), total copper, and total lead by reporting the mean, coefficient of variation, and average split to sample ratio (a split to sample ratio close to one indicates comparable split to sample results, >1 indicates that split results tended to be greater than sample results, and <1 indicates the opposite). For the reporting of summary statistics and for plotting purposes, non-detect results were set at 0.5 times their detection limits[2] except for TCDD TEQ which assumed a value of 10^{-10} ug/L value for non-detect results, and J-flag results were included, again except for TCDD TEQ which did not include DNQ congener results (i.e., these were treated as zero). A nonparametric sign test (α=0.05) was applied to the paired data to assess if the two datasets were statistically significantly different. A paired dataset that is different with statistical significance is considered unbiased, i.e., split results are statistically significantly greater than or less than their paired sample results. To allow a visual evaluation of the statistical significance of each paired dataset, the data was plotted on a log scale with 95% confidence limits on the mean response and a linear regression forced through zero.

Results

A summary of the sample and split statistical analysis, prior to and after implementation of the Dekaport splitter in February of 2011, are summarized in Table 1. Over 350 pairs of observations were analyzed, with approximately 30 to 80 pairs of data for each pollutant using the manual split method and 20 to 40 pairs of data for each pollutant using the Dekaport splitter.

With the exception of copper, which had nearly an 80% difference between split and sample coefficients of variation (COVs), the variation observed between laboratories was similar during the manual split period, ranging from 0 to 26%. After implementation of the Dekaport splitter, the variation still ranged from 9 to 50%. This suggests that there was some variation in different

[2] The detection limits varied between laboratories and between samples. For this reason, rather than setting ND results equal in the nonparametric sign test, ND results were replaced with 0.5*MDL.

laboratory procedures introduced after sample collection and splitting, and that, regardless of improved splitting techniques, this variation remained. Variation could have been due to differences in sample handling, transit times, hold times, lab analytical practices, lab analysis/reporting procedures, post-lab data validation practices, or other influencing factors.

The nonparametric sign test resulted in p values of 0.036 for dioxin, 0.016 for copper, and 7.4 x 10^{-14} for lead; three of four POCs have split and sample results considered statistically significantly different (based on the $p<0.05$ criteria for significance). In the Dekaport split sample set, dioxin and lead have a p less than 0.05, at 0.007 and 1.6e-6 respectively, which suggests that despite Dekaport implementation, these split and sample results are still considered statistically significantly different. As additional data are collected using the Dekaport splitter, it is anticipated that the datasets will be less statistically significantly different for all of the POCs, with the exception of the manually split sample set, which will remain limited to what was collected in the early sample period.

In the sampling period prior to February of 2011, the absolute value of the split to sample ratios ranged from 0.85 (for copper) to 94 (for dioxin). After Dekaport sampler implementation, the absolute value of split to sample ratios improved (or became closer to one) for each unique pollutant of concern (POC), with a range of from 0.87 (for lead) to 2.7 (for TSS). Looking at the split to sample ratio of lead, which is considered unbiased for both the manual and Dekaport split samples, the ratio improves from 0.72 to 0.87. These results suggest that splits obtained using the Dekaport splitter are more reliable (or precise) than those collected by taking two replicate sample manually. However, looking at the split to sample ratios themselves suggests that despite the improved sampling methods, there was still significant variability between laboratories.

Table 1. Sample Split Statistical Analysis

		TSS (mg/L)	**Dioxin (µg/L)**	**Copper (µg/L)**	**Lead (µg/L)**
Total pairs of observations		116	87	56	96
Split Samples Collected Manually (February 2010 – January 2011)					
Pairs of observations		79	55	35	66
Average (COV)	Sample result	29 (2.0)	2.2e-8 (2.9)	4.6 (0.9)	3.2 (1.5)
	Split result	66 (2.7)	2.7e-8 (3.0)	3.2 (0.5)	1.8 (1.5)
Average split to sample ratio		3.7	94	0.85	0.72
p by paired nonparametric sign test		0.368	**0.036**	**0.016**	**7.4e-14**
Split Samples Collected using Dekaport Splitter (February 2011 – March 2011)					
Pairs of observations		37	32	21	30
Average (COV)	Sample result	31 (3.5)	1.1e-08 (4.8)	5.1 (1.1)	1.3 (1.6)
	Split result	37 (3.2)	2.7e-09 (3.9)	3.7 (0.9)	0.96 (1.3)
Average split to sample ratio		2.7	0.90	0.85	0.87
p by paired nonparametric sign test		0.511	**0.008**	0.064	**1.6e-06**

The following scatter plots depict the sample results plotted against the split results for each of the four POCs for all pre- and post-Dekaport data (Figures 1 to 4). Each plot contains the regression slope (based on all paired data, both sample and split) forced through zero and 95% confidence limits on the coefficient. Where the 1:1 slope line fits within the confidence limits, the data are considered reliable. For copper and lead, most of the data fall to the right of the 1:1 line, therefore the sample results are more often greater than the split results. However this does not necessarily indicate that a statistically significant bias exists (the statistical tests are necessary to base this conclusion).

TSS results are plotted in Figure 1. There is considerable scatter outside of the 95% confidence limits on the coefficient, particularly for the manually split results. The fact that scatter for the manually split results remains large at higher concentrations (above about 30 mg/L), while scatter for the Dekaport cone splits is greatly reduced in this range suggests that the splitter is working properly in compensating for difficulties in splitting sediment samples. The regression line does fall within the confidence limits, which suggests the data are reliable. Similar trends are observed for the dioxin correlation (Figure 2), with more scatter in the manually split results and the combined regression line falling within the 95% confidence limits.

Copper (Figure 3) shows a regression line outside of the 95% confidence limits, suggesting that this comparison of sample to split results is not reliable. Similar scatter is observed for both the manual and Dekaport split samples. Lead (Figure 4), which is also the only POC with statistically significantly different split and sample datasets by the nonparametric sign test, exhibits the strongest correlation of the POCs with a coefficient of determination of 0.80, and shows similar scatter between the manual and Dekaport split samples. This indicates that the lead split results are consistent with sample results both before and after use of the Dekaport splitter. Both copper and lead results show significant lab bias with sample results being consistently greater than split results (i.e., data fall to the right of the red dashed 1:1 line).

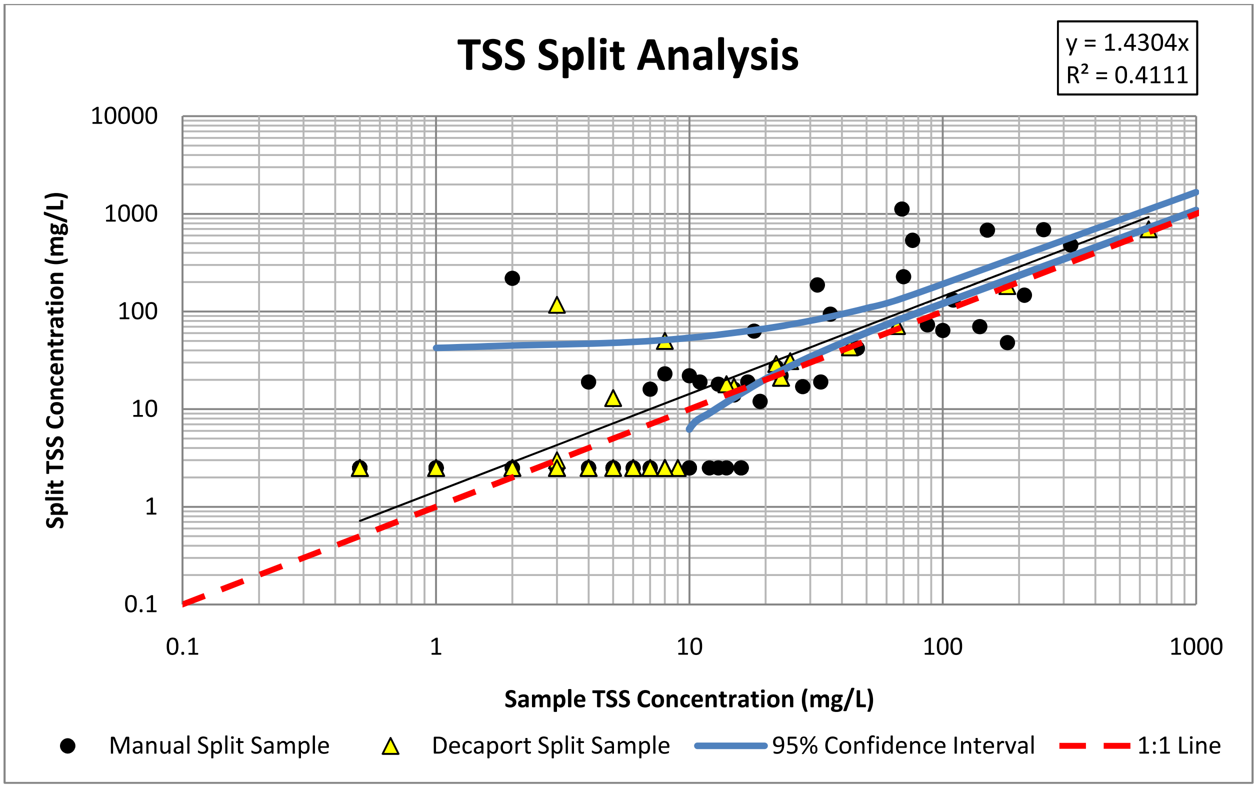


Figure 1. TSS Sample v. Split Results

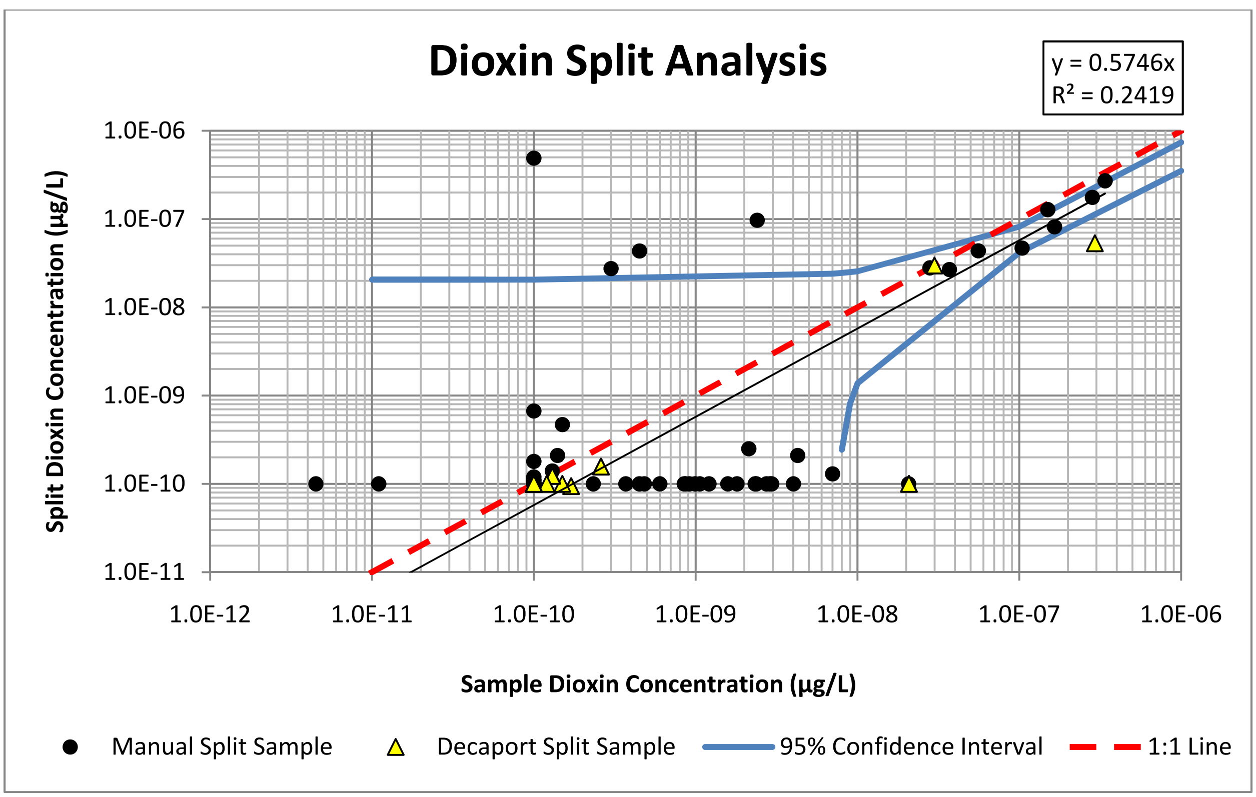


Figure 2. Dioxin Sample v. Split Results

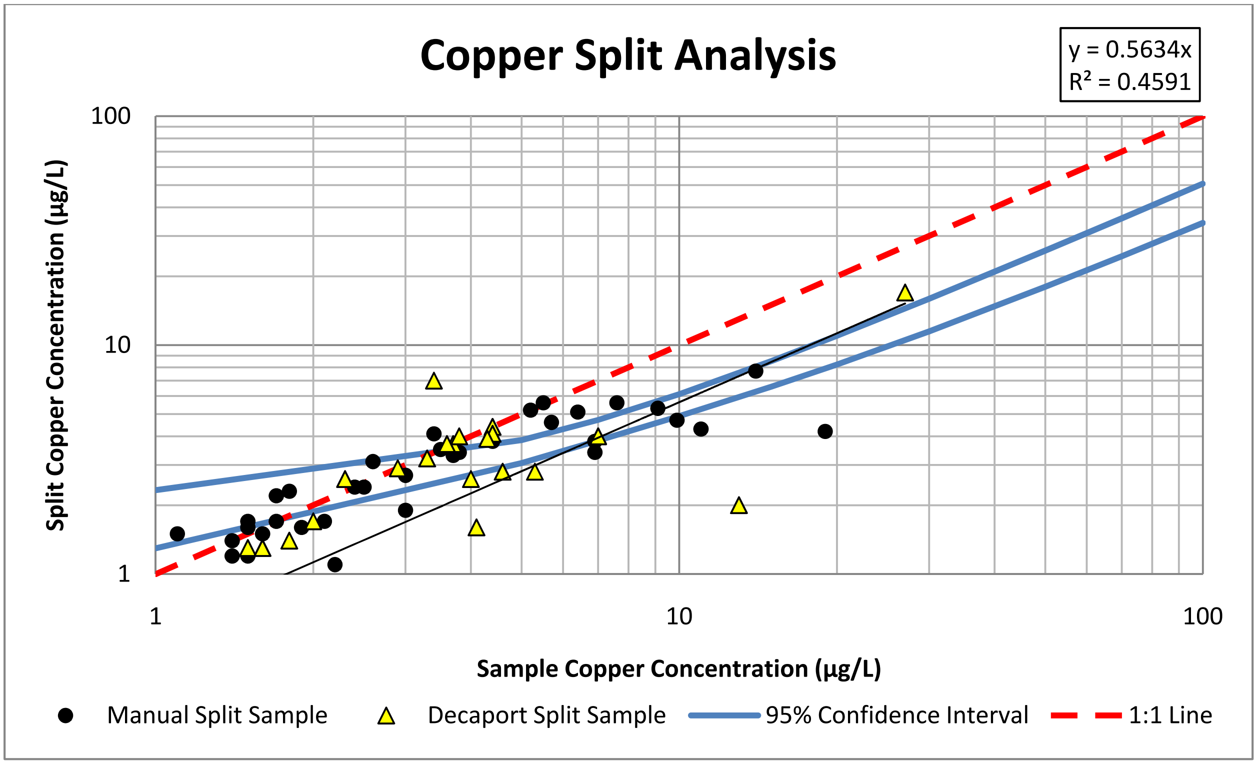


Figure 3. Copper Sample v. Split Results

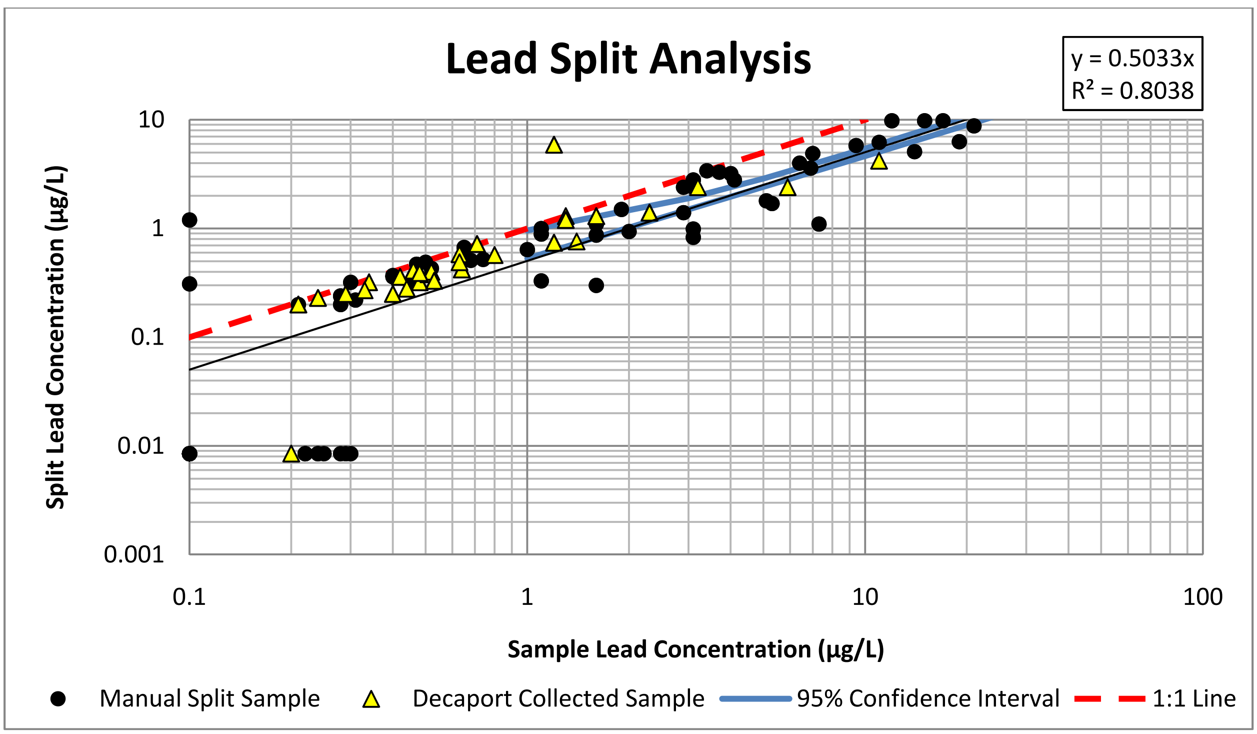


Figure 4. Lead Sample v. Split Results

Conclusions

- Based on the sample split statistical analysis, implementation of the Dekaport splitter generally appears to improve the correlation of split to sample results for all POCs evaluated.
- TSS results showed a strong correlation for samples collected post-Dekaport cone splitter implementation.
- Dioxin results were somewhat scattered but showed a decent correlations for samples with concentrations greater than 1e-8 µg/L (which are considered more accurate lab results) collected using the Dekaport cone splitter.
- Copper results showed a decent correlation but the regression fell outside of the 95% confidence intervals so both pre- and post-Dekaport split datasets are considered unreliable.
- Lead results showed a strong correlation for both pre- and post-Dekaport cone splitter implementation.
- A significant majority of sample results (i.e., analyzed by Boeing's lab) were greater than the split results (RWQCB lab) for copper and lead, indicating a bias that is possibly due to lab analysis methods. The Panel recommends a review of laboratory QA/QC methods to confirm that their standard analyses and other QA/QC results are all acceptable. Also, *Standard Methods*, and other literature should be reviewed to understand likely analytical error levels (although those results are usually very optimistic). As the Panel has recommended before, both labs should be sent a set of seven replicates of a standard as a double-blind test, for mixing in with the next SSFL sample batch. Additional double blind analyses should be periodically conducted during the monitoring season also, at least for copper and lead. TSS standards could be made from SilCoSil material (Dr. Pitt can provide additional detail upon request). Dioxin standard testing is not considered worth the additional cost at this time (particularly considering that significant lab bias was not observed in this data, possibly due to the high number of ND results), however as additional split results become available following the next monitoring season, this conclusion can be re-evaluated.
- Since the TSS data indicate that the Dekaport cone splitter is being used and functioning properly, it is possible that where data for specific POCs do not follow a reduction in scatter similar to that for TSS at sediment concentrations greater than about 30 mg/L, the discrepancies could be an indicator of differences in laboratory procedures. The value of this as an alert for checking laboratory QA/QC practices would have to be tested as additional data are collected.

References

WWE and Expert Panel, 2010. *Environmental Sampling of Dioxins and Other Low Solubility Pollutants at Parts-per-Billion and Lower Concentrations: Field Protocols for Collecting SSFL ISRA Performance Samples and Obtaining Replicate Splits Using a Dekaport Cone Splitter.* August 31.

* * * * *

APPENDIX F

PERFORMANCE MONITORING DATA EVALUATION

Memorandum

Date: 20 July 2011

To: The Boeing Company (Boeing), Santa Susana Field Laboratory

From: Geosyntec Consultants and the Storm Water Expert Panel

Subject: ISRA and CM Upgradient and Downgradient Analysis
Santa Susana Field Laboratory
Geosyntec Project: SB0363R

Data summarized below were collected at Boeing Santa Susana Field Laboratory (SSFL) between December 2009 and March 2011 from monitored culvert modification (CM) installations and Interim Source Removal Action (ISRA) locations. The purpose of this evaluation is to confirm whether 1) any of the excavated and stabilized ISRA areas are contributing pollutants of concern (POCs) (i.e., increasing concentrations as stormwater runoff sheetflows across each area), and 2) the CM treatment BMPs are reducing POCs (decreasing concentrations as stormwater ponds and filters through the media mounds and travels through each culvert liner). The POCs addressed in this analysis include total suspended solids (TSS), total copper, total lead, turbidity, and dioxin (TCDD TEQ, DNQ excluded).

Only paired data, or locations with both an upgradient and downgradient sample collected during the same storm event, are presented. Split samples, used for lab comparison purposes, are excluded from this analysis. The number of paired samples varies by constituent.

With respect to sampling at the CMs, upgradient grab samples are collected from flowing surface water upstream of the maximum extent of ponding observed to that date, with the ponded water created by the CM weir boards. When the extent of ponding increased at the CM-1 and CM-3 culvert basins on December 22, 2010 during heavy rain, the upgradient sample locations were moved upstream a sufficient distance to remain above the maximum ponded water footprint. CM downgradient grab samples are collected at the culvert outlets on the downstream side of the roads, where the culvert pipes discharge to the Northern Drainage. Flows from the culvert outlets may represent treated runoff (via sedimentation and media filtration in the CM) and partially treated runoff (flowing through or over the weir boards), in combination with other subsurface flows through the road embankment that may enter the culvert pipes at buried sections where the pipe is disconnected. In particular, at CM-3 where the slipline HDPE pipes that were inserted from both the upgradient and downgradient sides could not be sealed at the point where they meet, subsurface flows through the road embankment are known to have entered the pipe during rain events from February 2010 through March 2011 because water was observed discharging from the HDPE pipe outlet when no water was flowing into the inlet. Therefore CM-3 performance cannot be reliably assessed based on the downgradient sample results included here due to this sample contamination.

Finally, it should also be noted that CM-1 (upgradient-east), CM-3, CM-8, and CM-11 receive runoff from drainage areas that do not include any known historic industrial activities, although CM-3 area does include a clean soil borrow area at the top of the watershed. Therefore, upgradient sample results in general are relatively good quality, making it difficult to get additional POC reduction through the CMs.

1. LINE PLOTS

The following log-scale (with the exception of copper, which shows an arithmetic-scale y-axis) line plots illustrate the changes in measured concentration between upgradient and downgradient ISRA sampling locations for each set of ISRA and CM upgradient/downgradient sample pairs. The samples were obtained from ISRA locations CYN-1/DRG-1, CTLI, B1-2, A2LF-3, and A1LF and from CM locations CM-1, CM-3, CM-8, CM-9, and CM-11. At this time only downgradient samples have been collected at CTLI, so no paired data from this site has been included in the analysis. Similarly, while both upgradient and downgradient samples have been collected in the HVS area (Happy Valley), data from the only sampled downgradient site, HZSW007, could not be directly paired with any single upgradient site. For this reason, no paired data from any HVS sites have been included in the analysis. Paired data are presented by POC in Figures 1 through 10. Below each plot is the number of paired data available (N), the calculated p value based on the nonparametric sign test (α=0.05), and the average upgradient and downgradient concentrations. The statistical analysis of the CM and ISRA datasets is presented in Section 2 below.

It should be noted that the CM-1/A2LF-3 location has two upgradient sites: A2SW0001 (upgradient-west) receives runoff from an ISRA area, the NASA/ELV area, and a nearby paved road; A2SW0006 (upgradient-east) receives flows from a mostly undisturbed tributary (although these samples could possibly be impacted by ponded runoff from upgradient-west). The selection of the upgradient location used in the pairing evaluation was evaluated on a case by case basis, with similar sample dates taking precedence (between upgradient and downgradient); upgradient results were averaged in the two instances when two upgradient samples were available for the same downgradient-sampling storm event.

These charts are included for visual assessment purposes only; the statistical tests that follow are used to make conclusions regarding ISRA and CM performance.

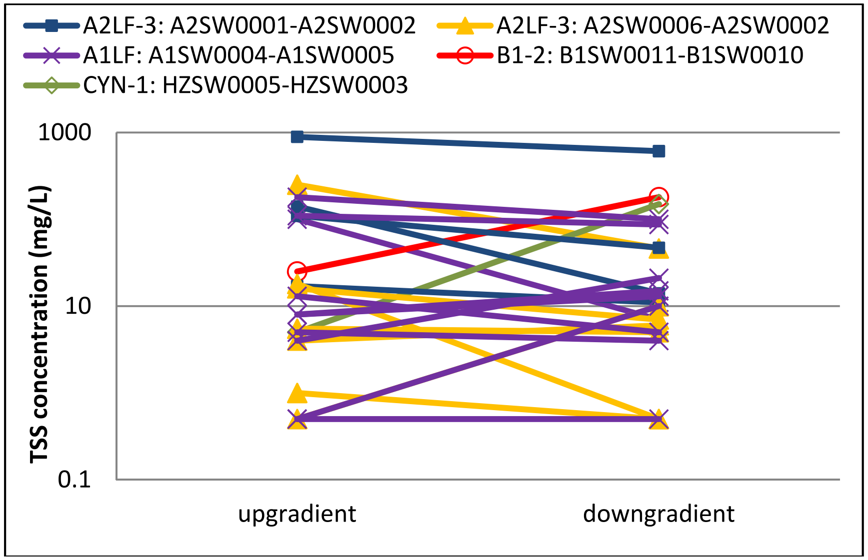


Figure 1. TSS at ISRA Locations

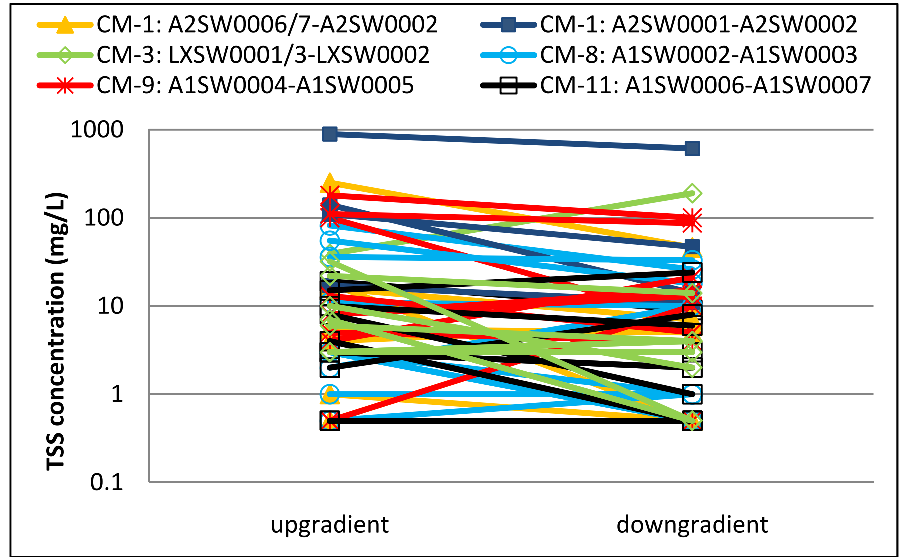


Figure 2. TSS at CM Locations

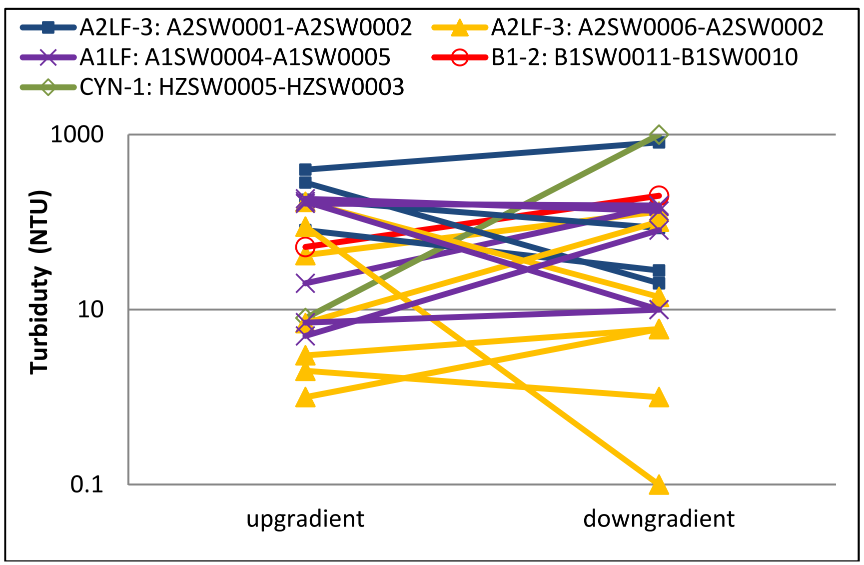


Figure 3. Turbidity at ISRA Locations

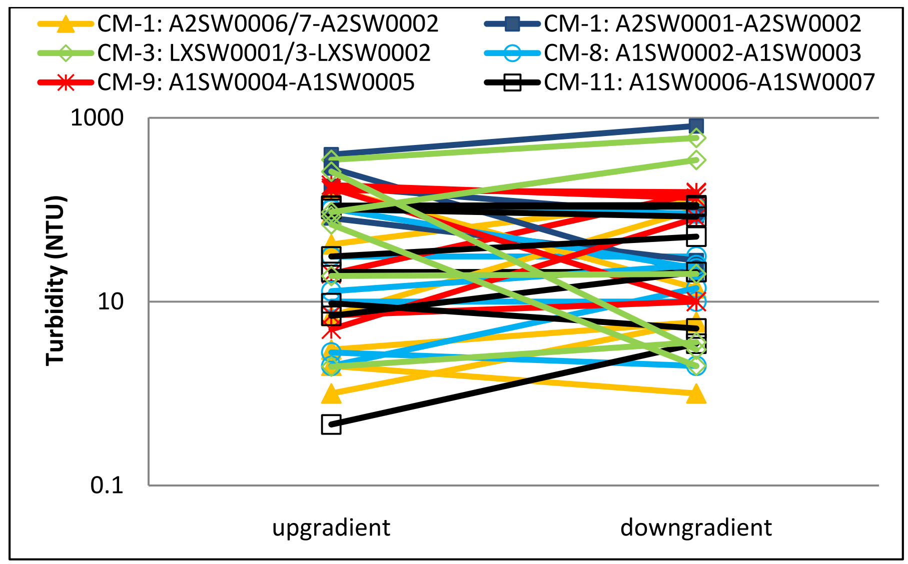


Figure 4. Turbidity at CM Locations

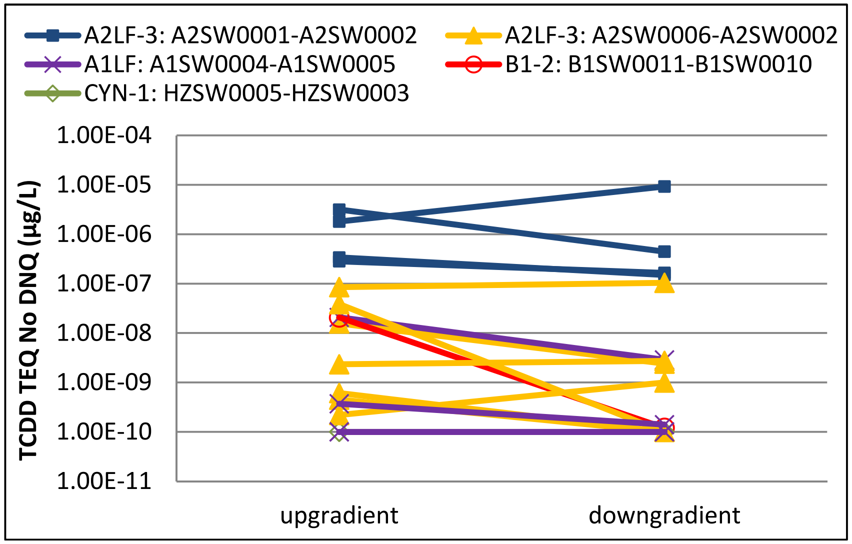


Figure 5. Dioxin at ISRA Locations

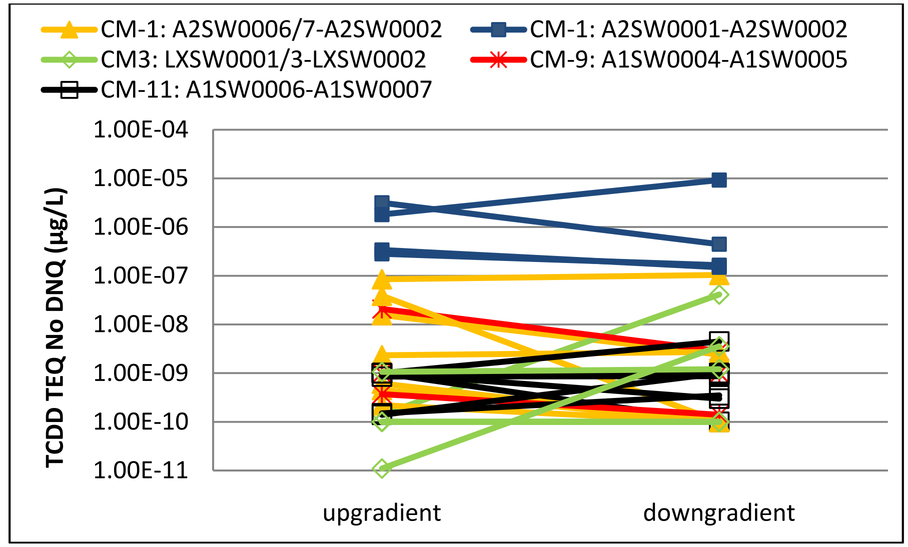


Figure 6. Dioxin at CM Locations

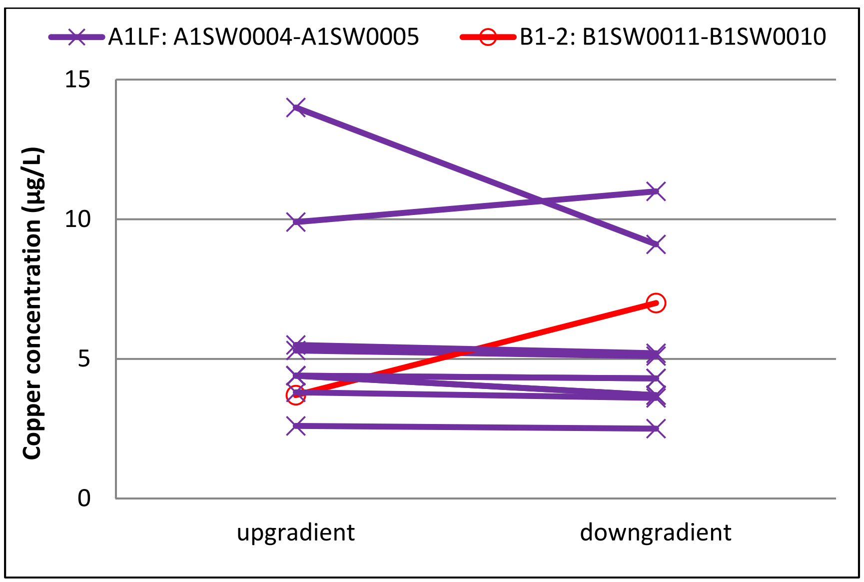


Figure 7. Copper at ISRA Locations

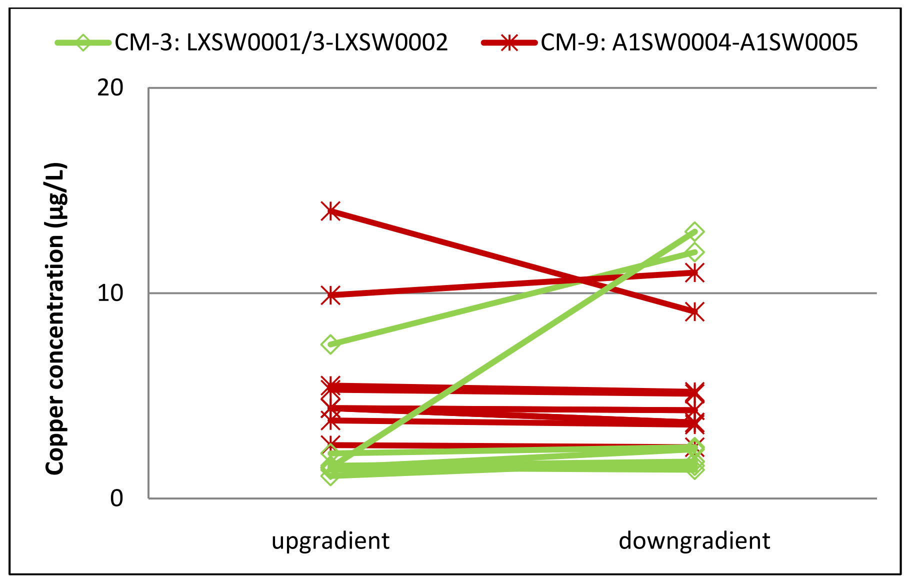


Figure 8. Copper at CM Locations

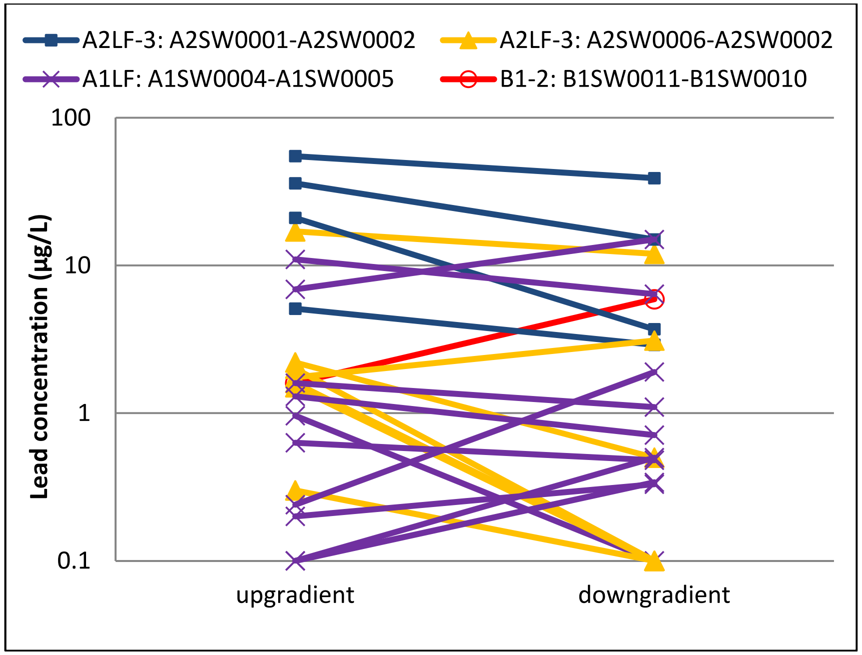


Figure 9. Lead at ISRA Locations

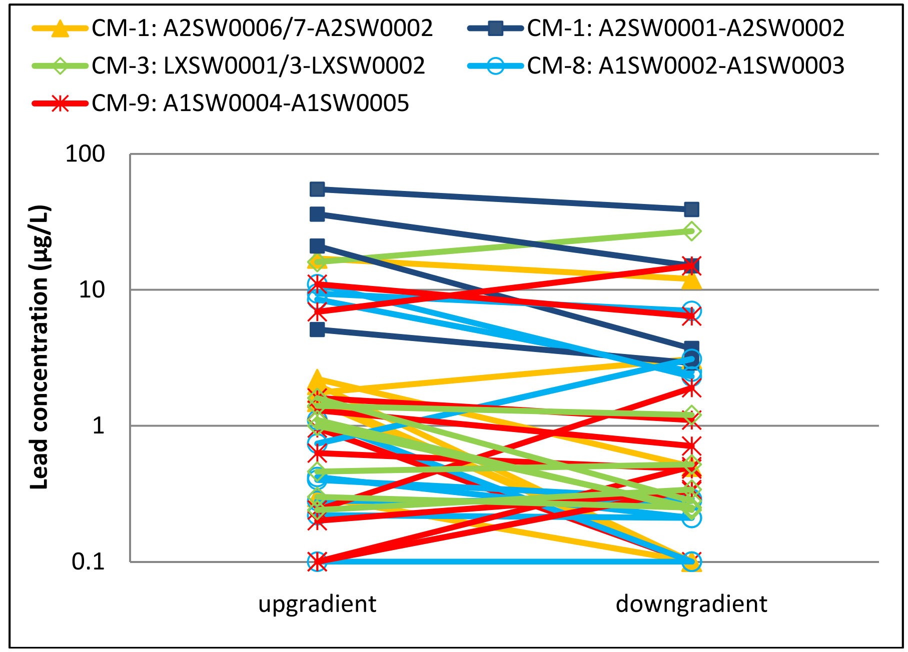


Figure 10. Lead at CM Locations

2. STATISTICAL ANALYSIS

Statistical summaries of the SSFL paired data using the non-parametric sign test are shown for the ISRA and CM datasets in Tables 1 and 2, respectively. This test is used to evaluate statistical difference between paired data, or in this case between upgradient and downgradient stormwater samples.

ISRA Areas

At the ISRA monitoring locations, the total number of collected upgradient and downgradient pairs range from 11 (copper) to 23 (TSS). Table 1 summarizes the number of paired observations for each constituent, the number of upgradient samples that had larger concentrations than the corresponding downgradient samples, the calculated p result using the nonparametric paired sign test, and the average concentration and coefficient of variation (COV) for both upgradient and downgradient pairs. These results suggest that the comparison of upgradient and downgradient concentrations is only nearly statistically significant for copper, with 9 out of 11 upgradient concentrations being greater than their paired downgradient concentrations. No POCs were found to be statistically significantly different for downgradient results being greater. This is a positive preliminary indication that stormwater concentrations are not increasing across the ISRA areas (like one might expect for runoff across highly impacted or unstabilized soil areas). Additional data are needed to determine statistical difference with acceptable confidence, especially in being able to evaluate each location separately which is expected to reduce the variability currently observed.

Table 1. ISRA Statistical Analysis

	TSS (mg/L)	**Turbidity[a] (NTU)**	**Dioxin (µg/L)**	**Copper (µg/L)**	**Lead (µg/L)**
Total pairs of observations	23	19	17	11	22
Number of upgradient samples having larger concentrations than downgradient samples	14	9	11	9	15
Number of downgradient samples having larger concentrations than upgradient samples	8	10	3	2	7
p by paired nonparametric sign test	0.29	1.0	0.10	0.065	0.13
Average (and COV) upgradient concentrations	83 (2.3)	102 (1.1)	3.4e-07 (2.5)	5.7 (0.6)	7.6 (1.8)
Average (and COV) downgradient concentrations	59 (2.2)	155 (1.8)	6.0e-07 (3.8)	5.4 (0.5)	5.0 (1.8)
Average percent change (- sign indicating lower downgradient results)	-29%	+51%	+76%	-5%	-34%

Note: Some results showed upgradient concentration = downgradient concentration; this explains why rows 2 and 3 do not necessarily sum to the total pairs of observations.

[a]Turbidity dataset is composed primarily of field turbidity measurements, except when both a field and laboratory result were analyzed on the same date, in which case the laboratory measurement was used in the analysis.

Culvert Modification Areas

The five monitored CMs (CM-1, CM-3, CM-8, CM-9, and CM-11) are in the 009 watershed. At the CM monitoring locations, the total number of collected upgradient and downgradient pairs ranged from 10 (copper) to 42 (TSS). Table 2 summarizes the paired data statistics for these locations[1]. Results suggest that the comparison of upgradient and downgradient concentrations for lead and TSS are statistically significant ($p < 0.05$) with upgradient concentrations greater than downgradient concentrations (i.e., POC reduction through the CMs). For TSS, 27 out of 42 (64%) of upgradient concentrations are greater than their paired downgradient concentrations. Figure 11 further demonstrates that significant sediment capture has been observed in the CM ponding areas. For lead, 24 out of 31 (77%) upgradient concentrations are greater than their paired downgradient concentrations. No POCs were found to be statistically significantly different for downgradient results being greater. Additional data are needed to determine statistical difference with acceptable confidence and to enable individual site analyses which will result in being able to better relate the concentration differences to the site characteristics (especially watershed drainage areas above the CMs). The average dioxin concentration increased from upgradient to downgradient, while turbidity had no change, and TSS, copper, and lead decreased by approximately 45%, 10%, and 39%, respectively; however these average statistics are much less reliable for making conclusions than the statistical tests of paired data.

Figure 11. Sediment accumulated behind weir boards at CM-3.

Table 2. CM Statistical Analysis (CM3 results excluded)

	TSS (mg/L)	Turbidity[a] (NTU)	Dioxin (µg/L)	Copper (µg/L)	Lead (µg/L)
Total pairs of observations	42	35	26	10	31
Number of upgradient samples having larger concentrations than downgradient samples	27	15	12	9	24
Number of downgradient samples having larger concentrations than upgradient samples	10	15	7	1	7
p by paired nonparametric sign test	0.0076	1.1	0.36	0.02	0.0033
Average (and COV) upgradient concentrations	51 (2.8)	70 (1.3)	2.2e-07 (3.2)	5.9 (0.6)	6.4 (1.9)
Average (and COV) downgradient concentrations	28 (3.4)	70 (2.0)	3.9e-07 (4.6)	5.3 (0.5)	3.9 (2.0)
Average percentage change (- sign indicating lower downgradient results)	-45%	0%	+77%	-10%	-39%

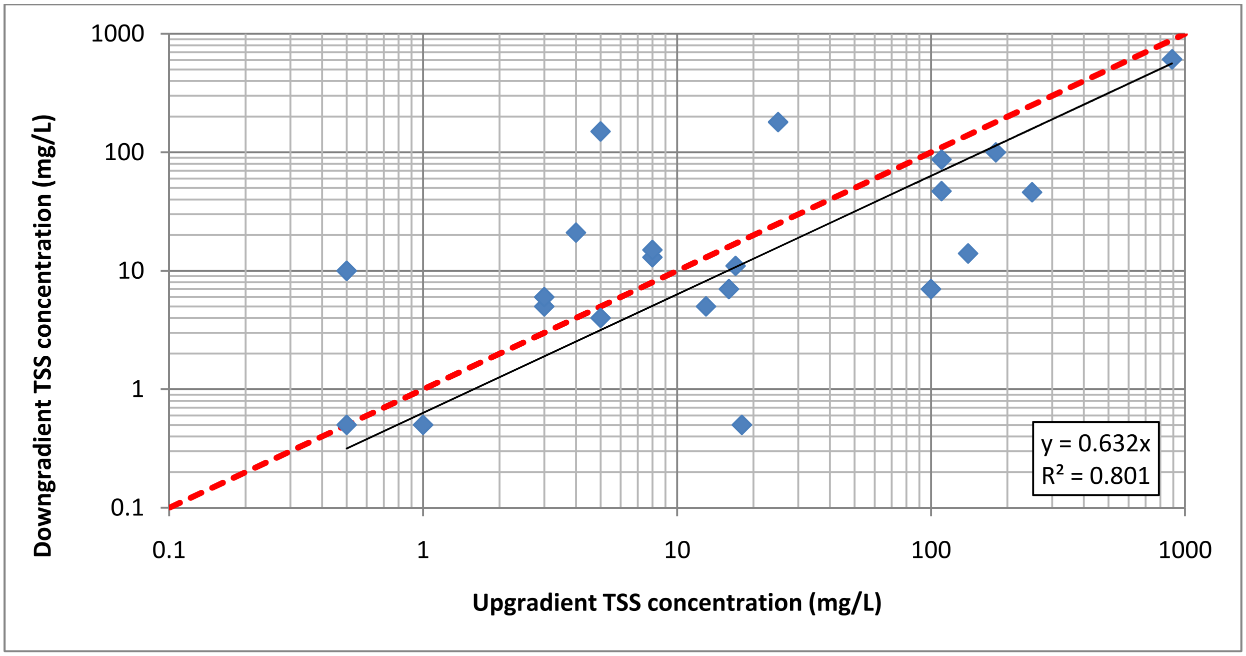
Note: Some results showed upgradient concentration = downgradient concentration; this explains why rows 2 and 3 do not necessarily sum to the total pairs of observations.

[a]Turbidity dataset is composed primarily of field turbidity measurements, except when both a field and laboratory result were analyzed on the same date, in which case the laboratory measurement was used in the analysis.

[1] As noted earlier in this memorandum, the CM-3 performance cannot be reliably assessed based on the downgradient sample results. For this reason, the CM-3 paired data were excluded from the statistical analysis presented in Table 2.

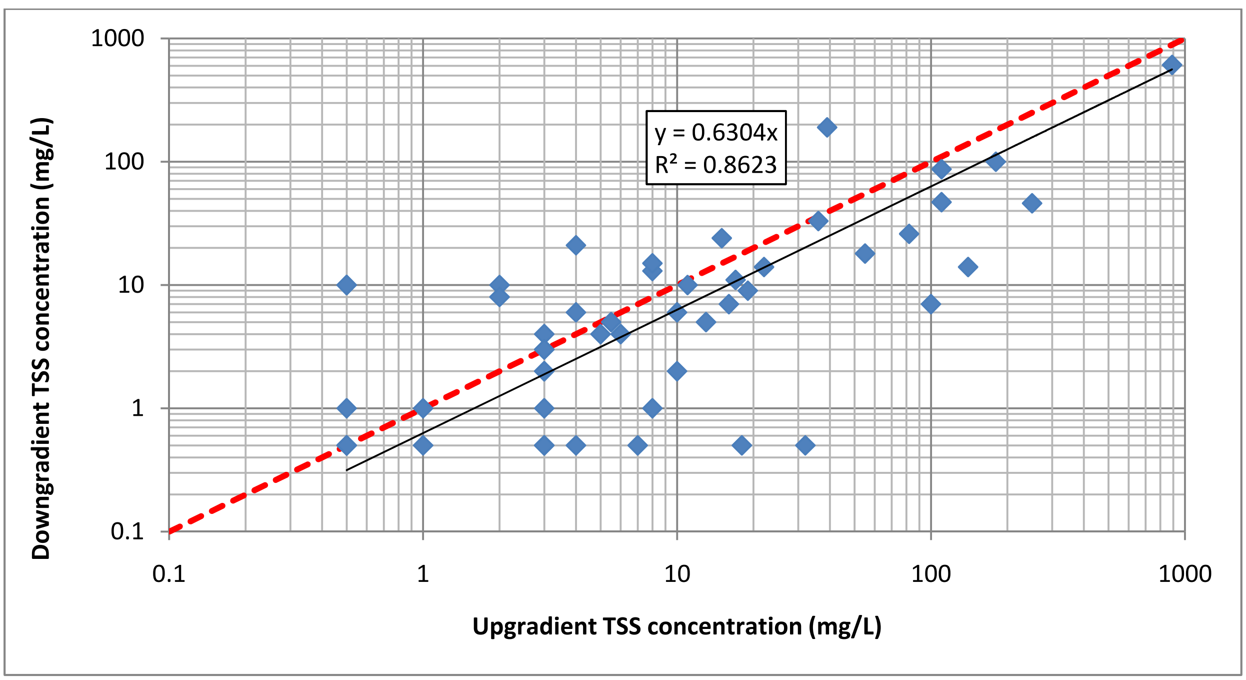
3. UPGRADIENT v. DOWNGRADIENT CORRELATION CHARTS

The following plots illustrate upgradient vs. downgradient concentrations for the paired data presented above. A 1:1 line (in red) has been added to each plot. Data above the 1:1 line indicate a downgradient increase in concentrations, while data below the 1:1 line indicate a downgradient decrease in concentrations (or positive BMP reduction in the case of the CMs, except for instances where the downgradient/end-of-culvert sample represents a blend of filtered stormwater with water percolating through the roadbed and into an unsealed seam in the liner pipe [e.g., CM-3]).



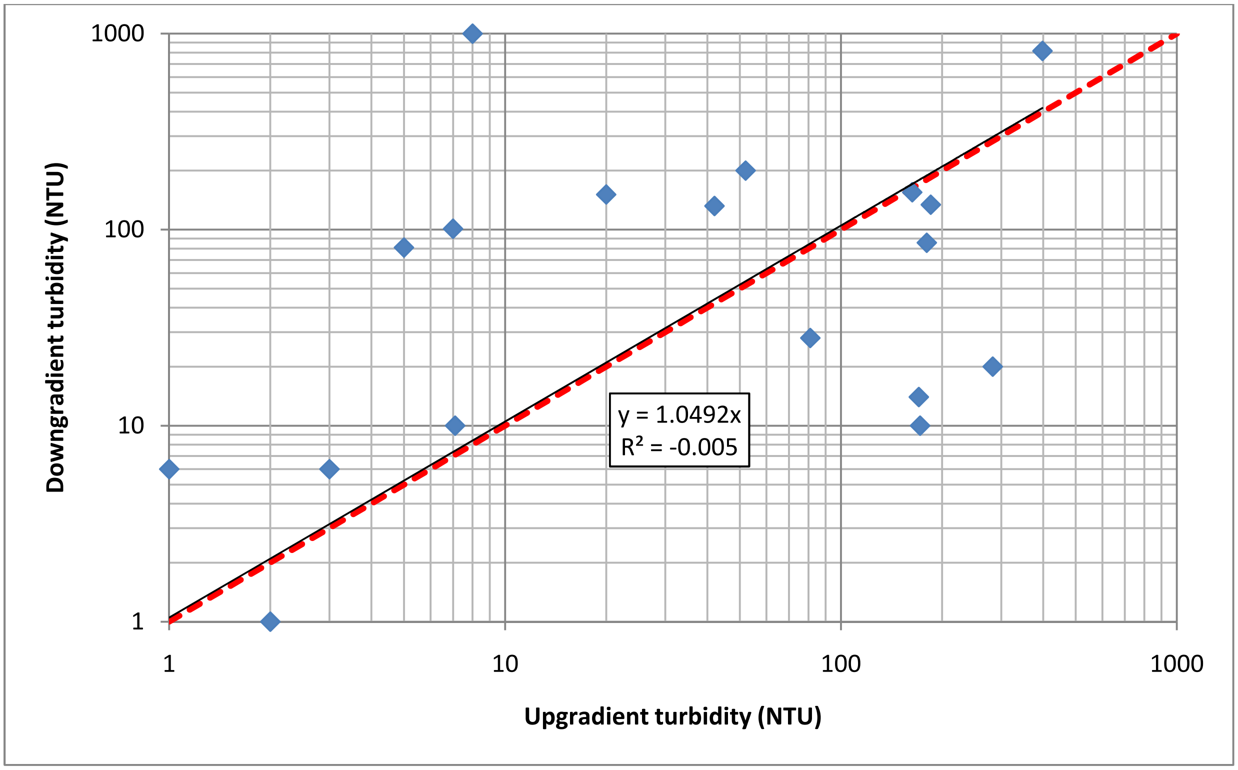
Note: 1:1 line shown in red

Figure 12: Paired TSS Concentrations at ISRA Sites



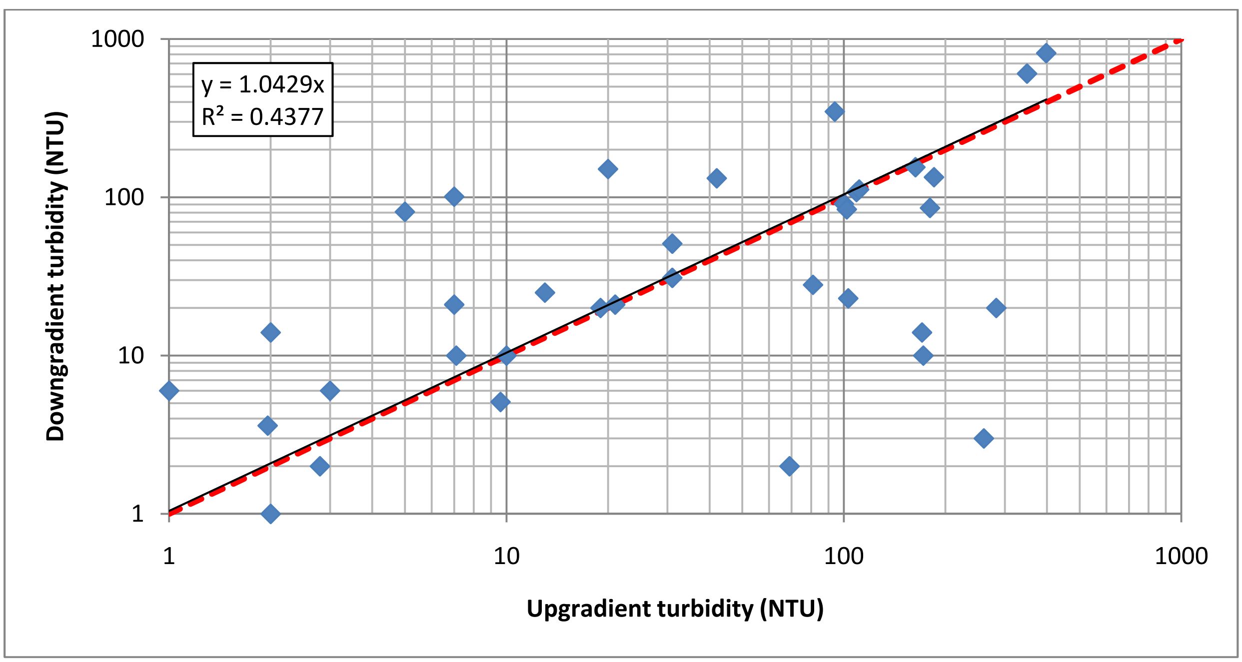
Note: 1:1 line shown in red

Figure 13: Paired TSS Concentrations at CM Sites



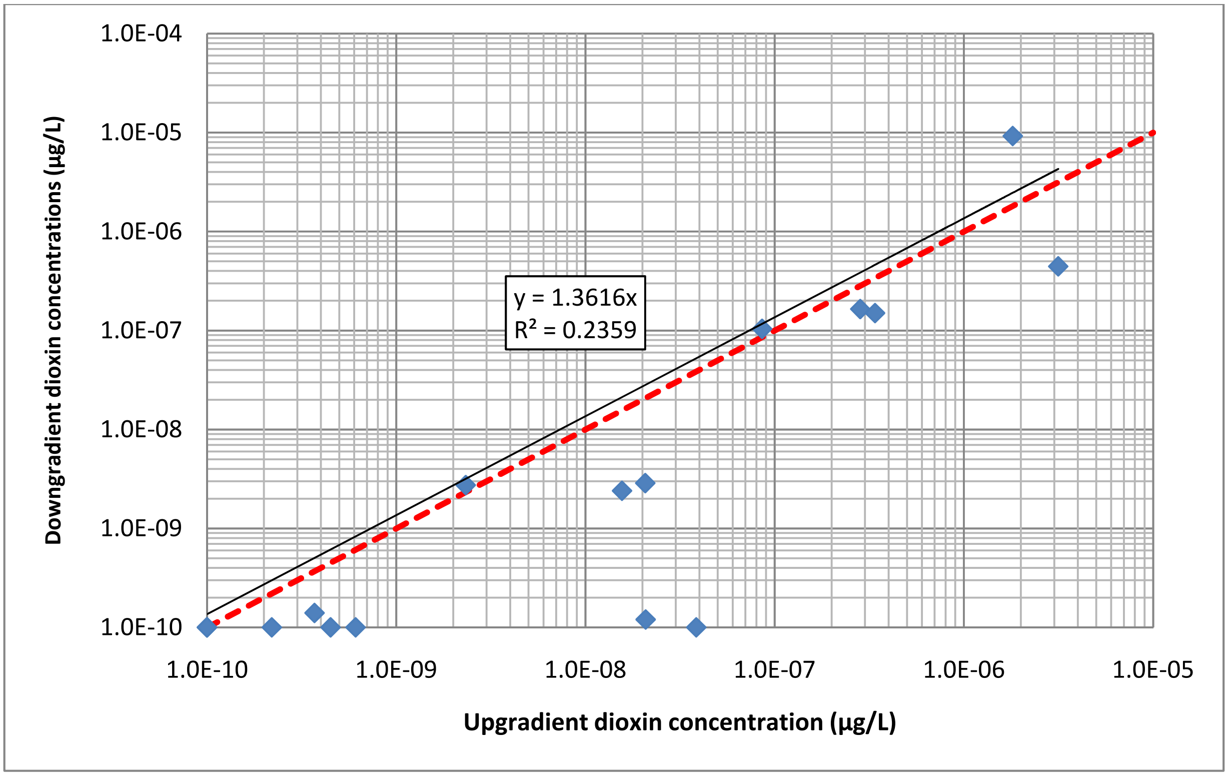
Note: 1:1 line shown in red

Figure 14: Paired Turbidity Concentrations at ISRA Sites



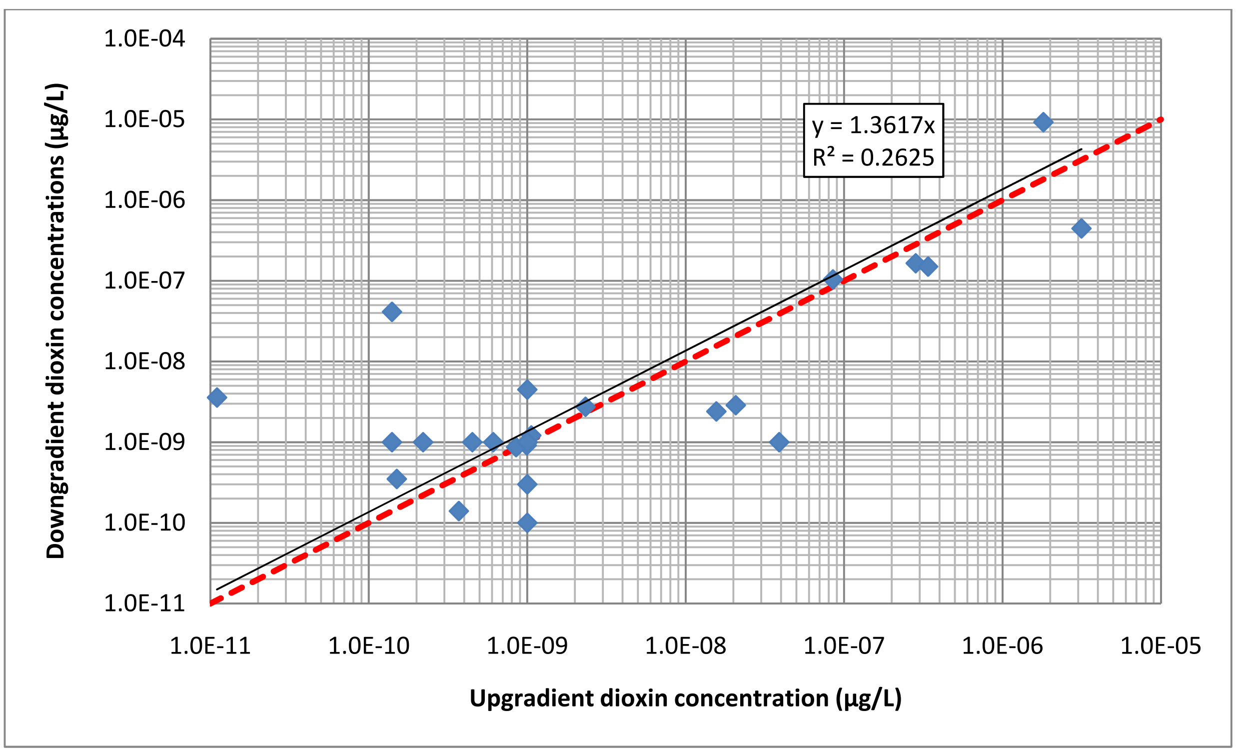
Note: 1:1 line shown in red

Figure 15: Paired Turbidity Concentrations at CM Sites



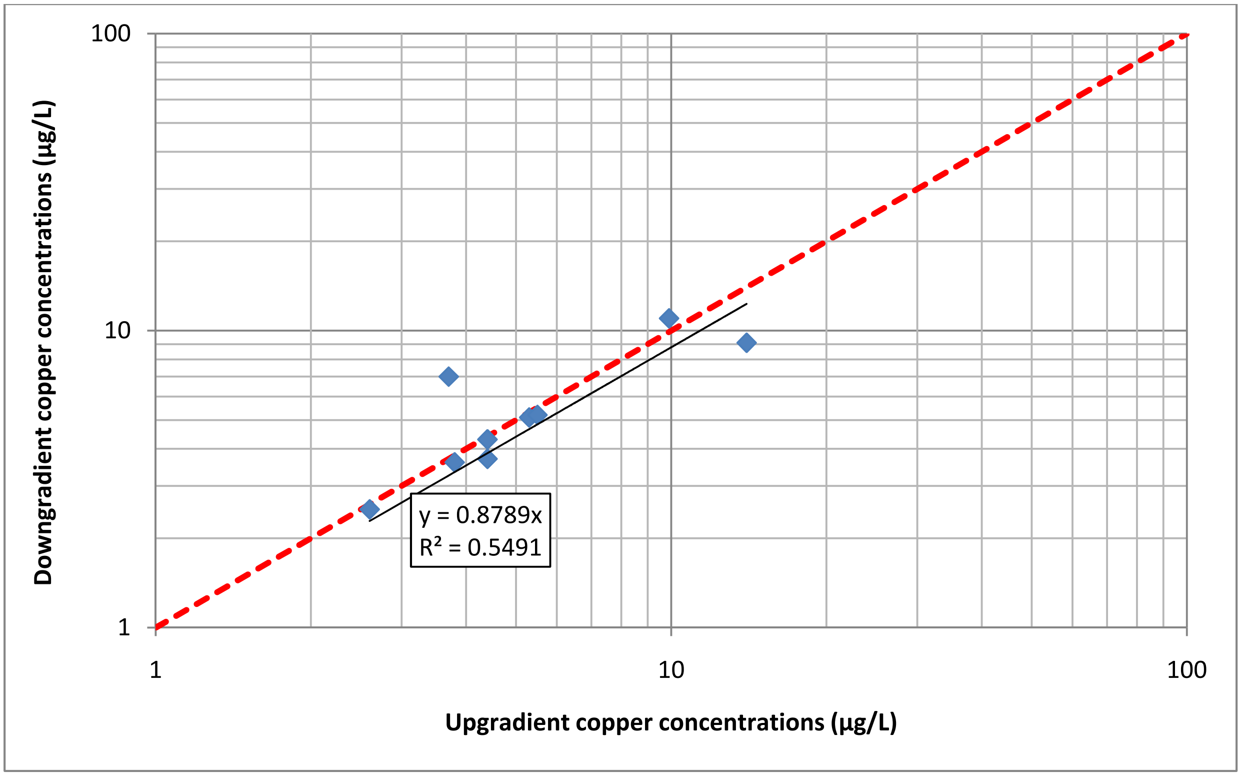
Note: 1:1 line shown in red

Figure 16: Paired Dioxin Concentrations at ISRA Sites



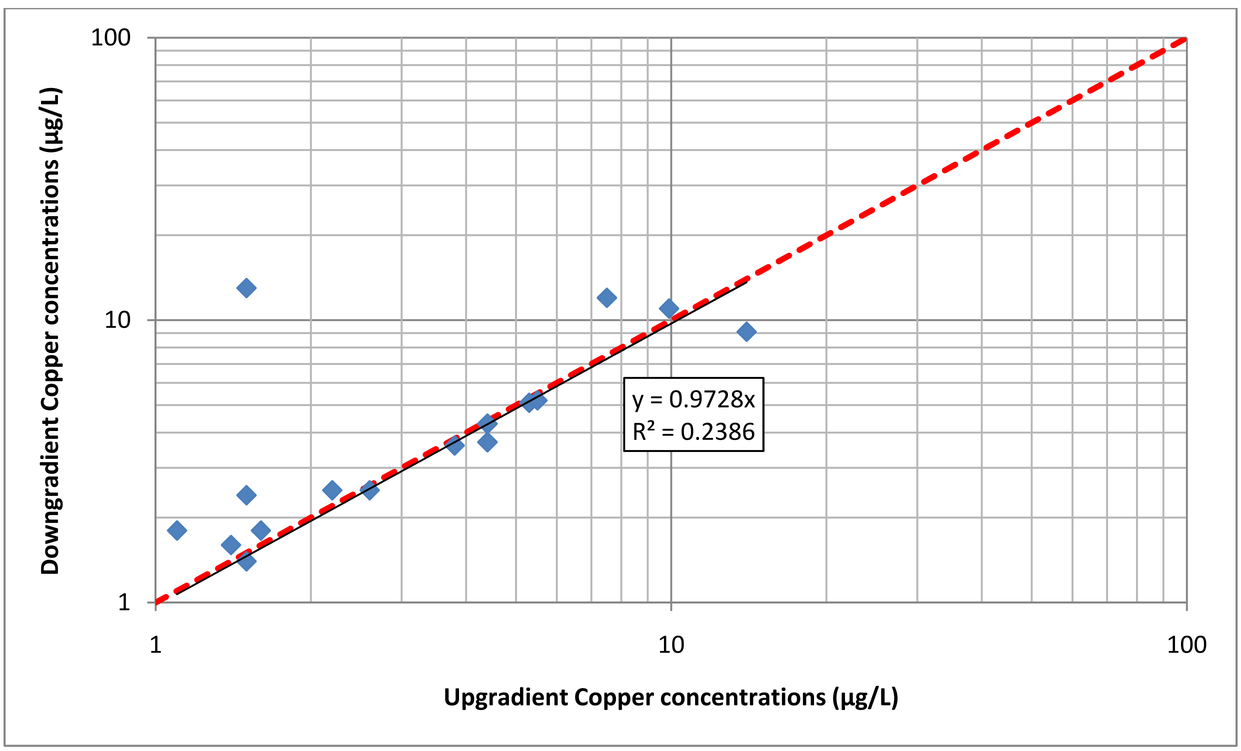
Note: 1:1 line shown in red

Figure 17: Paired Dioxin Concentrations at CM Sites



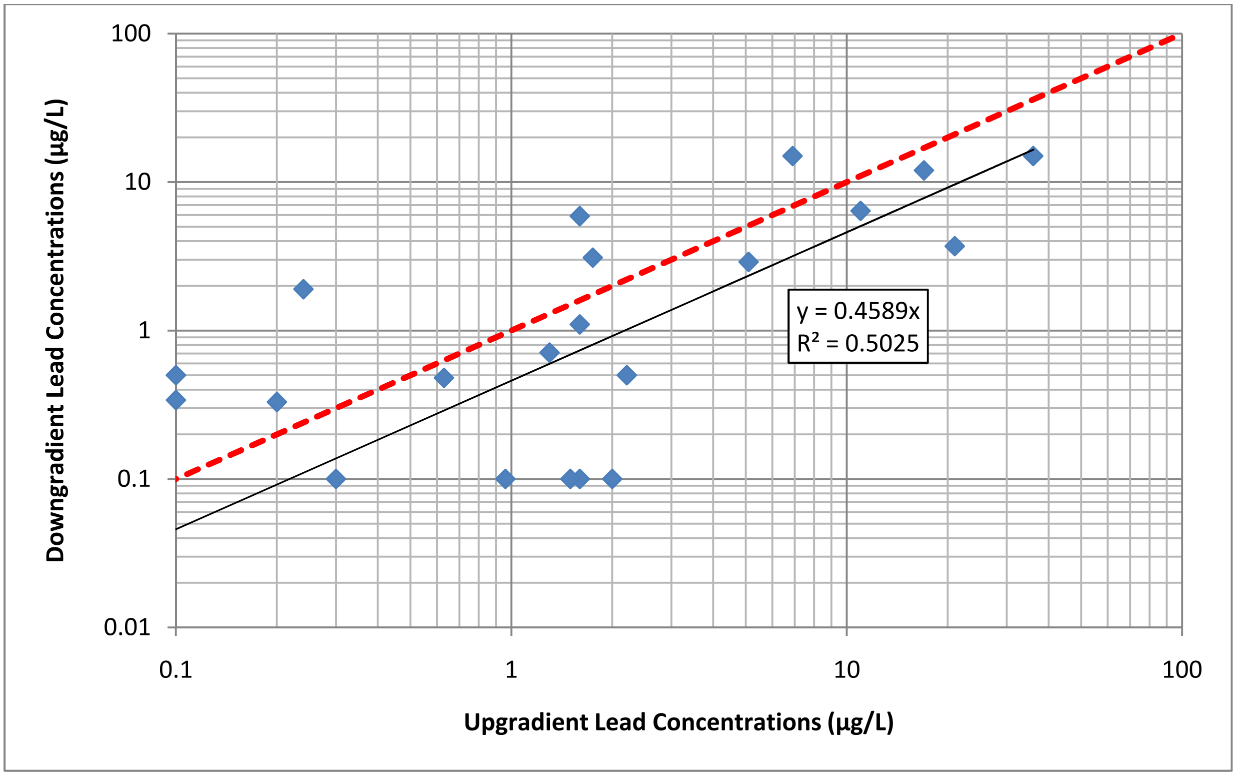
Note: 1:1 line shown in red

Figure 18: Paired Copper Concentrations at ISRA Sites



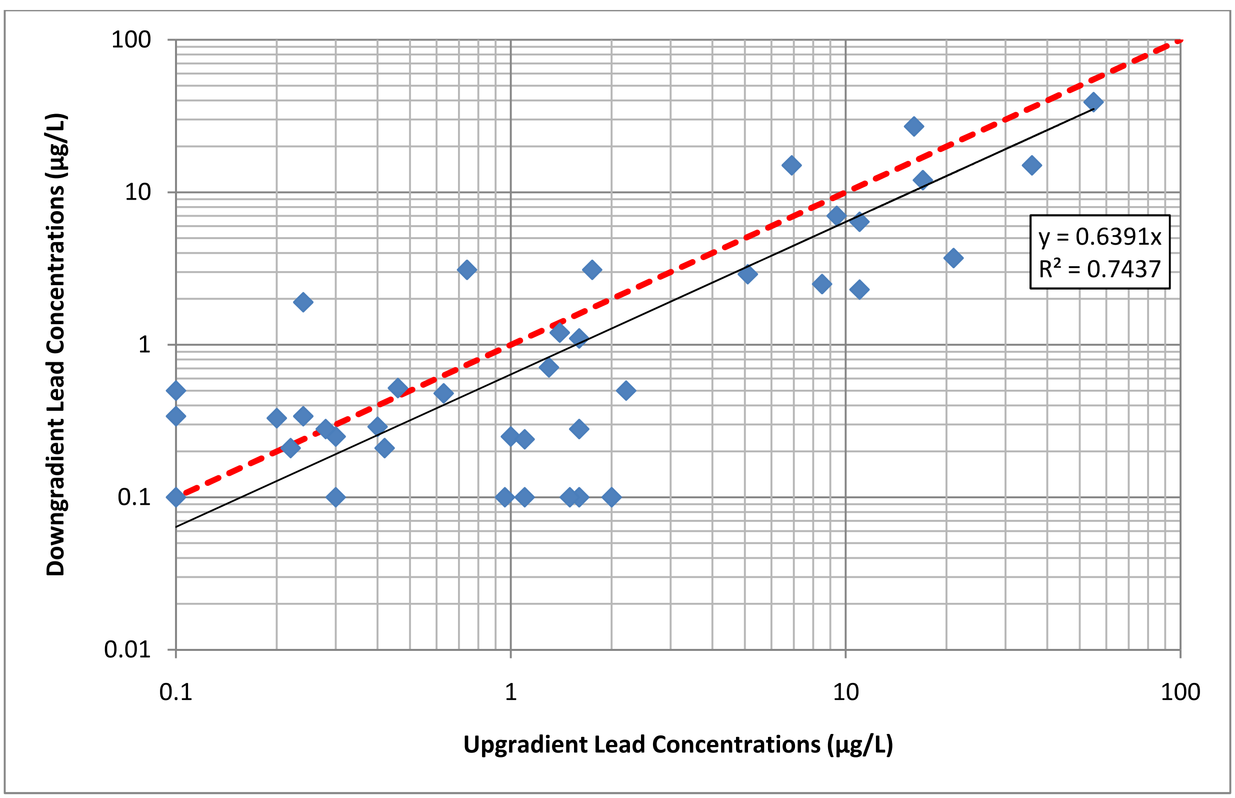
Note: 1:1 line shown in red

Figure 19: Paired Copper Concentrations at CM Sites



Note: 1:1 line shown in red

Figure 20: Paired Lead Concentrations at ISRA Sites



Note: 1:1 line shown in red

Figure 21: Paired Lead Concentrations at CM Sites

4. PROBABILITY PLOTS

Probability plots are prepared by ranking the available data and calculating their probability of occurrence. These probability values (shown on the vertical axis) are plotted against their concurrent concentrations. Where applicable, NPDES permit limits for each POC are also shown on the charts for comparison and are presented as vertical lines.

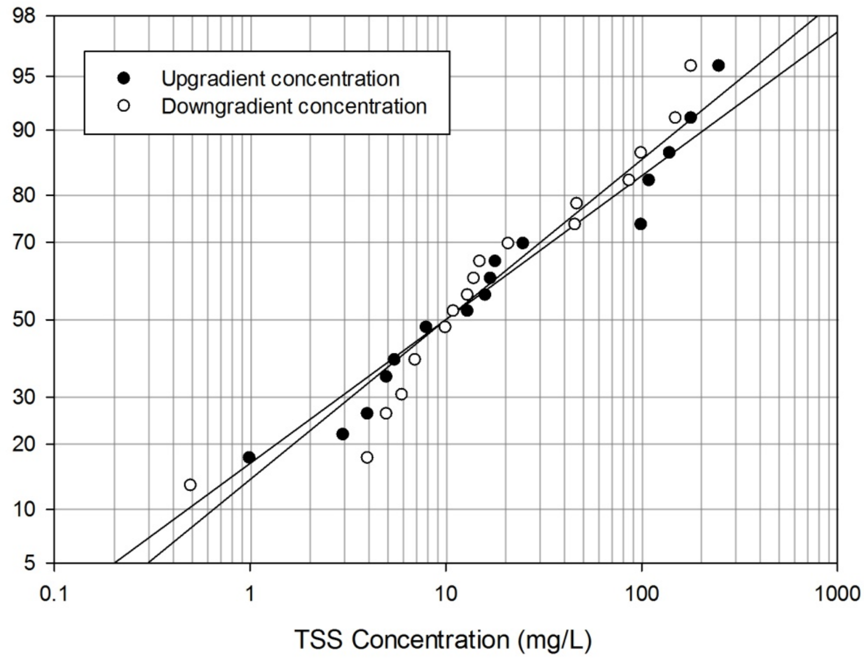


Figure 22: Probability Plot of TSS at ISRA Locations

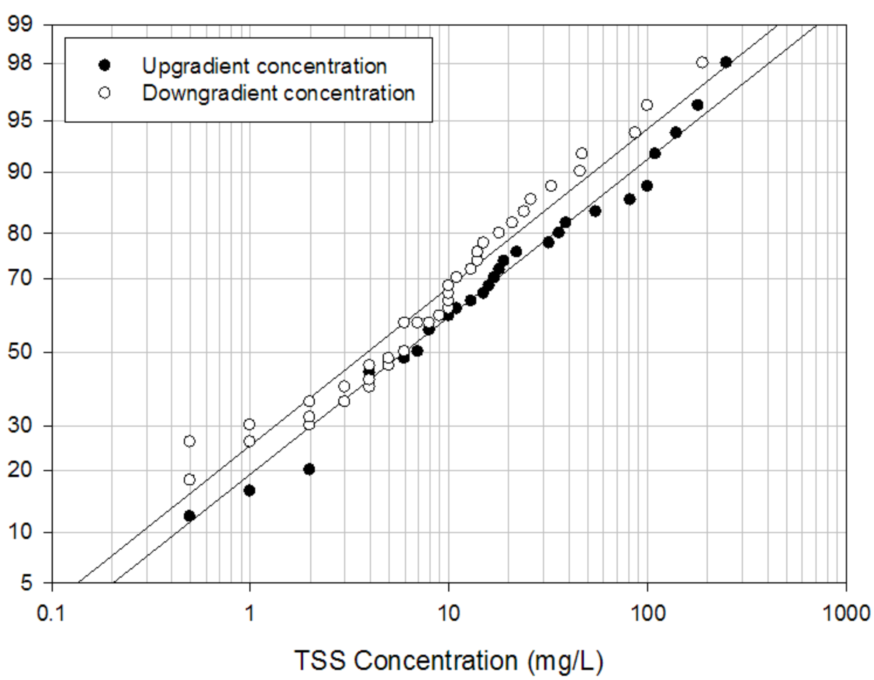


Figure 23: Probability Plot of TSS at CM Locations

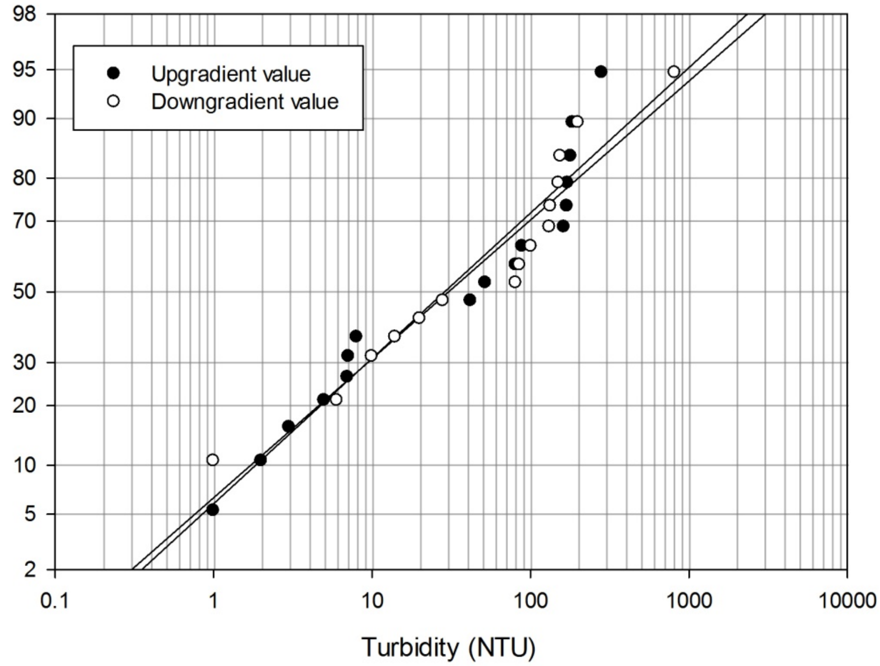


Figure 24: Probability Plot of Turbidity at ISRA Locations

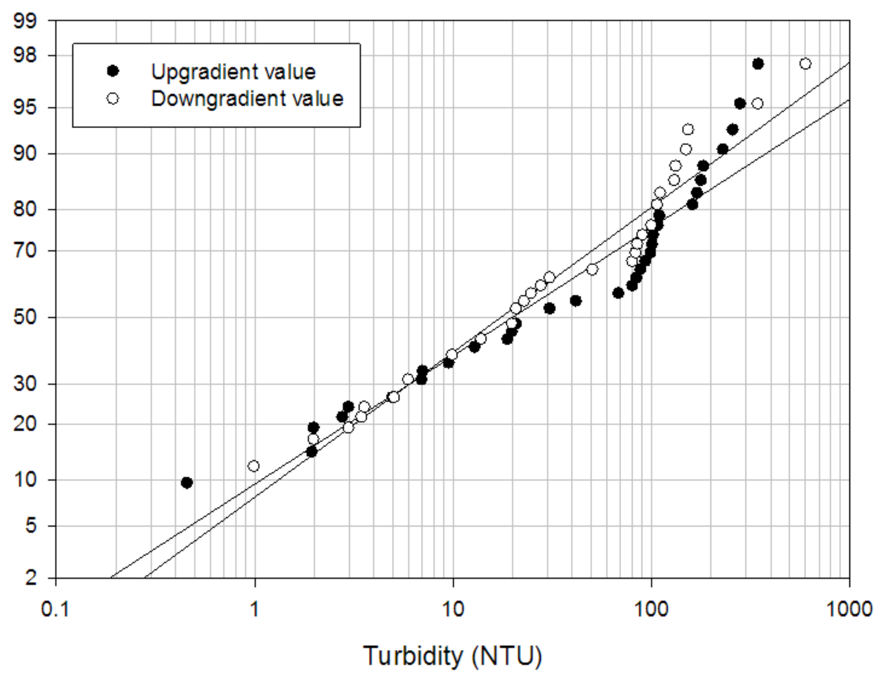


Figure 25: Probability Plot of Turbidity at CM Locations

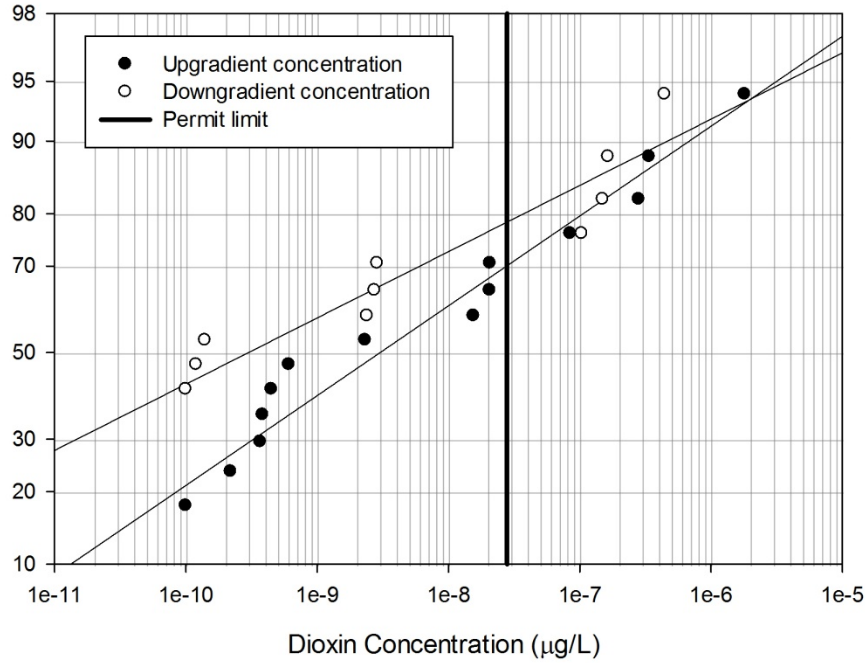


Figure 26: Probability Plot of Dioxins at ISRA Locations

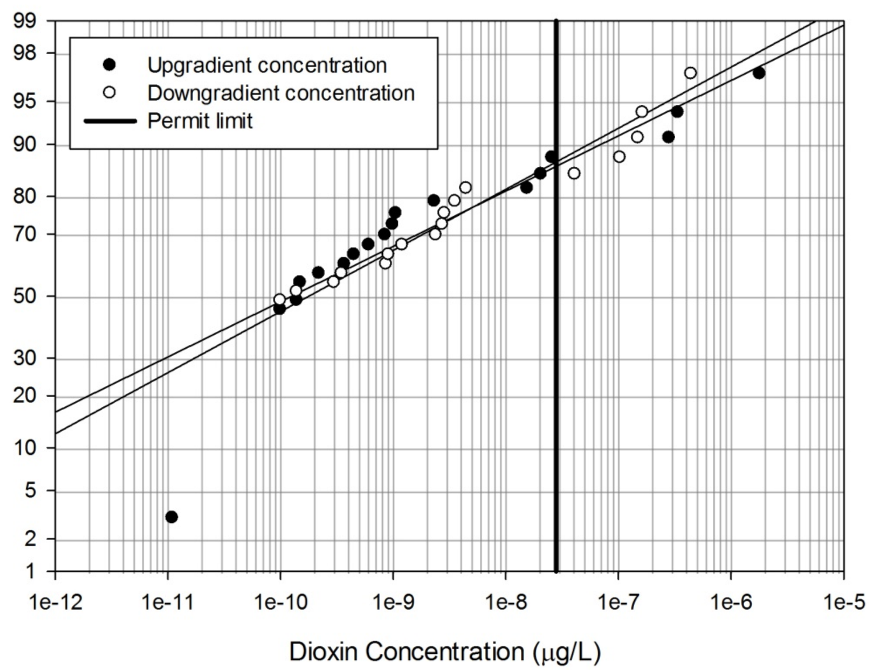


Figure 27: Probability Plot of Dioxins at CM Locations

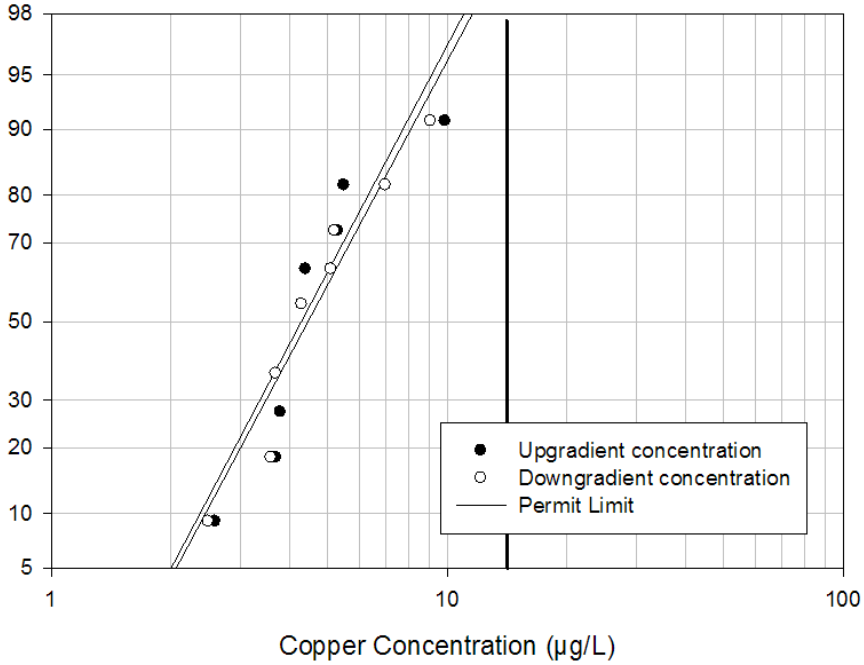


Figure 28: Probability Plot of Copper at ISRA Locations

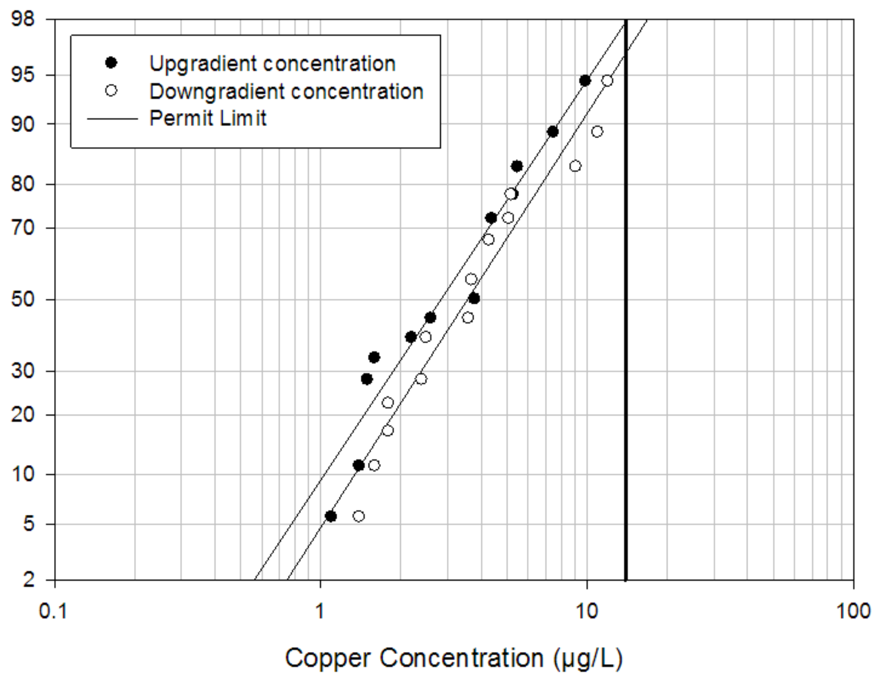


Figure 29: Probability Plot of Copper at CM Locations

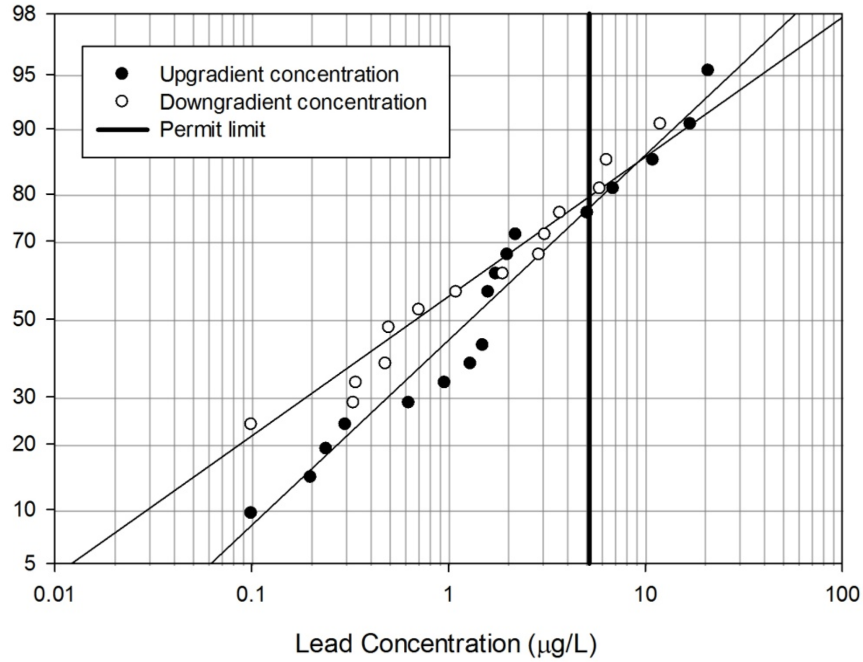


Figure 30: Probability Plot of Lead at ISRA Locations

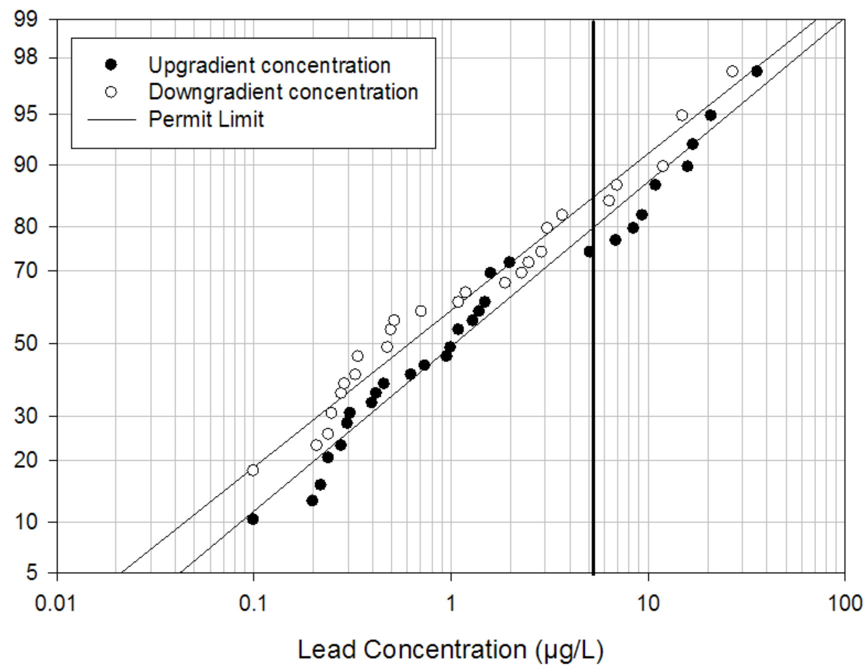


Figure 31: Probability Plot of Lead at CM Locations

7. FILTER MEDIA UNDERDRAIN SAMPLES

In a small sampling study that was intended to isolate a sample of stormwater treated by sedimentation and media filtration in the CM, single grab samples were collected at CM-3 and CM-8 on February 26, 2011 at the PVC underdrain pipes that collect filtered water beneath the media mounds and discharge to the culvert inlet behind the inlet headwall weir boards (Figure 32). These samples represent only fully treated runoff, without contributions from partially treated runoff or subsurface flows through a road embankment. Results from the underdrain samples (Tables 3 and 4) showed no permit limit exceedances of total cadmium, total copper, total lead, total mercury, and dioxins (TCDD TEQ_no DNQ). Therefore, although this dataset is very limited, these results suggest that fully treated stormwater from the CMs meet the SSFL NPDES permit limits, and that the very low influent concentrations -- such as those found at CM-3 and CM-8, which have generally unimpacted subwatersheds -- may already be at irreducible levels.

Figure 32. Filter media underdrain collection point

Table 3. February 26, 2011 CM-3 Sample Results (LXSW0001/2)

Parameter	NPDES Permit Limit (for comparison only)	Upgradient (flowing water entering ponded area)	Filter Media Underdrain	Downgradient (culvert outlet)
TSS (mg/L)	NA	3.0	ND (<1.0)	3.0
Total Cadmium (μg/L)	4.0	ND (<0.10)	ND (<0.10)	ND (<0.10)
Total Copper (μg/L)	14	1.5	1.7	13
Total Lead (μg/L)	5.2	0.24	0.28	0.34
Total Mercury (μg/L)	0.13	ND (<0.10)	ND (<0.10)	ND (<0.10)
TCDD TEQ_noDNQ (μg/L)	2.8×10^{-8}	ND	ND	ND

Table 4. February 26, 2011 CM-8 Sample Results (A1SW0002/3)

Parameter	NPDES Permit Limit (for comparison only)	Upgradient (flowing water entering ponded area)	Filter Media Underdrain	Downgradient (culvert outlet)
TSS (mg/L)	NA	3.0	ND (<1.0)	ND (<1.0)
Total Lead (μg/L)	5.2	0.42	ND (<0.20)	0.21

6. DISCUSSION

The following general observations were made based on the aforementioned data summary charts and tables.

1. In general, data indicate that downgradient ISRA and CM concentrations tend to be lower than corresponding upgradient samples, suggesting positive performance of ISRA excavation and stabilization efforts and of the CM treatment systems. Exceptions include turbidity (ISRA and CM) and dioxin (ISRA and CM), both of which have no noticeable downgradient increase or decrease. It should also be noted that for the ISRA areas, having comparable upgradient and downgradient datasets is considered a positive outcome as it suggests that these actions resulted in indistinguishable stormwater quality changes in comparison to unimpacted (upgradient) runoff quality.

2. Lead ($p = 0.0033$), TSS ($p = 0.0076$), and copper ($p = 0.02$) at the CM locations and copper at the ISRA locations (with $p = 0.065$, which was very near to the 0.05 threshold) had statistically significant differences between upgradient and downgradient results and each of these were found to show downgradient concentration reductions (i.e., water quality improvements).

3. Observational data at the CMs indicate that significant sediment is being captured at each site. In addition, limited underdrain sampling data initially indicate that filtered stormwater from the CMs, prior to traveling through the HDPE culverts, meets NPDES permit limits for the COCs.

4. The original ISRA Performance Monitoring Plan (2010) called for 2 years of data collection at each ISRA monitoring location. While the first phase Outfall 009 watershed ISRA sites (e.g., B-1 area) have only one year of data, this requirement has been fulfilled for the Outfall 008 watershed ISRA sites. For this reason it is recommend that future sampling at Outfall 008 watershed ISRA sites be conducted for every third storm event and re-evaluated next year to determine if there is sufficient confidence in the dataset to end sampling at that time. The Panel recommends continuing the Outfall 009 ISRA sampling program, including CM-1/A2LF-3, which does have two years of monitoring data available however these results indicate very high dioxin concentrations and should continue being monitored particularly as new BMPs are implemented at this area. Similarly, the Panel recommends continuing the monitoring of the five CM locations given the inconclusiveness of the dioxin performance results; additional data should help determine whether a statistically significant difference exists for this upgradient/downgradient data.

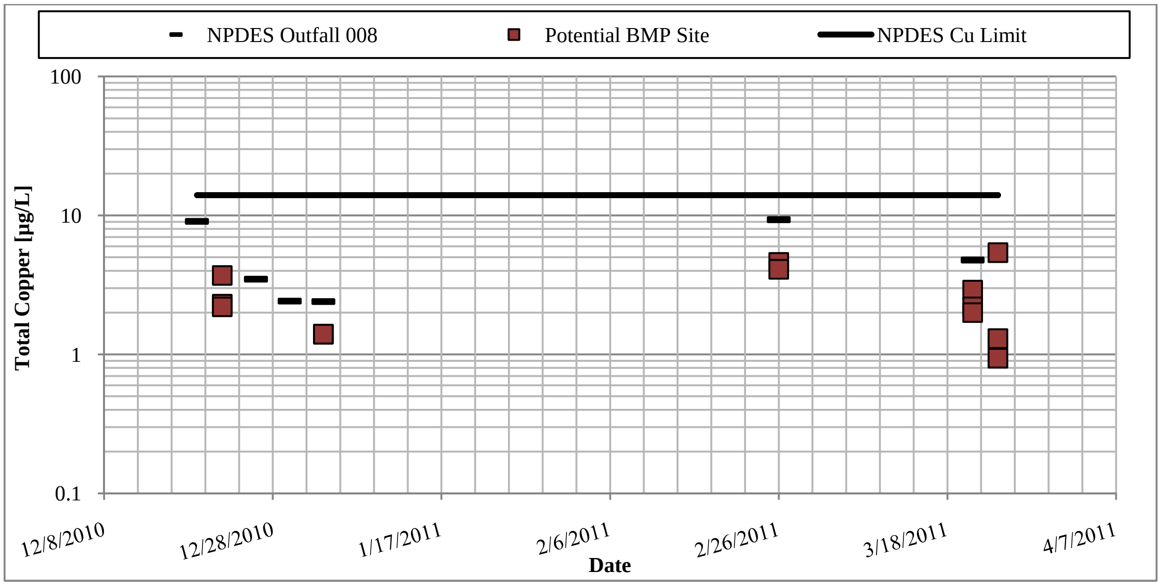
5. For future ISRA and CM performance reporting purposes, performance data will be analyzed on an individual site basis (as opposed to lumped together by POC as this memo has done). This will result in individual line plots and sign tests for each ISRA and CM site to evaluate site performance.

APPENDIX G-1

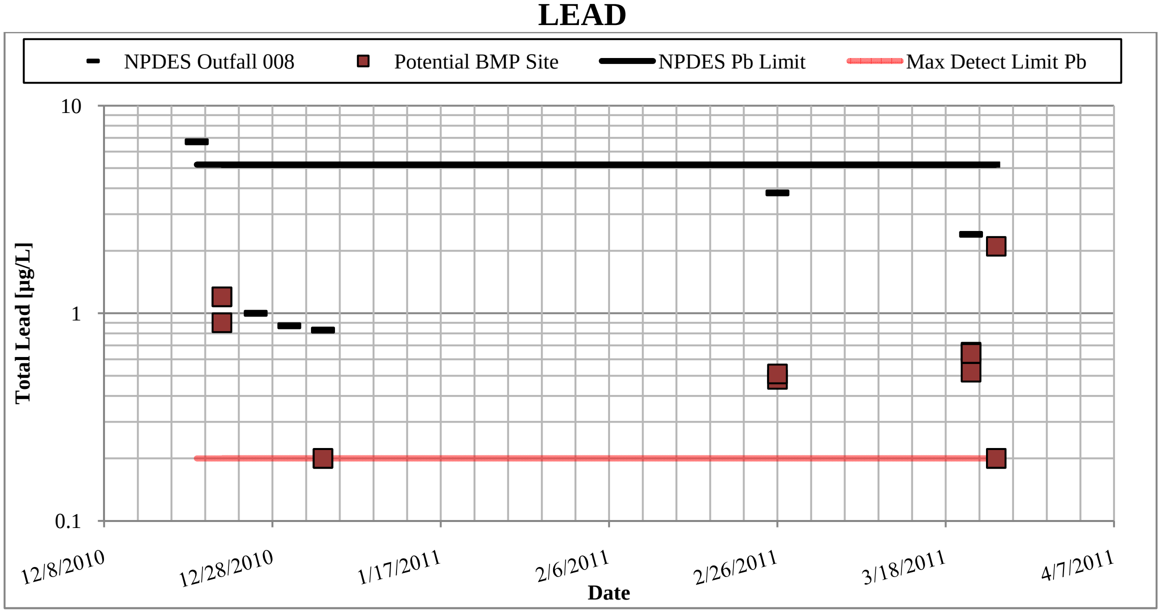
BMP MONITORING DATA GRAPHS VS. TIME

OUTFALL 008 TIME-SERIES CHARTS
POTENTIAL BMP SUBAREA MONITORING PROGRAM

COPPER

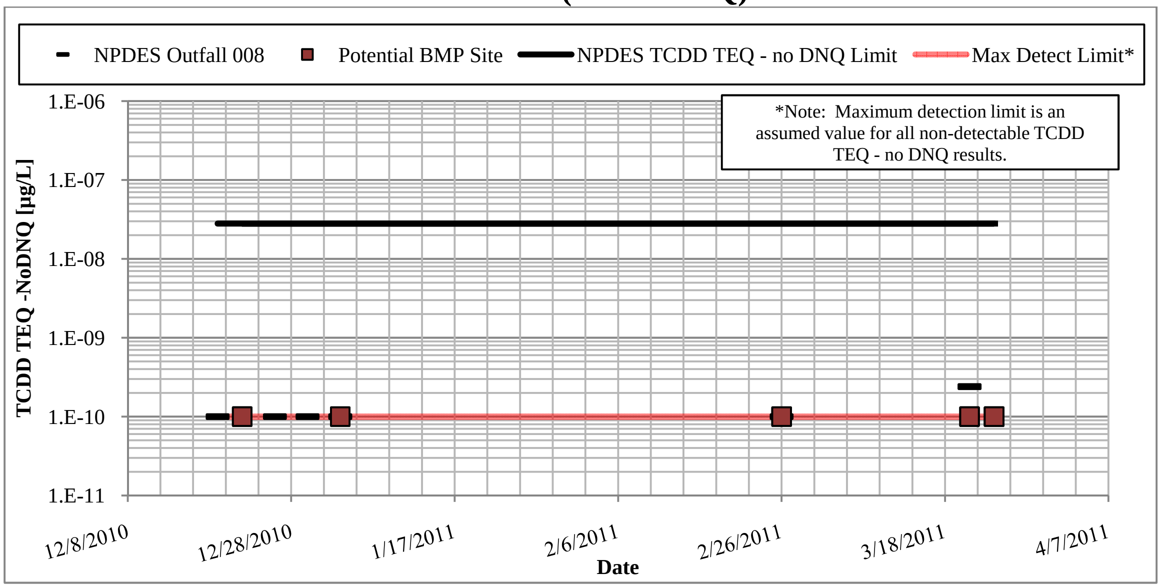


LEAD



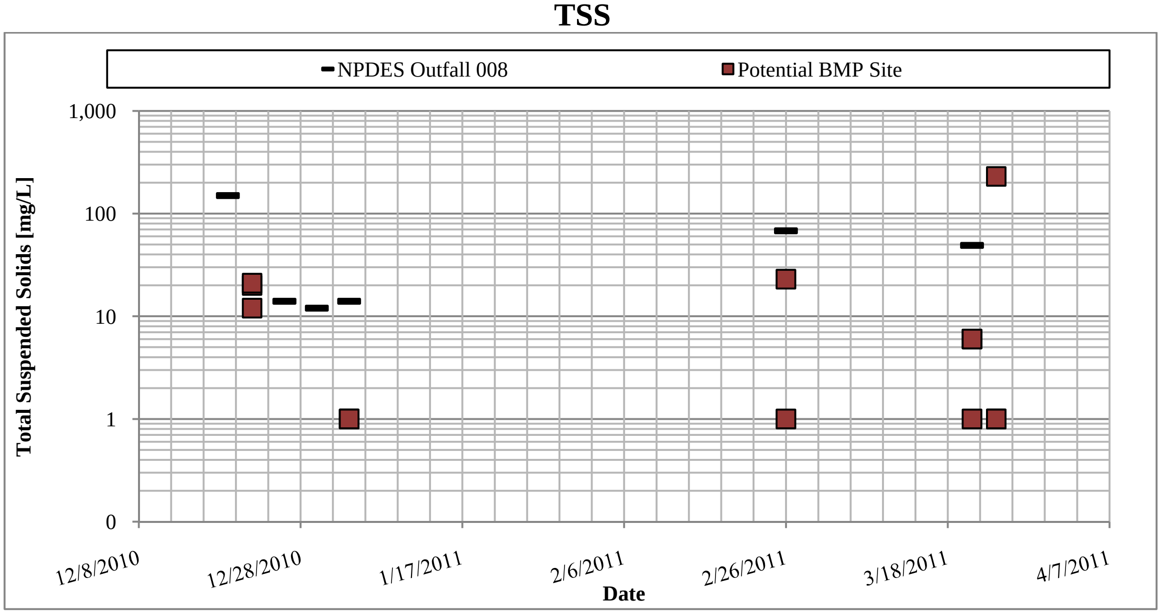
OUTFALL 008 TIME-SERIES CHARTS (CONTINUED)
POTENTIAL BMP SUBAREA MONITORING PROGRAM

DIOXINS (TCDD TEQ)



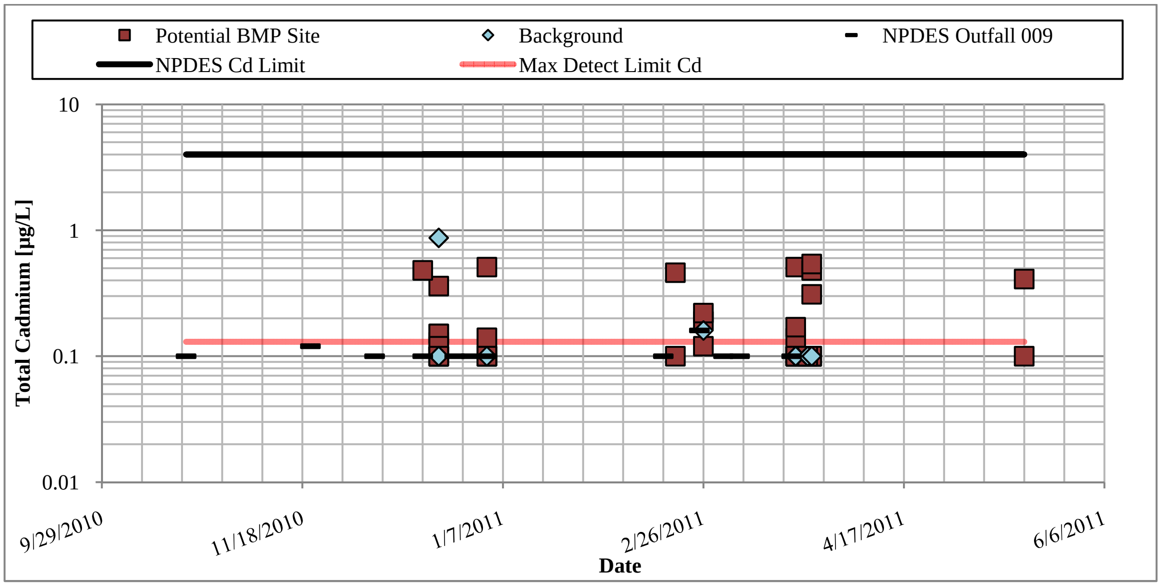
Note: Dioxin TEQ concentrations for NPDES samples collected during the 2010/2011 rainy season were calculated per the NPDES permit adopted on June 3, 2010 by multiplying each congener concentration by its respective TEF and BEF, and excluding congener DNQ results. Dioxin TEQ concentrations for NPDES samples collected prior to the 2010/2011 rainy season were calculated per pervious NPDES permits by multiplying each congener concentration by only its respective TEF, and excluding congener DNQ results.

TSS

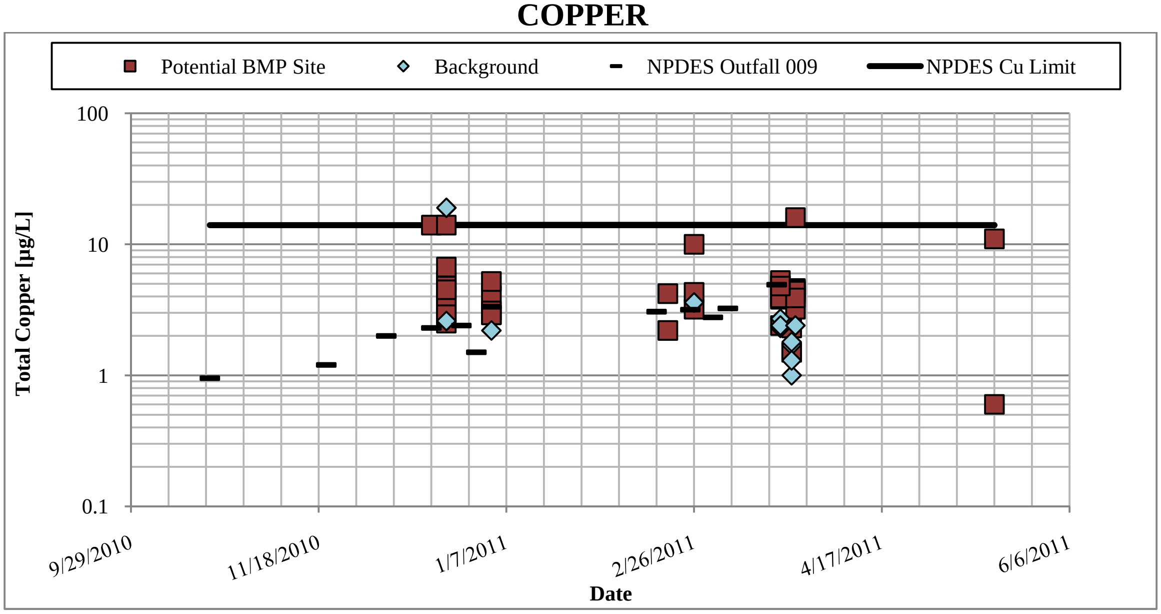


OUTFALL 009 TIME-SERIES CHARTS
POTENTIAL BMP SUBAREA MONITORING PROGRAM

CADMIUM

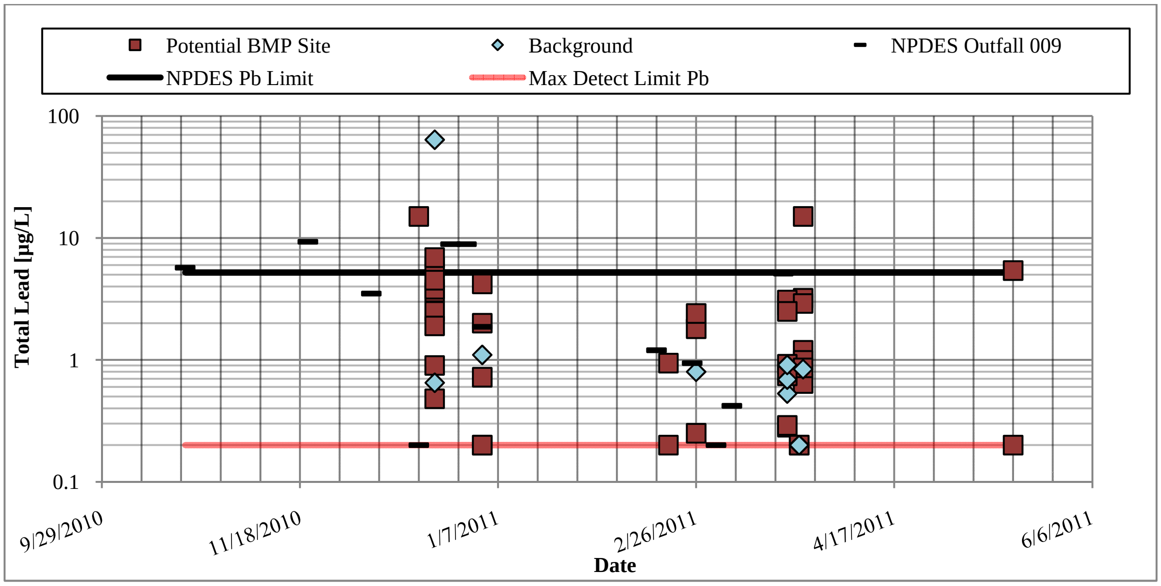


COPPER

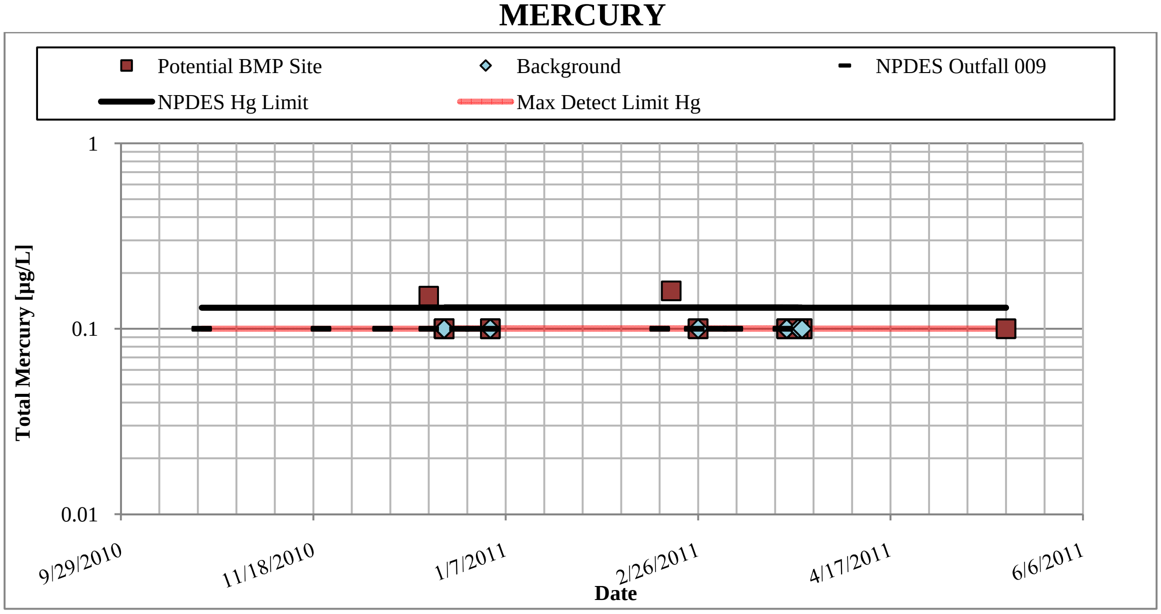


OUTFALL 009 TIME-SERIES CHARTS (CONTINUED)
POTENTIAL BMP SUBAREA MONITORING PROGRAM

LEAD

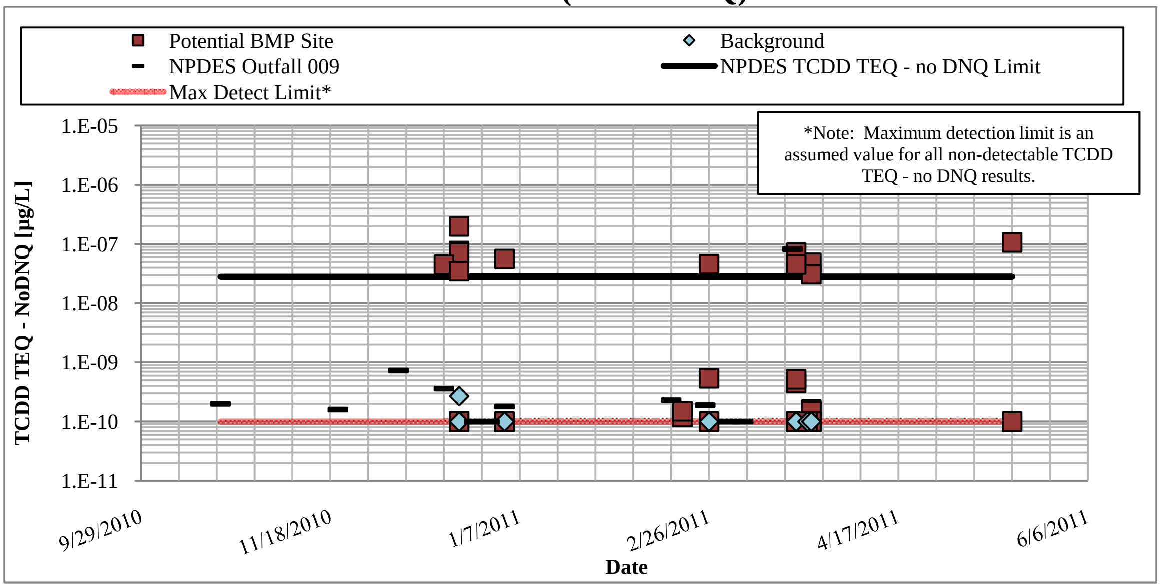


MERCURY



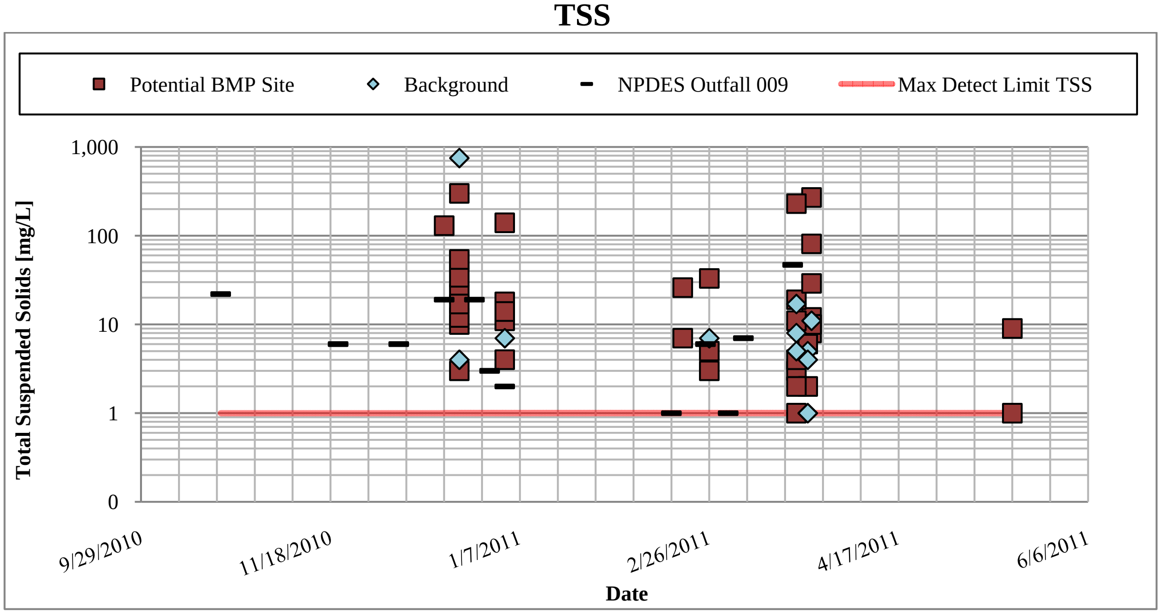
OUTFALL 009 TIME-SERIES CHARTS (CONTINUED)
POTENTIAL BMP SUBAREA MONITORING PROGRAM

DIOXINS (TCDD TEQ)



Note: Dioxin TEQ concentrations for NPDES samples collected during the 2010/2011 rainy season were calculated per the NPDES permit adopted on June 3, 2010 by multiplying each congener concentration by its respective TEF and BEF, and excluding congener DNQ results. Dioxin TEQ concentrations for NPDES samples collected prior to the 2010/2011 rainy season were calculated per pervious NPDES permits by multiplying each congener concentration by only its respective TEF, and excluding congener DNQ results.

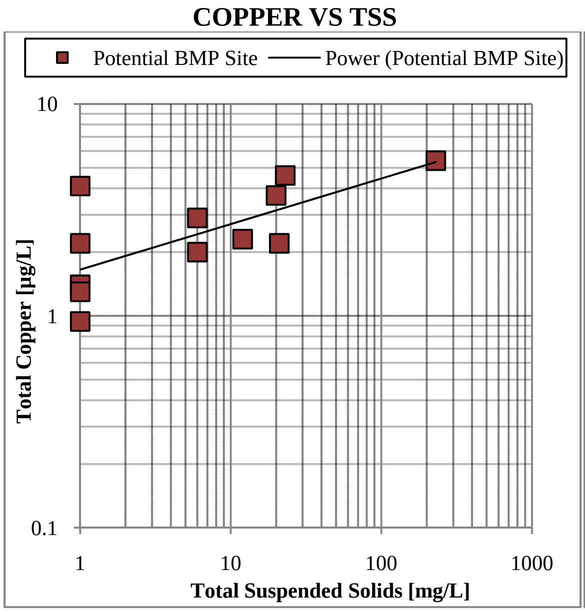
TSS

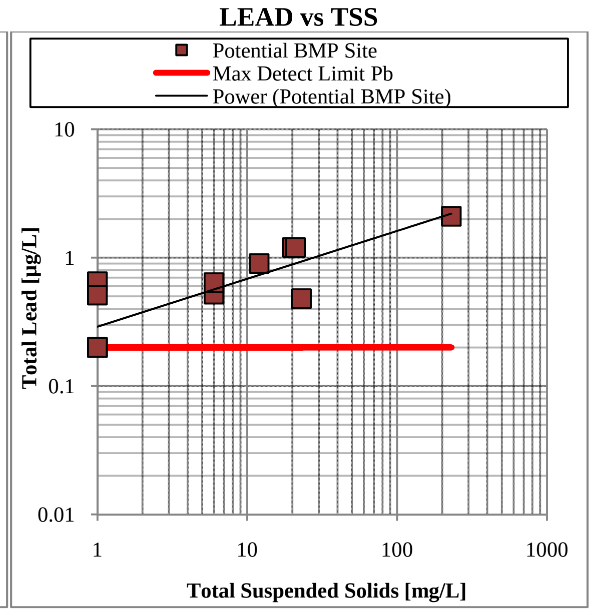


APPENDIX G-2

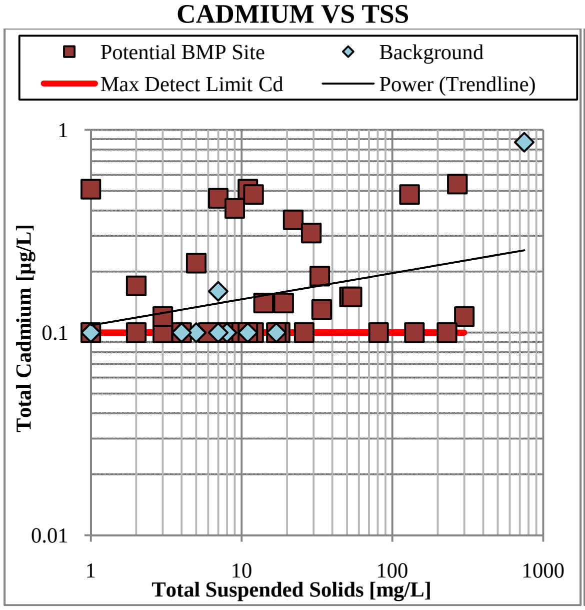
BMP MONITORING DATA GRAPHS – COC CORRELATIONS

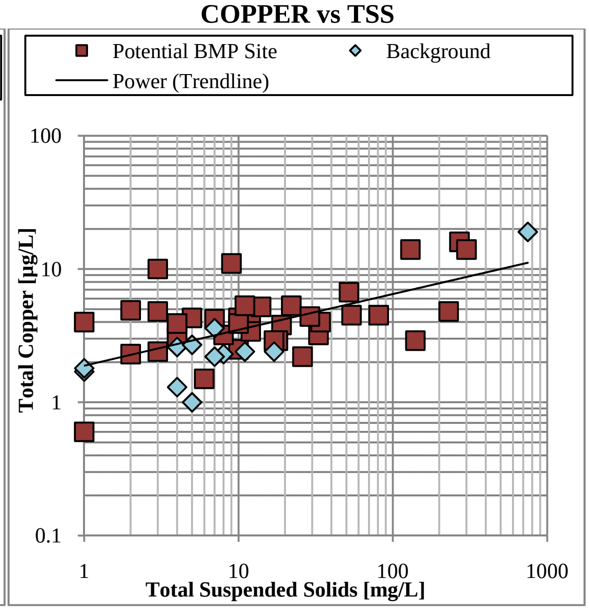
OUTFALL 008 CORRELATION CHARTS
POTENTIAL BMP SUBAREA MONITORING PROGRAM

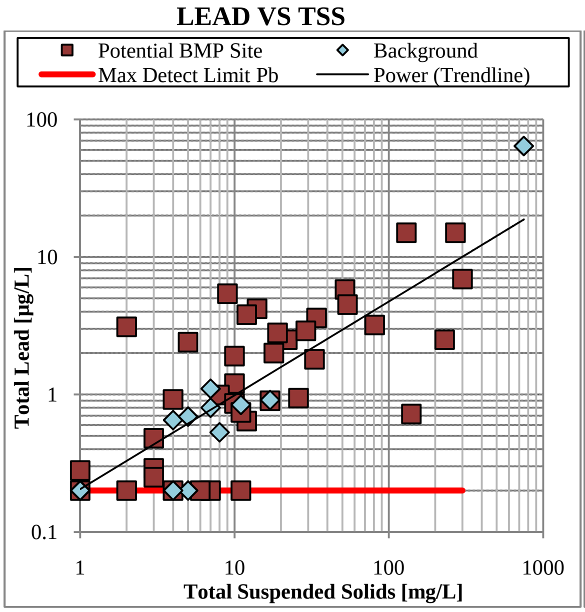


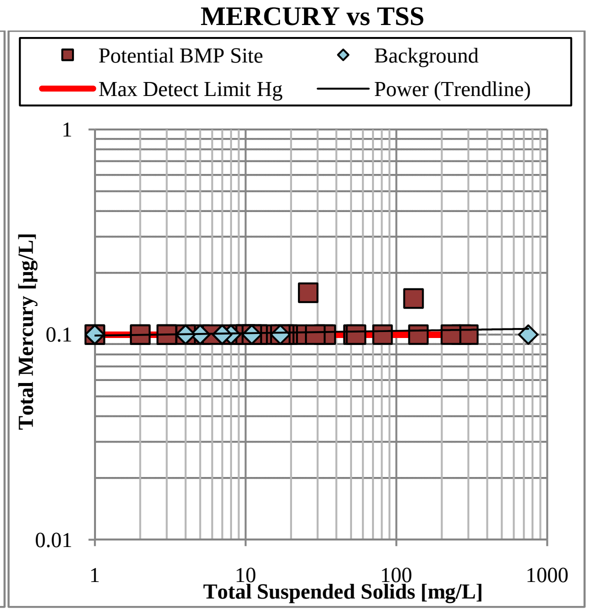


OUTFALL 009 CORRELATION CHARTS
POTENTIAL BMP SUBAREA MONITORING PROGRAM









OUTFALL 009 CORRELATION CHARTS (CONTINUED)
POTENTIAL BMP SUBAREA MONITORING PROGRAM