APPENDIX H

BMP SITE RANKING ANALYSIS

SSFL WATERSHED 008 AND 009 BMP SITE RANKING ANALYSIS

July 26, 2011

SSFL Stormwater Expert Panel

Geosyntec Consultants

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ATTACHMENTS

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LIST OF ACRONYMS

BEF	Bioaccumulation equivalency factors
BMP	Best management practice
Cd	Cadmium
CM	Culvert modification
CV	Coefficient of variation
Cu	Copper
CWB	California Water Board
Det	Detected
DNQ	Detected not quantified
ISRA	Interim Source Removal Action
µg/kg	micrograms per kilogram
µg/L	micrograms per liter
mg/L	milligram per liter
ND	Not detected
NPDES	National Pollutant Discharge Elimination System
Pb	Lead
PL	Permit limit
POC	Pollutant of concern
PS	Particulate strength
RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility Investigations
RWQCB	Regional Water Quality Control Board
SSFL	Santa Susana Field Laboratory
SW	Stormwater
Tc	Time of concentration
TCDD	Tetrachlorodibenzo-*p*-dioxin
TEQ	Toxic equivalence
TSS	Total suspended solids
USEPA	U.S. Environmental Protection Agency

EXECUTIVE SUMMARY

The Santa Susana Field Laboratory (SSFL) Stormwater Expert Panel (Panel) was tasked by 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). 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 measures 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 compliance at Outfalls 008 and 009(Order No. R4-2010-0090).

The purpose of this analysis was to rank subareas within Boeing's and NASA's 008 and 009 watersheds for potential implementation of new or enhanced stormwater controls, based on available data and site specific considerations. The Panel's recommended approach to this task was to rank potential BMP subarea monitoring sites based on the results of water quality sample comparisons between (a) stormwater concentrations and permit limits, and (b) stormwater particulate strengths[1] and stormwater background particulate strengths. A statistical methodology was developed to rank the sites based on these comparison results, while accounting for the number of useable data available at each site as well as number of data observations that fall above these thresholds (i.e., reflecting statistical confidence in how frequently each site will exceed the comparison thresholds). This methodology relied on "weighting factors" that are calculated for each POC for each site. In the end, the pollutant-specific weighting factors were summed to produce a multi-pollutant score to allow for relative ranking amongst the potential BMP sites.

The data included in this analysis fell into the following categories and periods of record: 1) Interim Source Removal Action (ISRA) and culvert modification (CM) performance monitoring data (2009-2011), 2) NPDES outfall monitoring data (2004-2011), and 3) potential BMP subarea monitoring data (2010-2011). Where available, data from co-located ISRA sites were combined with data from BMP subarea sites in order to provide a more robust dataset at potential BMP locations. The exact periods of record varied by dataset and by sample site. This evaluation will occur annually during the term of the 008/009 BMP Work Plan (i.e., through 2014), therefore this is the first of four annual BMP data analysis and recommendation reports.

Site Specific Evaluation of Top Ranked Sites

Based on these analysis results, the following monitoring locations were identified as the highest ranked subareas, with multi-pollutant scores ranging from 0.25 to 0.66 (see Table ES-1). Besides their multi-

[1] Particulate strength is determined by taking the total concentrations of the compound minus its dissolved concentrations and dividing by the total suspended solids. It then provides a measure of the mass of particulate form of the compound per mass of suspended sediment. These values are very useful when identifying erosion and other sources of the particulate-bound pollutants in the runoff.

pollutant scores, the following list is also of significance because it included: all sites that were ranked first and second for each of the pollutant categories (metals, dioxins, or TSS), all sites that had detections of the 2,3,7,8-TCDD dioxin congener (at low, DNQ-estimated quantities), the site with the highest observed dioxin concentrations (noting that the scores do not explicitly account for concentration *magnitude*s, but rather account for *frequency* of exceeding the concentration-based background and permit limit thresholds), five of the eight sites where both the 95th percentile background limits and permit limits were exceeded, seven of the top seven ranked sites for metals, eight of the top nine ranked sites for dioxins, and four of the top five ranked sites for TSS. This list also includes all of the subareas that will receive runoff treatment by two new treatment controls – the lower parking lot biofilter and the B1 culvert modification – that will be constructed later in 2011. This list is followed by the Panel's new BMP recommendations for implementation in 2012.

1. **EVBMP0002** (Helipad spillway): This monitoring site reflects sheetflow from the approximately 4 acre, fully paved helipad area, which is located in Area II (NASA) and includes no areas of surface soil contamination, such as those identified by the ISRA program. This area also represents a significant source of runoff to Outfall 009 during frequent small rain events given its large impervious area and direct connection to the outfall via a slope drain. This site was ranked first based on the multi-pollutant score of 0.66. This site was ranked sixth for metals and first for dioxins, and exceeded both the 95th percentile background limits and the permit limits. The Panel recommends new BMP actions to address runoff from this subarea.
2. **ILBMP0001** (lower parking lot 24-inch storm drain outlet below Boeing Building 436), tied for 2nd with LPBMP0001: This monitoring site reflects stormdrain flows from a 23 acre, 35% impervious subarea, which is located in Area I (Boeing) and includes undeveloped hillsides, parking lot, rooftop, and paved roadway surfaces, and includes no areas of surface soil contamination, such as those identified by the ISRA program. This site is ranked second overall, tied with the soil stockpile subarea, based on the multi-pollutant score of 0.5. This site was ranked first for metals (tied with soil stockpile, B1 culvert inlet, and Area I landfill) and second for dioxins (tied with soil stockpile and CM1 upgradient west), and exceeded both the 95th percentile background limits and the permit limits. This subarea will soon have treatment of low flows as part of the planned stockpile sediment basin and biofilter, which is a multi-stage treatment system with specially-selected filter media. The low flow diversion is currently estimated to capture and treat, on average, 21% of the runoff volume from this subarea, based on long-term continuous modeling and the existing 90% design plans. Current SSFL demolition plans will remove Building 436 and the adjacent parking lot in 2013 (a total impervious area of approximately 1 acre), which will reduce runoff volumes to this stormdrain and increase the percent capture of the low flow diversion. Given the planned demolition and biofilter at the downstream soil stockpile area, the Panel does not recommend additional actions to address runoff from this subarea at this time. Only two samples were collected from this monitoring site in 2010/11, therefore additional samples in 2011/12 will greatly improve our understanding of stormwater quality for this subarea.

2. **LPBMP001** (soil stockpile sheetflow), tied for 2nd with ILBMP0001: This monitoring site reflects sheetflow from the 5 acre, fully paved soil stockpile area (or lower parking lot), which is located in Area I (Boeing) and currently includes no areas of surface soil contamination but will be used in the future to manage stockpiled soils generated from the SSFL remediation program. As a result, it will continue to have the potential for discharge of pollutants. This site is ranked second overall, tied with lower parking lot stormdrain, based on the multi-pollutant score of 0.5. The stockpile area was ranked first for metals (tied with lower parking lot stormdrain, B1 culvert inlet, and Area I landfill) and second for dioxins (tied with lower parking lot stormdrain and CM1 upgradient west). The Plan had previously recommended a multi-stage treatment control (sediment basin followed by biofilter) for this 5 acre area that is sized to the site specific design storm, or 90% runoff volume capture, and installation is planned for 2011. Furthermore, construction SWPPP erosion and sediment control practices will be implemented during future soil stockpiling activities, and 1.8 acres of adjacent asphalt (not in this drainage area) will be removed on Boeing and Sage Ranch property in 2011. The Panel recommends no new actions to address runoff from this subarea. Only two samples were collected from this monitoring site in 2010/11 and additional sampling in 2011/12 will allow for an evaluation of the effectiveness of the construction of the multi-stage treatment system.

4. **A2SW0001** (ELV road runoff/CM1 upgradient west): This monitoring site reflects sheetflow from an approximately 13 acre area in Area II (NASA), which includes ELV ISRA areas, a completed Area II ISRA area, parking lot, rooftop, and paved roadway surfaces. This site was ranked fourth overall with a multi-pollutant score of 0.45. This site was ranked fifth for metals, second for dioxins (tied with lower parking lot stormdrain and soil stockpile, and included the J-flagged detection of 2,37,8-TCDD), second for TSS, and exceeded both the 95th percentile background limits and the permit limits. This site had the highest observed TCDD TEQ concentrations of those included in this BMP subarea ranking analysis. CM1 is an existing culvert modification that treats runoff from a 41 acre undisturbed subwatershed, as well as runoff from this subarea due to an existing broken asphalt channel below the ELV hillside that is diverting runoff toward the road and then toward CM1. The completed ISRA area is now covered with hydroseed mulch, straw wattle, and rip rap. ISRA removal activities are planned for the ELV area after 2011. The Panel also recommends new actions to address runoff from this subarea.

5. **LXBMP0002** (LOX mid): This monitoring site reflects sheetflow, collected along a LOX area dirt road, from an approximately 1.5 acre compacted pervious drainage area in Area I (NASA), and includes LOX ISRA areas. This site was ranked fifth overall with a multi-pollutant score of 0.31. LOX was ranked seventh for metals and sixth for dioxins. ISRA removal activities are planned for this subarea after 2011. The Panel recommends new actions to address runoff from this subarea. Only two samples were collected from this monitoring site in 2010/11, therefore additional samples in 2011/12 will greatly improve our understanding of stormwater quality for this subarea.

6. **B1BMP0001** (B1 culvert inlet): This monitoring site reflects runoff collected at the B1 culvert inlet from an approximately 4.4 acre drainage area, and is located in Area I (Boeing) near the SSFL entrance. This site is ranked sixth overall with a multi-pollutant score of 0.30. The B1 culvert inlet was ranked first for metals (tied with lower parking lot stormdrain, soil stockpile, and Area I landfill), eighth for dioxins, and first for TSS. The B1 ISRA areas were completed in 2011. The Panel previously recommended two new treatment controls at this site which will be completed before the 2011/12 rainy season– the B1 sediment basin and a culvert inlet filter. Furthermore, recent hillside erosion controls and vegetation growth will reduce sediment loading from the exposed slopes immediately surrounding this monitoring site. The Panel recommends no new actions to address runoff from this subarea.

7. **A1BMP0001** (A1LF): This monitoring site reflects runoff collected in a channel below the 1.2 acre Area I landfill drainage area, is located in Area I (Boeing), and includes the A1LF ISRA area. This site is ranked seventh overall with a multi-pollutant score of 0.28. A1BMP0001 was ranked first for metals (tied with lower parking lot stormdrain, soil stockpile, and B1 culvert inlet) and ninth for dioxins, and exceeded both the 95th percentile background limits and the permit limits. ISRA activities are planned for the A1LF after 2011. Runoff from this area is currently treated by CM9 (noting however that runoff from the southern portion of A1LF drains towards Outfall 011 where there is an active treatment system in place). An adjacent 1.5 acre parking lot is also planned for removal in 2011, and this will reduce runoff to CM9 thereby increasing the percent of runoff volume that is treated from the landfill. Also as part of the asphalt removal project a vegetated swale (or equivalent BMP) may be constructed; if that proceeds then it may be designed to also capture a portion of runoff from the top of the landfill and route it toward Outfall 011. The lower or hillside portion of the landfill is currently well vegetated or is occupied by an access road that is covered with erosion controls (hydroseed mulch and straw waddles). The Panel also recommends new actions to address runoff from this subarea, although it should be noted that no NPDES permit limits were exceeded in any of the five grab samples that were collected from this monitoring site in 2010/11.

8. **B1SW0011** (B1 paved roadside ditch): This monitoring site reflects paved road runoff from a very small drainage area near the SSFL entrance in Area I (Boeing), and includes no areas of surface soil contamination, such as those identified by the ISRA program. This site is ranked eighth overall with a multi-pollutant score of 0.25. The B1 ditch was ranked 15th for metals, second for dioxins (including the J-flagged detection of 2,3,7,8-TCDD), and exceeded both the 95th percentile background limits and the permit limits. This subarea will soon have a new treatment control (B1 culvert inlet filter). Runoff from this area will be treated by the B1 culvert inlet filter, which is to be completed in 2011. The Panel recommends no new actions to address runoff from this subarea.

Table ES-1. Subareas Ranked by Multi-Pollutant Score (sites recommended for stormwater controls in 2011 are highlighted)

Rank from Averaged Weights	Potential BMP Subarea (Co-location)	Watershed	Description	Approximate Upgradient DA (ac)	Multi-Pollutant Score	Rank from Maximum Metal Weighting	Rank from Maximum Dioxin Weighting
1	**EVBMP0002**	Outfall 009	Helipad spillway	~4.0	0.66	6	1
2	**ILBMP0001***	Outfall 009	Lower parking lot 24" stormdrain	23	0.5	1	2
2	LPBMP0001*	Outfall 009	Soil stockpile sheetflow	5.1	0.5	1	2
4	**A2SW0001**	Outfall 009	CM1 upgradient west (also ELV area and Area I road)	~13	0.45	5	2
5	LXBMP0002	Outfall 009	LOX mid	1.5	0.31	7	6
6	B1BMP0001* (B1SW0010)	Outfall 009	B1 culvert inlet	4.4	0.30	1	8
7	**A1BMP0001**	Outfall 009	A1LF downgradient	1.2	0.28	1	9
8	**B1SW0011***	Outfall 009	B1 paved roadside ditch	<1	0.25	15	2
9	**B1BMP0002**	Outfall 009	B1 parking lot culvert inlet	5.3	0.13	8	7
10	LXBMP0003	Outfall 009	LOX east (Sage Ranch tributary)	~24	0.03	10	9
11	HZBMP0001 (HZSW0007)	Outfall 008	HV downgradient	<29	0.02	9	13
12	**BGBMP0006** (A2SW0006)	Outfall 009	CM1 upgradient east	41	0.02	11	11
13	**HZBMP0003** (HZSW0003)	Outfall 008	DRG downgradient 2	<33	0.005	11	15
13	**A1SW0004**	Outfall 009	CM9 upgradient	14	0.0012	14	12
13	**Outfall 008****	Outfall 008	NPDES outfall 008	62	0.0003	13	15
16	EVBMP0001	Outfall 009	Helipad Road/ELV culvert inlet	unknown/small	0	16	15
16	ILBMP0002	Outfall 009	Road runoff to CM9	14	0	16	15
16	**Outfall 009****	Outfall 009	NPDES outfall 009	536	0	15	14
16	LXBMP0001	Outfall 009	LOX West	unknown/small	0	16	15
16	ILBMP0003	Outfall 009	A1LF parking lot	9.5	0	16	15
16	HZBMP0002 (HZSW0004)	Outfall 008	DRG downgradient	26	0	16	15

* These potential BMP subarea monitoring sites have new planned (i.e., designed and ready for construction) stormwater quality treatment controls.
** NPDES outfalls are included for comparison and method testing purposes only, stormwater controls are not being contemplated at these locations.
- The rounding of weights may account for similar weights being ranked differently
- Approximate drainage areas based on the cumulative drainage area of the SWMM catchment in which the monitoring location is located (Geosyntec, 2011). At locations where the monitoring point is upgradient of the catchment outfall a "<" sign is used.
- Bolded locations indicate that both the NPDES permit limit and 95th percentile background particulate strength threshold were exceeded.

The 9th ranked B1BMP0002 (parking lot culvert inlet southwest of B1 area) was the last subarea monitoring site that the Panel was contemplating siting new BMPs at since there was a relatively steep dropoff of multi-pollutant scores (from 0.13 to 0.03) after that. This site, along with six of the top eight ranked sites, had monitoring results that exceeded NPDES permit limits for dioxin and/or lead. However, based on further evaluation of this site, and in consideration of the fact that pavement removal may occur here in 2013, the Panel recommends that this location be closely tracked for another year so that it can be re-evaluated in 2012 after another season of monitoring data are collected. This will be part of the broader BMP subarea monitoring data analysis that will occur annually, the results of which may be the recommendation of additional BMPs in the outfall 008 or 009 watersheds.

New BMP Recommendations

Based on the above ranking results, and utilizing best professional judgment (including consideration of information on planned ISRA and demolition measures), the following new BMPs are recommended by the Expert Panel on either NASA or Boeing properties. Additional detail on these BMP concepts and the implementation schedule will be provided in the BMP Work Plan Addendum, submitted to the RWQCB in September 2011.

1. **Helipad (NASA)** – The Panel recommends sheetflow runoff storage and treatment, and/or asphalt removal. If asphalt removal is contemplated as part of this effort, the Panel recommends that it be combined with fine grading to create depressional areas (to promote infiltration and evapotranspiration) and rigorous application of erosion control and revegetation measures, as well as removal of any surficial soils that are above ISRA criteria for the Outfall 009 NPDES COCs that become exposed following pavement removal.
2. **ELV/CM1 (NASA)** – The Panel recommends ISRA removal at ELV (including robust erosion controls), reconstruction of existing drainage ditch below ELV, and installation of a new culvert inlet media filter near Helipad Road. The Panel also recommends continued inspection and maintenance (removal of accumulated sediment) of CM1 and of the adjacent ISRA erosion controls.
3. **LOX (NASA)** (middle sampling location) – The Panel recommends placement of a sandbag berm along the northern bank of the Northern Drainage channel to reduce bank erosion and encourage temporary ponding of this sheetflow runoff from LOX. ISRA removal is planned to occur here after 2011, and the Panel recommends that this be implemented without backfill to leave distributed areas for infiltration for runoff control until final remediation of the LOX RFI area.
4. **A1LF (BOEING)**– The Panel recommends inspection and maintenance (removal of accumulated sediment) of CM9, channel armoring erosion control in the drainage channel at the base of the hillside, and rerouting and/or treatment of sheetflow runoff from the top of the landfill as part of the proposed ISRA action and/or adjacent asphalt removal project.

Recommendations 1 through 3 above (helipad, ELV/CM1, and LOX sites) are on NASA property and the Panel recommends that NASA implement or authorize the implementation of these measures.

Although this analysis primarily focuses on the selection of potential stormwater treatment control locations, 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 unpaved roads and the implementation of source controls (including source removal, such as through the ISRA and demo programs).

1. INTRODUCTION

The purpose of this analysis is to rank subareas in the Santa Susana Field Laboratory (SSFL) Outfall 008 and 009 watersheds for potential implementation of new or enhanced stormwater controls[2], to improve National Pollutant Discharge Elimination System (NPDES) permit compliance at Outfalls 008 and 009. The SSFL Stormwater Expert Panel's (Panel) recommended approach[3] is to:

1. Compare potential BMP subarea[4] monitoring results with site-specific stormwater background[5] 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 best management practices (BMP) subarea monitoring sites based on these multi-pollutant ranking scores.

This general approach is summarized in the flow chart included as Attachment 1. SSFL stormwater background concentrations are established based on data from Interim Source Removal Action (ISRA) performance and potential BMP subarea monitoring locations that represent runoff from drainage areas with minimal to no RCRA Facility Investigations (RFI), ISRA, or developed (i.e., roof or pavement) areas.

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[2] For the purpose of this report, the overarching term "stormwater controls" will be used to describe the standard suite of passive control practices, including erosion controls, sediment controls, and treatment controls. For detailed definitions or examples of erosion and sediment controls, see the CASQA Construction BMP Handbook at http://www.cabmphandbooks.com; for a detailed definition or examples of treatment controls, see the Ventura County Technical Guidance Manual for Stormwater Quality Control Measures at http://www.vcstormwater.org/documents/workproducts/technicalguidancemanual/2010final/Ventura_TGM%2011-4-10.pdf. The more general term, "Best Management Practice" (or BMP), is used in this report as a synonym for "stormwater control" but is used only for referencing the "potential BMP subarea monitoring sites," or monitoring locations where new stormwater controls are being contemplated based on a review of available monitoring results.

[3] The recommended approach outlined herein was developed jointly by the SSFL Stormwater Expert Panel and Geosyntec Consultants, with review from The Boeing Company and the Los Angeles Regional Water Quality Control Board.

[4] "Potential BMP subarea monitoring locations" are defined here as approximately 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.

[5] "Stormwater background monitoring locations" are defined here as locations in these watersheds that generally 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.

The selection of potential BMP subarea monitoring locations is described in the December 16, 2010 sampling recommendations memo from the Panel and Geosyntec (Geosyntec, 2010). Although this analysis is based on concentrations, and does not account for pollutant load or watershed size, monitoring locations were selected based on the goal of capturing runoff from nearly all known areas of potential anthropogenic pollutant sources within these two watersheds. In cases where the drainage areas are small, they generally include mostly paved surfaces so that runoff volumes are still significant.

The Outfall 008 and 009 watershed monitoring locations used for this BMP evaluation are shown in Table 1. Each site is listed with its category (or data type), watershed, co-location (i.e., an alternate site identifier for the same location), a location description, and approximate drainage area. Potential BMP subarea sites include the letters "BMP" in the site identifier, while ISRA performance monitoring locations include the letters "SW" in the site identifier. At the Panel's recommendation, some ISRA and Culvert Modification (CM) performance monitoring locations are included here for BMP siting consideration. NPDES compliance monitoring outfalls 008 and 009 were also included here for comparison and method testing purposes. The locations of the monitoring sites listed in Table 1 are shown in the Attachment 2 map.

The data summarized and their periods of record in this report are as follows:

- ISRA and culvert modification (CM) performance monitoring data: 12/2009 – 3/2011
- NPDES outfall monitoring data: 10/2004 – 5/2011
- Potential BMP subarea monitoring data: 12/2010 – 5/2011

The number of sampling event results currently available for each of the potential BMP subarea monitoring locations is relatively small -- generally one to five storms sampled depending on the location – since this program has only been in place since late December 2010, and sites on Sage Ranch property weren't sampled until March 2011. In comparison, the ISRA performance monitoring program has been in place for nearly two wet seasons (2009/10 and 2010/11), and so these monitoring sites have more stormwater sample event results available. As such, where available, data from co-located ISRA sites were combined with data from BMP subarea sites in order to provide a more robust dataset at potential BMP locations. Additionally, the number of samples collected from sites within the 008 watershed is considerably fewer than the number of samples collected in the 009 watershed due in part to fewer events with sufficient runoff to enable sampling. The smaller frequency of runoff in the 008 watershed is likely due to the absence of directly connected impervious areas and hardened conveyance systems (e.g., paved roads, inlets, storm drains, and lined channels). As a result, there are currently significant limitations to the available stormwater background and potential BMP subarea monitoring datasets; consequently, only a limited number of stormwater control recommendations can be made at this point based on this initial round of data. This data collection and analysis process will be updated annually for the duration of the BMP work plan schedule (presently scheduled through 2014), which will result in more robust datasets and the potential addition of new treatment control recommendations in the future.

All stormwater sampling data reported here were provided by MWH and select analytes were validated by qualified lab quality review professionals[6]. All TCDD TEQ results include Bioaccumulation Equivalency Factors (BEFs), consistent with NPDES reporting requirements (see Appendix A for more information on the effects of BEFs on calculated TEQ results). For all parameters, lab results that are estimated (or "J-flagged," or results that are above the detection limit but below the reporting limit) are included in the analysis since it is the Panel's view that statistical confidence in these individual results is greater than confidence in the sample summary statistics due to the limited number of data available for many locations (and it is these summary statistics that serve as the basis for the Panel's BMP recommendations).

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.

This analysis follows prior reports prepared by the Panel on dioxin and metals stormwater background sources at SSFL (SSFL Stormwater Expert Panel, 2010; SSFL Stormwater Expert Panel, 2009), and is based on the October 2010 BMP Plan for the Outfall 008 and 009 Watersheds (MWH et al, 2010). This analysis is the most refined of several generations of alternatives that were iteratively developed and tested by the Panel and Geosyntec for the selection of potential BMP locations. The results of a prior approach, dated April 2011, are included as Appendix B and are provided as additional information to illustrate the Panel's iterative development process.

[6] Data validation is the process of evaluating data for program, method and laboratory quality control compliance, and will determine the validity and usability of the data. A Level II validation was performed on all dioxin results for the BMP monitoring program and for dioxin results above the permit limit for the performance monitoring program. In addition, validation was performed to investigate anomalous results at a Level II and validation was performed to investigate the performance of the Dekaport Cone Splitter at a Level IV. A Level II validation involves a review of field methods and a high level review of laboratory methods. The primary purpose of performing a Level II validation on the dioxin results was to address blank contamination and estimated maximum possible concentration (EMPC) values. An EMPC value is assigned to a dioxin isomer when a peak is within the retention time window of a target dioxin or furan isomer; however, at least one of the identification criteria from the method was not met for that peak. Therefore this peak cannot be positively identified as a dioxin or furan. The Level II validation process would evaluate the EMPC values and revise these values to non-detects at either the level of interference or the reporting limit, whichever is higher. A Level IV validation is a definitive evaluation of the data and involves a very detailed review of the field and laboratory processes including the raw data files used to identify and quantitate dioxins and furan. This level of validation requires the validator to reproduce a percentage of the result from the raw data files to ensure that systemic errors or errors of omission or transcription errors are not present in the final reported data.

Table 1. SSFL 008 and 009 Watershed BMP Evaluation Monitoring Sites (see Attachment 2 for maps with locations)

Site Identifier (Co-location)	Category	Watershed	Description	Approximate Upgradient Drainage Area (ac)[1]
A1SW0002	SW Background	Outfall 009	CM8 upgradient	<2.5
A1SW0006	SW Background	Outfall 009	CM11 upgradient	<8.3
BGBMP0001 (A2SW0007)	SW Background	Outfall 009	CM1 upgradient east new	<41.1
BGBMP0002 (LXSW0003)	SW Background	Outfall 009	CM3 upgradient new	<17.2
BGBMP0003	SW Background	Outfall 009	Sage Ranch near LOX	23.6
BGBMP0004	SW Background	Outfall 009	Sage Ranch near LOX2	81.4
BGBMP0005	SW Background	Outfall 009	Sage Ranch near entrance	<41.3
BGBMP0007 (LXSW0001)	SW Background	Outfall 009	CM3 upgradient	<17.2
HZSW0005	SW Background	Outfall 008	DRG upgradient	<25.9
HZSW0008	SW Background	Outfall 008	HV upgradient	<29
HZSW0011	SW Background	Outfall 008	HV upgradient	<29
HZSW0012	SW Background	Outfall 008	HV upgradient	<29
HZSW0014	SW Background	Outfall 008	HV upgradient	<29
HZSW0017	SW Background	Outfall 008	HV upgradient	<29
HZSW0020	SW Background	Outfall 008	HV upgradient	<29
A1BMP0001	Potential BMP subarea	Outfall 009	A1LF downgradient	1.2
B1BMP0001 (B1SW0010)	Potential BMP subarea	Outfall 009	B1 culvert inlet	<4.4
B1BMP0002	Potential BMP subarea	Outfall 009	B1 parking lot culvert inlet	5.3
BGBMP0006 (A2SW0006)	Potential BMP subarea	Outfall 009	CM1 upgradient east	<41.1
EVBMP0001	Potential BMP subarea	Outfall 009	ELV culvert inlet	<11.9
EVBMP0002	Potential BMP subarea	Outfall 009	Helipad spillway	<3.4
HZBMP0001 (HZSW0007)	Potential BMP subarea	Outfall 008	HV downgradient	<29
HZBMP0002 (HZSW0004)	Potential BMP subarea	Outfall 008	DRG downgradient	<25.9
HZBMP0003 (HZSW0003)	Potential BMP subarea	Outfall 008	DRG downgradient 2	<33
ILBMP0001	Potential BMP subarea	Outfall 009	Lower parking lot 24" stormdrain	<41.3
ILBMP0002	Potential BMP subarea	Outfall 009	Road runoff to CM9	<13.9
ILBMP0003	Potential BMP subarea	Outfall 009	A1LF parking lot	10.7

Site Identifier (Co-location)	Category	Watershed	Description	Approximate Upgradient Drainage Area (ac)[1]
LPBMP0001	Potential BMP subarea	Outfall 009	Soil stockpile sheetflow	5.1
LXBMP0002	Potential BMP subarea	Outfall 009	LOX mid	<1.5
LXBMP0003	Potential BMP subarea	Outfall 009	LOX east	0.4
A1SW0004*	CM upgradient	Outfall 009	CM9 upgradient	<13.9
A2SW0001*	ISRA upgradient	Outfall 009	ELV road runoff/CM1 upgradient west	41.1
B1SW0011*	ISRA upgradient	Outfall 009	B1 paved roadside ditch	<4.4
Outfall 008**	NPDES	Outfall 008	NPDES outfall 008	62
Outfall 009**	NPDES	Outfall 009	NPDES outfall 009	536
LXBMP0001***	Potential BMP subarea	Outfall 009	LOX west	<59.5

[1] Approximate drainage areas are based on the cumulative drainage area of the SWMM catchment in which the monitoring location is located (Geosyntec, 2011). At locations where the monitoring point is upgradient of the catchment outfall a "<" sign is used.

* At the Panel's request, these upgradient CM and ISRA performance monitoring locations are being included with the potential BMP subarea monitoring data for this site ranking analysis.

** NPDES outfall monitoring data are included in this analysis for comparison and method testing purposes only. New stormwater controls are not being contemplated at these locations.

*** No sample results were available for this site as of May 17, 2011.

2. DATA SUMMARY

Table 2A summarizes the various monitoring locations that were selected to be representative of onsite stormwater background runoff quality because they represent locations that are not expected to be impacted by historic or ongoing site activities. Due to the varying objectives of each of the monitoring programs, not all pollutants of concern (POCs) were sampled at all sites. For this BMP site ranking analysis, the POCs are defined as total suspended solids (TSS), cadmium (Cd), copper (Cu), lead (Pb), mercury (Hg), TCDD TEQ, and 2,3,7,8-TCDD because these constituents have periodically been measured at concentrations above the current NPDES permit limits at the 008 and 009 monitoring stations, with the exception of TSS and 2,3,7,8-TCDD which are without permit limits but are included here as alternative indicators of POC generation. The number of samples for each POC at each stormwater background site is summarized in Table 2A. Table 2B provides a similar summary for the locations where control practice needs are being evaluated, as well as Outfalls 008 and 009, which are included here for method testing purposes. A map that shows the locations of the stormwater monitoring sites is included as Attachment 2.

Table 2A. Stormwater background locations and number of sample results for indicated parameters

SW Background Location (Co-location)	Description	Number of Sample Results for Indicated Parameters						
		TSS	Cd	Cu	Pb	Hg	TCDD TEQ	2,3,7,8-TCDD
A1SW0002	CM8 upgradient	10	0	0	10	0	0	0
A1SW0006	CM11 upgradient	12	0	0	0	0	12	12
BGBMP0001 (A2SW007)	CM1 upgradient east new	4	4	4	4	4	4	4
BGBMP0002 (LXSW0003)	CM3 upgradient new	3	3	3	3	3	3	3
BGBMP0003	Sage Ranch near LOX	2	2	2	2	2	2	2
BGBMP0004	Sage Ranch near LOX2	2	2	2	2	2	2	2
BGBMP0005	Sage Ranch near entrance	1	1	1	1	1	1	1
BGBMP0007 (LXSW0001)	CM3 upgradient	7	7	7	7	7	7	7
HZSW0005	DRG upgradient	1	0	0	0	0	1	1
HZSW0008	HV upgradient	1	0	0	1	0	1	1
HZSW0011	HV upgradient	2	0	2	0	0	2	2
HZSW0012	HV upgradient	1	0	0	1	0	0	0
HZSW0014	HV upgradient	2	0	2	2	0	0	0
HZSW0017	HV upgradient	1	0	0	1	0	1	1
HZSW0020	HV upgradient	1	0	0	1	0	1	1
	Totals:	50	19	23	35	19	37	37

Table 2B. Locations where control practices are being evaluated and number of sample results for indicated parameters

Location (Co-location)	Description	Number of Sample Results for Indicated Parameters						
		TSS	Cd	Cu	Pb	Hg	TCDD TEQ	2,3,7,8-TCDD
A1BMP0001	A1LF	5	5	5	5	4	5	5
A1SW0004	CM9 upgradient	15	15	15	15	15	8	8
A2SW0001	ELV road runoff/CM1 upgradient west	7	0	0	7	0	7	7
B1BMP0001 (B1SW0010)	B1 culvert inlet	3	3	3	3	3	3	3
B1BMP0002	B1 parking lot culvert inlet	6	6	6	6	6	6	6
B1SW0011	B1 paved roadside ditch	3	3	3	3	3	3	2
BGBMP0006 (A2SW0006)	CM1 upgradient east	7	1	1	7	1	7	7
EVBMP0001	ELV culvert inlet	2	2	2	2	2	2	2
EVBMP0002	Helipad spillway	5	5	5	5	5	5	5
HZBMP0001 (HZSW0007)	HV downgradient	11	4	11	11	4	11	11
HZBMP0002 (HZSW0004)	DRG downgradient	3	4	4	4	4	4	4
HZBMP0003 (HZSW0003)	DRG downgradient 2	13	5	13	14	5	13	13
ILBMP0001	Lower parking lot 24" stormdrain	2	2	2	2	2	2	2
ILBMP0002	Road runoff to CM9	2	2	2	2	2	2	2
ILBMP0003	A1LF parking lot	4	4	4	4	4	4	4
LPBMP0001	Soil stockpile sheetflow	2	2	2	2	2	2	2
LXBMP0001	LOX west	0	0	0	0	0	0	0
LXBMP0002	LOX mid	2	2	2	2	2	2	2
LXBMP0003	LOX east	5	5	5	5	5	5	5
	Totals:	97	70	85	99	69	91	91

Notes

ug = upgradient; dg = downgradient

Table 3A summarizes the total samples, non-detects (NDs), and J-flagged (DNQ) numbers of observations, along with the minimum, median, and maximum concentration values for each of the POCs for the complete combined stormwater background dataset. TSS values are summarized by watershed as well as combined for both watersheds. All of the mercury and 2,3,7,8-TCDD stormwater background results are ND. Stormwater background concentration values for POCs that are higher than current permit limits (which apply only at the NPDES compliance outfalls) are highlighted in yellow. These results confirm previous observations by the Panel and others regarding natural background stormwater quality at the SSFL that occasionally exceeds NPDES permit limits for select metals (including

copper and lead). Table 3B provides a similar summary for all locations combined where control practices are being evaluated as well as for Outfalls 008 and 009 data.

Table 3A. Stormwater background samples (all sites combined) – Concentrations (mg/L for TSS, µg/L otherwise)

POC	# samples	# NDs	# DNQ	Min	Median	95th Percentile	Max	Permit limit for OF008 & OF009
TSS - 008	9	0	4	2.0	28	74	76	NA
TSS - 009	41	5	21	< 1.0	5.0	55	750	NA
TSS - all	50	5	25	< 1.0	6.5	73	750	NA
Cadmium	19	16	3	< 0.10	< 0.10	0.32	0.87	4
Copper	23	0	10	1.0	2.3	7.4	19	14
Lead	35	5	17	< 0.20	0.74	14.6	64	5.2
Mercury	19	19	0	< 0.10	< 0.10	<0.10	< 0.10	0.13
TCDD TEQ	37	10	NA	< 1.0E-10	6.0E-10	2.4E-07	8.5E-07	2.80E-08
2,3,7,8-TCDD	37	37	0	< 5.0E-08	< 8.7E-07	< 4.8E-06	< 5.4E-06	NA

Notes

1) No substitution assumptions were made in the attempt to quantify NDs. For example, "< 0.20" refers to a non-detect with a detection limit of 0.20 µg/L.
2) RWQCB split sample results excluded. A separate analysis will be provided in the July ISRA/BMP report to compare split results versus primary sample results.
3) All data from 'PS_Trigger_Analysis.xlsx'.
4) Mercury is not evaluated in the rest of this report because of the total lack of detected stormwater background results that are needed for the data analyses. Mercury will be examined again during future annual data reviews in case it is periodically detected in the stormwater background samples.
5) Highlighted values exceed the permit limit for that POC.
6) J flagged/DNQ results are included for all POCs.
7) With the exception of cadmium, which had all ND or J-flagged/estimated results, assumptions regarding the treatment of J-flag (or DNQ) results do not impact the 95th percentile stormwater background thresholds for any POC.
8) Metals results shown here are for the total form only, consistent with the permit limits.

Table 3B. Locations where control practices are being evaluated (all sites combined) – Concentrations (mg/L for TSS, µg/L otherwise)

POC	# samples	# NDs	# DNQ	Min	Median	95th Percentile	Max	Permit limit for OF008 & OF009
TSS - 008	27	4	7	< 1.0	15	300	840	NA
TSS - 009	70	6	22	< 1.0	12.5	260	890	NA
TSS - all	97	10	29	< 1.0	13	280	890	NA
Cadmium	70	31	39	< 0.1	0.13	0.51	0.96	4
Copper	85	0	10	0.6	4.1	14	27	14
Lead	99	19	30	< 0.2	1.2	15	55	5.2
Mercury	69	66	2	< 0.1	< 0.1	< 0.1	0.98	0.13
TCDD TEQ	91	21	NA	< 1.0E-10	3.8E-09	3.3E-06	1.4E-05	2.80E-08
2,3,7,8-TCDD	91	89	2	< 2.0E-08	< 1.0E-06	<6.5E-06	2.30E-06	NA

Notes

See notes for Table 3A

3. STORMWATER BACKGROUND SAMPLE DATA SUMMARY – PARTICULATE STRENGTH

Particulate strength (PS) is a means to normalize stormwater pollutant concentrations by TSS, which is helpful for evaluating locations that have high POC concentrations in the runoff as a result of high TSS concentrations[7]. This is especially true for the POCs that are highly associated with particulates and are not found in significant quantities in dissolved forms. This normalization with TSS was performed here to help identify critical POC source areas that may otherwise have mass discharges diluted by large flows. PS is computed as total POC concentration minus dissolved POC concentration divided by TSS concentration, or the estimated particulate POC mass per mass of suspended solids. PS values have been previously used by the Panel to assess sources of metals in SSFL NPDES outfall compliance monitoring data (SSFL Stormwater Expert Panel, 2009).

Calculations of PS are complicated by the fact that some of the dissolved metal data are not available (e.g., for ISRA samples since this monitoring program does not include analyses for dissolved metals); therefore procedures were established to make assumptions in lieu of missing information. These procedures also address situations where total, dissolved, or TSS results are not detected (ND, below the detection limit as reported by the analytical laboratory). Table 4 and Figure 1 summarize the procedures that were followed for this PS calculation analysis given these data limitations. It was not possible to calculate PS for sample events in which TSS or the total POC concentration was not available.

Table 4. Methods used in determining particulate strength

Measurement Result			PS Calculation Approach
Total	Dissolved	TSS	
Det	Det	Det	Compute PS normally
Det	Det	ND	Compute PS with TSS detection limit
Det	ND	ND	Compute PS with TSS & dissolved DLs if dissolved DL is < 30% of the total result. Otherwise use average dissolved fraction from NPDES OF008 and OF009 data to computer PS.
ND	ND	ND	Report PS result as "ND"
ND	ND	Det	Report PS result as "ND"
ND	Det	Det	Report PS result as "ND"
Det	ND	Det	Assume DL for dissolved concentration to get PS if dissolved DL is < 30% of the total result. Otherwise use average dissolved fraction from NPDES OF008 and OF009 data.
ND	Det	ND	Report PS result as "ND"
ND	Null	ND	Report PS result as "ND"
ND	Null	Det	Report PS result as "ND"
Det	Null	Det	Use average dissolved fraction from NPDES OF008 or OF009 data
Det	Null	ND	Compute PS with TSS DL. Use average dissolved fraction from NPDES OF008 or OF009 data

Notes

1) Det = detected, a measured result was obtained; Null = measurement not taken
2) ND = non-detected measurement result – the POC was not detected. Detection limits in these cases are often used to determine the range of possible particulate strengths. In 'PS Calculation Approach' column, ND encompasses all situations where the particulate strength either reflects a non-detect in the concentration, or is non-determinate for other reasons. This distinction is used in all particulate strength columns throughout the rest of this report.

[7] By applying particulate strengths, the Panel is not suggesting that stormwater at SSFL be regulated using such metrics, but rather the Panel is recommending the use of this solely as a diagnostic metric for the identification of source areas and for the ranking of potential BMP monitoring sites for placement of new stormwater controls.

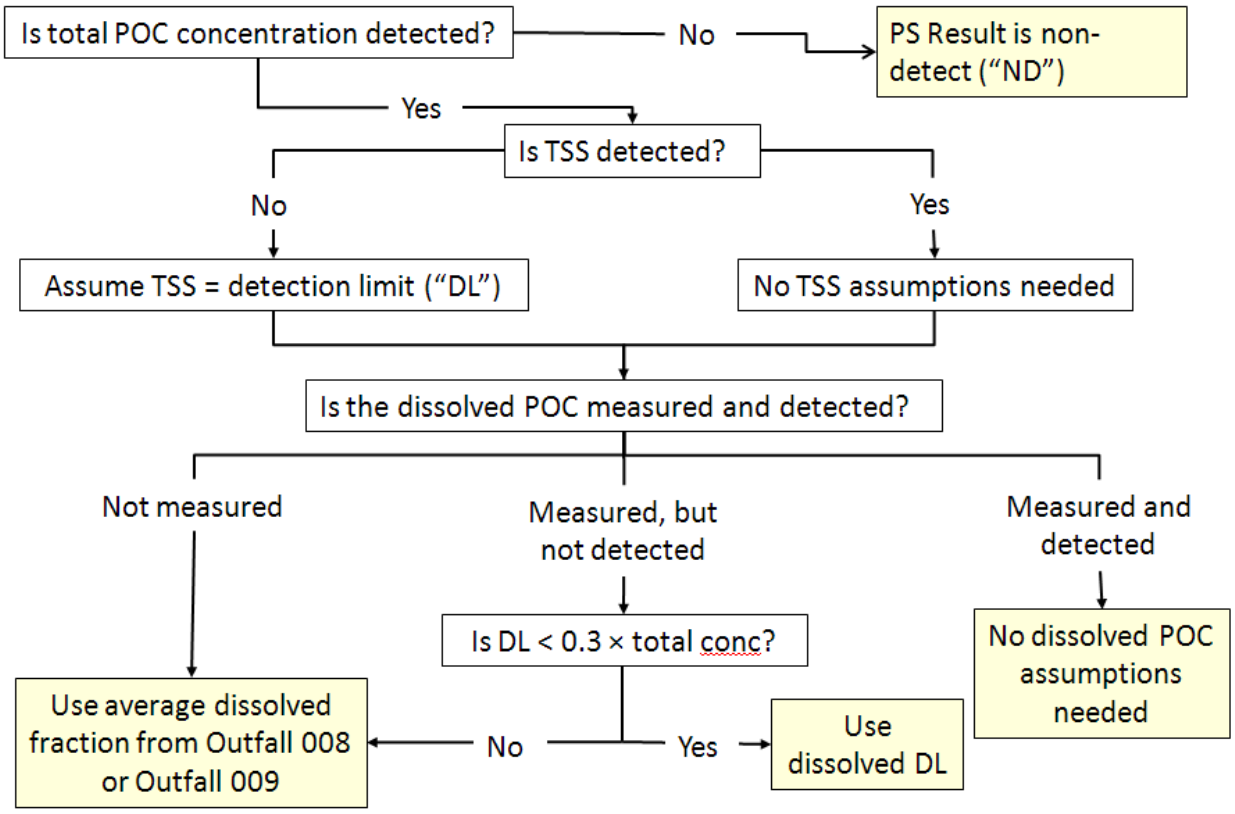

Figure 1. Particulate strength calculation flow chart

Dissolved metals were only analyzed at 6 of the 15 stormwater background monitoring locations since the other 9 locations are ISRA performance (upgradient) sample locations. Therefore, to obtain PS estimates for the ISRA stormwater background locations, as described in Table 4, dissolved concentrations were estimated by assuming that dissolved fractions (i.e., percentage of the total metal concentration) for each sample was equal to the average dissolved fraction at Outfalls 008 or 009. Dissolved concentrations were then estimated for ISRA stormwater background sites based on the watershed in which each site is located. This methodology was not necessary for the BMP monitoring stormwater background sites data, since dissolved metal measurements were available for those locations. The following example calculation demonstrates this method for a theoretical sampling point (X) located in Outfall 009:

TSS_X = 100 mg/L

Total Pb_X = 10 µg/L

Dissolved Pb_X = Sample not collected, so value estimated based on Table 5 = 10 µg/L * 0.18 = 1.8 µg/L

Estimated PS_X = (10 µg/L – 1.8 µg/L) / 100 mg/L = 8.2 µg/L / 100 mg/L = 82 mg/kg

Only samples at Outfalls 008 and 009, where both the total and dissolved concentrations were detectable, were used to determine the average dissolved fractions. These average dissolved fractions

used in the PS calculations are shown in Table 5. TCDD TEQ and 2,3,7,8-TCDD are assumed to have a dissolved fraction of zero because of their extremely low solubility and high affinity for solids. Cadmium was detected once at a single sampling event in the Outfall 008 watershed. At the recommendation of the Panel, the average dissolved fraction of cadmium in the Outfall 008 watershed was computed using the detection limits of the total cadmium analyses as a conservative estimate for dissolved cadmium. Future data will include additional dissolved and total analyses for these metals and these fractions will then be re-evaluated during the subsequent annual site subarea ranking analyses.

Table 5. Average dissolved fraction of POCs based on all available monitoring data in defined watershed; used in determination of particulate strength when dissolved POC not measured (e.g., ISRA and CM performance monitoring datasets)

	Outfall 008			Outfall 009		
POC	% dissolved	# samples	CV	% dissolved	# samples	CV
Cu	59%	20	0.43	65%	59	0.67
Pb	26%	9	0.74	18%	42	0.84
Cd	40%	18	NA	63%	10	0.38

Notes

1) CV = Coefficient of variation
2) # samples = samples with both total and dissolved detected and total > dissolved (results with total < dissolved were excluded from the analysis)
3) Only one sample in the Outfall 008 watershed was analyzed for dissolved cadmium as of March 2011. Dissolved fraction was estimated based on the detection limits of the total cadmium analyses.

Stormwater background sample PS estimates were computed for the POCs using the method described above. Results are shown in Table 6 for all stormwater background site data combined. The 95th percentile and maximum values are generally unaffected by the ND or missing dissolved data assumptions that were made for the PS estimates.

Table 6. Stormwater background results - particulate strength (mg/kg)

POC	# PS results	# NDs	Min	Median	95th Percentile	Max
Cd	18	16	ND	ND	2.1	8.2
Cu	18	0	ND	78	360	610
Hg	19	19	ND	ND	ND	ND
Pb	34	5	ND	79	250	340
TCDD TEQ	37	10	ND	6.6E-08	4.2E-05	4.8E-05
2,3,7,8-TCDD	37	37	ND	ND	ND	ND

Notes

1) Cells with ND refer to values based on total concentration non-detect results per Table 4.
2) RWQCB split sample results excluded
3) All data from 'PS_Trigger_Analysis.xlsx'
4) # NDs reflect the number of non-detects in the total concentration.
5) Particulate strength computation: PS = (Total concentration – Dissolved concentration) / Total Suspended Solids
6) Two copper samples were reported as having dissolved concentrations greater than total concentrations. These samples were omitted from the analysis.

4. DATA SUMMARY CHARTS

To allow for a visual and probabilistic comparison of the available stormwater sampling data, Figures 3 through 12 show probability plots of the POCs at locations grouped into the following categories:

- Stormwater background
- Potential BMP subarea
- Outfall 008 (for comparison)
- Outfall 009 (for comparison)

The x-axes show POC concentrations or PS and the y-axes show the probability of non-exceedance (or probability that values are below) the given x-axis values. The Cunnane equation (Helsel and Hirsch, 1992) was used to compute the plotting positions, and a best-fit line (assuming a lognormal distribution) is shown for the stormwater background data. Note that non-detect results were included in computing the plotting positions, but are not actually plotted (the other data observations are offset in their plotting position to appropriately consider the non-detect data in order to accurately estimate probability values). In general, these plots show that stormwater background concentrations frequently exceed[8] NPDES permit limits for lead (~18% probability) and TCDD TEQ (~13% probability, although this estimated probability is zero when DNQ results are excluded), and somewhat frequently for copper (~5% probability), but do not exceed the NPDES permit limits for cadmium. Note that for copper, the background data best-fit line (which assumes log distribution) does not cross the permit limit (i.e., 0% exceedance probability estimated) although actual data observations indicate a roughly 5% exceedance probability for this stormwater background dataset. This is due to the extreme concentrations not fitting the assumed probability distributions as accurately as the bulk of the data, a common result for water quality data. The 2,3,7,8-TCDD charts show very few data points because this congener is so rarely detected. Also, most of these 2,3,7,8-TCDD detections are lab estimates (i.e., DNQ) and not quantified at high reliability values. 2,3,7,8-TCDD also was never detected in a stormwater background sample. Furthermore, **dioxin congener DNQ results are included for this analysis in contrast to NPDES reporting practice which does not include DNQs, therefore the NPDES outfall results that are shown above the permit limit here do not reflect past NPDES exceedances at concentrations shown.**

Figure 2 provides a key for the POC probability charts. The yellow-orange area includes observations that were less than background conditions, but still exceeded the permit limits. The blue area includes observations that were less than both the stormwater background best-fit line and the permit limit. The red area includes data that exceeded both the stormwater background conditions and permit limits, while the purple area includes observations that exceeded the stormwater background conditions but not the permit limits. Fundamentally, the question is which sites contribute to downstream permit limit exceedances as a result of elevated POC concentrations that are most likely due to particulate strengths

[8] The term "exceed" is being used here as a statistical term only of the likely probability of occurrence. It is only accurate if the data perfectly matched the statistical distribution, which is rare. It indicates values that are greater than a given threshold. It is not intended to have regulatory or non-compliance implications. This is particularly true for TCDD TEQ data which include DNQ results here for statistical analysis purposes, in contrast to NPDES compliance assessment procedures, which require greater reliability for reporting and do not include DNQ results.

that are above site-specific background levels? These sites will be identified by potential BMP subarea stormwater sampling results that fall to the right of the Permit limit in the concentration chart (red and orange areas) **and** fall to the right of the stormwater background best-fit line on the particulate strength chart (in the purple and red areas), or in other words, those samples and sites which may contribute to downstream permit limit exceedances but their elevated POC concentrations are most likely due to particulate strengths that are above site-specific stormwater background levels. As will be discussed later in this report, the sites with data that fall within the red area will receive the highest scores for prioritizing sites for new or enhanced stormwater controls. Depending on the results for other POCs at an evaluation location, data within the purple and yellow-orange areas may also become a factor in prioritizing potential BMP sites.

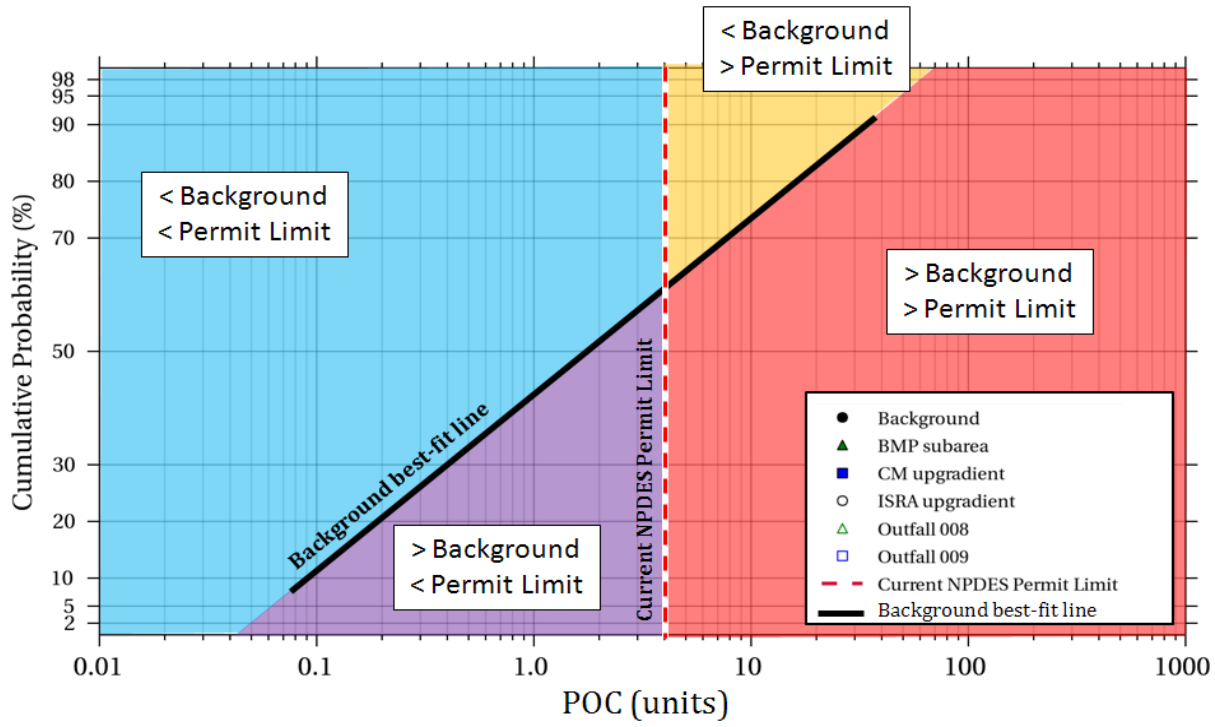

Figure 2. Probability plot key

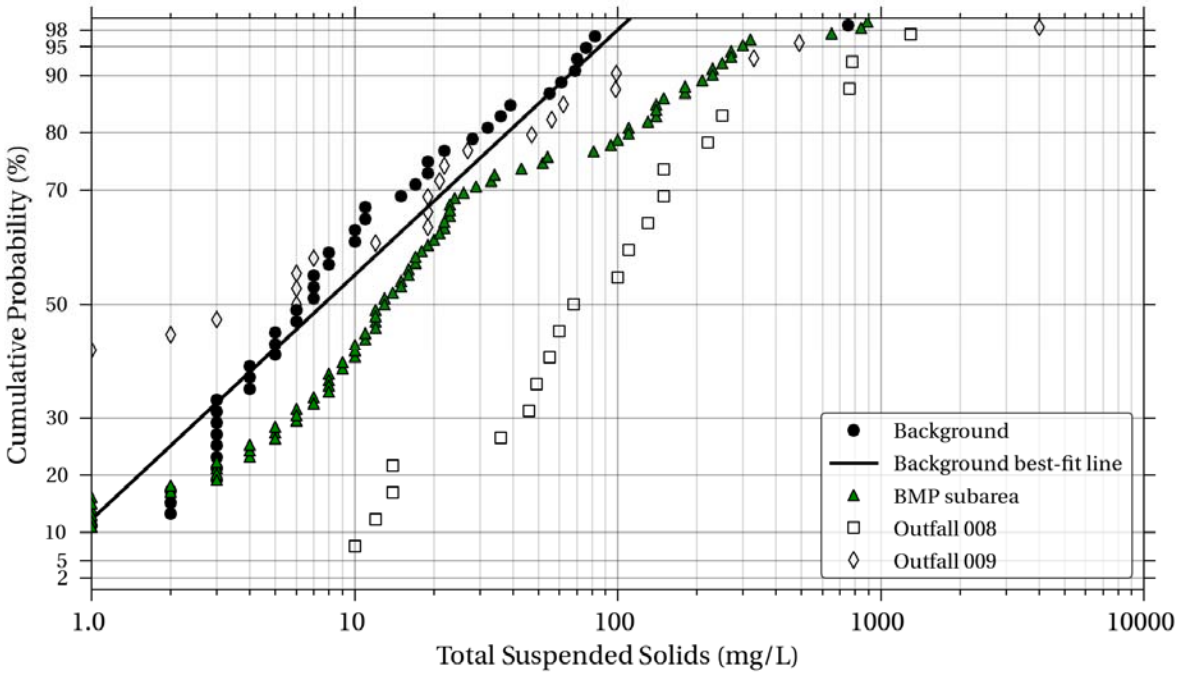

Figure 3. Probability plot for TSS concentrations[9]

[9] Note: Following the 2005 wildfire, an uncharacteristically high TSS value (4000 mg/L) was measured at Outfall 009 on 10/17/2005. This data point is shown near the upper right corner of Figure 3.

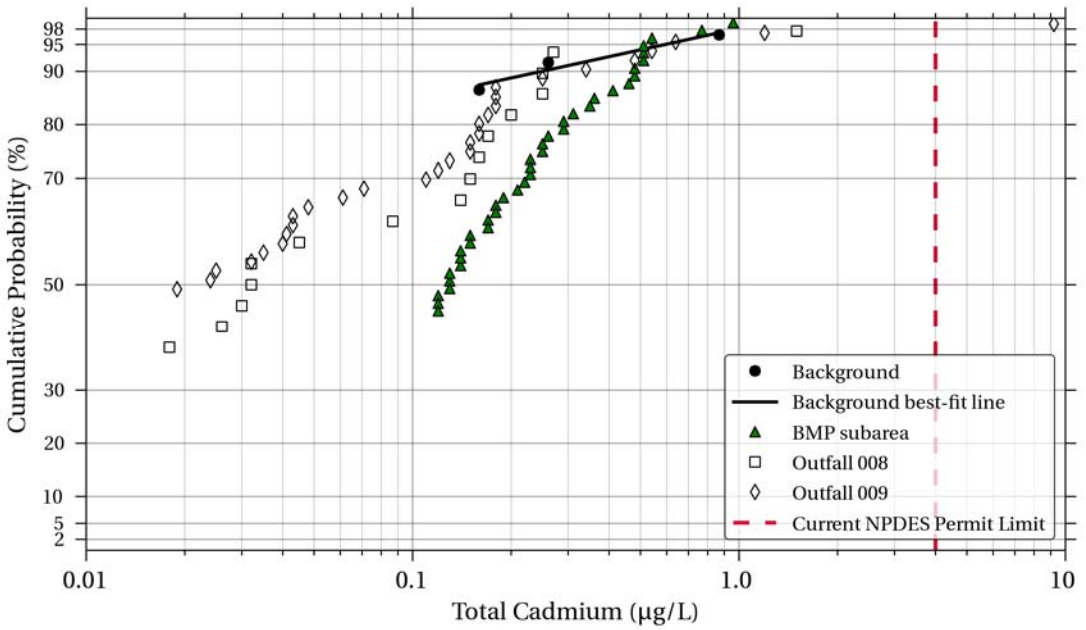

Figure 4. Probability plot for cadmium concentrations[10]

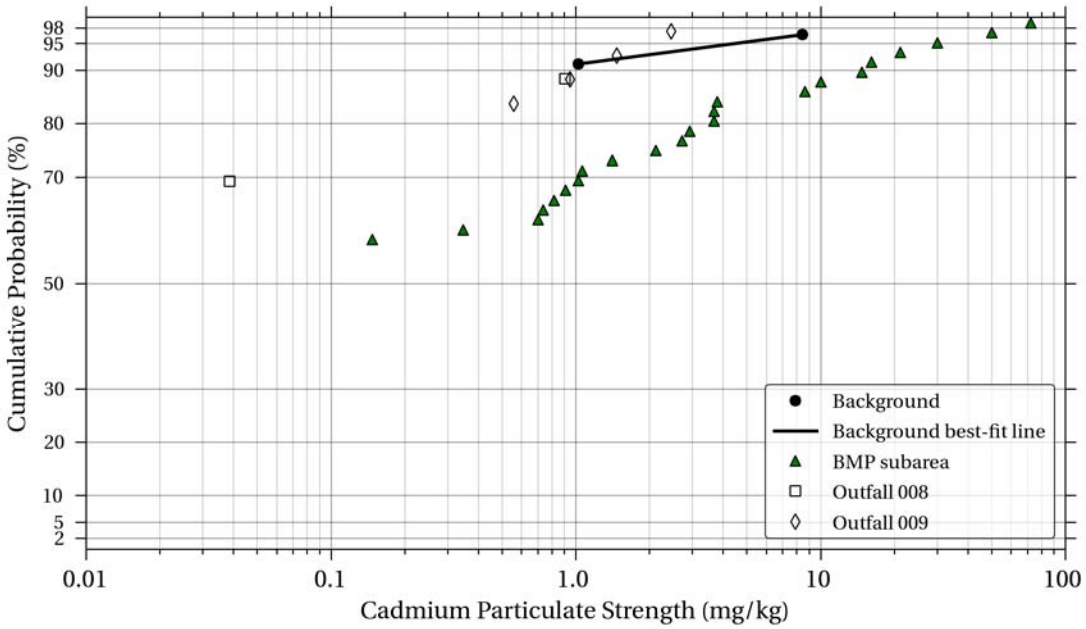

Figure 5. Probability plot for cadmium particulate strengths

[10] Following the 2005 wildfires, an uncharacteristically high cadmium concentration (9.2 µg/L) was measured at Outfall 009 on 10/17/2005. This data point is shown in the upper right corner of Figure 4.

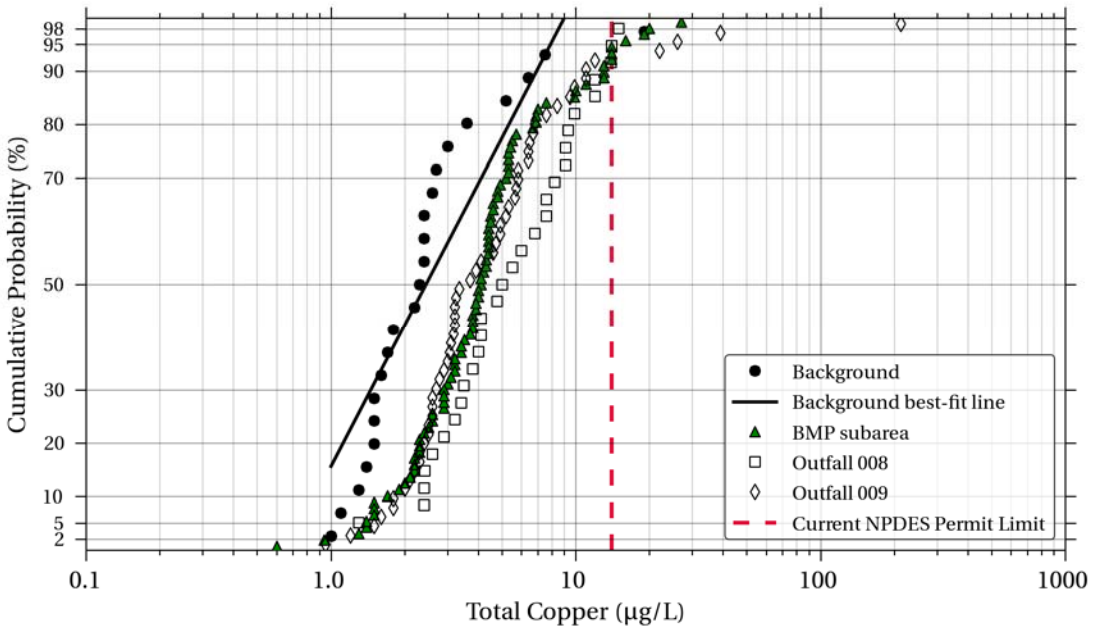

Figure 6. Probability plot for copper concentrations[11]

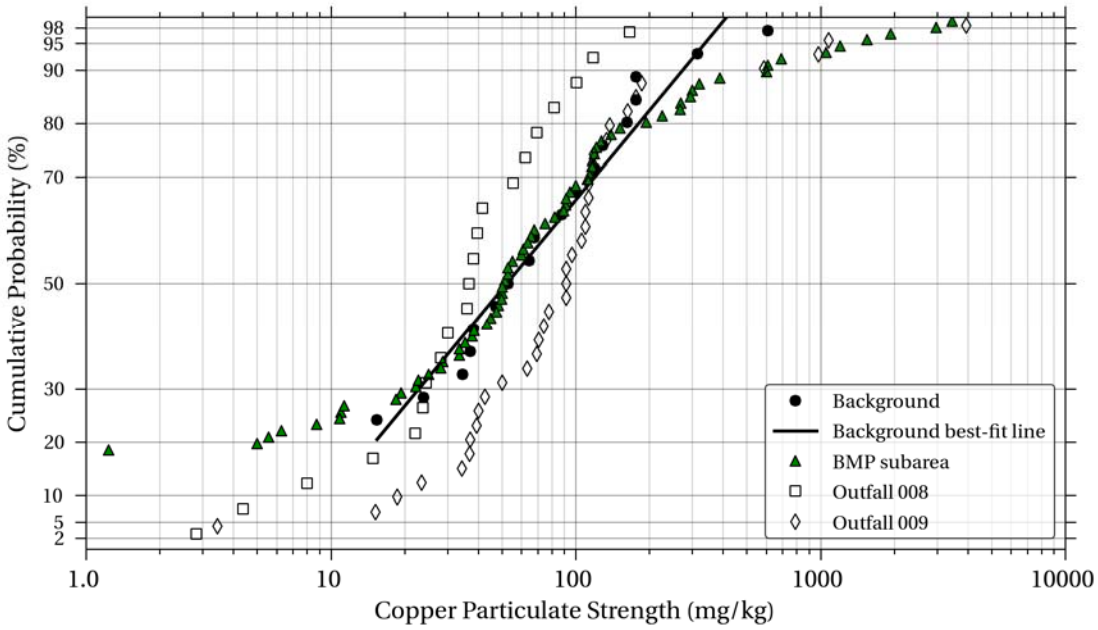

Figure 7. Probability plot for copper particulate strengths

[11] Following the 2005 wildfires, an uncharacteristically high copper concentration (212 µg/L) was measured at Outfall 009 on 10/17/2005. This data point is shown near the upper right corner of Figure 6.

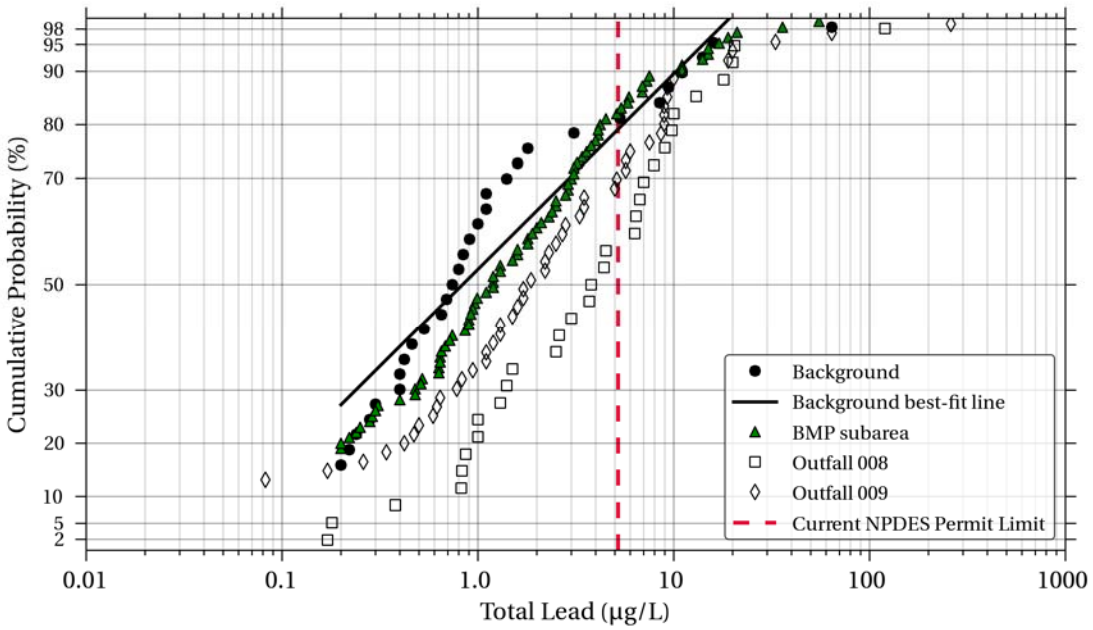

Figure 8. Probability plot for lead concentrations[12]

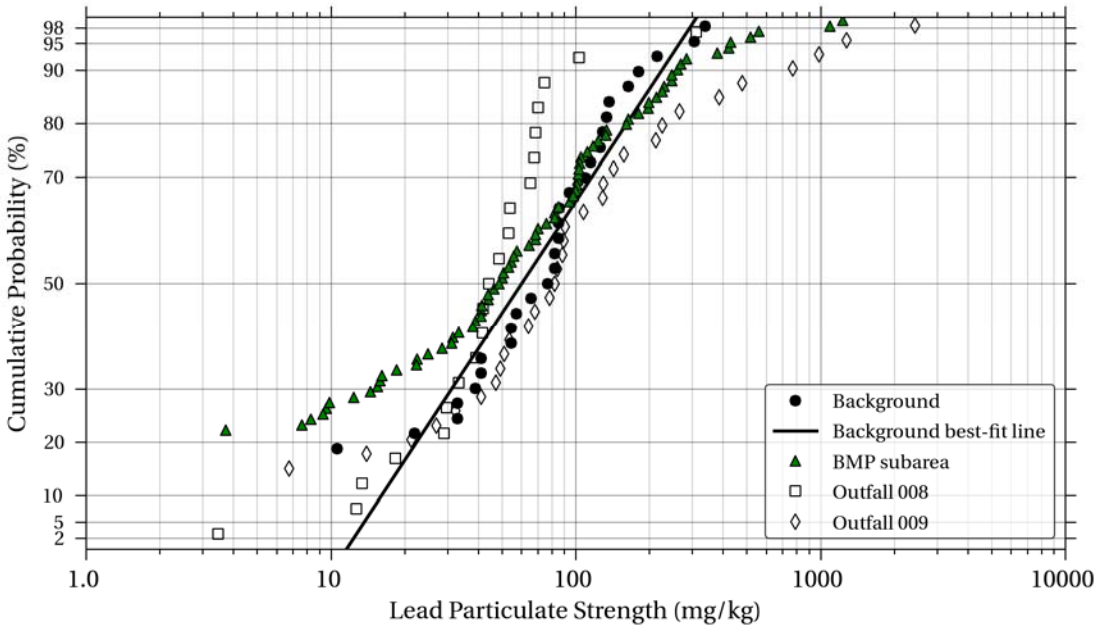

Figure 9. Probability plot for lead particulate strengths

[12] Following the 2005 wildfires, an uncharacteristically high lead concentration (260 µg/L) was measured at Outfall 009 on 10/17/2005. This data point is shown near the upper right corner of Figure 8.

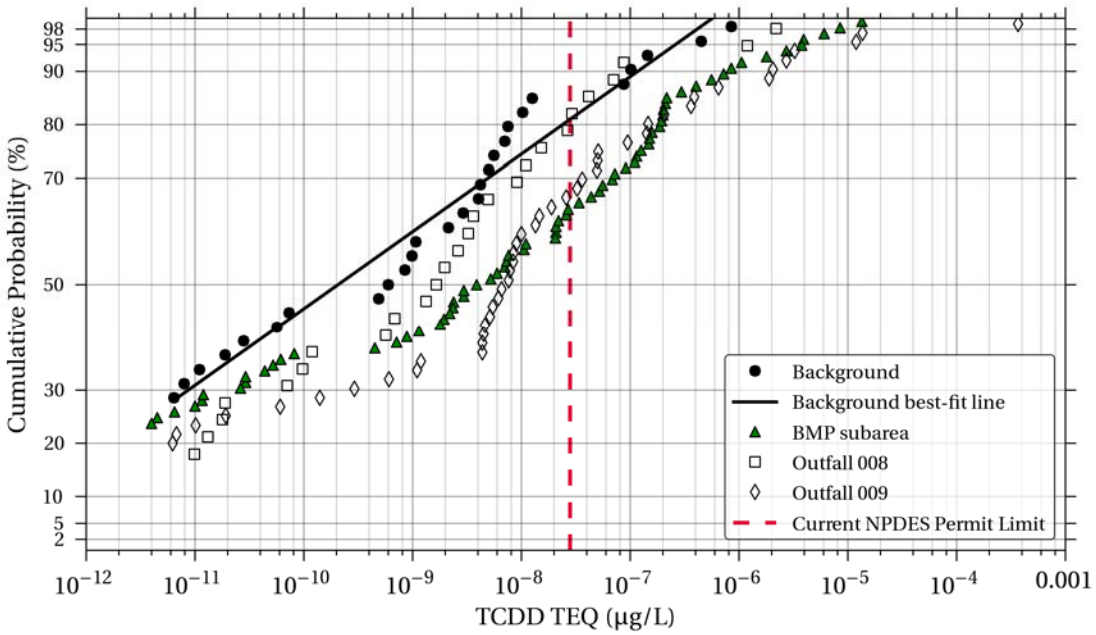

Figure 10. Probability plot for TCDD TEQ concentrations[13]

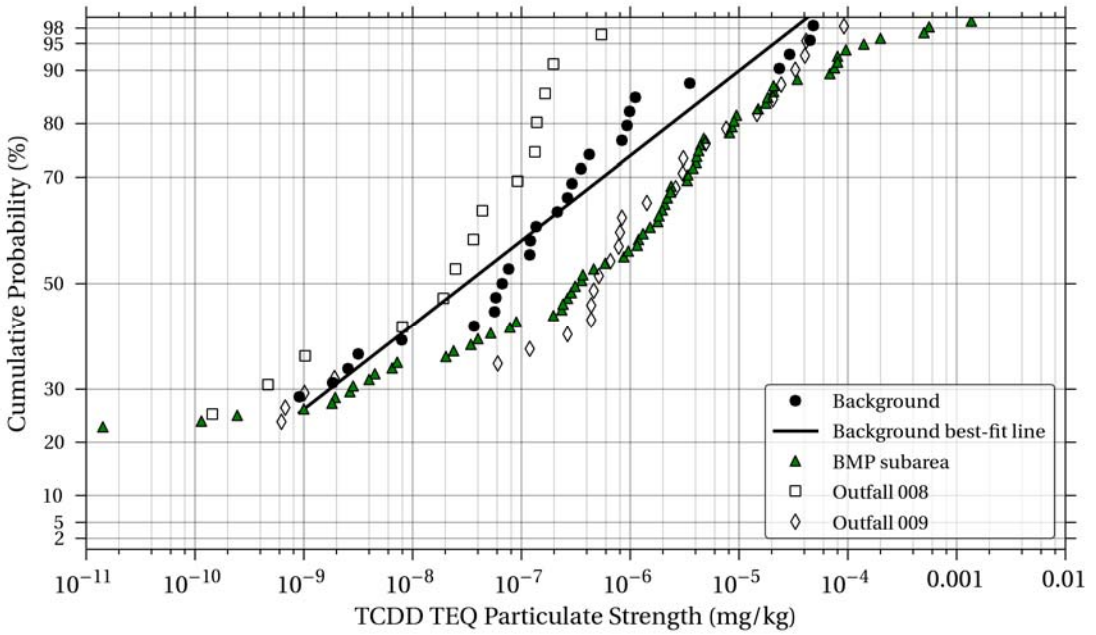

Figure 11. Probability plot for TCDD TEQ particulate strengths

[13] Following the 2005 wildfires, an uncharacteristically high TCDD TEQ concentration (3.6×10^{-4} µg/L) was measured at Outfall 009 on 10/17/2005. This data point is shown in the upper right corner of Figure 10.

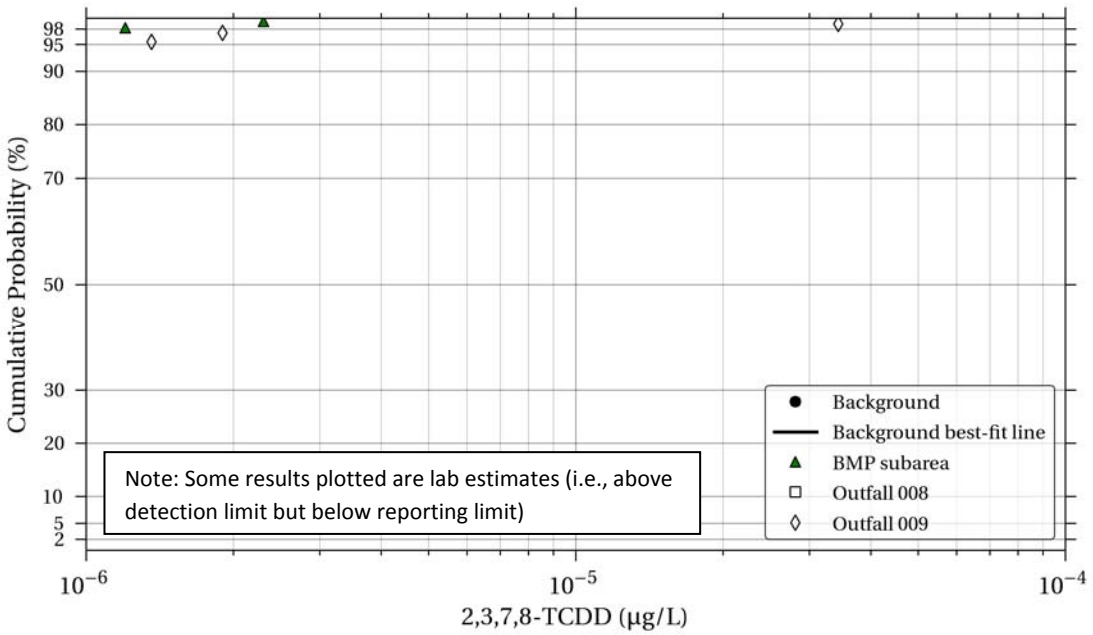

Figure 12. Probability plot for 2,3,7,8-TCDD concentrations[14]

[14] Following the 2005 wildfires, an uncharacteristically high 2,3,7,8-TCDD concentration (3.4×10^{-5} µg/L) was measured at Outfall 009 on 10/17/2005. This data point is shown in the upper right corner of Figure 12.

5. POTENTIAL BMP SUBAREA RANKING ANALYSIS

Potential BMP subarea monitoring sites were ranked based on the results of comparisons between (a) stormwater concentrations and permit limits, and (b) stormwater particulate strengths and stormwater background particulate strengths. A statistical methodology was developed to rank the sites based on these comparison results, while accounting for the number of useable data available at each site as well as number of data observations that fall above these thresholds (i.e., reflecting statistical confidence in how frequently each site will exceed the comparison thresholds). This methodology relies on "weighting factors" that are calculated for each POC for each site. In the end, the pollutant-specific weighting factors are summed to produce a multi-pollutant score to allow for relative ranking amongst the potential BMP sites. The highest ranked sites are then recommended for consideration for new or enhanced stormwater control placement.

The potential BMP subareas have been weighted based on general guidelines for small sample sets, provided by Dr. Pitt and included as Appendix C. These guidelines are based on the binomial distribution (single-tailed) corrected for use with small sample sets. This two-tiered method for determining the weighting factor helps identify significant differences between sets having different numbers of "critical" observations ("m", defined as the sum of the number of results exceeding either the permit limit or the 95th percentile stormwater background[15]) and different numbers of total observations ("n", defined as the number of particulate strength results plus the number of concentration results). This allows a statistically-based weighting factor to be applied to each site for each POC to reflect the number of observations simultaneously with the number of critical observations. As an example, a location having 20 critical observations out of 20 total observations has more confidence compared to a location only having 3 critical observations out of 3 total observations. The larger number of total observations results in a greater confidence of the findings. Similarly, if only 1 out of 10 observations are critical, that site has less confidence in a critical determination compared to a site that has 8 out of 10 critical observations. The weighting factors for small sample sets used in this part of the analysis are summarized in Table 7.

[15] The 95th percentile threshold was recommended by the Panel based on best professional judgment as well as a review of relevant surface water regulations and guidance (WWE, 2011, attached as Appendix D).

Table 7. Weighting Factors for Small Sample Sets (WF, %) (divided by 100 for use in the ranking analyses)

Total Number of Observations (n)	Total Number of Critical Values in Data Set (m)													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	50													
2	50	75												
3	50	50	87											
4	31	50	69	94										
5	19	50	50	81	97									
6	11	34	50	66	89	98								
7	6	23	50	50	77	94	99							
8	4	14	36	50	64	86	98	99						
9	2	9	25	50	50	75	96	98	99					
10	1	5	17	38	50	63	83	95	99	99				
11	1	3	11	27	50	50	73	89	97	99	99			
12	0	2	7	19	39	50	63	81	93	98	99	99		
13	0	1	5	13	29	50	50	71	87	95	99	99	99	
14	0	1	3	9	21	40	50	61	79	91	97	99	99	99
15	0	0	2	6	15	30	50	50	70	85	94	98	99	99

Where the total number of observations was greater than 15[16] and the number of critical values in the dataset was greater than 14, the weight was computed as the unadjusted value of the cumulative distribution function (CDF) of a binomial distribution with p = 0.5:

$$WF = \sum_{i=0}^{m} \binom{n}{i} p^i (1-p)^{n-i}$$

Where,

P = 0.5

$n = n_C + n_{PS}$, where

n_C = Number of concentration sample results

n_{PS} = Number of PS results

$m = m_C + m_{PS,}$, where

m_C = Number of concentrations sample results that exceed the Permit Limits

m_{PS} = Number of PS results that exceed the 95th percentile stormwater background PS results threshold

[16] This situation only occurs for Outfalls 008 and 009 which have several years of NPDES monitoring data available and are included here for method testing and results comparison purposes only (i.e., treatment controls are not being contemplated at these locations). The large sample sizes at these locations exceed the statistical capability of the methods used to determine the weighting factor. In future BMP site ranking analysis reports, this can be corrected by an adjustment that has been recommended by Dr Pitt.

The benefits of this statistically rigorous approach is that when comparing potential BMP subarea monitoring datasets with a combination of stormwater background and permit limit thresholds, this process allows for the accounting of both the size of the dataset (number of samples) and the number of samples that are above a stormwater background threshold, resulting in a more robust and defensible weight for ranking potential BMP sites based on need for treatment, and one that can be reevaluated in the future as the available data sets grow. Typical arbitrary (but possibly simpler) weighting factors, such as having fixed stormwater background threshold levels and a number of samples that are allowed to be exceeded before making a BMP decision, can be difficult to defend or update when more data become available, and likely do not appropriately consider the number of samples used in the analysis.

As shown in the example below, the ranking analysis calculated a single score for each POC for each potential BMP subarea. The highest score across all metals at a single site is assumed representative of the multi-pollutant "metals score" for each subarea. The highest score between TCDD TEQ and 2,3,7,8-TCDD at a single site is assumed representative of the multi-pollutant "dioxin score" for each subarea. A multi-pollutant score is then calculated as the average of the maximum metal and dioxin WF values. The TSS weighting factor and score are the same.

The following Table 8 example demonstrates this method for a theoretical monitoring location. Actual results for each BMP subarea are summarized in Tables 9, 10, and 11 (subareas are organized by weight, ranked highest to lowest) and illustrated in Attachments 3 and 4.

Table 8. Example Weighting Factor (WF) and Multi-Pollutant Score Calculation

	Site X									
	Metals						Dioxins			
	TPb		TCu		TCd		TCDD		2,3,7,8-TCDD	TSS
	>PL	>95%B	>PL	>95%B	>PL	>95%B	>PL	>95%B	>95%B	>95%B
Sample 1	**Y**	N	N	N	N	N	N	N	N	N
Sample 2	N	N	N	N	N	N	N	N	**Y**	N
Sample 3	**Y**	N	**Y**	N	N	N	**Y**	N	N	N
Sample 4	**Y**	**Y**	N	N	N	N	--	--	N	**Y**
Sample 5	N	--	N	--	N	N	--	--	N	N
Sample 6	N	--	**Y**	--	N	N	--	--	--	N
# Y / # samples	3/6	1/4	2/6	0/4	0/6	0/6	1/3	0/3	1/5	1/6
(sum Y) / (sum n)	4/10		2/10		0/12		1/6		1/5	1/6
WF	0.38		0.05		0		0.11		0.19	0.11
Max WF	0.38						0.19			0.11
Multi Pollutant Score	0.29									0.11
Exceeds Both PL&B?	**Y**		N		N		N		NA	NA

Notes

>PL = greater than Permit Limit concentration, >95%B = greater than 95th percentile stormwater background particulate strength (or concentration for TSS), **Y** = yes, N = no, WF = weighting factor, -- = no data.

Table 9. Metals Weighting Factor Results, by Potential BMP Site

Rank	Potential BMP Subarea (Co-location)	Watershed	Description	Maximum Metal Weight
1	B1BMP0001* (B1SW0010)	Outfall 009	B1 culvert inlet	0.5
1	**ILBMP0001***	Outfall 009	Lower parking lot 24" stormdrain	0.5
1	LPBMP0001*	Outfall 009	Soil stockpile sheetflow	0.5
1	A1BMP0001	Outfall 009	A1LF	0.5
5	**A2SW0001**	Outfall 009	CM1 upgradient west (also ELV area and Area I road)	0.4
6	EVBMP0002	Outfall 009	Helipad spillway	0.38
7	LXBMP0002	Outfall 009	LOX mid	0.31
8	B1BMP0002	Outfall 009	B1 parking lot culvert inlet	0.07
9	HZBMP0001 (HZSW0007)	Outfall 008	HV downgradient	0.04
10	LXBMP0003	Outfall 009	LOX east (Sage Ranch tributary)	0.02
11	**BGBMP0006** (A2SW0006)	Outfall 009	CM1 upgradient east	0.01
11	**HZBMP0003** (HZSW0003)	Outfall 008	DRG downgradient 2	0.01
13	**Outfall 008****	Outfall 008	NPDES outfall 008	0.001
14	**A1SW0004**	Outfall 009	CM9 upgradient	10^{-4}
15	**Outfall 009****	Outfall 009	NPDES outfall 009	10^{-7}
16	B1SW0011*	Outfall 009	B1 paved roadside ditch	0
16	EVBMP0001	Outfall 009	Helipad Road/ELV culvert inlet	0
16	ILBMP0002	Outfall 009	Road runoff to CM9	0
16	HZBMP0002 (HZSW0004)	Outfall 008	DRG downgradient	0
16	LXBMP0001	Outfall 009	LOX West	0
16	ILBMP0003	Outfall 009	A1LF parking lot	0

Notes

1) Potential BMP subareas sorted by maximum weight for the POC group, computed as described in Section 5.
2) (*)These potential BMP subarea monitoring sites have new planned (i.e., designed and ready for construction) stormwater quality treatment controls.
3) (**)NPDES outfalls are included for comparison and method testing purposes only; stormwater controls are not being contemplated at these locations.
4) The rounding of weights may account for similar weights being ranked differently.
5) Bolded locations indicate that both the NPDES permit limit and 95th percentile background particulate strength threshold were exceeded.

Table 10. Dioxin Weighting Factor Results, by Potential BMP Site

Rank	Potential BMP Subarea (Co-location)	Watershed	Description	Maximum Dioxin Weight
1	**EVBMP0002**	Outfall 009	Helipad spillway	0.95
2	**ILBMP0001***	Outfall 009	Lower parking lot 24" stormdrain	0.5
2	**A2SW0001**	Outfall 009	CM1 upgradient west (also ELV area and Area I road)	0.5
2	**B1SW0011***	Outfall 009	B1 paved roadside ditch	0.5
2	LPBMP0001*	Outfall 009	Soil stockpile sheetflow	0.5
6	LXBMP0002	Outfall 009	LOX mid	0.31
7	**B1BMP0002**	Outfall 009	B1 parking lot culvert inlet	0.19
8	B1BMP0001* (B1SW0010)	Outfall 009	B1 culvert inlet	0.11
9	**A1BMP0001**	Outfall 009	A1LF	0.05
9	LXBMP0003	Outfall 009	LOX east (Sage Ranch tributary)	0.05
11	**BGBMP0006** (A2SW0006)	Outfall 009	CM1 upgradient east	0.03
12	A1SW0004	Outfall 009	CM9 upgradient	0.002
13	HZBMP0001 (HZSW0007)	Outfall 008	HV downgradient	$6x10^{-5}$
14	**Outfall 009****	Outfall 009	NPDES outfall 009	10^{-7}
15	EVBMP0001	Outfall 008	Helipad Road/ELV culvert inlet	0
15	ILBMP0002	Outfall 008	Road runoff to CM9	0
15	HZBMP0003 (HZSW0003)	Outfall 009	DRG downgradient 2	0
15	Outfall 008**	Outfall 009	NPDES outfall 008	0
15	LXBMP0001	Outfall 008	LOX West	0
15	ILBMP0003	Outfall 009	A1LF parking lot	0
15	HZBMP0002 (HZSW0004)	Outfall 009	DRG downgradient	0

Notes

1) Potential BMP subareas sorted by maximum weight for the POC group, computed as described in Section 5.
2) No permit limit exists for 2,3,7,8-TCDD therefore weighting factors are only computed for detections (i.e., the detection limit is used as the single critical comparison threshold for this POC).
3) (*)These potential BMP subarea monitoring sites have new planned (i.e., designed and ready for construction) stormwater quality treatment controls.
4) (**)NPDES outfalls are included for comparison and method testing purposes only; stormwater controls are not being contemplated at these locations.
5) The rounding of weights may account for similar weights being ranked differently.
6) Bolded locations indicate that both the NPDES permit limit and 95th percentile background particulate strength threshold were exceeded.

Table 11. TSS Weighting Factor Results, by Potential BMP Site

Rank	Potential BMP Subarea (Co-location)	Watershed	Description	TSS Weight
1	B1BMP0001* (B1SW0010)	Outfall 009	B1 culvert inlet	0.87
2	A2SW0001	Outfall 009	CM1 upgradient west (also ELV area and Area I road)	0.5
2	HZBMP0001 (HZSW0007)	Outfall 008	HV downgradient	0.5
2	LPBMP0001*	Outfall 009	Soil stockpile sheetflow	0.5
2	LXBMP0002	Outfall 009	LOX mid	0.5
2	LXBMP0003	Outfall 009	LOX east (Sage Ranch tributary)	0.5
2	Outfall 008**	Outfall 008	NPDES outfall 008	0.5
8	B1BMP0002	Outfall 009	B1 parking lot culvert inlet	0.11
9	BGBMP0006 (A2SW0006)	Outfall 009	CM1 upgradient east	0.06
10	HZBMP0003 (HZSW0003)	Outfall 008	DRG downgradient 2	0.05
11	A1SW0004	Outfall 009	CM9 upgradient	0.02
12	Outfall 009**	Outfall 009	NPDES outfall 009	10^{-4}
13	B1SW0011*	Outfall 009	B1 paved roadside ditch	0
13	EVBMP0002	Outfall 009	Helipad spillway	0
13	EVBMP0001	Outfall 009	Helipad Road/ELV culvert inlet	0
13	ILBMP0002	Outfall 009	Road runoff to CM9	0
13	ILBMP0001*	Outfall 009	Lower parking lot 24" stormdrain	0
13	HZBMP0002 (HZSW0004)	Outfall 008	DRG downgradient	0
13	ILBMP0003	Outfall 009	A1LF parking lot	0
13	A1BMP0001	Outfall 009	A1LF	0
13	LXBMP0001	Outfall 009	LOX West	0

Notes

1) (*)These potential BMP subarea monitoring sites have new planned (i.e., designed and ready for construction) stormwater quality treatment controls.
2) (**)NPDES outfalls are included for comparison and method testing purposes only, stormwater controls are not being contemplated at these locations.
3) The rounding of weights may account for similar weights being ranked differently.

A “multi-pollutant” score was then calculated for each potential BMP subarea monitoring site by taking the arithmetic mean of the maximum metals and the maximum dioxin weighting factor values (Table 12). These two pollutant category values were weighted equally for the multi-pollutant score based on their very roughly comparable relative exceedance probabilities at Outfalls 008 and 009 -- the dioxin permit limit exceedance probability is approximately 15% at Outfall 008 and approximately 35% at Outfall 009, while the lead (most problematic metal) permit limit exceedance probability is approximately 40% at Outfall 008 and approximately 30% at Outfall 009.

A complete summary of the weights computed by potential BMP subarea monitoring site (including number of samples, number of NDs, median, maximum, comparison to background percentiles, weight, and rank) is included as Appendix E.

Table 12. Subareas Ranked by Multi-Pollutant Score

Rank from Averaged Weights	Potential BMP Subarea (Co-location)	Watershed	Description	Approximate Upgradient DA (ac)	Multi-Pollutant Score	Rank from Maximum Metal Weighting	Rank from Maximum Dioxin Weighting
1	**EVBMP0002**	Outfall 009	Helipad spillway	~4.0	0.66	6	1
2	**ILBMP0001***	Outfall 009	Lower parking lot 24" stormdrain	23	0.5	1	2
2	LPBMP0001*	Outfall 009	Soil stockpile sheetflow	5.1	0.5	1	2
4	**A2SW0001**	Outfall 009	CM1 upgradient west (also ELV area and Area I road)	~13	0.45	5	2
5	LXBMP0002	Outfall 009	LOX mid	1.5	0.31	7	6
6	B1BMP0001* (B1SW0010)	Outfall 009	B1 culvert inlet	4.4	0.30	1	8
7	**A1BMP0001**	Outfall 009	A1LF downgradient	1.2	0.28	1	9
8	**B1SW0011***	Outfall 009	B1 paved roadside ditch	<1	0.25	15	2
9	**B1BMP0002**	Outfall 009	B1 parking lot culvert inlet	5.3	0.13	8	7
10	LXBMP0003	Outfall 009	LOX east (Sage Ranch tributary)	~24	0.03	10	9
11	HZBMP0001 (HZSW0007)	Outfall 008	HV downgradient	<29	0.02	9	13
12	**BGBMP0006** (A2SW0006)	Outfall 009	CM1 upgradient east	41	0.02	11	11
13	**HZBMP0003** (HZSW0003)	Outfall 008	DRG downgradient 2	<33	0.005	11	15
13	**A1SW0004**	Outfall 009	CM9 upgradient	14	0.0012	14	12
13	**Outfall 008****	Outfall 008	NPDES outfall 008	62	0.0003	13	15
16	EVBMP0001	Outfall 009	Helipad Road/ELV culvert inlet	unknown/small	0	16	15
16	ILBMP0002	Outfall 009	Road runoff to CM9	14	0	16	15
16	**Outfall 009****	Outfall 009	NPDES outfall 009	536	0	15	14
16	LXBMP0001	Outfall 009	LOX West	unknown/small	0	16	15
16	ILBMP0003	Outfall 009	A1LF parking lot	9.5	0	16	15
16	HZBMP0002 (HZSW0004)	Outfall 008	DRG downgradient	26	0	16	15

Notes

1) Potential BMP subareas sorted by multi-pollutant score, computed as described in Section 5
2) (*)These potential BMP subarea monitoring sites have new planned (i.e., designed and ready for construction) stormwater quality treatment controls.
3) (**) NPDES outfalls are included for comparison and method testing purposes only, stormwater controls are not being contemplated at these locations.
4) The rounding of weights may account for similar weights being ranked differently
5) Approximate drainage areas based on the cumulative drainage area of the SWMM catchment in which the monitoring location is located (Geosyntec, 2011). At locations where the monitoring point is upgradient of the catchment outfall a "<" sign is used.
6) Bolded locations indicate that both the NPDES permit limit and 95^{th} percentile background particulate strength threshold were exceeded.
7) ug = upgradient; dg = downgradient

6. RESULTS DISCUSSION

- Dioxin TCDD TEQ and lead are the POCs most frequently responsible for producing high dioxin and metals weighting factors, respectively.

- No Outfall 008 sites were highly ranked for metals or dioxins, indicating that new treatment controls are not necessary within this watershed.

- The most highly ranked sites for TSS include B1 culvert inlet (B1BMP0001) and CM1 upgradient west (A2SW0001), both of which are immediately downgradient of bare slopes that were affected by ISRA removal activities and are now stabilized with erosion controls.

- All of the top four and six of the top nine ranked sites represent drainage areas with significant runoff contributions from paved surfaces (mostly parking lots and roads). This may indicate that elevated POC concentrations in the 009 watershed may be derived from asphalt or atmospheric deposition onto asphalt.

- 2,3,7,8-TCDD – a dioxin congener that is typically associated with anthropogenic sources -- was only detected twice, and both times at J-flagged (estimated) levels. These sites were A2SW0001 (CM1 upgradient west) and B1SW0011 (B1 paved roadside ditch). Both sites receive a significant quantity of road runoff, and both sites either currently are or soon will be treated by CM systems.

- The eight most highly ranked sites based on the multi-pollutant score include five sites on Boeing property – the lower parking lot stormdrain (ILBMP0001), the soil stockpile area (LPBMP0001), the B1 culvert inlet (B1BMP0001), and the B1 paved roadside ditch (B1SW0001) – that already have robust treatment controls planned for construction in 2011 (in the case of ILBMP0001 this will be treatment of low flows only). Three of these sites were also ranked highest for metals. Furthermore, the seventh ranked site, A1BMP0001 (Area I landfill) has an existing culvert modification treatment system located downstream of the site.

- Three sites in the top eight are located on NASA property and include, in order of rank, EVBMP0002 (the spillway at the eastern end of the helipad), A2SW0001 (CM1 upgradient west, which receives runoff from the ELV hillside and the paved road), and LXBMP0002 (the LOX dirt road sampling site, located in the middle of the LOX area near the truck scale). Of these sites, EVBMP0002 was ranked highest for dioxins.

- Very similar rankings resulted from previously tested approaches, suggesting that results are robust and not highly sensitive to the particular statistical methodology employed. This methodology has the advantage of considering the number of observations available, and can be updated as more data become available. In addition, this method also helps determine when sufficient data have been collected to satisfy statistically based confidence and power objectives which would then enable reduced future sampling efforts.

- The sites weighted the highest and second highest (ranked #1 and #2) based on maximum metals, dioxins, and TSS weighting factors are included in the top eight sites based on the multi-pollutant score, suggesting once again that rankings are robust and not highly sensitive to the particular methodology employed (or to the pollutants used to calculate the rankings).
- While the analysis approach is concentration based rather than load based, because such a large percentage of the watersheds (and of the watersheds developed or known impacted areas) are represented by the monitoring locations, the approach inherently addresses load reduction aspects.

7. BMP RECOMMENDATIONS

Site Specific Evaluation of Top Ranked Sites

Based on these analysis results, the following monitoring locations were identified as the highest ranked subareas, with multi-pollutant scores ranging from 0.25 to 0.66 (see Table ES-1). Besides their multi-pollutant scores, the following list is also of significance because it included: all sites that were ranked first and second for each of the pollutant categories (metals, dioxins, or TSS), all sites that had detections of the 2,3,7,8-TCDD dioxin congener (at low, DNQ-estimated quantities), the site with the highest observed dioxin concentrations (noting that the scores do not explicitly account for concentration *magnitude*s, but rather account for *frequency* of exceeding the concentration-based background and permit limit thresholds), five of the eight sites where both the 95th percentile background limits and permit limits were exceeded, seven of the top seven ranked sites for metals, eight of the top nine ranked sites for dioxins, and four of the top five ranked sites for TSS. This list also includes all of the subareas that will receive runoff treatment by two new treatment controls – the lower parking lot biofilter and the B1 culvert modification – that will be constructed later in 2011. This list is followed by the Panel's new BMP recommendations for implementation in 2012.

1. **EVBMP0002** (Helipad spillway): This monitoring site reflects sheetflow from the approximately 4 acre, fully paved helipad area, which is located in Area II (NASA) and includes no areas of surface soil contamination, such as those identified by the ISRA program. This area also represents a significant source of runoff to Outfall 009 during frequent small rain events given its large impervious area and direct connection to the outfall via a slope drain. This site was ranked first based on the multi-pollutant score of 0.66. This site was ranked sixth for metals and first for dioxins, and exceeded both the 95th percentile background limits and the permit limits. The Panel recommends new BMP actions to address runoff from this subarea.
2. **ILBMP0001** (lower parking lot 24-inch storm drain outlet below Boeing Building 436), tied for 2nd with LPBMP0001: This monitoring site reflects stormdrain flows from a 23 acre, 35% impervious subarea, which is located in Area I (Boeing) and includes undeveloped hillsides, parking lot, rooftop, and paved roadway surfaces, and includes no areas of surface soil contamination, such as those identified by the ISRA program. This site is ranked second overall, tied with the soil stockpile subarea, based on the multi-pollutant score of 0.5. This site was ranked first for metals (tied with soil stockpile, B1 culvert inlet, and Area I landfill) and second for dioxins (tied with soil stockpile and CM1 upgradient west), and exceeded both the 95th percentile background limits and the permit limits. This subarea will soon have treatment of low flows as part of the planned stockpile sediment basin and biofilter, which is a multi-stage treatment system with specially-selected filter media. The low flow diversion is currently estimated to capture and treat, on average, 21% of the runoff volume from this subarea, based on long-term continuous modeling and the existing 90% design plans. Current SSFL demolition plans will remove Building 436 and the adjacent parking lot in 2013 (a total impervious area of approximately 1 acre), which will reduce runoff volumes to this stormdrain and increase the percent capture of the low flow diversion. Given the planned demolition and biofilter at the downstream soil stockpile area, the

Panel does not recommend additional actions to address runoff from this subarea at this time. Only two samples were collected from this monitoring site in 2010/11, therefore additional samples in 2011/12 will greatly improve our understanding of stormwater quality for this subarea.

2. **LPBMP001** (soil stockpile sheetflow), tied for 2nd with ILBMP0001: This monitoring site reflects sheetflow from the 5 acre, fully paved soil stockpile area (or lower parking lot), which is located in Area I (Boeing) and currently includes no areas of surface soil contamination but will be used in the future to manage stockpiled soils generated from the SSFL remediation program. As a result, it will continue to have the potential for discharge of pollutants. This site is ranked second overall, tied with lower parking lot stormdrain, based on the multi-pollutant score of 0.5. The stockpile area was ranked first for metals (tied with lower parking lot stormdrain, B1 culvert inlet, and Area I landfill) and second for dioxins (tied with lower parking lot stormdrain and CM1 upgradient west). The Plan had previously recommended a multi-stage treatment control (sediment basin followed by biofilter) for this 5 acre area that is sized to the site specific design storm, or 90% runoff volume capture, and installation is planned for 2011. Furthermore, construction SWPPP erosion and sediment control practices will be implemented during future soil stockpiling activities, and 1.8 acres of adjacent asphalt (not in this drainage area) will be removed on Boeing and Sage Ranch property in 2011. The Panel recommends no new actions to address runoff from this subarea. Only two samples were collected from this monitoring site in 2010/11 and additional sampling in 2011/12 will allow for an evaluation of the effectiveness of the construction of the multi-stage treatment system

4. **A2SW0001** (ELV road runoff/CM1 upgradient west): This monitoring site reflects sheetflow from an approximately 13 acre area in Area II (NASA), which includes ELV ISRA areas, a completed Area II ISRA area, parking lot, rooftop, and paved roadway surfaces. This site was ranked fourth overall with a multi-pollutant score of 0.45. This site was ranked fifth for metals, second for dioxins (tied with lower parking lot stormdrain and soil stockpile, and included the J-flagged detection of 2,37,8-TCDD), second for TSS, and exceeded both the 95th percentile background limits and the permit limits. This site had the highest observed TCDD TEQ concentrations of those included in this BMP subarea ranking analysis. CM1 is an existing culvert modification that treats runoff from a 41 acre undisturbed subwatershed, as well as runoff from this subarea due to an existing broken asphalt channel below the ELV hillside that is diverting runoff toward the road and then toward CM1. The completed ISRA area is now covered with hydroseed mulch, straw wattle, and rip rap. ISRA removal activities are planned for the ELV area after 2011. The Panel also recommends new actions to address runoff from this subarea.

5. **LXBMP0002** (LOX mid): This monitoring site reflects sheetflow, collected along a LOX area dirt road, from an approximately 1.5 acre compacted pervious drainage area in Area I (NASA), and includes LOX ISRA areas. This site was ranked fifth overall with a multi-pollutant score of 0.31. LOX was ranked seventh for metals and sixth for dioxins. ISRA removal activities are planned for

this subarea after 2011. The Panel recommends new actions to address runoff from this subarea. Only two samples were collected from this monitoring site in 2010/11, therefore additional samples in 2011/12 will greatly improve our understanding of stormwater quality for this subarea.

6. **B1BMP0001** (B1 culvert inlet): This monitoring site reflects runoff collected at the B1 culvert inlet from an approximately 4.4 acre drainage area, and is located in Area I (Boeing) near the SSFL entrance. This site is ranked sixth overall with a multi-pollutant score of 0.30. The B1 culvert inlet was ranked first for metals (tied with lower parking lot stormdrain, soil stockpile, and Area I landfill), eighth for dioxins, and first for TSS. The B1 ISRA areas were completed in 2011. The Panel previously recommended two new treatment controls at this site which will be completed before the 2011/12 rainy season– the B1 sediment basin and a culvert inlet filter. Furthermore, recent hillside erosion controls and vegetation growth will reduce sediment loading from the exposed slopes immediately surrounding this monitoring site. The Panel recommends no new actions to address runoff from this subarea.

7. **A1BMP0001** (A1LF): This monitoring site reflects runoff collected in a channel below the 1.2 acre Area I landfill drainage area, is located in Area I (Boeing), and includes the A1LF ISRA area. This site is ranked seventh overall with a multi-pollutant score of 0.28. A1BMP0001 was ranked first for metals (tied with lower parking lot stormdrain, soil stockpile, and B1 culvert inlet) and ninth for dioxins, and exceeded both the 95th percentile background limits and the permit limits. ISRA activities are planned for the A1LF after 2011. Runoff from this area is currently treated by CM9 (noting however that runoff from the southern portion of A1LF drains towards Outfall 011 where there is an active treatment system in place). An adjacent 1.5 acre parking lot is also planned for removal in 2011, and this will reduce runoff to CM9 thereby increasing the percent of runoff volume that is treated from the landfill. Also as part of the asphalt removal project a vegetated swale (or equivalent BMP) may be constructed; if that proceeds then it may be designed to also capture a portion of runoff from the top of the landfill and route it toward Outfall 011. The lower or hillside portion of the landfill is currently well vegetated or is occupied by an access road that is covered with erosion controls (hydroseed mulch and straw waddles). The Panel also recommends new actions to address runoff from this subarea, although it should be noted that no NPDES permit limits were exceeded in any of the five grab samples that were collected from this monitoring site in 2010/11.

8. **B1SW0011** (B1 paved roadside ditch): This monitoring site reflects paved road runoff from a very small drainage area near the SSFL entrance in Area I (Boeing), and includes no areas of surface soil contamination, such as those identified by the ISRA program. This site is ranked eighth overall with a multi-pollutant score of 0.25. The B1 ditch was ranked 15th for metals, second for dioxins (including the J-flagged detection of 2,3,7,8-TCDD), and exceeded both the 95th percentile background limits and the permit limits. This subarea will soon have a new treatment control (B1 culvert inlet filter). Runoff from this area will be treated by the B1 culvert

inlet filter, which is to be completed in 2011. The Panel recommends no new actions to address runoff from this subarea.

The 9th ranked B1BMP002 (parking lot culvert inlet southwest of B1 area) was the last subarea monitoring site that the Panel was contemplating siting new BMPs at since there was a relatively steep dropoff of multi-pollutant scores (from 0.13 to 0.03) after that. This site, along with six of the top eight ranked sites, had monitoring results that exceeded NPDES permit limits for dioxin and/or lead. However, based on further evaluation of this site, and in consideration of the fact that pavement removal may occur here in 2013, the Panel recommends that this location be closely tracked for another year so that it can be re-evaluated in 2012 after another season of monitoring data are collected. This will be part of the broader BMP subarea monitoring data analysis that will occur annually, the results of which may be the recommendation of additional BMPs in the outfall 008 or 009 watersheds.

New BMP Recommendations

Based on the above ranking results, and utilizing best professional judgment (including consideration of information on planned ISRA and demolition measures), the following new BMPs are recommended by the Expert Panel on either NASA or Boeing properties. Additional detail on these BMP concepts and implementation schedule will be provided in the BMP Work Plan Addendum, submitted to the RWQCB in September 2011.

1. **Helipad (NASA)** – The Panel recommends sheetflow runoff storage and treatment, and/or asphalt removal. If asphalt removal is contemplated as part of this effort, the Panel recommends that it be combined with fine grading to create depressional areas (to promote infiltration and evapotranspiration) and rigorous application of erosion control and revegetation measures, as well as removal of any surficial soils that are above ISRA criteria for the Outfall 009 NPDES COCs and that become become exposed following pavement removal.
2. **ELV/CM1 (NASA)** – The Panel recommends ISRA removal at ELV (including robust erosion controls), reconstruction of existing drainage ditch below ELV, and installation of a new culvert inlet media filter near Helipad Road. The Panel also recommends continued inspection and maintenance (removal of accumulated sediment) of CM1 and of the adjacent ISRA erosion controls.
3. **LOX (NASA)** (middle sampling location) – The Panel recommends placement of a sandbag berm along the northern bank of the Northern Drainage channel to reduce bank erosion and encourage temporary ponding of this sheetflow runoff from LOX. ISRA removal is planned to occur here after 2011, and the Panel recommends that this be implemented without backfill to leave distributed areas for infiltration for runoff control until final remediation of the LOX RFI area.
4. **A1LF (BOEING)**– The Panel recommends inspection and maintenance (removal of accumulated sediment) of CM9, channel armoring erosion control in the drainage channel at the base of the

hillside, and rerouting and/or treatment of sheetflow runoff from the top of the landfill as part of the proposed ISRA action and/or adjacent asphalt removal project.

Recommendations 1 through 3 above (helipad, ELV/CM1, and LOX sites) are on NASA property and the Panel recommends that NASA implement or authorize the implementation of these measures.

Although this analysis primarily focuses on the selection of potential stormwater treatment control locations, 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 unpaved roads and the implementation of source controls (including source removal, such as through the ISRA and demo programs).

8. REFERENCES

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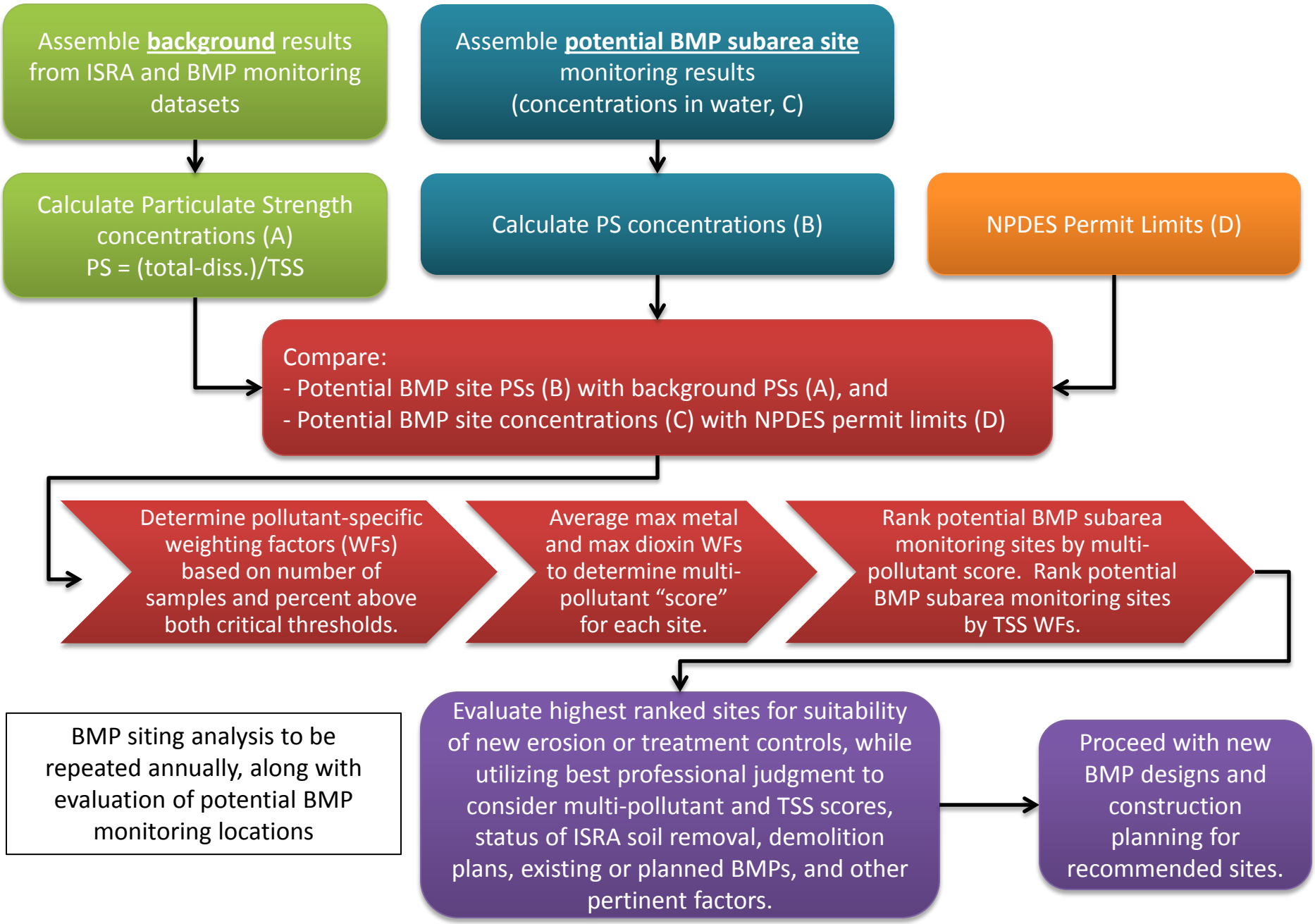
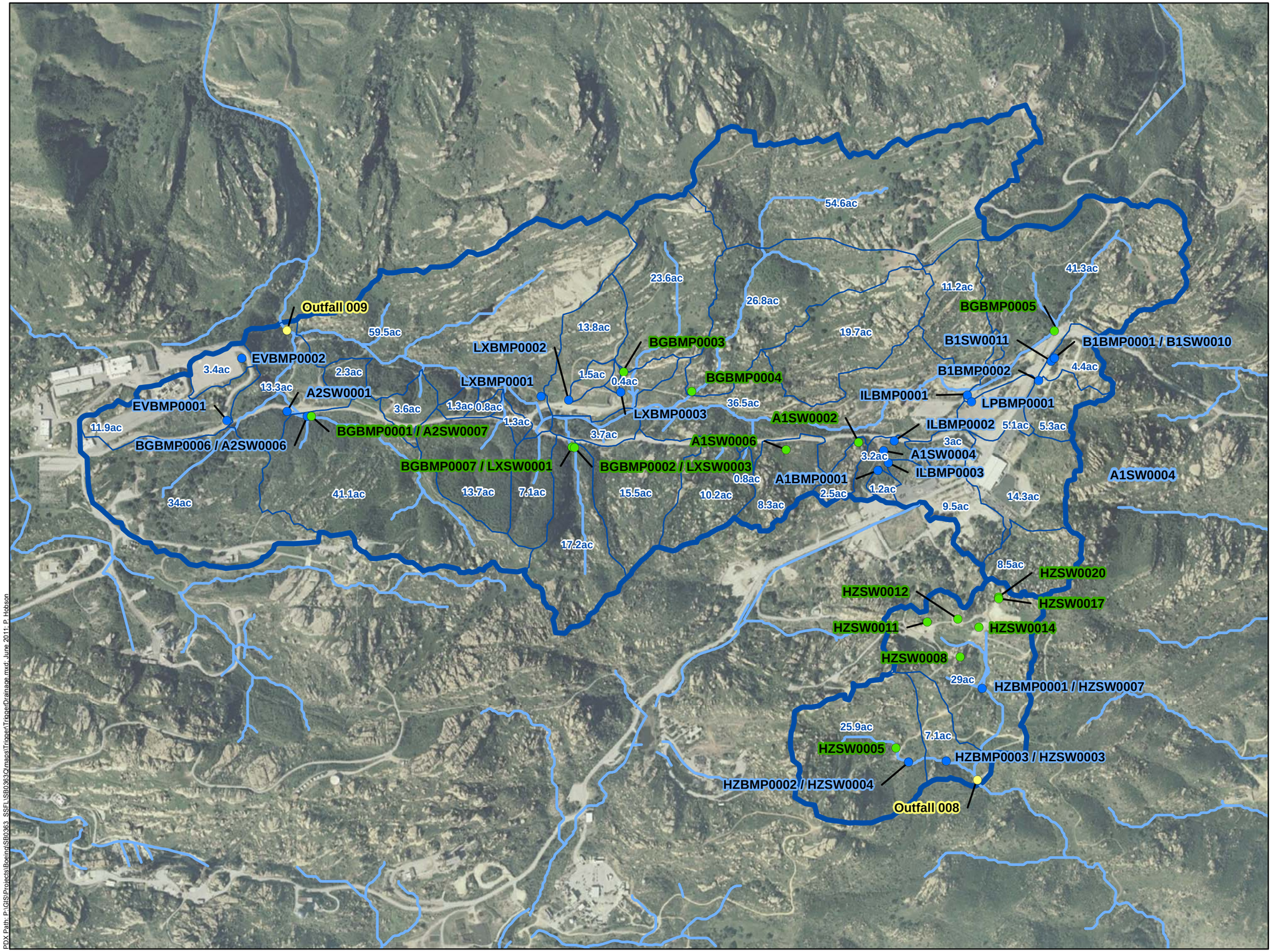
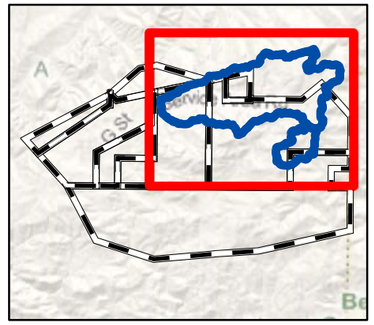
Attachment 1. Summary Flowchart for BMP Site Ranking Analysis Approach







N

Legend

- Potential BMP subarea site
- Stormwater background site
- Outfall monitoring sites
- SWMMSubareas_20101210
- Stream
- Outfall watershed boundary

Site Legend

BMP subarea site Outfalls

Background site

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

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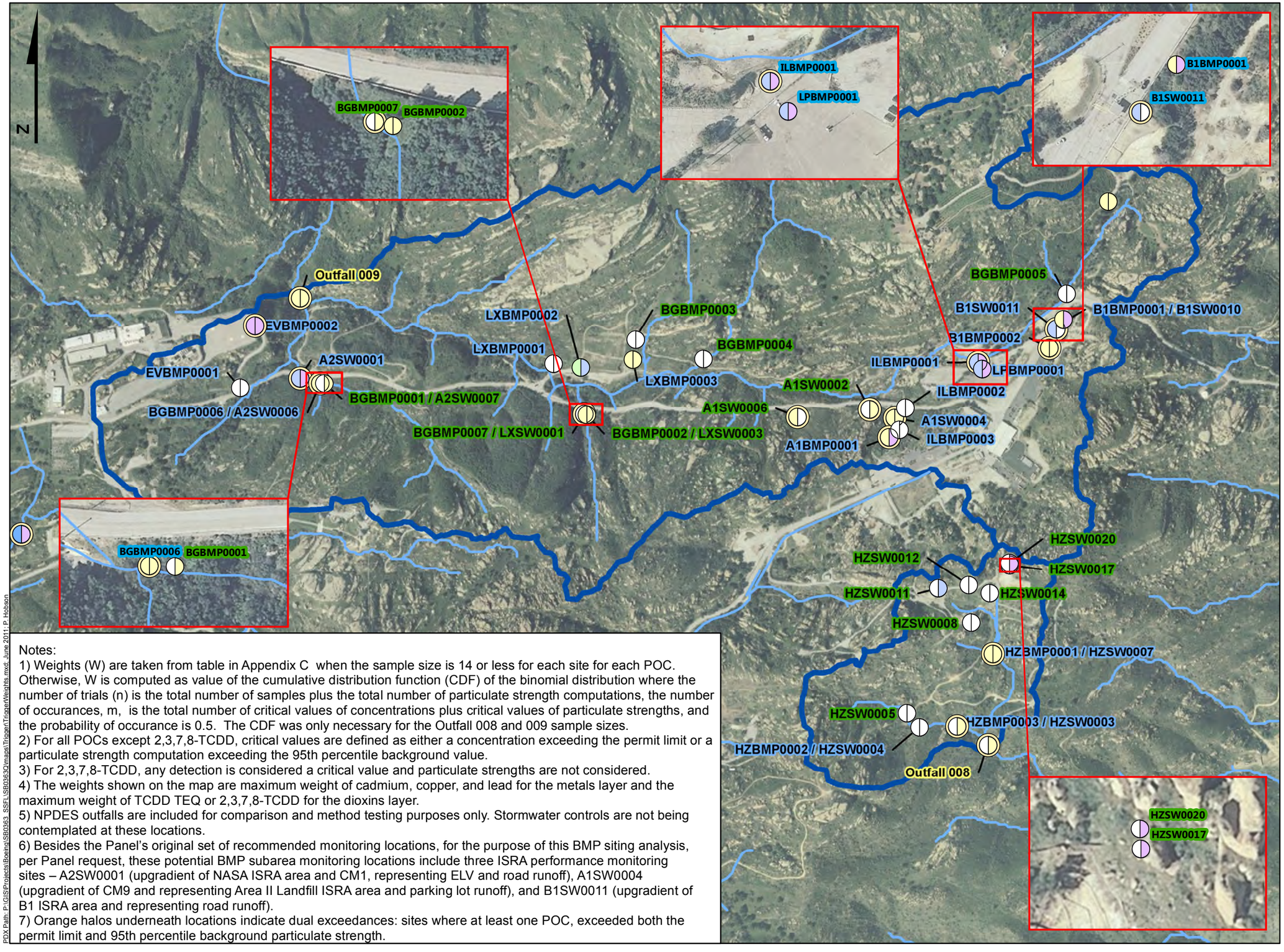

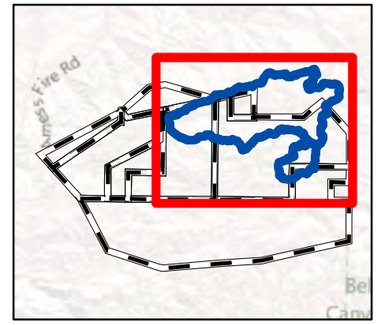

Features Legend

Max. Dioxin Weight

- 0
- 0 - 0.2
- 0.2 - 0.4
- 0.4 - 0.6
- 0.6 - 1.0

Max. Metals Weight

- 0
- 0 - 0.12
- 0.12 - 0.24
- 0.24 - 0.36
- 0.36 - 0.50
- Dual exceedances (note 7)
- Stream
- Outfall watershed boundary

Site Legend

BMP subarea site Outfalls

Stormwater background site

800 400 0 800

Feet

Notes:
1) Weights (W) are taken from table in Appendix C when the sample size is 14 or less for each site for each POC. Otherwise, W is computed as value of the cumulative distribution function (CDF) of the binomial distribution where the number of trials (n) is the total number of samples plus the total number of particulate strength computations, the number of occurances, m, is the total number of critical values of concentrations plus critical values of particulate strengths, and the probability of occurance is 0.5. The CDF was only necessary for the Outfall 008 and 009 sample sizes.
2) For all POCs except 2,3,7,8-TCDD, critical values are defined as either a concentration exceeding the permit limit or a particulate strength computation exceeding the 95th percentile background value.
3) For 2,3,7,8-TCDD, any detection is considered a critical value and particulate strengths are not considered.
4) The weights shown on the map are maximum weight of cadmium, copper, and lead for the metals layer and the maximum weight of TCDD TEQ or 2,3,7,8-TCDD for the dioxins layer.
5) NPDES outfalls are included for comparison and method testing purposes only. Stormwater controls are not being contemplated at these locations.
6) 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).
7) Orange halos underneath locations indicate dual exceedances: sites where at least one POC, exceeded both the permit limit and 95th percentile background particulate strength.

ATTACHMENT 3
Site Ranking Analysis: Metals and Dioxins in Outfall 008/009 Watersheds
Santa Susana Field Laboratory
Ventura County, CA

Geosyntec consultants

Portland, OR	June 2011

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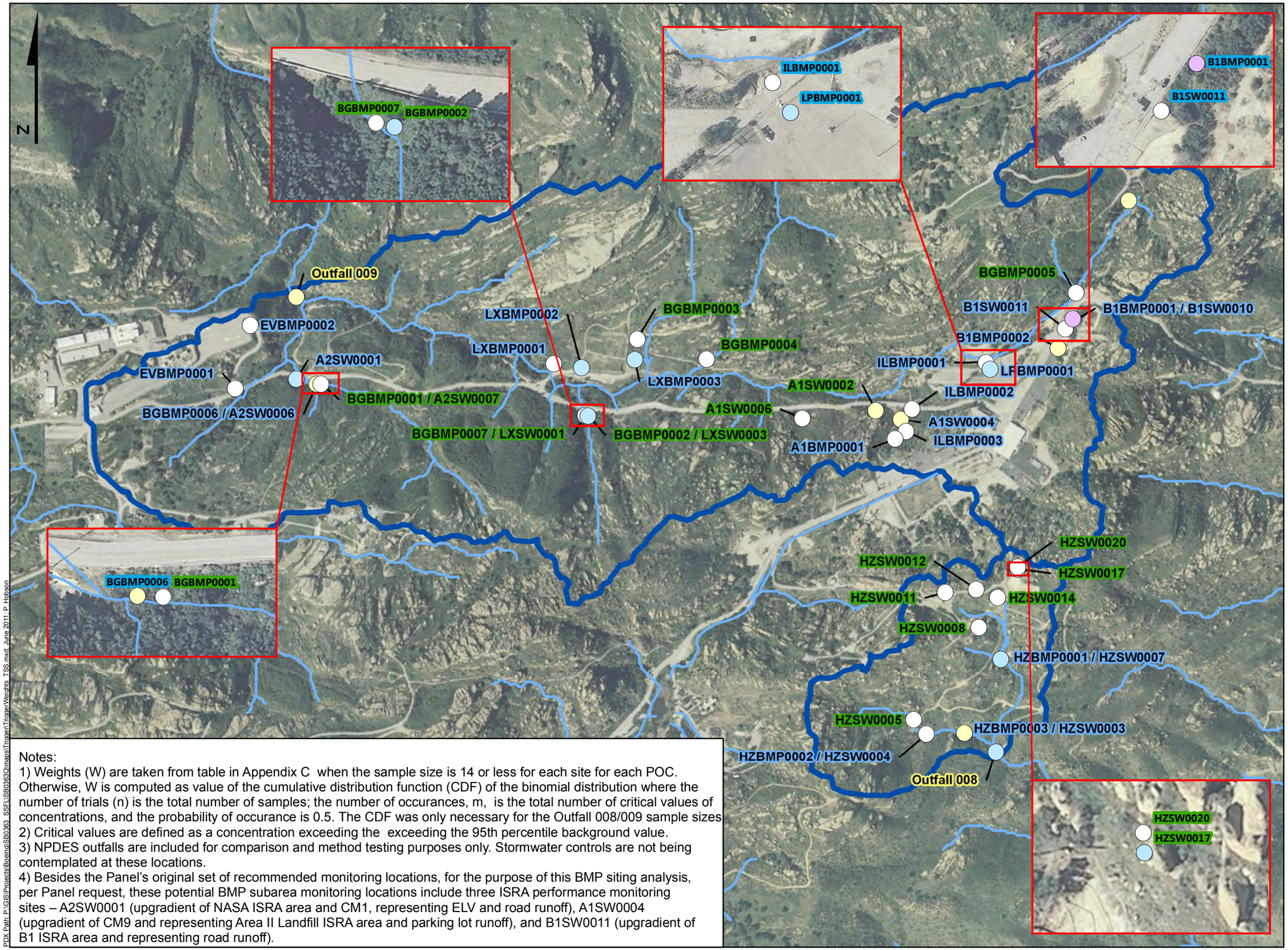

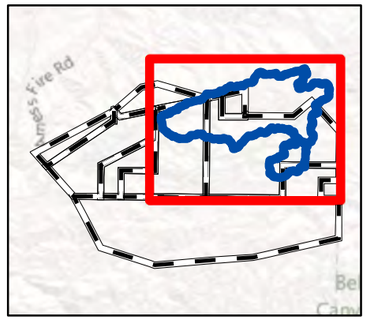

Features Legend

TSS Weights

- 0
- 0 - 0.2
- 0.2 - 0.4
- 0.4 - 0.6
- 0.6 - 1.0
- Stream
- Outfall watershed boundary

Site Legend

BMP subarea site Outfalls

Stormwater background site

800 400 0 800

Feet

Notes:
1) Weights (W) are taken from table in Appendix C when the sample size is 14 or less for each site for each POC. Otherwise, W is computed as value of the cumulative distribution function (CDF) of the binomial distribution where the number of trials (n) is the total number of samples; the number of occurances, m, is the total number of critical values of concentrations, and the probability of occurance is 0.5. The CDF was only necessary for the Outfall 008/009 sample sizes
2) Critical values are defined as a concentration exceeding the exceeding the 95th percentile background value.
3) NPDES outfalls are included for comparison and method testing purposes only. Stormwater controls are not being contemplated at these locations.
4) 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).

ATTACHMENT 4
Site Ranking Analysis:
Total Suspended Solids in 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\SB03630\maps\TriggerWeights TSS.mxd: June 2011: P. Hobson