APPENDIX B

MEMORANDUM, SSFL OUTFALL 009 SEDIMENT YIELD ANALYSIS FOR REMAINING ISRA PEAs (GEOSYNTEC, 2010)

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Memorandum

Date: April 30, 2010

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Subject: SSFL Outfall 009 Sediment Yield Analysis for Remaining ISRA PEAs

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INTRODUCTION

In December 2008, the Los Angeles Regional Water Quality Control Board (Regional Board) issued a California Water Code Section 13304 Cleanup and Abatement Order (CAO), which requires soil cleanup in the Santa Susana Field Laboratory (SSFL) watersheds of Outfall 008 and Outfall 009 to address sources of National Pollutant Discharge Elimination System (NPDES) stormwater constituents of concern (COCs). The CAO is referred to hereafter as the Interim Source Removal Action (ISRA) order. Two ISRA work plans, and several ISRA work plan addenda were submitted to the Regional Board for review and approval in 2009. These documents evaluated the preliminary ISRA evaluation areas (ISRA PEAs) within the Outfall 008 watershed, selected ISRA PEAs in the Outfall 009 watershed, identified ISRA areas, and recommended remedial actions. ISRA remedial actions performed in 2009 included ISRA activities recommended in these documents. This memorandum is intended to support the development of the 2010 ISRA Work Plan Addendum by providing The Boeing Company (Boeing) and MWH with estimates of erosion-based sediment and pollutant yield from the remaining ISRA PEAs within the Outfall 009 watershed. Refined boundaries of the ISRA PEAs were provided by MWH and CH2M HILL based on data gap and source delineation sampling results. The location and boundaries of the 23 refined PEAs are shown in Figure 1. These PEAs include those found on both Boeing and NASA properties within the watershed. This analysis was conducted consistent with the methodology employed in the previous ISRA work plan sediment yield technical memorandum dated April 24, 2009.

SEDIMENT YIELD MODEL SELECTION

The amount of erosion from a particular land surface can be determined from complex interrelations of several factors such as the erosive forces of rainfall and runoff, and the soil resistance to detachment and transport. Three commonly used mathematical models are the Erosion Risk Management Tool (ERMiT), Water Erosion Prediction Project (WEPP), and the

Revised Universal Soil Loss Equation (RUSLE). Detailed descriptions of these frameworks can be found in the previous technical memorandum dated April 24, 2009. In keeping with previous work, the analysis on the recently proposed PEAs was performed used the RUSLE methodology.

RUSLE estimates long-term annual average soil loss (A, tons/acre/year) from raindrop splash and runoff from specific field slopes base on 5 parameters:

$$A = R \times K \times LS \times C \times P$$

Where R = Rainfall-Runoff Erosivity Factor, K = Soil Erodibilty Factor, LS = Slope Length-Steepness Factor, C = Cover Management Factor, and P = Support Practice Factor.

***R* factor** quantifies the effect of raindrop impact and also reflects the amount and rate of runoff likely to be associated with precipitation events. The R-factor is calculated as total storm energy (E) times the maximum 30-minute intensity (I_{30}), or EI, and is expressed as the rainfall erosion index.

***K* factor** is the rate of soil loss per rainfall erosion index unit as measured on a standard plot. It represents the average long-term response of a specific soil and its profile to the combined effects of rainfall, runoff, and infiltration. It is expressed as the change in the soil loss per unit of applied external force or energy.

***LS* factor** represents a ratio of soil loss under given conditions to that at a site with the standard slope steepness of 9% and slope length of 72.6 feet. The steeper and longer the slope, the higher is the risk for erosion.

***C* factor** is used to reflect the effect of management practices on erosion rates. The RUSLE program user can easily compare the relative impacts of management options by making changes in the C-factor to reflect grazing impact or burning.

***P* factor** is the ratio of soil loss with a specific support practice to the corresponding loss with upslope and downslope tillage.

GIS-BASED APPROACH AND RUSLE CALCULATION RESULTS

Consistent with the previous memo (Geosyntec, 2009), a GIS raster-based approach was used to perform the RUSLE analysis of the PEAs. Rasters of 10 ft × 10 ft resolution were created for the topographic (LS) and erodibility (K) factors. All other parameters in the RUSLE equation (R, C, and P) were assumed to be constants in time and space. All five parameters were then multiplied together using the Raster Calculator function of Spatial Analyst. The result is a raster containing values representative of the average annual soil loss in tons/acre/year for each 100 square foot pixel (cell). This raster was then weighted for pixel size, yielding a raster with each pixel value representing tons of sediment per year. Values were summed for each PEA area as well as the entire Outfall 009 watershed. A bulk density conversion factor of 2000 tons/ac-ft was used to convert the weight-based results to volumetric sediment yields.

Parameter values for each input raster were estimated based on published values and/or methods. Table 1 summarizes the parameter estimates for the identified PEAs as well as for the entire Outfall 009 watershed. Note that multiplying the five factors in Table 1 will not result in the listed Sediment Yield values due to the fact that the calculation must also incorporate spatial heterogeneity within the catchments, which is accounted for in the cell by cell raster calculation.

A significant percentage of the watershed is covered by impervious features such as exposed bedrock, building structures, and paved parking areas, and these features are assumed to not contribute to erosion sediment yield. To account for this, such features were extracted digitally from aerial imagery and assigned *K* factor values of zero in the GIS input grid so that their RUSLE sediment yield results are also zero. As a result, impervious areas were accounted for in the RUSLE sediment yield calculations for the PEAs and the watershed. The only exceptions to the impervious feature extraction-based K factor dataset were for some of the IEL PEAs which recently saw asphalt or building demolition that is not captured in the aerial imagery. PEAs IEL-1, IEL-2, IEL-4, and IEL-5 were entirely assigned K factor values equal to the surrounding soil values; although most of them still have bare soil it was assumed that compaction and erosion control BMPs (per the site-wide Storm Water Pollution Prevention Plan) would result in this being a valid assumption. IEL-3 and IEL-6 however, which are still entirely covered by asphalt or buildings, were entirely assigned K factor values of zero consistent with their complete impervious cover.

Figure 2 shows the spatially-varying RUSLE parameters (*K* and *LS*) for the Outfall 009 watershed, respectively. Table 2 presents the estimated sediment yield for the identified PEAs and the percentage of erosion sediments that these PEAs are contributing to the annual sediment yields from corresponding entire Outfall 009 watersheds. Figure 3 shows the estimated sediment yield rates for the entire Outfall 009 watershed. As shown on these figures, the estimated sediment yield rates have high spatial variability within the watershed, which is caused by the high spatial variability of RUSLE parameters, most notably the value of the *LS* factor.

Individually the sediment yield rates of the PEAs, measured in tons/ac/year, vary greatly. Due to factors such as exposed bedrock or development, some PEAs are expected to yield very little sediment. Others have steep enough slopes to result in nearly twice the average sediment yield for the entire Outfall 009 watershed (i.e., 21 tons/ac/yr for the PEA versus 11 tons/ac/yr for the watershed).

Table 1 – Summary of RUSLE Parameters

ISRA PEA	Area (ac)	Mean K Factor[a]	Mean LS Factor[b]	R Factor[c]	C Factor[d]	P Factor[e]
PEA-A2LF2-2	0.56	0.32	10.3	50	0.1	1
PEA-A1LF-1	2.46	0.54	2.5	50	0.1	1
PEA-A1LF-2	0.19	0.55	5.2	50	0.1	1
PEA-AP/STP-1A	0.02	0.28	1.3	50	0.1	1
PEA-AP/STP-1B	0.47	0.27	3.0	50	0.1	1
PEA-AP/STP-1C	1.68	0.27	1.3	50	0.1	1
PEA-AP/STP-1D	0.10	0.27	1.2	50	0.1	1
PEA-AP/STP-1E	0.49	0.27	1.2	50	0.1	1
PEA-AP/STP-1F	0.24	0.28	4.9	50	0.1	1
PEA-B1-1	0.69	0.51	7.8	50	0.1	1
PEA-B1-2	0.19	0.49	5.4	50	0.1	1
PEA-CTL1-1	0.26	0.52	3.8	50	0.1	1
PEA-CTL1-2	0.03	0.51	7.7	50	0.1	1
PEA-IEL-1	0.02	0.39	0.2	50	0.1	1
PEA-IEL-2	0.11	0.50	1.8	50	0.1	1
PEA-IEL-3	0.05	0.02	0.04	50	0.1	1
PEA-IEL-4	0.02	0.39	1.6	50	0.1	1
PEA-IEL-5	0.01	0.28	0.05	50	0.1	1
PEA-IEL-6	0.01	0.37	0.12	50	0.1	1
PEA-LOX-1-A	0.05	0.32	10.1	50	0.1	1
PEA-LOX-1-B	2.19	0.32	0.3	50	0.1	1
PEA-LOX-1-C	0.13	0.32	2.4	50	0.1	1
PEA-LOX-1-D	0.17	0.32	1.7	50	0.1	1
ALL PEAs	**10**	**0.39**	**2.8**	**50**	**0.1**	**1**
Entire Outfall 009 Watershed	**536**	**0.38**	**5.5**	**50**	**0.1**	**1**

[a]Area-weighted value from U.S. Department of Agriculture, Natural Resources Conservation Service, SSURGO Database, 2008; [b]Area-weighted value from Ouyang D. and J. Bartholic, 2001; [c]Source: USEPA, 2001. [d]Source: http://cobweb.ecn.purdue.edu/~sedspec/sedspec/doc/usleapp.doc; [e]Parameter not applicable to this site

Table 2 – RUSLE Estimated Sediment Yield

ISRA PEA	Area (acres)	Average Sediment Yield Rate (tons/acre/year)	Total Annual Sediment Yield (ac-ft/year)	Total Annual Sediment Yield (tons/year)	Percentage of Watershed Annual Sediment Yield
PEA-A2LF2-2	0.56	16	0.0046	9.1	0.16%
PEA-A1LF-1	2.5	6.7	0.0083	17	0.28%
PEA-A1LF-2	0.18	14	0.0013	2.6	0.044%
PEA-AP/STP-1A	0.02	1.8	0.000019	0.0	0.00064%
PEA-AP/STP-1B	0.47	3.9	0.00091	1.8	0.031%
PEA-AP/STP-1C	1.7	1.8	0.0015	3.0	0.052%
PEA-AP/STP-1D	0.10	1.7	0.000081	0.16	0.0028%
PEA-AP/STP-1E	0.49	1.6	0.00038	0.8	0.013%
PEA-AP/STP-1F	0.24	6.9	0.0008	1.7	0.029%
PEA-B1-1	0.70	21	0.0073	15	0.25%
PEA-B1-2	0.19	14	0.0014	2.7	0.047%
PEA-CTL1-1	0.26	10	0.0014	2.7	0.047%
PEA-CTL1-2	0.03	20	0.00035	0.69	0.012%
PEA-IEL-1	0.02	0.45	0.0000036	0.0073	0.00012%
PEA-IEL-2	0.11	4.7	0.00025	0.50	0.0086%
PEA-IEL-3	0.06	0	0	0	0%
PEA-IEL-4	0.02	4.4	0.000051	0.10	0.0017%
PEA-IEL-5	0.01	0.108	0.00000049	0.00099	0.000017%
PEA-IEL-6	0.01	0	0	0	0%
PEA-LOX-1-A	0.05	16	0.00043	0.86	0.015%
PEA-LOX-1-B	2.2	0.48	0.00052	1.0	0.018%
PEA-LOX-1-C	0.13	3.9	0.00025	0.51	0.0087%
PEA-LOX-1-D	0.17	2.7	0.00024	0.47	0.0081%
All PEAs	**10**	**5.9**	**0.032**	**63**	**1.1%**
Entire Outfall 009 Watershed	**536**	**11**	**2.91**	**5800**	**100%**

SENSITIVITY ANALYSIS OF RUSLE SEDIMENT YIELDS

As RUSLE estimates are based on the direct linear relationship between different parameters (*R*, *K*, *LS*, *C* and *P*) and sediments yields, varying these parameter values will affect the predicted sediment yields. The reader is referred to the previous memo where a sensitivity and uncertainty analysis shows that the computed sediment yield rate for the Outfall 008 watershed can range from 7.3 to 24 tons/ac/yr by varying only the *K* and *LS* factors within their feasible ranges.

POLLUTANT MASS ASSOCIATED WITH SEDIMENT YIELDS

Table 3 shows the average annual pollutant yield associated with eroded sediment for the ISRA constituents of concern (COCs) identified for the Outfall 009 watershed based on background soil concentrations and RUSLE estimates. The background concentrations shown in Table 3 were provided by MWH (2005) and were approved by the Department of Toxic Substances Control (DTSC). These same values were also used in the previous sediment yield memo dated April 24, 2009. Since average soil pollutant concentrations for the watershed could not easily be determined, soil background concentrations and half of the background concentrations are used as a conservative measure for predicting the percentage of pollutant yields accompanying eroded sediment from the watershed.

Table 3 – Estimated Annual Pollutant Yields Associated with Eroded Sediment for the Outfall 009 Watershed

Pollutant (ISRA COCs)	Soil Background Concentration (mg/kg)[a]	Annual Pollutant Yield Associated with Sediment (kg/year)	
		Based on Soil Background Concentration	Based on 1/2 Soil Background Concentration
Cadmium	1	5.3	2.6
Copper	29	153	77
Lead	34	179	90
Mercury	0.09	0.47	0.24
Dioxins[b]	8.7E-07	4.6E-06	2.3E-06

[a] Soil background values from MWH, 2005.

[b] Here and elsewhere in this report, dioxins concentrations are presented as TCDD Toxicity Equivalent (TEQ) assuming that Detected but Not Quantified congener results are equal to zero.

Table 4 shows the maximum shallow soil COC concentration for each PEA, as provided by MWH, along with the estimated average annual pollutant yields associated with soil erosion. Using the maximum concentration for each PEA provides for a conservative estimate of the sediment pollutant yields from each PEA. Pollutant yields for each PEA are determined by multiplying the sediment yield from the RUSLE analysis by the soil pollutant maximum concentration. Calculated percentages of sediment pollutant yield from each PEA relative to the entire Outfall 009 watershed are also included in Table 4. Based on these results, most PEAs do not contribute significantly to pollutant yields from the entire watershed (i.e., most PEA contributions are less than 1% of the total watershed yield), but there were 10 exceptions out of the 23 total PEAs. Half of these exceptions were solely due to dioxins. In all instances where PEA pollutant yields are significant percentages of the total watershed yield, it is because maximum PEA soil concentrations are well above SSFL soil background concentration, rather than because soil erosion yield is large. PEA-B1-1 is the only PEA where COC yields (mercury and dioxins, specifically) are estimated to be greater than their yields for the entire watershed (assuming background soil concentrations for the watershed).

Table 4a – Estimated Annual Pollutant Yields Associated with Eroded Sediment from PEAs

ISRA Area and ISRA COC	Soil Concentration[a] (mg/kg)	Average Annual Sediment Yield (tons/year)	Sediment Pollutant Load (kg/year)	% of Watershed Annual Sediment Pollutant Yield	
				Based on Soil Background Concentration	Based on ½ Soil Background Concentration
PEA-A1LF-1					
Cadmium	5.4	17	0.081	1.5%	3.1%
Copper	45.8	17	0.69	0.45%	0.90%
Lead	5500	17	83	46%	92%
Mercury	0.52	17	0.0078	1.7%	3.3%
PEA-A1LF-2					
Cadmium	2.6	2.6	0.0061	0.11%	0.23%
Lead	42.5	2.6	0.099	0.056%	0.11%
Mercury	0.56	2.6	0.0013	0.28%	0.55%
Dioxins	1.05E-05	2.6	2.5E-08	0.54%	1.1%
PEA-A2LF2-2					
Mercury	0.17	9.1	0.0014	0.30%	0.59%
PEA-AP/STP-1A					
Dioxins	3.15E-05	0.04	1.1E-09	0.023%	0.046%
PEA-AP/STP-1B					
Cadmium	4.9	1.8	0.0081	0.15%	0.31%
Copper	52.2	1.8	0.087	0.06%	0.11%
Lead	2992	1.8	5.0	2.8%	5.5%
PEA-AP/STP-1C					
Cadmium	1.3	3.0	0.0036	0.067%	0.14%
Copper	37.7	3.0	0.10	0.068%	0.13%
Lead	95.2	3.0	0.26	0.15%	0.29%
Mercury	0.10	3.0	0.00027	0.058%	0.11%
Dioxins	2.37E-04	3.0	6.5E-07	14%	28%
PEA-AP/STP-1D					
Dioxins	5.13E-05	0.16	7.6E-09	0.16%	0.33%
PEA-AP/STP-1E					
Dioxins	2.11E-03	0.76	1.5E-06	32%	63%
PEA-AP/STP-1F					
Dioxins	1.35E-05	1.7	2.0E-08	0.45%	0.89%

[a] Maximum soil pollutant values provided by MWH

Table 4b – Estimated Annual Pollutant Yields Associated with Eroded Sediment from PEAs (cont'd)

ISRA Area and ISRA COC	Soil Concentration[a] (mg/kg)	Average Annual Sediment Yield (tons/year)	Sediment Pollutant Load (kg/year)	% of Watershed Annual Sediment Pollutant Yield	
				Based on Soil Background Concentration	Based on ½ Soil Background Concentration
PEA-B1-1					
Cadmium	3.7	14.6	0.050	0.94%	1.9%
Mercury	75	14.6	1.0	212%	416%
Dioxins	8.20E-04	14.6	1.1E-05	237%	474%
PEA-B1-2					
Cadmium	7.7	2.7	0.019	0.36%	0.74%
Copper	69.9	2.7	0.17	0.11%	0.23%
Lead	460	2.7	1.1	0.64%	1.3%
Dioxins	1.01E-04	2.7	2.5E-07	5.5%	11%
PEA-CTL1-1					
Copper	1900	2.7	4.7	3.1%	6.2%
Lead	450	2.7	1.1	0.63%	1.2%
Dioxins	9.42E-05	2.7	2.3E-07	5.1%	10%
PEA-CTL1-2					
Lead	52.4	0.69	0.03	0.018%	0.037%
PEA-IEL-1					
Mercury	1.5	0.01	0.000010	0.0021%	0.0041%
PEA-IEL-2					
Cadmium	2.8	0.50	0.0013	0.024%	0.049%
Lead	140	0.50	0.064	0.036%	0.071%
Mercury	4.5	0.50	0.0020	0.43%	0.85%
PEA-IEL-3					
Cadmium	4.8	0	0	0%	0%
Copper	290	0	0	0%	0%
Lead	320	0	0	0%	0%
Mercury	0.12	0	0	0%	0%
PEA-IEL-4					
Copper	33.6	0.10	0.0031	0.0020%	0.0040%
PEA-IEL-5					
Lead	40.1	0.00099	0.000036	0.000020%	0.000040%
PEA-IEL-6					
Mercury	0.10	0	0	0%	0%

[a] Maximum soil pollutant values provided by MWH

Table 4c – Estimated Annual Pollutant Yields Associated with Eroded Sediment from PEAs (cont'd)

ISRA Area and ISRA COC	Soil Concentration[a] (mg/kg)	Average Annual Sediment Yield (tons/year)	Sediment Pollutant Load (kg/year)	% of Watershed Annual Sediment Pollutant Yield	
				Based on Soil Background Concentration	Based on ½ Soil Background Concentration
PEA-LOX-1-A					
Copper	139	0.86	0.11	0.071%	0.14%
PEA-LOX-1-B					
Copper	84.1	1.0	0.079	0.052%	0.10%
Lead	71.4	1.0	0.067	0.037%	0.074%
Dioxins	1.16E-03	1.0	1.1E-06	24%	47%
PEA-LOX-1-C					
Copper	3480	0.51	1.6	1.0%	2.1%
PEA-LOX-1-D					
Copper	34.8	0.47	0.015	0.010%	0.019%

[a] Maximum soil pollutant values provided by MWH

POLLUTANT LOADS ASSOCIATED WITH SUSPENDED SEDIMENT IN STORMWATER DISCARGE AT THE OUTFALL

Between August 2004 and February 2009, Boeing collected and analyzed storm runoff water samples (which were collected as manual grab samples) from Outfall 009 for various NPDES COCs. Table 5 summarizes the Outfall 009 stormwater monitoring data for the ISRA COCs. Non-detect samples (ND) were substituted with a value of zero for computing average concentration. The results of this assumption are low estimates of average stormwater discharge suspended pollutant loads, or more importantly, conservatively high estimates of sediment erosion yields as percentages of stormwater discharge loads.

Geosyntec previously conducted long term continuous runoff modeling at Outfall 009 using the US EPA's Storm Water Management Model (SWMM) (Geosyntec, 2008). The modeling was conducted based on 58 years of hourly rainfall data to predict the runoff flow rates and volumes at the outfall over the long-term period. In Table 6, the estimate of annual average runoff volume from SWMM output is combined with the average total suspended solids (TSS) concentration from Table 5 to estimate the average annual TSS load in runoff from the Outfall 009 watershed. As discussed above, Geosyntec previously conducted RUSLE calculations for the entire Outfall 009 watershed for predicting the erosion sediment yields. Comparing the estimated annual TSS load at the outfall with the estimated annual erosion sediment yield from the corresponding outfall watershed, **less than 1% of eroded sediment from the Outfall 009 watershed (while**

acknowledging the significant uncertainty of this estimate) appears to be leaving the watershed as TSS in storm runoff discharges. The remaining potentially eroded sediment is likely being caught in depressions throughout the catchments or in the drainages, or is being transported as bed load material in the drainages, which is not captured in the TSS measurement.

For copper, lead, cadmium, and mercury, average particulate pollutant concentrations (which are not measured for stormwater runoff samples) in the runoff at the outfall were calculated by subtracting average dissolved concentrations from the average total concentrations. The resulting number was divided by average TSS concentration to get the average mass of particulate pollutant per mass of suspended sediment, or the particulate strength of suspended sediment as shown in Table 7. This number was then multiplied by the average annual runoff TSS load from Table 6 (39 tons/yr) to estimate annual particulate pollutant load in runoff at the watershed outfall.

Table 5 – Outfall 009 Discharge Water Quality Data Summary

Pollutant (ISRA COC)	Number of Samples	Minimum Concentration	Maximum Concentration	Average Concentration
Cadmium (µg/L)	36 (12 ND[a])	0 (ND)	9.2	0.39
Cadmium, dissolved (µg/L)	14 (12 ND)	0 (ND)	0.14	0.018
Copper (µg/L)	36 (0 ND)	1.6	39	6.7
Copper, dissolved (µg/L)	14 (1 ND)	0 (ND)	6.0	2.8
Lead (µg/L)	36 (4 ND)	0 (ND)	260	13
Lead, dissolved (µg/L)	14 (2 ND)	0 (ND)	1.40	0.45
Mercury (µg/L)	36 (24 ND)	0 (ND)	0.21	0.041
Mercury, dissolved (µg/L)	14 (14 ND)	0 (ND)	0 (ND)	0 (ND)
Dioxins (µg/L)	36 (11 ND)	0 (ND)	0.00091	0.000027
Total Suspended Solids (mg/L)	23 (14 ND)	0 (ND)	4000	223

[a]ND = Non detect.

Table 6 – TSS Load in Stormwater Discharges at Outfall 009

Average Annual Runoff Volume	128 ac-ft/yr
Average TSS Concentration in Runoff	223 mg/L
Average Annual TSS Load in Runoff	39 tons/yr
RUSLE Estimated Average Annual Sediment Load	5800 tons/yr
Annual TSS Load as Percent of Annual RUSLE Sediment Yield for Watershed	0.67 %

For the Outfall 009 watershed, only a small portion (0.40% to 1.4% based on soil background concentrations) of the estimated annual cadmium, copper, lead, and mercury yields associated with eroded sediment from the entire watershed are leaving the watershed in the suspended form (attached to TSS) in the runoff. These results indicate that a major portion of the estimated pollutant loads is either (a) being carried by stormwater discharges as bed load sediment or as dissolved fraction (through desorption/ion exchange processes), (b) being deposited in the catchments or drainages and not discharged in storm runoff at the outfall, or (c) erosion pollutant yield estimates are too high and/or suspended pollutant load estimates are too low.

These pollutant percentages are consistent with the estimated percentage of eroded sediment that is leaving the watershed as TSS in stormwater discharge at Outfall 009. In stormwater discharges in general, these metals tend to be sediment-associated rather than in the dissolved phase; this understanding is confirmed by monitoring data presented in Table 5 which shows low dissolved concentrations relative to total concentrations. This would imply that if bed load is also not significant (i.e., less than say, 5 times suspended sediment load), and if the RUSLE sediment yield estimates are correct and the soil pollutant concentrations that were used are representative of average conditions, then (b) would be the most likely explanation for the low mass of eroded sediment (and associated pollutants) being measured in stormwater discharges at the Outfall. Another possible explanation might be that recent dry years reflected in the storm runoff monitoring dataset has biased these sediment and pollutant loads low.

Table 7 – Estimated Annual Pollutant Yields Associated with Eroded Sediment

Pollutant (ISRA COC)	Particulate Strength[a] (mg Pollutant/kg TSS)	Average Annual Particulate Pollutant Load in Runoff (kg/year)	% of Watershed Annual Pollutant Yield	
			Based on Soil Background Concentration	Based on ½ Soil Background Concentration
Cadmium	1.7	0.058	1.1%	2.2%
Copper	17	0.61	0.40%	0.79%
Lead	56	2.0	1.1%	2.2%
Mercury	0.18	0.006	1.4%	2.7%
Dioxins	1.2E-04	4.2E-06	92%	180%

[a] Particulate strength = (Average total concentration – Average dissolved concentration) / (Runoff average TSS concentration).
[b] Average annual particulate pollutant load = Particulate strength × Average annual TSS load in runoff.

For the purpose of estimating the TSS-associated dioxins load, it is assumed that 100% of dioxins measured in stormwater discharge samples at the Outfall is associated with TSS. This assumption is acceptable based on the physical-chemical properties of dioxins, such as their low solubility and high organic-carbon partition coefficient (K_{oc}). It should also be noted that the dioxins stormwater monitoring data at the outfall includes a large number of non-detected values, which are replaced by zero for calculations purposes here (resulting in a slightly low estimate of runoff-associated pollutant loads) (Table 5). **For the Outfall 009 watershed however, a very high percentage (92% based on soil background concentration) of the estimated annual dioxins yield associated with erosion sediment from the entire watershed is leaving the watershed in the suspended form (attached to TSS) in the runoff at Outfall 009.** The relatively high dioxins concentrations in runoff samples at Outfall 009 are the cause of this higher percentage of dioxins associated with erosion sediment yield leaving the watershed with TSS in runoff. While interpreting the dioxins results at the Outfall, it is very important to recall that a larger number of non-detects are replaced by zero for the purpose of calculating average concentrations and that may introduce errors in the estimations. The observed average dioxins particulate strength in stormwater at Outfall 009 is about 150 times higher than the SSFL dioxins soil background concentration (i.e., 1.3E-04 mg/kg of TSS in stormwater samples versus 8.7E-07 mg/kg of soil in bulk soil samples). This is to be expected given that stormwater runoff tends to preferentially erode, resuspend, and/or transport finer-grained sediments which have greater surface area and organic carbon content (positive factors for pollutant adsorption), and therefore suspended sediment pollutant concentrations (i.e., mg pollutant per kg TSS) should exceed those measured in bulk soils.

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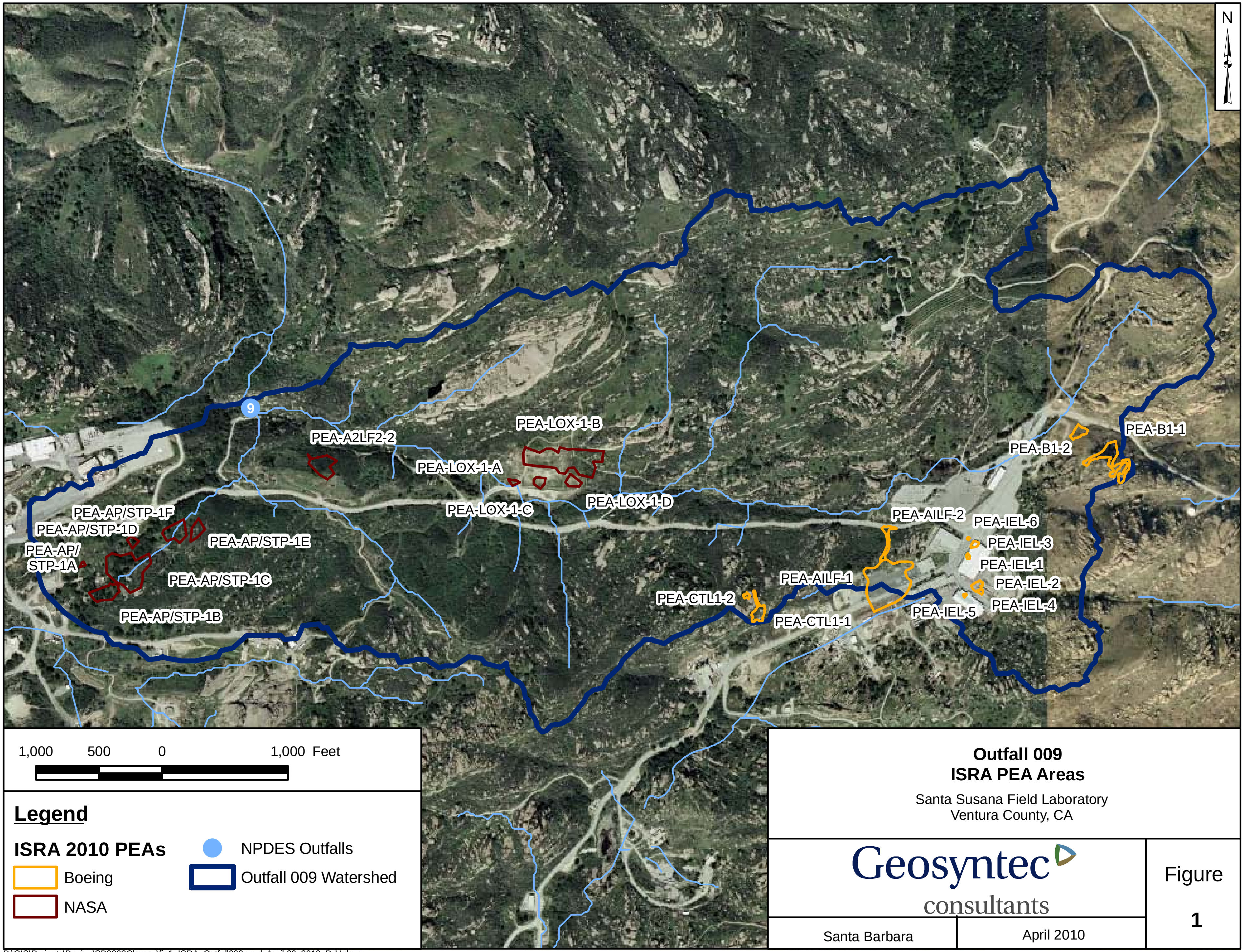

Outfall 009
ISRA PEA Areas

Santa Susana Field Laboratory
Ventura County, CA

Geosyntec consultants

Figure 1

Santa Barbara | April 2010

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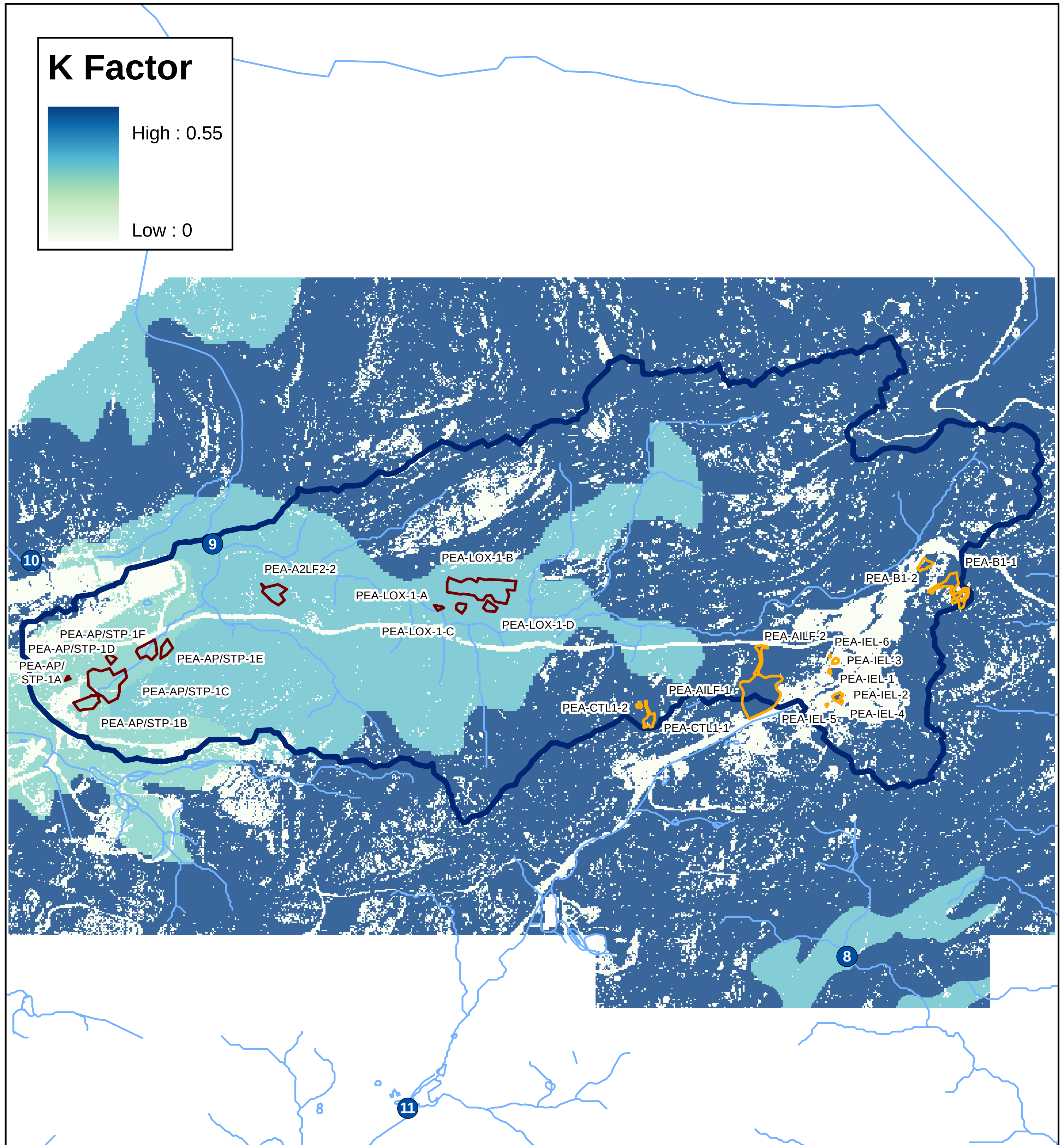

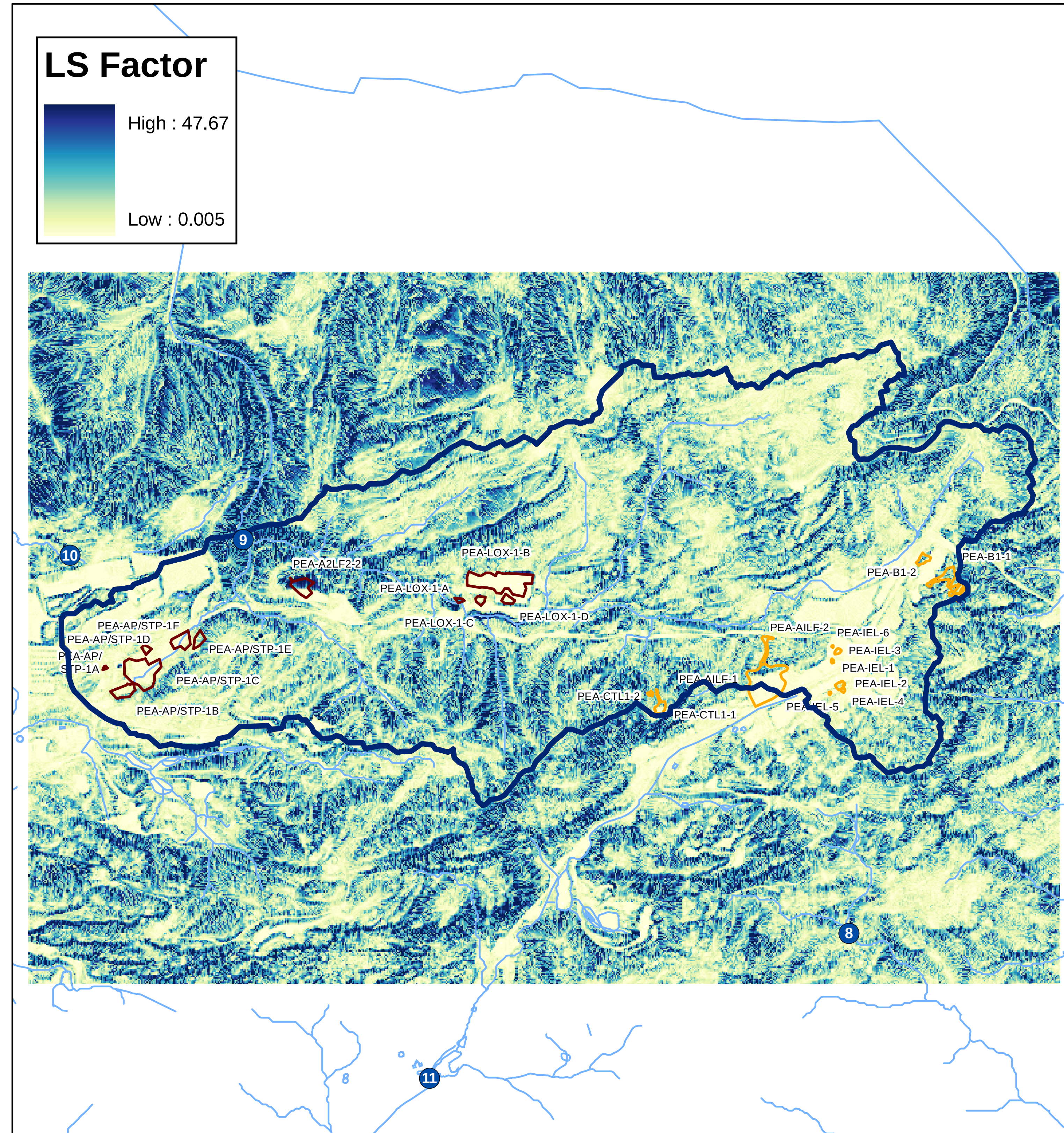

1,000 500 0 1,000 Feet

Soil data source: SSURGO, Natural Resources Conservation Service,
United States Department of Agriculture
LS data source: Derived from 10 meter LIDAR, County of Ventura

Outfall 009 Excavation Areas
RUSLE Calculation Parameters

Santa Susana Field Laboratory
Ventura County, CA

Geosyntec consultants

Santa Barbara

April 2010

Figure 2

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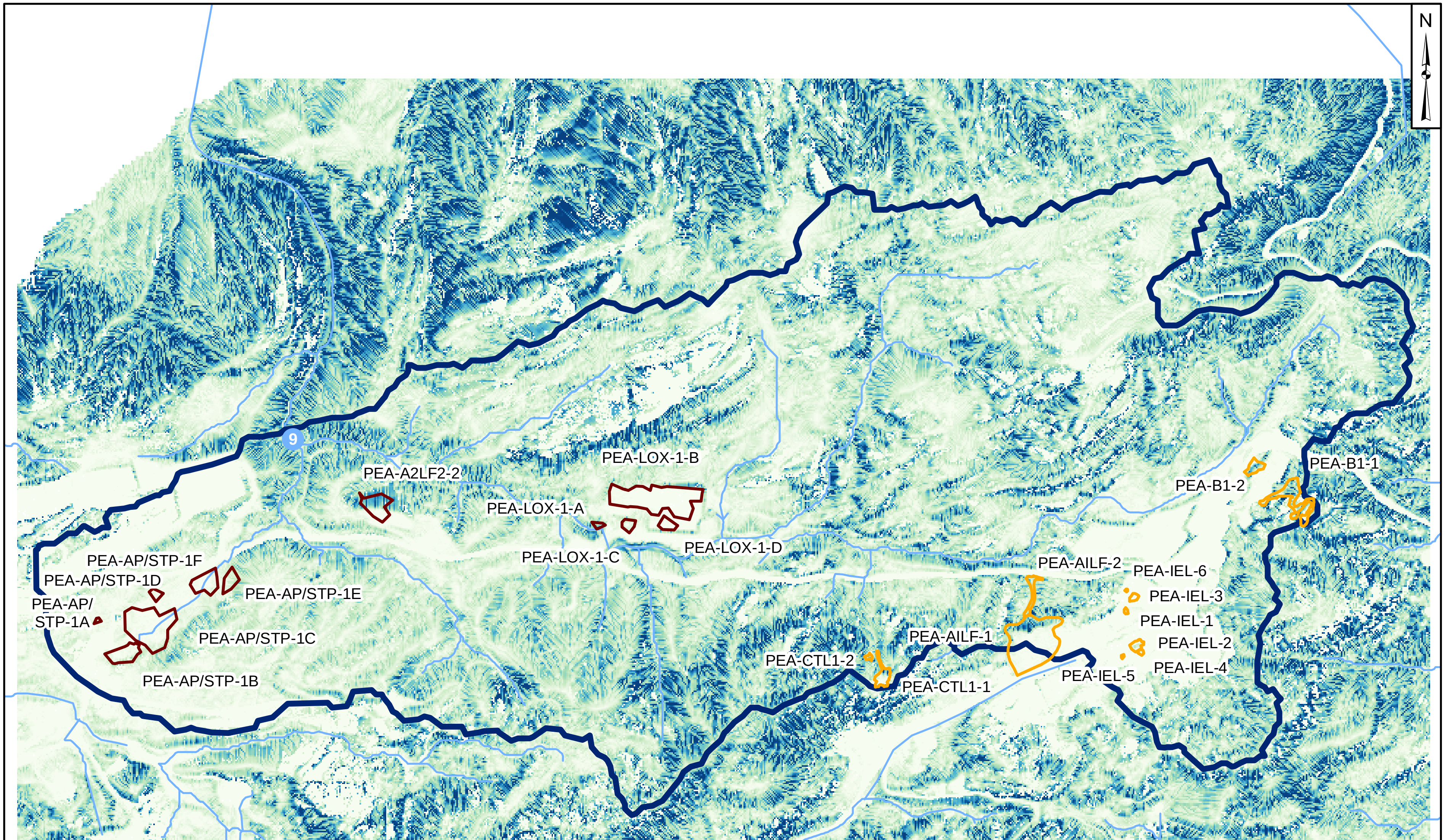

Legend

NPDES Outfalls

Outfall 009 Watershed

ISRA 2010 PEAs

Boeing

NASA

Estimated RUSLE Sediment Yield Rate (tons/ac/yr)

Value

High : 131

Low : 0

500 250 0 500 Feet

Outfall 009
Estimated RUSLE Sediment Yield Rate

Santa Susana Field Laboratory
Ventura County, CA

Geosyntec consultants

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Figure 3

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