ATTACHMENT D

Aquatic Plant Tissue Exposure Point Concentration Calculations

For polycyclic aromatic hydrocarbons (PAHs), aquatic plant tissue exposure point concentrations (EPCs) were estimated from sediment using an approach that incorporated the uptake differences between low molecular weight (LMW) and high molecular weight (HMW) PAH compounds. Due to the lack of sediment-to-plant uptake information in the scientific literature, the aquatic plant uptake was assumed to be identical uptake into terrestrial plants from soil. Therefore, the bioaccumulation approach from the PAH-specific ecological soil screening levels (Eco-SSL) document (USEPA, 2007) was used to estimate the total PAH (TPAH) concentration in aquatic plants using site-specific sediment PAH data.

The 17 PAH compounds analyzed in sediment, are categorized as follows:

LMW PAHs:

- 2-methylnaphthalene
- Acenaphthene
- Acenaphthylene
- Anthracene
- Fluorene
- Naphthalene
- Phenanthrene

HMW PAHs:

- Benzo(a)anthracene
- Benzo(a)pyrene
- Benzo(b)fluoranthene
- Benzo(g,h,i)perylene
- Benzo(k)fluoranthene
- Chrysene
- Dibenz(a,h)anthracene
- Fluoranthene
- Indeno(1,2,3-c,d)pyrene
- Pyrene

The following steps in the EPC calculation approach were used (all steps are reflected in Table E-1):

1. Calculate LMW and HMW TPAH concentrations in sediment – LWM and HWM TPAH concentrations were calculated for each sediment sample (including all field duplicates) by summing the concentration of detected PAHs in each category.
2. Estimate (model) LMW and HMW TPAH concentrations in plants – On a sample-specific basis, the LMW and HMW TPAH sediment concentrations calculated during Step 1 were used to estimate plant concentrations. For LMW TPAHs, the sediment

concentrations were multiplied by a BCF of 2.09 (Table 6.3 from USEPA, 2007). For HMW TPAHs, the sediment concentrations were calculated using the following regression model (Table 6.4 from USEPA, 2007):

$$\ln(Tissue_{aquatic\ plant}) = 0.9469 \times \ln(Sediment_{MW}) - 1.7026$$

Where:

ln = log normal
$Tissue_{aquatic\ plant}$ = concentration in aquatic plant tissue
$Sediment_{MW}$ = Step 1 molecular weight-specific TPAH concentration

3. Calculate TPAH concentration in aquatic plants – the LWM and HMW TPAH plant tissue concentrations were summed to calculate the overall TPAH concentration in aquatic plants from sediment samples.

4. Calculate EPC – First, the higher of the normal and corresponding field duplicate concentrations were selected for samples 308A, 314, 315 and 324 (the minimum concentration was ignored). Second, the 95 percent (%) upper confidence limit (UCL) of the mean (i.e., 95% UCL) was calculated for all 27 sample-specific aquatic plant tissue concentrations from Step 3 using USEPA's ProUCL version 4.00.05. This value was used as the TPAH EPC for aquatic plants in the food web assessment.

Table D-1
Calculation of Total PAHs in Aquatic Plant Tissues
Gowanus Canal Remedial Investigation
Brooklyn, New York

PAH/Category	301 GC-SD301-0.0-0.5 *Normal*	302 GC-SD302-0.0-0.5 *Normal*	303 GC-SD303-0.0-0.5 *Normal*	304 GC-SD304-0.0-0.5 *Normal*	305 GC-SD305-0.0-0.5 *Normal*	306 GC-SD306-0.0-0.5 *Normal*	307A GC-SD307A-0.0-0.5 *Normal*	307B GC-SD307B-0.0-0.5 *Normal*	308A D-062310-01 *Field Duplicate*	308A GC-SD308A-0.0-0.5 *Normal*	308B GC-SD308B-0.0-0.5 *Normal*	309 GC-SD309-0.0-0.5 *Normal*	310 GC-SD310-0.0-0.5 *Normal*	311 GC-SD311-0.0-0.5 *Normal*	312 GC-SD312-0.0-0.5 *Normal*	313 GC-SD313-0.0-0.5 *Normal*
Low Molecular Weight (LMW) PAHs																
2-methylnaphthalene	120 U	500	370	350 UJ	3,300 J	360 UJ	270	270 U	610 UJ	680 J	250 U	250 U	1,700 UJ	210 U	350	160 U
Acenaphthene	160	3,100 J	1,300	6,400 J	3,200 J	2,100 J	1,100	1,200	610 UJ	1,600 J	250 U	250 U	1,700 UJ	300	390	160 U
Acenaphthylene	270 J	2,100 J	270 U	4,200 J	2,700 U	360 UJ	230 U	270 U	760 J	620 UJ	720	250 U	1,700 UJ	210 U	1,100	160 U
Anthracene	330	3,000 J	1,800	7,300 J	3,300 J	3,900	1,000	1,500	660 J	2,400 J	250 U	610	1,700 UJ	550	810	730
Fluorene	130	1,400	270	4,100 J	260 U	360 UJ	360	270 U	610 UJ	1,800 J	250 U	250 U	1,700 UJ	260	500	160 U
Naphthalene	120	660	280	7,600 J	7,200 J	360 UJ	230 U	270 U	610 UJ	1,000 J	250 U	250 U	1,700 UJ	370	390	160 U
Phenanthrene	510	5,500 J	4,300 J	19,000 J	8,900 J	8,000 J	1,600	1,400	4,300 J	21,000 J	520 J	1,300	2,000 J	1,700 J	2,600 J	1,700 J
Total PAHs, LMW - Sediment[1]	1,520.0	16,260.0	8,050.0	48,600.0	25,900.0	14,000.0	4,330.0	4,100.0	5,720.0	28,480.0	1,240.0	1,910.0	2,000.0	3,180.0	6,140.0	2,430.0
Total PAHs, LMW - Aquatic Plant[2]	3,176.8	33,983.4	16,824.5	101,574.0	54,131.0	29,260.0	9,049.7	8,569.0	11,954.8	59,523.2	2,591.6	3,991.9	4,180.0	6,646.2	12,832.6	5,078.7
High Molecular Weight (HMW) PAHs																
Benzo(a)anthracene	1,100	4,200 J	3,400 J	11,000 J	6,500 J	5,100 J	1,900 J	2,200 J	2,500	12,000 J	1,600	1,700	4,800 J	1,600	2,400 J	1,300
Benzo(a)pyrene	1,200	5,200 J	3,600 J	8,400 J	5,400 J	4,800 J	2,800 J	2,400 J	2,900	8,100 J	1,700	250 U	8,700 J	1,900	2,300 J	1,300
Benzo(b)fluoranthene	1,000	3,500 J	3,400 J	8,900 J	6,000 J	7,100 J	3,100 J	2,900 J	2,200 J	11,000 J	1,200	250 U	11,000 J	1,800	1,900 J	1,900 U
Benzo(g,h,i)perylene	610	2,200 J	2,200	4,800 J	260 U	3,900 J	1,600	2,300	2,400	7,400 J	1,000	1,300	4,100 J	1,100	1,900	1,300
Benzo(k)fluoranthene	870	2,800 J	2,800 J	6,900 J	4,600 J	4,100 J	1,900	2,600	2,500 J	8,300 J	820	250 U	5,400 J	1,400	1,400	860 U
Chrysene	790 J	4,200 J	2,900 J	11,000 J	6,300 J	5,500 J	2,300 J	1,900 J	2,000 J	12,000 J	1,300 J	1,200 J	4,400 J	1,400 J	2,300 J	730 J
Dibenz(a,h)anthracene	200	920	520	1,400 J	700	1,500 J	460	990	910	2,500 J	420	340	1,700 UJ	400	800	210
Fluoranthene	1,200 J	6,600 J	4,200 J	12,000 J	9,300 J	6,900 J	3,600 J	3,400 J	3,800	24,000 J	1,800	2,200	8,200 J	2,700 J	4,700 J	2,200 J
Indeno(1,2,3-c,d)pyrene	1,000	3,000 J	2,400	9,000 J	3,900 J	5,300 J	2,100	1,500 J	1,900	7,100 J	1,200	2,500	5,300 J	1,800	1,200 J	1,700 J
Pyrene	1,400 J	9,500 J	5,900 J	18,000 J	13,000 J	9,600 J	5,000 J	4,400 J	3,900	22,000 J	2,200 J	2,600 J	13,000 J	2,100 J	4,900 J	1,900 J
Total PAHs, HMW - Sediment[1]	9,370.0	42,120.0	31,320.0	91,400.0	55,700.0	53,800.0	24,760.0	24,590.0	25,010.0	114,400.0	13,240.0	11,840.0	64,900.0	16,200.0	23,800.0	10,640.0
Total PAHs, HMW - Aquatic Plants[2]	1,050.5	4,360.1	3,293.5	9,080.1	5,680.9	5,497.3	2,636.4	2,619.3	2,661.6	11,230.4	1,457.4	1,311.1	6,565.8	1,764.2	2,539.5	1,184.9
Total PAHs																
Sedment[3]	10,890	58,380	39,370	140,000	81,600	67,800	29,090	28,690	30,730	142,880	14,480	13,750	66,900	19,380	29,940	13,070
Aquatic Plants[4]	4,227	38,344	20,118	110,654	59,812	34,757	11,686	11,188	14,616	70,754	4,049	5,303	10,746	8,410	15,372	6,264

Notes:

1 - Sum of detected LMW or HMW PAHs

2 - Aquatic plant bioaccummulation based in terrestrial plants via PAH Eco-SSL document (USEPA, 2007); For LMW PAHs, BCF of 2.09 taken from Table 6.3, and for HMW PAHs, BCF is regression model equation taken Table 6.4

3 - Sum of LMW and HMW Total PAHs in sediment

4 - Sum of LMW and HMW Total PAHs in aquatic plants

5 - 95% UCL calculated using ProUCL Version 4.00.05; maximum of "Normal" and "Field Duplicate" samples

Table D-1
Calculation of Total PAHs in Aquatic Plant Tissues
Gowanus Canal Remedial Investigation
Brooklyn, New York

	314		315		316	317	318	319	320	321	322	323	324		325	
	D-06182010-01	GC-SD314-0.0-0.5	D-06182010-02	GC-SD315-0.0-0.5	GC-SD316-0.0-0.5	GC-SD317-0.0-0.5	GC-SD318-0.0-0.5	GC-SD319-0.0-0.5	GC-SD320-0.0-0.5	GC-SD321-0.0-0.5	GC-SD322-0.0-0.5	GC-SD323-0.0-0.5	D-06212010-01	GC-SD324-0.0-0.5	GC-SD325-0.0-0.5	
PAH/Category	*Field Duplicate*	*Normal*	*Field Duplicate*	*Normal*	*Normal*	*Normal*	*Normal*	*Normal*	*Normal*	*Normal*	*Normal*	*Normal*	*Field Duplicate*	*Normal*	*Normal*	*95% UCL* [5]
Low Molecular Weight (LMW) PAHs																
2-methylnaphthalene	15,000	4,500 U	700,000 J	870,000 J	3,100 U	2,200 U	2,600 J	5,500 J	720 J	380	500	400	230 U	190 J	3,900 J	--
Acenaphthene	330,000 J	460,000 J	460,000 J	580,000 J	3,100 U	19,000	6,100 J	20,000 J	1,700 J	370	620	240	230 U	310 U	950	--
Acenaphthylene	100,000 J	150,000 J	110,000 J	130,000 J	3,100 U	12,000	13,000 J	10,000 J	3,600 J	260 U	320 U	480 J	230 U	310 U	240 U	--
Anthracene	230,000 J	350,000 J	360,000 J	610,000 J	3,100 U	16,000	9,700 J	21,000	3,200 J	1,100	1,500	830	450	330	2,800 J	--
Fluorene	99,000 J	130,000 J	420,000 J	540,000 J	3,100 U	13,000	3,200 J	11,000 J	1,100 J	430	460	330	230 U	310 U	1,400	--
Naphthalene	5,500	5,600	800,000 J	1,600,000 J	3,100 U	17,000	2,000	9,100 J	1,100 J	460	840	690	280	310 J	5,100 J	--
Phenanthrene	350,000 J	470,000 J	840,000 J	1,100,000 J	3,100 U	42,000 J	8,800 J	37,000 J	2,800 J	1,300	1,400	1,300	470	620	3,400 J	--
Total PAHs, LMW - Sediment[1]	1,129,500.0	1,565,600.0	3,690,000.0	5,430,000.0	--	119,000.0	45,400.0	113,600.0	14,220.0	4,040.0	5,320.0	4,270.0	1,200.0	1,450.0	17,550.0	--
Total PAHs, LMW - Aquatic Plant[2]	2,360,655.0	3,272,104.0	7,712,100.0	11,348,700.0	--	248,710.0	94,886.0	237,424.0	29,719.8	8,443.6	11,118.8	8,924.3	2,508.0	3,030.5	36,679.5	--
High Molecular Weight (HMW) PAHs																
Benzo(a)anthracene	230,000 J	320,000 J	260,000 J	490,000 J	4,800	38,000 J	25,000 J	21,000 J	9,000 J	3,000 J	3,300 J	1,900 J	940	1,500	6,300 J	--
Benzo(a)pyrene	140,000 J	200,000 J	110,000 J	140,000 J	7,100	48,000 J	15,000	14,000 J	6,500 J	4,100 J	3,100 J	2,200 J	1,800	310 U	5,200 J	--
Benzo(b)fluoranthene	110,000 J	210,000 J	170,000 J	98,000 J	11,000	17,000	17,000 J	13,000 J	5,000 J	3,400 J	2,000	1,600 J	1,900	5,300 J	3,400 J	--
Benzo(g,h,i)perylene	50,000	74,000 J	41,000 J	53,000 J	3,700	10,000	9,000 J	7,400 J	3,200 J	2,400	1,500 J	1,700	1,100	1,500	2,600 J	--
Benzo(k)fluoranthene	94,000 J	120,000 J	45,000 J	67,000 J	4,900	15,000	11,000 J	8,800 J	3,800 J	2,400	2,500 J	1,700	520	1,100	3,500 J	--
Chrysene	190,000 J	320,000 J	250,000 J	490,000 J	6,700 J	19,000 J	24,000 J	22,000 J	7,200 J	2,800 J	3,100 J	1,800 J	740 J	1,100 J	6,500 J	--
Dibenz(a,h)anthracene	14,000	14,000	8,200	10,000	3,100 U	2,200 U	3,100 J	2,500 J	1,100 J	650	320 U	390	440	600	740	--
Fluoranthene	400,000 J	630,000 J	290,000 J	530,000 J	8,200	27,000 J	31,000 J	29,000 J	14,000 J	3,500 J	4,200 J	2,500 J	230 U	2,000	7,400 J	--
Indeno(1,2,3-c,d)pyrene	67,000 J	120,000 J	54,000 J	63,000 J	5,600	13,000	11,000 J	11,000 J	4,200 J	2,100 J	1,400	1,900	1,200	1,800	1,700 J	--
Pyrene	450,000 J	670,000 J	420,000 J	630,000 J	15,000	62,000 J	44,000 J	47,000 J	15,000 J	5,500 J	5,500 J	3,900 J	230 U	310 U	11,000 J	--
Total PAHs, HMW - Sediment[1]	1,745,000.0	2,678,000.0	1,648,200.0	2,571,000.0	67,000.0	249,000.0	190,100.0	175,700.0	69,000.0	29,850.0	26,600.0	19,590.0	8,640.0	14,900.0	48,340.0	--
Total PAHs, HMW - Aquatic Plants[2]	148,226.7	222,363.8	140,429.0	213,941.9	6,766.8	23,454.8	18,165.1	16,859.5	6,957.9	3,147.0	2,821.6	2,112.0	972.9	1,629.9	4,967.5	--
Total PAHs																
Sediment[3]	2,874,500	4,243,600	5,338,200	8,001,000	67,000	368,000	235,500	289,300	83,220	33,890	31,920	23,860	9,840	16,350	65,890	1,950,282
Aquatic Plants[4]	2,508,882	3,494,468	7,852,529	11,562,642	6,767	272,165	113,051	254,283	36,678	11,591	13,940	11,036	3,481	4,660	41,647	2,522,138

Notes:
1 - Sum of detected LMW or HMW PAHs

2 - Aquatic plant bioaccummulation based in terrestrial plants via PAH Eco-SSL document (USEPA, 2007); For LMW PAHs, BCF of 2.09 taken from Table 6.3, and for HMW PAHs, BCF is regression model equation taken Table 6.4
3 - Sum of LMW and HMW Total PAHs in sediment
4 - Sum of LMW and HMW Total PAHs in aquatic plants
5 - 95% UCL calculated using ProUCL Version 4.00.05; maximum of "Normal" and "Field Duplicate" samples

	General UCL Statistics for Full Data Sets
User Selected Options	
From File	WorkSheet.wst
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Sediment_TPAHs

General Statistics

Number of Valid Observations	27	Number of Distinct Observations	27

Raw Statistics		**Log-transformed Statistics**	
Minimum	10890	Minimum of Log Data	9.296
Maximum	8001000	Maximum of Log Data	15.9
Mean	526509	Mean of log Data	11.13
Median	58380	SD of log Data	1.602
SD	1697250		
Coefficient of Variation	3.224		
Skewness	3.963		

Relevant UCL Statistics

Normal Distribution Test		**Lognormal Distribution Test**	
Shapiro Wilk Test Statistic	0.335	Shapiro Wilk Test Statistic	0.842
Shapiro Wilk Critical Value	0.923	Shapiro Wilk Critical Value	0.923
Data not Normal at 5% Significance Level		**Data not Lognormal at 5% Significance Level**	
Assuming Normal Distribution		**Assuming Lognormal Distribution**	
95% Student's-t UCL	1083625	95% H-UCL	713299
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	601208
95% Adjusted-CLT UCL (Chen-1995)	1329969	97.5% Chebyshev (MVUE) UCL	764932
95% Modified-t UCL (Johnson-1978)	1125146	99% Chebyshev (MVUE) UCL	1086536
Gamma Distribution Test		**Data Distribution**	
k star (bias corrected)	0.319	**Data do not follow a Discernable Distribution (0.05)**	
Theta Star	1648206		
MLE of Mean	526509		
MLE of Standard Deviation	931555		
nu star	17.25		
Approximate Chi Square Value (.05)	8.851	**Nonparametric Statistics**	
Adjusted Level of Significance	0.0401	95% CLT UCL	1063778
Adjusted Chi Square Value	8.467	95% Jackknife UCL	1083625
		95% Standard Bootstrap UCL	1069411
Anderson-Darling Test Statistic	4.389	95% Bootstrap-t UCL	9915259
Anderson-Darling 5% Critical Value	0.846	95% Hall's Bootstrap UCL	6306793
Kolmogorov-Smirnov Test Statistic	0.325	95% Percentile Bootstrap UCL	1112167
Kolmogorov-Smirnov 5% Critical Value	0.182	95% BCA Bootstrap UCL	1404077
Data not Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL	1950282
		97.5% Chebyshev(Mean, Sd) UCL	2566350
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL	3776495
95% Approximate Gamma UCL	1026119		
95% Adjusted Gamma UCL	1072672		
Potential UCL to Use		Use 95% Chebyshev (Mean, Sd) UCL	1950282

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002)
and Singh and Singh (2003). For additional insight, the user may want to consult a statistician.

Aquatic-Plants_TPAHs

General Statistics

Number of Valid Observations	27	Number of Distinct Observations	27

Raw Statistics		**Log-transformed Statistics**	
Minimum	4049	Minimum of Log Data	8.306
Maximum	11562642	Maximum of Log Data	16.26
Mean	601282	Mean of log Data	10.37
Median	15372	SD of log Data	1.951
SD	2289812		
Coefficient of Variation	3.808		
Skewness	4.625		

Relevant UCL Statistics

Normal Distribution Test		**Lognormal Distribution Test**	
Shapiro Wilk Test Statistic	0.289	Shapiro Wilk Test Statistic	0.844
Shapiro Wilk Critical Value	0.923	Shapiro Wilk Critical Value	0.923
Data not Normal at 5% Significance Level		**Data not Lognormal at 5% Significance Level**	
Assuming Normal Distribution		**Assuming Lognormal Distribution**	
95% Student's-t UCL	1352904	95% H-UCL	967754
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	562781
95% Adjusted-CLT UCL (Chen-1995)	1745242	97.5% Chebyshev (MVUE) UCL	728897
95% Modified-t UCL (Johnson-1978)	1418278	99% Chebyshev (MVUE) UCL	1055198
Gamma Distribution Test		**Data Distribution**	
k star (bias corrected)	0.24	**Data do not follow a Discernable Distribution (0.05)**	
Theta Star	2501306		
MLE of Mean	601282		
MLE of Standard Deviation	1226373		
nu star	12.98		
Approximate Chi Square Value (.05)	5.88	**Nonparametric Statistics**	
Adjusted Level of Significance	0.0401	95% CLT UCL	1326127
Adjusted Chi Square Value	5.576	95% Jackknife UCL	1352904
		95% Standard Bootstrap UCL	1298878
Anderson-Darling Test Statistic	4.655	95% Bootstrap-t UCL	21755179
Anderson-Darling 5% Critical Value	0.878	95% Hall's Bootstrap UCL	12745008
Kolmogorov-Smirnov Test Statistic	0.336	95% Percentile Bootstrap UCL	1443483
Kolmogorov-Smirnov 5% Critical Value	0.185	95% BCA Bootstrap UCL	1903311
Data not Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL	2522138
		97.5% Chebyshev(Mean, Sd) UCL	3353294
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL	4985938
95% Approximate Gamma UCL	1327445		
95% Adjusted Gamma UCL	1399871		
Potential UCL to Use		Use 95% Chebyshev (Mean, Sd) UCL	2522138

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.

These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002)

and Singh and Singh (2003). For additional insight, the user may want to consult a statistician.