Appendices

Appendix A: Development of RGs for the Buffalo River AOC

Appendix B: Human Health Evaluation for the Buffalo River AOC

Appendix C: Buffalo River Technical Memoranda

Appendix D: Guidelines for the Development of Remedy Alternative 5

Appendix E: Development of Remedy Alternative Costs

Appendix A
Development of RGs for the Buffalo River AOC

A1: PRG Summary Memorandum

A2: PAH PRG Memorandum

A3: PCB PRG Information
A3a: PCB PRG Memorandum and Attachments
A3b: PCB USACE Theoretical Bioaccumulation Potential

A4: Mercury and Lead PRG Memorandum

Appendix A1
PRG Summary Memorandum

Ecology Technical Subgroup

March 16, 2009

MEMORANDUM

To: Ecology Technical Subgroup

From: Ecology Technical Subgroup

Re: Summary of Preliminary Remedial Goals for Protection of Wildlife at the Buffalo River Area of Concern

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The Ecology Subgroup (Eco-Group) of the Great Lakes Legacy Act Buffalo River Project Coordination Team has collaborated to identify Preliminary Remedial Goals (PRGs) for use in the Buffalo River Feasibility Study (FS). PRGs were established for polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), mercury, and lead concentrations in sediments. From these PRGs, Remedial Goals (RGs) were identified by each of the stakeholder representatives. Table 1 provides the PRGs and RGs identified by the Eco-Group as being protective of environmental resources. The derivation of these values are documented in a series of PRG Memoranda developed via a collaborative Eco-Group effort, reports, and guidance (ENVIRON 2009a,b,c; USACE 2009a,b; NYSDEC 2007; CSC 2009). This summary memorandum and the associated series of PRG Memoranda that document the PRG development process will be provided as an appendix to the Feasibility Study.

The PRG development process involved a transparent effort among stakeholders; wherein, electronic calculation files were widely distributed and reviewed. Throughout this process, input from the various stakeholders was incorporated both quantitatively and qualitatively. New York State Department of Environmental Conservation (NYSDEC) criteria for wildlife and fish tissue were incorporated into the developed criteria when applicable. Alternative criteria and data where used to develop additional lines of evidence to support PRG decisions. The following general statements can be made regarding the PRGs for each of the four primary chemicals:

- <u>Total PAHs:</u> The PRG developed for Total PAHs (with 17 non-alkylated PAHs) is based on the United States Environmental Protection Agency (USEPA) Equilibrium Partitioning Approach. Supporting evidence was provided by multiple sediment toxicity tests both with and without toxic responses. It also includes evaluation of USEPA's target lipid model approach using bioaccumulation data developed by the United States Army Corps of Engineers (USACE). The PAH PRG identified by the Eco-Group is 16 mg/kg.
- <u>Total PCBs:</u> The total PCB PRG considered a risk-based evaluation using limited site-specific fish tissue data and NYSDEC fish tissue criteria

considered protective of piscivorous wildlife. The total PCB PRGs range from 0.18 to 0. 44 mg/kg.

- Lead: Recently sampled fish tissue from the river have contaminant concentrations that are below the NYSDEC fish tissue criteria for lead. A risk-based assessment was done to demonstrate an average sediment lead concentration that would likely be below levels that would result in adverse impacts to wildlife, including those that incidentally ingest sediment (e.g., ducks). Recent surface-weighted average lead sediment concentrations and corresponding current fish tissue data were evaluated as well as results from multiple toxicity tests. A member of the Eco-Group identified the NYSDEC screening value of 36 mg/kg as a selected RG. The site-specific RGs range from 85 to 103 mg/kg.
- Mercury: Recently sampled fish tissues from the river have chemical concentrations that are below the NYSDEC and USEPA fish tissue criteria for mercury. Risk-based assessments were done to demonstrate that current average sediment mercury concentrations in surface sediment throughout most of the Buffalo River are likely to be below levels that would result in adverse impacts to wildlife. Sediment toxicity testing results from 2005 and 2007 were included in this analysis (USACE 2009 and CSC 2009). Toxicity testing in 2005 did not show any toxic effects due to mercury (or any other chemical). Although, toxicity testing conducted in 2007 indicated benthic impairment due to sediment mercury concentrations is possible, it was noted that the highest concentrations of mercury from this analysis were based on samples collected deep in the sediment column, below the average current exposures expected for wildlife. Therefore, recent surface-weighted average mercury sediment concentrations and corresponding current fish tissue data were evaluated were used to help with mercury PRG development. A member of the Eco-Group identified the NYSDEC screening value of 0.18 mg/kg as a selected RG. The site-specific RGs range from 0.43 to 0.54 mg/kg.

It is acknowledged that the noted PRGs have inherent uncertainty; however, the derived values represent a best educated estimation given current available data and technical approaches.

References

CSC. 2009. Concentration Response Report. Submitted to USEPA Great Lakes National Program Office. Revised March 6.

ENVIRON. 2009a. Memorandum: Polycyclic Aromatic Hydrocarbon (PAH) Remedial Target Concentrations (RTC) Analysis for Buffalo River. 29 January 2009.

ENVIRON. 2009b. Preliminary Remedial Goals (PRG) for PCB-Exposed Wildlife at the Buffalo River AOC: Evaluation of Toxicity Studies That Form the Basis of the PRGs. 3 February 2009.

ENVIRON. 2009c. Memorandum: Preliminary Remedial Goal (PRG) for PCBs and Streamlined Risk Evaluation for PCB-Exposed Wildlife at the Buffalo River AOC. 14 February 2009.

ENVIRON. 2009d. Memorandum: Preliminary Remedial Goal (PRG) for Mercury and Lead for Wildlife at the Buffalo River AOC.

NYSDEC. 2007. Numerical Guidance Values for Assessing Risk to Aquatic Life from Contaminants in Sediment. Division of Fish, Wildlife, & Marine Resources. June 19.

USACE. 2009a. Use of 2005 Toxicity Test on Upper Buffalo River for PRG Development for Protection of Benthic Macroinvertebrates. Power Point presentation to the Ecology Subgroup, January 16, 2009, Buffalo, NY.

USACE. 2009b. Development of a Preliminary Remedial Goal for total Polychlorinated Biphenyls (PCBs): Theoretical Bioaccumulation Potential. February 25.
Pickard/SWP/4404.

Table 1: Preliminary Remedial Goal Summary Table

Chemical	PRGs develpment (a) (mg/kg)	PRG Identified in Concensus Process (a)	Stakeholder Group	Basis (a)	Source (b)
Total PAHs (17)	16			USEPA EqP Approach Estimates Based on Site Specific Risk Based Mean PRG	FS Appendix A2
	16.4			EcoTox NOEC	USACE 2009
	1.61			Sediment Screening Values	NYSDEC 2007
Total PAHs (17)	0.43 - 17			Correlation Analysis	CSC 2009
Fluorene	0.28 - 1.1			Correlation Analysis	CSC 2009
Anthracene	0.31 - 1.2			Correlation Analysis	CSC 2009
	11			Geostatistical 95% UCL after hot spot removal (c)	FS Data (calculation by NYSDEC)
Total PAHs (17)		**16**	**Concurrance among stakeholders**	**PAH developed for benthic protection because these organisms are highly sensitive to PAHs. PAH PRG not developed specifically for the protection of fish and wildlife but remedial action for benthics presumed protective for other wildlife.**	
Total PCBs	0.048 - 0.054			Estimated Range Site-Specific Risk-Based PRG for Piscivorous Wildlife (HQ=0.3)	FS Appendix A3a
	0.44 - 0.45			Estimated Mean Site-Specific Risk-Based PRG for Piscivorous Wildlife (HQ=1)	FS Appendix A3a
	0.1 - 1.3			Estimated Range Site-Specific Risk-Based PRG for Piscivorous Wildlife	FS Appendix A3a
	0.36			EcoTox NOEC (benthic)	USACE 2009
	0.18 - 0.2			Theoretical Bioacculation Potential (pumpkinseed extrapolation)	FS Appendix A3b
	0.005-0.06			Sediment Screening Values	NYSDEC 2007
	0.24 - 0.25			Dataset UCL (d)	FS Data (calculation by NYSDEC)
	0.15			Geostatistical 95% UCL after hot spot removal (c)	FS
Total PCBs		**0.44**	**GLNPO**	**Mean Site-Specific Risk-Based PRG**	
Total PCBs		**0.44**	**Honeywell**	**Mean Site-Specific Risk-Based PRG**	
Total PCBs		**0.20**	**Riverkeeper**	**USACE TBP**	
Total PCBs		**0.18**	**NYSDEC**	**USACE TBP**	
Total PCBs		**0.20**	**USACE**	**USACE TBP**	
Mercury (e)	0.54			Dataset UCL (d)	FS
	0.46 - 1.2			Dataset UCL (d)	FS
	0.41			Geostatistical 95% UCL after hot spot removal (c)	FS Data (calculation by NYSDEC)
	0.43			EcoTox NOEC (benthic)	USACE 2009
	0.01 - 0.18			Sediment Screening Values	NYSDEC 2007
	0.33 - 0.85			Correlation Analysis (f)	CSC 2009
Mercury		**0.46**	**GLNPO**	**Estimated based on SWAC in the Buffalo River (excludes averages in Ship Canal)**	
Mercury		**0.54**	**Honeywell**	**Estimated based on SWAC in the Buffalo River and Ship Canal**	
Mercury		**0.18**	**Riverkeeper**	**NYSDEC Screening Value**	
Mercury		**0.43**	**NYSDEC**	**Maximum value accepted for protection of all biota**	
Mercury		**0.46**	**USACE**	**Estimated based on SWAC in the Buffalo River (excludes averages in Ship Canal)**	
Lead (e)	323			Estimated Mean of Site-Specific Risk-Based PRG for Sediment-Worm Ingesting Wildlife	FS Appendix A4
	185 - 495			Estimated Range Site-Specific Risk-Based PRG for Sediment-Worm Ingesting Wildlife	FS Appendix A4
	103			Dataset UCL (d)	FS
	92 - 205			Dataset UCL (d)	FS
	73			Geostatistical 95% UCL after hot spot removal (c)	FS Data (calculation by NYSDEC)
	85			EcoTox NOEC	USACE 2009
	36			Sediment Screening Values	NYSDEC 2007
	31 - 53			Correlation Analysis (f)	CSC 2009
Lead		**92**	**GLNPO**	**Estimated based on SWAC in the Buffalo River (excludes averages in Ship Canal)**	
Lead		**103**	**Honeywell**	**Estimated based on SWAC in the Buffalo River and Ship Canal**	
Lead		**36**	**Riverkeeper**	**NYSDEC Screening Value**	
Lead		**85**	**NYSDEC**	**Maximum value accepted for protection of all biota**	
Lead		**92**	**USACE**	**Estimated based on SWAC in the Buffalo River (excludes averages in Ship Canal)**	

Notes

(a) A variety of approaches were considered that address risk directly via the calculation of values above which risks may occur or conservatively address risks indirectly (e.g., evaluation of current conditions using an upper confidence limit for consideration that remedial actions do not result in significantly increased concentrations and unbounded no effects concentrations).

(b) Souce identified; FS Appendix shows the compiled appendix in which PRG memoranda will be provided.

(c) UCLs derived using Statistix 7.0 software on 1/8th mile surface-weighted averages of the dataset and excluding hot spots by removing concentrations and corresponding surface areas that exceeding the 95% UCL.

(d) UCL derived using ProUCL software from SWACs from the complete data set.

(e) Risk based estimates show that mercury and lead do not pose unacceptable risks at current conditions in fish and sediment. Upper confidence limits represent the average concentrations in surface sediment that currently exist so that such conditions do not significantly increase following a remedial action that may exposure higher concentrations at depth.

(f) Unbounded NOEC and correlation analyses show correlation not causation.

EqP	Equilibrium Partitioning Approach	NE	Not Estimated
FS	Feasibility Study	PRG	Preliminary Remedial Goal
NE	Not Estimated	PCBs	Polychlorinated biphenyls
NOEC	No Effects Concentration	PAHs	Polycyclic Aromatic Hydrocarbons
TBP	Theoretical Bioaccumulation Potential	USEPA	United States Environmental Protection Agency
UCL	95 Percent Upper Confidence Limit	HQ	Hazard Quotient
USACE	United States Army Corps of Engineer	SWAC	Surface Weighted Average Concentration
NYSDEC	New York State Department of Env Cons		

Appendix A2
PAH PRG Memorandum

ENVIRON

February 11, 2009

MEMORANDUM

To: Ecology Technical Subgroup

From: Mary Sorensen, Darrel Lauren, and Jen Lyndall

Re: Polycyclic Aromatic Hydrocarbon (PAH) Preliminary Remedial Goal (PRG) for Buffalo River

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The Ecology Subgroup (Eco-Group) of the Great Lakes Legacy Act Buffalo River Project Coordination Team has collaborated on efforts to identify PRGs for use in the Buffalo River Feasibility Study (FS). The US Army Corps of Engineers (USACE) recommended a PRG of 16 mg ΣPAH[1]/kg dry weight sediment January 16, 2009 during a meeting in Buffalo, NY and this was discussed again during the January 26 weekly Eco-Group call. This memorandum summarizes the information discussed during the Eco-Group call, and provides a detailed summary of data that support this discussion so that Eco-Group members can make a final recommendation of the PAH Remedial Goal. Specifically, four lines of evidence demonstrate that the recommended PRG of 16 mg/kg is a protective, chronic concentration appropriate for consideration as part of the FS of the Buffalo River, as described below and illustrated on Figure 1:

1. ASci (2005) conducted bioassays of Buffalo River sediments using *Hyalella azteca* and *Chironomus tentans* exposed to sediments collected at eleven stations in the upper reaches of the Buffalo River. Results show no biologically significant toxicity at 16.4 mg Σ17 PAH/kg dry weight sediment, and therefore, this was considered a no effect concentration (NOEC) by the USACE and member of the Ecology Subgroup. Because these were 10-day bioassays, additional lines of evidence were evaluated to determine whether this value was protective of chronic exposures. The following analysis demonstrates that this NOEC is appropriate for considering chronic exposures.
2. The United States Environmental Protection Agency's *Equilibrium Partitioning (EqP) Approach for the Derivation of Sediment Quality Benchmarks for PAH Mixtures* (2003) was applied, using available sediment data from the ASci (2005) toxicity testing study.
    a. Results showed that the toxicity units (TUs[2]) for these samples were ≤1 for the Σ17 PAH/kg and for Σ34 PAH/kg (estimated based on the 2008 Buffalo

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[1] This document refers to the ΣPAH as the 17 unsubstituted (i.e., non-alkylated) PAHs that comprise the total PAH value, unless otherwise noted as .Σ34 PAHs. Reference to the Σ34 PAHs refers to both the alkylated and non-alkylated PAHs.
[2] Toxicity units are similar to the hazard quotient and hazard index because they represent the ratio of potential exposures and effects that are summed to a single value for evaluating whether adverse effects could occur. According to USEPA (2003) a TU≤1 indicate that PAHs in sediment are not biologically

River alkylated and non-alkylated PAH average conversion factor and average percent organic carbon content (Table 1)).

b. The basis of the USEPA EqP approach, the Target Lipid Model, starts with a no effect tissue residue, and therefore, is inherently a chronic (i.e., long term) exposure model for sediment dwelling organisms (USEPA 2003). Therefore, the TU for sediments from the ASci (2003) toxicity study samples demonstrate that 16 mg/kg dry weight sediment is a protective chronic value.

3. The USACE's (2003) bioaccumulation tests with *Lumbriculus variegatus* (an aquatic worm) were also considered using the USEPA's EqP approach. The sediment data and worm data provided opportunity for additional analysis using the EqP for a data set where both predictions in sediments could be compared to actual tissue residues.
   a. TUs were calculated using sediment data from the bioaccumulation study (Table 2). Some of the locations had TUs≤1 but other results showed that in the area of River Mile (RM) 3.7 to 4.6 TUs >2 (ranging from 2 to 3 where sediment concentrations were approximately 43 mg/kg to 68.5 mg/kg dry [Σ17 PAH]).
   b. Setting the TU=1 showed that the average Σ17 PAH remedial target would be 26 mg/kg (Table 2).
   c. TUs were evaluated for worm body burdens of PAHs and compared to the no effect body residue benchmark value (Table 3). These results were generally consistent with those seen in Table 2 because where the PAH TUs predicted toxicity (TU>2), the body burdens of PAHs in worm tissues were the highest and exceeded the no effect body residue yielding TUs of 8 and 11 (RM 3.7, referred to as Concrete Central in the USACE 2003 report) and TUs of 4 and 7 at RM 4.6 (referred to as the CSX Railbridge location in the USACE report). There was one location with predicted toxicity using sediment data (Table 2; TU=2; with 65 mgΣ17 PAHs/kg) at the Hamburg Street Drain (RM 0.7); however, as seen on Table 3, the body residues for PAHs in worms were low and did not exceed the no effects body residue. This finding is consistent with elevated organic carbon at this location.

4. The USEPA's *EqP* approach was also applied to the ASci (2007a) toxicity testing study conducted in the lower reaches of the Buffalo River, where such sample results were used as the technical basis of the Concentration-Response Analysis (USEPA 2008).
   a. Results showed that the toxicity units (TUs[3]) for these samples were ≤1 for Σ34 PAH/kg for some of the locations but other locations had TUs>2 showing that PAHs could have likely contributed to the toxicity seen (Table 4)).
   b. Setting the TU=1 showed that the average Σ17 PAH remedial target would be approximately 17 mg/kg is consistent with the 16 mg/kg value proposed by the USACE (Table 4).

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available and do not pose an unacceptable risk to wildlife. TUs set =1 can be used to derive protective, chronic sediment remedial targets.

[3] Toxicity units are similar to the hazard quotient and hazard index because they represent the ratio of potential exposures and effects that are summed to a single value for evaluating whether adverse effects could occur. According to USEPA (2003) a TU≤1 indicate that PAHs in sediment are not biologically available and do not pose an unacceptable risk to wildlife. TUs set =1 can be used to derive protective, chronic sediment remedial targets.

5. The USEPA's *EqP* approach was also applied to the ASci (2007b) toxicity testing study conducted in the navigational channel as part of the USACE evaluation of dredged sediment disposal. These data were considered in two ways because the total organic carbon content (TOC) of the samples was drastically different than that seen in the Buffalo River AOC and many of the locations tested were outside the AOC. Specifically, the EqP approach was applied using TOC from the actual study (Table 5a) and using average TOC from the Buffalo River (Table 5b).
    a. Results showed that the toxicity units (TUs[4]) for these samples were ≤1 for Σ34 PAH/kg at all locations except 1 (Table 5a)).
    b. Setting the TU=1 using TOC measures relevant to the Buffalo River showed that the average Σ17 PAH remedial target would be 14.6 mg/kg which is only slightly lower than the 16 mg/kg value proposed by the USACE (Table 5b). It is noted that Table 5a using the extremely low TOC values shows a lower Σ17 PAH remedial target than the 16 mg/kg value being discussed, it is important to recognize that the TOC values in these samples had only 15% of samples > 2% TOC (and only 2% >2.6% TOC) as compared to the Buffalo River sample characteristics with 77% of samples having >2% TOC (and an average of 2.6% TOC).
6. Finally, while not necessarily a separate line of evidence from that described above, it is also important to recognize that the approach used to estimate Σ17 PAH remedial targets in the tables attached is very conservative because it does not account for other sources of carbon in the river that also mitigate PAH toxicity, such as soot and black carbon.

Conclusions
Multiple lines-of-evidence demonstrate that the USACE 2009 proposed value of 16 mg ΣPAH/kg dry weight sediment is a protective, chronic remedial target concentration. Upon review of this data, the Eco-Group will make a formal recommendation regarding the use of the 16 mg/kg NOEC. The lines of evidence that that were identified herein that support this conclusion are:

- The toxicity testing study on Buffalo River sediments that identified a NOEC for PAHs (ASci 2005; USACE 2009).
- The USEPA's EqP target-lipid model, based on the assumption of chronic exposures, showed that the sediment data from the ASci 2005 toxicity study have a PAH TU ≤1 (i.e., the USEPA threshold considered for potential concern are TUs>1).
- USACE's bioaccumulation data sets were also evaluated to evaluate the USEPA's approach and this indicated the USEPA approach was consistent and conservative.
- Setting a TU =1 (a protective benchmark) and using a calculational approach that assumes that all of the toxicity of 34 PAHs is related to the 17 PAHs, average remedial targets that represent chronic NOEC values protective of benthic dwelling

[4] Toxicity units are similar to the hazard quotient and hazard index because they represent the ratio of potential exposures and effects that are summed to a single value for evaluating whether adverse effects could occur. According to USEPA (2003) a TU≤1 indicate that PAHs in sediment are not biologically available and do not pose an unacceptable risk to wildlife. TUs set =1 can be used to derive protective, chronic sediment remedial targets.

wildlife in sediments consistent with average organic carbon conditions such as those in the Buffalo River were seen as approximately 16 mg/kg (Table 1), 26 mg/kg (Table 2), 15 mg/kg (Table 5b), and 17 mg/kg (Table 4). These are very consistent values and justify the use of 16 mg/kg as the PRG for Buffalo River.

References

ASci Corporation. 2005. Results of Ten-Day Hyalella azteca and Chironomus tentans Toxicity Tests with Whole Sediments from Buffalo River. ASci Corporation, Duluth.

ASci Corporation. 2007a. Results of Ten-Day Hyalella azteca and Chironomus tentans Toxicity Tests with Whole Sediments from Buffalo River. ASci Corporation, Duluth. Samples collected in June 2007.

ASci Corporation. 2007b. Results of Ten-Day Hyalella azteca and Chironomus tentans Toxicity Tests with Whole Sediments from Buffalo River. ASci Corporation, Duluth. Samples collected in October 2007.

USACE. 2003. Sediment sampling, biological analyses, and chemical analyses for Buffalo River area of concern, Buffalo, New York. Vol.s 1 and 2. USACE, Vicksburg, MS.

USACE. 2009. Use of 2005 toxicity test on upper Buffalo River for PRG development. Protection of benthic macroinvertebrates. Power Point presentation to the Ecology Subgroup, January 16, 2009, Buffalo, NY.

USEPA. 2003. Procedures for the derivation of equilibrium partitioning sediment benchmarks (ESBs) for the protection of benthic organism: PAH mixtures. EPA-600-R-02-013. Office of Research and Development. Washington, DC 20460.

USEPA. 2008. Draft Concentration-Response Report prepared for GLNPO.

Table 1: Sediment PAH Analysis Using USACE's 2005 *Hyalella azteca* and *Chironomid tentans* Toxicity Data

Compound	**Final Chronic Value (mg/kg OC)**		**11 surface samples (full data set recommended by USACE)**	
		CF=	1.36	(a)
		2.6	**% Organic Carbon**	
Unsubstituted PAHs		**µg/kg**	**µg/gOC**	**TU (b)**
Acenaphthene	491	200	7.7	0.016
Acenaphthylene	452	26	1.0	0.002
Anthracene	594	650	25	0.042
Benzo (a) anthracene	841	1200	46	0.055
Benzo (a) pyrene	965	950	37	0.038
Benzo (b) fluoranthene	979	1200	46	0.047
Benzo (e) pyrene	967			
Benzo (g,h,i) perylene	1,095	460	17.7	0.016
Benzo (k) fluoranthene	981	930	36	0.036
Chrysene	844	1200	46	0.055
Dibenz (a,h) anthracene	1,123	150	6	0.005
Fluoranthene	707	3300	127	0.180
Fluorene	538	350	13	0.025
Indeno (1,2,3-cd) pyrene	1,115	430	17	0.015
Naphthalene	385	320	12	0.032
Phenanthrene	596	2100	81	0.136
Pyrene	697	2700	104	0.149
Alkylated PAHs				
2-Methylnaphthalene	447	200	7.7	0.017
	Sum 17 PAHs	16366	TU 17=	0.9
	Sum 34 PAHs	22258	TU 34=	1

PAH TU≤ 1	Toxicity from PAHs unlikely
PAH TU >1	Toxicity from PAH possible, additional evaluation warranted
CF	conversion factor
µg/gOC	microgram per gram of organic carbon
µg/kg	microgram per kilogram
PAH	polycyclic aromatic hydrocarbon
RM	river mile
TPAH	total polycyclic aromatic hydrocarbon
TU	toxicity unit (i.e., hazard quotient); rounded to one significant figure
USACE	US Army Corps of Engineers
(a)	The conversion factor between the full 34 PAH list and the 17 PAH list is 1.38 with the full data set and 1.36 based on this data set that includes 2-methylnapthylene.

Table 2: Sediment PAH Analysis Using USACE's 2003 *Lumbricululus variegatus* Data

Compound	Final Chronic Value (µg/goc)	Katherine St Peninsula (RM 3.3)			Concrete Central (RM 3.7)			CSX Railbridge (RM 4.6)			Upstream From Park Street Bridge (RM 5.5)			Hamburg Street Drain (RM 0.7)			Ship Canal		
		CF=	1.36		CF=	1.36		CF=	1.58		CF=	1.68		CF=	1.36		CF=	1.36	
			OC=	25		OC=	34		OC=	28		OC=	24		OC=	64		OC=	96
Unsubstituted PAHs		µg/kg	µg/gOC	TU (a)	µg/kg	µg/gOC	TU (a)	µg/kg	µg/gOC	TU (a)	µg/kg	µg/gOC	TU (a)	µg/kg	µg/gOC	TU (a)	µg/kg	µg/gOC	TU (a)
Acenaphthene	491	14	0.57	0.001	428	13	0.026	246	8.8	0.018	0	0	0	0	0	0	0	0	0
Acenaphthylene	452	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Anthracene	594	668	27	0.045	2010	59	0.100	809	29	0.049	149	6.2	0.010	1970	30.8	0.05	1490	16	0.03
Benzo (a) anthracene	841	745	30	0.035	4320	127	0.15	1740	62	0.074	374	15.6	0.019	4840	75.6	0.09	4390	46	0.05
Benzo (a) pyrene	965	324	13	0.013	3410	100	0.10	1180	42	0.044	363	15.1	0.016	4120	64.4	0.07	3390	35	0.04
Benzo (b) fluoranthene	979	516	21	0.021	3210	94	0.096	1240	44	0.045	372	15.5	0.016	4190	65.5	0.07	3210	33	0.03
Benzo (e) pyrene	967		0			0			0		0	0	0	0	0	0	0	0	0
Benzo (g,h,i) perylene	1,095	373	15	0.014	2040	60	0.055	754	27	0.025	255	10.6	0.010	1930	30	0.03	3450	36	0.033
Benzo (k) fluoranthene	981	514	21	0.021	3140	92	0.094	980	35	0.036	293	12.2	0.012	3930	61	0.06	2970	31	0.032
Chrysene	844	859	34	0.041	4640	136	0.16	1820	65	0.077	572	23.8	0.028	6350	99	0.12	4350	45	0.054
Dibenz (a,h) anthracene	1,123	98	3.9	0.003	550	16	0.014	217	8	0.007	0	0	0	0	0	0	0	0	0
Fluoranthene	707	1560	62	0.088	6860	202	0.29	3720	133	0.19	943	39.3	0.056	14600	228	0.32	8700	91	0.128
Fluorene	538	337	13	0.025	380	11	0.021	457	16	0.030	237	9.9	0.018	1260	20	0.04	0	0	0.000
Indeno (1,2,3-cd) pyrene	1,115	406	16	0.015	2380	70	0.063	205	7	0.007	261	10.9	0.010	3440	54	0.05	2150	22	0.020
Naphthalene	385	221	8.8	0.023	220	6	0.017	43	2	0.004	0	0	0	0	0	0	0	0	0
Phenanthrene	596	1060	42	0.071	2750	81	0.14	2400	86	0.144	407	17.0	0.028	8900	139	0.23	4850	51	0.085
Pyrene	697	1650	66	0.095	6900	203	0.29	3150	112.5	0.16	1000	41.7	0.060	13000	203	0.29	9190	96	0.137
	Sum 17 PAHs	9345	TU 17=	0.5	43238	TU 17=	2	18961	TU 17=	0.9	5226	TU 17=	0.3	68530	TU 17=	1	48140	TU 17=	0.6
	Sum 34 PAHs	12709	TU 34=	0.7	58804	TU 34=	2	25787	TU 34=	1	7107	TU 34=	0.4	93201	TU 34=	2	65470	TU 34=	1
Average 17 PAH Concentration (mg/kg) w/TU=1 (b)		**26**																	
Average 17 PAH Concentration (mg/kg) w/TU=1 (c)		**26**																	
Average 34 PAH Concentration (mg/kg) w/TU=1 (d)		**35**																	

PAH TU≤ 1 — Toxicity unit from PAHs unlikely
PAH TU >1 — Toxicity from PAH predicted but no toxicity observed
Value — Average protective Σ17PAH concentration calculated as described below.
CF — conversion factor based on site-specific Buffalo River sediment data provided in the attached worksheet
µg/gOC — microgram per gram of organic carbon
µg/kg — microgram per kilogram
(a) TUs were calculated by dividing the dry weight sediment concentrations normalized to organic carbon (OC) by the Final Chronic Value toxicity benchmarks (USEPA 2003).
(b) The average protective Σ17PAH concentration is calculated by setting the TU=1. Specifically, it is based on the average of (Σ34PAH dry weight sediment concentrations divided by the actual TU of 34PAHs) divided by (1.68*1000) to adjust 34 PAHs to 17PAHs and to convert units of microgram to milligram. Therefore, the formula =Average(Sum 34 PAHs per location/TU34 per location)/(1.68*1000) = 1
For this worksheet, the following cells are included in the above stated formula. '=AVERAGE(D43/F43,H43/J43,L43/N43,P43/R43,T43/V43,X43/Z43)/(1.68*1000)
(c) Alternative approach =Sum17 PAHs divided by the TU34 (converted to mg/kg). For TU=1, value =Sum 17 PAHs
For this worksheet, the following cells are included in the above stated formula. '=AVERAGE(D43/F43,H43/J43,L43/N43,P43/R43,T43/V43,X43/Z43)/(1.68*1000)
(d) Average protective Σ34PAH concentration calculated by dividing the Sum 34 PAHs by TU34.

PAH — polycyclic aromatic hydrocarbon
TPAH — total polycyclic aromatic hydrocarbon
TU — toxicity unit (i.e., hazard quotient); rounded to one significant figure
RM — river mile

Table 3: Worm Body Residue Analysis using the Target Lipid Model

	28-day *Lumbriculus variegatus* µg/g-lipid																
	Naphtalene	Acenaphthene	Fluorene	Phenanthrene	Fluoranhrene	Anthracene	Pyrene	Chrysene	BBA	BBF	BKF	BaP	IP	DBAA	BghiP	∑PAHs per replicate µg/g-lipid	Mean ∑PAHs per location µg/g-lipid
Molecular weight	128.19	154.21	166.2	178.2	202.26	178.2	202.26	228.29	228.29	252.32	252.32	252.32	276.34	278.35	276.34		
Upstream From Park Street Bridge (BR2; RM 5.5)	0.0	0.0	2.1	10.0	24.3	2.1	21.2	14.3	6.9	5.9	4.0	0.0	0.0	0.0	1.2	92	
2	0.0	0.0	3.8	19.9	44.8	3.8	42.0	27.6	8.8	16.0	8.8	0.0	2.7	0.0	3.8	182	
3	0.0	0.0	7.8	9.7	22.3	4.9	39.4	21.3	6.8	7.8	0.0	0.0	0.0	0.0		120	
4	0.0	0.0	2.6	16.0	37.5	2.6	41.0	23.1	8.7	14.1	10.3	5.1	3.2	0.0	3.8	168	
5	0.0	0.0	6.0	6.5	14.9	3.6	27.3	16.2	6.0	8.4	0.0	0.0	6.0	0.0	3.0	98	127
Ship Canal (BR5)	0.0	0.0	0.0	12.6	133.9	77.4	119.4	54.8	48.4	32.3	37.1	27.4	12.6	0.0	12.6	568	
2	0.0	0.0	0.0	0.0	30.1	0.0	28.1	13.7	9.8	10.5	9.8	7.8	3.8	0.0	3.8	117	
3	0.0	0.0	0.0	5.3	11.9	0.0	17.6	8.5	4.8	6.8	5.7	0.0	1.9	0.0	2.4	65	
4	0.0	0.0	0.0	3.7	11.1	0.0	15.3	8.9	3.7	6.8	6.3	0.0	0.0	0.0	2.6	58	
5	0.0	0.0	0.0	4.2	19.8	0.0	21.6	11.2	6.9	10.3	10.3	0.0	4.3	0.0	4.3	93	119
Katherine St Pen (BR4; RM3.3)	0.0	0.0	7.3	22.7	40.7	13.3	46.7	25.3	15.3	16.0	11.3	12.0	5.2	0.0	6.5	222	
2	0.0	0.0	2.4	6.7	10.3	3.3	13.2	6.5	3.1	3.3	2.2	2.2	0.0	0.0	1.3	54	
3	0.0	0.0	1.7	5.3	9.0	2.9	12.7	5.5	2.9	2.9	2.5	2.0	0.7	0.0	1.1	49	
4	0.0	0.9	3.3	9.7	15.6	4.9	23.0	10.0	6.1	5.6	5.4	4.6	1.4	0.0	1.9	92	
5	3.3	3.7	9.3	34.2	58.7	17.3	58.7	33.8	24.9	22.7	17.8	19.1	8.0	1.6	8.9	322	112
Hamburg Street Drain (BR6; RM 0.7)	0.0	0.0	6.0	37.7	82.6	5.7	71.9	44.9	17.4	31.1	17.4	6.6	4.6	0.0	6.6	332	
2	0.0	0.0	6.8	41.0	93.2	6.0	79.5	53.4	20.5	35.4	26.7	11.2	6.0	0.0	8.1	388	
3	0.0	0.0	8.0	47.7	124.8	7.2	97.2	69.7	24.8	45.9	30.3	12.8	7.2	0.0	11.0	487	
4	0.0	0.0	6.5	36.4	82.1	5.3	69.0	45.1	16.3	28.8	19.0	8.2	3.9	0.0	6.0	327	
5	0.0	0.0	8.4	50.4	112.6	8.2	92.4	62.2	24.4	40.3	23.5	10.1	5.6	0.0	8.2	446	391
Concrete Central (BR7; RM 3.7)	0.0	0.0	0.0	3.5	11.0	0.0	13.7	14.6	5.9	10.0	8.7	5.9	3.5	0.0	4.0	81	
2	0.0	0.0	0.0	5.3	23.9	4.8	28.2	79.1	22.1	28.8	28.2	23.3	11.0	2.4	12.3	270	
3	0.0	0.0	0.0	5.1	18.6	0.0	20.3	18.0	6.4	11.6	10.5	7.6	4.1	0.0	4.6	107	
4	36.9	34.8	46.1	242.6	957.4	446.1	829.8	730.5	688.7	692.9	603.5	704.3	427.7	57.4	305.0	6804	
5	15.7	20.7	23.1	143.8	1305.8	266.9	1181.8	1132.2	1115.7	1132.2	1000.0	1281.0	750.4	102.5	513.2	9985	692
CSX Railway Bridge (BR9; RM 4.6)	0.0	0.0	6.5	31.5	116.3	7.6	95.7	71.7	35.9	39.1	31.5	16.3	7.6		9.8	470	
2 Not available																	
3	11.1	40.0	42.9	202.9	1120.0	62.9	965.7	697.1	588.6	688.6	545.7	562.9	337.1	42.9	260.0	6168	
4	0.0	0.0	6.1	31.0	74.7	6.1	97.7	49.4	20.7	29.9	17.2	10.1	5.1	0.0	8.0	356	
5	5.5	83.5	76.9	446.2	511.0	116.5	439.6	252.7	233.0	161.5	149.5	141.8	85.7	14.3	75.8	2793	1303

Acenaphthene ND in all samples

	28-day *Lumbriculus variegatus* µmol/g-lipid															Sum PAH	TLM	HQ
River Mile 5.5	0.000	0.000	0.012	0.056	0.120	0.012	0.105	0.063	0.030	0.023	0.016	0.000	0.000	0.000	0.004	0.44	3.79	0.1
2	0.000	0.000	0.023	0.112	0.221	0.021	0.208	0.121	0.039	0.063	0.035	0.000	0.010	0.000	0.014	0.87	3.79	0.2
3	0.000	0.000	0.047	0.054	0.110	0.027	0.195	0.093	0.030	0.031	0.000	0.000	0.000	0.000	0.000	0.59	3.79	0.2
4	0.000	0.000	0.015	0.090	0.185	0.014	0.203	0.101	0.038	0.056	0.041	0.020	0.012	0.000	0.014	0.79	3.79	0.2
5	0.000	0.000	0.036	0.036	0.074	0.020	0.135	0.071	0.026	0.033	0.000	0.000	0.022	0.000	0.011	0.46	3.79	0.1
Ship Canal	0.000	0.000	0.000	0.071	0.662	0.434	0.590	0.240	0.212	0.128	0.147	0.109	0.046	0.000	0.046	2.7	3.79	0.7
2	0.000	0.000	0.000	0.000	0.149	0.000	0.139	0.060	0.043	0.041	0.039	0.031	0.014	0.000	0.014	0.53	3.79	0.1
3	0.000	0.000	0.000	0.030	0.059	0.000	0.087	0.037	0.021	0.027	0.023	0.000	0.007	0.000	0.009	0.30	3.79	0.1
4	0.000	0.000	0.000	0.021	0.055	0.000	0.075	0.039	0.016	0.027	0.025	0.000	0.000	0.000	0.010	0.27	3.79	0.1
5	0.000	0.000	0.000	0.024	0.098	0.000	0.107	0.049	0.030	0.041	0.041	0.000	0.016	0.000	0.016	0.42	3.79	0.1
Katherine St Penninsula (RM 3.3)	0.000	0.000	0.044	0.127	0.201	0.075	0.231	0.111	0.067	0.063	0.045	0.048	0.019	0.000	0.024	1.1	3.79	0.3
2	0.000	0.000	0.014	0.038	0.051	0.019	0.065	0.028	0.014	0.013	0.009	0.009	0.000	0.000	0.005	0.26	3.79	0.1
3	0.000	0.000	0.010	0.030	0.044	0.016	0.063	0.024	0.013	0.011	0.010	0.008	0.003	0.000	0.004	0.24	3.79	0.1
4	0.000	0.006	0.020	0.055	0.077	0.027	0.114	0.044	0.027	0.022	0.021	0.018	0.005	0.000	0.007	0.44	3.79	0.1
5	0.026	0.024	0.056	0.192	0.290	0.097	0.290	0.148	0.109	0.090	0.070	0.076	0.029	0.006	0.032	1.5	3.79	0.4
Hamburg Street Drain (RM 0.7)	0.000	0.000	0.036	0.212	0.409	0.032	0.355	0.197	0.076	0.123	0.069	0.026	0.016	0.000	0.024	1.6	3.79	0.4
2	0.000	0.000	0.041	0.230	0.461	0.033	0.393	0.234	0.090	0.140	0.106	0.044	0.022	0.000	0.029	1.8	3.79	0.5
3	0.000	0.000	0.048	0.268	0.617	0.040	0.481	0.305	0.109	0.182	0.120	0.051	0.026	0.000	0.040	2.3	3.79	0.6
4	0.000	0.000	0.039	0.204	0.406	0.030	0.341	0.198	0.071	0.114	0.075	0.032	0.014	0.000	0.022	1.5	3.79	0.4
5	0.000	0.000	0.051	0.283	0.557	0.046	0.457	0.272	0.107	0.160	0.093	0.040	0.020	0.000	0.029	2.1	3.79	0.6
Concrete Central (RM 3.7)	0.000	0.000	0.000	0.020	0.054	0.000	0.068	0.064	0.026	0.040	0.034	0.024	0.013	0.000	0.014	0.36	3.79	0.1
2	0.000	0.000	0.000	0.030	0.118	0.027	0.140	0.347	0.097	0.114	0.112	0.092	0.040	0.009	0.044	1.2	3.79	0.3
3	0.000	0.000	0.000	0.029	0.092	0.000	0.101	0.079	0.028	0.046	0.041	0.030	0.015	0.000	0.017	0.48	3.79	0.1
4	0.288	0.225	0.277	1.361	4.734	2.503	4.103	3.200	3.017	2.746	2.392	2.791	1.548	0.206	1.104	30	3.79	8
5	0.122	0.134	0.139	0.807	6.456	1.498	5.843	4.960	4.887	4.487	3.963	5.077	2.716	0.368	1.857	43	3.79	11
CSX Railway Bridge (RM4.6)	0.000	0.000	0.039	0.177	0.575	0.043	0.473	0.314	0.157	0.155	0.125	0.065	0.028	0.000	0.035	2.2	3.79	0.6
2 Not available																		
3	0.087	0.259	0.258	1.138	5.537	0.353	4.775	3.054	2.578	2.729	2.163	2.231	1.220	0.154	0.941	27	3.79	7
4	0.000	0.000	0.037	0.174	0.369	0.034	0.483	0.217	0.091	0.118	0.068	0.040	0.018	0.000	0.029	1.7	3.79	0.4
5	0.043	0.542	0.463	2.504	2.526	0.654	2.173	1.107	1.020	0.640	0.592	0.562	0.310	0.051	0.274	13	3.79	4

TU ≤ 1	Toxic units (i.e., hazard quotients) less than one indicates toxicity from PAHs unlikely
TU >1	Toxic unit (i.e., hazard quotients) greater than 1 indicates toxicity from PAH is predicted, but no toxicity was observed in this chronic study
(a)	conversion factor from 17 to 34 PAHs = 1.68 based on site-specific studies of Buffalo River sediment (2008)
µmol/g-lipid	microgram per gram of lipid

PAH	polycyclic aromatic hydrocarbon
TLM	target lipid model weight weight value
TU	toxic unit; rounded to one significant figure
RM	river mile

Table 4a: PAH Toxicity Units and Preliminary Remedial Goals Calculated Using the 2007 Toxicity Testing Study Conducted by ASci based on Data Used in the Concentration-Response Analysis

Sample ID #		**2-9-480-L58**				**14-9-495-L510**				**19-9-500-R03**			
Depth (ft)		**5.0 - 8.2**				**5.4 - 9.7**				**0 - 3**			
Buffalo River Conversion Factor (a)	1.35	3.7 % Organic Carbon				3.0 % Organic Carbon				3.2 % Organic Carbon			
Compound	Final Chronic Value (µg/goc)	PAH Concentration (ug/kg)	PAH Concentration (mg/kg)	PAH Concentration (µg/goc)	Toxic Units	PAH Concentration (ug/kg)	PAH Concentration (mg/kg)	PAH Concentration (µg/goc)	Toxic Units	PAH Concentration (ug/kg)	PAH Concentration (mg/kg)	PAH Concentration (µg/goc)	Toxic Units
Unsubstituted PAHs													
Acenaphthene	491	1200	1.2E+00	3.2E+01	6.5E-02	670	6.7E-01	2.2E+01	4.6E-02	160	1.6E-01	5.0E+00	1.0E-02
Acenaphthylene	452	480	4.8E-01	1.3E+01	2.8E-02	380	3.8E-01	1.3E+01	2.8E-02	320	3.2E-01	9.9E+00	2.2E-02
Anthracene	594	2600	2.6E+00	7.0E+01	1.2E-01	3000	3.0E+00	1.0E+02	1.7E-01	360	3.6E-01	1.1E+01	1.9E-02
Benzo (a) anthracene	841	1500	1.5E+00	4.0E+01	4.8E-02	1400	1.4E+00	4.7E+01	5.6E-02	930	9.3E-01	2.9E+01	3.4E-02
Benzo (a) pyrene	965	1300	1.3E+00	3.5E+01	3.6E-02	1100	1.1E+00	3.7E+01	3.8E-02	940	9.4E-01	2.9E+01	3.0E-02
Benzo (b) fluoranthene	979	1400	1.4E+00	3.7E+01	3.8E-02	1300	1.3E+00	4.3E+01	4.4E-02	1200	1.2E+00	3.7E+01	3.8E-02
Benzo (e) pyrene	967		0.0E+00	0.0E+00	0.0E+00		0.0E+00	0.0E+00	0.0E+00		0.0E+00	0.0E+00	0.0E+00
Benzo (g,h,i) perylene	1,095	230	2.3E-01	6.1E+00	5.6E-03	240	2.4E-01	8.0E+00	7.3E-03	260	2.6E-01	8.1E+00	7.4E-03
Benzo (k) fluoranthene	981	1400	1.4E+00	3.7E+01	3.8E-02	1500	1.5E+00	5.0E+01	5.1E-02	1400	1.4E+00	4.3E+01	4.4E-02
Chrysene	844	1600	1.6E+00	4.3E+01	5.1E-02	1500	1.5E+00	5.0E+01	5.9E-02	1300	1.3E+00	4.0E+01	4.8E-02
Dibenz (a,h) anthracene	1,123	84	8.4E-02	2.2E+00	2.0E-03	85	8.5E-02	2.8E+00	2.5E-03	73	7.3E-02	2.3E+00	2.0E-03
Fluoranthene	707	4000	4.0E+00	1.1E+02	1.5E-01	4200	4.2E+00	1.4E+02	2.0E-01	2600	2.6E+00	8.1E+01	1.1E-01
Fluorene	538	3400	3.4E+00	9.1E+01	1.7E-01	4100	4.1E+00	1.4E+02	2.5E-01	230	2.3E-01	7.1E+00	1.3E-02
Indeno (1,2,3-cd) pyrene	1,115	220	2.2E-01	5.9E+00	5.3E-03	240	2.4E-01	8.0E+00	7.2E-03	250	2.5E-01	7.8E+00	7.0E-03
Naphthalene	385	330	3.3E-01	8.8E+00	2.3E-02	330	3.3E-01	1.1E+01	2.9E-02	160	1.6E-01	5.0E+00	1.3E-02
Phenanthrene	596	4600	4.6E+00	1.2E+02	2.1E-01	3900	3.9E+00	1.3E+02	2.2E-01	1600	1.6E+00	5.0E+01	8.3E-02
Pyrene	697	3000	3.0E+00	8.0E+01	1.2E-01	3800	3.8E+00	1.3E+02	1.8E-01	1700	1.7E+00	5.3E+01	7.6E-02
Alkylated PAHs													
2-Methylnaphthalene	447	620	6.2E-01	1.7E+01	3.7E-02	1200	1.2E+00	4.0E+01	9.0E-02	110	1.1E-01	3.4E+00	7.6E-03
			Σ17PAH mg/kg		**Σ17PAH TU**		**Σ17PAH mg/kg**		**Σ17PAH TU**		**Σ17PAH mg/kg**		**Σ17PAH TU**
			28.0		**1**		**28.9**		**1**		**13.6**		**0.6**
			Σ34PAH mg/kg				**Σ34PAH mg/kg**				**Σ34PAH mg/kg**		
			37.7		**2**		**39.0**		**2**		**18.3**		**0.8**
Σ17PAH mg/kg, TU=1(b)					**18.3**				**14.5**				**17.7**
Σ34PAH mg/kg, TU=1(c)					**24.6**				**19.5**				**23.9**
***Average TOCs for the AOC**													

Average Sum of 17 PAHs mg/kg T **17.2**
Average Sum of 34 PAHs mg/kg T **23.2**

TU ≤ 1 — Toxic units (i.e., hazard quotients) less than one indicates toxicity from PAHs unlikely

TU >1 — Toxic unit (i.e., hazard quotients) greater than 1 indicates toxicity from PAH is predicted, but no toxicity was observed in this chronic study

(a) The conversion factor between the full 34 PAH list and the 17 PAH list is 1.36 with the full data set and 1.35 based on this data set that includes 2-methylnapthylene as indicated in the worksheet within this workbook.

(b) The average protective Σ17PAH concentration is calculated by setting the TU34=1. Specifically, it is based on the average of (Σ17PAH dry weight sediment concentrations divided by the actual TU of 34PAHs) divided by (1000) to convert units of microgram to milligram.

(c) The average protective Σ34PAH concentration is calculated by setting the TU34=1. Specifically, it is based on the average of (Σ34PAH dry weight sediment concentrations divided by the TU of 34PAHs) divided by (1000) to convert units of microgram to milligram.

CF	conversion factor	RM	river mile
µg/gOC	microgram per gram of organic carbon	TOC	total organic carbon
µg/kg	microgram per kilogram	TPAH	total polycyclic aromatic hydrocarbon
PAH	polycyclic aromatic hydrocarbon	TU	toxicity unit (i.e., hazard quotient); rounded to one significant figure
		USACE	US Army Corps of Engineers

Table 4a: PAH Toxicity Units and Preliminary Remedial Goals Calculated Using the 2007 Toxicity Testing Study Conducted by ASci based on Data Used in the Concentration-Response Analysis

Sample ID #	9-9-487-R46				26-9-515-L49				29-9-520-L79			
Depth (ft)	4.0 - 5.9				4.0 - 9.0				7.0 - 8.8			
Buffalo River Conversion Factor (a)	3.6 % Organic Carbon				2.9 % Organic Carbon				2.5 % Organic Carbon			
Compound	PAH Concentration (ug/kg)	PAH Concentration (mg/kg)	PAH Concentration (µg/goc)	Toxic Units	PAH Concentration (ug/kg)	PAH Concentration (mg/kg)	PAH Concentration (µg/goc)	Toxic Units	PAH Concentration (ug/kg)	PAH Concentration (mg/kg)	PAH Concentration (µg/goc)	Toxic Units
Unsubstituted PAHs												
Acenaphthene	640	6.4E-01	1.8E+01	3.6E-02	3500	3.5E+00	1.2E+02	2.4E-01	140	1.4E-01	5.7E+00	1.2E-02
Acenaphthylene	245	2.5E-01	6.7E+00	1.5E-02	1250	1.3E+00	4.3E+01	9.4E-02	63	6.3E-02	2.6E+00	5.6E-03
Anthracene	1300	1.3E+00	3.6E+01	6.0E-02	7600	7.6E+00	2.6E+02	4.4E-01	440	4.4E-01	1.8E+01	3.0E-02
Benzo (a) anthracene	1200	1.2E+00	3.3E+01	3.9E-02	3200	3.2E+00	1.1E+02	1.3E-01	890	8.9E-01	3.6E+01	4.3E-02
Benzo (a) pyrene	1100	1.1E+00	3.0E+01	3.1E-02	2000	2.0E+00	6.8E+01	7.1E-02	770	7.7E-01	3.1E+01	3.2E-02
Benzo (b) fluoranthene	1300	1.3E+00	3.6E+01	3.6E-02	1800	1.8E+00	6.1E+01	6.3E-02	930	9.3E-01	3.8E+01	3.8E-02
Benzo (e) pyrene		0.0E+00	0.0E+00	0.0E+00		0.0E+00	0.0E+00	0.0E+00		0.0E+00	0.0E+00	0.0E+00
Benzo (g,h,i) perylene	240	2.4E-01	6.6E+00	6.0E-03	380	3.8E-01	1.3E+01	1.2E-02	220	2.2E-01	8.9E+00	8.1E-03
Benzo (k) fluoranthene	1300	1.3E+00	3.6E+01	3.6E-02	2700	2.7E+00	9.2E+01	9.4E-02	1300	1.3E+00	5.3E+01	5.4E-02
Chrysene	1300	1.3E+00	3.6E+01	4.2E-02	3300	3.3E+00	1.1E+02	1.3E-01	1200	1.2E+00	4.9E+01	5.8E-02
Dibenz (a,h) anthracene	78	7.8E-02	2.1E+00	1.9E-03	140	1.4E-01	4.8E+00	4.3E-03	57	5.7E-02	2.3E+00	2.1E-03
Fluoranthene	3200	3.2E+00	8.8E+01	1.2E-01	13000	1.3E+01	4.4E+02	6.3E-01	2100	2.1E+00	8.5E+01	1.2E-01
Fluorene	2000	2.0E+00	5.5E+01	1.0E-01	7500	7.5E+00	2.6E+02	4.8E-01	370	3.7E-01	1.5E+01	2.8E-02
Indeno (1,2,3-cd) pyrene	230	2.3E-01	6.3E+00	5.7E-03	340	3.4E-01	1.2E+01	1.0E-02	190	1.9E-01	7.7E+00	6.9E-03
Naphthalene	190	1.9E-01	5.2E+00	1.4E-02	1100	1.1E+00	3.8E+01	9.8E-02	71	7.1E-02	2.9E+00	7.5E-03
Phenanthrene	2800	2.8E+00	7.7E+01	1.3E-01	16000	1.6E+01	5.5E+02	9.2E-01	960	9.6E-01	3.9E+01	6.5E-02
Pyrene	2700	2.7E+00	7.4E+01	1.1E-01	8900	8.9E+00	3.0E+02	4.4E-01	1900	1.9E+00	7.7E+01	1.1E-01
Alkylated PAHs												
2-Methylnaphthalene	245	2.5E-01	6.7E+00	1.5E-02	3000	3.0E+00	1.0E+02	2.3E-01	61	6.1E-02	2.5E+00	5.5E-03
		Σ17PAH mg/kg		**Σ17PAH TU**		**Σ17PAH mg/kg**		**Σ17PAH TU**		**Σ17PAH mg/kg**		**Σ17PAH TU**
		20.1		**1**		**75.7**		**4**		**11.7**		**0.6**
		Σ34PAH mg/kg				**Σ34PAH mg/kg**				**Σ34PAH mg/kg**		
		27.0		**1**		**102**		**5**		**15.7**		**0.8**
Σ17PAH mg/kg, TU=1(b)				**18.6**				**13.8**				**13.8**
Σ34PAH mg/kg, TU=1(c)				**25.1**				**18.6**				**18.6**
***Average TOCs for the AOC**												

Table 4a: PAH Toxicity Units and Preliminary Remedial Goals Calculated Using the 2007 Toxicity Testing Study Conducted by ASci based on Data Used in the Concentration-Response Analysis

Sample ID #	35-9-530-L510				50-9-551-L25				61-9-570-L810			
Depth (ft)	5.0 - 9.6				2.2 - 5.2				8.0 - 9.7			
Buffalo River Conversion Factor (a)	3.2 % Organic Carbon				3.6 % Organic Carbon				2.7 % Organic Carbon			
Compound	PAH Concentration (ug/kg)	PAH Concentration (mg/kg)	PAH Concentration (µg/goc)	Toxic Units	PAH Concentration (ug/kg)	PAH Concentration (mg/kg)	PAH Concentration (µg/goc)	Toxic Units	PAH Concentration (ug/kg)	PAH Concentration (mg/kg)	PAH Concentration (µg/goc)	Toxic Units
Unsubstituted PAHs												
Acenaphthene	3400	3.4E+00	1.1E+02	2.1E-01	2600	2.6E+00	7.1E+01	1.5E-01	780	7.8E-01	2.9E+01	6.0E-02
Acenaphthylene	850	8.5E-01	2.6E+01	5.8E-02	1.1E+03	1.1E+00	3.0E+01	6.7E-02	600	6.0E-01	2.3E+01	5.0E-02
Anthracene	6600	6.6E+00	2.0E+02	3.4E-01	6500	6.5E+00	1.8E+02	3.0E-01	2400	2.4E+00	9.0E+01	1.5E-01
Benzo (a) anthracene	2400	2.4E+00	7.4E+01	8.8E-02	2500	2.5E+00	6.9E+01	8.2E-02	2500	2.5E+00	9.4E+01	1.1E-01
Benzo (a) pyrene	1600	1.6E+00	5.0E+01	5.1E-02	1400	1.4E+00	3.8E+01	4.0E-02	2300	2.3E+00	8.6E+01	9.0E-02
Benzo (b) fluoranthene	1500	1.5E+00	4.6E+01	4.7E-02	1600	1.6E+00	4.4E+01	4.5E-02	2700	2.7E+00	1.0E+02	1.0E-01
Benzo (e) pyrene		0.0E+00	0.0E+00	0.0E+00		0.0E+00	0.0E+00	0.0E+00		0.0E+00	0.0E+00	0.0E+00
Benzo (g,h,i) perylene	300	3.0E-01	9.3E+00	8.5E-03	310	3.1E-01	8.5E+00	7.8E-03	470	4.7E-01	1.8E+01	1.6E-02
Benzo (k) fluoranthene	2300	2.3E+00	7.1E+01	7.3E-02	1400	1.4E+00	3.8E+01	3.9E-02	2400	2.4E+00	9.0E+01	9.2E-02
Chrysene	2600	2.6E+00	8.0E+01	9.5E-02	2600	2.6E+00	7.1E+01	8.5E-02	2600	2.6E+00	9.8E+01	1.2E-01
Dibenz (a,h) anthracene	120	1.2E-01	3.7E+00	3.3E-03	100	1.0E-01	2.7E+00	2.4E-03	200	2.0E-01	7.5E+00	6.7E-03
Fluoranthene	7700	7.7E+00	2.4E+02	3.4E-01	9800	9.8E+00	2.7E+02	3.8E-01	7500	7.5E+00	2.8E+02	4.0E-01
Fluorene	8500	8.5E+00	2.6E+02	4.9E-01	7700	7.7E+00	2.1E+02	3.9E-01	1600	1.6E+00	6.0E+01	1.1E-01
Indeno (1,2,3-cd) pyrene	290	2.9E-01	9.0E+00	8.1E-03	300	3.0E-01	8.2E+00	7.4E-03	450	4.5E-01	1.7E+01	1.5E-02
Naphthalene	740	7.4E-01	2.3E+01	6.0E-02	620	6.2E-01	1.7E+01	4.4E-02	280	2.8E-01	1.1E+01	2.7E-02
Phenanthrene	10000	1.0E+01	3.1E+02	5.2E-01	11000	1.1E+01	3.0E+02	5.1E-01	5100	5.1E+00	1.9E+02	3.2E-01
Pyrene	5600	5.6E+00	1.7E+02	2.5E-01	7100	7.1E+00	2.0E+02	2.8E-01	5600	5.6E+00	2.1E+02	3.0E-01
Alkylated PAHs												
2-Methylnaphthalene	1100	1.1E+00	3.4E+01	7.6E-02	950	9.5E-01	2.6E+01	5.8E-02	580	5.8E-01	2.2E+01	4.9E-02
		Σ17PAH mg/kg		**Σ17PAH TU**		**Σ17PAH mg/kg**		**Σ17PAH TU**		**Σ17PAH mg/kg**		**Σ17PAH TU**
		55.6		**3**		**57.6**		**2**		**38.06**		**2**
		Σ34PAH mg/kg				**Σ34PAH mg/kg**				**Σ34PAH mg/kg**		
		74.9		**4**		**77.6**		**3**		**51.29**		**3**
Σ17PAH mg/kg, TU=1(b)				**15.2**				**17.2**				**14.0**
Σ34PAH mg/kg, TU=1(c)				**20.4**				**23.2**				**18.8**
***Average TOCs for the AOC**												

Table 4a: PAH Toxicity Units and Preliminary Remedial Goals Calculated Using the 2007 Toxicity Testing Study Conducted by ASci based on Data Used in the Concentration-Response Analysis

Sample ID #	**79-9-801-L46**				**90-9-816+50-R34**				**103-9-841-L23**				**123-9-872+88-C01**			
Depth (ft)	**4.5 - 6.0**				**2.8 - 4.7**				**1.7 - 3.2**				**ponar**			
Buffalo River Conversion Factor (a)	4.0 % Organic Carbon				3.6 % Organic Carbon				3.1 % Organic Carbon				7.1 % Organic Carbon			
Compound	PAH Concentration (ug/kg)	PAH Concentration (mg/kg)	PAH Concentration (µg/goc)	Toxic Units	PAH Concentration (ug/kg)	PAH Concentration (mg/kg)	PAH Concentration (µg/goc)	Toxic Units	PAH Concentration (ug/kg)	PAH Concentration (mg/kg)	PAH Concentration (µg/goc)	Toxic Units	PAH Concentration (ug/kg)	PAH Concentration (mg/kg)	PAH Concentration (µg/goc)	Toxic Units
Unsubstituted PAHs																
Acenaphthene	690	6.9E-01	1.7E+01	3.5E-02	940	9.4E-01	2.6E+01	5.4E-02	500	5.0E-01	1.6E+01	3.3E-02	980	9.8E-01	1.4E+01	2.8E-02
Acenaphthylene	485	4.9E-01	1.2E+01	2.7E-02	600	6.0E-01	1.7E+01	3.7E-02	550	5.5E-01	1.8E+01	3.9E-02	4600	4.6E+00	6.5E+01	1.4E-01
Anthracene	3700	3.7E+00	9.3E+01	1.6E-01	1900	1.9E+00	5.4E+01	9.0E-02	2400	2.4E+00	7.8E+01	1.3E-01	1400	1.4E+00	2.0E+01	3.3E-02
Benzo (a) anthracene	1400	1.4E+00	3.5E+01	4.2E-02	2500	2.5E+00	7.0E+01	8.4E-02	1800	1.8E+00	5.8E+01	6.9E-02	2200	2.2E+00	3.1E+01	3.7E-02
Benzo (a) pyrene	1200	1.2E+00	3.0E+01	3.1E-02	2200	2.2E+00	6.2E+01	6.4E-02	1300	1.3E+00	4.2E+01	4.4E-02	2300	2.3E+00	3.3E+01	3.4E-02
Benzo (b) fluoranthene	1400	1.4E+00	3.5E+01	3.6E-02	2800	2.8E+00	7.9E+01	8.1E-02	2300	2.3E+00	7.4E+01	7.6E-02	2300	2.3E+00	3.3E+01	3.3E-02
Benzo (e) pyrene		0.0E+00	0.0E+00	0.0E+00		0.0E+00	0.0E+00	0.0E+00		0.0E+00	0.0E+00	0.0E+00		0.0E+00	0.0E+00	0.0E+00
Benzo (g,h,i) perylene	220	2.2E-01	5.5E+00	5.1E-03	470	4.7E-01	1.3E+01	1.2E-02	270	2.7E-01	8.7E+00	8.0E-03	810	8.1E-01	1.1E+01	1.0E-02
Benzo (k) fluoranthene	1300	1.3E+00	3.3E+01	3.3E-02	3400	3.4E+00	9.6E+01	9.8E-02	1900	1.9E+00	6.1E+01	6.3E-02	2800	2.8E+00	4.0E+01	4.0E-02
Chrysene	1700	1.7E+00	4.3E+01	5.1E-02	2700	2.7E+00	7.6E+01	9.0E-02	2300	2.3E+00	7.4E+01	8.8E-02	2400	2.4E+00	3.4E+01	4.0E-02
Dibenz (a,h) anthracene	68	6.8E-02	1.7E+00	1.5E-03	180	1.8E-01	5.1E+00	4.5E-03	97	9.7E-02	3.1E+00	2.8E-03	240	2.4E-01	3.4E+00	3.0E-03
Fluoranthene	3600	3.6E+00	9.1E+01	1.3E-01	7500	7.5E+00	2.1E+02	3.0E-01	6000	6.0E+00	1.9E+02	2.7E-01	5900	5.9E+00	8.3E+01	1.2E-01
Fluorene	3100	3.1E+00	7.8E+01	1.5E-01	1700	1.7E+00	4.8E+01	8.9E-02	1100	1.1E+00	3.6E+01	6.6E-02	4900	4.9E+00	6.9E+01	1.3E-01
Indeno (1,2,3-cd) pyrene	200	2.0E-01	5.0E+00	4.5E-03	520	5.2E-01	1.5E+01	1.3E-02	260	2.6E-01	8.4E+00	7.5E-03	810	8.1E-01	1.1E+01	1.0E-02
Naphthalene	320	3.2E-01	8.1E+00	2.1E-02	190	1.9E-01	5.4E+00	1.4E-02	230	2.3E-01	7.4E+00	1.9E-02	33000	3.3E+01	4.7E+02	1.2E+00
Phenanthrene	3800	3.8E+00	9.6E+01	1.6E-01	4500	4.5E+00	1.3E+02	2.1E-01	2600	2.6E+00	8.4E+01	1.4E-01	12000	1.2E+01	1.7E+02	2.8E-01
Pyrene	3200	3.2E+00	8.1E+01	1.2E-01	4700	4.7E+00	1.3E+02	1.9E-01	4000	4.0E+00	1.3E+02	1.9E-01	4700	4.7E+00	6.6E+01	9.5E-02
Alkylated PAHs																
2-Methylnaphthalene	1800	1.8E+00	4.5E+01	1.0E-01	600	6.0E-01	1.7E+01	3.8E-02	450	4.5E-01	1.5E+01	3.3E-02	5100	5.1E+00	7.2E+01	1.6E-01
		Σ17PAH mg/kg		**Σ17PAH TU**		**Σ17PAH mg/kg**		**Σ17PAH TU**		**Σ17PAH mg/kg**		**Σ17PAH TU**		**Σ17PAH mg/kg**		**Σ17PAH TU**
		28.18		**1**		**37.40**		**1**		**28.06**		**1**		**86.4**		**2**
		Σ34PAH mg/kg				**Σ34PAH mg/kg**				**Σ34PAH mg/kg**				**Σ34PAH mg/kg**		
		37.98		**1**		**50.40**		**2**		**37.81**		**2**		**116**		**3**
Σ17PAH mg/kg, TU=1(b)				**19.1**				**18.9**				**16.3**				**26.6**
Σ34PAH mg/kg, TU=1(c)				**25.7**				**25.4**				**21.9**				**35.8**
***Average TOCs for the AOC**																

Table 5a: Sediment PAH Analysis Using USACE's 2007 Toxicity Testing Data (with TOC from the Study)

USACE 2007		BL-1	Outside AOC		BL-2	Outside AOC		BL-3	Outside AOC		BL-4	Outside AOC		BH-16	RM 0.8		BH-17	RM 0.5	
Buffalo River Conversion Factor (a)	1.34	0.6 % Organic Carbon			1.0 % Organic Carbon			0.8 % Organic Carbon			0.8 % Organic Carbon			1.4 % Organic Carbon			1.9 % Organic Carbon		
Compound	Final Chronic Value (µg/goc)	PAH Concentration (mg/kg)	PAH Concentration (µg/goc)	Toxic Units	PAH Concentration (mg/kg)	PAH Concentration (µg/goc)	Toxic Units	PAH Concentration (mg/kg)	PAH Concentration (µg/goc)	Toxic Units	PAH Concentration (mg/kg)	PAH Concentration (µg/goc)	Toxic Units	PAH Concentration (mg/kg)	PAH Concentration (µg/goc)	Toxic Units	PAH Concentration (mg/kg)	PAH Concentration (µg/goc)	Toxic Units
Unsubstituted PAHs																			
Acenaphthene	491	3.0E-04	4.9E-02	1.0E-04	1.7E-03	1.8E-01	3.6E-04	3.4E-03	4.4E-01	9.0E-04	8.9E-03	1.1E+00	2.3E-03	3.8E-02	2.7E+00	5.4E-03	1.7E-02	8.8E-01	1.8E-03
Acenaphthylene	452	9.9E-04	1.6E-01	3.5E-04	2.9E-03	3.0E-01	6.7E-04	9.2E-03	1.2E+00	2.7E-03	7.6E-03	9.6E-01	2.1E-03	5.2E-02	3.6E+00	8.0E-03	2.5E-02	1.3E+00	2.9E-03
Anthracene	594	2.0E-03	3.3E-01	5.5E-04	6.0E-03	6.2E-01	1.0E-03	1.2E-02	1.5E+00	2.6E-03	2.3E-02	2.9E+00	4.9E-03	2.2E-01	1.5E+01	2.6E-02	5.0E-02	2.6E+00	4.4E-03
Benzo (a) anthracene	841	7.8E-03	1.3E+00	1.5E-03	2.1E-02	2.1E+00	2.6E-03	3.8E-02	4.9E+00	5.8E-03	7.6E-02	9.5E+00	1.1E-02	5.0E-01	3.5E+01	4.2E-02	2.1E-01	1.1E+01	1.3E-02
Benzo (a) pyrene	965	5.9E-03	9.6E-01	9.9E-04	1.6E-02	1.6E+00	1.7E-03	3.3E-02	4.3E+00	4.5E-03	6.3E-02	8.0E+00	8.3E-03	4.0E-01	2.8E+01	2.9E-02	2.0E-01	1.1E+01	1.1E-02
Benzo (b) fluoranthene	979	8.2E-03	1.3E+00	1.4E-03	1.9E-02	2.0E+00	2.0E-03	5.1E-02	6.7E+00	6.9E-03	9.4E-02	1.2E+01	1.2E-02	6.6E-01	4.6E+01	4.7E-02	3.8E-01	2.0E+01	2.0E-02
Benzo (e) pyrene	967		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
Benzo (g,h,i) perylene	1,095	4.2E-03	6.8E-01	6.2E-04	9.2E-03	9.5E-01	8.7E-04	2.4E-02	3.1E+00	2.8E-03	4.2E-02	5.3E+00	4.8E-03	2.5E-01	1.8E+01	1.6E-02	1.5E-01	7.6E+00	7.0E-03
Benzo (k) fluoranthene	981	4.2E-03	6.8E-01	6.9E-04	1.1E-02	1.1E+00	1.2E-03	1.9E-02	2.5E+00	2.6E-03	3.8E-02	4.8E+00	4.9E-03	2.2E-01	1.5E+01	1.5E-02	1.0E-01	5.3E+00	5.4E-03
Chrysene	844	4.5E-04	7.3E-02	8.6E-05	9.1E-03	9.5E-01	1.1E-03	5.5E-02	7.2E+00	8.5E-03	9.4E-02	1.2E+01	1.4E-02	5.7E-02	3.9E+00	4.6E-03	4.0E-01	2.1E+01	2.4E-02
Dibenz (a,h) anthracene	1,123	7.2E-04	1.2E-01	1.0E-04	1.8E-03	1.9E-01	1.7E-04	5.6E-03	7.4E-01	6.6E-04	5.0E-03	6.3E-01	5.6E-04	9.1E-02	6.3E+00	5.6E-03	1.1E-02	5.4E-01	4.8E-04
Fluoranthene	707	1.7E-02	2.8E+00	3.9E-03	4.4E-02	4.6E+00	6.4E-03	8.7E-02	1.1E+01	1.6E-02	1.6E-01	2.0E+01	2.8E-02	9.1E-01	6.3E+01	8.9E-02	4.6E-01	2.4E+01	3.4E-02
Fluorene	538	1.0E-03	1.7E-01	3.1E-04	4.0E-03	4.2E-01	7.8E-04	7.1E-03	9.3E-01	1.7E-03	1.7E-02	2.2E+00	4.0E-03	1.4E-01	9.7E+00	1.8E-02	3.1E-02	1.6E+00	3.0E-03
Indeno (1,2,3-cd) pyrene	1,115	3.5E-03	5.7E-01	5.1E-04	8.2E-03	8.5E-01	7.7E-04	2.0E-02	2.6E+00	2.4E-03	3.4E-02	4.3E+00	3.9E-03	1.9E-01	1.3E+01	1.2E-02	1.3E-01	6.7E+00	6.0E-03
Naphthalene	385	6.8E-04	1.1E-01	2.8E-04	1.9E-03	1.9E-01	5.0E-04	5.0E-03	6.5E-01	1.7E-03	6.9E-03	8.6E-01	2.2E-03	3.6E-02	2.5E+00	6.4E-03	1.6E-02	8.2E-01	2.1E-03
Phenanthrene	596	8.1E-03	1.3E+00	2.2E-03	2.9E-02	3.0E+00	5.0E-03	3.7E-02	4.8E+00	8.1E-03	8.1E-02	1.0E+01	1.7E-02	2.8E-01	1.9E+01	3.3E-02	1.9E-01	9.9E+00	1.7E-02
Pyrene	697	8.4E-04	1.4E-01	1.9E-04	2.8E-02	2.9E+00	4.1E-03	7.8E-02	1.0E+01	1.5E-02	1.5E-01	1.8E+01	2.6E-02	3.2E-02	2.2E+00	3.2E-03	5.3E-01	2.7E+01	3.9E-02
Alkylated PAHs																			
1-Methylnaphthalene	446	8.0E-04	1.3E-01	2.9E-04	1.6E-03	1.6E-01	3.6E-04	4.0E-03	5.2E-01	1.2E-03	5.1E-03	6.4E-01	1.4E-03	3.6E-02	2.5E+00	5.7E-03	1.1E-02	5.8E-01	1.3E-03
2-Methylnaphthalene	447	7.2E-04	1.2E-01	2.6E-04	1.4E-03	1.4E-01	3.2E-04	4.1E-03	5.4E-01	1.2E-03	5.6E-03	7.0E-01	1.6E-03	3.2E-02	2.2E+00	5.0E-03	1.3E-02	6.9E-01	1.6E-03
C1-Anthracenes/ Phenanthrenes	670		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C1-Chrysenes	929		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C1-Fluoranthenes/ Pyrenes	770		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C1-Fluorenes	611		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C2-Anthracenes/ Phenanthrenes	746		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C2-Chrysenes	1,008		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C2-Fluorenes	686		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C2-Napthalenes	510		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C3-Anthracenes/ Phenanthrenes	829		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C3-Chrysenes	1,112		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C3-Fluorenes	769		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C3-Napthalenes	581		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C4-Anthracenes/ Phenanthrenes	913		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C4-Chrysenes	1,214		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C4-Napthalenes	657		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
		Σ17PAH mg/kg		**Σ17PAH TU**	**Σ17PAH mg/kg**		**Σ17PAH TU**	**Σ17PAH mg/kg**		**Σ17PAH TU**	**Σ17PAH mg/kg**		**Σ17PAH TU**	**Σ17PAH mg/kg**		**Σ17PAH TU**	**Σ17PAH mg/kg**		**Σ17PAH TU**
		0.07		**0.01**	**0.21**		**0.03**	**0.49**		**0.09**	**0.90**		**0.1**	**4.15**		**0.4**	**2.92**		**0.2**
		Σ34PAH mg/kg			**Σ34PAH mg/kg**			**Σ34PAH mg/kg**			**Σ34PAH mg/kg**			**Σ34PAH mg/kg**			**Σ34PAH mg/kg**		
		0.09		**0.02**	**0.29**		**0.04**	**0.66**		**0.11**	**1.20**		**0.2**	**5.55**		**0.5**	**3.90**		**0.3**
Σ17PAH mg/kg, TU=1(b,c)				**3.5**			**5.4**			**4.3**			**4.5**			**8.4**			**11.3**
Σ34PAH mg/kg, TU=1(b,d)				**4.7**			**7.2**			**5.8**			**6.0**			**11.2**			**15.1**

***TOCs are NOT representative of the overall TOC of the AOC**

Average Sum of 17 PAHs mg/kg TU=1 AOC Data	**9.6**
Average Sum of 17 PAHs mg/kg TU=1 All Data	**8.6**
Average Sum of 34 PAHs mg/kg TU=1 All Data	**11.5**

Average TC 1.53

Geomean T 1.46

(a) The conversion factor between the full 34 PAH list and the 17 PAH list is 1.36 with the full data set and 1.35 based on this data set that includes 1 and 2-methylnapthylene, as indicated in the excel worksheet provided in the workbook associated with this table.

(b) This data set reflects samples collected within the navigational channel with only approximately 15% of samples with ≥ 2% TOC, which is significantly different than the overall AOC data set with > 75% of samples having ≥ 2% TOC.

(c) The average protective Σ17PAH concentration is calculated by setting the TU34=1. Specifically, it is based on the average of (Σ17PAH dry weight sediment concentrations divided by the actual TU of 34PAHs) divided by (1000) to convert units of microgram to milligram.

(d) The average protective Σ34PAH concentration is calculated by setting the TU34=1. Specifically, it is based on the average of (Σ34PAH dry weight sediment concentrations divided by the TU of 34PAHs) divided by (1000) to convert units of microgram to milligram.

Table 5a: Sediment PAH Analysis Using USACE's 2007 Toxicity Testing Data (with TOC from the Study)

USACE 2007	BH-18	RM 0.4		BH-18			BH-22	Outside AOC		BH-23	Outside AOC	
Buffalo River Conversion Factor (a)		1.6 % Organic Carbon		ΣPAH TU = 1				0.9 % Organic Carbon			1.2 % Organic Carbon	
Compound	PAH Concentration (mg/kg)	PAH Concentration (µg/goc)	Toxic Units	Concentrations where ΣPAH TU = 1	PAH Concentration (µg/goc)	Toxic Units	PAH Concentration (mg/kg)	PAH Concentration (µg/goc)	Toxic Units	PAH Concentration (mg/kg)	PAH Concentration (µg/goc)	Toxic Units
Unsubstituted PAHs												
Acenaphthene	2.4E-02	1.5E+00	3.0E-03	9.6E-02	5.9E+00	1.2E-02	3.0E-02	3.2E+00	6.6E-03	2.0E-02	1.6E+00	3.4E-03
Acenaphthylene	2.3E-02	1.4E+00	3.2E-03	9.3E-02	5.7E+00	1.3E-02	1.0E-01	1.1E+01	2.4E-02	5.9E-02	4.8E+00	1.1E-02
Anthracene	6.7E-02	4.1E+00	7.0E-03	2.7E-01	1.6E+01	2.8E-02	1.6E-01	1.7E+01	2.8E-02	9.3E-02	7.5E+00	1.3E-02
Benzo (a) anthracene	2.5E-01	1.5E+01	1.8E-02	9.9E-01	6.1E+01	7.3E-02	5.0E-01	5.3E+01	6.4E-02	2.7E-01	2.2E+01	2.6E-02
Benzo (a) pyrene	2.0E-01	1.2E+01	1.3E-02	8.0E-01	4.9E+01	5.1E-02	4.5E-01	4.8E+01	4.9E-02	2.6E-01	2.1E+01	2.2E-02
Benzo (b) fluoranthene	2.7E-01	1.7E+01	1.7E-02	1.1E+00	6.5E+01	6.7E-02	5.8E-01	6.2E+01	6.4E-02	3.4E-01	2.7E+01	2.8E-02
Benzo (e) pyrene		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
Benzo (g,h,i) perylene	1.4E-01	8.6E+00	7.8E-03	5.5E-01	3.4E+01	3.1E-02	2.2E-01	2.3E+01	2.1E-02	5.8E-03	4.7E-01	4.3E-04
Benzo (k) fluoranthene	2.0E-01	1.2E+01	1.2E-02	7.8E-01	4.8E+01	4.9E-02	2.1E-01	2.3E+01	2.3E-02	1.2E-01	9.9E+00	1.0E-02
Chrysene	3.9E-01	2.4E+01	2.8E-02	1.5E+00	9.4E+01	1.1E-01	5.7E-01	6.1E+01	7.2E-02	3.6E-01	2.9E+01	3.4E-02
Dibenz (a,h) anthracene	2.6E-02	1.6E+00	1.4E-03	1.0E-01	6.3E+00	5.6E-03	5.9E-02	6.3E+00	5.6E-03	1.5E-02	1.2E+00	1.1E-03
Fluoranthene	5.2E-01	3.2E+01	4.5E-02	2.0E+00	1.3E+02	1.8E-01	6.4E-01	6.9E+01	9.7E-02	4.1E-01	3.3E+01	4.7E-02
Fluorene	4.2E-02	2.6E+00	4.8E-03	1.7E-01	1.0E+01	1.9E-02	7.4E-02	7.9E+00	1.5E-02	4.6E-02	3.7E+00	6.8E-03
Indeno (1,2,3-cd) pyrene	1.3E-01	8.0E+00	7.2E-03	5.1E-01	3.2E+01	2.8E-02	2.0E-01	2.1E+01	1.9E-02	1.5E-01	1.2E+01	1.1E-02
Naphthalene	3.8E-02	2.4E+00	6.2E-03	1.5E-01	9.4E+00	2.4E-02	2.4E-01	2.6E+01	6.8E-02	1.5E-01	1.2E+01	3.1E-02
Phenanthrene	2.4E-01	1.5E+01	2.5E-02	9.4E-01	5.8E+01	9.8E-02	2.9E-01	3.1E+01	5.1E-02	2.0E-01	1.6E+01	2.7E-02
Pyrene	5.6E-01	3.4E+01	4.9E-02	2.2E+00	1.4E+02	2.0E-01	7.2E-01	7.6E+01	1.1E-01	4.7E-01	3.8E+01	5.4E-02
Alkylated PAHs												
1-Methylnaphthalene	1.3E-02	8.2E-01	1.8E-03	5.3E-02	3.2E+00	7.3E-03	2.6E-02	2.8E+00	6.2E-03	1.8E-02	1.4E+00	3.2E-03
2-Methylnaphthalene	1.8E-02	1.1E+00	2.4E-03	7.0E-02	4.3E+00	9.6E-03	2.4E-02	2.5E+00	5.6E-03	3.1E-02	2.5E+00	5.5E-03
C1-Anthracenes/ Phenanthrenes		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C1-Chrysenes		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C1-Fluoranthenes/ Pyrenes		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C1-Fluorenes		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C2-Anthracenes/ Phenanthrenes		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C2-Chrysenes		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C2-Fluorenes		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C2-Napthalenes		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C3-Anthracenes/ Phenanthrenes		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C3-Chrysenes		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C3-Fluorenes		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C3-Napthalenes		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C4-Anthracenes/ Phenanthrenes		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C4-Chrysenes		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C4-Napthalenes		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
	Σ17PAH mg/kg		Σ17PAH TU			Σ17PAH TU	Σ17PAH mg/kg		Σ17PAH TU	Σ17PAH mg/kg		Σ17PAH TU
	3.13		0.3			1	5.08		0.7	3.01		0.3
	Σ34PAH mg/kg						Σ34PAH mg/kg		1	Σ34PAH mg/kg		
	4.19		0.3				6.80		0.97	4.02		0.4
Σ17PAH mg/kg, TU=1(b,c)			**9.3**						**5.2**			**6.8**
Σ34PAH mg/kg, TU=1(b,d)			**12.4**						**7.0**			**9.0**

USACE 2007	BH-24	Outside AOC		BH-25	Outside AOC		BH-26	Outside AOC	
Buffalo River Conversion Factor (a)		1.6 % Organic Carbon			1.3 % Organic Carbon			1.3 % Organic Carbon	
Compound	PAH Concentration (mg/kg)	PAH Concentration (µg/goc)	Toxic Units	PAH Concentration (mg/kg)	PAH Concentration (µg/goc)	Toxic Units	PAH Concentration (mg/kg)	PAH Concentration (µg/goc)	Toxic Units
Unsubstituted PAHs									
Acenaphthene	3.9E-02	2.5E+00	5.0E-03	2.1E-01	1.6E+01	3.3E-02	3.2E-02	2.4E+00	4.8E-03
Acenaphthylene	1.2E-01	7.4E+00	1.6E-02	4.7E-01	3.8E+01	8.3E-02	7.6E-02	5.7E+00	1.3E-02
Anthracene	1.9E-01	1.2E+01	2.0E-02	8.7E-01	7.0E+01	1.2E-01	1.5E-01	1.1E+01	1.9E-02
Benzo (a) anthracene	5.6E-01	3.5E+01	4.2E-02	2.3E+00	1.8E+02	2.1E-01	4.4E-01	3.3E+01	4.0E-02
Benzo (a) pyrene	4.9E-01	3.1E+01	3.2E-02	2.1E+00	1.7E+02	1.7E-01	3.5E-01	2.6E+01	2.7E-02
Benzo (b) fluoranthene	6.9E-01	4.3E+01	4.4E-02	2.6E+00	2.0E+02	2.1E-01	5.1E-01	3.8E+01	3.9E-02
Benzo (e) pyrene		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
Benzo (g,h,i) perylene	1.2E-02	7.5E-01	6.8E-04	1.0E+00	8.2E+01	7.5E-02	2.1E-01	1.5E+01	1.4E-02
Benzo (k) fluoranthene	2.0E-01	1.3E+01	1.3E-02	9.5E-01	7.6E+01	7.8E-02	1.5E-01	1.1E+01	1.2E-02
Chrysene	7.3E-01	4.6E+01	5.5E-02	2.7E+00	2.2E+02	2.6E-01	5.7E-01	4.3E+01	5.1E-02
Dibenz (a,h) anthracene	3.0E-02	1.9E+00	1.7E-03	2.6E-01	2.1E+01	1.8E-02	2.2E-02	1.7E+00	1.5E-03
Fluoranthene	7.5E-01	4.7E+01	6.6E-02	3.3E+00	2.6E+02	3.7E-01	6.0E-01	4.5E+01	6.4E-02
Fluorene	7.7E-02	4.9E+00	9.0E-03	5.2E-01	4.1E+01	7.7E-02	6.6E-02	4.9E+00	9.2E-03
Indeno (1,2,3-cd) pyrene	2.5E-01	1.6E+01	1.4E-02	9.6E-01	7.7E+01	6.9E-02	1.9E-01	1.5E+01	1.3E-02
Naphthalene	3.4E-01	2.1E+01	5.5E-02	1.2E+00	9.5E+01	2.5E-01	2.2E-01	1.6E+01	4.3E-02
Phenanthrene	3.8E-01	2.4E+01	4.0E-02	2.1E+00	1.7E+02	2.8E-01	3.1E-01	2.3E+01	3.9E-02
Pyrene	8.3E-01	5.2E+01	7.5E-02	3.5E+00	2.8E+02	4.0E-01	6.6E-01	4.9E+01	7.1E-02
Alkylated PAHs									
1-Methylnaphthalene	3.0E-02	1.9E+00	4.3E-03	1.3E-01	1.0E+01	2.3E-02	2.5E-02	1.8E+00	4.1E-03
2-Methylnaphthalene	6.3E-02	4.0E+00	8.9E-03	1.2E-01	9.9E+00	2.2E-02	4.7E-02	3.5E+00	7.9E-03
C1-Anthracenes/ Phenanthrenes		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C1-Chrysenes		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C1-Fluoranthenes/ Pyrenes		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C1-Fluorenes		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C2-Anthracenes/ Phenanthrenes		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C2-Chrysenes		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C2-Fluorenes		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C2-Napthalenes		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C3-Anthracenes/ Phenanthrenes		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C3-Chrysenes		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C3-Fluorenes		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C3-Napthalenes		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C4-Anthracenes/ Phenanthrenes		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C4-Chrysenes		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C4-Napthalenes		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
	Σ17PAH mg/kg		Σ17PAH TU	Σ17PAH mg/kg		Σ17PAH TU	Σ17PAH mg/kg		Σ17PAH TU
	5.77		0.5	25.15		3	4.63		0.5
	Σ34PAH mg/kg			Σ34PAH mg/kg			Σ34PAH mg/kg		
	7.73		0.7	33.64		4	6.19		0.6
Σ17PAH mg/kg, TU=1(b,c)			**8.6**			**6.8**			**7.3**
Σ34PAH mg/kg, TU=1(b,d)			**11.5**			**9.2**			**9.8**

***TOCs are NOT representative of th**

TU ≤ 1	Toxic units (i.e., hazard quotients) less than one indicates toxicity from PAHs unlikely
TU >1	Toxic unit (i.e., hazard quotients) greater than 1 indicates toxicity from PAH is predicted, but no toxicity was observed in this chronic study
	TOC<2%
	TOC >2%
CF	conversion factor

µg/gOC	microgram per gram of organic carbon
µg/kg	microgram per kilogram
PAH	polycyclic aromatic hydrocarbon
RM	river mile
TOC	total organic carbon
TPAH	total polycyclic aromatic hydrocarbon
TU	toxicity unit (i.e., hazard quotient); rounded to one significant figure
USACE	US Army Corps of Engineers

Table 5a: Sediment PAH Analysis Using USACE's 2007 Toxicity Testing Data (with TOC from the Study)

USACE 2007	BH-27	Outside AOC		BH-28	Outside AOC		BH-19	Outside AOC		BH-20	Outside AOC		BH-21	Outside AOC		BH-21			BH-13	SC		BH-14	SC	
Buffalo River Conversion Factor (a)	2.1	% Organic Carbon		2.0	% Organic Carbon		1.8	% Organic Carbon		1.6	% Organic Carbon		1.2	% Organic Carbon		ΣPAH TU = 1			1.8	% Organic Carbon		1.6	% Organic Carbon	
Compound	PAH Concentration (mg/kg)	PAH Concentration (µg/goc)	Toxic Units	PAH Concentration (mg/kg)	PAH Concentration (µg/goc)	Toxic Units	PAH Concentration (mg/kg)	PAH Concentration (µg/goc)	Toxic Units	PAH Concentration (mg/kg)	PAH Concentration (µg/goc)	Toxic Units	PAH Concentration (mg/kg)	PAH Concentration (µg/goc)	Toxic Units	Concentrations where ΣPAH TU = 1	PAH Concentration (µg/goc)	Toxic Units	PAH Concentration (mg/kg)	PAH Concentration (µg/goc)	Toxic Units	PAH Concentration (mg/kg)	PAH Concentration (µg/goc)	Toxic Units
Unsubstituted PAHs																								
Acenaphthene	2.8E-02	1.3E+00	2.7E-03	3.4E-02	1.7E+00	3.4E-03	1.4E-02	7.7E-01	1.6E-03	1.9E-02	1.2E+00	2.4E-03	8.4E-03	6.9E-01	1.4E-03	3.5E-02	2.9E+00	5.8E-03	9.5E-03	5.3E-01	1.1E-03	8.1E-03	4.9E-01	1.0E-03
Acenaphthylene	6.5E-02	3.1E+00	6.8E-03	6.5E-02	3.2E+00	7.1E-03	1.7E-02	9.5E-01	2.1E-03	2.9E-02	1.9E+00	4.1E-03	3.7E-02	3.0E+00	6.7E-03	1.5E-01	1.3E+01	2.8E-02	1.6E-02	9.2E-01	2.0E-03	1.2E-02	7.6E-01	1.7E-03
Anthracene	1.2E-01	5.7E+00	9.5E-03	1.4E-01	6.7E+00	1.1E-02	3.8E-02	2.1E+00	3.6E-03	6.5E-02	4.2E+00	7.0E-03	6.4E-02	5.3E+00	8.9E-03	2.6E-01	2.2E+01	3.7E-02	2.8E-02	1.6E+00	2.7E-03	2.8E-02	1.7E+00	2.9E-03
Benzo (a) anthracene	3.9E-01	1.8E+01	2.2E-02	3.8E-01	1.9E+01	2.2E-02	1.3E-01	7.2E+00	8.5E-03	2.5E-01	1.6E+01	1.9E-02	2.4E-01	2.0E+01	2.4E-02	1.0E+00	8.3E+01	9.9E-02	1.0E-01	5.6E+00	6.7E-03	1.3E-01	7.9E+00	9.4E-03
Benzo (a) pyrene	3.3E-01	1.6E+01	1.6E-02	3.0E-01	1.5E+01	1.5E-02	1.2E-01	6.5E+00	6.8E-03	2.4E-01	1.5E+01	1.6E-02	2.5E-01	2.1E+01	2.1E-02	1.0E+00	8.6E+01	8.9E-02	7.8E-02	4.4E+00	4.5E-03	1.1E-01	6.6E+00	6.9E-03
Benzo (b) fluoranthene	4.7E-01	2.2E+01	2.3E-02	4.3E-01	2.1E+01	2.1E-02	1.9E-01	1.1E+01	1.1E-02	4.1E-01	2.6E+01	2.7E-02	4.1E-01	3.4E+01	3.5E-02	1.7E+00	1.4E+02	1.5E-01	1.2E-01	6.5E+00	6.6E-03	1.8E-01	1.1E+01	1.1E-02
Benzo (e) pyrene		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
Benzo (g,h,i) perylene	2.1E-01	1.0E+01	9.2E-03	1.9E-01	9.2E+00	8.4E-03	8.1E-02	4.6E+00	4.2E-03	1.8E-01	1.2E+01	1.1E-02	1.7E-01	1.4E+01	1.3E-02	6.9E-01	5.7E+01	5.2E-02	4.2E-02	2.4E+00	2.2E-03	6.8E-02	4.2E+00	3.8E-03
Benzo (k) fluoranthene	1.3E-01	6.3E+00	6.4E-03	1.3E-01	6.5E+00	6.6E-03	6.9E-02	3.9E+00	4.0E-03	1.2E-01	7.6E+00	7.7E-03	1.4E-01	1.1E+01	1.1E-02	5.6E-01	4.6E+01	4.7E-02	4.7E-02	2.6E+00	2.7E-03	7.1E-02	4.3E+00	4.4E-03
Chrysene	4.9E-01	2.3E+01	2.8E-02	4.9E-01	2.4E+01	2.9E-02	2.1E-01	1.2E+01	1.4E-02	4.2E-01	2.7E+01	3.1E-02	1.2E-02	1.0E+00	1.2E-03	5.1E-02	4.2E+00	5.0E-03	1.2E-01	7.0E+00	8.3E-03	1.8E-01	1.1E+01	1.3E-02
Dibenz (a,h) anthracene	2.2E-02	1.0E+00	9.2E-04	1.8E-02	8.7E-01	7.8E-04	6.6E-03	3.7E-01	3.3E-04	1.4E-02	9.2E-01	8.2E-04	4.4E-02	3.6E+00	3.2E-03	1.8E-01	1.5E+01	1.3E-02	1.4E-02	7.8E-01	7.0E-04	3.1E-02	1.9E+00	1.7E-03
Fluoranthene	5.3E-01	2.5E+01	3.5E-02	5.8E-01	2.8E+01	4.0E-02	2.6E-01	1.5E+01	2.1E-02	4.8E-01	3.0E+01	4.3E-02	4.4E-01	3.7E+01	5.2E-02	1.8E+00	1.5E+02	2.1E-01	1.5E-01	8.3E+00	1.2E-02	2.5E-01	1.5E+01	2.1E-02
Fluorene	5.8E-02	2.8E+00	5.1E-03	6.8E-02	3.4E+00	6.3E-03	2.9E-02	1.7E+00	3.1E-03	3.7E-02	2.3E+00	4.3E-03	2.8E-02	2.3E+00	4.3E-03	1.2E-01	9.5E+00	1.8E-02	1.4E-02	7.6E-01	1.4E-03	1.2E-02	7.3E-01	1.4E-03
Indeno (1,2,3-cd) pyrene	2.0E-01	9.3E+00	8.4E-03	1.8E-01	8.6E+00	7.7E-03	7.3E-02	4.1E+00	3.7E-03	1.6E-01	1.0E+01	9.3E-03	1.5E-01	1.2E+01	1.1E-02	6.0E-01	5.0E+01	4.5E-02	4.3E-02	2.4E+00	2.2E-03	6.9E-02	4.2E+00	3.8E-03
Naphthalene	1.7E-01	8.1E+00	2.1E-02	2.2E-01	1.1E+01	2.8E-02	1.4E-02	7.7E-01	2.0E-03	3.9E-02	2.5E+00	6.5E-03	4.5E-02	3.7E+00	9.6E-03	1.9E-01	1.5E+01	4.0E-02	1.6E-02	8.8E-01	2.3E-03	8.0E-03	4.8E-01	1.3E-03
Phenanthrene	2.7E-01	1.3E+01	2.1E-02	3.3E-01	1.6E+01	2.7E-02	1.3E-01	7.6E+00	1.3E-02	1.9E-01	1.2E+01	2.0E-02	1.3E-01	1.1E+01	1.8E-02	5.4E-01	4.5E+01	7.5E-02	5.1E-02	2.8E+00	4.8E-03	8.7E-02	5.3E+00	8.9E-03
Pyrene	6.1E-01	2.9E+01	4.1E-02	6.5E-01	3.2E+01	4.6E-02	2.9E-01	1.7E+01	2.4E-02	5.7E-01	3.6E+01	5.2E-02	1.5E-01	1.3E+01	1.8E-02	6.4E-01	5.3E+01	7.6E-02	1.4E-01	8.0E+00	1.1E-02	2.2E-01	1.4E+01	2.0E-02
Alkylated PAHs																								
1-Methylnaphthalene	2.2E-02	1.1E+00	2.4E-03	2.3E-02	1.1E+00	2.5E-03	8.7E-03	4.9E-01	1.1E-03	1.2E-02	7.3E-01	1.6E-03	8.0E-03	6.6E-01	1.5E-03	3.3E-02	2.7E+00	6.1E-03	7.6E-03	4.3E-01	9.5E-04	4.5E-03	2.8E-01	6.2E-04
2-Methylnaphthalene	3.9E-02	1.9E+00	4.2E-03	4.3E-02	2.1E+00	4.7E-03	1.1E-02	6.0E-01	1.3E-03	1.7E-02	1.1E+00	2.4E-03	7.0E-03	5.8E-01	1.3E-03	2.9E-02	2.4E+00	5.4E-03	9.9E-03	5.6E-01	1.2E-03	5.4E-03	3.3E-01	7.4E-04
C1-Anthracenes/ Phenanthrenes		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C1-Chrysenes		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C1-Fluoranthenes/ Pyrenes		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C1-Fluorenes		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C2-Anthracenes/ Phenanthrenes		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C2-Chrysenes		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C2-Fluorenes		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C2-Napthalenes		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C3-Anthracenes/ Phenanthrenes		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C3-Chrysenes		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C3-Fluorenes		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C3-Napthalenes		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C4-Anthracenes/ Phenanthrenes		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C4-Chrysenes		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C4-Napthalenes		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
	Σ17PAH mg/kg		**Σ17PAH TU**	**Σ17PAH mg/kg**		**Σ17PAH TU**	**Σ17PAH mg/kg**		**Σ17PAH TU**	**Σ17PAH mg/kg**		**Σ17PAH TU**	**Σ17PAH mg/kg**		**Σ17PAH TU**			**Σ17PAH TU**	**Σ17PAH mg/kg**		**Σ17PAH TU**	**Σ17PAH mg/kg**		**Σ17PAH TU**
	4.14		**0.3**	**4.24**		**0.3**	**1.68**		**0.1**	**3.25**		**0.3**	**2.33**		**0.2**			**1**	**1.00**		**0.07**	**1.47**		**0.1**
	Σ34PAH mg/kg		**0.4**	**Σ34PAH mg/kg**			**Σ34PAH mg/kg**			**Σ34PAH mg/kg**			**Σ34PAH mg/kg**						**Σ34PAH mg/kg**			**Σ34PAH mg/kg**		
	5.53		**0.35**	**5.67**		**0.4**	**2.25**		**0.2**	**4.35**		**0.4**	**3.12**		**0.3**				**1.34**		**0.1**	**1.96**		**0.2**
Σ17PAH mg/kg, TU=1(b,c)			**11.7**			**11.1**			**10.1**			**9.2**			**7.2**						**10.2**			**9.7**
Σ34PAH mg/kg, TU=1(b,d)			**15.7**			**14.8**			**13.5**			**12.3**			**9.7**						**13.7**			**13.0**
***TOCs are NOT representative of th**																								

Table 5a: Sediment PAH Analysis Using USACE's 2007 Toxicity Testing Data (with TOC from the Study)

USACE 2007	BH-15	SC		BH-10	RM 2.0		BH-11	RM 1.6		BH-11		
Buffalo River Conversion Factor (a)	1.7 % Organic Carbon			2.4 % Organic Carbon			1.2 % Organic Carbon			ΣPAH TU = 1		
Compound	PAH Concentration (mg/kg)	PAH Concentration (µg/goc)	Toxic Units	PAH Concentration (mg/kg)	PAH Concentration (µg/goc)	Toxic Units	PAH Concentration (mg/kg)	PAH Concentration (µg/goc)	Toxic Units	Concentrations where ΣPAH TU = 1	PAH Concentration (µg/goc)	Toxic Units
Unsubstituted PAHs												
Acenaphthene	2.9E-03	1.7E-01	3.5E-04	5.9E-03	2.5E-01	5.1E-04	1.3E-02	1.1E+00	2.3E-03	7.1E-02	6.1E+00	1.2E-02
Acenaphthylene	3.6E-03	2.1E-01	4.7E-04	7.2E-03	3.0E-01	6.7E-04	1.3E-02	1.1E+00	2.4E-03	7.1E-02	6.0E+00	1.3E-02
Anthracene	8.0E-03	4.7E-01	7.8E-04	1.9E-02	7.8E-01	1.3E-03	3.8E-02	3.2E+00	5.4E-03	2.1E-01	1.7E+01	2.9E-02
Benzo (a) anthracene	3.1E-02	1.8E+00	2.1E-03	8.1E-02	3.4E+00	4.0E-03	1.4E-01	1.2E+01	1.4E-02	7.7E-01	6.5E+01	7.8E-02
Benzo (a) pyrene	2.9E-02	1.7E+00	1.7E-03	7.6E-02	3.2E+00	3.3E-03	1.2E-01	9.9E+00	1.0E-02	6.4E-01	5.4E+01	5.6E-02
Benzo (b) fluoranthene	4.9E-02	2.8E+00	2.9E-03	1.1E-01	4.4E+00	4.5E-03	2.0E-01	1.7E+01	1.7E-02	1.1E+00	9.1E+01	9.3E-02
Benzo (e) pyrene		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Benzo (g,h,i) perylene	1.8E-02	1.1E+00	9.7E-04	4.3E-02	1.8E+00	1.7E-03	7.5E-02	6.3E+00	5.8E-03	4.1E-01	3.4E+01	3.1E-02
Benzo (k) fluoranthene	1.8E-02	1.1E+00	1.1E-03	4.8E-02	2.0E+00	2.1E-03	6.7E-02	5.7E+00	5.8E-03	3.6E-01	3.1E+01	3.1E-02
Chrysene	2.7E-02	1.6E+00	1.9E-03	1.1E-01	4.5E+00	5.3E-03	1.9E-01	1.6E+01	1.9E-02	1.0E+00	8.8E+01	1.0E-01
Dibenz (a,h) anthracene	4.0E-03	2.3E-01	2.1E-04	1.3E-02	5.7E-01	5.0E-04	3.3E-02	2.8E+00	2.5E-03	1.8E-01	1.5E+01	1.4E-02
Fluoranthene	6.5E-02	3.8E+00	5.3E-03	1.5E-01	6.2E+00	8.8E-03	2.8E-01	2.3E+01	3.3E-02	1.5E+00	1.3E+02	1.8E-01
Fluorene	6.3E-03	3.7E-01	6.8E-04	9.6E-03	4.0E-01	7.5E-04	2.0E-02	1.7E+00	3.1E-03	1.1E-01	9.2E+00	1.7E-02
Indeno (1,2,3-cd) pyrene	1.5E-02	8.5E-01	7.7E-04	3.9E-02	1.6E+00	1.5E-03	7.5E-02	6.4E+00	5.7E-03	4.1E-01	3.5E+01	3.1E-02
Naphthalene	2.9E-03	1.7E-01	4.4E-04	4.3E-03	1.8E-01	4.7E-04	1.1E-02	8.9E-01	2.3E-03	5.7E-02	4.9E+00	1.3E-02
Phenanthrene	3.1E-02	1.8E+00	3.1E-03	6.4E-02	2.7E+00	4.5E-03	1.4E-01	1.2E+01	2.0E-02	7.9E-01	6.7E+01	1.1E-01
Pyrene	5.9E-02	3.5E+00	5.0E-03	1.5E-01	6.2E+00	8.9E-03	2.6E-01	2.2E+01	3.2E-02	1.4E+00	1.2E+02	1.7E-01
Alkylated PAHs												
1-Methylnaphthalene	2.3E-03	1.3E-01	3.0E-04	2.8E-03	1.2E-01	2.6E-04	4.7E-03	4.0E-01	8.9E-04	2.6E-02	2.2E+00	4.9E-03
2-Methylnaphthalene	1.6E-03	9.2E-02	2.1E-04	3.1E-03	1.3E-01	3.0E-04	5.8E-03	4.9E-01	1.1E-03	3.2E-02	2.7E+00	6.0E-03
C1-Anthracenes/ Phenanthrenes		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
C1-Chrysenes		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
C1-Fluoranthenes/ Pyrenes		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
C1-Fluorenes		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
C2-Anthracenes/ Phenanthrenes		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
C2-Chrysenes		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
C2-Fluorenes		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
C2-Napthalenes		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
C3-Anthracenes/ Phenanthrenes		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
C3-Chrysenes		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
C3-Fluorenes		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
C3-Napthalenes		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
C4-Anthracenes/ Phenanthrenes		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
C4-Chrysenes		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
C4-Napthalenes		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Σ17PAH mg/kg		**Σ17PAH TU**	**Σ17PAH mg/kg**		**Σ17PAH TU**	**Σ17PAH mg/kg**		**Σ17PAH TU**			**Σ17PAH TU**
	0.37		**0.03**	**0.92**		**0.05**	**1.68**		**0.2**			**1**
	Σ34PAH mg/kg			**Σ34PAH mg/kg**			**Σ34PAH mg/kg**					
	0.50		**0.04**	**1.23**		**0.07**	**2.25**		**0.25**			
Σ17PAH mg/kg, TU=1(b,c)			**9.8**			**13.9**			**6.9**			
Σ34PAH mg/kg, TU=1(b,d)			**13.2**			**18.6**			**9.2**			

USACE 2007	BH-12	RM 1.0		BH-5	RM 4.2		BH-6	RM 3.8		BH-7	RM 3.5	
Buffalo River Conversion Factor (a)	1.4 % Organic Carbon			2.2 % Organic Carbon			1.9 % Organic Carbon			1.5 % Organic Carbon		
Compound	PAH Concentration (mg/kg)	PAH Concentration (µg/goc)	Toxic Units	PAH Concentration (mg/kg)	PAH Concentration (µg/goc)	Toxic Units	PAH Concentration (mg/kg)	PAH Concentration (µg/goc)	Toxic Units	PAH Concentration (mg/kg)	PAH Concentration (µg/goc)	Toxic Units
Unsubstituted PAHs												
Acenaphthene	3.5E-02	2.5E+00	5.0E-03	2.2E-02	1.0E+00	2.1E-03	1.0E-03	5.6E-02	1.1E-04	2.2E-03	1.5E-01	3.0E-04
Acenaphthylene	1.2E-02	8.5E-01	1.9E-03	2.0E-02	9.3E-01	2.1E-03	2.4E-03	1.3E-01	2.9E-04	3.6E-03	2.4E-01	5.3E-04
Anthracene	8.8E-02	6.1E+00	1.0E-02	5.3E-02	2.4E+00	4.1E-03	3.6E-03	1.9E-01	3.2E-04	6.3E-03	4.2E-01	7.0E-04
Benzo (a) anthracene	1.2E-01	8.5E+00	1.0E-02	2.1E-01	9.6E+00	1.1E-02	1.3E-02	6.7E-01	8.0E-04	3.0E-02	2.0E+00	2.4E-03
Benzo (a) pyrene	5.8E-02	4.0E+00	4.2E-03	1.8E-01	8.2E+00	8.5E-03	1.1E-02	5.7E-01	5.9E-04	2.9E-02	1.9E+00	2.0E-03
Benzo (b) fluoranthene	1.0E-01	7.2E+00	7.3E-03	2.8E-01	1.3E+01	1.3E-02	1.6E-02	8.8E-01	9.0E-04	4.7E-02	3.1E+00	3.2E-03
Benzo (e) pyrene		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
Benzo (g,h,i) perylene	2.8E-02	1.9E+00	1.8E-03	1.0E-01	4.7E+00	4.3E-03	6.0E-03	3.2E-01	3.0E-04	1.7E-02	1.1E+00	1.0E-03
Benzo (k) fluoranthene	2.8E-02	1.9E+00	2.0E-03	1.1E-01	5.0E+00	5.1E-03	5.9E-03	3.2E-01	3.2E-04	1.7E-02	1.2E+00	1.2E-03
Chrysene	2.2E-01	1.5E+01	1.8E-02	3.2E-01	1.5E+01	1.8E-02	5.5E-04	3.0E-02	3.5E-05	3.4E-02	2.2E+00	2.7E-03
Dibenz (a,h) anthracene	9.1E-03	6.3E-01	5.6E-04	2.9E-02	1.3E+00	1.2E-03	8.8E-04	4.7E-02	4.2E-05	3.8E-03	2.5E-01	2.2E-04
Fluoranthene	2.3E-01	1.6E+01	2.2E-02	4.1E-01	1.9E+01	2.7E-02	2.5E-02	1.3E+00	1.9E-03	6.4E-02	4.2E+00	6.0E-03
Fluorene	8.9E-02	6.2E+00	1.1E-02	3.6E-02	1.6E+00	3.1E-03	2.1E-03	1.2E-01	2.1E-04	4.4E-03	2.9E-01	5.4E-04
Indeno (1,2,3-cd) pyrene	2.4E-02	1.6E+00	1.5E-03	1.6E-02	7.3E-01	6.6E-04	5.0E-03	2.7E-01	2.4E-04	1.4E-02	9.3E-01	8.4E-04
Naphthalene	9.3E-03	6.4E-01	1.7E-03	5.9E-02	2.7E+00	7.1E-03	1.8E-03	9.5E-02	2.5E-04	2.0E-03	1.3E-01	3.4E-04
Phenanthrene	1.5E-01	1.0E+01	1.7E-02	2.0E-01	9.1E+00	1.5E-02	1.3E-02	7.1E-01	1.2E-03	2.7E-02	1.8E+00	3.0E-03
Pyrene	3.2E-01	2.2E+01	3.2E-02	4.1E-01	1.9E+01	2.7E-02	1.3E-02	7.1E-01	1.0E-03	6.4E-02	4.3E+00	6.1E-03
Alkylated PAHs												
1-Methylnaphthalene	1.2E-02	8.5E-01	1.9E-03	9.7E-03	4.5E-01	1.0E-03	1.2E-03	6.4E-02	1.4E-04	1.5E-03	9.7E-02	2.2E-04
2-Methylnaphthalene	1.2E-02	8.6E-01	1.9E-03	1.7E-02	7.6E-01	1.7E-03	9.7E-04	5.2E-02	1.2E-04	1.1E-03	7.2E-02	1.6E-04
C1-Anthracenes/ Phenanthrenes		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C1-Chrysenes		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C1-Fluoranthenes/ Pyrenes		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C1-Fluorenes		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C2-Anthracenes/ Phenanthrenes		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C2-Chrysenes		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C2-Fluorenes		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C2-Napthalenes		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C3-Anthracenes/ Phenanthrenes		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C3-Chrysenes		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C3-Fluorenes		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C3-Napthalenes		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C4-Anthracenes/ Phenanthrenes		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C4-Chrysenes		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C4-Napthalenes		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
	Σ17PAH mg/kg		**Σ17PAH TU**	**Σ17PAH mg/kg**		**Σ17PAH TU**	**Σ17PAH mg/kg**		**Σ17PAH TU**	**Σ17PAH mg/kg**		**Σ17PAH TU**
	1.54		**0.2**	**2.48**		**0.2**	**0.12**		**0.009**	**0.37**		**0.03**
	Σ34PAH mg/kg			**Σ34PAH mg/kg**			**Σ34PAH mg/kg**			**Σ34PAH mg/kg**		
	2.06		**0.2**	**3.32**		**0.2**	**0.16**		**0.01**	**0.49**		**0.04**
Σ17PAH mg/kg, TU=1(b,c)			**7.6**			**12.2**			**10.4**			**8.8**
Σ34PAH mg/kg, TU=1(b,d)			**10.2**			**16.4**			**13.9**			**11.8**

***TOCs are NOT representative of th**

Table 5a: Sediment PAH Analysis Using USACE's 2007 Toxicity Testing Data (with TOC from the Study)

USACE 2007	BH-8	RM 2.7		BH-9	RM 2.1		BH-1	RM 5.4		BH-2	RM 5.3		BH-3	RM 4.8		BH-4	RM 4.6	
Buffalo River Conversion Factor (a)	1.5 % Organic Carbon			1.7 % Organic Carbon			1.6 % Organic Carbon			1.8 % Organic Carbon			1.5 % Organic Carbon			2.2 % Organic Carbon		
Compound	PAH Concentration (mg/kg)	PAH Concentration (µg/goc)	Toxic Units	PAH Concentration (mg/kg)	PAH Concentration (µg/goc)	Toxic Units	PAH Concentration (mg/kg)	PAH Concentration (µg/goc)	Toxic Units	PAH Concentration (mg/kg)	PAH Concentration (µg/goc)	Toxic Units	PAH Concentration (mg/kg)	PAH Concentration (µg/goc)	Toxic Units	PAH Concentration (mg/kg)	PAH Concentration (µg/goc)	Toxic Units
Unsubstituted PAHs																		
Acenaphthene	3.9E-02	2.6E+00	5.2E-03	1.5E-03	8.8E-02	1.8E-04	9.4E-03	6.1E-01	1.2E-03	8.6E-02	4.7E+00	9.6E-03	3.5E-03	2.4E-01	4.8E-04	6.0E-03	2.8E-01	5.6E-04
Acenaphthylene	2.4E-01	1.6E+01	3.6E-02	2.8E-03	1.7E-01	3.7E-04	1.4E-02	9.1E-01	2.0E-03	1.2E-02	6.4E-01	1.4E-03	6.2E-03	4.2E-01	9.2E-04	4.8E-03	2.2E-01	4.9E-04
Anthracene	1.5E-01	9.7E+00	1.6E-02	4.9E-03	2.9E-01	4.9E-04	2.5E-02	1.6E+00	2.7E-03	1.7E-01	9.6E+00	1.6E-02	1.1E-02	7.3E-01	1.2E-03	1.2E-02	5.3E-01	8.8E-04
Benzo (a) anthracene	1.2E+00	8.1E+01	9.6E-02	2.2E-02	1.3E+00	1.6E-03	1.2E-01	7.9E+00	9.4E-03	1.1E-01	6.1E+00	7.3E-03	5.5E-02	3.7E+00	4.4E-03	2.3E-02	1.1E+00	1.3E-03
Benzo (a) pyrene	1.1E+00	7.5E+01	7.8E-02	1.4E-02	8.4E-01	8.7E-04	1.1E-01	7.4E+00	7.6E-03	8.5E-02	4.7E+00	4.9E-03	5.2E-02	3.5E+00	3.6E-03	2.1E-02	9.7E-01	1.0E-03
Benzo (b) fluoranthene	1.5E+00	9.7E+01	9.9E-02	2.5E-02	1.5E+00	1.5E-03	1.9E-01	1.2E+01	1.3E-02	1.2E-01	6.6E+00	6.7E-03	8.8E-02	5.9E+00	6.0E-03	3.3E-02	1.5E+00	1.5E-03
Benzo (e) pyrene		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
Benzo (g,h,i) perylene	5.6E-01	3.7E+01	3.4E-02	1.0E-02	6.1E-01	5.6E-04	8.5E-02	5.5E+00	5.0E-03	5.9E-02	3.3E+00	3.0E-03	4.1E-02	2.8E+00	2.5E-03	1.4E-02	6.3E-01	5.8E-04
Benzo (k) fluoranthene	4.7E-01	3.1E+01	3.2E-02	8.3E-03	5.0E-01	5.1E-04	6.5E-02	4.2E+00	4.3E-03	4.9E-02	2.7E+00	2.8E-03	3.3E-02	2.2E+00	2.3E-03	1.4E-02	6.6E-01	6.7E-04
Chrysene	1.3E+00	8.3E+01	9.9E-02	5.8E-04	3.5E-02	4.1E-05	2.0E-01	1.3E+01	1.5E-02	1.3E-02	7.0E-01	8.3E-04	8.4E-02	5.7E+00	6.7E-03	7.4E-03	3.4E-01	4.0E-04
Dibenz (a,h) anthracene	1.6E-01	1.1E+01	9.4E-03	2.5E-03	1.5E-01	1.3E-04	3.0E-02	1.9E+00	1.7E-03	2.0E-02	1.1E+00	1.0E-03	1.4E-02	9.5E-01	8.5E-04	3.5E-03	1.6E-01	1.4E-04
Fluoranthene	9.7E-01	6.4E+01	9.1E-02	3.5E-02	2.1E+00	2.9E-03	2.8E-01	1.8E+01	2.6E-02	2.2E-01	1.2E+01	1.7E-02	1.3E-01	8.6E+00	1.2E-02	5.2E-02	2.4E+00	3.3E-03
Fluorene	6.5E-02	4.3E+00	8.0E-03	3.5E-03	2.1E-01	3.9E-04	1.3E-02	8.3E-01	1.5E-03	1.0E-01	5.5E+00	1.0E-02	6.2E-03	4.2E-01	7.8E-04	7.5E-03	3.4E-01	6.3E-04
Indeno (1,2,3-cd) pyrene	5.5E-01	3.6E+01	3.2E-02	9.8E-03	5.9E-01	5.3E-04	7.8E-02	5.0E+00	4.5E-03	4.9E-02	2.7E+00	2.4E-03	3.7E-02	2.5E+00	2.2E-03	1.1E-02	4.8E-01	4.3E-04
Naphthalene	6.3E-02	4.2E+00	1.1E-02	1.9E-03	1.1E-01	2.9E-04	7.6E-03	4.9E-01	1.3E-03	9.7E-01	5.4E+01	1.4E-01	3.5E-03	2.4E-01	6.2E-04	5.2E-02	2.4E+00	6.1E-03
Phenanthrene	3.9E-01	2.6E+01	4.4E-02	1.5E-02	9.3E-01	1.6E-03	1.1E-01	7.0E+00	1.2E-02	2.1E-01	1.2E+01	2.0E-02	5.2E-02	3.5E+00	5.9E-03	3.0E-02	1.4E+00	2.3E-03
Pyrene	9.3E-01	6.2E+01	8.8E-02	1.3E-02	7.5E-01	1.1E-03	2.6E-01	1.6E+01	2.4E-02	7.2E-03	4.0E-01	5.7E-04	1.2E-01	8.1E+00	1.2E-02	4.2E-02	1.9E+00	2.7E-03
Alkylated PAHs																		
1-Methylnaphthalene	2.1E-02	1.4E+00	3.1E-03	1.0E-03	6.1E-02	1.4E-04	4.9E-03	3.1E-01	7.1E-04	6.3E-02	3.5E+00	7.8E-03	2.6E-03	1.7E-01	3.9E-04	4.7E-03	2.1E-01	4.8E-04
2-Methylnaphthalene	1.9E-02	1.3E+00	2.8E-03	1.2E-03	7.0E-02	1.6E-04	5.2E-03	3.3E-01	7.4E-04	5.8E-02	3.2E+00	7.1E-03	2.6E-03	1.8E-01	4.0E-04	4.9E-03	2.2E-01	5.0E-04
C1-Anthracenes/ Phenanthrenes		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C1-Chrysenes		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C1-Fluoranthenes/ Pyrenes		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C1-Fluorenes		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C2-Anthracenes/ Phenanthrenes		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C2-Chrysenes		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C2-Fluorenes		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C2-Napthalenes		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C3-Anthracenes/ Phenanthrenes		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C3-Chrysenes		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C3-Fluorenes		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C3-Napthalenes		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C4-Anthracenes/ Phenanthrenes		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C4-Chrysenes		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C4-Napthalenes		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
	Σ17PAH mg/kg		**Σ17PAH TU**	**Σ17PAH mg/kg**		**Σ17PAH TU**	**Σ17PAH mg/kg**		**Σ17PAH TU**	**Σ17PAH mg/kg**		**Σ17PAH TU**	**Σ17PAH mg/kg**		**Σ17PAH TU**	**Σ17PAH mg/kg**		**Σ17PAH TU**
	9.70		**0.8**	**0.17**		**0.01**	**1.61**		**0.1**	**2.41**		**0.3**	**0.74**		**0.06**	**0.34**		**0.02**
	Σ34PAH mg/kg			**Σ34PAH mg/kg**			**Σ34PAH mg/kg**			**Σ34PAH mg/kg**			**Σ34PAH mg/kg**			**Σ34PAH mg/kg**		
	12.97		**1**	**0.23**		**0.02**	**2.15**		**0.2**	**3.22**		**0.3**	**0.99**		**0.08**	**0.46**		**0.03**
Σ17PAH mg/kg, TU=1(b,c)			**9.3**			**9.6**			**9.1**			**7.0**			**8.7**			**10.6**
Σ34PAH mg/kg, TU=1(b,d)			**12.4**			**12.8**			**12.2**			**9.3**			**11.7**			**14.2**

***TOCs are NOT representative of th**

Table 5b: Sediment PAH Analysis Using USACE's 2007 Toxicity Testing Data and Average Buffalo River TOC

USACE 2007		BL-1	Outside AOC		BL-2	Outside AOC		BL-3	Outside AOC	
Buffalo River Conversion Factor (a)	1.34	2.6	% Organic Carbon		2.6	% Organic Carbon		2.6	% Organic Carbon	
Compound	Final Chronic Value (µg/goc)	PAH Concentration (mg/kg)	PAH Concentration (µg/goc)	Toxic Units	PAH Concentration (mg/kg)	PAH Concentration (µg/goc)	Toxic Units	PAH Concentration (mg/kg)	PAH Concentration (µg/goc)	Toxic Units
Unsubstituted PAHs										
Acenaphthene	491	3.0E-04	1.2E-02	2.4E-05	1.7E-03	6.5E-02	1.3E-04	3.4E-03	1.3E-01	2.7E-04
Acenaphthylene	452	9.9E-04	3.8E-02	8.4E-05	2.9E-03	1.1E-01	2.5E-04	9.2E-03	3.5E-01	7.8E-04
Anthracene	594	2.0E-03	7.7E-02	1.3E-04	6.0E-03	2.3E-01	3.9E-04	1.2E-02	4.5E-01	7.5E-04
Benzo (a) anthracene	841	7.8E-03	3.0E-01	3.5E-04	2.1E-02	8.0E-01	9.5E-04	3.8E-02	1.4E+00	1.7E-03
Benzo (a) pyrene	965	5.9E-03	2.3E-01	2.4E-04	1.6E-02	6.1E-01	6.3E-04	3.3E-02	1.3E+00	1.3E-03
Benzo (b) fluoranthene	979	8.2E-03	3.1E-01	3.2E-04	1.9E-02	7.2E-01	7.4E-04	5.1E-02	2.0E+00	2.0E-03
Benzo (e) pyrene	967		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
Benzo (g,h,i) perylene	1,095	4.2E-03	1.6E-01	1.5E-04	9.2E-03	3.5E-01	3.2E-04	2.4E-02	9.2E-01	8.4E-04
Benzo (k) fluoranthene	981	4.2E-03	1.6E-01	1.6E-04	1.1E-02	4.2E-01	4.3E-04	1.9E-02	7.5E-01	7.6E-04
Chrysene	844	4.5E-04	1.7E-02	2.0E-05	9.1E-03	3.5E-01	4.2E-04	5.5E-02	2.1E+00	2.5E-03
Dibenz (a,h) anthracene	1,123	7.2E-04	2.8E-02	2.5E-05	1.8E-03	7.0E-02	6.3E-05	5.6E-03	2.2E-01	1.9E-04
Fluoranthene	707	1.7E-02	6.5E-01	9.2E-04	4.4E-02	1.7E+00	2.4E-03	8.7E-02	3.4E+00	4.7E-03
Fluorene	538	1.0E-03	4.0E-02	7.4E-05	4.0E-03	1.5E-01	2.9E-04	7.1E-03	2.7E-01	5.1E-04
Indeno (1,2,3-cd) pyrene	1,115	3.5E-03	1.4E-01	1.2E-04	8.2E-03	3.2E-01	2.8E-04	2.0E-02	7.8E-01	7.0E-04
Naphthalene	385	6.8E-04	2.6E-02	6.7E-05	1.9E-03	7.2E-02	1.9E-04	5.0E-03	1.9E-01	5.0E-04
Phenanthrene	596	8.1E-03	3.1E-01	5.2E-04	2.9E-02	1.1E+00	1.8E-03	3.7E-02	1.4E+00	2.4E-03
Pyrene	697	8.4E-04	3.2E-02	4.6E-05	2.8E-02	1.1E+00	1.5E-03	7.8E-02	3.0E+00	4.3E-03
Alkylated PAHs										
1-Methylnaphthalene	446	8.0E-04	3.1E-02	6.9E-05	1.6E-03	6.0E-02	1.3E-04	4.0E-03	1.5E-01	3.4E-04
2-Methylnaphthalene	447	7.2E-04	2.8E-02	6.2E-05	1.4E-03	5.3E-02	1.2E-04	4.1E-03	1.6E-01	3.5E-04
C1-Anthracenes/ Phenanthrenes	670		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C1-Chrysenes	929		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C1-Fluoranthenes/ Pyrenes	770		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C1-Fluorenes	611		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C2-Anthracenes/ Phenanthrenes	746		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C2-Chrysenes	1,008		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C2-Fluorenes	686		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C2-Napthalenes	510		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C3-Anthracenes/ Phenanthrenes	829		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C3-Chrysenes	1,112		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C3-Fluorenes	769		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C3-Napthalenes	581		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C4-Anthracenes/ Phenanthrenes	913		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C4-Chrysenes	1,214		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C4-Napthalenes	657		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
		Σ17PAH mg/kg		**Σ17PAH TU**	**Σ17PAH mg/kg**		**Σ17PAH TU**	**Σ17PAH mg/kg**		**Σ17PAH TU**
		0.07		**0.003**	**0.21**		**0.01**	**0.49**		**0.02**
		Σ34PAH mg/kg			**Σ34PAH mg/kg**			**Σ34PAH mg/kg**		
		0.09		**0.005**	**0.29**		**0.01**	**0.66**		**0.03**
Σ17PAH mg/kg, TU=1(b,c)				**14.8**			**14.4**			**14.7**
Σ34PAH mg/kg, TU=1(b,d)				**19.8**			**19.3**			**19.7**
***Average TOCs for the AOC**										

USACE 2007		BL-4	Outside AOC		BH-16	RM 0.8		BH-17	RM 0.5	
Buffalo River Conversion Factor (a)	1.34	2.6	% Organic Carbon		2.6	% Organic Carbon		2.6	% Organic Carbon	
Compound	Final Chronic Value (µg/goc)	PAH Concentration (mg/kg)	PAH Concentration (µg/goc)	Toxic Units	PAH Concentration (mg/kg)	PAH Concentration (µg/goc)	Toxic Units	PAH Concentration (mg/kg)	PAH Concentration (µg/goc)	Toxic Units
Unsubstituted PAHs										
Acenaphthene	491	8.9E-03	3.4E-01	7.0E-04	3.8E-02	1.5E+00	3.0E-03	1.7E-02	6.5E-01	1.3E-03
Acenaphthylene	452	7.6E-03	2.9E-01	6.5E-04	5.2E-02	2.0E+00	4.4E-03	2.5E-02	9.7E-01	2.1E-03
Anthracene	594	2.3E-02	8.9E-01	1.5E-03	2.2E-01	8.6E+00	1.4E-02	5.0E-02	1.9E+00	3.2E-03
Benzo (a) anthracene	841	7.6E-02	2.9E+00	3.5E-03	5.0E-01	1.9E+01	2.3E-02	2.1E-01	7.9E+00	9.4E-03
Benzo (a) pyrene	965	6.3E-02	2.4E+00	2.5E-03	4.0E-01	1.5E+01	1.6E-02	2.0E-01	7.8E+00	8.1E-03
Benzo (b) fluoranthene	979	9.4E-02	3.6E+00	3.7E-03	6.6E-01	2.5E+01	2.6E-02	3.8E-01	1.5E+01	1.5E-02
Benzo (e) pyrene	967		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
Benzo (g,h,i) perylene	1,095	4.2E-02	1.6E+00	1.5E-03	2.5E-01	9.7E+00	8.9E-03	1.5E-01	5.7E+00	5.2E-03
Benzo (k) fluoranthene	981	3.8E-02	1.5E+00	1.5E-03	2.2E-01	8.3E+00	8.5E-03	1.0E-01	4.0E+00	4.0E-03
Chrysene	844	9.4E-02	3.6E+00	4.3E-03	5.7E-02	2.2E+00	2.6E-03	4.0E-01	1.5E+01	1.8E-02
Dibenz (a,h) anthracene	1,123	5.0E-03	1.9E-01	1.7E-04	9.1E-02	3.5E+00	3.1E-03	1.1E-02	4.0E-01	3.6E-04
Fluoranthene	707	1.6E-01	6.0E+00	8.4E-03	9.1E-01	3.5E+01	5.0E-02	4.6E-01	1.8E+01	2.5E-02
Fluorene	538	1.7E-02	6.6E-01	1.2E-03	1.4E-01	5.3E+00	9.9E-03	3.1E-02	1.2E+00	2.2E-03
Indeno (1,2,3-cd) pyrene	1,115	3.4E-02	1.3E+00	1.2E-03	1.9E-01	7.4E+00	6.7E-03	1.3E-01	5.0E+00	4.4E-03
Naphthalene	385	6.9E-03	2.6E-01	6.8E-04	3.6E-02	1.4E+00	3.6E-03	1.6E-02	6.1E-01	1.6E-03
Phenanthrene	596	8.1E-02	3.1E+00	5.2E-03	2.8E-01	1.1E+01	1.8E-02	1.9E-01	7.4E+00	1.2E-02
Pyrene	697	1.5E-01	5.6E+00	8.0E-03	3.2E-02	1.2E+00	1.8E-03	5.3E-01	2.0E+01	2.9E-02
Alkylated PAHs										
1-Methylnaphthalene	446	5.1E-03	2.0E-01	4.4E-04	3.6E-02	1.4E+00	3.1E-03	1.1E-02	4.3E-01	9.7E-04
2-Methylnaphthalene	447	5.6E-03	2.1E-01	4.8E-04	3.2E-02	1.2E+00	2.8E-03	1.3E-02	5.2E-01	1.2E-03
C1-Anthracenes/ Phenanthrenes	670		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C1-Chrysenes	929		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C1-Fluoranthenes/ Pyrenes	770		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C1-Fluorenes	611		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C2-Anthracenes/ Phenanthrenes	746		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C2-Chrysenes	1,008		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C2-Fluorenes	686		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C2-Napthalenes	510		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C3-Anthracenes/ Phenanthrenes	829		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C3-Chrysenes	1,112		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C3-Fluorenes	769		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C3-Napthalenes	581		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C4-Anthracenes/ Phenanthrenes	913		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C4-Chrysenes	1,214		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C4-Napthalenes	657		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
		Σ17PAH mg/kg		**Σ17PAH TU**	**Σ17PAH mg/kg**		**Σ17PAH TU**	**Σ17PAH mg/kg**		**Σ17PAH TU**
		0.90		**0.0**	**4.15**		**0.2**	**2.92**		**0.1**
		Σ34PAH mg/kg			**Σ34PAH mg/kg**			**Σ34PAH mg/kg**		
		1.20		**0.1**	**5.55**		**0.3**	**3.90**		**0.2**
Σ17PAH mg/kg, TU=1(b,c)				**14.8**			**15.1**			**15.2**
Σ34PAH mg/kg, TU=1(b,d)				**19.8**			**20.2**			**20.3**

Average Sum of 17 PAHs mg/kg TU=1 AOC Data	**14.6**
Average Sum of 17 PAHs mg/kg TU=1 All Data	**14.6**
Average Sum of 34 PAHs mg/kg TU=1 All Data	**19.5**

Average TOC 1.53

Geomean TOC 1.46

(a) The conversion factor between the full 34 PAH list and the 17 PAH list is 1.36 with the full data set and 1.34 based on this data set that includes 1 and 2-methylnapthylene as indicated in the excel worksheet provided in the workbook associated with this table.

(b) This data set reflects samples collected within the navigational channel with only approximately 2% of samples with ≥ 2% TOC, which is significantly different than the overall AOC data set with 77% of samples having ≥ 2% TOC (see associated TOC excel worksheet provided in the workbook).

(c) The average protective Σ17PAH concentration is calculated by setting the TU34=1. Specifically, it is based on the average of (Σ17PAH dry weight sediment concentrations divided by the actual TU of 34PAHs) divided by (1000) to convert units of microgram to milligram.

(d) The average protective Σ34PAH concentration is calculated by setting the TU34=1. Specifically, it is based on the average of (Σ34PAH dry weight sediment concentrations divided by the TU of 34PAHs) divided by (1000) to convert units of microgram to milligram.

Table 5b: Sediment PAH Analysis Using USACE's 2007 Toxicity Testing Data and Average Buffalo River TOC

USACE 2007		BH-18	RM 0.4		BH-22	Outside AOC		BH-23	Outside AOC		BH-24	Outside AOC		BH-25	Outside AOC		BH-26	Outside AOC	
Buffalo River Conversion Factor (a)	1.34	2.6 % Organic Carbon			2.6 % Organic Carbon			2.6 % Organic Carbon			2.6 % Organic Carbon			2.6 % Organic Carbon			2.6 % Organic Carbon		
Compound	Final Chronic Value (µg/goc)	PAH Concentration (mg/kg)	PAH Concentration (µg/goc)	Toxic Units	PAH Concentration (mg/kg)	PAH Concentration (µg/goc)	Toxic Units	PAH Concentration (mg/kg)	PAH Concentration (µg/goc)	Toxic Units	PAH Concentration (mg/kg)	PAH Concentration (µg/goc)	Toxic Units	PAH Concentration (mg/kg)	PAH Concentration (µg/goc)	Toxic Units	PAH Concentration (mg/kg)	PAH Concentration (µg/goc)	Toxic Units
Unsubstituted PAHs																			
Acenaphthene	491	2.4E-02	9.3E-01	1.9E-03	3.0E-02	1.2E+00	2.4E-03	2.0E-02	7.8E-01	1.6E-03	3.9E-02	1.5E+00	3.1E-03	2.1E-01	7.9E+00	1.6E-02	3.2E-02	1.2E+00	2.5E-03
Acenaphthylene	452	2.3E-02	9.0E-01	2.0E-03	1.0E-01	4.0E+00	8.8E-03	5.9E-02	2.3E+00	5.0E-03	1.2E-01	4.5E+00	1.0E-02	4.7E-01	1.8E+01	4.0E-02	7.6E-02	2.9E+00	6.4E-03
Anthracene	594	6.7E-02	2.6E+00	4.3E-03	1.6E-01	6.0E+00	1.0E-02	9.3E-02	3.6E+00	6.0E-03	1.9E-01	7.2E+00	1.2E-02	8.7E-01	3.4E+01	5.6E-02	1.5E-01	5.8E+00	9.7E-03
Benzo (a) anthracene	841	2.5E-01	9.6E+00	1.1E-02	5.0E-01	1.9E+01	2.3E-02	2.7E-01	1.0E+01	1.2E-02	5.6E-01	2.1E+01	2.6E-02	2.3E+00	8.7E+01	1.0E-01	4.4E-01	1.7E+01	2.0E-02
Benzo (a) pyrene	965	2.0E-01	7.8E+00	8.1E-03	4.5E-01	1.7E+01	1.8E-02	2.6E-01	1.0E+01	1.0E-02	4.9E-01	1.9E+01	2.0E-02	2.1E+00	8.0E+01	8.3E-02	3.5E-01	1.3E+01	1.4E-02
Benzo (b) fluoranthene	979	2.7E-01	1.0E+01	1.1E-02	5.8E-01	2.2E+01	2.3E-02	3.4E-01	1.3E+01	1.3E-02	6.9E-01	2.6E+01	2.7E-02	2.6E+00	9.8E+01	1.0E-01	5.1E-01	2.0E+01	2.0E-02
Benzo (e) pyrene	967		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
Benzo (g,h,i) perylene	1,095	1.4E-01	5.3E+00	4.9E-03	2.2E-01	8.3E+00	7.6E-03	5.8E-03	2.2E-01	2.1E-04	1.2E-02	4.6E-01	4.2E-04	1.0E+00	3.9E+01	3.6E-02	2.1E-01	7.9E+00	7.2E-03
Benzo (k) fluoranthene	981	2.0E-01	7.6E+00	7.7E-03	2.1E-01	8.2E+00	8.3E-03	1.2E-01	4.7E+00	4.8E-03	2.0E-01	7.7E+00	7.8E-03	9.5E-01	3.7E+01	3.7E-02	1.5E-01	5.8E+00	5.9E-03
Chrysene	844	3.9E-01	1.5E+01	1.8E-02	5.7E-01	2.2E+01	2.6E-02	3.6E-01	1.4E+01	1.6E-02	7.3E-01	2.8E+01	3.3E-02	2.7E+00	1.1E+02	1.2E-01	5.7E-01	2.2E+01	2.6E-02
Dibenz (a,h) anthracene	1,123	2.6E-02	9.9E-01	8.8E-04	5.9E-02	2.3E+00	2.0E-03	1.5E-02	5.9E-01	5.3E-04	3.0E-02	1.2E+00	1.0E-03	2.6E-01	9.9E+00	8.8E-03	2.2E-02	8.5E-01	7.5E-04
Fluoranthene	707	5.2E-01	2.0E+01	2.8E-02	6.4E-01	2.5E+01	3.5E-02	4.1E-01	1.6E+01	2.2E-02	7.5E-01	2.9E+01	4.1E-02	3.3E+00	1.3E+02	1.8E-01	6.0E-01	2.3E+01	3.3E-02
Fluorene	538	4.2E-02	1.6E+00	3.0E-03	7.4E-02	2.8E+00	5.3E-03	4.6E-02	1.8E+00	3.3E-03	7.7E-02	3.0E+00	5.5E-03	5.2E-01	2.0E+01	3.7E-02	6.6E-02	2.5E+00	4.7E-03
Indeno (1,2,3-cd) pyrene	1,115	1.3E-01	5.0E+00	4.5E-03	2.0E-01	7.5E+00	6.7E-03	1.5E-01	5.6E+00	5.0E-03	2.5E-01	9.8E+00	8.8E-03	9.6E-01	3.7E+01	3.3E-02	1.9E-01	7.5E+00	6.7E-03
Naphthalene	385	3.8E-02	1.5E+00	3.8E-03	2.4E-01	9.4E+00	2.4E-02	1.5E-01	5.7E+00	1.5E-02	3.4E-01	1.3E+01	3.4E-02	1.2E+00	4.6E+01	1.2E-01	2.2E-01	8.4E+00	2.2E-02
Phenanthrene	596	2.4E-01	9.2E+00	1.5E-02	2.9E-01	1.1E+01	1.9E-02	2.0E-01	7.6E+00	1.3E-02	3.8E-01	1.5E+01	2.5E-02	2.1E+00	8.0E+01	1.3E-01	3.1E-01	1.2E+01	2.0E-02
Pyrene	697	5.6E-01	2.1E+01	3.1E-02	7.2E-01	2.8E+01	4.0E-02	4.7E-01	1.8E+01	2.6E-02	8.3E-01	3.2E+01	4.6E-02	3.5E+00	1.3E+02	1.9E-01	6.6E-01	2.5E+01	3.6E-02
Alkylated PAHs																			
1-Methylnaphthalene	446	1.3E-02	5.1E-01	1.1E-03	2.6E-02	1.0E+00	2.2E-03	1.8E-02	6.8E-01	1.5E-03	3.0E-02	1.2E+00	2.6E-03	1.3E-01	5.0E+00	1.1E-02	2.5E-02	9.4E-01	2.1E-03
2-Methylnaphthalene	447	1.8E-02	6.8E-01	1.5E-03	2.4E-02	9.1E-01	2.0E-03	3.1E-02	1.2E+00	2.6E-03	6.3E-02	2.4E+00	5.4E-03	1.2E-01	4.8E+00	1.1E-02	4.7E-02	1.8E+00	4.1E-03
C1-Anthracenes/ Phenanthrenes	670		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C1-Chrysenes	929		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C1-Fluoranthenes/ Pyrenes	770		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C1-Fluorenes	611		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C2-Anthracenes/ Phenanthrenes	746		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C2-Chrysenes	1,008		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C2-Fluorenes	686		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C2-Napthalenes	510		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C3-Anthracenes/ Phenanthrenes	829		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C3-Chrysenes	1,112		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C3-Fluorenes	769		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C3-Napthalenes	581		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C4-Anthracenes/ Phenanthrenes	913		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C4-Chrysenes	1,214		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C4-Napthalenes	657		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
		Σ17PAH mg/kg		**Σ17PAH TU**	**Σ17PAH mg/kg**		**Σ17PAH TU**	**Σ17PAH mg/kg**		**Σ17PAH TU**	**Σ17PAH mg/kg**		**Σ17PAH TU**	**Σ17PAH mg/kg**		**Σ17PAH TU**	**Σ17PAH mg/kg**		**Σ17PAH TU**
		3.13		0.2	5.08		0.3	3.01		0.2	5.77		0.3	25.15		1	4.63		0.2
		Σ34PAH mg/kg			**Σ34PAH mg/kg**			**Σ34PAH mg/kg**			**Σ34PAH mg/kg**			**Σ34PAH mg/kg**			**Σ34PAH mg/kg**		
		4.19		0.2	6.80		0.4	4.02		0.2	7.73		0.4	33.64		2	6.19		0.3
Σ17PAH mg/kg, TU=1(b,c)				**14.9**			**14.5**			**14.2**			**14.1**			**14.2**			**14.3**
Σ34PAH mg/kg, TU=1(b,d)				**19.9**			**19.4**			**19.0**			**18.8**			**19.0**			**19.2**
***Average TOCs for the AOC**																			

TU ≤ 1	Toxic units (i.e., hazard quotients) less than one indicates toxicity from PAHs unlikely
TU >1	Toxic unit (i.e., hazard quotients) greater than 1 indicates toxicity from PAH is predicted, but no toxicity was observed in this chronic study
	TOC<2%
	TOC >2%

Table 5b: Sediment PAH Analysis Using USACE's 2007 Toxicity Testing Data and Average Buffalo River TOC

USACE 2007		**BH-27**	**Outside AOC**		**BH-28**	**Outside AOC**		**BH-19**	**Outside AOC**		**BH-20**	**Outside AOC**		**BH-21**	**Outside AOC**		**BH-13**	**SC**	
Buffalo River Conversion Factor (a)	1.34	2.6	% Organic Carbon		2.6	% Organic Carbon		2.6	% Organic Carbon		2.6	% Organic Carbon		2.6	% Organic Carbon		2.6	% Organic Carbon	
Compound	Final Chronic Value (µg/goc)	PAH Concentration (mg/kg)	PAH Concentration (µg/goc)	Toxic Units	PAH Concentration (mg/kg)	PAH Concentration (µg/goc)	Toxic Units	PAH Concentration (mg/kg)	PAH Concentration (µg/goc)	Toxic Units	PAH Concentration (mg/kg)	PAH Concentration (µg/goc)	Toxic Units	PAH Concentration (mg/kg)	PAH Concentration (µg/goc)	Toxic Units	PAH Concentration (mg/kg)	PAH Concentration (µg/goc)	Toxic Units
Unsubstituted PAHs																			
Acenaphthene	491	2.8E-02	1.1E+00	2.2E-03	3.4E-02	1.3E+00	2.7E-03	1.4E-02	5.2E-01	1.1E-03	1.9E-02	7.1E-01	1.4E-03	8.4E-03	3.2E-01	6.5E-04	9.5E-03	3.6E-01	7.4E-04
Acenaphthylene	452	6.5E-02	2.5E+00	5.5E-03	6.5E-02	2.5E+00	5.5E-03	1.7E-02	6.5E-01	1.4E-03	2.9E-02	1.1E+00	2.5E-03	3.7E-02	1.4E+00	3.1E-03	1.6E-02	6.3E-01	1.4E-03
Anthracene	594	1.2E-01	4.6E+00	7.7E-03	1.4E-01	5.3E+00	8.9E-03	3.8E-02	1.4E+00	2.4E-03	6.5E-02	2.5E+00	4.2E-03	6.4E-02	2.5E+00	4.1E-03	2.8E-02	1.1E+00	1.8E-03
Benzo (a) anthracene	841	3.9E-01	1.5E+01	1.8E-02	3.8E-01	1.4E+01	1.7E-02	1.3E-01	4.8E+00	5.8E-03	2.5E-01	9.5E+00	1.1E-02	2.4E-01	9.3E+00	1.1E-02	1.0E-01	3.8E+00	4.6E-03
Benzo (a) pyrene	965	3.3E-01	1.3E+01	1.3E-02	3.0E-01	1.2E+01	1.2E-02	1.2E-01	4.4E+00	4.6E-03	2.4E-01	9.3E+00	9.7E-03	2.5E-01	9.6E+00	1.0E-02	7.8E-02	3.0E+00	3.1E-03
Benzo (b) fluoranthene	979	4.7E-01	1.8E+01	1.8E-02	4.3E-01	1.6E+01	1.7E-02	1.9E-01	7.3E+00	7.5E-03	4.1E-01	1.6E+01	1.6E-02	4.1E-01	1.6E+01	1.6E-02	1.2E-01	4.4E+00	4.5E-03
Benzo (e) pyrene	967		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
Benzo (g,h,i) perylene	1,095	2.1E-01	8.2E+00	7.4E-03	1.9E-01	7.2E+00	6.5E-03	8.1E-02	3.1E+00	2.8E-03	1.8E-01	7.0E+00	6.4E-03	1.7E-01	6.4E+00	5.8E-03	4.2E-02	1.6E+00	1.5E-03
Benzo (k) fluoranthene	981	1.3E-01	5.1E+00	5.2E-03	1.3E-01	5.1E+00	5.2E-03	6.9E-02	2.7E+00	2.7E-03	1.2E-01	4.6E+00	4.7E-03	1.4E-01	5.2E+00	5.3E-03	4.7E-02	1.8E+00	1.8E-03
Chrysene	844	4.9E-01	1.9E+01	2.2E-02	4.9E-01	1.9E+01	2.2E-02	2.1E-01	7.9E+00	9.4E-03	4.2E-01	1.6E+01	1.9E-02	1.2E-02	4.8E-01	5.6E-04	1.2E-01	4.8E+00	5.7E-03
Dibenz (a,h) anthracene	1,123	2.2E-02	8.3E-01	7.4E-04	1.8E-02	6.8E-01	6.1E-04	6.6E-03	2.5E-01	2.3E-04	1.4E-02	5.5E-01	4.9E-04	4.4E-02	1.7E+00	1.5E-03	1.4E-02	5.3E-01	4.8E-04
Fluoranthene	707	5.3E-01	2.0E+01	2.9E-02	5.8E-01	2.2E+01	3.1E-02	2.6E-01	1.0E+01	1.4E-02	4.8E-01	1.8E+01	2.6E-02	4.4E-01	1.7E+01	2.4E-02	1.5E-01	5.7E+00	8.0E-03
Fluorene	538	5.8E-02	2.2E+00	4.1E-03	6.8E-02	2.6E+00	4.9E-03	2.9E-02	1.1E+00	2.1E-03	3.7E-02	1.4E+00	2.6E-03	2.8E-02	1.1E+00	2.0E-03	1.4E-02	5.2E-01	9.7E-04
Indeno (1,2,3-cd) pyrene	1,115	2.0E-01	7.5E+00	6.8E-03	1.8E-01	6.7E+00	6.0E-03	7.3E-02	2.8E+00	2.5E-03	1.6E-01	6.3E+00	5.6E-03	1.5E-01	5.6E+00	5.0E-03	4.3E-02	1.6E+00	1.5E-03
Naphthalene	385	1.7E-01	6.6E+00	1.7E-02	2.2E-01	8.3E+00	2.1E-02	1.4E-02	5.2E-01	1.4E-03	3.9E-02	1.5E+00	3.9E-03	4.5E-02	1.7E+00	4.5E-03	1.6E-02	6.0E-01	1.6E-03
Phenanthrene	596	2.7E-01	1.0E+01	1.7E-02	3.3E-01	1.3E+01	2.1E-02	1.3E-01	5.2E+00	8.6E-03	1.9E-01	7.3E+00	1.2E-02	1.3E-01	5.0E+00	8.4E-03	5.1E-02	1.9E+00	3.3E-03
Pyrene	697	6.1E-01	2.3E+01	3.3E-02	6.5E-01	2.5E+01	3.6E-02	2.9E-01	1.1E+01	1.6E-02	5.7E-01	2.2E+01	3.1E-02	1.5E-01	5.9E+00	8.5E-03	1.4E-01	5.5E+00	7.8E-03
Alkylated PAHs																			
1-Methylnaphthalene	446	2.2E-02	8.5E-01	1.9E-03	2.3E-02	8.7E-01	1.9E-03	8.7E-03	3.3E-01	7.5E-04	1.2E-02	4.4E-01	9.9E-04	8.0E-03	3.1E-01	6.9E-04	7.6E-03	2.9E-01	6.5E-04
2-Methylnaphthalene	447	3.9E-02	1.5E+00	3.4E-03	4.3E-02	1.7E+00	3.7E-03	1.1E-02	4.0E-01	9.0E-04	1.7E-02	6.4E-01	1.4E-03	7.0E-03	2.7E-01	6.0E-04	9.9E-03	3.8E-01	8.5E-04
C1-Anthracenes/ Phenanthrenes	670		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C1-Chrysenes	929		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C1-Fluoranthenes/ Pyrenes	770		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C1-Fluorenes	611		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C2-Anthracenes/ Phenanthrenes	746		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C2-Chrysenes	1,008		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C2-Fluorenes	686		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C2-Napthalenes	510		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C3-Anthracenes/ Phenanthrenes	829		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C3-Chrysenes	1,112		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C3-Fluorenes	769		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C3-Napthalenes	581		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C4-Anthracenes/ Phenanthrenes	913		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C4-Chrysenes	1,214		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C4-Napthalenes	657		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
		Σ17PAH mg/kg		**Σ17PAH TU**	**Σ17PAH mg/kg**		**Σ17PAH TU**	**Σ17PAH mg/kg**		**Σ17PAH TU**	**Σ17PAH mg/kg**		**Σ17PAH TU**	**Σ17PAH mg/kg**		**Σ17PAH TU**	**Σ17PAH mg/kg**		**Σ17PAH TU**
		4.14		**0.2**	**4.24**		**0.2**	**1.68**		**0.1**	**3.25**		**0.2**	**2.33**		**0.1**	**1.00**		**0.05**
		Σ34PAH mg/kg		**0.3**	**Σ34PAH mg/kg**			**Σ34PAH mg/kg**			**Σ34PAH mg/kg**			**Σ34PAH mg/kg**			**Σ34PAH mg/kg**		
		5.53		**0.28**	**5.67**		**0.3**	**2.25**		**0.1**	**4.35**		**0.2**	**3.12**		**0.1**	**1.34**		**0.1**
Σ17PAH mg/kg, TU=1(b,c)				**14.5**			**14.2**			**14.9**			**15.2**			**15.5**			**14.9**
Σ34PAH mg/kg, TU=1(b,d)				**19.4**			**18.9**			**19.9**			**20.3**			**20.8**			**20.0**
***Average TOCs for the AOC**																			

CF	conversion factor
µg/gOC	microgram per gram of organic carbon
µg/kg	microgram per kilogram
PAH	polycyclic aromatic hydrocarbon
RM	river mile
TOC	total organic carbon
TPAH	total polycyclic aromatic hydrocarbon
TU	toxicity unit (i.e., hazard quotient); rounded to one significant figure
USACE	US Army Corps of Engineers

Table 5b: Sediment PAH Analysis Using USACE's 2007 Toxicity Testing Data and Average Buffalo River TOC

USACE 2007		BH-14	SC		BH-15	SC		BH-10	RM 2.0		BH-11	RM 1.6		BH-12	RM 1.0		BH-5	RM 4.2	
Buffalo River Conversion Factor (a)	1.34	2.6 % Organic Carbon			2.6 % Organic Carbon			2.6 % Organic Carbon			2.6 % Organic Carbon			2.6 % Organic Carbon			2.6 % Organic Carbon		
Compound	Final Chronic Value (µg/goc)	PAH Concentration (mg/kg)	PAH Concentration (µg/goc)	Toxic Units	PAH Concentration (mg/kg)	PAH Concentration (µg/goc)	Toxic Units	PAH Concentration (mg/kg)	PAH Concentration (µg/goc)	Toxic Units	PAH Concentration (mg/kg)	PAH Concentration (µg/goc)	Toxic Units	PAH Concentration (mg/kg)	PAH Concentration (µg/goc)	Toxic Units	PAH Concentration (mg/kg)	PAH Concentration (µg/goc)	Toxic Units
Unsubstituted PAHs																			
Acenaphthene	491	8.1E-03	3.1E-01	6.3E-04	2.9E-03	1.1E-01	2.3E-04	5.9E-03	2.3E-01	4.6E-04	1.3E-02	5.0E-01	1.0E-03	3.5E-02	1.4E+00	2.8E-03	2.2E-02	8.5E-01	1.7E-03
Acenaphthylene	452	1.2E-02	4.8E-01	1.1E-03	3.6E-03	1.4E-01	3.1E-04	7.2E-03	2.8E-01	6.1E-04	1.3E-02	5.0E-01	1.1E-03	1.2E-02	4.7E-01	1.0E-03	2.0E-02	7.8E-01	1.7E-03
Anthracene	594	2.8E-02	1.1E+00	1.8E-03	8.0E-03	3.1E-01	5.2E-04	1.9E-02	7.2E-01	1.2E-03	3.8E-02	1.4E+00	2.4E-03	8.8E-02	3.4E+00	5.7E-03	5.3E-02	2.0E+00	3.4E-03
Benzo (a) anthracene	841	1.3E-01	5.0E+00	5.9E-03	3.1E-02	1.2E+00	1.4E-03	8.1E-02	3.1E+00	3.7E-03	1.4E-01	5.4E+00	6.4E-03	1.2E-01	4.7E+00	5.6E-03	2.1E-01	8.1E+00	9.6E-03
Benzo (a) pyrene	965	1.1E-01	4.2E+00	4.3E-03	2.9E-02	1.1E+00	1.1E-03	7.6E-02	2.9E+00	3.0E-03	1.2E-01	4.5E+00	4.7E-03	5.8E-02	2.2E+00	2.3E-03	1.8E-01	6.9E+00	7.1E-03
Benzo (b) fluoranthene	979	1.8E-01	6.8E+00	7.0E-03	4.9E-02	1.9E+00	1.9E-03	1.1E-01	4.0E+00	4.1E-03	2.0E-01	7.5E+00	7.7E-03	1.0E-01	4.0E+00	4.0E-03	2.8E-01	1.1E+01	1.1E-02
Benzo (e) pyrene	967		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
Benzo (g,h,i) perylene	1,095	6.8E-02	2.6E+00	2.4E-03	1.8E-02	7.0E-01	6.4E-04	4.3E-02	1.7E+00	1.5E-03	7.5E-02	2.9E+00	2.6E-03	2.8E-02	1.1E+00	9.7E-04	1.0E-01	4.0E+00	3.6E-03
Benzo (k) fluoranthene	981	7.1E-02	2.7E+00	2.8E-03	1.8E-02	7.0E-01	7.1E-04	4.8E-02	1.9E+00	1.9E-03	6.7E-02	2.6E+00	2.6E-03	2.8E-02	1.1E+00	1.1E-03	1.1E-01	4.2E+00	4.3E-03
Chrysene	844	1.8E-01	6.7E+00	8.0E-03	2.7E-02	1.0E+00	1.2E-03	1.1E-01	4.1E+00	4.8E-03	1.9E-01	7.3E+00	8.7E-03	2.2E-01	8.4E+00	9.9E-03	3.2E-01	1.2E+01	1.5E-02
Dibenz (a,h) anthracene	1,123	3.1E-02	1.2E+00	1.1E-03	4.0E-03	1.5E-01	1.4E-04	1.3E-02	5.2E-01	4.6E-04	3.3E-02	1.3E+00	1.1E-03	9.1E-03	3.5E-01	3.1E-04	2.9E-02	1.1E+00	1.0E-03
Fluoranthene	707	2.5E-01	9.5E+00	1.3E-02	6.5E-02	2.5E+00	3.5E-03	1.5E-01	5.7E+00	8.0E-03	2.8E-01	1.1E+01	1.5E-02	2.3E-01	8.7E+00	1.2E-02	4.1E-01	1.6E+01	2.2E-02
Fluorene	538	1.2E-02	4.6E-01	8.6E-04	6.3E-03	2.4E-01	4.5E-04	9.6E-03	3.7E-01	6.9E-04	2.0E-02	7.6E-01	1.4E-03	8.9E-02	3.4E+00	6.3E-03	3.6E-02	1.4E+00	2.6E-03
Indeno (1,2,3-cd) pyrene	1,115	6.9E-02	2.6E+00	2.4E-03	1.5E-02	5.6E-01	5.0E-04	3.9E-02	1.5E+00	1.3E-03	7.5E-02	2.9E+00	2.6E-03	2.4E-02	9.0E-01	8.1E-04	1.6E-02	6.2E-01	5.5E-04
Naphthalene	385	8.0E-03	3.1E-01	7.9E-04	2.9E-03	1.1E-01	2.9E-04	4.3E-03	1.7E-01	4.3E-04	1.1E-02	4.0E-01	1.0E-03	9.3E-03	3.6E-01	9.3E-04	5.9E-02	2.3E+00	5.9E-03
Phenanthrene	596	8.7E-02	3.3E+00	5.6E-03	3.1E-02	1.2E+00	2.0E-03	6.4E-02	2.5E+00	4.1E-03	1.4E-01	5.5E+00	9.3E-03	1.5E-01	5.7E+00	9.6E-03	2.0E-01	7.6E+00	1.3E-02
Pyrene	697	2.2E-01	8.6E+00	1.2E-02	5.9E-02	2.3E+00	3.3E-03	1.5E-01	5.7E+00	8.1E-03	2.6E-01	1.0E+01	1.4E-02	3.2E-01	1.2E+01	1.8E-02	4.1E-01	1.6E+01	2.2E-02
Alkylated PAHs																			
1-Methylnaphthalene	446	4.5E-03	1.7E-01	3.9E-04	2.3E-03	8.7E-02	1.9E-04	2.8E-03	1.1E-01	2.4E-04	4.7E-03	1.8E-01	4.0E-04	1.2E-02	4.7E-01	1.1E-03	9.7E-03	3.7E-01	8.4E-04
2-Methylnaphthalene	447	5.4E-03	2.1E-01	4.6E-04	1.6E-03	6.1E-02	1.4E-04	3.1E-03	1.2E-01	2.7E-04	5.8E-03	2.2E-01	5.0E-04	1.2E-02	4.8E-01	1.1E-03	1.7E-02	6.3E-01	1.4E-03
C1-Anthracenes/ Phenanthrenes	670		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C1-Chrysenes	929		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C1-Fluoranthenes/ Pyrenes	770		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C1-Fluorenes	611		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C2-Anthracenes/ Phenanthrenes	746		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C2-Chrysenes	1,008		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C2-Fluorenes	686		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C2-Napthalenes	510		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C3-Anthracenes/ Phenanthrenes	829		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C3-Chrysenes	1,112		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C3-Fluorenes	769		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C3-Napthalenes	581		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C4-Anthracenes/ Phenanthrenes	913		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C4-Chrysenes	1,214		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C4-Napthalenes	657		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
		Σ17PAH mg/kg		Σ17PAH TU	Σ17PAH mg/kg		Σ17PAH TU	Σ17PAH mg/kg		Σ17PAH TU	Σ17PAH mg/kg		Σ17PAH TU	Σ17PAH mg/kg		Σ17PAH TU	Σ17PAH mg/kg		Σ17PAH TU
		1.47		0.1	0.37		0.02	0.92		0.05	1.68		0.1	1.54		0.1	2.48		0.1
		Σ34PAH mg/kg			Σ34PAH mg/kg			Σ34PAH mg/kg			Σ34PAH mg/kg			Σ34PAH mg/kg			Σ34PAH mg/kg		
		1.96		0.1	0.50		0.02	1.23		0.06	2.25		0.11	2.06		0.1	3.32		0.2
Σ17PAH mg/kg, TU=1(b,c)				**15.4**			**15.0**			**15.3**			**15.1**			**13.8**			**14.6**
Σ34PAH mg/kg, TU=1(b,d)				**20.6**			**20.0**			**20.4**			**20.2**			**18.5**			**19.5**

***Average TOCs for the AOC**

Table 5b: Sediment PAH Analysis Using USACE's 2007 Toxicity Testing Data and Average Buffalo River TOC

USACE 2007		BH-6	RM 3.8		BH-7	RM 3.5		BH-8	RM 2.7		BH-9	RM 2.1		BH-1	RM 5.4		BH-2	RM 5.3	
Buffalo River Conversion Factor (a)	1.34	2.6 % Organic Carbon			2.6 % Organic Carbon			2.6 % Organic Carbon			2.6 % Organic Carbon			2.6 % Organic Carbon			2.6 % Organic Carbon		
Compound	Final Chronic Value (µg/goc)	PAH Concentration (mg/kg)	PAH Concentration (µg/goc)	Toxic Units	PAH Concentration (mg/kg)	PAH Concentration (µg/goc)	Toxic Units	PAH Concentration (mg/kg)	PAH Concentration (µg/goc)	Toxic Units	PAH Concentration (mg/kg)	PAH Concentration (µg/goc)	Toxic Units	PAH Concentration (mg/kg)	PAH Concentration (µg/goc)	Toxic Units	PAH Concentration (mg/kg)	PAH Concentration (µg/goc)	Toxic Units
Unsubstituted PAHs																			
Acenaphthene	491	1.0E-03	4.0E-02	8.1E-05	2.2E-03	8.6E-02	1.7E-04	3.9E-02	1.5E+00	3.0E-03	1.5E-03	5.6E-02	1.1E-04	9.4E-03	3.6E-01	7.4E-04	8.6E-02	3.3E+00	6.7E-03
Acenaphthylene	452	2.4E-03	9.4E-02	2.1E-04	3.6E-03	1.4E-01	3.1E-04	2.4E-01	9.4E+00	2.1E-02	2.8E-03	1.1E-01	2.4E-04	1.4E-02	5.4E-01	1.2E-03	1.2E-02	4.5E-01	9.9E-04
Anthracene	594	3.6E-03	1.4E-01	2.3E-04	6.3E-03	2.4E-01	4.1E-04	1.5E-01	5.6E+00	9.5E-03	4.9E-03	1.9E-01	3.2E-04	2.5E-02	9.5E-01	1.6E-03	1.7E-01	6.7E+00	1.1E-02
Benzo (a) anthracene	841	1.3E-02	4.8E-01	5.7E-04	3.0E-02	1.2E+00	1.4E-03	1.2E+00	4.7E+01	5.6E-02	2.2E-02	8.4E-01	1.0E-03	1.2E-01	4.7E+00	5.6E-03	1.1E-01	4.3E+00	5.1E-03
Benzo (a) pyrene	965	1.1E-02	4.1E-01	4.2E-04	2.9E-02	1.1E+00	1.1E-03	1.1E+00	4.3E+01	4.5E-02	1.4E-02	5.3E-01	5.5E-04	1.1E-01	4.4E+00	4.5E-03	8.5E-02	3.3E+00	3.4E-03
Benzo (b) fluoranthene	979	1.6E-02	6.3E-01	6.4E-04	4.7E-02	1.8E+00	1.8E-03	1.5E+00	5.6E+01	5.7E-02	2.5E-02	9.7E-01	9.9E-04	1.9E-01	7.3E+00	7.5E-03	1.2E-01	4.6E+00	4.7E-03
Benzo (e) pyrene	967		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
Benzo (g,h,i) perylene	1,095	6.0E-03	2.3E-01	2.1E-04	1.7E-02	6.6E-01	6.0E-04	5.6E-01	2.2E+01	2.0E-02	1.0E-02	3.9E-01	3.6E-04	8.5E-02	3.3E+00	3.0E-03	5.9E-02	2.3E+00	2.1E-03
Benzo (k) fluoranthene	981	5.9E-03	2.3E-01	2.3E-04	1.7E-02	6.7E-01	6.8E-04	4.7E-01	1.8E+01	1.9E-02	8.3E-03	3.2E-01	3.3E-04	6.5E-02	2.5E+00	2.5E-03	4.9E-02	1.9E+00	1.9E-03
Chrysene	844	5.5E-04	2.1E-02	2.5E-05	3.4E-02	1.3E+00	1.5E-03	1.3E+00	4.8E+01	5.7E-02	5.8E-04	2.2E-02	2.6E-05	2.0E-01	7.6E+00	9.0E-03	1.3E-02	4.9E-01	5.8E-04
Dibenz (a,h) anthracene	1,123	8.8E-04	3.4E-02	3.0E-05	3.8E-03	1.4E-01	1.3E-04	1.6E-01	6.1E+00	5.4E-03	2.5E-03	9.6E-02	8.5E-05	3.0E-02	1.1E+00	1.0E-03	2.0E-02	7.8E-01	7.0E-04
Fluoranthene	707	2.5E-02	9.5E-01	1.3E-03	6.4E-02	2.5E+00	3.5E-03	9.7E-01	3.7E+01	5.3E-02	3.5E-02	1.3E+00	1.9E-03	2.8E-01	1.1E+01	1.5E-02	2.2E-01	8.3E+00	1.2E-02
Fluorene	538	2.1E-03	8.2E-02	1.5E-04	4.4E-03	1.7E-01	3.1E-04	6.5E-02	2.5E+00	4.6E-03	3.5E-03	1.3E-01	2.5E-04	1.3E-02	5.0E-01	9.2E-04	1.0E-01	3.8E+00	7.1E-03
Indeno (1,2,3-cd) pyrene	1,115	5.0E-03	1.9E-01	1.7E-04	1.4E-02	5.4E-01	4.9E-04	5.5E-01	2.1E+01	1.9E-02	9.8E-03	3.8E-01	3.4E-04	7.8E-02	3.0E+00	2.7E-03	4.9E-02	1.9E+00	1.7E-03
Naphthalene	385	1.8E-03	6.8E-02	1.8E-04	2.0E-03	7.5E-02	2.0E-04	6.3E-02	2.4E+00	6.3E-03	1.9E-03	7.2E-02	1.9E-04	7.6E-03	2.9E-01	7.6E-04	9.7E-01	3.7E+01	9.7E-02
Phenanthrene	596	1.3E-02	5.1E-01	8.5E-04	2.7E-02	1.0E+00	1.7E-03	3.9E-01	1.5E+01	2.5E-02	1.5E-02	5.9E-01	9.9E-04	1.1E-01	4.2E+00	7.0E-03	2.1E-01	8.2E+00	1.4E-02
Pyrene	697	1.3E-02	5.1E-01	7.3E-04	6.4E-02	2.5E+00	3.5E-03	9.3E-01	3.6E+01	5.1E-02	1.3E-02	4.8E-01	6.9E-04	2.6E-01	9.8E+00	1.4E-02	7.2E-03	2.8E-01	4.0E-04
Alkylated PAHs																			
1-Methylnaphthalene	446	1.2E-03	4.6E-02	1.0E-04	1.5E-03	5.7E-02	1.3E-04	2.1E-02	7.9E-01	1.8E-03	1.0E-03	3.9E-02	8.7E-05	4.9E-03	1.9E-01	4.2E-04	6.3E-02	2.4E+00	5.4E-03
2-Methylnaphthalene	447	9.7E-04	3.7E-02	8.3E-05	1.1E-03	4.2E-02	9.4E-05	1.9E-02	7.4E-01	1.7E-03	1.2E-03	4.5E-02	1.0E-04	5.2E-03	2.0E-01	4.4E-04	5.8E-02	2.2E+00	5.0E-03
C1-Anthracenes/ Phenanthrenes	670		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C1-Chrysenes	929		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C1-Fluoranthenes/ Pyrenes	770		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C1-Fluorenes	611		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C2-Anthracenes/ Phenanthrenes	746		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C2-Chrysenes	1,008		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C2-Fluorenes	686		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C2-Napthalenes	510		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C3-Anthracenes/ Phenanthrenes	829		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C3-Chrysenes	1,112		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C3-Fluorenes	769		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C3-Napthalenes	581		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C4-Anthracenes/ Phenanthrenes	913		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C4-Chrysenes	1,214		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C4-Napthalenes	657		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00		0.0E+00	0.0E+00
		Σ17PAH mg/kg		**Σ17PAH TU**	**Σ17PAH mg/kg**		**Σ17PAH TU**	**Σ17PAH mg/kg**		**Σ17PAH TU**	**Σ17PAH mg/kg**		**Σ17PAH TU**	**Σ17PAH mg/kg**		**Σ17PAH TU**	**Σ17PAH mg/kg**		**Σ17PAH TU**
		0.12		**0.006**	**0.37**		**0.02**	**9.70**		**0.5**	**0.17**		**0.01**	**1.61**		**0.1**	**2.41**		**0.2**
		Σ34PAH mg/kg			**Σ34PAH mg/kg**			**Σ34PAH mg/kg**			**Σ34PAH mg/kg**			**Σ34PAH mg/kg**			**Σ34PAH mg/kg**		
		0.16		**0.01**	**0.49**		**0.02**	**12.97**		**0.6**	**0.23**		**0.01**	**2.15**		**0.1**	**3.22**		**0.2**
Σ17PAH mg/kg, TU=1(b,c)				**14.6**			**15.1**			**15.9**			**15.0**			**15.3**			**10.0**
Σ34PAH mg/kg, TU=1(b,d)				**19.5**			**20.2**			**21.3**			**20.1**			**20.5**			**13.4**
***Average TOCs for the AOC**																			

Table 5b: Sediment PAH Analysis Using USACE's 2007 Toxicity Testing Data and Average Buffalo River TOC

USACE 2007		**BH-3**	**RM 4.8**		**BH-4**	**RM 4.6**	
Buffalo River Conversion Factor (a)	1.34	2.6	% Organic Carbon		2.6	% Organic Carbon	
Compound	Final Chronic Value (µg/goc)	PAH Concentration (mg/kg)	PAH Concentration (µg/goc)	Toxic Units	PAH Concentration (mg/kg)	PAH Concentration (µg/goc)	Toxic Units
Unsubstituted PAHs							
Acenaphthene	491	3.5E-03	1.3E-01	2.7E-04	6.0E-03	2.3E-01	4.7E-04
Acenaphthylene	452	6.2E-03	2.4E-01	5.3E-04	4.8E-03	1.9E-01	4.1E-04
Anthracene	594	1.1E-02	4.2E-01	7.0E-04	1.2E-02	4.4E-01	7.4E-04
Benzo (a) anthracene	841	5.5E-02	2.1E+00	2.5E-03	2.3E-02	8.9E-01	1.1E-03
Benzo (a) pyrene	965	5.2E-02	2.0E+00	2.1E-03	2.1E-02	8.2E-01	8.4E-04
Benzo (b) fluoranthene	979	8.8E-02	3.4E+00	3.4E-03	3.3E-02	1.3E+00	1.3E-03
Benzo (e) pyrene	967		0.0E+00	0.0E+00		0.0E+00	0.0E+00
Benzo (g,h,i) perylene	1,095	4.1E-02	1.6E+00	1.4E-03	1.4E-02	5.3E-01	4.8E-04
Benzo (k) fluoranthene	981	3.3E-02	1.3E+00	1.3E-03	1.4E-02	5.5E-01	5.6E-04
Chrysene	844	8.4E-02	3.2E+00	3.8E-03	7.4E-03	2.8E-01	3.4E-04
Dibenz (a,h) anthracene	1,123	1.4E-02	5.4E-01	4.8E-04	3.5E-03	1.3E-01	1.2E-04
Fluoranthene	707	1.3E-01	4.9E+00	7.0E-03	5.2E-02	2.0E+00	2.8E-03
Fluorene	538	6.2E-03	2.4E-01	4.4E-04	7.5E-03	2.9E-01	5.3E-04
Indeno (1,2,3-cd) pyrene	1,115	3.7E-02	1.4E+00	1.3E-03	1.1E-02	4.1E-01	3.7E-04
Naphthalene	385	3.5E-03	1.4E-01	3.5E-04	5.2E-02	2.0E+00	5.2E-03
Phenanthrene	596	5.2E-02	2.0E+00	3.4E-03	3.0E-02	1.1E+00	1.9E-03
Pyrene	697	1.2E-01	4.6E+00	6.6E-03	4.2E-02	1.6E+00	2.3E-03
Alkylated PAHs							
1-Methylnaphthalene	446	2.6E-03	9.8E-02	2.2E-04	4.7E-03	1.8E-01	4.1E-04
2-Methylnaphthalene	447	2.6E-03	1.0E-01	2.3E-04	4.9E-03	1.9E-01	4.2E-04
C1-Anthracenes/ Phenanthrenes	670		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C1-Chrysenes	929		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C1-Fluoranthenes/ Pyrenes	770		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C1-Fluorenes	611		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C2-Anthracenes/ Phenanthrenes	746		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C2-Chrysenes	1,008		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C2-Fluorenes	686		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C2-Napthalenes	510		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C3-Anthracenes/ Phenanthrenes	829		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C3-Chrysenes	1,112		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C3-Fluorenes	769		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C3-Napthalenes	581		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C4-Anthracenes/ Phenanthrenes	913		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C4-Chrysenes	1,214		0.0E+00	0.0E+00		0.0E+00	0.0E+00
C4-Napthalenes	657		0.0E+00	0.0E+00		0.0E+00	0.0E+00
		Σ17PAH mg/kg		**Σ17PAH TU**	**Σ17PAH mg/kg**		**Σ17PAH TU**
		0.74		**0.04**	**0.34**		**0.02**
		Σ34PAH mg/kg			**Σ34PAH mg/kg**		
		0.99		**0.05**	**0.46**		**0.03**
Σ17PAH mg/kg, TU=1(b,c)				**15.3**			**12.6**
Σ34PAH mg/kg, TU=1(b,d)				**20.5**			**16.9**
***Average TOCs for the AOC**							

Appendix A3
PCB PRG Information

A3a: PCB PRG Memorandum and Attachments
A3b: PCB USACE Theoretical Bioaccumulation Potential

Appendix A3a
PCB PRG Memorandum
PCB Attachment 1

ENVIRON

March 13, 2009

MEMORANDUM

To: Ecology Technical Subgroup

From: Mary Sorensen, Darrel Lauren, and Jen Lyndall

Re: Preliminary Remedial Goal (PRG) for PCBs and Streamlined Risk Evaluation for PCB-Exposed Wildlife at the Buffalo River AOC

Executive Summary

The Ecology Subgroup (Eco-Group) of the Great Lakes Legacy Act Buffalo River Project Coordination Team has collaborated on efforts to identify preliminary remedial goals (PRGs)[1] of contaminants in sediments for use in the Buffalo River Feasibility Study (FS). This memorandum (memo) is focused on polychlorinated biphenyls (PCBs) and the fish tissue concentrations considered relevant as a basis of PRGs for Buffalo River.

This memo briefly describes the approach used for the development of sediment PRGs estimated based on target fish tissue concentrations that are protective of fish eating wildlife. The approach described herein is consistent with approaches discussed during weekly Eco-Group calls, including modifications made based on improvements identified during the February 2nd Eco-Group call. Several tables are provided to support this memo and Attachment 1 provides the electronic excel workbook of these tables in a calculational format. All supporting data used in the calculations are provided as linked worksheets to facilitate review by the Eco-Group. Upon final agreement of PRGs, a final version of this memo will be submitted from the Eco-Group as an appendix to the Buffalo River FS report.

A range of sediment PCB PRGs is identified herein for consideration in the Buffalo River FS. This approach is similar to that provided for the PAH PRG (memorandum dated February 11) where multiple lines of evidence were used to support the final proposed PRG. It was decided by the Eco-Group during the February 2nd conference call that a range of PCB PRGs was appropriate because it allowed consideration of multiple risk-based criteria valued by the Eco-Group. Four biological exposure "scenarios" based on the natural history of the most sensitive wildlife receptor, the mink, were developed. These were used to evaluate the influence of biologically important variables on the PRGs. These variables are briefly listed below (discussed in greater detail in the *PRG Development* and *Streamlined Risk Evaluation* sections of this memo).

- Fish tissue PCB concentration
- Area use factors (AUF)
- Percent of fish in mink diet

[1] The acronym PRG may be used interchangeably with remedial target concentration (RTC) indicating the targets being evaluated for use in the FS. Actual remedial goals will be identified in the FS.

- Biota-sediment accumulation factor (BSAFs)
- Toxicity reference values (TRVs)

Table 1 shows the sediment PCB PRGs proposed for the Buffalo River FS range from 0.048 mg/kg to 1.3 mg/kg, with average values ranging from 0.44 mg/kg for all scenarios to 0.45 mg/kg for biologically relevant scenarios.

The remainder of this memo describes the:

- PRG development approach, including tabular summary of PRG calculations, and
- Streamlined risk evaluation, including formulae used to derive the PRGs where HQs were set equal to 1

PRG Development Approach

The PRGs presented in Table 1 are based on the calculations provided in Table 2. As identified in Table 2, four "scenarios" were developed to evaluate the PRGs for mink that varied based on consideration of the following elements:

- The basis of fish tissue concentrations used in the analysis: The basis of fish tissue concentrations were set equal to the fish tissue criterion identified by NYSDEC for the Niagara River mink or estimated values where the hazard quotient (HQ) was set equal to the value of 1 (i.e., an HQ ≤ 1 indicates that chemical concentrations do not pose an unacceptable risk to wildlife). Note that separately from PRG development, sediment, worm, and fish tissues for Buffalo River were evaluated to demonstrate the risks posed by current conditions in the river, so that as part of the FS, risk reduction can be evaluated.
- AUFs, based on either 100% or 60% AUF: Habitat characteristics of the Buffalo River which will govern the use of the river by mink were estimated based on the US Fish and Wildlife Service Habitat Suitability Index (USFWS 1989) and consideration of mink exposure to fish tissue as described by NYSDEC in the wildlife narratives provided in the Niagara River report (1987). An estimate of 60% AUF is the maximum AUF that could reasonably be expected for individual mink in the Buffalo River given habitat requirements and conditions present in the Buffalo River, even considering high quality habitat restoration options that are being considered in the FS.
- Mink exposure based on 90%, 50%, or 60% fish in the diet: The 90% estimate was based on NYSDEC request. This is a highly conservative estimate because the NYSDEC (1987) wildlife narrative for mink indicates that "*While other authors also suggest the diet is almost 100% aquatic food depending on season and feeding location, normal fish content in the diet is deemed closer to 30% than 50% (Aulerich 1973; Linscombe et al. 1982). Aulerich et al. (1973) used 30% fish in their mink feeding studies because it is the percentage used in mink ranching to yield optimal development.*" The 50% to 60% estimates used for the PRG development were considered a reasonable compromise between the NYSDEC request for 90% and the NYSDEC (1987) statements of 30% being appropriate.
- BSAFs reflective of sediment to fish uptake calculated by the US Army Corps of Engineers (USACE) were used (Attachment 1). The scenarios varied between values

identified for the AOC as a whole (including the Ship Canal) or the BSAF for the Buffalo River.

- HQs were set equal to 1 with the exception of when the NYSDEC fish tissue criterion was used. The HQ generated using the NYSDEC criterion was 0.3 to 0.5 (unitless), which are values typically below those used to establish remedial goals. However, this information is included in the range of PRGs because it provides necessary consideration of fish tissue criteria valued by NYSDEC.
- TRVs were based on the no adverse effects level (NOAEL) fish tissue criteria toxicity reference values (TRVs) described in Attachment 2 which consider both the criteria identified by New York State Department of Environmental Conservation (NYSDEC 1987), and the US Environmental Protection Agency (USEPA) Great Lakes Initiative (GLI) (1995). For the PRG development, TRVs were consistently set to the USEPA GLI, with only one scenario with the exception where the TRV used by USEPA for the remediation of PCBs in Housatonic River sediments was considered (Bursian et al. 2003; USEPA 2004). These Michigan State University researchers (Bursian et al. 2003) performed studies on mink ingestion of PCBs that provide an updated insight of the base studies described in Attachment 2. An important consideration in the Bursian et al. 2003 study is that fish like carp are high in thiaminase, which metabolizes thiamine. Thiamine deficiency has many of the characteristics of PCB poisoning. More recent studies, such as Bursian et al. (2003) recognized this and added thiamine to the diet of mink fed fish with elevated thiaminase. Previous studies did not report the influence of thiaminase on the toxicity observed. It is also important to note that the study selected by USEPA GLI was Aulerich and Ringer (1977); and, Dr. Aulerich is Dr. Bursian's coauthor on the 2003 study.

Four scenarios for mink were developed, with an overview of these scenarios provided in Table 1. Generally, the four scenarios fell into three categories, as follows:

- Scenarios 1 and 2: Sediment PRGs Estimated Based on Mink Consumption of Fish Tissue Concentrations That Yield an HQ = 1
    - Scenarios 1 and 2 were essentially identical with the difference being consideration of the USACE BSAFs. Scenario 1 used the AOC wide BSAFs (i.e., those including the Ship Canal) and Scenario 2 used the Buffalo River (BR) BSAFs. As seen on Tables 1 and 2, there was little difference between these approaches.
- Scenario 3: Sediment PRGs Estimated Based on Mink Consumption of Fish Tissue Concentrations Equal to NYSDEC Criteria (HQs <1)
- Scenario 4: Sediment PRGs Estimated Based on Mink Consumption of Fish Tissue Concentrations That Yield an HQ = 1; Bursian et al. 2003 TRV (USEPA Housatonic 2004, 2006)

As seen in Tables 1 and 2, there are several iterations of each scenario (notated as Scenario 1a, 1b, 1c; 2a, 2b, 2c; 3a, 3b, 3c; and 4a, 4b, 4c). The differences between each are focused so that key elements of consideration could be quantified. Specifically, the following iterations were provided:

- Scenarios 1 and 2 a, b, c iterations vary based on AUF (100%, 60%, and 60%) and the percent of fish in diet (50%, 50%, and 90%). The AUF variation allowed fish tissue estimates (and thus back-calculated PRGs) to be based on consideration of both worst case HQ=1 and most biologically relevant HQ=1.

- Scenario 3 focused on iterations focused on the most biologically relevant AUF (60%) and included variations in percent of fish in diet (50%, 50%, and 90%), and variations in BSAF (AOC, BR, and BR).
- Scenario 4 is the only case where the USEPA GLI TRV was substituted with another study used by USEPA, the Bursian et al. 2003 study used as the basis of the remedial goals selected for the Housatonic River (USEPA 2004, 2006). The iterations within the scenario were kept at 100% AUF in efforts to keep the evaluation conservative for the benefit of the stakeholder group, the fish in diet was consistent with that from Scenarios 1, 2, and 3. The BSAFs were consistent with that from Scenario 3 (i.e., both AOC and BR were considered).

The estimated (Scenarios 1, 2, and 4) and designated (Scenario 3) fish tissue concentrations were used to back calculate a sediment PCB PRG (in mg/kg) as follows:

- Dry weight fish tissue concentrations (i.e., those needed to calculate HQs) were converted to wet weight by assuming fish are comprised of 75% water (i.e., dry weight values were divided by four).
- Wet weight fish tissues were lipid normalized so that they could be used with BSAFs that were organic carbon normalized. An average of 3% lipids and 2.6% total organic carbon (TOC) were used based on fish tissue data (Table 1 and linked data sources in Attachment 1).

Streamlined Risk Evaluation

A streamlined risk evaluation was also provided as part of this PRG effort because:

- Identification of baseline risks to mammalian and avian fish-eating receptors provides a basis to evaluate risk reduction in the FS
- concerns were raised during the January 16th Eco-Group meeting in Buffalo, NY about the potential risks for not only fish eating wildlife but also those avian receptors that may incidentally ingest sediment during foraging.

This streamlined risk evaluation was conducted in a manner consistent with the USEPA *Ecological Risk Assessment Guidance for Superfund* (1997) and the NYSDEC *Fish and Wildlife Impact Assessment* (1994). The wildlife species selected for this purpose were the mink, the belted kingfisher, and the semipalmated sandpiper. Mink and kingfisher were selected because they obtain a large percentage of their caloric requirements for fish consumption. The sandpiper was selected as a representative of a feeding guild that obtains its caloric requirements from benthic invertebrates and also incidentally ingests a large amount of sediment. The remainder of this memo briefly describes the formulae and data sources.

Formulae

The following general formula was used to estimate exposures for mink and kingfisher:

$$\text{Total Dose (mg/kg - BW - day)} = \left(\frac{\{(P_{FISH} \times C_{FISH}) + (P_{INV} \times C_{INV})\} \times (IR_F) \times (AUF)}{BW} \right)$$

Where:

P_{FISH} = Proportion of the diet comprised of fish (unitless)
C_{FISH} = Concentration of the constituent in fish (mg/kg)
P_{INV} = Proportion of the diet comprised of invertebrates (unitless)
C_{INV} = Concentration of the constituent in invertebrates (mg/kg)
IR_F = Ingestion rate of food (kg/day)
AUF = Area use factor (unitless)
BW = Body weight of the organism (kg)

A similar formula was used to evaluate a hypothetical avian receptor that would have maximum ingestion of sediment and worms during foraging:

$$\text{Total Dose (mg/kg - BW - day)} = \left(\frac{\{(P_{SED} \times C_{SED}) + (P_{INV} \times C_{INV})\} \times (IR_F) \times (AUF)}{BW} \right)$$

Where the parameters are similar to those already described and the following newly introduced parameters are:

P_{SED} = Proportion of the diet comprised of sediment (unitless)
C_{SED} = Concentration of the constituent in sediment (mg/kg)

Hazard quotients were calculated as follows:

$$\text{HQ (unitless)} = \left(\frac{(\text{Total Dose})}{\text{TRV}} \right)$$

Where:

HQ = Hazard quotient (unitless)
TRV = Toxicity Reference Value (mg/kg-BW-day)
Total Dose = Dose (mg/kg-BW-day)

Data Sources

The majority of the data sources have already been described (i.e., TOC, BSAFs, TRVs) as these are the same as those described for PRG development.

The only additional parameter that is unique to the streamlined risk evaluation are the fish and worm tissue data because those were not used directly in the PRG development. Fish tissue data were those from the NYSDEC (2007) study (Figure 1 provides a graphical illustration of the PCBs collected in fish tissues from the AOC; Attachment 1 provides the complete fish PCB data set). Forty-eight whole body fish concentrations of PCBs were evaluated. Fish size ranged from 8 to 1543 g wet weight. The intake formulae above require consideration of fish tissue in dry weight, therefore, wet weight fish tissues were converted to dry weight (Attachment 1).

The fish were evaluated by size for the kingfisher because PCBs increase with age and trophic level and kingfisher are physically limited in the size of the fish they can capture and carry in flight (USEPA 2003). As a further confirmation of the small fish PCB concentrations used for kingfisher, the 2007 data for fish < 50g was compared to the data reported by Preddice et al. (2006) for young-of-year bluntnose minnows collected from the Buffalo River at river mile (RM) 3.7. The PCB concentrations derived from smallest size class of fish collected in 2007 was identical (0.19 ug PCB/kg wet weight) to that reported by Preddice et al. (2006). The kingfisher exposures were considered using average fish tissue concentrations and the maximum fish tissue concentration from any location sampled.

Worm tissue concentrations used to evaluate the avian receptors that may incidentally ingest sediment during foraging were estimated using the USACE BSAFs for worms (data used is provided in Attachment 1). The wet weight worm concentrations were converted to dry weight units by assuming 80% body water and multiplying by 5.
Food ingestion rates were calculated according to allometric equations provided for mammalian and avian carnivores, as noted in USEPA's *Wildlife Exposure Factors Handbook* (2003), and average body weights were also obtained from this handbook. Incidental sediment ingestion rate (30%) was taken from USEPA (1996) and is the highest seen in Beyer et al. (2008) evaluation of sediment ingestion for waterfowl (where they identify 22% as the highest average in diet.

Results

The results are provided in Table 3. The HQs are less than or equal to a value of 1 for kingfisher, mink, and the sandpiper regardless of the particular criteria used (NYSDEC or USEPA GLI) or the AUF (100% or 60%) with one exception. A mink HQ of 2 is seen for mink that are assumed to ingest 90% fish and feed in the Buffalo River AOC 100% of the time. While these particular parameters are not considered biologically relevant for reasons already described for PRGs, they do show a basis upon which theoretical risk reduction can be quantitatively compared in the FS. It is noted that the fish tissue data for carp are in question between NYSDEC and USEPA and while the NYSDEC values for carp lipids are reflected in the data set used to calculate BSAFs, the updated carp tissue concentrations were not used in the risk estimates for mink (i.e., kingfisher eat smaller fish). As such, the risk results for mink are potentially underestimated. This uncertainty has no bearing on the PRG calculations presented earlier in this memorandum because the fish tissue concentrations are not used in those calculations.

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Table 1: PCB PRG Summary Matrix (a)

Scenario	Fish Basis (b)	AUF (c)	Fish in Diet % (d)	BSAF Basis (e)	HQ (f)	USEPA TRV Basis (g)	[Fish] mg/kg, wwt (h)	SD PRG mg/kg (i)
1a†	Buffalo River	100	50	AOC	1	GLI	0.28	0.10
1b*†	Estimated	60	50	AOC	1	GLI	0.46	0.17
1c†	Estimated	60	90	AOC	1	GLI	0.28	0.10
2a†	Estimated	100	50	BR	1	GLI	0.28	0.11
2b	Estimated	60	50	BR	1	GLI	0.46	0.19
2c†	Estimated	60	90	BR	1	GLI	0.28	0.11
3a*	NYSDEC	60	50	AOC	0.3	GLI	0.13	0.048
3b	NYSDEC	60	50	BR	0.3	GLI	0.13	0.054
3c	NYSDEC	60	90	BR	0.5	GLI	0.13	0.054
4a*†	Estimated	100	50	AOC	1	HR	3.13	1.1
4b†	Estimated	100	50	BR	1	HR	3.13	1.3
4c†	Estimated	100	90	BR	1	HR	2.13	0.78
Average of those scenarios with biologically relevant mink use of the river (as denoted with the symbol *):							1.24	0.45
Average of HQ=1 (as denoted with the symbol †):							1.16	0.44

Notes:

(a) The scenarios and detailed formulate and calculated values are provided in Table 2.

(b) Estimated values are those based on HQs equal to 1, unless noted as NYSDEC.

(c) AUF is based on Buffalo River habitat suitability characteristics for mink, as defined by the US Fish and Wildlife Service (1989). 60% use of the Buffalo River is considered the reasonably maximum that could be expected after anticipated (albeit yet undefined) restoration is implemented. 100% AUF is provided as a conservative estimate, but is not considered biologically relevant.

(d) Diet is based on NYSDEC request (90%) or those average estimates based on NYSDEC (1987) wildlife narrative. 50% fish in diet is considered a conservatively high level that is biologically relevant (NYSDEC 1987).

(e) US Army Corps of Engineers BSAF for sediment to fish used, with values representing the AOC as a whole or focused on the Buffalo River.

(f) HQ was set equal to 1, unless calculated for NYSDEC criteria.

(g) The USEPA GLI TRV was used for the majority of scenario evaluations. The USEPA Housatonic River TRV was also considered due to the value of this study (Bursian et al. 2003) provided as an attachment to this memo.

(h) Fish tissue and PRG values linked to Table 2 as denoted by color coding.

%	Percent
AOC	Area of Concern
AUF	Area Use Factor
BR	Buffalo River
BSAF	Biota-Sediment Accumulation Factor
HQ	Hazard Quotient
mg/kg	Milligram per Kilogram
NYSDEC	New York State Department of Environmental Conservation
PRG	Preliminary Remediation Goal
SD	Sediment
wwt	Wet Weight
(purple)	Wet Weight Fish Tissue Concentrations
(pink)	Sediment PRG

Table 2: Sediment PRGs Linked to Fish Tissue Residues

Sediment PRGs Estimated Based on Mink Consumption of Fish Tissue Concentrations That Yield an HQ = 1

Scenario 1a. HQ=1; 100% AUF; BSAF = USACE total AOC average; diet of 50% fish							**100% AUF (a)**	60% AUF (b)
Mink	BW (g)	IR (kg/kg/d)	[Fish] mg/kg	[Invertebrate] mg/kg	Total Dose (mg/kg/d)	TRV (mg/kg-BW-d)	**HQ**	HQ
(50% fish, 100% AUF, AOC BSAF)	1000	0.049	1.14	0.192	0.03	0.03	**1**	0.6
			(Estimate based on HQ=1)			(USEPA GLI Criterion)		
all fish are 75% water			0.284	mg wwt fish				
all fish are 3.6% lipid		3.6	8.0	g-lipid fish				
All AOC BSAF		2.0	4.0	ug/g-OC				
sediment OC		2.6	104	ug/kg				
PRG			0.104	mg/kg				

Scenario 1b. HQ=1; 60% AUF; BSAF = USACE total AOC average; diet of 50% fish							100% AUF (a)	**60% AUF (b)**
Mink	BW (g)	IR (kg/kg/d)	[Fish] mg/kg	[Invertebrate] mg/kg	Total Dose (mg/kg/d)	TRV (mg/kg-BW-d)	HQ	**HQ**
(50% fish, 60% AUF, AOC BSAF)	1000	0.049	1.85	0.192	0.05	0.03	2	**1**
			(Estimate based on HQ=1)			(USEPA GLI Criterion)		
all fish are 75% water			0.463	mg wwt fish				
all fish are 3.6% lipid		3.6	13.0	g-lipid fish				
All AOC BSAF		2.0	6.5	ug/g-OC				
sediment OC		2.6	169	ug/kg				
PRG			0.169	mg/kg				

Scenario 1c. HQ=1; 60% AUF; BSAF = USACE total AOC average; diet of 90% fish (NYSDEC Request)							100% AUF (a)	**60% AUF (b)**
Mink	BW (g)	IR (kg/kg/d)	[Fish] mg/kg	[Invertebrate] mg/kg	Total Dose (mg/kg/d)	TRV (mg/kg-BW-d)	HQ	**HQ**
(90% fish, 60% AUF, AOC BSAF)	1000	0.049	1.10	0.192	0.05	0.03	2	**1**
			(Estimate based on HQ=1)			(USEPA GLI Criterion)		
all fish are 75% water			0.275	mg wwt fish				
all fish are 3.6% lipid		3.6	7.7	g-lipid fish				
All AOC BSAF		2.0	3.9	ug/g-OC				
sediment OC		2.6	101	ug/kg				
PRG			0.101	mg/kg				

Scenario 2a. HQ=1 assuming 100% AUF; BSAF = USACE BR average, diet 50% fish							**100% AUF (a)**	60% AUF (b)
Mink	BW (g)	IR (kg/kg/d)	[Fish] mg/kg	[Invertebrate] mg/kg	Total Dose (mg/kg/d)	TRV (mg/kg-BW-d)	**HQ**	HQ
(50% fish, 60% AUF, BR BSAF)	1000	0.049	1.10	0.192	0.03	0.03	**1**	0.6
			(Estimate based on HQ=1)			(USEPA GLI Criterion)		
all fish are 75% water			0.275	mg wwt fish				
all fish are 3.6% lipid		3.6	7.7	g-lipid fish				
BR BSAF		1.8	4.4	ug/g-OC				
sediment OC		2.6	113	ug/kg				
PRG			0.113	mg/kg				

Scenario 2b. HQ=1 assuming 60% AUF; BSAF = USACE BR average, diet 50% fish							100% AUF (a)	**60% AUF (b)**
Mink	BW (g)	IR (kg/kg/d)	[Fish] mg/kg	[Invertebrate] mg/kg	Total Dose (mg/kg/d)	TRV (mg/kg-BW-d)	HQ	**HQ**
(50% fish, 60% AUF, BR BSAF)	1000	0.049	1.85	0.192	0.05	0.03	2	**1**
			(Estimate based on HQ=1)			(USEPA GLI Criterion)		
all fish are 75% water			0.463	mg wwt fish				
all fish are 3.6% lipid		3.6	13.0	g-lipid fish				
BR BSAF		1.8	7.3	ug/g-OC				
sediment OC		2.6	191	ug/kg				
PRG			0.191	mg/kg				

Scenario 2c. HQ=1 assuming 60% AUF; BSAF = USACE BR average, diet 90% fish (NYSDEC request)							100% AUF (a)	**60% AUF (b)**
Mink	BW (g)	IR (kg/kg/d)	[Fish] mg/kg	[Invertebrate] mg/kg	Total Dose (mg/kg/d)	TRV (mg/kg-BW-d)	HQ	**HQ**
(90% fish, 60% AUF, BR BSAF)	1000	0.049	1.10	0.192	0.05	0.03	2	**1**
			(Estimate based on HQ=1)			(USEPA GLI Criterion)		
all fish are 75% water			0.275	mg wwt fish				
all fish are 3.6% lipid		3.6	7.7	g-lipid fish				
BR BSAF		1.8	4.4	ug/g-OC				
sediment OC		2.6	113	ug/kg				
PRG			0.113	mg/kg				

Table 2: Sediment PRGs Linked to Fish Tissue Residues

Sediment PRGs Estimated Based on Mink Consumption of Fish Tissue Concentrations Equal to NYSDEC Criteria (HQs <1)

Scenario 3a. PRG based on NYSDEC mink criterion; BSAF = USACE AOC average, diet 50% fish							100% AUF (a)	60% AUF (b)
Mink	BW (g)	IR (kg/kg/d)	[Fish] mg/kg	[Invertebrate] mg/kg	Total Dose (mg/kg/d)	TRV (mg/kg-BW-d)	HQ	HQ
(NYSDEC, 50% fish, 60% AUF, BR BSAF)	1000	0.049	0.52	0.192	0.02	0.03	0.5	0.3
			(NYSDEC Criterion)			(USEPA GLI Criterion)		
all fish are 75% water			0.13	mg wwt fish				
all fish are 3.6% lipid		3.6	3.7	g-lipid fish				
BR BSAF		2.0	1.8	ug/g-OC				
sediment OC		2.6	48	ug/kg				
PRG			0.048	mg/kg				

Scenario 3b. PRG based on NYSDEC mink criterion; BSAF = USACE BR average, diet 50% fish							100% AUF (a)	60% AUF (b)
Mink	BW (g)	IR (kg/kg/d)	[Fish] mg/kg	[Invertebrate] mg/kg	Total Dose (mg/kg/d)	TRV (mg/kg-BW-d)	HQ	HQ
(NYSDEC, 50% fish, 60% AUF, BR BSAF)	1000	0.049	0.52	0.192	0.02	0.03	0.5	0.3
			(NYSDEC Criterion)			(USEPA GLI Criterion)		
all fish are 75% water			0.13	mg wwt fish				
all fish are 3.6% lipid		3.6	3.7	g-lipid fish				
BR BSAF		1.8	2.1	ug/g-OC				
sediment OC		2.6	54	ug/kg				
PRG			0.054	mg/kg				

Scenario 3c. PRG based on NYSDEC mink criterion; BSAF = USACE BR average, diet 90% fish							100% AUF (a)	60% AUF (b)
Mink	BW (g)	IR (kg/kg/d)	[Fish] mg/kg	[Invertebrate] mg/kg	Total Dose (mg/kg/d)	TRV (mg/kg-BW-d)	HQ	HQ
(NYSDEC, 90% fish, 60% AUF, BR BSAF)	1000	0.049	0.52	0.192	0.02	0.03	0.8	0.5
			(NYSDEC Criterion)			(USEPA GLI Criterion)		
all fish are 75% water			0.13	mg wwt fish				
all fish are 3.6% lipid		3.6	3.7	g-lipid fish				
BR BSAF		1.8	2.1	ug/g-OC				
sediment OC		2.6	54	ug/kg				
PRG			0.054	mg/kg				

Sediment PRGs Estimated Based on Mink Consumption of Fish Tissue Concentrations That Yield an HQ = 1; Bursian et al. 2003 TRV (U

Scenario 4a. HQ=1; 100% AUF; BSAF = USACE total AOC average; diet of 50% fish							**100% AUF (a)**	60% AUF (b)
Mink	BW (g)	IR (kg/kg/d)	[Fish] mg/kg	[Invertebrate] mg/kg	Total Dose (mg/kg/d)	TRV (mg/kg-BW-d)	**HQ**	HQ
(50% fish, 100% AUF, AOC BSAF)	1000	0.049	12.50	0.192	0.31	0.414	**1**	0.4
			(Estimate based on HQ=1)			(USEPA Housatonic)		
all fish are 75% water			3.13	mg wwt fish				
all fish are 3.6% lipid		3.6	88	g-lipid fish				
All AOC BSAF		2.0	44	ug/g-OC				
sediment OC		2.6	1145	ug/kg				
PRG			1.14	mg/kg				

Scenario 4b. HQ=1; 100% AUF; BSAF = USACE BR average; diet of 50% fish							**100% AUF (a)**	**60% AUF (b)**
Mink	BW (g)	IR (kg/kg/d)	[Fish] mg/kg	[Invertebrate] mg/kg	Total Dose (mg/kg/d)	TRV (mg/kg-BW-d)	**HQ**	**HQ**
(50% fish, 100% AUF, AOC BSAF)	1000	0.049	12.50	0.192	0.31	0.414	**1**	**0.4**
			(Estimate based on HQ=1)			(USEPA Housatonic)		
all fish are 75% water			3.13	mg wwt fish				
all fish are 3.6% lipid		3.6	88.0	g-lipid fish				
All AOC BSAF		1.8	49.6	ug/g-OC				
sediment OC		2.6	1289	ug/kg				
PRG			1.29	mg/kg				

Scenario 4c. HQ=1; 100% AUF; BSAF = USACE total AOC average; diet of 90% fish (NYSDEC Request)							**100% AUF (a)**	**60% AUF (b)**
Mink	BW (g)	IR (kg/kg/d)	[Fish] mg/kg	[Invertebrate] mg/kg	Total Dose (mg/kg/d)	TRV (mg/kg-BW-d)	**HQ**	**HQ**
(50% fish, 100% AUF, AOC BSAF)	1000	0.049	8.50	0.192	0.37	0.414	**1**	**0.5**
			(Estimate based on HQ=1)			(USEPA Housatonic)		
all fish are 75% water			2.13	mg wwt fish				
all fish are 3.6% lipid		3.6	59.8	g-lipid fish				
All AOC BSAF		2.0	29.9	ug/g-OC				
sediment OC		2.6	778	ug/kg				
PRG			0.778	mg/kg				

Notes:

AOC	Area of Concern	mg	Milligram
AUF	Area Use Factor	mg/kg	Milligram per Kilogram
BSAF	Biota-Sediment Accumulation Factor	mg/kg-BW-d	Milligram per Kilogram of Body Weight per Day
BW	Body Weight	OC	Organic Carbon
dwt	Dry Weight	PRG	Preliminary Remediation Goal
g	Gram	TRV	Toxicity Reference Value
GLI	Great Lakes Initiative	ug/g-OC	Microgram per Gram Organic Carbon
HQ	Hazard Quotient (rounded to one sig. figure)	USACE	United States Army Corp of Engineers
IR	Ingestion Rate	USEPA	United States Environmental Protection Division
kg/kg/d	Kilogram per Kilogram per Day	wwt	Wet Weight
NYSDEC	NY State Department of Environmental Conservation	%	Percent
(blue)	Exposure Notes	(pink)	Sediment
(yellow)	HQ > 1	(purple)	Wet Weight Fish Tissue Concentrations
(green)	HQ ≤ 1		

Table 3: Wildlife Streamlined Risk Calculations

Kingfisher Risk Calculations for Buffalo River using Site-Specific Information							
Buffalo River Site-Specific Exposure			Average Fish Tissue Concentration from AOC				100% AUF
Belted Kingfisher	BW (g)	IR (kg/kg/d)	[Fish] mg/kg, dwt	Dose- Fish	Total Dose (mg/kg/d), dwt	TRV (mg/kg-BW-d)	HQ
(Average Exposure)	150	0.157	0.81	0.127	0.13	0.6	0.2
			Maximum Fish Tissue Concentration from AOC				
Belted Kingfisher	BW (g)	IR (kg/kg/d)	[Fish] mg/kg, dwt	Dose- Fish	Total Dose (mg/kg/d), dwt	TRV (mg/kg-BW-d)	HQ
(Maximum Exposure)	150	0.157	0.81	0.127	0.13	0.6	0.2

Kingfisher Risk Calculations using NYSDEC and USEPA Criteria (a)							
NYSDEC Niagra Fish Tissue Criterion Exposure Concentration							
Belted Kingfisher	BW (g)	IR (kg/kg/d)	[Fish] mg/kg, dwt	Dose- Fish	Total Dose (mg/kg/d), dwt	TRV (mg/kg-BW-d)	HQ
(NYSDEC Criterion)	150	0.157	0.44	0.069	0.07	0.6	0.1
			(0.11 mg/kg wwt = 0.44 mg/kg dwt assuming fish = 75% water)				
USEPA GLI Fish Tissue Criterion Exposure Concentration							
Belted Kingfisher	BW (g)	IR (kg/kg/d)	[Fish] mg/kg, dwt	Dose- Fish	Total Dose (mg/kg/d), dwt	TRV (mg/kg-BW-d)	HQ
(USEPA GLI Criterion)	150	0.157	3.84	0.602	0.60	0.6	1
			(0.96 mg/kg wwt = 3.84 mg/kg dwt assuming fish = 75% water)				

Mink Risk Calculations for Buffalo River using Site-Specific Information								
Buffalo River Site-Specific Exposure			90% fish; NYSDEC Request, not realistic biologically (a)				100% AUF (a)	60% AUF (b)
Mink	BW (g)	IR (kg/kg/d)	[Fish] mg/kg, dwt	[Invertebrate] mg/kg	Total Dose (mg/kg/d), dwt	TRV (mg/kg-BW-d)	HQ	HQ
(90% fish ingestion)	1000	0.049	1.14	0.192	0.05	0.03	2	1
			50% fish; 30% invertebrates; remainder terrestrial (c)					
Mink	BW (g)	IR (kg/kg/d)	[Fish] mg/kg, dwt	[Invertebrate] mg/kg	Total Dose (mg/kg/d), dwt	TRV (mg/kg-BW-d)	HQ	HQ
(50% fish ingestion)	1000	0.049	1.14	0.192	0.03	0.03	1	0.6
			60% fish; 20% invertebrates; remainder terrestrial (d)					
Mink	BW (g)	IR (kg/kg/d)	[Fish] mg/kg, dwt	[Invertebrate] mg/kg	Total Dose (mg/kg/d), dwt	TRV (mg/kg-BW-d)	HQ	HQ
(60% fish ingestion)	1000	0.049	1.14	0.192	0.04	0.03	1	0.7

Table 3: Wildlife Streamlined Risk Calculations

Mink Risk Calculations using NYSDEC and USEPA Criteria (a)								
NYSDEC Niagra Fish Tissue Criterion Exposure Concentration					90% fish; NYSDEC Request		100% AUF (a)	60% AUF (b)
Mink	BW (g)	IR (kg/kg/d)	[Fish] mg/kg, dwt	[Invertebrate] mg/kg	Total Dose (mg/kg/d), dwt	TRV (mg/kg-BW-d)	HQ	HQ
(NYSDEC Criterion)	1000	0.049	0.52	0.192	0.02	0.03	0.8	0.5
			(0.13 mg/kg wwt = 0.52 mg/kg dwt assuming fish = 75% water)					
			50% fish; 30% invertebrates, remainder terrestrial (c)					
Mink	BW (g)	IR (kg/kg/d)	[Fish] mg/kg, dwt	[Invertebrate] mg/kg	Total Dose (mg/kg/d), dwt	TRV (mg/kg-BW-d)	HQ	HQ
(NYSDEC Criterion)	1000	0.049	0.52	0.192	0.02	0.03	0.5	0.3
			(0.13 mg/kg wwt = 0.52 mg/kg dwt assuming fish = 75% water)					
			60% fish; 20% invertebrates, remainder terrestrial (d)					
Mink	BW (g)	IR (kg/kg/d)	[Fish] mg/kg, dwt	[Invertebrate] mg/kg	Total Dose (mg/kg/d), dwt	TRV (mg/kg-BW-d)	HQ	HQ
(NYSDEC Criterion)	1000	0.049	0.52	0.192	0.02	0.03	0.6	0.3
			(0.13 mg/kg wwt = 0.52 mg/kg dwt assuming fish = 75% water)					
USEPA GLI Fish Tissue Criterion Exposure Concentration					90% fish; NYSDEC Request		100% AUF (a)	60% AUF (b)
Mink	BW (g)	IR (kg/kg/d)	[Fish] mg/kg, dwt	[Invertebrate] mg/kg	Total Dose (mg/kg/d), dwt	TRV (mg/kg-BW-d)	HQ	
(USEPA GLI Criterion)	1000	0.049	0.60	0.192	0.03	0.03	0.9	0.5
			(0.15 mg/kg wwt = 0.6 mg/kg dwt assuming fish = 75% water)					
			50% fish; 30% invertebrates, remainder terrestrial (c)					
Mink	BW (g)	IR (kg/kg/d)	[Fish] mg/kg, dwt	[Invertebrate] mg/kg	Total Dose (mg/kg/d), dwt	TRV (mg/kg-BW-d)	HQ	
(USEPA GLI Criterion)	1000	0.049	0.60	0.192	0.02	0.03	0.6	0.3
			(0.15 mg/kg wwt = 0.6 mg/kg dwt assuming fish = 75% water)					
			60% fish; 20% invertebrates, remainder terrestrial (d)					
Mink	BW (g)	IR (kg/kg/d)	[Fish] mg/kg, dwt	[Invertebrate] mg/kg	Total Dose (mg/kg/d), dwt	TRV (mg/kg-BW-d)	HQ	
(USEPA GLI Criterion)	1000	0.049	0.60	0.192	0.02	0.03	0.6	0.4
			(0.15 mg/kg wwt = 0.6 mg/kg dwt assuming fish = 75% water)					

Table 3: Wildlife Streamlined Risk Calculations

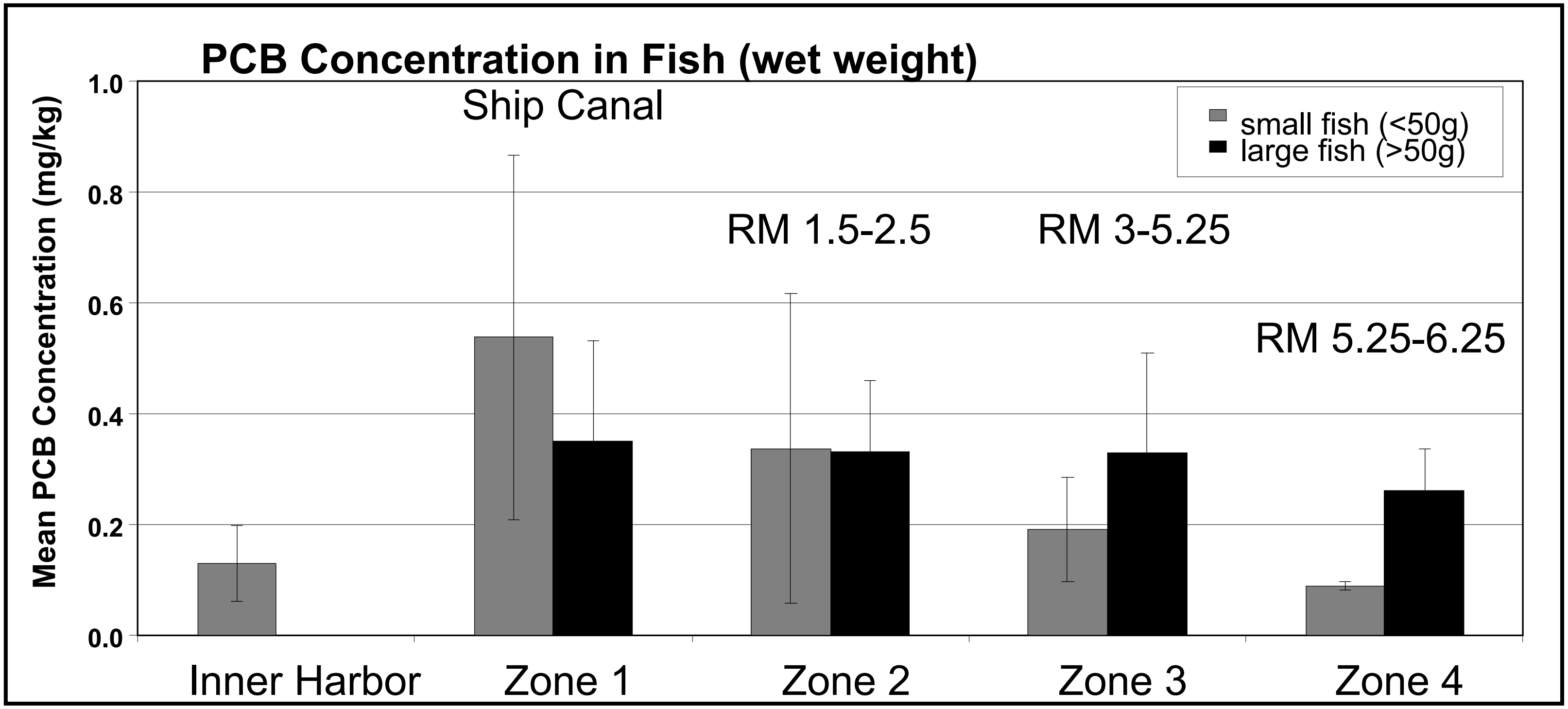
Mink Risk Calculations for Buffalo River using Site-Specific Information and Bursian et al. 2003 TRV								
Buffalo River Site-Specific Exposure			90% fish; NYSDEC Request, not realistic biologically (a)				100% AUF (a)	60% AUF (b)
Mink	BW (g)	IR (kg/kg/d)	[Fish] mg/kg, dwt	[Invertebrate] mg/kg	Total Dose (mg/kg/d), dwt	TRV (mg/kg-BW-d)	HQ	HQ
(90% fish ingestion)	1000	0.049	1.14	0.192	0.05	0.414	0.1	0.07
			50% fish; 30% invertebrates; remainder terrestrial (c)					
Mink	BW (g)	IR (kg/kg/d)	[Fish] mg/kg, dwt	[Invertebrate] mg/kg	Total Dose (mg/kg/d), dwt	TRV (mg/kg-BW-d)	HQ	HQ
(50% fish ingestion)	1000	0.049	1.14	0.192	0.03	0.414	0.07	0.04
			60% fish; 20% invertebrates; remainder terrestrial (d)					
Mink	BW (g)	IR (kg/kg/d)	[Fish] mg/kg, dwt	[Invertebrate] mg/kg	Total Dose (mg/kg/d), dwt	TRV (mg/kg-BW-d)	HQ	HQ
(60% fish ingestion)	1000	0.049	1.14	0.192	0.04	0.414	0.08	0.05

Worm and Sediment Ingesting Bird: Risk Calculations for Buffalo River using Site-Specific Information									100% AUF
Semipalmated sandpiper	BW (g)	IR (kg/kg/d)	[Sediment] mg/kg	[Invertebrate] mg/kg	Dose - Invertebrates	Dose - Sediment	Total Dose (mg/kg/d), dwt	TRV (mg/kg/d)1	HQ
	55	0.220	0.071	0.19	0.0423	0.005	0.047	0.6	0.08

Notes:

%	percent	kg/kg/d	Kilogram per Kilogram per Day
AOC	Area of Concern	mg/kg	Milligram per Kilogram
AUF	Area Use Factor	IR (kg/kg/d)	IR (kg/kg/d)
BW	Body Weight	NYSDEC	New York State Department of Environmental Conservation
dwt	Dry Weight	PRG	Preliminary Remediation Goal
g	Gram	TRV	Toxicity Reference Value
GLI	Great Lakes Initiative	USEPA	United States Environmental Protection Division
IR	Ingestion Rate	wwt	Wet Weight
HQ	Hazard Quotient (rounded to one sig. figure)		
(blue)	Exposure Notes		
(yellow)	HQ > 1		
(green)	HQ ≤ 1		

- Measured Fish Tissue Concentrations in Buffalo River
  - Measured maximum residues= 0.87 mg/kg small fish to 0.69 (large fish) whole body (wet weight)



RM River Mile

ENVIRON

PCB Concentration in Fish

Figure 1

Appendix A3a
PCB PRG Memorandum
Attachment 2

ENVIRON

February 3, 2009

MEMORANDUM

To: Ecology Technical Subgroup

From: Mary Sorensen, Darrel Lauren, and Jen Lyndall

Re: Preliminary Remedial Goals (PRG) for PCB-Exposed Wildlife at the Buffalo River AOC: Evaluation of Toxicity Studies That Form the Basis of the PRGs

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The Ecology Subgroup (Eco-Group) of the Great Lakes Legacy Act Buffalo River Project Coordination Team has collaborated on efforts to identify preliminary remedial goals (PRGs)[1] of contaminants in sediments for use in the Buffalo River Feasibility Study (FS). This memorandum is focused on polychlorinated biphenyls (PCBs) and the fish tissue concentrations considered relevant as a basis of PRGs for Buffalo River.

New York State Department of Environmental Conservation (NYSDEC) identified a PCB fish tissue concentration considered protective of fish-eating wildlife in the Niagara River (0.11 mg/kg wet weight; Table 26 of NYSDEC 1987) for use in establishing PRGs for sediment PCBs in the Buffalo River. The basis of the fish tissue concentration used for the Niagara River was evaluated in light of two decades of scientific developments since the Niagara report was published. This memorandum provides a summary of the review, and shows that while the value used for the Niagara River was appropriate for use by NYSDEC in 1987, a more current United States Environmental Protection Agency (USEPA) Great Lakes Initiative (GLI) tissue concentration protective of fish-eating wildlife should be considered for the Buffalo River because it better reflects current scientific understanding of PCB toxicity to wildlife, and is consistent with the current consideration of more than 50 studies of PCBs in wildlife (USEPA 2006; Fuchsman et al. 2008). The specific rationales that support this recommendation are:

1. The USEPA GLI criterion being identified for use in the development of Buffalo River PRGs is a no observable adverse effects level (NOAEL) that is not substantially different than that identified for use by NYSDEC when comparable units are considered. Specifically, the fish tissue criterion identified by NYSDEC (1987) 0.11 mg PCB/kg, wet weight is protective of fish eating birds and is the lowest of the estimated fish tissue benchmarks considered for the Niagara River. The NYSDEC (1987) fish criterion for mink is only slightly greater (0.13 mg PCB/kg, wet weight) than that identified for birds. The USEPA GLI fish tissue criterion for mink is very similar (15 mg PCB/kg wet weight[2]) to the NYSDEC value for mink, when units are

[1] The acronym PRG may be used interchangeably with remedial target concentration (RTC) indicating the targets being evaluated for use in the FS. Actual remedial goals will be identified in the FS.
[2] The mink criterion identified in the GLI is provided on Page 4-7 of USEPA 1995.

converted from an ingestion dose value into a wet weight fish tissue criterion[3]. The USEPA (1995) fish tissue criterion for fish eating birds (i.e., 0.96 mg PCB/kg wet weight fish tissue[4]) is higher than that identified by NYSDEC (1987) and thus, the lower mink value from USEPA (1995) would be the more stringent value for consideration in the PRG development.

2. The NYSDEC (1987) fish tissue criterion protective of fish eating mammals, 0.13 mg PCB/kg wet weight, is based on a study by Platonow and Karstad (1973) in which mink were fed beef from Aroclor-fed cattle. The lowest concentrations tested, 0.64 mg PCB/kg, resulted in adverse effects. NYSDEC (1987) assumed that the no effect concentration would be obtained by multiplying this concentration by an uncertainty factor of 0.2.

   The USEPA (1995) reviewed the Platonow and Karstad (1973) paper and reported that that "reproductive impairment occurs in mink at even lower concentrations when PCBs fed to mink have been metabolized by [mammalian] species". Fish do not metabolize PCBs like mammals, so mink eating fish are exposed to less toxic congener profiles than mink that are fed PCBs in cattle. Therefore, USEPA (1995) also reviewed nine other studies and selected a study by Aulerich and Ringer (1977) as the best study upon which to base water quality concentrations that are protective of mammalian wildlife in the Great Lakes. These authors exposed mink to Aroclor 1254 at 0, 5, and 10 mg/kg for nine-months. They also exposed mink to Aroclor 1016, 1221, 1242, and 1254 for 297-days. Only Aroclor 1254 had an adverse effect on mink reproduction. USEPA (1995) estimated a lowest effect concentration of 2 mg PCB/kg and calculated a lowest observable adverse effects level (LOAEL) of 0.3 mg PCB/kg body weight per day. They then applied an uncertainty factor of 10 to estimate the no observable adverse effects level (NOAEL). This value, 0.03 mg PCB/ kg body weight per day was nearly identical to that obtained by Hornshaw et al. (1983) by feeding Great Lakes fish to mink for 290-days during the reproductive cycle. Therefore, since USEPA (1995) provides a full description of the tests and recognized the importance of metabolism, and the value presented herein for mink is consistent with that identified in other studies and that identified for use by NYSDEC for mink in the Niagara River, 0.03 mg PCB/ kg body weight per day (i.e., 0.15 mg/kg wet weight fish tissue) is the appropriate NOAEL for the mink for the Buffalo River.

3. As mentioned previously, the NYSDEC (1987) fish tissue criterion is based on protection of fish eating birds, 0.11 mg PCB/kg wet weight. This concentration is based on a study by Britton and Huston (1973) in laying hens exposed to Aroclor

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[3] USEPA 1995 reports the criterion in units of milligram per kilogram of body weight per day (mg/kg-BW-day), which converts to mg/kg wet weight fish tissue by considering that (1) mink have a body weight of 1 kilogram; (2) mink consume 0.049 kg/kg-BW-day; and (3) that fish are comprised of 75% water (i.e., ([0.03 mg/kg-BW-day/0.049 kg/kg-BW-day]/4 = 0.15mg/kg wet weight fish tissue).

[4] The dose based benchmark of 0.6mg/kg-BW-day identified in USEPA (1995) page 4-14 equates to 0.96 mg/kg wet weight fish using a similar equation as that described for mink except substituting a belted kingfisher ingestion rate of 0.157 kg/kg-BW-day (i.e., [0.6 mg/kg-BW-day/0.157 kg/kg-BW-day]/4 = 0.96mg/kg wet weight fish tissue).

1242. NYSDEC (1987) report a NOAEL of 0.224 mg PCB/kg body weight per day and then divided this value by ten to account for the possibility that the kingfisher might be more sensitive than the chicken. This equates to an estimated fish tissue concentration of 0.11 mg PCB/kg wet weight.

USEPA (1995) reviewed chronic studies with birds but selected the study by Dahlgren et al. (1972) as the best study upon which to base water quality concentrations that are protective of avian wildlife in the Great Lakes. Dahlgren et al. (1972) administered Aroclor 1254 at 12.5 of 50 mg once a week by gelatin capsule to ring-necked pheasant for sixteen-weeks during the reproductive cycle. USEPA (1995) reported that no effects were found on egg fertility or chick growth at 12.5 mg/week. This study was selected in part because preference was given to studies with wildlife species, rather than chickens. USEPA (1995) calculated a LOAEL of 1.8 mg Aroclor 1254/kg body weight per day and used a 3-fold application factor because they considered that kingfisher may be more sensitive than pheasant, and an additional uncertainty factor of 3 to convert the LOAEL to a NOAEL of 0.2 mg Aroclor 1254/kg body weight per day. USEPA (1995) provides a description of these studies and calculated a NOAEL of 3.4 mg PCB/kg body weight per day.

In 1987 and 1995, it was not known that Gallinaceous birds such as the chicken are the most sensitive species of birds tested (Karchner et al. 2006; Head 2008) and current practice does not add an additional application factor when applying these NOAELs to other avian species. For example, Head et al. (2008) reported that common tern are 260-fold less sensitive than chicken and American kestrel are 122 to 163-fold less sensitive chicken. Wood duck are >46-fold less sensitive than chicken. Therefore, no additional uncertainty factors should be applied to the avian NOAELs discussed above. This means that the NYSDEC (1987) LOAEL should have been 0.22 mg Aroclor 1254/kg body weight per day and the USEPA (1995) NOAEL should be 0.6 mg Aroclor 1254/kg body weight per day. Since USEPA (1995) provides a full description of these experiments, ENVIRON believes that 0.6 mg Aroclor 1254/kg body weight per day is the appropriate NOAEL for avian receptors. This value equates to 0.96 mg PCB/kg wet weight. It is worthy of note that the NYSDEC value of 0.22 mg Aroclor 1254/kg body weight per day equates to 0.35 mg/kg wet weight fish tissue (refer to previous footnotes for conversion factors and approaches), and thus is higher than the mink fish tissue criterion discussed earlier in this memo.

Conclusions

Appropriate PRGs for the Buffalo River should be based on scientifically valid approaches, with consideration of regulatory precedent to the extent that such approaches used in the past reflect our current understanding of physical, chemical, and biological environment. This memorandum provides a detailed description of the rationales that support the use of mammalian and avian fish tissue criteria of 0.15 mg/kg and 0.96 mg/kg wet weight fish, respectively, for consideration of PRG development. The mink value in particular is very similar to that identified by NYSDEC for use in the Niagara River.

These values are based on studies cited for use in the Great Lakes (USEPA 1995) and reflect concentrations consistent with those being used as remedial targets in the Hudson and Housatonic Rivers (USEPA 2004; 2006). In addition, because the mixture of PCBs in the Buffalo River small fish most resembles 1242/1248 (i.e., 97% total PCB in small fish) and is approximately equally split in all fish (i.e., 54% of total PCBs), these fish tissue targets are considered highly conservative for both mammals and birds. The values described herein for mink and fish eating birds, will be considered for use in development of PRGs within a risk-based context.

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Appendix A3b
PCB USACE Theoretical Bioaccumulation Potential

CELRB-TD-EA

25 February 2009
Pickard/swp/4404

MEMORANDUM FOR RECORD

SUBJECT: Buffalo River Area of Concern (AOC) – Development of a Preliminary Remediation Goal (PRG) for total polychlorinated biphenyls (PCBs)

1. The purpose of this memorandum is to document the development of a preliminary remediation goal (PRG) for total polychlorinated biphenyls (PCBs) in Buffalo River Area of Concern (AOC) sediments relative to the protection of pelagic fish. This approach offers a single line of evidence toward the development of PRGs for total PCBs.

2. The development of this PRG is summarized as follows:

a. AOC sediment PCB contamination. Total PCB concentrations in AOC sediments range from non-detectable to 33 mg/kg based on existing data. The predominant Aroclors identified in the sediments were 1242, 1254 and 1260. Analysis of three composite surficial sediments from the AOC collected in 2003 for bioaccumulation experiments showed detectable mixtures of Aroclor 1248 and 1260, with total PCB concentrations ranging from 0.28 to 0.58 mg/kg (USAERDC 2003). A PCB profile based on congener-specific analysis of one of these sediment samples obtained near Katherine Street Peninsula is presented in Figure 1 (sum of PCB congeners = 191 µg/kg).

b. Bioaccumulation modeling. Bioaccumulation is an appropriate biological measurement endpoint to evaluate the potential exposure to PCBs in the aquatic environment. Theoretical bioaccumulation potential (TBP) is an equilibrium theory-based algorithm used to predict the potential bioaccumulation of neutral, organic compounds, such as PCBs, from sediment into benthic organisms (McFarland 1984). This model is expressed as:

$$TBP = BSAF_b\,(L_b)\,\frac{C_s}{TOC} \qquad (1)$$

Where:
TBP = Predicted whole body tissue concentration of total PCBs in target benthic organism, mg/kg wet weight
$BSAF_b$ = Benthic biota-sediment accumulation factor
L_b = Concentration of lipid in target benthic organism, percent of wet weight

C_s = Concentration of total PCBs in sediment, mg/kg dry weight
TOC = Total organic carbon concentration in sediment, percent of dry weight

In order to extrapolate fish bioaccumulation from this benthic model, a trophic transfer factor (TTF) for total PCBs was calculated. TTFs using lipid-normalized bioaccumulation experiment data on AOC sediment using the aquatic worm (oligochaete) *Lumbriculus variegatus* (USAERDC 2003), and lipid-normalized tissue residue data on AOC collected largemouth bass (*Micropterus salmoides)* (NYSDEC 2007) were determined as follows:

$$TTF = \frac{C_{tf}/L_f}{C_{tb}/L_b} \qquad (2)$$

Where:
C_{tf}= Concentration of total PCBs in whole fish, mg/kg wet weight
L_f= Concentration of lipid in fish, percent of wet weight
C_{tb}= Concentration of total PCBs in *L. variegatus* tissue, mg/kg wet weight
L_b= Concentration of lipid in *L. variegatus* tissue, percent of wet weight

A mean of these individual sample values was then calculated for an AOC-specific TTF of 1.5 for total PCBs. Note that PCB residues in fish tissue were identified as Aroclors 1242, and 1254/1260, while those identified in worm tissue were Aroclors 1248 and 1260. To estimate PCB body burden in pelagic fish, this TTF can be applied to the TBP model as follows:

$$TBP_f = (BSAF_b)\ (L_b) \frac{C_s}{TOC}\ (TTF) \qquad (3)$$

Where:

TBP_f= Theoretical bioaccumulation potential extrapolated to pelagic fish, mg/kg wet weight

While this approach does not employ food web modeling, it can be used as a reasonable estimate of pelagic fish bioaccumulation. In addition, it offers several advantages: (1) it is based almost entirely on site-specific data (except for the benthic organism lipid level, every variable in this model is based on measured Buffalo River AOC-specific data); (2) it addresses the site-specific bioavailability of total PCBs; (3) it is less convoluted than the typical relationship of sediment to fish through benthos; and (4) the critical benthic diet component is measured rather than estimated using sediment partitioning relationships (typical for food web bioaccumulation models).

c. Linking sediment concentration to effects-based bioaccumulation in pelagic fish. A simple manipulation of the TBP model extrapolation to pelagic fish can link a total PCB sediment concentration to a given fish body burden toxicity threshold (BBTT) by solving the equation for C_s, substituting PRG_{PCB} for C_s and $BBTT_f$ for TBP_f, yielding:

(4)

$$PRG_{PCB} = \frac{(BBTT_f)\,(TOC)}{(BSAF_b)(L_b)(TTF)}$$

Where:
PRG_{PCB} = Preliminary remediation goal for total PCBs in sediment, mg/kg dry weight
$BBTT_f$ = Body burden toxicity threshold in fish, mg/kg wet weight

In this case, *L. variegatus* was used as the target benthic animal and representative oligochaete worm in AOC sediments. The characteristic average lipid level in *L. variegatus* is about 1% (USAERDC 2009). For TOC, an average calculated level of 23,550 mg/kg in AOC sediments was used. A mean total PCB benthic BSAF of 0.88 for the AOC was used based on *L. variegatus* bioaccumulation experiment data from USAERDC (2003) (Pickard, unpublished data), along with the calculated TTC of 1.5.

Dyer *et al.* (1993) calculated a PCB tissue benchmark for fish (termed "toxic screening concentration" [TSC]) using a critical body-burden concept as follows (Carl Mach, personal communication):

(5)

$$BBTT_f = (FWC_c)\,(BF)\,(CF)$$

Where:
FWC_c = Federal chronic freshwater criterion for total PCBs in water, µg/L
BF = Average water-to-fish bioaccumulation factor
CF = Conversion factor of 1/1000 to convert µg to mg

A total PCB FWC_c of 0.014 ug/L, BF of 31,200 L/kg and CF of 1000 produces a $BBTT_f$ of 0.44 mg/kg. Based on this $BBTT_f$, a total PCB PRG of 0.79 mg/kg is yielded using Equation 4. This model could also be used to link a fish tissue concentration that is protective of pisciverous wildlife (such as mink or kingfisher) to a sediment concentration. For example, a total PCB PRG of 0.18

mg/kg is produced based on a 0.1 mg/kg total PCB concentration in whole fish that is protective of birds and animals (U.S. Environmental Protection Agency [USEPA] 2007). If a TTF of 1.33 relative to pumpkinseed sunfish (*Lepomis gibbosus*) is used in concert with the same benchmark tissue level of 0.1 mg/kg in fish, this translates to a total PCB PRG of 0.2 mg/kg that is protective of birds and mammals.

3. In summary, extrapolation of a benthic bioaccumulation model to pelagic fish using a TTF and site-specific data can be used to estimate ecologically relevant threshold sediment concentrations in fish and wildlife.

4. The POC in this matter is the undersigned, who can be reached at extension 4404.

SCOTT W. PICKARD
Ecologist

CF:
CELRB-TD-EA
CELRB-TD-EH
CELRB-PM-PB

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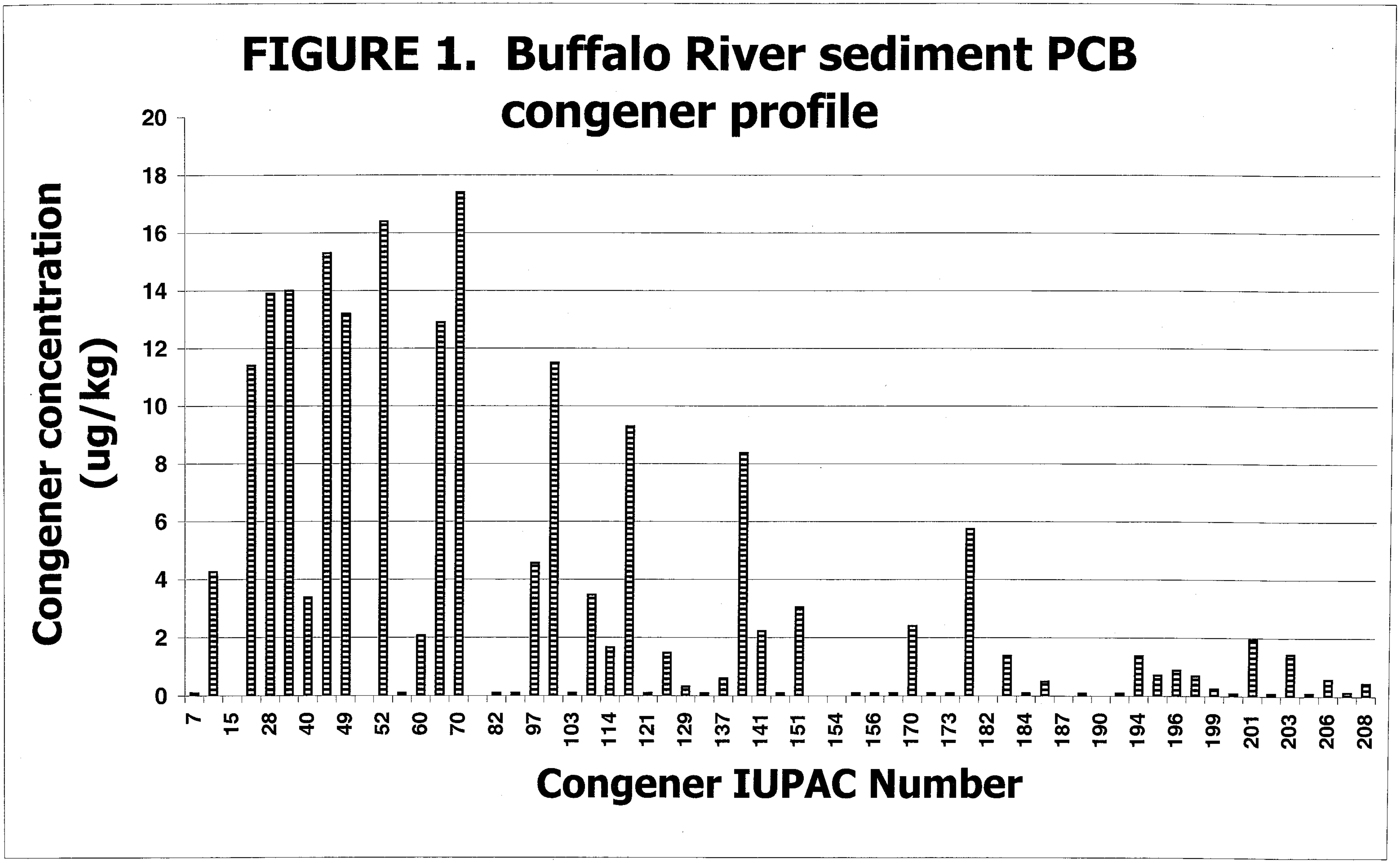
FIGURE 1. Buffalo River sediment PCB congener profile
Congener concentration (ug/kg)
0
2
4
6
8
10
12
14
16
18
20
7
15
28
40
49
52
60
70
82
97
103
114
121
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184
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199
201
203
206
208
Congener IUPAC Number

Appendix A4
Mercury and Lead PRG Memorandum

ENVIRON

March 12, 2009

MEMORANDUM

To: Ecology Technical Subgroup

From: Mary Sorensen, Darrel Lauren, and Jen Lyndall

Re: Preliminary Remedial Goals (PRGs) for Mercury and Lead with a Streamlined Risk Evaluation for Exposed Wildlife at the Buffalo River AOC

Executive Summary

The Ecology Subgroup (Eco-Group) of the Great Lakes Legacy Act Buffalo River Project Coordination Team has collaborated on efforts to identify preliminary remedial goals (PRGs)[1] of contaminants in sediments for use in the Buffalo River Feasibility Study (FS). This memorandum (memo) is focused on mercury and lead and the fish tissue concentrations considered relevant as a basis of PRGs for Buffalo River.

This memo briefly describes the approach used for the development of sediment PRGs for mercury and lead based on target fish tissue and sediment concentrations that are protective of wildlife. The approach described herein is conservative but consistent with approaches discussed during weekly Eco-Group calls, including those already presented for polychlorinated biphenyls (PCBs) (ENVIRON 2009a). Several tables are provided to support this memo and Attachment 1 provides the electronic excel workbook of these tables in a calculational format. Supporting data used in the calculations are provided as linked worksheets to facilitate review by the Eco-Group. This memo will be included as an appendix to the Buffalo River FS report, along with supporting documentation.

Risk-based assessments were done to demonstrate that current average sediment mercury and lead concentrations in surface sediment throughout most of the Buffalo River are likely to be below levels that would result in adverse impacts to wildlife. Sediment toxicity testing results from 2005 and 2007 were also included in this analysis (USACE 2009 and CSC 2009). Based on the evaluation of data, the PRGs for mercury and lead reflect the current surface-weighted average mercury sediment concentrations so that average concentrations following the remedial action do not results in significant long term increases in surficial concentrations of mercury and lead. The ranges of mercury and lead PRGs described herein are as follows:

- Mercury: 0.41 mg/kg to 0.54 mg/kg based on average conditions which are well below the USEPA and NYSDEC fish tissue criterion
- Lead: 73 mg/kg to 103 mg/kg based on average conditions and 320 mg/kg for protective estimates of average exposures to avian species that may incidentally ingest sediment.

[1] The acronym PRG may be used interchangeably with remedial target concentration (RTC) indicating the targets being evaluated for use in the FS. Actual remedial goals will be identified in the FS.

Mercury PRG Development Approach

The lines of evidence considered by the Eco-Group to establish the Buffalo River mercury PRG were:

- NYSDEC 2007 fish tissue study showing maximum and average fish tissue concentrations at or below the USEPA and NYSDEC fish tissue criterion of 0.5 and 0.3 mg mercury/kg (wet weight), respectively
- Buffalo River sediment toxicity testing showing a no effects concentration (NOEC) at 0.43 mg mercury/kg sediment
- Current Buffalo River sediment mercury concentrations, as reflected by the 95 percent upper confidence limits (UCLs)

Mercury Fish Tissue Residues in the Buffalo River

NYSDEC (Pers. Comm. 2009) has identified USEPA's (1995) fish tissue criterion of 0.5 mg/kg wet weight as the criterion for consideration of PRGs for the Buffalo River. The available whole fish tissue concentrations of mercury collected by NYSDEC in 2007 are presented in Figure 1. Fish species collected included blunt-nose minnow, round goby, pumpkinseed sunfish, yellow perch, brown bullhead, large mouth bass, and carp. Fish sizes ranged from 8 to 7,350 grams (wet weight). Small fish (i.e., less than 50 g), and all fish had geometric mean mercury contents of 0.034, and 0.06 mg/kg wet weight, respectively (Table 1). The maximum mercury fish tissue concentration from any size fish was 0.24 mg/kg. These results show that the maximum tissue concentrations seen in the Buffalo River are lower than the NYSDEC and USEPA fish tissue criterion identified for Buffalo River (0.5 mg/kg wet weight based on USEPA Great Lakes Initiative, 1995). Given that the maximum fish tissue concentration is half the NYSDEC value and that the average mercury fish tissue concentrations are more than an order of magnitude below the fish tissue concentration, these results indicate that current conditions in the surface sediment of Buffalo River are on average below levels that would pose an adverse impact to wildlife.

Sediment Toxicity Testing Study

Sediment toxicity testing results from 2005 and 2007 were included in this analysis (USACE 2009 and CSC 2009). The USACE reported an unbounded NOEC of 0.43 mg total mercury/kg sediment on the basis of bioassays conducted in 2005 with *Hyalella azteca* and *Chironomus tentans*. Several higher NOECs from controlled and field toxicity tests have also been reported in the literature as was discussed in detail in the *Sediment Remedial Investigation Report [SRIR]* (ENVIRON and MacTec 2009). In the only study of mercury toxicity alone, Sferra et al. (1999) reported an NOEC of 3.8 mg total mercury/kg in spiked sediment bioassays with *H. azteca*. These additional studies support the conclusion that the USACE NOEC is an appropriate and conservative PRG for the Buffalo River. Toxicity testing conducted in 2007 indicated benthic impairment due to sediment mercury concentrations is possible; however, it was noted that the highest concentrations of mercury from this analysis were based on samples collected deep in the sediment column, below the average current depth where exposures might be expected for wildlife. The concentrations seen in the 2007 toxicity testing samples were well above those no effect concentrations identified in the *SRIR*. CSC performed a concentration-response analysis and reported that mercury PRGs ranged from 0.33 mg/kg to 0.85 mg/kg.

Buffalo River Mercury 95% Upper Confidence Limits

Surface-weighted average mercury sediment concentrations were used to identify current conditions in the Buffalo River. Average conditions were defined as the upper confidence limit of the mean (i.e., 95% UCL). Figure 2 shows data distributions and average estimates using the full data set organized by river mile (Figure 2a) and by decreasing concentrations (Figure 2b). Figure 2c shows the data frequency distribution in increasing concentrations wherein the 95% UCL estimates are based on values excluded from the database if they exceeded the 75th percentile or 95% UCL. The adjusted mercury UCLs, which reflect current conditions of fish tissue concentrations in a range that do not pose adverse effects to wildlife, range from 0.41 mg/kg to 0.54 mg/kg.

Lead PRG Development Approach

Three lines of evidence are available to establish the Buffalo River lead PRG:

- Buffalo River sediment toxicity testing showing a NOEC at 0.85 mg mercury/kg sediment
- Current Buffalo River sediment lead concentrations, as reflected by the 95% UCL
- A risk-based evaluation of fish ingestion for mink and kingfisher
- A risk-based evaluation of worm and incidental sediment ingestion for ducks

Sediment Toxicity Testing Study NOEC

The USACE 2009 reported an unbounded NOEC of 85 mg lead/kg sediment on the basis of bioassays conducted in 2005 with *Hyalella azteca* and *Chironomus tentans*. Several higher no effect concentrations from controlled toxicity tests have also been reported in the literature as was discussed in detail in the *SRIR* (ENVIRON and MacTec 2009). These additional studies support the conclusion that the USACE designated NOEC is a conservative but appropriatevalue that can be considered a PRG for the Buffalo River.

Buffalo River Lead 95% Upper Confidence Limits

Surface-weighted average lead sediment concentrations were used to identify current conditions in the Buffalo River in a manner consistent with that described for mercury. Figure 3 shows data distributions and average estimates using the full data set organized by river mile (Figure 3a) and by decreasing concentrations (Figure 3b). Figure 3c shows the data frequency distribution in increasing concentrations wherein 95% UCL estimates are based values excluded from the database if the exceeded the 75th percentile or 95% UCL. The adjusted lead 95% UCLs range from 73 mg/kg to 103 mg/kg.

Risk-Based Evaluation of Fish Ingestion for Mink and Kingfisher

The risk-based evaluation focused on the ingestion of fish by mink and kingfishers is consistent with the formulae and approaches presented in the PCB PRG memorandum (ENVIRON 2009a). Each of the exposure parameter estimates are identical to those already described in the PCB memo, and thus this detail is not repeated herein. The difference in the evaluation is based on site-specific exposure concentrations for lead measured in fish tissues (Table 2) and the toxicity reference value (TRVs) for lead. Associated data and spreadsheets used in the calculations are provided in Attachment 1. The two TRVs used in the analyss are those identified by NYSDEC (Pers. Comm. 2009) and USEPA (2005). Because lead does not bioaccumulate in fish tissues, the PRGs associated with mink and kingfisher are greater than 500 mg/kg of lead (Table 3) based on estimates identified in Table 4. Table 5 provides a risk-based evaluation of current conditions in the Buffalo River and shows that hazard quotient (HQs) are well below the USEPA threshold value of 1 considered protective of wildlife.

Risk-Based Evaluation of Worm and Incidental Sediment Ingestion for Ducks

Due to concerns raised by stakeholders at the Eco-Group meeting in Buffalo NY on January 16, 2009, consideration was given to potential receptors more likely to come in direct contact to sediment, such as an American wood duck. While much of the Buffalo River is beyond a depth that dabbling ducks might be exposed, this analysis was considered because concerns were raised about such hypothetical receptors. Results are presented in Tables 3, 4, and 5 showing that current conditions yield HQ below the USEPA threshold value of 1 considered protective of wildlife. PRGs were calculated using a variety of scenarios that reflect the use of NYSDEC and USEPA TRVs and various calculational methods, as described in the tables and Attachment 1. The primary difference among methods was consideration of 100% bioavailablity of sediment ingested versus a more realistic bioavailability estimate of 35% (this applies to incidental sediment ingestion and assimilation which is well documented to be less than 100%). The range of PRGs derived using these estimates and the USACE defined approach for linking sediment and worms via a bioaccumulation model presented in Attachment 1 is 185 mg/kg to 495 mg/kg with an average of 185 mg/kg.

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Table 1: Mercury in Fish Tissues from Buffalo River

LABNO	TAGNO	SPP	SDATE	LOCATION	PREP	LENMM	WGTG	PROGRAM	TISSUEWGTG	g wet weight	Whole Body All/Zone	Whole Body Small/Zone	mg/kg Wwt	Hg Wwt All/Zone	Hg Wwt Small/Zone
07-0038-H	346	RGOBY	20071002	INNER HARBOR	W		8	BUFFALO R-2007		8			0.012		
07-0037-H	437	RGOBY	20070927		W		16	BUFFALO R-2007		16			0.027		
07-0036-H	416	RGOBY	20070927		W		20	BUFFALO R-2007		20	NA	13.7	0.0194	0.018	0.018
07-0050-W	387	PKSD	20071002	ZONE 1- SHIP CANAL	W	127	33	BUFFALO R-2007	35.4	35.4			0.0476		
07-0047-W	334	PKSD	20071002		W	128	40	BUFFALO R-2007	35.2	35.2			0.0166		
07-0049-W	343	PKSD	20071002		W	130	42	BUFFALO R-2007	35.2	35.2			0.0231		
07-0044-W	371	BB	20071002		W	230	270	BUFFALO R-2007	152	270			0.0126		
07-0040-W	327	LMB	20071002		W	315	325	BUFFALO R-2007	462	325			0.11		
07-0042-W	311	LMB	20071002		W	290	350	BUFFALO R-2007	330	350			0.101		
07-0043-W	305	LMB	20071002		W	300	430	BUFFALO R-2007	430	430			0.118		
07-0041-W	386	LMB	20071002		W	295	450	BUFFALO R-2007	305	450			0.0747		
07-0039-W	339	LMB	20071002		W	450	1500	BUFFALO R-2007	1543	1500			0.217		
07-0056-W	396	YP	20071002		W	195	90	BUFFALO R-2007	76.8	90			0.0492		
07-0045-W	389	BB	20071002		W	362	520	BUFFALO R-2007	588	520			0.0469		
07-0055-W	373	CARP	20071002		W	621	3700	BUFFALO R-2007	3470	3700			0.0695		
07-0053-W	352	CARP	20071002		W	653	4500	BUFFALO R-2007	4245	4500			0.121		
07-0054-W	314	CARP	20071002		W	670	4900	BUFFALO R-2007	4745	4900			0.100		
07-0051-W	379	CARP	20071002		W	689	6180	BUFFALO R-2007	6080	6180			0.0741		
07-0052-W	388	CARP	20071002		W	768	7350	BUFFALO R-2007	7190	7350	548.85	35.27	0.117	0.064	0.026
07-0063-W	384	PKSD	20071001	ZONE 2- RM 1.5-2.2	W	132	40	BUFFALO R-2007	37.6	37.6			0.0842		
07-0062-W	341	PKSD	20071001		W	132	46	BUFFALO R-2007	41.9	41.9			0.0304		
07-0060-W	378	PKSD	20071001		W	155	70	BUFFALO R-2007	66.8	66.8			0.0639		
07-0057-H	398A	BNOSE	20071001		W		73	BUFFALO R-2007		73			0.0317		
07-0058-H	398B	BNOSE	20071001		W		73	BUFFALO R-2007		73			0.0253		
07-0069-W	333	YP	20071001		W	210	104	BUFFALO R-2007	100.3	104			0.0573		
07-0071-W	391	BB	20071001		W	253	226	BUFFALO R-2007	211	226			0.0198		
07-0066-W	377	LMB	20071001		W	282	352	BUFFALO R-2007	334	352			0.134		
07-0068-W	330	LMB	20071001		W	290	404	BUFFALO R-2007	379	404			0.164		
07-0067-W	392	LMB	20071001		W	301	428	BUFFALO R-2007	417	428			0.177		
07-0065-W	394	LMB	20071001		W	315	532	BUFFALO R-2007	484	532			0.19		
07-0064-W	399	LMB	20071001		W	367	872	BUFFALO R-2007	793	872			0.244		
07-0070-W	390	YP	20071001		W	169	60	BUFFALO R-2007	54.4	54.4			0.044		
07-0072-W	376	BB	20071001		W	240	202	BUFFALO R-2007	187	202	153.66	39.69	0.0994	0.073	0.051
07-0074-W	443	PKSD	20070927	ZONE 3 RM 3.2-5.3	W	122	32	BUFFALO R-2007	30.4	30.4			0.0728		
07-0084-W	426	YP	20070927		W	159	41.5	BUFFALO R-2007	41.9	41.9			0.0889		
07-0075-W	428	PKSD	20070927		W	137	47.5	BUFFALO R-2007	43.3	43.3			0.111		
07-0088-W	372	YP	20070927		W	161	49	BUFFALO R-2007	54.2	54.2			0.0735		
07-0087-W	432	YP	20070927		W	176	64	BUFFALO R-2007	61.5				0.0725		
07-0076-W	454	PKSD	20070927		W	154	72.5	BUFFALO R-2007	69.7	69.7			0.157		
07-0073-H	441	BNOSE	20070927		W		84	BUFFALO R-2007		84			0.0205		
07-0085-W	445	YP	20070927		W	203	100	BUFFALO R-2007	98.4	100			0.0744		
07-0086-W	433	YP	20070927		W	219	135	BUFFALO R-2007	107.6	135			0.0536		
07-0083-W	382	LMB	20070927		W	206	140	BUFFALO R-2007	118	140			0.105		
07-0091-W	440	BB	20070927		W	220	156	BUFFALO R-2007	137	156			0.0959		
07-0090-W	431	BB	20070927		W	238	195	BUFFALO R-2007	170				0.0807		
07-0079-W	430	LMB	20070927		W	302	225	BUFFALO R-2007	389	225			0.18		
07-0092-W	434	BB	20070927		W	265	225	BUFFALO R-2007	206	225			0.0152		
07-0089-W	438	BB	20070927		W	290	290	BUFFALO R-2007	268	290			0.0546		
07-0093-W	436	BB	20070927		W	275	329	BUFFALO R-2007	280	329			0.208		
07-0081-W	435	LMB	20070927		W	220	330	BUFFALO R-2007	318	330			0.173		
07-0080-W	427	LMB	20070927		W	280	360	BUFFALO R-2007	347	360			0.112		
07-0082-W	444	LMB	20070927		W	319	500	BUFFALO R-2007	588	500			0.178		
07-0096-W	381	CARP	20070927		W	580	3200	BUFFALO R-2007	3211	3200			0.119		
07-0094-W	338	CARP	20070927		W	615	3300	BUFFALO R-2007	3280	3300			0.129		
07-0095-W	308	CARP	20070927		W	618	4050	BUFFALO R-2007	3880	4050			0.0794		
07-0097-W	383	CARP	20070927		W	632	4150	BUFFALO R-2007	3950	4150	251.73	9.52	0.105	0.088	0.022
07-0105-W	411	PKSD	20070925	ZONE 4- RM 5.3-6.3	W	135	47	BUFFALO R-2007	42.7	42.7			0.084		
07-0103-W	407	PKSD	20070925		W	135	48	BUFFALO R-2007	44	44			0.0714		
07-0106-W	412	PKSD	20070925		W	130	48	BUFFALO R-2007	44.4	44.4			0.0841		
07-0109-W	415	LMB	20070925		W	271	250	BUFFALO R-2007	242	250			0.154		
07-0111-W	402	LMB	20070925		W	280	310	BUFFALO R-2007	289	310			0.19		
07-0112-W	418	LMB	20070925		W	295	320	BUFFALO R-2007	316	320			0.102		**RM 5.3-6.3**
07-0108-W	419	LMB	20070925		W	299	390	BUFFALO R-2007	390	390			0.122		**Upper River**
07-0110-W	409	LMB	20070925		W	294	410	BUFFALO R-2007	394	410			0.114		
07-0102-W	414	CARP	20070925		W	602	3300	BUFFALO R-2007	3170	3300			0.0514		
07-0099-W	403	CARP	20070925		W	615	3800	BUFFALO R-2007	3530	3800			0.0986		
07-0101-W	406	CARP	20070925		W	684	4810	BUFFALO R-2007	4600	4810			0.0597		
07-0098-W	410	CARP	20070925		W	652	5000	BUFFALO R-2007	4790	5000			0.111		
07-0100-W	405	CARP	20070925		W	750	6290	BUFFALO R-2007	6020	6290	567.105	43.694	0.19	0.102	0.080
		AOC-Wide Geometric Mean=								**281.0**	**331.2**	**24.0**	**0.076**	**0.060**	**0.034**
		AOC Maximum											**0.244**		

Table 2: Lead in Fish Tissues from Buffalo River

Zone	Species	BW g wet weight	All Fish	Small Fish	[Pb] ug/kg Wwt	All Fish	Small Fish	% Water		[Pb] ug/kg Dwt	All Fish	Small Fish
Inner Harbor	RG	20			82			77.7		367.7		
		16			140			79		666.7		
		8	NA	13.7	190	NA	129.7	81.38	137.3	1020.4	NA	630.1
Zone 1- Ship Canal	BB	152			110			75.8		454.5		
		588			114			67		345.5		
	Carp	6080			45			58.6		108.7		
		7190			83.8			65.2		240.8		
		4245			196			64.6		553.7		
		4745			32.8			61.6		85.4		
		3470			71.5			58.5		172.3		
	LMB	1543			9.25			70.9		31.8		
		462			12			73.5		45.3		
		305			4.64			75.2		18.7		
		330			16.2			75.1		65.1		
		430			10.6			73.8		40.5		
		42.3			66.1			75.5		269.8		
		35.2			68.1			77.4		301.3		
		40.1			98.9			76.1		413.8		
	YP	76.8	529.9	39.1	47.6	39.9	76.4	76.8	61.7	205.2	137.5	322.8
Zone 2 RM 1.5-2.2	BNM	73			810			77.21		3554.2		
		73			930			77.42		4118.7		
	BB	211			339			69.2		1100.6		
		187			153			72.7		560.4		
	LMB	793			32.2			74.8		127.8		
		484			24.5			74.1		94.6		
		334			25.8			73.7		98.1		
		417			10.7			73.3		40.1		
		379			18.1			74.1		69.9		
	PkS	66.78			119			74.9		474.1		
		41.9			121			73.7		460.1		
		37.6			93.9			76.2		394.5		
	YP	100.3			101			75.4		410.6		
		54.4	148.1	NA	24.7	81.0	107	75.7	200.2	101.6	317.9	NA
Zone 3- RM 3.2-5.3	BNM	84			480			76.39		2033.0		
	BB	268			331			79.3		1599.0		
		170			93.5			75.4		380.1		
		137			98.3			77		427.4		
		206			83.6			76.6		357.3		
		280			248			74.9		988.0		
	Carp	3280			186			69.2		603.9		
		3880			98.6			62.9		265.8		
		3210			185			51.8		383.8		
		3950			132			62		347.4		

Table 2: Lead in Fish Tissues from Buffalo River

Zone	Species	BW g wet weight	All Fish	Small Fish	[Pb] ug/kg Wwt	All Fish	Small Fish	% Water		[Pb] ug/kg Dwt	All Fish	Small Fish
	LMB	389			14			72.2		50.4		
		347			10.6			74.3		41.2		
		318			14.4			74.8		57.1		
		588			38.1			73.8		145.4		
		118			19.4			74		74.6		
	PkS	30.4			368.0			76.7		1579.4		
		43.3			119.0			76.1		497.9		
		68.77			115			75.4		467.5		
	YP	41.9			196			NA		NA		
		98.4			64.3			NA		NA		
		107.6			130			NA		NA		
		61.5			80.4			NA		NA		
		54.2	770.916087	41.9	228	144.9217391	196	NA	144.9	NA	572.1819937	151.7
Zone 4- RM 5.3-6.3	Carp	3790			99.9			63.3		272.2		
		3530			107			75.3		433.2		
		6020			115			77		500.0		
		4600			72.5			63.4		198.1		
		3170			82.1			69.1		265.7		
	LMB	390			43			75.8		177.7		
		242			31.8			72.5		115.6		
		394			51.6			73.1		191.8		
		289			32.4			72.2		116.5		
		316			45.9			74.3		178.6		
	PkS	44			167			76.2		701.7		
		42.7			260			75.5		1061.2		
		44.4	540.1	43.7	163.0	79.9	192.0	76.7	97.8	699.6	295.8	804.6

	BW g	[Pb] ug/kg Wwt	Water %	[Pb] ug/kg Dwt
AOC-Wide Geomean=	264.9	73.8	72.5	268.1
Small Fish AOC-Wide Geomean=	29.9	136.3	77.1	595.0

Table 3: Lead PRG Summary Matrix (a)

Scenario	Basis (b)	AUF (c)	Biota in Diet % (d)	Sediment Bioavailability (e)	HQ (f)	TRV Basis (g)	[Fish] mg/kg, wwt	[INV] mg/kg wwt	SD PRG mg/kg
Mink 1a	Fish Estimated	100	50	100	1	NYSDEC	25	NA	5926
Mink 1b	Estimated	100	90	100	1	NYSDEC	14	NA	3259
Mink 2a	Fish Estimated	100	50	100	1	USEPA	48	NA	11259
Mink 2b	Fish Estimated	100	90	100	1	USEPA	28	NA	6519
Kingfisher 3a	Fish Estimated	100	100	100	1	NYSDEC	4	NA	948
Kingfisher 3b	Fish Estimated	100	100	100	1	USEPA	3	NA	593
Duck 4a	INV Estimated	100	100	100	1	USEPA	NA	4.0	106
Duck 4b	SD Estimated	100	100	100	1	NYSDEC	NA	NA	400
Duck 4c	SD Estimated + mean INV	100	100	100	1	USEPA	NA	1.65	160
Duck 4d	SD Estimated	100	100	35	1	NYSDEC	NA	NA	1125
Duck 4e	SD Estimated + mean INV	100	100	35	1	NYSDEC	NA	8.26	850
Duck 4f	SD Estimated	100	100	35	1	USEPA	NA	NA	770
Duck 4g	SD Estimated + mean INV	100	100	35	1	USEPA	NA	8.26	490
Duck 5a	SD Estimated	100	100	100	1	USEPA	NA	7.0	185
Duck 5b	SD Estimated	100	100	100	1	NYSDEC	NA	10.42	275
Duck 5c	SD Estimated	100	100	35	1	NYSDEC	NA	12.69	335
Duck 5d	SD Estimated	100	100	35	1	USEPA	NA	18.75	495
				Minimum Duck Scenario 5 (USACE Approach)				7.01	**185**
				Maximum Duck Scenario 5 (USACE Approach)				18.8	**495**
				Average Duck Scenario 5 (USACE Approach)				12.2	**323**

Notes:

(a) The scenarios and detailed formulate and calculated values are provided in Table 2.

(b) Estimated medium; Fish, Sediment (SD), or Invertebrates (INV).

(c) AUF = 100% for all receptors.

(d) Diet is based on NYSDEC request (90%) or those average estimates based on NYSDEC (1987) wildlife narrative. 50% fish in diet is considered a conservatively high level that is biologically relevant (NYSDEC 1987).

(e) Sediment [Pb] adjusted for relative bioavailability of lead sulfide vs. lead acetate (Dieter et al. 1993; Davis et al. 1992; Ruby et al. 1992)

(f) HQ was set equal to 1 for all scenarios.

(g) NYSDEC TRVs and USEPA Eco-SSL (2005) TRVs

%	Percent
AOC	Area of Concern
AUF	Area Use Factor
BR	Buffalo River
BSAF	Biota-Sediment Accumulation Factor
HQ	Hazard Quotient
mg/kg	Milligram per Kilogram
NYSDEC	New York State Department of Environmental Conservation
PRG	Preliminary Remediation Goal
SD	Sediment
wwt	Wet Weight
INV	Invertebrate
(purple)	Wet Weight Fish Tissue Concentrations
(pink)	Sediment PRG

Table 4: Lead Sediment PRGs Estimates

Sediment PRGs Estimated Based on Mink Consumption of Fish Tissue Concentrations That Yield an HQ = 1

Scenario 1a. HQ=1; diet of 50% fish; NYSDEC TRV							100% AUF (a)	60% AUF (b)
Mink	BW (g)	IR (kg/kg/d)	[Fish] mg/kg	[Invertebrate] mg/kg	Total Dose (mg/kg/d)	TRV (mg/kg-BW-d)	**HQ**	HQ
(50% fish, 100% AUF, AOC BSAF)	1000	0.049	100	8.3	2.55	2.5	**1**	0.6
all fish are 75% water			25.000	mg wwt fish				
All AOC BSAF		0.0042						
PRG			5926	mg/kg				

Scenario 1b. HQ=1; 100% AUF; diet of 90% fish; NYSDEC TRV							100% AUF (a)	60% AUF (b)
Mink	BW (g)	IR (kg/kg/d)	[Fish] mg/kg	[Invertebrate] mg/kg	Total Dose (mg/kg/d)	TRV (mg/kg-BW-d)	**HQ**	HQ
(90% fish, 100% AUF, AOC BSAF)	1000	0.049	55	8.3	2.41	2.5	**1**	0.6
all fish are 75% water			13.750	mg wwt fish				
All AOC BSAF		0.0042						
PRG			3259	mg/kg				

Scenario 2a. HQ=1 assuming 100% AUF; diet 50% fish; USEPA TRV							100% AUF (a)	60% AUF (b)
Mink	BW (g)	IR (kg/kg/d)	[Fish] mg/kg	[Invertebrate] mg/kg	Total Dose (mg/kg/d)	TRV (mg/kg-BW-d)	**HQ**	HQ
(50% fish, 60% AUF, BR BSAF)	1000	0.049	190.00	8.3	4.74	4.7	**1**	0.6
all fish are 75% water			47.500	mg wwt fish				
BR BSAF		0.0042						
PRG			11259	mg/kg				

Scenario 2b. HQ=1 assuming 100% AUF; diet 90% fish; USEPA TRV							100% AUF (a)	60% AUF (b)
Mink	BW (g)	IR (kg/kg/d)	[Fish] mg/kg	[Invertebrate] mg/kg	Total Dose (mg/kg/d)	TRV (mg/kg-BW-d)	**HQ**	HQ
(90% fish, 60% AUF, BR BSAF)	1000	0.049	110	8.3	4.81	4.7	**1**	0.6
all fish are 75% water			27.500	mg wwt fish				
BR BSAF		0.0042						
PRG			6519	mg/kg				

Scenario 3a. HQ=1; 100% AUF; diet of 100% fish; NYSDEC TRV							100% AUF (a)
Kingfisher	BW (g)	IR (kg/kg/d)	[Fish] mg/kg	[Invertebrate] mg/kg	Total Dose (mg/kg/d)	TRV (mg/kg-BW-d)	**HQ**
(50% fish, 100% AUF, AOC BSAF)	150	0.157	16.00	0.0	2.51	2.4	**1**
all fish are 75% water			4.000	mg wwt fish			
All AOC BSAF		0.0042					
PRG			948	mg/kg			

Scenario 3b. HQ=1; 100% AUF; diet of 100% fish; USEPA TRV							100% AUF (a)
Kingfisher	BW (g)	IR (kg/kg/d)	[Fish] mg/kg	[Invertebrate] mg/kg	Total Dose (mg/kg/d)	TRV (mg/kg-BW-d)	**HQ**
(50% fish, 100% AUF, AOC BSAF)	150	0.157	10.00	0.0	1.57	1.63	**1**
all fish are 75% water			2.500	mg wwt fish			
All AOC BSAF		0.0042					
PRG			593	mg/kg			

Worm and Sediment Ingesting Bird: Risk Calculations for Buffalo River using Site-Specific Information and USEPA TRV

Scenario 4a. Invertebrate HQ=1									100% AUF
American Wood Duck	BW (g)	IR (kg/kg/d)	[Sediment] mg/kg	[Invertebrate] mg/kg	Dose - Invertebrates	Dose - Sediment	Total Dose (mg/kg/d), dwt	TRV (mg/kg-BW-d)	**HQ**
	1500	0.072	43.6	20.00	1.4	0.3	1.71	1.63	**1.0**
all worms are 80% water			4.00	mg wwt worms					
All AOC worm BSAF		0.0379							
PRG			106	mg/kg					

Worm and Sediment Ingesting Bird: Risk Calculations for Buffalo River using Site-Specific Information and NYSDEC TRV

Scenario 4b. Sediment HQ=1									100% AUF
American Wood Duck	BW (g)	IR (kg/kg/d)	[Sediment] mg/kg	[Invertebrate] mg/kg	Dose - Invertebrates	Dose - Sediment	Total Dose (mg/kg/d), dwt	TRV (mg/kg-BW-d)	**HQ**
	1500	0.072	400.0	0.00	0.000	2.4	2.43	2.4	**1.0**

Worm and Sediment Ingesting Bird: Risk Calculations for Buffalo River using Site-Specific Information and USEPA TRV

Scenario 4c. Sediment + Invertebrate HQ=1									100% AUF
American Wood Duck	BW (g)	IR (kg/kg/d)	[Sediment] mg/kg	[Invertebrate] mg/kg	Dose - Invertebrates	Dose - Sediment	Total Dose (mg/kg/d), dwt	TRV (mg/kg-BW-d)	**HQ**
	1500	0.072	160.0	8.26	0.597	1.0	1.57	1.63	**1.0**

Table 4: Lead Sediment PRGs Estimates

Worm and Sediment Ingesting Bird: Risk Calculations for Buffalo River using Site-Specific Information and NYSDEC TRV									35% Bioavail
Scenario 4d. Sediment HQ=1									
American Wood Duck	BW (g)	IR (kg/kg/d)	[Sediment] mg/kg	[Invertebrate] mg/kg	Dose - Invertebrates	Dose - Sediment	Total Dose (mg/kg/d), dwt	TRV (mg/kg-BW-d)	**HQ**
	1500	0.072	1125.0	0.00	0.000	2.4	2.39	2.4	**1.0**

Worm and Sediment Ingesting Bird: Risk Calculations for Buffalo River using Site-Specific Information and NYSDEC TRV									35% Bioavail
Scenario 4e. Sediment + Invertebrate HQ=1									
American Wood Duck	BW (g)	IR (kg/kg/d)	[Sediment] mg/kg	[Invertebrate] mg/kg	Dose - Invertebrates	Dose - Sediment	Total Dose (mg/kg/d), dwt	TRV (mg/kg-BW-d)	**HQ**
	1500	0.072	850.0	8.26	0.597	1.8	2.40	2.4	**1.0**

Worm and Sediment Ingesting Bird: Risk Calculations for Buffalo River using Site-Specific Information and USEPA TRV									35% Bioavail
Scenario 4f. Sediment HQ=1									
American Wood Duck	BW (g)	IR (kg/kg/d)	[Sediment] mg/kg	[Invertebrate] mg/kg	Dose - Invertebrates	Dose - Sediment	Total Dose (mg/kg/d), dwt	TRV (mg/kg-BW-d)	**HQ**
	1500	0.072	770.0	0.00	0.000	1.6	1.63	1.63	**1.0**

Worm and Sediment Ingesting Bird: Risk Calculations for Buffalo River using Site-Specific Information and USEPA TRV									35% Bioavail
Scenario 4g. Sediment + Invertebrate HQ=1									
American Wood Duck	BW (g)	IR (kg/kg/d)	[Sediment] mg/kg	[Invertebrate] mg/kg	Dose - Invertebrates	Dose - Sediment	Total Dose (mg/kg/d), dwt	TRV (mg/kg-BW-d)	**HQ**
	1500	0.072	490.0	8.26	0.597	1.0	1.64	1.63	**1.0**

Worm and Sediment Ingesting Bird: USEPA TRV (USACE Linked SD and Worm Approach)									100% AUF
Scenario 5a. Sediment + Invertebrate HQ=1									
American Wood Duck	BW (g)	IR (kg/kg/d)	[Sediment] mg/kg	[Invertebrate] mg/kg	Dose - Invertebrates	Dose - Sediment	Total Dose (mg/kg/d), dwt	TRV (mg/kg-BW-d)	HQ
BAF = 0.0379	1500	0.072	185	7.01	0.506	1.1	1.63	1.63	1.0

Worm and Sediment Ingesting Bird: NYSDEC TRV (USACE Linked SD and Worm Approach)									100% AUF
Scenario 5b. Sediment + Invertebrate HQ=1									
American Wood Duck	BW (g)	IR (kg/kg/d)	[Sediment] mg/kg	[Invertebrate] mg/kg	Dose - Invertebrates	Dose - Sediment	Total Dose (mg/kg/d), dwt	TRV (mg/kg-BW-d)	HQ
BAF = 0.0379	1500	0.072	275.0	10.42	0.752	1.7	2.42	2.4	1.0

Worm and Sediment Ingesting Bird: USEPA TRV 35% bioavail (USACE Linked SD and Worm Approach)									100% AUF
Scenario 5c. Sediment + Invertebrate HQ=1									
American Wood Duck	BW (g)	IR (kg/kg/d)	[Sediment] mg/kg	[Invertebrate] mg/kg	Dose - Invertebrates	Dose - Sediment	Total Dose (mg/kg/d), dwt	TRV (mg/kg-BW-d)	HQ
BAF = 0.0379	1500	0.072	335	12.69	0.916	0.7	1.63	1.63	1.0

Worm and Sediment Ingesting Bird: NYSDEC TRV 35% bioavail (USACE Linked SD and Worm Approach)									100% AUF
Scenario 5d. Sediment + Invertebrate HQ=1									
American Wood Duck	BW (g)	IR (kg/kg/d)	[Sediment] mg/kg	[Invertebrate] mg/kg	Dose - Invertebrates	Dose - Sediment	Total Dose (mg/kg/d), dwt	TRV (mg/kg-BW-d)	HQ
BAF = 0.0379	1500	0.072	495	18.75	1.354	1.1	2.40	2.4	1.0

Notes:

AOC	Area of Concern
AUF	Area Use Factor
Bioavail	Bioavailability
BSAF	Biota-Sediment Accumulation Factor
BW	Body Weight
dwt	Dry Weight
GLI	Great Lakes Initiative
HQ	Hazard Quotient (rounded to one sig. figure)
IR	Ingestion Rate
kg/kg/d	Kilogram per Kilogram per Day
NYSDEC	NY State Department of Environmental Conservation
(blue)	Exposure Notes
(yellow)	HQ > 1
(green)	HQ ≤ 1
g; mg	Gram or Milligram
mg/kg	Milligram per Kilogram
mg/kg-BW-d	Milligram per Kilogram of Body Weight per Day
OC	Organic Carbon
PRG	Preliminary Remediation Goal
TRV	Toxicity Reference Value
ug/g-OC	Microgram per Gram Organic Carbon
USACE	United States Army Corp of Engineers
USEPA	United States Environmental Protection Division
wwt	Wet Weight
%	Percent
(pink)	Sediment
(purple)	Wet Weight Fish or Worm Tissue Concentrations

Table 5: Lead Wildlife Streamlined Risk Calculations

Kingfisher Risk Calculations for Buffalo River using Site-Specific Information and USEPA TRV

Buffalo River Site-Specific Exposure			Average Fish Tissue Concentration from AOC				100% AUF
Belted Kingfisher	BW (g)	IR (kg/kg/d)	[Fish] mg/kg, dwt	Dose- Fish	Total Dose (mg/kg/d), dwt	TRV (mg/kg-BW-d)	HQ
(Average Exposure)	150	0.157	0.60	0.093	0.09	1.63	0.06

Kingfisher Risk Calculations for Buffalo River using Site-Specific Information and NYSDEC TRV

Buffalo River Site-Specific Exposure			Average Fish Tissue Concentration from AOC				
Belted Kingfisher	BW (g)	IR (kg/kg/d)	[Fish] mg/kg, dwt	Dose- Fish	Total Dose (mg/kg/d), dwt	TRV (mg/kg-BW-d)	HQ
(Average Exposure)	150	0.157	0.60	0.093	0.09	2.4	0.04
						(NYSDEC)	

Mink Risk Calculations for Buffalo River using Site-Specific Information and USEPA TRV

Buffalo River Site-Specific Exposure			90% fish; NYSDEC Request (a)				100% AUF (a)	60% AUF (b)
Mink	BW (g)	IR (kg/kg/d)	[Fish] mg/kg, dwt	[Invertebrate] mg/kg	Total Dose (mg/kg/d), dwt	TRV (mg/kg-BW-d)	HQ	HQ
(90% fish ingestion)	1000	0.049	0.27	8.3	0.01	4.7	0.002	0.001
						(USEPA)		
			50% fish; 30% invertebrates; remainder terrestrial (c)					
Mink	BW (g)	IR (kg/kg/d)	[Fish] mg/kg, dwt	[Invertebrate] mg/kg	Total Dose (mg/kg/d), dwt	TRV (mg/kg-BW-d)	HQ	HQ
(50% fish ingestion)	1000	0.049	0.27	8.3	0.13	4.7	0.03	0.02
						(USEPA)		
			60% fish; 20% invertebrates; remainder terrestrial (d)					
Mink	BW (g)	IR (kg/kg/d)	[Fish] mg/kg, dwt	[Invertebrate] mg/kg	Total Dose (mg/kg/d), dwt	TRV (mg/kg-BW-d)	HQ	HQ
(60% fish ingestion)	1000	0.049	0.27	8.3	0.09	4.7	0.02	0.011

Mink Risk Calculations for Buffalo River using Site-Specific Information and NYSDEC TRV

Buffalo River Site-Specific Exposure			90% fish; NYSDEC Request, not realistic biologically (a)				100% AUF (a)	60% AUF (b)
Mink	BW (g)	IR (kg/kg/d)	[Fish] mg/kg, dwt	[Invertebrate] mg/kg	Total Dose (mg/kg/d), dwt	TRV (mg/kg-BW-d)	HQ	HQ
(90% fish ingestion)	1000	0.049	0.27	8.3	0.01	2.5	0.005	0.003
						(NYSDEC)		
			50% fish; 30% invertebrates; remainder terrestrial (c)					
Mink	BW (g)	IR (kg/kg/d)	[Fish] mg/kg, dwt	[Invertebrate] mg/kg	Total Dose (mg/kg/d), dwt	TRV (mg/kg-BW-d)	HQ	HQ
(50% fish ingestion)	1000	0.049	0.27	8.3	0.13	2.5	0.05	0.03
						(NYSDEC)		
			60% fish; 20% invertebrates; remainder terrestrial (d)					
Mink	BW (g)	IR (kg/kg/d)	[Fish] mg/kg, dwt	[Invertebrate] mg/kg	Total Dose (mg/kg/d), dwt	TRV (mg/kg-BW-d)	HQ	HQ
(60% fish ingestion)	1000	0.049	0.27	8.3	0.09	2.5	0.04	0.02
						(NYSDEC)		

Worm and Sediment Ingesting Bird: Risk Calculations for Buffalo River using Site-Specific Information and USEPA TRV

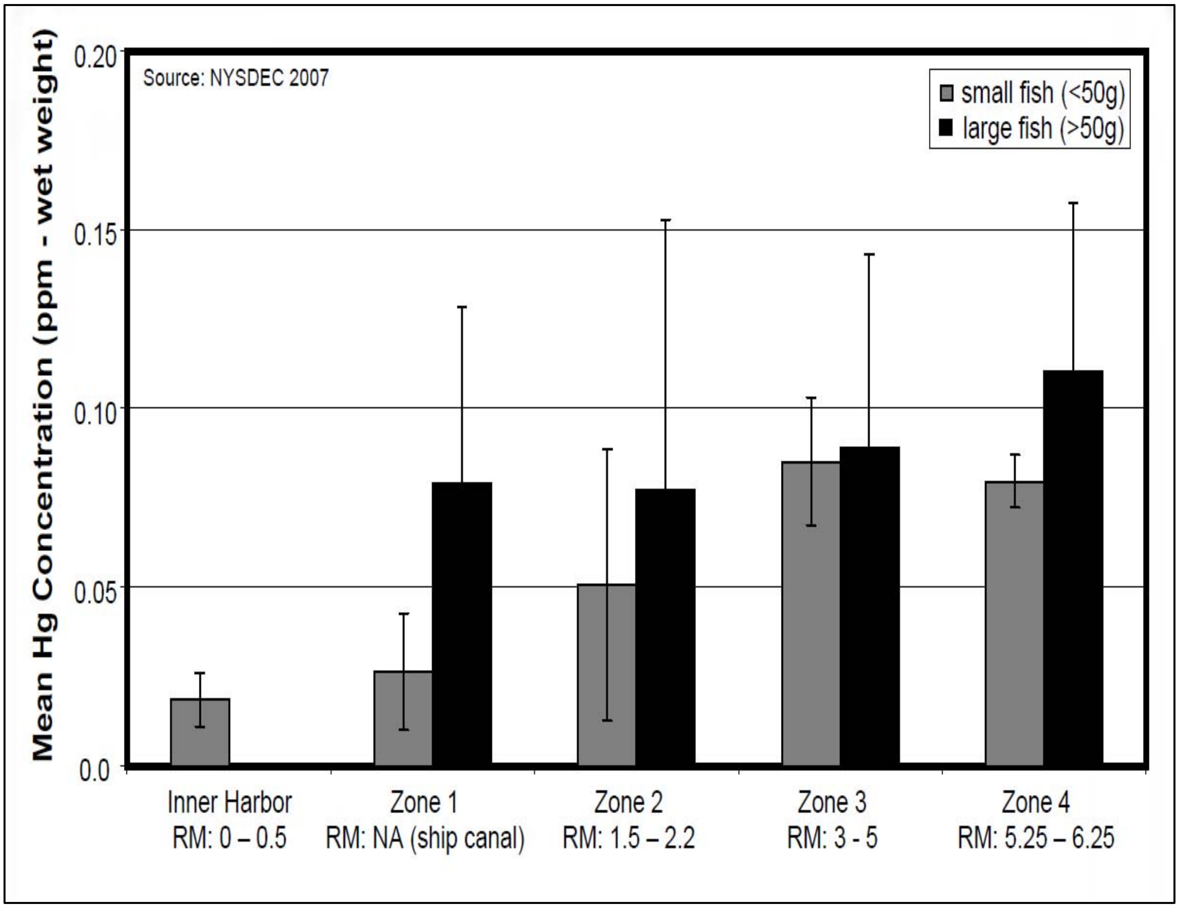
									100% AUF
American Wood Duck	BW (g)	IR (kg/kg/d)	[Sediment] mg/kg	[Invertebrate] mg/kg	Dose - Invertebrates	Dose - Sediment	Total Dose (mg/kg/d), dwt	TRV (mg/kg-BW-d)	HQ
	1500	0.072	43.6	8.26	0.597	0.3	0.86	1.63	0.5

Worm and Sediment Ingesting Bird: Risk Calculations for Buffalo River using Site-Specific Information and NYSDEC TRV

									100% AUF
American Wood Duck	BW (g)	IR (kg/kg/d)	[Sediment] mg/kg	[Invertebrate] mg/kg	Dose - Invertebrates	Dose - Sediment	Total Dose (mg/kg/d), dwt	TRV (mg/kg-BW-d)	HQ
	1500	0.072	43.6	8.26	0.597	0.3	0.86	2.4	0.4

Notes:

%	percent	kg/kg/d	Kilogram per Kilogram per Day
AOC	Area of Concern	mg/kg	Milligram per Kilogram
AUF	Area Use Factor	IR (kg/kg/d)	IR (kg/kg/d)
BW	Body Weight	NYSDEC	New York State Department of Environmental Conservation
dwt	Dry Weight	PRG	Preliminary Remediation Goal
g	Gram	TRV	Toxicity Reference Value
GLI	Great Lakes Initiative	USEPA	United States Environmental Protection Division
IR	Ingestion Rate	wwt	Wet Weight
HQ	Hazard Quotient (rounded to one sig. figure)		
(blue)	Exposure Notes		
(yellow)	HQ > 1		
(green)	HQ ≤ 1		



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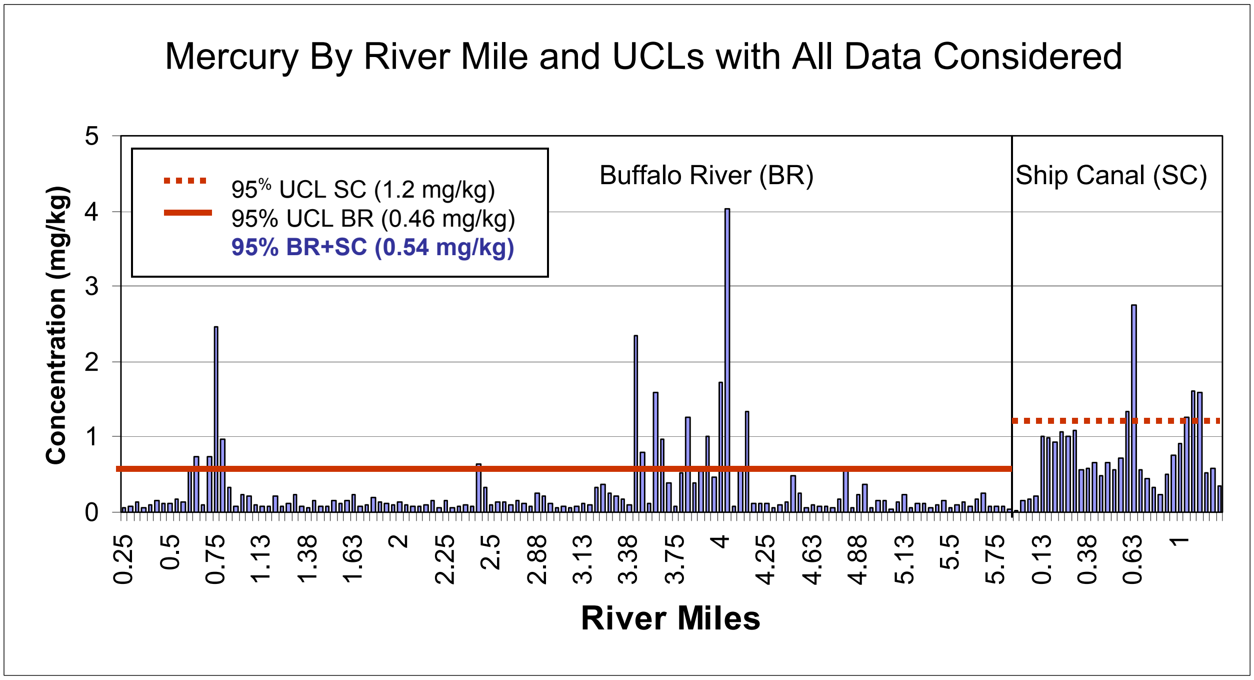
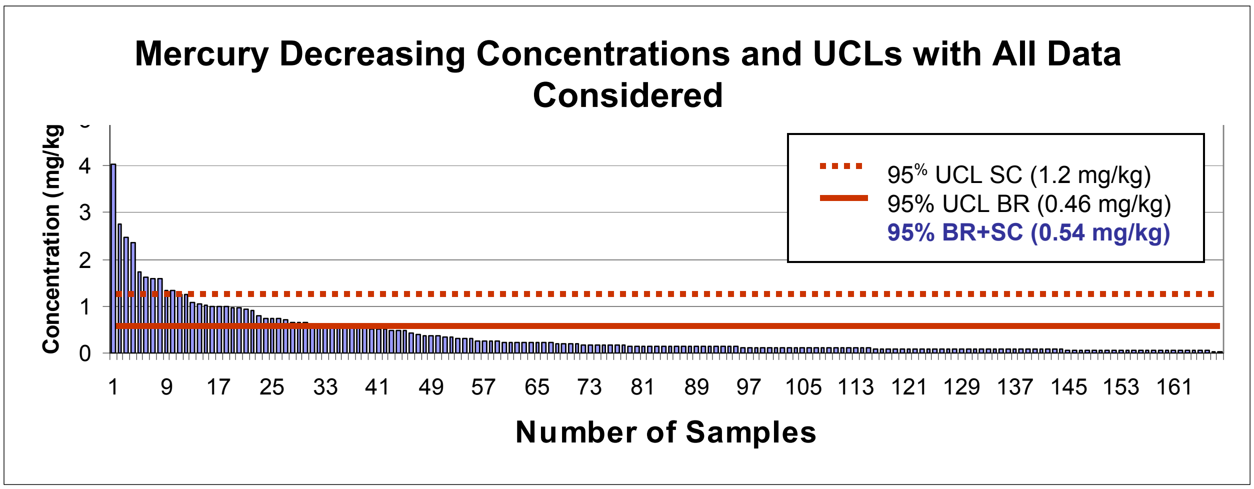
Mercury in Fish from Buffalo River

Figure 1

Figure 2: Mercury Histograms and Average Conditions in the River





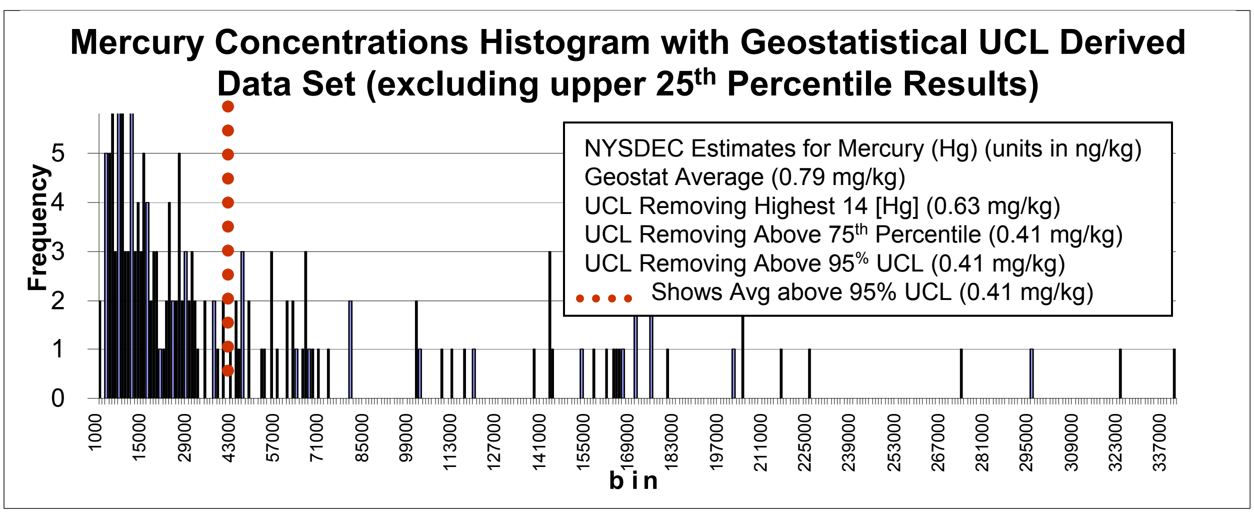
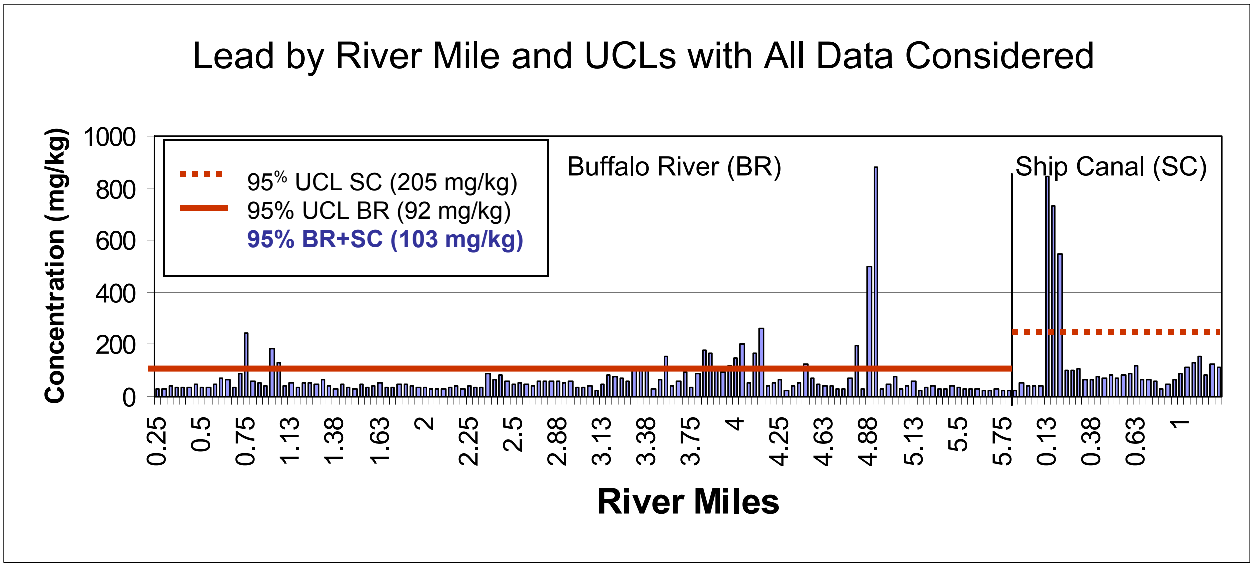
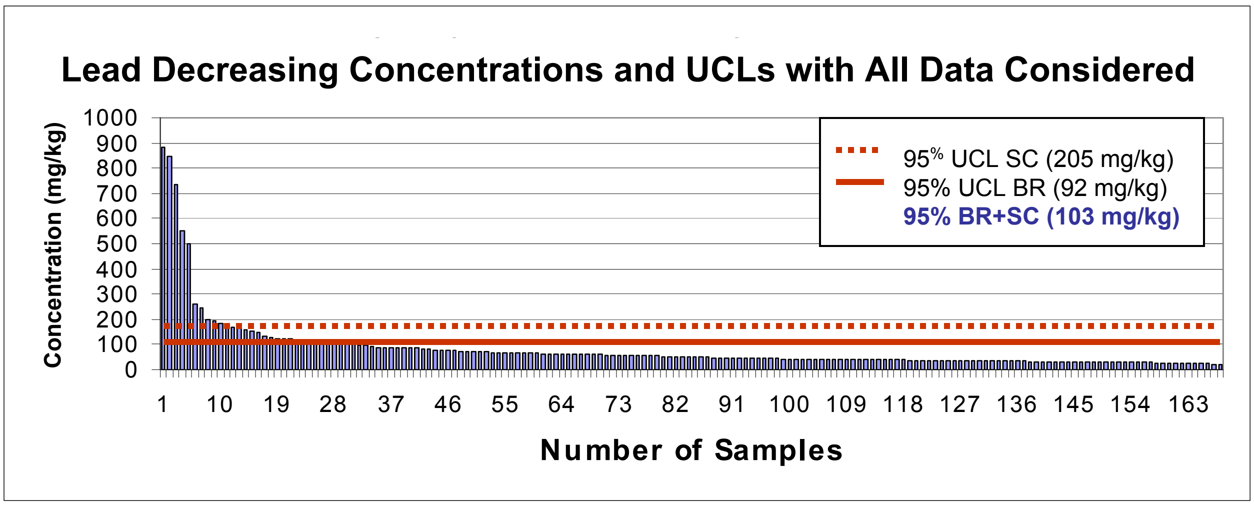
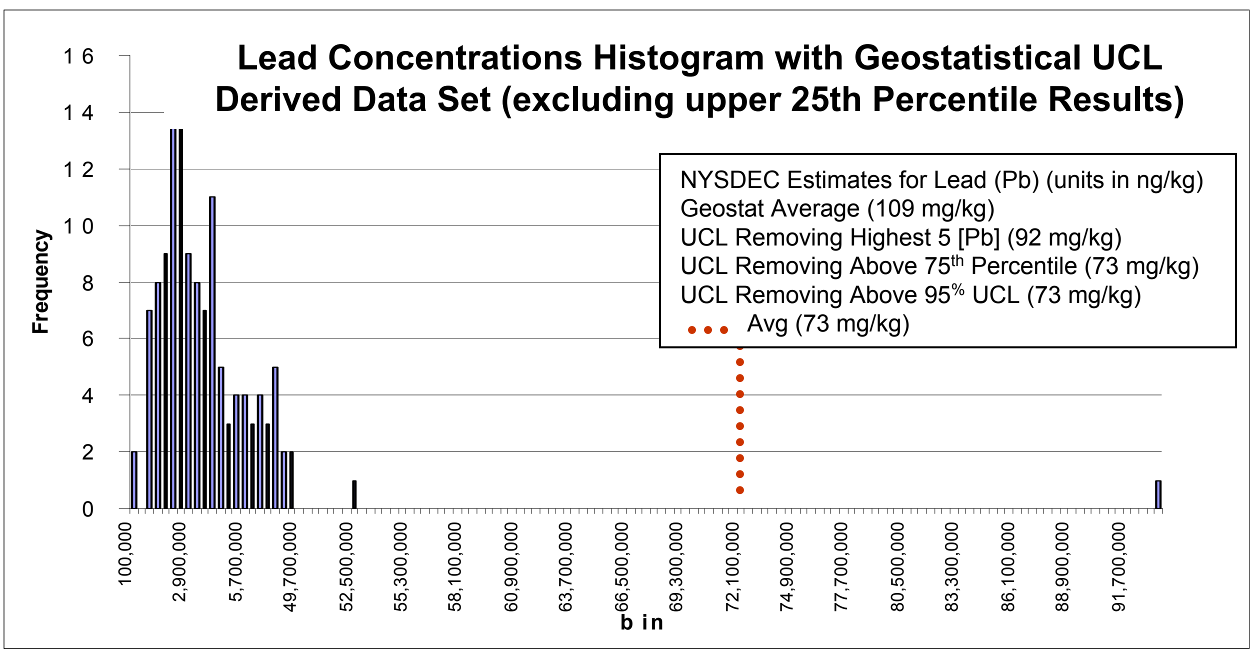


Figure 3: Lead Histograms and Average Conditions in the River







Appendix B
Human Health Evaluation for the Buffalo River AOC

B1: Human Health Evaluation for the Buffalo River Feasibility Study

B2: Supplemental Human Health Risk Evaluation of Potential Recreational Exposure, Buffalo River AOC

Appendix B1
Human Health Evaluation for the Buffalo River Feasibility Study

Human Health Risk Evaluation for the Feasibility Study
Buffalo River AOC, Buffalo, New York

ENVIRON International Corporation (ENVIRON) has performed a risk evaluation to support the analysis of remedy alternatives being considered for sediments in the Buffalo River AOC in Buffalo, New York. As part of this evaluation, hypothetical human health risks were estimated based on fish tissue data collected in October 2007 from the Buffalo River to identify potentially significant human exposures. In addition, the potential reduction of risks for human exposures that would be achieved under the proposed remedy alternatives for sediment was evaluated. In assessing hypothetical risks as a result of ingestion of fish, the potential exposures were evaluated for three hypothetical receptor populations[1] (RME Fisherman, Typical Fisherman, and DOH RME Fishermen) to identify potentially significant human exposures. In addition, potential exposure of recreators in the Buffalo River via contact with surface water and sediment were also calculated for the five proposed remedial alternatives (ENVIRON et al 2009) to evaluate reduction of risks associated with these other potential exposure pathways.

As discussed below, PCBs detected in fish tissue were the only chemicals identified as presenting a potentially significant risk via fish ingestion based on recent sampling data. Potential exposure to PCBs via fish ingestion was, therefore, further evaluated by modeling fish tissue concentrations that would result from uptake from sediments in the Buffalo River under current and post-remedy conditions. For this evaluation, surface weighted average concentrations (SWACs) of PCBs in sediment estimated for the five proposed remedial alternatives were used to estimate fish concentrations (ENVIRON et al 2009). For the direct exposure pathways of recreators to surface water and sediment, the estimated risks are within or below the acceptable risk range.

EVALUATION OF FISH INGESTION

Fish tissue results from the October 2007 sampling performed by NYSDEC (2008) were used to identify potentially significant human exposures to PAHs, PCBs, lead, and mercury via fish ingestion. Estimates of cumulative cancer risk and noncancer hazard quotient (HQ) are calculated using exposure factors developed in the prior human health risk assessments (i.e., “RME Fisherman” and “Typical Fisherman”) conducted by USEPA (1993) and SulTRAC (2007), as well as for the “DOH RME Fishermen” (exposure factors are summarized on Table 1) which incorporates the ingestion rate and fraction contacted assumptions recommended by NYSDOH staff (2009).

[1] The RME Fisherman and Typical Fisherman reflect exposure assumptions presented in prior risk assessments prepared for the Buffalo River AOC (USEPA 1993, SulTRAC 2007). The DOH RME Fisherman reflects exposures assumptions recommended by NYSDOH staff (2009).

Estimates of cancer risk associated with potential exposure to a carcinogenic chemical via ingestion are calculated by multiplying an estimate of the lifetime average daily dose (*LADD*) for a particular exposure scenario by the cancer slope factor (*SF*) for the chemical, as follows:

$$Risk = LADD \cdot SF$$

Estimates of HQ associated with potential exposure via ingestion of a chemical being evaluated for potential noncarcinogenic health effects is calculated by dividing an estimate of the average daily dose (*ADD*) for a particular exposure scenario by the reference dose (*RfD*) for the chemical, as follows:

$$HQ = \frac{ADD}{RfD}$$

The potential cancer risk and noncancer effects that may result from exposure to the combination of constituents at an area are estimated following USEPA's *Risk Assessment Guidance for Superfund. Volume I, Human Health Evaluation Manual* (1989), as follows:

$$Cumulative\ Risk = \sum_i Risk_i$$

$$Hazard\ Index = \sum_i HQ_i$$

where:

$Risk_i$	=	estimated cancer risk for the *i*th constituent
HQ_i	=	hazard quotient for the *i*th constituent

Table 2a and Table 2b summarize the toxicity values and physical chemical parameters for each constituent evaluated in this risk evaluation, respectively. Table 3 presents fish tissue concentrations for individual PAHs, total PCBs (principally, Aroclor 1254 and Aroclor 1260), lead, and mercury. Concentrations presented on Table 3 are the highest concentrations from the limited number of carp or largemouth bass (in the case of mercury) data reported by NYSDEC (2008).

Cancer risk and HQ estimates for all of the chemicals included in this risk evaluation are shown on Table 3. These risk estimates may be used to identify constituent concentrations in fish tissue that would present a potentially significant human exposure if people were eating fish from the Buffalo River and thus should be considered in the Feasibility Study. As shown on Table 3, using the highest detected concentrations, the cumulative risk estimates for fish ingestion exceed USEPA's cumulative cancer risk and/or hazard index (HI) limits of 10^{-4} and 1 (USEPA 1991), respectively, for the RME Fisherman, the Typical Fisherman, and the DOH RME Fisherman.

The cumulative cancer risk and HI estimates in excess of the risk limits are the result of the highest detected concentration of PCBs in carp fillet (2.03 mg/kg-wet weight fish) from samples analyzed by NYSDEC. Estimated risks associated with concentrations of other chemicals are within USEPA's acceptable risk range and contribute negligibly to the cumulative cancer risk and HI estimates presented on Table 3.

Potential exposure to lead in fish tissue is evaluated using the blood lead level as an index of exposure, rather than in terms of cancer risk or HQ. Therefore, the mean lead concentration in carp fish tissue (0.019 mg/kg-wet weight fish) reported by NYSDEC (2008) was compared to the lead concentration that is assumed to be present in USEPA's All Ages Lead Model (0.01 mg/kg-fish). The mean lead concentration in fish tissue in the Buffalo River is similar to the concentration USEPA assumed to be the default concentration that an individual would contact via fish ingestion. Therefore, the concentrations of lead in fish are believed to be within typical background levels as they are similar to default concentrations of lead in fish assumed by USEPA and thus lead does not need to be explicitly considered in the Feasibility Study.

RISK REDUCTION OF PCBs VIA FISH INGESTION

Based on the risk estimates developed using the 2007 fish tissue data presented in Table 3, further evaluation of PCB concentrations in fish was conducted. This additional evaluation included a review of risks estimated using fish tissue data collected prior to 2007 and presented as part of the prior risk assessments (USEPA 1993, SulTRAC 2007) to identify potential tends in PCB concentrations (and resultant risks) over time. Specifically, the fish tissue data reported in the prior human health risk assessments prepared for the Buffalo River were used to estimate potential risks from exposure via fish ingestion for all three fish consumption scenarios (i.e., RME Fisherman, Typical Fisherman, and DOH RME Fishermen). In order to consistently evaluate risks from ingestion of PCB-contaminated fish, these cancer risk and HQ estimates incorporate the following: current IRIS toxicity values for PCBs, and losses of lipophilic compounds from preparation (trimming and cooking), as recommended by the Great Lakes Fish Advisory Task Force (1993). Thus, these risk estimates may differ from those presented in the original risk assessment documents. These results are presented on Table 4.

The concentrations of PCBs in fish tissue have decreased between a factor of 2 and 6 from 1993 to 2007, as summarized on Table 4. This decrease in PCB concentrations in fish tissue has resulted in decreases in the cancer risk and HQ estimates that are consistent with the decrease in tissue concentrations. The cumulative cancer risk and HQ estimates based on the fish tissue data (presented on Table 3 and summarized again on Table 4) reported by NYSDEC (2008) are within or above USEPA's acceptable risk range for the three exposure scenarios. Therefore, additional calculations were performed to evaluate the amount of risk reduction via fish ingestion that would be achieved as a result of sediment removal defined under each of the five proposed remedy alternatives for sediment.

To assess the risks associated with chemical concentrations in sediment, the sediment SWAC from the Buffalo River (including the man-made ship canal) for each of the five proposed remedy alternatives (RA1 through RA5) and the biota-sediment accumulation factor (BSAF) developed for the Buffalo River (USACE January 16, 2009 presentation) are used to calculate fish tissue concentrations. Specifically, the sediment SWACs used to estimate fish ingestion risks are the maximum of the SWACs calculated for the entire "Main Channel" of the Buffalo River or the entire "Ship Canal" (presented on Table 6-2 of the Feasibility Study) as these are the concentrations most representative of carp's exposure to sediment. The PCB concentration in fish (C_{fish}) that would result from the sediment SWACs is calculated as follows:

$$C_{fish} = \frac{\left(C_{sed} \cdot BSAF\right) \cdot L}{TOC}$$

where C_{sed} is the sediment SWAC (in mg/kg dry weight), BSAF is the biota-sediment accumulation factor (1.5), L is wet weight lipid content in fish fillet (1.6%), and TOC is the dry weight total organic carbon content in sediment (2.6%).

The calculated fish tissue concentrations are used to estimate risks via fish ingestion for all three exposure scenarios. As shown on Table 4, all five of the cancer risk and HQ estimates for potential fish ingestion exposure based on sediment SWACs for PCBs, including the No Action alternative (RA1), are at or below USEPA's acceptable risk limits, except for the HQ estimate for the DOH Fisherman's exposure under RA1. These estimates also indicate that the sediment removal-based alternatives result in an approximately 2.1 to 3.6 fold reduction in human health risks associated with ingestion of fish from the Buffalo River. It is also noted that all of the sediment SWACs result in PCBs in fish tissue below 1 mg/kg-fish, which is a guideline and one of several factors considered when NYSDOH determines specific fish advisories based on PCBs. This is also the threshold concentration used in setting the fish advisory for carp in 1987.

Measured PCB concentrations in fish reported in 2008 differ from the calculated concentration under RA1 (No Action) by approximately 1.6 to 11.3 fold. This difference in carp concentrations is likely due to the lag in an observed decrease in sediment concentrations and those observed in carp which are sizable fish with long lifespans. Therefore, the current concentrations in carp tissue likely reflect past sediment/source conditions when concentrations of PCBs in sediment were higher than those observed in sampling conducted during period of 2005 to 2008. Therefore, even under the No Action alternative, PCB concentrations in carp are expected to decline as a result of the lower PCB concentrations in surface sediment due to coverage by clean sediment.

RISK REDUCTION OF NON-PCBs VIA FISH INGESTION

The cancer risk and HQ estimates for non-PCBs via fish ingestion were determined to be negligible, as discussed above. However, remedy alternatives that include removal or capping of contaminated sediment will result in further risk reduction. This risk reduction is illustrated below based on a comparison of the maximum pre-remediation sediment SWACs calculated every 1/3 mile along the Main Channel and the Ship Canal, with the maximum sediment SWACs calculated every 1/3 mile along the Main Channel and the Ship Canal for remedial alternatives developed to achieve ecological-based remedy targets:

Chemical	No Action SWAC (mg/kg sed)	Sediment Removal SWAC Range (mg/kg sed)
Total PAHs	70	7.8 to 10
Lead	330	61 to 78
Mercury	1	0.25 to 0.42

As indicated on the above table, the remedial alternatives under consideration that result in removal of sediments result in an approximately 2.4 to 8.9 fold reduction in sediment concentrations for the constituents where ecological-based remedy targets have been developed. The concentration reduction would result in a 2.4 to 8.9 fold reduction in risks via fish ingestion for non-PCBs, assuming these sediments are the only source of exposure to the fish and pre- and post-remedy exposure assumptions are constant.

EVALUATION OF SEDIMENT AND SURFACE WATER CONTACT

Potential recreation exposures to sediment and surface water within the Buffalo River were also evaluated for PCBs and non-PCBs using the sediment SWACs for each of the five proposed remedial alternatives. The SWACs used to estimate potential recreation exposures are the maximum SWACs calculated every 1/3 mile along the Main Channel and the Ship Canal (presented on Table 6-2 of the Feasibility Study) as these are conservative estimates of the concentrations most representative of direct human exposure to sediment. Estimates of cumulative cancer risk and noncancer HQ are calculated using exposure factors developed in the prior human health risk assessments for contact with sediment (i.e., "Future RME") and surface water (i.e., "RME" and "Typical") conducted by SulTRAC (2007) and USEPA (1993), respectively, as well as for the "Alternate Recreational" exposure (exposure factors are summarized on Table 1) which is based on exposure assumptions ENVIRON has used in prior risk assessments in USEPA Region 5. Table 5 and Table 6 summarize the risk estimates for sediment and surface water, respectively. As shown on these tables, all of the cumulative cancer risk and HI estimates are within or below USEPA's acceptable risk limits. These estimates indicate that the remedial alternatives under consideration that result in removal of sediments result in a negligible reduction in human health risks associated with sediment or surface water contact with PCBs and non-PCBs during occasional recreational activities in the Buffalo River.

Potential exposure to lead in sediment is evaluated using the blood lead level as an index of exposure, rather than in terms of cancer risk or HQ. The sediment SWACs (Table 5) are all lower than the residential direct contact criterion for lead in soil (400 mg/kg).

Recreational exposures to sediment in the Buffalo River are expected to be less than those of residents and thus use of the residential soil contact criterion for lead is conservative.

REFERENCES

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Table 1
Exposure Factors
Buffalo River AOC, Buffalo, New York

		RME Fishermen		Typical Fishermen		DOH RME Fishermen		Alternate Recreational Age 1-6	Alternate Recreational Age 7-31		SulTRAC "Future" RME Age 1-6	SulTRAC "Future" RME Age 7-18	SulTRAC "Future" RME Adult		1993 HHRA RME	1993 HHRA Typical
Sediment Ingestion																
Ingestion Rate (mg/d)	IR							100	50	b	200	100	100	g		
Conversion Factor (kg/mg)	CF							1E-06	1E-06		1E-06	1E-06	1E-06	g		
Fraction Contacted (unitless)	FC							1.0	1.0		1.0	1.0	1.0	g		
Exposure Frequency (d/yr)	EF							24	24	e	68	68	68	g		
Exposure Duration (yr)	ED							6	24	b	6	12	30	g		
Body Weight (kg-bw)	BW							15	70	a	15	47	70	g		
Averaging Time, carc (d)	AT_c							25,550	25,550	a	25,550	25,550	25,550	g		
Averaging Time, noncarc (d)	AT_{nc}							2,190	8,760	a	2,190	4,380	10,950	g	Exposure to sediment was not considered	
Sediment Dermal Contact																
Adherence Factor (mg/cm^2)	AD							0.2	0.07	d	0.3	0.3	0.3	g		
Skin Surface Area (cm^2/d)	SA							3,950	9,000	d	809	1,640	2,129	g		
Conversion Factor (kg/mg)	CF							1E-06	1E-06		1E-06	1E-06	1E-06	g		
Fraction Contacted (unitless)	FC							1.0	1.0		1.0	1.0	1.0	g		
Exposure Frequency (d/yr)	EF							24	24	e	68	68	68	g		
Exposure Duration (yr)	ED							6	24	b	6	12	30	g		
Body Weight (kg-bw)	BW							15	70	a	15	47	70	g		
Averaging Time, carc (d)	AT_c							25,550	25,550	a	25,550	25,550	25,550	g		
Averaging Time, noncarc (d)	AT_{nc}							2,190	8,760	a	2,190	4,380	10,950	g		
Incidental Surface Water Ingestion																
Drinking Rate (L/hr per event)	DR							0.05	0.05	a					0.05	0.05
Exposure Time (h)	ET							1	1	e					0.5	0.5
Exposure Frequency (d/yr)	EF							24	24	e					6	3
Expoure Duration (yr)	ED							6	24	b					30	9
Body Weight (kg-bw)	BW							15	70	a					70	70
Averaging Time, canc (d)	AT_c							25,550	25,550	a					25,550	25,550
Averaging Time, noncanc (d)	AT_{nc}							2,190	8,760	a					10,950	3,285
Surface Water Dermal Contact																
Event Time (hr)	t							1	1	e						
Skin Surface Area (cm^2)	SA							3,520	9,000	d		Exposure to surface water was not considered				
Events per Day (event/d)	EV							1	1	e						
Exposure Frequency (d/yr)	EF							24	24	e						
Expoure Duration (yr)	ED							6	24	b						
Body Weight (kg)	BW							15	70	a						
Averaging Time, cancer (days)	AT_c							25,550	25,550	a						
Averaging Time, noncancer (days)	AT_{nc}							2,190	8,760	a						
Surface Water Vapor Inhalation																
Fraction Contacted (unitless)	FC							1	1							
Exposure Frequency (d/yr)	EF							24	24	e						
Exposure Duration (yr)	ED							6	24	b						
Averaging Time, carc (d)	AT_c							25,550	25,550	a						
Averaging Time, noncarc (d)	AT_{nc}							2,190	8,760	a						
Fish Ingestion																
Ingestion Rate (kg/d - wet weight)	IR	0.054	f, g	0.0192	f, g	0.032	h									
FI (fraction from contaminated area)	FI	0.25	f, g	0.1	f, g	1	h									
Exposure Frequency (d/yr)	EF	350	f, g	350	f, g	350	b									
Exposure Duration (yr)	ED	30	f, g	9	f, g	30	b									
Body Weight (kg)	BW	70	f, g	70	f, g	70	a									
Averaging Time, carc (d)	AT_c	25,550	f, g	25,550	f, g	25,550	a									
Averaging Time, noncarc (d)	AT_{nc}	10,950	f, g	3,285	f, g	10,950	a									

References:

a. Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part A) Interim Final (EPA 1989)

b. Standard default exposure factors. OSWER Directive 9285.6-03 (EPA 1991)

d. Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual: Part E, Supplemental Guidance for Dermal Risk Assessment, Interim Final (EPA 2001)

e. Based on professional judgement and site-specific considerations as follows:

- Alternate Recreational Exposure: The exposure time and frequency is based on an anticipated exposure of two events per week during the months when the mean daily temperature is over 65 F in water depths less than 6-feet deep.

f. USEPA 1993 Human Health Risk Assessment

g. SulTRAC 2007 Human Health Risk Assessment

h. NYSDOH exposure assumptions discussed during 1/28/09 human health subgroup conference call.

Table 2a
Toxicity Values
Buffalo River AOC, Buffalo, New York

Chem Group	Chemical	CASRN	Cancer Class Group	Cancer Class Ref	Cancer Class Note	Oral Slope Factor, SF_{oral} $(mg/kg/d)^{-1}$ Value	Ref	Notes	Dermal Slope Factor, SF_{derm} $(mg/kg/d)^{-1}$ Value	Ref	Notes	Unit Risk Factor, URF $(mg/m^3)^{-1}$ Value	Ref	Notes
SVOC	Acenaphthene	83-32-9												
SVOC	Acenaphthylene	208-96-8	D	1										
SVOC	Anthracene	120-12-7	D	1										
SVOC	Benzo(b)fluoranthene	205-99-2	B2	1		7.3E-01	10	5	7.3E-01	125	104	8.9E-02	128	45
SVOC	Benzo(g,h,i)perylene	191-24-2	D	1										
SVOC	Benzo(k)fluoranthene	207-08-9	B2	1		7.3E-02	10	5	7.3E-02	125	104	8.9E-03	128	45
SVOC	Chrysene	218-01-9	B2	1		7.3E-03	10	5	7.3E-03	125	104	8.9E-04	128	45
SVOC	Dibenz(a,h)anthracene	53-70-3	B2	1		7.3E+00	10	5	7.3E+00	125	104	8.9E-01	128	45
SVOC	Fluoranthene	206-44-0	D	1										
SVOC	Fluorene	86-73-7	D	1										
SVOC	Indeno(1,2,3-cd)pyrene	193-39-5	B2	1		7.3E-01	10	5	7.3E-01	125	104	8.9E-02	128	45
SVOC	Naphthalene	91-20-3	C	1										
SVOC	Phenanthrene	85-01-8	D	1										
SVOC	Pyrene	129-00-0	NC	126										
PCB	PCBs (total)	1336-36-3	B2	1		2.0E+00	1	30,32	2.0E+00	125	104	5.7E-01	1	30,32, 45
INORG	Mercury	7439-97-6	D	1										
INORG	Lead	7439-92-1												
SVOC	PAHs (total)	130498-29-2			a	7.3E+00	1	a	7.3E+00	125	104, a	8.9E-01	128	45, a

Chemical	Oral Reference Dose, RfD_{oral} (mg/kg/d) Value	UF	Ref	Notes	Dermal Reference Dose, RfD_{derm} (mg/kg/d) Value	UF	Ref	Notes	Reference Concentration, RfC (mg/m^3) Value	UF	Ref	Notes
Acenaphthene	6.0E-02	3,000	1		6.0E-02	3,000	125	104	2.1E-01	3,000	1	4, 44
Acenaphthylene	3.0E-02	3,000	1	20	3.0E-02	3,000	125	104	1.1E-01	3,000	1	4, 20, 44
Anthracene	3.0E-01	3,000	1		3.0E-01	3,000	125	104			2	90
Benzo(b)fluoranthene												
Benzo(g,h,i)perylene	3.0E-02	3,000	1	20	3.0E-02	3,000	125	104	1.1E-01	3,000	1	4, 20, 44
Benzo(k)fluoranthene												
Chrysene												
Dibenz(a,h)anthracene												
Fluoranthene	4.0E-02	3,000	1		4.0E-02	3,000	125	104	1.4E-01	3,000	1	4, 44
Fluorene	4.0E-02	3,000	1		4.0E-02	3,000	125	104	1.4E-01	3,000	1	4, 44
Indeno(1,2,3-cd)pyrene												
Naphthalene	2.0E-02	3,000	1		2.0E-02	3,000	125	104	3.0E-03	3,000	1	
Phenanthrene	3.0E-02	3,000	1	20	3.0E-02	3,000	125	104	1.1E-01	3,000	1	4, 20, 44
Pyrene	3.0E-02	3,000	1		3.0E-02	3,000	125	104	1.1E-01	3,000	1	4, 44
PCBs (total)	2.0E-05	300	1	72	2.0E-05	300	125	104				
Mercury	1.0E-04	10	1	137	2.1E-05	1,000	125	104	3.0E-04	30	1	
Lead												
PAHs (total)	2.0E-02	3,000	1	a	2.0E-02	3,000	125	104, a	3.0E-03	3,000	1	a

Chemical	Subchronic Oral Reference Dose $S\text{-}RfD_{oral}$ (mg/kg/d) Value	UF	Ref	Notes	Subchronic Dermal Reference Dose, $S\text{-}RfD_{dermal}$ (mg/kg/d) Value	UF	Ref	Notes	Subchronic Reference Concentration, S-RfC (mg/m^3) Value	UF	Ref	Notes	ABS_{GI} Value	Ref	Notes
Acenaphthene	6.0E-01	300	129	111, 113	6.0E-01	300	125	104	2.1E-01	3,000	1	4, 44, 62			
Acenaphthylene	3.0E-01	300	126	20	3.0E-01	300	125	104	1.1E-01	3,000	1	4, 20, 44, 62			
Anthracene	1.0E+01	100	129	111, 113	1.0E+01	100	125	104			2	62, 90			
Benzo(b)fluoranthene															
Benzo(g,h,i)perylene	3.0E-01	300	126	20	3.0E-01	300	125	104	1.1E-01	3,000	1	4, 20, 44, 62			
Benzo(k)fluoranthene															
Chrysene															
Dibenz(a,h)anthracene															
Fluoranthene	4.0E-01	300	129	111, 113	4.0E-01	300	125	104	1.4E-01	3,000	1	4, 44, 62			
Fluorene	4.0E-01	300	129	111, 113	4.0E-01	300	125	104	1.4E-01	3,000	1	4, 44, 62			
Indeno(1,2,3-cd)pyrene															
Naphthalene	2.0E-01	300	1	110	2.0E-01	300	125	104	3.0E-03	3,000	1	62			
Phenanthrene	3.0E-01	300	126	20	3.0E-01	300	125	104	1.1E-01	3,000	1	4, 20, 44, 62			
Pyrene	3.0E-01	300	126		3.0E-01	300	125	104	1.1E-01	3,000	1	4, 44, 62			
PCBs (total)	3.0E-05	300	129	111, 113, 72	3.0E-05	300	125	104					0.8	125	105
Mercury	1.0E-04	10	2	137	2.1E-04	100	125	104	3.0E-04	30	2		0.07	125	51
Lead															
PAHs (total)	2.0E-01	300	1	110, a	2.0E-01	300	125	104, a	3.0E-03	3,000	1	62, a			

References:

1 USEPA. Integrated Risk Information System (IRIS). On-line database.
2 USEPA. 1997. Health Effects Assessment Summary Tables (HEAST). FY-1997 Update. EPA 540/R-97-036. July.
10 USEPA. 1993. Provisional Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons. EPA/600/2-93/089. July.
125 USEPA. 2004. Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. July.
126 Provisional Peer Reviewed Toxicity Values for Superfund (PPRTV) Database.
128 USEPA. Region 6. 2006. Human Health Medium-Specific Screening Levels. December.
129 ATSDR. 2007. Minimal Risk Levels. November.

Notes:

a ENVIRON used cancer toxicity values from Benzo(a)pyrene [CASRN 50-32-8] and noncancer toxicity values from Naphthalene [CASRN 91-20-3] from the indicated references as a surrogate.
4 ENVIRON obtained value by route-to-route extrapolation.
5 Based on potency relative to Benzo(a)pyrene [CASRN 50-32-8], as described in the indicated reference.
20 ENVIRON used Pyrene [CASRN 129-00-0] value from the indicated reference as a surrogate.
30 Upper-bound slope factor.
32 High risk & persistence tier for: food chain exposure; sediment/soil ingestion; dust/aerosol inhalation; dermal exposure, if an absorption factor is applied; presence of dioxin-like, tumor-promoting/persistent congeners; and all early life exposures.
44 ENVIRON derived inhalation RfC from inhalation RfD value presented in the indicated reference, using standard USEPA methodology presented in HEAST.
45 ENVIRON derived inhalation URF from Inhalation Slope Factor value presented in the indicated reference, using standard USEPA methodology presented in HEAST.
51 ENVIRON used Mercuric Chloride [CASRN 7487-94-7] value from the indicated reference as a surrogate.
62 ENVIRON used chronic value as a surrogate for the subchronic value.
72 ENVIRON used Aroclor 1254 [CASRN 11097-69-1] value from the indicated reference as a surrogate for PCBs [CASRN 1336-36-3].
90 Inadequate data exist to derive a toxicity value, according to the indicated reference.
104 Dermal toxicity value is extrapolated from oral toxicity value in accordance with the referenced USEPA guidance.
105 Adjustment for gastrointestinal absorption efficiencies should not be applied according to the indicated reference.
110 The value is based on discussion in the indicated reference regarding the principal study USEPA used in extrapolating from subchronic to chronic.
111 Value as published is an MRL in the indicated reference.
113 The value is derived for intermediate exposure durations from 2 weeks to 1 year, rather than the subchronic period of 2 weeks to 7 years as defined in USEPA RAGS Part A (1989).
137 ENVIRON used methyl mercury [CASRN 22967-92-6] values from the indicated reference as a surrogate.

Table 2b
Physical and Chemical Properties
Buffalo River AOC, Buffalo, New York

Chem Group	Chemical	CASRN	Molecular Weight, MW (g/mole)			Organic Carbon Partition Coefficient, K_{oc} (L/kg)			Partition Coefficient for Soil, K_d (L/kg)			Henry's Law Constant and Reference Temperature H (unitless) and Temp (°C)				Solubility, s (mg/L)		
			Value	Ref	Notes	Value	Ref	Notes	Value	Ref	Notes	Value	Temp	Ref	Notes	Value	Ref	Notes
SVOC	Acenaphthene	83-32-9	1.5E+02	1		7.1E+03	44	82				6.4E-03	2.5E+01	44		4.2E+00	44	
SVOC	Acenaphthylene	208-96-8	1.5E+02	50.1		7.5E+03	69	82				4.6E-03	2.0E+01	50.1	92, 123	1.6E+01	50.1	92
SVOC	Anthracene	120-12-7	1.8E+02	50.1		3.0E+04	44	82				2.7E-03	2.5E+01	44		4.3E-02	44	
SVOC	Benzo(b)fluoranthene	205-99-2	2.5E+02	50.1		1.2E+06	44	82				4.6E-03	2.5E+01	44		1.5E-03	44	
SVOC	Benzo(g,h,i)perylene	191-24-2	2.8E+02	50.1		1.3E+07	69	82				5.8E-06	2.0E+01	50.1	92, 123	2.6E-04	50.1	92
SVOC	Benzo(k)fluoranthene	207-08-9	2.5E+02	50.1		1.2E+06	44	82				3.4E-05	2.5E+01	44		8.0E-04	44	
SVOC	Chrysene	218-01-9	2.3E+02	50.1		4.0E+05	44	82				3.9E-03	2.5E+01	44		1.6E-03	44	
SVOC	Dibenz(a,h)anthracene	53-70-3	2.8E+02	50.1		3.8E+06	44	82				6.0E-07	2.5E+01	44		2.5E-03	44	
SVOC	Fluoranthene	206-44-0	2.0E+02	50.1		1.1E+05	44	82				6.6E-04	2.5E+01	44		2.1E-01	44	
SVOC	Fluorene	86-73-7	1.7E+02	50.1		1.4E+04	44	82				2.6E-03	2.5E+01	44		2.0E+00	44	
SVOC	Indeno(1,2,3-cd)pyrene	193-39-5	2.8E+02	50.1		3.4E+06	44	82				6.6E-05	2.5E+01	44		2.2E-05	44	
SVOC	Naphthalene	91-20-3	1.3E+02	50.1		2.0E+03	44	82				2.0E-02	2.5E+01	44		3.1E+01	44	
SVOC	Phenanthrene	85-01-8	1.8E+02	50.1		2.4E+04	69	82				9.5E-04	2.0E+01	50.1	92, 123	1.2E+00	50.1	92
SVOC	Pyrene	129-00-0	2.0E+02	50.1		1.1E+05	44	82				4.5E-04	2.5E+01	44		1.4E-01	44	
PCB	PCBs (total)	1336-36-3	3.3E+02	64	116	2.5E+06	64	116, 82				8.2E-02	2.0E+01	64	116, 123	1.2E-02	64	116
INORG	Mercury	7439-97-6	2.0E+02	67					1.0E+03	67		2.9E-01	2.0E+01	67	123	5.6E-02	1	
INORG	Lead	7439-92-1																
SVOC	PAHs (total)	130498-29-2	2.5E+02	50.1	a	1.0E+06	44	82, a				4.6E-05	2.5E+01	44	a	1.6E-03	44	a

Chemical	Vapor Pressure, VP (mm Hg)			Diffusivity in Air, D_{air} (m^2/d)			Diffusivity in Water, D_{water} (m^2/d)			Dermal Permeability Coefficient, K_p (cm/hr)			Dermal Absorption Fraction, ABS_d (unitless)			Fraction Absorbed, FA (unitless)			Biota-Sediment Accumulation Factor, BSAF (unitless)			Trimming and Cooking Reduction (unitless)		
	Value	Ref	Notes	Value	Ref	Notes	Value	Ref	Notes	Value	Ref	Notes	Value	Ref	Notes	Value	Ref	Notes	Value	Ref	Notes	Value	Ref	Notes
Acenaphthene	2.5E-03	50.1	92	3.6E-01	44		6.6E-05	44		8.4E-02	44	115	1.3E-01	62		1.0E+00	62	117				3.0E-01	b	
Acenaphthylene	9.1E-04	50.1	92	3.9E-01	69		6.0E-05	69		8.9E-02	69	115	1.3E-01	62		1.0E+00	62	114				3.0E-01	b	
Anthracene	2.7E-06	50.1	92	2.8E-01	44		6.7E-05	44		1.6E-01	44	115	1.3E-01	62		1.0E+00	62	117				3.0E-01	b	
Benzo(b)fluoranthene	5.0E-07	50.1	92	2.0E-01	44		4.8E-05	44		7.6E-01	44	115	1.3E-01	62		8.0E-01	62	117				3.0E-01	b	
Benzo(g,h,i)perylene	1.0E-10	50.1	92	1.9E-01	69		4.5E-05	69		2.7E+00	69	115	1.3E-01	62		7.0E-01	62	117				3.0E-01	b	
Benzo(k)fluoranthene	2.0E-09	50.1	92	2.0E-01	44		4.8E-05	44		7.6E-01	44	115	1.3E-01	62		8.0E-01	62	117				3.0E-01	b	
Chrysene	6.2E-09	50.1	92	2.1E-01	44		5.4E-05	44		4.8E-01	44	115	1.3E-01	62		9.0E-01	62	117				3.0E-01	b	
Dibenz(a,h)anthracene	1.0E-10	50.1	92	1.7E-01	44		4.5E-05	44		1.1E+00	44	115	1.3E-01	62		7.0E-01	62	117				3.0E-01	b	
Fluoranthene	7.8E-06	50.1	94	2.6E-01	44		5.5E-05	44		2.8E-01	44	115	1.3E-01	62		1.0E+00	62	117				3.0E-01	b	
Fluorene	6.3E-04	50.1	92	3.1E-01	44		6.8E-05	44		1.1E-01	44	115	1.3E-01	62		1.0E+00	62	117				3.0E-01	b	
Indeno(1,2,3-cd)pyrene	1.0E-10	50.1	92	1.6E-01	44		4.9E-05	44		1.1E+00	44	115	1.3E-01	62		7.0E-01	62	117				3.0E-01	b	
Naphthalene	8.5E-02	50.1	92	5.1E-01	44		6.5E-05	44		5.0E-02	44	115	1.3E-01	62		1.0E+00	62					3.0E-01	b	
Phenanthrene	1.1E-04	50.1	92	3.2E-01	69		6.5E-05	69		1.4E-01	69	115	1.3E-01	62		1.0E+00	62	117				3.0E-01	b	
Pyrene	4.6E-06	50.1	92	2.4E-01	44		6.3E-05	44		2.8E-01	44	115	1.3E-01	62		1.0E+00	62	117				3.0E-01	b	
PCBs (total)	7.7E-05	64	116	1.7E-01	69	116	4.3E-05	69	116	4.5E-01	64	116, 115	1.4E-01	62		7.0E-01	62	117, 110	1.5E+00	a		3.0E-01	b	
Mercury	2.0E-03	50.1	92	2.7E-01	44		5.4E-05	44		1.0E-03	62			62					8.6E-01					
Lead																								
PAHs (total)	5.5E-09	50.1	92, a	3.7E-01	44	a	7.8E-05	44	a	6.6E-01	44	115, a	1.3E-01	62	a	8.0E-01	62	117, a						

References:

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67 USEPA. 1997. Mercury Study Report to Congress. EPA's Office of Air Quality Planning and Standards and Office of Research and Development. December.
69 USEPA. 2004. WATER9. Version 2.0.0. Office of Air Quality Planning and Standards. July.

Notes:

a ENVIRON used physical and chemical properties from Benzo(a)pyrene [CASRN 50-32-8] from the indicated reference as a surrogate.
82 ENVIRON used Equation (70) from Reference 44 to calculate Koc value using Log Kow value from indicated reference.
92 Indicated source cites CHEMFATE.
110 ENVIRON used the value for 4-Chlorobiphenyl [CASRN 2051-62-9] from the indicated reference as a surrogate.
115 ENVIRON calculated Kp value using equation 3.8 (p.3-7) in reference 62 with log Kow from the indicated reference and the MW presented in table.
116 ENVIRON used the value for Aroclor-1254 [CASRN 11097-69-1] from the indicated reference as a surrogate.
117 ENVIRON derived the FA based on Exhibit A-4 in the indicated reference.
123 Value has been assigned a default reference temperature.

Table 3
Estimates of Cumulative Cancer Risk and HI via Fish Ingestion
Buffalo River AOC, Buffalo, New York

					RME Fishermen		Typical Fishermen		DOH RME Fishermen	
Chem Group	**Chemical**	**CASRN**	**NYSDEC 2008 Max C_{fish} (mg/kg)**	**$C_{cooked\ fillet}$ (mg/kg)**	**Cancer Risk**	**HQ**	**Cancer Risk**	**HQ**	**Cancer Risk**	**HQ**
SVOC	Acenaphthene	83-32-9	3.5E-02	2.5E-02		8E-05		1E-05		2E-04
SVOC	Acenaphthylene	208-96-8	3.7E-02	2.6E-02		2E-04		2E-05		4E-04
SVOC	Anthracene	120-12-7	*2.0E-02*	1.4E-02		9E-06		1E-06		2E-05
SVOC	Benzo(a)anthracene	56-55-3	*2.0E-02*	1.4E-02	8E-07		3E-08		2E-06	
SVOC	Benzo(a)pyrene	50-32-8	*2.0E-02*	1.4E-02	8E-06		3E-07		2E-05	
SVOC	Benzo(b)fluoranthene	205-99-2	*2.0E-02*	1.4E-02	8E-07		3E-08		2E-06	
SVOC	Benzo(g,h,i)perylene	191-24-2	*2.0E-02*	1.4E-02		9E-05		1E-05		2E-04
SVOC	Benzo(k)fluoranthene	207-08-9	*2.0E-02*	1.4E-02	8E-08		3E-09		2E-07	
SVOC	Chrysene	218-01-9	*2.0E-02*	1.4E-02	8E-09		3E-10		2E-08	
SVOC	Dibenz(a,h)anthracene	53-70-3	*2.0E-02*	1.4E-02	8E-06		3E-07		2E-05	
SVOC	Fluoranthene	206-44-0	*2.0E-02*	1.4E-02		6E-05		9E-06		2E-04
SVOC	Fluorene	86-73-7	4.3E-02	3.0E-02		1E-04		2E-05		3E-04
SVOC	Indeno(1,2,3-cd)pyrene	193-39-5	*2.0E-02*	1.4E-02	8E-07		3E-08		2E-06	
SVOC	Naphthalene	91-20-3	1.4E-01	9.5E-02		9E-04		1E-04		2E-03
SVOC	Phenanthrene	85-01-8	2.8E-02	2.0E-02		1E-04		2E-05		3E-04
SVOC	Pyrene	129-00-0	*2.0E-02*	1.4E-02		9E-05		1E-05		2E-04
PCB	PCBs (total)	1336-36-3	2.0E+00	1.4E+00	2E-04	1E+01	1E-05	2E+00	5E-04	3E+01
INORG	Mercury	7439-97-6	3.3E-01	3.3E-01		6E-01		9E-02		1E+00
INORG	Lead	7439-92-1	1.0E-01	1.0E-01						
				Cumulative Risk/HI:	**2E-04**	**1E+01**	**1E-05**	**2E+00**	**6E-04**	**3E+01**

Notes:
Fish tissue data are the highest detected concentrations in carp except those results identified in italics, which are the highest detection limits for non-detects, and the highest mercury concentration, which is from largemouth bass.
Risk estimates are calculated using the exposure factors presented on Table 1.
Concentration in cooked fillet ($C_{cooked\ fillet}$) reflects a 30% reduction of lipophilic chemicals in fish tissue as a result of preparation (trimming and cooking), as recommended by the *Protocol for a Uniform Great Lakes Sport Fish Consumption Advisory* (1993).

Table 4
Cancer Risk and HQ Estimates via Ingestion of PCBs in Fish
Buffalo River AOC, Buffalo, New York

			RME Fishermen		Typical Fishermen		DOH RME Fishermen	
		C_{fish} (mg/kg)	Cancer Risk	HQ	Cancer Risk	HQ	Cancer Risk	HQ
Risk Estimates based on Measured Fish Concentrations	USACE 1993 HHRA Mean Carp (Young - Old)	1.96 to 4.14 (a)	2E-04 to 5E-04	10 to 30	9E-06 to 2E-05	2 to 4	5E-04 to 1E-03	30 to 60
	SulTRAC 2007 HHRA Detect (Mean)	0.338 (a)	4E-05	2	2E-06	0.3	9E-05	5
	NYSDEC 2008 Carp data (Min - Max)	0.29 to 2.03 (a)	3E-05 to 2E-04	2 to 10	1E-06 to 1E-05	0.3 to 2	8E-05 to 5E-04	4 to 30
Risk Estimates based on Sediment Concentrations	RA1 No Removal Sediment SWAC	0.18 (b)	2E-05	1	9E-07	0.2	5E-05	3
	RA2 MNR Sediment SWAC	< 0.18 (b)	< 2E-05	< 1	< 9E-07	< 0.2	< 5E-05	< 3
	RA3 Post-Removal Sediment SWAC	0.05 (b)	5E-06	0.3	2E-07	0.05	1E-05	0.8
	RA4 Post-Removal Sediment SWAC	0.087 (b)	1E-05	0.6	4E-07	0.08	2E-05	1
	RA5 Post-Removal Sediment SWAC	0.077 (b)	9E-06	0.5	4E-07	0.07	2E-05	1

Notes:
(a) Fish tissue concentration ranges from the indicated references.
(b) Fish tissue concentrations estimated using sediment the maximum among SWACs for the entire Main Channel or the entire Ship Canal and USACE BSAFs from the Buffalo River AOC (USACE 2009).
C_{fish} is the concentration of the raw and untrimmed fillet.
Risk estimates for RME Fisherman and Typical Fisherman are updated from prior risk assessments to account for the following:
Trimming and cooking losses of 30% were assumed (Great Lakes Sport Fish Advisory Task Force 1993).
Toxicity values as published by IRIS (1997).
All SWACs were calculated on 10/7/09.
RA1 - No Action (sediment SWAC is the pre-removal value of 0.196 mg/kg in the Buffalo River).
RA2 - Monitored Natural Remediation (no sediment SWAC calculated).
RA3 - Remediation of sediment at all depth with TU=1 (post-remedy sediment SWAC of 0.054 mg/kg is for the Buffalo River).
RA4 - Remediation of surface sediment with TU=1 (post-remedy sediment SWAC of 0.095 mg/kg is for the Buffalo River).
RA5 - Remediation of surface sediment with TU=1 and maximum residual concentrations for PAHs, PCBs, Hg and Pb (post-remedy sediment SWAC of 0.084 mg/kg is for the Buffalo River).

Table 5
Cumulative Cancer Risk and HI Estimates for Recreator Exposure to Sediment
Buffalo River AOC, Buffalo, New York

		Sediment Concentration (a) (mg/kg)	SulTRAC "Future" RME Age 1-6		SulTRAC "Future" RME Age 7-18		SulTRAC "Future" RME Adult		Alternate Recreational Age 1-6		Alternate Recreational Age 7-31	
			Cancer Risk	HQ/HI	Cancer Risk	HQ/HI	Cancer Risk	HQ/HI	Cancer Risk	HQ/HI	Cancer Risk	HQ/HI
RA1 No Removal Sediment SWAC	PAHs (total)	7.0E+01	1E-04	1E-03	6E-05	2E-03	1E-04	2E-03	4E-05	3E-04	2E-05	4E-04
	PCBs (total)	7.5E-01	4E-07	7E-02	2E-07	3E-02	3E-07	2E-02	1E-07	2E-02	7E-08	5E-03
	Lead	3.3E+02										
	Mercury	1.0E+00		3E-02		4E-03		3E-03		4E-03		5E-04
	CUMULATIVE		**1E-04**	**1E-01**	**6E-05**	**3E-02**	**1E-04**	**2E-02**	**4E-05**	**3E-02**	**2E-05**	**6E-03**
RA2 MNR Sediment SWAC	PAHs (total)	< 7.0E+01	< 1E-04	< 1E-03	< 6E-05	< 2E-03	< 1E-04	< 2E-03	< 4E-05	< 3E-04	< 2E-05	< 4E-04
	PCBs (total)	< 7.5E-01	< 4E-07	< 7E-02	< 2E-07	< 3E-02	< 3E-07	< 2E-02	< 1E-07	< 2E-02	< 7E-08	< 5E-03
	Lead	< 3.3E+02										
	Mercury	< 1.0E+00		< 3E-02		< 4E-03		< 3E-03		< 4E-03		< 5E-04
	CUMULATIVE		**< 1E-04**	**< 1E-01**	**< 6E-05**	**< 3E-02**	**< 1E-04**	**< 2E-02**	**< 4E-05**	**< 3E-02**	**< 2E-05**	**< 6E-03**
RA3 Post-Removal Sediment SWAC	PAHs (total)	7.8E+00	1E-05	1E-04	6E-06	3E-04	1E-05	2E-04	4E-06	3E-05	2E-06	5E-05
	PCBs (total)	1.6E-01	8E-08	2E-02	4E-08	5E-03	7E-08	4E-03	3E-08	5E-03	1E-08	1E-03
	Lead	6.1E+01										
	Mercury	2.52E-01		6E-03		1E-03		7E-04		1E-03		1E-04
	CUMULATIVE		**1E-05**	**2E-02**	**6E-06**	**7E-03**	**1E-05**	**5E-03**	**4E-06**	**6E-03**	**2E-06**	**1E-03**
RA4 Post-Removal Sediment SWAC	PAHs (total)	1.0E+01	2E-05	1E-04	8E-06	3E-04	2E-05	3E-04	6E-06	5E-05	3E-06	6E-05
	PCBs (total)	1.9E-01	1E-07	2E-02	4E-08	6E-03	8E-08	5E-03	3E-08	6E-03	2E-08	1E-03
	Lead	7.8E+01										
	Mercury	4.22E-01		1E-02		2E-03		1E-03		2E-03		2E-04
	CUMULATIVE		**2E-05**	**3E-02**	**8E-06**	**8E-03**	**2E-05**	**6E-03**	**6E-06**	**8E-03**	**3E-06**	**2E-03**
RA5 Post-Removal Sediment SWAC	PAHs (total)	8.9E+00	2E-05	1E-04	7E-06	3E-04	1E-05	2E-04	5E-06	4E-05	3E-06	5E-05
	PCBs (total)	1.7E-01	8E-08	2E-02	4E-08	6E-03	7E-08	4E-03	3E-08	5E-03	1E-08	1E-03
	Lead	7.7E+01										
	Mercury	3.53E-01		9E-03		1E-03		9E-04		2E-03		2E-04
	CUMULATIVE		**2E-05**	**2E-02**	**7E-06**	**7E-03**	**1E-05**	**5E-03**	**5E-06**	**7E-03**	**3E-06**	**1E-03**

Notes:
Risk estimates for "Future" RME exposures are calculated using the exposure factors from SulTRAC 2007 (also shown on Table 1).
(a) Sediment concentrations are as follows:
All sediment SWACs are the maximum of the 1/3 mile SWACs from the Main Channel or the Ship Canal calculated on 10/2/09.
RA1 - No Action.
RA2 - Monitored Natural Remediation (no sediment SWAC calculated).
RA3 - Remediation of sediment at all depth with TU=1.
RA4 - Remediation of surface sediment with TU=1.
RA5 - Remediation of surface sediment with TU=1 and maximum residual concentrations for PAHs, PCBs, Hg and Pb.

Table 6
Cumulative Cancer Risk and HI Estimates for Recreator Exposure to Surface Water
Buffalo River AOC, Buffalo, New York

		Surface Water Concentration (a) (mg/L)	**1993 HHRA RME**		**1993 HHRA Typical**		**Alternate Recreational Age 1-6**		**Alternate Recreational Age 7-31**	
			Cancer Risk	**HQ/HI**	**Cancer Risk**	**HQ/HI**	**Cancer Risk**	**HQ/HI**	**Cancer Risk**	**HQ/HI**
RA1 No Removal Sediment SWAC	PAHs (total)	1.62E-03	3E-08	5E-08	4E-09	2E-08	4E-05	4E-04	8E-05	2E-03
	PCBs (total)	1.17E-05	6E-11	2E-06	9E-12	1E-06	8E-08	1E-02	2E-07	1E-02
	Lead									
	Mercury	1.02E-03		6E-05		3E-05		4E-02		4E-02
	CUMULATIVE		**3E-08**	**6E-05**	**4E-09**	**3E-05**	**4E-05**	**5E-02**	**8E-05**	**5E-02**
RA2 MNR Sediment SWAC	PAHs (total)	< 1.62E-03	< 3E-08	< 5E-08	< 4E-09	< 2E-08	< 4E-05	< 4E-04	< 8E-05	< 2E-03
	PCBs (total)	< 1.17E-05	< 6E-11	< 2E-06	< 9E-12	< 1E-06	< 8E-08	< 1E-02	< 2E-07	< 1E-02
	Lead									
	Mercury	< 1.02E-03		< 6E-05		< 3E-05		< 4E-02		< 4E-02
	CUMULATIVE		**< 3E-08**	**< 6E-05**	**< 4E-09**	**< 3E-05**	**< 4E-05**	**< 5E-02**	**< 8E-05**	**< 5E-02**
RA3 Post-Removal Sediment SWAC	PAHs (total)	2.96E-04	5E-09	9E-09	8E-10	4E-09	7E-06	8E-05	2E-05	3E-04
	PCBs (total)	2.56E-06	1E-11	5E-07	2E-12	3E-07	2E-08	3E-03	4E-08	3E-03
	Lead									
	Mercury	2.52E-04		1E-05		7E-06		9E-03		9E-03
	CUMULATIVE		**5E-09**	**2E-05**	**8E-10**	**8E-06**	**7E-06**	**1E-02**	**2E-05**	**1E-02**
RA4 Post-Removal Sediment SWAC	PAHs (total)	3.92E-04	7E-09	1E-08	1E-09	6E-09	9E-06	1E-04	2E-05	4E-04
	PCBs (total)	2.99E-06	2E-11	6E-07	2E-12	3E-07	2E-08	4E-03	5E-08	3E-03
	Lead									
	Mercury	4.22E-04		2E-05		1E-05		2E-02		2E-02
	CUMULATIVE		**7E-09**	**3E-05**	**1E-09**	**1E-05**	**9E-06**	**2E-02**	**2E-05**	**2E-02**
RA5 Post-Removal Sediment SWAC	PAHs (total)	3.36E-04	6E-09	1E-08	9E-10	5E-09	8E-06	9E-05	2E-05	4E-04
	PCBs (total)	2.60E-06	1E-11	5E-07	2E-12	3E-07	2E-08	3E-03	4E-08	3E-03
	Lead									
	Mercury	3.53E-04		2E-05		1E-05		1E-02		1E-02
	CUMULATIVE		**6E-09**	**2E-05**	**9E-10**	**1E-05**	**8E-06**	**2E-02**	**2E-05**	**2E-02**

Notes:
Risk estimates for the RME and Typical exposures are calculated using the exposure factors from USEPA 1993 (also shown on Table 1).
(a) Surface Water concentrations are calculated from sediment SWACs assuming equilibrium conditions using the soil/water partitioning coefficient (K_d) for lead and mercury; and the organic carbon/water partitioning coeffient (K_{oc}) multiplied by the fraction of organic carbon (foc).
The sediment SWACs used to calculate surface water concentrations are the maximum of the 1/3 mile SWACs from the Main Channel or the Ship Canal calculated on 10/2/09.
RA1 - No Action.
RA2 - Monitored Natural Remediation (no sediment SWAC calculated).
RA3 - Remediation of sediment at all depth with TU=1.
RA4 - Remediation of surface sediment with TU=1.
RA5 - Remediation of surface sediment with TU=1 and maximum residual concentrations for PAHs, PCBs, Hg and Pb.

Appendix B2
Supplemental Human Health Risk Evaluation of Potential Recreational Exposure, Buffalo River AOC

Supplemental Human Health Risk Evaluation of Potential Recreational Exposure Buffalo River AOC, Buffalo, New York

The Human Health Risk Evaluation for the Feasibility Study performed by ENVIRON International Corporation (ENVIRON) did not identify significant recreational exposure to sediment or surface water under current or post-remedy conditions in the Buffalo River AOC in Buffalo, New York (ENVIRON 2009). However, at the request of the Buffalo/Niagara Riverkeeper, this supplemental evaluation was performed to estimate hypothetical human health risks from exposure to the maximum detected concentrations in sediment at ten areas identified by Riverkeeper as having the potential for direct access to the Buffalo River either currently or in the future.

Potential recreation exposures to sediment and surface water within the Buffalo River were evaluated for PCBs and non-PCBs using the maximum detected sediment concentration from samples collected within each of the areas of public access for remedial alternative (RA) 1 and RA5. Estimates of cumulative cancer risk and noncancer HQ are calculated using exposure factors developed for the "Alternate Recreational" exposure (see Table 1, Appendix B1) which is based on exposure assumptions ENVIRON has used in prior risk assessments in USEPA Region 5. Table 1 summarizes the maximum detected concentrations for PAHs, PCBs, lead and mercury in each of the identified areas. Table 2 and Table 3 summarize the risk estimates for sediment and surface water, respectively. As shown on these tables, all of the cumulative cancer risk and HI estimates are below USEPA's cumulative cancer risk and/or hazard index (HI) limits of 10^{-4} and 1 (USEPA 1991), respectively, for reasonable maximum exposure. These estimates confirm the conclusions of the Human Health Risk Evaluation presented in Appendix B1 which indicated that the remedial alternatives under consideration that result in removal of sediments result in a negligible effect on human health risks associated with sediment or surface water contact with PCBs and non-PCBs during occasional recreational activities in the Buffalo River.

Potential exposure to lead in sediment is evaluated using the blood lead level as an index of exposure, rather than in terms of cancer risk or HQ. The mean lead concentration is typically used to evaluated blood lead level; however, for expediency the maximum detected concentrations were used for this evaluation. The maximum sediment concentrations (Table 1) for RA1 and RA5 are all lower than the residential direct contact criterion for lead in soil (400 mg/kg), except for the maximum detected concentration in Area E for RA1. The mean lead concentration, which is appropriate for evaluating lead exposure, in Area E for RA1 is 226 mg/kg, which is lower than the residential direct contact criterion for lead in soil. Recreational exposures to sediment in the Buffalo River are expected to be less than those of residents and thus use of the residential soil contact criterion for lead is conservative.

These results confirm that significant exposure during occasional recreational activities at these areas in the Buffalo River is unlikely.

REFERENCES

United States Environmental Protection Agency (USEPA). 1991. Role of the baseline risk assessment in Superfund remedy selection decisions. Memorandum from Don R. Clay to Regional Directors. OSWER Directive 9355.0-30. April 22.

Table 1
Sediment Concentrations at Potential Park Areas along the Buffalo River
Buffalo River AOC, Buffalo, New York

Chem Group	Chemical	CASRN	Pre-Remedy										Post-RA5									
			Area A	Area B	Area C	Area D	Area E	Area F	Area G	Area H	Area I	Area J	Area A	Area B	Area C	Area D	Area E	Area F	Area G	Area H	Area I	Area J
SVOC	Acenaphthene	83-32-9	2.40E-01	5.00E-02	4.20E-02	1.35E-02	2.30E+01	1.00E-01	7.70E-02	4.40E-02	3.10E-02	--	1.30E-01	5.00E-02	4.20E-02	1.35E-02	3.90E-02	1.15E-01	--	4.40E-02	3.10E-02	--
SVOC	Acenaphthylene	208-96-8	9.30E-02	3.70E-02	1.75E-02	1.80E-02	2.50E-01	8.50E-01	5.00E-02	9.50E-02	1.65E-02	--	9.30E-02	4.10E-02	1.75E-02	1.80E-02	9.00E-02	1.10E-01	--	9.50E-02	1.65E-02	--
SVOC	Anthracene	120-12-7	4.10E-01	1.00E-01	9.20E-02	2.80E-02	1.90E+01	3.80E-01	1.80E-01	9.50E-02	5.10E-02	--	4.10E-01	1.00E-01	9.20E-02	2.80E-02	6.00E-02	3.40E-01	--	9.50E-02	5.10E-02	--
SVOC	Benzo(a)anthracene	56-55-3	9.70E-01	3.50E-01	3.10E-01	1.10E-01	1.10E+01	1.40E+00	5.40E-01	3.60E-01	2.20E-01	--	9.70E-01	3.50E-01	3.10E-01	1.10E-01	2.10E-01	6.00E-01	--	3.60E-01	2.20E-01	--
SVOC	Benzo(a)pyrene	50-32-8	9.20E-01	3.90E-01	3.40E-01	1.30E-01	6.60E+00	1.60E+00	6.00E-01	3.50E-01	2.30E-01	--	9.20E-01	3.90E-01	3.40E-01	1.30E-01	3.00E-01	6.60E-01	--	3.50E-01	2.30E-01	--
SVOC	Benzo(b)fluoranthene	205-99-2	1.30E+00	6.50E-01	4.60E-01	1.80E-01	1.00E+01	2.30E+00	5.80E-01	4.50E-01	3.20E-01	--	1.30E+00	6.50E-01	4.60E-01	1.80E-01	3.30E-01	1.00E+00	--	4.50E-01	3.20E-01	--
SVOC	Benzo(g,h,i)perylene	191-24-2	3.70E-01	1.80E-01	1.70E-01	5.20E-02	3.90E+00	1.00E+00	2.50E-01	2.00E-01	1.30E-01	--	3.70E-01	1.80E-01	1.70E-01	5.20E-02	1.80E-01	2.80E-01	--	2.00E-01	1.30E-01	--
SVOC	Benzo(k)fluoranthene	207-08-9	1.00E+00	6.30E-01	4.60E-01	1.90E-01	2.60E+00	2.40E+00	9.70E-01	4.70E-01	2.40E-01	--	1.00E+00	6.30E-01	4.60E-01	1.90E-01	4.60E-01	7.50E-01	--	4.70E-01	2.40E-01	--
SVOC	Chrysene	218-01-9	1.20E+00	6.30E-01	4.80E-01	1.90E-01	1.10E+01	2.50E+00	7.50E-01	4.90E-01	3.30E-01	--	1.20E+00	6.30E-01	4.80E-01	1.90E-01	4.30E-01	8.90E-01	--	4.90E-01	3.30E-01	--
SVOC	Dibenz(a,h)anthracene	53-70-3	1.40E-02	5.70E-02	4.50E-02	1.25E-02	3.00E-01	3.50E-01	1.10E-01	4.00E-02	3.50E-02	--	1.20E-02	5.70E-02	4.50E-02	1.25E-02	6.80E-02	1.00E-01	--	9.50E-02	3.50E-02	--
SVOC	Fluoranthene	206-44-0	2.30E+00	9.60E-01	7.90E-01	3.50E-01	3.60E+01	4.20E+00	1.20E+00	7.10E-01	7.20E-01	--	2.30E+00	9.60E-01	7.90E-01	3.50E-01	7.10E-01	1.30E+00	--	7.10E-01	7.20E-01	--
SVOC	Fluorene	86-73-7	2.50E-01	6.40E-02	3.60E-02	1.65E-02	1.70E+01	1.20E-01	2.50E-01	8.30E-02	3.90E-02	--	1.80E-01	6.40E-02	3.60E-02	1.65E-02	6.90E-02	1.20E-01	--	8.30E-02	3.90E-02	--
SVOC	Indeno(1,2,3-cd)pyrene	193-39-5	3.50E-01	1.80E-01	1.60E-01	4.30E-02	3.70E+00	8.80E-01	1.80E-01	1.70E-01	1.30E-01	--	3.50E-01	1.80E-01	1.60E-01	4.30E-02	1.50E-01	2.70E-01	--	1.70E-01	1.30E-01	--
SVOC	Naphthalene	91-20-3	2.80E-01	5.00E-02	2.60E-02	2.25E-02	4.60E+00	6.30E-01	4.70E-02	9.00E-02	2.10E-02	--	9.70E-02	5.00E-02	2.60E-02	2.25E-02	9.00E-02	6.30E-01	--	9.00E-02	2.10E-02	--
SVOC	Phenanthrene	85-01-8	1.20E+00	4.20E-01	2.30E-01	1.40E-01	5.90E+01	2.20E+00	5.10E-01	6.20E-01	4.60E-01	--	1.00E+00	4.20E-01	2.30E-01	1.40E-01	3.50E-01	8.70E-01	--	6.20E-01	4.60E-01	--
SVOC	Pyrene	129-00-0	1.90E+00	8.50E-01	5.80E-01	2.50E-01	2.50E+01	4.50E+00	1.50E+00	1.10E+00	4.90E-01	--	1.90E+00	8.50E-01	5.80E-01	2.50E-01	5.90E-01	1.50E+00	--	1.10E+00	4.90E-01	--
PCB	PCBs (total)	1336-36-3	2.64E-01	8.50E-02	1.06E-01	7.10E-02	1.03E+01	2.65E-01	4.65E-02	9.10E-02	4.20E-02	--	2.64E-01	8.50E-02	1.06E-01	7.10E-02	5.10E-02	2.65E-01	--	9.10E-02	4.20E-02	--
INORG	Mercury	7439-97-6	1.10E+00	1.60E-01	1.60E-01	8.30E-02	8.40E+00	1.10E-01	7.00E-02	1.40E-01	1.60E-02	--	1.10E+00	1.60E-01	1.60E-01	8.30E-02	1.20E-01	1.10E-01	--	1.40E-01	1.60E-02	--
INORG	Lead	7439-92-1	1.19E+02	5.02E+01	4.24E+01	3.29E+01	8.92E+02	3.64E+01	3.49E+01	2.56E+01	1.96E+01	--	1.19E+02	5.02E+01	4.24E+01	3.29E+01	5.08E+01	3.64E+01	--	2.56E+01	1.96E+01	--

Notes:
Concentrations are the maximum detected sediment concentrations from each of the Potential Park Areas along the Buffalo River.
No sediment sampling locations are associated with Area J, which is not immediately adjacent to the Buffalo River.
RA5 is proposed to remove all sediment sampling locations associated with Area G.

Table 2
Estimates of Cumulative Cancer Risk and HI via Recreator Exposure to Sediment at Potential Park Areas along the Buffalo River
Buffalo River AOC, Buffalo, New York

Area	Pre-Remedy		Post-RA5	
	Cancer Risk	HI	Cancer Risk	HI
A - Marina	7E-07	1E-02	8E-07	6E-03
B - Park	3E-07	3E-03	5E-07	3E-03
C - Habitat Corridor/Park	3E-07	4E-03	4E-07	3E-03
D - Proposed Park	1E-07	3E-03	3E-07	3E-03
E - Park	7E-06	4E-01	4E-07	3E-03
F - Proposed Greenway	1E-06	9E-03	6E-07	9E-03
G - Proposed Connector/Greenway	5E-07	2E-03	--	--
H - Proposed Greenway	3E-07	3E-03	3E-07	3E-03
I - Park	2E-07	1E-03	2E-07	1E-03
J - Proposed Restoration	--	--	--	--

Notes:

Risk estimates are for "Alternate Recreational" exposure factors shown in Table 1 of Appendix B1 of the FS.

Risk estiamtes are calculated using the maximum detected concentrations in each area for 16 individual PAHs, PCBs, and mercury.

RA5 - Remediation of surface sediment with TU=1 and maximum residual concentrations for PAHs, PCBs, Hg and Pb.

No sediment sampling locations are associated with Area J, which is not immediately adjacent to the Buffalo River.

RA5 is proposed to remove all sediment sampling locations associated with Area G.

Table 3
Estimates of Cumulative Cancer Risk and HI via Recreator Exposure to Surface Water at Potential Park Areas along the Buffalo River
Buffalo River AOC, Buffalo, New York

Area	Pre-Remedy		Post-RA5	
	Cancer Risk	HI	Cancer Risk	HI
A - Marina	2E-06	7E-02	2E-06	5E-02
B - Park	1E-06	1E-02	1E-06	1E-02
C - Habitat Corridor/Park	9E-07	1E-02	9E-07	1E-02
D - Proposed Park	4E-07	6E-03	4E-07	6E-03
E - Park	2E-05	9E-01	8E-07	1E-02
F - Proposed Greenway	4E-06	6E-02	2E-06	6E-02
G - Proposed Connector/Greenway	2E-06	7E-03	--	--
H - Proposed Greenway	1E-06	1E-02	1E-06	1E-02
I - Park	6E-07	3E-03	6E-07	3E-03
J - Proposed Restoration	--	--	--	--

Notes:
Risk estimates are for "Alternate Recreational" exposure factors shown in Table 1 of Appendix B1 of the FS.
Risk estiamtes are calculated using the maximum detected concentrations in each area for 16 individual PAHs, PCBs, and mercury.
Surface Water concentrations are calculated from sediment assuming equilibrium conditions using the soil/water partitioning coefficient (K_d) for mercury; and the organic carbon/water partitioning coeffient (K_{oc}) multiplied by the fraction of organic carbon (foc).
RA5 - Remediation of surface sediment with TU=1 and maximum residual concentrations for PAHs, PCBs, Hg and Pb.
No sediment sampling locations are associated with Area J, which is not immediately adjacent to the Buffalo River.
RA5 is proposed to remove all sediment sampling locations associated with Area G.

Appendix C
Buffalo River Technical Memoranda

C1: Rationale for SWAC Areas for the Buffalo River AOC

C2: Post Remedy Alternative 5 SWAC Analysis, One-Third Mile SWAC Areas Divided by Navigation Channel

C3: Buffalo River Sedimentation and Long-Term Sediment Stability

C4: Seven Additional Chemicals of Potential Concern

Appendix C1
Rational for SWAC Areas for the Buffalo River AOC

MEMORANDUM

Date: September 2, 2009

To: Mary Beth Giancarlo-Ross, USEPA

From: Darrel Lauren, Jen Lyndall, Mary Sorensen, and Victor Magar, ENVIRON

Re: Rationale for SWAC Areas for the Buffalo River AOC

The Ecology Subgroup (Eco-Group) of the Buffalo River Project Coordination Team identified Remedial Goals (RGs) for the four indicator chemicals (total PAHs, total PCBs, lead, and mercury) for use in the Buffalo River Feasibility Study (FS). Of these four chemicals, a point concentration RG was developed for total PAHs and surface weighted average concentration (SWAC) RGs was developed for total PCBs, lead, and mercury. In this memo, we review the:

- approach used to determine the SWAC RGs:,
- rationale for determining the SWAC surface area, based on fish life information from the literature; and
- precedents from other sites.

The review supports our recommendation to base SWACs on 1/3-mile intervals in the river, measured bank to bank.

Rationale Based on Buffalo River Site-Specific SWAC Remedial Goals

Total PCBs: The total PCB RG considered a risk-based evaluation using site-specific fish tissue data and NYSDEC fish tissue criteria back-calculated to sediment concentrations. SWACs were derived to estimate concentrations of total PCBs in fish tissues protective of piscivorous wildlife. As such, the fish life history information was considered relevant in determining SWAC areas.

Mercury and Lead: An evaluation of fish tissue concentrations against fish flesh criteria considered protective of piscivorous wildlife demonstrated that current conditions in fish were below criteria. For mercury, the highest mercury fish tissue concentration was less than one half the protective criterion and average concentrations of both small and large fish were approximately an order of magnitude below the criterion. Based on these data, the Eco-Group demonstrated that current conditions in surface sediment are protective concentrations for mercury and lead; and, SWACs for these constituents were based on fish life history information.

Estimate of SWAC Lengths Based on Fish Life Information

Many of the fish that inhabit the Buffalo River have large home ranges, non-specific home ranges, or are opportunistic in their use of the river, and therefore, SWACs that reflect large areas are appropriate for many species. This is particularly true for carp which are long lived fish that move throughout the river and the lake and have relatively large home ranges. However, as a conservative approach for the Feasibility Study SWAC estimates, small home range fish species and life stages were identified. In order to provide scientifically valid SWAC lengths, fish forage ranges were developed for two different species of fish considered to be important indicators of health for the Buffalo River, brown bullhead and spottail shiners.

Brown bullhead was evaluated because it is a bottom-feeding species key to the evaluation of fish tumors. Spottail shiners were evaluated for two reasons:

1. NYSDEC (2006) collected young-of-the-year (YOY) for tissue chemical analyses; and
2. concentrations of chemicals in older fish cannot be directly linked to the year-by-year changes in sediment chemistry that will occur during remediation.

Sakaris et al. (2005) showed that brown bullhead forage range changes seasonally, from 1.0 km (0.62 miles) during the spring, 0.5 km (0.31 miles) during the summer, and 3.1 km (1.93 miles) in the fall. The average for three seasons is 1.5 km or 0.93 miles. Choy et al. (2008) reported that spottail shiners have 0.5 km (0.31 mile) forage range. Therefore, the lower range value, 0.31 miles, was used to calculate SWAC lengths.

There is no scientific justification to separate the SWAC lengths into right, left and central areas. Sakaris et al. (2005) reported that the forage areas of brown bullhead for the three seasons varied between 4.5 and 19.7 hectares (11.1 to 48.7 acres). This distance easily encompasses the width of the Buffalo River.

SWAC Areas Used at Other Contaminated River Sites

- **Ashtabula River** – PCB SWAC calculations were based on the entire remedial area (approximately one river mile).
- **Fox River, OU1** – PCB SWAC calculations were based on the entire operational unit (approximately 4 river miles)
- **Hudson Rive**r – PCB SWACs for post-remedy performance standards were calculated for areas ranging from 5 to 40 acres

Recommended SWAC Areas for the Buffalo River Feasibility Study

We recommend basing SWACs on 1/3-mile intervals in the river for the final Buffalo River FS, and we also recommend measuring SWACs across the entire width of the river. By using the shortest fish range reported, this constitutes a highly conservative approach, consistent with our understanding of fish behavior in the river, and more than adequately protective of ecological and human receptors. Additional analyses have been provided to the PCT that show SWACs on 1/3-mile intervals with the river divided by right, left and central areas, but because we could find no scientific justification to separate the SWAC lengths into right, left and central areas, we do not recommend using these additional analyses to inform the remedy.

References

Choy, E., P. Hodson, L. Campbell, A. Fowlie, and J. Ridal. 2008. Spatial and temporal trends in mercury concentrations in young-of-the-year spottail shiners (*Notripis hudsonius*) in the St. Lawrence River at Cornwall, ON. Arch. Env. Contam. Toxicol. 54: 473-481.

NYSDEC. 2006. PCBs and organochlorine pesticides in young-of-year fish from traditional near-shore sampling areas, NYS's Great Lakes Basin, 2003. Bureau of Habitat, NYSDEC, August 2006.

Sakaris, P., R. Jensen, and A. Pinkney. 2005. Brown bullhead as an indicator species: Seasonal movement patterns and home ranges within the Anacostia River, Washington, D.C. Trans. Am. Fish. Soc. 134: 1262-1270.

Appendix C2
Post Remedy Alternative 5 SWAC Analysis, On-Third Mile SWAC Areas Divided by Navigation Channel

January 29, 2010

To: Mary Beth Ross, USEPA GLNPO

From: Kristin Searcy Bell & Victor Magar, ENVIRON
Mark Kamilow, Honeywell

Re: Post-Remedy Alternative 5 SWAC Analysis, 1/3-mile SWAC Areas Divided by Navigation Channel

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As part of the preferred remedy analysis for the Buffalo River Feasibility Study, post-Remedy Alternative 5 SWACs were calculated based on areas 1/3-mile in length and divided longitudinally by the left bank, right bank and navigation channel. This analysis was conducted per the request of New York State Department of Environmental Conservation (NYSDEC) who expressed concerns that SWACs calculated over the entire width of the river may dilute deposits of elevated surface sediment chemical concentrations along the banks. The results of this additional post-Remedy Alternative 5 SWAC for analysis for mercury (Hg), lead (Pb), and total PAHs are presented in Table 1.

Segmenting the Buffalo River Area of Concern (AOC) into a 1/3-mile SWAC areas, divided longitudinally by the left bank, right bank and navigation channel, resulted in 192 separate SWAC areas. As presented in Table 1, post-Remedy Alternative 5 conditions are estimated to achieve the SWAC RGs for Hg (0.44 mg/kg), Pb (90 mg/kg), and total PCBs (0.20 mg/kg) for the large majority of these SWAC areas. When divided longitudinally along the river, only three post-Remedy Alternative 5 SWAC areas are estimated to be greater than the SWAC RGs. At River Mile (RM) 1.0-1.33, the post-Remedy Alternative 5 SWAC for Pb along the left bank is estimated to be 123.7 mg/kg, while the Pb SWAC RG is 90.0 mg/kg. However, this area of the river will be resampled as part of Remedy Alternative 5, and results from the resampling effort will be used to further delineate the Remedy Alternative 5 footprint in this area. Along the right bank of RM 1.33-1.67 post-Remedy Alternative 5 SWACs are estimated to be 0.48 mg/kg Hg and 0.22 mg/kg total PCBs. These post-Remedy Alternative 5 SWACs are slightly greater than the SWAC RGs. However, portions of RM 1.33-1.67 are will also be resampled as part of Remedy Alternative 5. Along the left bank of the City Ship Canal at mile 1.33-1.67, the post-Remedy Alternative 5 SWAC for Hg is estimated to be 0.45 mg/kg, while the SWAC RG for Hg is 0.44 mg/kg.

In summary, when SWACs are calculated based on a 1/3-mile SWAC areas, divided longitudinally by the left bank, right bank and navigation channel, only three of the 192 SWAC areas are estimated to exceed the SWAC RGs under post-Remedy Alternative 5 conditions. Two of most of these three areas will be resampled prior to finalizing the Remedy Alternative 5 footprint and one area exceeded the SWAC RG by only 0.01 mg/kg. The results of this analysis demonstrate that calculating SWACs across of the Buffalo River and City Ship Canal do not dilute elevated surface sediment chemical concentrations along the banks. Thus, no additional areas are recommended to be included in the Remedy Alternative 5 footprint as a result of this analysis.

Table 1

Post-Remedy Alterative 5 SWACs -1/3 Mile Areas Divided by Navigation Channel, Surface Depth of 0-2 ft

Buffalo, NY

Waterbody	Downstream rivermile	Position	Lead	Mercury	Total PCBs
			Post-Remedy 5 SWAC (mg/kg) using 0-2 ft surface depth [1,2]		
SWAC Remedial Goals			**90.0**	**0.44**	**0.20**
Range of SWAC Remedial Goals			**85-103**	**0.43-0.54**	**0.18-0.44**
Buffalo River	0.33	Left	46.1	0.16	0.13
Buffalo River	0.33	Navigation channel	42.1	0.19	0.12
Buffalo River	0.33	Right	31.6	0.22	0.11
Buffalo River	0.67	Left	37.2	0.13	0.06
Buffalo River	0.67	Navigation channel	53.8	0.32	0.13
Buffalo River	0.67	Right	41.6	0.25	0.11
Buffalo River	1.00	Left	**123.7**	0.32	0.11
Buffalo River	1.00	Navigation channel	71.5	0.17	0.08
Buffalo River	1.00	Right	50.7	0.17	0.11
Buffalo River	1.33	Left	45.0	0.12	0.08
Buffalo River	1.33	Navigation channel	40.2	0.21	0.11
Buffalo River	1.33	Right	68.6	**0.48**	**0.22**
Buffalo River	1.67	Left	46.7	0.15	0.10
Buffalo River	1.67	Navigation channel	40.5	0.18	0.10
Buffalo River	1.67	Right	43.2	0.24	0.11
Buffalo River	2.00	Left	35.8	0.12	0.09
Buffalo River	2.00	Navigation channel	37.1	0.13	0.08
Buffalo River	2.00	Right	34.4	0.10	0.07
Buffalo River	2.33	Left	55.0	0.32	0.17
Buffalo River	2.33	Navigation channel	66.8	0.24	0.18
Buffalo River	2.33	Right	43.9	0.09	0.10
Buffalo River	2.67	Left	43.5	0.08	0.09
Buffalo River	2.67	Navigation channel	48.0	0.10	0.12
Buffalo River	2.67	Right	40.0	0.07	0.12
Buffalo River	3.00	Left	37.9	0.12	0.09
Buffalo River	3.00	Navigation channel	43.9	0.16	0.08
Buffalo River	3.00	Right	31.8	0.06	0.05
Buffalo River	3.33	Left	37.9	0.32	0.06
Buffalo River	3.33	Navigation channel	67.9	0.27	0.08
Buffalo River	3.33	Right	78.3	0.13	0.06
Buffalo River	3.67	Left	35.3	0.09	0.05
Buffalo River	3.67	Navigation channel	36.0	0.12	0.06
Buffalo River	3.67	Right	21.8	0.03	0.01
Buffalo River	4.00	Left	49.9	0.19	0.11
Buffalo River	4.00	Navigation channel	37.0	0.10	0.10
Buffalo River	4.00	Right	30.6	0.06	0.08
Buffalo River	4.33	Left	36.0	0.13	0.05
Buffalo River	4.33	Navigation channel	39.1	0.12	0.05
Buffalo River	4.33	Right	49.7	0.14	0.05

Table 1

Post-Remedy Alterative 5 SWACs -1/3 Mile Areas Divided by Navigation Channel, Surface Depth of 0-2 ft

Buffalo, NY

Waterbody	Downstream rivermile	Position	Lead	Mercury	Total PCBs
			Post-Remedy 5 SWAC (mg/kg) using 0-2 ft surface depth [1,2]		
SWAC Remedial Goals			**90.0**	**0.44**	**0.20**
Range of SWAC Remedial Goals			**85-103**	**0.43-0.54**	**0.18-0.44**
Buffalo River	4.67	Left	34.7	0.10	0.07
Buffalo River	4.67	Navigation channel	35.2	0.10	0.07
Buffalo River	4.67	Right	24.9	0.07	0.03
Buffalo River	5.00	Left	28.5	0.07	0.06
Buffalo River	5.00	Navigation channel	38.7	0.25	0.20
Buffalo River	5.00	Right	76.5	0.43	0.17
Buffalo River	5.33	Left	30.7	0.07	0.06
Buffalo River	5.33	Navigation channel	29.5	0.11	0.08
Buffalo River	5.33	Right	32.8	0.16	0.11
Buffalo River	5.67	Left	32.5	0.07	0.05
Buffalo River	5.67	Navigation channel	25.6	0.08	0.06
Buffalo River	5.67	Right	25.0	0.11	0.07
Buffalo River	5.67	Above navigation channel	43.2	0.03	0.08
City Ship Canal	0.00	Left	58.0	0.30	0.10
City Ship Canal	0.00	Navigation channel	49.2	0.28	0.09
City Ship Canal	0.00	Right	42.4	0.24	0.08
City Ship Canal	0.33	Left	59.6	**0.45**	0.12
City Ship Canal	0.33	Navigation channel	45.8	0.32	0.09
City Ship Canal	0.33	Right	38.7	0.26	0.07
City Ship Canal	0.67	Left	24.6	0.18	0.05
City Ship Canal	0.67	Navigation channel	39.7	0.31	0.09
City Ship Canal	0.67	Right	45.4	0.40	0.14
City Ship Canal	1.00	Left	34.3	0.20	0.05
City Ship Canal	1.00	Navigation channel	37.5	0.25	0.06
City Ship Canal	1.00	Right	43.8	0.35	0.08

NOTES:

1) Post remediation SWACs are calculated by applying average upstream surface sediment concentrations to remediated areas. The average upstream surface sediment concentrations are total PAHs, 6.1 mg/kg; Pb, 21.7 mg/kg; Hg, 0.029 mg/kg; total PCBs, 0.014 mg/kg.

2) Per the request of NYSDEC, post-Remedy Alternative 5 SWACs based on 1/3-mile river segments, divided longitudinally along the right bank, left bank, and navigation channel were calculated using a surface sediment depth of 0-2 ft.

Appendix C3
Buffalo River Sedimentation and Long-Term Sediment Stability

LimnoTech
Water | Environment | Scientists | Engineers

MEMORANDUM

DATE: June 18, 2009

FROM: Tim Dekker

PROJECT: BUFHON

TO: Buffalo River GLLA Project Coordination Team

SUBJECT: *Technical Memorandum: Buffalo River Sedimentation and Long-term Sediment Stability*

INTRODUCTION

The Buffalo River sediment transport environment has been studied extensively under numerous programs and by investigators in academia, government, and consulting (USACE, 1988; DePinto et al., 1994; Atkinson et al, 1994; SAIC, 1995; Inamdar, 2004; McLaren and Singer, 2008; Singer et al., 2008; Ecology and Environment, 2008). The existing body of study provides a comprehensive and reasonably consistent account of the sediment transport environment, providing basic information needed for supporting the Buffalo River remedy assessment and feasibility study activities undertaken by the Buffalo River GLLA Project Coordination Team. This document provides a brief summary of historical estimates of sedimentation mechanisms and rates, a conceptual model for sedimentation in the lower Buffalo River, and an assessment of sediment stability and potential for scour.

SEDIMENT LOADING AND DEPOSITION

Estimates of sediment load delivered to the river and corresponding sedimentation rates have been made by numerous investigators. A 1988 sedimentation study conducted by the Buffalo District Corps of Engineers provided estimates of shoaling rates at locations throughout the river, with post-dredging rates of sedimentation varying significantly by location at 0.2 – 0.4 ft/year (USACE, 1988). Current estimates of annual dredged export of sediment from the lower river based on USACE records from 1990 to 2008 is on the order of 70,000 cubic yards/year, consistent with the earlier sedimentation study.

Under the USEPA Assessment and Remediation of Contaminated Sediments (ARCS) program, in-stream measurements of suspended sediment under a broad range of flow conditions were integrated to give an estimate of annual suspended sediment load of 45,000 cubic yards/year (DePinto et al., 1994), a result that is not inconsistent with the USACE dredged export estimates, given the substantial volume of bed load not investigated under this study. A subsequent study focusing on watershed production of solids (Inamdar, 2004) provided a mass estimate of 86,700 tons/year of solids, based on numerical modeling of the watershed solids production. Again, these findings are not inconsistent with previous volumetric estimates of solids load.

Based on the above estimates of solids load, a conceptual model of sediment transport and deposition is presented in Figure 1, showing sediment dynamics at the head of the Buffalo navigational channel. Here it assumed that the 45,000 CY/year of suspended

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sediment as estimated in the ARCS program reports is transported as suspended material in the water column, with some deposition at the head of the channel and broadly distributed deposition throughout the lower reaches of the river. In contrast, the heavier bed load component of the sediment load is expected to deposit primarily at the head end of the navigational channel, resulting in the formation of a depositional wedge similar to a river delta. With the assumption that bed load material makes of 35% of the total dredged volume of material reported by the USACE Buffalo District, the remaining suspended load is highly consistent with the ARCS estimates.

Hydrodynamic modeling of the lower Buffalo River conducted as part of the GLLA project feasibility study showed an abrupt decrease in velocity and bottom stress at the head of the navigational channel under most flow conditions, creating a depositional environment supporting the conceptual model shown in Figure 1. The Buffalo District also gives anecdotal reports of the formation of a depositional wedge in this area, and such behavior is common to many navigationally dredged Great Lakes tributaries.

The continual delivery of solids to the lower Buffalo, both as suspended and bed load, has important implications for the proposed dredging remedy. While sediment transport modeling was not conducted as part of the feasibility study activities, the historical USACE study (1988) can be used to estimate rates of infilling in areas of proposed dredging. Figure 2 shows areas proposed for dredging under the Remedy 5 alternative, proposed depths of dredging, and estimated rates of infilling. Based on these estimates, substantial infilling (~2-3 feet) will occur in the first 5 years post-dredging, though complete infilling may require 10-20 years.

SEDIMENT GEOCHRONOLOGY

A pilot study (four cores) of sediment geochronology was conducted in fall of 2008 to explore sediment Cesium-137 and Lead-210 profiles and determine if the data would be suitable for estimating sedimentation rates. Cores were typically 4-6 feet in length, and were collected from locations outside of the navigational channel where sedimentation would be expected to be less impacted by ongoing dredging activities. Findings of the geochronology study are reported in a project memorandum (LimnoTech, 2009)

Of the four cores collected, only a core collected across from Buffalo Color showed clear indications of a steady rate of deposition in both the lead and Cesium-137 results. The estimated soil accretion rate was based on the determination of the 1963 horizon at 119 cm and ranged from 2.5 to 3.0 cm per year. The absolute magnitudes of cesium-137 activities in this core and other cores are typical of riverine deposits originating from watershed solids transport, with relatively low, dilute concentrations compared with systems with very proximate sources. While not conclusive, this suggests that a significant proportion of the sediment solids originate well up in the watershed.

Sediment accretion rates could not be estimated in the other three sediment cores due to the vertical (uniform) nature of the profile in the upper foot of the cores, along with the uniform stable lead profile, which generally indicates mixing or rapid sedimentation, although a mixing process is more likely in this case. Dredging is a known mixing process at the site and could account for the observed degree of mixing either by direct impacts to the sediments, or by dredging in the vicinity and sloughing of sediments adjacent to the dredging activity. The observed rate of sedimentation observed in the core near Buffalo color is not inconsistent with other rates of sedimentation, given the expected slowing in sedimentation rate as the sediment bed approaches equilibrium in the shoulder areas.

SEDIMENT STABILITY AND SCOUR

Evaluation of the effectiveness and permanence of the proposed remedy also requires consideration of the vulnerability of buried materials to scour under high flow conditions. The 100 year event is commonly used as a reasonable threshold of protectiveness for evaluating sediment stability. While the hydrodynamics of this event are well understood and can be reliably extrapolated from the long record of hydrologic data and hydrodynamic modeling, the sediment transport dynamics of such an event are dependent on many factors that are not as well understood. An extreme flow event may result in localized erosion of the sediment bed, vertical mixing of sediments, but also likely broad deposition of watershed solids. The degree of erosion is a function of 1) the physical condition of the bed, and how it has adapted to 40-50 years of flow-related stresses since deposition of the contaminants of concern, and 2) the watershed , and how much / what kind of sediment load is delivered under a 100 year event.

Typically, data required to make such an assessment would require making site-specific measures of sediment cohesiveness and armoring, using a sediment erodibility flume (SEDFLUME), and collecting data on sediment critical shear strength, particle size grading, cohesiveness, and bedload. Collecting these data and developing an understanding of how load varies across a range of flow events would require a program of flow and solids/bedload measurements under high flow conditions, likely requiring a long period of study.

In the absence of such a program of investigation, and a sediment transport model to provide a quantitative estimate of the degree of scour, mixing and deposition, a simplified analysis based on hydrodynamics and available sediment properties was conducted. As noted above, the response of a river bed to extreme high stress conditions will almost always be a combination of localized erosion, vertical mixing of sediments, and widespread deposition of watershed solids. A hydrodynamic model can be used to identify areas of potential localized erosion, which commonly have the following characteristics:

- High bottom shear stress (greater than 20-40 dynes/cm2)
- Longitudinally increasing stress (supporting a gain in sediment load with distance downstream)
- High stream power (to sustain transport)

To identify areas with the above characteristics, hydrodynamic model results for the 100 year event were processed to identify areas with elevated stresses and a sufficient longitudinal gradient in stress to allow for a gaining sediment load, supporting erosion. Stream power was not assessed, as velocities in all cases were sufficient to maintain sediment transport.

Zones of elevated scour potential are mapped according to the above criteria in Figure 3. These areas have a greater probability of having significant scour due to local hydrodynamics that result primarily from river geomorphology, as river bends and bathymetry create local acceleration in flows.

As noted above, it is difficult to make estimates of the depth of scour in the identified areas of high erosion potential without data on bed characteristics and storm event watershed solids loads. However, a model of a similar Great Lakes tributary with similar bed characteristics and watershed geology (Lower Don River, Toronto) shows maximum scour depths of less than 1.5 feet (0.5 meter) under shear stress conditions similar to the 100 year event on the Buffalo River. The same model also shows broad areas of solids deposition due to greatly increased loads of watershed solids under high event flow conditions.

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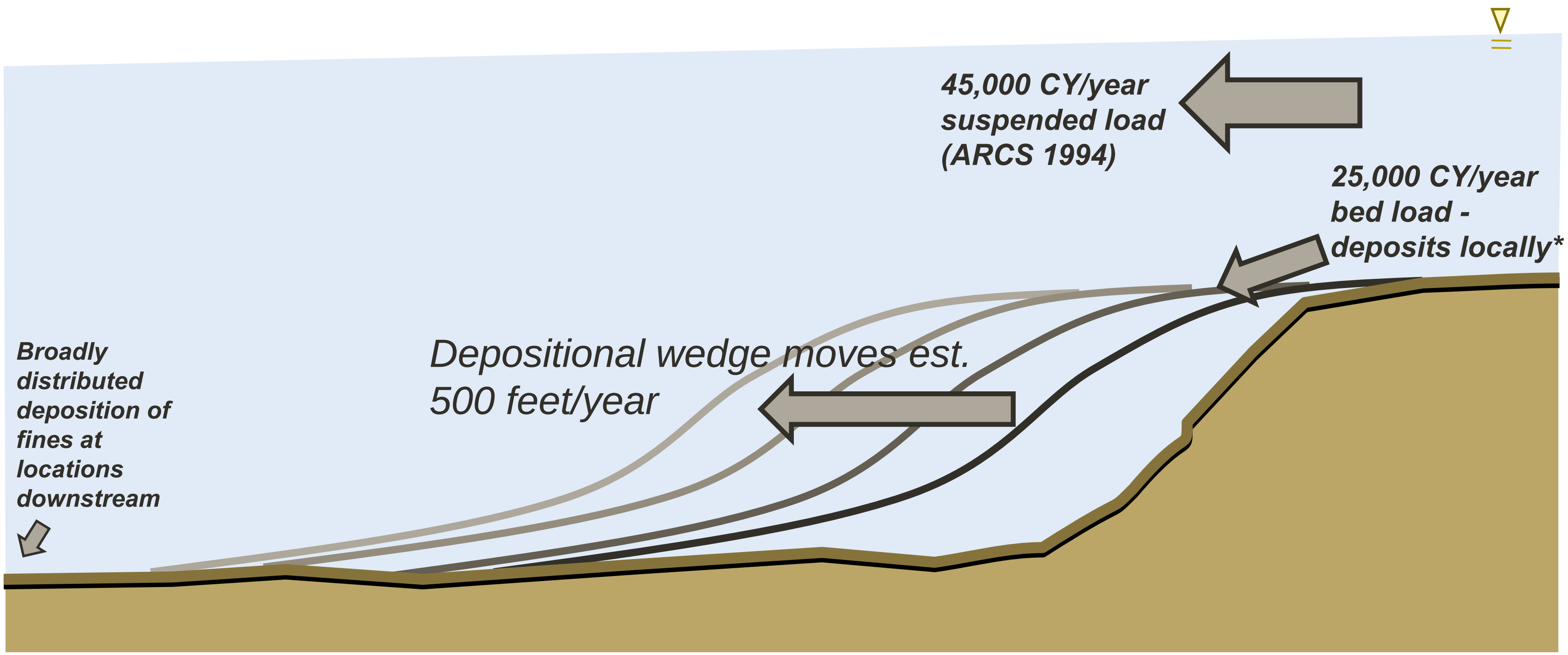

* Bed load assumed 35% of total annual dredged volume of 70,000 CY, consistent with ARCS suspended load estimate

Figure 1: Conceptual Model for Navigational Channel Sediment Transport

Figure 2: Remedy 5 Dredged Depths and Estimated Infilling Rates

NOTE: The Remedy Alternative 5 dredge footprint was expanded following the submission of this memorandum. Estimated infilling rates of the additional dredge areas are expected to be consistent with the rates presented in this figure.

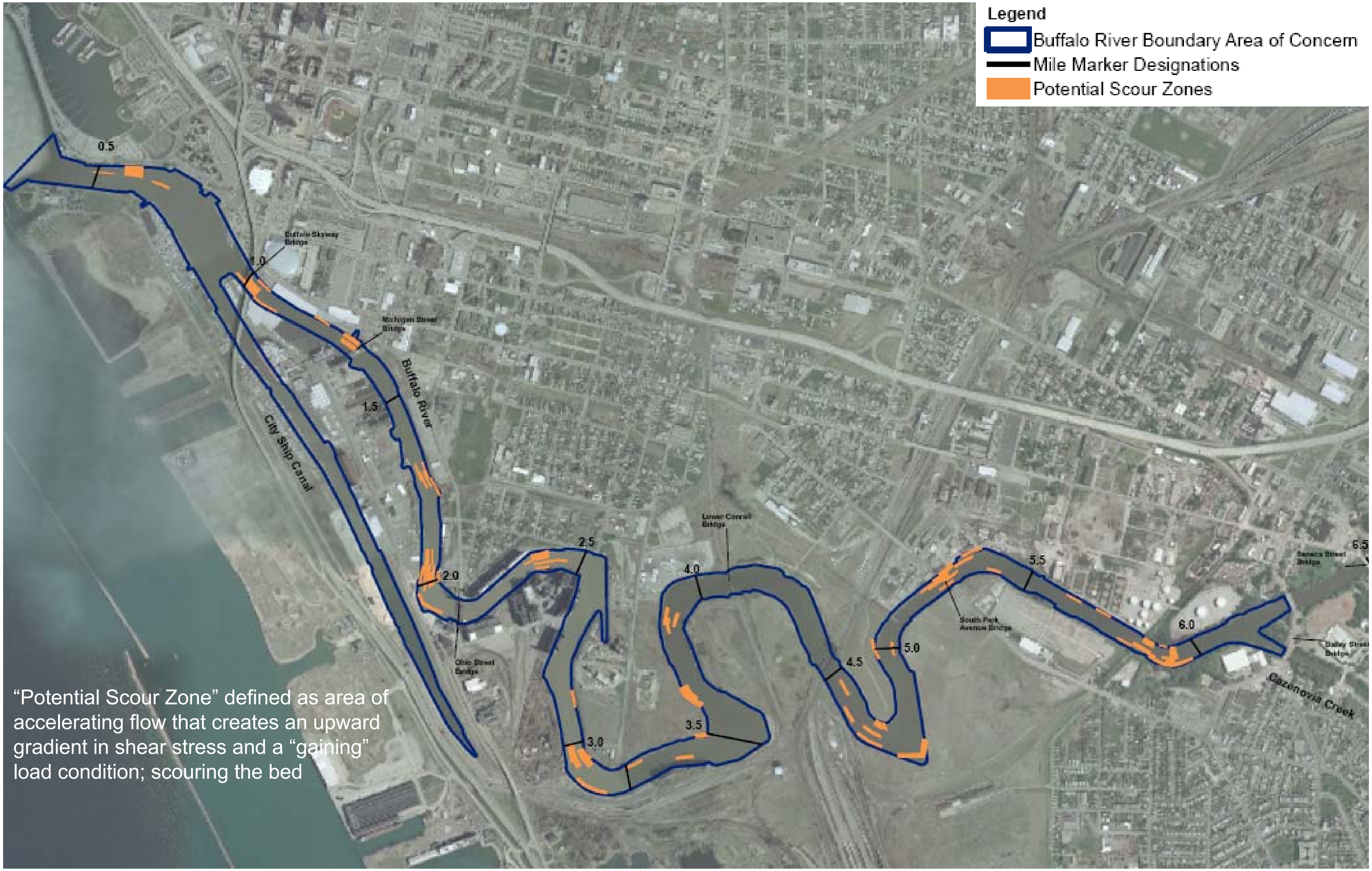

Figure 3: Potential Scour Zones

Appendix C4
Seven Additional Chemicals of Potential Concern

ENVIRON

September 2, 2009

MEMORANDUM

To: Mary Beth Giancarlo-Ross, USEPA

From: Mary Sorensen, ENVIRON International Corporation
Darrel Lauren, ENVIRON International Corporation
Victor S. Magar, ENVIRON International Corporation

Re: Seven Additional Chemicals of Potential Concern

Executive Summary

The draft Buffalo River Feasibility Study (FS) identifies potential remedial measures based on risks represented by total PAHs, total PCBs, mercury, and lead. The Buffalo River Project Coordination Team (PCT) requested that ENVIRON analyze the proposed FS Remedy Alternative 6[1] (RA6) with respect to its protectiveness for seven additional chemicals of potential concern (COPCs). This memorandum summarizes that analysis and includes consideration of:

- New York State Department of Environmental Conservation (NYSDEC) Sediment Guidance Values (SGVs)
- Probable Effects Concentrations (PECs) routinely used by the United States Environmental Protection Agency (USEPA)
- Various lines of evidence based on elements of geochemistry, bioavailability, and toxicology.

The analysis concludes that only limited occurrence of the seven additional COPCs will exist in the biologically active zone of sediments following the implementation of RA6. Given the low COPC concentrations relative to concentrations predictive of toxicological impacts, and given the dispersed locations where these COPC concentrations exist, there is sufficient evidence to conclude that these residual concentrations will not pose an unacceptable impact to fish and wildlife populations or communities.

Introduction

The draft Buffalo River Feasibility Study (FS) identifies potential remedial measures based on risks represented by total PAHs, total PCBs, mercury, and lead. The Buffalo River Project Coordination Team (PCT) requested that ENVIRON analyze the proposed FS RA6 with respect to its protectiveness for seven additional chemicals of potential concern (COPCs). This memorandum presents lines of evidence used to evaluate risks associated with the seven additional COPCs following implementation of RA6.

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[1] Following the submission of this memorandum, Remedy Alternative 6 was renamed Remedy Alternative 5.

The additional COPCs for the Buffalo River are:

Metals	Pesticides	PAHs
▪ Arsenic	▪ DDT	▪ Benzo(a)anthracene
▪ Chromium	▪ Gamma Chlordane	▪ Benzo(a)pyrene
▪ Copper		

The evaluation of these COPCs presented herein includes:

- Comparison of COPC concentrations in sediment to NYSDEC SGVs – both surface sediment concentrations and concentrations at depths within the sediment column
- Comparison of COPC concentrations in sediment to PECs routinely used by the USEPA (MacDonald et al. 2000) – both surface sediment concentrations and concentrations at depths within the sediment column
- Consideration of additional lines of evidence, such as:
    - The spatial scale of SGV and PEC exceedances relative to potential impacts to organism populations and the sediment dwelling organism community
    - Geochemical and organic carbon conditions in the Buffalo River that can be used to predict COPC bioavailability and toxicity
    - Concentrations of pesticides in fish tissues and predicted impacts for wildlife exposed to pesticides
    - An evaluation of residual concentrations of the two identified individual PAHs following the remedial action focused on total PAHs
    - PAH toxicity units (TUs) for the two individual PAHs as contributions to the overall PAH TU that is predictive of toxic effects to benthic organisms

A significant portion of the evaluation of the seven COPCs is based on comparisons to sediment quality criteria, such as the NYSDEC SGVs and the USEPA PECs. In addition, toxicity testing on Buffalo River sediments has provided an important line of evidence that is discussed throughout this memorandum. These values are summarized in Table 1 of Attachment 1. A brief description of these criteria and no effects concentrations derived from toxicity testing is provided.

- The NYSDEC (2007) SGVs are provided as screening values defined using several methods, such as equilibrium-partitioning based approaches for organics and empirically-based threshold effects concentration (TEC) methods for metals. SGVs such as the TECs are intended to identify the concentrations of sediment-associated contaminants below which, adverse effects on sediment dwelling organisms are not expected to occur (NYSDE 2007; MacDonald et al. 2000). However, concentrations exceeding these values do not necessarily indicate that sediments are toxic (i.e., additional consideration is needed to evaluate toxicity).
- Probable effects concentrations (PECs) are used often by the USEPA for making remedial management decisions because these are values used to classify sediments as toxic. PECs for both organics and metals are based on sediment

samples from the database that were known to be toxic, at least 75% of the time (NYDSEC 2007; MacDonald et al. 2000).

- Toxicity testing conducted on Buffalo River sediments provides no effects concentrations (NOECs) that generally fall between the SGVs and the PECs. These values reflect unbounded NOECs, which means these are the highest concentrations below which toxicity was not observed and the 2005 toxicity testing effort showed almost no toxic response[2] at any location. Since no toxicity was observed, and since toxicity was not attributed to any particular chemical, it is highly likely that concentrations above these NOECs would also show no toxic response. Therefore, the exceedance of these NOEC values for any particular chemical does not mean that toxicity will occur. For this reason, these NOECs are discussed qualitatively and consideration was given to the PEC because it is reported as a value above which toxicity is reliably predicted.

Regardless of the type of criteria (SGV and PEC) consideration must be given to River-specific factors that mitigate toxicity related to the chemical. The total organic carbon (TOC) in sediment mitigates the toxicity of some chemicals because when bound to TOC, they are not biologically available to cause toxicity. Similarly, the presence of sulfides also indicates that some chemicals are tightly bound to ferrous iron or sulfides and therefore not biologically available. The average TOC in sediment from Buffalo River (2.7%) is higher than the average TOC used in the derivation of SGVs (2%) and PECs (1%), and therefore, the NYSDEC SGVs and PECs are conservatively protective when used for the Buffalo River. Similarly, studies of sulfides in the Buffalo River showed reducing conditions in sediment that would significantly limit the toxicity of some chemicals. This is evidenced by the sediment toxicity testing conducted on Buffalo River sediments, showing that sediment concentrations higher than the SGVs were not toxic (Table 1). Therefore, while the SGVs and PECs are considered valued lines of evidence for consideration of potential toxicity, additional considerations are also necessary to understand the spatial extent and magnitude of exceedances of criteria, site-specific toxicity testing results showing no toxicity, as well as additional information such as measured concentrations of chemicals in fish tissues and toxicity units that can help inform the overall potential for adverse impacts to the aquatic environment.

The evaluation of the overall protectiveness of RA6 is focused upon the residual chemicals that remain in sediment within the biologically active zone, which is the upper 6 inches of the sediment. Historic sampling of the river often included surficial zones of 0 to 1 foot or 0 to 2 feet below sediment surface. Therefore, the analysis presented herein includes historic data from this 0 to 1 foot and 0 to 2 foot zones as well as the more appropriate upper 6 inch zone available from more recent sampling efforts.

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[2] The lack of toxic response was seen only in the 2005 toxicity testing. Subsequent 2007 toxicity testing showed a wide range of toxic responses. It is noted that the toxicity seen in 2007 testing was consistently linked with total PAHs with toxicity units that exceeded the threshold value of 1 (as described in detail in Preliminary Remedial Goal derivation memoranda developed by the Ecology Group which is included in the FS).

The remainder of this memorandum is organized by classes of chemicals (metals, pesticides, and PAHs) for the detailed discussion of the seven COPCs. Figures and tables that support this memorandum are provided in Attachment 1.

METALS

The metals COPCs addressed in this memorandum are arsenic, chromium, and copper. Figures illustrating the residual concentrations of metals following implementation of RA6 are provided in Attachment 1, as follows:

- Table 1 provides a summary of SGVs and PECs compiled by the USACE for consideration on the Buffalo River
- Table 2 identifies the number of SGV and locations outside RA6 footprint with chemical levels above their respective PEC values
- Figures 1a through 1c illustrate COPC concentrations relative to SGVs
- Figures 1d through 1f illustrate COPC concentrations relative to PECs

Arsenic

The SGV for arsenic of 10 mg/kg is compared to the Buffalo River RA6 footprint in Figure 1a through 1c. This SGV was shown to be not toxic in 2005 site-specific toxicity testing summarized by the USACE (Table 1) where a NOEC for arsenic of 27 mg/kg was observed. The PEC of 33 mg/kg is based on a much larger dataset and is illustrated in Figures 1d through 1f.

Arsenic was analyzed in the surface sediment at 290 locations, with 16% of locations exceeding the SGV under post RA6 conditions, but none exceeding the PEC under post RA6 conditions (Table 2, Figures 1a through 1f). Figures 1e and 1f shows that only few limited locations outside the RA6 footprint will remain, and these locations are deep within the sediment column. Because there are no residual concentrations of arsenic that will persist in the biologically active zone following RA6 implementation, RA6 is considered protective with regard to arsenic.

In addition to the absence of arsenic concentrations in the biological active zone above the PEC, the arsenic cycle is well understood in sediments and informs the understanding of future toxicity. Arsenic cycles between soluble forms (AsIII) under reducing conditions and insoluble forms (AsV) under aerobic conditions. The aerobic form is bound with iron oxyhydroxides in surficial sediment and form colloids that settle to the sediment surface, where they are buried in subsurface sediments and complete the cycle of soluble to insoluble forms. Arsenic was measured in fish tissue in 2008 but arsenic is not present in a toxic form in fish (Shiomi et al. 1995; Irvin and Ingolic 1988) and does not constitute a risk to piscivorous wildlife. Therefore, residual concentrations of arsenic that remain in sediment associated with RA6 do not pose an unacceptable risk for benthic invertebrates, fish, and wildlife.

Chromium

The SGV for chromium of 43.4 mg/kg is compared to the Buffalo River RA6 footprint in Figure 1a through 1c. This SGV was shown to be not toxic in 2005 site-specific toxicity testing summarized by the USACE (Table 1) where a NOEC for chromium of 64 mg/kg was observed. The PEC of 111 mg/kg is based on a much larger dataset and is illustrated in Figures 1d through 1f.

Chromium was analyzed in the surface sediment at 290 locations, with 7% of locations exceeding the SGV under post RA6 conditions, but only 1% exceeding the PEC under post RA6 conditions (Table 2, Figures 1a through 1f). Figures 1e and 1f shows that only few limited locations outside the RA6 footprint will remain, and the majority of those in the surface sediment are less than 2 times the PEC. RA6 is protective of wildlife regardless of residual concentrations of chromium outside of the remedy footprint for a number of reasons, as described briefly below:

- Chromium is an essential macronutrient and chromium geochemistry is very predictable in aquatic environments.
- The locations with concentrations greater than the PEC are very limited in number and thus are not broadly distributed in the river, meaning that few organisms would be exposed to concentrations greater than the PEC.
- One of the fundamental limitations of the chromium PEC is that it is not based on any consideration of the geochemical state of chromium, and thus currently is considered by USEPA and others as being highly overprotective (e.g., USEPA 2005, Berry et al. 2004, Besser et al. 2004, Martello et al. 2007, Sorensen et al. 2007).
- Berry et al (2004) showed that where acid-volatile sulfides (AVS) were present in chromium-spiked sediments they were non-toxic because all chromium was present in an inert form. This observation was expanded to natural sediments where no effects were found at up to 3,000 mg/kg.
- Becker et al. 2005 showed that concentrations of total chromium in sediment as high as 1,310-1,490 mg/kg did not result in toxicity to sediment dwelling organisms.
- Martello et al. (2007) showed that concentrations as high as 1,900 mg/kg caused no effects on sediment dwelling organisms.
- Besser et al. (2004) performed a sediment spiking study and showed that in sediments with elevated TOC and AVS, reported that sediments containing 1,500 mg/Cr kg did not result in toxicity to the freshwater amphipod.
- The conditions of the Buffalo River are such that chromium exists in its relatively nontoxic trivalent [Cr(III)] form as opposed to its toxic hexavalent (Cr(VI)] form. Specifically, the Sediment Remedial Investigtion Report (ENVIRON and MacTec 2009) showed that AVS is abundant in Buffalo River sediments, providing evidence according to USEPA (2005) that chromium exists as Cr(III).
- Sorensen et al. (2008) showed that ingestion of chromium from sediment by foraging birds does pose unacceptable risk at concentrations > 1,100 mg/kg
- Oshieda et al. (1986) showed that polychaetes can live, ingest, build tubes from, and breed in Cr(III) precipitate with a 293-day multigenerational study.
- Cr(III) in sediment is geochemically stable and does not oxidize to Cr(VI). Johns Hopkins University Researchers showed that aeration of sediments in freshwater for 10 days did not result in any measurable concentrations of Cr(VI) in water at concentrations > 1,000 mg/kg (Graham and Wadhaman 2009). This is similar to

Copper

The SGV for copper of 32 mg/kg is compared to the Buffalo River RA6 footprint in Figure 1a through 1c. This SGV was shown to be not toxic in 2005 site-specific toxicity testing summarized by the USACE (Table 1) where a NOEC for copper of 86 mg/kg was observed. The PEC of 149 mg/kg is based on a much larger dataset and is illustrated in Figures 1d through 1f.

Copper was analyzed in the surface sediment at 290 locations, with 23% of locations exceeding the SGV under post RA6 conditions but only 0.4% (i.e., one location) exceeding the PEC under post RA6 conditions (Table 2, Figures 1a through 1f). Figures 1e and 1f shows that the single location outside the RA6 footprint that will remain is less than 2 times the PEC and it is located up at the Cazenovia Creek confluence (Figure 1e). Having only a single location greater than the PEC outside the footprint demonstrates that RA6 is protective of wildlife. Additional considerations also show that RA6 is protective with regard to copper:

- Copper is an essential micronutrient that organisms are capable of regulating via uptake and excretion.
- Copper forms insoluble salts in sediments with AVS and these are not available to cause toxicity. Studies of sediments in the Buffalo River showed the presence of excess AVS, such that toxicity due to copper would not be expected (ENVIRON and MACTEC 2009).
- Copper is also bound and immobilized by TOC. USEPA (2005) reported that toxicity of excess metal is unlikely when it is present at less than 130 µmol/gOC. Using this USEPA (2005) benchmark consideration for TOC and considering an average TOC of 2.7% for the Buffalo River (ENVIRON and MACTEC 2009), a site-specific no effect concentration for copper based on organic carbon alone (i.e., assuming no AVS) would be approximately 223 mg/kg. There are no residual copper concentrations that would exceed this value.

PESTICIDES

The pesticide COPCs addressed in this memorandum are DDT and chlordane. Figures illustrating the residual concentrations of pesticides following implementation of RA6 are provided in Attachment 1, as follows:

- Table 1 provides a summary of SGVs and PECs compiled by the USACE for consideration on the Buffalo River
- Table 2 identifies the number of SGV and PEC exceedances exist outside the RA6 footprint
- Figures 2a through 2c illustrate COPC concentrations relative to SGVs
- Figures 2d through 2f illustrate COPC concentrations relative to PECs
- Figure 2g presents pesticides (DDE, as a DDT metabolite) in fish tissues

Total DDT

The SGV for total DDT of 5 µg/g (0.005 mg/kg) is compared to the Buffalo River RA6 footprint in Figure 2a through 2c. This SGV was shown to be not toxic in 2005 site-specific toxicity testing summarized by the USACE (Table 1) where a NOEC for total DDT of 26 µg/g (0.026 mg/kg) was observed. The PEC for total DDT is 57.2 µg/g (0.572 mg/kg). Comparisons of data to the PEC are illustrated in Figures 2d through 2f.

DDT was analyzed in the surface sediment at 281 locations, with 2% of locations exceeding the SGV under post RA6 conditions but none exceeding the PEC outside the RA6 footprint (Table 2, Figures 2a through 2f). Considering that the PEC for total DDT is not exceeded at any locations outside the RA6 footprint demonstrates that RA6 is protective of the environment with regard to total DDT. Additional considerations also show that the residual concentrations of DDT do not pose an unacceptable risk to the environment, such as:

- Laboratory studies of DDT suggest that the TOC of Buffalo River would significantly mitigate any toxicity related to DDT. Swartz et al. (1994) showed in 10-day DDT-only sediment bioassays with *Hyalella azteca* that the NOEC for toxicity is 300 µg ΣDDT/gOC. At an average of 2.7% TOC (i.e., 27 g/kg) in the Buffalo River, this is 8100 µg/kg.
- Lotufo et al. (2001) reported a low observed effect concentration (LOEC) of 3510 µg ΣDDT/kg in 28-d tests with *H. azteca*.
- The highest fish tissue concentration of ΣDDT was 116 µg/kg measured in carp in 2007 (Skinner et al. 2008). This is approximately half of the NYSDEC fish tissue criterion of 200 µg/kg and less than 20% of the effect concentration of 600 µg/kg published by Beckvar et al. (2005). The highest ΣDDT were 78.4 and 24.2 µg/kg in brown bullhead and bluntnose minnow, respectively, and below method detection limits in pumpkinseed and yellow perch. Therefore, the ΣDDT in fish is not a source of risk for the fish or piscivorous wildlife populations.
- The SulTrac ecological risk assessment (ERA) predicted a risk to piscivorous wildlife exposed to DDT, but this was based on estimated fish tissue concentrations that were more than 10 times that seen in the measured tissue concentrations that became available after the SulTrac ERA was completed. Using currently measured fish tissue concentrations and the SulTrac ERA assumptions would not predications of unacceptable risks.
- Figure 2g shows that DDT metabolite (DDE) is decreasing in fish over time. Therefore, conditions in the Buffalo River are improving.

Gamma Chlordane

The SGV for total gamma chlordane of 3 µg/g (0.003 mg/kg) is compared to the Buffalo River RA6 footprint in Figure 2a through 2c. The PEC for total DDT is 1.76 µg/g (0.0176 mg/kg). Comparisons of data to the PEC are illustrated in Figures 2d through 2f.

Gamma chlordane was analyzed in the surface sediment at 281 locations, with 1% of locations exceeding the SGV under post RA6 conditions but none exceeding the PEC under post RA6 conditions (Table 2, Figures 2a through 2f). Only 1 of the surficial sediment locations exceed the PEC within the RA6 footprint (Figures 2d, 2e, and 2f). Considering that the PEC for gamma chlordane is not exceeded at any locations outside the RA6 footprint demonstrates that RA6 is protective of the environment with regard to this pesticide. Additional considerations also show that the residual concentrations of gamma chlordane do not pose an unacceptable risk to the environment, such as:

- Using site-specific TOC values from the Buffalo River and the formula for deriving SGVs from NYSDEC would yield SGVs significantly higher than the one used in this evaluation. Similarly, using TOC normalized data to derive a PEC would yield a value much higher than the one used in this analysis.
- The highest fish tissue concentration of γ-chlordane was 1.2 µg/kg measured in carp in 2007 (Skinner et al. 2008). This is far lower than the NYSDEC (1987) fish tissue criterion of 500 µg/kg. γ-chlordane was below method detection limits in brown bullhead, bluntnose minnow, pumpkinseed, and yellow perch. Therefore, γ-chlordane in fish is not a source of risk for the fish or piscivorous wildlife populations.

A combination of the PECs, equilibrium partitioning, and non-exceedance of measured fish tissue residue show that no adjustments need to be made to the dredge areas to provide protection from γ-chlordane for benthic, fish, or wildlife populations.

Individual PAHs

The PAH COPCs addressed in this memorandum are benzo(a)anthracene and benzo(a)pyrene. Figures illustrating the residual concentrations of these individual PAHs following implementation of RA6 are provided in Attachment 1, as follows:

- Table 1 provides a summary of SGVs and PECs compiled by the USACE for consideration on the Buffalo River
- Table 2 identifies locations where concentrations are greater than their respective SGV and PEC levels, outside the RA6 footprint
- Figures 3a through 3c illustrate COPC concentrations relative to SGVs
- Figures 3d through 3f illustrate COPC concentrations relative to PECs
- Figure 3d also shows the individual PAH toxicity units (TUs) for locations outside the Remedy 6 footprint that exceed the PECs
- Figure 3g shows the correlation between total PAHs and these individual PAHs

While individual PAHs may cause toxicity, they act in addition to other PAHs and the additive toxicity of PAHs was used to design the dredge areas. The two individual PAHs which exceeded sediment quality criteria are nearly insoluble due to their high log K_{ow} values and would be toxic only under extraordinary circumstances.

Benzo(a)anthracene and Benzo(a)Pyrene

The SGV for benzo(a)anthracene [B(a)A] is 0.11 mg/kg is compared to the Buffalo River RA6 footprint in Figure 3a through 3c. This SGV was shown to be not toxic in 2005 site-specific toxicity testing summarized by the USACE (Table 1) where a NOEC for B(a)A of 1.2 mg/kg was observed. The PEC for B(a)A is 1.05 mg/kg and comparisons of data to the PEC are illustrated in Figures 3d through 3f.

The SGV for benzo(a)pyrene [B(a)P] is 0.15 mg/kg is compared to the Buffalo River RA6 footprint in Figure 3a through 3c. This SGV was shown to be not toxic in 2005 site-specific toxicity testing summarized by the USACE (Table 1) where a NOEC for B(a)A of 0.95 mg/kg was observed. The PEC for B(a)A is 1.45 mg/kg and comparisons of data to the PEC are illustrated in Figures 3d through 3f. Figure 3g shows that the vast majority of B(a)A and B(a)P are captured in the RA6 remedy focused on total PAHs.

B(a)A was analyzed in the surface sediment at 389 locations, with 62% of locations exceeding the SGV under post RA6 conditions but only 2% (8 locations) exceeding the PEC under post RA6 conditions (Table 2, Figures 3a through 3f). Of the 8 locations that will remain in the river surficial sediments following implementation of RA6, the majority of these are less than 2 times the PEC. B(a)P was analyzed in the surface sediment at 389 locations, with 61% of locations outside the RA6 footprint exceeding the SGV and none exceeding the PEC outside the RA6 footprint (Table 2, Figures 3a through 3f).

Although a comparison of B(a)A and B(a)P concentrations to SGVs and PECs is provided, the USEPA equilibrium approach for PAH mixtures shows that PAH TUs are the appropriate manner to estimate toxicity due to PAHs, as discussed throughout the FS. As such, consideration was given to the individual PAH TU contributions of each of these two individual PAHs. As indicated on Figure 3d, for each of the locations where the B(a)A concentration exceeded the PEC, the TU for this individual PAH was sufficiently low (i.e., less than 1), such that the particular PAH concentration would not be predicted to cause toxicity.

Conclusions

The conclusion of this analysis is that only limited occurrences of the seven additional COPCs will exist in the biologically active zone at of sediments at levels of concern following the implementation of RA6. Given the low COPC concentrations relative to concentrations predictive of toxicological impacts, and given the dispersed locations where these COPC concentrations exist, there is sufficient evidence to conclude that these residual concentrations will not pose an unacceptable impact to fish and wildlife populations or communities.

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ATTACHMENT 1
Memorandum Addressing Seven COPCs
TABLES and FIGURES

Tables

- Table 1: Development of Preliminary Remedial Goals for Benthic Protection
- Table 2: Surface Sediment Samples Greater Than NYS DEC and EPA PEC Values

Figures Addressing Metals

- Figure 1a: Metals in Surface Samples Exceeding SGV
- Figure 1b: Post Remedy 6 Metals Concentrations Compared to SGVs, Buffalo River
- Figure 1c: Post Remedy 6 Metals Concentrations Compared to SGVs, City Ship Canal
- Figure 1d: Metals Surface Samples Exceeding USEPA PECs
- Figure 1e: Post Remedy 6 Metals Concentrations Compared to PECs, Buffalo River
- Figure 1f: Post Remedy 6 Metals Concentrations Compared to PECs, City Ship Canal

Figures Addressing Pesticides

- Figure 2a: Pesticides Surface Samples Exceeding NYS SGV
- Figure 2b: Post Remedy 6 Pesticide Concentrations Compared to SGVs, Buffalo River
- Figure 2c: Post Remedy 6 Pesticide Concentrations Compared to SGVs, City Ship Canal
- Figure 2d: Pesticides Surface Samples Exceeding USEPA PECs
- Figure 2e: Post Remedy 6 Pesticide Concentrations Compared to PECs, Buffalo River
- Figure 2f: Post Remedy 6 Pesticide Concentrations Compared to PECs, City Ship Canal
- Figure 2g: Pesticides (DDE) in Fish Tissues

Figures Addressing PAHs

- Figure 3a: PAH Compounds Surface Samples Exceeding SGV
- Figure 3b: Post Remedy 6 PAH Concentrations Compared to SGVs, Buffalo River
- Figure 3c: Post Remedy 6 PAH Concentrations Compared to SGVs, City Ship Canal
- Figure 3d: PAH Compounds Surface Samples Exceeding PECs and PAH Toxicity Units in Sediment
- Figure 3e: Post Remedy 6 PAH Concentrations Compared to PECs, Buffalo River
- Figure 3f: Post Remedy 6 PAH Concentrations Compared to PECs, City Ship Canal
- Figure 3g. Correlation Between Total PAH and Individual PAH Concentrations

Table 1
Development of Preliminary Remedial Goals for Benthic Protection
Buffalo River, NY

	New!	compare to other Benthic PRGs			Upstream concentrations	
	2005 Tox Results	**2007 Tox Results (CSC)**	**2007 NYSDEC Draft SGV**	**EPA PEC**	**Maximum**	**Upper Prediction Limit**
ARSENIC	27		10	33.0	8.1	9.3
CHROMIUM	64	13	*43.4*	111	11.6	13
COPPER	86	56	32	149	49.4	46.8
LEAD	**85**		**36**	**128**	**64**	**42**
MERCURY	**0.43**	**0.2**	**0.18**	**1.06**	**0.14**	--
Total DDT	0.026		*0.005*	0.572	ND	ND
GAMMA-CHLORDANE	0.0024		0.003	0.0176	ND	ND
TOTAL PCB	**0.36**		**0.06**	**0.676**	**0.067 J**	**ND to 0.067**
BENZO(A)ANTHRACENE	1.20		0.11	1.05	1.2	1.2
BENZO(A)PYRENE	0.95		0.15	1.45	0.66	1.09
TOTAL PAHS	**16**		***4***	**22.8**	**3.4**	**3.5**
			TEC is 1.6			

Notes:

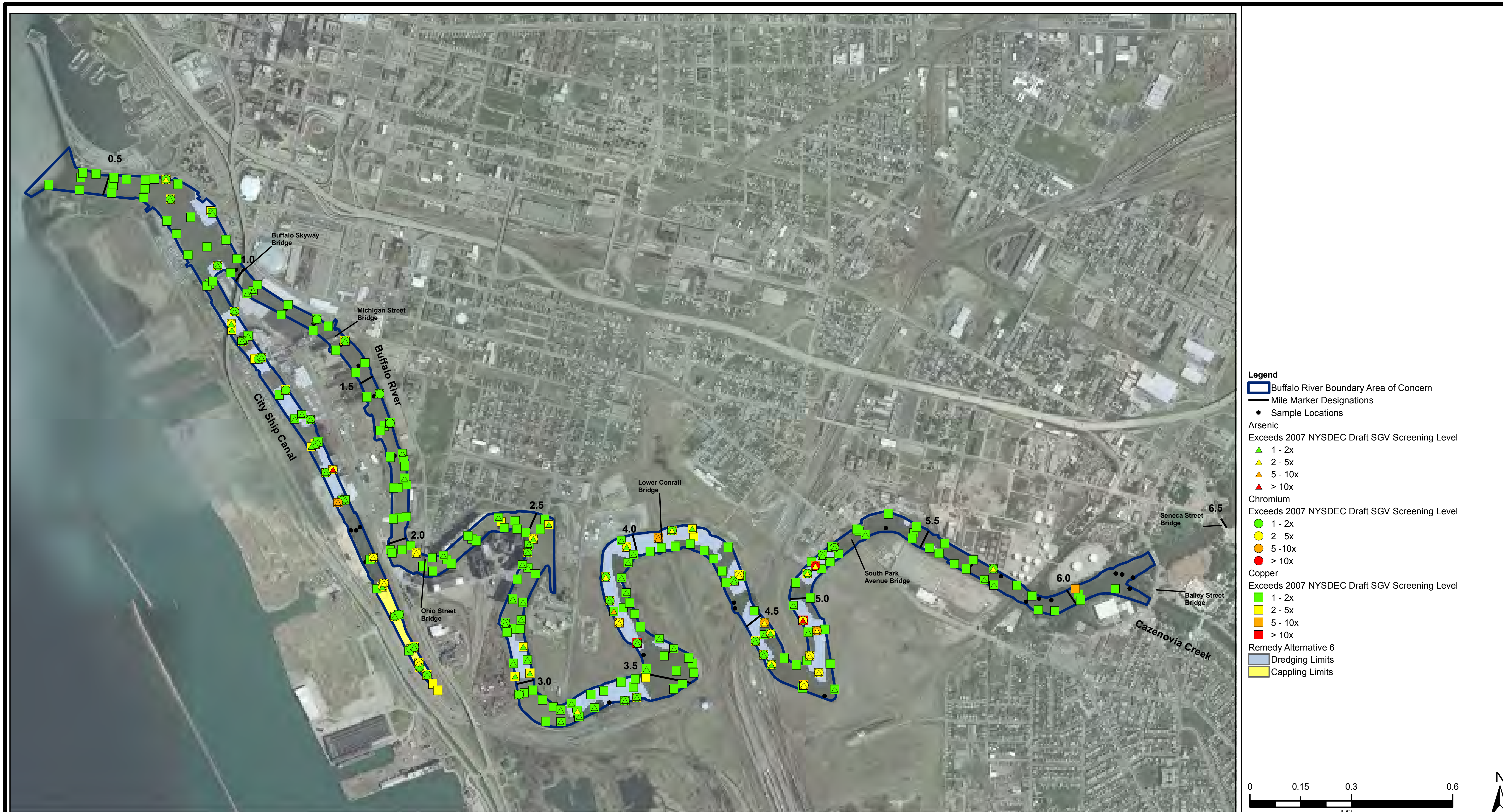
Units in mg/kg

Compiled by the U.S. Army Corps of Engineers for the January 2009 Premedial Remedial Goal development meeting in Buffalo, NY.

Based on maximum detected concentrations in 2005 toxicity testing samples.

Table 2
Surface Sediment Samples Greater Than NYS SGVs and PECs
Buffalo River, NY

Analyte	Total No. Surface Samples	NYS SGVs				PECs			
		No. Samples > NYS SGV	Percent > NYS SGV	No. Outside Remedy 6 > NYS SGV	Percent Outside Remedy 6 > NYS SGV	No. Samples > PEC	Percent > PEC	No. Outside Remedy 6 > PEC	Percent Outside Remedy 6 > PEC
Arsenic	290	102	35%	47	16%	11	4%	0	0%
Chromium (total)	290	61	21%	20	7%	15	5%	4	1%
Copper	290	257	89%	68	23%	11	4%	1	0%
gamma-Chlordane	281	12	4%	2	1%	1	0%	0	0%
DDT (total)	281	32	11%	7	2%	0	0%	0	0%
Benzo(a)anthracene	389	372	96%	243	62%	65	17%	8	2%
Benzo(a)pyrene	389	363	93%	236	61%	38	10%	0	0%



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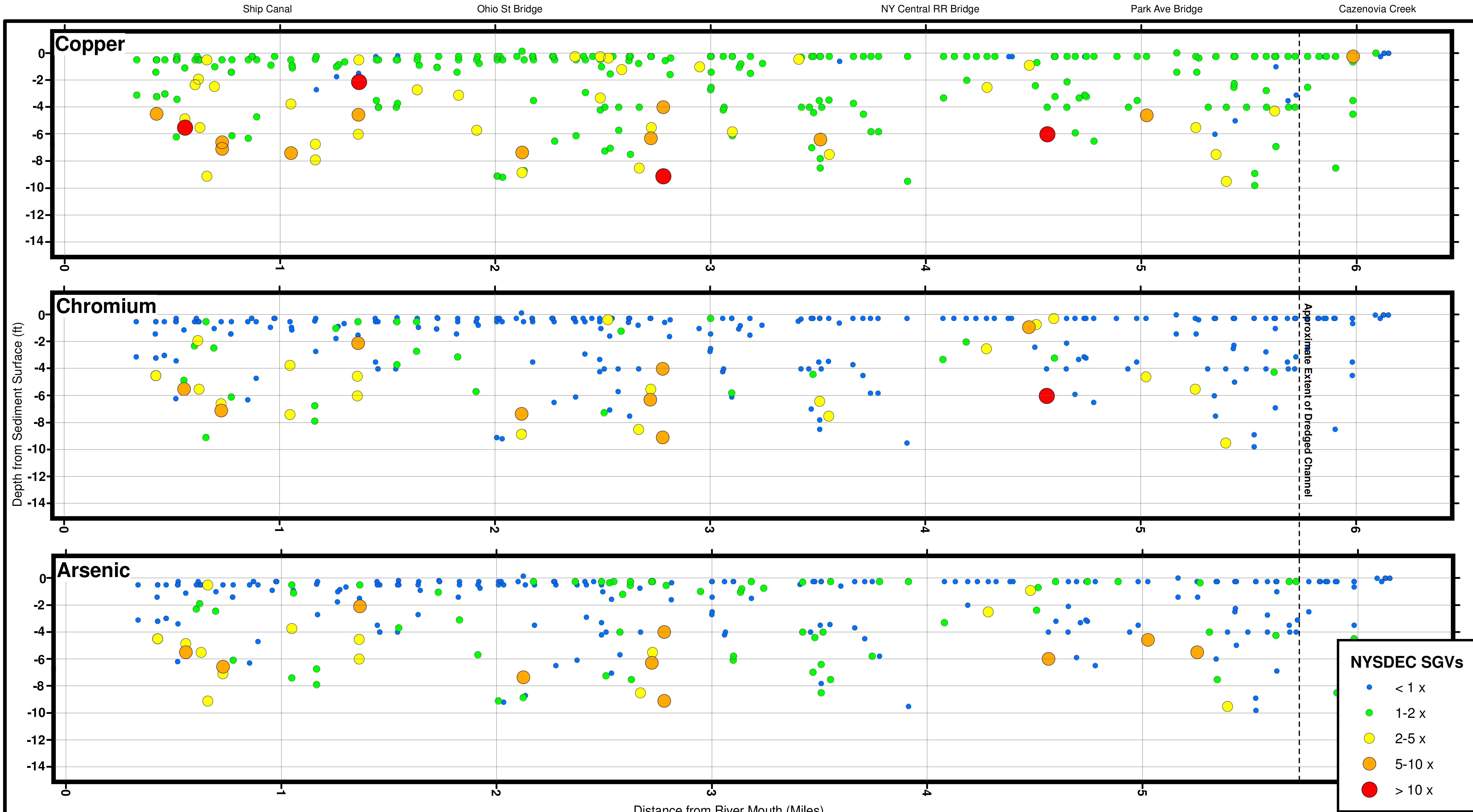
SURFACE SEDIMENT METAL CONCENTRATIONS EXCEEDING NYSDEC SGV
REMEDY ALTERNATIVE 6
BUFFALO RIVER, NY

Figure 1a

Drafter: B. Radakovich
Date: 08/07/2009
File Name: 20090807_SurfaceMetals_Remedy6e_SGV.mxd



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Post Remedy 6 Metals Concentrations Compared to SGVs, Buffalo River

Figure 1b

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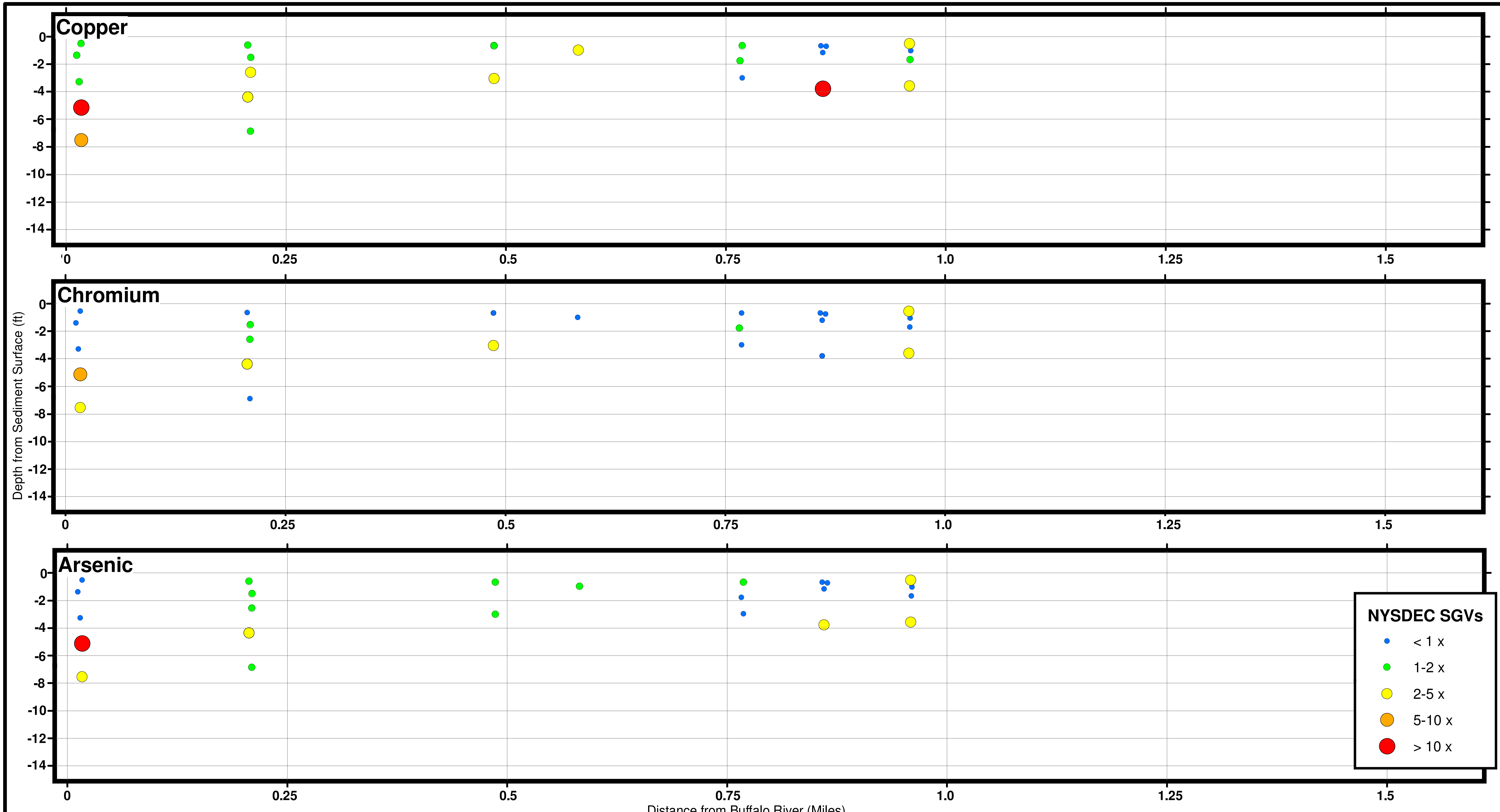

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Post Remedy 6 Metals Concentrations Compared to SGVs, City Ship Canal

Figure 1c

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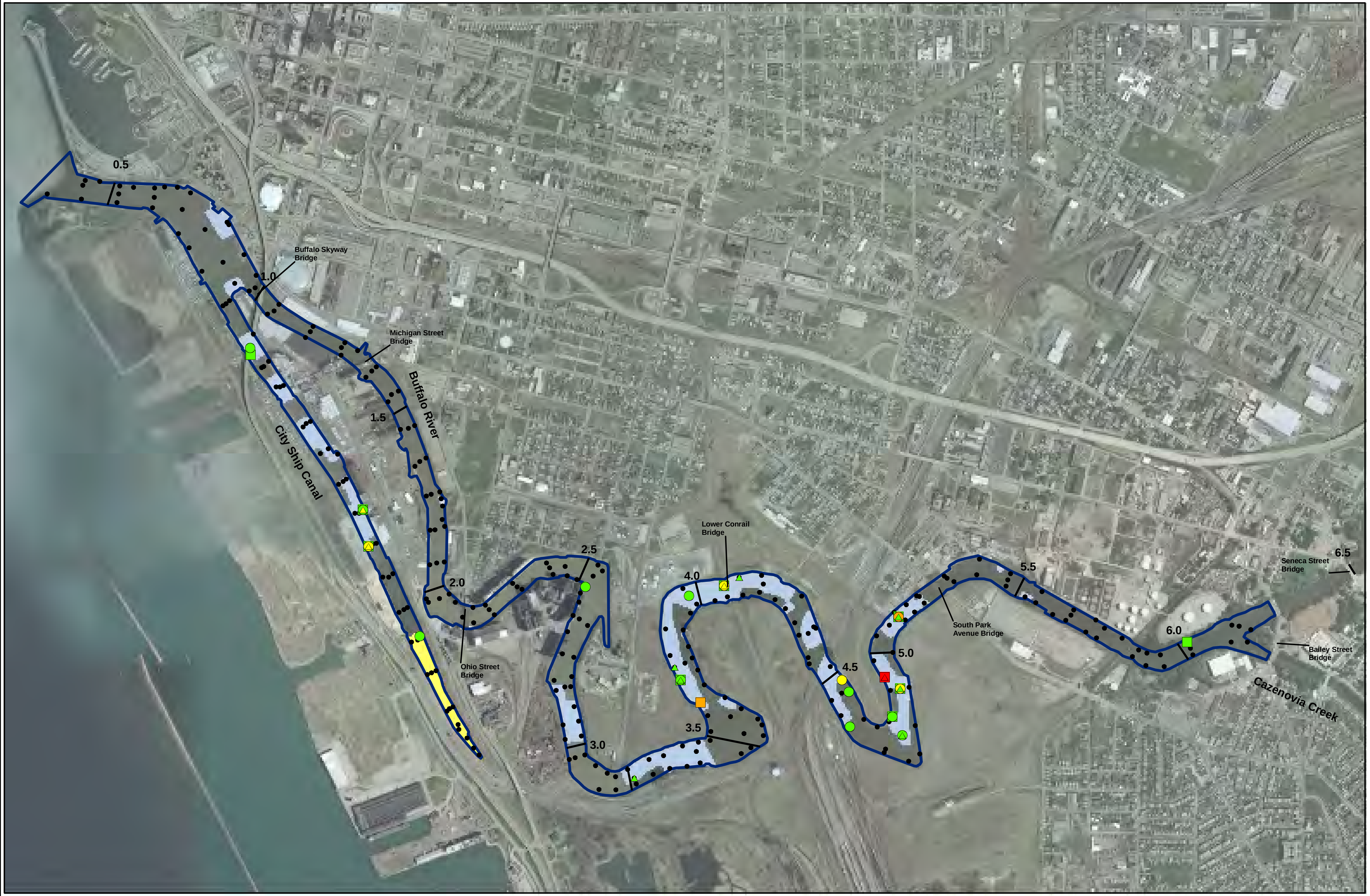

Legend

- Buffalo River Boundary Area of Concern
- Mile Marker Designations
- Sample Locations

Arsenic

Exceeds EPA PEC Screening Level

- 1 - 2x
- 2 - 5x
- 5 - 10x
- > 10x

Chromium

Exceeds EPA PEC Screening Level

- 1 - 2x
- 2 - 5x
- 5 - 10x
- > 10x

Copper

Exceeds EPA PEC Screening Level

- 1 - 2x
- 2 - 5x
- 5 - 10x
- > 10x

Remedy Alternative 6

- Dredging Limits
- Capping Limits

0 0.15 0.3 0.6

Miles

N

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SURFACE SEDIMENT METAL CONCENTRATIONS EXCEEDING EPA PEC
REMEDY ALTERNATIVE 6
BUFFALO RIVER, NY

Figure 1d

Drafter: B. Radakovich
Date: 08/07/2009
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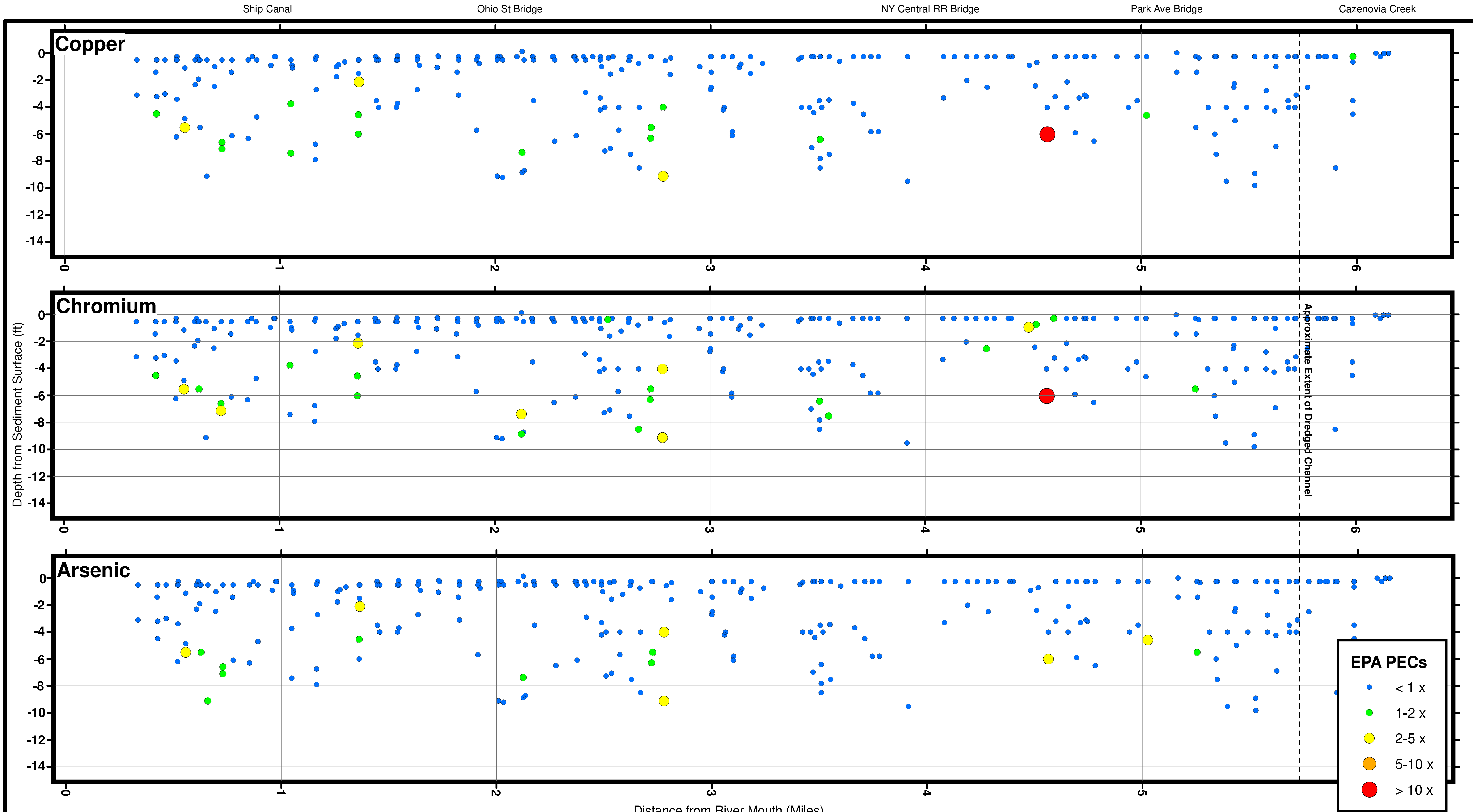

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Post Remedy 6 Metals Concentrations Compared to PECs, Buffalo River

Figure 1e

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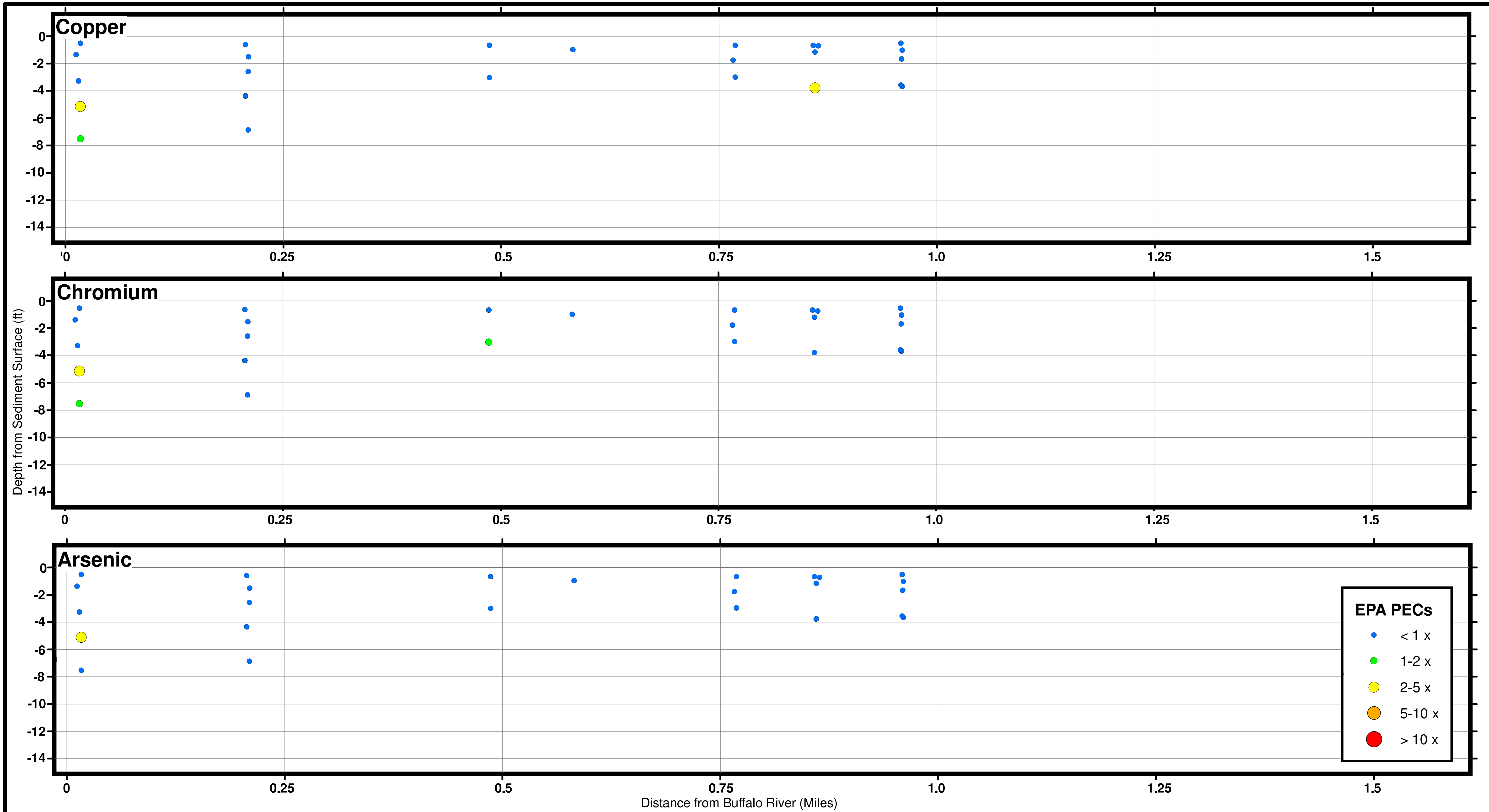

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Post Remedy 6 Metals Concentrations Compared to PECs, City Ship Canal

Figure 1f

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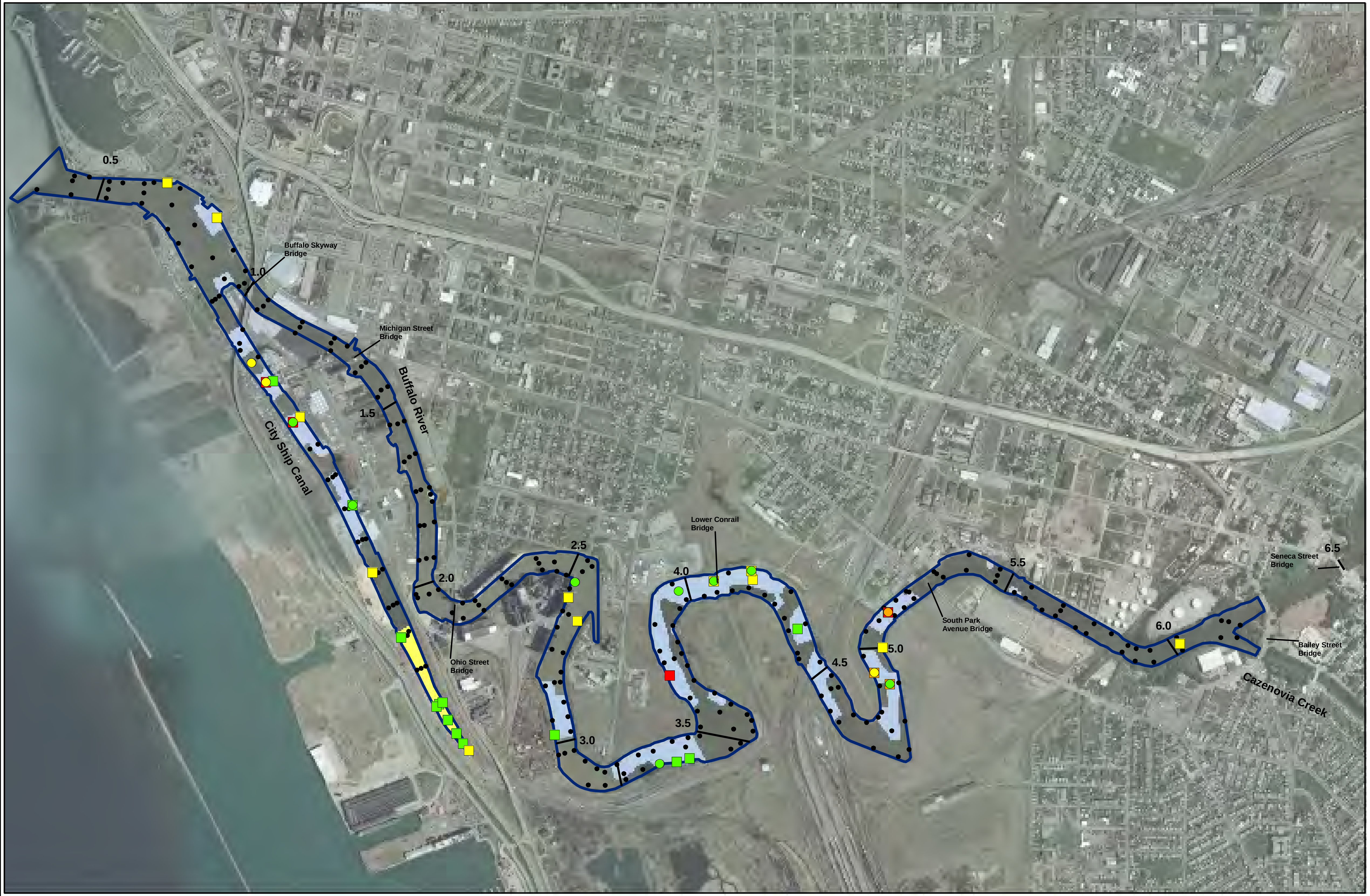

Legend

- Buffalo River Boundary Area of Concern
- Mile Marker Designations
- Sample Locations

Gamma - Chlordane
Exceeds 2007 NYSDEC Draft SGV Screening Level
- 1 - 2x
- 2 - 5x
- 5 - 10x
- > 10x

Total DDT
Exceeds 2007 NYSDEC Draft SGV Screening Level
- 1 - 2x
- 2 - 5x
- 5 - 10x
- > 10x

Remedy Alternative 6
- Dredging Limits
- Cappling Limits

0 0.15 0.3 0.6
Miles

N

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PESTICIDE SURFACE CONCENTRATIONS EXCEEDING NYSDEC SGV
REMEDY ALTERNATIVE 6
BUFFALO RIVER, NY

Figure 2a

Drafter: B. Radakovich
Date: 08/07/2009
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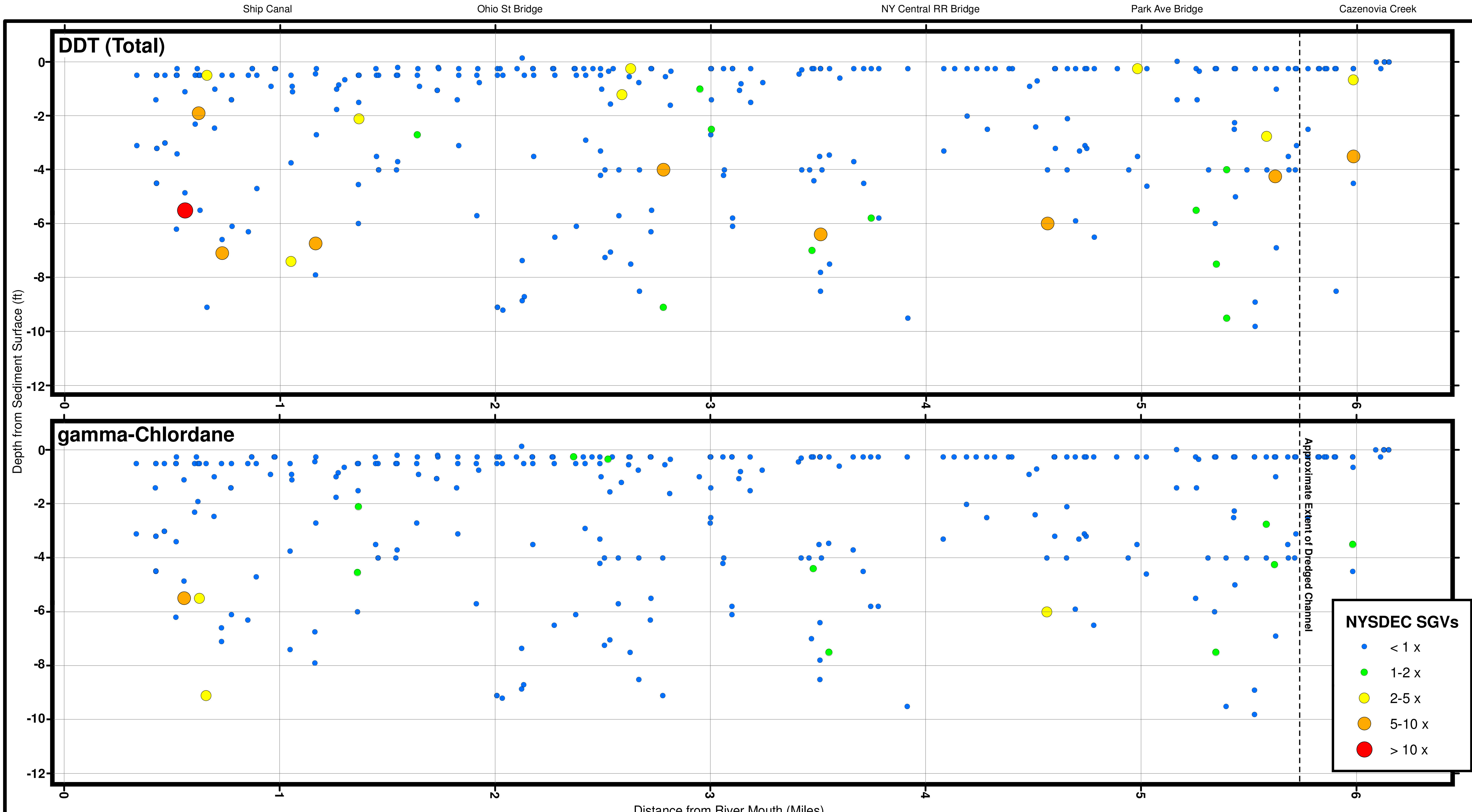

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Post Remedy 6 Pesticide Concentrations Compared to SGVs, Buffalo River

Figure 2b

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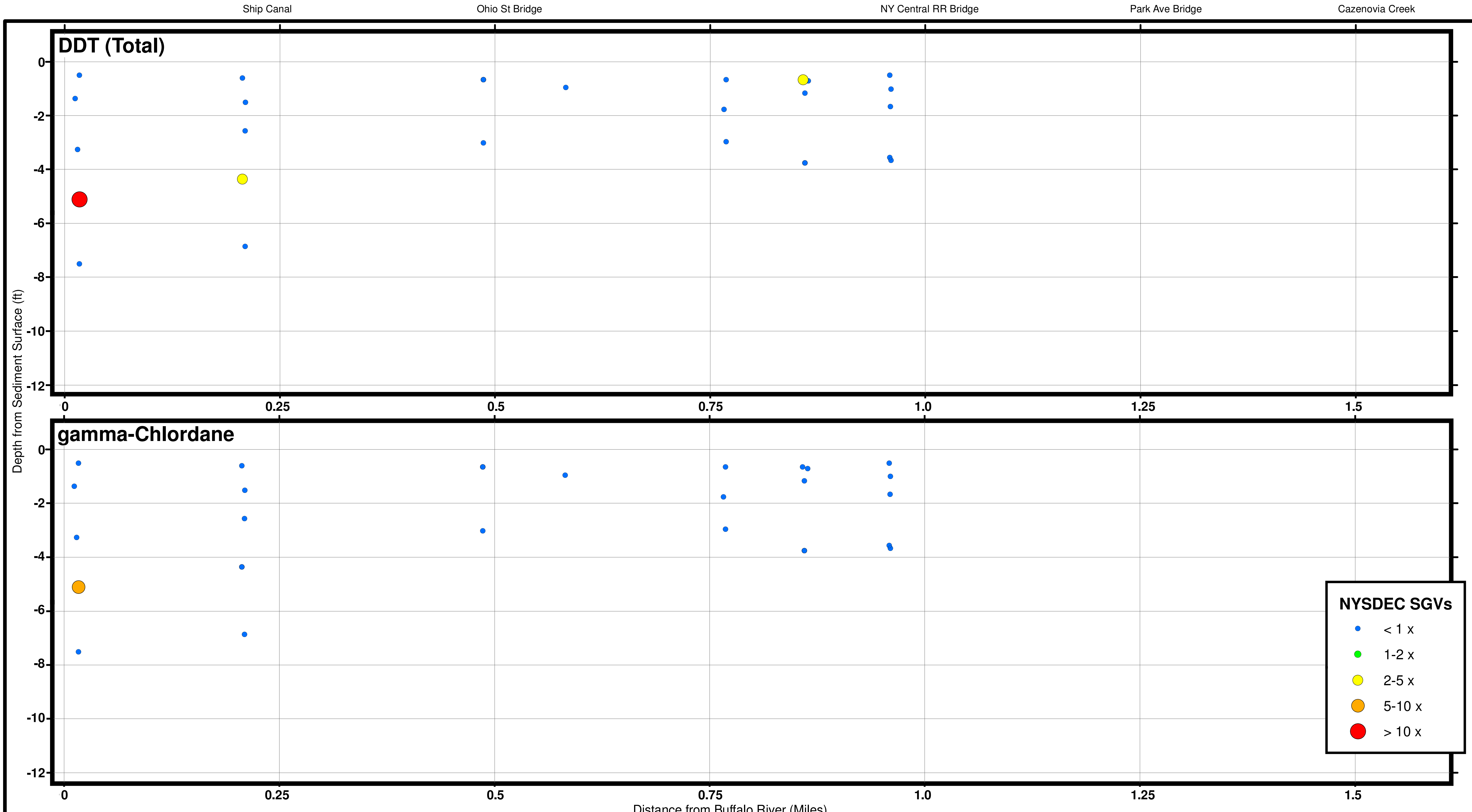

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Post Remedy 6 Pesticide Concentrations Compared to SGVs, City Ship Canal

Figure 2c

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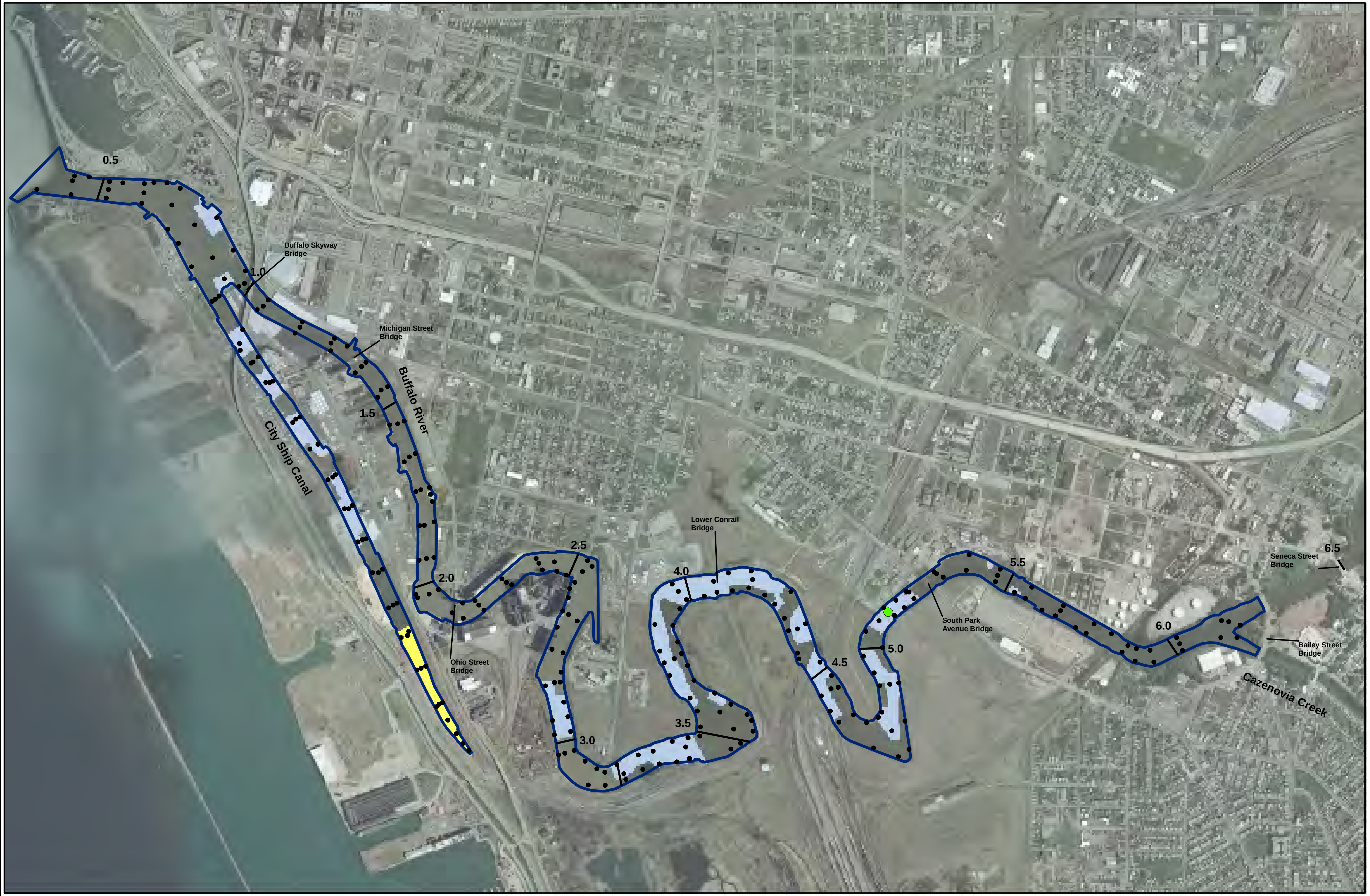

Legend

- Buffalo River Boundary Area of Concern
- Mile Marker Designations
- Sample Locations

Gamma - Chlordane
Exceeds EPA PEC Screening Level
- 1 - 2x
- 2 - 5x
- 5 - 10x
- > 10x

Total DDT
Exceeds EPA PEC Screening Level
- 1 - 2x
- 2 - 5x
- 5 - 10x
- > 10x

Remedy Alternative 6
- Dredging Limits
- Cappling Limits

0 0.15 0.3 0.6
Miles

N

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PESTICIDE SURFACE CONCENTRATIONS EXCEEDING EPA PECS
REMEDY ALTERNATIVE 6
BUFFALO RIVER, NY

Figure 2d

Drafter: B. Radakovich
Date: 08/07/2009
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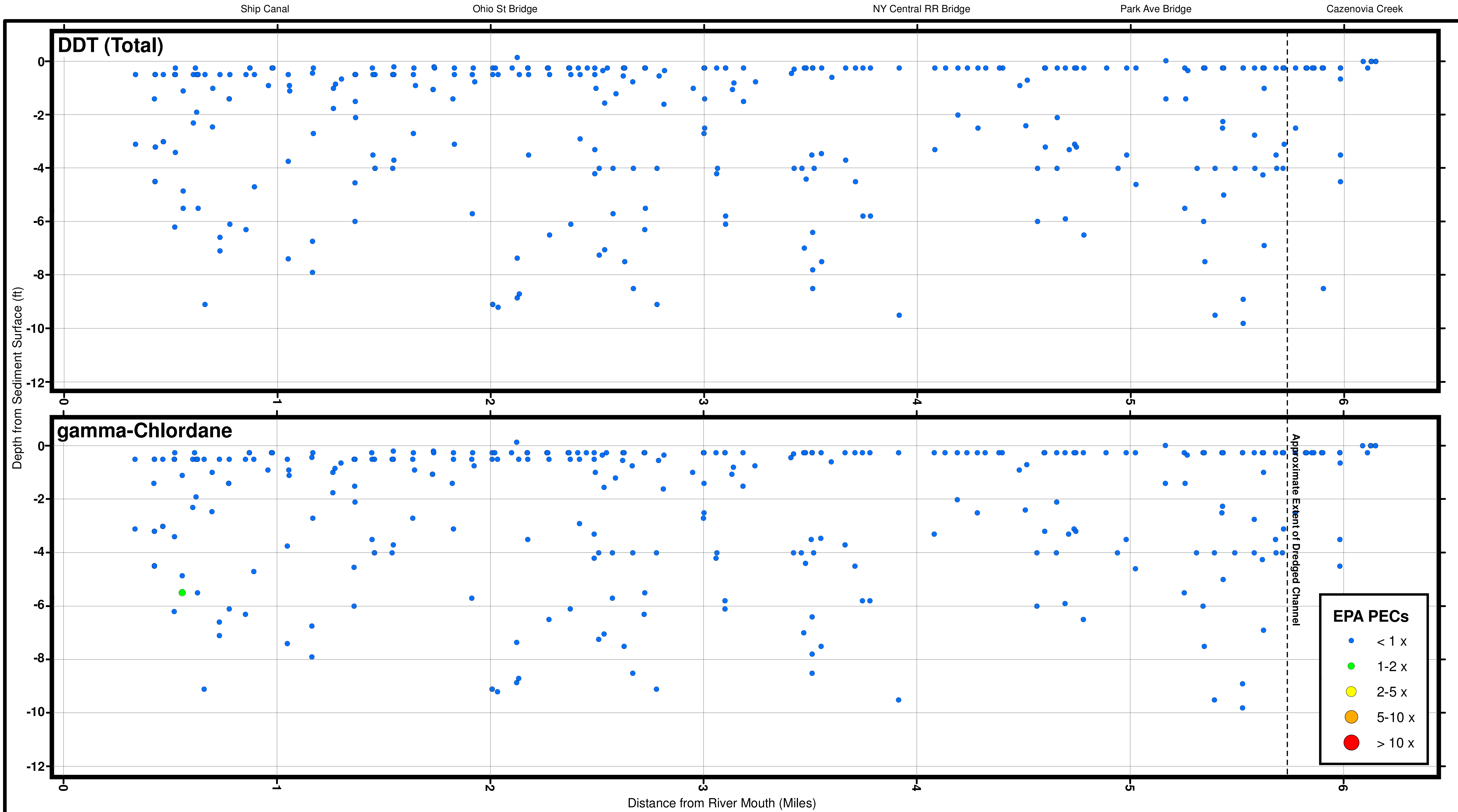

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Post Remedy 6 Pesticide Concentrations Compared to PECs, Buffalo River

Figure 2e

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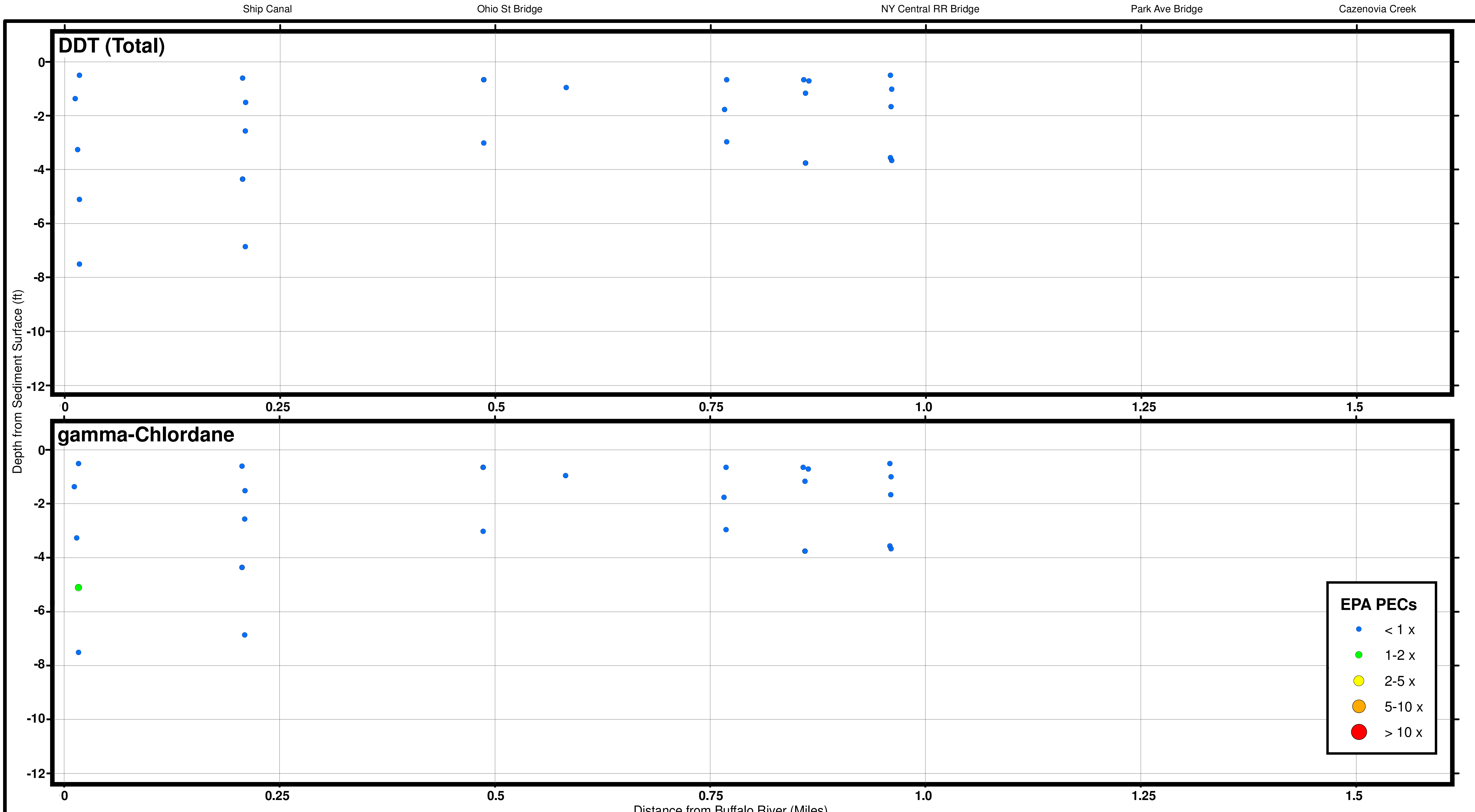

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Post Remedy 6 Pesticide Concentrations Compared to PECs, City Ship Canal

Figure 2f

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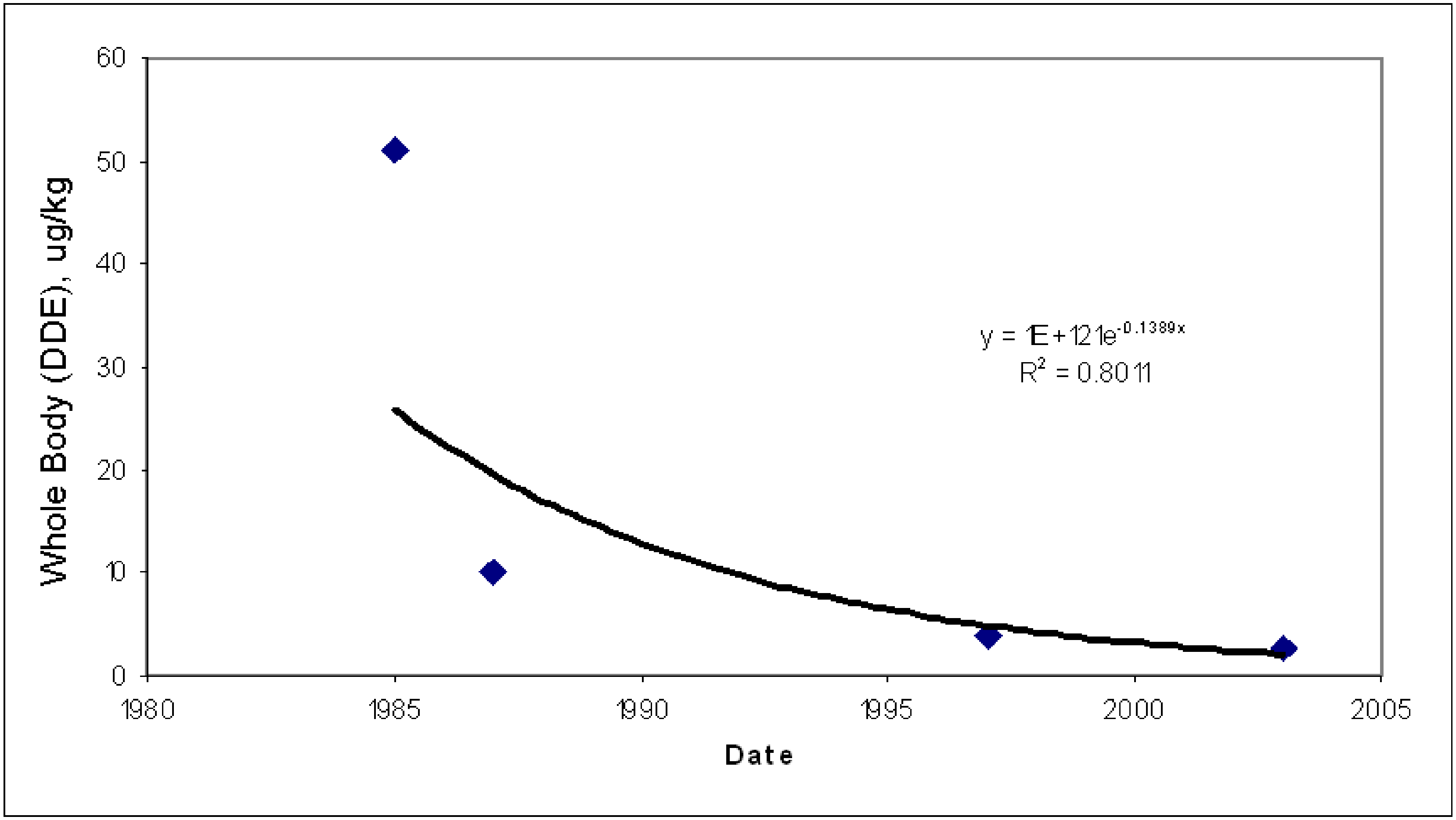

*Pesticides in fish tissues have decreased over time

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Pesticides (DDE) in Fish Tissues

Figure 2g

Legend

- Buffalo River Boundary Area of Concern
- Mile Marker Designations
- Sample Locations

Benzo(a)Anthracene
Exceeds 2007 NYSDEC DRAFT SVG Screening Level
- 1 - 2x
- 2 - 5x
- 5 - 10x
- >10x

Benzo(a)Pyrene
Exceeds 2007 NYSDEC DRAFT SVG Screening Level
- 1 - 2x
- 2 - 5x
- 5 - 10x
- > 10x

Remedy Alternative 6
- Dredging Limits
- Cappling Limits

0 0.15 0.3 0.6
Miles

N

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PAH COMPOUNDS SURFACE CONCENTRATIONS EXCEEDING NYSDEC SVG
REMEDY ALTERNATIVE 6
BUFFALO RIVER, NY

Figure 3a

Drafter: B. Radakovich
Date: 08/07/2009
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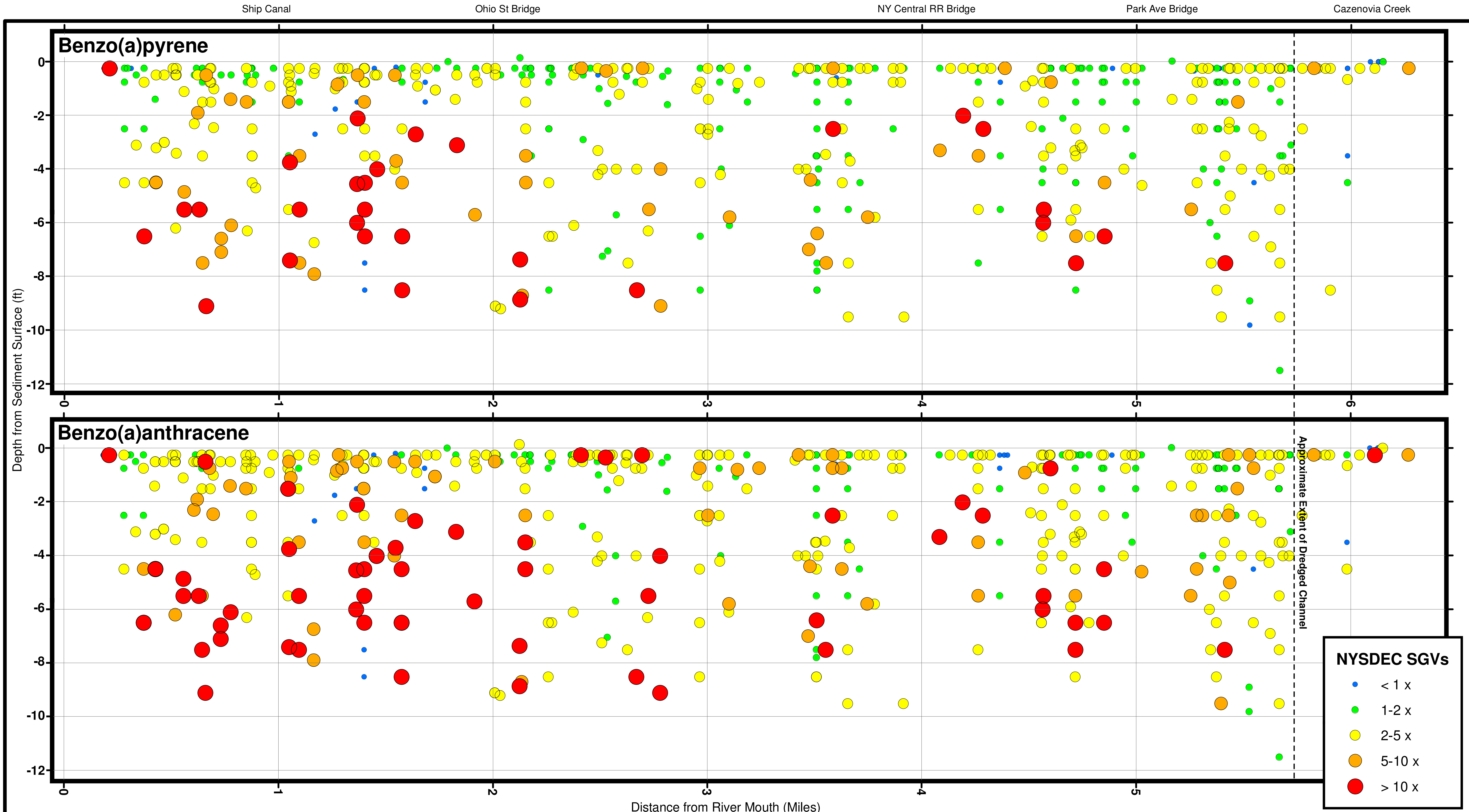

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Post Remedy 6 PAH Concentrations Compared to SGVs, Buffalo River

Figure 3b

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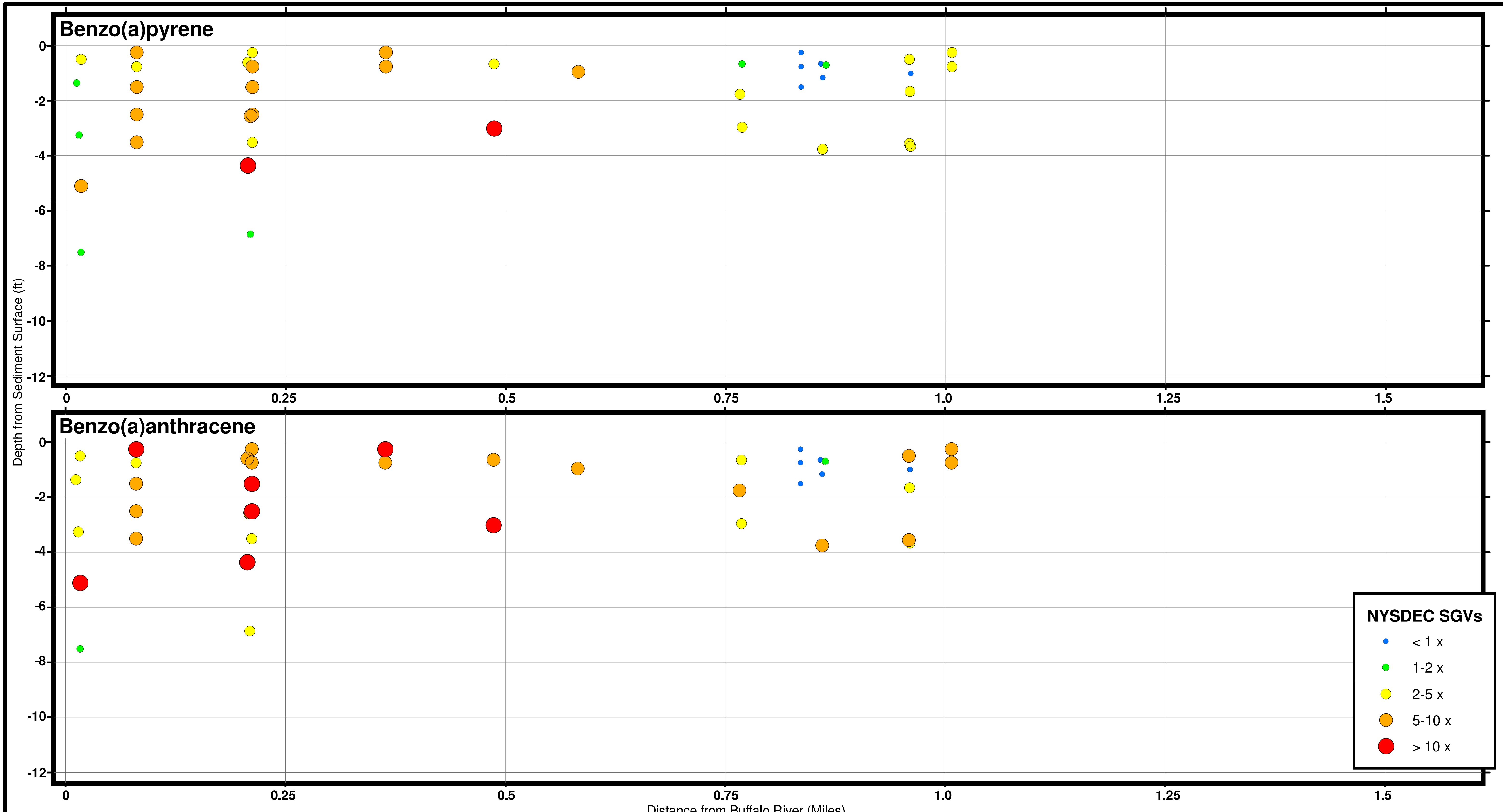

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Post Remedy 6 PAH Concentrations Compared to SGVs, City Ship Canal

Figure 3c

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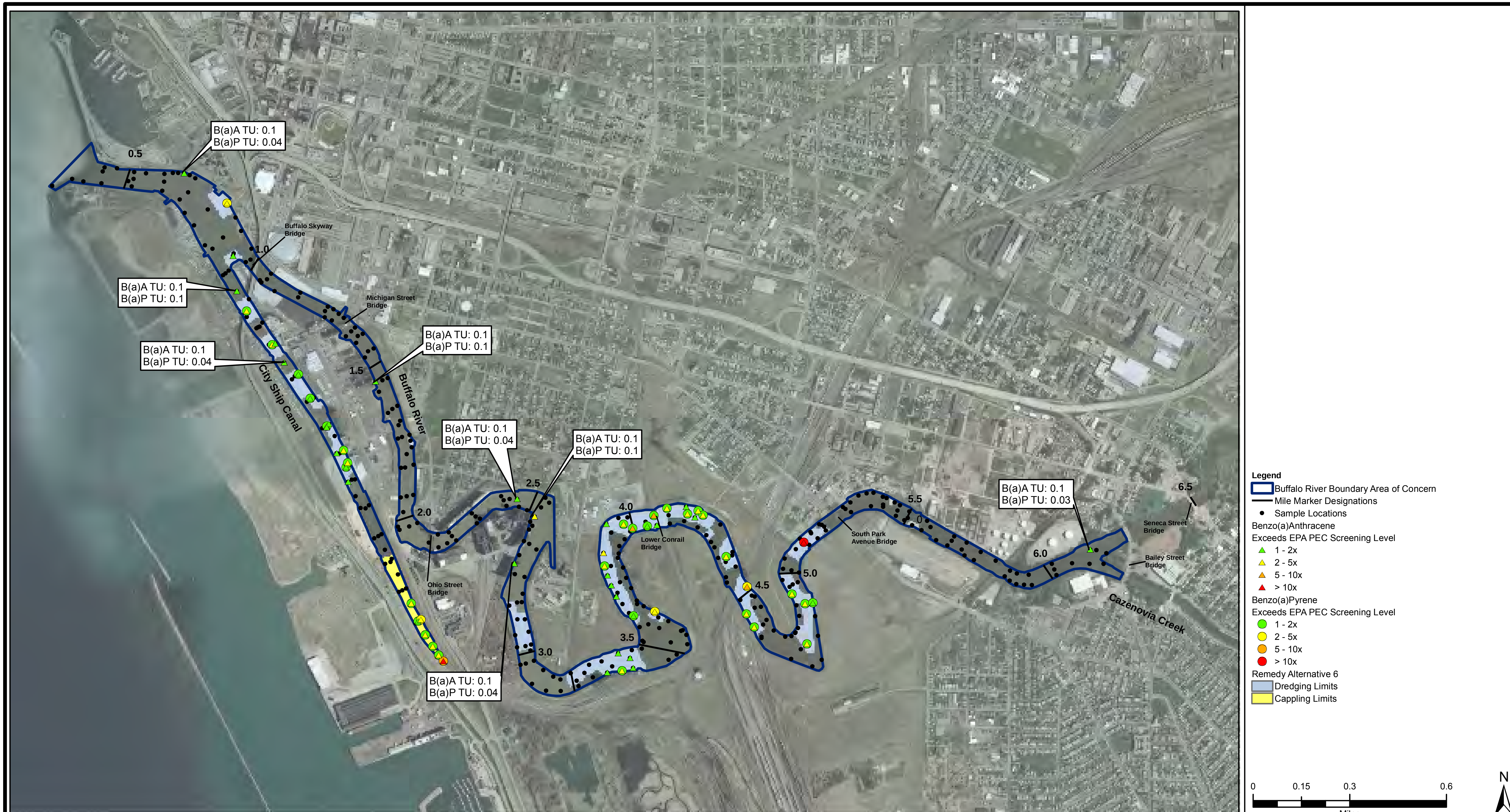

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PAH COMPOUNDS SURFACE SAMPLES
EXCEEDING PECS AND PAH TOXICITY UNITS IN SEDIMENT
REMEDY ALTERNATIVE 6
BUFFALO RIVER, NY

Figure 3d

Drafter: B. Radakovich
Date: 08/27/2009
File Name: 20090827_SurfaceBenzoTU_Remedy6e_EPA.mxd

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Post Remedy 6 PAH Concentrations Compared to PECs, Buffalo River

Figure 3e

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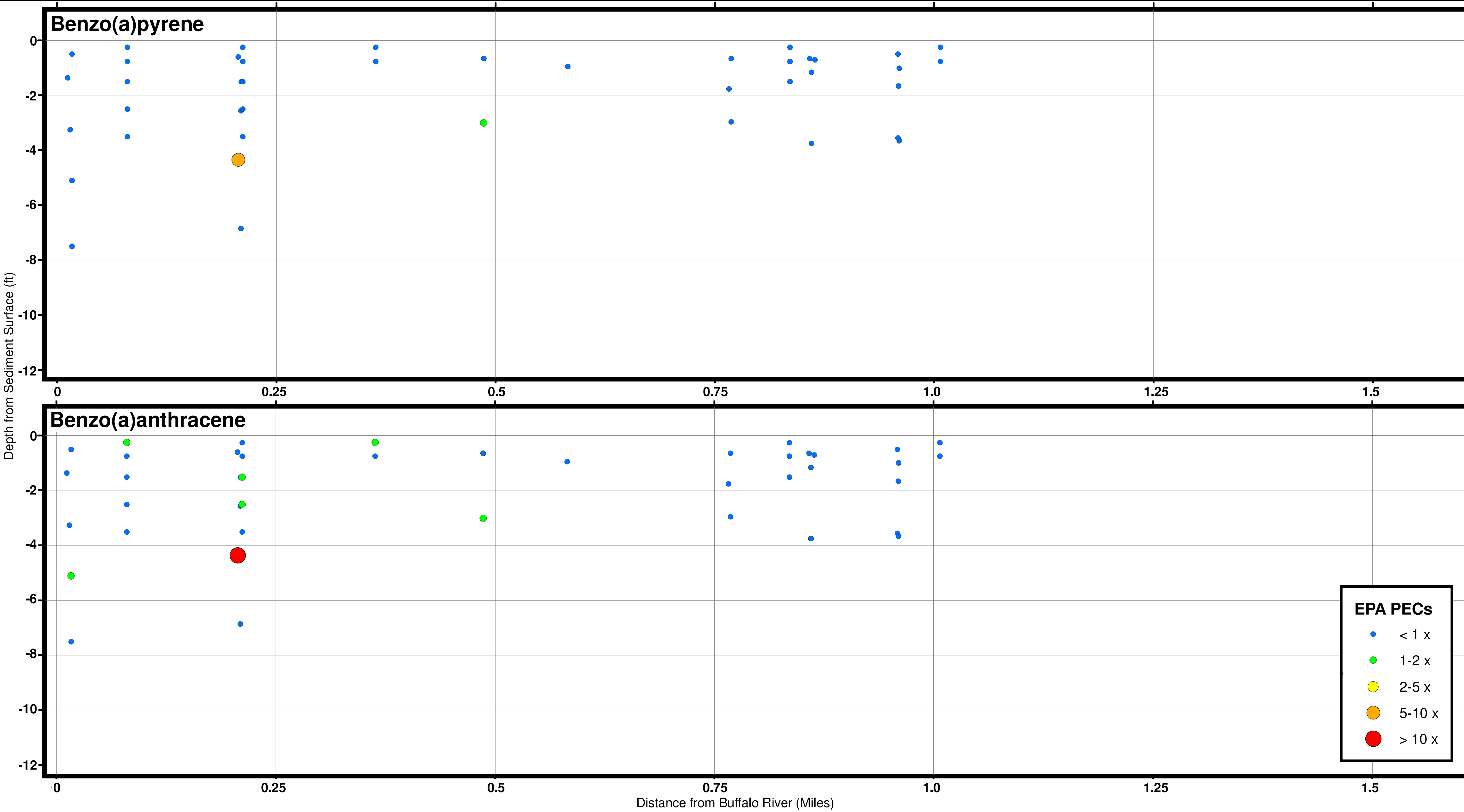

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Post Remedy 6 PAH Concentrations Compared to PECs, City Ship Canal

Figure 3f

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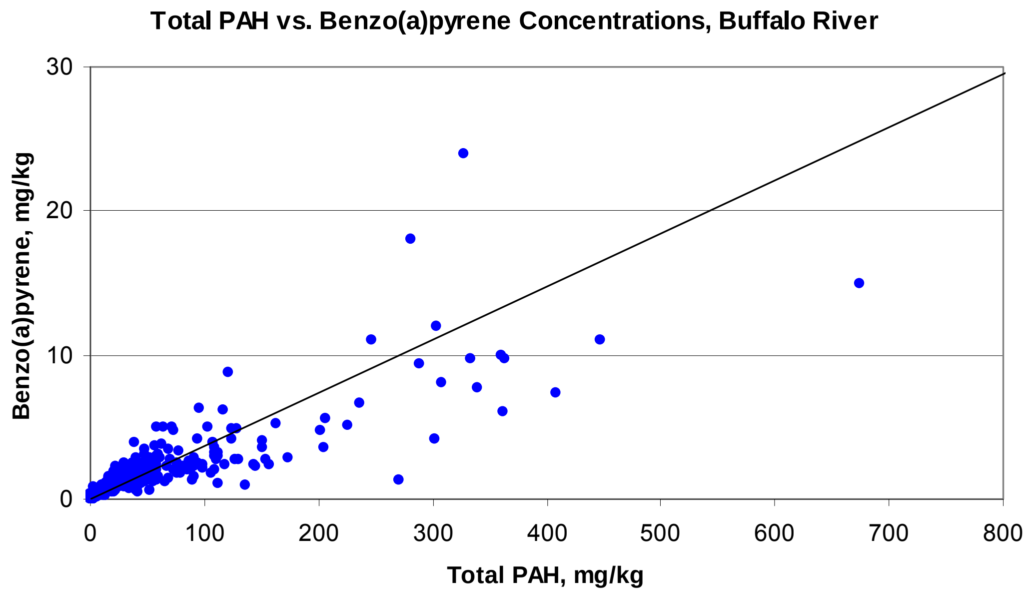

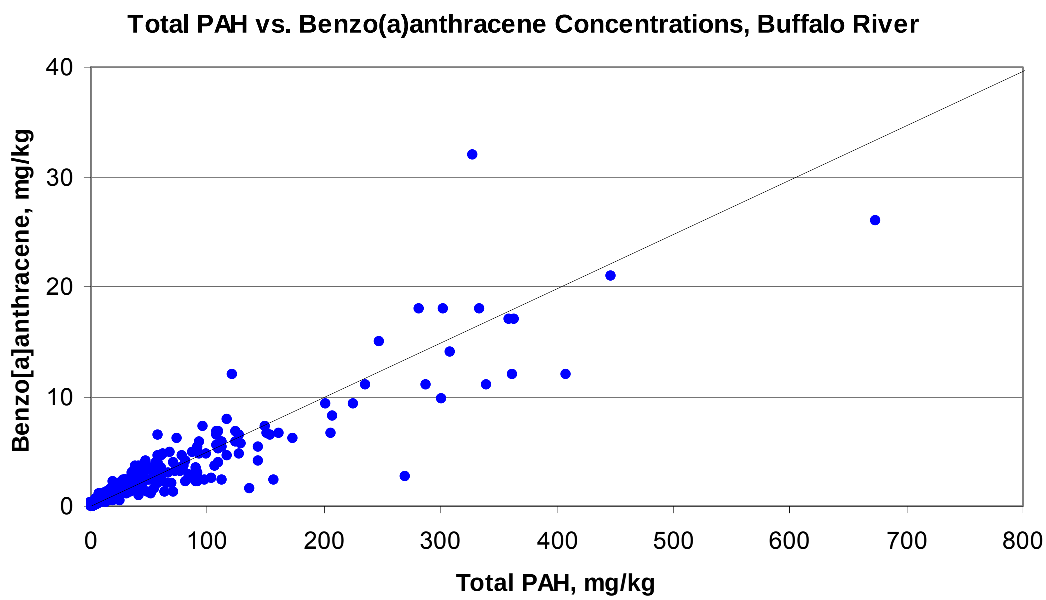

* Targeting the removal of elevated total PAHs removes elevated concentrations of B(a)A and B(a)P

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Correlation Between Total PAH and Individual PAH Concentrations

Figure 3g

Appendix D
Guidelines for the Development of Remedy Alternative 5

D1: Sediment Chemistry Guidelines

D2: Oil and Grease Guidelines

D3: Guidelines for Potential Scour Areas

D4: Guidelines for Public Access and Ship Traffic Areas

Appendix D1
Sediment Chemistry Guidelines

Sediment Chemistry Rules
Buffalo River AOC
9/21/09

This paper defines the rules to decide when contaminated sediment should be removed. Once a decision to dredge is made, the dredging will continue until the target concentrations are met. In general, the following applies:

1. The Surface Weighted Average Concentration (SWAC) value is derived by averaging samples over a 1/3 mile or otherwise predetermined area.

2. The Remedial Goals (RGs) are as follows:

   a. Total PAHs = 16 ppm
   b. SWAC Mercury (Hg) = 0.44 ppm
   c. SWAC Lead (Pb) = 90 ppm
   d. SWAC Total PCBs = 0.2 ppm

3. The RGs always apply in addition to the additional criteria A., B. and C. below.

A. **ZERO TO ONE FOOT**

Surface Sediment Chemistry Rules – Evaluation of each segment of the river bank/navigational channel begins with evaluating the surface (0-1') concentration.

- Must meet the SWAC RGs for Hg, Pb, and total PCBs in the top foot of sediment
- Must meet Total PAHs =16 ppm (Point concentration RG)

B. **ZERO TO 2 FEET**

Rule to address chemical concentrations in the top 2 ft of sediment. The point concentration shall not exceed:

- Pb = 400 ppm
- Hg = 3 ppm
- Total PCBs = 3 ppm [1]
- Total PAHs = 32 ppm

C. **2 FEET TO 4 FEET**

Rule to address chemical concentrations in the top 2 – 4 ft of sediment. The point concentration shall not exceed:

- Pb = 800 ppm

[1] This is based on an average PCB concentrations driving remediation at 19 sediment sites across the US, where target PCB concentrations driving remediation were below TSCA levels. The average concentration was 3 ppm ± 4 ppm.

- Hg = 6 ppm
- Total PCBs = 6 ppm
- Total PAHs = 80 ppm

1) Isolated areas exceeding the above criteria need to be defined by more than 1 sample location to warrant removal

2) The following approaches may be considered for dredged areas that do not satisfy the above rules:
    a. Re-dredge (after confirmation sampling) as appropriate to address target areas and to meet RGs
    b. At high depositional areas, evaluate whether natural sedimentation can provide adequate cover within two years, and before the 5-year monitoring period
    c. In areas that do not meet the above criteria, cover with sufficient material to achieve adequate cover in 2 years and before the 5-year monitoring period, using:
        i. River sediment borrowed from upstream (this sediment must meet appropriate criteria for reuse).
        ii. Borrow material that meets the specifications of the river.

3) Manually address locations with sediment deposits buried deeper than 4 ft below the sediment surface having residual chemical concentrations greater than Rule C.

D. **TARGET DREDGE DEPTHS**

Once dredging of an area commences the dredging will continue until the following conditions are met:

- Dredge to USACE 24-ft authorized dredge depth (elevation of 545.2 ft), or

- Dredge to a depth where the sediment chemistry meets the following point concentration criteria:

    a. Achieve the SWAC RGs for PCB, Hg, and Pb
    b. Total PAHs < 16 ppm
    c. Pb < 200 ppm
    d. Hg < 1 ppm
    e. Total PCBs < 1 ppm

Appendix D2
Oil and Grease Guidelines

New York State Department of Environmental Conservation
Division of Environmental Remediation, Region 9
270 Michigan Avenue, Buffalo, New York 14203-2915
Phone: (716) 851-7220; **Fax** (716) 851-7226
Website: www.dec.ny.gov

Alexander B. Grannis
Commissioner

MEMORANDUM

From: Linda Ross, DER

To: Martin Doster, PE, Regional Hazardous Waste Remediation Engineer

Date: June 26, 2009

Re: Rules for Grossly Contaminated Media (Oil and Grease) for the Buffalo River Area of Concern (AOC)

As per 6 NYCRR Part 375 Section 1.2 of the Environmental Remediation Program, effective December 14, 2006 "Grossly contaminated media" means soil, sediment, surface water or groundwater which contains sources or substantial quantities of mobile contamination in the form of NAPL, as defined in subdivision 3.75-1.x (ac), that is identifiable either visually, through strong odor, by elevated contaminant vapor levels or is otherwise readily detectable without laboratory analysis. This is the regulation that is currently being used by the Division of Environmental Remediation (DER) for remediation.

Based on this definition and interpreting it for use on the Buffalo River, the following rule applies for grossly contaminated media. The sediment being evaluated must have three of the following identifiable features:

1. Chemical odor
2. Petroleum odor
3. Staining
4. Sheen
5. Field screening with a Photoionization Device (PID) greater than 50 ppm (part per million), this is the approximate cutoff point used by the Spills Program in DER

By reviewing the geologic logs from the Buffalo River 2005, 2007 and 2008 field studies the following sediment samples are considered as being grossly contaminated:

Sample number	Interval (ft)
2005	
4-753-00-L56	5-6.7
1-713-00-C07	5.5-6.5
1-720-00-C45	4.0-6.0
1-730-00-C57	5.2-6.8
6-698-00-L35, L89	0-8.6

Samples number	Interval(ft)
2-665-00-L56	3.8-5.9
2-665-00-R45	4.0-5.2
2-610-00-L34	3.2-3.4
2-630-00-R34	3.0-4.2
2-635-00-R06,R67	2.2-2.4
4-638-00-R06	0-1.8
6-638-00-L02	0.9-1.3
2007-None	
2008	
062-EA3-L-C	2.4-4.8
075-MA1-C-C	5.25-8.0
083-EA1-R-C	4.4-4.9
101-EA3-R-C	6.7-8.8

The points are plotted on the attached .pdf map with red circles.

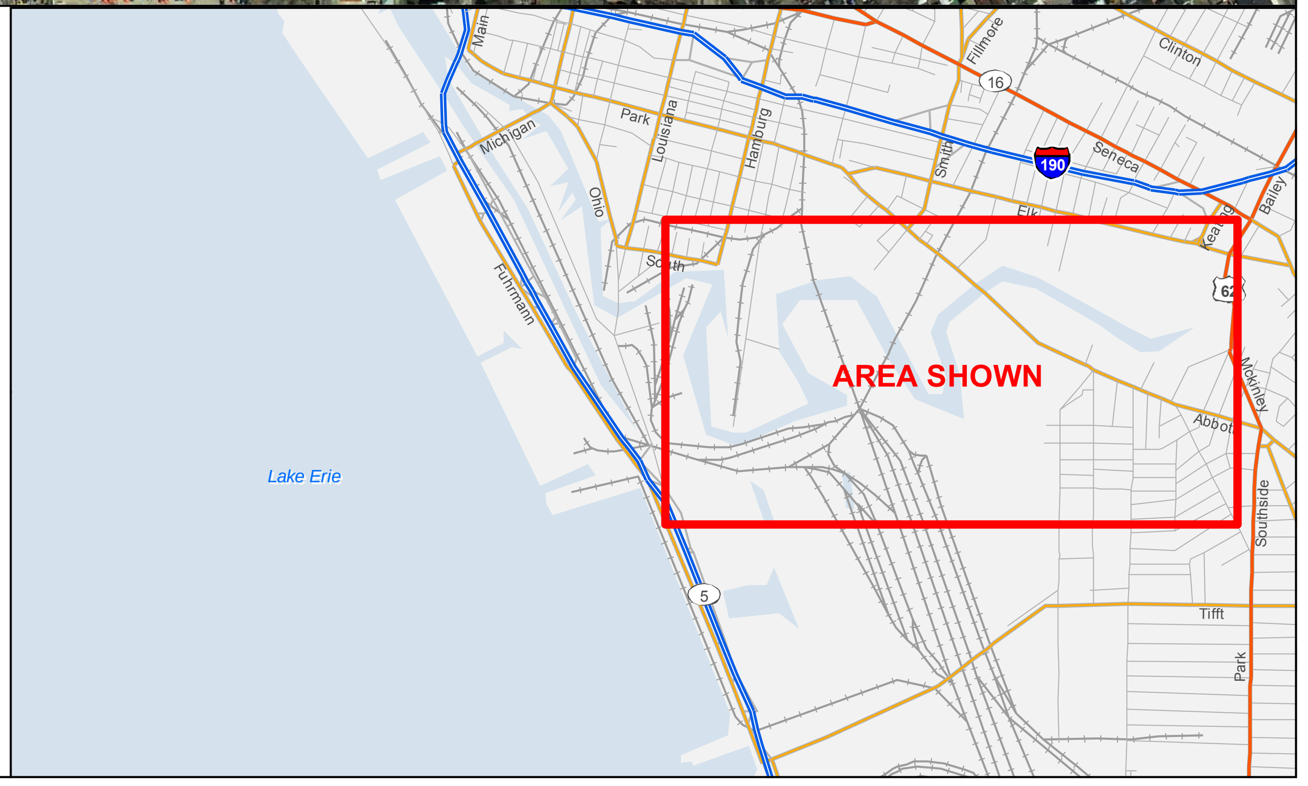
Sediment Thickness Reading Location	Park
Sediment Sampling Location	SPDES Facility
Geochronology Location	Brownfield Cleanup Program Site
Elutriate Core Location	Environmental Restoration Program Site
2005 and 2007 Sample Location	State Superfund Program Site
Approximate Utility Crossing Location	Voluntary Cleanup Program Site
Geologic Cross Section Location	Grain Elevator

Figure 2-1C: Sediment Sampling and Thickness Measurement Locations
Eastern Portion, Buffalo River AOC

N

SCALE

0 0.0625 0.125 0.25 0.375 0.5 Miles



Appendix D3
Guidelines for Potential Scour Areas

Rules for Potential Sediment Scour Areas
Buffalo River AOC

Background: Identification of Potential Scour Areas and Corresponding Sediment Chemical Concentrations

The response of river bed to a high stress condition is typically a combination of localized erosion, vertical mixing of sediments, and widespread deposition of watershed solids. In the absence of a sediment transport model for the Buffalo River AOC, an analysis based on available hydrodynamics and available sediment properties was conducted to identify areas of potential localized erosion under a 100-year event. The EFDC hydrodynamic model completed for the Buffalo River was used to identify areas of potential localized erosion, which commonly have the following characteristics:

- High bottom shear stress (greater than 20-40 dynes/cm2)
- Longitudinally increasing stress (supporting a gain in sediment load with distance downstream)
- High stream power (to sustain transport)

To identify areas with the above characteristics, hydrodynamic model results for the 100-year event were processed to identify areas with elevated stresses and a sufficient longitudinal gradient in stress to allow for a gaining sediment load, supporting erosion. Stream power was not assessed, as velocities in all cases were sufficient to maintain sediment transport.

Zones of elevated scour potential are mapped according to the above criteria in Figure 1. As noted above, it is difficult to make estimates of the depth of scour in the identified areas of high erosion potential without data on bed characteristics and storm event watershed solids loads. However, a model of a similar Great Lakes tributary with similar bed characteristics and watershed geology (Lower Don River, Toronto) shows maximum scour depths of less than 1.5 feet under shear stress conditions similar to the 100 year event on the Buffalo River. The same model also shows broad areas of solids deposition due to greatly increased loads of watershed solids under high event flow conditions. Thus, even in potential scour areas under 100-year flow conditions, net scour depths greater than one foot are not expected within the Buffalo River AOC.

Decision Criterion for Potential Scour Areas

1) Delineate potential scour areas that exceed the sediment chemistry criteria in the top 2 feet of sediment. (A net scour depth of more than 1 foot is not expected during a 100-yr event, thus a depth of two feet will meet the sediment criteria for the sediment that is potentially eroded and the resulting surface sediments below the eroded material.)

Table 1 shows post Remedy Alternative 5 SWACs assuming 1 ft of sediment is removed in the potential scour zones. Figure 1 shows three areas where a total PAH concentration greater than 1 TU may be exposed following a scour event, assuming post Remedy Alternative 5 conditions. This information, in conjunction with the sediment chemistry decision criteria being developed for the Feasibility Study, will be used to identify potential scour areas that should be included in the preferred remedy alternative footprint.

Table 1
Post Scour SWACs under Post Remedy Alternative 5 Conditions
Buffalo, NY

Reach (River Miles)	Total PAHs, mg/kg	Lead, mg/kg	Mercury, mg/kg	Total PCBs, mg/kg
Buffalo River				
0.33 - 0.67	5.1	39	0.18	0.10
0.67 - 1.0	7.1	51	0.35	0.12
1.0 - 1.33	6.3	76	0.19	0.08
1.33 - 1.67	6.1	39	0.13	0.09
1.67 - 2.0	5.0	38	0.12	0.08
2.0 - 2.33	4.5	34	0.11	0.08
2.33 - 2.67	6.8	62	0.21	0.17
2.67 - 3.0	5.6	43	0.08	0.11
3.0 - 3.33	6.0	40	0.10	0.08
3.33 - 3.67	6.4	64	0.20	0.07
3.67 - 4.0	6.7	32	0.08	0.04
4.0 - 4.33	7.5	32	0.07	0.07
4.33 - 4.67	7.7	39	0.13	0.05
4.67 - 5.0	7.8	35	0.12	0.08
5.0 - 5.33	6.1	36	0.18	0.14
5.33 - 5.67	4.7	29	0.08	0.06
5.67 -6.0	5.0	35	0.06	0.07
City Ship Canal				
0.0 - 0.33	7.3	50	0.24	0.08
0.33 - 0.67	8.9	46	0.31	0.08
0.67 - 1.0	4.9	38	0.29	0.09
1.0 - 1.33	6.3	37	0.25	0.05
1.33 - 1.67	6.1	22	0.03	0.01

NOTE: Post scour SWACs assume 1 foot of sediment will be removed in pontential scour zones.

Legend

- Buffalo River Boundary Area of Concern
- Mile Marker Designations

Remedy Alternative 5

- Dredging Limits
- Capping Limits
- Areas to be Resampled
- Potential Scour Zones

0 0.15 0.3 0.6
Miles

N

ENVIRON
MACTEC
LimnoTech
Water | Environment | Scientists | Engineers

POTENTIAL SCOUR ZONES
BUFFALO RIVER, NY

Figure 1

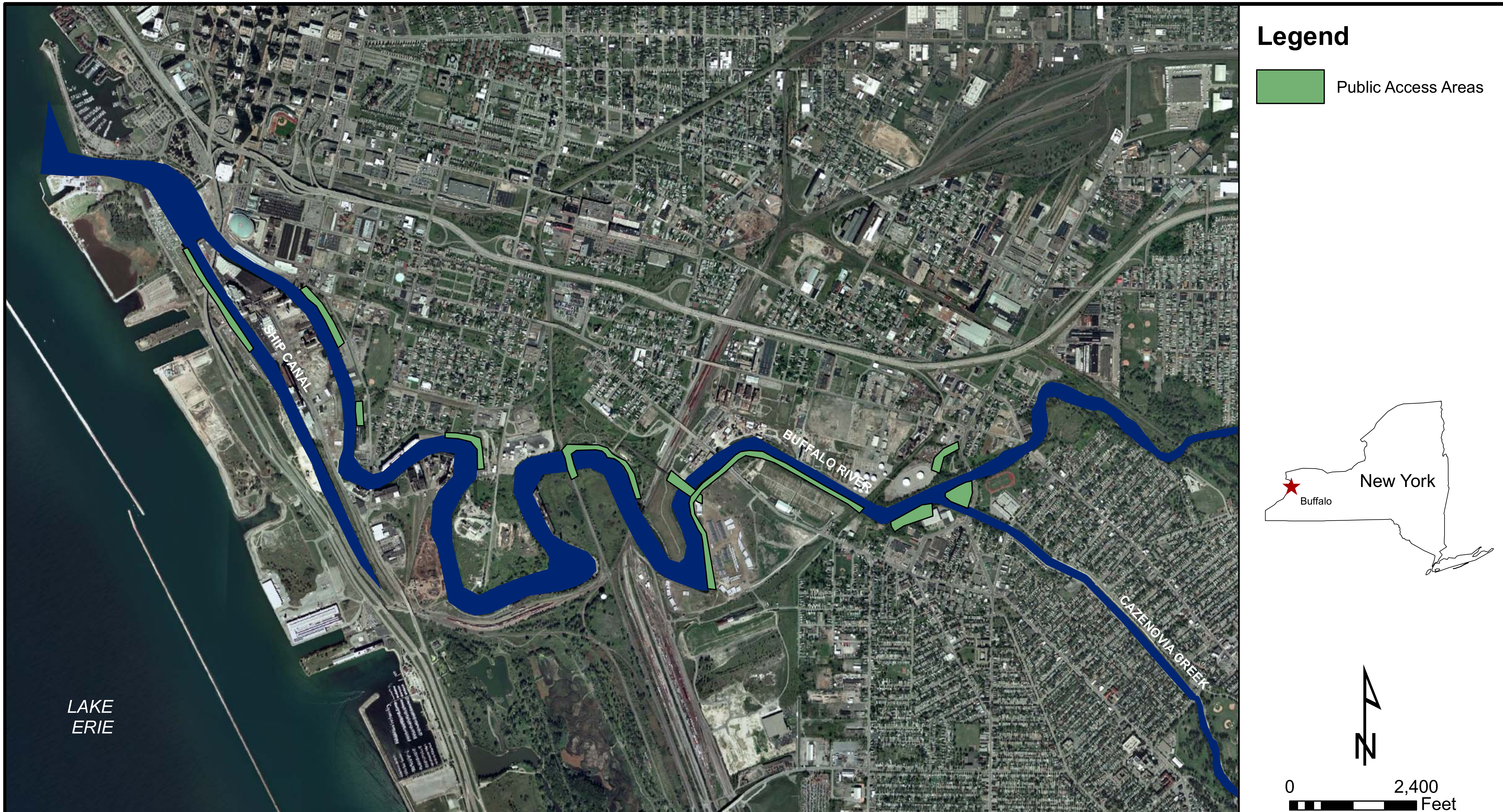
Drafter: B. Radakovich
Date: 10/05/2009
File Name: 20091005_ScourZones_Remedy5.mxd

Appendix D4
Guidelines for Public Access and Ship Traffic Areas

Public Access and Ship Traffic Guidelines for Alternative 5

1. Public Access/Human Contact
    a. Is the area on or near formally designated (or soon to be developed) park, marina, boat launch, or conservation area?
    b. Does the area of shoreline have a natural slope, is it easily accessible (legally or illegally) and has frequent human recreational use (wading, swimming, diving, etc.) been observed?

2. Potential sediment disturbance related to freighter traffic and/or commercial use
    a. Is contaminated sediment at depth in an area of the river that supports lake freighter traffic where exposure or re-suspension of contaminants is possible due to prop wash or physical disturbance (i.e.: docking, “bumping channel walls” or “running aground”) within and outside the navigation channel?



ENVIRON
MACTEC

BUFFALO RIVER PUBLIC ACCESS AREAS

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Appendix E
Development of Remedy Alternative Costs

1 INTRODUCTION

This appendix provides cost estimate details for each of the Buffalo remedial alternatives presented in Section 5 of the *Buffalo River Feasibility Study* (*FS*) report. The costs presented in this appendix have been developed at the feasibility study level and are provided for the purposes of comparison of the level of effort, schedule, and complexities among different remedy alternatives. The actual costs of different pre-remedy, remedy implementation, and post-remedy activities, subcontractors, and equipment for each sediment remedy may be higher or lower than the costs presented herein, within a range typical of an alternatives analysis (e.g., +50%, -30%).

1.1 COST ESTIMATES TABLES

Preliminary costs are calculated using net present value for each sediment remedy alternative and process options supporting each alternative. Preliminary costs are presented in the following tables:

- Table 1 presents a summary of the calculated net present value of each alternative, with a seven percent discount rate. The long-term monitoring duration is assumed to span 10 years for Monitored Natural Recovery (MNR).
- Table 2 shows the detailed costs of Remedial Alternative 2, MNR.
- Table 3 presents the detailed costs of Remedial Alternative 3, Sediment removal targeting the PAH RG of 1 TU at all sediment depths, and SWAC RGs for PCBs, Hg, and Pb, and capping the end of the City Ship Canal.
- Table 4 shows the detailed costs of Remedial Alternative 4, Remedial Alternative 4: Sediment removal targeting the PAH RG of 1 TU in surface (0-1 ft) sediment, and SWAC RGs for PCBs, Hg, and Pb, and capping the end of the City Ship Canal.
- Table 5 presents the detailed costs of Remedial Alternative 5, Sediment removal targeting the PAH RG of 1 TU in surface (0-1 ft) sediment, SWAC RGs for PCBs, Hg, and Pb, and maximum residual PAH, PCB, Hg, and Pb concentrations in buried and surface sediments, and capping the end of the City Ship Canal.

1.2 COST ESTIMATE BASIS

Capital and annual operation and maintenance (O&M) costs were used to estimate total costs for each alternative. Capital costs consist of direct (construction) costs and indirect (non-construction and overhead) costs estimated in 2009 dollars. Direct capital costs include costs associated with construction and equipment, land and site-preparation, transportation, and disposal. Indirect capital costs include costs associated with engineering and management and various contingency allowances.

Annual O&M costs are post-construction costs required to assess the continued effectiveness of a remedial action and may include operating labor costs, maintenance materials and labor costs, costs to conduct periodic site reviews, and long-term monitoring. O&M costs were estimated for a 10 year period, discounted to a Net Present Value (NPV) in 2009 dollars. The overall cost for each alternative is the sum of the capital and discounted annual costs. The discounted costs were calculated based on the NPV methods described in the 2000 USEPA guidance document, *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study*. As per the 2000 USEPA guidance document, the discount rate selected for the net present worth calculations is seven percent. The cost estimates provided have an accuracy of +50 percent to –30 percent in compliance with the 1988 USEPA guidance document, *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA.*

Table 1 presents a summary of the net present value for each of the remedial alternatives, with a seven percent discount rate. The long-term monitoring duration is assumed to span 10 years for MNR. The remedial alternative comparisons presented in the RAA report are based on these projections.

The cost for each alternative was calculated by estimating unit costs for:

- Equipment mobilization/demobilization
- Upland site preparation (including CDF improvements construction requirements[1])
- Construction control measures (e.g., turbidity monitoring and health and safety)
- Remedy implementation (e.g., MNR or dredging and capping)
- Sediment excavation by mechanical means in conformance with historical USACE dredging activities at the Buffalo River
- Sediment transport via barge to CDF No. 4 for disposal in the lagoon or upland areas without additional confinement, if suitable
- Dewatering and in-barge stabilization
- Construction of a bermed area using site soils within the upland portion of the CDF
- Debris screening in the upland portion of the CDF prior to off-site disposal

---

1 Considering the reported condition of the existing off-loading lines, it is assumed that off-loading of material into the CDF will require Contractor laid tubing/lines from the off-loading area to the disposal areas. Additional improvements may be required to the off-loading facility to allow docking of barges.

- Disposal within the bermed area in the CDF of the dredged material unsuitable for placement in the lagoon of the CDF or in upland areas without additional confinement
- Disposal of dredged materials directly in the open water of the CDF
- Post-remediation sampling and site restoration
- Miscellaneous costs

Direct labor costs were not calculated. Instead, labor costs were integrated into direct unit costs for each remedial alternative line item. To the extent practicable, unit costs associated with each line item were confirmed by contractors, material suppliers, disposal facilities, or the USACE. The unit costs are considered a reasonable based on knowledge of the industry and industry reports, and includes labor, equipment and materials necessary to complete the line item activities. For costing purposes for this FS, and for comparison of remedial alternatives on the basis of cost, this approach is considered reasonable. Indirect construction costs were estimated based on the subtotal project cost estimate, adding contractor engineering and administration (10% of the subtotal), and a general contingency (30% of the subtotal).

Critical input data used to develop cost estimates include MNR areas, capping areas, and dredging volumes for the alternatives, production rates for dredging and capping, and sediment bulking and consolidation via dewatering, transportation and disposal rates, infrastructure construction requirements, monitoring requirements, remediation verification monitoring requirements, and long-term monitoring requirements.

The actual duration of each alternative may vary based on factors such as final design, construction approach, and timing restrictions to implement the remedial action. The duration for each alternative was determined by estimated unit production rates based on typical industry values and dividing those rates into total cap or dredge material quantities. These values were then used in combination with other factors such as mobilization/demobilization, submittals review, and verification testing times to generate overall estimates of construction time frame.

It was assumed that materials not suitable for direct placement into the CDF lagoon would be placed in the upland portions of the CDF with additional confinement. As per communications with the USACE, the additional confinement would consist of a bermed area constructed from materials within the upland portion of the CDF. After the bermed area fulfills its purpose it would be capped with clean sand[2]. For the purpose of this estimate, it was assumed that 5% of the dredged material would require additional confinement. The USACE and USEPA have the final determination as to which materials will require special handling with the CDF and which can be placed directly

[2] Other management measures, to be determined at a later date by the USACE, may be require in addition to confinement with a berm on the upland portion and capping with suitable material.

into the CDF lagoon or upland areas without confinement. The final cost estimate will be revised to reflect this determination. It was further assumed that none of the dredged material will be handled or managed as hazardous waste.

The bermed area was also assumed to serve as a staging area for debris removed as part of the dredging activities. Although, no geophysical surveys have been performed of the Buffalo River, it was assumed that debris would amount to 2.5% of the total volume of dredged materials. This assumption is based on the fact that (a) between 50% and 75% of the area to be dredged under Alternatives 3, 4, and 5 have been periodically dredged by the USACE as part of the maintenance of the navigational channel within the Buffalo River; and (b) approximately 73 to 76% of the sediment would originate from the shoulders of the navigational channel, which are not typically dredged by the USACE. As such, large amounts of buried debris are not anticipated in the navigational channel but could potentially be encountered outside the navigational channel. The USACE has indicated that it would not be unreasonable to expect to encounter large debris during off-channel dredging.

The cost estimates assume that shoreline improvements will not be performed as the bulkheads are the responsibility of the corresponding site owners. Dredging around these physical constraints will be addressed during the design phase.

Long-term O&M is based on monitoring for the MNR alternative (Alternative 2) and the capping component of Alternatives 3, 4 and 5. Detailed assumptions are provided as footnotes to the cost estimates.

Table E-1
Remedial Alternative Cost Estimate Summary
Buffalo, NY

		Remedial Area	Remedial Volume	Cap Area	Total Cost	Unit Cost
Remedy 1	No Action	0 SF	0 CY	0 SF	$0	
Remedy 2	Monitored Natural Recovery of the Entire River	11,632,400 SF	0 CY	0 SF	$2,453,000	$0.21 /SF
Remedy 3	Sediment removal targeting the PAH RG of 1 TU at all sediment depths, and SWAC RGs for PCBs, Hg, and Pb and capping of the ship canal	6,309,200 SF	1,750,000 CY	292,400 SF	$73,883,000	$38 /CY dredged $9 /SF capped
Remedy 4	Sediment removal targeting the PAH RG of 1 TU in surface (0-1 ft) sediment, and SWAC RGs for PCBs, Hg, and Pb and capping of the ship canal	2,074,800 SF	640,000 CY	292,400 SF	$31,817,000	$41 /CY dredged $9 /SF capped
Remedy 5	Sediment removal targeting the PAH RG of 1 TU in surface (0-1 ft) sediment, SWAC RGs for PCBs, Hg, and Pb, and maximum residual PAH, PCB, Hg, and Pb concentrations in buried and surface sediments and capping of the ship canal	2,780,800 SF	820,000 CY	292,800 SF	$38,733,000	$41 /CY dredged $9 /SF capped

Key assumptions

USACE performs the dredging and only turbidity monitoring is required.
The percent debris in the total volume of sediments is 2.5 percent.
The percent of the total volume of sediments requiring additional confinement within the CDF is 5 percent.
None of the excavated sediments will require off-site disposal as hazardous waste.
No shoreline stabilization or improvements will be performed as part of the remedy.
Additional confinement within CDF will be performed using on-site materials. No importation will be required.

CDF	Confined Disposal Facility
CY	Cubic Yards
SF	Square feet
Hg	Mercury
PAH	Polycyclic aromatic hydrocarbon
Pb	Lead
PCB	Polychlorinated biphenyl

Table E-2
Remedial Alternative 2 Cost Estimate
Buffalo, NY

Proposed Remedial Action Remediate/Dredge PAHs >1 T.U. in sediment column

	NAVIGATIONAL CHANNEL		NON- NAVIGATIONAL CHANNEL	
	Proposed Action	If dredging, entity performing the dredging	Proposed Action	If dredging, entity performing the dredging
Main Channel	MNR	Honeywell	MNR	Honeywell
Ship Canal	MNR	Honeywell	MNR	Honeywell

Scenario Summary

Total Dredged Volume (CY)	**0**
Total Area of Capping (SF)	**0**
Total MNR Area (SF)	**11,632,400**

Cost Summary

Activity	***Cost***		
Fixed Actions	**$0**		
Dredging	**$0**		
Disposal	**$0**		
Capping	**$0**		
MNR	**$1,751,000**		
Total Direct Construction Costs	**$0**		
Total O&M Costs	**$1,751,000**		
Engineering (10% of TOMC)	**$176,000**		
Contingency (30% of TOMC)	**$526,000**	**$0.21**	**$/SF for MNR**
TOTAL	**$2,453,000**		

Table E-2 (Continued)
Remedial Alternative 2 Cost Estimate
Buffalo, NY

CAPITAL AND FIXED COSTS

Item	Quantity	Units	Unit Cost	Present Worth	Source
Design and Procurement Support				**$0**	
Construction Cost (USACE Dredging)				**$0**	
Construction Cost (Debris Removal and CDF Disposal)				**$0**	
Construction Cost (Debris Removal and CDF Disposal with additional confinement)				**$0**	
Construction Cost (Debris Removal and Hazardous Waste Disposal)				**$0**	

OPERATION AND MAINTENANCE COSTS

Item	Quantity	Units	Unit Cost	Cost per Event	Present Worth	Source
Long Term Monitoring of MNR (10 years)					**$1,751,000**	
10.02 Bathymetric Survey	267	acre	$901	$240,580	$715,000	Ocean Survey
10.03 Sediment Profile Imaging	267	acre	$90	$24,060	$71,000	Germano & Associates
10.04 Sediment Sampling	267	sample	$885	$236,240	$702,000	Various Laboratories
10.05 Fish Tissue	50	sample	$800	$40,000	$49,000	Various Laboratories
10.06 Field Management Support	1	event	$60,000	$60,000	$178,000	ENVIRON
10.07 Reporting	1	event	$12,000	$12,000	$36,000	ENVIRON

Notes:

1. This opinion of probable cost was prepared using costs considered appropriate for typical operations. It is intended for use in comparing the relative cost of remedial alternatives. Actual costs may differ.
2. As per EPA-500-R00-002, an interest rate of 7% was used in present worth calculations.
3. The long term monitoring duration is assumed to span 10 years for MNR. Sediment sampling assumes 1 sample per MNR acre collected at 1, 3, 5 and 10 years.
4. For MNR, fish tissue sampling assumes 50 samples at 5 and 10 years each.

Table E-3
Remedial Alternative 3 Cost Estimate
Buffalo, NY

Proposed Remedial Action Remediate/Dredge PAHs >1 T.U. in sediment column

	NAVIGATIONAL CHANNEL		NON- NAVIGATIONAL CHANNEL	
	Proposed Action	If dredging, entity performing the dredging	Proposed Action	If dredging, entity performing the dredging
Main Channel	Dredge	USACE	Dredge	USACE
Ship Canal	Cap	USACE	Cap	USACE

Scenario Summary

Total Dredged Volume (CY)	**1,750,000**	
Dredge Volume Suitable for CDF Disposal		1,662,500
Dredge Vol. Requiring Additional Confinement for CDF Disposal		87,500
Dredge Volume Requiring Hazardous Waste Disposal		0
Total Area of Capping (SF)	**292,400**	

Cost Summary

Activity	***Cost***		
Fixed Actions	**$2,136,000**		
Dredging	**$29,358,000**		
USACE	$29,108,000		
Post-Dredge Monitoring	$250,000		
Disposal	**$18,917,000**		
CDF Disposal	$17,623,000		
CDF Disposal w/ Confinement	$1,294,000		
Hazardous Waste	$0		
Capping	**$2,678,000**		
Capping post-dredging of access	$1,822,000		
Cap Monitoring (30 years)	$856,000		
Total Direct Construction Costs	**$51,983,000**		
Total O&M Costs	**$1,106,000**		
Engineering (10% of TDCC)	**$5,199,000**	**$38**	**$/CY Dredged**
Contingency (30% of TDCC)	**$15,595,000**	**$9**	**$/SF Capped**
TOTAL	**$73,883,000**		

Table E-3 (Continued)
Remedial Alternative 3 Cost Estimate
Buffalo, NY

CAPITAL AND FIXED COSTS

Item		Quantity	Units	Unit Cost	Present Worth	Source
Design and Procurement Support					**$2,136,000**	
1.01	Construction Management/On-site Superintendent/Site Administration	27	Month	$68,000	$1,836,000	Terra Contracting
1.02	Set Up of Temporary Facilities	2	Staging Area	$25,000	$50,000	DeMaximis
1.03	Breakdown Temporary Facilities	2	Staging Area	$25,000	$50,000	DeMaximis
1.04	Site Restoration	2	Staging Area	$100,000	$200,000	Terra Contracting
Construction Cost (USACE Dredging)					**$29,108,000**	
2.01	Pre-dredge Soundings	1	Lump Sum	$100,000	$100,000	MACTEC
2.02	Health and Safety	24	Month	$32,000	$768,000	Terra Contracting
2.03	Mobilization set-up, and demobilization	1	Lump Sum	$600,000	$600,000	Terra Contracting
2.04	Temporary Facilities	25	Facility-Month	$20,000	$500,000	DeMaximis
2.05	Establish Remediation Management Units (RMUs)	1	LS	$200,000	$200,000	Terra Contracting
2.06	Turbidity Monitoring	24	Month	$35,000	$840,000	ENVIRON
2.07	Shoreline Stabilization	0	Linear Feet	$65	$0	MACTEC
2.08	Dredging and Transportation of Contaminated Sediment (USACE)	1,750,000	Cubic Yard	$13	$22,750,000	USACE recent bids
2.09	Improvements to the offloading facility at the CDF	1	Lump Sum	$1,000,000	$1,000,000	MACTEC/ENVIRON
2.09	Periodic Soundings/GPS Tracking to Document Progress	27	Month	$50,000	$1,326,000	MACTEC
2.10	Support Boats	24	Month	$1,000	$24,000	DeMaximis
2.11	Annual Mobe/Demobe	5	Field Season	$200,000	$1,000,000	Terra Contracting
Construction Cost (Debris Removal and CDF Disposal)					**$17,623,000**	
4.01	Sediment Disposal in CDF	1,662,500	Cubic Yard	$7	$11,638,000	USACE
4.02	Debris Removal and Stockpiling	41,563	Cubic Yard	$30	$1,247,000	Terra Contracting
4.03	Debris Transportation/Disposal	49,875	Ton	$95	$4,738,000	Sevenson
Construction Cost (Debris Removal and CDF Disposal with additional confinement)					**$1,294,000**	
5.01	Sediment Disposal in CDF	87,500	Cubic Yard	$7	$613,000	USACE
5.02	Debris Removal and Stockpiling	2,188	Cubic Yard	$30	$66,000	Terra Contracting
5.03	Debris Transportation/Disposal	2,625	Ton	$95	$249,000	Sevenson
5.04	Construct Earth Berms (no material importation)	21,000	Cubic Yard	$2	$42,000	Terra Contracting
5.05	Soil capping of additional confinement area	18,000	Square Yard	$18	$324,000	ENVIRON
Construction Cost (Capping after dredging)					**$1,822,000**	
8.02	Health and Safety	2	Month	$22,000	$44,000	Terra Contracting
8.03	Temporary Facilities	4	Facility-Month	$20,000	$80,000	DeMaximis
8.04	Turbidity Monitoring	2	Month	$35,000	$70,000	ENVIRON
8.05	Sand Capping Materials (Delivered)	12,996	Ton	$16	$208,000	Buffalo Crushed Stone, Inc.
8.06	Armoring Stone (Delivered)	16,244	Ton	$22	$357,378	Buffalo Crushed Stone, Inc.
8.07	Placement of Sand Cap	8,122	Cubic Yard	$30	$244,000	Terra Contracting
8.08	Placement of Armoring Stone	8,122	Cubic Yard	$70	$568,556	Terra Contracting
8.09	Periodic Soundings/GPS Tracking to Document Progress	1	Month	$50,000	$48,000	MACTEC
8.10	Support Boats	2	Month	$1,000	$2,000	DeMaximis

Table E-3 (Continued)
Remedial Alternative 3 Cost Estimate
Buffalo, NY

8.11 Annual Mobe/Demobe	1	Field Season	$200,000	$200,000	Terra Contracting

OPERATION AND MAINTENANCE COSTS

Item	Quantity	Units	Cost per Event	Present Worth	Source
Monitoring of Cap (30 years)				**$856,000**	
9.02 Long-Term Monitoring	2	event	$400,000	$634,000	MACTEC
9.03 Dive Inspections	2	event	$40,000	$64,000	Russell Marine/MACTEC
9.04 Reporting	2	event	$100,000	$158,000	MACTEC
Dredging Monitoring				**$250,000**	
11.02 Post-dredging Sampling	1	Lump Sum	$250,000	$250,000	MACTEC

Notes:

1. This opinion of probable cost was prepared using costs considered appropriate for typical operations. It is intended for use in comparing the relative cost of remedial alternatives. Actual costs may differ.
2. As per EPA-500-R00-002, an interest rate of 7% was used in present worth calculations.
3. Staging area is upland and will be relocated as operations move down river.
4. All dredging is assumed will be performed by mechanical means based on historical USACE dredging activities at the Buffalo River.
5. For USACE dredging, assume 3,000 cyds per day dredge production via mechanical dredging plus time to establish RMUs, move RMUs, setup, breakdown, upland site restoration, etc. Transport of dredged materials assumed to be via barge. Assume a 6 day work week.
6. Post-dredge sampling assumes one sample per every 200 feet of shoreline, $300 per sample, collect 10 samples per day, $10,000 per week for subs/ODCs/Labor, 10% duplicates, 25% mobilization.
7. No long term monitoring activities are assumed for dredging.
8. Dredge volumes base on straight column dredging, no sloping. Shoreline improvement costs are not included, as it is assumed that the actual dredging program will be designed to allow safe removal of sediments along banks to prevent slope bank/bulkhead failure.
9. A five (5) month dredging window has been assumed to estimate dredging durations. This estimate is based on timing restrictions for dredging (January through June), bird nesting restrictions on the use of the CDF (March through July) and freezing of the river (typically December to January).
10. Debris is estimated to be 1.2 tons/cyd.
11. For off-site disposal, assume 25 cy rolloff boxes.
12. Sediment solidification estimated at 25% addition by volume and solidified sediment at 1.5 tons/cyd.
13. Geotube quantities based on a geotube length of 100 feet and capacity of 600 CY, and a dredged material expansion of 25% following dredging.
14. Given the reported condition of the existing off-loading lines, it is assumed that off-loading of material into the CDF will require Contractor laid tubing/lines from the off-loading area to the disposal area.
15. Additional confinement within CDF assumes that existing upland soils will be reconfigured to create an earthen berm with 2:1 (horizontal to vertical) slopes for disposal of pumped sediments (20% solids). No material importation will be required to construct the berms.
16. Other management measures, to be determined at a later date by the USACE, may be required in addition to confinement with a berm on the upland portion and capping with suitable material. Cost estimates for these additional measures have not been developed.
17. If suitable, some dredged material may be able to be placed in the upland portion of the CDF without confinement. This placement alternative is in addition to placement directly in the lagoon and placement upland areas of the CDF with additional confinement. Cost estimates for this potential alternative have not been developed.
18. Assume 2,000 cyds per day cap installation production (mechanical placement) plus time to establish RMUs, move RMUs, setup, breakdown, upland site restoration, etc.
19. Sand estimates for capping include required thickness with 50% increase to account for compaction and loss/waste.
20. Sand estimated at 1.6 tons/cyd.
21. Stone estimates include 20% extra to extend beyond extent of sand cap.
22. Stone estimated at 2.0 tons/cyd.
23. The long term monitoring duration is assumed to span 5 years for capping. Cap long term monitoring assumes events at 2 and 5 years.
24. Implementation of the remedial action will only require turbidity monitoring and no turbidity control. In addition, best management practices, such as operational controls and specialty equipment, will be used to limit suspended sediment.

Table E-4
Remedial Alternative 4 Cost Estimate
Buffalo, NY

Proposed Remedial Action Remediate/Dredge PAHs >1 T.U. in sediment column

	NAVIGATIONAL CHANNEL		NON- NAVIGATIONAL CHANNEL	
	Proposed Action	If dredging, entity performing the dredging	Proposed Action	If dredging, entity performing the dredging
Main Channel	Dredge	USACE	Dredge	USACE
Ship Canal	Cap	USACE	Cap	USACE

Scenario Summary

Total Dredged Volume (CY)	**640,000**	
Dredge Volume Suitable for CDF Disposal		608,000
Dredge Vol. Requiring Additional Confinement for CDF Disposal		32,000
Dredge Volume Requiring Hazardous Waste Disposal		0
Total Area of Capping (SF)	**292,400**	

Cost Summary

Activity	***Cost***		
Fixed Actions	**$1,184,000**		
Dredging	**$12,255,000**		
USACE	$12,005,000		
Post-Dredge Monitoring	$250,000		
Disposal	**$6,925,000**		
CDF Disposal	$6,445,000		
CDF Disposal w/ Confinement	$480,000		
Hazardous Waste	$0		
Capping	**$2,678,000**		
Capping post-dredging of access	$1,822,000		
Cap Monitoring (30 years)	$856,000		
Total Direct Construction Costs	**$21,936,000**		
Total O&M Costs	**$1,106,000**		
Engineering (10% of TDCC)	**$2,194,000**	**$41**	**$/CY Dredged**
Contingency (30% of TDCC)	**$6,581,000**	**$9**	**$/SF Capped**
TOTAL	**$31,817,000**		

Table E-4 (Continued)
Remedial Alternative 4 Cost Estimate
Buffalo, NY

CAPITAL AND FIXED COSTS

Item		Quantity	Units	Unit Cost	Present Worth	Source
Design and Procurement Support					**$1,184,000**	
1.01	Construction Management/On-site Superintendent/Site Administration	13	Month	$68,000	$884,000	Terra Contracting
1.02	Set Up of Temporary Facilities	2	Staging Area	$25,000	$50,000	DeMaximis
1.03	Breakdown Temporary Facilities	2	Staging Area	$25,000	$50,000	DeMaximis
1.04	Site Restoration	2	Staging Area	$100,000	$200,000	Terra Contracting
Construction Cost (USACE Dredging)					**$12,005,000**	
2.01	Pre-dredge Soundings	1	Lump Sum	$100,000	$100,000	MACTEC
2.02	Health and Safety	10	Month	$32,000	$320,000	Terra Contracting
2.03	Mobilization set-up, and demobilization	1	Lump Sum	$600,000	$600,000	Terra Contracting
2.04	Temporary Facilities	11	Facility-Month	$20,000	$220,000	DeMaximis
2.05	Establish Remediation Management Units (RMUs)	1	LS	$200,000	$200,000	Terra Contracting
2.06	Turbidity Monitoring	10	Month	$35,000	$350,000	ENVIRON
2.07	Shoreline Stabilization	0	Linear Feet	$65	$0	MACTEC
2.08	Dredging and Transportation of Contaminated Sediment (USACE)	640,000	Cubic Yard	$13	$8,320,000	USACE recent bids
2.09	Improvements to the offloading facility at the CDF	1	Lump Sum	$1,000,000	$1,000,000	MACTEC/ENVIRON
2.09	Periodic Soundings/GPS Tracking to Document Progress	10	Month	$50,000	$485,000	MACTEC
2.10	Support Boats	10	Month	$1,000	$10,000	DeMaximis
2.11	Annual Mobe/Demobe	2	Field Season	$200,000	$400,000	Terra Contracting
Construction Cost (Debris Removal and CDF Disposal)					**$6,445,000**	
4.01	Sediment Disposal in CDF	608,000	Cubic Yard	$7	$4,256,000	USACE
4.02	Debris Removal and Stockpiling	15,200	Cubic Yard	$30	$456,000	Terra Contracting
4.03	Debris Transportation/Disposal	18,240	Ton	$95	$1,733,000	Sevenson
Construction Cost (Debris Removal and CDF Disposal with additional confinement)					**$480,000**	
5.01	Sediment Disposal in CDF	32,000	Cubic Yard	$7	$224,000	USACE
5.02	Debris Removal and Stockpiling	800	Cubic Yard	$30	$24,000	Terra Contracting
5.03	Debris Transportation/Disposal	960	Ton	$95	$91,000	Sevenson
5.04	Construct Earth Berms (no material importation)	7,700	Cubic Yard	$2	$15,000	Terra Contracting
5.05	Soil capping of additional confinement area	7,000	Square Yard	$18	$126,000	ENVIRON
Construction Cost (Capping after dredging)					**$1,822,000**	
8.02	Health and Safety	2	Month	$22,000	$44,000	Terra Contracting
8.03	Temporary Facilities	4	Facility-Month	$20,000	$80,000	DeMaximis
8.04	Turbidity Monitoring	2	Month	$35,000	$70,000	ENVIRON
8.05	Sand Capping Materials (Delivered)	12,996	Ton	$16	$208,000	Buffalo Crushed Stone, Inc.
8.06	Armoring Stone (Delivered)	16,244	Ton	$22	$357,378	Buffalo Crushed Stone, Inc.
8.07	Placement of Sand Cap	8,122	Cubic Yard	$30	$244,000	Terra Contracting
8.08	Placement of Armoring Stone	8,122	Cubic Yard	$70	$568,556	Terra Contracting
8.09	Periodic Soundings/GPS Tracking to Document Progress	1	Month	$50,000	$48,000	MACTEC
8.10	Support Boats	2	Month	$1,000	$2,000	DeMaximis

8.11 Annual Mobe/Demobe	1	Field Season	$200,000	$200,000	Terra Contracting

OPERATION AND MAINTENANCE COSTS

Item	Quantity	Units	Cost per Event	Present Worth	Source
Monitoring of Cap (30 years)				**$856,000**	
9.02 Long-Term Monitoring	2	event	$400,000	$634,000	MACTEC
9.03 Dive Inspections	2	event	$40,000	$64,000	Russell Marine/MACTEC
9.04 Reporting	2	event	$100,000	$158,000	MACTEC
Dredging Monitoring				**$250,000**	
11.02 Post-dredging Sampling	1	Lump Sum	$250,000	$250,000	MACTEC

Notes:

1. This opinion of probable cost was prepared using costs considered appropriate for typical operations. It is intended for use in comparing the relative cost of remedial alternatives. Actual costs may differ.
2. As per EPA-500-R00-002, an interest rate of 7% was used in present worth calculations.
3. Staging area is upland and will be relocated as operations move down river.
4. All dredging is assumed will be performed by mechanical means based on historical USACE dredging activities at the Buffalo River.
5. For USACE dredging, assume 3,000 cyds per day dredge production via mechanical dredging plus time to establish RMUs, move RMUs, setup, breakdown, upland site restoration, etc. Transport of dredged materials assumed to be via barge. Assume a 6 day work week.
6. Post-dredge sampling assumes one sample per every 200 feet of shoreline, $300 per sample, collect 10 samples per day, $10,000 per week for subs/ODCs/Labor, 10% duplicates, 25% mobilization.
7. No long term monitoring activities are assumed for dredging.
8. Dredge volumes base on straight column dredging, no sloping. Shoreline improvement costs are not included, as it is assumed that the actual dredging program will be designed to allow safe removal of sediments along banks to prevent slope bank/bulkhead failure.
9. A five (5) month dredging window has been assumed to estimate dredging durations. This estimate is based on timing restrictions for dredging (January through June), bird nesting restrictions on the use of the CDF (March through July) and freezing of the river (typically December to January).
10. Debris is estimated to be 1.2 tons/cyd.
11. For off-site disposal, assume 25 cy rolloff boxes.
12. Sediment solidification estimated at 25% addition by volume and solidified sediment at 1.5 tons/cyd.
13. Geotube quantities based on a geotube length of 100 feet and capacity of 600 CY, and a dredged material expansion of 25% following dredging.
14. Given the reported condition of the existing off-loading lines, it is assumed that off-loading of material into the CDF will require Contractor laid tubing/lines from the off-loading area to the disposal area.
15. Additional confinement within CDF assumes that existing upland soils will be reconfigured to create an earthen berm with 2:1 (horizontal to vertical) slopes for disposal of pumped sediments (20% solids). No material importation will be required to construct the berms.
16. Other management measures, to be determined at a later date by the USACE, may be required in addition to confinement with a berm on the upland portion and capping with suitable material. Cost estimates for these additional measures have not been developed.
17. If suitable, some dredged material may be able to be placed in the upland portion of the CDF without confinement. This placement alternative is in addition to placement directly in the lagoon and placement upland areas of the CDF with additional confinement. Cost estimates for this potential alternative have not been developed.
18. Assume 2,000 cyds per day cap installation production (mechanical placement) plus time to establish RMUs, move RMUs, setup, breakdown, upland site restoration, etc.
19. Sand estimates for capping include required thickness with 50% increase to account for compaction and loss/waste.
20. Sand estimated at 1.6 tons/cyd.
21. Stone estimates include 20% extra to extend beyond extent of sand cap.
22. Stone estimated at 2.0 tons/cyd.
23. The long term monitoring duration is assumed to span 5 years for capping. Cap long term monitoring assumes events at 2 and 5 years.
24. Implementation of the remedial action will only require turbidity monitoring and no turbidity control. In addition, best management practices, such as operational controls and specialty equipment, will be used to limit suspended sediment.

Table E-5
Remedial Alternative 5 Cost Estimate
Buffalo, NY

Proposed Remedial Action Remediate/Dredge PAHs >1 T.U. in sediment column

	NAVIGATIONAL CHANNEL		NON- NAVIGATIONAL CHANNEL	
	Proposed Action	If dredging, entity performing the dredging	Proposed Action	If dredging, entity performing the dredging
Main Channel	Dredge	USACE	Dredge	USACE
Ship Canal	Cap	USACE	Cap	USACE

Scenario Summary

Total Dredged Volume (CY)	**820,000**	
Dredge Volume Suitable for CDF Disposal		779,000
Dredge Vol. Requiring Additional Confinement for CDF Disposal		41,000
Dredge Volume Requiring Hazardous Waste Disposal		0
Total Area of Capping (SF)	**292,800**	

Cost Summary

Activity	***Cost***		
Fixed Actions	**$1,320,000**		
Dredging	**$15,108,000**		
USACE	$14,858,000		
Post-Dredge Monitoring	$250,000		
Disposal	**$8,874,000**		
CDF Disposal	$8,257,000		
CDF Disposal w/ Confinement	$617,000		
Hazardous Waste	$0		
Capping	**$2,680,000**		
Capping post-dredging of access	$1,824,000		
Cap Monitoring (30 years)	$856,000		
Total Direct Construction Costs	**$26,876,000**		
Total O&M Costs	**$1,106,000**		
Engineering (10% of TDCC)	**$2,688,000**	**$41**	**$/CY Dredged**
Contingency (30% of TDCC)	**$8,063,000**	**$9**	**$/SF Capped**
TOTAL	**$38,733,000**		

Table E-5 (Continued)
Remedial Alternative 5 Cost Estimate
Buffalo, NY

CAPITAL AND FIXED COSTS

Item		Quantity	Units	Unit Cost	Present Worth	Source
Design and Procurement Support					**$1,320,000**	
1.01	Construction Management/On-site Superintendent/Site Administration	15	Month	$68,000	$1,020,000	Terra Contracting
1.02	Set Up of Temporary Facilities	2	Staging Area	$25,000	$50,000	DeMaximis
1.03	Breakdown Temporary Facilities	2	Staging Area	$25,000	$50,000	DeMaximis
1.04	Site Restoration	2	Staging Area	$100,000	$200,000	Terra Contracting
Construction Cost (USACE Dredging)					**$14,858,000**	
2.01	Pre-dredge Soundings	1	Lump Sum	$100,000	$100,000	MACTEC
2.02	Health and Safety	12	Month	$32,000	$384,000	Terra Contracting
2.03	Mobilization set-up, and demobilization	1	Lump Sum	$600,000	$600,000	Terra Contracting
2.04	Temporary Facilities	13	Facility-Month	$20,000	$260,000	DeMaximis
2.05	Establish Remediation Management Units (RMUs)	1	LS	$200,000	$200,000	Terra Contracting
2.06	Turbidity Monitoring	12	Month	$35,000	$420,000	ENVIRON
2.07	Shoreline Stabilization	0	Linear Feet	$65	$0	MACTEC
2.08	Dredging and Transportation of Contaminated Sediment (USACE)	820,000	Cubic Yard	$13	$10,660,000	USACE recent bids
2.09	Improvements to the offloading facility at the CDF	1	Lump Sum	$1,000,000	$1,000,000	MACTEC/ENVIRON
2.09	Periodic Soundings/GPS Tracking to Document Progress	12	Month	$50,000	$622,000	MACTEC
2.10	Support Boats	12	Month	$1,000	$12,000	DeMaximis
2.11	Annual Mobe/Demobe	3	Field Season	$200,000	$600,000	Terra Contracting
Construction Cost (Debris Removal and CDF Disposal)					**$8,257,000**	
4.01	Sediment Disposal in CDF	779,000	Cubic Yard	$7	$5,453,000	USACE
4.02	Debris Removal and Stockpiling	19,475	Cubic Yard	$30	$584,000	Terra Contracting
4.03	Debris Transportation/Disposal	23,370	Ton	$95	$2,220,000	Sevenson
Construction Cost (Debris Removal and CDF Disposal with additional confinement)					**$617,000**	
5.01	Sediment Disposal in CDF	41,000	Cubic Yard	$7	$287,000	USACE
5.02	Debris Removal and Stockpiling	1,025	Cubic Yard	$30	$31,000	Terra Contracting
5.03	Debris Transportation/Disposal	1,230	Ton	$95	$117,000	Sevenson
5.04	Construct Earth Berms (no material importation)	9,900	Cubic Yard	$2	$20,000	Terra Contracting
5.05	Soil capping of additional confinement area	9,000	Square Yard	$18	$162,000	ENVIRON
Construction Cost (Capping after dredging)					**$1,824,000**	
8.02	Health and Safety	2	Month	$22,000	$44,000	Terra Contracting
8.03	Temporary Facilities	4	Facility-Month	$20,000	$80,000	DeMaximis
8.04	Turbidity Monitoring	2	Month	$35,000	$70,000	ENVIRON
8.05	Sand Capping Materials (Delivered)	13,013	Ton	$16	$208,000	Buffalo Crushed Stone, Inc.
8.06	Armoring Stone (Delivered)	16,267	Ton	$22	$357,867	Buffalo Crushed Stone, Inc.
8.07	Placement of Sand Cap	8,133	Cubic Yard	$30	$244,000	Terra Contracting
8.08	Placement of Armoring Stone	8,133	Cubic Yard	$70	$569,333	Terra Contracting
8.09	Periodic Soundings/GPS Tracking to Document Progress	1	Month	$50,000	$48,000	MACTEC
8.10	Support Boats	2	Month	$1,000	$2,000	DeMaximis

Table E-5 (Continued)
Remedial Alternative 5 Cost Estimate
Buffalo, NY

8.11 Annual Mobe/Demobe	1	Field Season	$200,000	$200,000	Terra Contracting

OPERATION AND MAINTENANCE COSTS

Item	Quantity	Units	Cost per Event	Present Worth	Source
Monitoring of Cap (30 years)				**$856,000**	
9.02 Long-Term Monitoring	2	event	$400,000	$634,000	MACTEC
9.03 Dive Inspections	2	event	$40,000	$64,000	Russell Marine/MACTEC
9.04 Reporting	2	event	$100,000	$158,000	MACTEC
Dredging Monitoring				**$250,000**	
11.02 Post-dredging Sampling	1	Lump Sum	$250,000	$250,000	MACTEC

Notes:

1. This opinion of probable cost was prepared using costs considered appropriate for typical operations. It is intended for use in comparing the relative cost of remedial alternatives. Actual costs may differ.
2. As per EPA-500-R00-002, an interest rate of 7% was used in present worth calculations.
3. Staging area is upland and will be relocated as operations move down river.
4. All dredging is assumed will be performed by mechanical means based on historical USACE dredging activities at the Buffalo River.
5. For USACE dredging, assume 3,000 cyds per day dredge production via mechanical dredging plus time to establish RMUs, move RMUs, setup, breakdown, upland site restoration, etc. Transport of dredged materials assumed to be via barge. Assume a 6 day work week.
6. Post-dredge sampling assumes one sample per every 200 feet of shoreline, $300 per sample, collect 10 samples per day, $10,000 per week for subs/ODCs/Labor, 10% duplicates, 25% mobilization.
7. No long term monitoring activities are assumed for dredging.
8. Dredge volumes base on straight column dredging, no sloping. Shoreline improvement costs are not included, as it is assumed that the actual dredging program will be designed to allow safe removal of sediments along banks to prevent slope bank/bulkhead failure.
9. A five (5) month dredging window has been assumed to estimate dredging durations. This estimate is based on timing restrictions for dredging (January through June), bird nesting restrictions on the use of the CDF (March through July) and freezing of the river (typically December to January).
10. Debris is estimated to be 1.2 tons/cyd.
11. For off-site disposal, assume 25 cy rolloff boxes.
12. Sediment solidification estimated at 25% addition by volume and solidified sediment at 1.5 tons/cyd.
13. Geotube quantities based on a geotube length of 100 feet and capacity of 600 CY, and a dredged material expansion of 25% following dredging.
14. Given the reported condition of the existing off-loading lines, it is assumed that off-loading of material into the CDF will require Contractor laid tubing/lines from the off-loading area to the disposal area.
15. Additional confinement within CDF assumes that existing upland soils will be reconfigured to create an earthen berm with 2:1 (horizontal to vertical) slopes for disposal of pumped sediments (20% solids). No material importation will be required to construct the berms.
16. Other management measures, to be determined at a later date by the USACE, may be required in addition to confinement with a berm on the upland portion and capping with suitable material. Cost estimates for these additional measures have not been developed.
17. If suitable, some dredged material may be able to be placed in the upland portion of the CDF without confinement. This placement alternative is in addition to placement directly in the lagoon and placement upland areas of the CDF with additional confinement. Cost estimates for this potential alternative have not been developed.
18. Assume 2,000 cyds per day cap installation production (mechanical placement) plus time to establish RMUs, move RMUs, setup, breakdown, upland site restoration, etc.
19. Sand estimates for capping include required thickness with 50% increase to account for compaction and loss/waste.
20. Sand estimated at 1.6 tons/cyd.
21. Stone estimates include 20% extra to extend beyond extent of sand cap.
22. Stone estimated at 2.0 tons/cyd.
23. The long term monitoring duration is assumed to span 5 years for capping. Cap long term monitoring assumes events at 2 and 5 years.
24. Implementation of the remedial action will only require turbidity monitoring and no turbidity control. In addition, best management practices, such as operational controls and specialty equipment, will be used to limit suspended sediment.