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:

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

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

ENVIRON International Corporation, MACTEC Engineering & Consulting, Inc., and LimnoTech. 2009. Feasibility Study for the Buffalo River, New York. March.

Great Lakes Fish Advisory Task Force. 1993. Protocol for a Uniform Great Lakes Sport Fish Consumption Advisory. September.

New York State Department of Environmental Conservation (NYSDEC). 2008. Draft Data Report for Residues of Organic Chemicals and Four Metals in Edible Tissues and Whole Fish for Fish Taken from The Buffalo River, New York.

New York State Department of Health (NYSDOH). 2009. Personal communication with Mr. Tony Forti of NYSDOH during the Buffalo River AOC Human Health Subgroup Conference Call on January 28.

SulTRAC. 2007. Human Health Risk Assessment: Upper Buffalo River Area of Concern, Buffalo, New York. October.

United States Army Corps of Engineers (USACE). 2009. Buffalo River Area of Concern (AOC): Site-Specific Fish PCB BSAFs and Mercury Discussion. January 16.

United States Environmental Protection Agency (USEPA). 1989. Office of Emergency and Remedial Response. Risk Assessment Guidance for Superfund. Volume I, Human Health Evaluation Manual. Washington, DC. EPA/540-1-89-002. OSWER Directive 9285.7-01a. December.

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.

United States Environmental Protection Agency (USEPA). 1993. Baseline Human Health Risk Assessment: Buffalo River, New York, Area of Concern. December.

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	Exposure to sediment was not considered	
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		
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	Exposure to surface water was not considered				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						
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

Chem Group	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
SVOC	Acenaphthene	6.0E-02	3,000	1		6.0E-02	3,000	125	104	2.1E-01	3,000	1	4, 44
SVOC	Acenaphthylene	3.0E-02	3,000	1	20	3.0E-02	3,000	125	104	1.1E-01	3,000	1	4, 20, 44
SVOC	Anthracene	3.0E-01	3,000	1		3.0E-01	3,000	125	104			2	90
SVOC	Benzo(b)fluoranthene												
SVOC	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
SVOC	Benzo(k)fluoranthene												
SVOC	Chrysene												
SVOC	Dibenz(a,h)anthracene												
SVOC	Fluoranthene	4.0E-02	3,000	1		4.0E-02	3,000	125	104	1.4E-01	3,000	1	4, 44
SVOC	Fluorene	4.0E-02	3,000	1		4.0E-02	3,000	125	104	1.4E-01	3,000	1	4, 44
SVOC	Indeno(1,2,3-cd)pyrene												
SVOC	Naphthalene	2.0E-02	3,000	1		2.0E-02	3,000	125	104	3.0E-03	3,000	1	
SVOC	Phenanthrene	3.0E-02	3,000	1	20	3.0E-02	3,000	125	104	1.1E-01	3,000	1	4, 20, 44
SVOC	Pyrene	3.0E-02	3,000	1		3.0E-02	3,000	125	104	1.1E-01	3,000	1	4, 44
PCB	PCBs (total)	2.0E-05	300	1	72	2.0E-05	300	125	104				
INORG	Mercury	1.0E-04	10	1	137	2.1E-05	1,000	125	104	3.0E-04	30	1	
INORG	Lead												
SVOC	PAHs (total)	2.0E-02	3,000	1	a	2.0E-02	3,000	125	104, a	3.0E-03	3,000	1	a

Chem Group	Chemical	Subchronic Oral Reference Dose S-RfD_{oral} (mg/kg/d) Value	UF	Ref	Notes	Subchronic Dermal Reference Dose, S-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
SVOC	Acenaphthene	6.0E-01	300	129	111, 113	6.0E-01	300	125	104	2.1E-01	3,000	1	4, 44, 62			
SVOC	Acenaphthylene	3.0E-01	300	126	20	3.0E-01	300	125	104	1.1E-01	3,000	1	4, 20, 44, 62			
SVOC	Anthracene	1.0E+01	100	129	111, 113	1.0E+01	100	125	104			2	62, 90			
SVOC	Benzo(b)fluoranthene															
SVOC	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			
SVOC	Benzo(k)fluoranthene															
SVOC	Chrysene															
SVOC	Dibenz(a,h)anthracene															
SVOC	Fluoranthene	4.0E-01	300	129	111, 113	4.0E-01	300	125	104	1.4E-01	3,000	1	4, 44, 62			
SVOC	Fluorene	4.0E-01	300	129	111, 113	4.0E-01	300	125	104	1.4E-01	3,000	1	4, 44, 62			
SVOC	Indeno(1,2,3-cd)pyrene															
SVOC	Naphthalene	2.0E-01	300	1	110	2.0E-01	300	125	104	3.0E-03	3,000	1	62			
SVOC	Phenanthrene	3.0E-01	300	126	20	3.0E-01	300	125	104	1.1E-01	3,000	1	4, 20, 44, 62			
SVOC	Pyrene	3.0E-01	300	126		3.0E-01	300	125	104	1.1E-01	3,000	1	4, 44, 62			
PCB	PCBs (total)	3.0E-05	300	129	111, 113, 72	3.0E-05	300	125	104					0.8	125	105
INORG	Mercury	1.0E-04	10	2	137	2.1E-04	100	125	104	3.0E-04	30	2		0.07	125	51
INORG	Lead															
SVOC	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)			Vapor Pressure, VP (mm Hg)		
			Value	Ref	Notes	Value	Ref	Notes	Value	Ref	Notes	Value	Temp	Ref	Notes	Value	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		2.5E-03	50.1	92
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	9.1E-04	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		2.7E-06	50.1	92
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		5.0E-07	50.1	92
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	1.0E-10	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		2.0E-09	50.1	92
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		6.2E-09	50.1	92
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		1.0E-10	50.1	92
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		7.8E-06	50.1	94
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		6.3E-04	50.1	92
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		1.0E-10	50.1	92
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		8.5E-02	50.1	92
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	1.1E-04	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		4.6E-06	50.1	92
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	7.7E-05	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		2.0E-03	50.1	92
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	5.5E-09	50.1	92, a

Chem Group	Chemical	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
SVOC	Acenaphthene	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	
SVOC	Acenaphthylene	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	
SVOC	Anthracene	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	
SVOC	Benzo(b)fluoranthene	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	
SVOC	Benzo(g,h,i)perylene	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	
SVOC	Benzo(k)fluoranthene	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	
SVOC	Chrysene	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	
SVOC	Dibenz(a,h)anthracene	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	
SVOC	Fluoranthene	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	
SVOC	Fluorene	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	
SVOC	Indeno(1,2,3-cd)pyrene	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	
SVOC	Naphthalene	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	
SVOC	Phenanthrene	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	
SVOC	Pyrene	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	
PCB	PCBs (total)	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	
INORG	Mercury	2.7E-01	44		5.4E-05	44		1.0E-03	62			62					8.6E-01					
INORG	Lead																					
SVOC	PAHs (total)	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:

a USACE. 2009. "Buffalo River Area of Concern (AOC): Site-Specific Fish PCB BSAFs and Mercury Discussion". January 16.
b Great Lakes Sport Fish Advisory Task Force. 1993. Protocol for a Uniform Great Lakes Sport Fish Consumption Advisory. September.
1 USEPA. 1992. Handbook of RCRA Ground-Water Monitoring Constituents. Chemical and Physical Properties (40 CFR Part 264, Appendix IX). EPA-530-R-92-022. September.
44 USEPA. 1996. Soil Screening Guidance: Technical Background Document and User Guide. Office of Emergency and Remedial Response. EPA/540/R-95/128. May.
50.1 USEPA. 1997. Superfund Chemical Data Matrix (SCDM). Office of Emergency and Remedial Response. September 12.
50.2 USEPA. 2004. Superfund Chemical Data Matrix (SCDM). Office of Emergency and Remedial Response. January.
62 USEPA. 2004. Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. July.
64 Agency for Toxic Substances and Disease Registry (ATSDR). November 2000. Toxicological Profile for Polychlorinated Biphenyls (PCBs).
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

		C_{fish} (mg/kg)	RME Fishermen Cancer Risk	RME Fishermen HQ	Typical Fishermen Cancer Risk	Typical Fishermen HQ	DOH RME Fishermen Cancer Risk	DOH RME Fishermen 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

			Pre-Remedy										Post-RA5									
Chem Group	Chemical	CASRN	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	*Post-Remedy 5 SWAC (mg/kg) using 0-2 ft surface depth* [1,2]		
			Lead	Mercury	Total PCBs
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

			Post-Remedy 5 SWAC (mg/kg) using 0-2 ft surface depth [1,2]		
Waterbody	**Downstream rivermile**	**Position**	**Lead**	**Mercury**	**Total PCBs**
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

DATE: June 18, 2009

MEMORANDUM

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.

REFERENCES:

Atkinson, J.F., T. Bajak, M. Morgante, S. Marshall, and J.V. DePinto. "Model Data Requirements and Mass Loading Estimates for the Buffalo River Mass Balance Study (ARCS/RAM Program)." Technical Report prepared for EPA, Great Lakes National Program Office, Report No. EPA 905-R94-005 (May, 1994).

DePinto, J.V., M. Morgante, J. Zaraszczak, T. Bajak, and J.F. Atkinson. "Application of Mass Balance Modeling to Assess Remediation Options for the Buffalo River (ARCS/RAM Program)." Final Technical Report for Cooperative Agreement CR-X995915 to U.S. EPA, Great Lakes National Program Office, Chicago, IL. Report No. EPA 905-R95-007. (April, 1995).

Ecology and Environment, Inc., 2008. Buffalo River Section 312 Environmental Dredging Existing Conditions Report. Prepared for: Department of the Army. Buffalo District Corps of Engineers. Buffalo, NY.

Inamdar, S., 2004. Sediment Modeling for the Buffalo River Watershed. Great Lakes Center, Buffalo College, Buffalo, NY.

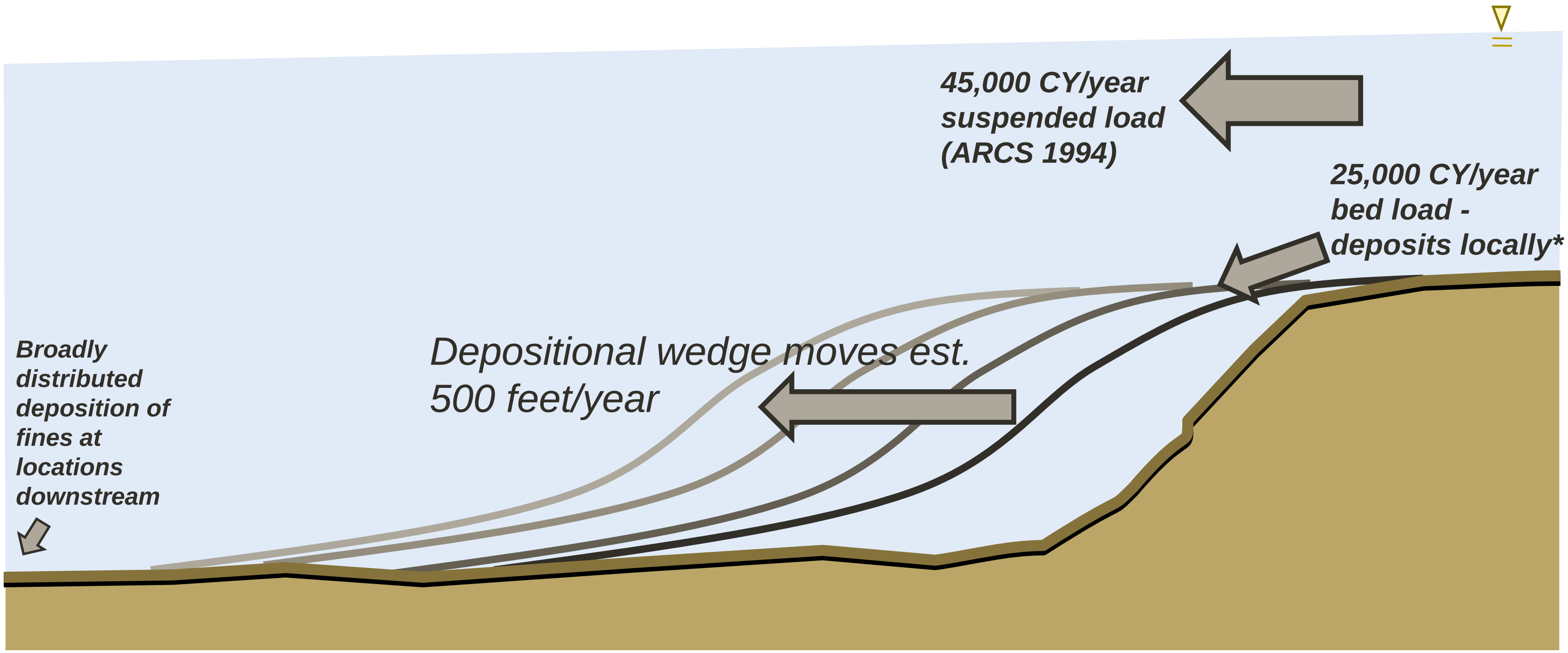
LimnoTech, 2009. Buffalo River Geochoronological Analyses, Fall, 2008. Project Memorandum dated June 18, 2009.

McLaren, P., and Singer, J., 2008. Sediment Transport and Contaminant Behavior in the Buffalo River, New York: Implications for River Management. Journal of Coastal Research (24):4

Science Applications International Corporation (SAIC), 1995. Assessment and Remediation of Contaminated Sediments (ARCS): Assessment of Sediments in the Buffalo River Area of Concern. Submitted to: USEPA GLNPO, Chicago, IL.

Singer, J., Atkinson, J., Manley, P., and McLaren, P. 2008. Understanding sediment dynamics using geological and engineering approaches: A case study of the Buffalo River area of concern, Buffalo, NewYork. Intl J. River Basin Management (6):1

US Army Corps of Engineers (USACE), 1988. Buffalo River Sedimentation Study: Buffalo and West Seneca, NY. USACE Buffalo District, Buffalo, NY



* 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.

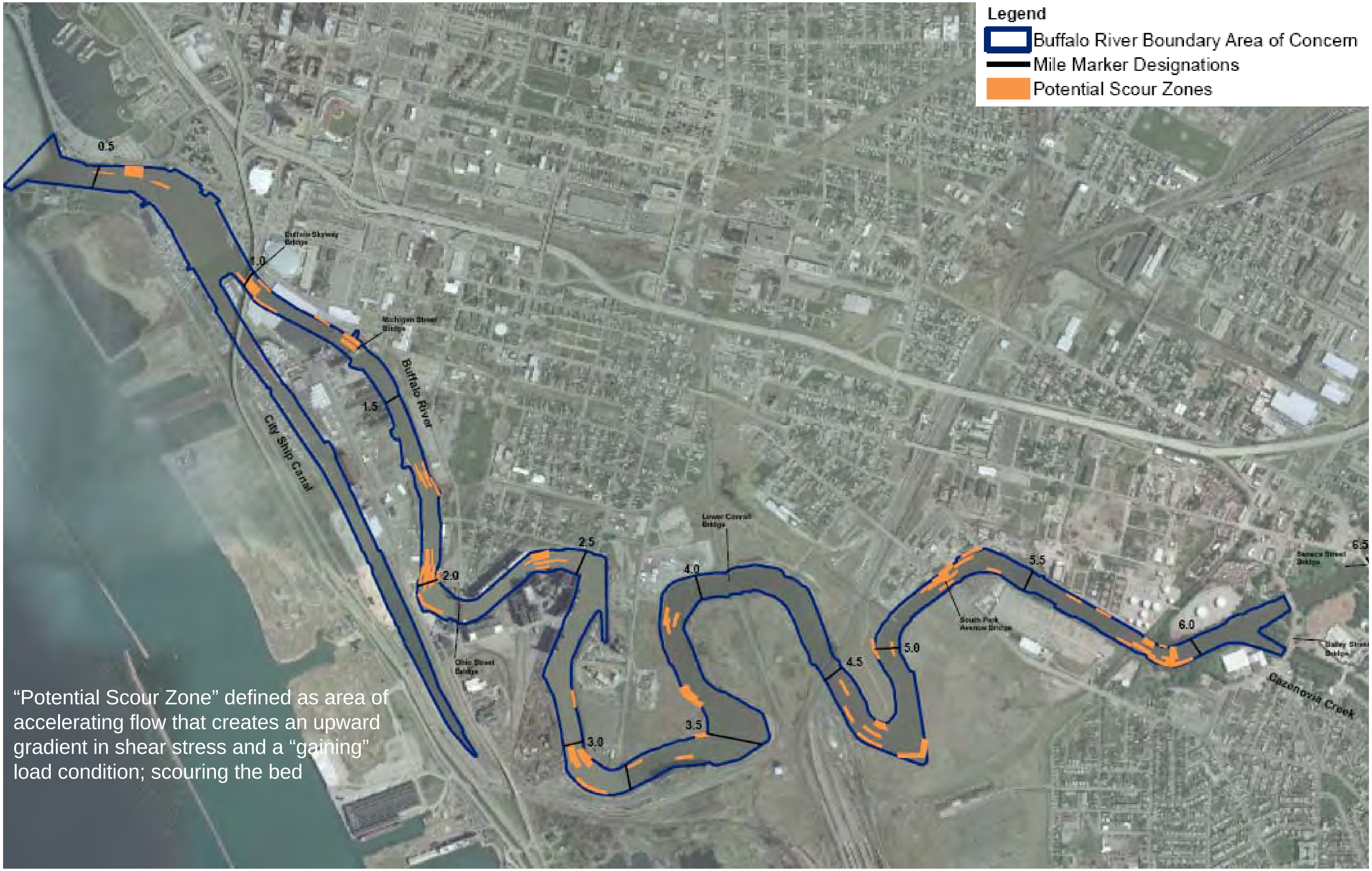


Figure 3: Potential Scour Zones

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.

References

Becker, D., E. Long, D. Proctor, and T. Ginn. 2006. Evaluation of potential toxicity and bioavailability of chromium in sediments associated with chromite ore processing residue. Env. Toxicol. Chem. 25: 2576-2583.

Beckvar, N., T. Dillon, and L. Read. 2005. Approaches for linking whole-body tissue residues of mercury and DDT to biological effects thresholds. Env. Toxicol. Chem. 24: 2094-2105.

Berry, W., W. Boothman, J. Serbst, and P. Edwards. 2004. Predicting the toxicity of chromium in sediments. Env. Toxicol. Chem. 23: 2981-2992.

ENVIRON and MACTEC. 2009. Sediment Remedial Investigation Report for the Buffalo River.

Irvin, T. and K. Irgolic. 1988. Arsenobetaine and arsenocholine: two marine arsenic compounds without embryotoxicity. Appl. Organomet. Chem. 2: 509-514.

McDonald, D.D., C.G. Ingersoll, and T.A. Berger. 2000. Development and evaluation of consensus-based sediment quality guidelines for freshwater ecosystems. Arch. Environ. Contam. Toxicol. 39: 20-31

NYSDEC. 1987. Niagara River biota contamination project: Fish flesh criteria for piscivorous wildlife. Technical Report 87-3.

NYSDEC. 1999. Technical guidance for screening contaminated sediments.

NYSDEC. 2007. Draft- Numerical guidance values for assessing risk to aquatic life from contaminants in sediments.

Shiomi, K., Y. Sugiyama, K. Shimakura, and Y. Nagashima. 1995. Arsenobetaine as the major arsenic compound in the muscle of two species of freshwater fish. Appl. Organomet. Chem. 9: 105-109.

Skinner, L., B. Trometer, A. Gudlewski, B. Buanno, and J. Bourbon. 2009. Data report for residues of organic chemicals and four metals in edible tissues and whole fish for fish taken from the Buffalo River, New York.

Sorensen, M., J. Conder, P. Fuchsman, L. Martello, and R. Wenning. 2007. Using a sediment quality triad approach to evaluate benthic toxicity in the lower Hackensack River, New Jersey. Arch. Env. Contam. Toxicol. 53: 36-49.

USEPA. 2003a. Procedures for the derivation of equilibrium partitioning sediment benchmarks (ESBs) for the protection of benthic organisms: Dieldrin. USEPA-600-R-02-010.

USEPA. 2003b. Procedures for the derivation of equilibrium partitioning sediment benchmarks (ESBs) for the protection of benthic organisms: Endrin. USEPA-600-R-02-009.

USEPA. 2003c. Procedures for the derivation of equilibrium partitioning sediment benchmarks (ESBs) for the protection of benthic organisms: PAH mixtures. USEPA-600-R-02-013.

USEPA. 2005. Procedures for the derivation of equilibrium partitioning sediment benchmarks (ESBs) for the protection of benthic organisms: Metal mixtures. USEPA-600-R-02-011.

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

		NYS SGVs				PECs			
Analyte	**Total No. Surface Samples**	**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%

Legend

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

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

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

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

Figure 1a

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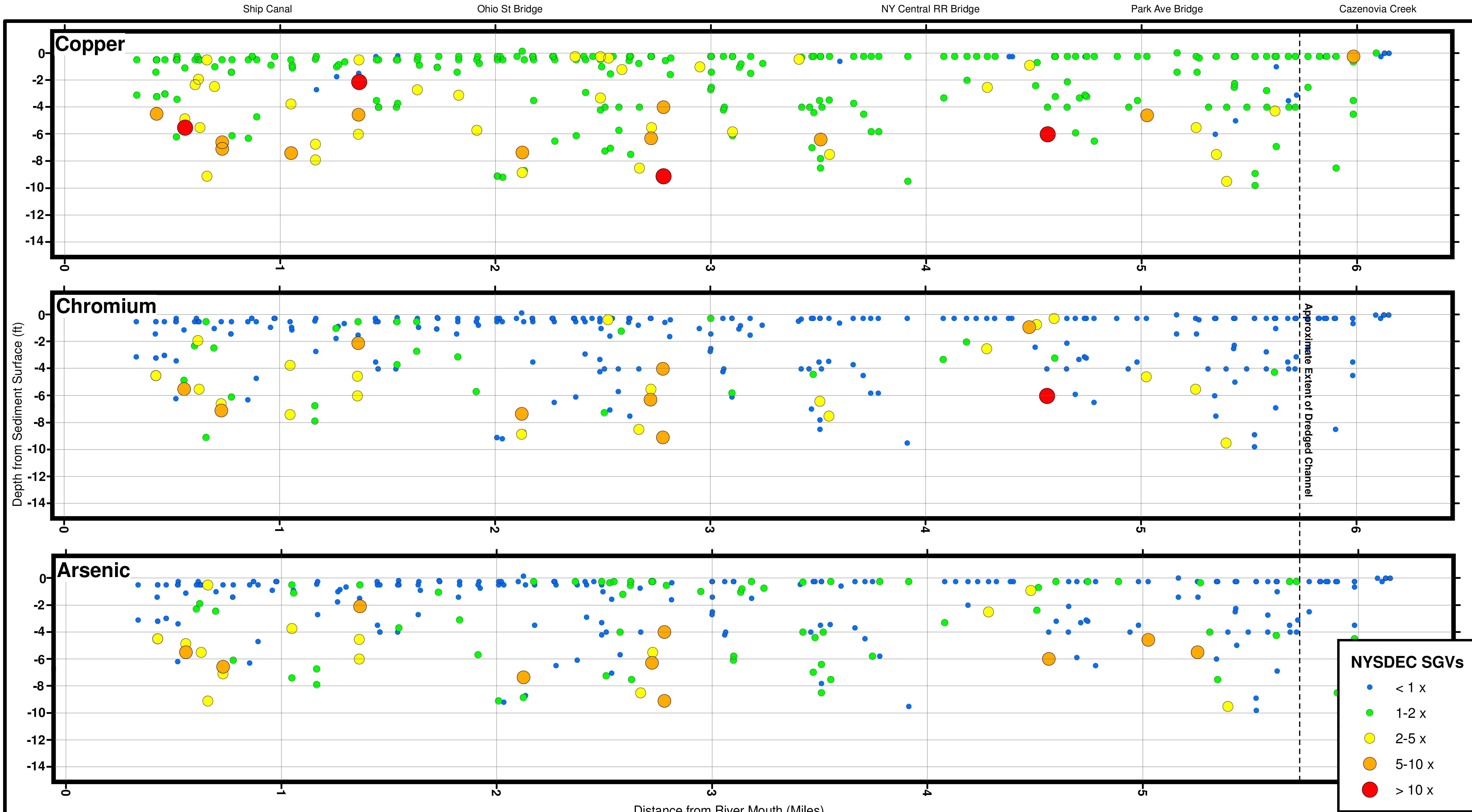

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Post Remedy 6 Metals Concentrations Compared to SGVs, Buffalo River

Figure 1b

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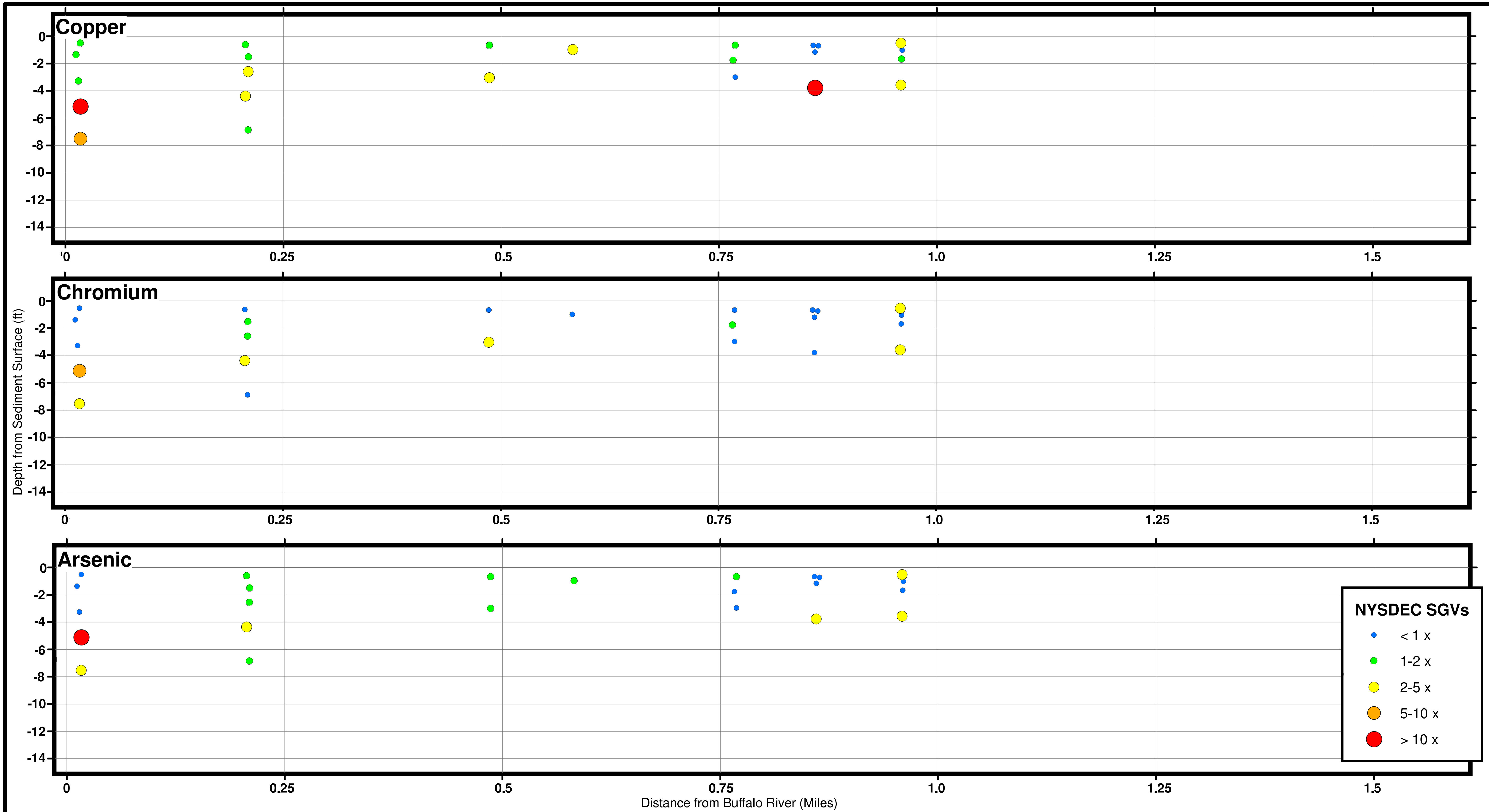

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Post Remedy 6 Metals Concentrations Compared to SGVs, City Ship Canal

Figure 1c

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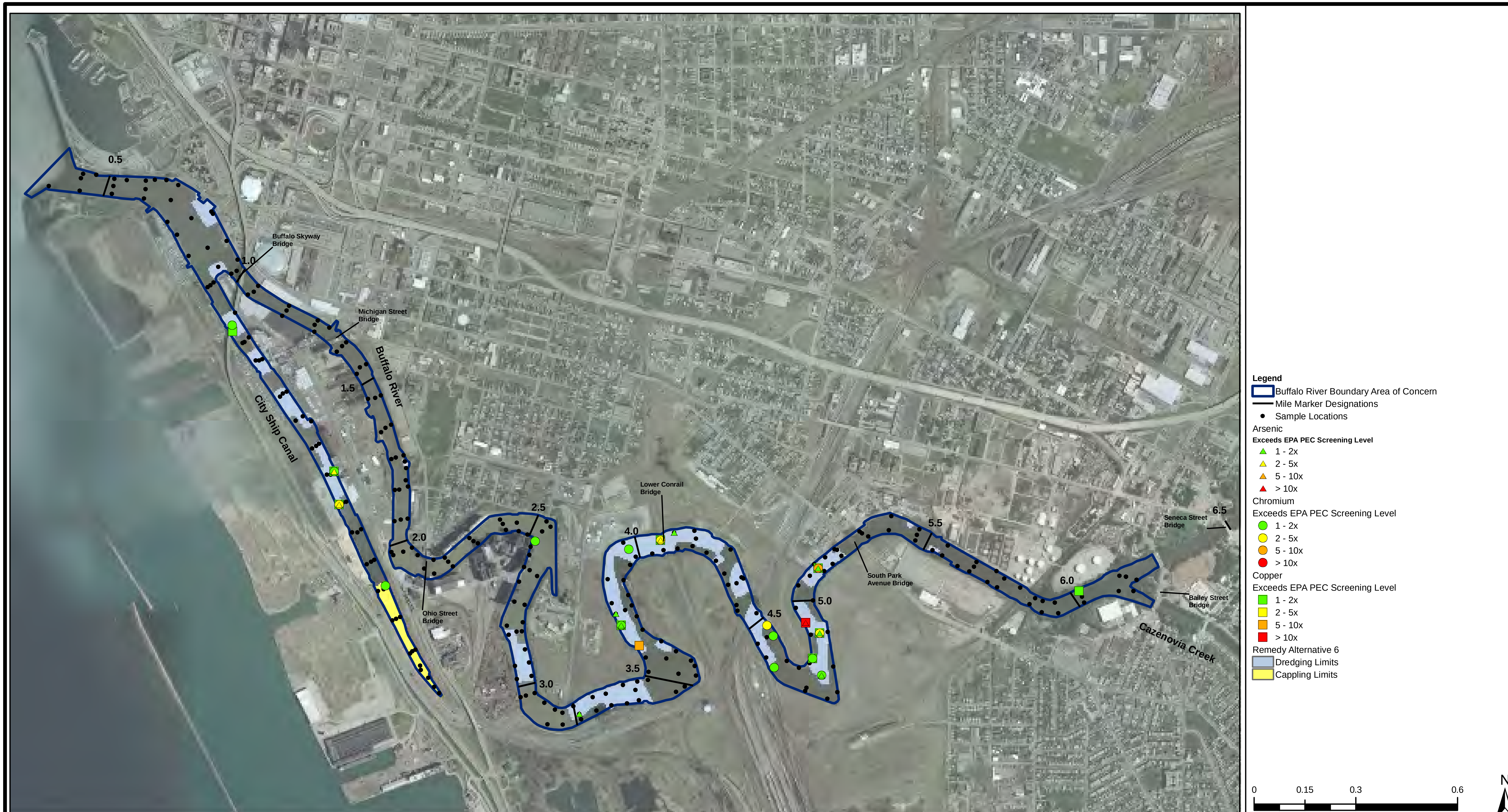

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SURFACE SEDIMENT METAL CONCENTRATIONS EXCEEDING EPA PEC
REMEDY ALTERNATIVE 6
BUFFALO RIVER, NY

Figure 1d

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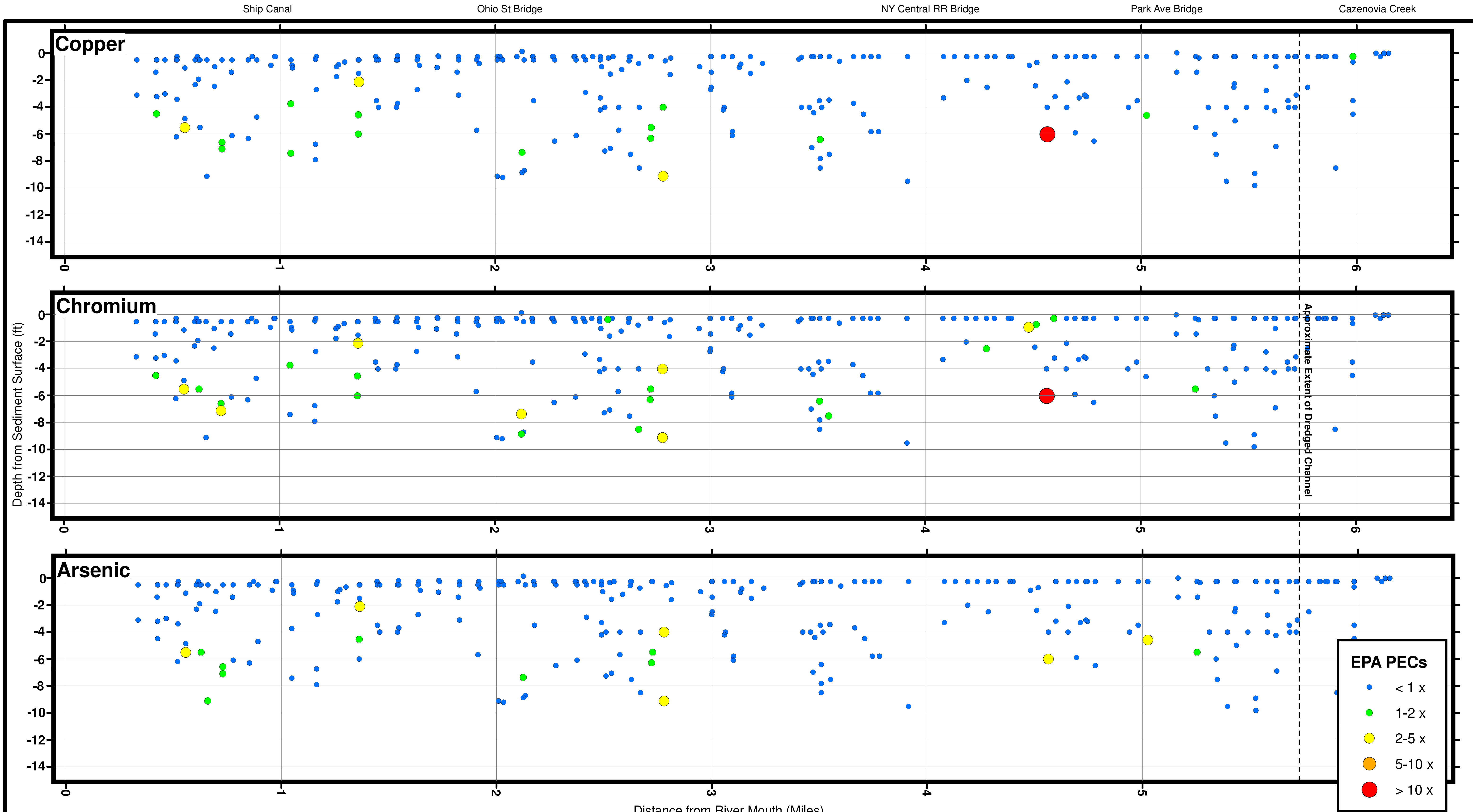

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Post Remedy 6 Metals Concentrations Compared to PECs, Buffalo River

Figure 1e

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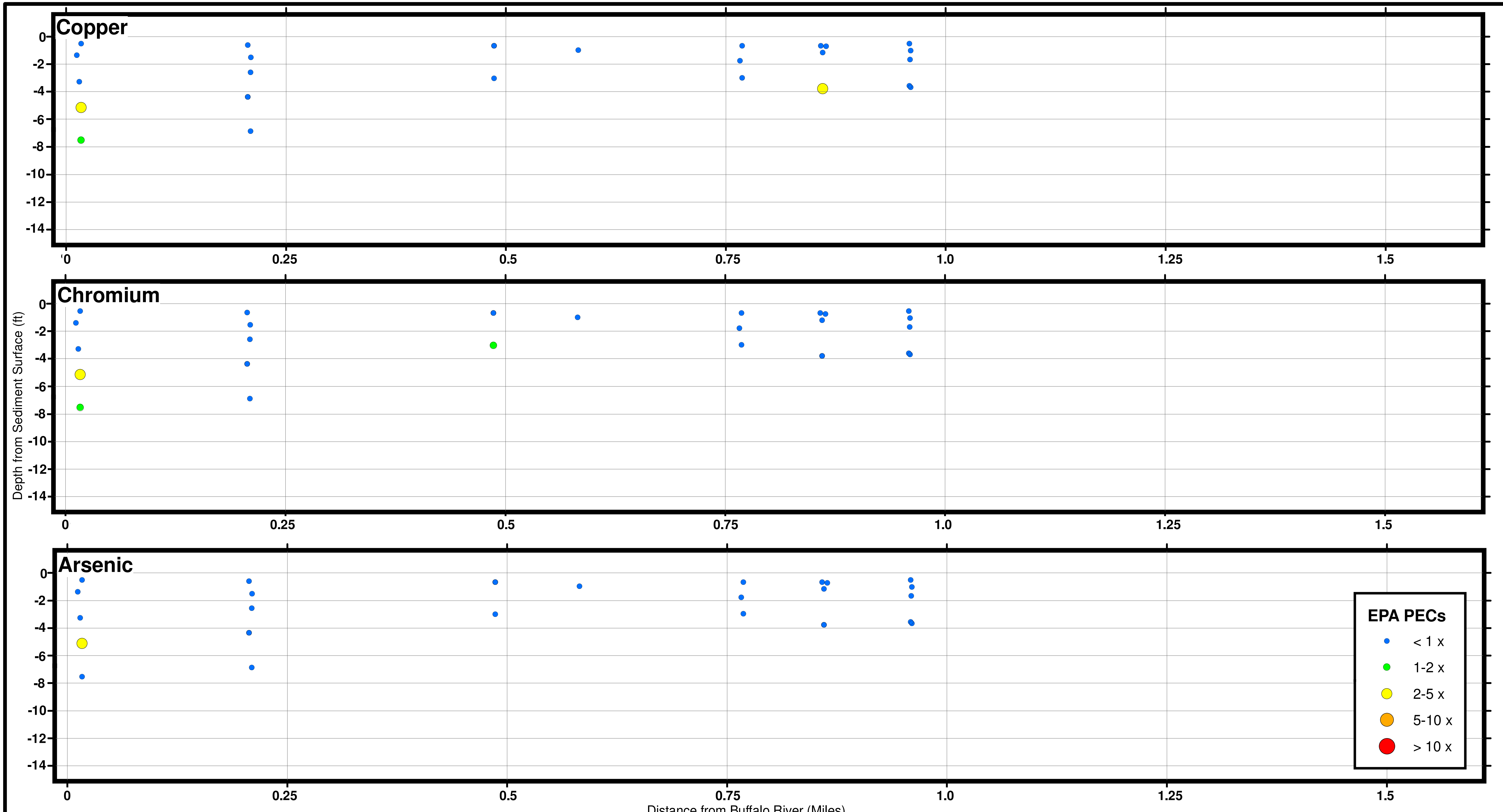

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Post Remedy 6 Metals Concentrations Compared to PECs, City Ship Canal

Figure 1f

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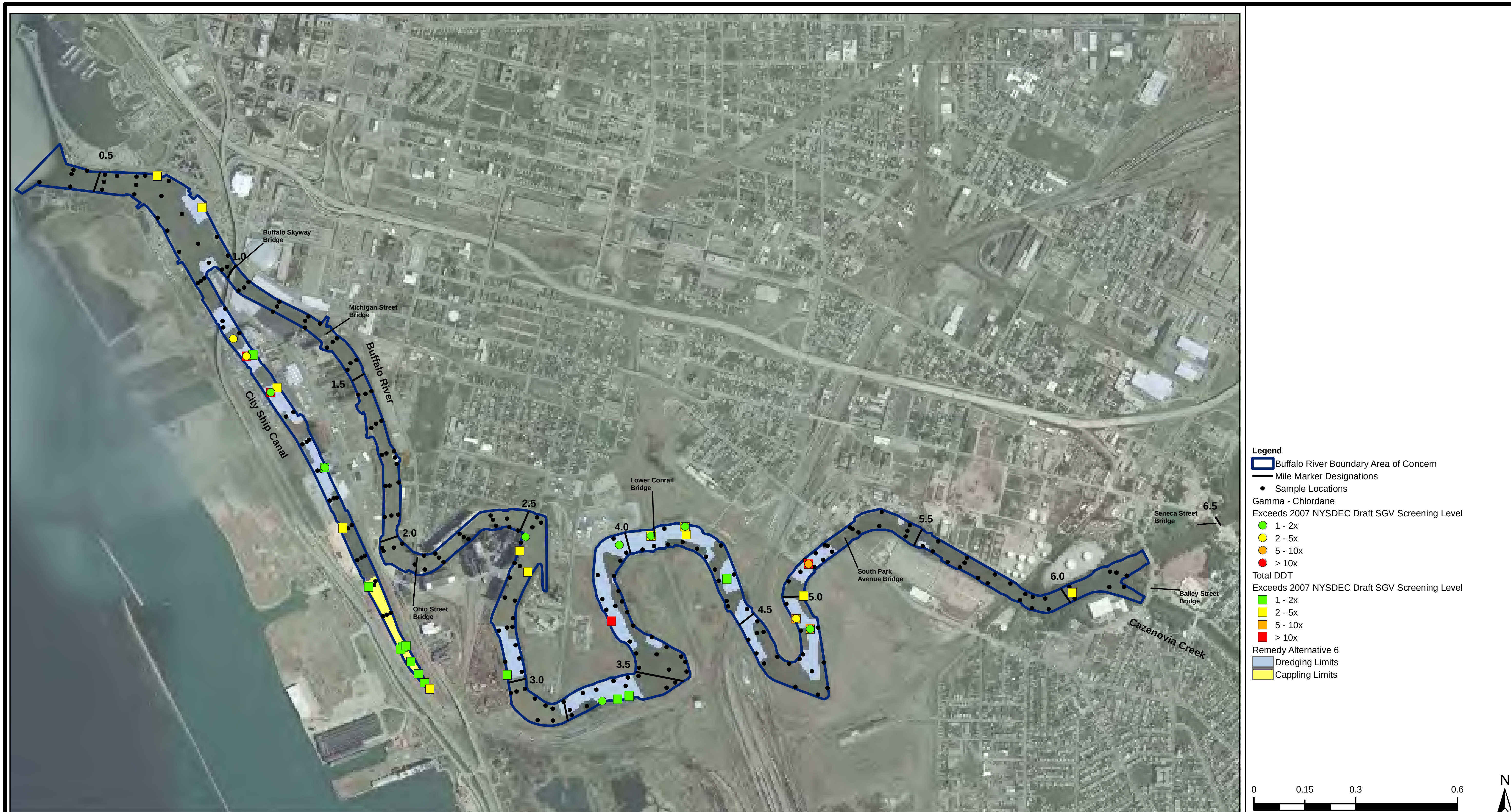

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PESTICIDE SURFACE CONCENTRATIONS EXCEEDING NYSDEC SGV
REMEDY ALTERNATIVE 6
BUFFALO RIVER, NY

Figure 2a

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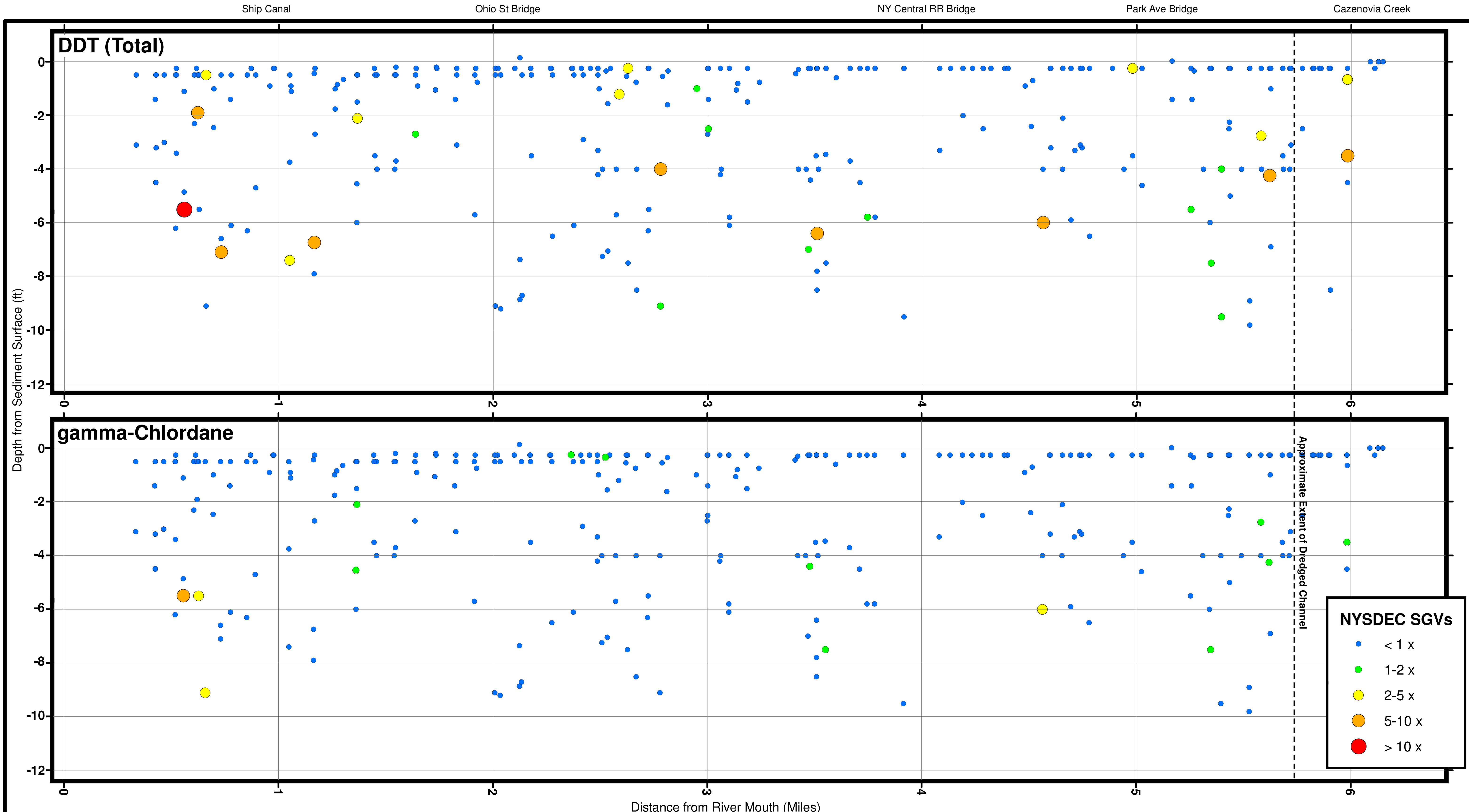

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Post Remedy 6 Pesticide Concentrations Compared to SGVs, Buffalo River

Figure 2b

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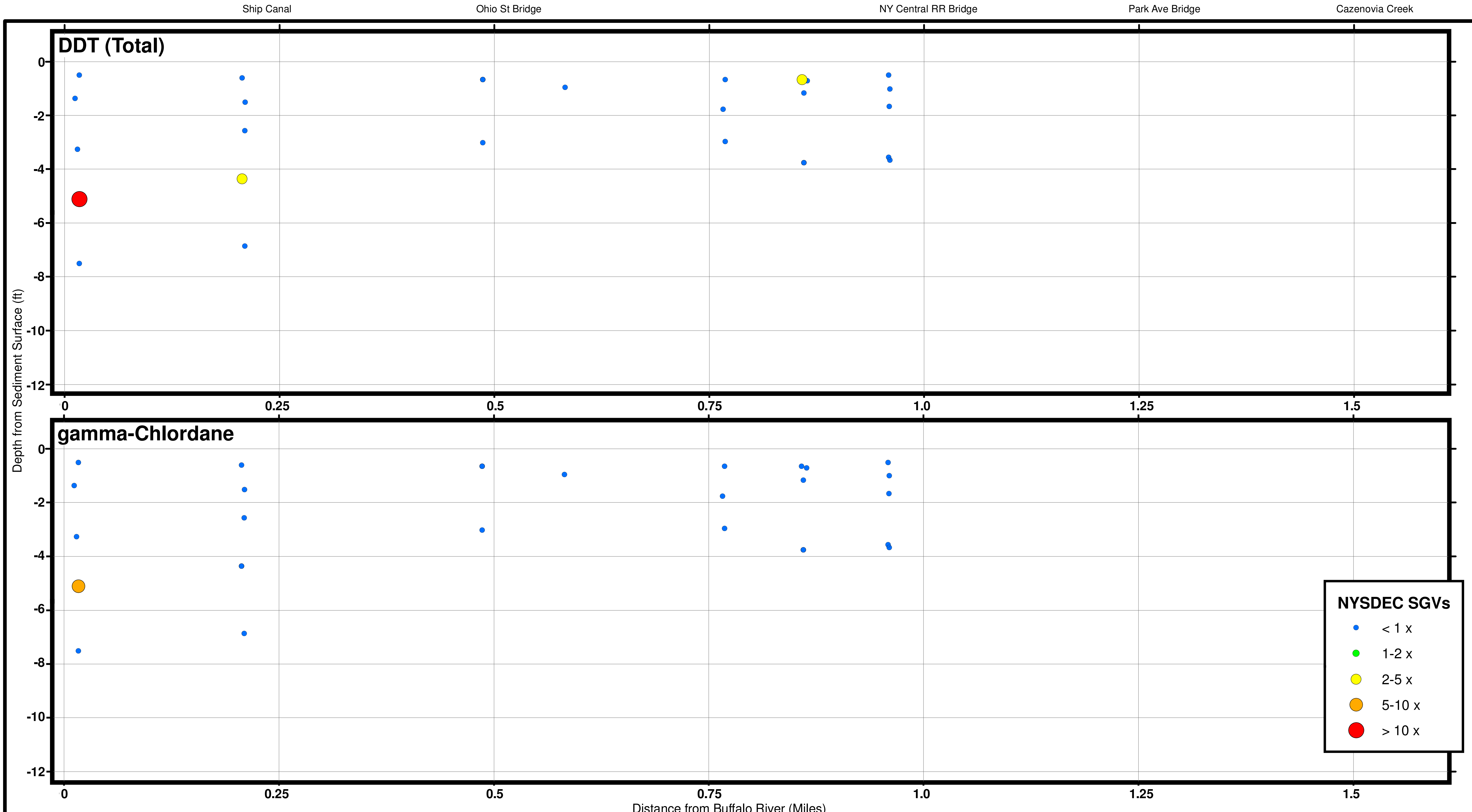

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Post Remedy 6 Pesticide Concentrations Compared to SGVs, City Ship Canal

Figure 2c

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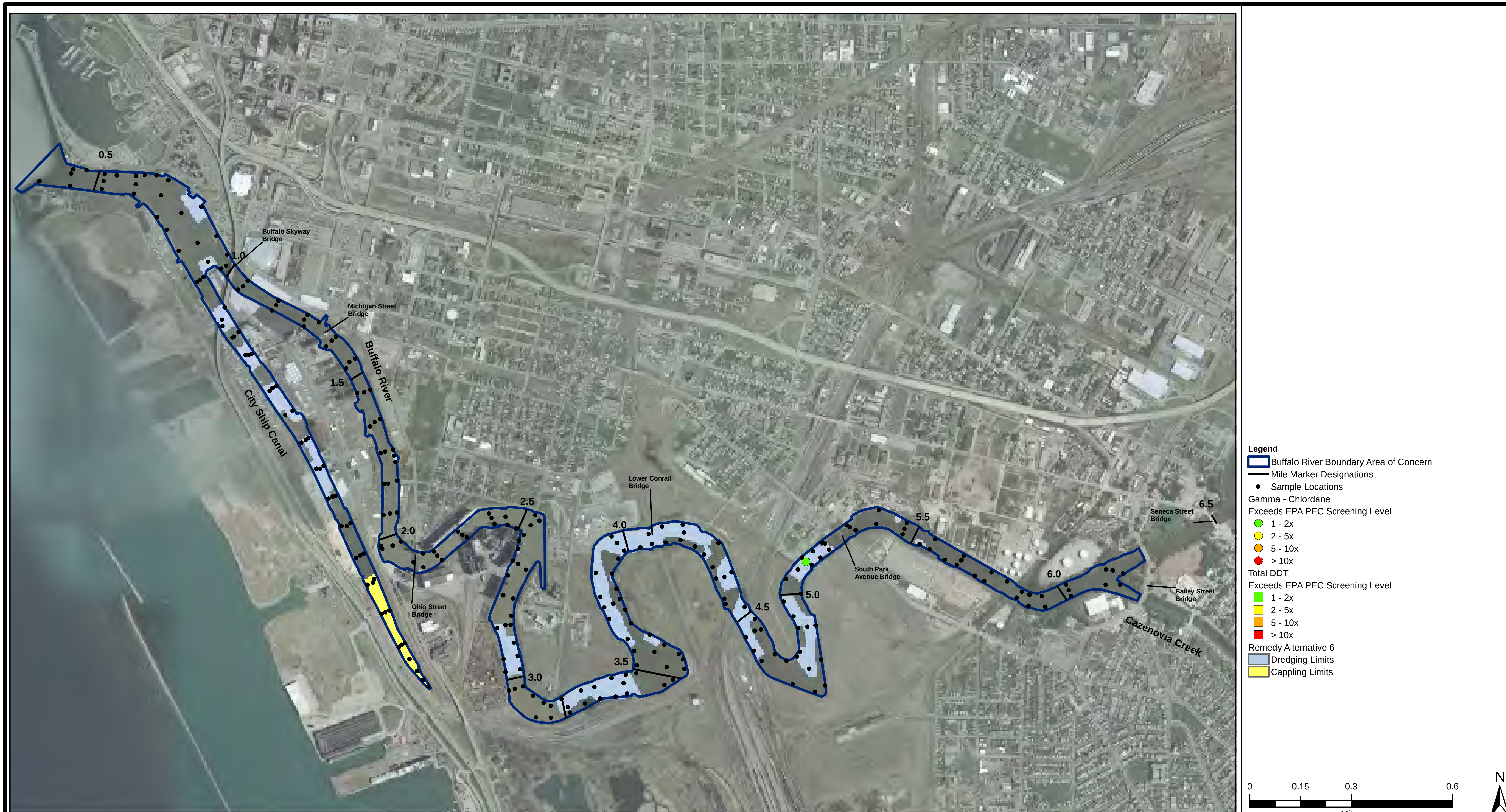

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PESTICIDE SURFACE CONCENTRATIONS EXCEEDING EPA PECS
REMEDY ALTERNATIVE 6
BUFFALO RIVER, NY

Figure 2d

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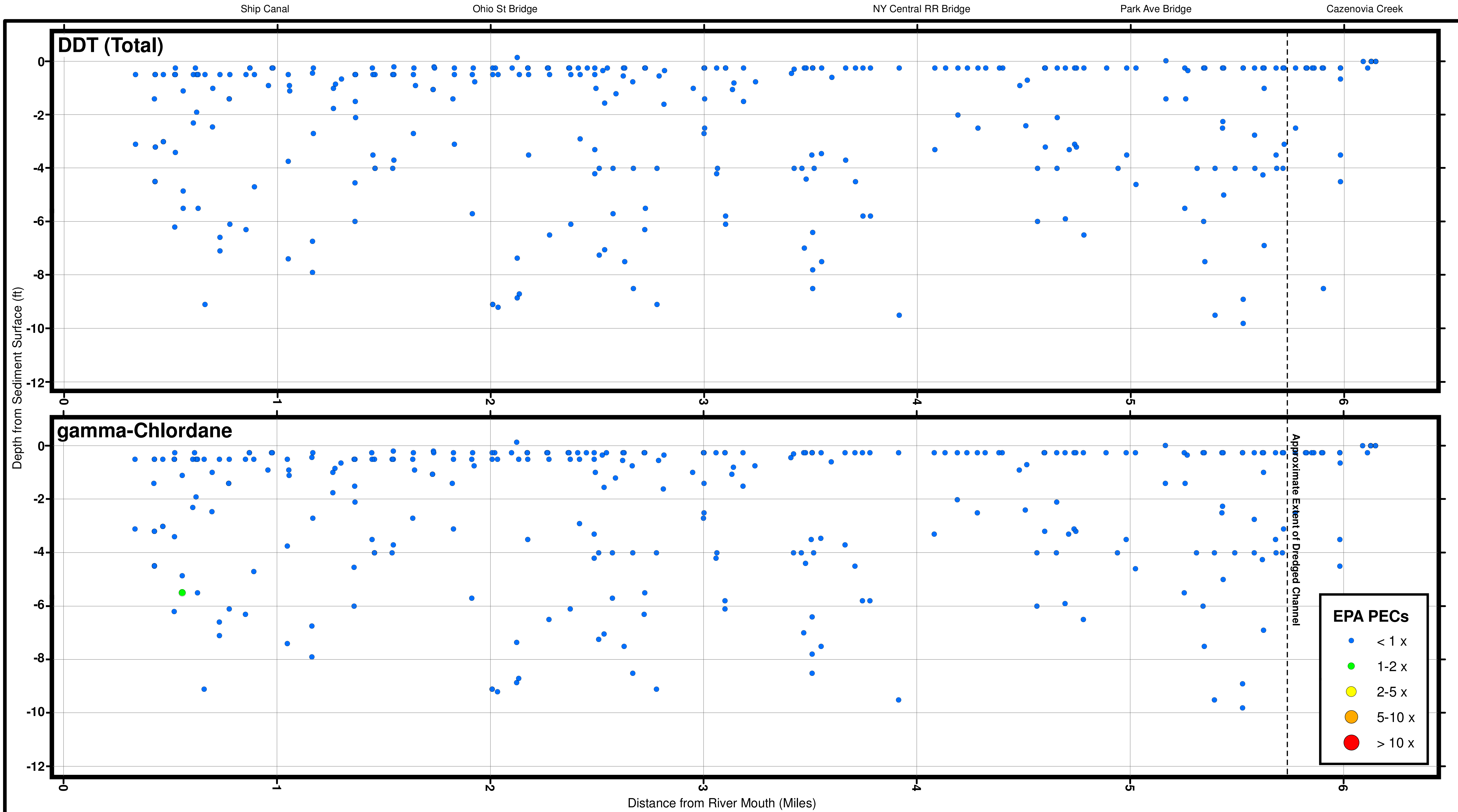

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Post Remedy 6 Pesticide Concentrations Compared to PECs, Buffalo River

Figure 2e

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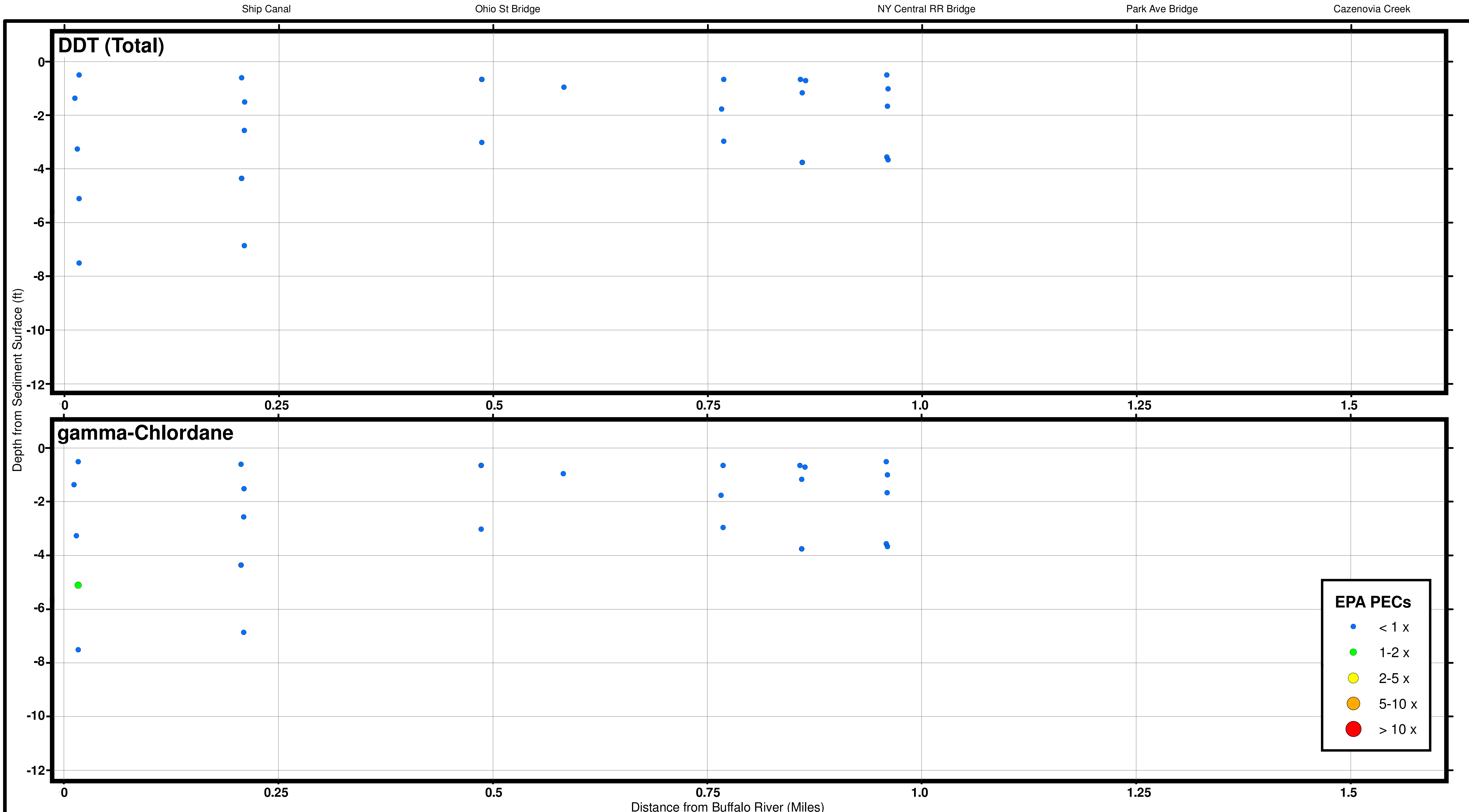

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Post Remedy 6 Pesticide Concentrations Compared to PECs, City Ship Canal

Figure 2f

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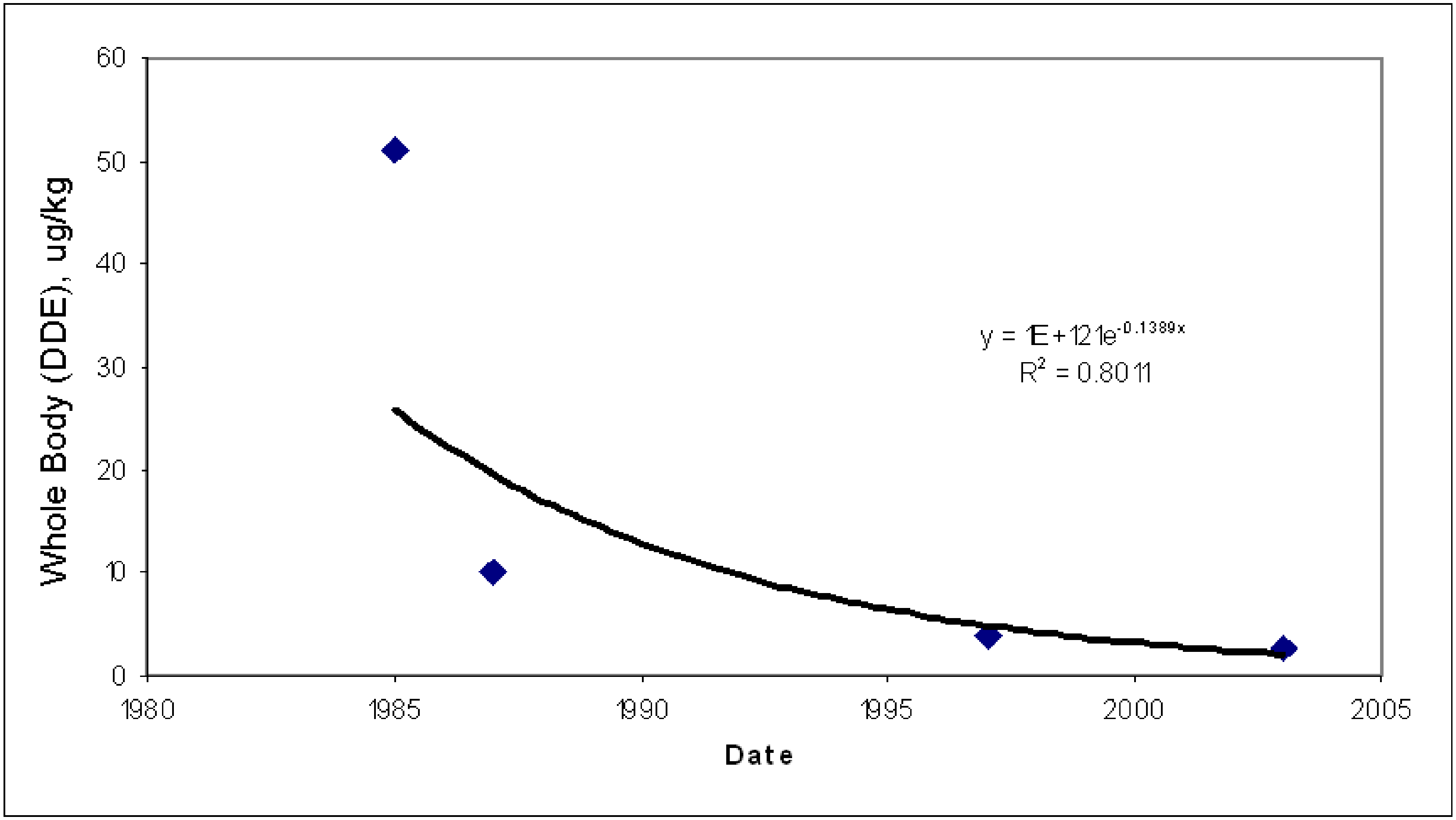

*Pesticides in fish tissues have decreased over time

ENVIRON MACTEC LimnoTech Water | Environment | Scientists | Engineers	**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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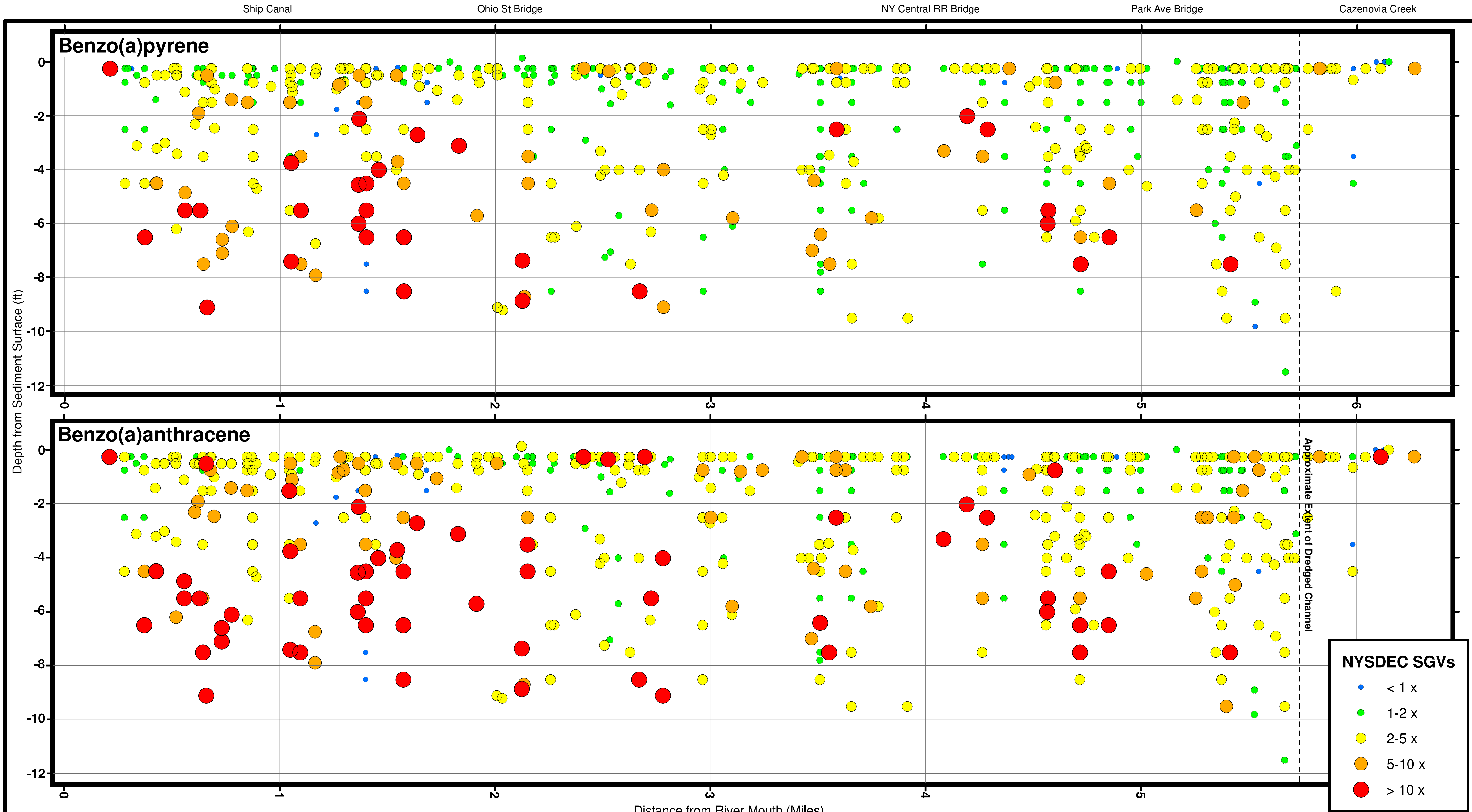

ENVIRON

Post Remedy 6 PAH Concentrations Compared to SGVs, Buffalo River

Figure 3b

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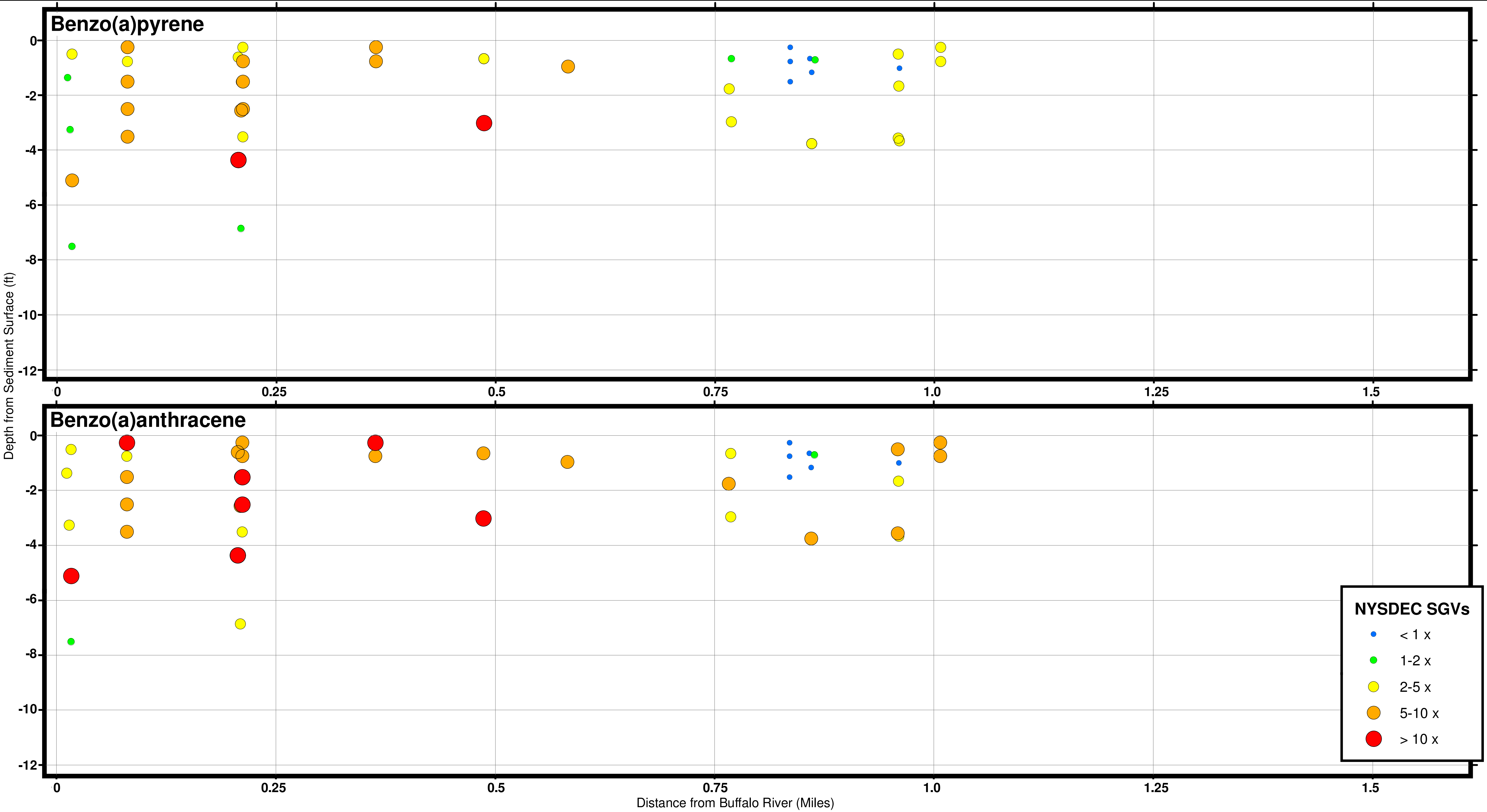

ENVIRON

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

Figure 3c

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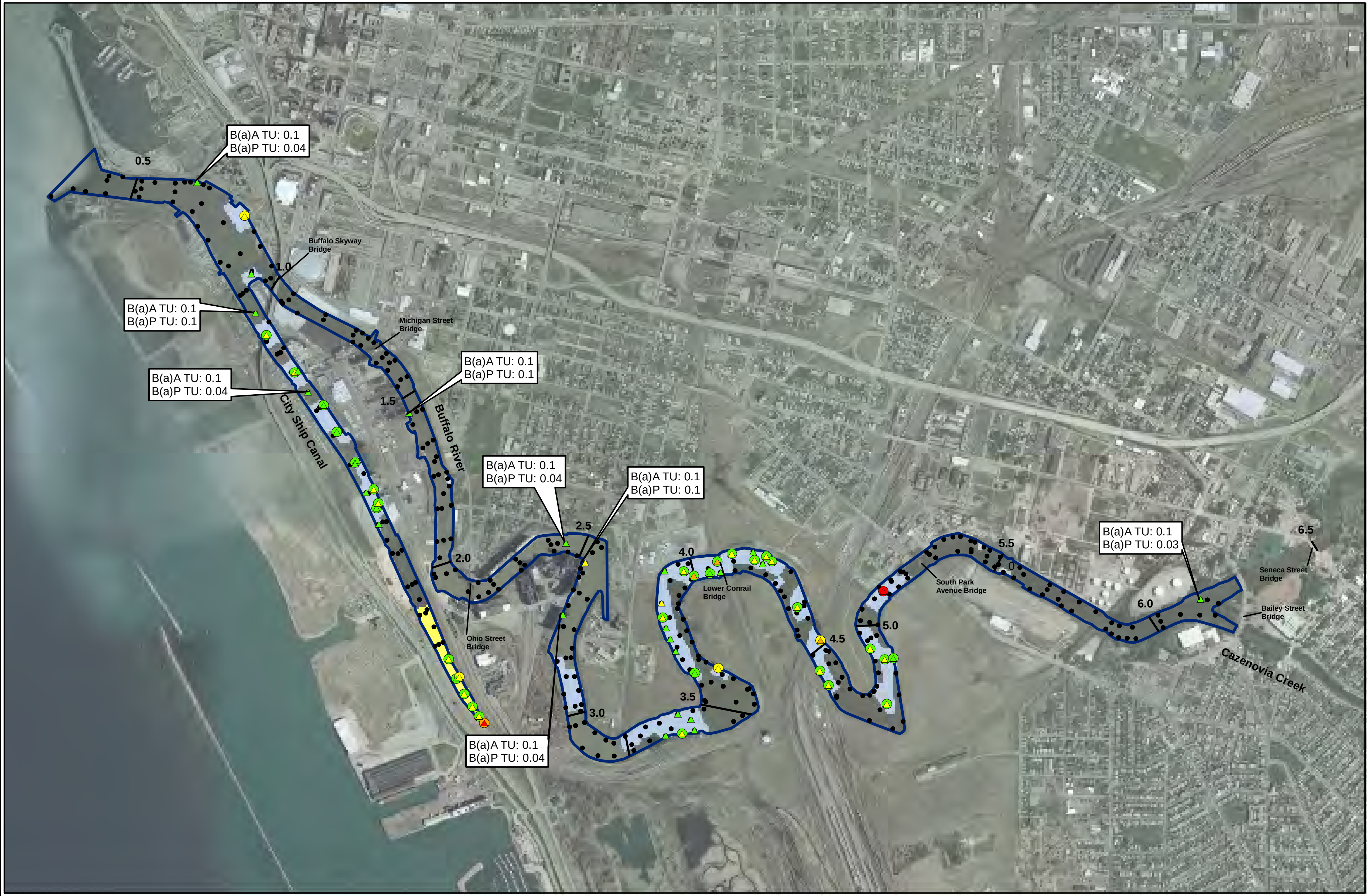

Legend

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

Benzo(a)Anthracene
Exceeds EPA PEC Screening Level
- 1 - 2x
- 2 - 5x
- 5 - 10x
- > 10x

Benzo(a)Pyrene
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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PAH COMPOUNDS SURFACE SAMPLES EXCEEDING PECS AND PAH TOXICITY UNITS IN SEDIMENT REMEDY ALTERNATIVE 6 BUFFALO RIVER, NY

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

Figure 3d

ENVIRON

Post Remedy 6 PAH Concentrations Compared to PECs, Buffalo River

Figure 3e

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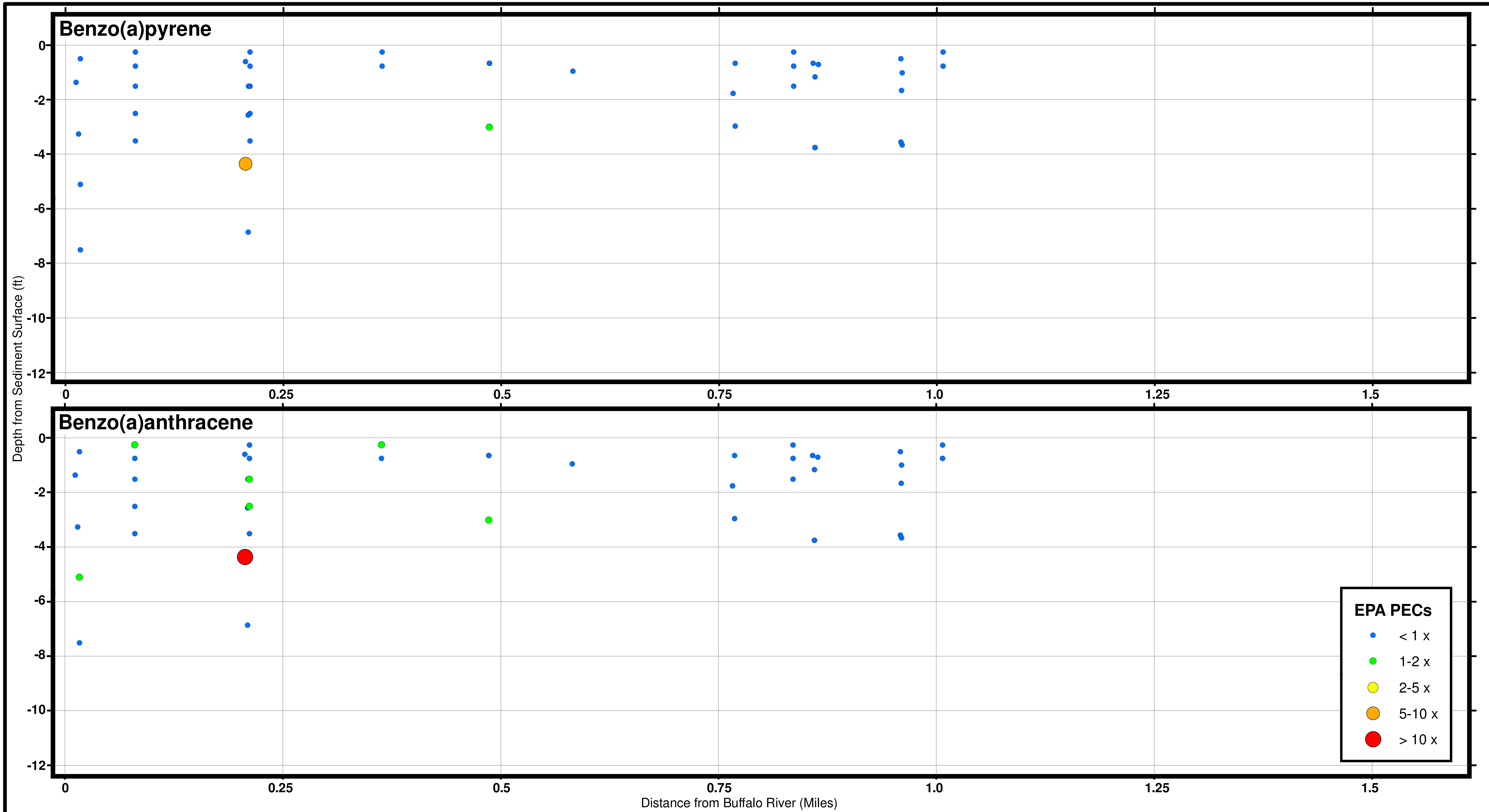

ENVIRON

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

Figure 3f

Wednesday, August 12, 2009 9:12:13 AM
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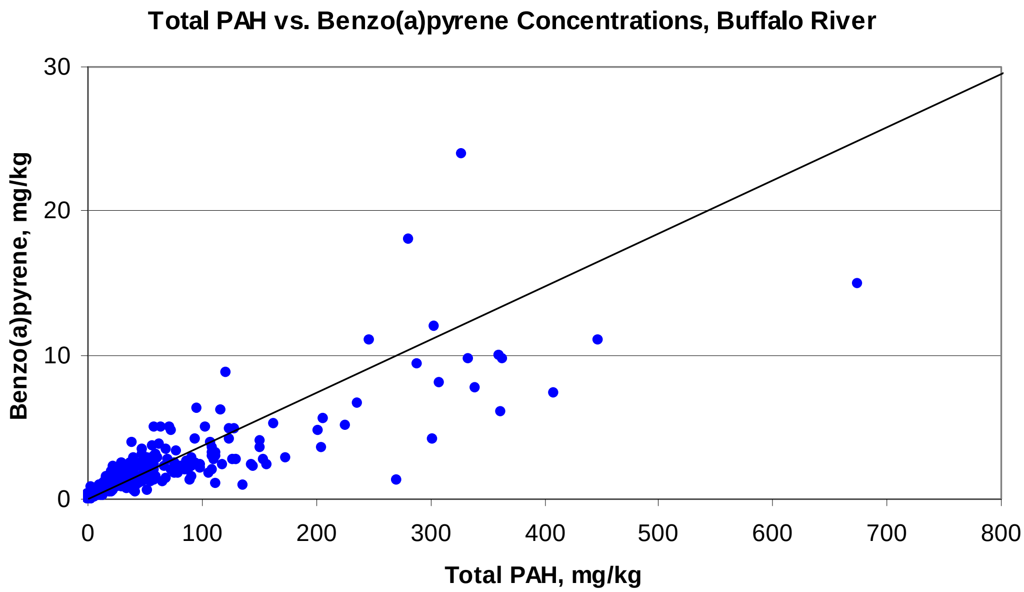

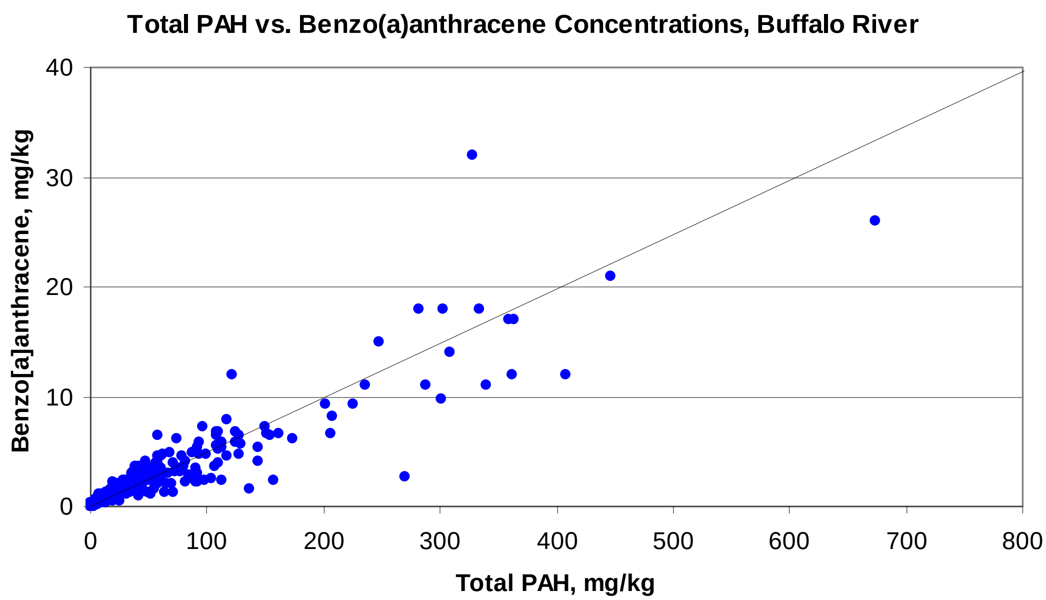

* Targeting the removal of elevated total PAHs removes elevated concentrations of B(a)A and B(a)P

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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

M E M O R A N D U M

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.

© Ecology and Environment Engineering, P.C. (EEEPC); . GIS Department   Project #
L:\Buffalo\BuffaloRiver\MAPS\MXD\Sept_08_fieldmaps\october14_2008\Sampling_cores_part2.mxd 01/29/2008

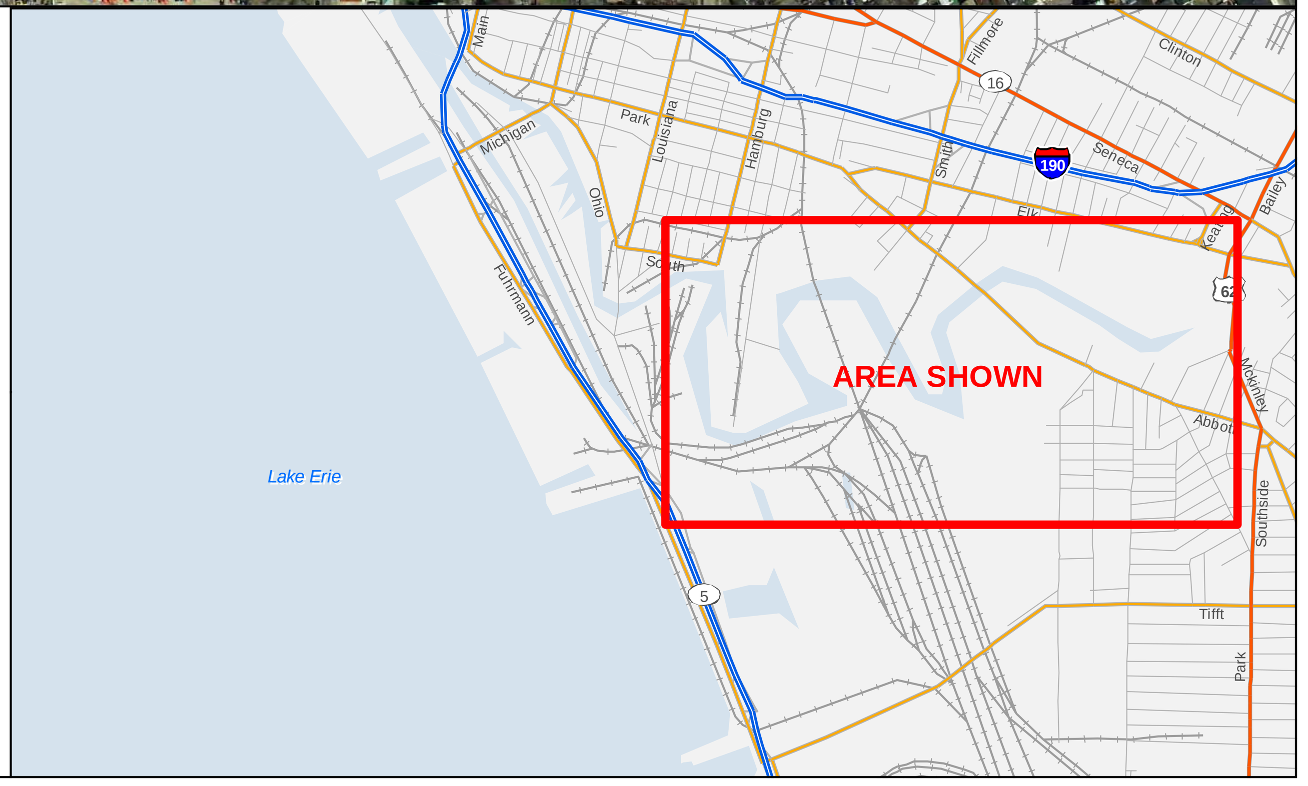
- Sediment Thickness Reading Location
- Sediment Sampling Location
- Geochronology Location
- Elutriate Core Location
- 2005 and 2007 Sample Location
- Approximate Utility Crossing Location
- Geologic Cross Section Location
- Park
- SPDES Facility
- Brownfield Cleanup Program Site
- Environmental Restoration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

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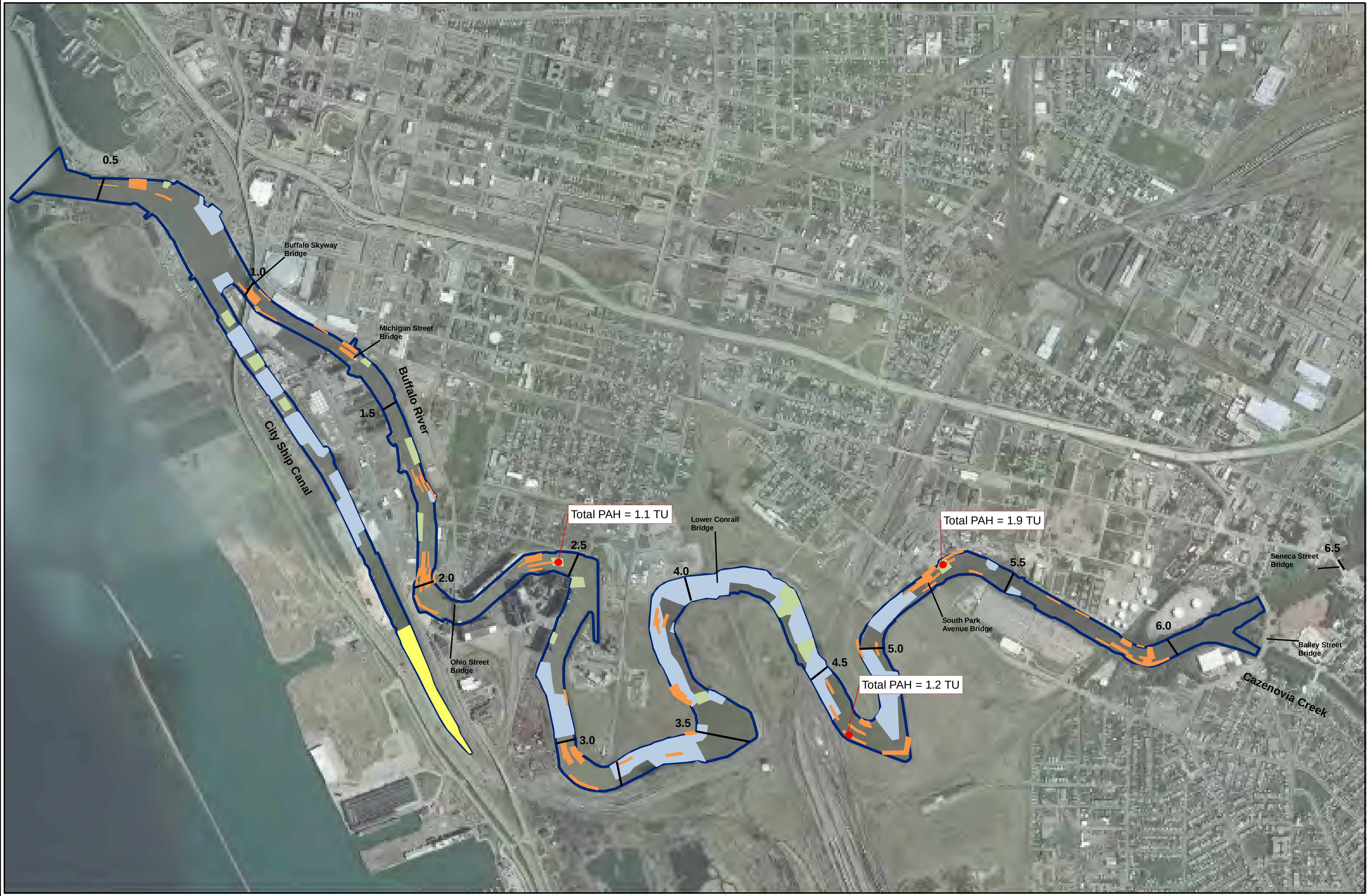

Legend

- 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

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POTENTIAL SCOUR ZONES
BUFFALO RIVER, NY

Figure 1

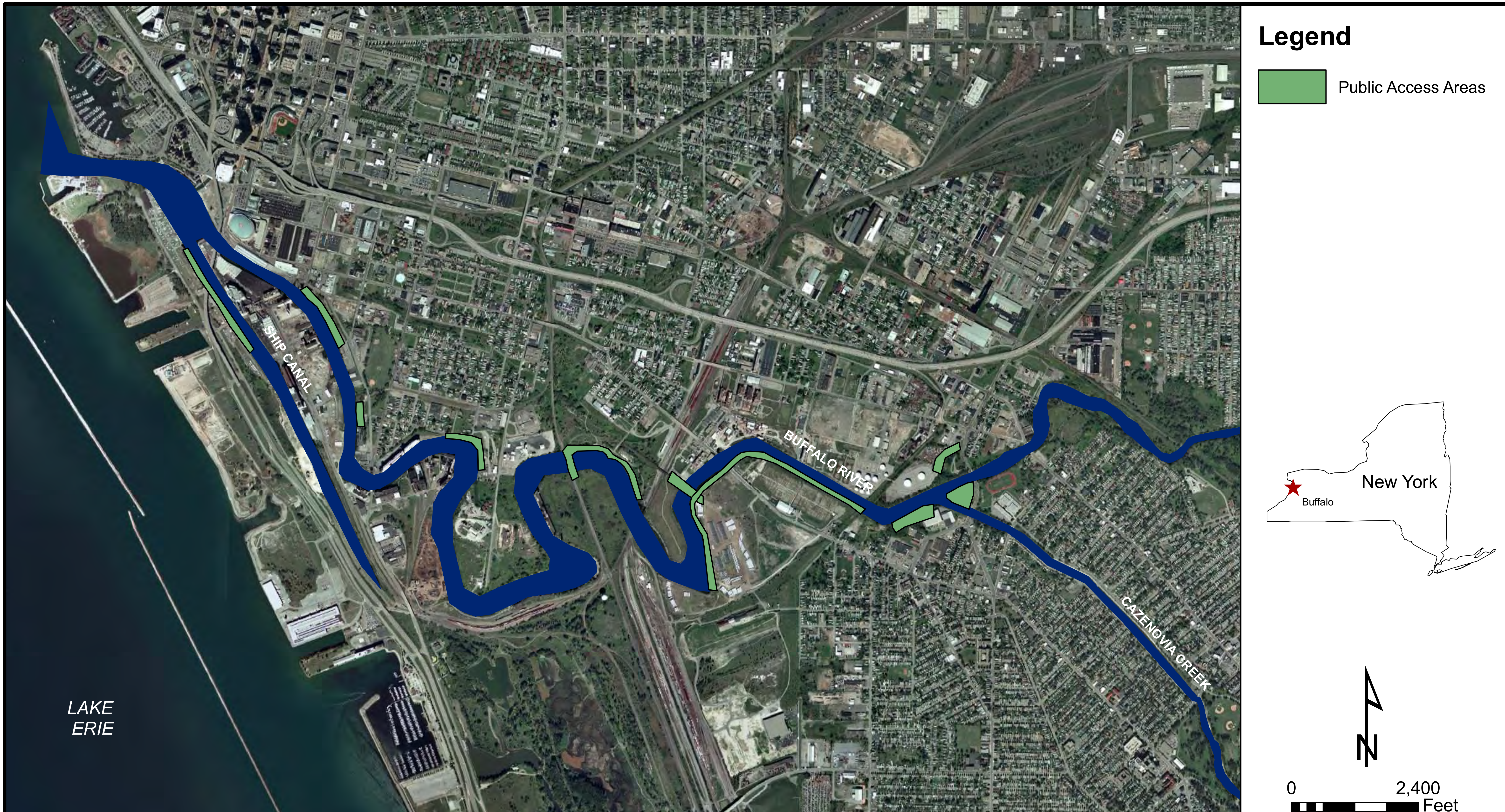
Drafter: B. Radakovich
Date: 10/05/2009
File Name: 20091005_ScourZones_Remedy5.mxd

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?



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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

Table E-4 (Continued)
Remedial Alternative 4 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-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.