DRAFT FINAL DATA REPORT

for

BLACKSTONE RIVER FEASIBILITY STUDY

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1. Introduction

The Army Corps of Engineers, North Atlantic Division, New England (NAE) is conducting a multi-year feasibility study to identify restoration opportunities in the Blackstone River Basin in Massachusetts. The goals of this study are to identify environmental restoration needs and opportunities in the basin, develop plans and cost estimates for restoration projects, assess benefits and costs of alternative restoration plans, select a recommended watershed restoration plan, and prepare appropriate NEPA documentation.

To aid in the evaluation, a sediment survey was conducted in the Blackstone River Basin on October 18-22, 26 and 30, 1999. Sediment samples were collected from three ponds located within the Blackstone River Basin including Fisherville Pond, Singing Pond and Wildwood Pond (i.e., the reference pond). Soil samples were also collected from wet meadow sites in Fisherville Pond. Table 1 provides a summary of the soil/sediment samples collected and the corresponding sampling locations and dates. Approximate sample locations are plotted in Figures 1-3 (Attachment 1). Samples were analyzed at the instruction of NAE for physical, chemical and biological parameters as shown in Table 1.

Table 1. Soil/Sediment Samples Collected for the Blackstone River Feasibility Study.

Sample ID	Site No.	Battelle ID	Collection Date	Required Evaluations per NAE				
				Soil/Sed Chemistry[1]	Pore Water Chemistry[2]	Toxicity	TIE[3]	Benthic
Fisherville Pond								
FP1101899CH	1	X2224	10/18/99	4	4	4	4	4
FP2101899CH	2	X2225	10/18/99	4	4	4	4	4
FP3A101899CH	3A	X2226	10/18/99	4	4	4		4
FP4101899CH	4	X2227	10/18/99	4	4	4		4
FP5101999CH	5	X2228	10/19/99	4	4	4		4
FP6101999CH	6	X2229	10/19/99	4	4	4	4	4
FP7101999CH	7	X2230	10/19/99	4	4	4		4
FP8101999CH	8	X2231	10/19/99	4	4	4	4	4
FP9102299CH	9	X2273	10/22/99	4	4	4	4	4
FP10102299CH	10	X2276	10/22/99	4	4	4		4
FP11102299CH	11	X2275	10/22/99	4	4	4	4	4
FP12102299CH	12	X2274	10/22/99	4	4	4	4	4
Wildwood Pond								
RP1102099CH	1	X2232	10/20/99	4	4	4		4
RP2102099CH	2	X2233	10/20/99	4	4	4		4
Fisherville Wet Meadow								
WM1102199CH	1	X2270	10/21/99	4[4]				
WM2102199CH	2	X2271	10/21/99	4[4]				
WM3102199CH	3	X2272	10/21/99	4[4]				
Fisherville Pond Hot Spot								
HS1102299CH	1	X2264	10/22/99	4[4]				
HS2102299CH	2	X2265	10/22/99	4[4]				
HS3102299CH	3	X2266	10/22/99	4[4]				
HS4102299CH	4	X2267	10/22/99	4[4]				
HS5102299CH	5	X2268	10/22/99	4[4]				
HS6102299CH	6	X2269	10/22/99	4[4]				
Singing Pond								
SP1102699CH	1	X2569	10/26/99	4	4	4	4	4
SP2102699CH	2	X2570	10/26/99	4	4	4	4	4
SP3102699CH	3	X2571	10/26/99	4	4	4		4
SP4102699CH	4	X2572	10/26/99	4	4	4	4	4

[1]Soil/Sediment chemistry parameters include grain size, TOC, metals, AVS/SEM, PAH and Pest/PCB analyses.
[2] Pore water samples analyzed for metals only.
[3] Toxicity Identification Evaluation (TIE) – TIE analyses were performed on pore water from these sampling locations.
[4] Soil samples analyzed for grain size, TOC, metals, and AVS/SEM only.

NAE collected fish samples on October 7, 8, 13, 27 and 29, 1999. Table 2 provides a summary of the fish samples collected and the corresponding sampling locations and dates. Samples were stored frozen and held by NAE until transfer to Battelle on December 6, 1999. At the instruction of NAE, fish samples were processed and analyzed for metals and PCBs.

Table 2. Summary of Fish Samples Collected and Compositing Scheme.

Composite Sample (analytical) [1]	Species	Sampling Location	Sample ID	Battelle ID	Collection Date	Fillet or Whole Body
1	Largemouth Bass	Fisherville, South Pool	LMB-01-001	X3289	10/07/99	F
			LMB-01-002	X3290	10/07/99	
2	Bluegill Sunfish	Fisherville, South Pool	BG-009-001	X3280	10/27/99	WB
3	Largemouth Bass	Fisherville, East Pool	LMB-02-001	X3291	10/08/99	F
			LMB-02-002	X3292	10/08/99	
4	Bluegill Sunfish	Fisherville, East Pool	BG-002-001	X3276	10/08/99	WB
5	Largemouth Bass	Fisherville, Central Pool (S)	LMB-03-001	X3293	10/08/99	F
			LMB-03-002	X3294	10/08/99	
6	Bluegill Sunfish	Fisherville, Central Pool (S)	BG-003-001	X3277	10/08/99	WB
7	Largemouth Bass	Fisherville, Central Pool (NE)	LMB-04-001	X3295	10/08/99	F
8	Bluegill Sunfish	Fisherville, Central Pool (NE)	BG-004-001	X3278	10/08/99	WB
9	White Sucker	Singing Pond, Lower	WS-005-001	X3287	10/13/99	F
			WS-005-002	X3288	10/13/99	
10	Brown Bullhead	Singing Pond, Lower	BB-005-001	X3282	10/13/99	F
			BB-005-002	X3283	10/13/99	
11	Brown Bullhead	Singing Pond, Upper	BB-006-001	X3284	10/13/99	F
			BB-006-002	X3285	10/13/99	
			BB-006-003	X3286	10/13/99	
12	Largemouth Bass	Fisherville, North Pool	LMB-008-001	X3296	10/27/99	F
13	Bluegill Sunfish	Fisherville, North Pool	BG-008-001	X3279	10/27/99	WB
14	Bluegill Sunfish	Lake Wildwood	BG-010-001	X3281	10/29/99	WB
15	Largemouth Bass	Lake Wildwood	LMB-11-001	X3297	10/29/99	F
			LMB-11-002	X3298	10/29/99	F

[1] Samples with same "Composite Sample (analytical)" number (column 1) were used to form composite samples.

This report presents the results of the physical, chemical, and biological analyses performed. Aerial photographs with approximate sample locations plotted are provided in Attachment 1. The complete details of the survey operation are provided in Attachment 2 (Field Report; January 7, 2000). Custody records (soil/sediment, fish) for all samples collected are provided in Attachment 3. Summary chemistry results for all field and associated QC samples are provided in Attachments 4 and 5, respectively. Results from the toxicity tests are provided in Attachment 6. Results from the Toxicity Identification Evaluation (TIE) tests are provided in Attachment 7. Results from the benthic community analyses are provided in Attachment 8.

2. Methods

2.1. Soil/Sediment Evaluations

Sediment samples were collected for evaluation of whole sediment and pore water chemistry, bulk soil/sediment toxicity testing, TIE and benthic community analyses. Table 1 summarizes the tests performed at each sampling location. Sediment chemistry parameters included grain size, total organic carbon (TOC), metals, acid volatile sulfide/simultaneously extracted metals (AVS/SEM), polychlorinated biphenyls (PCB), chlorinated pesticides, and polycyclic aromatic hydrocarbons (PAH) analyses. Soil samples were also collected from three locations in the Fisherville Pond Wet Meadow area (Table 1). The analytical methods used for these soil samples are the same as methods used for the sediment samples, as described below.

2.1.1. Grain Size

Water content and grain size distributions were determined by ASTM D-422. Grain size analyses were performed at Applied Marine Sciences (AMS) of League City, Texas.

2.1.2. Total Organic Carbon

Total Organic Carbon (TOC) was analyzed according to EPA Method 9060 and results are reported in percent dry weight. TOC analyses were performed at Applied Marine Sciences.

2.1.3. Metals

Soil/Sediment – samples samples were analyzed for ten (10) metals including arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), lead (Pb), mercury (Hg), nickel (Ni), silver (Ag), tin (Sn) and zinc (Zn). To prepare the samples for analysis, they were first freeze-dried then blended in a Spex mixer-mill. Aliquots of dried, homogeneous soil/sediment sample were digested using concentrated nitric acid and hydrochloric acids following a modified version of EPA Method 200.2 (EPA 1991a). Digestates were analyzed by inductively coupled plasma mass spectrometry (ICP/MS) for As, Cd, Cr, Cu, Pb, Ni, Sn and Zn following a modified version of EPA Method 200.8 (EPA 1991b). Silver (Ag) was analyzed by graphite furnace atomic absorption (GFAA) according to EPA Method 200.9 (EPA 1991c). Mercury (Hg) was analyzed using cold-vapor atomic absorption (CVAA) spectroscopy according to EPA Method 245.5 (EPA 1991d).

Pore Water – samples were analyzed for ten (10) metals including As, Cd, Cr, Cu, Pb, Hg, Ni, Ag, Sn and Zn. All metals except Hg were analyzed by ICP/MS following EPA Method 200.8 (EPA 1991b). Mercury was analyzed by cold-vapor atomic fluorescence (CVAF) by EPA Method 1631 (EPA 1999).

TIE Water – water samples associated with the TIE analysis were analyzed for cadmium by ICP/MS following EPA Method 200.8 (EPA 1991b).

2.1.4. Acid Volatile Sulfide/Simultaneously Extracted Metals

Soil/sediment samples were analyzed for AVS/SEM. The AVS method followed Allen (1991). The method involves reacting the sample with 1N HCl and quantifying the evolved hydrogen sulfide (operationally defined as AVS), which has been trapped in NaOH, using a mixed diamine reagent that develops a blue color in the sample with an intensity proportional to the concentration of H2S present. This solution was then quantified using colorimetry. The sample/acid slurry was centrifuged and the liquid phase decanted off. This solution was analyzed for metals by ICP/MS (Cd, Cu, Ni, Pb, and Zn) which comprised the simultaneously extracted metals.

2.1.5. Polychlorinated Biphenyl and Chlorinated Pesticides

Soil/Sediment – samples were analyzed for PCB/Pesticides following a modified version of EPA Method 8081. Soil/sediment samples were extracted three times with methylene chloride using shaker techniques. Sample extracts were reduced in volume and cleaned using alumina column chromatography and HPLC. A portion of the extract was exchanged into hexane and analyzed for PCB/Pesticides using gas chromatography/electron capture detection (GC/ECD). Dual column confirmation was performed for all analytes. Sample data were quantified by the method of internal standards, using the recovery internal standard (RIS) compounds.

TIE Water – samples were extracted for gamma-chlordane using a separatory funnel liquid-liquid extraction procedure following EPA Method 3510. Prior to extraction, the pH was adjusted to 5 using a buffer solution (0.05-M potassium phosphate, pH 8). Approximately 60-mL of TIE water sample was extracted three times with dichloromethane using shaker techniques. The combined extract was dried over anhydrous sodium sulfate, concentrated to approximately 2-mL and processed through alumina column. The extract was concentrated, fortified with RIS, solvent exchanged with hexane and analyzed directly using gas chromatography/electron capture detection (GC/ECD) following EPA method 8081 (Modified).

2.1.6. Polycyclic Aromatic Hydrocarbons

PAHs in soil/sediment were extracted along with PCB/Pesticides as described above. Extracts were reduced, cleaned using alumina column chromatography and HPLC, and a portion of the extract analyzed in the selected ion monitoring (SIM) mode using gas chromatography/mass spectrometry (GC/MS) following a modified version of EPA Method 8270C. Sample data were quantified by the method of internal standards, using the recovery internal standard (RIS) compounds.

2.1.7. Toxicity Testing

Soil/sediment samples collected from Fisherville Pond (12 locations), Singing Pond (4 locations) and a Wildwood Pond (2 locations) were used for bulk sediment toxicity testing. Testing procedures followed ASTM's "Standard Guide for Conducting Sediment Toxicity Tests with Freshwater Invertebrates" (Designation E 1383-94a; ASTM, 1994) as defined in Appendix C of the Task C workplan (Battelle, 1999).

In addition to the 18 test locations collected as described above, one control sample was also evaluated. Soil/sediment for this control was obtained from Aquatic Bio Systems in Fort Collins, Colorado. Organisms (*H. azteca*) for these tests were obtained from an independent supplier (i.e., Aquatic Biosystems) and maintained in the laboratory according to standard procedures (ASTM, 1994) prior to the initiation of the test.

2.1.8. Toxicity Identification Evaluation

Phase I Toxicity Identification Evaluation (TIE) tests were performed at Science Applications International Corporation (SAIC) of Newport, Rhode Island. Soil/sediment samples from Fisherville Pond, Singing Pond, and one reference location were evaluated using TIE methods and standard toxicity tests. TIE manipulations were performed according to methods described in U.S. EPA (1991e) and U.S. EPA (1991f), and toxicity tests were performed as described by U.S. EPA (1993) and modified in Ankley *et al.* (1991), Jop *et al.* (1991), and U.S. EPA (1991f).

For the Blackstone TIE investigation, the Phase I characterization consisted of the following recommended steps or tiers: (1) baseline/pH 8; (2) C_{18}; (3) graduated pH(2 treatments < ambient pH); (4) sodium thiosulfate; (5) EDTA; and (6) zeolite. Complete details of TIE methods are provided in Attachment 6.

2.1.9. Benthic Community

Soil/sediment samples collected in triplicate at Fisherville, Wildwood and Singing Ponds were analyzed for benthic community parameters at Barry A. Vittor and Associates, Inc. (BVA) of Mobile, Alabama. Per the direction of NAE, the triplicate samples collected at each location were homogenized and an aliquot representing one third of the total sample volume was evaluated.

2.2. Fish Evaluations

Fillets (skin-on) – Fish samples for fillet analysis were generally a composite of two or more fish. Fish were filleted (skin-on), fillets from individual fish homogenized, equal amounts of homogenized fillet composited (Table 3) and the composite homogenized once more. Sub-samples were removed for organic and metal analyses. Samples were stored frozen until analysis.

Table 3. Summary of Fish Samples Compositing Scheme.

Composite Sample (analytical) [1]	Species	Sampling Location	Sample ID	Composite ID	Amount in Composite (g wet)	Fillet or Whole Body
1	Largemouth Bass	Fisherville, South Pool	LMB-01-001 LMB-01-002	X3724	12.162 12.154	F
3	Largemouth Bass	Fisherville, East Pool	LMB-02-001 LMB-02-002	X3723	13.481 13.795	F
5	Largemouth Bass	Fisherville, Central Pool (S)	LMB-03-001 LMB-03-002	X3718	11.245 11.118	F
7	Largemouth Bass	Fisherville, Central Pool (NE)	LMB-04-001	X3295	39.245	F
9	White Sucker	Singing Pond, Lower	WS-005-001 WS-005-002	X3720	19.608 19.629	F
10	Brown Bullhead	Singing Pond, Lower	BB-005-001 BB-005-002	X3722	5.695 5.689	F
11	Brown Bullhead	Singing Pond, Upper	BB-006-001 BB-006-002 BB-006-003	X3719	2.315 2.302 2.364	F
12	Largemouth Bass	Fisherville, North Pool	LMB-008-001	X3296	53.985	F
15	Largemouth Bass	Lake Wildwood	LMB-11-001 LMB-11-002	X3721	24.360 24.141	F F

[1] Samples with same "Composite Sample (analytical)" number (column 1) were used to form composite samples.

Whole Body – Fish samples for whole body analysis were homogenized whole and sub-samples removed for organic and metal analyses. Samples were stored frozen until analysis.

2.2.1. Metals

Tissue samples were analyzed for ten metals including As, Cd, Cr, Cu, Pb, Hg, Ni, Ag, Sn and Zn. To prepare the tissues for analysis, they were first freeze-dried, then ground in a plastic ball mill. Aliquots of dried, homogeneous sample were digested using nitric and hydrofluoric acids similar to EPA Method 200.3 (EPA 1991a), and the digestates were analyzed. As, Cd, Cr, Cu, Pb, Ni, Ag, Sn and Zn were analyzed by ICP/MS following EPA Method 200.8 (EPA 1991b). Mercury was analyzed using CVAA spectroscopy according to EPA Method 245.5 (EPA 1991d).

2.2.2. Polychlorinated Biphenyls

Tissue samples were analyzed for PCBs following a modified version of EPA Method 8081. Tissue samples were extracted three times with methylene chloride using maceration techniques. Sample extracts were reduced in volume and cleaned using alumina column chromatography and HPLC. The extract was exchanged into hexane and analyzed for PCBs using gas chromatography/electron capture detection (GC/ECD). Dual column confirmation was performed for all analytes. Sample data were quantified by the method of internal standards, using the recovery internal standard (RIS) compounds.

3. Results

3.1. Soil/Sediment Evaluations

3.1.1. Grain Size

Grain size analysis results including water content and plots are provided in Attachment 4. Associated quality control results are provided in Attachment 5.

3.1.2. Total Organic Carbon

TOC results for soil/sediment samples are provided in Attachment 4. Associated quality control results are provided in Attachment 5.

3.1.3. Metals

Metals results for all soil/sediment, pore water and TIE water field and quality control samples are provided in Attachments 4 and 5, respectively.

3.1.4. Acid Volatile Sulfide/Simultaneously Extracted Metals

AVS/SEM results of for all soil/sediment field and quality control samples are provided in Attachments 4 and 5, respectively.

3.1.5. Polychlorinated Biphenyl and Chlorinated Pesticides

PCB/pesticide results for all soil/sediment (PCB/pesticide) and TIE water (gamma-chlordane) field and quality control samples are provided in Attachments 4 and 5, respectively.

3.1.6. Polycyclic Aromatic Hydrocarbons

PAH results for all soil/sediment field and quality control samples are provided in Attachments 4 and 5, respectively.

3.1.7. Toxicity Testing

Results of toxicity tests are provided in Attachment 6.

3.1.8. Toxicity Identification Evaluation

Results of TIE manipulations are provided in Attachment 7.

3.1.9. Benthic Community

Results of the benthic community analysis, including a taxonomic species list, community parameters and major taxa tables are provided in Attachment 8.

3.2. Fish Evaluations

3.2.1. Metals

Metals results for all tissue field and quality control samples are provided in Attachments 4 and 5, respectively.

3.2.2. Polychlorinated Biphenyls

PCB results for all tissue field and quality control samples are provided in Attachments 4 and 5, respectively.

4. References

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ATTACHMENT 1

Aerial Photographs

ATTACHMENT 2

Field Report

ATTACHMENT 3

Custody Records

ATTACHMENT 4

Chemistry Field Sample Results

Grain size – Soil/Sediment

TOC - Soil/Sediment

Metals – Soil/Sediment

AVS/SEM – Soil/Sediment

PCB/Pesticide – Soil/Sediment

PAH – Soil/Sediment

Metals – Pore Water

Metals – TIE Water

Pesticides – TIE Water

Metals – Fish Tissue
(dry and wet weight)

PCB – Fish Tissue
(dry and wet weight)

ATTACHMENT 5

Chemistry QA/QC Results

Grain size – Soil/Sediment

TOC – Soil/Sediment

Metals – Soil/Sediment

AVS/SEM – Soil/Sediment

PCB/Pesticide – Soil/Sediment

PAH – Soil/Sediment

Metals – Pore Water

Metals – TIE Water

Pesticides – TIE Water

Metals – Fish Tissue

PCB – Fish Tissue

ATTACHMENT 6

Toxicity Tests

ATTACHMENT 7

TIE Tests

ATTACHMENT 8

Benthic Community

Taxonomic Species List

Community Parameters Table

Major Tax Table

Summary Reports by Station