

EXECUTIVE SUMMARY

- The remedial action process for the Buffalo River Area of Concern (AOC) is at the stage that aquatic habitat restoration projects (including removal of contaminated sediment) are being considered. The objective of this study was to document the biological, water quality, and use characteristics of 10 promising habitat restoration sites located between Michigan Avenue and the river's confluence with Cazenovia Creek. All habitat restoration sites are located in shallow water areas near the shoreline and outside of the designated navigable channel. As part of the evaluation, the study developed a characterization matrix for each of the 10 candidate sites. The matrix was designed to serve as guidance for stakeholders and decision makers, allowing them to quickly review comprehensive assessments of the potential for effective habitat remediation.
- Larval fishes were sampled at the 10 study sites in June and August of 2003 and 2004 (four surveys total). Larval fish were collected at each site using two 0.5 m plankton nets with 560 μ m mesh. The nets were towed at a speed of approximately 50 cm per second for 15 min in a circular pattern (shore to shore, but within the dredged channel of the river). One net was towed near the surface (depth of 1.0 – 2.5 m) and one closer to the river bottom (depth of 2.5 – 6.5 m).
- Sampling for juvenile and adult fish was carried out in June and August of 2003 and 2004 (four surveys total). Buffalo State College's 18' electrofishing boat, equipped with a Smith-Root type VI-A electrofishing unit, was used for each survey. At each site a single pass was made along both shorelines for a total of 300 seconds per site. Pulsed direct current was used at a pulse rate of 30-60 pps; output was maintained at approximately 3,000 watts for each survey.
- Benthos was sampled using a Ponar dredge at the 10 habitat restoration sites and at six sites within the dredged navigation channel. Samples were collected three times between mid-June and the end of October, 2003 and twice between the end of June and end of September, 2004.
- Presence/absence vegetation surveys were conducted at the 10 habitat sites in August, 2004 and 2005, while percentage of overhanging shoreline cover was estimated both from field observation and detailed digital satellite imagery.
- Water quality was evaluated principally through the use of Hydrolab Datasonde 4a's to measure dissolved oxygen, pH, turbidity, temperature, and conductivity. Hydrolabs were installed at three sites (two sites near the top of the AOC and Ohio St. Bridge) to continuously monitor these parameters from June through September of 2003 and 2004. Suspended sediment samples were collected once per week at the three Hydrolab sites. In addition, a Hydrolab Datasonde 4a was used to measure the same analytes at all 10 habitat sites, at three depths, 0.5 m below the surface; 1.0 m below the surface; and near the bed. This profiling was

done once per week for 16 weeks in 2003 and 17 weeks in 2004. Finally, sampling was done for *Escherichia coli* analysis during a major runoff event and three dry days in September, 2004.

- A recreational use survey of the habitat sites and 15 other sites along the AOC was conducted by boat for a total of 73 days in 2003-04. The surveys were done during randomly selected time slots (7-9 am; 9am-12 pm; 12 pm-3 pm; 3-6 pm) on randomly selected days of the week.
- The larval fish sampling showed similar species diversity and abundance in 2003-2004 as compared to 1993 (8-10 species found). No site-specific trends were observed. The adult/juvenile fish sampling showed similar species diversity and abundance in 2003-2004 compared to 1993 (15-20 species across all sites). Lowest species diversity occurred at sites 1, 2, 5, and 10.
- DELT anomalies: varied greatly among species, with a low of 14% in pumpkinseed to a high of 87% in brown bullhead. For the river as a whole, DELT scores averaged 37%, which is much higher than what would be expected for a moderately impacted (2-5%) or unimpacted (<2%) river.
- Index of Biotic Integrity (IBI): Low site-specific species diversity and high DELT scores contributed to low IBI scores. Seven sites (#3, 4, 5, 7, 8, 9, and 10) would be rated “poor” and three (#1, 2, and 6) “very poor” using standard IBI criteria.
- Overall: Based on species diversity, IBI, and DELT scores, sites 3, 4, 7, and 8 tended to score higher in terms of fish community health while sites 1, 2, 5, 6, 9, and 10 tended to score lower.
- The Buffalo River AOC continues to be dominated by a low diversity benthic invertebrate community that is broadly tolerant of pollution and environmental degradation. High densities of tubificid oligochaetes (though lower than historical maxima), and their numerical dominance of the benthos, suggest poor environmental health. Oligochaete densities were higher in the channel than at shoreline habitat restoration sites. Fewer invertebrate families were collected in this study than in the early 1990’s, possibly even indicating some reversal of biotic recovery. Substantially more families occurred at shoreline sites than in the channel, although the habitat restoration sites were still dominated by pollution-tolerant oligochaetes and chironomids. Likewise, chironomid taxonomic richness was markedly higher at habitat restoration sites than in the channel, but samples largely constituted pollution-tolerant species and genera. Chironomid mouthpart deformities remain very high at channel sites (as they were in 1990-93), but, interestingly, all of the rather limited number of larvae from shoreline sites had developed normally.
- More than 50 plant species were collected from the Buffalo River shoreline and herbaceous vegetation was well-developed at all sites. The 10 potential restoration

sites differed considerably in their development of overhanging cover, ranging from 0 to 80%. Submerged macrophyte beds are not extensive, but are present at most sites. The presence of invasive plant species, including tree-of-heaven, Japanese knotweed, purple loosestrife, and submerged Eurasian watermilfoil degrades many of the sites and should be subject to eradication campaigns as part of habitat restoration efforts.

- Dissolved oxygen levels frequently were below state guidelines within the dredged portion of the AOC (representing all habitat sites except Site 1), while levels upstream of the dredged channel more frequently were above state guidelines. The low dissolved oxygen levels appear related to a combination of thermal stratification, system hydraulics, high sediment oxygen demand, and background biochemical oxygen demand. At the habitat sites, dissolved oxygen tended to be lower near the riverbed and higher near the surface. During dry periods, turbidity was relatively low (<20 NTU) in the upper 1m at all habitat sites, increasing to about 20-100 NTU near the bed. Turbidity increased during storm events, occasionally reaching values of 1,000 NTU. The levels of *E. coli* were high during the sampled storm event (up to 38,700 m.o./100 mL) and lower (50-2,200 m.o./100 mL) during dry periods. These results were consistent with past studies and re-emphasize the importance of the upper watershed as a source of bacteria.
- A total of 887 person-days of activity were observed through the recreational use survey. Fishing, boating, and “hanging out” in riparian areas were the most frequently observed activities (27%, 28%, and 22% of all activity, respectively). Swimming represented 3% of the observed activities. The observed level of 887 person-days underestimates actual activity because it only represents a three hour segment of each sample date. Adjusting the sampled person-day activity to reflect all daylight hours for the entire week, it is estimated that actual activity may have been on the order of 12,784 person-days in 2003-04. There was spatial variability in the frequency of activity, with habitat sites 3, 4, 5, 6, 8, and 10 having the lowest level of activity of all survey sites (≤ 8 person-days (unadjusted value) over the two year period).
- The site evaluation matrix was developed using an index approach for various biotic and abiotic categories. The benthic indices included the number of benthic families, oligochaete density, and the product of chironomid biotic score and number of chironomid taxa. The fish indices included species diversity, Index of Biotic Integrity, and DELT (Deformities, Eroded fins, Lesions, and Tumors). The vegetation indices were shading (% overhang) and macrophyte species diversity. The water quality indices were the National Sanitation Foundation Water Quality Index (dissolved oxygen, pH, turbidity) and the Canadian Council of Ministers of the Environment Water Quality Index (dissolved oxygen only). No single site scored consistently high in all indices. Based strictly on the aggregate matrix scores, habitat sites 4, 7, and 8 had the best biological/water quality health while sites 2, 5, 6, and 10 scored lower. Interestingly, based on a recent Corps of

Engineers study, habitat sites 7 and 8 had PAH values in sediment that exceeded probable effect level for benthic organisms.

- Ecological integrity, as reflected by biota and water quality, certainly has improved in the Buffalo River AOC, as compared to 1970's conditions. However, there does not appear to be any improvement since the early 1990's. Habitat restoration measures such as improved overhang cover, macrophyte plantings, eradication of exotic plant species, removal of old dock pilings, naturalization of shorelines, or removal of contaminated bed sediment could improve ecological integrity at selected sites. Constraints on ecological integrity that may prove more challenging to overcome include warmer water temperatures and low dissolved oxygen levels.
- Chapter 8 has been prepared by Buffalo Niagara Riverkeeper based on our own interpretation of the data reported by Buffalo State College and Youngstown State University, and is therefore outside of the Buffalo River Remedial Advisory Committee recommendations of required actions. Riverkeeper strongly supports the findings of the water quality, benthic, fishery, and vegetation analysis. Riverkeeper suggests a continuation of river usage surveys into the future in combination with a market analysis of the river corridor. Riverkeeper strongly supports the ranking and evaluation system that was created for the "Site Characterization Matrix," though Riverkeeper wants to emphasize that the ranking system is just one of many tools available to decision-makers when prioritizing sites for restoration.
- The next steps for the data generated from this study include: the application of the results in the USACE's Environmental Dredging Feasibility Study, and the use of the data during the development of the updated Buffalo River Remedial Strategy and Delisting Criteria/Restoration Targets. Riverkeeper will coordinate an effort to fully investigate sites 5 and 6 regarding its unexplained poor ratings and high deformities. In addition, Riverkeeper will coordinate with the local efforts dedicated to Inner Harbor revitalization in terms of obtaining additional user surveys and a market analysis of the AOC in the near future.
- Buffalo River stakeholders will use this site matrix to prioritize restoration efforts and to identify possible funding sources, generate local community support, and coordinate partnerships for the implementation of recommended remedial actions- as identified by the Buffalo River Remedial Advisory Committee.

TABLE OF CONTENTS

Chapter 1	Introduction	1
	1.1 Background to Study	1
	1.2 The Buffalo River Watershed and Area of Concern	2
	1.3 Habitat Assessment Sites and Study Approach	4
	1.4 References	5
Chapter 2	Fish Survey	11
	2.1 Introduction	11
	2.2 Larval Fishes	11
	2.2.1 Methods	11
	2.2.2 Results	11
	2.3 Juvenile and Adult Fishes	13
	2.3.1 Methods	13
	2.3.2 Species Diversity	13
	2.3.3 Fish Health (DELT anomalies)	15
	2.3.4 Index of Biotic Integrity	17
	2.4 Conclusion	18
	2.5 References	19
Chapter 3	Benthic Invertebrates	31
	3.1 Introduction	31
	3.2 Benthic Sampling	32
	3.3 Data Analysis	33
	3.3.1 Benthic Community Metrics	33
	3.4 Results and Discussion	35
	3.4.1 Benthic Invertebrate Families	35
	3.4.2 Oligochaetes	40
	3.4.3 Chironomid Densities	40
	3.4.4 Chironomid Richness and Pollution Tolerance	40
	3.4.5 Chironomid Mouthpart Deformities	45
	3.5 Conclusions	46
	3.6 References	46
Chapter 4	Vegetation	49
	4.1 Introduction	49
	4.2 Methods	49
	4.3 Results and Discussion	49
	4.4 References	50
Chapter 5	Water Quality	56
	5.1 Introduction	56
	5.2 Hydrolab Sample Methods	56
	5.2.1 Continuous Logging	56

	5.2.2 Hydrolab Profiling	59
5.3	<i>E. coli</i> and Suspended Solids Sampling and Analysis	60
5.4	Results and Discussion	60
	5.4.1 Mean Conditions from Fixed Hydrolab Monitoring	60
	5.4.2 Dissolved Oxygen Guidelines	62
	5.4.3 Storm Event Dynamics	64
	5.4.4 Turbidity-TSS Relationships	69
	5.4.5 Habitat Site Water Column Profiling with Hydrolab Datasonde	71
	5.4.6 Profile vs. Continuous Logging Results	73
	5.4.7 <i>E. coli</i> Results	75
5.5	Conclusion	76
5.6	References	77
Chapter 6	Use Surveys	83
6.1	Introduction	83
6.2	Methodology for Recreational Use Survey	83
6.3	Results and Discussion for Recreational Use Survey	84
6.4	Land Ownership – Riparian Zone	87
6.5	References	87
Chapter 7	Site Evaluation Matrix	94
7.1	Introduction	94
7.2	Water Quality Indices	94
7.3	Benthic Macroinvertebrate Indices	98
	7.3.1 Species Richness	99
	7.3.2 EPT Richness	99
	7.3.3 Hilsenhoff Biotic Index	100
	7.3.4 Percent Model Affinity	100
7.4	Fisheries Indices	100
	7.4.1 Index of Biotic Integrity	101
7.5	The Components of the Site Evaluation Matrix	101
	7.5.1 Water Quality Indices	101
	7.5.2 Benthic Organism Indices	103
	7.5.3 Fish Indices	103
	7.5.4 Vegetation Indices	103
7.6	Calculation of Site Characterization Matrix	104
7.7	Interpretation of Site Matrix	104
	7.7.1 Other Considerations	106
7.8	Acknowledgements	110
7.9	References	110
Chapter 8	Buffalo Niagara Riverkeeper Interpretation	114
8.1	Introduction	114

	8.2	About Buffalo Niagara Riverkeeper	114
	8.3	Water Quality	114
	8.4	Fisheries	115
	8.5	Benthic Macroinvertebrates	116
	8.6	Vegetation	117
	8.7	Use Surveys	117
	8.8	Site Matrix	118
	8.9	Next Steps	118
Appendices	Appendix 1.1	Habitat Assessment Sites	7
	Appendix 2.1	Numbers and Average Lengths of Larval Fishes Collected at Each Site and Collection Date	21
	Appendix 2.2	Numbers, Lengths, and Size Ranges of Juvenile and Adult Fishes Collected at Each Site and Collection Date	24
	Appendix 5.1	Hydrolab Sites during Dry Weather and Event of 9/9/04	80
	Appendix 6.1	Fixed Recreational Use Survey Sites	88
	Appendix 6.2	Land Ownership in the Buffalo River Riparian Zone	92

TABLES

2.1	Larval Fish Occurrences in the Buffalo River AOC (1993 and 2003-04)	12
2.2	Juvenile and Adult Fish Occurrences from Electroshocking Surveys (1993, 2003, and 2004)	14
2.3	IBI Metrics for the Buffalo River AOC	17
3.1	Occurrence of Invertebrate Families in the Buffalo River	36
3.2	Site-mean Benthic Invertebrate Parameters in the Buffalo River	37
3.3	Occurrence of Chironomid Taxa in the Buffalo River	43
3.4	Ranges and Interpretations of Biotic Index Scores	45
4.1	Occurrence of Shoreline Plant Species in Buffalo River AOC	51
5.1	Near Bottom Sample Depths (m) for Profiling, 2003	59
5.2	Near Bottom Sample Depths (m) for Profiling, 2004	59
5.3	Number (and Per Cent) of Days when Daily Mean Dissolved Oxygen was $<5.0 \text{ mg L}^{-1}$ during the Periods 6/4/03-10/6/03 and 6/2/04-9/29/04	63
5.4	Per Cent of Time when Dissolved Oxygen was $<4.0 \text{ mg L}^{-1}$ during the Periods 6/4/03-10/6/03 and 6/2/04-9/29/04	63
5.5	Mean Dissolved Oxygen (mg L^{-1}) and Turbidity (NTU) Based on Weekly Samples, 6/11-9/24/03	71
5.6	Mean Dissolved Oxygen (mg L^{-1}) and Turbidity (NTU) Based on Weekly Samples, 6/25-9/24/04	71
5.7	<i>E. coli</i> Levels per 100 mL, 2004	75
7.1	NSF WQI Analytes and Weights	95
7.2	Components of the Site Evaluation Matrix	102
7.3	Site Characterization Matrix (Rank Scores)	104
7.4	Sediment Chemistry for Habitat Sites	107
7.5	Summary of Habitat Positives and Deficiencies	109

FIGURES

1.1	Buffalo River Watershed and USGS gauging stations	3
1.2	Study sample sites	4
2.1	Number of larval fishes collected per site (2003-2004)	12
2.2	Mean number of fish species (\pm SE) collected per site (2003-2004)	15
2.3	Mean Percentage of individuals (\pm SE) with DELT anomalies in the six most commonly encountered species collected in 2003 and 2004	16
2.4	Composite fish health scores for each site based on DELT values for the six most commonly encountered species collected in 2003 and 2004	16
2.5	Mean IBI scores (\pm SE) for each study site using data from 2003-2004	18
3.1	Location of shoreline habitat restoration and mid-channel sites from which benthic invertebrates were sampled during 2003-2004	32
3.2	Larval head capsule morphology and examples of mentum (mouthpart) Deformities	34
3.3	Site-mean richness of benthic invertebrate families during 2003-2004 at A) shoreline habitat restoration sites, and B) mid-channel sites	38
3.4	Whole river temporal trends in A) invertebrate family richness, B) oligochaete density, and C) chironomid density	39
3.5	Site-mean densities of tubificid oligochaetes during 2003-2004 at A) shoreline habitat restoration, and B) mid-channel sites	41
3.6	Site-mean densities of chironomid larvae during 2003-2004 at A) shoreline habitat restoration, and B) mid-channel sites	42
3.7	Number of chironomid genera/species collected during 2003-2004 at A) shoreline habitat restoration, and B) mid-channel sites	44
4.1	Aerial views of potential habitat restoration sites	52
4.2	Percentage of shoreline with overhanging woody vegetation at potential habitat restoration sites	55
5.1	Location of sample sites	57
5.2	Hydrolab Site 2, Seneca St. Bridge	58
5.3	Hydrolab Site 7, Mouth of Cazenovia Creek	58
5.4	Hydrolab Site 4, Ohio St. Bridge	58
5.5	Weekly mean Hydrolab values, 2003	61
5.6	Weekly mean Hydrolab values, 2004	62
5.7	Factors influencing development of low dissolved oxygen levels in the AOC	64
5.8	Dilution of conductivity, 7/16/04 event	65
5.9	Dilution of conductivity, 7/27/04 event	65
5.10	Dilution of conductivity, 9/9/04 event	65
5.11	Storm event of 8/6/03. The dilution effect on conductivity is more apparent for the upstream sites (2 and 7) as compared to the downstream site (4)	66
5.12	Storm event of 7/16/04 (turbidity)	67
5.13	Storm event of 7/27/04 (turbidity)	67
5.14	Storm event of 8/6/03 (turbidity)	67
5.15	Depositional areas for moderate sized events	68

5.16	Storm event of 9/9/04 (turbidity)	67
5.17	Example of increasing D.O. at site 4, storm event of 7/16/04	67
5.18	D.O. Site 4, event of 8/6/03	67
5.19	Example of diurnal pattern in dissolved oxygen, Site 2	69
5.20	Model calibration results for suspended sediment estimates at Site 7 and near Site 4	70
5.21	Turbidity-Total Suspended Solids rating curves	72
5.22	Hydrolab continuously logged data (Hydrolab Site 4) vs. water column profile results (1 m depth) at Habitat Site 9	74
5.23	Hydrolab continuously logged data (Hydrolab Site 7) vs. water column profile results (1 m depth) at Habitat Site 1	75
6.1	Summary of Buffalo River activities, 2003-04	85
6.2	Daily mean temperature data from the Buffalo Airport	85
6.3	Monthly rainfall data from the Buffalo Airport	86
7.1	Conceptual model of the CCME WQI	98
7.2	Q-value rating curves for NSF WQI	102
7.3	Water quality index rank score by site	105
7.4	Fish indices rank score by site	105
7.5	Benthic organism rank score by site	106
7.6	Vegetation (% overhang cover and number of macrophyte species) indices scores by site	106