Biological Programs 2006
Intensive Survey Results
Series 3
Report 3

A Biological Study of the Ohio River

The Greenup Pool

Executive Summary

- Since 2004, ORSANCO has been using a probabilistic (random) design for monitoring fish communities in the Ohio River and conducting biological assessments.

- The Ohio River was divided into 20 assessment units based primarily on the locations of navigational dams. Using the random design, each assessment unit was assigned 15 sampling locations.

- Once sampled, each site is graded as passing or failing. For an assessment unit to meet its aquatic life use designation, more than 75% of the sites assessed must be in passing condition.

- In 2006, 80% of the sites assessed in Greenup pool were in passing condition. This percentage indicates the pool is passing; however, the confidence and precision (17%) of the measurement is not at the desired level of the current protocol.

- After considering the results and additional relevant information about the pool, Greenup was listed as passing. Since no other data indicated impairment, the Biological Water Quality Subcommittee decided that reassessing the pool is a lower priority compared to assessing other areas of the Ohio River.

- Previous analyses have indicated that increased flows may cause lower ORFIn scores due to decreased sampling efficiency and changes in fish behavior.

- Flows fluctuated in 2006, but were not elevated when sampling was conducted.

- Recommendations include:

    - Accepting the assessment of Greenup pool as meeting its aquatic life use designation.
    - Resources would be better spent assessing another pool rather than reassessing a pool that appears to be passing.
    - Continue to monitor flow and its influence on assessment results.

Table of Contents

A Biological Study of the Greenup Pool of the Ohio River (2006)

1.0 Introduction

The Ohio River Valley Water Sanitation Commission (ORSANCO) is an interstate water pollution control agency created in 1948 by an act of Congress to monitor and improve the water quality of the Ohio River. Until that time, water quality issues on the Ohio River had been charged to state water quality agencies. However, due to large-scale interstate implications and large pollution loads received by the Ohio River, these agencies were not sufficiently equipped to work with such a system. ORSANCO's role is to work in conjunction with state agencies to develop a set of pollution control standards exclusive to the Ohio River. The creation of these standards requires the establishment of monitoring programs that can efficiently be used on the Ohio River.

The routine ambient monitoring programs of ORSANCO are primarily directed at three monitoring and assessment priorities: spill detection (through an organics detection system), trend assessment (manual sampling system), and aquatic resource characterization (macroinvertebrate and fish studies). Another priority, water quality impacts assessment, is achieved through entire watershed intensive surveys.

In 1993, following direction from state and federal agencies, ORSANCO staff developed and implemented an intensive survey design that used electrofishing methods designed for the navigational pools of the Ohio River. This entailed extensive sampling of fish communities throughout the entire length of a particular pool. The surveys were intended to provide background information on fish populations and lay a foundation for establishing biological criteria (biocriteria) for the Ohio River. With appropriate biocriteria in place, information on the biological community provides insight into the health of the Ohio River.

After several years of collecting background data on the fish population of the Ohio River, ORSANCO developed the Ohio River Fish Index (ORFIn, Emery et al. 2003). The ORFIn incorporates 13 attributes, or metrics, of the fish community that when compiled provide an accurate representation of the overall condition of the Ohio River fish community. These 13 metrics take into account several different aspects of the fish population, including diversity, abundance, feeding and reproductive guilds, pollution tolerance/intolerance, and fish health.

An important aspect of biological monitoring is the reduction of human induced bias in the samples. The use of probability-based sample site selection was designed to reduce this bias. Within this design, sample sites are randomly selected by computer generation, eliminating the tendency to sample only in the best or worst locations. Many states already have programs in place that use this design for sampling on smaller streams, and it is also used by the U.S. Environmental Protection Agency's (USEPA) Environmental Monitoring and Assessment Program (EMAP). ORSANCO has now begun using this approach on the Ohio River for its biological monitoring. In 2006, the Montgomery, Willow Island, Greenup, and Cannelton pools were sampled as part of ORSANCO's normal monitoring. This report presents the 2006 survey of the Greenup pool including the data collected and assessment results based on the fish population surveys.

2.0 Study Area

2.1 Ohio River

The Ohio River (Figure 1) begins at the confluence of the Monongahela and Allegheny rivers and flows 981 miles in a southwesterly direction to the confluence with the Mississippi River. Twenty navigational dams maintain a nine-foot minimum depth for commercial navigation throughout the entire length of the river. There are over 600 permitted discharges to the Ohio River, 49 of which are power-generating facilities. The Ohio River Basin contains nearly ten percent of the nation's population, more than 25 million people, and serves as an avenue for transportation of approximately 250 million tons of cargo each year (ORSANCO 1994). The Ohio River dissects four ecoregions: the Western Allegheny Plateau, the Interior Plateau, the Interior River Lowland, and the Mississippi Alluvial Plain (Omernik 1987).

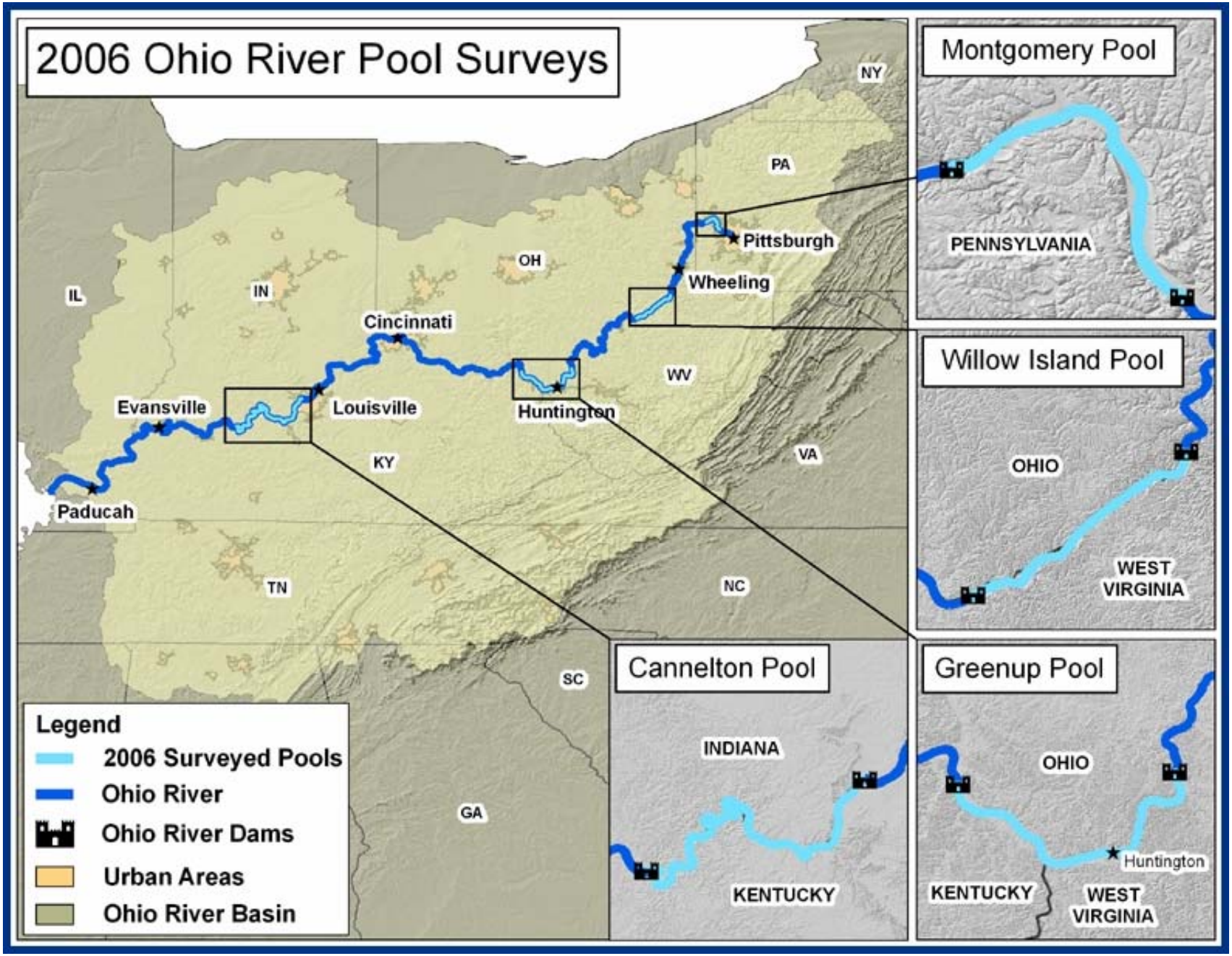


Figure 1. *The Ohio River Basin and the four pools selected for 2006 sampling.*

2.2 Greenup Pool

The Greenup pool is 61.8 miles long, extending from Robert C. Byrd Locks and Dam (ORM 279.2) to Greenup Locks and Dam (ORM 341.0). The pool has a gradient drop of 0.4 feet per mile and averages 1111 feet wide and 26 feet deep. The pool is bordered by the states of West Virginia and Ohio at the upper end and by Ohio and Kentucky downstream of the Big Sandy River. This pool lies in a portion of the Ohio River heavily influenced by industry with a large amount of barge activity. The Greenup pool receives water from five major sub-basins: the Guyandotte, Big Sandy, and Little Sandy rivers and Twelvepole and Symmes creeks. These watersheds are primarily forested, but also have significant influences from surface mining and the cities of Huntington, WV and Ashland, KY.

3.0 Methods

3.1 Survey Design and Site Location

A random, probability-based survey design was used to select sampling site locations within each Ohio River survey pool. The USEPA National Health and Environmental Effects Laboratory, Western Ecology Division provided assistance by generating the survey design for this project. The target population was the linear shorelines of the Greenup pool of the Ohio River from mile marker 279.2 (Robert C. Byrd Locks and Dam) to 341.0 (Greenup Locks and Dam). The total linear extent of the target population was approximately 61.8 miles. The sample frame was generated using RF3 river double lines for the Ohio River and river mile coverages provided by ORSANCO. A generalized random tessellation stratified (GRTS) survey design for a linear network with reverse hierarchical randomization (RHR) was used to select all sampling locations. This survey design provided coordinates for 15 sampling sites in each of the selected pools. The data collected from these sites were used to make an assessment of the pool (see Section 3.6 and Appendix A).

Sites were to be sampled as close as possible to the location generated from the design, but in cases of restricted access or unsafe sampling conditions (e.g. barge loading/mooring area), sampling zones could be shifted (up to a maximum of 500m up- or downstream). The survey design supplied additional sampling sites to be used if a site could not be placed within 500m of the original location.

3.2 Index Period and Sampling Restrictions

All sampling was conducted under the required conditions as described by Emery et al. (2003). This included sampling between July 1 and October 31 when water levels were within one meter of "normal flat pool" and Secchi depths were greater than 0.3m. These sampling restrictions were used to reduce community variability by increasing the likelihood that samples were collected during the stable, low-flow conditions usually present on the Ohio River during the summer and early fall months.

3.3 Fish Collections

Standard collection techniques were employed throughout the surveys as described by Emery et al. (2003). Fish were collected using boat electrofishing techniques at night because nighttime electrofishing typically yields samples of increased diversity and richness (Sanders 1992).

ORSANCO crew conducting night-time electrofishing

A sampling crew consisted of a three-person team working from an 18-foot aluminum johnboat. Each boat was equipped with a 5000-watt generator and a Smith-Root Type VI-A electrofishing unit. Sampling was conducted over a 500m long section of near-shore habitat (shoreline out to a maximum distance of 100 ft or a depth of 20 ft.) and was sampled for a minimum of 1800 seconds (Gammon 1998). Time could vary depending upon the complexity of the habitat within a given zone. Stunned fish were captured with nets and placed into large, aerated tubs for processing. Each fish was weighed, measured, inspected for anomalies, and identified to lowest possible taxonomic level (species) before being returned to the water. Fish

that could not be confidently identified in the field (e.g. minnows) were preserved in a ten percent formalin solution and identified in the laboratory.

Typical 500 meter electrofishing reach

3.4 Habitat Characterizations

Large rivers have distinct habitat types, including unique microhabitats (Reash 1999). Therefore, extensive habitat surveys were conducted for each electrofishing zone, including thorough substrate and depth measurements. Descriptions of the riparian corridor adjacent to the sampling zone and the presence of woody material available as fish cover were also recorded. Depth and substrate composition were measured at 66 points throughout each 500m zone. Six points along the shoreline were selected throughout the length of the zone, at 0, 100, 200, 300, 400 and 500m. From each of these points, depth was recorded at 10ft intervals beginning at the shore/water interface and moving away from the shore for 100ft. Woody cover, which included submerged brush, logs, and stumps, was estimated visually. Using these data, each site, or electrofishing zone, was assigned to one of three existing classes of habitat: 'A', 'B', or 'C'. By assigning each sampling site to one of three habitat categories, biologists can reduce the amount of assessment variability, or 'noise', because each habitat class has a slightly different expectation. Sites assigned to habitat class 'A' are characterized by the presence of large substrates such as cobble and boulders. Sites that fall in habitat class 'C' are dominated by sand and other small substrates, and habitat class 'B' describes sites that fall between 'A' and 'C' with a mix of large and small substrate materials.

3.5 Water Quality and Flow Condition Data

Basic measures of water quality were collected at each site prior to sampling. The following parameters were measured with a YSI meter: water temperature, pH, dissolved oxygen (DO), and conductivity. Secchi depth was measured using a standard Secchi disk. Flow data were obtained from the U.S. Army Corps of Engineers. These included daily average flow volumes and velocities from the sampling station within or nearest to the sampled pool. Harmonic mean flow (HMF) values were determined by ORSANCO using 30-year means for the flow data obtained from the U.S. Army Corps of Engineers (ORSANCO 2003).

3.6 Pool Assessment

In 2006, ORSANCO employed a probability-based sampling and assessment approach to provide a thorough assessment of biological condition. For the purpose of assessment, individual navigational pools served as the primary assessment units. Therefore, the Greenup pool served as one distinct assessment unit (AU) and will be reported on as such in the 305(b) report issued to EPA. The approach to assessing each AU involved sampling a statistically determined number of sites (15) and comparing observed ORFIn scores to habitat derived expectations for each site (Emery et al. 2003).

The three distinct habitat classes ('A', 'B', and 'C') each exhibit different levels of ORFIn performance. Performance expectations for each habitat class were determined based on the statistical distribution of data (ORFIn scores) gathered from 'least impacted' (reference) sites within each habitat class. The 25th percentile value for each habitat class was established as the criterion for determining whether an individual site 'passes' (meets its aquatic life use designation) or 'fails' (does not meet its aquatic life use designation, Figure 2).

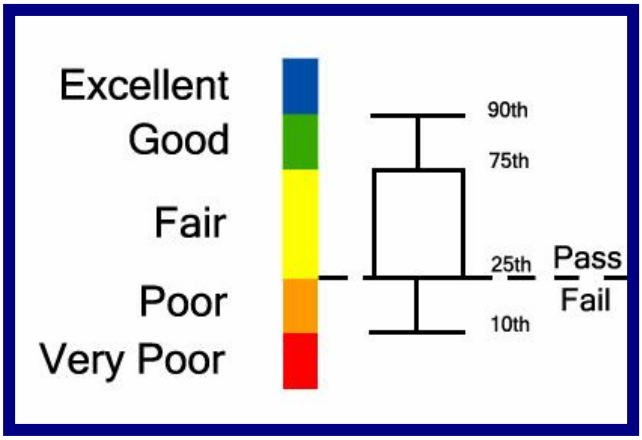


Figure 2. *Approach used to assign habitat condition ratings.*

Individual site scores were compared to expected values and the percentage of failing sites in the pool was then calculated. A precision estimate for the percentage of sites failing was also calculated (see Appendix A for a detailed explanation). The precision estimate was used to create a 90% confidence interval around the percentage of sites failing. The threshold for the pool assessment was set at 25% failure. The pool passed the assessment if the entire confidence interval fell below 25%. If the whole confidence interval was greater than 25%, the pool was assessed as failing. If the confidence interval overlapped the 25% threshold, the assessment required additional sampling to determine the result. To further characterize the condition of each pool, sites were given individual condition ratings. These ratings were based on the same distribution of data from 'least impacted' sites used to determine expectations and consisted of Excellent, Good, Fair, Poor and Very Poor. The 90^{th}, 75^{th}, 25^{th}, and 10^{th} percentiles were used as cutoff points for the different ratings. Any sites that were classified as Poor or Very Poor were also sites that failed to meet expectations (Figures 2 and 3).

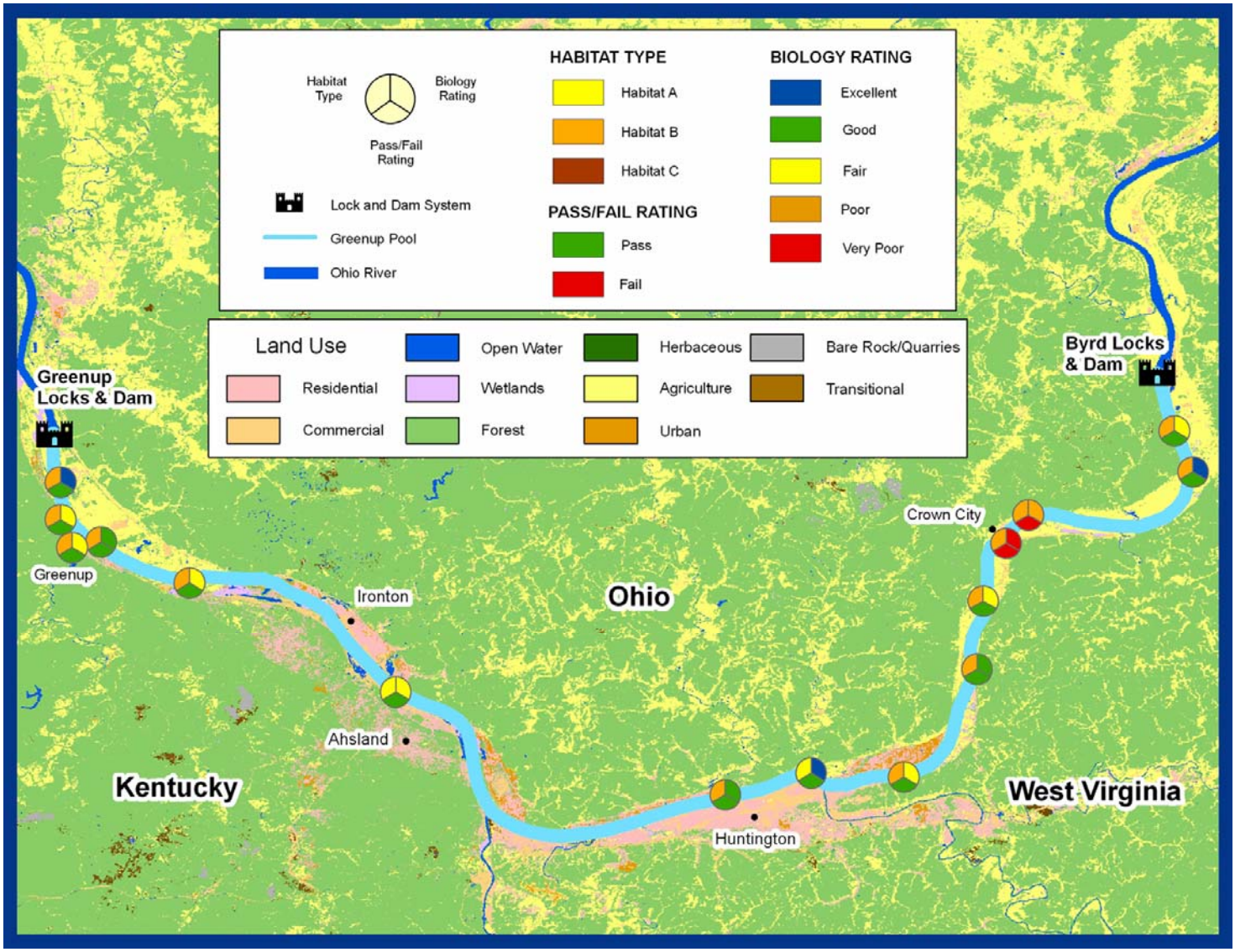


Figure 3. *Locations and results of sampling at 15 sites within the Greenup pool.*

4.0 Results

4.1 Fish Population

In 2006, fish population data (Appendix B) were collected from 15 randomly selected locations throughout the length of the Greenup pool (Table 1). These collections produced 39 species, representing 10 different families (Table 2). Three of these taxa are listed in OH as either threatened or of special concern. These include river redhorse (*Moxostoma carinatum*), river darter (*Percina shumardi*), and channel darter (*Percina copelandi*). Black buffalo (*Ictiobus niger*), another species collected, is listed as a species of special concern in KY. WV has no system for listings species. No federally listed taxa were collected from the Greenup Pool. At the species level, the most abundant species were gizzard shad (*Dorosoma cepedianum*) and sauger (*Sander canadensis*), which comprised 19.7% and 15.1% of the catch respectively (Figure 4). The dominance of these two species was directly reflected at the family level. The shad and herring family (Clupeidae) dominated in abundance, making up 19.7% of the total catch, followed by the perch family (Percidae) which made up 17.3% of the catch (Figure 5).

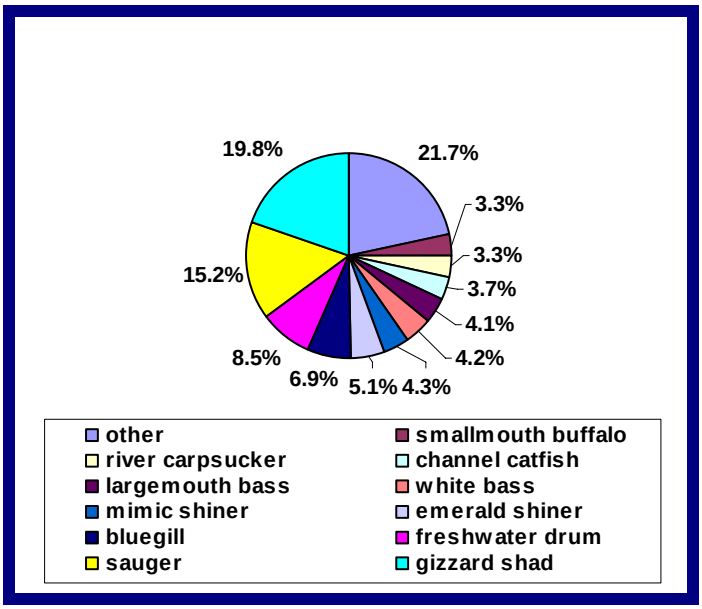


Figure 4. *Species composition of fish sampled in Greenup pool.*

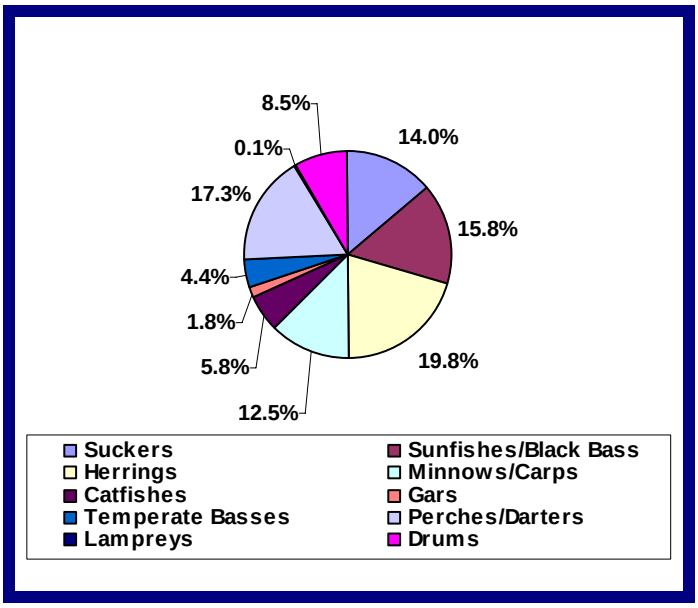


Figure 5. *Sampled fish composition by family in the Greenup pool.*

Table 1. *Electrofishing site list for the Greenup pool, including habitat designation, ORFIn scores and status.*

Site #	River Mile	Bank	Date	Latitude	Longitude	Habitat Class	ORFIn Expectation	Observed ORFIn	Site Result	Rating
1	281.6	RDB	16-Aug-06	38.6486	82.1797	B	33	39	PASS	FAIR
2	283.4	LDB	16-Aug-06	38.6235	82.1684	B	33	47	PASS	EXCELLENT
3	290.2	RDB	17-Aug-06	38.5972	82.2683	B	33	22	FAIL	POOR
4	291.2	RDB	17-Aug-06	38.5871	82.2817	B	33	18	FAIL	VERY POOR
5	294.3	RDB	16-Aug-06	38.5448	82.2956	B	33	41	PASS	FAIR
6	297.3	LDB	18-Aug-06	38.5028	82.2992	B	33	43	PASS	GOOD
7	302.5	LDB	19-Sep-06	38.4398	82.3998	A	39	53	PASS	EXCELLENT
8	305.8	RDB	19-Sep-06	38.4374	82.3437	B	33	35	PASS	FAIR
9	308.7	RDB	19-Sep-06	38.4267	82.4518	B	33	43	PASS	GOOD
10	323.5	LDB	20-Sep-06	38.4889	82.6515	A	39	37	FAIL	POOR
11	332.5	LDB	20-Aug-06	38.5558	82.7765	B	33	35	PASS	FAIR
12	335.9	RDB	19-Aug-06	38.5808	82.8301	B	33	45	PASS	GOOD
13	336.4	LDB	19-Aug-06	38.5815	82.8402	B	33	41	PASS	FAIR
14	336.7	LDB	19-Sep-06	38.5850	82.8440	B	33	35	PASS	FAIR
15	338.9	RDB	20-Aug-06	38.6172	82.8546	B	33	47	PASS	EXCELLENT

LDB = Left Descending Bank
RDB = Right Descending Bank

Table 2. *Species collected in the Greenup pool during the 2006 survey.*

Family	Species	Latin Name	OH	WV	KY
Petromyzontidae	silver lamprey	*Ichthyomyzon unicuspis*		S2S3	
Lepisosteidae	longnose gar	*Lepisosteus osseus*			
Clupeidae	gizzard shad	*Dorosoma cepedianum*			
Cyprinidae	spotfin shiner	*Cyprinella spiloptera*			
Cyprinidae	common carp	*Cyprinus carpio*			
Cyprinidae	silver chub	*Macrhybopsis storeriana*		S3S4	
Cyprinidae	emerald shiner	*Notropis atherinoides*			
Cyprinidae	mimic shiner	*Notropis volucellus*			
Cyprinidae	bluntnose minnow	*Pimephales notatus*			
Catostomidae	river carpsucker	*Carpiodes carpio*		S2S3	
Catostomidae	quillback	*Carpiodes cyprinus*			
Catostomidae	highfin carpsucker	*Carpiodes velifer*		S1	
Catostomidae	smallmouth buffalo	*Ictiobus bubalus*			
Catostomidae	black buffalo	*Ictiobus niger*		S2	SC
Catostomidae	spotted sucker	*Minytrema melanops*			
Catostomidae	silver redhorse	*Moxostoma anisurum*			
Catostomidae	smallmouth redhorse	*Moxostoma breviceps*			
Catostomidae	river redhorse	*Moxostoma carinatum*	SC	S3	
Catostomidae	golden redhorse	*Moxostoma erythrurum*			
Ictaluridae	brown bullhead	*Ameiurus nebulosus*			
Ictaluridae	channel catfish	*Ictalurus punctatus*			
Ictaluridae	flathead catfish	*Pylodictis olivaris*			
Moronidae	morone sp	*Morone sp*			
Moronidae	white bass	*Morone chrysops*			
Moronidae	striped bass	*Morone saxatilis*			
Centrarchidae	green sunfish	*Lepomis cyanellus*			
Centrarchidae	bluegill	*Lepomis macrochirus*			
Centrarchidae	longear sunfish	*Lepomis megalotis*			
Centrarchidae	redear sunfish	*Lepomis microlophus*			
Centrarchidae	smallmouth bass	*Micropterus dolomieu*			
Centrarchidae	spotted bass	*Micropterus punctulatus*			
Centrarchidae	largemouth bass	*Micropterus salmoides*			
Centrarchidae	white crappie	*Pomoxis annularis*			
Percidae	logperch	*Percina caprodes*			
Percidae	channel darter	*Percina copelandi*	T	S2S3	
Percidae	slenderhead darter	*Percina phoxocephala*		S1	
Percidae	river darter	*Percina shumardi*	T		
Percidae	sauger	*Sander canadensis*			
Percidae	walleye	*Sander vitreus*			

SC = Special Concern T = Threatened

A paddlefish collected by ORSANCO shown on a measuring board.

4.2 Metric Performance

Thirteen metrics were used to calculate ORFIn scores for each electrofishing site (Emery et al. 2003). Each site's performance and scores for the ORFIn metrics are shown in Table 3. The number of native species collected at each site ranged from 9 to 24, with an average of 16.4 species per site. Ten of the fifteen sites scored a 3 for the number of native species metric, with most of the remaining sites scoring a 5. The number of sucker species found at each site ranged from 3 to 8 and all of the sites scored either 3 or 5 for this metric. The number of centrarchid species varied from 0 to 6 and the majority of the metric scores were either 1 or 3. Most sites had 1 or 0 great river species and scores of 1 or 0. The number of intolerant species ranged from 0 to 5 at the sampled sites. The percentage of tolerant individuals at each site range between 0 and 5.9%, and ten of the sites scored a 5 for this metric percent of tolerant individuals, the remaining sites scored a 3 or lower. The percentage of simple lithophils was between 16.9% and 67.9%, and scores for this metric were 1, 3, and 5. All sites had below 4.4% non-native individuals and eleven of the sites scored a 5 for this metric. The percent detritivores ranged from 3.8% to 21.0% and most sites scored either a 1 or 5. The percent invertivores had a large range, 2.9% to 60.4%, with most sites scoring a 1 or 3 for this metric. The percent piscivores ranged from 24.6% to 64.7%. Eight sites scored a 3 and the others scored either 1 or 5 for the percent piscivores metric. The majority of sites had a single DELT (deformities, eroded fins, lesions and tumors) anomaly or none and only one site scored less than 5. The CPUE (catch per unit effort) ranged from 32 to 165 individuals per site. All the sites scored a 1, except for the site with a CPUE of 165 which received a 3 for the metric.

4.3 Habitat Surveys

Intensive habitat surveys at each of the 15 sampling locations revealed that the bottom substrate in the Greenup pool was almost equally composed of sand, fines, and gravel with a small percentage of cobble and boulders (Figure 6).

However, there was some variation among the individual sites (Figure 7). The percentages of substrate variables were used to give each site a

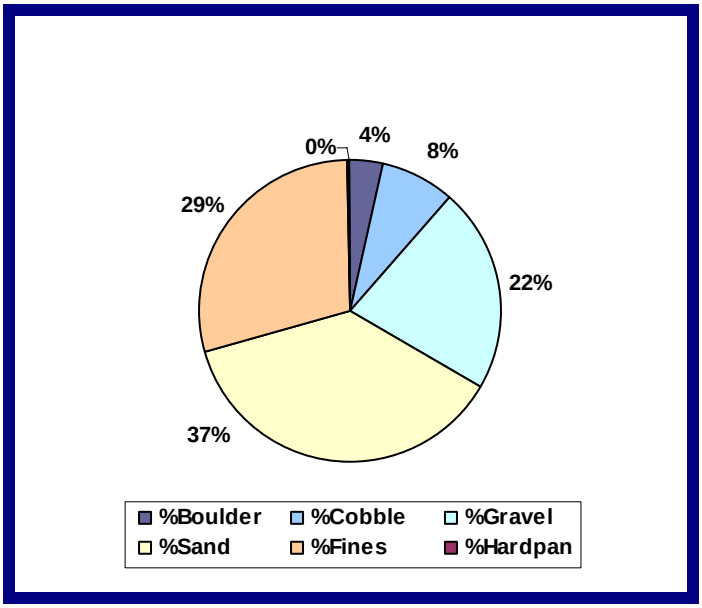


Figure 6. *Substrate composition of the Greenup pool.*

habitat classification of 'A', 'B', or 'C' (Table 1). Thirteen sites in the Greenup pool were classified as class 'B' habitats and the remaining sites were class 'A' habitats. There were no class 'C' habitats sampled in the pool. Woody cover was present in 7 of the 15 sites sampled. Riparian land use was primarily natural with some residential and industrial uses present. Barge activity is heavy throughout the pool, but mooring structures were present at only one of the sites sampled. (see Appendix C).

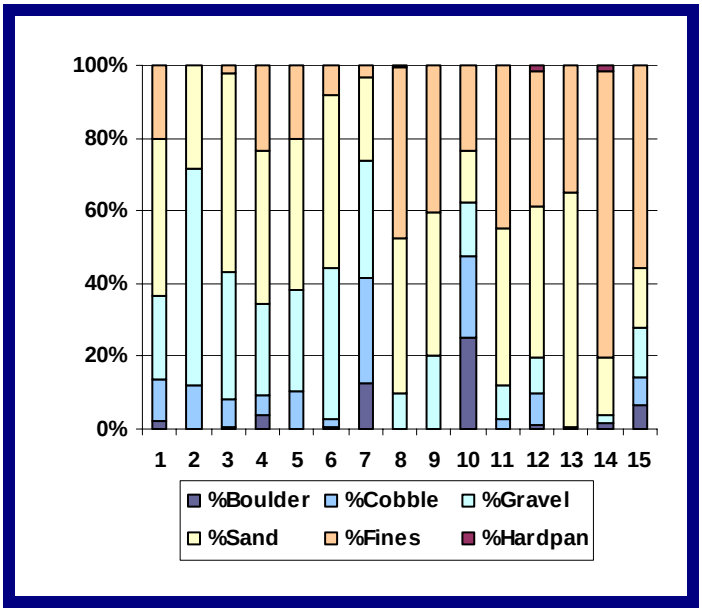


Figure 7. *Substrate composition at each site sampled in the Greenup pool.*

Table 3. ORFIN metrics and scores from the 2006 Willow Island pool survey.

Site #	River Mile	Bank	# Individuals	# Individuals w/o G & E	# Individuals w/o GETHEx	# Species	# Species Score	# Suckers	Suckers Species Score	# Centrarchid Species	Centrarchid Species Score	# Great River Species	Great River Species Scores	# Intolerant Species	Intolerant Species Score	% Tolerant Individuals	Tolerant Individuals Score	% Simple Lithophils	Simple Lithophils Score	% Non-native Individuals	Non-native Individuals Score	% Detritivores	Detritivores Score	% Invertivores	Invertivores Score	% Piscivores	Piscivores Score	# DELTs	DELT Score	CPUE	CPUE Score	ORFIn Expectation	Observed ORFIn	Site Result
1	281.6	R	70	61	61	17	3	5	3	2	1	2	3	2	1	0.0	5	31.1	3	0.0	5	13.1	3	42.6	3	36.1	3	0	5	70	1	33	39	PASS
2	283.4	L	54	53	53	15	3	4	3	2	1	1	1	5	5	0.0	5	67.9	5	0.0	5	3.8	5	60.4	5	34.0	3	0	5	54	1	33	47	PASS
3	290.2	R	38	29	28	12	3	4	3	2	1	0	0	3	3	3.4	1	51.7	1	3.4	1	10.3	1	41.4	1	48.3	1	1	5	37	1	33	22	FAIL
4	291.2	R	32	29	29	13	3	4	3	1	1	0	0	2	1	0.0	0	20.7	1	0.0	0	17.2	1	27.6	1	48.3	1	0	5	32	1	33	18	FAIL
5	294.3	R	79	65	64	20	5	6	5	3	3	1	1	3	3	1.5	5	16.9	1	0.0	5	21.5	1	35.4	3	24.6	3	0	5	78	1	33	41	PASS
6	297.3	L	95	62	62	20	5	7	5	4	3	0	1	4	3	0.0	5	29.0	3	0.0	5	21.0	1	32.3	3	27.4	3	0	5	95	1	33	43	PASS
7	302.5	L	122	111	110	24	5	6	5	5	3	1	1	5	5	0.9	5	48.6	5	0.9	5	5.4	5	25.2	3	50.5	5	0	5	121	1	39	53	PASS
8	305.8	R	77	51	50	9	1	3	3	0	0	0	0	0	0	2.0	1	39.2	1	2.0	1	7.8	1	3.9	1	64.7	1	0	5	76	1	33	16	FAIL
9	308.7	R	94	76	75	15	3	5	3	4	3	0	1	1	1	1.3	5	53.9	5	0.0	5	2.6	5	13.2	1	59.2	5	0	5	93	1	33	43	PASS
10	323.5	L	124	68	64	15	3	4	3	2	1	0	1	1	1	5.9	3	41.2	5	4.4	3	7.4	5	2.9	1	60.3	5	1	5	120	1	39	37	FAIL
11	332.5	L	101	86	86	14	3	5	3	2	1	1	1	1	1	0.0	5	37.2	3	0.0	5	17.4	3	20.9	1	29.1	3	0	5	101	1	33	35	PASS
12	335.9	R	151	126	121	20	5	8	5	5	3	0	1	4	3	4.0	3	20.6	3	2.4	5	7.1	5	38.9	3	34.1	3	1	5	146	1	33	45	PASS
13	336.4	L	114	70	70	17	3	3	3	5	3	1	1	2	1	0.0	5	28.6	3	0.0	5	12.9	3	30.0	3	52.9	5	0	5	114	1	33	41	PASS
14	336.7	L	125	100	98	18	3	3	3	6	5	1	1	1	1	1.0	5	23.0	3	1.0	5	24.0	1	21.0	1	34.0	3	2	3	123	1	33	35	PASS
15	338.9	R	165	137	137	17	3	6	5	4	3	1	1	2	1	0.0	5	21.9	3	0.0	5	8.0	5	50.4	5	33.6	3	1	5	165	3	33	47	PASS

R = Right Descending Bank
L = Left Descending Bank
w/o G & E = Individuals minus gizzard shad and emerald shiners
w/o GETHEx = Individuals minus gizzard shad, emerald shiners, tolerants, hybrids, and exotics
Centrarchid Species = black bass, sunfishes, crappie
Great River Species = fish expected to be predominant in great rivers
Intolerant Species = species with low pollution/disturbance tolerance
Tolerant Individuals = individuals with high pollution/disturbance tolerance
Simple Lithophils = fish that are sensitive to substrate disturbance based on reproductive needs
Detritivore = fish that feed primarily on detritus
Invertivore = fish that feed primarily on invertebrates
Piscivore = fish that feed primarily on other fish
DELT = individuals with Deformities, Eroded fins, Lesions, and/or Tumors
CPUE = Catch Per Unit Effort

4.4 Water Quality and Flow Conditions

Rain events kept the river levels and flows fluctuating for much of the sampling period in 2006. However, no sampling was conducted in Greenup pool when flows were above the harmonic mean flow (HMF) for the pool. The HMF for this part of the river is 38.4 kcfs and sampling was conducted between 28% and 89% of the HMF (Figure 8). Measurements of water quality parameters did not reveal any unusual or poor water conditions present at the time of sampling (Appendix D). Secchi depths at the time of sampling ranged from 18 to 43 inches.

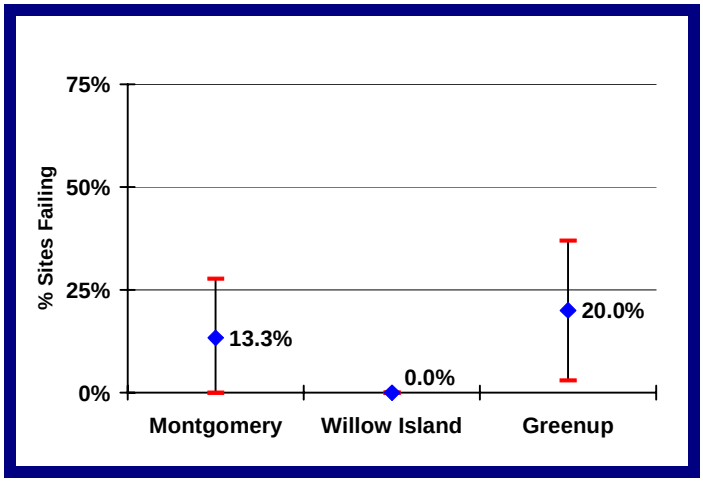


Figure 9. *2006 pool assessment results with 90% confidence intervals.*

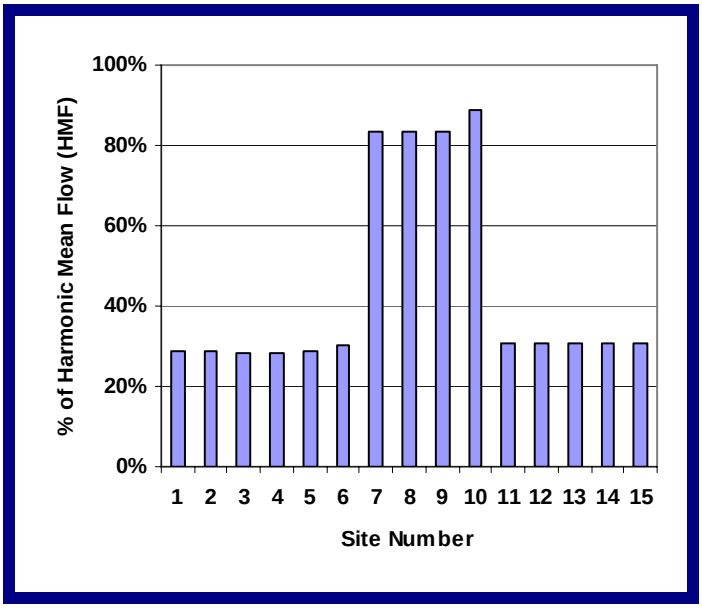


Figure 8. *Relative flows (%HMF) at the time of sampling.*

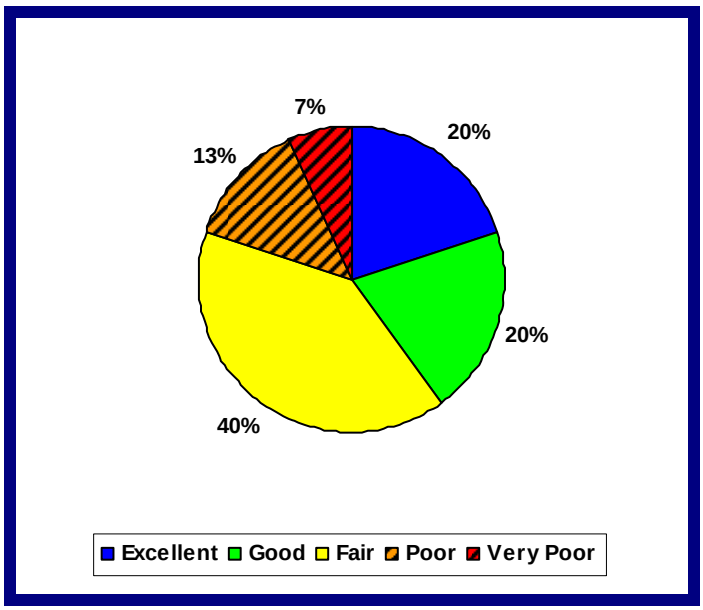


Figure 10. *Condition of the Greenup Pool based on ORFIn scores at 15 sites (Pass=Excellent-Fair, Fail=Poor-Very Poor).*

4.5 Assessment of Condition

ORFIn scores were calculated for each of the sites sampled. The maximum score achieved by any site in this pool out of a possible 65 was 53 and the minimum was 18. By comparing observed and expected ORFIn scores, ORSANCO assessed each site as either passing or failing (Table 3). All but three of the 15 sites sampled in 2006 scored higher than the minimum expected scores and received passing evaluations (Table 1). 20% of the sites were in passing condition with an estimated precision of +/- 17% (Figure 9). Three sites (20%) received an excellent condition rating, three sites (20%) were found to be in good condition, and six (40%) were in fair condition, two sites (13%) were in poor condition, and one site (7%) was 'very poor' (Figure 10).

5.0 Discussion

5.1 Fish Population

The fish population of Greenup pool appears to be in fair to good condition. This is supported by the diversity and types of species collected from the pool. Multiple pollution intolerant species such as smallmouth redhorse (*Moxostoma breviceps*), river redhorse (*M. carinatum*), smallmouth bass (*Micropterus dolomieu*), channel darter (*Percina copelandi*), slenderhead darter (*P. phoxocephala*) and logperch (*P. caprodes*) were collected from the Greenup pool, indicating that pollution is not a problem in the area. No invasives, such as white perch (*Morone americana*) or Asian carp species

(*Hypophthalmichthys sp*), were found in the survey of the pool.

5.2 Metric Performance

Two metrics stood out as the lowest performing metrics in Greenup pool: the # of great river species and CPUE metrics. For these metrics, most sites scored a one and none scored a five. Low scores for the great river species metric are expected because the metric is designed to show community response if/when these species return to the Ohio River system. There was no specific reason or explanation for the low catch rates (CPUE).

5.3 Habitat Surveys

The habitat assessments show that most areas of Greenup pool are classified as class 'B' habitats and that there are some 'A' habitats and few, if any, class 'C' habitats. The dominance of small substrate particles (fines and sand) is less than ideal; however, there is plenty of adequate habitat to support the fish population of the Greenup pool. At some sites, the quality of the available habitat is supplemented by the presence of woody cover.

5.4 Water Quality and Flow Conditions

The fluctuating river levels did not affect the survey of Greenup pool. Sampling was conducted between rain events when flows were low. All Secchi depths indicated sufficient visibility for sampling. There were no water quality measurements that were out of the ordinary or that provided any major insight into the assessment results for Greenup Pool.

5.5 Assessments of Condition and Conclusions

The analysis of Greenup pool estimates that 20% (+/- 17%) of the pool is in failing condition This estimate overlaps the threshold (25%) established to determine if a pools meets its aquatic life use designation (Appendix A). Normally the pool would require additional sampling, however, ORSANCO biologists have decided to accept the Greenup pool as meeting its aquatic life use designation, focusing more on the estimate of 20% than on the range of precision. Biologists have decided that limited resources are better spent assessing new areas of the Ohio River and are willing to accept this assessment as sufficient.

This decision was supported by the members of the ORSANCO Biological Water Quality Subcommittee.

Literature Cited

Emery, E.B., T.P. Simon, F.H. McCormick, P.L. Angermeier, J.E. Deshon, C.O. Yoder, R.E. Sanders, W.D. Pearson, G.D. Hickman, R.J. Reash, and J.A. Thomas. 2003. Development of a multimetric index for assessing the biological condition of the Ohio River. Transactions of the American Fisheries Society. 132:791-808.

Gammon, J.R. 1998. The Wabash River Ecosystem. Indiana University Press, Bloomington, IN.

Omernik, J.M. 1987. Ecoregions of the conterminous United States. Annals of the Association of American Geographers. 77:179-190.

ORSANCO (Ohio River Valley Water Sanitation Commission). 1994. Ohio River Fact Book. ORSANCO, Cincinnati, OH.

ORSANCO (Ohio River Valley Water Sanitation Commission). 2003. Pollution Control Standards for Discharges to the Ohio River. ORSANCO, Cincinnati, OH.

Reash, R.J. 1999. Considerations for characterizing Midwestern large river habitats. Pages 463-473, *In* T.P. Simon. 1999. Assessing the Sustainability and Biological Integrity of Water Resources Using Fish Communities. CRC Press, Boca Raton, FL.

Sanders, R.E. 1992. Day versus night electrofishing catches from near-shore waters of the Ohio and Muskingum Rivers. Ohio Journal of Science 92:51-59.

Appendix A: Assessment Unit Criteria Details

- Each individual navigational pool will serve as a separate and distinct Assessment Unit (AU).

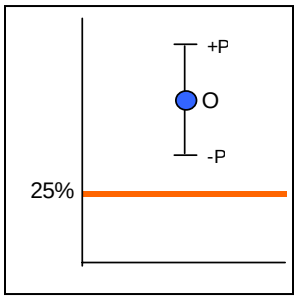
- All AUs will be sampled and assessed on a 5-year rotating basis. This is consistent with state schedules, and it allows ORSANCO (after one full rotation) in each 305(b) report, to incorporate 5 years worth of data and report on 100% of the resource. USEPA accepts 305(b) reports which use the most recent 5 years of data.

- AUs that yield >25% failure will be considered for listing as non-supporting.
  - Recognizing that even the least impacted (LI) sites in the Ohio River exhibit variability in condition, the 25th percentile of LI sites is used as the biocriteria within each habitat class.
    - Even among a random draw of LI sites, up to 25% of sites could be expected to fail, or fall below the criterion.
  - AUs with more than 25% failure rate could be listed as impaired if the BWQSC feels an "adequate assessment", as defined below, is made.

- Characteristics of "Adequate Assessments"
  - Each AU is assessed with a minimum of 15 sites, regardless of pool length.
  - 1 of 3 situations occurs after sampling 15 sites (illustrated in figure below):

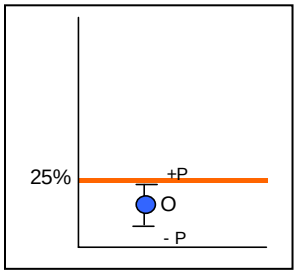
Situation 'A'

- If an observation 'O' of > 25% of the sites failing is made and O minus (-) the estimated precision (P) is >25%, the assessment is accepted as valid, the AU is listed as 'Assessed' and failing to meet the established aquatic life use. The entire AU will be properly listed on the 303(d) list.
  - If O – P > 25% then AU fails.



*Precision (P) = Z_{1-a} * 100 * Sqrt [p(1-p)/n]*

Z_{1-a} is related to the desired level of confidence
1.645 is used for 90% confidence
(use 1.96 for 95% confidence)

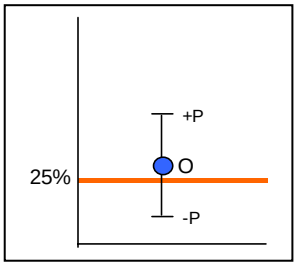


Situation 'B'

- If an observation 'O' of < 25% of the sites failing is made and O + P (precision) is <25%, the assessment is accepted as valid, the AU is listed as 'Assessed' and as meeting the established aquatic life use.
  - If O + P < 25% then AU passes.

Situation 'C'

- If after sampling 15 sites, O +/- P includes (overlaps) the criterion (25%), 1 of 2 scenarios will occur:
  - **<u>C1:</u>** if resources allow, an "Optimal Assessment" as defined below, will be conducted.
    - Additional probability sites will be sampled the next year to increase the sample size and improve precision (reducing the error bars).



- This process is repeated until one of the following occurs:
    - either Situation A or Situation B (above) is achieved.
    - precision of +/- 12 is achieved.
    - maximum of 45 samples is reached.
- At that point the AU will be considered 'Assessed', the results will be considered valid and accepted, and condition will be reported.

- **C2:** in cases where resources are limited, the BWQSC will consider other available and relevant information when deciding to accept the assessment as valid or to require more sampling.
    - Additional information to be considered in these cases include (but are not limited to):
        - additional available statistics from the current assessment
        - additional available biological & water chemistry data
        - prior performance
        - presence of known impacts
    - In these cases, ORSANCO biologists will provide a narrative justification explaining how information other than the assessment in question was used to make the assessment
    - If O + P includes 25% and multiple lines of evidence indicate that the AU is in acceptable condition, then the AU may be listed as attaining.
    - If O – P includes 25% and multiple lines of evidence indicate that the AU is in unacceptable condition, then the AU may be listed as impaired.
    - If O +/- P includes 25% and multiple lines of evidence are inconclusive, then the AU will be listed as "unassessed" and additional samples would be needed.

- Listing on the 303(d) list as
    - 4a if the determined case already has an approved TMDL is in place
    - 4b if the impairment is expected to be removed by other programs (SF, RCRA, NPDES, 319, harbor dredging)
    - 4c if the impairment is caused by something other than a pollutant
        - Habitat, natural, hydrologic, etc.
    - 5a if there is an impaired biological condition due to unknown stressor/cause.
        - Follow-up work would be needed.
            - e.g., examining WQ/Habitat/Bio interactions as a data exercise or through additional field work.
    - 5b if it is determined impairment is based on fish tissue contamination, in which case no TMDL is required.
    - 5c if a pollutant is positively identified, triggering the need for the development of a TMDL for that pollutant.

It is most likely that if any of the AUs fail, it will be listed as Category 5a.
- If follow-up work determines that a pollutant is the cause, it will be listed as Category 5c.
- If follow-up work shows impairment due to something other than a pollutant, it will be listed as Category 4c.

It will be possible to list an AU under any one of the categories shown above, although listing in any category other than 5a will require additional work, data integration, and the utmost certainty beforehand because of the resource implications of potentially triggering the need to develop a TMDL.

Appendix B. Fish survey data from the Greenup pool.

Site #	River Mile	Bank	Date	Common Name	Latin Name	Count	Weight (kg)
1	281.6	RDB	16-Aug-06	emerald shiner	*Notropis atherinoides*	3	0.004
1	281.6	RDB	16-Aug-06	freshwater drum	*Aplodinotus grunniens*	5	0.005
1	281.6	RDB	16-Aug-06	gizzard shad	*Dorosoma cepedianum*	6	0.596
1	281.6	RDB	16-Aug-06	golden redhorse	*Moxostoma erythrurum*	2	0.284
1	281.6	RDB	16-Aug-06	highfin carpsucker	*Carpiodes velifer*	1	0.096
1	281.6	RDB	16-Aug-06	largemouth bass	*Micropterus salmoides*	1	0.153
1	281.6	RDB	16-Aug-06	logperch	*Percina caprodes*	1	0.010
1	281.6	RDB	16-Aug-06	longnose gar	*Lepisosteus osseus*	1	0.063
1	281.6	RDB	16-Aug-06	mimic shiner	*Notropis volucellus*	21	0.020
1	281.6	RDB	16-Aug-06	quillback	*Carpiodes cyprinus*	3	0.395
1	281.6	RDB	16-Aug-06	river carpsucker	*Carpiodes carpio*	3	0.742
1	281.6	RDB	16-Aug-06	river darter	*Percina shumardi*	1	0.002
1	281.6	RDB	16-Aug-06	sauger	*Sander canadensis*	14	1.117
1	281.6	RDB	16-Aug-06	silver chub	*Macrhybopsis storeriana*	1	0.001
1	281.6	RDB	16-Aug-06	smallmouth buffalo	*Ictiobus bubalus*	1	0.117
1	281.6	RDB	16-Aug-06	spotted bass	*Micropterus punctulatus*	1	0.002
1	281.6	RDB	16-Aug-06	white bass	*Morone chrysops*	5	0.321
2	283.4	LDB	16-Aug-06	channel darter	*Percina copelandi*	20	0.013
2	283.4	LDB	16-Aug-06	emerald shiner	*Notropis atherinoides*	1	0.001
2	283.4	LDB	16-Aug-06	flathead catfish	*Pylodictis olivaris*	2	1.219
2	283.4	LDB	16-Aug-06	freshwater drum	*Aplodinotus grunniens*	1	1.700
2	283.4	LDB	16-Aug-06	golden redhorse	*Moxostoma erythrurum*	5	1.382
2	283.4	LDB	16-Aug-06	largemouth bass	*Micropterus salmoides*	1	0.293
2	283.4	LDB	16-Aug-06	logperch	*Percina caprodes*	1	0.001
2	283.4	LDB	16-Aug-06	longnose gar	*Lepisosteus osseus*	2	1.496
2	283.4	LDB	16-Aug-06	mimic shiner	*Notropis volucellus*	5	0.002
2	283.4	LDB	16-Aug-06	quillback	*Carpiodes cyprinus*	1	0.106
2	283.4	LDB	16-Aug-06	sauger	*Sander canadensis*	9	0.552
2	283.4	LDB	16-Aug-06	smallmouth bass	*Micropterus dolomieu*	1	0.331
2	283.4	LDB	16-Aug-06	smallmouth buffalo	*Ictiobus bubalus*	1	0.988
2	283.4	LDB	16-Aug-06	smallmouth redhorse	*Moxostoma breviceps*	1	0.288
2	283.4	LDB	16-Aug-06	white bass	*Morone chrysops*	3	0.322
3	290.2	RDB	17-Aug-06	bluegill	*Lepomis macrochirus*	1	0.075
3	290.2	RDB	17-Aug-06	common carp	*Cyprinus carpio*	1	2.682
3	290.2	RDB	17-Aug-06	emerald shiner	*Notropis atherinoides*	3	0.002
3	290.2	RDB	17-Aug-06	gizzard shad	*Dorosoma cepedianum*	6	0.784
3	290.2	RDB	17-Aug-06	golden redhorse	*Moxostoma erythrurum*	7	2.836
3	290.2	RDB	17-Aug-06	longnose gar	*Lepisosteus osseus*	3	0.647
3	290.2	RDB	17-Aug-06	mimic shiner	*Notropis volucellus*	2	0.004
3	290.2	RDB	17-Aug-06	quillback	*Carpiodes cyprinus*	1	0.955
3	290.2	RDB	17-Aug-06	river carpsucker	*Carpiodes carpio*	1	0.107
3	290.2	RDB	17-Aug-06	sauger	*Sander canadensis*	6	0.276

Site #	River Mile	Bank	Date	Common Name	Latin Name	Count	Weight (kg)
3	290.2	RDB	17-Aug-06	smallmouth bass	*Micropterus dolomieu*	2	1.101
3	290.2	RDB	17-Aug-06	smallmouth redhorse	*Moxostoma breviceps*	2	0.779
3	290.2	RDB	17-Aug-06	white bass	*Morone chrysops*	3	0.517
4	291.2	RDB	17-Aug-06	channel catfish	*Ictalurus punctatus*	1	1.061
4	291.2	RDB	17-Aug-06	emerald shiner	*Notropis atherinoides*	1	0.001
4	291.2	RDB	17-Aug-06	freshwater drum	*Aplodinotus grunniens*	1	0.001
4	291.2	RDB	17-Aug-06	gizzard shad	*Dorosoma cepedianum*	2	0.265
4	291.2	RDB	17-Aug-06	golden redhorse	*Moxostoma erythrurum*	1	0.311
4	291.2	RDB	17-Aug-06	longnose gar	*Lepisosteus osseus*	1	2.100
4	291.2	RDB	17-Aug-06	mimic shiner	*Notropis volucellus*	5	0.006
4	291.2	RDB	17-Aug-06	quillback	*Carpiodes cyprinus*	1	0.169
4	291.2	RDB	17-Aug-06	river carpsucker	*Carpiodes carpio*	4	3.329
4	291.2	RDB	17-Aug-06	sauger	*Sander canadensis*	3	0.168
4	291.2	RDB	17-Aug-06	smallmouth redhorse	*Moxostoma breviceps*	2	0.316
4	291.2	RDB	17-Aug-06	spotted bass	*Micropterus punctulatus*	5	0.017
4	291.2	RDB	17-Aug-06	white bass	*Morone chrysops*	5	0.654
5	294.3	RDB	16-Aug-06	bluegill	*Lepomis macrochirus*	1	0.065
5	294.3	RDB	16-Aug-06	bluntnose minnow	*Pimephales notatus*	1	0.001
5	294.3	RDB	16-Aug-06	channel catfish	*Ictalurus punctatus*	3	0.770
5	294.3	RDB	16-Aug-06	emerald shiner	*Notropis atherinoides*	12	0.015
5	294.3	RDB	16-Aug-06	flathead catfish	*Pylodictis olivaris*	2	0.695
5	294.3	RDB	16-Aug-06	freshwater drum	*Aplodinotus grunniens*	8	0.022
5	294.3	RDB	16-Aug-06	gizzard shad	*Dorosoma cepedianum*	2	0.627
5	294.3	RDB	16-Aug-06	golden redhorse	*Moxostoma erythrurum*	4	0.755
5	294.3	RDB	16-Aug-06	largemouth bass	*Micropterus salmoides*	4	0.715
5	294.3	RDB	16-Aug-06	longear sunfish	*Lepomis megalotis*	1	0.002
5	294.3	RDB	16-Aug-06	mimic shiner	*Notropis volucellus*	14	0.014
5	294.3	RDB	16-Aug-06	quillback	*Carpiodes cyprinus*	3	0.480
5	294.3	RDB	16-Aug-06	river carpsucker	*Carpiodes carpio*	7	4.547
5	294.3	RDB	16-Aug-06	river redhorse	*Moxostoma carinatum*	1	0.528
5	294.3	RDB	16-Aug-06	sauger	*Sander canadensis*	4	0.833
5	294.3	RDB	16-Aug-06	silver chub	*Macrhybopsis storeriana*	1	0.003
5	294.3	RDB	16-Aug-06	smallmouth buffalo	*Ictiobus bubalus*	3	5.045
5	294.3	RDB	16-Aug-06	smallmouth redhorse	*Moxostoma breviceps*	1	0.120
5	294.3	RDB	16-Aug-06	spotfin shiner	*Cyprinella spiloptera*	1	0.001
5	294.3	RDB	16-Aug-06	white bass	*Morone chrysops*	6	0.293
6	297.3	LDB	18-Aug-06	bluegill	*Lepomis macrochirus*	1	0.038
6	297.3	LDB	18-Aug-06	emerald shiner	*Notropis atherinoides*	11	0.014
6	297.3	LDB	18-Aug-06	flathead catfish	*Pylodictis olivaris*	2	0.741
6	297.3	LDB	18-Aug-06	freshwater drum	*Aplodinotus grunniens*	11	2.601
6	297.3	LDB	18-Aug-06	gizzard shad	*Dorosoma cepedianum*	22	1.805
6	297.3	LDB	18-Aug-06	golden redhorse	*Moxostoma erythrurum*	4	0.554

Site #	River Mile	Bank	Date	Common Name	Latin Name	Count	Weight (kg)
6	297.3	LDB	18-Aug-06	highfin carpsucker	*Carpiodes velifer*	2	0.284
6	297.3	LDB	18-Aug-06	largemouth bass	*Micropterus salmoides*	2	0.237
6	297.3	LDB	18-Aug-06	logperch	*Percina caprodes*	2	0.018
6	297.3	LDB	18-Aug-06	longnose gar	*Lepisosteus osseus*	2	0.337
6	297.3	LDB	18-Aug-06	mimic shiner	*Notropis volucellus*	7	0.004
6	297.3	LDB	18-Aug-06	quillback	*Carpiodes cyprinus*	1	0.118
6	297.3	LDB	18-Aug-06	river carpsucker	*Carpiodes carpio*	1	0.084
6	297.3	LDB	18-Aug-06	sauger	*Sander canadensis*	6	0.232
6	297.3	LDB	18-Aug-06	silver redhorse	*Moxostoma anisurum*	4	0.624
6	297.3	LDB	18-Aug-06	smallmouth bass	*Micropterus dolomieu*	1	0.704
6	297.3	LDB	18-Aug-06	smallmouth buffalo	*Ictiobus bubalus*	9	2.936
6	297.3	LDB	18-Aug-06	smallmouth redhorse	*Moxostoma breviceps*	2	0.260
6	297.3	LDB	18-Aug-06	spotfin shiner	*Cyprinella spiloptera*	1	0.001
6	297.3	LDB	18-Aug-06	spotted bass	*Micropterus punctulatus*	4	0.148
7	302.5	LDB	16-Aug-06	channel catfish	*Ictalurus punctatus*	1	0.002
7	302.5	LDB	16-Aug-06	common carp	*Cyprinus carpio*	1	2.074
7	302.5	LDB	16-Aug-06	emerald shiner	*Notropis atherinoides*	30	0.042
7	302.5	LDB	16-Aug-06	flathead catfish	*Pylodictis olivaris*	2	0.255
7	302.5	LDB	16-Aug-06	freshwater drum	*Aplodinotus grunniens*	3	1.408
7	302.5	LDB	16-Aug-06	gizzard shad	*Dorosoma cepedianum*	40	1.786
7	302.5	LDB	16-Aug-06	largemouth bass	*Micropterus salmoides*	1	0.400
7	302.5	LDB	16-Aug-06	logperch	*Percina caprodes*	1	0.011
7	302.5	LDB	16-Aug-06	longnose gar	*Lepisosteus osseus*	1	0.002
7	302.5	LDB	16-Aug-06	mimic shiner	*Notropis volucellus*	6	0.002
7	302.5	LDB	16-Aug-06	river carpsucker	*Carpiodes carpio*	1	0.106
7	302.5	LDB	16-Aug-06	sauger	*Sander canadensis*	3	0.395
7	302.5	LDB	16-Aug-06	slenderhead darter	*Percina phoxocephala*	1	0.003
7	302.5	LDB	16-Aug-06	smallmouth buffalo	*Ictiobus bubalus*	2	2.946
7	302.5	LDB	16-Aug-06	smallmouth redhorse	*Moxostoma breviceps*	5	0.457
7	302.5	LDB	16-Aug-06	white bass	*Morone chrysops*	3	0.177
7	302.5	LDB	19-Sep-06	bluegill	*Lepomis macrochirus*	1	0.076
7	302.5	LDB	19-Sep-06	channel catfish	*Ictalurus punctatus*	15	4.528
7	302.5	LDB	19-Sep-06	common carp	*Cyprinus carpio*	1	4.400
7	302.5	LDB	19-Sep-06	emerald shiner	*Notropis atherinoides*	3	0.004
7	302.5	LDB	19-Sep-06	flathead catfish	*Pylodictis olivaris*	1	0.340
7	302.5	LDB	19-Sep-06	freshwater drum	*Aplodinotus grunniens*	6	0.416
7	302.5	LDB	19-Sep-06	gizzard shad	*Dorosoma cepedianum*	8	0.818
7	302.5	LDB	19-Sep-06	golden redhorse	*Moxostoma erythrurum*	2	0.604
7	302.5	LDB	19-Sep-06	largemouth bass	*Micropterus salmoides*	1	0.400
7	302.5	LDB	19-Sep-06	logperch	*Percina caprodes*	3	0.046
7	302.5	LDB	19-Sep-06	longnose gar	*Lepisosteus osseus*	5	3.548
7	302.5	LDB	19-Sep-06	mimic shiner	*Notropis volucellus*	4	0.004
7	302.5	LDB	19-Sep-06	morone sp	*Morone sp*	1	0.025
7	302.5	LDB	19-Sep-06	quillback	*Carpiodes cyprinus*	1	0.702

Site #	River Mile	Bank	Date	Common Name	Latin Name	Count	Weight (kg)
7	302.5	LDB	19-Sep-06	river carpsucker	*Carpiodes carpio*	2	1.688
7	302.5	LDB	19-Sep-06	river redhorse	*Moxostoma carinatum*	4	7.153
7	302.5	LDB	19-Sep-06	sauger	*Sander canadensis*	30	3.052
7	302.5	LDB	19-Sep-06	silver chub	*Macrhybopsis storeriana*	1	0.003
7	302.5	LDB	19-Sep-06	smallmouth bass	*Micropterus dolomieu*	1	0.011
7	302.5	LDB	19-Sep-06	smallmouth buffalo	*Ictiobus bubalus*	2	2.839
7	302.5	LDB	19-Sep-06	smallmouth redhorse	*Moxostoma breviceps*	13	3.619
7	302.5	LDB	19-Sep-06	spotted bass	*Micropterus punctulatus*	1	0.004
7	302.5	LDB	19-Sep-06	walleye	*Sander vitreus*	1	0.212
7	302.5	LDB	19-Sep-06	white bass	*Morone chrysops*	14	2.665
7	302.5	LDB	19-Sep-06	white crappie	*Pomoxis annularis*	1	0.135
8	305.8	RDB	15-Aug-06	bluegill	*Lepomis macrochirus*	1	0.057
8	305.8	RDB	15-Aug-06	emerald shiner	*Notropis atherinoides*	3	0.003
8	305.8	RDB	15-Aug-06	freshwater drum	*Aplodinotus grunniens*	9	0.057
8	305.8	RDB	15-Aug-06	gizzard shad	*Dorosoma cepedianum*	17	0.585
8	305.8	RDB	15-Aug-06	largemouth bass	*Micropterus salmoides*	1	0.373
8	305.8	RDB	15-Aug-06	longnose gar	*Lepisosteus osseus*	5	3.516
8	305.8	RDB	15-Aug-06	mimic shiner	*Notropis volucellus*	4	0.003
8	305.8	RDB	15-Aug-06	sauger	*Sander canadensis*	11	1.744
8	305.8	RDB	15-Aug-06	silver chub	*Macrhybopsis storeriana*	3	0.005
8	305.8	RDB	15-Aug-06	smallmouth buffalo	*Ictiobus bubalus*	2	2.554
8	305.8	RDB	15-Aug-06	spotted bass	*Micropterus punctulatus*	1	0.001
8	305.8	RDB	15-Aug-06	white bass	*Morone chrysops*	1	0.010
8	305.8	RDB	19-Sep-06	channel catfish	*Ictalurus punctatus*	1	1.200
8	305.8	RDB	19-Sep-06	common carp	*Cyprinus carpio*	1	0.393
8	305.8	RDB	19-Sep-06	freshwater drum	*Aplodinotus grunniens*	11	0.647
8	305.8	RDB	19-Sep-06	gizzard shad	*Dorosoma cepedianum*	26	1.045
8	305.8	RDB	19-Sep-06	longnose gar	*Lepisosteus osseus*	5	1.887
8	305.8	RDB	19-Sep-06	quillback	*Carpiodes cyprinus*	2	0.202
8	305.8	RDB	19-Sep-06	sauger	*Sander canadensis*	18	1.806
8	305.8	RDB	19-Sep-06	silver redhorse	*Moxostoma anisurum*	2	0.303
8	305.8	RDB	19-Sep-06	smallmouth buffalo	*Ictiobus bubalus*	1	0.093
8	305.8	RDB	19-Sep-06	white bass	*Morone chrysops*	10	1.064
9	308.7	RDB	15-Aug-06	bluegill	*Lepomis macrochirus*	1	0.058
9	308.7	RDB	15-Aug-06	channel catfish	*Ictalurus punctatus*	1	1.272
9	308.7	RDB	15-Aug-06	emerald shiner	*Notropis atherinoides*	1	0.001
9	308.7	RDB	15-Aug-06	freshwater drum	*Aplodinotus grunniens*	6	0.573
9	308.7	RDB	15-Aug-06	gizzard shad	*Dorosoma cepedianum*	1	0.098
9	308.7	RDB	15-Aug-06	golden redhorse	*Moxostoma erythrurum*	1	0.120
9	308.7	RDB	15-Aug-06	green sunfish	*Lepomis cyanellus*	1	0.002
9	308.7	RDB	15-Aug-06	longnose gar	*Lepisosteus osseus*	1	0.707
9	308.7	RDB	15-Aug-06	river carpsucker	*Carpiodes carpio*	5	3.411
9	308.7	RDB	15-Aug-06	sauger	*Sander canadensis*	15	0.868

Site #	River Mile	Bank	Date	Common Name	Latin Name	Count	Weight (kg)
9	308.7	RDB	15-Aug-06	silver chub	*Macrhybopsis storeriana*	2	0.028
9	308.7	RDB	15-Aug-06	smallmouth bass	*Micropterus dolomieu*	1	0.034
9	308.7	RDB	15-Aug-06	smallmouth buffalo	*Ictiobus bubalus*	1	2.011
9	308.7	RDB	15-Aug-06	smallmouth redhorse	*Moxostoma breviceps*	1	0.084
9	308.7	RDB	15-Aug-06	spotted bass	*Micropterus punctulatus*	3	0.013
9	308.7	RDB	15-Aug-06	striped bass	*Morone saxatilis*	1	0.007
9	308.7	RDB	15-Aug-06	white bass	*Morone chrysops*	1	0.101
9	308.7	RDB	19-Sep-06	channel catfish	*Ictalurus punctatus*	6	1.146
9	308.7	RDB	19-Sep-06	flathead catfish	*Pylodictis olivaris*	1	0.330
9	308.7	RDB	19-Sep-06	freshwater drum	*Aplodinotus grunniens*	12	0.052
9	308.7	RDB	19-Sep-06	gizzard shad	*Dorosoma cepedianum*	18	0.821
9	308.7	RDB	19-Sep-06	golden redhorse	*Moxostoma erythrurum*	3	0.837
9	308.7	RDB	19-Sep-06	green sunfish	*Lepomis cyanellus*	1	0.010
9	308.7	RDB	19-Sep-06	longear sunfish	*Lepomis megalotis*	1	0.006
9	308.7	RDB	19-Sep-06	river carpsucker	*Carpiodes carpio*	1	1.190
9	308.7	RDB	19-Sep-06	sauger	*Sander canadensis*	32	3.932
9	308.7	RDB	19-Sep-06	silver redhorse	*Moxostoma anisurum*	4	0.502
9	308.7	RDB	19-Sep-06	smallmouth buffalo	*Ictiobus bubalus*	1	0.070
9	308.7	RDB	19-Sep-06	smallmouth redhorse	*Moxostoma breviceps*	2	0.447
9	308.7	RDB	19-Sep-06	spotted bass	*Micropterus punctulatus*	3	0.142
9	308.7	RDB	19-Sep-06	white bass	*Morone chrysops*	7	0.686
9	308.7	RDB	19-Sep-06	white crappie	*Pomoxis annularis*	2	0.055
10	323.5	LDB	20-Sep-06	brown bullhead	*Ameiurus nebulosus*	1	0.056
10	323.5	LDB	20-Sep-06	channel catfish	*Ictalurus punctatus*	14	7.206
10	323.5	LDB	20-Sep-06	common carp	*Cyprinus carpio*	3	7.226
10	323.5	LDB	20-Sep-06	emerald shiner	*Notropis atherinoides*	8	0.011
10	323.5	LDB	20-Sep-06	flathead catfish	*Pylodictis olivaris*	1	0.901
10	323.5	LDB	20-Sep-06	freshwater drum	*Aplodinotus grunniens*	4	1.134
10	323.5	LDB	20-Sep-06	gizzard shad	*Dorosoma cepedianum*	48	1.907
10	323.5	LDB	20-Sep-06	golden redhorse	*Moxostoma erythrurum*	1	0.292
10	323.5	LDB	20-Sep-06	largemouth bass	*Micropterus salmoides*	3	0.930
10	323.5	LDB	20-Sep-06	river carpsucker	*Carpiodes carpio*	1	0.851
10	323.5	LDB	20-Sep-06	sauger	*Sander canadensis*	26	1.861
10	323.5	LDB	20-Sep-06	silver lamprey	*Ichthyomyzon unicuspis*	1	0.017
10	323.5	LDB	20-Sep-06	smallmouth buffalo	*Ictiobus bubalus*	1	0.131
10	323.5	LDB	20-Sep-06	smallmouth redhorse	*Moxostoma breviceps*	1	0.246
10	323.5	LDB	20-Sep-06	spotted bass	*Micropterus punctulatus*	6	0.737
10	323.5	LDB	20-Sep-06	white bass	*Morone chrysops*	5	0.412
11	332.5	LDB	20-Aug-06	black buffalo	*Ictiobus niger*	1	3.815
11	332.5	LDB	20-Aug-06	bluegill	*Lepomis macrochirus*	4	0.103
11	332.5	LDB	20-Aug-06	channel catfish	*Ictalurus punctatus*	4	0.068
11	332.5	LDB	20-Aug-06	flathead catfish	*Pylodictis olivaris*	3	0.973
11	332.5	LDB	20-Aug-06	freshwater drum	*Aplodinotus grunniens*	24	0.170

Site #	River Mile	Bank	Date	Common Name	Latin Name	Count	Weight (kg)
11	332.5	LDB	20-Aug-06	gizzard shad	*Dorosoma cepedianum*	15	0.405
11	332.5	LDB	20-Aug-06	highfin carpsucker	*Carpiodes velifer*	1	0.168
11	332.5	LDB	20-Aug-06	largemouth bass	*Micropterus salmoides*	4	2.507
11	332.5	LDB	20-Aug-06	logperch	*Percina caprodes*	1	0.006
11	332.5	LDB	20-Aug-06	quillback	*Carpiodes cyprinus*	1	0.137
11	332.5	LDB	20-Aug-06	river carpsucker	*Carpiodes carpio*	6	2.903
11	332.5	LDB	20-Aug-06	sauger	*Sander canadensis*	18	1.970
11	332.5	LDB	20-Aug-06	silver chub	*Macrhybopsis storeriana*	13	0.043
11	332.5	LDB	20-Aug-06	smallmouth buffalo	*Ictiobus bubalus*	6	8.689
12	335.9	RDB	19-Aug-06	bluegill	*Lepomis macrochirus*	38	1.495
12	335.9	RDB	19-Aug-06	channel catfish	*Ictalurus punctatus*	2	1.364
12	335.9	RDB	19-Aug-06	common carp	*Cyprinus carpio*	3	12.132
12	335.9	RDB	19-Aug-06	flathead catfish	*Pylodictis olivaris*	8	3.047
12	335.9	RDB	19-Aug-06	freshwater drum	*Aplodinotus grunniens*	17	1.902
12	335.9	RDB	19-Aug-06	gizzard shad	*Dorosoma cepedianum*	25	1.227
12	335.9	RDB	19-Aug-06	golden redhorse	*Moxostoma erythrurum*	2	1.645
12	335.9	RDB	19-Aug-06	green sunfish	*Lepomis cyanellus*	2	0.041
12	335.9	RDB	19-Aug-06	largemouth bass	*Micropterus salmoides*	18	3.598
12	335.9	RDB	19-Aug-06	logperch	*Percina caprodes*	3	0.033
12	335.9	RDB	19-Aug-06	longear sunfish	*Lepomis megalotis*	1	0.016
12	335.9	RDB	19-Aug-06	quillback	*Carpiodes cyprinus*	1	0.101
12	335.9	RDB	19-Aug-06	river carpsucker	*Carpiodes carpio*	2	2.272
12	335.9	RDB	19-Aug-06	river redhorse	*Moxostoma carinatum*	1	0.121
12	335.9	RDB	19-Aug-06	sauger	*Sander canadensis*	12	2.523
12	335.9	RDB	19-Aug-06	silver redhorse	*Moxostoma anisurum*	1	0.467
12	335.9	RDB	19-Aug-06	smallmouth bass	*Micropterus dolomieu*	1	0.181
12	335.9	RDB	19-Aug-06	smallmouth buffalo	*Ictiobus bubalus*	3	11.303
12	335.9	RDB	19-Aug-06	smallmouth redhorse	*Moxostoma breviceps*	3	0.246
12	335.9	RDB	19-Aug-06	spotted sucker	*Minytrema melanops*	4	0.591
12	335.9	RDB	19-Aug-06	white bass	*Morone chrysops*	4	0.353
13	336.4	LDB	19-Aug-06	bluegill	*Lepomis macrochirus*	15	0.525
13	336.4	LDB	19-Aug-06	channel catfish	*Ictalurus punctatus*	2	1.058
13	336.4	LDB	19-Aug-06	emerald shiner	*Notropis atherinoides*	8	0.002
13	336.4	LDB	19-Aug-06	flathead catfish	*Pylodictis olivaris*	2	0.953
13	336.4	LDB	19-Aug-06	freshwater drum	*Aplodinotus grunniens*	1	0.002
13	336.4	LDB	19-Aug-06	gizzard shad	*Dorosoma cepedianum*	36	1.413
13	336.4	LDB	19-Aug-06	largemouth bass	*Micropterus salmoides*	11	1.649
13	336.4	LDB	19-Aug-06	longear sunfish	*Lepomis megalotis*	1	0.023
13	336.4	LDB	19-Aug-06	longnose gar	*Lepisosteus osseus*	1	0.003
13	336.4	LDB	19-Aug-06	mimic shiner	*Notropis volucellus*	2	0.001
13	336.4	LDB	19-Aug-06	quillback	*Carpiodes cyprinus*	1	0.199
13	336.4	LDB	19-Aug-06	river carpsucker	*Carpiodes carpio*	3	0.805
13	336.4	LDB	19-Aug-06	sauger	*Sander canadensis*	17	1.229

Site #	River Mile	Bank	Date	Common Name	Latin Name	Count	Weight (kg)
13	336.4	LDB	19-Aug-06	silver chub	*Macrhybopsis storeriana*	3	0.017
13	336.4	LDB	19-Aug-06	smallmouth bass	*Micropterus dolomieu*	1	0.177
13	336.4	LDB	19-Aug-06	smallmouth buffalo	*Ictiobus bubalus*	5	6.848
13	336.4	LDB	19-Aug-06	spotted bass	*Micropterus punctulatus*	5	0.897
14	336.7	LDB	19-Aug-06	bluegill	*Lepomis macrochirus*	9	0.282
14	336.7	LDB	19-Aug-06	channel catfish	*Ictalurus punctatus*	4	4.180
14	336.7	LDB	19-Aug-06	flathead catfish	*Pylodictis olivaris*	5	2.272
14	336.7	LDB	19-Aug-06	freshwater drum	*Aplodinotus grunniens*	16	7.102
14	336.7	LDB	19-Aug-06	gizzard shad	*Dorosoma cepedianum*	25	0.671
14	336.7	LDB	19-Aug-06	green sunfish	*Lepomis cyanellus*	1	0.001
14	336.7	LDB	19-Aug-06	largemouth bass	*Micropterus salmoides*	7	2.484
14	336.7	LDB	19-Aug-06	longear sunfish	*Lepomis megalotis*	2	0.013
14	336.7	LDB	19-Aug-06	longnose gar	*Lepisosteus osseus*	3	0.057
14	336.7	LDB	19-Aug-06	mimic shiner	*Notropis volucellus*	1	0.001
14	336.7	LDB	19-Aug-06	morone sp	*Morone sp*	1	0.003
14	336.7	LDB	19-Aug-06	quillback	*Carpiodes cyprinus*	1	0.082
14	336.7	LDB	19-Aug-06	redear sunfish	*Lepomis microlophus*	1	0.044
14	336.7	LDB	19-Aug-06	river carpsucker	*Carpiodes carpio*	12	12.195
14	336.7	LDB	19-Aug-06	sauger	*Sander canadensis*	15	1.354
14	336.7	LDB	19-Aug-06	silver chub	*Macrhybopsis storeriana*	8	0.087
14	336.7	LDB	19-Aug-06	smallmouth buffalo	*Ictiobus bubalus*	11	21.094
14	336.7	LDB	19-Aug-06	white bass	*Morone chrysops*	2	0.023
14	336.7	LDB	19-Aug-06	white crappie	*Pomoxis annularis*	1	0.096
15	338.9	RDB	20-Aug-06	bluegill	*Lepomis macrochirus*	42	1.390
15	338.9	RDB	20-Aug-06	channel catfish	*Ictalurus punctatus*	6	2.533
15	338.9	RDB	20-Aug-06	flathead catfish	*Pylodictis olivaris*	5	1.545
15	338.9	RDB	20-Aug-06	freshwater drum	*Aplodinotus grunniens*	4	2.643
15	338.9	RDB	20-Aug-06	gizzard shad	*Dorosoma cepedianum*	28	1.054
15	338.9	RDB	20-Aug-06	golden redhorse	*Moxostoma erythrurum*	8	1.669
15	338.9	RDB	20-Aug-06	largemouth bass	*Micropterus salmoides*	13	3.674
15	338.9	RDB	20-Aug-06	logperch	*Percina caprodes*	1	0.009
15	338.9	RDB	20-Aug-06	longear sunfish	*Lepomis megalotis*	8	0.117
15	338.9	RDB	20-Aug-06	river carpsucker	*Carpiodes carpio*	6	8.034
15	338.9	RDB	20-Aug-06	sauger	*Sander canadensis*	10	0.819
15	338.9	RDB	20-Aug-06	silver chub	*Macrhybopsis storeriana*	6	0.073
15	338.9	RDB	20-Aug-06	silver redhorse	*Moxostoma anisurum*	1	0.176
15	338.9	RDB	20-Aug-06	smallmouth buffalo	*Ictiobus bubalus*	5	4.448
15	338.9	RDB	20-Aug-06	smallmouth redhorse	*Moxostoma breviceps*	3	0.236
15	338.9	RDB	20-Aug-06	spotted bass	*Micropterus punctulatus*	18	1.467
15	338.9	RDB	20-Aug-06	spotted sucker	*Minytrema melanops*	1	0.884

Appendix C. Habitat survey data from the Greenup pool.

Site #	River Mile	Bank	% Boulder	% Cobble	% Gravel	% Sand	% Fines	% Hardpan	Depth	% Submerged Vegetation	% Woody Cover	% Overhanging Vegetation	Land Use	Human Influence	Bank Profile	% Bank Erosion
1	281.6	RDB	2.3	11.2	22.8	43.0	20.3	0.0	9.6	0	0	0	NF	boats, docks	gradual	none
2	283.4	LDB	0.0	12.1	59.7	28.2	0.0	0.0	8.1	0	0	0	NF	none	flat	none
3	290.2	RDB	0.6	7.8	34.7	54.7	2.2	0.0	10.7	0	11	0	NF	none	steep/ sloped	none
4	291.2	RDB	3.6	5.8	25.2	41.8	23.6	0.0	11.0	0	18	0	NF	none	gradual	none
5	294.3	RDB	0.0	10.4	28.0	41.7	19.9	0.0	8.3	0	0	0	-	none	steep/ sloped	none
6	297.3	LDB	0.3	2.4	41.3	47.7	8.3	0.0	9.8	0	0	0	-	none	gradual	none
7	302.5	LDB	12.6	29.0	32.3	22.7	3.3	0.0	10.3	0	0	0	NF	none	-	none
8	305.8	RDB	0.0	0.0	9.6	42.9	46.7	0.8	6.7	0	0	0	NF	none	-	none
9	308.7	RDB	0.0	0.0	20.4	39.3	40.4	0.0	12.2	0	0	3	R, NF	boats, docks	-	none
10	323.5	LDB	25.0	22.7	14.4	14.7	23.3	0.0	16.0	0	0	0	I	none	-	none
11	332.5	LDB	0.0	2.6	9.2	43.7	44.5	0.0	5.4	0	48	76	NF	none	steep	none
12	335.9	RDB	0.9	8.7	10.0	41.8	36.9	1.8	8.7	2	16	0	R	none	sloped	none
13	336.4	LDB	0.0	0.0	0.8	64.4	34.8	0.0	11.8	0	100	100	NF	moorings	steep	none
14	336.7	LDB	1.6	0.0	2.4	15.9	78.6	1.6	7.1	0	92	90	I	none	steep	none
15	338.9	RDB	6.6	7.5	13.6	16.7	55.7	0.0	8.2	0	26	6	R, NF	none	steep	none

Appendix D. Water quality parameters measured prior to sampling.

River Mile	pH	Temp (˚C)	Dissolved Oxygen (mg/L)	Conductivity	Secchi (in)
281.6	7.14	28.93	6.86	357	26
283.4	7.21	28.91	6.87	360	26
290.2	7.48	29.15	7.15	358	26
291.2	7.48	29.15	7.15	358	26
294.3	7.41	28.7	7.41	355	30
297.3	7.53	28.65	6.46	354	30
302.5	7.41	28.7	7.41	355	43
305.8	N/A	N/A	N/A	N/A	36
308.7	N/A	N/A	N/A	N/A	24
323.5	7.52	28.1	7.02	345	18
332.5	7.42	27.68	6.58	347	23
335.9	7.07	27.4	7.4	344	26
336.4	7.4	27.4	7.07	344	24
336.7	7.4	27.4	7.07	344	26
338.9	7.52	27.7	7.26	362	26