west virginia dep department of environmental protection

Mid Ohio Watersheds

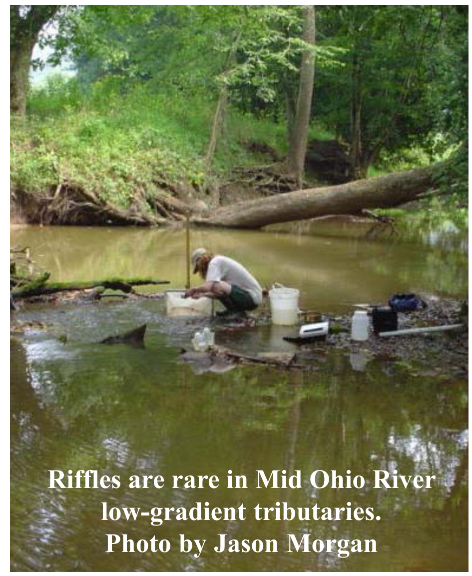
A summary of the Watershed Assessment Section's 1998-99 & 2003-04 monitoring efforts

INTRODUCTION

The West Virginia Department of Environmental Protection's (DEP) Watershed Assessment Section (WAS) assesses watersheds of the state by monitoring biological integrity, water quality, and habitat condition. Each watershed is monitored on a five-year cycle. The scheduled sampling years for the Mid Ohio North and South watersheds were 1998 and 2003. However, both low and high extremes in flow conditions due first to drought and then exceptionally wet weather, required the sampling teams to extend sampling into the springs of 1999 and 2004. This summary report is based upon data generated from these efforts.

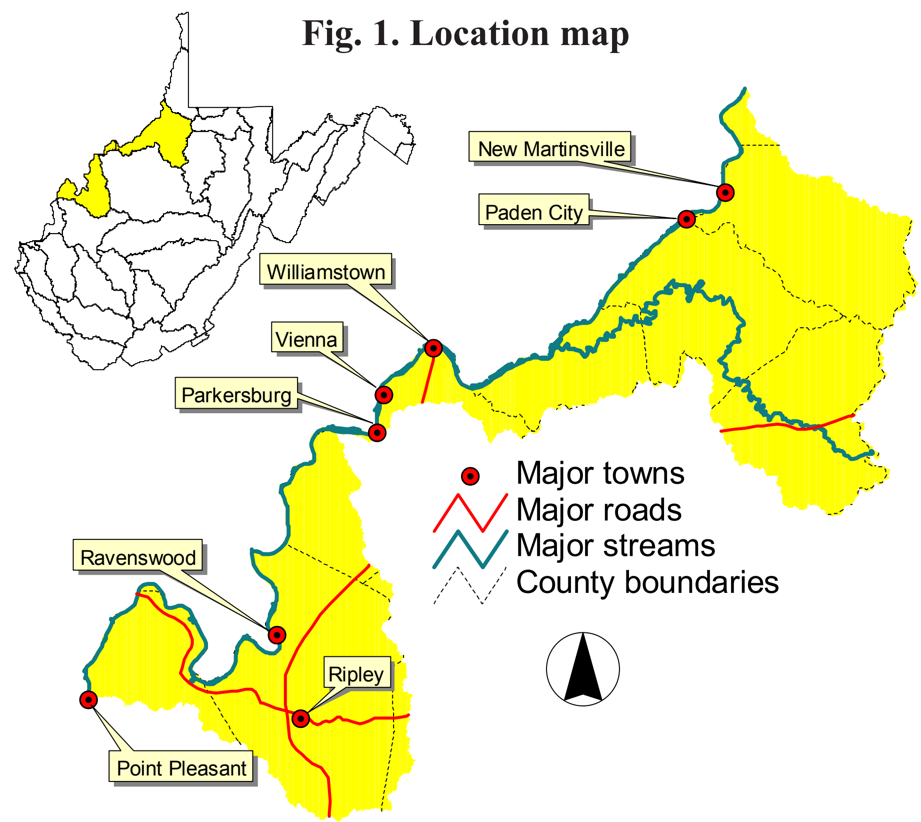
DESCRIPTION

The Middle Ohio River North and South (Mid Ohio N&S) watersheds encompass an area of approximately 955 square miles. The drainage area includes all those Ohio River tributary watersheds within West Virginia that are downstream of *Fish Creek* and upstream of *Kanawha River*, excluding *Little Kanawha River* (see Fig. 1). As with most other Allegheny Plateau Physiographic Province watersheds, the drainage pattern of the Mid Ohio N&S watersheds is dendritic. Located primarily within the Permian Hills Subecoregion of the Western Allegheny Plateau Ecoregion (Omernik, et. al. 1992), this watershed is typified by moderate to low-gradient streams that are well buffered against acidic inputs. Many stream segments behind old mill dams, low-water bridges, and protruding rock shelves, as well as those located within the backwater influence of the partially impounded Ohio River are slow-moving and prone to temperature stratification. This can be problematic in late summer when high stream temperature and algal respiration can lead to oxygen depletion.



Riffles are rare in Mid Ohio River low-gradient tributaries. Photo by Jason Morgan

Fig. 1. Location map



The rock strata exposed in these watersheds are primarily those classified in the Dunkard Group of both the Pennsylvanian and Permian Systems. They are cyclic sequences of sandstone, siltstone, shale, limestone, and coal. Due of the abundance of shale as parent material, many of the soils have a high clay content so they drain poorly. Consequently, erosion is a significant problem in the watersheds.

AmerIndian agriculture, primarily slash-and-burn, was practiced in these watersheds for centuries before Dutch, French, and British explorers and traders

SAMPLING SUMMARY

Water quality sampling sites	**233**
Benthic sample sites	**203**
Comparable benthic sites	**182**
Habitat assessment sites	**205**
Random sites sampled	**107**
Reference sites	**0**
2006 303(d) waters	**35**

plied their trades in the Ohio Valley. However, it was only after the area southeast of Ohio River was wrested from natives by Virginians in the late 18th century that vast acreages were cleared for pasture, hay, and crop production. While agriculture remains a significant land use in the watersheds, it is practiced over only a small fraction of the area it occupied before World War I. Perhaps the greatest water quality problem associated with wide scale agriculture is sedimentation.

Other water quality problems are caused by permanent channel restrictions, improperly designed streambank stabilization projects, inadequate sewage disposal, timber harvest, oil and gas well development, road construction and maintenance, and building construction. Steep, inadequately vegetated road cuts frequently bleed clay into the watersheds' streams. This is especially noticeable along Interstate highway 77.

ECO-ASSESSMENT

The watersheds were assessed in 1998, 1999, 2003, and 2004 using biological, water quality, and habitat evaluation techniques. The evaluation of these three key ecological components allows the agency to generate a clearer picture of stream health than single component assessment would allow. The sampling techniques and assessment methods for each of the components are summarized in the following paragraphs. These techniques and methods are based upon Rapid Bioassessment Protocols (RBPs) developed for the U.S. Environmental Protection Agency (EPA) and published in a document titled *Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers - Periphyton, Benthic Macroinvertebrates, and Fish* (Barbour et

Photo by Robert Row

al. 1999). This document can be viewed and downloaded from the website listed in the reference section. The diversity of applications provided by the RBPs was the primary reason they were adopted by the Watershed Assessment Section for use in assessing watersheds.

BIOLOGICAL SAMPLING

Benthic macroinvertebrates are small animals without backbones that live on the bottoms of streams and lakes. Insects comprise the largest diversity of these animals, but snails, mussels, aquatic worms, and crayfish are also members of the benthic community. These animals are important in the processing and cycling of nutrients, and are major food sources for fish and other aquatic animals. In general, a clean stream has a diverse array of benthic organisms that occupy a variety of ecological niches. Polluted streams generally have a lower diversity and often are devoid of pollution sensitive species.

Benthic macroinvertebrates can be collected using several techniques. The

Young softshell turtles (voracious predators of macroinvertebrates) are abundant in the watershed. Photo by Michael Ong

Watershed Assessment Section used the EPA's RBP II with some modifications. Because the vast majority of stream miles in the state have riffle/run habitat, the "Single Habitat Approach" was the benthic collection method adopted by the Watershed Assessment Section. In each stream with adequate riffle/run habitat, the Watershed Assessment Section used a rectangular-frame kick-net to capture organisms dislodged by kicking and brushing substrate objects in a specified area (two square meters in 1998-99 and one square meter in 2003-04).

Determining the biological condition of each site involved calculating and summarizing six community metrics based upon the benthic macroinvertebrate data:

Photo by Jeffrey Bailey

- Total taxa
- EPT index (see glossary)
- % 2 dominant taxa
- % EPT (see glossary)
- % Chironomids
- Hilsenhoff's biotic index (modified)

The six benthic community metrics were combined into a single index, the West Virginia Stream Condition Index (WVSCI) developed by Tetra Tech Inc. (Gerritsen et. al. 2000) using the DEP's watershed assessment data. The WVSCI has proven itself as a useful and cost effective tool for assessing the health of West Virginia streams. The impairment categories developed within the WVSCI are important tools the Watershed Assessment Section uses in making management decisions and in allocating limited resources to the streams that need them most.

WATER QUALITY SAMPLING

Numerous disease-causing organisms may accompany fecal coliform bacteria, which are released to the environment in feces. Therefore, the presence of such bacteria in a water sample indicates the potential presence of human pathogens. A fecal coliform bacteria sample was collected at nearly every assessment site during this study.

Physicochemical samples were collected at each site to help determine what types of stressors, if any, were negatively impacting each benthic community. The physicochemical data were helpful in providing clues about the sources of stressors. Some of the more important physicochemical parameters studied are found in the tables at the back of this document.

Assessment teams did not measure stream flows in the Middle Ohio River watersheds, but they did record each stream's flow status relative to typical flows for the visitation date.

HABITAT EVALUATION

An eight-page stream assessment form was completed at each site. At most sites, a 100-meter section of stream and the land in its immediate vicinity were evaluated for instream and streamside habitat conditions. The team recorded physical stream measurements, erosion potential, possible point and nonpoint sources of pollution, and any anthropogenic activities and disturbances. It also recorded observations about the substrate, water, and riparian zone.

An important part of each assessment was the completion of a two-page rapid habitat assessment form, which produced a numerical score of the habitat conditions most likely to affect aquatic life. The following 10 parameters were evaluated:

- Epifaunal substrate/fish cover
- Riffle frequency
- Embeddedness
- Channel flow status
- Velocity/depth regimes
- Bank stability
- Channel alteration
- Bank vegetative protection
- Sediment deposition
- Width of undisturbed vegetation zone

Photo by Scott Lemons

SUMMARY OF KEY STRESSORS

Excess sediment deposition

Inadequately treated sewage

Inadequate riparian buffer zones

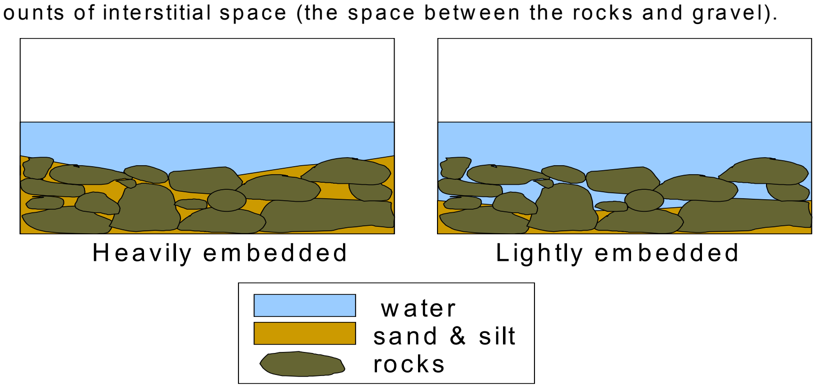
Dredging and channelization

While all the parameters measure important aspects of stream habitat, some affect the benthic community at the specific location more than others. *Embeddedness* is the measurement of the amount of silt and sand surrounding the larger substrate particles (cobbles and boulders). Embedding limits the interstitial space (areas between and below cobbles and boulders) that benthic organisms depend on for shelter and for finding food. Figure 2 illustrates stream substrate embeddedness.

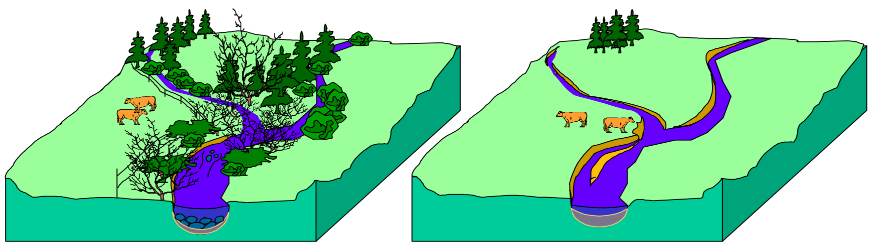
Another important habitat parameter is the *width of undisturbed vegetation zone*. The condition of the land next to a stream has an important effect on the instream conditions (see Figure 3). An intact riparian zone, (i.e., one with a combination of mature trees, saplings, and ground cover), serves as a buffer to pollutants entering a stream from runoff, controls erosion, and provides habitat and slow-release nutrient input into the stream.

Fig. 2. Illustration of embeddedness (cross-section)

The view on the left is heavily embedded with sand and silt. Notice the different amounts of interstitial space (the space between the rocks and gravel).



Fig, 3. Stream with and without riparian buffer zone



ASSESSMENT RESULTS

A variety of techniques was used to evaluate the three ecological components assessed at each stream sampling site within the Mid Ohio watersheds. Essentially, two data sets were used in this evaluation: (1) data from all sampled sites (targeted and randomly selected) within the Mid Ohio watersheds for the years 1998, 1999, 2003, and 2004, and (2) data limited to randomly selected sites for the years 1997 through 2001.

The results from the random selection effort provide greater confidence in inferences made about the ecological condition of whole watersheds. This is true because sites selected randomly have a known probability of selection. Therefore, results based upon random sampling can be scaled up to the entire population of sites (all stream reaches) within the watershed. Several of the charts and graphs in this report compare the results of data analyses between the random samples collected from the Mid Ohio watersheds in 1998 and 1999, and those collected statewide (including Mid Ohio) within the five-year cycle (1997-2001). These analyses are identified in the graphs and text as *random data*.

Detailed analyses of individual sampling sites have been performed in the development of total maximum daily loads, 303(d) impaired stream reach lists, stream protection category lists (such as Tier 2.5), and 305(b) water quality assessments. However, for the purposes of this report, statistical analyses of the whole data sets (not individual sampling sites) were performed.

BIOLOGICAL SAMPLING

Of the 182 comparable samples collected from the Mid Ohio watersheds during the four years sampled, approximately 24% had WVSCI scores of 60.6 or lower, thus placing them in the impaired category. Approximately 54% of the samples scored in the unimpaired category. The "gray zone" is the range in which a definitive call cannot be made because the variability in results found in duplicate sampling indicates that, within this range, certainty of impairment status is low. Further sampling is often conducted on streams with gray zone sites. The remaining approximately 22% of the samples had WVSCI scores in the gray zone (See Figure 4).

Figure 5 graphically represents the ranges of the WVSCI score averages by subwatershed for the combined 1998, 1999, 2003, and 2004 data. The *Direct Drains no. 12* subwatershed had the highest average score (approximately 82) and the *Direct Drains no. 19* subwatershed had the lowest average score (29). However, these average scores are based upon sample populations of only two and one, respectively.

Figure 6 contrasts the Mid Ohio watersheds' showing in the WVSCI categories relative to the statewide random

Fig. 4, % sites in WVSCI ranges, Mid Ohio watersheds, 1998-99 & 2003-04

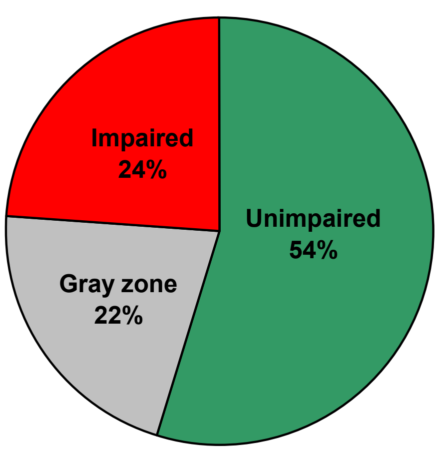


Fig. 5. Relative rank of Avg. WVSCI of subwatersheds

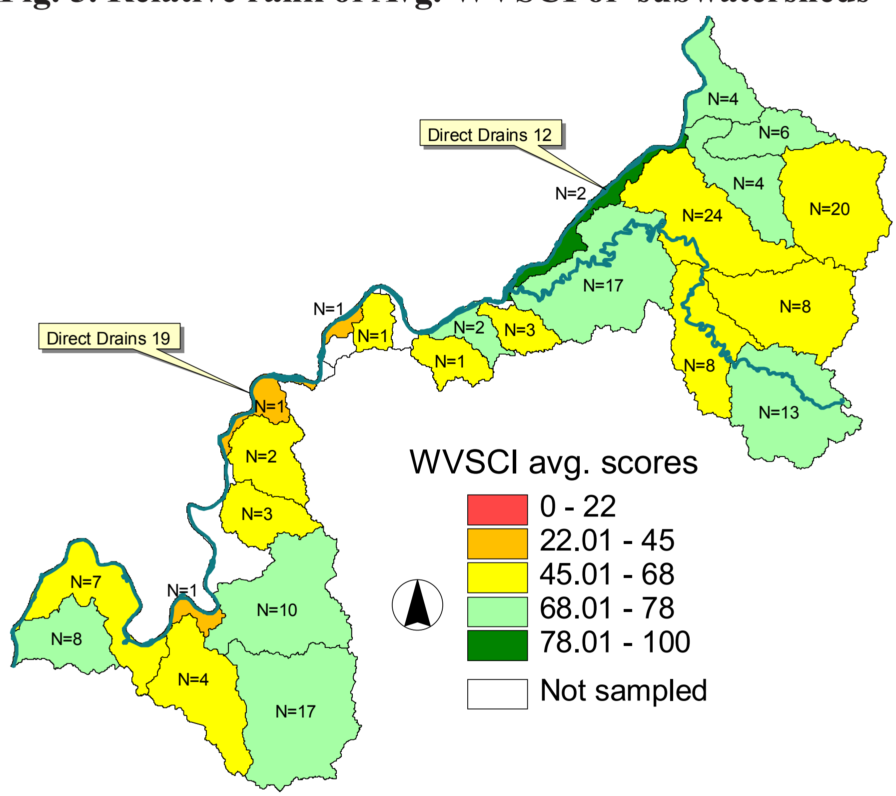
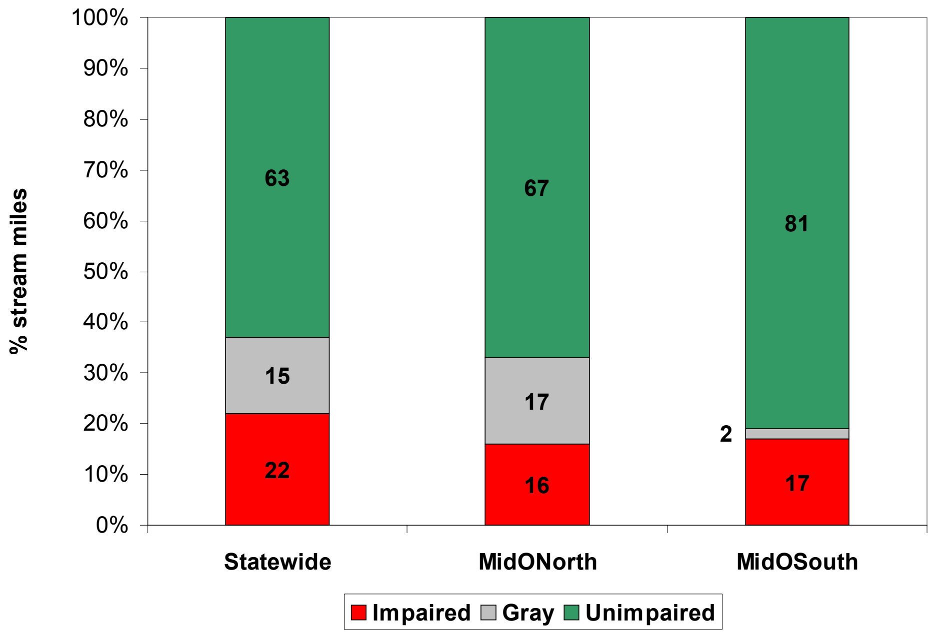


Fig. 6. Random data,% stream miles in WVSCI ranges, Mid Ohio vs. statewide



dataset. Note the greater percentage of unimpaired stream miles in the Mid Ohio South watershed relative to both the North watershed and the statewide dataset.

WATER QUALITY SAMPLING

Over the four years of sampling, water was collected from 233 sites.

The fecal coliform bacteria concentrations were not striking. Figure 7 shows that of the three datasets compared, the Mid Ohio River South watershed had a slightly higher percentage of stream miles with levels above 400 colony forming units per 100 milliliters (usually written 400cfu/100mL), which is a flag value based upon the state's water quality standard for contact recreation. In order for a stream to meet the water quality standard, bacteria cannot exceed this level in more than 10 percent of all samples taken during the month. However, the Mid Ohio South watershed had lower percent stream miles in the two higher bacteria concentration categories shown in Figure 7. Only one stream was placed on the 2004 303(d) list due to impairment by fecal coliform bacteria--*Middle Island Creek*.

As the landuse map (Fig. 9) shows, agriculture occupies a significant portion of the land surface area within the two watersheds. Most of the agricultural land coverage is livestock production, including grazing lands and hayfields. Untreated and inadequately treated sewage are likely primary sources of high bacteria concentrations during the base-flow sampling conditions that prevailed during the assessment.

Very few streams in the two watersheds showed evidence of mine drainage. Sulfate concentrations above 50 mg/L usually reflect some level of mine drainage in streams. Of the 135 samples analyzed for sulfate, only nine produced results greater than this threshold. Five of these nine streams are discussed in the *Implications* section of this report. Coal seams in these watersheds tend to be few, thin, and high in sulfur, making them unattractive to the mining industry. However, oil and gas wells are quite abundant throughout both watersheds.

Fig. 7. Random data,% stream miles in various fecal coliform bacteria categories, Mid Ohio vs. statewide

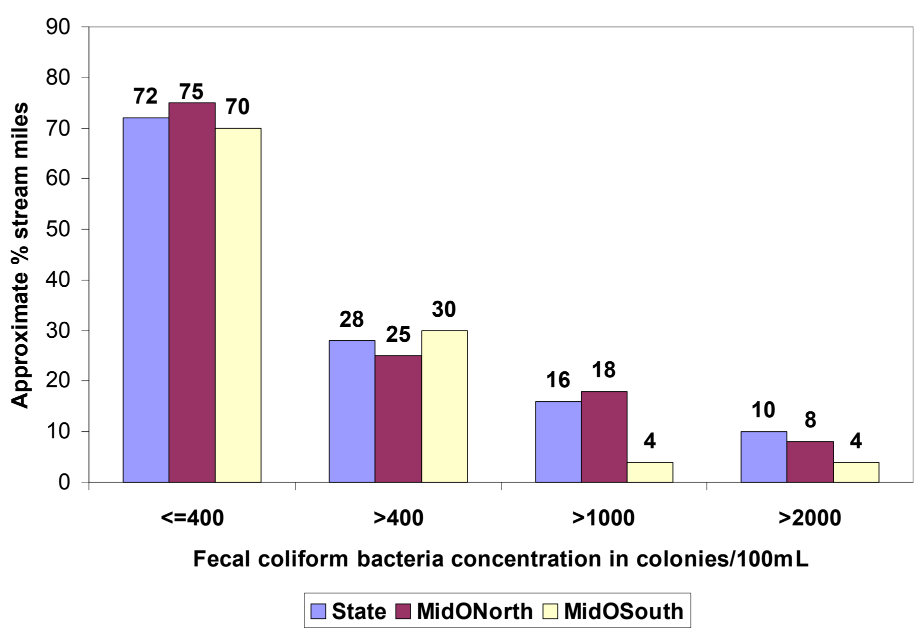
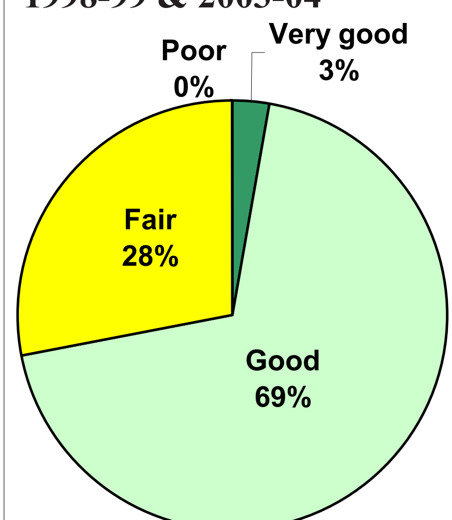


Fig. 8. % sites in RBP habitat ranges, Mid Ohio, 1998-99 & 2003-04



HABITAT EVALUATION

As Figure 8 shows, none of the Mid Ohio sites at which habitat was assessed received a total RBP habitat score within the poor range. Only 3% of the scores fell within the range at the opposite end of the scoring spectrum, the very good category. The vast majority (69%) scored within the good range.

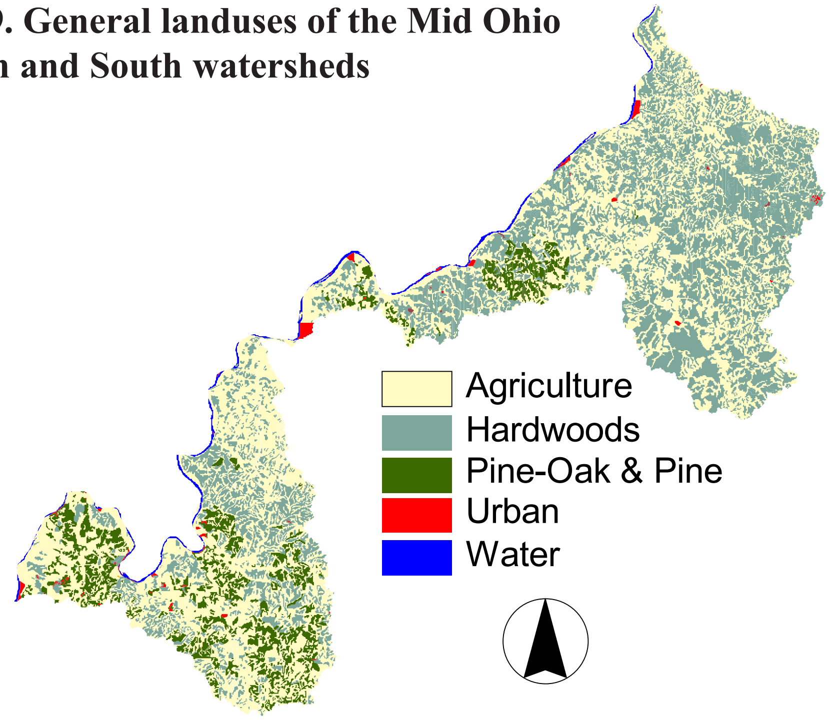
Figure 9 reveals that significant areal coverage of each watershed is in agricultural production. Most of this coverage is in hay and pasturage dedicated to livestock production. Note the greater percent coverage of the pine and pine-oak forest types in the Mid Ohio South watershed relative to that in the Mid Ohio North watershed. This is likely due to a larger percentage of the land converting from agricultural uses to forest, where Virginia pine (*Pinus virginiana*) is an important early colonizing species.

Figure 10 reveals that the Mid Ohio South watershed did not fare as well as the Mid Ohio North when percent stream miles in total RBP habitat categories are compared to those of the statewide database.

The random data set indicates that the Mid Ohio North watershed had better conditions than the Mid Ohio South watershed in the combined habitat parameter category of embeddedness plus sediment deposition. Figure 11 shows that the percentage of the North watershed's stream miles in the good category was greater than that percentage of the South's stream miles (approximately 20 more percentage points). In the very good category, the North watershed also outshone the South watershed. The higher percentage of land in active farming in the South watershed relative to the North watershed may account for the South's poorer showing in this combined habitat category.

Figure 12 shows the relationship between the WVSCI scores and the total scores from the RBP Habitat Assessments for all comparably sampled sites in the Mid Ohio watersheds' 1998-99 and 2003-04 dataset. Note there is only a weak positive correlation between the two scores (R = +0.262386674 at the 95% confidence interval). In most ecological assessments a weak correlation usually indicates that factors other than habitat quality are determining the condition of many biological communities within the study area. In the Mid Ohio watersheds, both water quality and unusual climatological events were probably contributing to benthic community conditions at many of the sites sampled.

Fig. 9. General landuses of the Mid Ohio North and South watersheds



IMPLICATIONS

Based in part upon the data generated from these sampling efforts, 13 tributary stream segments from the Mid Ohio North watershed and 11 tributary stream segments from the Mid Ohio South watershed were placed upon the 2004 303(d) impaired waterbody list because of their biological impairment status. The list may be viewed at the DEP website www.wvdep.org by performing a search on 303(d).

The 1998 *Peach Fork* (WVOMI-23-G) sample produced poor water quality reflected in high conductivity, alkalinity,

Fig. 10. Random data,% stream miles in RBP habitat categories, Mid Ohio vs. statewide

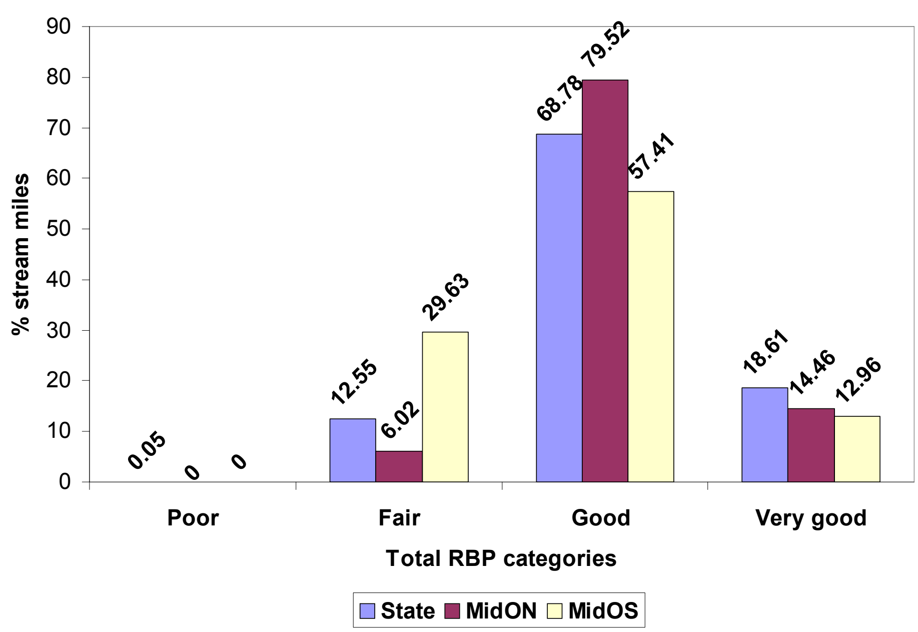
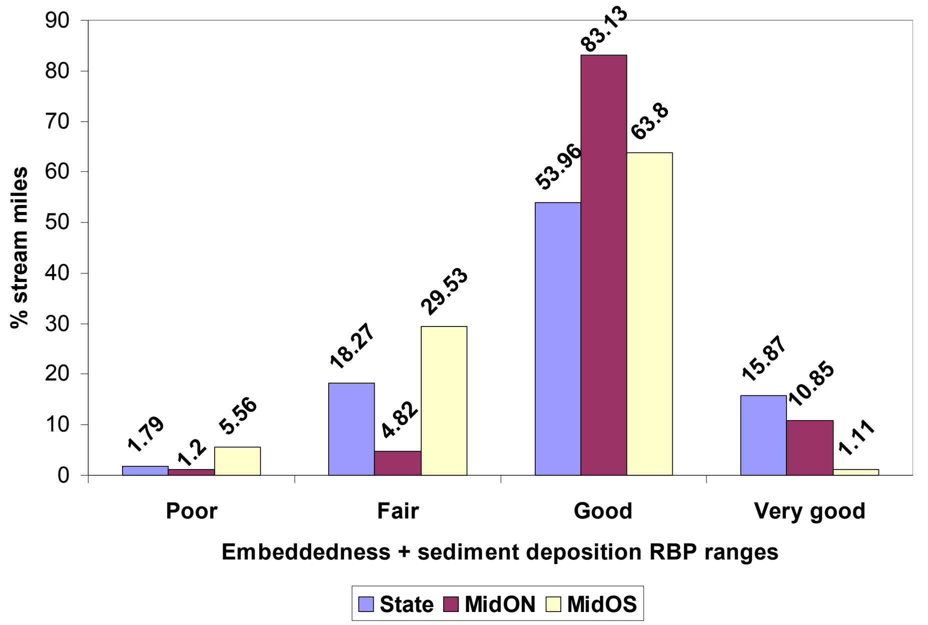


Fig.11. Random data,% stream miles in categories of Embeddedness + Sediment



sulfate, chloride, copper, manganese, nitrite + nitrate, and fecal coliform bacteria. An assessment form note reads "Wetzel County Landfill is upstream approx 1/2 mile." This stream produced impaired WVSCI scores in 1998 and 2000.

Three sites produced samples with water quality constituents usually attributable to mine drainage. An unnamed tributary of *Sliding Hill Creek* (WVO-24-A-{0.1}) sampled in 2003, *Sliding Hill Creek* mainstem (WVO-24) in 1998, and *Tenmile Creek* (WVO-23-{3.4}) in 2003 produced high conductivities, high sulfates, and low WVSCI scores (see Table 7). However, the first two sites were actually impacted by an old salt rendering facility, not by coal mine drainage. On the other hand, Tenmile Creek produced a pH of 4.67 and a total hot acidity of 36.10 mg/L, showing that it was indeed impacted by acid mine drainage. As the sulfate data show in Figures 13 and 14, relative to the statewide dataset, Mid Ohio North and South watersheds likely had very few mine drainage impacted streams.

Oil and gas extraction is extensive in these watersheds, but particularly in the Mid Ohio North watershed (Figure 15).

Only one stream site (*Bogart Run*, WVOMI-6-{0.7}) met all the criteria necessary to obtain Level I reference site status. No streams were proposed for the 2005 Tier 2.5 list for special protection under the Antidegradation Implementation Rule (60CSR5) passed by the legislature in 2001. Nonetheless, many of the streams within these watersheds had relatively good water quality and unimpaired benthic communities.

Fig. 12. Mid Ohio data, WVSCI scores vs. RBP habitat scores

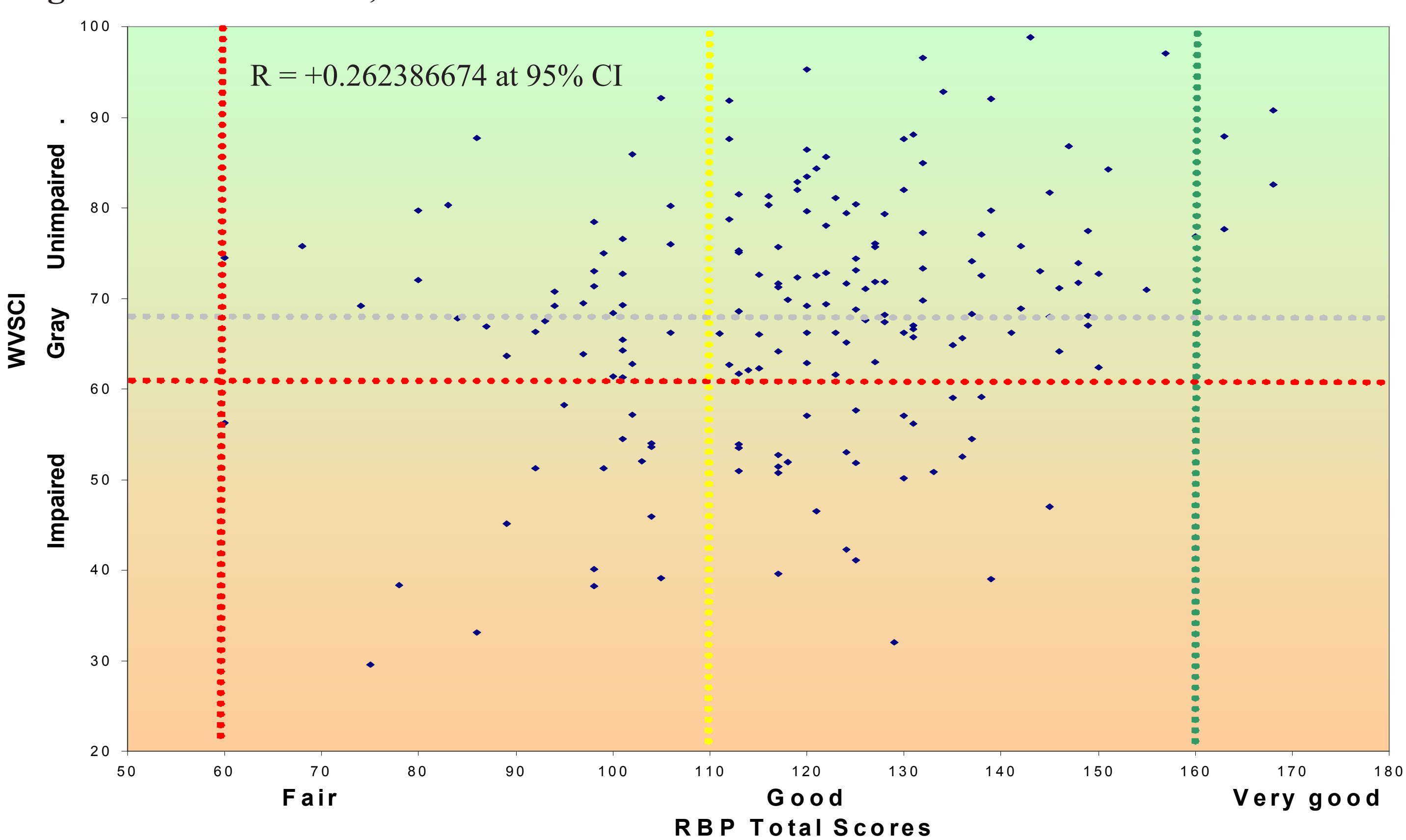


Fig.13. Random data, average sulfate in mg/L

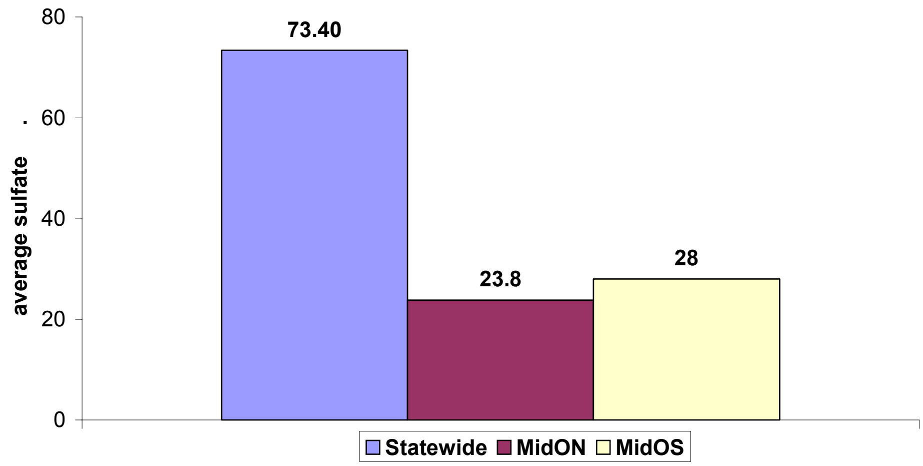
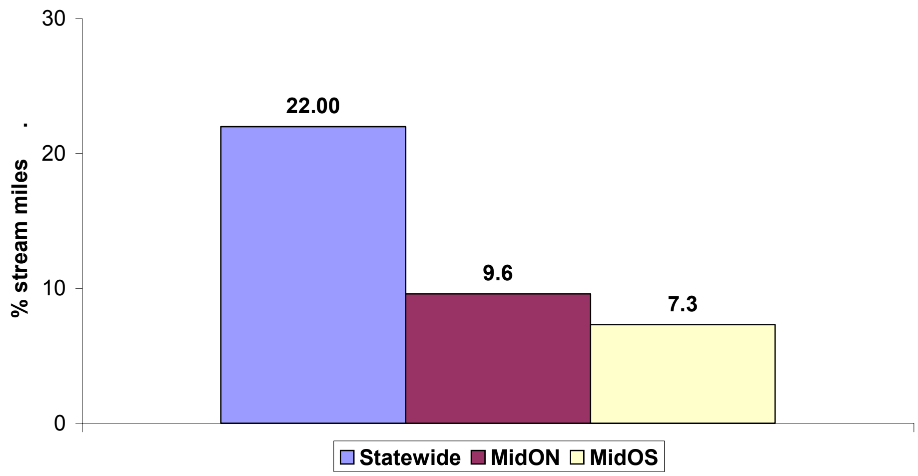


Fig.14. Random data, % stream miles with sulfate >50mg/L



GLOSSARY

cfu - bacteria colony forming unit.
DEP - West Virginia **D**epartment of **E**nvironmental **P**rotection.
EPA - **E**nvironmental **P**rotection **A**gency.
EPT - **E**phemeroptera, **P**lecoptera, & **T**richoptera orders of insects generally considered sensitive to pollution.
parameter - a factor that restricts what is possible or what results.
RBP - **R**apid **B**ioassessment **P**rotocol.
TMDL - **T**otal **M**aximum **D**aily **L**oad.
WAS - **W**atershed **A**ssessment **S**ection.
WVSCI - **W**est **V**irginia **S**tream **C**ondition **I**ndex.

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Fig. 15. Oil and gas wells in the Mid Ohio North and South watersheds

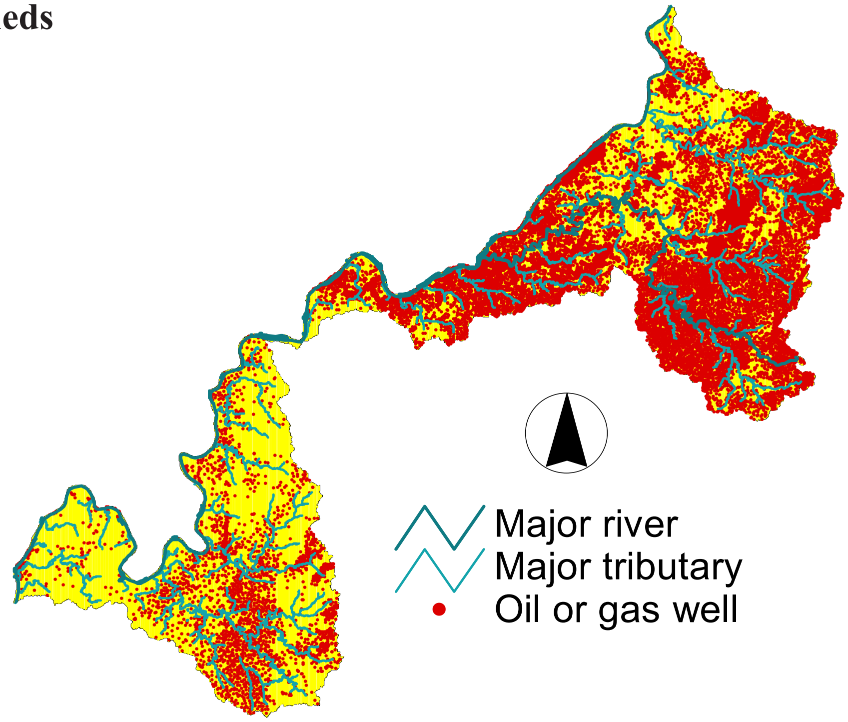
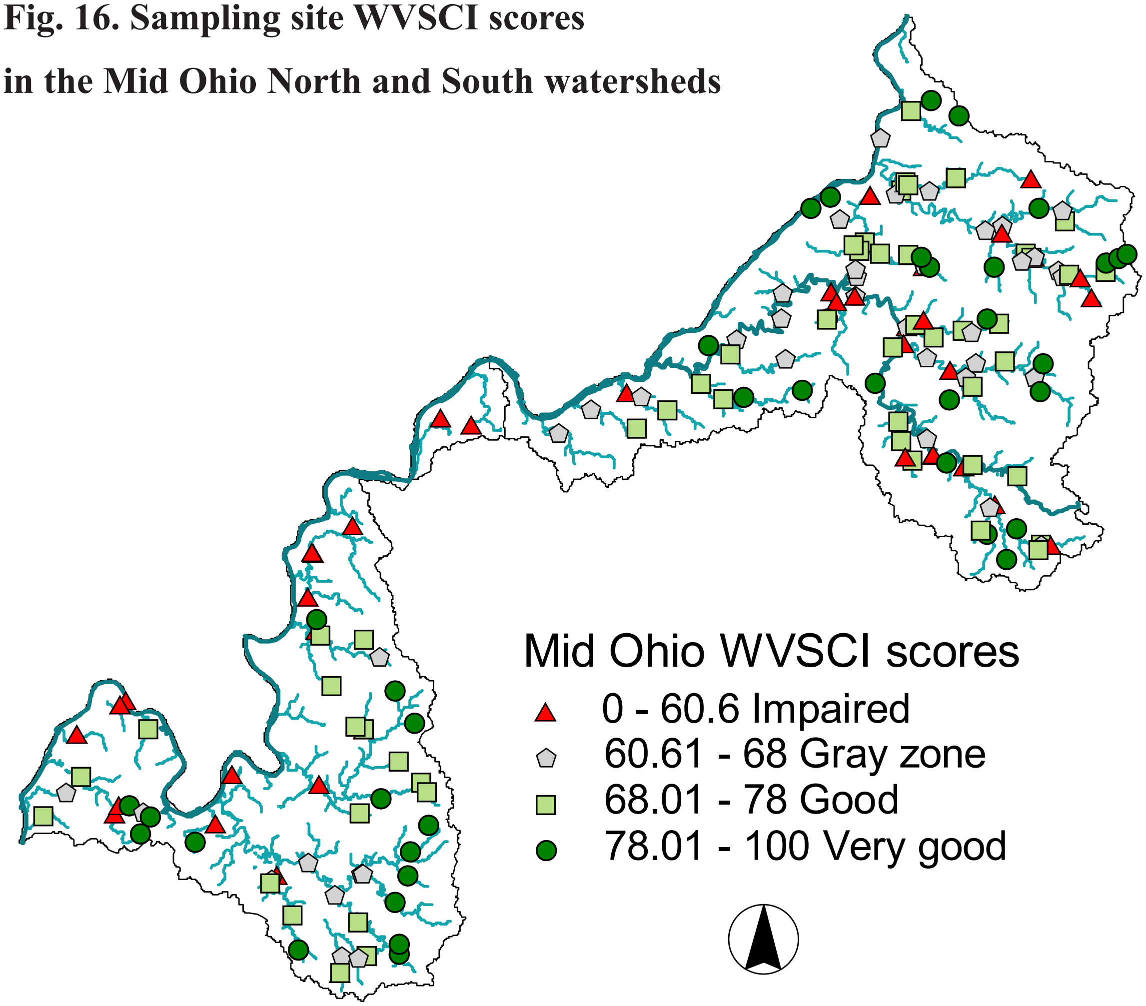


Fig. 16. Sampling site WVSCI scores in the Mid Ohio North and South watersheds



Bogart Run (WVOMI-6-{0.7}) was classified as a reference stream because of its overall high aquatic integrity. Photo by Robin Dolin

Peach Fork (WVOMI-23-G{0.0}) was severly impacted by a landfill discharge and by dredging. Photo by Mike Sovic

Fig.17. Middle Ohio River Subwatersheds

The following data tables are organized by the subwatersheds shown here.

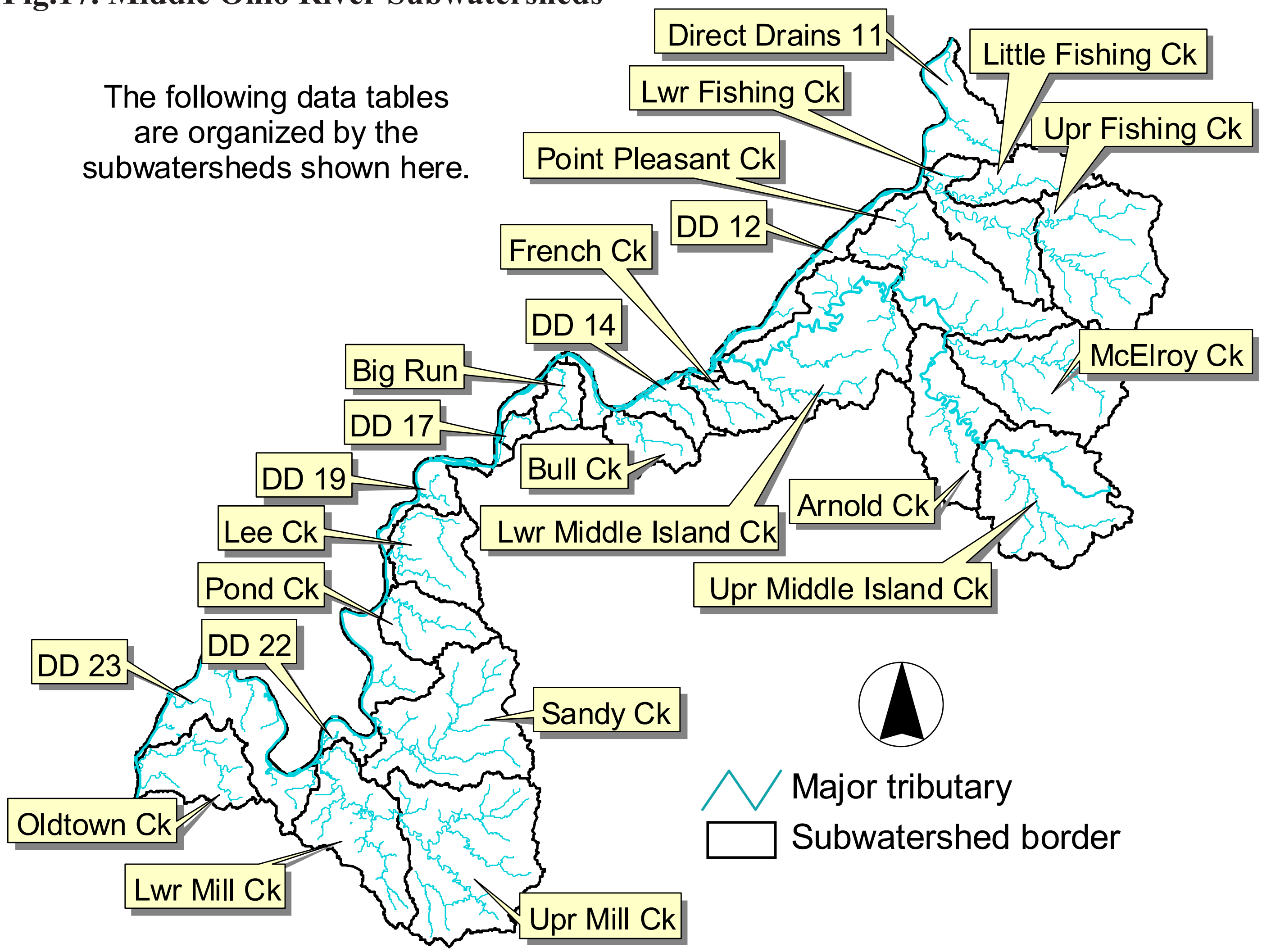


TABLE 1. Lower Middle Island Creek Subwatershed

Date	Stream Name	ANCode	Mile Point	WVSCI	RBP	pH	Sp Cond (umhos/cm)	Sulfate (mg/L)	TSS (mg/L)	Total Al (mg/L)	Total Fe (mg/L)	Fecal (col./ 100mL)
8/13/1998	Middle Island Creek	WVOMI	4.5			7.30	175	26		0.0725	0.382	<5
9/17/2003	Middle Island Creek	WVOMI	12.4	67.56	126	7.58	172					60
2/24/2004	Middle Island Creek	WVOMI	12.9			7.44	157	25	3	0.14	0.33	24
5/27/2004	Middle Island Creek	WVOMI	12.9			7.34	127	15.8	4	0.58	0.63	400
8/31/2004	Middle Island Creek	WVOMI	12.9			7.39	127	30.5	5	0.34	0.32	126
12/1/2004	Middle Island Creek	WVOMI	12.9			7.02	128	17.6	47.6	1.57	2.35	1250
8/12/1998	Middle Island Creek	WVOMI	22.4	66.99	131	7.50	186			0.16	0.318	280
9/17/2003	Middle Island Creek	WVOMI	36.2	52.06	103	7.86	135					73
9/17/2003	McKim Creek	WVOMI-4	1.3	73.14	125	7.66	174					200
5/3/1999	McKim Creek	WVOMI-4	4.8	64.81	135	7.20	155	20.9		<0.1	0.277	5700
8/13/1998	McKim Creek	WVOMI-4	4.8	75.8	142	7.60	190	16		<0.05	0.155	31
4/30/1999	McKim Creek	WVOMI-4	7.4	66.22	141	7.30	130	19.1		<0.1	0.231	56
8/13/1998	McKim Creek	WVOMI-4	7.4	79.71	139	7.50	233	16		<0.05	0.299	69
9/17/2003	McKim Creek	WVOMI-4	11.7	60.98	113	7.35	170					490
4/30/1999	McKim Creek	WVOMI-4	14.9	92.07	105	7.50	117	19.4		<0.1	0.184	82
5/28/2003	Bogart Run	WVOMI-6	0.7	97.09	157	7.20	172	27.9	8	0.83	1.02	20
9/17/2003	Sugar Creek	WVOMI-9	0.6	72.69	150	7.72	198					36
9/17/2003	Sugar Creek	WVOMI-9	9.3	63.89	97	7.75	215					180
8/12/1998	Cedar Run	WVOMI-12				7.10	250					30
8/12/1998	Allen Run	WVOMI-13				7.50	312					2800
9/11/2003	Buffalo Run	WVOMI-15	1.4	67.04	149	7.30	251					580
8/11/1998	Allen Run	WVOMI-19		49.16	97	7.50	446					440
9/8/2003	Sancho Creek	WVOMI-21	0.3	57.02	130	8.04	244		2			164
4/29/1999	Little Sancho Creek	WVOMI-21-A	1.6	81.32	116	8.00	151	24.4		<0.1	0.0695	54
8/10/1998	Little Sancho Creek	WVOMI-21-A	1.6	77.26	132	7.20	226	21.7		<0.05	0.194	550
8/11/1998	Grimms Run	WVOMI-21-D			78	7.30	304					99
5/6/2003	Indian Creek	WVOMI-29	11	72.96	144	7.45	114	16.9	6	0.35	0.41	<1

With no trees to hold the soil on this Mid Ohio North streambank, there is no “safe guard against Freshes” (see quote on next page).

TABLE 2. Mid Middle Island Creek Subwatershed

Date	Stream Name	ANCode	Mile Point	WVSCI	RBP	pH	Sp Cond (umhos/cm)	Sulfate (mg/L)	TSS (mg/L)	Total Al (mg/L)	Total Fe (mg/L)	Fecal (col./ 100mL)
5/4/1999	Middle Island Creek	WVOMI	42.8	59.11	138	7.70	149	18.1		<0.1	0.332	130
8/10/1998	Middle Island Creek	WVOMI	42.8	63.69	89	7.30	192	17.5		0.769	0.37	310
8/11/1998	Point Pleasant Creek	WVOMI-23		62.77	102	7.40	259					90
9/8/2003	Point Pleasant Creek	WVOMI-23	1	64.09	146	7.76	276					300
9/11/2003	Point Pleasant Creek	WVOMI-23	5.5	73.28	132	8.36	263					200
8/11/1998	First Run	WVOMI-23-0.1A		49.57	95	7.20	458					9
9/11/2003	Pursley Creek	WVOMI-23-A	0.2	69.36	122	7.75	271					200
8/11/1998	Dry Run	WVOMI-23-A-1		75.72	68	6.70	322					160
9/11/2003	Elk Fork	WVOMI-23-B	1.9	72.8	122	8.07	162					110
8/12/1998	Elk Fork	WVOMI-23-B	7.8	82.81	119	7.40	231	15.5		<0.05	0.128	56
5/5/1999	Elk Fork	WVOMI-23-B	7.8	57.68	125	7.20	141	17.4		<0.1	0.124	2000
9/8/2003	Elk Fork	WVOMI-23-B	7.9	65.61	136	7.68	157					410
4/21/2004	Elk Fork	WVOMI-23-B	8.5	87.6	130	7.54	107	16.3	<3	0.17	0.23	44
8/12/1998	Mudlick Run	WVOMI-23-B-3		51.92	118	8.80	131					32000
9/8/2003	Mudlick Run	WVOMI-23-B-3	0.1	72.53	138	7.18	118					89
4/21/2004	Lick Run	WVOMI-23-B-5	0.4	92.83	134	7.10	113	22.4	<3	0.22	0.62	20
8/11/1998	Coallick Run	WVOMI-23-C		48.53	98	7.00	256					690
5/20/2003	Buck Run	WVOMI-23-E-1	1	64.1	117	7.74	224	40.59	18	0.72	0.77	2
8/12/1998	Peach Fork	WVOMI-23-G		54.46	137	7.90	1634	198		<0.05	0.05	1900
9/8/2003	Peach Fork	WVOMI-23-G	0	50.93	113	7.83	351					10
8/10/1998	Jug Run	WVOMI-25		46.58	138	6.90	229	31		0.0587	0.279	2500
8/12/1998	Indian Creek	WVOMI-29	0	54.51	101	7.20	275	15		<0.05	0.554	300
9/9/2003	Indian Creek	WVOMI-29	0.2	66.21	123	7.45	227					140
8/19/1998	Indian Creek	WVOMI-29	1			7.50	283					
5/4/1999	Indian Creek	WVOMI-29	3.8	68.84	142	7.50	237	16.6		<0.1	0.267	220
9/9/2003	Indian Creek	WVOMI-29	7.5	73.91	148	7.29	277		<3			280
5/4/1999	Indian Creek	WVOMI-29	8.8	62.94	127	7.30	266	15.1		<0.1	0.212	180
9/9/2003	Big Run	WVOMI-29-A	0.4	71.63	124	7.80	228					62
5/4/1999	Big Run	WVOMI-29-A	1.4	46.47	121	8.40	132	21.9		<0.1	0.16	30
5/4/1999	UNT/Stackpole Rn RM0.8	WVOMI-29-H-2	0	91.85	112	7.70	121	15.6		<0.1	0.109	<2

"...clear five Acre fields in handsome squares upon every other Lott along the River Bank (leaving the Trees next the River standing, as a safe guard against Freshes [high flows] and Ice)..."

--George Washington's instructions to Valentine Crawford for leaving a riparian buffer zone on the lots he was developing for sale in the Mid Ohio North watershed. March 30, 1774.

TABLE 3. Upper Middle Island Creek Subwatershed												
Date	Stream Name	ANCode	Mile Point	WVSCI	RBP	pH	Sp Cond (umhos/cm)	Sulfate (mg/L)	TSS (mg/L)	Total Al (mg/L)	Total Fe (mg/L)	Fecal (col./ 100mL)
9/9/2003	McElroy Creek	WVOMI-30	0.3			6.70	241					116
5/3/1999	McElroy Creek	WVOMI-30	0.4	33.14	86	7.60	140	16.6		<0.1	0.329	220
8/19/1998	McElroy Creek	WVOMI-30	4.8	62.27	115	7.40	187	14		0.144	0.345	76
5/3/1999	McElroy Creek	WVOMI-30	8.8	41.13	125	7.80	132	16.1		<0.1	0.403	45
9/9/2003	McElroy Creek	WVOMI-30	12.4	67.97	145	7.34	169					50
9/8/2003	McElroy Creek	WVOMI-30	21	68.36	100	7.61	168					410
9/18/2003	Flint Run	WVOMI-30-H	0.8	67.46	93	7.74	195					48
5/4/1999	Flint Run	WVOMI-30-H	2	68.78	125	7.60	133	17.4		<0.1	0.267	260
5/3/1999	UNT/Little Flint Run	WVOMI-30-H-1-D	1.6	95.23	120	8.30	99	17.4		<0.1	0.121	110
9/9/2003	Broad Run	WVOMI-30-L	0.1	75.67	127	7.03	166					45
5/4/1999	Talkington Fork	WVOMI-30-N	1.6	78.76	112	7.60	113	16.4		<0.1	0.122	40
5/4/1999	Big Battle Run	WVOMI-30-O-2	1.5	85.6	122	7.60	118	16.9		<0.1	0.0659	600
9/10/2003	Middle Island Creek	WVOMI	57.8	81.66	145	7.58	175			0.46	0.55	109
9/11/2003	Middle Island Creek	WVOMI	73.9	52.55	136	7.72	206		8	0.21	0.56	380
9/18/2003	Middle Island Creek	WVOMI	73.9	53.61	104	7.77	234					300
5/3/1999	Conaway Run	WVOMI-32	0.8	75.05	113	7.70	96	16.4		<0.1	0.23	21000
9/10/2003	Arnold Creek	WVOMI-40	0.7	75.96	106	7.54	245					250
4/21/2004	Arnold Creek	WVOMI-40	4.2	74.09	137	8.41	175	20.1	<3	0.13	0.2	18
9/10/2003	Arnold Creek	WVOMI-40	6.4	76.52	101	7.47	260		12			168
8/18/1998	Wilhelm Run	WVOMI-40-E		51.81	125	7.30	366					240
5/3/1999	UNT/Middle Island Creek	WVOMI-41.5	0	65.16	124	7.60	141	18.9		<0.1	0.0911	<9
9/10/2003	Bluestone Creek	WVOMI-43	0.4	80.24	106	7.51	229		10			370
8/18/1998	Meathouse Fork	WVOMI-46		59.03	135	7.60	140					330
9/16/2003	Meathouse Fork	WVOMI-46	7.3	57.08	120	7.34	154					109
9/18/2003	Meathouse Fork	WVOMI-46	15.4	74.46	60	7.46	170					140
5/4/1999	Meathouse Fork	WVOMI-46	15.5	62.67	112	7.60	120	14.6		<0.1	0.326	72
4/19/2004	Meathouse Fork	WVOMI-46	16.5	52.71	117	7.27	148	14.6	<3	0.21	0.3	25
8/18/1998	Toms Fork	WVOMI-46-E		52.91	147	7.40	132					150
9/16/2003	Toms Fork	WVOMI-46-E	0.5	66.08	111	7.44	166					10
9/16/2003	Toms Fork	WVOMI-46-E	3.4	79.75	80	7.48	190					100
8/18/1998	Little Toms Fork	WVOMI-46-E-1		71.27	117	7.60	148					9700
5/4/1999	Brushy Fork	WVOMI-46-H	3	87.57	112	7.40	97	13.1		<0.1	0.35	1000
5/4/1999	UNT/Snake Run	WVOMI-46-I-1	0.4	96.54	132	7.70	75	14.6		<0.01	0.207	3600
8/18/1998	Beech Lick	WVOMI-46-L		75.64	117	7.50	109					400
9/9/2003	Buckeye Creek	WVOMI-47	0.4	71.15	146	8.05	243					158
9/9/2003	Long Run	WVOMI-47-D	0.2	72.56	121	7.87	184					173

TABLE 4. Upper Fishing Creek, Lower Fishing Creek, & Little Fishing Creek Subwatersheds												
Date	Stream Name	ANCode	Mile Point	WVSCI	RBP	pH	Sp Cond (umhos/cm)	Sulfate (mg/L)	TSS (mg/L)	Total Al (mg/L)	Total Fe (mg/L)	Fecal (col./ 100mL)
8/11/1998	Fishing Creek	WVO-69	6.6	72.32	119	7.30	210	25		0.05	0.139	27
9/10/2003	Fishing Creek	WVO-69	7.2	68.03	149	8.29	177					30
4/27/1999	Little Fishing Creek	WVO-69-C	0.4	50.12	130	7.90	163	29.5		0.1	0.179	70
8/11/1998	Little Fishing Creek	WVO-69-C	0.4	68.61	113	7.40	266	25		0.05	0.175	690
9/10/2003	Little Fishing Creek	WVO-69-C	0.9	70.92	155	8.36	168					200
4/27/1999	Little Fishing Creek	WVO-69-C	5.6	66.22	130	7.70	169	28		0.1	0.159	84
9/10/2003	Little Fishing Creek	WVO-69-C	9.3	78.07	122	7.87	198					150
9/10/2003	Little Fishing Creek	WVO-69-C	9.3	76.01	127	7.87	198					150
4/20/2004	Little Fishing Creek	WVO-69-C	17.6	47	145	7.82	162	22	<3	0.07	0.07	9
9/10/2003	Piney Fork	WVO-69-K	0.3	66.56	131	7.52	193					126
4/27/1999	Piney Fork	WVO-69-K	5	81.99	119	7.80	107	21.4		0.1	0.104	52
8/13/1998	South Fork/Fishing Creek	WVO-69-N		62.02	114	7.30	263					18000
9/9/2003	South Fork/Fishing Creek	WVO-69-N	0.8	42.22	124	7.97	184					78
5/7/2003	South Fork/Fishing Creek	WVO-69-N	5.7	71.78	127	7.69	128	21.21	<3	0.17	0.22	4
8/13/1998	South Fork/Fishing Creek	WVO-69-N	6.6	69.73	132	7.60	309	20.6		<0.05	0.121	
4/26/1999	South Fork/Fishing Creek	WVO-69-N	6.6	39.05	139	8.90	132	21.9		<0.1	0.159	9
8/13/1998	South Fork/Fishing Creek	WVO-69-N	7	66.05	115	7.70	306	27		<0.05	0.083	<6
4/26/1999	South Fork/Fishing Creek	WVO-69-N	7	56.18	131	8.90	131	22.4		<0.1	0.182	9
9/9/2003	South Fork/Fishing Creek	WVO-69-N	11.1	65.74	131	8.09	209					250
8/12/1998	South Fork/Fishing Creek	WVO-69-N	13.2		114	8.20	279	22.6		<0.05	0.176	110
4/26/1999	South Fork/Fishing Creek	WVO-69-N	13.2			9.00	118	21.7		<0.1	0.161	260
8/12/1998	South Fork/Fishing Creek	WVO-69-N	16.8	81.13	127	7.20	320	29		<0.05	0.0696	430
4/29/1999	South Fork/Fishing Creek	WVO-69-N	16.8	32	129	8.20	113	20.7		<0.1	0.0706	1100
8/12/1998	Stout Run	WVO-69-N-11		61.05	115	7.50	312					5600
9/9/2003	Buffalo Run	WVO-69-N-5	0.8	66.97	131	8.24	149					80
8/12/1998	Archers Fork	WVO-69-N-7		68.18	128	7.90	199					8000
8/12/1998	Fallen Timber Run	WVO-69-N-8		74.39	125	7.70	491					4000
9/9/2003	Price Run	WVO-69-N-9	0.4	50.84	133	7.82	187					2350
8/12/1998	Buck Run	WVO-69-N-9-B		75.32	113	7.00	263					2700
5/6/2003	Buck Run	WVO-69-N-9-B	0.8	79.33	128	7.32	106	22.6	12	0.49	0.63	6
8/12/1998	UNT/Pickenpaw Run	WVO-69-N-9-C-1	0.3	81.8	99	7.00	132	20.6		0.0586	0.169	38
4/26/1999	UNT/Pickenpaw Run	WVO-69-N-9-C-1	0.3	83.42	120	8.30	102	26.7		<0.1	0.181	9
4/20/2004	UNT/PickenpawRn RM1.6	WVO-69-N-9-C-2	0.6	92.01	139	6.95	80	18.4	7	0.39	0.36	12
9/9/2003	North Fork/Fishing Creek	WVO-69-O	0.2	65.35		7.73	163					550
8/11/1998	North Fork/Fishing Creek	WVO-69-O	8.2	66.12	125	6.80	181	16.7		<0.05	0.166	180
4/27/1999	North Fork/Fishing Creek	WVO-69-O	8.2	81.51	113	7.90	126	23.2		<0.1	0.141	250
9/10/2003	North Fork/Fishing Creek	WVO-69-O	11	71.84	128	7.58	159					550
8/11/1998	Betsy Run	WVO-69-O-2	0.4	66.88	125	7.20	229	25.7		<0.05	0.207	110
8/11/1998	Maud Run	WVO-69-O-3	0.4	61.43	114	7.00	236					420
8/11/1998	Garrison Fork	WVO-69-O-5-A		64.56	103	6.80	175					18
9/10/2003	Willey Fork	WVO-69-O-6	0.5	67.38	128	7.39	182					330
8/11/1998	Big Run	WVO-69-O-6-A		48.31	110	6.70	263					90

TABLE 5. Upper & Lower Mill Creek Subwatersheds

Date	Stream Name	ANCode	Mile Point	WVSCI	RBP	pH	Sp Cond (umhos/cm)	Sulfate (mg/L)	TSS (mg/L)	Total Al (mg/L)	Total Fe (mg/L)	Fecal (col./ 100mL)
8/20/2003	Mill Creek	WVO-32	4.1			7.81	146		19			104
9/3/1998	Mill Creek	WVO-32	18.7	61.68	113	6.30	124	12		0.231	1.49	520
4/12/1999	Mill Creek	WVO-32	19.6	21.74	88	7.80	143	18		<0.1	0.615	200
8/25/2003	Mill Creek	WVO-32	25	67.8	84	7.06	157		8			175
8/21/2003	Parchment Creek	WVO-32-H	1.3	58.23	95	6.93	202		7			160
4/19/1999	Parchment Creek	WVO-32-H	2.2	61.55	123	8.30	190	21.1		0.128	0.711	620
8/24/1998	Parchment Creek	WVO-32-H	2.4	71.98	80	7.20	191	11		1.3	1.5	600
4/12/1999	Parchment Creek	WVO-32-H	4.8	37.51	103	6.70	212	21		0.108	0.736	320
4/12/1999	Parchment Creek	WVO-32-H	7.4	73.02	98	7.10	206	20		0.128	0.69	300
4/21/2004	Wolfe Creek	WVO-32-H-8	1.3	81.07	123	8.19	188	18.8	<3	0.23	0.19	110
4/22/1999	Bear Fork	WVO-32-L-4.5	0.4	77.63	163	7.40	123	18.9		<0.1	0.21	20
8/25/1998	Grasslick Creek	WVO-32-L-7	2.9	69.27	101	7.50	248					360
5/28/2003	Grasslick Creek	WVO-32-L-7	3	71.02	126	7.45	214	17.47	13	0.37	0.69	350
8/26/2003	Grasslick Creek	WVO-32-L-7	9.4	61.42	100	7.73	320		4			114
4/12/1999	Grasslick Creek	WVO-32-L-7	11.6	39.62	117	6.90	260	19		<0.1	0.073	20000
8/25/1998	Stonelick Run	WVO-32-L-7-B		64.22	101	7.20	286	12		0.8	0.093	27
8/25/1998	Pleasant Valley Run	WVO-32-L-7-F		69.13	74	7.90	229					200
4/22/1999	Bear Fork	WVO-32-L-8	2.4	90.77	168	7.60	136	18.1		0.106	0.293	320
4/22/1999	Laurel Run	WVO-32-L-8-B	0.8	86.84	147	7.50	134	19.4		<0.1	0.05	200
8/25/1998	Elk Fork	WVO-32-M	6.8	80.28	83	7.30	166	14.2		<0.05	0.103	500
8/25/1998	Little Mill Creek	WVO-32-N		66.93	87	7.10	178					220
8/25/2003	Little Mill Creek	WVO-32-N	0.2	62.89	120	7.08	180		7			>1200
4/20/1999	Frozencamp Creek	WVO-32-N-3	2	98.83	143	7.90	119	19.4		<0.1	0.167	18
4/19/1999	Little Creek	WVO-32-N-5	0.8	79.57	120	8.30	139	18.8		<0.1	0.155	130
4/20/1999	UNT/Poplar Fork	WVO-32-N-5-B-2	0.5	88.06	131	7.80	133	22.4		0.464	0.84	1000

TABLE 6. Sandy Creek Subwatershed

Date	Stream Name	ANCode	Mile Point	WVSCI	RBP	pH	Sp Cond (umhos/cm)	Sulfate (mg/L)	TSS (mg/L)	Total Al (mg/L)	Total Fe (mg/L)	Fecal (col./ 100mL)
8/24/1998	Sandy Creek	WVO-36	4.6			7.10	285	15.2		<0.05	0.297	400
8/27/2003	Sandy Creek	WVO-36	6.4									52
8/24/1998	Sandy Creek	WVO-36	7.2	45.14	89	6.80	232	16.7		0.315	1.05	240
8/27/2003	Sandy Creek	WVO-36	7.4			6.94	297					56
4/13/1999	Sandy Creek	WVO-36	8.6	48.74	111	7.20	232	24		<0.1	0.797	84
4/26/1999	Trace Fork	WVO-36-G	2.6	70.75	94	7.80	160	24.2		<0.1	0.0691	320
4/15/1999	Right Fork/Sandy Creek	WVO-36-I	4.2	87.68	86	7.10	165	21		<0.1	1.05	510
4/15/1999	Fallen Timber Run	WVO-36-I-10	0.6	78.38	98	7.40	174	28		<0.1	0.0948	430
5/28/2003	Cabin Run	WVO-36-I-12	0	69.17	94	8.05	145	19.7	<3	0.18	0.21	1750
9/3/1998	Left Fork/Sandy Creek	WVO-36-J	1			7.00	284	8		<0.05	0.329	>60000
4/13/1999	Left Fork/Sandy Creek	WVO-36-J	1.2	43.57	115	7.30	231	27		0.375	0.992	280
4/12/1999	Left Fork/Sandy Creek	WVO-36-J	10.8		79	7.50	186	26		<0.1	0.211	900
4/12/1999	UNT/Nicholas Hollow	WVO-36-J-10-A	0.3	85.94	102	7.50	184	31		<0.1	0.51	18
4/26/1999	Turkey Fork	WVO-36-J-3	3.6	71.61	117	7.20	193	24.4		<0.1	0.0817	400
8/27/2003	Nesselroad Run	WVO-36-J-5	0.1			7.40	347					150
4/12/1999	Nesselroad Run	WVO-36-J-5	1.4	56.25	60	7.50	296	32		<0.1	0.0975	520
5/28/2003	Redbush Run	WVO-36-J-5-C	0	71.36	98	7.69	190	23.8	6	0.26	0.29	530
5/28/2003	Redbush Run	WVO-36-J-5-C	0.9	71.74	148	7.13	158	24.6	<3	0.36	0.38	220
4/21/2004	Lockhart Fork	WVO-36-J-8	1.4	86.38	120	7.46	160	24	5	0.61	0.51	102

TABLE 7. Mid Ohio River Direct Drains Subwatersheds

Date	Stream Name	ANCode	Mile Point	WVSCI	RBP	pH	Sp Cond (umhos/cm)	Sulfate (mg/L)	TSS (mg/L)	Total Al (mg/L)	Total Fe (mg/L)	Fecal (col./ 100mL)
8/19/2003	Tenmile Creek	WVO-23	3.4	50.7	117	4.67	1024	580	10	7.05	6.23	<2
8/25/1998	Sliding Hill Creek	WVO-24		45.89	104	7.20	1401	520		1.4	0.82	108
8/20/2003	UNT/Sliding Hill Ck RM1.2	WVO-24-A	0.1	53.03	124	7.02	1014	478	<5	0.06	0.35	82
8/20/2003	Broad Run	WVO-25	2.3	69.48	97	7.16	321		<3			260
4/13/1999	Claylick Run	WVO-30-A	1.6	84.25	151	7.10	171	37		<0.1	0.05	60
8/27/2003	Little Mill Creek	WVO-31	4.4			7.05	315					230
8/24/1998	Little Mill Creek	WVO-31		51.19	92	7.50	264	10		0.94	0.24	162
4/13/1999	Right Fork/Little Mill Ck	WVO-31-A	0.6	81.93	130	6.70	111	28		<0.1	0.0573	64
8/24/1998	Spring Creek	WVO-33		39.16	105	7.30	261					1800
4/26/1999	Little Sandy Creek	WVO-38	2.1	41.84	120	7.60	237	31.5		<0.01	0.317	340
5/29/2003	UNT/Sandy Ck RM 4.5	WVO-46-J	0.7	29.53	75	7.52	208	23.6	<3	0.18	0.36	570
4/19/2004	Briscoe Run	WVO-49	1.4	40.08	98	8.18	340	43.1	<3	0.11	0.14	8
9/11/2003	Cow Creek	WVO-55	1.8	62.34	150	7.68	500	38.5	7	0.19	0.46	130
5/20/2003	Bukey Run	WVO-55-F.7	1	77.39	149	7.08	175	42.1	8	0.22	0.26	9
8/11/1998	Sugarcamp Run	WVO-63				7.50	555	121		0.507	0.835	250
8/11/1998	Owl Run	WVO-68		84.9	132	7.10	378					140
4/27/1999	UNT/Ohio R RM 159.6	WVO-68.2	0.9	80.27	116	7.80	211	46.9		0.605	0.0819	10
8/11/1998	UNT/Ohio R RM 159.6	WVO-68.2	1.1	68.89	129	7.40	223	39		0.264	0.447	400
4/28/1999	Williams Run	WVO-70	0.2	61.27	101	7.90	281	51.9		<0.1	0.089	18
9/9/2003	Proctor Creek	WVO-72	1.1	76.86	160	8.18	237					109
4/29/1999	UNT/Proctor Creek	WVO-72-A.11	2.6	87.86	163	7.40	208	29		0.263	0.398	28
4/28/1999	UNT/Left Fk/Proctor Ck	WVO-72-A-3	0.6	82.61	168	8.00	186	34.3		<0.1	0.104	18

TABLE 8. Mid Ohio Miscellaneous Tributary Subwatersheds													
Date	Stream Name	ANCode	Mile Point	WVSCI	RBP	pH	Sp Cond (umhos/cm)	Sulfate (mg/L)	TSS (mg/L)	Total Al (mg/L)	Total Fe (mg/L)	Fecal (col./ 100mL)
4/19/1999	Crooked Creek	WVO-20.5	2.6	77	138	8.20	307	55.4		<0.1	0.231	210
8/25/1998	Oldtown Creek	WVO-21	6.7	66.35	92	7.20	218	12		1.3	0.65	36
8/19/2003	Oldtown Creek	WVO-21	8.7	72.61	115	7.20	213		14			1100
8/19/2003	Oldtown Creek	WVO-21	15.1	53.92	113	7.07	223		3			600
4/13/1999	Potter Creek	WVO-21-A	0	58.28	103	7.20	298	73		<0.1	0.133	32
8/18/2003	Trace Fork	WVO-21-C	0.6	54	104	6.99	195		<3			170
4/20/1999	Trace Fork	WVO-21-C	2.4	79.41	124	8.10	199	36.3		<0.1	0.141	24
5/27/2003	Trace Fork	WVO-21-C	3.6	66.24	120	7.43	224	54.9	8	0.39	0.45	600
6/2/2003	UNT/Oldtown Ck RM20.3	WVO-21-J	0.5	80.41	125	7.82	244	34.9	6	0.34	0.4	210
8/28/2003	Pond Creek	WVO-43	10			7.23	340					1350
4/28/1999	Pond Creek	WVO-43	3.6	38.36	78	7.50	269	31.3		0.1	0.85	400
4/28/1999	Pond Creek	WVO-43	5.8	72.74	101	7.60	269	30.8		<0.1	0.67	360
4/21/2004	Long Run	WVO-43-C	0.1	84.31	121	7.67	223	30.5	4	0.73	0.62	120
8/28/2003	Little Pond Creek	WVO-43-D	0.8			7.37	267					82
4/20/2004	Little Pond Creek	WVO-43-D	6.6	74.98	99	7.68	215	33	3	0.53	0.43	4
6/2/2003	Jerrys Run	WVO-43-H	1.9	69.18	120	7.79	272	23.7	4	0.1	0.12	2750
4/19/2004	Joshus Fork	WVO-43-K	0.1	66.21	106	8.30	273	25.3	<3	0.14	0.12	22
8/26/1998	South Fork/Lee Creek	WVO-44-A				7.10	307	19		0.139	0.364	1000
4/29/1999	South Fork/Lee Creek	WVO-44-A	3	57.13	102	7.70	255	35.8		<0.1	0.47	200
8/28/2003	South Fork/Lee Creek	WVO-44-A	3.4			7.27	263					76
8/26/1998	North Fork/Lee Creek	WVO-44-B				6.80	276	14		<0.05	0.201	300
8/28/2003	North Fork/Lee Creek	WVO-44-B	2.6			7.22	295					42
4/29/1999	North Fork/Lee Creek	WVO-44-B	3	53.54	113	7.80	246	29.2		<0.1	0.376	80
4/20/2004	North Fork/Lee Creek	WVO-44-B	3.3	38.24	98	7.82	216	23.7	<3	0.25	0.55	17
8/27/2003	North Fork/Lee Creek	WVO-44-B	9.9			7.16	288					150
4/29/1999	Big Run	WVO-50	9	51.41	117	7.90	364	43.8		<0.1	0.0615	84
9/15/2003	Bull Creek	WVO-53	3.7	65.41	101	7.76	292					1300
4/28/1999	French Creek	WVO-57	1.8			7.60	200	31.3		<0.1	0.343	100
8/13/1998	French Creek	WVO-57	1.8	51.26	99	7.50	215	25		0.296	0.483	300
9/15/2003	French Creek	WVO-57	3.6	68.25	137	7.71	240					850
9/17/2003	French Creek	WVO-57	7.7	69.82	118	8.01	221					390

NOTES

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