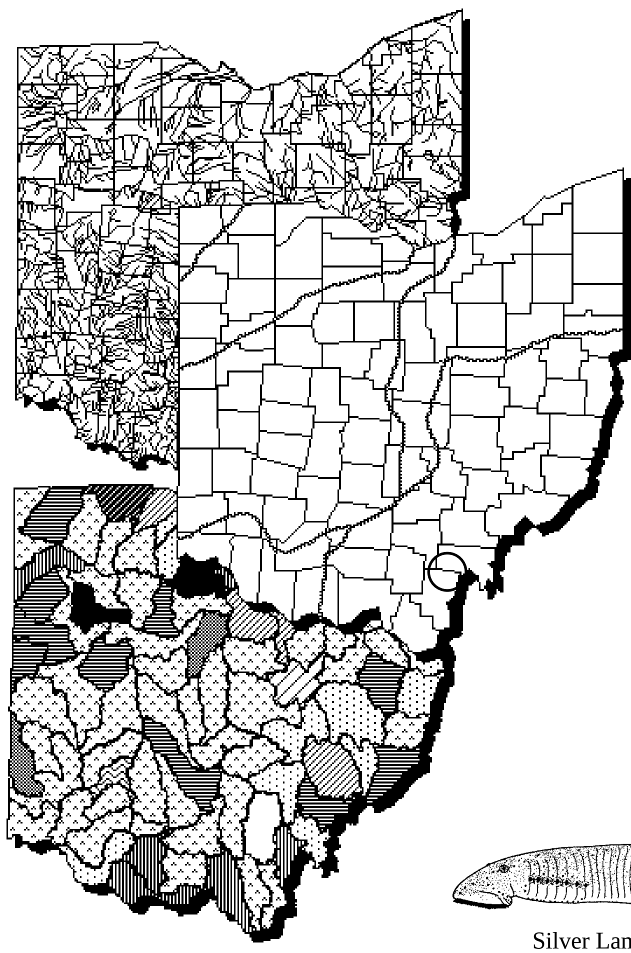
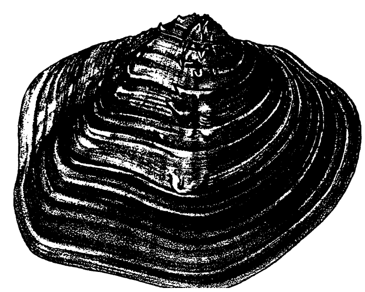
State of Ohio
Environmental Protection Agency

Ecological Assessment Section
Division of Surface Water

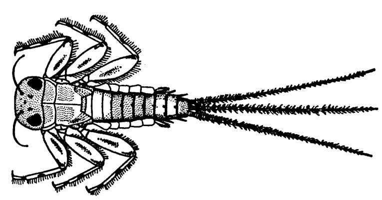
Ecological Recovery Endpoints for Streams Affected by the Meigs #31 Mine Discharges during July - September 1993

Leading Creek & Raccoon Creek Watersheds
Meigs, Vinton, and Gallia Counties



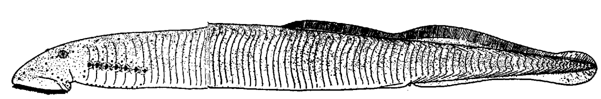


Mapleleaf
(*Quadrula quadrula*
Rafinesque, 1820)



Mayfly *(Stenonema)*

March 2, 1994
-Final-



Silver Lamprey(*Ichthyomyzon unicuspis*)

P.O. Box 1049, 1800 WaterMark Dr., Columbus, Ohio 43266-0149

Ecological Recovery Endpoints for Streams Affected by the Meigs #31 Mine Discharges during July - September 1993

OEPA Report Number EAS/1994-1-1

March 2, 1994

Ohio EPA, Division of Surface Water
Ecological Assessment Section
1685 Westbelt Drive
Columbus, Ohio 43228

Errata Sheet for

"Ecological Recovery Endpoints for Streams Affected by the Meigs # 31 Mine Discharges during July-September 1993"

This errata sheet (1) clarifies the monitoring schedule required in these segments, and (2) adds some new "key" macroinvertebrate taxa, thought to be sensitive to metal toxicity in sediments, to some of the segments in the study area, (3) - (5) clarifies sampling effort and biological index calculation for endpoint attainment, (6) clarifies amphibian endpoints, and (7) clarifies and modifies the procedure for counting key fish and macroinvertebrate taxa.

1. Clarification of Monitoring Requirements: This text replaces and clarifies the text relating to monitoring at the bottom of page four:

"Monitoring will be required until final endpoints are reached for all organism groups. After an individual organism group's final endpoints are reached for two consecutive years, the sampling effort will be reduced in frequency to a single macroinvertebrate artificial substrate sample per station or two fish samples per station. After both fish and macroinvertebrates attain endpoints for three consecutive years, the sampling effort is further reduced to monitoring of key stations in each segment to confirm that endpoints are being maintained until all applicable organism group endpoints are attained."

2. Key Macroinvertebrate Taxa:

For Leading Creek Segment 3 (RM 9.1-15.6):

REMOVE: *Polycentropodidae*

ADD: *Nytiophylax* sp.

Microtendipes "caelum"

For Raccoon Creek:

ADD: *Cyrnellus fraternus*

Hydropsyche (H.) *simulans*

Polypedium (*Tripodura*) *halterale* gr.

Dicrotendipes modestus

For Strongs Run:

ADD: *Tanytarsus glabrescens* gr.

For Sugar Run:

ADD: *Oxyethira* sp.
Dicrotendipes modestus

For Robinson Run

ADD: *Tanytarsus guerlus* gr.
Hexagenia sp.

3. ***Sampling Effort*** - Ohio EPA sampling guidance documents for collecting biosurvey data discuss problems with inadequate fish sampling efforts (i.e., underestimating the actual fish community biological integrity due to a poor estimate of fish species richness, abundance, and variability of proportional metrics). While over-sampling is much less of a likelihood than undersampling (i.e., estimates of relative abundance and proportional metrics are not likely to be affected), the biocriteria were calibrated on samples collected with a "reasonable" level of effort and certain of the "structural" metrics (e.g., species richness) could be inflated if sampling effort is extraordinarily intensive. The 90th percentile time fished for wadeable sites in Ohio streams is 55 minutes (median = 32.8 minutes; N = 3,648 samples). To ensure that IBI scores are not inflated by an extraordinary sampling effort, samples where the time fished is greater than the 90th percentile (55.0 minutes) may not be considered valid upon examination by Ohio EPA biologists.

4. ***Clarification of IBI Calculations Based on "Minimum" Species Richness for a Segment*** - IBI values calculated where the number of species in a sample pass are less than the "minimum" defined for a segment shall be used in calculating an average IBI for interim endpoint achievement (being sure to make all low-end scoring adjustments). However, achievement of a final endpoint cannot be certified unless the minimum species richness is met or exceeded for each sampling pass in a given year. IBI values calculated with less than the minimum number of species are not to be ignored in characterizing the conditions in these streams.

Achievement of a final IBI endpoint needs to consider the influence of young-of-the-year fish (YOY) on index calculation. The achievement of MIwb endpoints will be considered sufficient evidence that multiple-year classes for most fish species are present in streams > 20 sq mi drainage. If conductivity precludes MIwb calculation in Leading Creek (*i.e.*, the IBI becomes the sole endpoint for fish) or the Ohio EPA determines that YOY fish may be having an undo influence on IBI calculations (*i.e.*, adult fish are in low abundance), Ohio EPA may require that the IBI be calculated for certain sites in two ways:

1.) with YOY individuals included in the statistics and,

2.) with YOY individuals excluded from the data.

YOY fish to be excluded are fish greater than 15-20 mm (fish 15-20 mm should not be collected at all) that are obviously hatched in the present year. By September or when such fish cannot be readily distinguished from year I fish, they are considered juveniles or adults and not YOY fish. To be considered usable for achievement of final endpoints an IBI score cannot be affected by the presence of YOY fish more than:

1) the IBI is affected at control stations (e.g., Leading Creek at RM 16.8), plus:

2) four points (to account for natural variation).

Thus, for example, if in segment 3 of Leading Creek the control site variation in the IBI with and without YOY is 4 points (e.g.,$IBI_{YOY} - IBI_{NOYOY} = 4$, + 4 points to account for natural variation) then an IBI at an affected site where $IBI_{YOY} - IBI_{NOYOY} > 8$ points would not achieve the IBI endpoint for that sampling station.

5. ***ICI scores treated individually for attainment of endpoints*** **-** Unlike IBI and MIwb values, which are averaged to determine endpoint attainment, each individual, valid ICI score at a sampling station must independently meet the appropriate endpoint. However, one valid ICI score will suffice to demonstrate achievement of the final endpoint if circumstances preclude the collection of two samples and the calculation of two valid ICI scores. This supersedes the notation of a “minimum mean ICI” as depicted in Figure 4 on page 11 of the document.

6. ***Clarification of Amphibian Endpoints*** **--**This paragraph modified and clarifies the required endpoints for amphibians in the Endpoints Document. Collection of mudpuppies at four sampling stations in segment 3 and one site in segment 1 or 2 is the stated endpoint. In response to a suggestion from SOCCO, we have modified the designated sampling stations for demonstrating the attainment of the amphibian endpoint in Leading Creek as follows:

SOCCO has identified seven locations in Segment 3 that appear to have suitable mudpuppy habitat. Once biological sampling demonstrates the presence of adults and juveniles in at least four of the seven aforementioned sampling stations, then OEPA will select four of these locations as the Sampling Stations for demonstration of attainment of the amphibian final endpoint. The new Sampling Stations shall merely replace the locations identified in the Endpoints Document. OEPA will provide both SOCCO and U.S. EPA with notice of its selection in writing. Sampling Stations will not be redesignated after such notice.

Although the Endpoints Document did not specify that adults and juveniles must be collected in Leading Creek, this has been the intent with each of the other organism groups (fish, macroinvertebrates, and mussels). Thus, we are clarifying that, not withstanding anything suggested in Table 1 of the Endpoints Document, for this endpoint both juveniles and adults must be collected at each Sampling Station approved by OEPA pursuant to the preceding paragraph for three consecutive years to satisfy the final endpoint.

7. ***Relatively Rare Species and Counting of Key Taxa*** **-** Upon recovery of the effected streams most of the key fish and macroinvertebrate taxa would be expected to be routinely captured in each segment during each year of monitoring by SOCCO. Some species, however, may be relatively less frequently captured. For three key fish species, shorthead redhorse, black redhorse, and silver lamprey, Ohio EPA collections may be used, in addition to SOCCO collections, to determine whether these species have been collected in a given segment for a given year. In addition, for the shorthead redhorse, the presence of adults will suffice for determination of endpoint attainment. For the silver lamprey and least brook lamprey the presence of ammocoetes is sufficient to confirm the presence of these species. For purposes of demonstrating return of key macroinvertebrate taxa, all collections by SOCCO and Ohio EPA at sampling sites within a segment in a given year can be used. This includes any sample deemed invalid for the computation of an ICI score during the summer/fall index period.

Although the river redhorse is a regular member of the Ohio River ichthyofauna, there is uncertainty about whether it is a permanent member of the Leading Creek ichthyofauna. The river redhorse is most likely to be present as adults during spring or early summer to spawn and/or feed on the mollusk community of Leading Creek. The existing endpoints may be used to satisfy the requirements for this species (adults captured each year in segment three of Leading Creek for three consecutive years). As an alternative, however, SOCCO may conduct a three year study on the status of this species in Leading Creek and a similar sized reference stream (that is also a direct tributary to the Ohio River). This data can be used to show that populations of river redhorse in Leading Creek are not substantially different from minimally impacted reference streams, and then, by inference, from pre-discharge conditions in Leading Creek. Possible reference streams in the same area of the state with similar drainage areas, populations of mollusks, and that are direct tributaries to the Ohio River include the Shade River, Pine Creek, and the Little Scioto River. The study shall consist of a search (visual and trap netting, fyke netting or electrofishing) for spawning adults in Leading Creek and the reference stream (similar effort in each stream) in late April and early May (the species has been observed spawning in Ohio in early May at 16 ˚ C; Alban and Thoma, personal communication) and a similar search for feeding adults during late May and early June. The earlier period will coincide with the time period that SOCCO will be searching for the silver lamprey in Leading Creek. The three year period will extend sampling until *Corbicula* and other mollusk populations recover sufficiently to act as a food source. A short proposal will be prepared by SOCCO and approved by Ohio EPA.

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NOTICE TO USERS

Ohio EPA adopted biological criteria into the Ohio Water Quality Standards (WQS; Ohio Administrative Code 3745-1) regulations in February 1990 (Effective May 1990). These criteria consist of numeric values for the Index of Biotic Integrity (IBI) and Modified Index of Well-Being (MIwb), both of which are based on fish, and for the Invertebrate Community Index (ICI), which is based on macroinvertebrates. Criteria for each index are specified for each of Ohio's five ecoregions, and are further organized by organism group, index, site type, and aquatic life use designation. These criteria, along with the chemical and whole effluent toxicity evaluation methods, figure prominently in the assessment of Ohio’s surface water resources.

Several documents support the adoption of the biological criteria by outlining the rationale for using biological information, the specific methods by which the biocriteria were derived and calculated, the field methods by which sampling must be conducted, and the process for evaluating results. These documents are:

Ohio Environmental Protection Agency. 1987a. Biological criteria for the protection of aquatic life: Volume I. The role of biological data in water quality assessment. Division of Water Quality Monitoring & Assessment, Surface Water Section, Columbus, Ohio.

Ohio Environmental Protection Agency. 1987b. Biological criteria for the protection of aquatic life: Volume II. Users manual for biological field assessment of Ohio surface waters. Division of Water Quality Monitoring & Assessment, Surface Water Section, Columbus, Ohio.

Ohio Environmental Protection Agency. 1989a. Addendum to Biological criteria for the protection of aquatic life: Volume II. Users manual for biological field assessment of Ohio surface waters. Division of Water Quality Planning & Assessment, Ecological Assessment Section, Columbus, Ohio.

Ohio Environmental Protection Agency. 1989b. Biological criteria for the protection of aquatic life: Volume III. Standardized biological field sampling and laboratory methods for assessing fish and macroinvertebrate communities. Division of Water Quality Planning & Assessment, Ecological Assessment Section, Columbus, Ohio.

Ohio Environmental Protection Agency. 1990a. The use of biological criteria in the Ohio EPA surface water monitoring and assessment program. Division of Water Quality Planning & Assessment, Ecological Assessment Section, Columbus, Ohio.

Rankin, E.T. 1989. The qualitative habitat evaluation index (QHEI): rationale,methods, and application. Division of Water Quality Planning & Assessment, Ecological Assessment Section, Columbus, Ohio.

These documents and this document can be obtained by writing to:

Ohio EPA - DSW
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Ecological Recovery Endpoints for Streams Affected by the Meigs #31 Mine Discharges during July - September 1993

Introduction

This document lays out the specific ecological endpoints that the Ohio EPA will use to ascertain recovery of the biological, physical, and chemical characteristics of the streams affected by the discharge of untreated and partially treated mine waters from the Meigs # 31 Mine during July - September 1993. These endpoints were derived from pre-discharge and historical data and also incorporate the concepts underlying the biological criteria in Ohio's Water Quality Standards. Biological data from the impacted streams will be used to determine whether or not recovery has occurred. The overall assessment process is summarized in the flow chart in Figure 1.

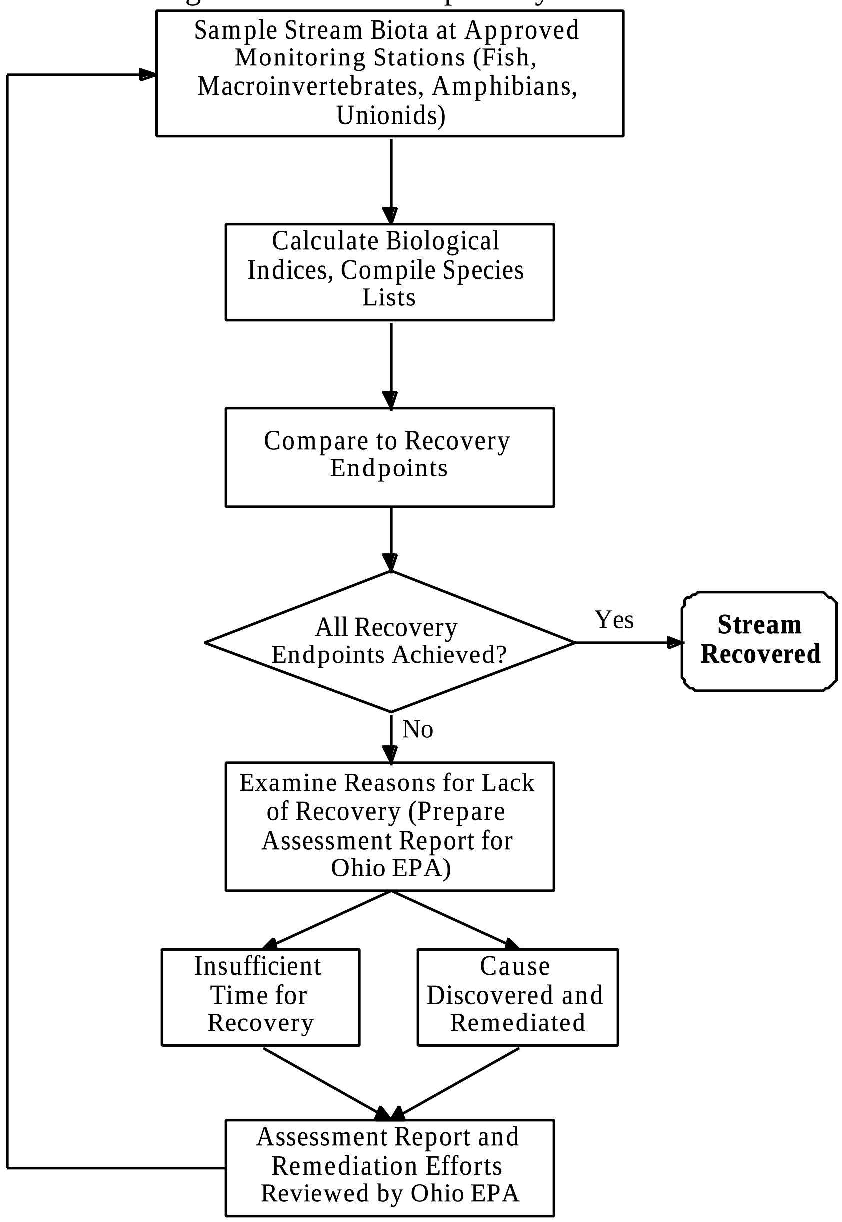


Figure 1. Process for assessing progress towards recovery endpoints in streams affected by the Meigs #31 Mine discharge during 1993.

General Considerations

Ecological Endpoints

Attainment of the ecological endpoints detailed here will be determined on the basis of data collected using approved Ohio EPA protocols for biological (fish and macroinvertebrates; Ohio EPA 1987, 1989a, 1989b; Rankin 1989), chemical, and physical data (Ohio EPA 1992) or, for amphibians and unionids mussels, generally accepted sampling methods supported by the scientific literature.

Fish Communities

For fish assemblage data, a satisfactory demonstration of full recovery will be dependent on samples (minimum of three sampling passes) collected between June 15 and October 15 under normal summer flow conditions. However, data collected outside of this index period may provide information which is useful to support a showing that recovery is occurring. This summer-fall index period is when resident fish species comprise the majority of the specimens that are usually collected and when there is evidence that successful reproduction and growth has occurred. The ecological endpoints specified here *do not* require that each fish species be found in the *exact* proportions which occurred in the historical data. Instead, we are relying on the attainment of *similar* biological index scores (IBI, MIwb, ICI) found under pre-discharge conditions which reflect the composite of: 1) a similar species richness[1], 2) a restoration of *similar* structural and functional proportions within the assemblage, and 3) the return of a similar abundance of all *key fish species* that indicate the return of environmental attributes found during pre-discharge conditions.[2] These key species must be present as both *recruits and as sexually mature individuals* for species where such distinctions are usually evident (*e.g.*, centrarchids, suckers, some cyprinids). Ecological endpoints are specified by the individual stream and stream segments affected by the discharges.

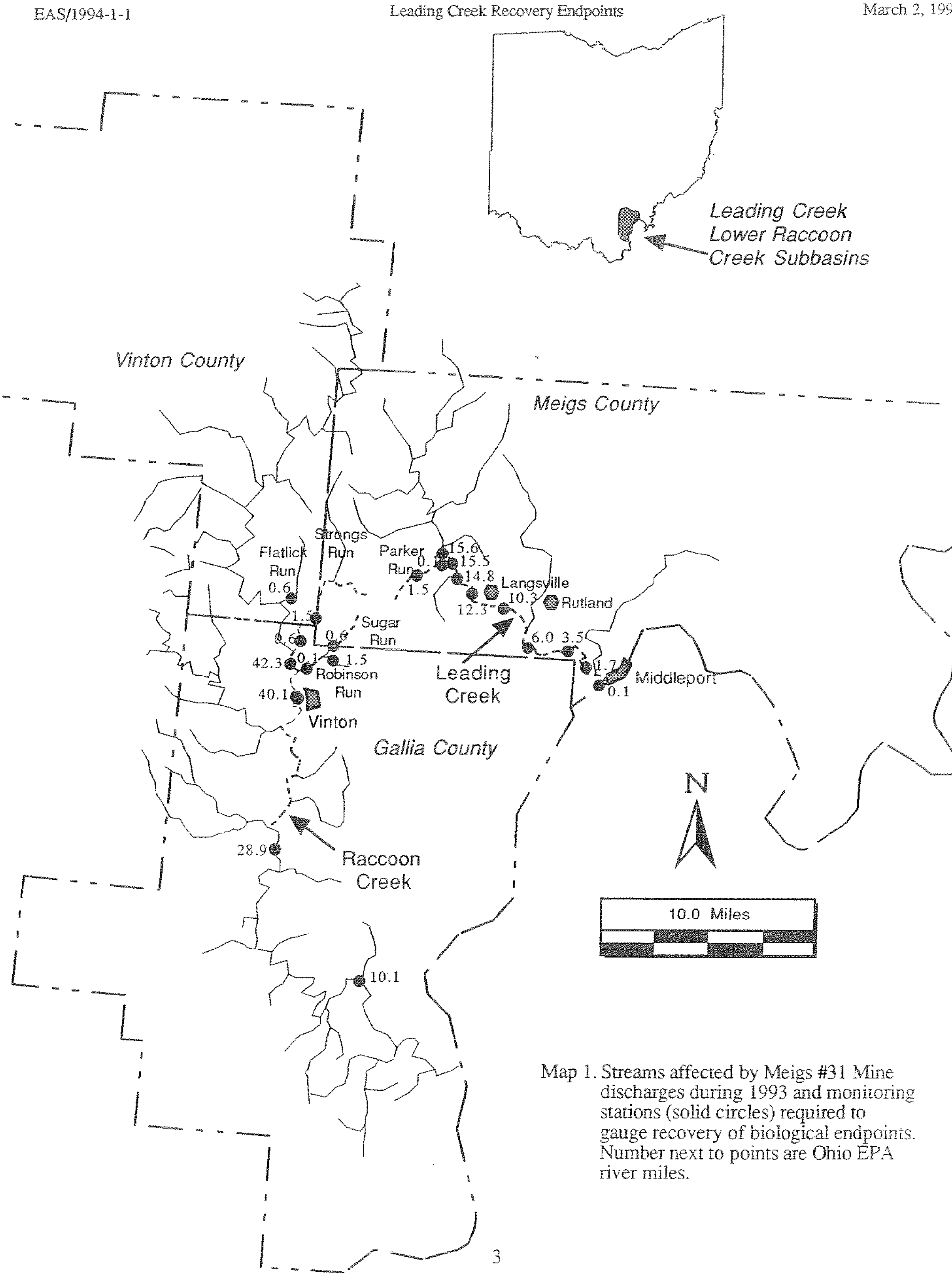
Macroinvertebrate Communities
Requirements for recovery of the macroinvertebrate community will be similar to those for the fish community and will include a principal reliance on biological index scores (ICI) found under pre-discharge conditions which reflect the composite of: 1) the return of key macroinvertebrate species, 2) the restoration of *similar* structural and functional proportions within the assemblage, and 3) a *similar* taxa richness based on Ohio EPA approved methods as specified in Ohio EPA's biological methods manuals (Ohio EPA 1987, 1989a, 1989b).

Unionid Mussel Communities
Requirements for the recovery of the unionid mussel community will be based on the collection of recruits *and* sexually mature individuals of the species previously known to exist in each stream or stream segment (Appendix Table 3). Because of the length of time needed to recolonize, monitoring for unionid mussel recovery is likely to extend for at least 3-10 years or more before attainment of the recovery endpoints can be verified.

Amphibian Communities
ODNR fish kill investigations and electrofishing collections by Ohio EPA staff documented the presence of mudpuppies (*Necturus maculosus*) from multiple sites in Leading Creek (Appendix Table 5). This species will be used as the indicator species for amphibians. Many amphibians have declined in distribution in Ohio (Pfingsten and Downs 1989) and worldwide (Lohmeier 1990) and the population of mudpuppies in Leading Creek is significant for this area (Western Allegheny Plateau ecoregion) of Ohio. The presence of mudpuppies at *each* of the four locations in segment 3 of Leading Creek, where individuals (mostly dead) were collected during the summer discharge of untreated mine water, and at *one other* site in segment 1 or 2, will be the endpoint for this group. Collections can be made using traps and/or other methods as discussed in Pfingsten and Downs (1989) or other relevant sources (*e.g.*, Heyer *et al.* 1993).

[1]When comparing post-discharge IBIs to endpoints based on historical and pre-discharge IBIs, a similar species richness should be present. "Minimum" species richness values for each stream or segment have been defined based on the low range of species richness in a stream or segment. Although IBIs calulated with fewer species are "valid" (e.g., for determination of interim endpoints), such IBIs will likely be missing key species and thus, the segment or stream will not acheive the final endpoint for that segment.

[2]The following species must have at least one specimen collected for each applicable stream preserved as a voucher to be deposited at the Ohio State University Museum of Biological Diversity: river redhorse, shorthead redhorse, black redhorse, longnose gar, sand shiner, silver lamprey (ammocoete), and least brook lamprey (ammocoete).



Map 1. Streams affected by Meigs #31 Mine discharges during 1993 and monitoring stations (solid circles) required to gauge recovery of biological endpoints. Number next to points are Ohio EPA river miles.

Other Biological Communities
Although major impacts to non-aquatic species were not expected, the loss of the aquatic fauna in the area streams as a food source for terrestrial species (e.g., fish-eating mammals and birds) *or* the transfer of contaminants to these terrestrial species via ingestion of water, aquatic organisms, or precipitate is a possibility. Any reports about declines in these groups will be investigated, and if needed, recovery endpoints will be generated for these terrestrial species as well.

Physical/Chemical Considerations
Although the recovery of the biological communities discussed above will be the primary focus of the Meigs #31 Mine restoration, achieving these ecological endpoints will be precluded by inadequate water quality and degraded habitats, as was amply demonstrated during and after the discharges. The restoration of key chemical and physical attributes is a prerequisite for ecological recovery and these will also need to be monitored. Ohio EPA will focus on the response of lithophilic and psammophilic species to detect effects of degraded and contaminated sediments. Attributes considered important include:

1. <u>Sediment chemistry</u>: Concentrations of heavy metals in fine sediments should be similar to ecoregional reference levels for Western Allegheny Plateau ecoregion streams. Concentrations can be compared to ecoregional reference values (available from Ohio EPA) as well as results from upstream sites and pre-discharge results.
2. <u>Sediment/Precipitate Deposition in Pools and Margins</u>: Pool, margin, and backwater areas of streams should be free from significant deposits of precipitates and excess sediment – disturbance of the substrate should not result in the suspension of reddish precipitates (i.e., those indicative of the past untreated mine discharges). These habitats are also likely to be the most susceptible to ecological damage thus affecting the re-colonization of these depositional areas. Recent laboratory work on these precipitates by the ODNR Divsion of Reclamation suggests that dewatering of stream margins could result in low pH values (≈ 4.6) from the hydrolysis of iron at the sediment-stream interface (Kirk Beach, personal communication).
3. <u>Sediment/Precipitate Deposition in Riffle/Run Habitats</u>: Reddish precipitates also accumulated in the interstitial spaces between riffle/run substrates. The disturbance of the coarse substrates resulted in "clouds" of precipitate being released into the water column. Riffle/run areas should also be free of "cementing" or "armor plating" of the substrate. Coarse substrates should be easily dislodged with only a minimal effort and not cemented together.

Time Frames For Recovery and Actions
This document lays out the ecological recovery endpoints for these streams. Time frames for achievement of these interim and final endpoints for each biological group are summarized in Table 1. Time frames for requiring potential restoration or enhancement options, based on a lack of recovery, are also listed in Table 1. A listing of potential restoration or enhancement options that Ohio EPA may require if recovery does not occur, or does not occur quickly enough, is listed in Table 2. Some of these options may be modified and other options may be added to this list as recovery data are collected and the actions necessary to complete the restoration process become clear. Any restoration activities required by Ohio EPA will not be "punitive" actions, but will be designed to restore or enhance the long term ecological integrity of these streams. When final endpoints are reached, monitoring requirements for an organism group will cease after a second year of monitoring confirms that endpoints have been maintained; however, if final endpoints are not realized, special studies may be required to identify the impediments to recovery.

Table 1. Time frames for examining interim and final recovery of ecological endpoints and for requiring restoration actions if these endpoints are not reached. Specified monitoring durations and frequencies will be reduced if interim and final endpoints are acheived on schedule. Long-term monitoring is designed to ensure that all groups acheive endpoints simultaneously at some point, as was the condition prior to discharge.

Date	Macro-invertebrates	Fish	Amphib-ians[1]	Unionids (Mussels)	Water Chemistry	Restoration Options
March-April 1994					• Quarterly Monitoring	1. Removal of WPA Dam
June 15-October 15, 1994	• Two Sets of Samples (Artificial Substrates w/quals) from study sites on impaired streams	• Three electrofishing sampling passes from study sites on impaired streams	• Amphibian populations examined (traps, etc.)	• Recruitment Monitored	• Quarterly Monitoring	1. Ohio EPA Monitoring Staff Assess Possible Restoration Options During Field Season.
October 16-December 31, 1994	• *Begin Interim Endpoint Assessment:* • Taxa Richness (based on Frequency Distribution, Fig 3) within 10% of historical/pre-discharge data • All ICI values out of "poor" range • 80% of key taxa collected	*Begin Interim Endpoint Assessment:* • All sites out of the "poor" range for the IBI	•Assess Monitoring Data	•Assess Monitoring Data	• Quarterly Monitoring •Assess Monitoring Data	*If Interim Endpoints Are Not Met, Ohio EPA Will Require Restoration Options That May Include, But Not Be Limited To:* 1. Increased monitoring of biota and water/sediment chemistry; possible special studies. 2. Site-specific removal of floc and deposits. 3. Site-specific habitat improvment structures designed to cleanse and restore areas affected by deposition.

June 15-October 15, 1995	• Two Sets of Samples (Artificial Substrates w/quals) from study sites on impaired streams	• Three electrofishing sampling passes from study sites on impaired streams	• Amphibian populations examined (traps, etc.)	• Recruitment Monitored	• Quarterly Monitoring	1. Ohio EPA Monitoring Staff Assess Possible Restoration Options and Efficacy of Previous Restoration (1994) Efforts During Field Work
October 16 to December 31, 1995	• *Begin Final Endpoint Assessment:* • 95% of Endpoints for each stream reached (ICI) • Taxa Richness (based on Frequency Distribution, Fig 3) within 10% of historical/pre-discharge data • All key taxa collected	• *Begin Final Endpoint Assessment:* •95% of Endpoints for each stream reached (IBI) • Species Richness (based on Frequency Distribution, Fig 3) within 10% of historical/pre-discharge data • All key fish species collected	•Assess Monitoring Data	•Assess Monitoring Data	• Quarterly Monitoring •Assess Monitoring Data	*If Final Endpoints Are Not Met, Ohio EPA Will Require Restoration Options That May Include, But Not Be Limited To:* 1. Further monitoring of biota and water/sediment chemistry to determine limits to biotic recovery; possible special studies. 2. Site-specific removal of floc and deposits. 3. More widespread restoration and enhancement options including those discussed above plus options designed to speed overall recovery process via habitat/riparian enhancement with the purpose of improving substrate quality, including (but not limited to): a.) riparian zone easements to improve other aspects of habitat quality, b.) bank restoration.
June 15-October 15, 1996	• One Set of Samples (Artificial Substrates w/quals) from study sites on impaired streams	• Two electrofishing sampling passes from study sites on impaired streams	• Amphibian populations examined (traps, etc.)	• Recruitment Monitored • Sites Examined for Sex. Mature Adults	• Quarterly Monitoring	1. Ohio EPA Monitoring Staff Assess Possible Restoration Options and Efficacy of Previous Restoration Efforts (1995) During Field Work
October 16 to December 31, 1996	• **Total Recovery** • *Assess For Maintenance of Final Endpoints*	• **Total Recovery** • *Assess For Maintenance of Final Endpoints*	•Assess Monitoring Data	•Assess Monitoring Data	• Quarterly Monitoring	Further restoration efforts dependent on recovery and efficacy of existing (1996) restoration (See Above).

June 15-October 15, 1997	• One Set of Samples (Artificial Substrates w/ quals) from study sites on impaired streams	• Two electrofishing sampling passes from study sites on impaired streams	• Amphibian populations examined (traps, etc.)	• Recruitment Monitored • Sites Examined for Sex. Mature Adults	• Quarterly Monitoring	1. Ohio EPA Monitoring Staff Assess Possible Restoration Options and Efficacy of Previous Restoration Efforts (1996) During Field Work
Oct 16 to December 31, 1997	• **Total Recovery** • *Assess For Maintenance of Final Endpoints*	• **Total Recovery** • *Assess For Maintenance of Final Endpoints*	• *Begin Final Endpoint Assessment:* • Mudpuppies found at locations specified in text.	• *Begin Interim Endpoint Assessment:*• Unionid Recruits of All Species (Some Present as Adults)	• Quarterly Monitoring	Further restoration efforts dependent on recovery and efficacy of existing (1996) restoration (See Above), plus: 1. If mudpuppies not found, examine whether all amphibians suppressed and consider stocking options[2] in cooperation with ODNR.
June 15-October 15, 1998	• One Set of Samples (Artificial Substrates w/ quals) from study sites on impaired streams	• Two electrofishing sampling passes from study sites on impaired streams	• Amphibian populations examined (traps, etc.)	• Recruitment Monitored • Sites Examined for Sex. Mauture Adults	• Quarterly Monitoring	1. Ohio EPA Monitoring Staff Assess Possible Restoration Options and Efficacy of Previous Restoration Efforts (1996) During Field Work
October 16 to December 31, 1998	• **Total Recovery** • *Assess For Maintenance of Final Endpoints*	• **Total Recovery** • *Assess For Maintenance of Final Endpoints*	• **Total Recovery** • *Assess For Maintenance of Final Endpoints*	• *Continue Interim Endpoint Assessment:* • Unionid Recruits (All Species) Present, Sexually Mature of Some Species Present	• Quarterly Monitoring	Further restoration efforts dependent on recovery and efficacy of existing (1997) restoration (See Above), plus: 1. If mudpuppies not found, examine whether all amphibians suppressed and consider stocking options[2] in cooperation with ODNR. 2. If unionid recruits not found, examine cause of suppression and consider stocking options[2] in cooperation with ODNR.

June 15-October 15, 1999 and 2000	• One Set of Samples (Artificial Substrates w/quals) from study sites on impaired streams	• Two electrofishing sampling passes from study sites on impaired streams	• Amphibian populations examined (traps, etc.)	• Recruitment Monitored • Sites Examined for Sex. Mature Adults	• Quarterly Monitoring	1. Ohio EPA Monitoring Staff Assess Possible Restoration Options and Efficacy of Previous Restoration Efforts (1998,99) During Field Work
October 16 to December 31, 2000	• **Total Recovery** • *Assess For Maintenance of Final Endpoints*	• **Total Recovery** • *Assess For Maintenance of Final Endpoints*	• **Total Recovery** • *Assess For Maintenance of Final Endpoints*	• *Final Endpoint Assessment:*•• Unionid Recruits (All Species) Present, Sexually Mature of All Species Present	• Quarterly Monitoring	Further restoration efforts dependent on recovery and efficacy of existing (1999) restoration (See Above), plus: 1. If mudpuppies not found, examine whether all amphibians suppressed and consider stocking options[2] in cooperation with ODNR. 2. If unionids recruits not found, examine cause of suppression and consider stocking options[2] in cooperation with ODNR.

[1] mudpuppies (*Necturus maculosus*) use as an indicator species.
[2] if no other impediments to population survival are evident.

Table 2. Some potential restoration actions that Ohio EPA may require to ensure full recovery of the biological communities in streams affected by the Meigs #31 Mine discharges.

Short-Term

- Removal of the WPA Dam.
- Removal of precipitate and floc deposits from streams.

Mid-Term

- Removal of precipitate and floc deposits from streams.
- Special studies to investigate the impediments to recovery and identify recovery/enhancement actions most likely to eliminate these impediments.
- Installation of habitat improvement structures to rehabilitate substrates.
- Site specific bank restoration activities designed to decrease sediment delivery to streams, and thus, increase capacity of streams to remove channel deposits of sediments (that could contain precipitates and floc).

Long-Term

- Special studies to investigate the impediments to recovery, identify the success of the implementation of any short- and moderate-term restoration activities, and identify further recovery actions most likely to eliminate impediments to recovery.
- More extensive implementation of successful short- and moderate-term restoration/enhancement activities.
- Establishment of riparian easements and riparian enhancement projects along streams to speed recovery of biological communities though enhancement of habitat features currently limiting to these populations.
- Consider, as a last resort, and in close consultation with ODNR - Division of Wildlife, stocking options for fauna that has not recovered, and that does not appear to be limited by any cause other than a lack of recolonizing individuals.

Specific Considerations

Leading Creek Watershed

The Leading Creek watershed suffered the most extensive damage from the Meigs #31 Mine discharges. Essentially, the entire fish, aquatic insect, unionid mussel, and amphibian assemblages were eliminated from Parker Run downstream from the Meigs #31 discharge and from Leading Creek 0.5 miles upstream from Parker Run (where the high volume of the discharge created a backflow of approximately 0.5 miles in length) to the Ohio River. Figure 2 summarizes the historical, pre-discharge, and most recent (29 Nov - 1 Dec) post-discharge IBI data from Leading Creek (a State Resource Water - SRW) to illustrate the minimal recovery in 1993 and the amount of recovery yet to occur to achieve the endpoints specified in this document.

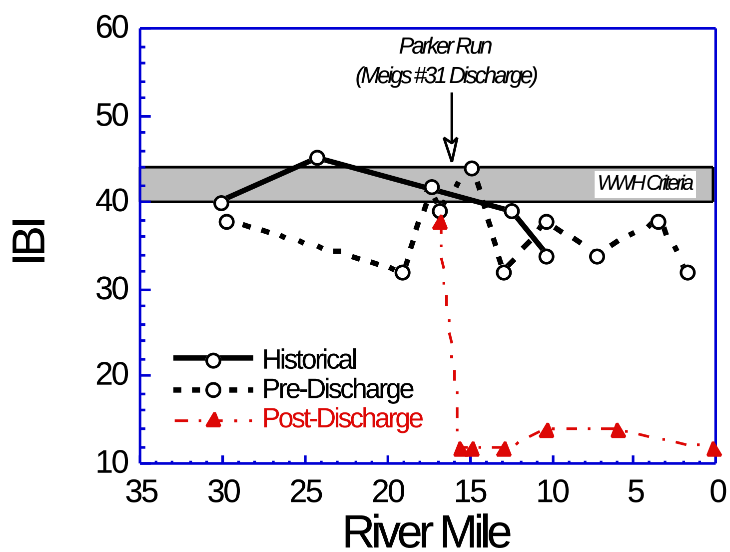


Figure 2. Plot of IBI versus river mile for historical, pre-discharge, and most recent (29 Nov - 1 Dec) post-discharge data from Leading Creek upstream and downstream of Parker Run (location of the Meigs #31 Mine discharge.

Essential to enhancing the full recovery of Leading Creek is the removal of the old WPA dam located at approximately RM 11.0. The dam, presently in disrepair, is a barrier to the upstream migration of fish and unionid mussel larvae (via their large river fish hosts). For example, the removal of the dam would enhance the survival of sensitive fish species such as the Ohio threatened silver lamprey. This species has a multi-year larval life stage (up to seven years) in which it resides in soft sediments as a filter feeder. All of the extant larval year classes were likely destroyed by the Meigs #31 Mine discharges. A portion of the adults that emerged during 1993 prior to the discharges are currently in the Ohio River or elsewhere, and will return to spawn in the spring of 1994. It is not assured that the substrates of the impacted segments of Leading Creek will be suitable for egg development and larval survival by that time. The removal of the dam at RM 11.0 would open access to reaches of Leading Creek upstream from the discharge impacted areas for spawning of this and other species. Because the majority of the best habitat in Leading Creek is located upstream from this dam, the recovery of populations of sport fish, such as sauger and spotted bass, would also be enhanced. It has been our experience that the recovery of streams occurs more quickly when repopulation occurs from the downstream reaches; thus, the removal of the dam would speed the recovery process.

Ecological Endpoints

There have been 49 fish species, 162 macroinvertebrate taxa (excluding unionids), and 10 species of unionid mussels recorded from Leading Creek and tributaries during the past twelve years (Appendix Tables 1A, 2, and 3). For impaired segments of Leading Creek and Parker Run, "Cumulative Frequency Plots" of Invertebrate Taxa or Fish Species, that had been collected in those segments prior to discharge, were plotted versus the number of samples and fitted with a logarithmic curve (Figure 3). Species counts in streams, and other types of habitats, have been shown to be related to sampling effort in a logarithmic fashion. To ensure that a similar species richness exists post-discharge, *based on similar effort*, the species/sample relationship must asymptote within 10% of the value found in pre-discharge data for each stream (Figure 3). All unionid species, recorded in both the historical and pre-discharge samples, must be recorded in post-discharge sampling (as specified on page 2) for recovery to be considered complete in the affected areas of Leading Creek.

Monitoring will be required at nine locations in Leading Creek (Table 3). The specific ecological endpoints for determining recovery in Leading Creek will differ depending on location and segment. The format for specifying the endpoints for each segment is illustrated in Figure 4. We have divided Leading Creek into 3 segments or habitat types on the basis of habitat quality (QHEI), substrate score (QHEI), stream gradient (ft/mi), and riffle score (QHEI) for the purposes of gauging recovery. These habitat attributes are illustrated in Figure 5.

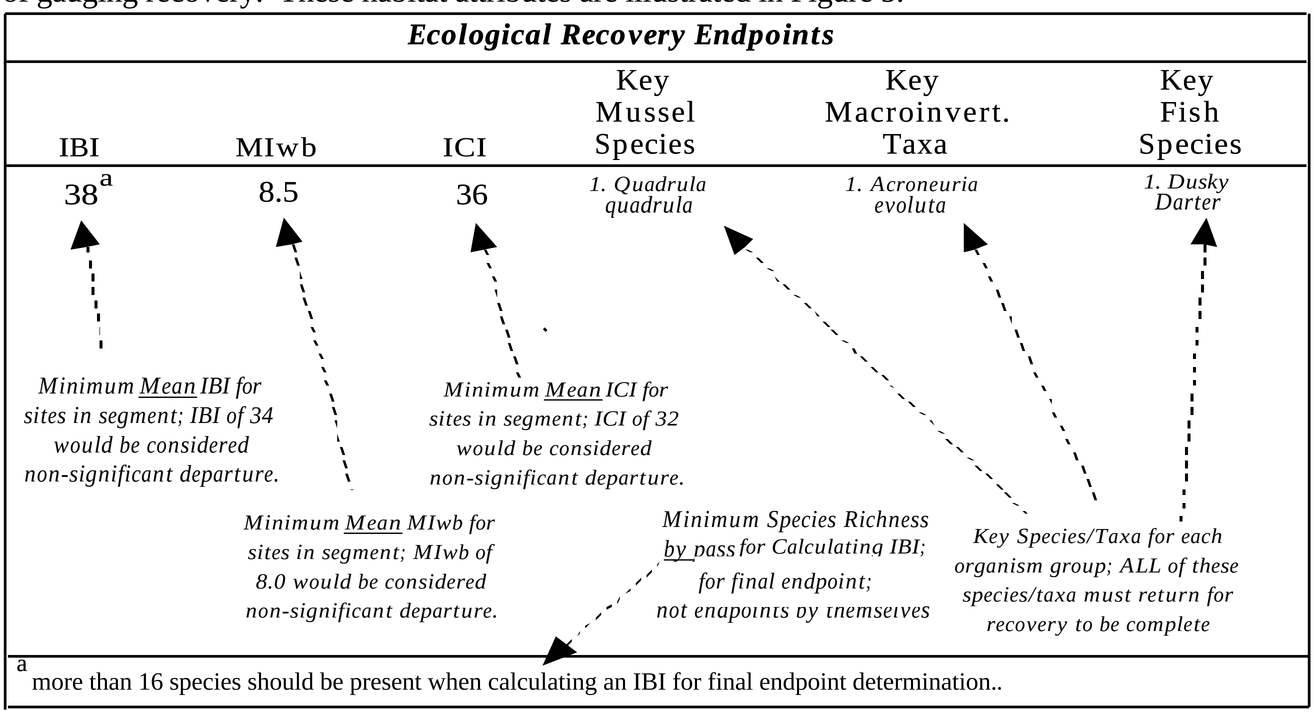
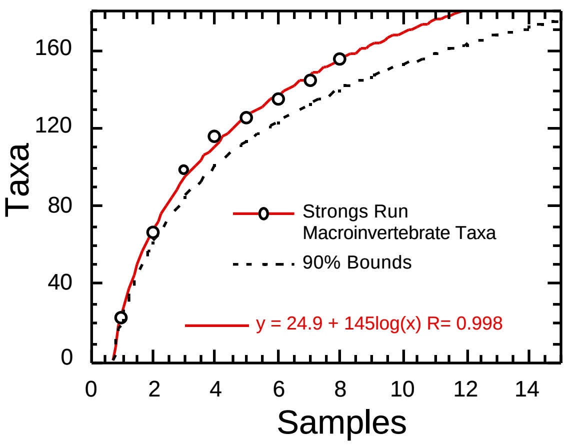
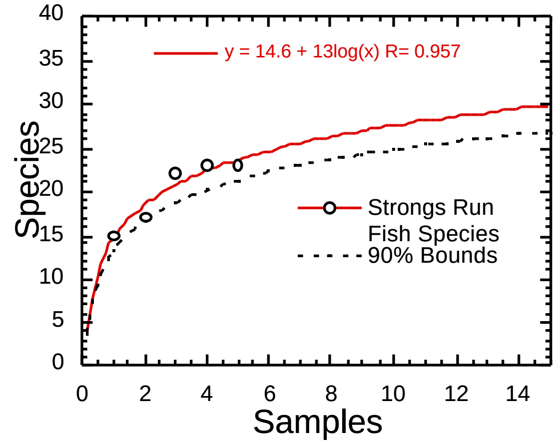
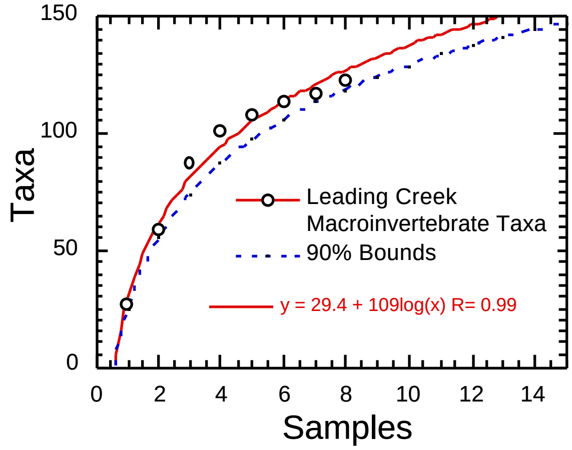
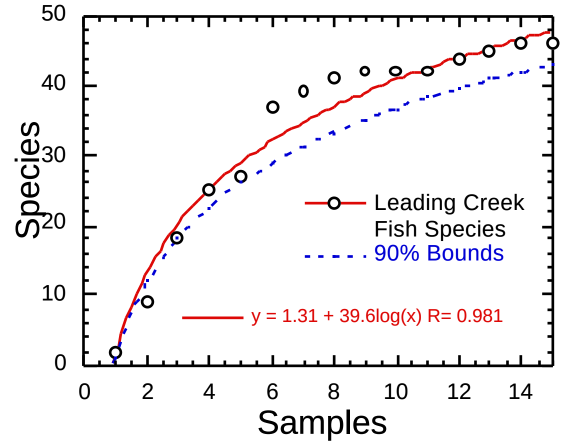


Figure 4. Illustration of the format for presenting ecological endpoints for streams or stream segments in the Leading Creek/Raccoon Creek study area.









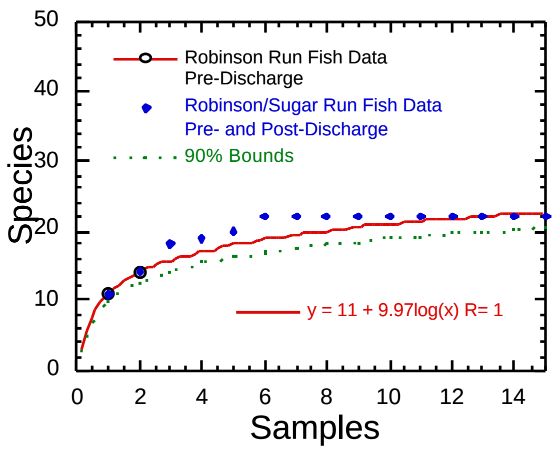


Figure 3. Cumulative frequency distribution plots of taxa (macroinvertebrates) or fish species versus number of samples for Strongs Run, Robinson/Sugar Run, and Leading Creek/Parker Run. Dashed lines indicate 90% of species represented by the regression line.

Table 3.Required monitoring locations for determining the attainment of recovery endpoints in Leading Creek and Parker Run.

RM	Fish	Macro-inverts.	Unionid Mussels	Amphibs.	Site Description
Leading Creek					
0.1	X	X			Dst. U.S. ACE boat ramp [Segment I recovery monitoring]
1.8	X	X		X	0.25 mi upstream of Route 7 [Segment II recovery monitoring]
3.5	X	X		X	Private bridge off Leading Cr. Rd. [Segment II recovery monitoring]
6.0/7.2	X	X		X	Twp. Rt. 351 bridge *or* Co. Rt. 12 bridge [Segment II recovery monitoring]
10.3	X	X	X	X	Twp. Rt. 41 bridge [Segment III recovery monitoring; historical site]
12.3/12.9	X	X	X	X	St. Rt. 124 *or* ford adj. Co. Rt. 10 [Segment III recovery monitoring]
14.8	X	X	X	X	Malloons Run Rd. [Segment III recovery monitoring]
15.5	X	X	X	X	Immediately dst. Parker Run [Segment III recovery monitoring]
15.6	X	X	X	X	Immediately ust. Parker Run [Segment III recovery monitoring; recovery of ust. affected area]
Parker Run					
0.1	X	X			At mouth [Parker Run recovery monitoring]
1.6	X	X			Twp. Rt. 18 bridge [Parker Run recovery monitoring]

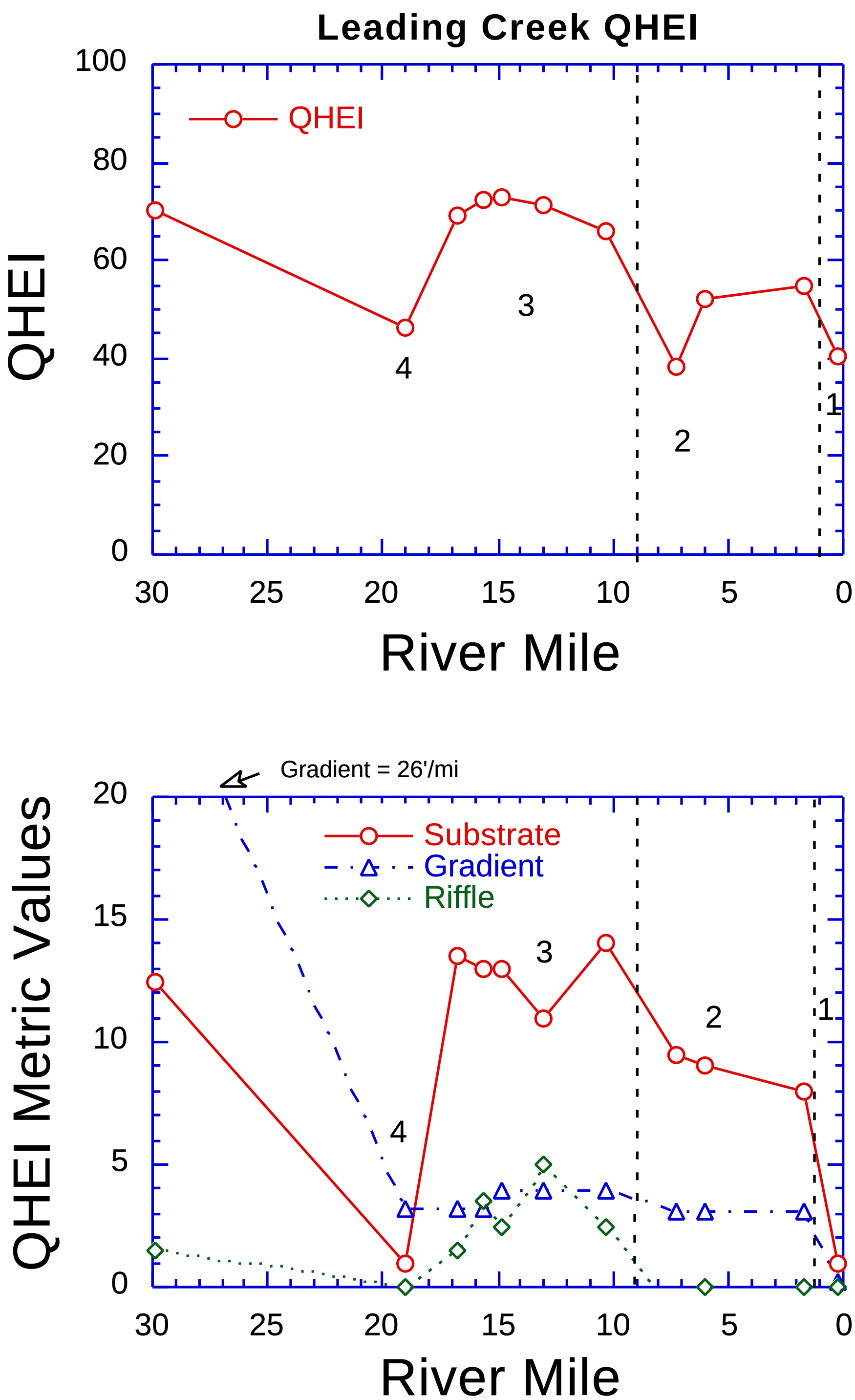


Figure 5. Habitat characterstics and values in the four segments of Leading Creek.

Leading Creek

Segment 1 - Ohio River Backwater (RM 0.0-1.0): Approximately the lower mile of Leading Creek is influenced by the water levels of the Ohio River. The biological communities found here are strongly influenced by the biological communities of the Ohio River and the backwater habitat characteristics of this segment. Thus, the recovery endpoints reflect these characteristics as well. Quantitative background data collected by EA Engineering prior to discharge was hampered by equipment problems. Seining data collected by Ted Cavender (OSU Museum of Biodiversity) and Dan Rice (ODNR-NAP) at the Leading Creek boat ramp provided information on key fish species which must reoccur for recovery to be considered complete in addition to the other ecological endpoints.

Ecological Recovery Endpoints for Segment 1:

IBI	MIwb	ICI	Key Mussel Species	Key Macroinvertebrate Taxa	Key Fish Species
30[†a]	6.6[†]	22[†]	None	None	*Channel Shiner* *Longear Sunfish* *Dusky Darter* *Smallmouth Buffalo* *Adult Spotted Bass* *Adult Channel Catfish*

[†]Ohio EPA Modified Warmwater Habitat - Impoundment biocriteria (Ohio Water Quality Standards); these apply to streams designated as Modified Warmwater Habitat; here they are being used as recovery criteria in lieu of quantitative historical data.
[a] more than 13 species should be present when calculating an IBI for final endpoint determination.

Segment 2 - Low Gradient Lower Leading Creek (RMs 1.1-9.0): Upstream from the impounded segment, Leading Creek has a very low gradient and has a historically high sand bedload from previous mining activities and upland erosion in the watershed. As a result, certain habitat attributes are either absent or present in reduced abundance (see Figure 5) and this segment will have somewhat lower biological performance expectations, particularly for the fish assemblages, when compared to the higher gradient upstream reaches. Thus, the recovery endpoints reflect the reduced expectations and are based largely on pre-discharge results. Macroinvertebrate community performance, based on Hester-Dendy multiple plate samplers, should be able to attain the WWH ICI value of 36. This macroinvertebrate sampling method generally reflects water quality more strongly than macrohabitat conditions; thus, the high sand bedload and other negative habitat attributes should not preclude attainment of the WWH ICI biocriterion.

Ecological Recovery Endpoints for Segment 2:					
IBI	MIwb	ICI	Key Mussel Species	Key Macroinvertebrate Taxa	Key Fish Species
34‡,a	8.0◊	36§	None	*Acroneuria evoluta* *Orconectes sanbornii* *Polycentropodidae* *Hydropsychidae*	*Sand Shiner* *Channel Shiner* *Silverjaw Minnow* *Longear Sunfish* *Blackside Darter* *Dusky Darter* *Logperch* *Golden Redhorse*

‡Based on pre-discharge data in Appendix Table 4
◊ estimated value
§ICI biocriterion for WWH in WAP ecoregion;
[a] more than 13 species should be present when calculating an IBI for final endpoint determination.

The key macroinvertebrate taxa include *Acroneuria evoluta*, a perlid stonefly with a multi-year larval stage, the crayfish *Orconectes sanbornii* , and caddisflies from the families Polycentropodidae (*Polycentropus* and *Nyctiophylax*) and Hydropsychidae (*Cheumatopsyche* and *Hydropsyche*). All were collected by Ohio EPA prior to the discharge and will need to be found in order for recovery to be considered complete (in addition to attainment of the biological criteria).

<u>Segment 3 -Middle Leading Creek (RM 9.1-15.6)</u>: Much of the middle section of Leading Creek (below Parker Run to RM 9.0) has sufficient gradient to ameliorate the effects of the high sand bedload and has relatively high quality habitat. These are the most ecologically diverse segments of Leading Creek and the location of the highest number of sensitive fish species and the highest populations of unionid mussels. Historical data from this segment of Leading Creek indicates that populations of sensitive species were resident here, including Ohio threatened and special concern species such as silver lamprey, river redhorse, and sand darter. The biological index scores at sites both upstream and downstream from Paker Run (segments 2 and 3) indicated marginal attainment (*i.e.*, index scores in non-significant departure from the biocriteria), partial attainment, and even non-attainment of the WWH criteria (Appendix Table 4). The most recent coordinated subbasin survey (Ohio EPA 1991) indicated full WWH attainment upstream and partial attainment downstream from Parker Run. This indicates that some impairment of the WWH use designation existed prior to the discharge of untreated and partially treated mine waters from Meigs #31, although the impairment after the discharge was much more severe.

Ecological Recovery Endpoints [¥] *for Segment 3:*					
IBI	MIwb	ICI	Key Mussel Species	Key Macroinvertebrate Taxa	Key Fish Species
38[‡,a]	8.0◊	36[§]	*Wabash pigtoe* *fatmucket* *pink heelsplitter* *plain pocketbook* *cylindrical papershell* *giant floater* *white heelsplitter* *fragile papershell* *mapleleaf* *squawfoot*	*Acroneuria evoluta* *Orconectes sanbornii* *Polycentropodidae* *Hydropsychidae*	*Silver Lamprey* [b] *River Redhorse* *Shorthead Redhorse* *Black Redhorse* *N. Hog Sucker* *Sand Shiner* *Redfin Shiner* *Longnose Gar* *Spotted Bass* *Longear Sunfish* *Fantail Darter* *Blackside Darter* *Logperch*

¥ Mudpuppies must be found all sites in this segment where found by ODNR during the fish kill (Appendix Table 5) and at one location in segment 1 or 2 of Leading Creek.
‡Based on pre-discharge data in Appendix Table 4
◊ estimated value
§ICI biocriterion for WWH in WAP ecoregion;
[a] more than 16 species should be present when calculating an IBI for final endpoint determination.
[b] adults can be collected during the spring, ammocoetes during spring or summer.

Parker Run

Parker Run was the initial receiving stream for the untreated Meigs Mine discharges. Because of its small size and the high discharge flow, problems with buildup from iron-laden precipitates was less serious of a problem than in Leading Creek where deposition was greater. However, like Leading Creek, the aquatic fauna was completely eliminated because of the acutely toxic discharges. Pre-discharge sampling in 1993 revealed full attainment of the IBI biocriterion. Thus, the recovery endpoints for Parker Run reflect attainment of the WWH biocriteria for the Western Allegheny Plateau ecoregion.

Ecological Recovery Endpoints for Parker Run:					
IBI	MIwb	ICI	Key Mussel Species	Key Macroinvertebrate Taxa	Key Fish Species
44[‡,a]	N.A.	36[§]	None	*Acroneuria evoluta*	*Blacknose Dace* *So. Redbelly Dace* *Silverjaw Minnow* *Fantail Darter*

‡Based on pre-discharge data in Appendix Table 4
§ ICI biocriterion for WWH in WAP ecoregion;
[a] more than 12 species should be present when calculating an IBI for final endpoint determination.

Raccoon Creek Watershed

The Raccoon Creek watershed received a lesser amount of untreated mine discharge waters than Leading Creek. Historic and pre-discharge species/taxa collected in Raccoon Creek and the affected tributaries are listed in Appendix Tables 1-B, 2, and 3. Although a fish kill was reported from Raccoon Creek between Strongs Run and Robinson Run, the stream was not impacted as severely as Leading Creek. Several of the smaller tributaries, however, were impacted quite severely. Impairment of the WWH aquatic life use was evident prior to the Meigs #31 Mine discharges. However, impairment was not severe in Raccoon Creek as evidenced by IBI scores in the mid 30's and ICI scores indicative of near exceptional performance (Appendix Table 4).

Raccoon Creek

The results obtained by the 1990 survey (Ohio EPA 1991) indicate that aquatic community recovery from the previous severely impaired status has been considerable. Thus, the threat imposed by the untreated mine discharges was substantial. The recovery endpoints for Raccoon Creek reflect the accomplishments of the accumulated efforts of surface and underground mine reclamation in the watershed. Required monitoring stations for ascertaining recovery are listed in Table 4.

Ecological Recovery Endpoints for Raccoon Creek:

IBI	MIwb	ICI	Key Mussel Species	Key Macroinvertebrate Taxa	Key Fish Species
32[‡,a]	6.5[‡]	Greater of 36[§] or ICI at RM 50.1	*pink heelsplitter* *fragile papershell*	*Cheumatopsyche* sp. *Stenacron* sp. *Stenonema* sp. *Isonychia* sp. *Caenis* sp	*Golden Redhorse* *N. Hog Sucker* *Spotted Sucker* *Adult Spotted Bass* *Longear Sunfish* *Warmouth* *Dusky Darter* *Blackside Darter* *Grass Pickerel*

‡Based on pre-discharge data in Appendix Table 4
§ICI biocriterion for WWH in WAP ecoregion;
[a] more than 13 species should be present when calculating an IBI for final endpoint determination.

Strongs Run

Strongs Run, a State Resource Water, was severely impaired by the Meigs #31 Mine untreated discharge water with pH values as low as 2.1 S.U. resulting in a complete kill of aquatic life. Historical data, pre-discharge collections, and, to a lesser extent, collections in the nearby Flatlick Creek provided reliable sources of endpoint information. Curves of fish species and macroinvertebrate taxa vs. sampling effort were dervied for Strongs Run and are illustrated in Figure 3. To ensure that a similar species richness exists post-discharge, based on similar effort, the species or taxa/sample relationship must asymptote within 10% of the value found in pre-discharge data for each stream (Figure 3).

Ecological Recovery Endpoints for Strongs Run:					
IBI	MIwb	ICI	Key Mussel Species	Key Macroinvertebrate Taxa	Key Fish Species
34[‡,a]	N. A.	36[§]	None	*Centroptilum* sp. *Stenacron* sp. *Stenonema femoratum* *Caenis* sp *Cheumatopsyche* sp.	*Least Brook Lamprey* *Longear Sunfish* *So. Redbelly Dace* *Dusky Darter*

‡Based on pre-discharge data in Appendix Table 4
§ICI biocriterion for WWH in WAP ecoregion;
[a] more than 11 species should be present when calculating an IBI for final endpoint determination.

Table 4.Required monitoring stations for determining the attainment of recovery endpoints in Raccoon Creek, Strongs Run, Sugar Run, and Robinson Run.

RM	Fish	Macro-inverts.	Unionid Mussels	Site Description
Raccoon Creek				
42.3	X	X		McGhee Rd. (dst. Strongs Run ust. Robinson Run) [Monitor Strongs Run discharge, 1993 fish kill]
40.1-39.9	X	X	X	Dst. Vinton Dam [Monitor Strongs Run and Robinson Run discharge]
29.9 or 28.9	X	X	X	near Bob Evans Farms [Monitor far-field effects of discharge]
Strongs Run				
0.6	X	X		Adney Rd. [Strongs Run recovery monitoring location]
1.5 or 2.2	X	X		Co. Rt. 2W or Co. Rt. 1W [Strongs Run recovery monitoring site]
Sugar Run				
0.1 or 0.6	X	X		Keesee Rd. or Driveway of Mr. Smith [Sugar Run recovery monitoring site]
Robinson Run				
1.5	X	X		Ust. Sugar Run [Robinson Run recovery monitoring site]
0.2	X	X		St. Rt. 325 [Robinson Run recovery monitoring site]

Sugar Run

Although Sugar Run received untreated mine discharge water with high levels of suspended and dissolved solids, the aquatic life kill was partial. Fish were present during all post-discharge collections. Pre-discharge data was lacking, thus, recovery endpoints are based largely on the ecoregional biocriteria.

Ecological Recovery Endpoints for Sugar Run:					
IBI	MIwb	ICI	Key Mussel Species	Key Macroinvertebrate Taxa	Key Fish Species
44 [§,a]	N.A.	36[§]	None	*Centroptilum* sp. *Paraleptophlebia* sp. *Stenonema femoratum* *Hexagenia* sp. *Caenis* sp	*Least Brook Lamprey* *Redfin Shiner* *So. Redbelly Dace*

§ICI biocriterion for WWH in WAP ecoregion.
a more than 7 species should be present when calculating an IBI for final endpoint determination.

Robinson Run

Sugar Run is a tributary to Robinson Run entering at RM 1.4. Data was collected at sites upstream and downstream from the Sugar Run confluence by EA Engineering. Curves of fish species vs. sampling effort were dervied for Robinson and Sugar Run (combined) and are illustrated in Figure 3. To ensure that a similar species richness exists post-discharge, based on similar effort, the species/sample relationship must asymptote within 10% of the value found in pre-discharge data for each stream (Figure 3).

Ecological Recovery Endpoints for Robinson Run:					
IBI	MIwb	ICI	Key Mussel Species	Key Macroinvertebrate Taxa	Key Fish Species
32[‡,a]	N.A.	36[§]	None	*Stenacron* sp. *Isonychia* sp. *Cheumatopysche* sp.	*Least Brook Lamprey* *Redfin Shiner* *So. Redbelly Dace*

‡Based on pre-discharge data in Appendix Table 4.
§ICI biocriterion for WWH in WAP ecoregion.
a more than 10 species should be present when calculating an IBI for final endpoint determination.

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Appendix Table 1-A. Fish species captured in Leading Creek and its tributaries between 1982 and 1993. Data sources include Ohio EPA, Ohio DNR - DOW, Ohio DNR - NAP, ODOT.

	Segment 1	Segment 2	Segment 3	
Species	Ohio River Backwater RM 0.1-1.0	Lower Leading Cr. Low Gradient RM 1.1-9.0	Mid. Leading Cr. High Gradient RM > 9.0	Mid. Leading Cr. Low Gradient RM > 9.0
Silver Lamprey			X	
Least Brook Lamprey			X	
Longnose Gar			X	
Gizzard Shad	X	X	X	X
Grass Pickerel			X	
Smallmouth Buffalo	X			
Quillback Carpsucker			X	X
Silver Redhorse			X	
Black Redhorse			X	
Golden Redhorse		X	X	X
Shorthead Redhorse			X	
River Redhorse			X	
Northern Hog Sucker		X	X	
White Sucker	X	X	X	X
Spotted Sucker		X	X	X
Common Carp	X		X	X
Blacknose Dace		X	X	
Creek Chub		X	X	X
Suckermouth Minnow			X	
Southern Redbelly Dace			X	X
Emerald Shiner	X	X	X	
Rosyface Shiner			X	
Redfin Shiner			X	X
Striped Shiner		X	X	X
Spotfin Shiner	X	X	X	
Sand Shiner		X	X	
Channel Shiner	X	X	X	
Silverjaw Minnow		X	X	X
Bluntnose Minnow	X	X	X	X
Central Stoneroller		X	X	X
Channel Catfish	X	X		
Yellow Bullhead			X	X
Troutperch			X	X
White Bass	X	X	X	
White Crappie			X	X

Appendix Table 1. (continued)

Species	Segment 1	Segment 2	Segment 3	
	Ohio River Backwater RM 0.1-1.0	Low. Lead. Cr. Low Gradient RM 1.1-9.0	Mid Lead. Cr. High Gradient RM > 9.0	Mid Lead. Cr. Low Gradient RM > 9.0
Smallmouth Bass		X	X	
Spotted Bass	X	X	X	X
Largemouth Bass	X		X	
Green Sunfish	X	X	X	X
Bluegill Sunfish	X	X	X	X
Longear Sunfish	X	X	X	X
Sauger			X	
Dusky Darter	X	X	X	
Blackside Darter		X	X	X
Logperch		X	X	X
Johnny Darter	X	X	X	X
Fantail Darter			X	X
Sand Darter†			X†	
Freshwater Drum	X		X	X
Totals: **49**	**18**	**26**	**47**	**25**

† collected by Tom Watters at the mouth of Parker Run on July 23, 1993.

Appendix Table 1-B. Fish species captured in Raccoon Creek and its tributaries between 1984 and 1993. Data sources include Ohio EPA, Ohio DNR - DOW, Ohio DNR - NAP, and EA Engineering and Science.

Species	Raccoon Creek	Strongs Run	Robinson/Sugar Run	Flatlick Creek
Least Brook Lamprey	X	X	X	X
Longnose Gar	X			
Gizzard Shad	X			
Grass Pickerel	X	X	X	X
Smallmouth Buffalo	X			
Silver Redhorse	X			
Black Redhorse	X			
Golden Redhorse	X	X	X	
Shorthead Redhorse	X			
Northern Hog Sucker	X			
White Sucker	X	X	X	X
Spotted Sucker	X	X		X
Common Carp	X			
Golden Shiner	X			X
Silver Chub	X			
Blacknose Dace		X	X	X
Creek Chub	X	X	X	X
Southern Redbelly Dace		X	X	X
Emerald Shiner	X			
Silver Shiner	X			
Redfin Shiner	X	X	X	
Striped Shiner	X	X	X	X
River Shiner	X			
Spotfin Shiner	X			
Sand Shiner	X			
Silverjaw Minnow	X	X	X	X
Bluntnose Minnow	X	X	X	X
Central Stoneroller	X	X	X	
Channel Catfish	X			
Yellow Bullhead	X	X	X	X
Brown Bullhead	X			
Black Bullhead	X			
Flathead Catfish	X			
Eastern Banded Killifish	X			
White Bass	X			
White Crappie	X			

Appendix Table 1-B. (continued)

Species	Raccoon Creek	Strongs Run	Robinson/Sugar Run	Flatlick Creek
Rockbass	X			
Spotted Bass	X	X	X	
Largemouth Bass	X		X	X
Warmouth	X	X		
Green Sunfish	X	X		X
Bluegill Sunfish	X	X	X	X
Longear Sunfish	X	X	X	X
Sauger	X			X
Dusky Darter	X	X		X
Blackside Darter	X	X	X	X
Logperch	X			
Johnny Darter	X	X	X	X
Greenside Darter			X	
Fantail Darter	X	X	X	X
Freshwater Drum	X			
Totals: **51**	**48**	**23**	**22**	**22**

Appendix Table 2. Macroinvertebrate taxa collected from Leading Creek, Raccoon Creek, and tributary sites by the Ohio EPA Prior to the Meigs # 31 Mine discharge, 1987-1993.

Taxa Code	Taxa Name	Leading Cr/Parker Run	Raccoon Creek	Strongs Run	Robinson/ Sugar Run
01320	*Hydra sp*	X	X	X	
01801	Turbellaria	X	X		
03360	*Plumatella sp*	X	X	X	
03451	*Urnatella gracilis*			X	
03600	*Oligochaeta*	X	X	X	X
04686	*Placobdella papillifera*				X
04687	*Placobdella parasitica*			X	
05800	*Caccidotea sp*	X	X	X	
06700	*Crangonyx sp*	X	X	X	
06810	*Gammarus fasciatus*		X		
07820	*Cambarus (Cambarus) bartonii cavatus*	X	X	X	X
07880	*Cambarus (Lacunicambarus) diogenes*	X		X	X
08250	*Orconectes (Procericambarus) rusticus*			X	
08260	*Orconectes (Crokerinus) sanbornii sanbornii*	X	X	X	X
08601	Hydracarina	X	X	X	X
10550	*Ameletus sp* *			X	
10600	*Siphlonurus sp**	X			
11100	*Baetis sp*	X		X	
11130	*Baetis intercalaris*		X		
11150	*Baetis propinquus*		X		
11200	*Callibaetis sp*			X	X
11300	*Centroptilum sp*	X	X	X	X
11400	*Cloeon sp*	X	X	X	X
11700	*Pseudocloeon sp*	X		X	
12200	*Isonychia sp*	X	X		

13000	*Leucrocuta sp*	X			
13120	*Nixe perfida*	X		X	
13400	*Stenacron sp*	X	X	X	
13510	*Stenonema exiguum*		X		
13521	*Stenonema femoratum*	X		X	X
13590	*Stenonema vicarium*	X	X		
15000	*Paraleptophlebia sp*	X	X	X	X
16700	*Tricorythodes sp*		X		
17100	*Brachycercus sp*		X		
17200	*Caenis sp*	X	X	X	X
17600	*Baetisca sp*	X	X		
18700	*Hexagenia sp*	X		X	X
21200	*Calopteryx sp*	X	X	X	X
21300	*Hetaerina sp*	X		X	
22001	Coenagrionidae	X	X		X
22300	*Argia sp*	X	X		X
23600	*Aeshna sp*	X			X
23804	*Basiaeschna janata*	X	X	X	X
23905	*Boyeria grafiana*		X		
23909	*Boyeria vinosa*	X	X	X	X
23950	*Epiaeschna heros*				X
24710	*Dromogomphus spinosus*	X	X		
24900	*Gomphus sp*	X	X	X	X
25010	*Hagenius brevistylus*	X	X		
25410	*Progomphus obscurus*		X	X	
26100	*Cordulegaster sp*	X		X	X
26600	*Didymops transversa*		X	X	
26700	*Macromia sp*		X	X	
27500	*Somatochlora sp*	X	X	X	X
27610	*Epitheca (Tetragoneuria) cynosura*	X			X
28955	*Plathemis lydia*			X	
28908	*Perithemis tenera*			X	

32205	*Amphinemura delosa**	X			
34130	*Acroneuria evoluta*	X			
34500	*Perlesta sp**	X		X	
35570	*Isoperla transmarina**	X		X	
42700	*Belostoma sp*	X	X		
43300	*Ranatra sp*	X	X		
43570	*Neoplea sp*		X		
45100	*Palmacorixa sp*	X	X	X	X
45300	*Sigara sp*	X		X	X
45400	*Trichocorixa sp*	X	X		
45900	*Notonecta sp*			X	X
47600	*Sialis sp*	X	X	X	X
48200	*Chauliodes sp*	X	X		
48410	*Corydalus cornutus*		X		
48620	*Nigronia serricornis*	X	X	X	
50315	*Chimarra obscura*	X	X		
51206	*Cyrnellus fraternus*		X		
51300	*Neureclipsis sp*		X		
51400	*Nyctiophylax sp*	X	X	X	
51500	*Phylocentropus sp*			X	
51600	*Polycentropus sp*	X	X	X	
52200	*Cheumatopsyche sp*	X	X	X	X
52315	*Diplectrona modesta*			X	
52500	*Hydropsyche (H.) sp*			X	
52530	*Hydropsyche (H.) depravata* group	X	X		
52570	*Hydropsyche (H.) simulans*	X	X		
53800	*Hydroptila sp*	X	X		
54100	*Neotrichia sp*		X		
54300	*Oxyethira sp*				X
55300	*Ptilostomis sp*			X	
57900	*Pycnopsyche sp*	X	X	X	
59500	*Oecetis sp*	X	X	X	

59700	*Triaenodes sp*	X			
59950	*Parapoynx sp*		X		
60300	*Dineutus sp*	X	X	X	
60400	*Gyrinus sp*	X	X	X	X
60900	*Peltodytes sp*		X	X	X
61400	*Agabus sp*			X	
63300	*Hydroporus sp*	X	X	X	X
63700	*Ilybius sp*			X	X
63900	*Laccophilus sp*	X			X
65800	*Berosus sp*		X		
66200	*Cymbiodyta sp*			X	X
66500	*Enochrus sp*			X	
66901	*Helocombus bifidus*			X	
67000	*Helophorus sp*	X		X	X
67300	*Hydrochus sp*			X	
67500	*Laccobius sp*	X		X	X
67700	*Paracymus sp*	X		X	
67750	*Sperchopsis tesselatus*	X			
67800	*Tropisternus sp*	X		X	X
68130	*Helichus sp*	X	X	X	X
68201	Scirtidae	X			
68601	*Ancyronyx variegata*	X	X	X	
68708	*Dubiraphia vittata* group	X	X	X	X
68901	*Macronychus glabratus*	X	X		
69400	*Stenelmis sp*	X	X		
70900	*Gonomyia sp*			X	
71100	*Hexatoma sp*	X			
71300	*Limonia sp*	X			
71700	*Pilaria sp*	X		X	
71900	*Tipula sp*	X		X	X
71910	*Tipula abdominalis*	X	X		X
72160	*Psychoda sp*	X		X	

72340	*Dixella sp*				X
72700	*Anopheles sp*	X	X	X	X
72900	*Culex sp*			X	X
74100	*Simulium sp*	X	X	X	
74501	Ceratopogonidae	X	X	X	X
74650	*Atrichopogon sp*			X	
77115	*Ablabesmyia janta*	X	X	X	
77120	*Ablabesmyia mallochi*	X	X	X	X
77130	*Ablabesmyia rhamphe* group	X	X	X	
77355	*Clinotanypus pingus*				X
77500	*Conchapelopia sp*	X	X	X	
77750	*Thienemannimyia sp*	X	X	X	
77800	*Helopelopia sp*	X		X	
78101	*Labrundinia becki*		X	X	
78140	*Labrundinia pilosella*	X	X	X	
78200	*Larsia sp*		X		
78350	*Meropelopia sp*	X		X	
78401	*Natarsia* species *A (sensu* Roback, 1978)	X	X	X	X
78450	*Nilotanypus fimbriatus*	X	X		
78500	*Paramerina fragilis*			X	X
78650	*Procladius sp*	X	X	X	X
79010	*Tanypus carinatus*		X		
79400	*Zavrelimyia sp*	X		X	
79832	*Monodiamesa depectinata*			X	
80204	*Brillia flavifrons* group	X			
80370	*Corynoneura "taris" (sensu* Simpson and Bode 1980)	X	X	X	
80410	*Cricotopus (C.) sp***	X	X	X	X
80420	*Cricotopus (C.) bicinctus*	X	X	X	
80430	*Cricotopus (C.) tremulus* group	X	X	X	
80440	*Cricotopus (C.) trifascia* group	X			

81240	*Nanocladius (N.) distinctus*		X		
81250	*Nanocladius (N.) minimus*	X			
81231	*Nanocladius (N.) crassicornus*	X			
81270	*Nanocladius (N.) spiniplenus*	X	X		
81460	*Othocladius (O.) sp*			X	
81530	*Orthocladius (Symposiocladius) lignicola*	X			
81631	*Parakiefferiella sp*	X	X	X	
81650	*Parametriocnemus sp*	X		X	X
81825	*Rheocricotopus (Psilocricotopus) robacki*	X	X	X	
82121	*Thienemanniella* "nr *fusca*" (*sensu* Simpson and Bode 1980)	X	X		
82141	*Thienemanniella xena*	X	X	X	
82300	*Xylotopus par*		X		X
82730	*Chironomus (C.) decorus* group	X	X	X	X
82770	*Chironomus (C.) riparius* group	X		X	X
82780	*Chironomus (C.) staegeri* group			X	
82800	*Cladopelma sp*		X		
82820	*Cryptochironomus sp*	X	X	X	X
82880	*Cryptotendipes sp*			X	X
82890	*Demeijerea sp*	X			
83002	*Dicrotendipes modestus*	X	X	X	X
83003	*Dicrotendipes fumidus*				X
83040	*Dicrotendipes neomodestus*	X	X	X	X
83050	*Dicrotendipes lucifer*	X	X	X	
83051	*Dicrotendipes simpsoni*	X		X	X
83158	*Endochironomus nigricans*	X	X	X	X
83300	*Glyptotendipes (Phytotendipes) sp*	X	X	X	X
83380	*Goeldichironomus holoprasinus*			X	
83410	*Harnischia curtilamellata*	X	X		
83600	*Kiefferulus dux*	X			X

83820	*Microtendipes "caelum"* (*sensu* Simpson & Bode, 1980)	X			
83840	*Microtendipes pedellus* group	X	X	X	X
83900	*Nilothauma sp*	X		X	
84060	*Parachironomus pectinatellae*		X		
84155	*Paralauterborniella nigrohalteralis*	X	X		
84210	*Paratendipes albimanus*	X		X	X
84300	*Phaenopsectra prob. dyari* (sensu Simpson and Bode, 1980)	X	X	X	X
84302	*Phaenopsectra flavipes*	X	X	X	
84410	*Polypedilum (Pentapedilum) tritum*	X			
84440	*Polypedilum (P.) aviceps*			X	
84450	*Polypedilum (P.) convictum*	X	X	X	
84460	*Polypedilum (P.) fallax* group	X	X	X	X
84470	*Polypedilum (P.) illinoense*	X	X	X	X
84475	*Polypedilum (P.) ophioides*		X		
84520	*Polypedilum (Tripodura) halterale* group	X	X	X	
84540	*Polypedilum (Tripodura) scalaenum* group	X	X	X	
84700	*Stenochironomus sp*	X	X		
84750	*Stictochironomus sp*	X	X	X	X
84790	*Tribelos fuscicorne*	X	X	X	
84800	*Tribelos jucundum*	X	X	X	X
84960	*Pseudochironomus sp*	X	X		
85201	*Cladotanytarsus* species group A	X	X		
85230	*Cladotanytarsus mancus* group	X	X	X	
85264	*Cladotanytarsus vanderwulpi* group	X			
85500	*Paratanytarsus sp*	X		X	X
85615	*Rheotanytarsus distinctissimus* group	X	X	X	
85625	*Rheotanytarsus exiguus* group	X	X	X	X
85700	*Stempellina sp*		X	X	
85800	*Tanytarsus sp****	X	X	X	X

85802	*Tanytarsus curticornis* group****	X	X	X	
85814	*Tanytarsus glabrescens* group	X	X	X	
85840	*Tanytarsus guerlus* group	X	X	X	X
86050	*Chlorotabanus crepuscularis*				X
86100	*Chrysops sp*	X	X	X	X
87400	*Stratiomys sp*	X			
87501	Empididae	X	X	X	X
87601	Dolichopodidae		X	X	
89501	Ephydridae	X		X	
94400	*Fossaria sp*	X			
95100	*Physella sp*	X	X	X	X
95501	Planorbidae		X		
96002	*Heliosoma anceps anceps*		X	X	X
96900	*Ferrissia sp*	X	X	X	
97601	*Corbicula fluminea*	X	X		
98200	*Pisidium sp*	X		X	X
98600	*Sphaerium sp*	X		X	
*Spring Species. ** Will key to "other Cricotopus" in Simpson and Bode 1990. *** Will key to "other Tanytarsus" in Simpson and Bode 1990. **** in Wiederholm, T. (1986).					
Totals:	(excluding Spring Species)	157	137	142	83

Appendix Table 3. List of unionid mussels (living, freshdead, or weathered) collected in Leading Creek since 1964.

	Stream/Date/Collector/Site									
	Leading Cr.	Leading Cr.	Leading Cr.	Leading Cr.	Leading Cr.	Leading Cr.	Leading Cr.	Leading Cr.	Leading Cr.	Leading Cr.
	18 June 64†	02 Oct 84‡	12 Aug 87§	12 Aug 87§	12 Aug 87§	12 Aug 87§	12 Aug 87§	23 Jul 93§	23 Jul 93§	23 Jul 93
Species	12.3	12.3	12.3	10.3	7.1	5.1	1.7	15.5	14.8	12.3
Wabash pigtoe	X			X						
fatmucket	X	X	X	X				X	X	
pink heelsplitter	X		X	X					X	
plain pocketbook		X	X					X	X	
cylindrical papershell			X	X						
giant floater			X	X				X	X	X
white heelsplitter			X	X						
fragile papershell			X	X				X	X	X
mapleleaf				X						
squawfoot			X	X					X	
Total Species (10)	3	2	8	9	0	0	0	4	6	2

†J. Jenkinson et al.
‡R. Sanders
§G. T. Watters

Appendix Table 3 continued. List of unionid mussels (living, freshdead, or weathered) collected in Leading Creek since 1964.

	Stream/Date/Collector/Site						
	Leading Cr.	Parker Run	Leading Cr.	Leading Cr.	Leading Cr.	Raccoon Cr	Raccoon Cr
	23 Jul 93§	23 Jul 93§	28 Jul 93*	28 Jul 93*	13 Sep 93*	28 Jul 93*	13 Sep 93*
Species	10.3	1.5	10.3	14.8	12.9	40.1	39.9
Wabash pigtoe	X		X				
fatmucket	X		X	X	X		
pink heelsplitter	X		X			X	
plain pocketbook	X		X	X	X		
cylindrical papershell							
giant floater	X		X				
white heelsplitter				X	X		
fragile papershell	X			X	X		X
mapleleaf	X				X		
squawfoot	X						
Total Species (10)	8	0	5	4	5	1	1

§G. T. Watters
*Ohio EPA

Appendix Table 4. Aquatic life use attainment status for the Warmwater Habitat (WWH) use designation in Leading Creek, Raccoon Creek, and tributaries based on historical data and data collected by EA Engineering and the Ohio Division of Wildlife during July 1993.

RM Fish/Inv.	Date	Mean Fish Species	Macro. Taxa	IBI	Modified Iwb[a]	ICI[b]	QHEI[c]	WWH Attainment Status[d]	Comment
Leading Creek									
30.2/–	1986	15	–	¤40[ns]	–	–	–	(Full)	ODOT Survey - Carpenter Rd
29.9/–	1993	11	–	†38*	N/A	–	† 70.0	**(Non)**	Carpenter Rd
–/26.0	1991	–	30	–	–	†30*	–	**(Non)**	Co.Rd. 10
–/26.0	1990	–	44	–	–	†40	–	(Full)	" "
–/26.0	1989	–	32	–	–	†28*	–	**(Non)**	" "
–/26.0	1988	–	36	–	–	†26*	–	**(Non)**	" "
24.3/24.3	1987	16	30	§44	–	†26*	–	Partial	Twp. Rd. 13
19.0/–	1993	21	–	†32*	8.0[ns]	–	†46.5	(Partial)	Twp. Rd. 27
17.3/–	1993	24	–	‡42[ns]	8.6	–	–	(Full)	Co. Rd. 4 (near Dexter)
16.8/16.7	1993	20	34	†39*	7.5*	†MG	†69.0	Partial	Co. Rd. 10 (Dexter)
14.8/14.8	1993	17	36	‡44	–	†F	†73.0	Partial	Co. Rd. 8 (Malloons Run Rd)
12.9/–	1993	13	–	‡32*	–	–	†71.5	**(Non)**	Tractor Crossing off Co. Rd. 10; "Big Rock"
12.3/–	1982	19	–	¤39*	–	–	–	**(Non)**	SR 124

Appendix Table 4. Continued.

RM Fish/Inv.	Date	Mean Fish Species	Macro. Taxa	IBI	Modified Iwb[a]	ICI[b]	QHEI[c]	WWH Attain- ment Status[d]	Comment
10.3/10.3	1993	19	41	‡42*	–	†F	†66.0	**Non**	Twp. Rd. 41
10.3/10.3	1990	21	37	†36*	8.5	†36	†72.0	(Partial)	“ “
–/10.3	1989		31	–	–	†34ns	–	(Full)	“ “
–/10.3	1988		38	–	–	†28*	–	**(Non)**	“ “
–/10.3	1987	29	35	§39*	–	†32ns	–	Partial	“ “
7.2/7.1	1993	14	26	‡34*	–	†F	†38.5	**Non**	Co. Rd. 12 (Titus Road)
3.5/–	1993	16	–	‡38*	–	–	–	**(Non)**	Private Rd off Leading Cr Rd.; .75 mi W SR 7
1.8/–	1993	15	–	‡32*	–	–	†55.0	**(Non)**	Upstream SR 7
Little Leading Creek									
0.4/–	1993	14	–	†32*	–	–	†48.0	**(Non)**	Twp. Rd. 176
0.1/–	1993	12	–	‡32*	–	–	–	**(Non)**	Mouth
Parker Run									
2.7/–	1993	13	–	‡48	–	–	–	(Full)	Meigs #31 Mine Property upst. discharge
1.5/1.6	1993	14	24	‡46	–	†F	†70.0	Partial	Co. Rd. 18 (Parkers Run Rd)
L. Parker Run									
0.4/–	1993	5	–	†40ns	–	–	†51.0	(Full)	Co. Rd. 18 (Parkers Run Rd)
Malloons Run									
0.2/–	1993	12	–	†42ns	–	–	†55.0	(Full)	Co. Rd. 8 (Malloons Run Rd)
0.1/–	1993	10	–	‡42ns	–	–	–	(Full)	“ “

Appendix Table 4. Continued.

RM Fish/Inv.	Date	Mean Fish Species	Macro. Taxa	IBI	Modified Iwb[a]	ICI[b]	QHEI[c]	WWH Attainment Status[d]	Comment
Dexter Run									
–/1.6									
0.8/–	1987	9	–	§42ns	–	–	–	(Full)	Co. Rd. 4
Thomas Fork									
2.8/–	1993	0	–	†<u>12</u>	–	–	†45.5	**(Non)**	Twp. Rd. 361
Trib to Ogden Run									
–/1.0	1990	–	28	–	–	†30*	–	**(Non)**	
–/1.0	1989	–	27	–	–	†38	–	(Full)	
–/1.0	1988	–	37	–	–	†30*	–	**(Non)**	
Raccoon Creek									
50.2/50.1	1993	12.5	28	†‡ 34*	6.4	†G	–	Partial	Humpback Bridge
40.2/40.1	1990	15.5	37	†35*	7.6*	†46	†48.5	Partial	Vinton Dam - (Boat)
40.1/40.1	1993	21	38	†36*	7.8*	†G	†73.0	Partial	" " (Wading)
40.1/-	1993	14	–	‡32*	6.7*	–	–	**(Non)**	" " (Wading)
39.9/–	1993	22	–	†35*	9.0	–	†71.0	(Partial)	dst Vinton Dam (Boat)
–/29.1	1993	–	42	–	–	†G	–	(Full)	SR 588, Adamsville
–/29.1	1980	–	15	–	–	†6*	–	**(Non)**	" "
27.1	1993	15	–	‡38ns	6.5*	–	–	(Partial)	Garners Ford Rd
10.2/-	1993	12	–	‡ 30*	6.4*	–	–	**(Non)**	dst Northrup, OH
10.0/–	1990	18.5	28	†35*	8.8	†46	†81.0	(Partial)	" "

Appendix Table 4. Continued.

RM Fish/Inv.	Date	Mean Fish Species	Macro. Taxa	IBI	Modified Iwb[a]	ICI[b]	QHEI[c]	WWH Attainment Status[d]	Comment
Strongs Run									
6.7/–	1993	10	–	‡30*	–	–	–	**(Non)**	Co. Rd. 52
–/5.9	1990	–	31	–	–	†28*	–	**(Non)**	SR 124
–/5.9	1988	–	29	–	–	†24*	–	**(Non)**	SR 124
5.9/–	1987	7	–	§36ns	–	–	–	(Full)	SR 124
2.3/–	1993	18	–	‡ 38*	–	–	–	**(Non)**	Co. Rd. 1W
–/1.5	1993	–	32	–	–	†MG	–	(Full)	Co. Rd. 2W
–/1.5	1991	–	26	–	–	†34ns	–	(Full)	Co. Rd. 2W
–/1.5	1990	–	34	–	–	†46	–	(Full)	Co. Rd. 2W
–/1.5	1989	–	40	–	–	†40	–	(Full)	Co. Rd. 2W
–/1.5	1988	–	33	–	–	†34ns	–	(Full)	Co. Rd. 2W
0.6/–	1993	12	–	◊32*	–	–	†61.5	**(Non)**	Adney Road
–/0.6	1988	–	33	–	–	†26*	–	**(Non)**	Adney Road
0.6/–	1987	15	–	§30*	–	–	–	**(Non)**	Adney Road
Robinson Run									
–/1.6	1993	–	33	–	–	†MG	–	(Full)	Ust Sugar Run
0.2/–	1993	13	–	‡ 34*	–	–	†66.5	**(Non)**	SR 325
Sugar Run									
0.6/–	1993	–	–	–	–	–	†62.5	–	Willi Smith driveway/SR 325
0.1/0.1	1993	–	29	–	–	†MG	†42.0	(Full)	Keesee Road

Appendix Table 4. Continued.

RM Fish/Inv.	Date	Mean Fish Species	Macro. Taxa	IBI	Modified Iwb[a]	ICI[b]	QHEI[c]	WWH Attain-ment Status[d]	Comment
Flatlick Run									
0.7/–	1993	16	–	†40[ns]	–	–	–	(Full)	ust. Co. Rd. 8
0.6/0.6	1993	15.5	29	†29*	–	†MG	†67.0	Partial	dst. Co. Rd. 8
–/0.6	1991	–	30			†32[ns]		(Full)	" "
–/0.6	1990	–	35			†38		(Full)	" "
–/0.6	1988	–	35			†28*		**(Non)**	" "
0.6/–	1987	18	–	§40[ns]	–	–	–	(Full)	" "

† - Ohio EPA Data
‡ - EA Engineering Data
§ - ODNR - NAP Data
◊ - ODNR - DOW Data
¤ - ODOT Data
* - significant departure from ecoregion biocriteria (> 4 IBI or ICI units; > 0.5 Iwb units); poor and very poor results are underlined.
ns- Nonsignificant departure from biocriterion (≤ 4 IBI or ICI units; ≤ 0.5 Iwb units).
a - Modified Iwb does not apply in Headwaters habitats.
b - Narrative evaluation based on qualitative samples from the natural substrates; G = Good, MG = marginally good, F = fair, P = poor.
c - all Qualitative Habitat Evaluation Index (QHEI) values are based on the most recent version (Rankin 1989).
d - Attinment status based on one organism group is parentheically expressed

Ecoregion Biocriteria: Western Allegheny Plateau (WAP)

INDEX - Site Type	WWH	EWH	MWH[e]
IBI - Headwaters	44	50	24
IBI - Wading	44	50	24
IBI - Boat	40	48	24
Mod. Iwb - Headwaters	N/A	N/A	N/A
Mod. Iwb - Wading	8.4	9.4	6.2
Mod. Iwb - Boat	8.6	9.6	5.8
ICI	36	48	24

e - Modified Warmwater Habitat for channelized areas.

Appendix Table 5. ODNR Fish kill stations and associated number of mudpuppies recovered at these locations. Collection conditions were marginal (high flow, low transparency), thus these number are likely underestimates of individuals killed.

Location	No. of Mudpuppies
Dst Parker Run confluence	0
Malloons Road Bridge	2
Insinger Road Bridge	3
SR 124 (Langsville)	1
Parkinson Run Road (Twp. 41)	1
Lasher Road	0
Titus Road	0
Wells Road	0
Leading Creek Road (iron bridge)	1
SR 7 Bridge	4
Middleport Boat Ramp	0