Guidance for Conducting a Demonstration as a Requirement of a 316(a) Alternative Thermal Effluent Limitation Request

DRAFT

March 2015

Indiana Department of Environmental Management
Office of Water Quality
Permits Branch and
Watershed Assessment and Planning Branch
Indiana Government Center-North
100 North Senate Avenue
Indianapolis, Indiana

Contents

List of Figures

.

List of Tables

List of Appendices

EXECUTIVE SUMMARY

A demonstration for alternative thermal effluent limitations, in accordance with section 316(a) of the Clean Water Act and 327 Indiana Administrative Code (IAC) 5-7, should provide the National Pollution Discharge and Elimination System (NPDES) permitting authority, the Indiana Department of Environmental Management (IDEM), with adequate information to establish alternative thermal effluent limitations that will ensure the protection and propagation of a balanced, indigenous community (BIC) in and on the waters into which a thermal discharge is made. The information that IDEM will need in order to authorize alternative thermal effluent limitations in a NPDES permit will be provided by the discharger through the Alternative Thermal Effluent Limitations Application and the required Type I, II, or III Demonstration. The demonstration must be conducted in accordance with this guidance.

This document contains the guidance necessary for completing an application for alternative thermal effluent limitations, a Type I, II, or III Demonstration, and sampling and monitoring consistent with associated standard operating procedures. The standard operating procedures provide the necessary steps for NPDES dischargers to follow for conducting comprehensive monitoring programs for temperature in a waterbody, conducting comprehensive monitoring programs to delineate the thermal discharge plume in the receiving waterbody, and conducting biological community assessments. IDEM may approve, approve with modification, or deny any alternative thermal effluent limitations proposed in a demonstration. IDEM may also at its discretion, request additional information if needed in accordance with 327 IAC 5-7. The U.S. EPA has a strong interest in reviewing these demonstrations. Therefore, IDEM will provide updates to and request comment during the alternative thermal effluent limitations approval process from U.S. EPA.

Except for Outstanding Natural Resource Waters(ONRW) and Outstanding State Resource Waters (OSRW) any determination made by the commissioner in accordance with Section 316 of the CWA concerning alternative thermal effluent limitations shall be considered to be consistent with the antidegradation standards contained in 327 IAC 2-1.3-3.

The burden of proof is wholly on the NPDES discharger requesting the alternative thermal effluent limitations. Therefore, the demonstration must demonstrate to the satisfaction of IDEM that the proposed alternative thermal effluent limitations will assure the protection and propagation of a balanced, indigenous community or balanced, indigenous population of shellfish, fish, and wildlife in and on the body of water into which the discharge is made. Failure by the discharger to verify that the alternative thermal effluent limitations will protect and propagate the balanced indigenous community may result in denial of the application for the proposed alternative thermal effluent limitations.

1.0 INTRODUCTION

1.1 Regulatory Framework

327 IAC 2-1-6 and 327 IAC 2-1.5-8 contain the water quality standards for temperature in waters outside of the Lake Michigan Basin and within the Lake Michigan Basin respectively. The water quality based effluent limitations (WQBEL) for temperature included in NPDES permits are based on the water quality standards contained in these rules. 327 IAC 5-5-2 contains the technology standards for dischargers in waters within the State. The technology based effluent limitations (TBEL) for temperature included in NPDES permits are based upon the technology standards contained within these rules or as developed under Best Professional Judgment (BPJ) in accordance with 327 IAC 5-5-2. NPDES permits require the discharger to meet the more stringent of the WQBEL or TBEL that is applicable to the discharge.

In accordance with 327 IAC 5-7 and Section 316(a) of the Clean Water Act, NPDES dischargers may request alternative thermal effluent limitations (ATEL) for a discharge based on a demonstration that the proposed effluent limitations for temperature are more stringent than necessary for the protection and propagation of the receiving waterbody's balanced, indigenous community (BIC) or balanced indigenous population (BIP) of shellfish, fish, and wildlife in and on the body of water. 327 IAC 5-7 is based on federal regulations (40 CFR Part 125.70 through 125.73) designed to implement Section 316(a) of the Clean Water Act.

This means that a new or existing discharger may request an ATEL to the thermal effluent limitations otherwise imposed by IDEM based on the water quality criteria for the receiving waterbody or the technology standards, using the following demonstration types as applicable:

Type I Demonstration

A demonstration based on field studies conducted to demonstrate the "absence of prior appreciable harm" to the BIC or BIP from a discharge. A Type I Demonstration has many of the same requirements of a Type II Demonstration but focuses on actual field studies rather than literature review to make a determination. Type I Demonstrations can be used by existing dischargers (U.S. EPA 1977).

Type II Demonstration

A predictive demonstration based on literature, lab, and field studies conducted to assure that proposed ATEL will provide adequate protection and propagation of Representative Important Species (RIS) despite previous harm or lack of historical data and that the RIS adequately represent a BIC or BIP. Type II Demonstrations can be used by new discharger or existing dischargers applying for an ATEL (U.S. EPA 1977).

Type III Demonstration

A demonstration that is conducted to address low potential impact discharges or when a custom study is necessary to ensure the BIC or BIP would be protected. These studies incorporate many of the features of a Type I and Type II Demonstration. Essentially, this is a term for any demonstration type agreed to by the NPDES discharger and the permitting authority that would not strictly adhere to the protocols established in this guidance for a Type I or II Demonstration (U.S. EPA 1977).

New Dischargers

New dischargers (that have never discharged wastewater to a water of the State) requesting ATEL may attempt to show that calculated thermal effluent limitations are more stringent than necessary to assure protection and propagation of the receiving waterbody's biological community using a predictive study (Type II Demonstration).

During the initial NPDES permit cycle (maximum of five years), new permittees that have approved ATEL based on a Type II Demonstration should demonstrate the accuracy of their predictive study by showing that the approved ATEL assure the protection and propagation of a BIC or BIP of shellfish, fish and wildlife in and on the body of water into which the discharge is made through additional field studies (Type I).

Existing Dischargers

Existing NPDES dischargers may have existing ATEL in their current NPDES permit for which they seek renewal, or may request new ATEL due to changes in their operations, changes in water quality standards, or changes in ambient temperatures in the receiving waterbody that affect their ability to meet effluent limitations.

An existing discharger may:

1) Apply for renewal of ATEL for an existing discharge based on an absence of prior appreciable harm to the BIC or BIP if a previously approved demonstration, historical data, or an appropriate reference area is available for comparison (Type I Demonstration),
2) Apply for new ATEL for a new thermally impacted wastestream based on the protection and propagation of BIC or BIP (Type II Demonstration), or
3) Apply for new, increased, decreased or an alternate expression of ATEL for an existing wastestream using an alternative demonstration (Type III Demonstration).

327 IAC 5-7-3(c) states that an application requesting a renewal of an ATEL need only include such information as described in subsection (a) and (b) as the Commissioner of IDEM requests not later than one year prior to the date on which the NPDES permit

renewal application is due unless the Commissioner can demonstrate good cause for making such a request at a later date.

Criteria

327 IAC 5-7-4 contains the criteria and standards for granting an ATEL. The discharger must demonstrate to the satisfaction of the Commissioner of IDEM that thermal effluent limitations required under section 301 or 306 of the Clean Water Act and Indiana Water Quality Standards are more stringent than necessary to assure the protection and propagation of a BIC or BIP of shellfish, fish and wildlife in and on the body of water into which the discharge is made.

Federal regulations regarding Section 316(a) are found at 40 C.F.R. Part 125 Subpart H. The federal guidance document available to guide the approach to making a demonstration for an ATEL or for rendering a decision on the appropriateness of a requested ATEL is the *Draft Interagency 316(a) Technical Guidance Manual and Guide for Thermal Effects Sections of Nuclear Facilities Environmental Impact Statements. May 1, 1977. U.S. EPA, Office of Water Enforcement, Permits Division, Industrial Permits Branch, Washington D.C. (http://www.epa.gov/npdes/pubs/owm0001.pdf).* That guidance provides information that may be useful to dischargers seeking an ATEL, but does not duplicate the requirements of Indiana state law verbatim. Indiana rules distinguish between "new" and "existing" discharges in 327 IAC 5-7.

An additional federal guidance document which may be used to guide the approach to making a demonstration for an ATEL is the *U.S. EPA. Guidelines for Ecological Risk Assessment. U.S. Environmental Protection Agency, Risk Assessment Forum, Washington, DC, EPA/630/R095/002F, 1998.*

1.2 Proposed Approach for Existing Dischargers to Apply for Alternative Thermal Effluent Limitations (Type I Demonstration - Absence of Prior Appreciable Harm)

A Type I Demonstration is conducted by existing dischargers seeking renewal of existing ATEL.

Existing dischargers will begin the process by contacting IDEM's Office of Water Quality, Industrial NPDES Permits Section to inform IDEM of their intent to apply for new ATEL or seek renewal of ATEL. A Type I Demonstration will evaluate the thermal impact of the discharge on the BIC or BIP of the receiving stream to determine whether or not there has been prior appreciable harm to the BIC or BIP. In order to be eligible to conduct a Type I Demonstration, a previous demonstration, historical data, or an appropriate reference area must be available for comparison to evaluate the findings. If a demonstration has not previously been conducted, there is no historical data, or an

appropriate reference area isn't available, the discharger will be ineligible to conduct a Type I Demonstration and must conduct a Type III Demonstration instead.[1] Existing dischargers are required to conduct a new Type I Demonstration if they have not completed a Type I Demonstration within the past 10 years[2].

The Type I Demonstration for Indiana is based on a combination of the 1977 Draft EPA 316(a) Demonstration Guidance and the information that the Commissioner of IDEM has determined to be necessary to make a decision whether or not the current or proposed ATEL assure the protection and propagation of a BIC or BIP of shellfish, fish and wildlife in and on the body of water into which the discharge is made.

A Type I Demonstration focuses on actual field studies and has many of the same requirements as a Type II Demonstration. As part of the demonstration, dischargers applying for an ATEL will be required to conduct a comprehensive monitoring program for temperature in the receiving stream and of their effluent to delineate the thermal plume in the receiving waterbody and conduct fish community, or other biological community assessments, which may include phytoplankton, zooplankton, periphyton, and benthic macroinvertebrates, utilizing standardized sampling, data acquisition and assessment protocols.

Dischargers applying for ATEL will monitor the thermal impact of their discharge on the receiving waterbody by installing temperature monitoring equipment that is set upstream and downstream of the discharge in ¼ sections across the stream to measure the thermal plume downstream of the discharge, or in semi-circular based transects radiating out from the shoreline discharge point on lakes, reservoirs, or Lake Michigan.[3]

Dischargers applying for ATEL will also measure flow upstream of the discharge, or outside of the influence of the discharge, and the flow of the discharge itself to calculate the mixed river or lake temperature. The in-stream flow and temperature measurements will provide very accurate information about the thermal plume. A computer model must be used by the discharger to delineate the thermal plume extent and direction.

A completed demonstration will include: all of the data collected during the comprehensive monitoring program and biological assessments, a computer model delineation of the thermal plume, the requested thermal mixing zone, the proposed

[1] One exception to this would be for an existing discharger that doesn't have a previous demonstration, historical data, or an appropriate reference area, who is proposing to discharge a NEW thermally impacted wastestream. In that case the existing discharger would qualify for a Type II Demonstration.
[2] IDEM expects any discharger to have information available to support the renewal of an ATEL at the time of permit reissuance, but recognizes that the scope of the required studies may vary when requesting renewal of an ATEL.
[3] IDEM will consider other means of obtaining temperature data on a site-specific basis (for example, via remote sensing.)

ATEL, the proposed point of compliance for the ATEL, and a signed application for ATEL (Appendix O of this guidance document). Ultimately, the Type I Demonstration must demonstrate the absence of prior appreciable harm due to thermal load discharges to the BIC or BIP in and on the body of water into which the discharge is made.

1.3 Proposed Approach for New or Existing Dischargers to Apply for Alternative Thermal Effluent Limitations (ATEL) (Type II Demonstration - Representative Important Species)

A Type II Demonstration is conducted by new dischargers seeking new ATEL or existing dischargers seeking new ATEL for a newly proposed thermally impacted wastestream.

New or existing dischargers will begin the process of applying for a CWA Section 316(a) variance and request ATEL by contacting IDEM's Office of Water Quality, Industrial NPDES Permits Section to inform IDEM of their intent to apply for new ATEL. A discharger seeking approval for new ATEL for a discharge from a particular outfall should submit an initial application containing early screening information per 327 IAC 5-7-3(a). Per 327 IAC 5-7-3(b), within ninety (90) days of submitting the initial application/early screening information, a discharger shall submit a detailed study plan.

The detailed study plan for new ATEL should be developed to support a Type II Demonstration. A Type II Demonstration will predict and evaluate the thermal impact of the discharge on the RIS that represent the BIC or BIP through the use of literature, laboratory studies and field studies to determine whether or not the proposed ATEL will ensure the protection and propagation of the RIS in and on the receiving waterbody.

The Type II Demonstration for Indiana is based on a combination of the 1977 Draft EPA 316(a) Demonstration Guidance and the information that the Commissioner of IDEM has determined to be necessary to make a decision whether or not the proposed ATEL will assure the protection and propagation of a BIC or BIP of shellfish, fish and wildlife in and on the body of water into which the discharge is made.

As part of the demonstration, dischargers will be required to conduct a comprehensive monitoring program for temperature in the receiving stream and of their effluent to delineate the thermal plume in the receiving waterbody and conduct fish community, or other biological community assessments (which may include phytoplankton, zooplankton, periphyton, and benthic macroinvertebrates), utilizing standardized sampling, data acquisition and assessment protocols, based on RIS determinations.

Applicants should develop a proposed list of RIS for review by IDEM following the guidelines in this document. This list should identify all species known to be present

and any that would be expected to be present if pollutants other than heat were controlled as required by the Clean Water Act[4]. The list should provide a basis for why a species is proposed as RIS as well as a basis for excluding a species from the list. IDEM has the ability to evaluate and approve the RIS based on state and federal databases representing years of studies in Indiana waters.

Once the discharge commences, dischargers will monitor the thermal impact of their discharge on the receiving waterbody by installing temperature monitoring equipment that is set upstream and downstream of the discharge in ¼ sections across the stream to measure the thermal plume downstream of the discharge, or in semi-circular based transects radiating out from the shoreline discharge point on lakes, reservoirs, or Lake Michigan.

Dischargers will also measure flow upstream of the discharge, or outside of the anticipated influence of the discharge, and project the flow of the discharge to calculate the mixed river or lake temperature. The in-stream flow and temperature measurements will provide a prediction of the thermal plume. A computer model must be used by the discharger to delineate the thermal plume extent and direction.

The completed demonstration will include: all of the data collected during the comprehensive monitoring program and biological assessments, a computer model delineation of the thermal plume, IDEM approved RIS assessment, the requested thermal mixing zone, the proposed ATEL, the proposed point of compliance for the ATEL, and a signed application for ATEL (Appendix O of this guidance document). Ultimately, the demonstration must verify that the proposed ATEL will assure the protection and propagation of the RIS in and on the body of water into which the discharge is made.

Type III Demonstrations are discussed in detail in Section 3.3 of this document.

1.4 The 316(a) ATEL Application Process[5]

a. For a new applicant (an ATEL has never been applied for nor granted), an initial application/early screening information should be submitted per 327 IAC 5-7-3. The initial application/early screening information is not required for ATEL renewals. A discharger applying for ATEL then submits a proposed Type I, II, or III Demonstration study plan to IDEM for review of completeness. For a Type II

[4] The applicant should be prepared to conduct waterbody surveys to determine what species are present if information is unavailable or inadequate. IDEM encourages applicants to engage with IDEM early in the process to determine what biotic categories require assessment and inclusion in the RIS.
[5] IDEM recognizes that the scope of the Application Process may be less when requesting renewal of an ATEL.

Demonstration, the demonstration study plan must include a list of the proposed RIS for IDEM to review.

b. IDEM may at its discretion request additional information from the discharger to make the study plan complete. When the study plan is complete and satisfies the requirements of the guidance, IDEM will inform the discharger in writing that the Demonstration Study Plan is complete so that the discharger may begin the study. IDEM will also provide the discharger with the accepted RIS.

c. The discharger initiates the Demonstration Study Plan within the next two (2) years.

d. The discharger submits the completed Type I, II, or III Demonstration and application for ATEL to IDEM. The application must be signed by a certifying official in compliance with 40 CFR 122.22 (or comparable state regulation). The demonstration and application for ATEL will be reviewed by IDEM for completeness. The demonstration and application typically are submitted with the NPDES permit application. A complete demonstration consists of the following:

1. A quantitative description and rationale for the proposed ATEL,

2. The Absence of Prior Appreciable Harm assessment or RIS assessment supporting the proposed ATEL

3. All of the thermal and biological data collected during the Demonstration in its most detailed form, provided in Microsoft Excel® or Microsoft Access® format. Summarized data and data compilations alone will NOT be accepted,

4. Executive Summary of Study Findings,

5. Request for Thermal Mixing Zone. The Thermal Mixing Zone request must specify the temperature within and at the edge of the Zone of Initial Dilution (ZID), the temperature at the edge of the mixing zone (the point at which the temperature stabilizes) and the proposed sizes of the mixing zones as applicable,

6. Any other information deemed necessary and developed by the discharger for the demonstration.

7. A delineation/model of the thermal plume under representative flow conditions based on in-stream temperature monitoring data, and with the proposed point of compliance for the proposed thermal limits, and

8. Any additional studies conducted since the last Demonstration was completed and an analysis of any changes from the previous assessments and conclusions.

e. IDEM reviews the proposed ATEL.

f. IDEM reviews the proposed point of compliance for the proposed ATEL. The point of compliance may be determined through a formula designed to simulate the mixed river temperature.

g. Once the application for ATEL is deemed complete, IDEM will make a tentative decision to either approve or deny the ATEL. The tentative decision will be included in a draft NPDES permit that is placed on public notice for a 30-day public comment period. The public notice will provide the proposed ATEL and the limitations that would have been required otherwise. A public hearing may be requested during the 30 day comment period.

h. IDEM will respond to all comments received during the 30 day comment period and from a public hearing, if applicable, and make a final decision regarding the ATEL. The final decision regarding the ATEL will be included in the final NPDES permit with the opportunity to appeal the final decision during the eighteen (18) day appeal period after the final permit is issued.

1.5 Demonstrating Absence of Prior Appreciable Harm

Type I Demonstrations made to demonstrate the “absence of prior appreciable harm” due to thermal load discharges should demonstrate that the current effluent quality has achieved the “protection and propagation of a balanced, indigenous community” and include the following as described below. In making a demonstration of “absence of prior appreciable harm,” the following topics are to be addressed:

a) **Facility Information:** This section should provide IDEM with general information about the operation of the facility, including, but not limited to:

Evidence of compliance with applicable water quality standards and effluent limitations for temperature, any variances or site specific mixing zones granted by IDEM, copies of all thermal water quality related communications for the past five years between the discharger and any other regulatory agencies (other than IDEM), and records of operational modification or shutdowns that could effect thermal loadings to the receiving water body. This should include changes in processes at the facility and any changes that would affect the flow or temperature of the discharge. Any evidence of adverse thermal effects from

shutdowns or nonattainment of thermal water quality standards and effluent limitations should be discussed and rationale should be provided as to why this did not cause appreciable harm to the balanced, indigenous community. Dischargers should note any time in the past five years when short-term excursions for zebra mussel (or other mussel) control occurred as allowed under their NPDES permits.

b) **Physical Data:** This section should provide and analyze all relevant physical data related to the hydrology of the waterbody and facility discharge properties. Hydrological data recommended to fulfill this section include pertinent meteorological data, bathymetric data, monthly flow profiles, current profiles, stratification/salinity variability, and ambient temperature profiles of the receiving water[6]. Discharge properties that should be addressed include information on thermal loadings and estimates of heat rejected via the discharge as a function of time (short and long-term), thermal plume characteristics, time-temperature information, and intake and receiving water temperature contours.

c) **Biological analysis:** The purpose of this section is to describe the biological community within the waterbody and analyze the impacts or potential impacts of thermal discharge to the biota. This section should include a list of species present and their general abundance and distribution within the waterbody, particularly in the area(s) impacted by the discharge. Species of particular interest include representative, important species, as defined in 327 IAC 5-7-2. These species may include primary producers, macroinvertebrates, native unionid mussels, fish, endemic species, indigenous species, economically important species, principal macro-benthic species, sport fish species, temperature sensitive species, nuisance species, and threatened or endangered species. IDEM and the discharger will identify specific species for which the analysis of impact must be conducted. This report should identify for specific species: reproductive and nursery areas, reproductive periods (dates), ambient temperatures during critical biological phases, and migratory routes. Analysis of these data should be provided to support the “absence of prior appreciable harm” and the continued protection and propagation of the biological community. This analysis should also discuss in detail any impacts or changes to the biological community due to the thermal discharge. If applicable, rationale should be provided as to why these impacts do not constitute “appreciable harm”.

d) **Mixing Zone Information:** This section should include general information about the mixing zone including its physical size, shape, and positioning, taking into account seasonal and temporal variability that may exist. This section should also discuss and analyze the quality of the zone and its potential impacts to the biological community, particularly during critical hydrological (low flow),

[6] See Section 3.0 for more complete descriptions of the data required.

meteorological or biological periods. If multiple mixing zones exist within a waterbody (including those from other facilities), consideration should be given as to how they interact and what impact this interaction has on the biotic environment. This should also discuss how the mixing zone will interact with or influence the impact of other pollutants or water quality parameters.

e) **Far-field and Indirect Effects:** This section should discuss potential impacts to the entire waterbody segment. This should include direct impacts (i.e., from the actual heating of water) and indirect impacts. Indirect impact may include increased toxicity of other compounds or increased susceptible of fish/shellfish mortality or morbidity due to the thermal stress. See definition of far field.

f) **Other Data:** IDEM may request additional information to render a decision. These data may include an impact analysis on recreational or economic activities. To the degree possible, requests for additional data will be provided during consultation with IDEM prior to initiating any field studies.

Dischargers that have completed a Type II Demonstration using the protocols in this guidance in the past in support of a 316(a) ATEL demonstration may use the Type II Demonstration as the baseline condition for consideration by IDEM. It should be noted; however, that some prior demonstrations have been found to be lacking even though previously approved by EPA and/or IDEM. When conducting a Type I Demonstration, the discharger must demonstrate why they believe that:

a) The current local biological community and the predominant local biological community that existed when the historical data were collected are similar in makeup and in regards to response to thermal influences,

b) The current operating conditions at the permitted facility are similar to those that were evaluated when the historical data were collected, and

c) Any changes in the physical characteristics of the waterbody or changes in ambient water quality would not alter the conclusions drawn to support the ATEL.

1.6 Demonstrating that the ATEL will Provide Protection & Propagation of Representative Important Species

Type II Demonstrations made to demonstrate that an ATEL will provide adequate "protection and propagation of the representative, important species" must show that despite previous harm, lack of historical data or lack of operational data, the proposed ATEL will assure the protection and propagation of a balanced, indigenous community of shellfish, fish, and wildlife in and on the water using representative, important species to represent the potentially affected biological community. In order to fulfill the requirements of a Type II Demonstration, the discharger will provide all of the data

described in Section 1.5 above except 1.5.c (Demonstrating Absence of Prior Appreciable Harm) in addition to the following:

a) **Representative, Important Species Information:** This section should include a list of species present and their general abundance and distribution within the waterbody, particularly in the area(s) impacted by the discharge. The discharger must propose to IDEM a list of representative, important species as defined in 327 IAC 5-7-2 for this demonstration type. These species may include primary producers, macroinvertebrates, native unionid mussels, fish, endemic species, indigenous species, economically important species, principal macro-benthic species, sport fish species, temperature sensitive species, nuisance species, and threatened or endangered species. Representative, important species may include species with high biomass, species with large numerical abundance, economically important species, or thermally sensitive species. Threatened or endangered species must also be accounted for in any demonstration. IDEM biologists will evaluate the proposed list and either accept, not accept, or accept with modifications and notify the discharger in writing. Once these species have been identified and accepted by IDEM, a complete analysis should be conducted in order to determine the potential impacts of the thermal discharge on these species. This analysis should include life history thermal effects data and data analysis. This analysis should identify for the RIS: reproductive and nursery areas, reproductive periods (dates), ambient temperatures during critical biological phases, and migratory routes. Rationale should be provided to support that the discharge will assure the protection and propagation of a balanced, indigenous community.

b) **Biotic Community Information:** Consideration must be given to the biotic community as a whole. This section should provide data and data analysis as to whether trophic shifts will occur as a direct or indirect result of the thermal discharge. This could include the absence of a given species or the expanded presence of nuisance/thermally tolerant species as a result of the discharge.

1.7 Using the Index of Biotic Integrity (IBI) for ATEL

Historically demonstrations for ATEL relied very heavily on fish studies. The basic problem with fish studies is that they often did not provide reproducible results year after year because the stream conditions are different every year due to weather and an ever changing stream. The number of variables that impact the results of a fish study made it very difficult to draw any conclusions about the protection and propagation of the representative important species during critical stream conditions. Response signatures have been developed, calibrated and now accepted in the scientific and regulatory communities to discriminate between different stressor types and the range of stressor conditions that can occur in aquatic systems. Unique

combinations of biological community characteristics that aid in distinguishing one impact type over another are detected in the biological community data and respond with discrete signatures.

Biological response signatures are the bases for determining patterns in the multi-metric assessment. A number of these metrics have been selected for their response to a variety of structural, compositional, and functional attributes of large and great rivers. The Index of Biotic Integrity (IBI) is a standardized and calibrated multi-metric index that integrates structure, composition, trophic ecology, and reproductive attributes of fish assemblages at multiple levels of ecological organization. The power of the IBI is that it evaluates a variety of ecological levels of organization including ecosystems, communities, populations, and individuals. Advances in the development of IBI calibrations based on regional and waterbody type reference conditions has enabled us to make assessments on or determine impacts on waterbodies from year to year with consistency and confidence. Least impacted sites will have lower temporal variation than impacted sites. Although Fish community species makeup can vary temporally, variation of the structure, composition and function within the community will be minimized with changes reflected relative to natural factors and their variation to human impact. Simon (2006) found that even with annual variations in IBI scores that sites remained in the same integrity class.

2.0 Definitions and Concepts

The definitions and descriptions in this section pertain to a number of terms and concepts which are pivotal to the development and evaluation of 316(a) studies. These are developed for a general case to aid IDEM in delineating a set of working definitions and concise endpoints requisite to a satisfactory demonstration for a given discharge.

Aquatic Macroinvertebrates

Aquatic macroinvertebrates are those invertebrates that are large enough to be retained by a U.S. Standard No. 30 sieve (0.595-mm openings) and generally can be viewed without visual aid.

Balanced, Indigenous Community (BIC)

The term “balanced, indigenous community” as defined here is synonymous with the term “balanced, indigenous population” in section 316(a) of the Clean Water Act and 40 CFR section 125.71(c). A balanced, indigenous community means a biotic community typically characterized by diversity, the capacity to sustain itself through cyclic seasonal changes, presence of necessary food chain species and by a lack of domination by pollution tolerant species. Such a community may include historically non-native species introduced in connection with a program of wildlife management and species whose presence or abundance results from substantial, irreversible environmental modifications. Normally, however, such a community will not include species whose presence or abundance is attributable to the introduction of pollutants that will be eliminated through compliance by all sources with section 301(b)(2) of the Act; and may not include species whose presence or abundance is attributable to alternative effluent limitations imposed pursuant to section 316(a).

Balance, Indigenous Population (BIP)

For the purposes of 316(a) demonstrations, the term “balanced, indigenous population” is synonymous with the term “balanced, indigenous community” as defined above.

Community

A community in general is any assemblage of populations living in a prescribed area or physical habitat; it is an organized unit to the extent that it has characteristics additional to its individual and population components, and functions as a unit through coupled metabolic transformations.

Dominant Species

Dominant species are defined as any species representing five percent of the total number of organisms in the sample collected according to recommended sampling procedures.

Far Field Study Area (FFSA)

The far field study area is that portion of the receiving waterbody, exclusive of the primary study area, in which impacts of the thermal discharge and its interaction with other pollutants are likely to occur. The area shall include:

1. The zones where the habitats are comparable to those existing in the primary study area, and
2. The zones inhabited by populations of organisms that may encounter the thermal effluent during their lifetime.

The actual boundary of the far field study area should be agreed upon by IDEM.

Thermal impacts are more likely to occur within the near field of the mixing zone.

Habitat Formers

Habitat formers are any assemblage of plants and/or animals characterized by a relatively sessile life stage with aggregated distribution and functioning as:

1. A living and/or formerly living substrate for the attachment of epibiota;
2. Either a direct or indirect food source for the production of shellfish, fish, and wildlife;
3. A biological mechanism for the stabilization and modification of sediments and contributing to the development of soil;
4. A nutrient cycling path or trap; or
5. Specific sites for spawning and providing nursery, feeding, and cover areas for fish and shellfish.

Macroinvertebrates

For this document, the term “macroinvertebrates” may be considered synonymous with “aquatic macroinvertebrates” as defined above.

Meroplankton

Meroplankton are organisms that are planktonic for only a part of their life cycles, usually the larval stage. For the purposes of this document, meroplankton are defined as planktonic life stages (often eggs or larvae) of fish or invertebrates.

Nuisance Species

Any microbial, plant or animal species which indicates a hazard to ecological balance or human health and welfare that is not naturally a dominant feature of the indigenous community may be considered a nuisance species.

Nuisance species of phytoplankton include those algae taxa which in high concentration are known to produce toxic, foul tasting, or odoriferous compounds to a degree that the quality of water is impaired.

Phytoplankton

Plant microorganisms such as certain algae and cyanobacteria living unattached in the water column.

Plankton

Organisms of relatively small size, mostly microscopic, that either have relatively small powers of locomotion or drift in the waters subject to the action of waves and currents.

Prior Appreciable Harm

Under 40 CFR § 125 "Prior Appreciable Harm" has not been rigidly defined. However, using the definition of "balanced, indigenous community," a variance is granted under either of the following circumstances:

> 1. When a discharger shows that the characteristics of a Balanced Indigenous Community (i.e., diversity, the capacity to sustain itself through cyclic seasonal changes, presence of necessary food chain species, and a lack of domination by pollution tolerant species) exist. Stated another way, the existence of such characteristics demonstrate that the aquatic community has not been appreciably harmed; or
>
> 2. Despite any evidence of previous harm, the characteristics of a Balanced Indigenous Community, as stated above, will nevertheless be protected and assured under the alternate limit.

A successful 316(a) demonstration does **not** require that prior appreciable harm be absent, but only that if such harm is noted that the existing or proposed variance does not prevent the protection or establishment of the Balanced Indigenous Community (i.e., it is not the existing or proposed thermal standards that limit the aquatic community).

Representative, Important Species (RIS)

Representative, important species are those species which are: representative, in terms of their biological requirements, of a balanced, indigenous community of shellfish, fish, and wildlife in the body of water into which the discharge is made. Specifically included are those species which are:

1. Represent the full range of response to environmental conditions from sensitive through tolerant,

2. Commercially or recreationally valuable (i.e., within the top ten species landed—by dollar value),

3. Representative of each community trophic level,

4. Threatened, rare, or endangered,

5. Critical to the structure and function of the ecological system (e.g., habitat formers),

6. Dominate the community in terms of density and biomass and potentially capable of becoming localized nuisance species,

7. Necessary in the food chain for the well-being of species determined in 1-4, or

8. Representative of the thermal requirements of important species but which themselves may not be important.

Shellfish

All mollusks and crustaceans (such as clams, mussels, and crayfish,) which, in the course of their life cycle, constitute important components of the benthic, planktonic, or nektonic fauna in fresh water.

Threatened or Endangered Species

A threatened or endangered species is any plant or animal that has been determined by the Secretary of Commerce or the Secretary of the Interior to be a threatened or endangered species pursuant to the Endangered Species Act of 1973, as amended. Threatened or Endangered Species lists specific to Indiana may be obtained by contacting the Indiana Natural Heritage Data Center, Division of Nature Preserves, Indiana Department of Natural Resources.

Type I Demonstration

A demonstration based on field studies conducted to demonstrate the “absence of prior appreciable harm” to the BIC or BIP from a discharge. A Type I Demonstration has many of the same requirements of a Type II Demonstration but focuses on actual field studies rather than literature review to make a determination. Type I Demonstrations can be used by existing dischargers (U.S. EPA 1977).

Type II Demonstration

A predictive demonstration based on literature, lab, and field studies conducted to assure that proposed ATEL will provide adequate protection and propagation of Representative Important Species (RIS) despite previous harm or lack of historical data and the RIS will adequately represent a BIC or BIP. Type II Demonstrations can be used by new discharger or existing dischargers applying for an ATEL (U.S. EPA 1977).

Type III Demonstration

A demonstration that is conducted to address low potential impact discharges or when a custom study is necessary to ensure the BIC or BIP would be protected. These studies incorporate many of the features of a Type I and Type II Demonstration. Essentially this is a term for any demonstration type agreed to by the NPDES discharger and the permitting authority that would not adhere to the protocols established in this guidance for a Type I or II Demonstration (U.S. EPA 1977).

Waterbody Segment

A waterbody segment is a portion of a basin the surface waters of which have common hydrologic characteristics (or flow regulation patterns); common natural physical, chemical, and biological processes, and which have common reactions to external stress, e.g., discharge of pollutants. Where they have been defined, the waterbody segments determined by the State Continuing Planning Process under Section 303(a) of the Clean Water Act apply.

Zooplankton

Animal microorganisms living unattached in water column. They include small crustacea such as daphnia and cyclops, and single-celled animals such as protozoa, etc.

3.0 Demonstrations for Alternative Thermal Effluent Limitations

3.1 Type I Demonstrations (Absence of Prior Appreciable Harm)

Type I Demonstrations are applicable to existing dischargers applying for renewal of a current ATEL because the nature of a Type I Demonstration is confirmatory.

A Type I Demonstration consists of field studies conducted to demonstrate the absence of prior appreciable harm. In order to successfully develop a Type I Demonstration, the applicant must have historical data (such as a demonstration conducted within the last 10 years) or identify an appropriate reference area (example: upstream) upon which a baseline may be established and used in comparison with new field studies.

The Type I Demonstration should be designed to provide complete biotic category rationales, engineering and hydrological data, and synthesis of all information into an Executive Summary of Findings. This section provides a discussion of the recommended components of the demonstration and a proposed format.

3.1.1 Development of Biotic Category Rationales

IDEM recommends that applicants conduct pilot field surveys and literature searches to determine whether or not the site is one of low potential impact for the individual biotic categories and to determine what additional studies will be required to develop biotic category rationales responsive to the decision criteria. Each Biotic Category Rationale should provide a complete discussion as to why, in the judgment of the discharger, the results show that the site is a low potential impact area for that biotic category. In the rationale, the discharger should address each decision criteria for the biotic category in question. The discussion should include an evaluation of the impacts of the discharges into the receiving waterbody. The conclusions drawn should be supported with an analysis of the data collected during the demonstration activities. The conclusions should represent a logical extension of the information available and be scientifically defendable. Additional information on Biotic Category Rationales is provided in Section 3.2.1 below.

3.1.2 Engineering and Hydrological Data for a Type I Demonstration

The engineering and hydrologic information and data supplied in support of a 316(a) demonstration should be accompanied by adequate descriptive and citation material concerning its source. Data from field work, analytical modeling, infrared surveys and hydraulic modeling will all be acceptable, assuming adequate scientific justification for their use is presented.

In addition to the results obtained from analytical hydraulic models the discharger should present, under separate cover, the model which was used. The model should contain a

rationale explaining why this particular model was used and explanations of all modifications to the original work.

3.1.2.1 Plant Operating Data

1. Cooling water flow. Complete Table A at the end of section 3.1.5 (indicate units) and provide a descriptive flow diagram.

2. Submit a time-temperature profile graph indicating temperature on the vertical and time on the horizontal scale. The graph should indicate status of water temperature from ambient conditions through the cooling system, and finally the discharge plume out to the 1^{o}C isotherm. The worst case, anticipated average conditions, and ideal (e.g., minimum time/temperature impact) conditions should be illustrated (preferably on the same graph) consistent with the representative plumes illustrated.

3. Provide the amount of chlorine used daily, monthly, and annually, the frequency and duration of chlorination and the maximum total residual chlorine at the point of discharge to the receiving waterbody obtained during any chlorination cycle; the chlorine demand of the receiving waterbody; a time-concentration graph of total chlorine residual at the point of discharge to the receiving waterbody during a chlorination event.

4. Provide a list of any other chemicals, additives or other discharges (with schematic diagrams) which discharge into the cooling water system including generic name, amount (including frequency and duration of application and the maximum concentration obtained prior to the dilution), chemical composition and the reason for discharge.

5. Provide a map of existing Dissolved Oxygen (D.O.) levels including vertical profiles in the plume and discharge to the waterbody vicinity in 0.5 mg/L increments for both average and worst case conditions. Where stratification or the presence of Biochemical Oxygen Demand (BOD) discharges will possibly lead to depression of oxygen levels as a result of the thermal discharge, the extent of the effect should be estimated.

6. Provide information on operations utilizing metrics such as percent capacity utilized or percent production on a monthly and annual basis and how these metrics correspond to the thermal discharge. See Table A at end of Section 3.1.5.

3.1.2.2 Hydrologic Information

1. Flow: Provide information requested below as applicable to the location of the discharge.

   A. Rivers: flow—monthly means and minima (rolling mean, 7-day, 10-year low flows

($Q_{7, 10}$)) for each month. Statistical flows for the receiving water are derived from historical data.

B. Reservoirs: flow through time, release schedules—monthly means and minima.

2. Currents: Provide the information requested below, as applicable to the site:

A. Rivers: maximum, minimum, and mean current speed providing daily, monthly or seasonal fluctuations and variations across cross-sections as appropriate to describe hydrodynamics of the thermal discharge plume. Include speeds at mean annual flow to 7-day, 10-year low flow.

B. Large lakes: offshore prevailing currents, near shore currents/eddies; local tidal and seasonal changes in current speed and direction.

3. Tabulate or illustrate monthly and seasonal gradients for both thermally induced stratification at representative locations in the study area (consistent with the complexity of the study area conditions). If discharge conditions are identical then state as so and provide only one tabulation or illustration. This data requirement is applicable to every month for which an ATEL is being requested.

4. Tabulate or illustrate ambient temperature of the receiving waters, providing monthly means and monthly extremes for the preceding 10 years as data availability permits. If comparable site waters are used, indicate the basis and limits of comparability. In addition, for biologically critical periods, weekly means and extremes, frequency distributions and daily variation should be provided. Temperature data upon which these values are based should, if possible, be obtained at least once hourly.

5. Indicate receiving water(s) depth contours at 1 meter intervals and any changes which may occur due to sediment movements, construction, etc. Indicate bottom type. Provide other significant features (e.g., thermal bar) and characteristics needed to evaluate the hydrodynamics of the thermal discharge plume. Provide information on waterbody size, surface area, volume, mean depth and maximum depth. Sediment characterization is not a requirement of this guidance.

3.1.2.3 Meteorological Data

If energy budget computations are included as part of the 316(a) demonstration, provide the following daily average meteorological data for the plant site, providing both monthly means and seasonal extremes (indicate units).

1. Wet bulb air temperature.

2. Dry bulb air temperature (verified to site conditions).
3. Wind speed and direction.
4. Long wave (atmospheric) radiation (may be calculated).
5. Short wave (solar) radiation (may be calculated).
6. Cloud cover.
7. Evapotranspiration (may be calculated).

3.1.2.4 Outfall Configuration and Operation

Provide the following information on outfall configuration and operation, indicating units:

1. Length of discharge pipe or canal.
2. Area and dimensions of discharge port(s).
3. Number of discharge port(s).
4. Spacing (on centers) of discharge ports.
5. Depth (mean and extremes).
6. Angle of discharge as a function of:
    A. horizontal axis,
    B. vertical axis,
    C. current directions, and/or
    D. a diffuser.

3.1.2.5 Plume Data Requirements

The discharger shall furnish field data of the following plume data for all months in which an ATEL has been requested:

1. Utilizing Table A at the end of section 3.1.5, the load information, wind rose data and tidal/current data, a plume rose or locus of plumes shall be provided for each calendar

month. The plumes shall be provided for each calendar month. The plumes shall be bounded by the 2 °C above ambient isotherm. This shall be done for both surface isotherms and bottom isotherms when contact with benthic areas is made.

2. Representative plumes of the maximum size and most frequently occurring plumes shall be detailed showing instantaneous isotherms at the 2 °C intervals to within 1 °C of ambient for conditions of variations in tide, wind and current.

   A. Rivers: Plumes for average and 7-day, 10-year low flows should be provided.

   B. Lakes and Reservoirs: Plumes for summer conditions, winter conditions and after spring and fall overturns should also be provided. For flood control reservoirs, plumes for various water levels should be provided.

3. For isotherm plots required in number 2 above, vertical temperature profiles along the plume centerline extending to the bottom of the waterbody at 2 °C intervals to within 1 °C of ambient shall be provided.

3.1.3 Synthesis of All Information into an Executive Summary of Findings

The Executive Summary of Findings of the demonstration should summarize the key findings in a concise manner and should form a convincing argument that there is an absence of prior appreciable harm. The findings should include a summary of an “overall picture” of the ecosystem as projected by the six Biotic Category Rationales, the resource zones impacted, and a summary of why the information in the rationales, the engineering and hydrological data, and other key facts, suggest absence of prior appreciable harm.

3.1.4 Suggested Format for a Type I Demonstration (Example) Table of Contents

I. Introduction

II. Executive Summary of Findings for Demonstration

III. Biotic Category Rationales

   A. Phytoplankton

      1. Decision Criteria
      2. Rationale

   B. Zooplankton

      1. Decision Criteria

2. Rationale

C. Habitat Formers
   1. Decision Criteria
   2. Rationale

D. Shellfish/Macroinvertebrates

   1. Decision Criteria
   2. Rationale

E. Fish

   1. Decision Criteria
   2. Rationale

F. Other Vertebrate Wildlife

   1. Decision Criteria
   2. Rationale

IV. Brief Summary of Engineering and Hydrological Data and Why the Data is Supportive of the Conclusions in the Above Rationales.

V. Demonstration Appendices

   A. Information Supporting Executive Summary of Findings

   B. Information Supporting Biotic Category Rationales

   C. Engineering and Hydrological Information

      1. Baseline Data
      2. Discussion of Relationship of the Physical Data to the Summary Rationales and Choice of Models.

   D. Raw Data Not From the Open Scientific Literature.

Table A. Cooling Water Characteristics[1,2]

% Capacity	% Time at Fractional Load	Intake Velocity		Rate of Circulating Cooling water Flow[3]	Condenser Rise □□T	Discharge □□T[4]	Rate of Discharge		Discharge Velocity[5]
		Channel Entrance	Screens				Cooling Water	Non-Cooling Water	
40% and Less									
40–50									
50–60									
60–70									
70–80									
80–90									
90–100									

[1] A separate table should be prepared for each generating unit and for all units combined.
[2] If seasonal variations occur, this should be indicated.
[3] Variations of intake velocity with changes in ambient conditions (e.g., river flow, tidal height, water level) should be noted.
[4] Discharge □T = Discharge temperature – Intake temperature (in many cases, condenser □T
case for plants with supplemental cooling).
[5] Discharge velocity should be provided at the point where cooling water leaves the discharge structure. Variations in discharge velocity, with changes in ambient conditions (e.g., river flow, tidal height, water level) should be noted.

3.2 Type II Demonstrations (Representative Important Species)

Type II Demonstrations are applicable to new and existing dischargers applying for new ATEL for proposed thermally impacted discharges because the nature of a Type II Demonstration is predictive.

A Type II Demonstration, which consists of literature, lab, and field studies, is a predictive demonstration conducted to demonstrate that the proposed alternative thermal effluent limitations for a proposed new discharge will assure adequate protection and propagation of the RIS in the receiving waterbody despite previous harm or lack of historical data, and the RIS will maintain a balanced indigenous community. Due to changes which occur in receiving waterbodies, climate, and individual facilities over time, these demonstrations should be conducted at least once every 10 years. IDEM may require a discharger to conduct additional field studies to confirm that any ATEL proposed and approved of through a Type II Demonstration achieves the standard of protection and propagation of the BIC or BIP.

The Type II Demonstration should be designed in such a manner to fully develop the three key biological components: Completion of the Biotic Category Rationales (possibly begun during early screening procedures), development of RIS rationales, and synthesis of all information into an Executive Summary of Findings.

3.2.1 Development of Biotic Category Rationales

As was introduced in Section 3.1.1, each Biotic Category Rationale should provide a complete discussion as to why, in the judgment of the discharger, the results show that the site is a low potential impact area for that biotic category. In the rationale, the discharger should address each decision criteria for the biotic category in question. The discussion should include an evaluation of the impacts of the discharges into the receiving waterbody. Often these rationales are developed during the early screening process to identify whether RIS species should be selected from a particular biotic category.

The conclusions drawn should be supported with an analysis of the data collected during the demonstration activities and/or by the inclusion of supportive reports, documents and citations to the scientific literature. The conclusions should represent a logical extension of the information available and be scientifically defensible. Where citations are used that are not readily available in scientific journals (i.e., interim reports, various types of department documents, annual reports, theses, etc.), the documents themselves should be provided.

If the impact of the discharge is projected using a mathematical model, the discharger should provide a complete documentation of the model that is used. The documentation should include a discussion of the merits and disadvantages of the model. The discharger should also provide sensitivity analyses of the model and a verification study. In addition, the

statistical reliability of the model's predictions should be included along with a justification of the methods used in the statistical evaluation.

3.2.2 Development of Representative Important Species Rationale

The RIS Rationale should summarize why the results of the laboratory and literature studies suggest that the RIS will be protected and propagated despite the impacts of the heated discharge. The assumptions in the concept of RIS are:

1. It is not possible to study in great detail every species at a site; there is not enough time, money or expertise.

2. Since all species cannot be studied in detail, some smaller number will have to be chosen.

3. The species of concern are those causally related to thermal impacts.

4. Some species will be economically important in their own right, e.g., commercial and sports fishes or nuisance species, and thus "important."

5. Some species, termed "representative," will be particularly vulnerable or sensitive to thermal impacts or have sensitivities of most other species and, if protected, will reasonably assure protection of other species at the site.

5. Wide-ranging species at the extremes of their ranges would generally not be considered acceptable as "particularly vulnerable" or "sensitive" representative species but they could be considered as "important."

6. Often, all organisms that might be considered "important" or "representative" cannot be studied in detail, and a smaller list (e.g., greater than 1 but less than 15) may have to be selected as the "representative and important" list.

7. Often, but not always, the most useful list would include mostly sensitive fish, shellfish, or other species of direct use to man or for structure or functioning of the ecosystem.

8. Officially listed "threatened or endangered species" are automatically important."

3.2.2.1 Selection of the Representative Important Species

As previously discussed, dischargers first meet with IDEM to discuss selection of the RIS. The number of RIS selected for a particular site may be high (5–15) if the plans for biotic category field studies are not comprehensive, or low (2–5) if plans for additional field studies are extensive.

Some of the criteria for selection of RIS are found in the definition of the term (see section 2.0, Definitions and Concepts). Keeping in mind these criteria and the assumptions given above, IDEM may select RIS from any combination of the following biotic categories: fish, shellfish, habitat formers or wildlife.

Dischargers should be prepared to explain why any species that is present in the community was not selected for inclusion in the RIS. For example, species "A" is represented by another species, is thermally tolerant, or is not present when thermal impacts would occur due to migratory behavior.

1. Species Selection Where Information is Adequate. The discharger will suggest species for IDEM's consideration and may, as a part of its demonstration, challenge any selection made by IDEM. Other considerations are as follows:

   A. *Applicable State Water Quality Standards*. If the State's approved water quality standards designate particular species as requiring protection, these species should be designated, but alone may not be sufficient for purposes of a Type II Demonstration.

   B. *Consultation with Secretaries of Commerce and Interior*.
   The Secretary of Commerce (National Marine Fisheries Service) and the Secretary of the Interior (Fish and Wildlife Service), or their designees, and other appropriate persons (e.g., university biologists with relevant expertise), should be consulted and their timely recommendations should be considered.

   C. *Threatened or Endangered Species*. Species selection should specifically consider any present threatened or endangered species, at whatever biotic category or trophic level, except that no information should be requested that would require field sampling prohibited by the Endangered Species Act, 16 U.S.C. 1531 *et seq*.

   D. *Thermally Sensitive Species*. The most thermally sensitive species (and species group) in the local area should be identified and their importance should be given special consideration, since such species (or species groups) might be most readily eliminated from the community if effluent limitations allowed existing water temperatures to be altered. Consideration of the most sensitive species will best involve a total aquatic community viewpoint.

   Reduced tolerance to elevated temperature may also be predicted, for example in species which experience natural population reduction during the summer. Species having the greatest northern range and least southward distribution may also possess reduced thermal tolerance.

E. *Commercially or Recreationally Valuable Species*. Selection of commercially or recreationally valuable species should be based on a consideration of the benefits of assuring their protection.

F. *Indirect Effects*. Consideration should include the entire waterbody segment. For example, an upstream cold water source should not be warmed to an extent that would adversely affect downstream biota. The impact of additive or synergistic effects of heat combined with other existing thermal or other pollutants in the receiving waters should also be considered.

G. *Species Necessary (e.g., in the Food Chain or Habitat Formers) for the Well-Being of Species Determined Above*. In addition to the above considerations, it is suggested that the discharger ask the following questions before selecting the RIS:

1) Is the potential problem with this species credible (documented, a problem elsewhere, a good prediction)?

2) Is the problem likely to be significant?

3) Which species are present at the location?

4) Which species is likely to be closely involved with the source or damage?

5) Does the problem species rank as “important”?

6) Does the list of problem species fall in the range 5–15 or 2–5 (see text above)?

7) Are the identified problem species “representative”?

8) Should other species not clearly a problem be included as representative or important?

2. Species Selection Where Information is Inadequate. Where the available information is not adequate to enable the discharger to select appropriate RIS, IDEM may request the discharger attempting to make a Type II Demonstration to conduct such studies and furnish such evidence as may be necessary to enable such selection. Where species selection is based on information supplied by the discharger, the appropriateness of the species as representative and important is an aspect of the discharger’s burden of proof.

3.2.2.2 Laboratory and Literature Studies

Literature reviews to be done for each RIS should be restricted to those which are necessary to fill out summary Tables B and C and develop (on the basis of the data summaries in those tables) the RIS Rationale (tables located at the end of this section). Not all of the data listed in Tables B and C may be appropriate for a particular site or taxa. If the discharger feels that some are inappropriate and should be deleted, it should be discussed with IDEM at the same time other discussions about the RIS are taking place.

Assumptions for Tables B and C

1. The tables are mere aids to organizing biological data believed to be useful and important for making decisions regarding thermal discharge effects.

2. The species table should be workable for any important or representative species selected, whether it is selected as a species for protection or avoidance (e.g., nuisance species).

3. All thermal characteristics do not apply in a similar context to all taxonomic groups (taxa), requiring some special definitions or omission of a characteristic for a particular taxon.

4. There will be non-thermal influences (e.g., chemicals, scouring), often occurring simultaneously with thermal influences, that are not included in this table but which should be considered in their own right.

5. There may not be differences between adults and juveniles of all taxa, or there may be more than two distinct sensitivity categories. Distinctly different life stage requirements should be listed.

6. Data can be collected by the discharger for those thermal characteristics of the RIS that have not yet been determined but for which standardized methods are readily available.

7. For certain parameters that are still in the research or development stage, as opposed to standardized testing (e.g., gametogenesis requirements or predation on thermally stressed meroplankton), all available published data would be useful but it would not be necessary to develop new data for this category.

8. If more than one set of data is available for any category, the multiple sets should be presented (and referenced) and the rationale presented to aid in selecting one set for decision-making at the site in question.

9. Dates for gametogenesis and spawning imply appropriate seasonal times which will vary from area to area and year to year even without the influence of the thermal discharge. The important point is whether these events would be seasonally precluded.

10. In fishes, optimum temperatures for growth and some performance factors (e.g., maximum swimming speed, greatest metabolic scope, final temperature preference, etc.) have been shown to be coincident for enough fishes that this coincidence is acceptable as a generalization. Exceptions could be important, however, and should be identified.

Table B. Sample Table to Summarize Data for Each Representative Important Species (RIS)

Scientific Name: _____ **Common Name:** _____

Thermal Effects Parameter	Temperature Limit or Range (°C)	Source Reference (If Appropriate)	Mean and Maximum Area Unavailable for Function (m^2)$_a$	Mean and Maximum Time Unavailable for Function (Days)$_a$	Is Effect, if any, Expected to Affect the Population of the RIS? (Yes or No)

[a] That area or time under average and worst case conditions that will not permit the specific biological function to occur satisfactorily.

Summary Conclusion of Effect of Heat on the Representative Important Species (RIS): _____

Table C. Thermal Effects Parameters Applicable to Aquatic Organisms Potentially Selected as RIS

Thermal Effects Parameters	Possible Methods for Determination	Potential Taxa for RIS
1. High Temperature Survival Aquatic Adult Juvenile (Immature)	TL_{50}, 24 hours TL_{50}, 24 hours	
2. Thermal Shock Tolerance (Heat and Cold) Aquatic Adult Juvenile (Immature) Early Developmental Stages (incl. meroplankton)	thermal gradient including worst case ΔT single shock to simulate plant shutdown double shock (up and down) in traversing plume	
3. Optimum Temperature for Performance and Growth Non-breeding Adult Juvenile	length, weight changes; productivity; DNA/RNA Ratio[2] length, weight changes; DNA/RNA Ratio[2]	
4. Maximum Temperature Regime Allowing Early Development Completion	long-term temperature exposure throughout development to juvenile	
5. Normal Spawning Dates and Temperatures	months; range for spawning	
6. Special Temperature Requirements for Reproduction	[1]	

[1] As available in the literature only.

[2] Indicated by final preference for fish.

Narrative for Table C — Thermal Effects Parameters Applicable to Aquatic Organisms Selected as Representative Important Species

Thermal effects studies applicable to major taxa or broad biotic categories are summarized in Table C. Applicable thermal effects data should be obtained for each RIS selected. Remarks on study and notes of application of the results to make 316(a) decisions are indicated here.

1. High temperature survival for juveniles and adults:

   Method: Determine TL_{50} (e.g., 48-hr. = ultimate incipient lethal temperature) for juveniles and no-breeding adults. Acclimation temperature should approximate the highest temperature at which the fish can be held. Expose animal to elevated temperatures in an acute (instantaneous) manner.

   Application of Results: The TL_{50} value can be used for estimation of the upper non-lethal limit for the life-history stage in question (24-hr. TL_{50} minus 2 °C). The TL_{50} value also can be used to estimate the upper temperature limit for appreciable growth (24-hr. - TL_{50} minus optimum growth time).

2. Thermal shock tolerance of selected life-history stages:

   a) For juveniles and adults, simulate winter plant shutdown stress of plume entrained fishes and motile macro-crustacean.

      Method: Expose organisms to acute temperature drops equal to the range of expected discharge Δt's, using maximum winter plume temperature as the acclimation temperature. Indicate temperature test regimes which produce equilibrium loss of 50% of the sample within 4 hours and mortality after 24 hours.

      Application of Results: Identified winter plume vs. ambient temperature conditions which could result in thermal shock in the event of plant shutdown, and an ensuing high loss of organisms due to markedly increased susceptibility to predation.

   b) For meroplankton, simulate temperature shock upon traversing a thermal plume.

      Method: Expose eggs, embryos, and larvae to acute temperature elevations, followed by an acute drop in temperature at a series of exposure times and temperature gradients reflecting plume resident times and temperatures. Acclimation temperature should equal natural seasonal ambient conditions.

Maximum test temperature should range up to the TL_{50} level for adults. Indicate time-temperature regime lading to death of 50% of the sample.

Application of Results: Lethal time-temperature stress regime minus 2 ^{o}C can be used to estimate temperature limits of normal prey avoidance behavior. Increased temperature results in higher predation pressure.

3. Estimation of optimum temperature for growth:

   a) Fish and macroinvertebrates — determine rate of growth (length or weight increase) when maintained at a series of elevated temperatures and at otherwise near-optimum environmental conditions, with food provided *ad libitum*.

   b) Fish — determinations of final behavioral temperature preference will closely correspond to the temperature which is optimal for many physiological processes, including growth.

   c) Macrophytes — determine temperature producing maximum net photosynthesis for at least a 24-hour period, using an appropriate photoperiod.

   Application of Results: Optimum temperature for growth can be combined with ultimate incipient lethal temperature limit for acceptable growth (see #1 above).

4. Minimum optimum and maximum temperatures allowing completion of early development. Note: Studies to be conducted only for RIS which are capable of being readily reared in the laboratory.

   Method: Maintain fertilized eggs under a series of elevated temperature regimes to determine minimum, optimum and maximum conditions permitting greater than 80% survival to completion of development of juvenile (i.e., post-larval metamorphosis; in fish, to the point of successful initiation of feeding). Note that diurnally cyclic temperature regimes with a 5 °C total range can be more adaptive for enhanced thermal tolerance than is a constant, non-cyclic temperature regime.

5. Normal spawning dates and temperatures:

   Method: Cite range of dates (by month) and threshold temperatures reported to initiate and inhibit gametogenesis and spawning, as reported in the literature for areas closely related to the waterbody segment in question.

   Application of Results: To provide background information to evaluate seasonally the relative impact of thermal discharge on timing of reproductive activities.

6. Special temperature requirement for reproduction:

   Method: Information should be provided as available in previously published studies. Examples of relevant "special requirements" include:

   a) Minimum of 10 °C must be experienced before gametogenesis can be initiated in two boreal barnacles; and

   b) Winter chill required for successful development in yellow perch.

3.2.3 Engineering and Hydrological Data for a Type II Demonstration

The engineering and hydrological information and data supplied in support of a 316(a) demonstration should be accompanied by adequate descriptive material concerning its source. Data from scientific literature, field work, laboratory experiments, analytical modeling, infrared surveys and hydraulic modeling will all be acceptable, assuming adequate scientific justification for their use is presented.

In addition to the results obtained from analytical hydraulic models the discharger should present, under separate cover, the model which was used. The model should contain a rationale explaining why this particular model was used and explanations of all modifications to the original work.

3.2.3.1 Plant Operating Data

1. Cooling water flow. Complete Table A at the end of section 3.2.5 (indicate units) and provide a descriptive flow diagram.

2. Submit a time-temperature profile graph indicating temperature on the vertical and time on the horizontal scale. The graph should indicate status of water temperature from ambient conditions through the cooling system, and finally the discharge plume out to the 1^{o}C isotherm. The worst case, anticipated average conditions, and ideal (e.g., minimum time/temperature impact) conditions should

be illustrated (preferably on the same graph) consistent with the representative plumes illustrated.

3. Provide the amount of chlorine used daily, monthly, and annually, the frequency and duration of chlorination and the maximum total residual chlorine at the point of discharge to the receiving waterbody obtained during any chlorination cycle; the chlorine demand of the receiving waterbody; a time-concentration graph of total chlorine residual at the point of discharge to the receiving waterbody during a chlorination event.

4. Provide a list of any other chemicals, additives or other discharges (with schematic diagrams) which discharge into the cooling water system including generic name, amount (including frequency and duration of application and the maximum concentration obtained prior to the dilution), chemical composition and the reason for discharge.

5. Provide a map of existing Dissolved Oxygen (D.O.) levels including vertical profiles in the plume and discharge to the waterbody vicinity in 0.5 mg/L increments for both average and worst case conditions. Where stratification or the presence of Biochemical Oxygen Demand (BOD) discharges will possibly lead to depression of oxygen levels as a result of the thermal discharge, the extent of the effect should be estimated.

6. Provide information on operations utilizing metrics such as percent capacity utilized or percent production on a monthly and annual basis and how these metrics correspond to the thermal discharge. See Table A at end of Section 3.2.5.

3.2.3.2 Hydrologic Information

1. Flow: Provide information requested below as applicable to the location of the discharge.

   A. Rivers: flow—monthly means and minima (rolling mean, 7-day, 10-year low flows ($Q_{7, 10}$)) for each month. Statistical flows for the receiving water are derived from historical data.

   B. Reservoirs: flow through time, release schedules—monthly means and minima.

2. Currents: Provide the information requested below, as applicable to the site:

A. Rivers: maximum, minimum, and mean current speed providing daily, monthly or seasonal fluctuations and variations across cross-sections as appropriate to describe hydrodynamics of the thermal discharge plume. Include speeds at mean annual flow to 7-day, 10-year low flow.

B. Large lakes: offshore prevailing currents, near shore currents/eddies; local tidal and seasonal changes in current speed and direction.

3. Tabulate or illustrate monthly and seasonal gradients for both thermally induced stratification at representative locations in the study area (consistent with the complexity of the study area conditions). If discharge conditions are identical then state as so and provide only one tabulation or illustration. This data requirement is applicable to every month for which an ATEL is being requested.
4. Tabulate or illustrate ambient temperature of the receiving waters, providing monthly means and monthly extremes for the preceding 10 years as data availability permits. If comparable site waters are used, indicate the basis and limits of comparability. In addition, for biologically critical periods, weekly means and extremes, frequency distributions and daily variation should be provided. Temperature data upon which these values are based should, if possible, be obtained at least once hourly.

5. Indicate receiving water(s) depth contours at 1 meter intervals and any changes which may occur due to sediment movements, construction, etc. Indicate bottom type. Provide other significant features (e.g., thermal bar) and characteristics needed to evaluate the hydrodynamics of the thermal discharge plume. Provide information on waterbody size, surface area, volume, mean depth and maximum depth. Sediment characterization is not a requirement of this guidance.

3.2.3.3 Meteorological Data

If energy budget computations are included as part of the 316(a) demonstration, provide the following daily average meteorological data for the plant site, providing both monthly means and seasonal extremes (indicate units).

1. Wet bulb air temperature.

2. Dry bulb air temperature (verified to site conditions).

3. Wind speed and direction.

4. Long wave (atmospheric) radiation (may be calculated).

5. Short wave (solar) radiation (may be calculated).
6. Cloud cover.
7. Evapotranspiration (may be calculated).

3.2.3.4 Outfall Configuration and Operation

Provide the following information on outfall configuration and operation, indicating units:

1. Length of discharge pipe or canal.
2. Area and dimensions of discharge port(s).
3. Number of discharge port(s).
4. Spacing (on centers) of discharge ports.
5. Depth (mean and extremes).
6. Angle of discharge as a function of:
    A. horizontal axis,
    B. vertical axis,
    C. current directions, and/or
    D. a diffuser.

3.2.3.5 Plume Data Requirements

The discharger shall furnish field data of the following plume data for all months in which an ATEL has been requested:

1. Utilizing Table A at the end of section 3.2.5, the load information, wind rose data, and tidal/current data, a plume rose or locus of plumes shall be provided for each calendar month. The plumes shall be provided for each calendar month. The plumes shall be bounded by the 2 °C above ambient isotherm. This shall be done for both surface isotherms and bottom isotherms when contact with benthic areas is made.

2. Representative plumes of the maximum size and most frequently occurring plumes shall be detailed showing instantaneous isotherms at the 2 °C intervals to within 1 °C of ambient for conditions of variations in tide, wind and current.

    A. Rivers: Plumes for average and 7-day, 10-year low flows should be provided.

    B. Lakes and Reservoirs: Plumes for summer conditions, winter conditions and after spring and fall overturns should also be provided. For flood control reservoirs, plumes for various water levels should be provided.

3. For isotherm plots required in number 2 above, vertical temperature profiles along the plume centerline extending to the bottom of the waterbody at 2 °C intervals to within 1 °C of ambient shall be provided.

3.2.4 Synthesis of All Information into an Executive Summary of Findings

The Executive Summary of Findings of the demonstration should summarize the key findings in a concise manner and should form a convincing argument that the Balanced, Indigenous Community will be protected. The findings should include a summary of an "overall picture" of the ecosystem as projected by the six Biotic Category Rationales, the resource zones impacted, and a summary of why the information in the rationales, along with the predictions in the RIS Rationale, the engineering and hydrological data, and other key facts, assure that the balanced indigenous community will be protected.

3.2.5 Suggested Format for Type II Demonstration (Example) Table of Contents

I. Introduction

II. Executive Summary of Findings for Demonstration

III. Representative Important Species Rationale

IV. Biotic Category Rationales

    A. Phytoplankton

        1. Decision Criteria
        2. Rationale

    B. Zooplankton

        1. Decision Criteria
        2. Rationale

C. Habitat Formers

1. Decision Criteria
2. Rationale

D. Shellfish/Macroinvertebrates

1. Decision Criteria
2. Rationale

E. Fish

1. Decision Criteria
2. Rationale

F. Other Vertebrate Wildlife

1. Decision Criteria
2. Rationale

V. Brief Summary of Engineering and Hydrological Data and Why the Data is Supportive of the Predictions in the Above Rationales.

VI. Demonstration Appendices

A. Information Supporting Executive Summary of Findings

B. Information Supporting Representative Important Species Rationale

C. Information Supporting Biotic Category Rationales

D. Engineering and Hydrological Information

1. Baseline Data
2. Discussion of Relationship of the Physical Data to the Summary Rationales and Choice of Models or Other Predictive Methods.

E. Supportive Reports, Documents, and Raw Data Not From the Open Scientific Literature.

Table A. Cooling Water Characteristics[1,2]

% Capacity	% Time at Fractional Load	Intake Velocity		Rate of Circulating Cooling water Flow[3]	Condenser Rise □□T	Discharge □□T[4]	Rate of Discharge		Discharge Velocity[5]
		Channel Entrance	Screens				Cooling Water	Non-Cooling Water	
40% and Less									
40–50									
50–60									
60–70									
70–80									
80–90									
90–100									

[1] A separate table should be prepared for each generating unit and for all units combined.
[2] If seasonal variations occur, this should be indicated.
[3] Variations of intake velocity with changes in ambient conditions (e.g., river flow, tidal height, water level) should be noted.
[4] Discharge □T – Intake temperature (in many cases, condenser □T case for plants with supplemental cooling).
[5] Discharge velocity should be provided at the point where cooling water leaves the discharge structure. Variations in discharge velocity, with changes in ambient conditions (e.g., river flow, tidal height, water level) should be noted.

3.3 Type III Demonstrations (Alternative Demonstration)

Type III Demonstrations address low potential impact discharges or are conducted when a custom study is necessary to ensure the BIC or BIP will be protected. Type III Demonstrations may be conducted by new or existing dischargers. These studies incorporate many of the features of a Type I and Type II Demonstration. A Type III Demonstration is a term for any alternative demonstration type agreed to by the discharger and IDEM.

If IDEM agrees with a new or existing discharger or otherwise determines that a site is one of low potential impact for all biotic categories (typically based on results from early screening studies) and/or there are other factors (small size or volume of water impacted, low percentage of cross section of receiving water affected, etc.) suggesting low potential impact, the discharger may elect to conduct a Low Potential Impact Type III Demonstration. The basic concept is that those dischargers whose sites or proposed facilities which obviously pose little potential threat to BIC or BIP should be required to conduct less extensive studies than other dischargers.

Low Potential Impact Type III Demonstrations consider information from each biotic category. This ensures that no major biotic category is ignored, ensuring that both IDEM and the applicant have examined and made judgments for each biotic category, but discourages collection of excess or unnecessary data. After preliminary studies and determinations that all biotic categories are of low potential impact, the applicant should summarize the information (along with engineering and hydrological data and any other relevant information) in one master rationale document and submit the demonstration to IDEM for review of completeness.

For a Type III Demonstration that is not conducted to address Low Potential Impact, the demonstration should reflect a degree of detail and proof comparable to a Type I or II Demonstration. While Type III Demonstrations may differ in thrust and focus, the supporting documents for the demonstration should be as comprehensive as those required in Type I or II Demonstrations and result in similar levels of assurance of protection of the BIC or BIP. Each item of information of data submitted as part of a Type III Demonstration must be accompanied by rationales comparable to those outlined in Section 3.2. The format of a Type III Demonstration should be similar to that suggested in Section 3.1.

Existing dischargers may also be eligible to conduct a Type III Demonstration when applying for new, increased, or decreased ATEL, or when applying for an alternate expression of ATEL (such as BTU limitations rather than temperature) for an existing wastestream.

3.4 Discussion of Why the Required Data is Necessary for Making 316(a) Determinations

As with Sections 3.1.1 and 3.2.2, IDEM recommends that applicants conduct pilot field surveys and literature searches to determine whether or not the site is one of low potential impact for the individual biotic categories and to determine what additional studies will be required to develop biotic category rationales responsive to the decision criteria. Each Biotic Category Rationale should provide a complete discussion as to why, in the judgment of the discharger, the results show that the site is a low potential impact area for that biotic category. In the rationale, the discharger should address each decision criteria for the biotic category in question. The discussion should include an evaluation of the impacts of the discharges into the receiving waterbody. The conclusions drawn should be supported with an analysis of the data collected during the demonstration activities. The conclusions should represent a logical extension of the information available and be scientifically defendable. Additional information on Biotic Category Rationales is provided below.

Biotic Categories

1. **Phytoplankton.** The organisms of the phytoplankton community are a principal food source for most zooplankton and for some fish species. They may also become important in relation to industrial or recreational water use if blooms of certain species occur, which can have a variety of deleterious effects (e.g., clog filters and intake pipes, impart tastes and odors to water).

   Many waterbodies, such as the majority of rivers and streams, can be classified as “low potential impact areas” for phytoplankton, and relatively little information is necessary for a 316(a) demonstration. Nevertheless, more detailed data may be necessary in some instances if phytoplankton is a substantial component of food chains supporting the balanced indigenous population or if the thermal discharge is likely to cause a shift towards nuisance species. Even if firm predictions cannot be made on the basis of the increased data, these data may be necessary as a base for comparison with post-operational monitoring surveys to detect long-term community shifts.

   The phytoplankton section of the 316(a) demonstration will be judged successful if the applicant can show that the site is a low potential impact area for these organisms, or that:

   1. A shift towards nuisance species of phytoplankton is not likely to occur.

   2. There is little likelihood that the discharge will alter the indigenous community from a detrital to a phytoplankton based system.

3. Appreciable harm to the balanced indigenous population is not likely to occur as a result of phytoplankton community changes caused by the heated discharge.

2. **Zooplankton and Meroplankton.** The zooplankton-meroplankton community is a key supportive component of the aquatic system. It is a primary food source for larval fish and shellfish and also makes up a portion of the diets of some adult species. Many important species of fish and wildlife have planktonic life stages (termed meroplankton, to differentiate them from organisms which are planktonic throughout their entire life cycle). If a heated discharge kills or prevents development of the meroplankton, fewer adult fish and shellfish will be produced each year.

   The zooplankton and meroplankton section of the 316(a) demonstration will be judged successful if the applicant can show that the site is a low potential impact area for these organisms, or that:

   1. Changes in the zooplankton and/or meroplankton community will not result in appreciable harm to the BIC.

   2. The heated discharge is not likely to alter the standing crop, relative abundance, with respect to natural population fluctuations in the far field area from those typical of the receiving water body.

   3. The thermal plume does not constitute a lethal barrier to the free movement (drift) of zooplankton and/or meroplankton.

3. **Habitat Formers.** The role of habitat formers in an aquatic system remains unquestionably unique and essential to the propagation and well-being of fish, shellfish, and wildlife. Furthermore, habitat formers are a limited resource, slow to re-establish, and non-renewable in some cases. These organisms are subject to damage by a discharge plume in a number of ways. Rooted aquatic plants may be damaged or destroyed by excessive temperature, velocities, turbidity, or siltation. Organisms may be damaged or destroyed by chlorine or other biocides contained in sinking plumes that flow along the bottom in winter. Thermal discharges may affect the natural balance of the bacteria and algae populations, favoring the bacteria. This situation, in turn, could reduce oxygen levels by increasing the amount of decomposing materials and could adversely affect habitat formers.

   The habitat formers section of the 316(a) demonstration will be judged successful if the applicant can show that the site is a low potential impact area for habitat formers, or that:

1. The heated discharge will not result in any deterioration of the habitat formers community or that no appreciable harm to the BIC will result from such deteriorations.

2. The heated discharge will not have an adverse impact on threatened or endangered species as a result of impact upon habitat formers.

4. **Shellfish/Macroinvertebrates.** Functionally the macroinvertebrate fauna serves man in numerous ways. They are an important component of aquatic food webs and many invertebrates are directly important to man as a source of high-quality protein and as bait for sport and commercial fishermen. They modify and condition aquatic substrates and also aid in the breakdown and decomposition of detritus, thus contributing to detrital food chains, detrital transport, and nutrient cycling.

   A thermal discharge may have a variety of effects on macroinvertebrates. Aquatic insects having an emergent stage may enter the atmosphere early as a result of artificial heating of the water. The adults may emerge into cold air and die because of exposure, because food items are not in phase, or because normal egg laying conditions do not exist. Thermal discharges may stress ecosystems and cause shifts in community structure such that although the total biomass may not change significantly, desirable species may be replaced by less desirable species not involved directly in the food chain. The discharge of heat may cause stratification, which may diminish dissolved oxygen in the bottom layer and possibly eliminate benthic fauna.

   The shellfish/macroinvertebrate section of a 316(a) demonstration will be judged successful if the applicant can demonstrate that no appreciable harm to the BIC will occur as a result of macroinvertebrate community changes caused by the heated discharge. For areas classified as ones of low potential impact for the shellfish/macroinvertebrates, relatively little new field work may be required. Decision criteria related to individual parameters are discussed as follows:

   1. Standing Crop. Reductions in the standing crop of shellfish and macroinvertebrates may be a cause for denial of a 316(a) variance request unless the applicant can show that such reductions caused no appreciable harm to the BIC within the waterbody segment.

   2. Community Structure. Reductions in the components of diversity may be cause for the denial of a 316(a) variance request unless the applicant can show that the critical functions of the macroinvertebrate fauna are being maintained in the waterbody segment.

3. Drift. Drifting invertebrate fauna is not harmed by passage through the thermal plume.

4. Critical Functions. Areas which serve as spawning and nursery sites for important shellfish/or macroinvertebrate fauna.

5. **Fish.** The discharge of waste heat can affect fish populations in many ways. The various data required are necessary in order to provide characterization of the indigenous fish community for the development of the RIS concept, to identify habitat utilization by the various populations, and to provide baseline information for comparison with post-operational studies.

   The fish section of a 316(a) demonstration will be judged successful if the applicant can demonstrate that the site qualifies as a low potential impact area for fish. For other sites, the fish section of a 316(a) demonstration will be judged successful if the applicant can demonstrate that fish communities will not suffer appreciable harm from:

   1. Direct or indirect mortality from cold shocks.

   2. Direct or indirect mortality from excess heat.

   3. Reduced reproductive success or growth as a result of plant discharges.

   4. Exclusion from unacceptably large areas.

   5. Blockage of migration.

6. **Other Vertebrate Wildlife.** The term “other vertebrate wildlife” includes wildlife which are vertebrates such as ducks, geese, beaver, muskrat, etc. Data will be required in relatively few cases for this biotic category. In those cases where data are required, the type of data needed is decided by the discharger. The data selected should be the least amount of data necessary to complete this section of the demonstration.

   This section of the demonstration dealing with other vertebrates will be judged successful if the applicant can show the site is one of low potential impact for other vertebrates and that other wildlife community components will not suffer appreciable harm or will actually benefit from the heated discharge.

7. **Representative Important Species.** Making predictions about “what will happen” are difficult without detailed information on the environmental requirements of communities or at least many populations and species. It is not

economically feasible to study each species in great detail at each site. Therefore a few species are selected for detailed laboratory and literature survey. The data requirements of Tables B and C (section 3.2.2.2) are recommended as being helpful to those making 316(a) decisions for the following reasons:

A. They allow an estimation of the size of the areas which will be excluded for key biological functions and the duration of the exclusion.

B. They provide the basis for at least rough predictions of high temperature survival, heat and cold shock, and effects on reproduction and growth.

3.5 Successful Demonstrations

3.5.1 IDEM will find a Type I (or III) Demonstration successful if all of the following are true:

1. The current local biological community and the predominant local biological community that existed when the historical data were collected are similar in makeup and in regards to response to thermal influences.

2. The current operating conditions at the permitted facility are similar to those that were evaluated when the historical data were collected.

3. Changes in the physical characteristics of the waterbody or changes in ambient water quality have not altered the balanced, indigenous community that existed, or that the proposed ATEL will adequately protect and assure no appreciable harm to the species now present (or that should be present) due to any changes in physical characteristics or ambient water quality.

4. There is no convincing evidence that there has been damage to the balanced, indigenous community, or community components, resulting in such phenomena as those identified in the definition of appreciable harm.

5. The receiving waters are not of such quality that in the absence of the proposed thermal discharge excessive growths of nuisance organisms would take place.

6. A zone of passage has not been impaired to the extent that it does not provide for the normal movement of populations of dominant species of fish, and economically (commercial or recreational) important species of fish, shellfish, and wildlife.

7. There is no evidence of adverse impact on threatened, rare or endangered species.

8. There has been no destruction of unique or rare habitat.

3.5.2 IDEM will find a Type II (or III) Demonstration successful if all of the following are true:

1. There is no convincing evidence that there will be damage to the balanced, indigenous community, or community components, resulting in such phenomena as those identified in the definition of appreciable harm.

2. Receiving water temperatures outside any (IDEM established or approved) mixing zone will not be in excess of the upper temperature limits for survival, growth, and reproduction, as applicable, of any RIS occurring in the receiving water.

3. The receiving waters are not of such quality that in the absence of the proposed thermal discharge excessive growths of nuisance organisms would take place.

4. A zone of passage will not be impaired to the extent that it will not provide for the normal movement of populations of RIS, dominant species of fish, and economically (commercial or recreational) important species of fish, shellfish, and wildlife.

5. There will be no adverse impact on threatened, rare or endangered species.

6. There will be no destruction of unique or rare habitat without a detailed and convincing justification of why the destruction should not constitute a basis for denial.

4.0 Quantification of Thermal Discharge Plumes based on the Placement of Automatic Recording Devices

4.0.1 Background

Water temperature has an important physiological, behavioral, and functional impact on aquatic biota by affecting individuals, populations, and communities (Hynes 1972). Different species have varying tolerance to temperature, which give rise to thermal preferences for growth, reproduction, and survivorship. These temperature preferences cause acute and chronic effects that may cause avoidance or increased densities around thermal discharges. Heat has synergistic effects with other stressors (Bell 1973) and has an important role in the function of aquatic ecosystems since changes in temperature change thermal capacity, specific heat, and downstream stability of aquatic assemblages. Many human activities impact temperature and U.S. EPA has required states to adopt temperature criteria into Water Quality Standards (Clesceri et al. 1998; Idaho Department of Health and Welfare 1999). These limits are used to define numeric water temperature criteria to protect recruitment and survivorship of species in various stream types. The State of Indiana has designed temperature standards in the State Water Quality Administrative Code for cold water, general use for warm water fish assemblages, Lake Michigan, and the Ohio River (327 IAC 2-1-6, 327 IAC 2-1.5-8). Water temperature is also used, along with pH, to define numeric criteria for unionized and total ammonia (327 IAC 2-1-6 Table 6-4, 327 IAC 2-1.5-8 Table).

Factors that influence water temperature include water source, ground water recharge and discharge, precipitation runoff, solar radiation (including riparian corridor shading), ambient air temperature, prevailing climate, and geologic setting (Stevens et al. 1975). Placement of temperature sensing devices and the interpretation of temperature data must consider these influential factors in the study design of any water temperature determination. This protocol is intended to reduce the variability of temperature data due to sampling techniques and contribute to a standardized process for collection of temperature data using data loggers by National Pollutant Discharge and Elimination System (NPDES) permittees.

4.0.2 Scope

The purpose of this protocol is to describe guidelines for the placement, retrieval, and documentation of temperature data loggers and subsequent temperature data handling and format issues. These data will be collected by NPDES dischargers that have thermal limits in their monitoring requirements. The method is based on the State of Idaho protocol developed by Zaroban (1999). This approach is developed for multiple data loggers, and this protocol may be applied to each logger used in such circumstances. This protocol is developed for lakes, reservoirs, and large non-wadeable rivers. It is also intended to supplement existing data logger methodology

developed by the Idaho Division of Environmental Quality (DEQ) technical procedures manual (Ralston and Browne 1976); however, in light of recent advances in temperature monitoring technology this method provides background information, methods, forms, and a suggested equipment list.

Table D. Name, Phone Number, and Web Site Address of Common Temperature Data Logger Manufacturers.

Manufacturer	Phone Number	Web Site Address
Onset Computer Corporation	(800) 564-4377	www.onsetcomp.com
Ryan Instruments	+353 (86) 257-0007	www.read-out.net/ryaninst/
Vemco Limited	(902) 852-3047	www.vemco.com

4.1 Methods

4.1.1 Pre-placement Procedures

The objectives of the Monitoring Plan must be developed prior to going into the field and prior to data collection. The monitoring plan needs to document: 1) The rationale for the proposed data collection; 2) What data is to be collected; 3) Time, place(s), and duration of data collection; and 4) Responsible personnel and their roles.

Monitoring objectives, such as assessments of compliance, or assessment of beneficial use status, must be documented. If the monitoring is being conducted to assess representative aquatic species (RAS) or other fish-related uses, the investigators must also document the species of interest, most sensitive life stages, and critical time period(s). Once the reasons for conducting the study have been documented, data quality objectives must be established and the primary use of the data defined. The quantity and quality of the data to be collected can then be determined. A minimum of ten (10) percent of the sites should be replicated for quality assurance purposes. The investigator needs to describe the duration and frequency (including the temperature recording interval and reported value) of the data collection and the “acceptable” loss rate of the data loggers. The study should include the desired information on the time line, milestones, and products. Lastly, the responsible personnel and their roles need to be identified.

4.1.2 Temperature Data Logger Selection

Select a logger with a measurement range and accuracy resolution appropriate for the purposes of the study. Record manufacturer, customer support phone number, E-mail, website, mailing addresses, model, serial number(s), and date of purchase, at a minimum. Additionally, consideration needs to be given to the transparency of the case in which the logger will reside. If not totally shaded, loggers placed in clear or translucent cases may act as heat collectors and give artificially high values due to solar radiation warming inside the case. White, non-translucent cases are recommended to avoid solar radiation warming.

4.1.3 Calibration Check of Temperature Data Loggers

Appropriate temperature logger calibration establishes a linear relationship that indicates accuracy throughout the measuring range of the temperature logger, including the target range to be measured. Temperature data loggers should be checked at a minimum of three temperature points across the range of the instrument through a period of time in order to determine accuracy and precision. An ice bath and boiling point are referenceable calibration check points. Any reference point in between must be verified with a National Institute of Standards and Technology (NIST) certified thermometer. Use a laboratory thermometer certified accurate by the NIST at a minimum of every 10^{o}C for the calibration check. A Single point calibration check is not acceptable. Temperature Data Loggers should be within their specified limits for precision and accuracy. If a temperature data logger is not within the manufacturer's limits of tolerance it should be excluded from deployment in the temperature model study. Documentation of pre and post calibration check QA/QC is required. An example of a temperature data logger calibration check form is provided in Appendix A.

4.1.4 Placement Procedures for Temperature Data Loggers

The dischargers will monitor their thermal impact on the receiving waterbody by installing temperature monitoring equipment that is set upstream and downstream of the discharge in ¼ sections across the stream to measure the thermal plume downstream of the discharge, or in semi-circular based transects radiating out from the shoreline discharge point on lakes, reservoirs or Lake Michigan. The dischargers will also measure the temperature and flow upstream of the discharge, or outside of the influence of the discharge, and the temperature and flow of the discharge itself to calculate the mixed river or lake temperature.

4.1.4.1 Launching the Temperature Data Loggers

Launch the logger according to the manufacturer's recommendations. Program the logger to meet the specific objectives of the study. A measurement interval of no less

than every 15 minutes is recommended for comparisons to Indiana water quality temperature criteria. To facilitate assessment of the temperature criteria, program the logger to record temperature measurements in degrees Celsius using a date format of mm/dd/yyyy and a time format of hh/mm/ss (24 hour clock). Record the logger serial number, period of record, interval, site description, whether triggered or delayed start, multiple or single measurement, and whether the reported value is an average, minimum, or maximum measurement. **Single temperature measurement values are the recommended values to record for comparisons to Indiana water quality temperature criteria.** Other temperature statistics, such as daily or weekly averages and maximums, can be determined from these data. An example of a temperature data logger metadata sheet for recording pertinent location information and logger settings is provided in Appendix B.

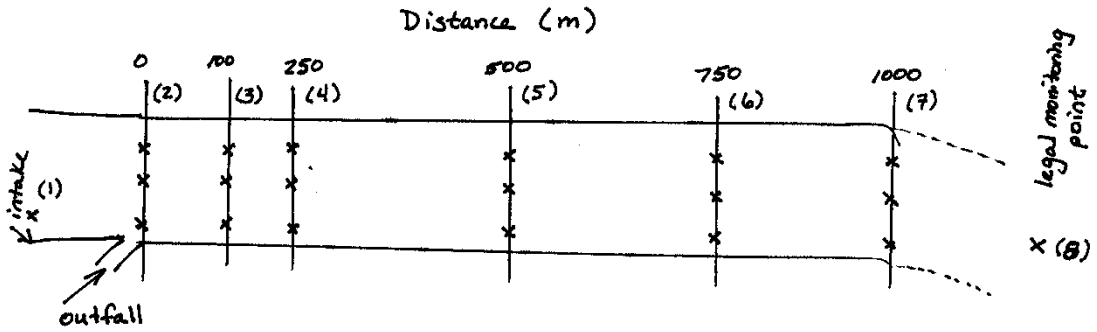


Figure 1. Placement of logging devices using inter-quartile method along a longitudinal gradient for rivers.

4.1.4.2 Site Selection

The site selected for logger placement must be representative in terms of the goal and objectives of the monitoring activity. If the monitoring is being conducted to assess point source temperature impacts, the logger should be placed following a transect inter-quartile point approach. Transects are established at perpendicular angles to the linear length of the stream channel (Figure 1). Transects should be established at: 1) the plant intake or in an area that possesses ambient water temperature without any influence from upstream facilities ; 2) downstream of the discharge pipe ; 3) a transect 100 m downstream; 4) 250 m downstream; 5) 500 m downstream ; 6) 750 m downstream ; 7) 1000 m downstream ; and 8) downstream at the legal monitoring point at end of a reach (single unit). Transects should be established so that inter-quartile points provide equidistant distribution across the stream width. Temperature data loggers are to be placed just upstream of the discharge point and at the legal monitoring point to establish ambient and final compliance temperatures. Temperature mixing

zone assessments will require additional loggers to be placed within the mixing zone. The investigator must be aware of the spatial and temporal scale(s) at which the data is anticipated to be analyzed and select sites accordingly. For example, the data may be used to assess attainment of temperature criteria at a site, stream reach, catchment, watershed, cataloging unit, or basin scales.

4.1.4.3 Temperature Data Logger Placement

A list of suggested equipment for installing temperature data loggers is provided in Appendix C. An example of a temperature data logger field form (Horsburgh and Steed 1997) is provided in Appendix D. Set the recording interval of the logger to meet study and data quality objectives (if not done during pre-placement). Document the logger serial number. Lubricate the o-ring with silicone each time, add a form of identification inside the case (business card, etc. or label the outside of the case with appropriate contact and phone numbers if found), be sure the logger case has a water tight seal and add new desiccant as a precaution. Once in the channel, find a spot where the water is adequately mixed and not influenced by localized warm or cool water sources such as ground water.

The site should not be susceptible to excessive scour that may move the temperature data logger (Dunham and Vinyard 1998). Verify that the site is **well-mixed** horizontally and vertically with instantaneous temperature measurements (see chapter 5) using a calibrated hand-held thermometer or other calibrated instantaneous temperature measuring device. Record patterns in these findings for each temperature data logger site in a field log book. When selecting a site, choose one that is expected to remain wet throughout the monitoring period. Sites with moderately turbulent flows, such as the tailouts of lateral scour and plunge pools, tend to make good logger placement spots.

Securely attach the temperature data logger (cable is recommended) to structure(s) that will not move in the event of a large runoff event. Use of a 16” x 16” x 8” cinder block or series of bricks with premade holes may be used with a lanyard. The temperature data logger should be chained separate from the buoy that is used to mark the unit. The use of a cinder block enables a Hobo® case to fit inside the premade holes and is held in place by the lanyard enabling quick release. In addition, the cinder block will provide some protection from moving debris and provide for secure attachment with a cable. Transect points that are more than one meter in depth may require vertical placement of temperature data loggers also at each transect point. For example, at the surface and at the bottom for greater than one meter depth but less than two meter depth. Specifics on temperature data logger placement should be worked out and described in the study proposal. Knowledge of the bathymetry of the water body is essential for logger placement.

4.1.5 Locality Documentation

Temperature data from each logger, and all data associated with the placement of each logger must be linked to its unique geospatial location for verification and mapping purposes. Therefore, geographic positioning system (GPS) coordinates data will be collected for each logger's placement point. A thorough and complete description of the locality for each site must be completed to help ensure the logger can be relocated and to account for factors that influence surface water temperature. The locality description should, at a minimum, include waterbody name, 12 digit hydrologic unit code (HUC) index number (National Hydrography Data set (NHD) 2010), U.S. Geological Survey cataloging unit, latitude and longitude, public land survey, elevation in meters, a site map, photographs of the site, instantaneous water temperature (see Chapter 5), date, and time of the actual placement. An example of locality information needed to assess aquatic life temperature criteria is listed on the calibrated instantaneous temperature measurement device metadata sheet in Appendix D. An identification number should be assigned to each site logger prior to entering data into the temperature database. Directions to the site from relatively permanent landmarks should be recorded. Depending on the purposes of the monitoring activity, additional measurements or observations may be useful in interpreting the temperature data. Parameters that can influence temperature measurements include, but are not limited to, water depth, water velocity, stream discharge, habitat type, channel width, solar input, distance from the stream bank, overhead cover, and air temperature. These parameters should be considered for measurement in each surface water temperature monitoring activity.

4.1.6 Retrieval Procedures

Whenever feasible, it is recommended to make an interim visit to the site to make any needed adjustment to the logger. An interim visit is especially important for Spring high flow placements. When an interim visit is made, record the date, time, and instantaneous water temperature (see Chapter 5). Take the interim temperature measurement within a few minutes of an expected logger recording.

Upon arrival at the site to retrieve the logger, document the condition of the site and the logger. At a minimum, record such things as whether the logger is still in the water, any signs of vandalism or disturbance, and the integrity of the logger. Also, record the date, time, and instantaneous water temperature (see Chapter 5). Follow manufacturers' procedures for downloading of the data. All raw temperature data, with corresponding site placement information, should be in an Excel spreadsheet format.

5.0 Instantaneous Measurement of Thermal Discharge Plumes Based on a Transect Method

5.0.1 Background

The instantaneous measurement of water temperature on site is an important consideration for selecting stream reaches and determining plume characteristics for traveling zone electrofishing. Discharge plume is influenced by turbulence, water temperature of discharged water including water source, local industrial recharge and discharge issues, additional inputs, bank modifications (including riparian corridor shading), ambient air temperature, bottom modifications, and local setting (Emery and Thomas 2003; Dufour et al. 2003). The placement of temperature sensing devices and the interpretation of temperature data may be used in combination with this method (see Chapter 1); however, instantaneous measurements must consider that plume characteristics may change with season, generation need and capacity, stream flow, and habitat changes. This protocol is intended to reduce the variability of temperature data due to sampling techniques and contribute to a standardized process for collection of temperature data using an instantaneous measurement protocol that will provide reliable data that can be used in combination with data loggers collected by National Pollutant Discharge and Elimination System (NPDES) permittees.

5.0.2 Scope

The purpose of this protocol is to describe guidelines for the establishment of transects, collection of data, and subsequent temperature data handling and format issues. These data will be collected at places where NPDES dischargers have effluent thermal limits. The information collected using this approach will be specifically used to assess the compliance of discharge requirements of 305(a). The method is based on the State of Indiana protocol developed by Newhouse et al. (1999). This approach is developed for multi-transect approaches and this protocol may be applied to each transect or series of transects used in such circumstances. This protocol was developed for lakes, reservoirs, and large non-wadeable rivers and is intended to supplement existing data logger methodology developed by IDEM and provides updated requirements for traveling zone studies including advances in temperature monitoring technology based on background information, methods, forms, and a suggested equipment list.

5.1 Methods

5.1.1 Pre-survey Procedures

The pre-survey procedures should include the development of a Monitoring Plan. The objectives of the Monitoring Plan must be developed prior to going into the field. This plan needs to document: 1) the rationale for the proposed data collection, 2) what data

is to be collected, 3) time, place(s), and duration of data collection, and 4) responsible personnel and their roles.

The primary monitoring objective using this method is the assessment of compliance and must adhere to strict quality assurance procedures. The data can be used to evaluate discharge plume characteristics or to evaluate traveling zone reach selection. Once the reasons for conducting the study have been documented, data quality objectives must be established and the primary use of the data defined. The quantity and quality of the data to be collected can then be determined. The investigator needs to describe the duration and frequency (including the temperature recording interval and reported value) of the data collection and the "acceptable" distance between transects. The study should include the desired information on the time line, milestones, and products. Lastly, the responsible personnel and their roles need to be identified.

5.1.2 Select Site

Select an instantaneous measurement device that is calibrated against a laboratory thermometer certified accurate at a minimum of every 10 ^{o}C by the NIST for the calibration of instantaneous measurements. On the data sheet record the manufacturer, customer support phone number, E-mail, website, mailing addresses, model, serial number(s), and date of purchase. Manufacturers of temperature data measurement devices that are commonly used in the United States include a variety of vendors, such as YSI, Hach, Dow-Corning, etc. Additionally, when selecting an instantaneous measurement device consideration needs to be given to the temperature range of the unit, calibration, precision and accuracy, and minimum detection levels.

5.1.3 Calibrate Measurement Device

Appropriate instantaneous temperature measurement device calibration establishes a linear relationship that indicates accuracy throughout the measuring range of the device including the target range to be measured. Calibration should be checked at a minimum of three temperature points across the range of the instrument in order to determine accuracy and precision. An ice bath and boiling point are referenceable calibration points. Any reference point in between must be verified with a National Institute of Standards and Technology (NIST) certified thermometer. A Single point calibration check is not acceptable. Instantaneous temperature measurement device should be within their specified limits for precision and accuracy. If a instantaneous temperature measuring device is not within the manufacturer's limits of tolerance it should be excluded from use. Documentation of pre and post calibration check QA/QC is required. An example of a instantaneous temperature measuring device calibration form is provided in Appendix E.

5.1.4 Locality Documentation

A thorough and complete description of the locality for each transect must be completed to help ensure that the transect may be re-located and to account for factors that influence surface water temperature. All sampling data for each sampling point must be linked to its unique geospatial location for verification and mapping purposes. GPS coordinates data will be collected for each instantaneous measuring point. The locality description should, at a minimum, include waterbody name, 12 digit HUC index number (NHD 2010), U.S. Geological Survey cataloging unit, latitude and longitude, public land survey, elevation in meters, a site map, photographs of the site, instantaneous water temperature, date, and time of the actual placement. An example of a calibrated instantaneous temperature measurement device metadata sheet for recording pertinent location information and logger settings is provided in Appendix B. An identification number should be assigned to each site transect prior to entering data into the temperature database, i.e., Transect A, B, C. Directions to the site from relatively permanent landmarks should be recorded.

Additional measurements or observations may be useful in interpreting the temperature data. Parameters that can influence temperature measurements include, but are not limited to, water depth, water velocity, stream discharge, habitat type, channel width, solar input, distance from the stream bank, overhead cover, and air temperature. These parameters should be considered for measurement in each surface water temperature monitoring activity. A list of suggested equipment for instantaneous temperature measurement is provided in Appendix C. An example of an instantaneous calibrated instantaneous temperature measurement device field form (Horsburgh and Steed 1997) is provided in Appendix D. Record the time of day that the instantaneous measurement is made and how many of the plant stacks may be in operation to meet study and data quality objectives. Document the instantaneous measurement device serial number. Once in the channel, find a spot where the water is adequately mixed and not influenced by localized warm or cool water sources such as ground water. Inter-quartile points should be established so that the measurement will provide relationships between shore and mid-channel. Vertical depth temperature measurement is required only if depths are greater than 1 meter.

Verify that the site is **well-mixed** horizontally and vertically with instantaneous temperature measurements using a calibrated hand-held thermometer or calibrated instantaneous temperature measurement device. Record patterns in these findings for each calibrated instantaneous temperature measurement device site in a field log book. When selecting a site, choose one that is expected to remain wet throughout the monitoring period.

Pre-survey reconnaissance: Prior to data collection, it is recommended that transects be pre-established so that time is efficiently spent in the field during traveling zone

sampling. Transects can be marked with orange paint, flagging, or other descriptive permanent features, such as bridges, docks, or other structures. A calibrated metric tape should be used to measure 100 meter zones. When establishing the beginning of the first zone (immediately downstream of the discharge) it is best if the zone is established at the end of the discharge canal and often best if slightly below the canal mouth. Once transect A is established, simply measure 100 meter reaches downstream of the discharge canal, complete a field sheet for each transect, which includes description of the transect, GPS reading, and mark appropriately so that the study objectives will be fulfilled. For example, if the study is a multi-year study more permanent marking may be required. Mark transects A - K every 100 meters so that ten (10) 100 meter reaches are established downstream of the discharge.

5.1.5 Retrieval Procedures

Instantaneous temperature measurement: Once on-site at the beginning of the field day, begin downstream of the discharge at transect K and work upstream. At the top of the field sheet record the date (MM/DD/YYYY), time of day (military time), and how many air emission stacks appear to have output. Record any important comments related to plant operation. For example, during warm summer months an increased demand for power is observed on weekends. As a result plants will increase production on Friday-Sunday to meet this demand, and reduce production on Monday-Wednesday to do maintenance. During sampling events one should attempt to sample facilities according to peak demand periods and when facilities are on-line rather than in maintenance mode.

When beginning to record instantaneous measurements, position the boat so that the boat is faced into the current. Confirm the transect location based on either physical or GPS measurement. Lower the measurement device to the bottom (if necessary) and measure a vertical profile of the water column at predetermined intervals. Water column measurement (if required) will be described in the approved Study Plan. Remain in the selected location until temperature equilibrates. Record the temperature on the Field data sheet. Move from left to right to complete a transect. Often a scum line of annealed algae is observed downstream of thermal discharges as a result of algal cells exploding from exposure to plant temperature. This scum line usually follows the discharge plume. Sometimes the scum line is narrow and the measurement of temperature on either side of the scum line may result in a 5-10 ^{o}F (1-3 ^{o}C) temperature difference. **NOTE: When necessary to make a decision on measurement placement -- always measure the warmest temperature observed within the horizontal profile.** Once data are recorded for three equidistant transect locations, move upstream to the next transect and confirm transect location through either physical or GPS measurement. Proceed along the transect from right to left repeating the same pattern along each transect until K-A is completed. At the conclusion of instantaneous temperature measurement proceed upstream of the discharge and

measure an intake temperature or an ambient temperature that is unaffected by the discharge plume. NOTE: Be sure to recognize that some plants have some influence upstream from slurry ponds, other discharges, or due to eddy currents that may influence upstream ambient temperatures. Ensure that upstream temperatures are representative of background or “true” upstream conditions. Attempt to stay out of shaded areas or from groundwater seeps when recording ambient temperature. Guidelines for temperature data handling are provided in Appendix E (Chapter 1).

6.0 Collection of Fish Assemblage Information based on Electrofishing

6.1 Introduction

6.1.1 Background

Electrofishing can be applied to all large and great rivers, inland lakes, and Lake Michigan nearshore sites sampled for assessing thermal discharges. When properly applied, electrofishing consistently catches more species and individuals in less time and effort than other sampling methods used. It is a widely used method for assessing fish community assemblage and is the standard method by which IDEM's multimetric Index of Biotic Integrity is calibrated. It is the only method that can be used under all habitat conditions thus yielding a database that is easily comparable (in terms of catch/effort) under the variable conditions encountered.

An accepted method of determining the effect of an outfall on a stream is to compare fish assemblage information of the impacted area to an upstream, unimpaired "reference" condition with the use of electrofishing approaches. This method can work well and can be very effective in determining the extent of an impairment, but it also has several drawbacks that researchers need to account. Primarily, the upstream site must reflect what the unimpaired study area conditions should be. Researchers should consider the importance of changes in microhabitat features (i.e., substrate type, depth, stream morphology) within the study area and the upstream reference area, carefully matching these conditions as closely as possible. We account for this variability by conducting a detailed examination of the microhabitats of the outfall zone. Based on the requirements of 316(a), it is not necessary to evaluate or match upstream locations since reference conditions have already been established for the mainstem rivers and inland lakes.

A limitation of the upstream/downstream comparison is that of multiple impairments. It is often difficult, particularly in large and great rivers, to find an upstream reference site that matches the habitat of a study area, yet is not impacted by another outfall (Dufour et al. 2003). It is common also for the study area itself to be impacted by multiple dischargers (Emery et al. 2003). Isolating the effect of one particular effluent in an area where several outfalls can sometimes be found within a 500 m segment of a great river can be very difficult using a typical upstream/downstream study. However, using the T-zone method it is possible to detect change in the biological community at the site of each impairment.

6.2 Method

6.2.1 Purpose

To describe method for sampling fish assemblages in large and great rivers, lakes, and Lake Michigan nearshore sites using DC electrofishing equipment for the purpose of assessing water quality.

6.2.2 Scope/Limitations

This procedure applies to all sites that will be sampled for fish communities for assessing thermal discharges in large and great rivers, lake shorelines, and Lake Michigan nearshore sites. Data for this analysis will include collecting data on fish community composition, species richness, reproductive and feeding function, CPUE, and DELT anomalies.

6.2.3 General Information

The electrofishing method can be applied to assessing any type of discharge, assuming that the plume characteristics of the stream can be determined by an instantaneous measure (see Chapter 5), or the stream width is not of sufficient size to warrant differences along different shores. If shoreline differences are suspected but immeasurable using an instantaneous measurement device, then both shores can be sampled and appropriate water chemistry samples taken and analyzed at a later time so that pattern correlations can be compared. Although the reasons for visiting a particular site may vary, the fish sampling procedures in this document applies to all site types unless otherwise noted. This procedure must be implemented simultaneously with an assessment of habitat (Section 7), and water temperature (Section 5) for an assessment of thermal discharges.

6.2.4 Requirements

Personnel conducting this procedure must be capable of operating electrofishing equipment, be certified to operate boats, and be capable of identifying freshwater North American fish species. In addition, the personnel must have excellent map reading skills and demonstrate proficiency in the use of a GPS receiver and an orienteering compass. Because sites may be located miles from the nearest road, it is often necessary to wade through wetlands, canoe or boat, or hike for long distances overland to reach a site. Personnel conducting a fish community assessment must have the physical ability to accomplish this task. The station summary form (Appendix A) must be used to record pertinent information for each site visit.

A. Qualifications of crew leaders: The crew leader should be a professional aquatic

biologist with a minimum of a Bachelor of Science degree in biology with an ichthyology, fisheries science, aquatic entomology, invertebrate zoology, or closely related specialization. Additionally, they should have at least six months experience working under a fish biologist in the areas of community sampling methodology and taxonomy.

B. Qualifications of field technicians - interns: A field technician should have at least one year of college education and coursework in environmental and/or biological sciences.

6.2.5 Responsibilities

A. Field Crew leader: Ensures that data generated under this procedure meets the standards and objectives of the integrated condition monitoring program. Carry out the procedures outlined in the action steps.

B. Technical personnel: Carry out the procedures outlined in the action steps including equipment stocking, calibration of equipment, data collection, and recording. Personnel must be attentive to following instructions and be capable of expressing themselves when information is not understood.

6.2.6 Quality Assurance and Quality Control

Compliance with this procedure will be maintained through annual internal reviews. Technical personnel will conduct periodic self-checks by comparing their results with other trained personnel. Calibration of equipment will be conducted according to the guidelines specified in the manufacturers' manuals.

In addition to adhering to the specific requirements of this sampling protocol and any site supplementary specific procedures, the minimum QA/QC requirements for this activity are the following:

A. Control of deviations: Deviation shall be sufficiently documented to allow repetition of the activity as actually performed.

B. QC samples: Ten percent of all sites sampled within any given year are resampled as a means of determining sampling variability.

C. Verification: The field crew leader should conduct periodic reviews of field personnel to ensure that technical personnel are following the procedures according to this SOP.

6.2.7 Training

A. All personnel should receive instruction annually from a trainer designated by the program manager. Major revisions in this procedure will require that all personnel be retrained in the revised procedure by an authorized trainer.

B. The responsibility of the field crew leader includes training activities that should include instruction in the field, as well as, a field test to ensure that personnel can successfully implement this procedure. The crew chief should be boat operator certified.

6.2.8 Action Steps

A. <u>Suggested Equipment List</u>

Ensure that the following items are present before implementing this procedure:

Boat (and necessary equipment—e.g., throw cushions, personal floatation device [for each passenger], whistle, paddles, anchor, gasoline, tool box, and appropriately rated boat motor
DC electrofishing unit including miscellaneous parts and pieces (generator and VVP unit)
3/16 inch mesh dip nets
Appropriate sized scales and fish board (preferably in metric units for length and weight)
Two buckets and miscellaneous sorting chambers (capable of holding water)
Station Summary form, previously completed with attached copies of 1: 24,000 USGS topographic maps
Latitude and longitude and Geographic Positioning System device
County plat maps
State specific atlas and Gazetteer (Delorme)
Aerial photographs
Pencils/Blunt-tipped Sharpies
Permanent/Alcohol proof markers
Labeling tape
Fish sample identification labels
10% formalin, enough to preserve one day's worth of samples, ca. 4 L/site
Waterproof notebook including data sheets & permits (water temperature form, fish field sheets, collection permit)
Chest-high waders and rain-gear
Habitat gear (meter tape or hip chain, densitometer, Philadelphia rod)
10-20 jars or bottles, in which the sample is to be preserved; preferably non-breakable synthetic, minimum 1 L capacity ("A" and "B" jars) including labels (interior & exterior)
Box or crate to store sample bottles

Canoe or stream shocker (including gloves, ear protection)
GPS receiver, battery, and antenna
Flagging
Cellular telephone and first aid kit
Digital, or 35 mm film camera

B. Data collection method

The objective of assessing point source discharge thermal plumes is to determine if impairments are occurring to the biological indicator that has been specifically designed to measure various large and great rivers, lakes, and Lake Michigan nearshore systems. The project will document the current downstream discharge conditions, determine zones of recovery, and establish the instantaneous pattern of the outfall discharge plume.

6.3 Fish Sampling

All fish collected will be identified to species, enumerated, examined for external anomalies, and either returned to the waterbody or preserved as voucher specimens. Each site will have an instantaneous measure of temperature taken prior to sampling (see Section 5.0) and habitat data sheet filled out for each 500 meter (m) reach (see Section 7.0).

Previous Ohio EPA (Thoma 1999) work indicated that night electrofishing would likely capture more species and individuals than day electrofishing. Sampling on the Ohio River is based on night electrofishing methods. However, sampling of the Wabash and White Rivers, inland lakes, and Lake Michigan nearshore for Indiana are based on day electrofishing methods. These procedures must be followed in order to apply the established reference conditions.

Applicants are referred to the American Fisheries Society's "Standard Methods for Sampling North American Freshwater Fishes" (Bonar et. Al. 2009) and "Fisheries Techniques" (Zale et. al. 2013) for appropriate gear selection, electrofishing setup and efficiency standards. Appropriate electrofishing setups or other gear type selections will be determined by water body type, size and depths. It is the responsibility of the applicant to establish sampling protocols, minimum quality assurance measures, and sampler qualifications to document and assure the highest efficiency in catch per unit of effort is achieved.

Sampling station distances for riverine sites are 15 times the mean wetted width (MWW) in length. Mean wetted width (MWW) rounded to the nearest whole meter is used to define the length of the electrofishing sampling reach in riverine sites. The minimum sampling distance for riverine sites is 150 m while the maximum length is 500 m. This

length is based on the distance necessary to capture most species present and is based on a desire to sample greater than 3 habitat cycles.

For nearshore inland lake shorelines, nearshore Lake Michigan, and large and great rivers each sample effort unit will be 500 m in length. For inland lakes the number of zones will be based on the open wetted surface area of the waterbody. For streams 33 meters or less in width the sampling reach will be 15X the MWW. Once the MWW for a station has been determined, this value is used for all future sampling, including future years when riparian land use or other factors may have changed the actual site width.

In electrofishing a set sampling time should not be used. Sampling time may vary between 1,800-5,000 seconds and will be dependent on habitat complexity. The greater the number of fish to be captured in the zone and the greater the complexity of the shore line the longer it will take to complete the sample. A crew of three active individuals should be used in all electrofishing efforts. During boat sampling two individuals will be positioned on the bow of the boat with dip nets with 1/8 inch stretch mesh and serve as the principal collectors of fish captured in the electrical field while the third person will operate the outboard motor, pulsator controls (and spot lights at night), and collect any fish that surface at the back of the boat. The crew is to attempt to capture all fish that are stunned in the electric field. All fish will be placed in live-wells supplied with fresh water. IDEM recommends that Common carp should be placed in their own live-well to avoid excess oxygen consumption and the death of small fish that otherwise would frequently be trapped in common carp mouths and crushed. Any asian carp captured are to be killed immediately and not be returned to the water body as per Indiana Department of Natural Resources General Fishing Regulations IDNR(2014).

6.3.1 Lake Michigan Considerations

For Lake Michigan, sampling should be conducted when winds are generally from off shore and wave action is 0.6 m or less. Winds resulting in waves greater than 0.6 m prevent effective sampling, especially at nearshore Lake Michigan sites. If winds are from the southwest, zones will be sampled from the west to the east. If winds are from the south east, zones will be sampled from the east to the west. This will allow the boat and stunned fish to move with the shoreline currents. After periods of sustained on-shore winds and heavy wave action, sampling will be avoided to allow for stabilization. If the water level appears to be substantially above normal, sampling should not occur (see Station Summary Fish Habitat Evaluation for determination of water levels) and will require a revisit of the site when appropriate conditions exist.

6.3.2 Night Sampling Methods for the Ohio River

Ohio River electrofishing efforts are conducted at night. All night collections should be made at least 30 minutes after sunset and before 5:00 AM. Above surface lights are to

be used during night sampling. For example, six 12-volt flood lights will be mounted on the bow 1 m above the water. Four 12-volt flood lights mounted at the stern, 1 m above the surface, two on each side of the boat will illuminate the sides of the boat aft of the bow. Lights should be directed forward and perpendicular to the side. A hand held spot light can be used to search for stunned fish outside these illuminated areas (especially behind the boat) and to scan the shoreline. When sampling is completed lights can be directed at the sample processing area to process the sample.

6.3.3 General Procedures for Collections at All Sites

Habitat should be checked against the recorded Qualitative Habitat Evaluation Index (QHEI) (see Section 7) field sheet each time fish are sampled. A single QHEI assessment occurs for the entire sampling reach (up to 500 meters). Any changes in habitat quality should be noted on the datasheet based on the date observed. Since sampling is conducted repeatedly in the same year it would be infrequent that changes in the QHEI would occur between sampling events. Sampling of fish is done in the same site reach that is sampled for habitat.

Fish community composition and species relative abundance are estimated over the entire length of each station using catch-per-unit of effort (CPUE) sampling procedures. A single electrofishing run is made from the upstream to downstream end of the station in boatable riverine sites starting at the discharge. In inland lakes or Lake Michigan nearshore habitats, fish sampling runs are started along the nearest shoreline where mixing occurs immediately downstream of the discharge and would usually be in a direction following current or wind direction. No block nets are ever used. All fish (greater than 20 mm in total length (TL)) observed are collected. At the end of the pass, minimum and maximum length and batch weight are measured for all species encountered. Number and aggregate weight of adults and young-of-the-year are recorded separately for all fish species. Fish specimens less than 20 mm TL should not be counted in the number of specimens but listed separately, with the exception of species that as adults do not attain lengths greater than 25 mm (e.g., *Gambusia affinis, Etheostoma microperca*).

For fish species that are greater than 20 mm TL, but are too hard to identify accurately, place these specimens in the unknown jar for the site. Only fish that were batch weighed and counted are to be vouchered in the voucher jar. Inspect all fish for deformities, eroded fins, lesions, and tumors (DELT).

Fish should be handled carefully to minimize mortality. Sort the fish into containers, such as a live well with water and aeration, which will keep the fish in a healthy condition for later release. After processing, fish are released alive other than vouchers upstream of the station reach or in an area where the same individual will not be collected in a downstream sample. For any species that cannot be identified with 100%

certainty in the field, preserve the fish in the "B" jar and bring it back to the laboratory to be identified. Generally, 2-3 individuals of each species should be vouchered per site. Photographs of large specimens are acceptable as long as the photograph shows key identification traits, site information and scale for size determination.

6.4 Fish Community Evaluation

Data sheets used in the Fish Community Evaluation include the Station Summary and Catch Summary data sheets. Both sheets apply to the whole station. There is a single Station Summary sheet per station and one or more of the catch summary sheets depending on the number and diversity of fish captured. Guidelines for filling out each sheet and examples of blank sheets are provided on the following pages.

6.4.1 Station Summary (Appendix I)

This sheet summarizes the location, sampling characteristics, and gear used for the station. Some of the data on this form are derived from maps or from other data sheets. The location information should be identical to that collected during the Habitat Evaluation (see chapter 7). The variables on this sheet follow:

6.4.1.1 Location

1) Waterbody name - The name of the waterbody as shown on the most recent USGS 7.5" topographic map. The name used here should be identical to that used on the other data sheets and all other stations on the same waterbody. Make sure that the spelling of the name is accurate and include all parts of the waterbody name (e.g., West Branch, Middle Fork, River, Creek, Lake) to avoid confusion. Other commonly used names for the waterbody can be written here in parentheses (Herdendorf et al. 1981).

2) Station number - The station number must correspond to the station number assigned for the site by IDEM. This number may refer to NPDES permit number or may be a site location number generated by AIMS.

3) Date - Fill in the date when the fish community data were collected for the station.

4) Starting location - A precise verbal description of the point on the stream where the fish sampling began (i.e., the upstream edge of the first 100-m sampling zone). The description should include the exact distance and direction from the start to a "permanent" landmark such as a bridge (include road identification) or road marker. Avoid using landmarks that might be lost during future years (e.g., don't use tree or fence lines). Make the description as specific and precise as possible so that someone visiting the station for the first time can easily find the starting point. GPS measurement of transects should be recorded from pre-survey sampling of instantaneous temperature

(see Chapter 5). Installation of a permanent stake to mark the downstream end of the station is desirable if conditions permit. Be sure to confer with the landowner if the stake could interfere with the normal use of that area. Be sure to provide accurate and complete site description information. **For example, a complete identification would include: West Branch Dunes Creek, 0.75 mi u/s SR 49 bridge, 2 mi N Chesterton, Nowhere Twp, Lat. 41.3334, Lon 86.2323.**

5) State - Indicate state where sampling is occurring. For example, if sampling on the lower Wabash River, indicate whether sampling is along the Indiana or Illinois shoreline.

6) County - The name of the county the station is located. Include county in other states if along a state boundary on the Wabash or Ohio rivers.

7) Township, Range, Section, 1/16 Section, 1/4 Section - Legal description for the station within the Public Lands System. These can be determined from recent USGS 7.5" topographic maps or a detailed county map. On a topographic map, a "land locator" template is useful for determining the 1/16 and 1/4 sections, indicate by a compass direction (NW, NE, SW, or SE). Note that for Indiana Townships can be either "N" (north) or "S" (south), as can Range be either "E" or "W" (east or west). Make sure that the appropriate letter is included for both Township and Range. For example, T 18N R 2W S 3, NE ¼, NE 1/4 .

6.4.1.2 Sampling Description

1) Sampling type - The type of fish sampling done at a station. Circle the appropriate category. Generally, during this project a single pass catch-per-unit-of-effort (CPUE) sampling is done. In special cases, other types of sampling could be added onto the sheet such as "depletion", "trawling" or "mark-recapture" may also be done at a station.

2) Station length - The length following the riverine wetland channel of the station. This length is based on 15 times the average stream width. For most discharge assessment surveys, this will be 500 m of Large or Great River habitat.

3) Number of passes - The total number of times a shocker is passed through the station during fish sampling. Normally, for "CPUE" sampling there will only be one downstream pass, and for inland lake and Lake Michigan nearshore sites a total of 1800 seconds of sampling/ 500 m or 360 s / 100 m is required. This may result in multiple passes within each 100 m reach, especially when there is limited habitat heterogeneity.

4) Time - The time range during which the sampling was completed. "Start" refers to the time when the first shocking pass was started, and "finish" refers to the time when the last shocking pass was completed. Use military time to the nearest minute. In addition, the shock time collected in each 100 m zone should be recorded in seconds at

the bottom of each sample zone.

5) Type of pass - A description of the direction of sampling through the station during a pass. "Downstream only" refers to a pass that begins at the upstream end of the station, proceeds downstream, and then ends at the downstream end of the 100-m reach. This is the type of pass used for "CPUE" sampling. "Downstream, then Upstream" may occur in an inland lake or Lake Michigan sample and refers to a pass that begins in a downstream direction, then at the end of the station (usually because of a lack of sampling time in the zone), sampling stops and the boat proceeds upstream to the upstream end of the station, and then electrofishing continues again as the boat proceeds back downstream to the downstream end of the station.

6.4.1.3 Gear Description

1) Gear - A description of the number and type of electroshockers used in sampling. Specify the number of each type of gear that applies. Sampling will normally involve boat mounted electroshockers for most site conditions; however, this method can also be applied to smaller rivers and wadeable streams using a backpack electroshocker or tote-barge for smaller river sites.

2) Number of anodes per unit - The number of anodes per shocker. Normally there is one for backpacks and either one or two for boat electroshockers.

a. For Backpacks and Stream Shockers -

3a) Anode size - The length of the long axis of the anode (the diamond-shaped or circular stainless steel tip on the hand-held probe), measured with a tape measure to the nearest 0.001 m. If multiple anodes are used on a shocker, they must all have the same anode size, shape, and material thickness. Anode size can be changed (by replacing the tip with a larger tip, or covering part of the tip with electrical tape or raising a ball out of the water) if necessary to maintain a relatively constant voltage and amperage. Also, please describe the shape of the anode, i.e., spherical, diamond, triangle.

4a) Anode material thickness - The thickness (diameter) of the metal used to form the tip of the anode. Measure with calipers or a ruler to the nearest 0.001 m.

b. For Boat-Mounted Shockers

5b) Anode length - The length of the exposed metal portion of either the cylindrical dropper(s) that come off of the boom or the diameter of the metal ball that dangles into the water. Measure with a tape measure to the nearest 0.01 m.

6b) Anode diameter -The outside diameter of the exposed metal portion of the droppers on the front boom. Measure with calipers or a ruler to the nearest 0.001 m. Please indicate shape, i.e., spherical with 12 droppers or single electrosphere.

7b) Number of front droppers - The number of individual droppers on the front boom.

6.4.1.4 Meter Readings

1) Type of electrofishing current - The type of electrical current (AC, DC, or pulsed DC) that the shocker emits into the water (this will often be different from that emitted by the generator in the shocker). Check the appropriate category.

2) Electroshocker control box meter reading - The typical output readings (i.e., not the extreme high or low readings) observed during sampling. Note for boat mounted systems the units of amperage and voltage for the meters when recording the meter values. Effort should be made to keep readings fairly constant during shocking within a station, between stations, within a site, and among samples of the same waterbody type over time. Preliminary sampling just downstream of the station may be necessary to determine the output readings associated with the most effective shocking. As a rule, try to keep the voltage above 150 V and average amperage above 2 A. Voltage can be adjusted by changing the number and surface area of anodes (see below), and amperage can be adjusted by increasing generator output (adjusting generator throttle, using a boost switch if present, or using a generator with a different power rating). For AC or pulsed DC, some control box output ammeters read peak rather than average amperage; if this is the case, this should be noted on the sheet. Peak amperage approximates four times average amperage. If output meters are not present or are broken, note this on the sheet. Always try to use electroshockers with functioning output meters.

3) If Pulsed DC - This refers to two important variables, “pulse rate” and “duty cycle”, of pulsed DC current. Some shockers allow values for these variables to be varied, whereas others have a single fixed value for each parameter. If values can be changed, they should be set to the appropriate level at the beginning of sampling and not changed during sampling. This may require preliminary sampling just outside the station to determine the values where shocking is most effective. The same values should be used for all sampling within a station, between stations within a study reach, and among samples for the same reach over time. Sampling for many species is most effective and least harmful at pulse rates of 40-80 per second and at duty cycles of 10-20%. For the frequency and wavelength of back-pack units, record the number and letter associated with the settings.

4) COMMENTS/NOTES: Any and all information that appear relevant to the fish community survey but is not recorded anywhere else on the data sheet should be

noted. This information should include weather, water, habitat conditions (e.g., glare, wind, precipitation, water clarity, unusually deep or shallow areas) and gear performance (e.g., problems with generators or meters) that influenced sampling effectiveness. Any evidence of fish kills (i.e., dead fish in the water or on the bank) or angler use of the stream (e.g., hooks and lines caught in bushes; evidence of cleaned fish on the bank; footprints from waders) should also be noted. Don't hesitate to make comments, if in doubt – write it down!

6.4.2 Catch Summary (Appendix J)

This data sheet is for summarizing and recording the numbers and aggregate weights by species of fish captured during each sampling pass. The parameters on this sheet are as follows:

1) Station Number – Same as for **Station Summary** data sheet.

2) Date – Same as for **Station Summary** data sheet.

3) Time - The starting and ending time of the actual fish shocking for the pass should be recorded. If the shocking time is interrupted (e.g., to work up fish when the holding tank is too full, or due to equipment failure, etc.) the time of the interruption should be noted as the End time; the actual shocking was resumed and finally ended should be recorded in the parentheses.

4) County – Indicate the name of the County the survey is being conducted.

5) Collectors – Initials of all individuals participating in the sampling.

6) Waterbody Name – Same as for **Station Summary** data sheet.

7) Gear Type – Indicate the type of equipment being used.

8) Seconds Fished -- Elapsed shocking time (in seconds) should be recorded after Total.

CATCH SUMMARY (Appendix J)

This section of the data sheet is used to summarize the identity, total number, total weight, number of fish with deformities, eroded fins, lesions, and tumors (DELT), and the number of voucher specimens retained for each species captured based on each 100 m reach. For species that are individually measured, transcribe these individual totals from the Individual Fish data sheet.

1) Species - The identity of each species captured during the pass. Only accepted American Fisheries Society common names should be used (see Appendix K). Do not use abbreviations. If a species cannot be identified with 100% certainty then preserve **all unknowns in the "B" jar** for later complete identifications; **do not count and weigh any individuals in the "B" jar.**

NOTE

"A" jars contain vouchered specimens (generally 2-3 individuals), while the "B" jar contain the unknowns. The "A" jar should be identified, batch weighed, and have minimum and maximum lengths recorded. The "B" jar does not require any data collection.

2) Species Code - The species code is provided in Appendix C. These three digit codes must be entered into this field for data entry next to the species name.

3) Minimum and maximum total length (TL) mm – The distance from the tip of the snout to the posterior tip of the longest caudal (tail) lobe of each individual fish. The caudal lobes should be pinched together slightly when measuring this distance. Measure to the nearest 1.0 mm, using a meter stick or measuring board.

4) Weight (Wt) - The total wet weight (g) of all individuals of the same fish species captured during the pass. Weigh to the nearest 0.1 g or to the nearest 1% of total weight, whichever is larger. For example, for a species with an aggregate weight of about 8 g, weigh to the nearest 0.1 g; for a species with an aggregate weight of about 60 g, weight to the nearest 1 g; for a species with an aggregate weight of about 250 g, weigh to the nearest 3 g; for a species with an aggregate weight of about 1450 g, weigh to the nearest 15 g; and so on. Weigh groups of fish in a calibrated net or plastic bag using an appropriately sized balance or scale (gross weight), and don't forget to subtract the weight of the net or bag (tare weight) to get the actual weight of the fish (FINAL weight).

NOTE

The Final Weight of each fish species is based on wet weight. Weigh to the nearest 0.1 or 1% of body weight, whichever is larger.

5) Number caught (N) - The total number of individuals of each species captured during the pass.

6) Number of DELT - The total number of fish of a species that have deformities, eroded fins or scales, lesions, or tumors ("DELT"). Only obvious deformities, eroded fins or

scales, lesions, and tumors observed on live fish should be counted. These should be written into the appropriate t-zone and circled. For example, D1 would indicate that one individual of that species had a deformity. Electroshocking (usually AC current only) sometimes causes wounds or burns; do not count these as DELT. Record each type of DELT separately. Indicate if light <20% of body (L) or heavy > 20% of body (H) or if multiple types of DELT (M).

NOTE

Deformities (D), Eroded Fins (E), Lesions (L), and Tumors (T) need to be tallied separately. The magnitude of the DELT anomaly should be noted as light < 20% of body (L) or heavy > 20% of body (H), or if multiple types of DELT (M).

7) Number of vouchers – The total number of individuals of a species that were retained as vouchers. All fish species that can be identified to species with certainty should be preserved in 10% formalin and put in the "A" jar. Number of vouchers can be written in a colored red pencil next to the species name. All jars should have a double label including an internal tag (fill out Fish Collection Tag Record) and then a strip of tape should be placed across the top of the jar with the station number.

NOTE

Double label all jars with an internal "wet" label printed on write-in-rain type paper or index weight labels. Place a label tape across the top of the jar and label with the appropriate transect and station number.

8) Picture identification – In this field should be noted the size of the fish photographed and the abbreviated frame reference for site vouchers that are recorded as pictures (e.g., JE1-24). Specimens that are too large to preserve, but are documented with a photograph should show important characters. For example, to differentiate between a walleye and a sauger the spinous dorsal fin should be spread to show the mottling in the spinous dorsal fin for sauger and two distal pigment spots in walleye. Multiple specimens can be photographed simultaneously; however, each frame should have the station number and t-zone number included on a 3" x 5" card written with a Sharpie and placed visibly in the frame. Images should also contain some ruler or the fish measuring board to provide size scale. Specimens that are photographed should be noted next to the species on the form indicating the filename for digital images, or the frame and roll number for film images.

NOTE

Vouchers can be specimens or pictures of specimens. Next to the species name, note in the appropriate place how many specimens and the picture ID. On the Photo Record Form, note the location and a description of the location. Make sure a card is inserted into the picture frame that shows the site transect and station number. Images should also contain some ruoler or the fish measuring board to provide scale.

Effort should be made to minimize handling mortality by using live wells, coolers, or quickly sorting fish into wet containers. Keep hands wet or use wet surgical gloves to minimize disruption of mucous layer. Although every effort may be made to return all fish back to the site alive, some mortality is inevitable. Dead fish should be preserved or disposed of by burying. DO NOT DISPOSE OF DEAD FISH BY DUMPING THEM BACK INTO THE WATERBODY SINCE OTHERS MAY THINK A FISH KILL HAS OCCURRED.

9) Laboratory check vouchers – When voucher specimens are preserved, verify the Number of Vouchers retained and record a check next to the number if correct. If the number preserved (after a lab count) does not match the number vouchers, place a line through the number vouchered and record the correct number. Verify the identification of vouchers and record a check in the "ID" column. If the field identification (under species) was incorrect, based on a lab examination, change species to the correct identification.

6.4.3 Required Records

Station Summary Form

A. The Station Summary Form will be completed during the actual field sampling process. This information will be placed in the biological database.

B. The Station Summary Form should be inserted into a file that was created for each site that includes on the outside of the file the station number, including a photocopy of the 7.5 minute U.S. Geological Survey topographic map (reduced to show perspective of the site), and a copy of the site location sheet.

Catch Summary Form

A. The completely filled out form should include the species name, number, minimum and maximum length, aggregated weight, and presence of DELT anomalies by date. Species code information must be listed on the form for processing. Number of specimens vouchered by species should be written in red on the datasheet.

B. The Photograph Record Form must be included for the groups of samples and identified using the appropriate labeling designation.

All specimen data must be entered electronically into a database structure format that is approved by IDEM. An acceptable spreadsheet structure can be downloaded from the Indiana Biological Survey Aquatic Research Center website (http://www.indiana.edu/~inbsarc/) from the "Collections" web page.

6.5 Defining Zones of Recovery (Traveling Zone)

A technique for evaluating fish community response, applicable for situations where the zone of impairment is too small to be adequately represented by a standard sized boat-electrofishing zone was developed by Emery and Thomas (2003). This approach is known as the traveling zone (T-zone). By collecting data in 100 m increments along a continuous 1000 m, they were able to construct traveling zones, or T-zones, each 500 m in length and incrementally move them 100 m further from the point of impact. This technique should be applied to sampling heated-effluent impacts from power generating facilities and requires the sampling effort equivalent of two standard sized boat-electrofishing zones, but provides results that are equivalent of six standard sized boat-electrofishing zones. This overlapping technique provides 100 m resolution, increasing the ability to assess community response usually overlooked by standard 500 m zones. This method is to be used for sampling outfalls in large and great river, lake shorelines, and Lake Michigan nearshore sites.

The traveling zone technique has been successfully shown to reveal gradients at the outfalls that were not stressed at two normal concurrent 500 m zones (Emery and Thomas 2003). Emery and Thomas (2003) showed that the percent of individuals as piscivores increased from the upper 500 m zone to the lower 500 m zone on the Ohio River. However, the T-zone approach better defines this increase. For example, while looking at these data with only the two 500 m zones, it can only be determined that after 500 m the outfall no longer affects the piscivores. However, by using the T-zone approach, it can be determined that the effect may be diminished by T5, indicating that the effluent was diluted enough for the piscivore numbers to return to normal after 800 m. This conclusion can be drawn by observing that the last effluent effect on the percent of individuals as piscivores was seen at T4, which was the compilation of data from the 500 m between 300 m to 800 m. When evaluating the data from the last two 100 m zones, the percent piscivores returned to expected conditions, suggesting an end of the effluent effect on the piscivore populations.

At the completion of 10 (ten) 100-m sampling t-zones, providing a cumulative total of 1000 m, data are analyzed based on 500 m reaches. The fish data is arranged so that the first T-zone (T1) consists of the first five 100 meter zones starting at the outfall. The second traveling zone (T2) is the compilation of the data from the second to the sixth

100 meter zones, and so on downstream to T6, which is the last five 100 m zones (Fig. 2).

In order to determine the T-zone length for any size stream use the following calculation. Take the distance needed for sampling based on the MWW length (minimum distance is 150 m and maximum is 500 m), multiply this distance by 2 to get a final distance, then divide the final distance by 10. For example, if the minimum distance is 150 m, multiply by 2 (so that two complete minimum zones would be sampled). This gives a distance of 300 m. Divide this distance by 10 so that each T-zone would be 30 m in length. By combining five T-zones the IBI is calculated and then proceeds normally so that six (150 m) T-zones can be calculated by substitution from the 300 m total distance.

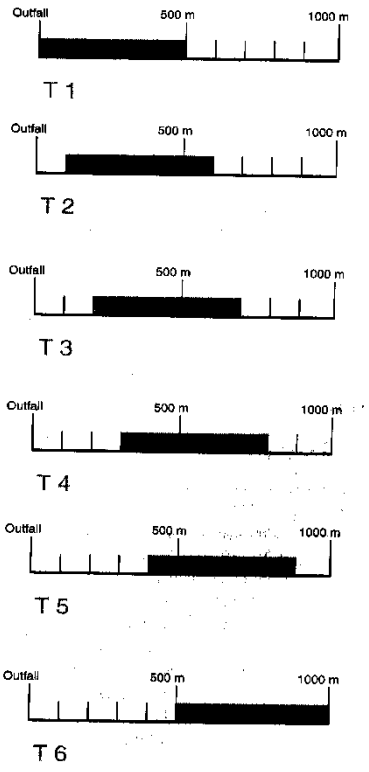


Figure 2. Traveling zone analysis procedure for calculating T1 to T6, which corresponds to the downstream subtraction of an upstream 100-m reach fish assemblage catch and the addition of the downstream 100-m fish assemblage catch.

6.5.1 T-Zone Data Analysis

The six T-zones are created after the data is entered into a database based on 100-m reaches and can be reconfigured. Fish metrics are calculated from the data from these new 500 m zones (Dufour 2002; Emery et al., 2003; Simon 2003;and Appendix L of this document). These metrics are graphed and appropriate statistical methods are applied to reveal trends observed from T1 to T6.

7.0 Assessment of River and Stream Habitat Using the Qualitative Habitat Evaluation Index (QHEI)

7.0.1 Background

Characterization of habitat structure related to fish, macroinvertebrate, and aquatic macrophyte communities in rivers stream and lakes is critical supporting information for understanding and interpreting the existing biological communities being assessed. For rivers and streams IDEM uses the flowing waters QHEI method developed by Ohio EPA (OHEPA 1989b, 2006). For near-shore lake habitats IDEM recommends the use of the Ohio EPA's method for assessing habitat in Lake Erie shoreline waters using the QHEI (OHEPA 2010) or the U.S. EPA littoral and shoreline physical habitat characterization (USEPA 2011). A general site evaluation is made while sampling each location using an appropriate qualitative habitat evaluation method.

The QHEI is a physical habitat index designed to provide an empirical, quantified evaluation of the general macrohabitat characteristics that are important to fish or macroinvertebrate communities. The flowing waters QHEI provides information on a stream's ability to support healthy fish and macroinvertebrate communities by evaluating in-stream habitat and the land that surrounds it. The QHEI is composed of six separate metrics each designed to evaluate a different portion of a stream site. When the 6 metrics are added together you get a total QHEI score. The higher the total score, the better the habitat. The maximum QHEI score is 100 points. The following instructions are for the completion of the flowing waters QHEI. This serves as an example of QHEI assessments. Dischargers should refer to the referenced methods for all other qualitative habitat assessments. A listing of definitions follows to serve as a guide for the proper completion of the QHEI. These instructions will follow the QHEI field sheet in a top to bottom, left to right direction for each of the section/metrics

7.0.2 Scope

The QHEI data sheet is completed at the sampling site on a day of fish or macroinvertebrate community sampling. The only time you would need to complete an additional QHEI data sheet would be if a significant modification, such as the construction of a bridge or dam, occurred upstream of your sampling location. The person completing the QHEI will need to walk up and downstream of the sample location to get an accurate idea of the in-stream habitat and its surroundings. Therefore, it is best to complete the QHEI after you've taken your water chemistry and biological samples to avoid disturbing your sampling location. Since the QHEI is based on reach specific information, QHEI scores should be derived for large and great rivers and lake habitats based on distances of 500 m. Since traveling zone distances are 1000 m, two QHEI's should be prepared based on 0-500 m (0 to end of 400 m

segment), and from 500-1000 (beginning of 500 m segment to end of 1000 m reach). This method is useful only for large and great rivers. See Simon (2000) and Thoma (2010) for a modified QHEI appropriate for lake habitats.

7.1 Methods

7.1.1 Habitat Types

The following method for performing a QHEI scoring is an example for Indiana river and stream habitats. To complete the QHEI it will take about 30-60 minutes for the first time. The more familiar you become with the data sheet and the different metrics the less time it will take. In order to complete the QHEI accurately, you need to be familiar with the different habitats that occur in the stream and their definitions.

1. Riffle: This is the area of a stream where the water is flowing fast! The water surface appears to be bubbling. Water in this section of the stream is usually shallow. The bottom of the stream is rugged and can be difficult to walk in.

2. Run: A “run” usually occurs downstream of a riffle. The water slows down a bit and the surface appears smooth. Runs are deeper than riffles and the bottom of the stream is often flat.

3. Pool: This is the area that has slow moving water and is deeper than the riffle and run areas. This is usually the widest area in a stream. The bottom of a pool is often shaped like a bowl.

The following is a description of each of the six QHEI metrics and the individual metric components. Guidelines on how to score each are presented. In certain cases, the biologist completing the QHEI sheet may decide a habitat characteristic falls between the multiple choices. In cases where this is allowed (denoted by the phrase “or check two and average”), two boxes may be checked and their scores averaged.

The QHEI field sheet (which is a modification from the Ohio EPA 2006 field sheet) can be viewed in Appendix M.

7.1.2 Metrics

7.1.2.1 Metric 1: Substrate

This metric includes four components: substrate type, substrate origin, silt cover, and embeddedness.

a) Substrate type: There are two columns of substrate types (such as, boulder, cobble, gravel, artificial, and others). There are two check boxes in front of each substrate type for predominant substrate, and two blanks behind each substrate type to indicate presence of the substrate. For each substrate type, the first box and blank represents pool areas and the second box and blank represent riffle areas.

First, determine which substrate type is most dominant (greater than 75 percent of bottom area), or functional, in the riffles and pools. Place a check mark in the box beside the dominant substrate type (first column pools, second column riffles). DO NOT check more than two boxes per column. If no pool or riffle is present, double check the most predominant substrate type present.

Second, determine ALL substrate types present by placing check marks in the blank spaces. All substrate observed per riffle and pool in the sampling area may be checked. IDEM's modification of the substrate presence is to estimate the percentage contribution of each substrate type that is checked off.

Third, check the total number of substrate types as greater than 4 if more than four substrate types are present.

Substrate Types are defined as:

Bedrock – solid rock forms a continuous surface.

Boulder/Slabs – rounded stones over 256 mm (>10 inches) in diameter or large "slabs" more than 256 mm in length.

Cobble – stones from 64-256 mm (2.5-10 inches) in diameter.

Gravel – mixture of rounded coarse material from 2-64 mm (1.5-2.5 inches) in diameter.

Sand – Materials 0.06-2.0 mm in diameter, generally this is fine material that feels "gritty" between fingers. Sand can be picked up and held in hand.

Silt – materials 0.004-0.06 mm in diameter, generally this is fine material that feels "greasy" between finger. Silt would not be able to be picked up or held in your hands.

Hardpan – particles less than 0.004 mm in diameter, usually known as "clay", forms dense gummy surfaces that are difficult to penetrate.

Detritus – dead unconsolidated organic material covering the bottom that might include sticks, pieces of wood, leaves, or other partially or decaying plant matter.

Muck – black, fine, flocculent, of completely decomposing organic matter. Muck makes great mud pies and can be rolled and held in your hand (sewage sludge is not considered muck).

Artificial – Banks are lined with rip rap, concrete, or other unnatural substrates.

NOTE: Sludge that originates from point sources is not included as a substrate. The substrate score is based on the underlying material. Note sludge presence on the data sheet and report to IDEM immediately.

b) **Substrate Origin:** Substrate origin refers to the "parent" material that the stream substrate is derived. Check one box. If the parent material is from multiple, predominant sources (e.g., rip/rap and tills), check two boxes and average the score. Consulting geological maps may be helpful to complete this metric.

Limestone – sedimentary rock consisting mainly of calcium carbonate.

Tills – glacial drift composed of rock fragments that range from clay to boulder size and randomly arranged without bedding.

Wetlands – substrate typically rich in organic matter with stream originating in swamp or marsh.

Hardpan – general term for a relatively hard layer of soil at or just below the ground surface, impervious clay cemented together does not become plastic when mixed with water.

Sandstone – sedimentary rock composed primarily from sediments derived from persisting rock (mostly quart grains) or fossils.

Rip-Rap – pile of large, similar sized angular boulders placed along the shore to prevent erosion by current.

Lacustrine – stream substrates influenced by lake or lentic habitats.

Shale – sedimentary rocks composed of detrital sediment particles (mostly clay grade) that tend to be red, brown, black, or gray and usually originate in relatively still waters, may be rich in fossils and is easily broken off or chipped.

Coal fines – mined area where coal influences the substrate, usually composed of dark, pyrite minerals.

c) **Silt Cover:** This is the extent that substrates are covered by silt. Check one box.

Silt heavy – means that nearly the entire stream bottom is layered with a deep covering of silt (greater than one inch thick).

Silt Moderate – includes extensive covering of silt, but with some areas of clean substrates (e.g., riffle areas).

Silt Normal – includes areas where silt is deposited in small amounts along the stream margin, or is present as a "dusting" that appears to have little functional significance.

Silt Free – should be checked if substrates are exceptionally clean throughout the sampling area.

d) **Embeddedness:** Embeddedness is the degree that gravel, cobble, boulder substrates are surrounded, or covered by fine materials (sand and silt). Substrates should be considered embedded if greater than 50 percent of their surfaces are surrounded by fine material. Embedded substrates cannot be easily dislodged. Naturally sandy streams are not considered embedded. However, sand predominated streams as the result of human activities are considered embedded. Check one box

Extensive – is greater than 75 percent of sampling area embedded.

Moderate – is 50-75 percent of the sampling area embedded.

Low/Normal – is 25-50 percent of sampling area embedded.

None is less than 25 percent of sampling area embedded.

Substrate Metric Score: Although the theoretical maximum metric score is greater than 20, the maximum score allowed for this QHEI metric is limited to 20 points. The minimum score is zero.

7.1.2.2 Metric 2: In-stream Cover

This metric consists of two components, including in-stream cover types and the amount (availability) of in-stream cover.

a) **Type:** Check ALL of the cover types present in the stream. The types should be present in greater than 5 percent of sampling area. Cover should not be counted when it occurs in areas of the stream with insufficient depth (less than 20 cm), or dry portions of the stream.

   Cover types include undercut banks, overhanging vegetation, shallows in slow water (less than 20 cm), root-mats, logs or woody debris, deep pools (greater than 70 cm), oxbows, boulders, aquatic macrophytes, and root-wads (tree roots that extend into stream). **NOTE: Do not check undercut banks and root-wads unless undercut banks exist along with root-wads as a major component.**

b) **Amount:** Check one box. If cover is thought to be intermediate in amount between two categories, check two boxes and average the score.

   Extensive – cover is present throughout the sampling area, generally greater than 75 percent of the sampling area.

   Moderate – cover occurs in 25-75 percent of the sampling area.

   Sparse – cover is present in less than 25 percent of the sampling area (usually exists in isolated patches).

   Nearly Absent – cover does not occur in any large patches for any type anywhere in the sampling area. This situation is usually found in recently channelized streams or other highly modified reaches (e.g., ship canals).

In-stream Cover Metric Score: Although the theoretical maximum is greater than 20 points, the maximum score assigned for the QHEI metric in-stream cover is limited to 20 points.

7.1.2.3 Metric 3: Channel Morphology

This metric emphasizes the quality of the stream channel that relates to the creation and stability of the in-stream habitat. This metric has five categories: channel sinuosity, channel development, channelization, stability, and modifications. One box beneath each category should be checked; however, if the conditions are intermediate between categories, then check two and average the scores.

a) **Sinuosity**: This is the degree that a stream meanders.

   High – sinuosity is more than 2 or 3 well defined outside bends within the sampling area with deep areas outside and shallow areas inside the bends.

Moderate – sinuosity is more than 2 outside bends, with at least one bend well defined.

Low – sinuosity is a channel with only 1 or 2 poorly defined outside bends in sampling area, or slight meandering within modified banks.

No – sinuosity is a straight channel.

b) **Development**: This is the development of riffle/pool complexes.

Excellent – development of riffles with well developed larger substrates, e.g., gravel, cobble, or boulder; pools have variation in depth that includes a maximum depth of greater than 1 m, and riffle and run depths greater than 0.5 m.

Good – similar to excellent with following exceptions, pools show variability in depth and a distinct transition exists between pools and riffles.

Fair – riffles poorly developed, or absent; however, pools are more developed with greater variation in depth.

Poor – riffles are absent, or if present, shallow with sand and fine gravel substrates, pools are shallow (less than 0.2 m).

c) **Channelization**: Refers to the influence of anthropogenic disturbance by the straightening of channels.

None – No man made channel modifications present.

Recovered – streams have been channelized in the past and have recovered most of their natural channel characteristics within the channelized levees (e.g., riffle/pool complexes, sinuosity, etc.).

Recovering – channelized streams are in the process of regaining natural characteristics; however, habitats are still degraded.

Recent or No Recovery – streams that were recently channelized or show no sign of recovery of habitats (e.g., no regrowth of trees, bare dirt along banks, rock rip-rapped banks).

d) **Stability**: Channel stability is determined by the lack of erosion and bank instability.

High – stable banks and substrates, with little or no erosion and no moving bed-load.

Moderate – stable riffle/pool and channel characteristics, but exhibit some symptoms of instability, e.g., high bed-load, eroding banks, or show effects of fluctuating water levels that cause widening of the stream channel.

Low – unstable and severely eroding banks, possess fine substrates in riffles that often change location and high bed-load that slowly moves downstream.

e) **Modifications/Other**: This category identifies specific channel disturbances and habitat modifications in the sampling area. Check all that apply but these are not scored.

Channel Morphology Metric Score: The maximum QHEI metric score for Channel Morphology is 20 points.

7.1.2.4 Metric 4: Riparian Zone And Bank Erosion

This metric emphasizes the quality of the riparian buffer zone and the quality of the floodplain vegetation. Each of the three components requires scoring the LEFT and RIGHT banks (looking downstream). The AVERAGE score of the LEFT and RIGHT banks, per category, is the recorded value. Check one box per bank unless conditions are considered to be intermediate between two categories, then check two boxes and average the scores.

a) **Riparian Width:** This is the width of the stream bank vegetation, old fields, and shrub or forest areas. Urban, residential, construction, pasture, and row crops are not included in the width of the riparian zone. Check one box per stream bank and average the scores.

b) **Floodplain Quality:** Floodplain means the areas immediately outside of the riparian zone, or greater than 100 ft (30.48 m) from each side of the stream. These are areas adjacent to the stream that have direct runoff and erosional effects. Check one box per bank for the predominant floodplain quality type and average the score.

c) **Bank Erosion:** The alteration of the stream-bank either by water flow or animals. False banks are used in the sense of Platts et al. (1983) to mean banks that are no longer adjacent to the normal flow of the channel, but have been moved back into the floodplain most commonly as a result of livestock trampling. Check one box per bank and average the scores.

None/Little – stream-banks are stable and not altered by water flows or animals (e.g., livestock). Less than 25 percent of the stream-bank is receiving any kind of stress. Less than 25 percent of the stream-bank is false, broken down, or eroding.

Moderate – stream-banks are receiving moderate alteration along the transect line. At least 50 percent of the stream-bank is in a natural stable condition, and less than 50 percent of the stream-bank is false, broken down, or eroding.

Heavy/Severe – stream-banks are receiving major alterations along the transect line. Less than 50 percent of the stream-bank is in a stable condition and greater than 50 percent of the stream-bank is false, broken down, or eroding.

Riparian Zone and Bank Erosion metric maximum score: 10 points.

7.1.2.5 Metric 5: Pool And Riffle/Run Quality

This metric emphasizes the quality of the pool or riffle/run habitats. There are six categories, which include depth, diversity of current velocities, morphology, substrate stability, and embeddedness in the riffle and run areas.

a) **Maximum Pool Depth**: Pools with maximum depths of less than 20 cm are considered to have lost function and the total metric score is 0. **NOTE: If maximum depth is < 20 cm, then no other characteristic needs to be scored.** Check one box.

b) **Morphology**: Check one box.

c) **Current Velocity**: (Pools and Riffles): Check ALL that are present in the sampling area.

Torrential – extremely turbulent and fast flowing water with large standing waves. Water surface is very broken with no definable, connected surface; usually limited to gorges and dam spillway tailwaters.

Fast – mostly non-turbulent flow with small standing waves in riffle-run areas. Water surface may be partially broken, but there is a visibly connected surface.

Moderate – non-turbulent flow that is detected and visible (i.e., floating objects are readily transported downstream). Water surface is visibly connected.

Slow – water flow is perceptible, but very sluggish.

Eddies – small areas of reverse circular current motion, usually formed in pools immediately downstream from riffle-run areas.

Interstitial – water flow is perceptible only in the interstitial spaces between substrate particles in riffle-run areas.

Intermittent – no flow is evident anywhere, standing pools are separated by dry areas.

Pool Quality: The maximum score is 12 points with a minimum of zero.

d) **Riffle/Run Depth**: Check one box for the depth of riffle and runs. Score 0 if no riffles are present, or less than 5 cm in depth. **NOTE: No other characteristics need to be scored if no riffle is present or the maximum depth is < 5 cm.**

d) **Riffle/Run Substrate**: Check one box that best describes the substrate and stability of the riffle habitats.

f) **Riffle/Run Embeddedness**: This category is used to describe embeddedness in the riffle areas. Use the same criteria as used to evaluate embeddedness in Metric 1 (SUBSTRATE). Check only one box.

The maximum score assigned to the **Riffle/Run Quality** section is 8 points with a minimum of zero.

7.1.2.6 Metric 6: Gradient

a) **Average width**: Determine the representative width of the stream. Measurements are taken from wetted edge to wetted edge at a point that best represents the typical stream width in the sampling area. Average narrow riffles and wide pools. Record width to the nearest meter for large and great rivers.

b) **Local gradient**: is calculated from 7.5-minute U.S. Geological Survey topographical maps by measuring the elevation drop through the sampling area. This is done by measuring the stream length between the first contour line upstream and the first contour line downstream of the sampling site and dividing the distance by the contour interval. If the contour lines are closely “packed” a minimum distance of a least one mile should be used. Some judgment may be necessary in certain anomalous areas (e.g., vicinity of waterfalls, impounded areas).

c) **Drainage area**: is calculated using "Drainage Areas of Indiana Streams" (Hoggatt 1975). Drainage area of a stream at a specified location is that area, measured in a horizontal plane, enclosed by a topographic divide influenced by direct surface runoff from precipitation normally drained by gravity into the stream above the specified location. Estimate drainage area by using Arcview or find the point along the stream in Hoggatt (1975). Use a 1:24,000 scale topographical map (7.5-minute scale) to estimate drainage area. The drainage area for a specific point on a stream includes the water drained from the left and right banks up to the highest elevation in the surrounding area upstream from the site. Looking at the contour lines, draw the area on the map by extending lines out from the site up to the highest elevation or hill including all of the areas drained into the site at that location. The township lines encompass one square mile so estimate how many square miles are in the watershed up to the site location to calculate drainage area.

Scoring for ranges of stream gradient accounts for varying influences of gradient with stream size, preferable measured as drainage area in square miles or stream width. Score criteria are found in Table E.

Gradient Quality: Maximum score assigned is 10 points.

Table E. Classification of Stream Gradient Corrected for Stream Size.

Average stream width (meters)				
0.3-4.7	4.8-9.2	9.2-13.8	13.9-30.6	>30.6
Drainage Area (sq. miles)				
0-9.2	9.2-41.6	41.6-103.7	103.7-622.9	>622.9
Gradient (ft/mile)				
Very Low				
0-1.0	0-1.0	0-1.0	0-1.0	--
2	**2**	**2**	**4**	**--**
Low				
1.1-5.0	1.1-3.0	1.1-2.5	1.1-2.0	0-0.5
4	**4**	**4**	**6**	**6**
Low-Moderate				
5.1-10.0	3.1-6.0	2.6-5.0	2.1-4.0	0.6-1.0
6	**6**	**6**	**8**	**8**
Moderate				
10.1-15.0	6.1-12.0	5.1-7.5	4.1-6.0	1.1-2.5
8	**10**	**8**	**10**	**10**
Moderate-High				
15.1-20.0	12.1-18.0	7.6-12.0	6.1-10.0	2.6-4.0
10	**10**	**10**	**10**	**10**
High				
20.1-30.0	18.0-30.0	12.1-20.0	10.1-15.0	4.1-9.0
10	**8**	**8**	**8**	**10**
Very High				
30.1-40.0	30.1-40.0	20.1-30.0	15.1-25.0	>9.0
8	**6**	**6**	**6**	**8**

Any site with a gradient greater than the upper bound of the “very high” gradient classification is assigned a score of 4.

7.1.3 Impacts/ Miscellaneous

All other information included on the QHEI field sheet is not required to calculate a total QHEI score, but is needed to assist in making biological assessments. These measures indicate the cause or source of any possible impairments.

Additional Information is recorded on the reverse side of the QHEI field sheet and is described as **Impacts/Miscellaneous**.

Major Suspected Impacts – different types of pollution sources that could be a major factor influencing the habitat characteristics affecting the biological integrity.

Subjective Rating – Rating from 1-10 on the functionality of the stream for aquatic organisms. One being poor habitat and 10 being great habitat for diverse aquatic community.

Aesthetic Rating – Rating from 1-10 that is based on the appeal of the stream and not the functionality (i.e., how well you expect the stream to be for diverse organisms prior to actual sampling). Streams rated a "1" would likely be poor habitat with steep eroding banks, turbid water, no riparian zones, while a "10" would include a meandering stream with excellent riffle/pool development that flows through forested riparian corridors and has clear water visibility.

Canopy Cover (% Open) – This is the percentage of the sampling site that is not covered or shaded by woody bank vegetation. The cover will be determined by using a spherical densiometer following manufacturer's instructions. Streams with an average width of 10 m or less will have a single reading from mid-channel. Readings are made facing upstream, downstream, left bank, and right bank from the "most typical" canopy area representing the sample reach. Streams with a width greater than 10 m will have three readings taken at mid-channel, left bank, and right bank of the stream.

Percent Pool, Riffle, Run – Estimate the percentage across the entire reach per habitat type. Cumulative total cannot exceed 100%.

Is Reach Representative of the Stream – Answer YES if the stream reach where the biological sample is collected resembles areas upstream and downstream of the reach.

General QHEI Notes – Record any special comments concerning the habitat including any pollution or obvious problems.

Stream Drawing – Draw the entire sampled section so that the stream is sketched in the area provided. Important physical features are noted on the map with standard symbols. Include direction (N), direction of flow, floodplain and riparian zone characteristics, pools, riffles, runs, denote deep areas with an "X", and indicate where sampling begins and stops.

7.1.4 Quality Assurance

At the conclusion of the field season, two rounds of quality control will be done on the calculations to determine the total QHEI score. Appendix N explains the calculations. After all data sheets have been QC'd, the data will be entered into the recommended habitat data base provided by IDEM. For additional information on QA/QC, see Appendix C.

8.0 Methods for the Collection of Aquatic Macroinvertebrate Assemblage Information

8.1 Introduction

8.1.1 Background

This section is reserved for the addition of macroinvertebrate collection protocols – unionid mussel surveys, MHAB and modified Hester-Dendy artificial substrate samplers, or other techniques. Protocols will be developed and implemented on a project specific basis as needed.

9.0 Methods for the Collection of Phytoplankton and Periphyton Assemblage Information

9.1 Introduction

9.1.1 Background

This section is reserved for the addition of phytoplankton collection protocols. Protocols will be developed and implemented on a project specific basis as needed.

10.0 Methods for the Collection of Zooplankton/Meroplankton Assemblage Information

10.1 Introduction

10.1.1 Background

This section is reserved for the addition of zooplankton/meroplankton collection protocols. Protocols will be developed and implemented on a project specific basis as needed.

11.0 Methods for the Collection of Habitat Former Assemblage Information

11.1 Introduction

11.1.1 Background

This section is reserved for the addition of habitat former collection protocols. Protocols will be developed and implemented on a project specific basis as needed.

12.0 Methods for the Collection of Other Vertebrate Wildlife Assemblage Information

12.1 Introduction

12.1.1 Background

This section is reserved for the addition of other vertebrate wildlife collection protocols. Protocols will be developed and implemented on a project specific basis as needed.

13.0 Data Management

13.0.1 Overview

IDEM expects that all data collected in relation to the demonstration project will be managed as raw data both electronically and through maintenance of original field data forms. IDEM does not expect the discharger to use a specific electronic data format. However, the data is to be managed completely in its most basic form as transcribed from field data sheets. This will enable independent assessment of all data as necessary.

13.1 Data Validation and Usability

Quality assurance reports including data validation and usability are also important components of the project design which insures good quality data for this project. A quality assurance audit report will be submitted for this project should problems arise and need to be investigated and corrected. Data validation and usability will be achieved through data reduction (the process of converting raw analytical data into final results in proper reporting units), data validation (the process of qualifying analytical/ measurement data on the performance of field and laboratory quality control measures incorporated into the sampling and analysis procedures), and data reporting (the detailed description of the data deliverables used to completely document the calibration, analysis, quality control measures, and calculations).

All information will be maintained in the raw field and/or laboratory data forms and in Microsoft Excel®, Access® or similar spreadsheet or data basing software. The data maintained includes:

- All accounts about each sampling event including matrix, date, time, transect or reach, weather conditions, river or lake conditions, canopy cover, reach gradient, etc.

- All temperature monitoring data points, including instantaneous and remote data logging are to be managed as raw data and linked to their respective GPS site coordinates.

- All temperature monitoring QA data, including pre- and post-calibrations of temperature sensors and calibrated instantaneous temperature measurement devices, maintenance and notes on performance.

- All fish accounts cross-referenced to IDEM's Assessment Information Management System's (AIMS) IDEM_Taxon_ID. (This is a three digit code unique to each

species or hybrid likely to be encountered in Indiana. IDEM_Taxon_ID codes can be found in Appendix K.)

- All Fish account data, species accounts, counts, weights, lengths, DELT information, etc. and are linked to the specific transect, reach, or T-Zone from which they were collected.

- All QHEI scoring information including checked items that are not part of the actual scoring, scoring items, metric scores and total QHEI scores.

- All other organism types account data, species accounts, counts, etc. and are linked to the specific transect, reach, or T-Zone from which they were collected.

- In the event that macroinvertebrate, periphyton or other plankton are sampled, the project manager will work with IDEM to achieve information cross-reference with AIMS taxa files.

IDEM will work with the project manager to assure that all relevant data are captured and managed in a format that will insure ease of usability and assessment toward the goals of the project.

References

Bell, M.C. 1973. Fisheries handbook of engineering requirements and biological criteria. North Pacific Division, U.S. Army Corps of Engineers. Portland, OR.Bonar, S.A., W.A. Hubert, and D.W. Willis, editors. 2009. Standard Methods for Sampling North American Freshwater Fishes. American Fisheries Society. ISBN: 978-1-934874-10-3

Clesceri, L.S., A. E. Greenberg, and A. D. Eaton, editors. 1998. Standard Methods for the Examination of Water and Wastewater, 20th Edition. American Public Health Association, American Water Works Association, and Water Environment Federation. Washington, D.C.

Dufour, R.L. 2002. Guide to appropriate metric selection for calculating the index of biotic integrity (IBI) for Indiana rivers and streams. Indiana Department of Environmental Management, Indianapolis, Indiana.

Dufour, R.L., T.P. Simon, and S.A. Newhouse. 2003. Evaluating the effects of thermal discharges on aquatic life: Patterns in multi-metric indices from three case studies in large and great rivers of the Midwestern United States. Pp. 495-516. In T.P. Simon (ed). Biological Response Signatures: Indicator Patterns using Aquatic Communities. CRC Press, Boca Raton, FL.

Dunham, J.B. and G.L. Vinyard. 1998. Stream temperature monitoring protocol. Biological Resources Research Center, University of Nevada-Reno. Reno, NV. 5 p.

Emery, E.B. and J.A. Thomas. 2003. A method for assessing outfall effects on Great River Fish populations: the traveling zone approach. Pp. 157-164. In T.P. Simon (ed). Biological Response Signatures: Indicator Patterns using Aquatic Communities. CRC Press, Boca Raton, FL.

Emery, E.B., F.H. McCormick, and T.P. Simon. 2003. Response patterns of Great River fish assemblage metrics to outfall effects from point source discharges. Pp. 481-494. In T.P. Simon (Ed.). Biological Response Signatures: Indicator Patterns using Aquatic Communities. CRC Press, Boca Raton, FL.

Emery, E.B., T.P. Simon, F.H. McCormick, P.L. Angermeier, J.E. Deshon, C.O. Yoder, R.E. Sanders, W.D. Pearson, G.D. Hickman, R.J. Reash, and J.A. Thomas. 2003. Development of a Multimetric Index for Assessing the Biological Condition of the Ohio River. Transactions of the American Fisheries Society 132: 791–808.

Essig, D.A. 1998a. The dilemma of applying uniform temperature criteria in a diverse environment: an issue analysis. Water Quality Assessment and Standards Bureau, Idaho Division of Environmental Quality. Boise, ID. 29 p.

Herdendorf, C.E., S.M. Hartley, M.D. Barnes. 1981. Fish and wildlife resources of the Lake Michigan coastal wetlands within the United States. FWS/OBS-81/001 (six volume set). U.S. Department of the Interior, Fish and Wildlife Service, Washington, D.C.

Hoggatt, R.E. 1975. Drainage Areas of Indiana streams. U.S. Geological Survey, Indianapolis, Indiana.

Horsburgh, B. R. and R. Steed. 1997. Owyhee Mountains thermograph placement work plan. Idaho Division of Environmental Quality, Boise Regional Office. Boise, Idaho. 3p.

Hynes, H.B.N. 1972. The Ecology of Running Waters. University of Toronto Press. Toronto.

Idaho Department of Health and Welfare. 1999. Water quality standards and wastewater treatment requirements. Idaho Department of Health and Welfare Rules, Title 01, Chapter 02. (IDAPA 16.01.02) Boise, ID.

Indiana Department of Environmental Management (IDEM). 1992. Biological Studies Section Standard Operating Procedures. Office of Water Management, Assessment Branch, Biological Studies Section. Indianapolis, Indiana.

Indiana Department of Environmental Management (IDEM). 2010. Multi-Habitat (MHAB) Macroinvertebrate collection procedure. S-100-OWQ-W-BS_10-T-R0. Technical Standing Operating Procedure. Indiana Department of Environmental Management, Office of Water Quality, Indianapolis, IN.

Indiana Department of Environmental Management (IDEM). 2013. Assessment Information Management System (AIMS). Indiana Department of Environmental Indiana Department of Natural Resources (IDNR), 2014. Indiana Fishing Regulations 2014-2015. Indiana Department of Natural Resources, Division of Fish and Wildlife. Indianapolis, IN.

Newhouse, S.A.; C.M. Newhouse; S.L. Sobat 1999. Temperature Profiles of the Wabash River Upstream and Downstream of the CINERGY Generating Stations at Cayuga and Terre Haute, Indiana, July 1999. Biological Studies Section, Assessment Branch, Office of Water Management, Indiana Department of Environmental Management. IDEM/32/03/003/1999. 17p

National Hydrography Data Set (NHD). 2010. USGS in Cooperation with U.S. EPA, USDA Forest Service, and other Federal, State and Local Partners. (www.nhd.usgs.gov)

Ohio Environmental Protection Agency (OHEPA). 1989a. Standardized biological field sampling and laboratory methods for assessing fish and macroinvertebrate communities. Volume III. Ohio Environmental Protection Agency, Division of Water Quality Planning and Assessment, Columbus, Ohio.

Ohio Environmental Protection Agency(OHEPA). 1989b. Biological Criteria for the Protection of Aquatic Life. Volume III. Standardized biological field sampling and laboratory methods for assessing fish and macroinvertebrate communities. Ohio EPA, Ecological Assessment Section, Division of Water Quality, Columbus, Ohio.

Ohio Environmental Protection Agency (OHEPA). 2006. Methods for Assessing Habitat in Flowing Waters: Using the Qualitative Habitat Evaluation Index (QHEI). OHIO EPA Technical Bulletin EAS/2006-06-1. Revised by the Midwest Biodiversity Institute for State of Ohio Environmental Protection Agency, Division of Surface Water, Ecological Assessment Section, Groveport, Ohio.

Ohio Environmental Protection Agency (OHEPA). 2010. Methods for Assessing Habitat in lake Erie Shoreline Waters Using the Qualitative Habitat Evaluation Index (QHEI) Approach (Version 2.1). Ohio Environmental Protection Agency, Division of Surface Water. Columbus, Ohio

Omernik, J.M. and A.L. Gallant. 1988. Ecoregions of the Upper Midwest States. USEPA, ERL, Corvallis, OR. EPA/600/3-88/037.

Platts, W.S., W.F. Megahan, and G.W. Minshall. 1983. Methods for evaluating stream, riparian, and biotic conditions. General Technical Report INT-138. U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station, Ogden, Utah. 70 pp.

Ralston, G. L. and M.L. Browne. 1976. Technical procedures manual for water quality monitoring. Bureau of Water Quality, Idaho Department of Health and Welfare-Division of Environment. Boise, ID. 92 p.

Rankin, E.T. 1995. Habitat indices in water resource quality assessments. Pp.181-208. In W.S. Davis and T.P. Simon (eds.). Biological Assessment and Criteria: Tools for Water Resource Planning and Decision Making. Lewis Publishers, Boca Raton, FL.

Reutter, J.M. and C.E. Herdendorf. 1976. Thermal discharge from a nuclear power plant: predicted effects on Lake Erie fish. Ohio J. Sci. 76(1):39-45.

Robins, C.R., R.M. Bailey, C.E. Bond, J.R. Brooker, E.A. Lachner, R.N. Lea, and W. B. Scott. 1991. Common and scientific names of fishes from the United States and

Canada. 5th ed. Bethesda (MD): American Fisheries Society Special Publication 20. 181 p.

Simon, T.P. 1991. Development of Index of Biotic Integrity expectations for the Ecoregions of Indiana. I. Central Corn Belt Plain. U.S. Environmental Protection Agency, Region V, Chicago, IL. EPA 905/9-91/025.

Simon, T.P. 1992. Biological Criteria Development for Large Rivers with an Emphasis on an Assessment of the White River Drainage, Indiana. U.S. Environmental Protection Agency, Region v, Chicago, IL. EPA 905/R-92/006.

Simon, T.P. 1994. Development of Index of Biotic Integrity expectations for the Ecoregions of Indiana. II. Huron-Erie Lake Plain. U.S. Environmental Protection Agency, Region V, Water Division, Watershed and Non-Point Source Branch. Chicago, IL. EPA 905/R-92/007.

Simon, T.P. 1997. Biological characterization of the Middle Fork Anderson River, Perry County, Indiana. U.S. Environmental Protection Agency, Region 5, Chicago, IL. EPA 905-R-96-007.

Simon, T.P. 1997. Development of Index of Biotic Integrity expectations for the Ecoregions of Indiana. IV. Interior River Lowland. U.S. Environmental Protection Agency, Region V, Water Division, Watershed and Non-Point Source Branch. Chicago, IL. EPA 905/R-96/002.

Simon, T.P. 1998a. Development of Index of Biotic Integrity expectations for the Ecoregions of Indiana. III. Northern Indiana Till Plain. U.S. Environmental Protection Agency, Region V, Water Division, Watershed and Non-Point Source Branch. Chicago, IL. EPA 905/R-96/002.

Simon, T.P. 1998b. Modification of an index of biotic integrity and development of reference condition expectations for dunal, palustrine wetland fish communities along the southern shore of Lake Michigan. Aquatic Ecosystem Health and Management 1:49-62.

Simon, T.P. 1998c. Development of fish community reference conditions for dunal, palustrine wetlands along the southern shore of Lake Michigan. Aquatic Ecosystem Health and Management 1: 57-70.

Simon, T.P. 2001. Development, calibration, and validation of an index of biotic integrity for littoral fish assemblages for inland warmwater lakes in northern and central Indiana. State of Indiana, Department of Environmental Management, Indianapolis, IN.

Simon, T.P. 2002. Development, calibration, and validation of an index of biological sustainability for oxbow lakes and reservoirs in southern Indiana. State of Indiana, Department of Environmental Management, Indianapolis, IN.

Simon, T.P. 2004b. Evaluation of Lake Michigan nearshore coastal wetlands with emphasis on development of watershed biotic indicators and status. U.S. Department of the Interior, Fish and Wildlife Service, Bloomington, IN.

Simon, T.P. 2006. Development, Calibration, and Validation of an Index of Biotic Integrity for the Wabash River. Proceedings of the Indiana Academy of Science 115(2):170-186.

Simon, T.P. and R.L. Dufour. 1998. Development of Index of Biotic Integrity expectations for the Ecoregions of Indiana. V. Eastern Corn Belt Plain. U.S. Environmental Protection Agency, Region V, Water Division, Watershed and Non-Point Source Branch. Chicago, IL. EPA 905/R-96/003.

Simon, T.P. and R.L. Dufour. 2006. Guide to Appropriate Metric Selection for Calculating the Index of Biotic Integrity (IBI) for Indiana large and Great Rivers, Inland Lakes, and Lake Michigan Nearshore. U.S. Department of the Interior, Fish and Wildlife Service, Bloomington, IN.

Simon, T.P. and E.B. Emery. 1995. Modification and assessment of an index of biotic integrity to quantify water resource quality in Great Rivers. Regulated Rivers Research and Management 11: 283-298.

Simon, T.P., R. Jankowski, and C. Morris. 2000. Modification of an index of biotic integrity for vernal ponds and small palustrine wetlands using amphibians, crayfish, and fish assemblages along southern Lake Michigan. Aquatic Ecosystem Health and Management 3: 407-418.

Simon, T.P. and R.E. Sanders. 1999. Applying an index of biotic integrity based on Great River fish communities: considerations in sampling and interpretation. Pp. 475-506. In T.P. Simon (Ed.). Assessing the Sustainability and Biological Integrity of Water Resources Using Fish Communities. CRC Press, Boca Raton, FL.

Simon, T.P. and J.R. Stahl. 1998. Development of biotic integrity expectations for the Wabash River. U.S. Environmental Protection Agency, Region V, Water Division, Watershed and Non-Point Source Branch. Chicago, IL. EPA 905/R-96/005

Simon, T.P. and P.M. Stewart. 2006. Coastal Wetlands of the Laurentian Lake Michigan: Health, Habitat, and Indicators. Authorhouse Press, Bloomington, Indiana.

Simon, T.P., J.O. Whitaker, Jr., J.S. Castrale, and S.A. Minton. 2002. Revised checklist of the vertebrates of Indiana. Proceedings of the Indiana Academy of Science 111: 182-214.

StatSoft, Inc. 1999. STATISTICA for Windows [Computer program manual]. StatSoft Inc., 2300 East 14th Street, Tulsa, OK 74104, phone (918) 749-1119, fax. (918) 749-2217, email: info@statsoft.com, WEB: http://www.statsoft.com

Stevens, H.H., Jr., J.F. Ficke, and G.F. Smoot. 1975. Water temperature – influential factors, field measurement, and data presentation. Techniques of water-resources investigations of the United States Geological Survey, Book 1, Chapter D1. U.S. Department of the Interior. U.S. Government Printing Office, Washington, DC. 65p.

Thoma, R. 1999. Biological monitoring and an index of biotic integrity for Lake Erie's nearshore waters. Pp. 417-462. In. T.P. Simon (Ed.). Assessing the Sustainability and Biological Integrity of Water Resources Using Fish Communities. CRC Press, Boca Raton, FL.

Thoma, R. 2010. Methods of Assessing Habitat in Lake Erie Shoreline Waters Using the Qualitative Habitat Evaluation Index (QHEI) Approach (Version 2.1. Ohio Environmental Protection Agency. Columbus, OH.

U.S. Environmental Protection Agency (USEPA). 1977. Interagency 316(a) Technical Guidance Manual and Guide for Thermal Effects Sections of Nuclear Facilities Environmental Impact Statements (DRAFT). U.S. Environmental Protection Agency. Office of Water Enforcement, Permits Division, Industrial Permits Branch. Washington, D.C.

U.S. Environmental Protection Agency (USEPA). 1988. Standard Operating Procedures for conducting rapid assessment of ambient surface water quality using fish. USEPA. Region V. Central Regional Laboratory. Chicago, IL.

U.S. Environmental Protection Agency (USEPA). 2011. 2012 National Lakes Assessment. Field Operations Manual. EPA 841-B-11-003. U.S. Environmental Protection Agency, Washington, DC.

Wang, L., J. Lyons, P. Kanehl, and T.P. Simon. 1998. Fish sampling procedures for Northern Lakes and Forest Streams. In. T.P. Simon and P.M. Stewart (eds.). Standard Operating Procedures for Development of Watershed Indicators in REMAP: Northern Lakes and Forest Streams. U.S. Environmental Protection Agency, Chicago, Illinois.

Wismer, D.A. and A.E. Christie. 1987. Relationships of Lake Michigan Fishes: A Data Compilation . Lake Michigan Fish. Comm. Spec. Pub. 87-3. 165p. Lake Michigan Fisheries Commission. Ann Arbor, MI.

Yoder, C.O. B.J. Armitage, and E.T. Rankin. 2005. Re-evaluation of the Technical Justification for the Existing Ohio River Mainstem Temperature Criteria. Report to the Ohio River Valley Water Sanitation Commission (ORSANCO) ad hoc Committee on Temperature Criteria Re-evaluation. Technical Report MBI/05-05-2. Midwest Biodiversity Institute. Columbus OH.

Zaroban, D.W. 1999. Protocol for placement and retrieval of calibrated instantaneous measurement devices in Idaho streams. Water Quality Monitoring Protocols – Report No. 10. Idaho Department of Environmental Quality. Boise, Idaho.

Zale, A.V. , D.L. Parrish, and T.M. Sutton, editors, 2013. Fisheries Techniques 3rd Edition. American Fisheries Society. ISBN: 978-1-934874-29-5.

Page Intentionally Left Blank

APPENDIX A

Temperature Data Logger Calibration Check Form Example

Temperature Calibration Form

Logger/Device:

Manufacturer_____ Model_____

Serial number_____

Conducted by_____Calibration date_____

NIST certified thermometer: Manufacturer_____

Model_____Serial number_____

Time (24hour clock)	Bath Temperature (^{o}C)	Logger/Device Temperature (^{o}C)	Discrepancy (^{o}C)

Temperature Calibration Form (*Example – Completed Form)*

Logger/Device:

Manufacturer: Hobo Model: Boxcar

Serial number SXXXXXXXXXX

Conducted by John Doe Calibration date: 6/24/2010

NIST certified thermometer: manufacturer Accutherm

model Exact temp thermometer serial number XXXXXXXX

Time (24 hour clock)	Bath Temperature (^{o}C)	Logger/Device Temperature (^{o}C)	Discrepancy (^{o}C)
8:35 6/24/2010 #1	21.6 C	21.5	0.1
#2	21.6	21.6	0
#3	21.6	21.6	0
#4	21.6	21.6	0
#5	21.6	21.6	0
#6	21.6	21.5	0.1
#7	21.6	21.6	0
#8	21.6	21.6	0
#9	21.6	21.6	0
#10	21.6	21.6	0
#11	21.6	21.5	0.1
# 12	21.6	21.6	0
# 13	21.6	21.6	0
#14	21.6	21.6	0
# 15	21.6	21.6	0
# 16	21.6	21.6	0
# 17	21.6	21.5	0.1
# 18	21.6	21.6	0

APPENDIX B

Temperature Data Logger Metadata Form

Temperature Metadata Sheet

Metadata Sheet: Database Entry:

SITE ID NUMBER: _____

LOCATION INFORMATION (bold fields required)

Waterbody name:

Site description:

USGS cataloging unit:
Waterbody index number:

BURP ID:

Public land survey: township _____, range _____, section _____, _____¼ of the_____¼

County:
Latitude:_____N decimal degrees
Longitude: -_____W decimal degrees
Lat/long source: map GIS GPS

Datum: NAD27 NAD83 Other If other, explain:

If GPS, differential correction: corrected uncorrected unknown

Ecoregion:

Map elevation (meters):

Comments:

Date edited: _____ By: _____
Date QA'd:_____ By: _____
Date Entered: _____ By: _____
Date QC'd: _____ By: _____
LOGGER/DEVICE INFORMATION (bold fields required)
Manufacturer: Model:

Serial number: **Raw data file name:**

Storage file type: ASCII text dtf xls mdb dbf wk4_____
Raw data file location:

Instrument calibrated? Yes no If yes, then calibration factor: 0.____ ^{o}C

Period of record (month and year):

Interval (hours):

Start type: launched in field triggered delayed

Measurement type: single multiple

Value type **(required if multiple measurement type)**: average minimum maximum

Contact name:

STATISTICS
Calibration factor applied to calculation of statistics? yes no

Instantaneous maximum: _____ _____ . _____ ^{o}C

Instantaneous minimum: _____ _____ . _____ ^{o}C

Overall mean: _____ _____ . _____ ^{o}C

Mean daily maximum: _____ _____ . _____ ^{o}C

Mean daily average: _____ _____ . _____ ^{o}C

Mean daily minimum: _____ _____ . _____ ^{o}C

Maximum daily average: _____ _____ . _____ ^{o}C

Maximum 7-day maximum: _____ _____ . _____ ^{o}C

Maximum 7-day average: _____ _____ . _____ ^{o}C

Minimum 7-day minimum: _____ _____ . _____ ^{o}C

Temperature Metadata Sheet

Metadata Sheet: Database Entry:
SITE ID NUMBER: __# 1_____

LOCATION INFORMATION (bold fields required)

Waterbody name: Wabash River

Site description: Right Descending Bank - attached to bridge piling on downstream side of SR 234 bridge, ca 2.6 mi E Cayuga.

USGS cataloging unit:
Waterbody index number: Assigned IDEM number

BURP ID:

Public land survey: township __18N_, range __2W__, section _3__, __NE_¼ of the__NE__¼

County: **Vermillion**
Latitude: __39.95221 N decimal degrees
Longitude: -87.42058 W decimal degrees

Lat/long source: map GIS **GPS**

Datum: NAD27 **NAD83** Other If other, explain:

If GPS, differential correction: **corrected** uncorrected unknown

Ecoregion: Interior River Lowland

Map elevation (meters): 149.35 m

Comments: Launch location is immediately across the river on LDB. The area immediately in front of the bridge is extremely shallow.

Date edited: _____ By: _____
Date QA'd:_____ By: _____
Date Entered: _____ By: _____
Date QC'd: _____ By: _____
LOGGER/DEVICE INFORMATION (bold fields required)

Manufacturer: HOBO Model: Boxcar

Serial number: SXXXXX **Raw data file name: WBR6_24_2006_1**

Storage file type: **ASCII text** dtf xls mdb dbf wk4____ASCII text_
Raw data file location:

Instrument calibrated? **yes** no If yes, then calibration factor: 0.5_ ^{o}C

Period of record (month and year): 6/24/2010 – 9/30/2010

Interval (hours): 24 hrs (measurement every 15 minutes)

Start type: **launched in field** triggered delayed

Measurement type: single **multiple**

Value type **(required if multiple measurement type)**: average minimum maximum

Contact name:

STATISTICS
Calibration factor applied to calculation of statistics? **yes** **no**

Instantaneous maximum: _____ _____ . _____ ^{o}C

Instantaneous minimum: _____ _____ . _____ ^{o}C

Overall mean: _____ _____ . _____ ^{o}C

Mean daily maximum: _____ _____ . _____ ^{o}C

Mean daily average: _____ _____ . _____ ^{o}C

Mean daily minimum: _____ _____ . _____ ^{o}C

Maximum daily average: _____ _____ . _____ ^{o}C

Maximum 7-day maximum: _____ _____ . _____ ^{o}C

Maximum 7-day average: _____ _____ . _____ ^{o}C

Minimum 7-day minimum: _____ _____ . _____ ^{o}C

APPENDIX C

Suggested Field Equipment List for Placing Temperature Data Logger Measurement Devices

Suggested Field Equipment List

- calibrated loggers (± 0.7^{o}C)
- backup loggers
- calibrated (NIST certified) thermometer (± 0.7^{o}C)
- calibrated electronic measurement device (± 0.7^{o}C)
- cable clamps
- cable
- steel fence posts
- GPS data logger unit(capable of + 3 meter or higher accuracy)
- pliers
- sledge hammer
- post driver
- camera/film
- waders
- laptop computer (if field launch/download)
- interface cable
- submersible cases (don't use clear cases)
- silicone grease
- silicone rings
- field book
- time piece
- desiccant
- backup batteries
- surveyor's flagging tape
- metadata sheets - field forms
- wrenches
- locks
- wire cutters
- wire
- pocket knife
- brush cutting tools
- first aid kit
- maps/aerial photos
- camouflage gauze
- bricks with holes
- tape measure
- metal tags
- cable ties
- thermocouple
- compression fittings
- crimping tool

APPENDIX D

Calibrated Instantaneous Temperature Measurement Device Field Form

CALIBRATED INSTANTANEOUS TEMPERATURE MEASUREMENT DEVICE FIELD FORM

Logger Placement

Waterbody name_____

Date_____

SiteID_____Boundaries_____

_

_____¼, _____¼, Sec. _____, T _____, R _____

Elevation_____ m

Latitude_____Longitude_____

__

(decimal degrees)

Instantaneous temperature_____ ^{o}C

Time_____hours

Permanent landmark

_____

_____

Site Sketch

Logger Retrieval

Date _____ Instantaneous temperature_____^{o}C

Time_____hours (24 hour clock)

Condition of
site/logger_____

CALIBRATED INSTANTANEOUS TEMPERATURE MEASUREMENT DEVICE FIELD FORM *(Completed Example)*

Logger Placement

Waterbody name____Wabash River_____

Date_4/26/2005__

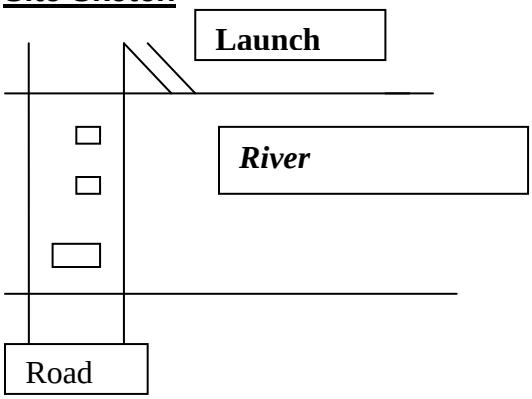
SiteID__#1_____Boundaries__Wabash River RDB_____
__NE__¼, __NE__¼, Sec. __3__, T __18N, R _2W__

Elevation____149.35____ m

Latitude_39.95221 N_____Longitude__-87.42058 W_____
(decimal degrees)
Instantaneous temperature__24.3_____ °C

Time_Every 15 minutes over 24 hrs Permanent landmark _RDB bridge piling SR 234 bridge_____

Site Sketch



Logger Retrieval

Date _9/30/2010_ Instantaneous temperature__26.8_____°C

Time_13:25_____hours (24 hour clock)

Condition of site/logger: Good condition, covered with diatoms, but otherwise no problems_____

APPENDIX E

Temperature Calibration Check Form for Instantaneous Temperature Measurements

Temperature Calibration Form

Logger/Device:

Manufacturer____ _____ model_____

serial number_____

conducted by_____calibration date_____

NIST certified thermometer: manufacturer_____

model_____serial number_____

Time (24 hour clock)	Bath Temperature (^{o}C)	Logger/Device Temperature (^{o}C)	Discrepancy (^{o}C)

APPENDIX F

Calibrated Instantaneous Temperature Measurement Device Metadata Form for Instantaneous Temperature Measurements

Temperature Metadata Sheet

Metadata Sheet: Database Entry:

SITE ID NUMBER: _____

LOCATION INFORMATION (bold fields required)

Waterbody name:

Site description:

USGS cataloging unit:
Waterbody index number:

BURP ID:

Public land survey: township _____, range _____, section _____, _____¼ of the_____¼

County:
Latitude: **N** decimal degrees
Longitude: - **W** decimal degrees
Lat/long source: map GIS GPS

Datum: NAD27 NAD83 Other If other, explain:

If GPS, differential correction: corrected uncorrected unknown

Ecoregion:

Map elevation (meters):

Comments:

Date edited: _____ By: _____
Date QA'd:_____ By: _____
Date Entered: _____ By: _____
Date QC'd: _____ By: _____
DEVICE INFORMATION (bold fields required)

Manufacturer: Model:

Serial number: **Raw data file name:**

Storage file type: ASCII text dtf xls mdb dbf wk4_____
Raw data file location:

Instrument calibrated? Yes No If yes, then calibration factor: 0.____ ^{o}C

Period of record (month and year):
Interval (hours):
Start type: launched in field triggered delayed

Measurement type: single multiple

Value type **(required if multiple measurement type)**: average minimum maximum

Contact name:

STATISTICS
Calibration factor applied to calculation of statistics? **Yes** **No**

Instantaneous maximum: _____ _____ . _____ ^{o}C

Instantaneous minimum: _____ _____ . _____ ^{o}C

Overall mean: _____ _____ . _____ ^{o}C

Mean daily maximum: _____ _____ . _____ ^{o}C

Mean daily average: _____ _____ . _____ ^{o}C

Mean daily minimum: _____ _____ . _____ ^{o}C

Maximum daily average: _____ _____ . _____ ^{o}C

Maximum 7-day maximum: _____ _____ . _____ ^{o}C

Maximum 7-day average: _____ _____ . _____ ^{o}C

Minimum 7-day minimum: _____ _____ . _____ ^{o}C

APPENDIX G

Suggested Field Equipment List for Instantaneous Temperature Measurements

Suggested Field Equipment List

- calibrated thermometer (± 0.7°C)
- calibrated electronic measurement device (± 0.7°C)
- cable clamps
- cable
- steel fence posts
- GPS unit
- pliers
- sledge hammer
- post driver
- camera/film
- waders
- field book
- time piece
- backup batteries
- surveyor's flagging tape
- surveyor's orange paint
- metadata sheets - field forms
- wrenches
- locks
- wire cutters
- wire
- pocket knife
- brush cutting tools
- first aid kit
- maps/aerial photos
- camouflage gauze
- 100 m tape measure
- metal tags
- cable ties
- crimping tool

APPENDIX H

Form for Instantaneous Temperature Measurements

INSTANTANEOUS TEMPERATURE FIELD FORM

Device Measurement____ **TRANSECT: A B C D E F G H I J K**
(circle one)

Waterbody name_____

Date_____ SiteID_____

Plant Operation notes: _____

_____¼, _____¼, Sec. _____, T _____, R _____ Elevation_____ meters

Latitude_____Longitude_____
__

Time_____(24 hour clock)

Permanent landmark
_____

_____
__

Site Sketch

Data Collected

Date(s) _____ Time_____hour

Condition of site/_____

_____

SITE INSTANTANEOUS TEMPERATURE FIELD FORM

Facility Name _____ Waterbody Name_____

Date _____ Start time _____

Ambient temp: _____ **NOTE: Mark placement of heated discharge**

RDB	***Flow*** ↓	***LDB***	***Distance***
_____	_____ _____	**A**	**0**
_____	_____ _____	**B**	**100 meters**
_____	_____ _____	**C**	**200 m**
_____	_____ _____	**D**	**300 m**
_____	_____ _____	**E**	**400 m**
_____	_____ _____	**F**	**500 m**
_____	_____ _____	**G**	**600 m**
_____	_____ _____	**H**	**700 m**
_____	_____ _____	**I**	**800 m**
_____	_____ _____	**J**	**900 m**
_____	_____ _____	**K**	**1000 m**

APPENDIX I

Station Summary Forms

FISH COMMUNITY EVALUATION STATION SUMMARY

LOCATION _____

Waterbody Name _____

Station No. _____ Date: _____ _____ Starting Location: _____

State: _____ County: _____ Township: _____

SAMPLING DESCRIPTION _____

Sampling Type (Circle one): CPUE Mark/Recapture Depletion

Total Station Length (m): _____ Number Passes: _____ Time (military): Start _____ End _____

Type of Pass (Check one): ____Downstream only _____Downstream then Upstream_____ Other

GEAR DESCRIPTION _____

Gear (indicate number of each type) __ Backpack __ Tote Barge __ 12-14 Jon Boat __16+ ft Jon Boat

Number of Anodes per unit _____ Shape _____

For Backpacks and Tote Barges

Anode size (long axis or diameter, m) _____ Anode material thickness (diameter, m): _____

Anode shape: _____

Boat Mounted Electrofishing Units

Number of front droppers (circle one) 1 2 Type (circle one): Electrosphere Wisconsin ring Other ____

Anode Length (m) _____ Anode diameter _____

METER READINGS_____

Type of Electrofishing current (check one): _____ AC _____DC _____ Pulse DC

Electroshocker Control Box Readings: Voltage (V) _____ Amps (A) _____

For Jon Boat Shockers

If Pulsed DC Pulse Rate _____ Duty Cycle (%) _____ Wave Length (indicate letter) _____

For Backpack shockers

Frequency _____ Wave Length _____
COMMENTS/NOTES (Continue on back of sheet if necessary):

APPENDIX J

Examples of Fish Summary Catch Field Sheets

Sample #:		Stream Name:		Site ID:	
Site #:		Site Description:			

EventID	Equipment Used	Voltage	Time At Site (hh:mm)	Time Fished (sec)	Distance Fished (m)	Water Depth (m) Max.	Water Depth (m) Avg.	Museum Data	
								Initials	ID Date

Avg. Stream Width (m)	Voucher Jars	Unknown Jars	Bridge In Reach?	Is Reach Representative?	Why Is Reach Not Representative?	Special Comments	Jar Count	Fish Total
			☐	☐				

Coding for Anomalies:
D – deformities: E – eroded fins: L – lesion: T – tumor: M – multiple DELT anomalies: AW – anchor worm: LE – leeches: SS – swirled scales: PO – popeye: EM – emaciated: FU – fungus: PA – Parasites

Species		Physical Characteristics					Anomalies						
		Weight (g)					D	E	L	T	M	AW	LE
Fish Detail#:		Total	Min	Max	Mean								
Museum Total	Total Fish	Length (mm)			Age (yrs)		SS	PO	EM	FU	PA	Other Anomaly	
		Min	Max	Mean	Min	Max							

Species		Physical Characteristics					Anomalies						
		Weight (g)					D	E	L	T	M	AW	LE
Fish Detail#:		Total	Min	Max	Mean								
Museum Total	Total Fish	Length (mm)			Age (yrs)		SS	PO	EM	FU	PA	Other Anomaly	
		Min	Max	Mean	Min	Max							

Species		Physical Characteristics					Anomalies						
		Weight (g)					D	E	L	T	M	AW	LE
Fish Detail#:		Total	Min	Max	Mean								
Museum Total	Total Fish	Length (mm)			Age (yrs)		SS	PO	EM	FU	PA	Other Anomaly	
		Min	Max	Mean	Min	Max							

Species		Physical Characteristics					Anomalies						
		Weight (g)					D	E	L	T	M	AW	LE
Fish Detail#:		Total	Min	Max	Mean								
Museum Total	Total Fish	Length (mm)			Age (yrs)		SS	PO	EM	FU	PA	Other Anomaly	
		Min	Max	Mean	Min	Max							

Species		Physical Characteristics					Anomalies						
		Weight (g)					D	E	L	T	M	AW	LE
Fish Detail#:		Total	Min	Max	Mean								
Museum Total	Total Fish	Length (mm)			Age (yrs)		SS	PO	EM	FU	PA	Other Anomaly	
		Min	Max	Mean	Min	Max							

Species		Physical Characteristics					Anomalies						
		Weight (g)					D	E	L	T	M	AW	LE
Fish Detail#:		Total	Min	Max	Mean								
Museum Total	Total Fish	Length (mm)			Age (yrs)		SS	PO	EM	FU	PA	Other Anomaly	
		Min	Max	Mean	Min	Max							

Species		Physical Characteristics					Anomalies						
		Weight (g)					D	E	L	T	M	AW	LE
Fish Detail#:		Total	Min	Max	Mean								
Museum Total	Total Fish	Length (mm)			Age (yrs)		SS	PO	EM	FU	PA	Other Anomaly	
		Min	Max	Mean	Min	Max							
Species		Physical Characteristics					Anomalies						
		Weight (g)					D	E	L	T	M	AW	LE
Fish Detail#:		Total	Min	Max	Mean								
Museum Total	Total Fish	Length (mm)			Age (yrs)		SS	PO	EM	FU	PA	Other Anomaly	
		Min	Max	Mean	Min	Max							
Species		Physical Characteristics					Anomalies						
		Weight (g)					D	E	L	T	M	AW	LE
Fish Detail#:		Total	Min	Max	Mean								
Museum Total	Total Fish	Length (mm)			Age (yrs)		SS	PO	EM	FU	PA	Other Anomaly	
		Min	Max	Mean	Min	Max							
Species		Physical Characteristics					Anomalies						
		Weight (g)					D	E	L	T	M	AW	LE
Fish Detail#:		Total	Min	Max	Mean								
Museum Total	Total Fish	Length (mm)			Age (yrs)		SS	PO	EM	FU	PA	Other Anomaly	
		Min	Max	Mean	Min	Max							
Species		Physical Characteristics					Anomalies						
		Weight (g)					D	E	L	T	M	AW	LE
Fish Detail#:		Total	Min	Max	Mean								
Museum Total	Total Fish	Length (mm)			Age (yrs)		SS	PO	EM	FU	PA	Other Anomaly	
		Min	Max	Mean	Min	Max							
Species		Physical Characteristics					Anomalies						
		Weight (g)					D	E	L	T	M	AW	LE
Fish Detail#:		Total	Min	Max	Mean								
Museum Total	Total Fish	Length (mm)			Age (yrs)		SS	PO	EM	FU	PA	Other Anomaly	
		Min	Max	Mean	Min	Max							
Species		Physical Characteristics					Anomalies						
		Weight (g)					D	E	L	T	M	AW	LE
Fish Detail#:		Total	Min	Max	Mean								
Museum Total	Total Fish	Length (mm)			Age (yrs)		SS	PO	EM	FU	PA	Other Anomaly	
		Min	Max	Mean	Min	Max							

CATCH SUMMARY

Date:______________ Time:_____ County:_______________________Collectors:

Waterbody:______________________ Gear Type: BP BT SC

Shore:	RDB		LDB			RDB		LDB					RDB	LDB	
	0 - 100 meters					**100 - 200 meters**					**200 - 300 meters**				
Species/Code	Min	Max	Wt	N	DELTs	Min	Max	Wt	N	DELTs	Min	Max	Wt	N	DELTs

CATCH SUMMARY

Date:______________ Time:_____ County:______________________Collectors:

Waterbody:______________________ Gear Type: BP BT SC

Shore: RDB LDB RDB LDB RDB LDB

	300 - 400 meters					**400 - 500 meters**					**500 - 600 meters**				
Species/Code	Min	Max	Wt	N	DELTs	Min	Max	Wt	N	DELTs	Min	Max	Wt	N	DELTs

CATCH SUMMARY

Date:______________ Time:_____ County:______________________Collectors:

Waterbody:______________________ Gear Type: BP BT SC

Shore: RDB LDB RDB LDB RDB LDB

	600 - 700 meters					700 - 800 meters					800 - 900 meters				
Species/Code	Min	Max	Wt	N	DELTs	Min	Max	Wt	N	DELTs	Min	Max	Wt	N	DELTs

CATCH SUMMARY

Date:______________ Time:_____ County:_______________________Collectors:

Waterbody:______________________ Gear Type: BP BT SC

Shore: RDB LDB RDB LDB RDB LDB

	900 - 1000 meters					meters					meters				
Species/Code	Min	Max	Wt	N	DELTs	Min	Max	Wt	N	DELTs	Min	Max	Wt	N	DELTs

CATCH SUMMARY

Date:______________ Time:_____ County:______________________Collectors:

Waterbody:______________________ Gear Type: BP BT SC

Shore: RDB LDB RDB LDB RDB LDB

	900 - 1000 meters					meters					meters				
Species/Code	Min	Max	Wt	N	DELTs	Min	Max	Wt	N	DELTs	Min	Max	Wt	N	DELTs

APPENDIX K

Fish Species Codes (IDEM taxon ID) for use in Studies of Indiana Waters from IDEM Assessment Information Management System (AIMS).

IDEM/OWQ/Species List of Indiana Fish

(Indexed by Phylogenetic Code)				Author	IDEM Taxon ID	Common name	Range/Abundance/Status/		
05			**CLASS:** Cephalaspidomorphi						
01			**ORDER:** Petromyzontiformes						
001			**FAMILY:** Petromyzontidae						
000	000	*N/A*	*N/A*		221	Ammocoetes			
002	006	*Lampetra*	*appendix*	DeKay	2	American brook lamprey	NW	O	
002	003	*Lampetra*	*aepyptera*		1	least brook lamprey	SW	R	
004	001	*Ichthyomyzon*	*bdellium*	Jordan	4	Ohio lamprey	W,S	R	
004	002	*Ichthyomyzon*	*castaneus*	Girard	5	chestnut lamprey	SW	O	
004	003	*Ichthyomyzon*	*fossor*	Reighard & Cummins	6	northern brook lamprey	NE	R	ST
004	006	*Ichthyomyzon*	*unicuspis*	Hubbs & Trautman	7	silver lamprey	W,S	O	
003	001	*Petromyzon*	*marinus*	Linnaeus	3	sea lamprey	NW,X	O	
07			**CLASS:** Osteichthyes						
05			**ORDER:** Acipenseriformes						
001			**FAMILY:** Acipenseridae						
001	006	*Acipenser*	*fulvescens*	Rafinesque	8	lake sturgeon	W,S	R	SE
002	002	*Scaphirhynchus*	*platorynchus*	Rafinesque	9	shovelnose sturgeon	W,SE	O	
002			**FAMILY:** Polyodontidae						
001	001	*Polyodon*	*spathula*	Walbaum	10	paddlefish	W,SE	O	
06			**ORDER:** Lepisosteiformes						
001			**FAMILY:** Lepisosteidae						

002	001	*Atractosteus*	*spatula*	Lacepede	14	alligator gar	Ex1976		
001	002	*Lepisosteus*	*oculatus*	Winchell	12	spotted gar	NE,SW	O	
001	001	*Lepisosteus*	*osseus*	Linnaeus	11	longnose gar	I	C	
001	003	*Lepisosteus*	*platostomus*	Rafinesque	13	shortnose gar	W,S	O	
07		**ORDER:** Amiiformes							
001		**FAMILY:** Amiidae							
001	001	*Amia*	*calva*	Linnaeus	15	bowfin	N,S	O	
09		**ORDER:** Anguilliformes							
001		**FAMILY:** Anguillidae							
001	001	*Anguilla*	*rostrata*	LeSueur	16	American eel	W,S	R	
11		**ORDER:** Clupeiformes							
002		**FAMILY:** Clupeidae							
001	004	*Alosa*	*alabamae*	Jordan & Evermann	17	Alabama shad	Ex1902		
001	006	*Alosa*	*chrysochloris*	Rafinesque	20	skipjack herring	W,S	C	
001	005	*Alosa*	*pseudoharengus*	Wilson	18	alewife	NW	A	X
005	001	*Dorosoma*	*cepedianum*	LeSueur	19	gizzard shad	I	A	
005	002	*Dorosoma*	*petenense*	Gunther	21	threadfin shad	S	C	X
12		**ORDER:** Osteoglossiformes							
003		**FAMILY:** Hiodontidae							
001	001	*Hiodon*	*alosoides*	Rafinesque	22	goldeye	S	O	
001	002	*Hiodon*	*tergisus*	LeSueur	23	mooneye	W,S	O	
14		**ORDER:** Salmoniformes							
001		**FAMILY:** Salmonidae							
001	008	*Coregonus*	*artedi*	LeSueur	25	cisco or lake herring	NW	R	SC

001	006	*Coregonus*	*clupeaformis*	Mitchill	24	lake whitefish	NW	C	SC
001	009	*Coregonus*	*hoyi*	Milner	26	bloater	NW	R	
001	800	*Coregonus*	*kiyi*	Koelz	223	kiyi	NW	R	
001	012	*Coregonus*	*nigripinnis*	Gill	27	blackfin cisco	Ex		
001	013	*Coregonus*	*reighardi*	Koelz	28	shortnose cisco	Ex1972		
001	014	*Coregonus*	*zenithicus*	Jordan & Evermann	29	shortjaw cisco	NW	R	
002	003	*Oncorhynchus*	*kisutch*	Walbaum	30	coho salmon	NW	C	X
002	011	*Oncorhynchus*	*mykiss*	Walbaum	32	rainbow trout	N	C	X
002	011	*Oncorhynchus*	*mykiss*	Walbaum	227	Steelhead	N,X	C	
002	006	*Oncorhynchus*	*tshawytscha*	Walbaum	31	chinook salmon	NW	C	X
003	005	*Salmo*	*salar*	Linnaeus	33	Atlantic salmon	NW	O	X
003	006	*Salmo*	*trutta*	Linnaeus	34	brown trout	N	C	X
004	004	*Salvelinus*	*fontinalis*	Mitchill	36	brook trout	NW	R	
004	003	*Salvelinus*	*namaycush*	Walbaum	35	lake trout	NW	O	
003		**FAMILY:** Osmeridae							
003	002	*Osmerus*	*mordax*	Mitchill	37	rainbow smelt	NW	C	X
011		**FAMILY:** Esocidae							
001	002	*Esox*	*americanus*	Gmelin	39	grass pickerel	I	C	
001	001	*Esox*	*lucius*	Linnaeus	38	northern pike	N	O	
001	900	*Esox*	*lucius x masquinongy*		208	tiger muskie	NC		
001	004	*Esox*	*masquinongy*	Mitchill	41	Lake Michigans muskellunge	Ex1910		
001	004	*Esox*	*ohioensis*	Mitchill	40	Ohio River muskellunge	S	R	SC
012		**FAMILY:** Umbridae							
001	002	*Umbra*	*limi*	Kirtland	42	central mudminnow	N	A	

18 **ORDER:** Cypriniformes

021		**FAMILY:** Cyprinidae							
014	001	*Campostoma*	*anomalum*	Rafinesque	77	central stoneroller	I	A	
014	002	*Campostoma*	*oligolepis*	Hubbs & Greene	78	largescale stoneroller	N	A	
003	001	*Carassius*	*auratus*	Linnaeus	44	goldfish	I	C	X
003	900	*Carassius*	*auratusxcarpio*	Linnaeus	224	goldfish x carp	I,X		
007	002	*Clinostomus*	*elongatus*	Kirtland	50	redside dace	E	R	SE
022	001	*Couesius*	*plumbeus*	Agassiz	82	lake chub	NW	R	
023	001	*Ctenopharyngodon*	*idella*	Valenciennes	83	grass carp	NW,C	O	X
076	014	*Cyprinella*	*lutrensis*	Baird & Girard	87	red shiner	NW	C	X
076	019	*Cyprinella*	*spiloptera*	Cope	88	spotfin shiner	I	A	
076	022	*Cyprinella*	*whipplei*	Girard	89	steelcolor shiner	C,S	C	
001	001	*Cyprinus*	*carpio*	Linnaeus	43	carp	I	A	X
011	111	*Ericymba*	*buccata*	Cope	73	silverjaw minnow	I	C	
077	002	*Erimystax*	*dissimilis*	Kirtland	90	streamline chub	NW	R	
077	005	*Erimystax*	*x-punctatus*	Hubbs & Crowe	91	gravel chub	W	R	
005	005	*Hybognathus*	*hankinsoni*	Hubbs	47	brassy minnow	NW	H	
005	006	*Hybognathus*	*hayi*	Jordan	48	cypress minnow	SW	R	
005	002	*Hybognathus*	*nuchalis*	Agassiz	46	Mississippi silvery minnow	SC,SW	C	
012	001	*Hybopsis*	*amblops*	Rafinesque	74	bigeye chub	NW	C	
012	011	*Hybopsis*	*amnis*	Hubbs & Greene	75	pallid shiner	W	R	SE
056	001	*Hypophthalmichthys molitrix*		Valenciennes	86	silver carp	SE,SW	R	X
056	800	*Hypophthalmichthys nobilis*		Richardson	214	bighead carp	SW	O	X
078	004	*Luxilus*	*chrysocephalus*	Rafinesque	92	striped shiner	I	A	
078	006	*Luxilus*	*cornutus*	Mitchill	93	common shiner	N	O	
079	001	*Lythrurus*	*fasciolaris*	Gilbert	94	scarletfin shiner	SE	C	
079	004	*Lythrurus*	*fumeus*	Evermann	95	ribbon shiner	SW	R	
079	008	*Lythrurus*	*umbratilis*	Girard	96	redfin shiner	W,C	C	
080	001	*Macrhybopsis*	*hyostoma*	Girard	99	shoal chub	W,S	O	
080	004	*Macrhybopsis*	*storeriana*	Kirtland	97	silver chub	W	C	
800	800	*Mylopharyngodon*	*piceus*		213	black carp	S	H	X
000	000	*N/A*	*N / A*		226	Cyprinidae hybrid			
010	004	*Nocomis*	*biguttatus*	Kirtland	55	hornyhead chub	N	C	

010	001	*Nocomis*	*micropogon*	Cope	54	river chub	NE,C	C	
006	001	*Notemigonus*	*crysoleucus*	Mitchill	49	golden shiner	I	C	
011	032	*Notropis*	*anogenus*	Forbes	65	pugnose shiner	Ex1945		
011	034	*Notropis*	*ariommus*	Cope	66	popeye shiner	Ex1894		
011	012	*Notropis*	*atherinoides*	Rafinesque	59	emerald shiner	I	A	
011	040	*Notropis*	*blennius*	Girard	67	river shiner	W,S	C	
011	041	*Notropis*	*boops*	Gilbert	68	bigeye shiner	C	C	
011	014	*Notropis*	*buchanani*	Meek	60	ghost shiner	NW,S	O	
011	004	*Notropis*	*chalybaeus*	Cope	56	ironcolor shiner	NW	O	
011	058	*Notropis*	*dorsalis*	Agassiz	69	bigmouth shiner	NW	R	SC
011	067	*Notropis*	*heterodon*	Cope	70	blackchin shiner	N	R	
011	068	*Notropis*	*heterolepis*	Eigenmann & Eigenm	71	blacknose shiner	N	R	
011	006	*Notropis*	*hudsonius*	Clinton	57	spottail shiner	NW	A	
011	086	*Notropis*	*photogenis*	Cope	72	silver shiner	C,SE	O	
011	008	*Notropis*	*rubellus*	Agassiz	58	rosyface shiner	N,C	C	
011	021	*Notropis*	*shumardi*	Girard	61	silverband shiner	SW	C	
011	023	*Notropis*	*stramineus*	Girard	62	sand shiner	I	A	
011	024	*Notropis*	*texanus*	Girard	63	weed shiner	NW	R	
011	027	*Notropis*	*volucellus*	Cope	64	mimic shiner	E,C,S	O	
011	119	*Notropis*	*wickliffi*	Trautman	207	channel shiner	S	C	
013	900	*Notropis Sp.*	*N / A*		225	Lythrurus X Notropis hybrid	C	R	
082	001	*Opsopoeodus*	*emiliae*	Hay	98	pugnose minnow	N,SW	R	SC
013	001	*Phenacobius*	*mirabilis*	Girard	76	suckermouth minnow	C,S	C	
037	003	*Phoxinus*	*erythrogaster*	Rafinesque	84	southern redbelly dace	NW,C	O	
016	001	*Pimephales*	*notatus*	Rafinesque	79	bluntnose minnow	I	A	
016	002	*Pimephales*	*promelas*	Rafinesque	80	fathead minnow	N,SE	C	
016	003	*Pimephales*	*vigilax*	Baird & Girard	81	bullhead minnow	W,S	O	
009	001	*Rhinichthys*	*atratulus*	Hermann	52	blacknose dace	NW,C,SE	C	
009	002	*Rhinichthys*	*cataractae*	Valenciennes	53	longnose dace	N	O	SC
042	001	*Scardinius*	*erythrophthalmus*	Linnaeus	85	rudd	NW	R	X
008	002	*Semotilus*	*atromaculatus*	Mitchill	51	creek chub	I	A	

024		**FAMILY:** Catostomidae								
002	002	*Carpiodes*	*carpio*	Rafinesque	103	river carpsucker	W,S	C		
002	001	*Carpiodes*	*cyprinus*	LeSueur	102	quillback	I	C		
002	003	*Carpiodes*	*velifer*	Rafinesque	104	highfin carpsucker	W,S	O		
001	001	*Catostomus*	*catostomus*	Forster	100	longnose sucker	NW	R		SC
001	002	*Catostomus*	*commersoni*	Lacepede	101	white sucker	I	A		
006	001	*Cycleptus*	*elongatus*	Lesueur	114	blue sucker	C,S	O		FC
003	002	*Erimyzon*	*oblongus*	Mitchill	106	creek chubsucker	NW,C,SW	O		
003	001	*Erimyzon*	*sucetta*	Lacepede	105	lake chubsucker	N	O		
005	001	*Hypentelium*	*nigricans*	LeSueur	113	northern hogsucker	N,C	C		
007	001	*Ictiobus*	*bubalus*	Rafinesque	115	smallmouth buffalo	W,S	C		
007	002	*Ictiobus*	*cyprinellus*	Valenciennes	116	bigmouth buffalo	W,S	O		
007	003	*Ictiobus*	*niger*	Rafinesque	117	black buffalo	NW,S	R		
010	001	*Lagochila*	*lacera*	Jordan & Brayton	119	harelip sucker	Ex1893			
008	001	*Minytrema*	*melanops*	Rafinesque	118	spotted sucker	NE,C	C		
004	004	*Moxostoma*	*anisurum*	Rafinesque	108	silver redhorse	N,C	C		
004	007	*Moxostoma*	*carinatum*	Cope	109	river redhorse	C	O		
004	009	*Moxostoma*	*duquesnei*	LeSueur	110	black redhorse	C	C		
004	010	*Moxostoma*	*erythrurum*	Rafinesque	111	golden redhorse	I	A		
004	001	*Moxostoma*	*m. breviceps*		218	Ohio redhorse	S	O		
004	001	*Moxostoma*	*macrolepidotum*	LeSueur	107	shorthead redhorse	I	A		
004	018	*Moxostoma*	*valenciennesi*	Jordan	112	greater redhorse	N	R		SE
026		**FAMILY:** Cobitidae								
001	001	*Misgurnus*	*anguillicaudatus*	Cantor	230	oriental weatherfish	NW			X
19		**ORDER:** Siluriformes								
002		**FAMILY:** Ictaluridae								
006	002	*Ameiurus*	*catus*	Linnaeus	130	white catfish	S	O		X
006	003	*Ameiurus*	*melas*	Rafinesque	131	black bullhead	I	A		
006	004	*Ameiurus*	*natalis*	LeSueur	132	yellow bullhead	I	A		

006	005	*Ameiurus*	*nebulosus*	LeSueur	133	brown bullhead	S	C	
001	002	*Ictalurus*	*furcatus*	LeSueur	120	blue catfish	S	O	
001	005	*Ictalurus*	*punctatus*	Rafinesque	121	channel catfish	I	C	
002	007	*Noturus*	*eleutherus*	Jordan	124	mountain madtom	W,C	O	
002	008	*Noturus*	*exilis*	Nelson	125	slender madtom	C	H	
002	011	*Noturus*	*flavus*	Rafinesque	126	stonecat	I	C	
002	001	*Noturus*	*gyrinus*	Mitchill	122	tadpole madtom	I	C	
002	018	*Noturus*	*miurus*	Jordan	127	brindled madtom	C	O	
002	003	*Noturus*	*nocturnus*	Jordan & Gilbert	123	freckled madtom	W	O	
002	023	*Noturus*	*stigmosus*	Taylor	128	northern madtom	W,C	R	SC
003	001	*Pylodictus*	*olivaris*	Rafinesque	129	flathead catfish	I	C	
20		**ORDER:** Percopsiformes							
003		**FAMILY:** Percopsidae							
001	001	*Percopsis*	*omiscomaycus*	Walbaum	137	trout-perch	NW,S	R	SC
24		**ORDER:** Gadiformes							
013		**FAMILY:** Lotidae							
007	001	*Lota*	*lota*	Linnaeus	138	burbot	NW,WE	O	
25		**ORDER:** Atheriniformes							
013		**FAMILY:** Atherinidae							
008	001	*Labidesthes*	*sicculus*	Cope	145	brook silverside	I	C	
003	001	*Menidia*	*beryllina*	Cope	219	inland silverside	S	R	X
30		**ORDER:** Gasterosteiformes							
001		**FAMILY:** Gasterosteidae							
004	001	*Culaea*	*inconstans*	Kirtland	147	brook stickleback	N,SE		

001	001	*Gasterosteus*	*aculeatus*	Linnaeus	220	threespine stickleback	NW	O	X	
002	001	*Pungitius*	*pungitius*	Linnaeus	146	ninespine stickleback	NW	O		
33		**ORDER:** Scorpaeniformes								
014		**FAMILY:** Cottidae								
008	007	*Cottus*	*bairdi*	Girard	149	mottled sculpin	I	C		
008	009	*Cottus*	*carolinae*	Gill	150	banded sculpin	SC	O		
008	002	*Cottus*	*cognatus*	Richardson	148	slimy sculpin	NW	R		
008	023	*Cottus*	*ricei*	Nelson	151	spoonhead sculpin	N	H		
019	012	*Myoxocephalus*	*thompsoni*	Girard	152	deepwater sculpin	NW	R		
36		**ORDER:** Perciformes								
002		**FAMILY:** Moronidae								
001	001	*Morone*	*americana*	Gmelin	217	white perch	NW	R		X
001	004	*Morone*	*chrysops*	Rafinesque	154	white bass	W	C		
001	900	*Morone*	*chrysopsxsaxatilis*		209	wiper	S			
001	005	*Morone*	*mississippiensis*	Jordan & Eigenmann	155	yellow bass	W,S	O		
001	002	*Morone*	*saxatilis*	Walbaum	153	striped bass	S	O		X
016		**FAMILY:** Centrarchidae								
002	001	*Ambloplites*	*rupestris*	Rafinesque	156	rock bass	I	C		
003	001	*Centrarchus*	*macropterus*	Lacepede	157	flier	SW	O		
005	002	*Lepomis*	*cyanellus*	Rafinesque	158	green sunfish	I	A		
005	005	*Lepomis*	*gibbosus*	Linnaeus	161	pumpkinseed	I	C		
005	003	*Lepomis*	*gulosus*	Cuvier	159	warmouth	N	C		
005	006	*Lepomis*	*humilis*	Girard	162	orangespotted sunfish	N	O		
005	004	*Lepomis*	*macrochirus*	Rafinesque	160	bluegill	I	A		
005	008	*Lepomis*	*megalotis*	Rafinesque	163	longear sunfish	I	A		
005	009	*Lepomis*	*microlophus*	Gunther	164	redear sunfish	N,S	C		
005	010	*Lepomis*	*miniatus*	Jordan	165	redspotted sunfish	SW	R		

005	011	*Lepomis*	*symmetricus*	Forbes	166	bantam sunfish	W	R		SE
005	900	*Lepomis*	*x-hybrid*		211	hybrid sunfish				
006	001	*Micropterus*	*dolomieu*	Lacepede	167	smallmouth bass	I	A		
006	003	*Micropterus*	*punctulatus*	Rafinesque	169	spotted bass	S	A		
006	002	*Micropterus*	*salmoides*	Lacepede	168	largemouth bass	I	A		
007	001	*Pomoxis*	*annularis*	Rafinesque	170	white crappie	I	C		
007	002	*Pomoxis*	*nigromaculatus*	LeSueur	171	black crappie	I	C		
020		**FAMILY:** Percidae								
005	004	*Ammocrypta*	*clara*	Jordan & Meek	202	western sand darter	NW,S	O		
005	006	*Ammocrypta*	*pellucida*	Agassiz	203	eastern sand darter	C,SW	O	FC	
007	001	*Crystallaria*	*asprella*	Jordan	204	crystal darter	Ex1895			
001	013	*Etheostoma*	*asprigene*	Forbes	176	mud darter	S	C		
001	017	*Etheostoma*	*blennioides*	Rafinesque	177	greenside darter	C,E	C		
001	020	*Etheostoma*	*caeruleum*	Storer	178	rainbow darter	N,C	C		
001	021	*Etheostoma*	*camurum*	Cope	179	bluebreast darter	C	R		
001	006	*Etheostoma*	*chlorosoma*	Hay	172	bluntnose darter	W	R		
001	034	*Etheostoma*	*exile*	Girard	180	Iowa darter	N	O		
001	035	*Etheostoma*	*flabellare*	Rafinesque	181	fantail darter	E,C	C		
001	007	*Etheostoma*	*gracile*	Girard	173	slough darter	SW	O		
001	039	*Etheostoma*	*histrio*	Jordan & Gilbert	182	harlequin darter	S	R		
001	049	*Etheostoma*	*maculatum*	Kirtland	184	spotted darter	C	R		SC
001	052	*Etheostoma*	*microperca*	Jordan & Gilbert	185	least darter	N	C		
001	010	*Etheostoma*	*nigrum*	Rafinesque	175	johnny darter	I	A		
001	065	*Etheostoma*	*proeliare*	Hay	228	cypress darter	SW	R		SC
001	009	*Etheostoma*	*spectabile*	Agassiz	174	orangethroat darter	C	A		
001	900	*Etheostoma*	*spectabilexcaeruleum*		222	orangethroat rainbow hybrid				
001	075	*Etheostoma*	*squamiceps*	Jordan	186	spottail darter	SW	R		
001	082	*Etheostoma*	*tippecanoe*	Jordan & Evermann	187	Tippecanoe darter	C	R		SC
001	085	*Etheostoma*	*variatum*	Kirtland	188	variegate darter	SE	R		SE
001	088	*Etheostoma*	*zonale*	Cope	189	banded darter	NW,SE	C		
006	001	*Gymnocephalus*	*cernuus*	Linnaeus	212	ruffe		H		

002	001	*Perca*	*flavescens*	Mitchill	190	yellow perch	N	C		
003	001	*Percina*	*caprodes*	Rafinesque	191	logperch	I	C		
003	009	*Percina*	*copelandi*	Jordan	201	channel darter	C	R		SE
003	012	*Percina*	*evides*	Jordan & Copeland	193	gilt darter	C	O		SE
003	017	*Percina*	*maculata*	Girard	194	blackside darter	I	C		
003	024	*Percina*	*phoxocephala*	Nelson	195	slenderhead darter	C	C		
003	004	*Percina*	*sciera*	Swain	192	dusky darter	C	C		
003	027	*Percina*	*shumardi*	Girard	196	river darter	C,S	O		
003	030	*Percina*	*uranidea*	Jordan & Gilbert	197	stargazing darter	Ex1920			
003	033	*Percina*	*vigil*	Hay	198	saddleback darter	SW	R		
004	002	*Sander*	*canadense*	Griffith & Smith	200	sauger	W,S	C		
004	900	*Sander*	*canadense x vitreus*		210	saugeye	S			
004	001	*Sander*	*vitreus*	Mitchill	199	walleye	I	C		
044		**FAMILY:** Sciaenidae								
026	001	*Aplodinotus*	*grunniens*	Rafinesque	205	freshwater drum	I	C		
118		**FAMILY:** Gobiidae								
003	001	*Neogobius*	*melanostomus*	Pallas	215	round goby	NW	A		X
001	005	*Proterorhinus*	*marmoratus*		216	tube nose goby	N	H		
146		**FAMILY:** Elassomatidae								
001	001	*Elassoma*	*zonatum*	Jordan	206	banded pygmy sunfish	SW	R		SC
39		**ORDER:** Aphredoderiformes								
001		**FAMILY:** Amblyopsidae								
002	002	*Amblyopsis*	*spelaea*	DeKay	134	northern cavefish	S	R	FC	SE
004	001	*Typhilchthys*	*subterraneus*	Girard	135	southern cavefish	S	R		SE
002		**FAMILY:** Apherododeridae								
001	001	*Aphredoderus*	*sayanus*	Gilliams	136	pirate perch	N,SW	C		

40		**ORDER:** Cyprinodoniformes							
007		**FAMILY:** Fundulidae							
002	016	*Fundulus*	*catenatus*	Storer	141	northern studfish	C	C	
002	002	*Fundulus*	*diaphanus*	LeSueur	139	banded killifish	N	C	
002	028	*Fundulus*	*dispar*	Agassiz	143	northern starhead topminnow	NW	C	
002	019	*Fundulus*	*notatus*	Rafinesque	142	blackstripe topminnow	I	A	
002	011	*Fundulus*	*olivaceus*	Storer	140	blackspotted topminnow	W,NE	R	
011		**FAMILY:** Poeciliidae							
001	001	*Gambusia*	*affinis*	Baird & Girard	144	western mosquitofish	W	O	
41		**ORDER:** Mugiliformes							
	072	**FAMILY:** Mugilidae							
001	001	*Mugil*	*cephalus*	Linnaeus	229	striped mullet	S	R	X

Range Distribution Code, I=Statewide, N=North, S=South, W=West, E= East, NW=Northwest, NE= Northeast,SW=Southwest, SE=Southeast, C=Central, X=Exotic, Ex=Extirpated.
Abundance Code, A=Abundant, C=Common, H=State Hypothetical, O=Occasional, R=Rare.
Federal Status, FE=Endangered, FT=Threatened, FC=Candidate.
State Status, SE=Endangered, ST=Threatened, SC=Special Concern

IDEM_TAXON_RID	Common Name	Large River Species	Large River Tolerant	IBI Trophic Guild	RND_BODY_SUCKER_IND	IBI Sensitivity	Reproductive Guild	Headwater Species	Origin	Hybrid	Cool/Cold	Pioneer Species	BENTHIC_INSECTIVORE_I	LAKE_HABITAT_SPECIES_IND	OHIO_RIVER_IND	MISSISSIPPI_IND	GREAT_LAKES_IND	OBLIGATE_GL_SPECIES_I	Lake Tolerance	Trophic Class Lake	Tertiary Reproductive Guild
1	least brook lamprey	N			N	SI	N	Y		N	CL	N	N	N	N	N	N	N			
2	American brook lamprey	N			N	SI	N	Y		N	CL	N	N	N	N	N	Y	N	R	D	Lithophils
3	sea lamprey	N			N		N	N	N	N		N	N	N	N	N	Y	N			Lithophils
4	Ohio lamprey	N			N	S	N	N		N		N	N	N	N	N	N	N			
5	chestnut lamprey	Y		C	N		N	N		N		N	N	N	N	N	Y	N			Lithophils
6	northern brook lamprey	N			N	S	N	N		N	CL	N	N	N	N	N	Y	N	S	D	Lithophils
7	silver lamprey	Y		C	N		N	N		N		N	N	N	N	N	Y	N			Lithophils
8	lake sturgeon	Y		V	N		S	N		N		N	Y	N	N	N	Y	Y		I	
9	shovelnose sturgeon	Y		V	N		S	N		N		N	N	N	N	N	N	N		I	
10	paddlefish	Y			N	SI	S	N		N		N	N	N	N	N	Y	N	S		
11	longnose gar	N		C	N	T	M	N		N		N	N	N	N	N	Y	N		C	
12	spotted gar	N		C	N		M	N		N		N	N	N	N	N	Y	N			Phytophils
13	shortnose gar	Y		C	N	T	M	N		N		N	N	N	N	N	Y	N		C	Phytophils
14	alligator gar	Y		C	N		M	N		N		N	N	N	N	N	N	N		C	
15	bow fin	N		C	N		C	N		N		N	N	N	N	N	Y	N		C	Phytophils
16	American eel	Y		C	N		-	N		N		N	N	N	N	N	Y	N	T	C	
17	Alabama shad	N			N		N	N		N		N	N	N	N	N	N	N			
18	alew ife	N			N		M	N	N	N		N	N	N	N	N	Y	N			
19	gizzard shad	N		O	N	T	M	N		N		N	N	N	N	N	Y	N			
20	skipjack herring	Y		C	N		M	N		N		N	N	N	N	N	Y	N			
21	threadfin shad	Y		O	N		M	N		N		N	N	N	N	N	N	N			
22	goldeye	Y		V	N	SI	M	N		N		N	N	N	N	N	N	N		I	
23	mooneye	Y		V	N	SI	M	N		N		N	N	N	N	N	Y	N		I	
24	lake w hitefish	N		V	N		M	N		N	CD	N	N	N	N	N	Y	Y		I	
25	cisco	N			N		M	N		N	CD	N	N	N	N	N	Y	Y			
26	bloater	N			N		M	N		N	CD	N	N	Y	N	N	Y	Y			

IDEM_TAXON_RID	Common Name	Large River Species	Large River Tolerant	IBI Trophic Guild	RND_BODY_SUCKER_IND	IBI Sensitivity	Reproductive Guild	Headwater Species	Origin	Hybrid	Cool/Cold	Pioneer Species	BENTHIC_INSECTIVORE_I	LAKE_HABITAT_SPECIES_IND	OHIO_RIVER_IND	MISSISSIPPI_IND	GREAT_LAKES_IND	OBLIGATE_GL_SPECIES_I	Lake Tolerance	Trophic Class Lake	Tertiary Reproductive Guild
27	blackfin cisco	N			N		N	N		N	CD	N	N	N	N	N	Y	Y			
28	shortnose cisco	N			N		N	N		N	CD	N	N	N	N	N	Y	Y			
29	shortjaw cisco	N			N		M	N		N	CD	N	N	N	N	N	Y	Y			
30	coho salmon	N		V	N		N	N	N	N	CD	N	N	Y	N	N	Y	N		C	Lithophils
31	chinook salmon	N		V	N		N	N	N	N	CD	N	N	Y	N	N	Y	N		C	Lithophils
32	rainbow trout	N		V	N		N	N	N	N	CD	N	N	Y	N	N	Y	N		C	Lithophils
33	Atlantic salmon	N		V	N		N	N	N	N	CD	N	N	N	N	N	Y	N			Lithophils
34	brow n trout	N		V	N		N	N	E	N	CD	N	N	Y	N	N	Y	N		C	Lithophils
35	lake trout	N			N		N	N		N	CD	N	N	Y	N	N	Y	Y		C	Lithophils
36	brook trout	N		V	N		N	N		N	CD	N	N	Y	N	N	Y	N		C	Lithophils
37	rainbow smelt	N		V	N		M	N	N	N		N	N	Y	N	N	Y	N		C	
38	northern pike	N		C	N		M	N		N	CL	N	N	Y	N	N	Y	N		C	Phytophils
39	grass pickerel	N		C	N		M	N		N	CL	N	N	Y	N	N	Y	N	P	C	Phytophils
40	Ohio River muskellunge	N			N		M	N		N		N	N	Y	N	N	N	N		C	
41	Great Lakes muskellunge	N			N		M	N		N	CL	N	N	Y	N	N	Y	N			Phytophils
42	central mudminnow	N	T	V	N	T	C	N		N	CL	N	Y	N	N	N	Y	N		I	Phytophils
43	common carp	N	T	D	N	T	M	N	E	N		N	N	N	N	N	Y	N		D	
44	goldfish	N	T	V	N	T	M	N	E	N		N	Y	N	N	N	Y	N		I	Phytophils
46	Mississippi silvery minnow	Y		D	N		S	N		N		N	N	N	N	N	N	N			
47	brassy minnow	N		O	N		-	N		N		N	N	N	N	N	Y	N			Phytophils
48	cypress minnow	N		O	N		S	N		N		N	N	N	N	N	N	N			
49	golden shiner	N	T	V	N	T	M	N		N		N	Y	N	N	N	Y	N		I	Phytophils
50	redside dace	N		V	N	S	S	Y		N	CL	N	N	N	N	N	Y	N		I	Lithophils
51	creek chub	N	T		N	T	N	N		N	CL	Y	Y	N	N	N	Y	N		I	Lithophils
52	w estern blacknose dace	N	T	V	N	T	S	Y		N	CL	N	Y	Y	N	N	Y	N		I	

IDEM_TAXON_RID	Common Name	Large River Species	Large River Tolerant	IBI Trophic Guild	RND_BODY_SUCKER_IND	IBI Sensitivity	Reproductive Guild	Headwater Species	Origin	Hybrid	Cool/Cold	Pioneer Species	BENTHIC_INSECTIVORE_I	LAKE_HABITAT_SPECIES_IND	OHIO_RIVER_IND	MISSISSIPPI_IND	GREAT_LAKES_IND	OBLIGATE_GL_SPECIES_I	Lake Tolerance	Trophic Class Lake	Tertiary Reproductive Guild
53	longnose dace	N		V	N	S	S	N		N	CL	N	Y	Y	N	N	Y	N	R	I	
54	river chub	Y		V	N	SI	N	N		N		N	N	N	N	N	Y	N	I	I	Lithophils
55	hornyhead chub	N		V	N	SI	N	N		N		N	Y	N	N	N	Y	N	I	I	Lithophils
56	ironcolor shiner	N		V	N	S	M	N		N		N	N	N	N	N	Y	N		I	
57	spottail shiner	Y		V	N		M	N		N		N	Y	N	N	N	Y	N	P	I	
58	rosyface shiner	N		V	N	SI	S	N		N		N	Y	N	N	N	Y	N	I	I	Lithophils
59	emerald shiner	Y		I	N			N		N		N	N	Y	N	N	Y	N		I	
60	ghost shiner	N		I	N		M	N		N		N	N	N	N	N	Y	N		I	
61	silverband shiner	Y		I	N	SI	S	N		N		N	N	N	N	N	N	N		I	
62	sand shiner	N		V	N	S	M	N		N		N	Y	Y	N	N	Y	N		I	Phytophils
63	weed shiner	N		D	N	S	M	N		N		N	N	N	N	N	Y	N		I	
64	mimic shiner	Y		V	N	SI	M	N		N		N	Y	N	N	N	Y	N	I	I	Phytophils
65	pugnose shiner	N		D	N	S	M	N		N		N	N	N	N	N	Y	N	S	I	
66	popeye shiner	N			N	S	S	N		N		N	N	N	N	N	Y	N		I	
67	river shiner	Y		V	N		S	N		N		N	N	N	N	N	Y	N		I	
68	bigeye shiner	N		V	N	SI	S	N		N		N	N	N	N	N	Y	N		I	
69	bigmouth shiner	N			N		M	N		N		N	N	N	N	N	Y	N		I	
70	blackchin shiner	N		V	N	S	M	N		N		N	Y	N	N	N	Y	N	R	I	Phytophils
71	blacknose shiner	N		V	N	S	M	N		N		N	Y	N	N	N	Y	N	S	I	Phytophils
72	silver shiner	N		V	N	SI	S	N		N		N	N	N	N	N	Y	N		I	
73	silverjaw minnow	N		V	N		M	N		N		Y	N	N	N	N	Y	N		I	
74	bigeye chub	N		V	N	SI	S	N		N		N	N	N	N	N	Y	N		I	
75	pallid shiner	N			N	S	S	N		N		N	N	N	N	N	N	N			
76	suckermouth minnow	N		V	N		S	N		N		N	N	N	N	N	Y	N		I	
77	central stoneroller	N			N		N	N		N		Y	N	N	N	N	Y	N			Lithophils
78	largescale stoneroller	N			N		N	N		N		Y	N	N	N	N	Y	N			Lithophils

IDEM_TAXON_RID	Common Name	Large River Species	Large River Tolerant	IBI Trophic Guild	RND_BODY_SUCKER_IND	IBI Sensitivity	Reproductive Guild	Headwater Species	Origin	Hybrid	Cool/Cold	Pioneer Species	BENTHIC_INSECTIVORE_I	LAKE_HABITAT_SPECIES_IND	OHIO_RIVER_IND	MISSISSIPPI_IND	GREAT_LAKES_IND	OBLIGATE_GL_SPECIES_I	Lake Tolerance	Trophic Class Lake	Tertiary Reproductive Guild
79	bluntnose minnow	N	T	D	N	T	C	N		N		Y	N	N	N	N	Y	N		D	
80	fathead minnow	N	T	D	N	T	C	N		N		Y	N	N	N	N	Y	N		D	
81	bullhead minnow	Y		V	N		C	N		N		N	Y	N	N	N	N	N		I	
82	lake chub	N		V	N		S	N		N	CL	N	Y	N	N	N	Y	N		I	
83	grass carp	N	T	O	N	T	M	N	E	N		N	N	N	N	N	Y	N			
84	southern redbelly dace	N			N		S	Y		N	CL	N	N	N	N	N	Y	N			
85	rudd	N		O	N		M	N	E	N		N	N	N	N	N	Y	N	T		
86	silver carp	Y	T		N	T	M	N	E	N		N	N	N	N	N	N	N		H	
87	red shiner	N		V	N	T	N	N	N	N		N	N	N	N	N	N	N		I	
88	spotfin shiner	N		V	N		M	N		N		N	Y	Y	N	N	Y	N		I	
89	steelcolor shiner	N		V	N		M	N		N		N	N	N	N	N	N	N		I	
90	streamline chub	Y		I	N	SI	S	N		N		N	N	N	N	N	N	N		I	
91	gravel chub	Y		I	N	SI	S	N		N		N	N	N	N	N	Y	N		I	Lithophils
92	striped shiner	N		V	N		S	N		N		N	N	N	N	N	Y	N		I	
93	common shiner	N		V	N		S	N		N		N	Y	N	N	N	Y	N		I	Lithophils
94	scarlet shiner	N			N		S	N		N		N	N	N	N	N	N	N			
95	ribbon shiner	N		I	N		M	N		N		N	N	N	N	N	N	N		I	
96	redfin shiner	N		I	N		N	N		N		N	N	N	N	N	Y	N		I	
97	silver chub	Y		V	N		M	N		N		N	N	N	N	N	Y	N		I	
98	pugnose minnow	N		D	N	S	M	N		N		N	N	N	N	N	Y	N		I	
99	shoal chub	Y		V	N	S	M	N		N		N	Y	N	N	N	N	N		I	
100	longnose sucker	N		V	N		S	N		N	CD	N	Y	Y	N	N	Y	Y		I	
101	white sucker	N	T	D	N	T	S	N		N	CL	N	N	N	N	N	Y	N		D	
102	quillback	N		D	N	T	M	N		N		N	N	N	N	N	Y	N		D	
103	river carpsucker	N		D	N	T	M	N		N		N	N	N	N	N	Y	N		D	
104	highfin carpsucker	N		D	N	SI	M	N		N		N	N	N	N	N	Y	N			

IDEM_TAXON_RID	Common Name	Large River Species	Large River Tolerant	IBI Trophic Guild	RND_BODY_SUCKER_IND	IBI Sensitivity	Reproductive Guild	Headwater Species	Origin	Hybrid	Cool/Cold	Pioneer Species	BENTHIC_INSECTIVORE_I	LAKE_HABITAT_SPECIES_IND	OHIO_RIVER_IND	MISSISSIPPI_IND	GREAT_LAKES_IND	OBLIGATE_GL_SPECIES_I	Lake Tolerance	Trophic Class Lake	Tertiary Reproductive Guild
105	lake chubsucker	N		V	Y		M	N		N		Y	Y	Y	N	N	Y	N		I	
106	creek chubsucker	N		V	Y		M	N		N		Y	Y	N	N	N	Y	N		I	
107	shorthead redhorse	N		V	Y	SI	S	N		N	CL	N	Y	Y	N	N	Y	N		I	Lithophils
108	silver redhorse	N		V	Y	SI	S	N		N	CL	N	Y	Y	N	N	Y	N		I	Lithophils
109	river redhorse	N		V	Y	SI	S	N		N	CL	N	Y	Y	N	N	Y	N		I	Lithophils
110	black redhorse	N		V	Y	SI	S	N		N	CL	N	Y	Y	N	N	Y	N		I	Lithophils
111	golden redhorse	N		V	Y	SI	S	N		N	CL	N	Y	Y	N	N	Y	N		I	Lithophils
112	greater redhorse	N		V	Y	S	S	N		N	CL	N	Y	Y	N	N	Y	N	R	I	Lithophils
113	northern hog sucker	N		V	Y	SI	S	N		N		N	Y	N	N	N	Y	N		I	Lithophils
114	blue sucker	Y		V	Y	SI	S	N		N		N	N	N	N	N	N	N		I	
115	smallmouth buffalo	Y		V	N	T	M	N		N		N	N	N	N	N	Y	N		I	
116	bigmouth buffalo	Y		V	N	T	M	N		N		N	N	N	N	N	Y	N		I	
117	black buffalo	Y		O	N		M	N		N		N	N	N	N	N	Y	N		I	
118	spotted sucker	N		V	Y		S	N		N		N	Y	N	N	N	Y	N		I	
119	harelip sucker	N		V	N		-	N		N		N	N	N	Y	N	Y	N			
120	blue catfish	Y		C	N		C	N		N		N	N	N	N	N	N	N		C	
121	channel catfish	Y		C	N	T	C	N		N		N	Y	N	N	N	Y	N		I	
122	tadpole madtom	N		V	N		C	N		N		N	Y	N	N	N	Y	Y		I	
123	freckled madtom	N		V	N	SI	C	N		N		N	Y	N	Y	N	N	N		I	
124	mountain madtom	N		V	N	SI	C	N		N		N	Y	N	Y	N	N	N		I	
125	slender madtom	N		V	N	S	C	N		N		N	Y	N	N	N	N	N		I	
126	stonecat	N		V	N	SI	C	N		N		N	Y	N	N	N	Y	N	I	I	
127	brindled madtom	N		V	N	SI	C	N		N		N	Y	N	Y	N	Y	N	R	I	
128	northern madtom	N			N	S	C	N		N		N	Y	N	N	N	Y	N		I	
129	flathead catfish	Y		C	N	T	C	N		N		N	N	N	N	N	Y	N			
130	white catfish	N		V	N		C	N	N	N		N	N	N	N	N	N	N		I	

IDEM_TAXON_RID	Common Name	Large River Species	Large River Tolerant	IBI Trophic Guild	RND_BODY_SUCKER_IND	IBI Sensitivity	Reproductive Guild	Headwater Species	Origin	Hybrid	Cool/Cold	Pioneer Species	BENTHIC_INSECTIVORE_I	LAKE_HABITAT_SPECIES_IND	OHIO_RIVER_IND	MISSISSIPPI_IND	GREAT_LAKES_IND	OBLIGATE_GL_SPECIES_I	Lake Tolerance	Trophic Class Lake	Tertiary Reproductive Guild
131	black bullhead	N	T	V	N	T	C	N		N		N	Y	N	N	N	Y	N	T	I	
132	yellow bullhead	N		V	N	T	C	N		N		N	Y	N	N	N	Y	N	P	I	
133	brown bullhead	N		V	N	T	C	N		N		N	Y	N	N	N	Y	Y	P	I	
134	northern cavefish	N			N	S	C	N		N		N	N	N	N	N	N	N			
135	southern cavefish	N			N	S	C	N		N		N	N	N	N	N	N	N			
136	pirate perch	N		V	N		M	N		N		N	N	N	N	N	Y	N		I	
137	trout-perch	N		V	N		M	N		N	CL	N	Y	Y	N	N	Y	N		I	Lithophils
138	burbot	Y		V	N		S	N		N		N	N	N	N	N	Y	N		C	
139	banded killifish	N		V	N	T	M	N		N		N	Y	N	N	N	Y	Y		I	Phytophils
140	blackspotted topminnow	N		V	N		M	N		N		N	N	N	N	N	N	N		I	
141	northern studfish	N		V	N	S	M	N		N		N	N	N	N	N	N	N		I	
142	blackstripe topminnow	N		V	N		M	N		N		N	N	N	N	N	Y	N		I	Phytophils
143	northern starhead topminnow	N		V	N	S	M	N		N		N	N	N	N	N	Y	N		I	
144	western mosquitofish	N		V	N		N	N	N	N		N	N	N	N	N	Y	N		I	
145	brook silverside	N		V	N	S	M	N		N		N	Y	N	N	N	Y	N		I	
146	ninespine stickleback	N			N		C	N	N	N	CL	N	N	N	N	N	Y	N		I	
147	brook stickleback	N		V	N		C	Y		N	CL	N	N	N	N	N	Y	N		I	
148	slimy sculpin	N		V	N		C	N		N	CL	N	Y	N	N	N	Y	N		I	
149	mottled sculpin	N		V	N		C	Y		N	CL	N	Y	Y	N	N	N	N		I	
150	banded sculpin	N		V	N		C	Y		N	CL	N	Y	N	Y	N	N	N		I	
151	spoonhead sculpin	N		V	N		C	N		N	CL	N	Y	N	N	N	Y	Y		I	
152	deepwater sculpin	N			N		C	N		N		N	Y	N	N	N	Y	Y		I	
153	striped bass	Y		C	N		M	N	N	N		N	N	N	N	N	Y	N		C	
154	white bass	Y		C	N	T	M	N		N		N	Y	N	N	N	Y	N		I	

IDEM_TAXON_RID	Common Name	Large River Species	Large River Tolerant	IBI Trophic Guild	RND_BODY_SUCKER_IND	IBI Sensitivity	Reproductive Guild	Headwater Species	Origin	Hybrid	Cool/Cold	Pioneer Species	BENTHIC_INSECTIVORE_I	LAKE_HABITAT_SPECIES_IND	OHIO_RIVER_IND	MISSISSIPPI_IND	GREAT_LAKES_IND	OBLIGATE_GL_SPECIES_I	Lake Tolerance	Trophic Class Lake	Tertiary Reproductive Guild
155	yellow bass	Y		C	N		M	N		N		N	N	N	N	N	Y	N			
156	rock bass	N		C	N	S	C	N		N		N	Y	Y	N	N	Y	N		I	
157	flier	N		V	N		C	N		N		N	N	N	N	N	N	N		I	
158	green sunfish	N	T	V	N	T	C	N		N		Y	Y	N	N	N	Y	N	T	I	
159	warmouth	N		C	N		C	N		N		N	Y	Y	N	N	Y	N		I	Lithophils
160	bluegill	N		V	N		C	N		N		N	Y	Y	N	N	Y	N	P	I	
161	pumpkinseed	N		V	N		C	N		N		N	Y	Y	N	N	Y	N	P	I	
162	orangespotted sunfish	N		V	N		C	N		N		N	N	N	N	N	Y	N		I	Lithophils
163	longear sunfish	N		V	N	SI	C	N		N		N	N	N	N	N	Y	N		I	
164	redear sunfish	N		V	N		C	N		N		N	Y	N	N	N	Y	N		I	
165	redspotted sunfish	N		V	N		C	N		N		N	N	N	N	N	N	N		I	
166	bantam sunfish	N		V	N		C	N		N		N	N	N	N	N	N	N		I	
167	smallmouth bass	N		C	N	SI	C	N		N		N	Y	N	N	N	Y	N		I	
168	largemouth bass	N		C	N		C	N		N		N	N	N	N	N	Y	N		C	
169	spotted bass	N		C	N		C	N		N		N	N	N	N	N	N	N		C	
170	white crappie	N		V	N		C	N		N		N	Y	Y	N	N	Y	N		I	Phytophils
171	black crappie	N		V	N		C	N		N		N	Y	Y	N	N	Y	N		I	Phytophils
172	bluntnose darter	N		V	N		M	N		N	CL	N	Y	N	N	N	Y	N		I	Phytophils
173	slough darter	N		V	N		N	N		N	CL	N	Y	N	Y	N	N	N		I	
174	orangethroat darter	N		V	N		S	N		N	CL	Y	Y	N	Y	Y	Y	N		I	Lithophils
175	johnny darter	N		V	N		C	N		N	CL	Y	Y	Y	N	N	Y	N		I	
176	mud darter	N		V	N		M	N		N	CL	N	Y	N	Y	N	N	N		I	
177	greenside darter	N		V	N	SI	M	N		N	CL	N	Y	N	Y	N	N	N		I	Phytophils
178	rainbow darter	N		V	N	SI	S	N		N	CL	N	Y	N	N	N	Y	N		I	Lithophils
179	bluebreast darter	N		V	N	SI	S	N		N	CL	N	Y	N	Y	N	N	N		I	
180	lowa darter	N		V	N		M	N		N	CL	N	Y	Y	N	N	Y	N		I	Phytophils
181	fantail darter	N		V	N		C	Y		N	CL	N	Y	N	N	N	Y	N		I	

IDEM_TAXON_RID	Common Name	Large River Species	Large River Tolerant	IBI Trophic Guild	RND_BODY_SUCKER_IND	IBI Sensitivity	Reproductive Guild	Headwater Species	Origin	Hybrid	Cool/Cold	Pioneer Species	BENTHIC_INSECTIVORE_I	LAKE_HABITAT_SPECIES_IND	OHIO_RIVER_IND	MISSISSIPPI_IND	GREAT_LAKES_IND	OBLIGATE_GL_SPECIES_I	Lake Tolerance	Trophic Class Lake	Tertiary Reproductive Guild
182	harlequin darter	Y		V	N	SI	S	N		N	CL	N	Y	N	Y	N	N	N		I	
184	spotted darter	N		I	N	S		N		N	CL	N	Y	N	Y	N	N	N			
185	least darter	N		V	N		N	N		N	CL	N	Y	N	Y	Y	Y	N		I	Phytophils
186	spottail darter	N		I	N	S	C	N		N	CL	N	Y	N	Y	N	N	N		I	
187	Tippecanoe darter	N		V	N	SI	S	N		N	CL	N	Y	N	Y	N	N	N		I	
188	variegate darter	N		V	N	S	S	N		N	CL	N	Y	N	Y	N	N	N		I	
189	banded darter	N		V	N	S	M	N		N	CL	N	Y	N	Y	Y	Y	N		I	Phytophils
190	yellow perch	N		V	N		M	N		N	CL	N	Y	Y	N	N	Y	N		I	
191	logperch	N		V	N	S	S	N		N	CL	N	Y	N	N	N	Y	N		I	Lithophils
192	dusky darter	N		V	N	S	S	N		N	CL	N	Y	N	Y	N	Y	N		I	Lithophils
193	gilt darter	N		V	N	SI	S	N		N	CL	N	Y	N	Y	N	Y	N	R	I	Lithophils
194	blackside darter	N		V	N		S	N		N	CL	N	Y	N	N	N	Y	N		I	Lithophils
195	slenderhead darter	N		V	N	SI	S	N		N	CL	N	Y	N	Y	Y	Y	N		I	Lithophils
196	river darter	Y		I	N	I	S	N		N	CL	N	Y	N	Y	N	Y	N		I	Lithophils
197	stargazing darter	N		I	N	S	S	N		N	CL	N	Y	N	N	N	N	N			
198	saddleback darter	N		V	N	S	S	N		N	CL	N	Y	N	N	N	N	N		I	
199	w alleye	Y		C	N		S	N		N	CL	N	N	Y	N	N	Y	N		C	
200	sauger	Y		C	N		S	N		N	CL	N	N	N	N	N	Y	N			
201	channel darter	Y		V	N	SI	S	N		N	CL	N	Y	N	Y	N	Y	N	S	I	Lithophils
202	w estern sand darter	Y		V	N	SI	S	N		N	CL	N	Y	N	Y	Y	Y	N		I	
203	eastern sand darter	Y		V	N	SI	S	N		N	CL	N	Y	N	Y	N	Y	N	R	I	
204	crystal darter	Y		V	N	S	S	N		N	CL	N	Y	N	Y	N	N	N		I	
205	freshw ater drum	Y		V	N	T	M	N		N		N	Y	N	N	N	Y	N	P	I	
206	banded pygmy sunfish	N		V	N		C	N		N		N	N	N	N	N	N	N		I	
207	channel shiner	Y		I	N	S	M	N		N		N	Y	N	N	N	Y	N		I	
208	tiger muskie	N			N			N		Y		N	N	N	N	N	Y	N			
209	w iper	N			N			N	N	Y		N	N	N	N	N	N	N			
210	saugeye	N			N			N		Y		N	N	N	N	N	N	N			
211	hybrid sunfish	N			N			N		Y		N	N	N	N	N	N	N			

IDEM_TAXON_RID	Common Name	Large River Species	Large River Tolerant	IBI Trophic Guild	RND_BODY_SUCKER_IND	IBI Sensitivity	Reproductive Guild	Headwater Species	Origin	Hybrid	Cool/Cold	Pioneer Species	BENTHIC_INSECTIVORE_I	LAKE_HABITAT_SPECIES_IND	OHIO_RIVER_IND	MISSISSIPPI_IND	GREAT_LAKES_IND	OBLIGATE_GL_SPECIES_I	Lake Tolerance	Trophic Class Lake	Tertiary Reproductive Guild
212	ruffe	N			N			N	E	N		N	N	N	N	N	Y	N			
213	black carp	N		O	N	T	M	N	E	N		N	N	N	N	N	N	N			
214	bighead carp	N	T	V	N	T	M	N	E	N		N	N	N	N	N	N	N		I	
215	round goby	N			N		C	N	E	N		N	Y	N	N	N	Y	N		I	
216	tubenose goby	N			N			N	E	N		N	Y	N	N	N	Y	N		I	
217	white perch	N		V	N		M	N	N	N		N	Y	N	N	N	Y	N		I	
218	smallmouth redhorse	Y			Y	S		N		N	CL	N	Y	N	Y	N	Y	N		I	
219	inland silverside	N			N		M	N	N	N		N	N	N	Y	N	N	N			
220	threespine stickleback	N		V	N		C	N	N	N	CL	N	N	N	N	N	Y	N		I	
221	Ammocoetes	N			N			N		N		N	N	N	N	N	N	N			
222	orangethroat rainbow hybrid	N			N			N		Y		N	N	N	N	N	N	N			
223	kiyi	N			N			N		N		N	N	N	N	N	N	N			
224	goldfish x carp	N			N			N	E	Y		N	N	N	N	N	Y	N			
225	Lythrurus X Notropis hybrid	N			N			N		Y		N	N	N	N	N	N	N			
226	Cyprinidae hybrid	N			N			N		Y		N	N	N	N	N	N	N			
227	steelhead	N			N		N	N	N	N	CD	N	N	Y	N	N	N	N		C	
228	cypress darter	N		V	N		N	N		N	CL	N	Y	N	N	N	N	N		I	
229	striped mullet	N		D	N			N		N		N	N	N	N	N	N	N			
230	oriental weatherfish	N			N			N	E	N		N	N	N	N	N	Y	N			

IBI Trophic Guild Assignment = Detritivore-D, Omnivore-O, Invertivore-V, Insectivore-I, Carnivore-C
IBI Sensitivity = Sensitive-S, Intolerant-I, Both Sensitive & Intolerant (SI), Tolerant-T
Reproductive Guild = Simple lithophil-S, Complex with parental care-C, Simple miscellaneous-M, Complex with no parental care-N

Origin = Native-N, Introduced-E, Hybrid-H
Cool/Cold = Cool-CL, Cold-CD
Hybrid, Pioneer, Lake Habitat Species, Benthic Insectivore, Ohio River, Mississippi, Great Lakes, Obligate G.L. **N**=False, **Y**=True

APPENDIX L

IDEM's Guide to Appropriate Metric Selection for Calculating the Index of Biotic Integrity (IBI) for Indiana Large and Great Rivers, Inland Lakes, and Lake Michigan Nearshore Habitats

The following is a summary of the appropriate metrics that should be used for assessing anthropogenic influences in the State of Indiana. Information from this document are summarized for simplicity of use, but further reading should be based on information contained in each of the individual biological indicator documents, papers, or reports.

Collection procedures follow the U.S. Environmental Protection Agency (USEPA) Standard Operating Procedures for conducting rapid assessment of ambient surface water quality using fish (1988). All graphs were produced using Statistica (1999). The format for this document is similar to a diagnostic key. For each couplet, choose the appropriate selection and follow the directions. For a detailed list of documents used to create this guide, please refer to the reference section of this paper.

1. Determine waterbody type

a) Lotic, flowing waters including creeks, streams, large and great rivers, and Ohio River ……**step 2**

b) Lentic, standing waters including wetlands, ponds, inland lakes, Lake Michigan nearshore habitats…… **step 3**

2. Determine drainage area (sq mi)

a) Less than 1000 square miles*……**step 4**

b) Greater than or equal to 1000 square miles ……**step 5**

* If sampling location is a large river (greater than or equal to 1000 square miles) in either the St. Joseph River, St. Mary's River, or Maumee River (Huron Erie Lake Plain), or the St. Joseph River (Lake Michigan drainage), Pigeon River, and Elkhart River (Northern Indiana Till Plain) follow this step. These rivers were included in the calibration for each of these ecoregions.

3. **Determine surface area (ha). NOTE: Waterbody biological indicators for lentic systems < 20 ha are described for ponds, pannes, and palustrine wetlands in Simon (1998) and for vernal ponds and wetlands in Simon et al. (2000). These waterbody types are not covered further in this document.**

a) Less than 20 ha (vernal pond, wetland, pond)…
see Simon 1998, Simon et al. 2000

b) Greater than 20 ha (inland lake, Lake Michigan nearshore)……**step 6**
see Simon 2001, 2004b, Simon & Stewart 2006

4. **Determine the ecoregion that your stream is located or drains. If your sampling location occurs on or near an ecoregion boundary line, select the ecoregion that the stream drains, see map next page (Figure L1). These stream sizes are summarized in Dufour (2002) and has been described in detail in the information contained below.**

Consult Dufour (2002) to determine guidance or refer to appropriate Ecoregion document.

a) Central Corn Belt Plain ……. see Simon 1991
b) Eastern Corn Belt Plain …… ……. see Simon & Dufour 1998
c) Northern Indiana Till Plain ……... see Simon 1998
d) Huron Erie Lake Plain ……. see Simon 1994
e) Interior River Lowland ……. see Dufour 2002
f) Interior Plateau …….. see Simon 1997

5. Determine appropriate category

a) Drainage area (sq mi) is greater than or equal to 1000, (large river includes Wabash and White rivers)……. (see Simon 1992 or Simon & Stahl 1998).

NOTE: Calibrations for these two rivers are revised and include additional information not previously available. Consult Simon (1992) or Simon & Stahl (1998) for metric explanation and metric species membership.

b) Drainage area (sq mi) is greater than or equal to 2000 (sq. mi), mainstem Wabash River or Ohio River
(Wabash River see Simon & Stahl 1998) or (Ohio River see Emery et al. 2003).

NOTE: Calibration for the lower Wabash River is based on original information. Consult Simon & Stahl (1998) for information on metrics and metric species membership.

6. Determine appropriate category or Ecoregion based on location of waterbody. NOTE: Lake Michigan nearshore requires use of Lake Michigan calibrations for Lake Michigan coastal wetlands. Harbor and embayment criteria are in preparation by Simon & Morris (in preparation).

a) Lake Michigan nearshore ……. see Simon & Stewart 2006,

b) Natural lakes and reservoirs of the Central Corn Belt Plain, Northern Indiana Till Plain, and Eastern Corn Belt Plain Ecoregions ……..…see Simon 2001

c) Reservoirs and oxbow lakes Interior River Lowland and Interior Plateau Ecoregions……..see Simon 2004a

Figure L1. Ecoregions of Indiana (Omernik and Gallant 1988).

White River Metrics

Determine the appropriate stream category to use:

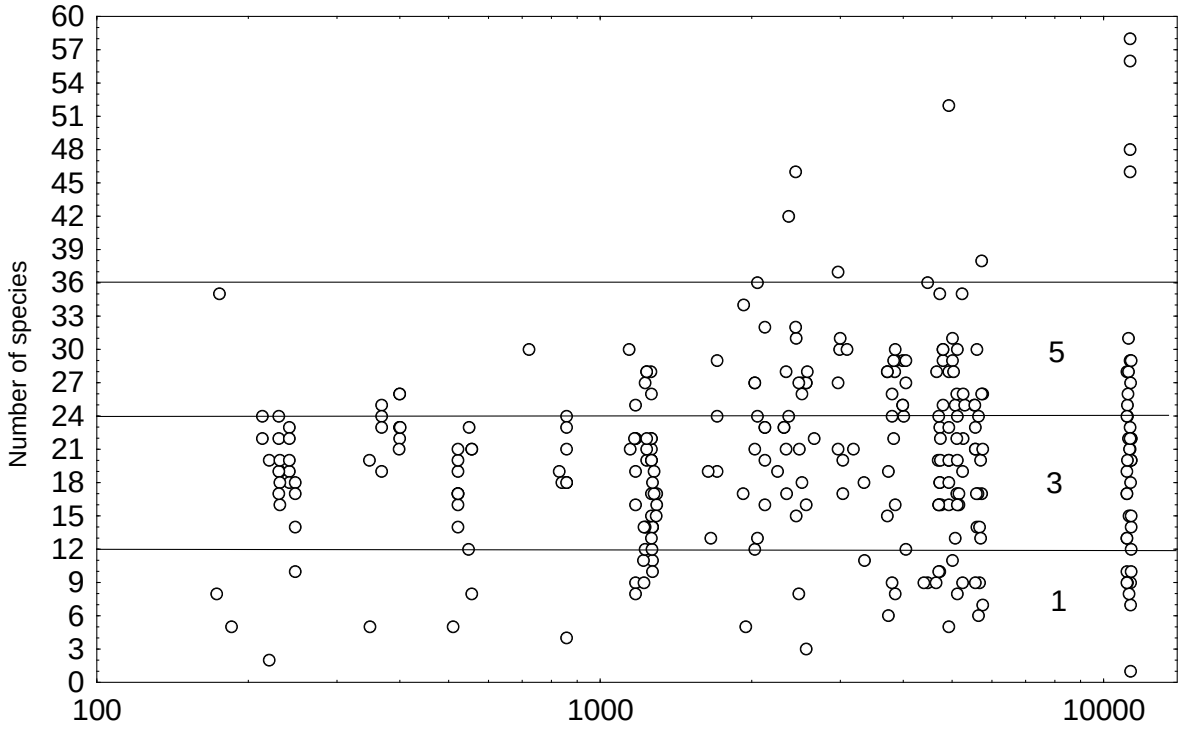
a) Greater than or equal to 1000 (sq mi), but less than 2000 (sq mi) ……..**use B, and LR metrics**

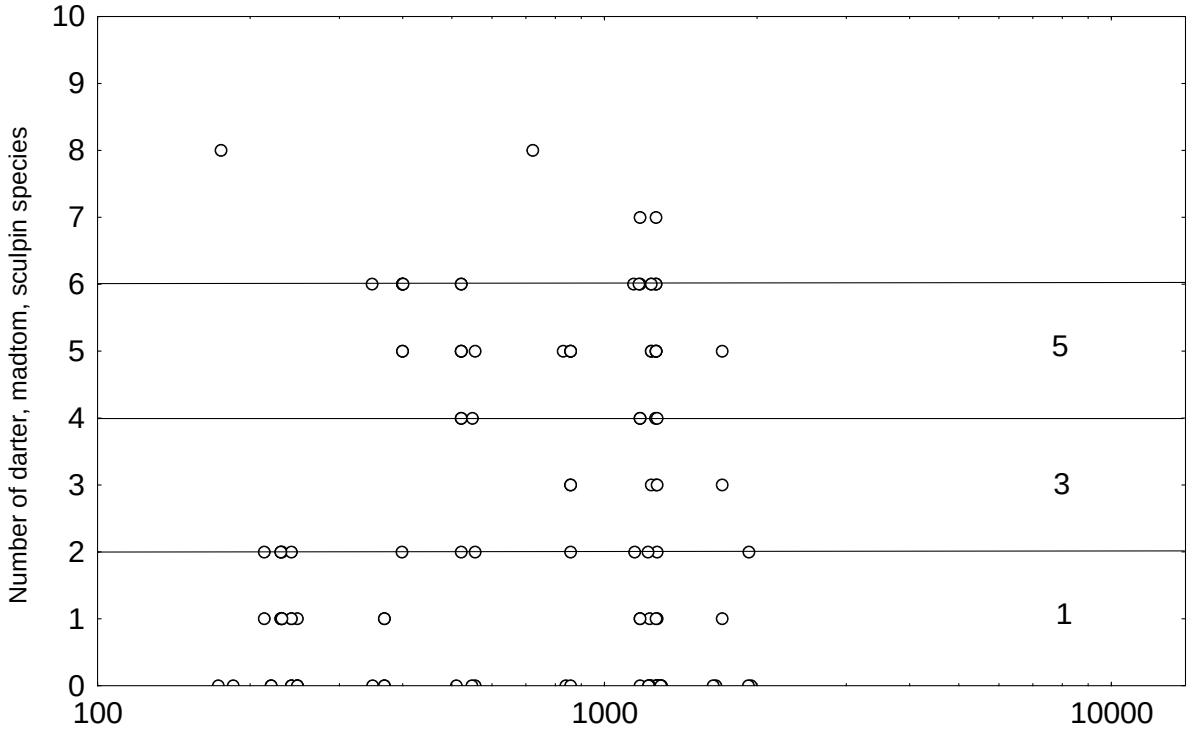
b) Great river (larger than or equal to 2000 sq mi)……**use B, and GR metrics**

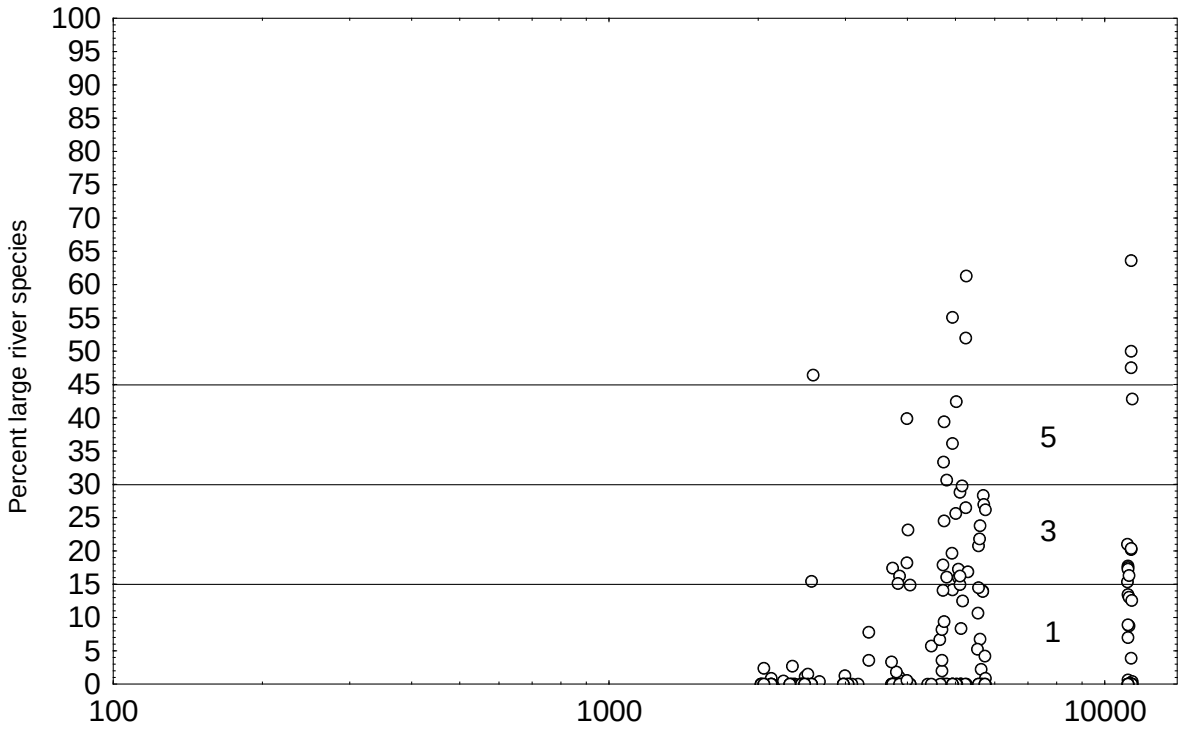
NOTE: Large numbers of a single species can often "swamp" certain metrics making it difficult to assess site status. Therefore, it is essential to remove gizzard shad (*Dorosoma cepedianum*) from this particular set of data prior to IBI calculations (see metric CPUE-gizzard shad).

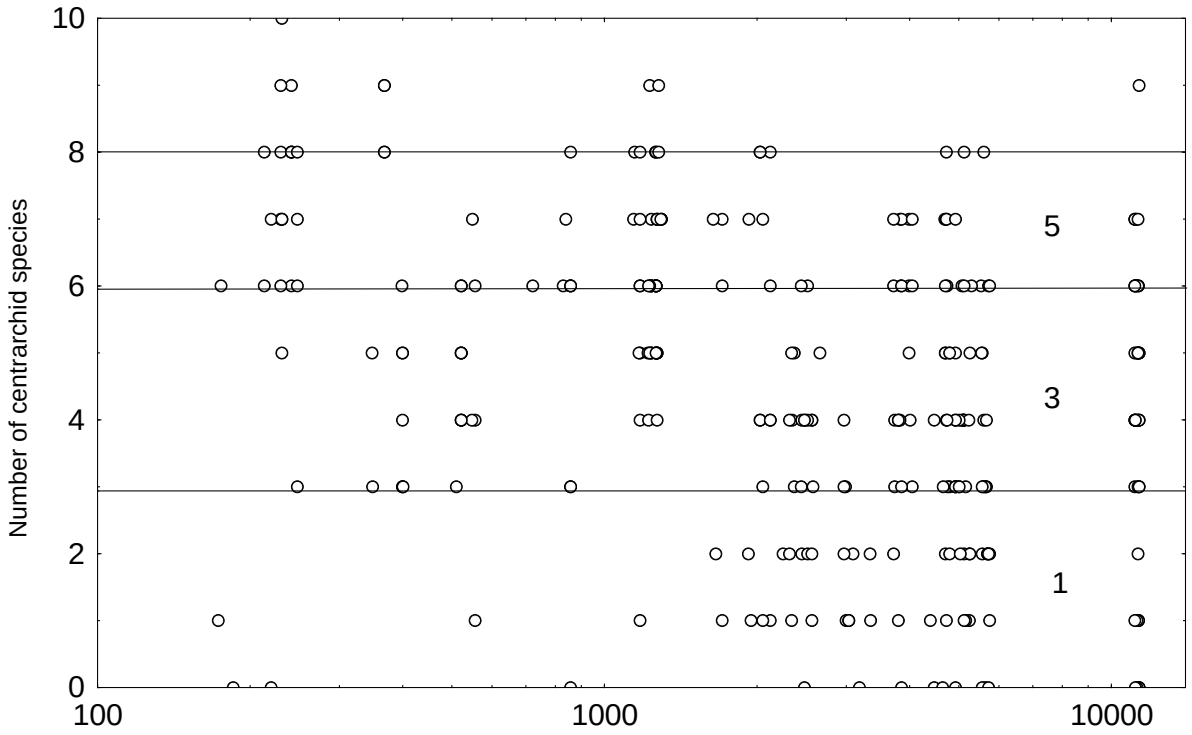
Category	Metric	5	3	1
B	Total number of species	**≥ 24**	**12-23**	**<12**
LR	Number of darter, madtom, and sculpin spp.	**≥ 4**	**2-3**	**< 2**
GR	Percent large river species as individuals	**>30%**	**15-30%**	**<15%**
B	Number of centrarchid species	**≥ 6**	**3-5**	**≤ 2**
B	Number of round-bodied sucker species	**≥ 4**	**2-3**	**< 2**
B	Number of sensitive species	**≥ 8**	**4-7**	**< 4**
B	Percent tolerant species as individuals	**< 33%**	**33-66%**	**> 66%**
B	Percent omnivore species as individuals	**< 30%**	**30-60%**	**>60%**
B	Percent insectivore species as individuals	**> 66%**	**33-66%**	**< 33%**
B	Percent carnivore species as individuals	**> 30%**	**15-30%**	**< 15%**
B	Catch Per Unit Effort-gizzard shad (number of individuals)	**>1,000**	**500-1,000**	**< 500**
B	Percent simple lithophilic spawning as individuals	**> 33.4%**	**16.7-33.4%**	**<16.7%**
B	Percent DELT anomalies as individuals	**< 0.1%**	**0.1-1.3%**	**> 1.3%**

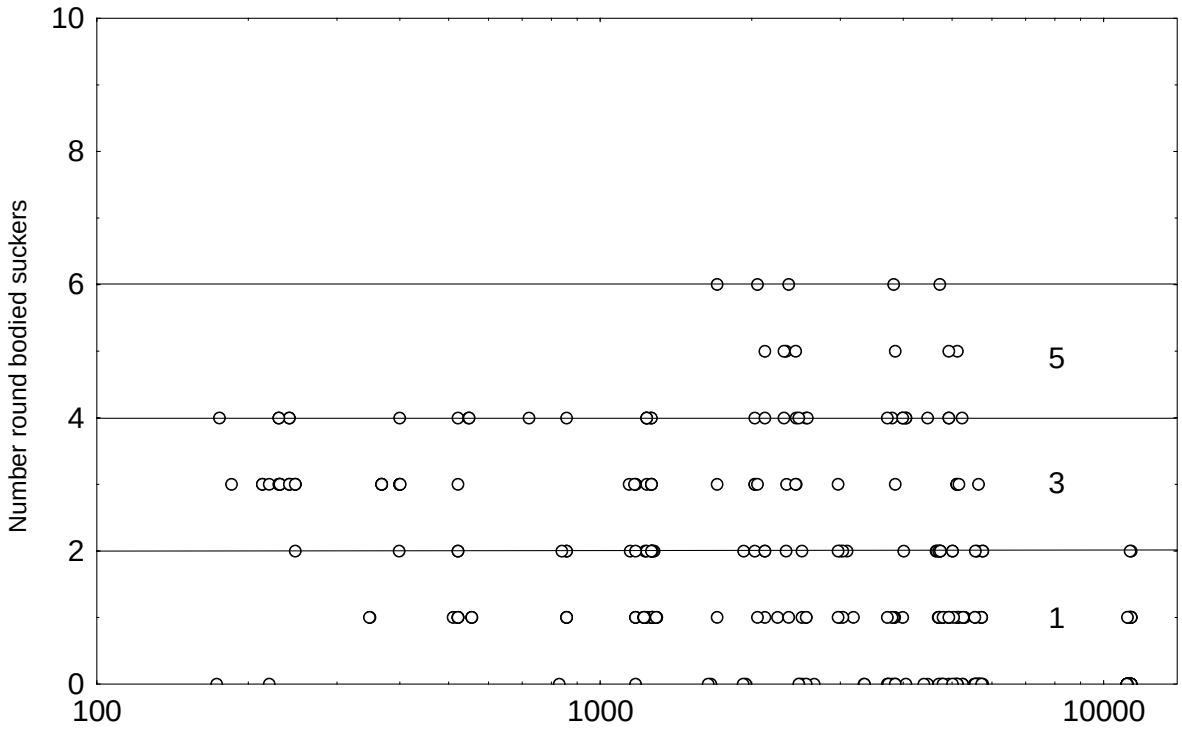
NOTE: Scoring modifications are made when CPUE is <100 individuals (with gizzard shad) or <50 (without gizzard shad) in a 500 m zone. Scoring modifications include scoring all percentage metrics "1".

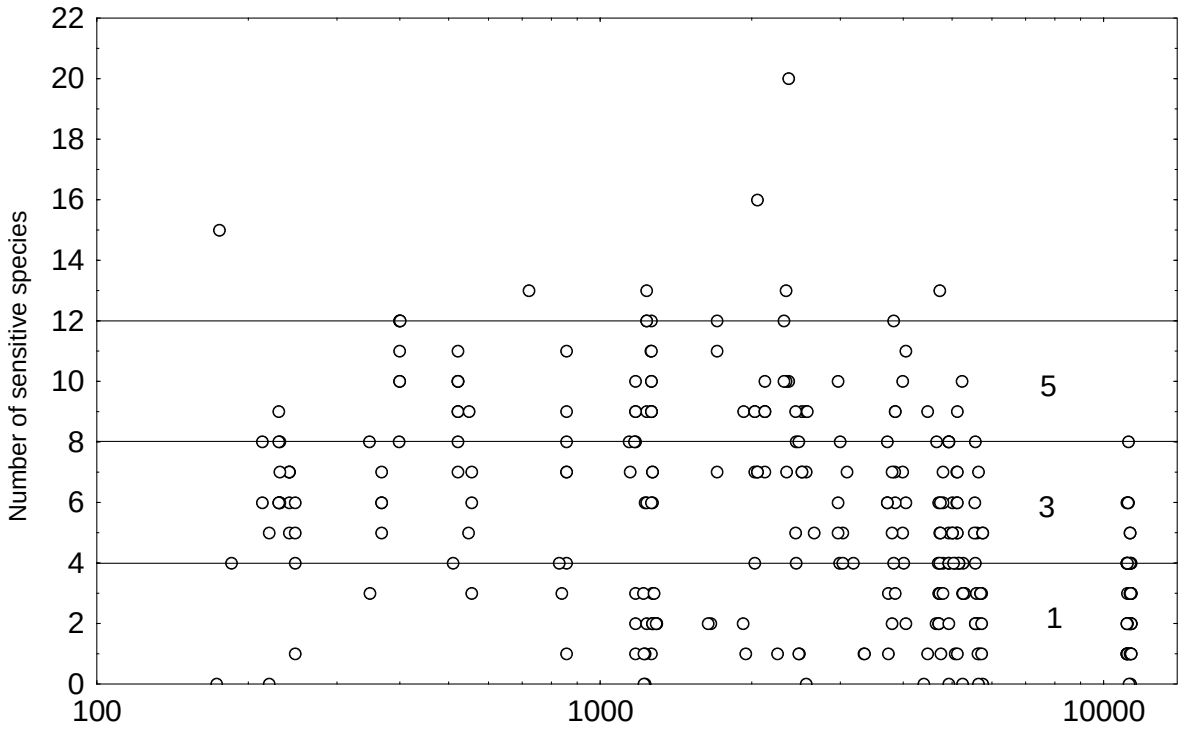

Number of species
60
57
54
51
48
45
42
39
36
33
30
27
24
21
18
15
12
9
6
3
0
100
1000
10000
5
3
1

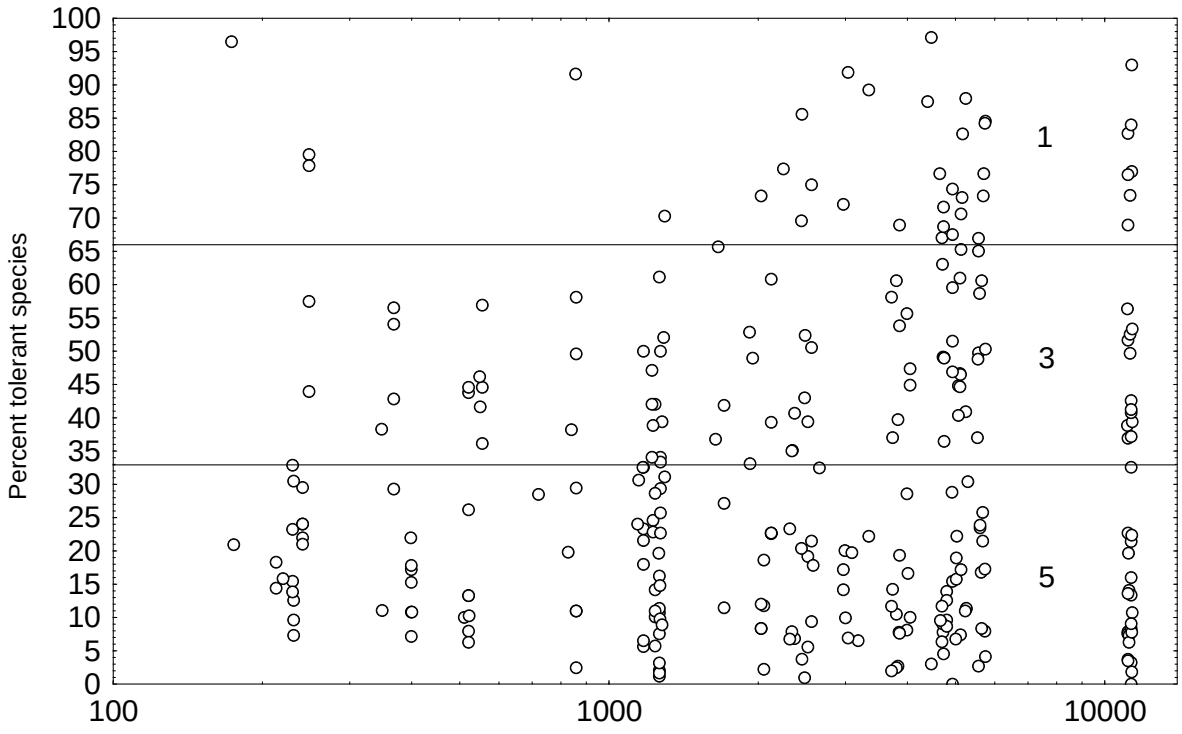

Number of darter, madtom, sculpin species
10
9
8
7
6
5
4
3
2
1
0
100
1000
10000
5
3
1

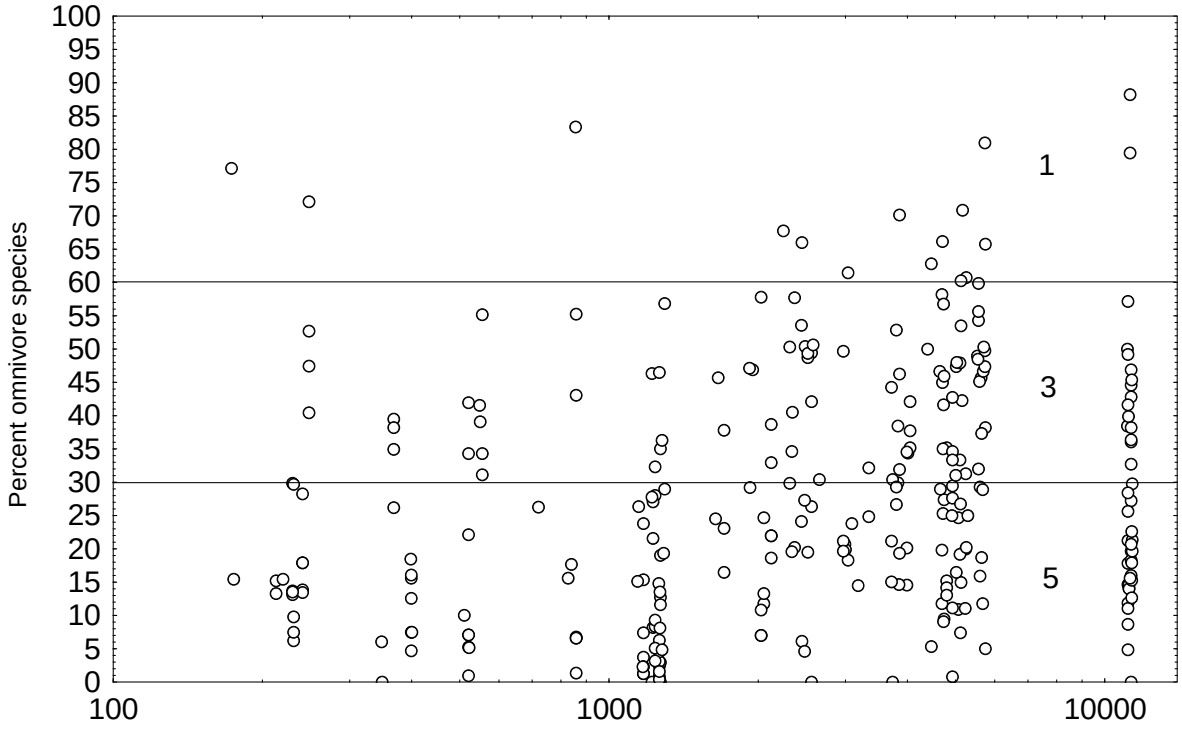

Percent large river species
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
100
1000
10000
5
3
1

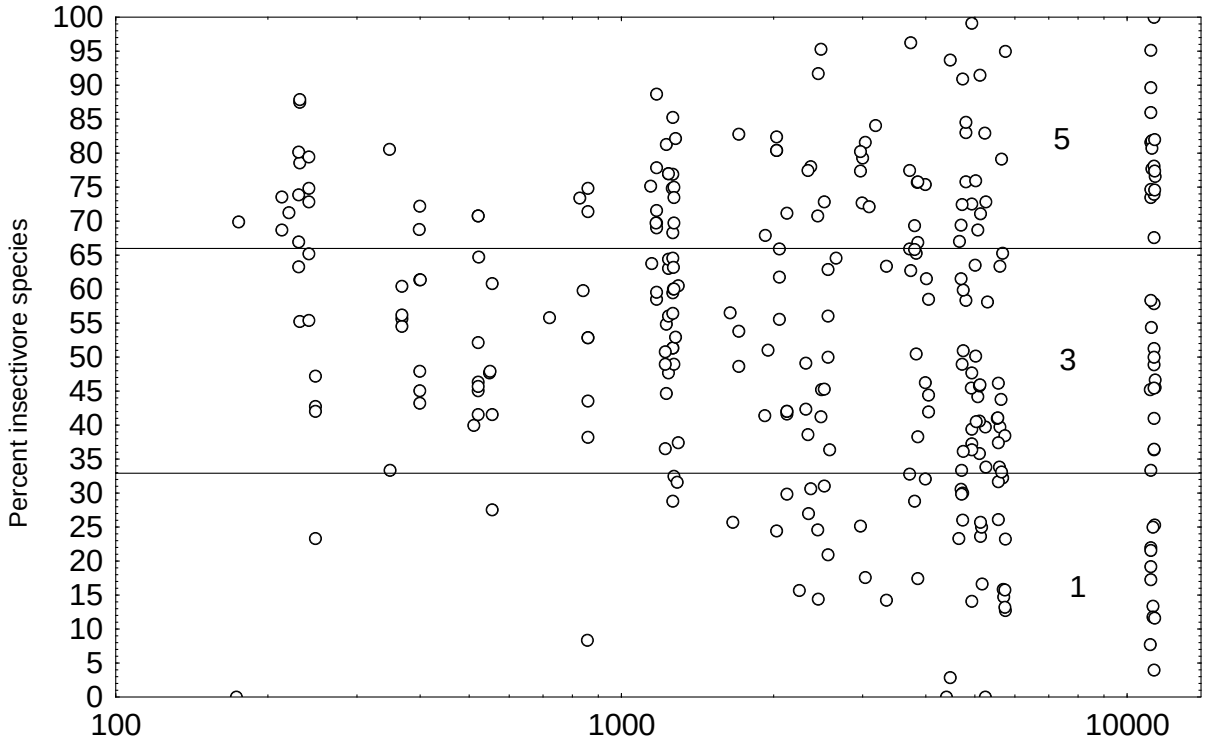

Number of centrarchid species
10
8
6
4
2
0
100
1000
10000
5
3
1

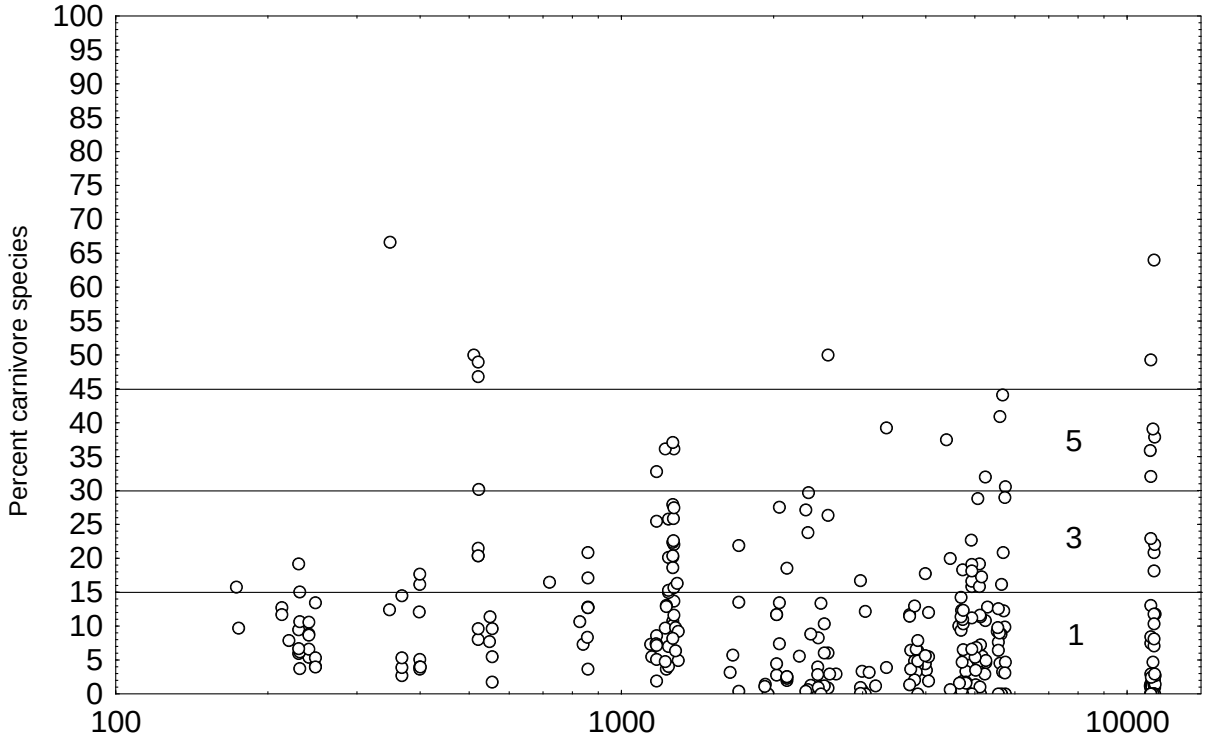

Number round bodied suckers
10
8
6
4
2
0
100
1000
10000
5
3
1

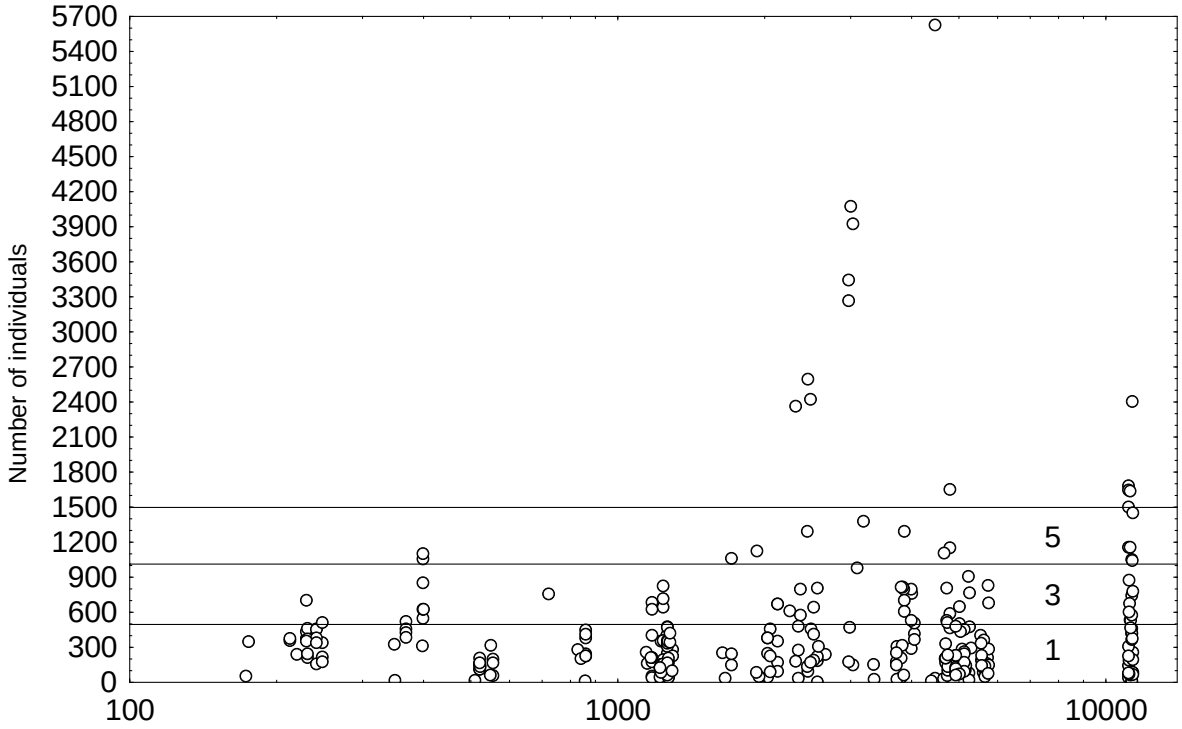

Number of sensitive species
22
20
18
16
14
12
10
8
6
4
2
0
100
1000
10000
5
3
1

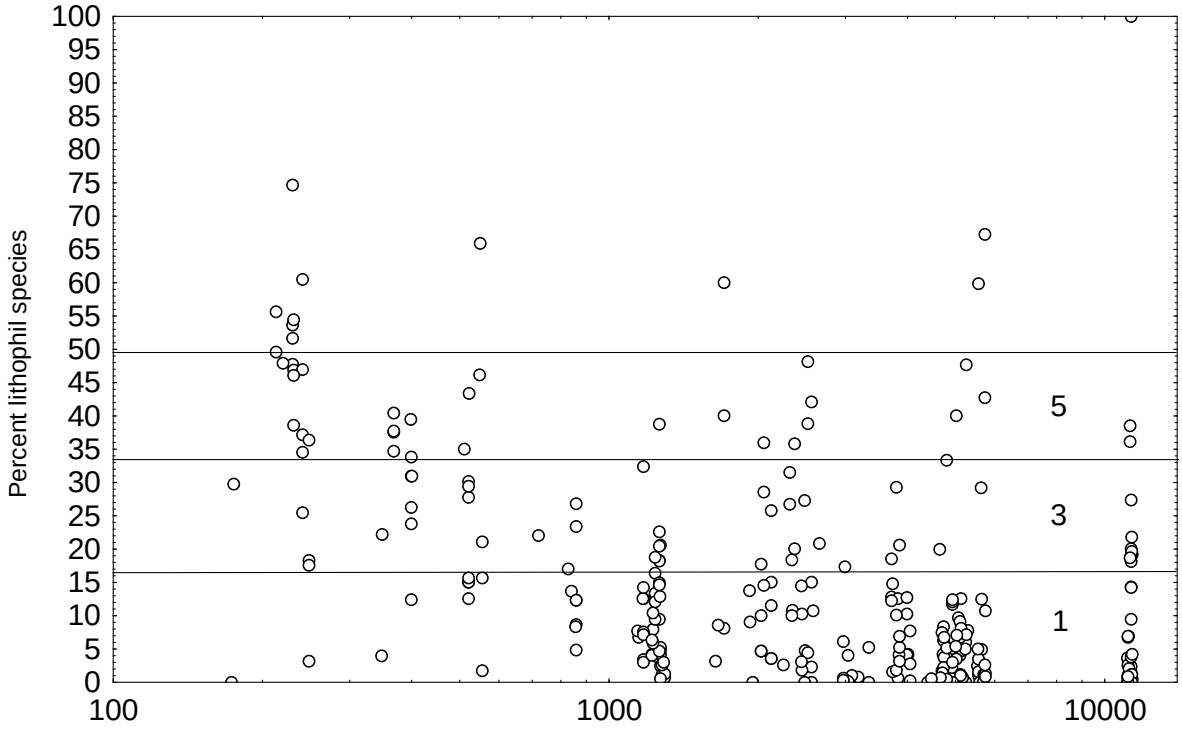

Percent tolerant species
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
100
1000
10000
1
3
5

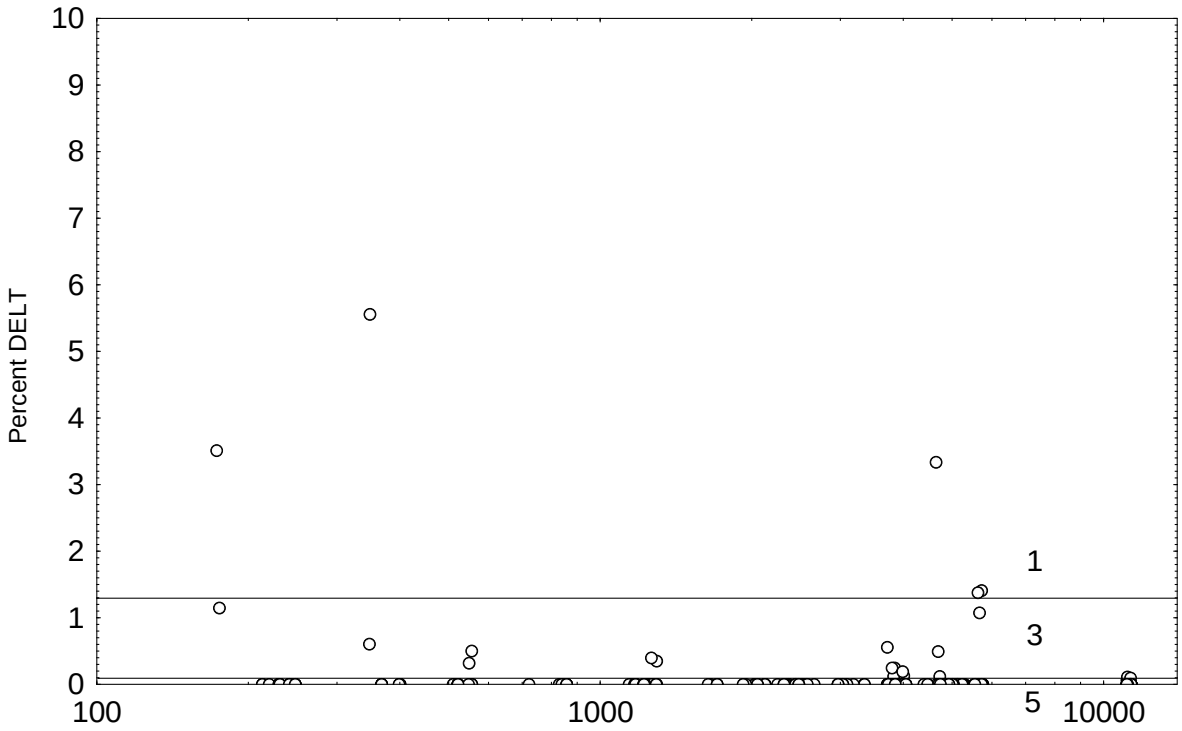

Percent omnivore species
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
100
1000
10000
1
3
5


Percent insectivore species
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
100
1000
10000
5
3
1


Percent carnivore species
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
100
1000
10000
5
3
1


Number of individuals
5700
5400
5100
4800
4500
4200
3900
3600
3300
3000
2700
2400
2100
1800
1500
1200
900
600
300
0
100
1000
10000
5
3
1


Percent lithophil species
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
100
1000
10000
5
3
1


Percent DELT
10
9
8
7
6
5
4
3
2
1
0
100
1000
10000
1
3
5

Wabash River Metrics

NOTE: Large numbers of a single species can often "swamp" certain metrics making it difficult to assess site status. Therefore, it is essential to remove gizzard shad (*Dorosoma cepedianum*) from this particular set of data prior to IBI calculations (see metric CPUE-gizzard shad).

Step 1: Actual Observation values for percentage metrics and Catch Per Unit Effort (CPUE)

Calculate Actual Observation values for percentage metrics and CPUE without gizzard shad individuals or individuals of schooling species if >50% of total catch. Schooling Species for the purpose of this calibration are from the Family Cyprinidae (minnows, except carp species which are not considered schooling), Family Clupeidae (herring), as well as Family Atherinidae (silverside). Classification of species can be found in the Appendix of Simon (2006).

% Large River Individuals = Remove large river schooling individuals (like threadfin shad or bullhead minnow) if >50% of total catch from the numerator. Gizzard shad should be removed from total number of individuals in the denominator as well as the total number of schooling individuals if >50% of total catch.

$$\left(\frac{\left(\left(TotalLargeRiverIndividuals\right)-\left(TotalLargeRiverSchoolingIndividuals>50\%TotalCatch\right)\right)}{\left(\left(TotalIndividuals\right)-\left(TotalGizzardShad\right)-\left(TotalSchoolingIndividuals>50\%TotalCatch\right)\right)}\right)\times 100$$

% Large River Tolerant Individuals = Remove large river tolerant schooling individuals (like bluntnose minnow or creek chub) if >50% of total catch from the numerator. Gizzard shad should be removed from total number of individuals in the denominator as well as the total number of schooling individuals if >50% of total catch.

$$\left(\frac{\left(\left(TotalLargeRiverTolerantIndividuals\right)-\left(TotalLargeRiverTolerantSchoolingIndividuals>50\%TotalCatch\right)\right)}{\left(\left(TotalIndividuals\right)-\left(TotalGizzardShad\right)-\left(TotalSchoolingIndividuals>50\%TotalCatch\right)\right)}\right)\times 100$$

% Omnivore Individuals = Remove omnivore schooling individuals (like Mississippi silvery minnow or shad) if >50% of total catch from the numerator. Gizzard shad should be removed from total number of individuals in the denominator as well as the total number of schooling individuals if >50% of total catch.

$$\left(\frac{\left(\left(TotalOmnivoreIndividuals\right)-\left(TotalGizzardShad\right)-\left(TotalOmnivoreSchoolingIndividuals>50\%TotalCatch\right)\right)}{\left(\left(TotalIndividuals\right)-\left(TotalGizzardShad\right)-\left(TotalSchoolingIndividuals>50\%TotalCatch\right)\right)}\right)\times 100$$

% Insectivore Individuals = Insectivore also includes invertivore species. Remove insectivore or invertivore schooling individuals (like silver chub, emerald shiner, and brook silverside) if >50% of total catch from the numerator. Gizzard shad should be removed from

total number of individuals in the denominator as well as the total number of schooling individuals if >50% of total catch.

$$\left(\frac{((TotalInsectivoreIndividuals)-(TotalInsectivoreSchoolingIndividuals>50\%TotalCatch))}{((TotalIndividuals)-(TotalGizzardShad)-(TotalSchoolingIndividuals>50\%TotalCatch))}\right)\times 100$$

% Carnivore Individuals = Carnivore also includes piscivore species. Remove carnivore or piscivore schooling individuals (skipjack herring) if >50% of total catch from the numerator. Gizzard shad should be removed from total number of individuals in the denominator as well as the total number of schooling individuals if >50% of total catch.

$$\left(\frac{((TotalCarnivoreIndividuals)-(TotalCarnivoreSchoolingIndividuals>50\%TotalCatch))}{((TotalIndividuals)-(TotalGizzardShad)-(TotalSchoolingIndividuals>50\%TotalCatch))}\right)\times 100$$

Catch Per Unit Effort (CPUE) = Gizzard shad should be removed from total number of individuals as well as the total number of schooling individuals if >50% of total catch.

$$((TotalIndividuals)-(TotalGizzardShad)-(TotalSchoolingIndividuals>50\%TotalCatch))$$

% Simple Lithophilic Individuals = Remove simple lithophilic schooling individuals (like bigeye chub and river shiner) if >50% of total catch from the numerator. Gizzard shad should be removed from total number of individuals in the denominator as well as the total number of schooling individuals if >50% of total catch.

$$\left(\frac{((TotalSimpleLithophilicIndividuals)-(TotalSimpleLithophilicSchoolingIndividuals>50\%TotalCatch))}{((TotalIndividuals)-(TotalGizzardShad)-(TotalSchoolingIndividuals>50\%TotalCatch))}\right)\times 100$$

% Individuals with Deformities, Eroded Fins, Lesions, and Tumors (DELT) = Remove schooling individuals with DELT if >50% of total catch from the numerator. Gizzard shad should be removed from total number of individuals in the denominator as well as the total number of schooling individuals if >50% of total catch.

$$\left(\frac{((TotalIndividualsWithDELT)-(TotalGizzardShadIndividualsWithDELT)-(TotalSchoolingIndividualsWithDELT>50\%TotalCatch))}{((TotalIndividuals)-(TotalGizzardShad)-(TotalSchoolingIndividuals>50\%TotalCatch))}\right)\times 100$$

Step 2: Actual Observation values for species count metrics.

Total Native Species = Remove hybrid, exotic, or non-indigenous species.

Centrarchidae Species = Remove hybrid species and only include species in the Centrarchidae family (sunfish and black basses).

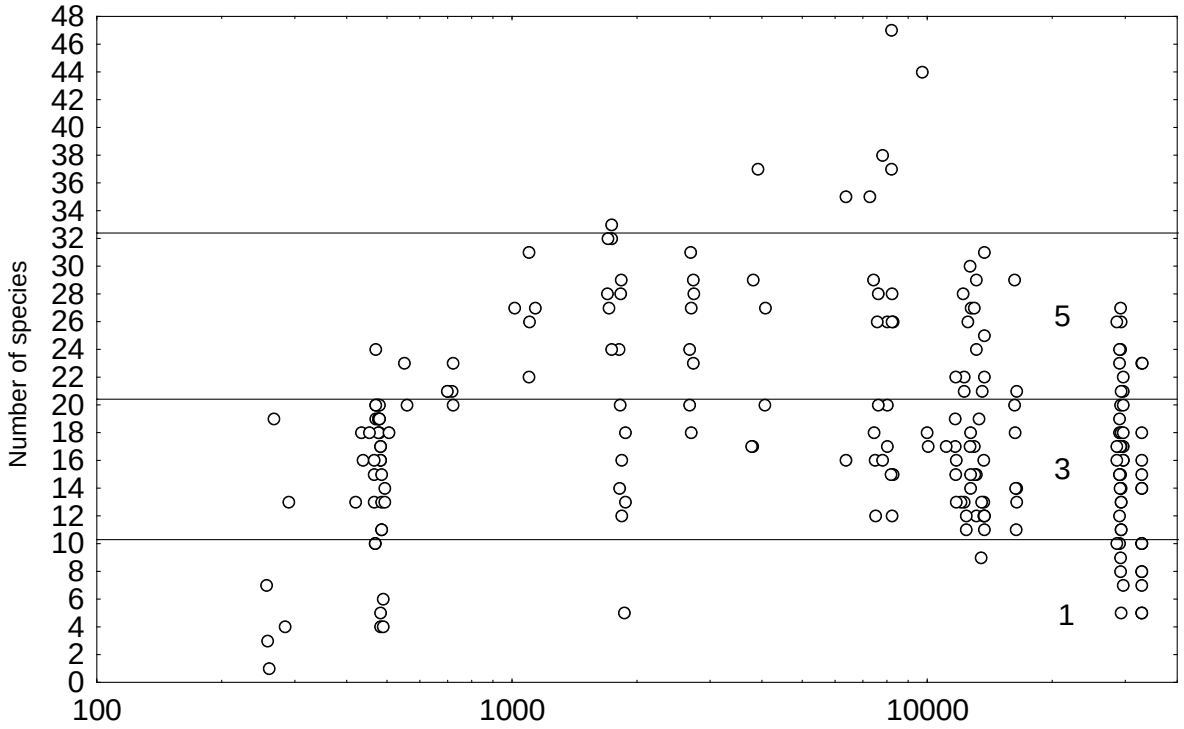
Round-bodied Sucker Species = Remove hybrid species and include species in the genera *Cycleptus* (blue sucker), *Hypentelium* (hog sucker), *Minytrema* (spotted sucker), *Erimyzon* (chubsuckers), and *Moxostoma* (redhorses).

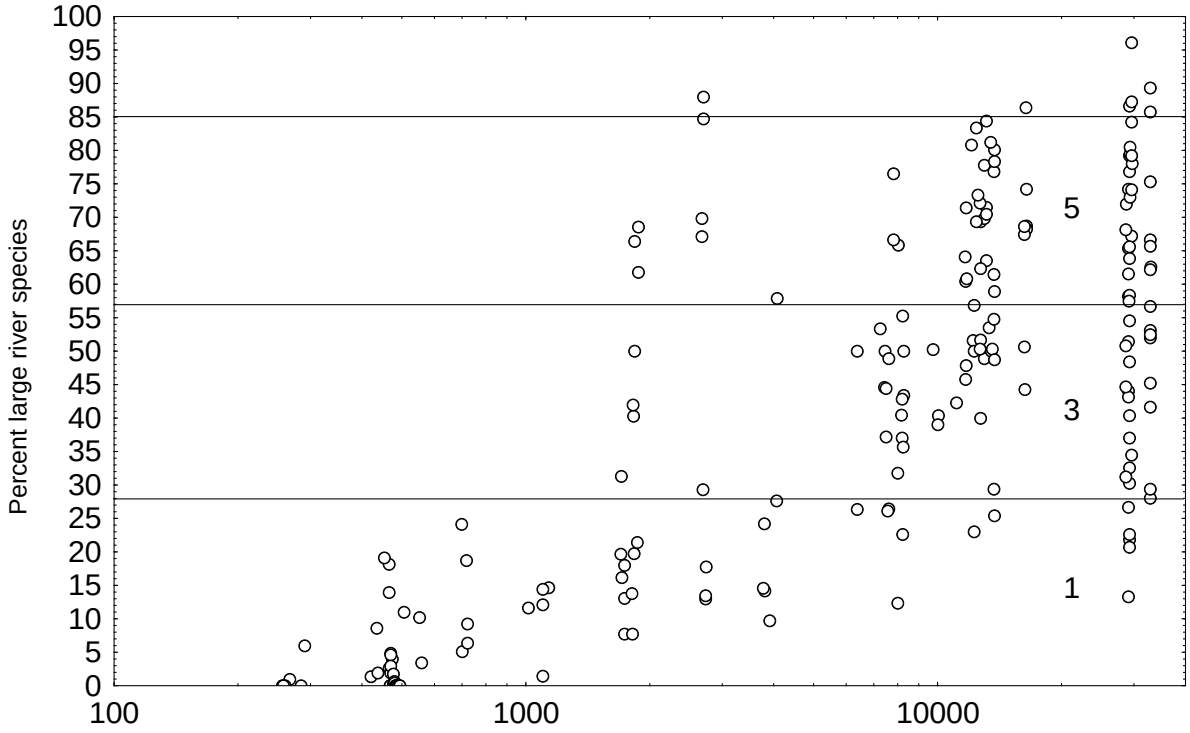
Sensitive Species = Remove hybrid species and only include those species classified as intolerant.

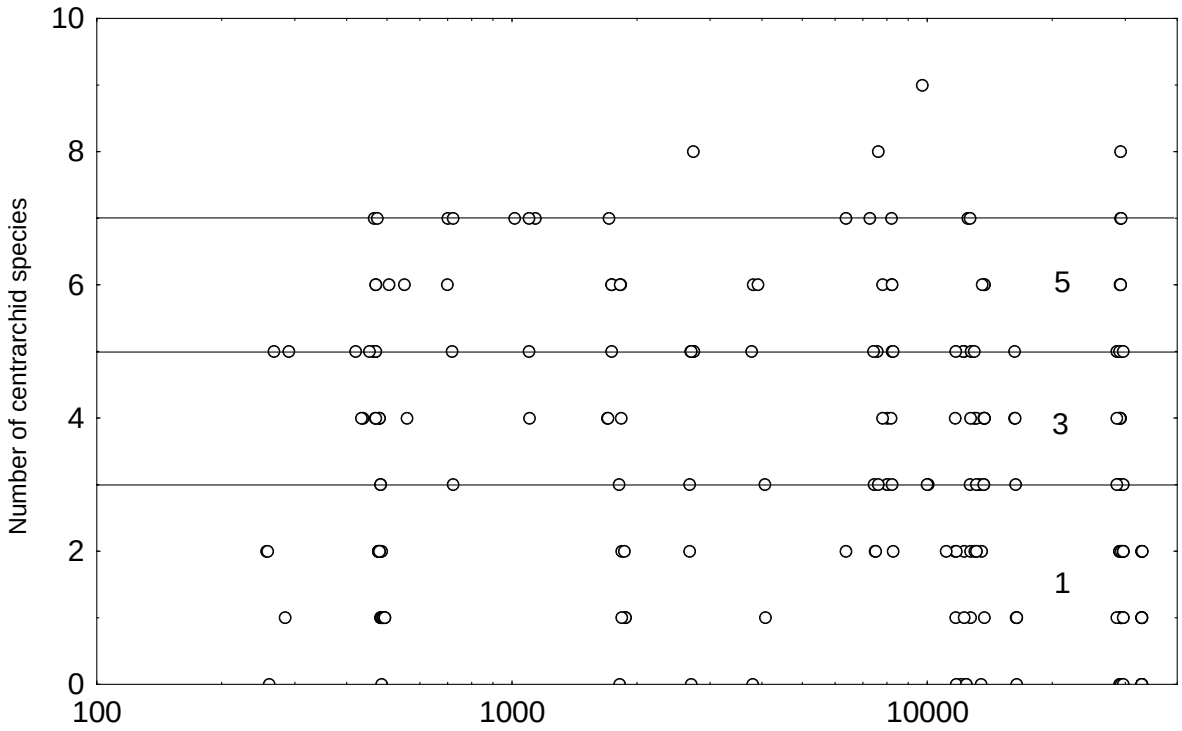
Step 3: Metric scores for Actual Observation values = 0,1,3,5 (No fish, all metrics score 0). Total IBI range 0 to 60.

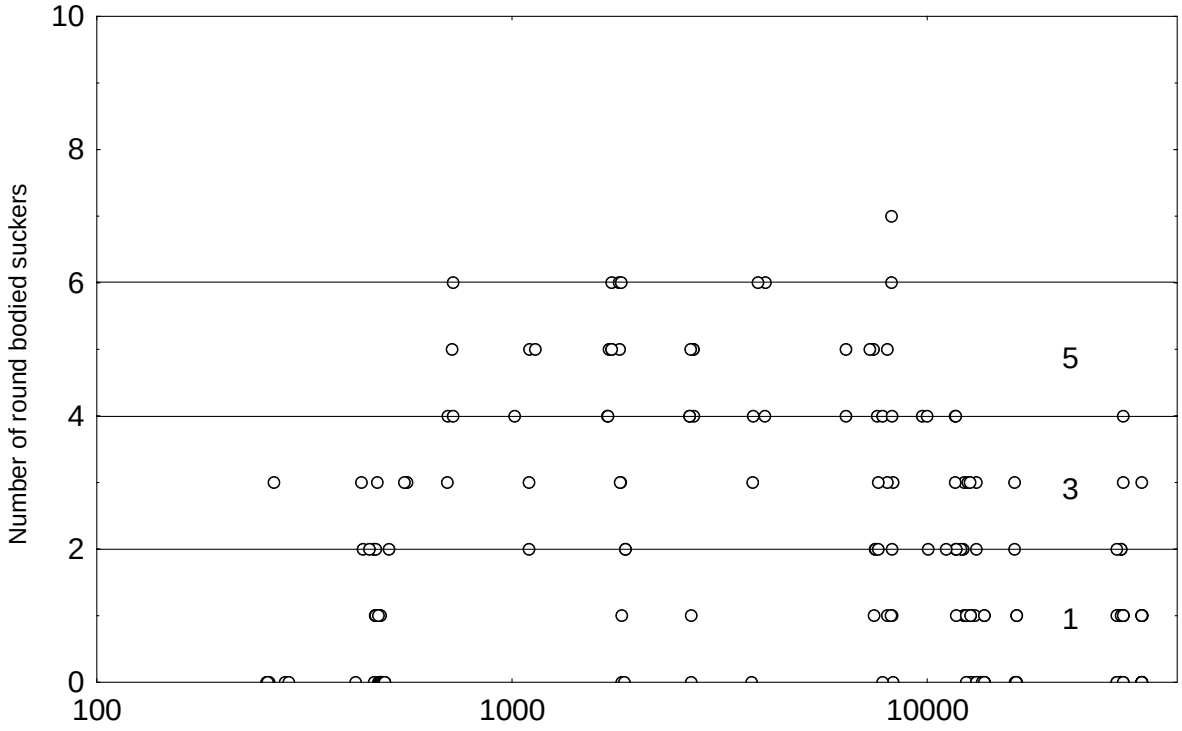
Wabash River IBI Metric Scoring Criteria.					
Location	**Metric**	**5**	**3**	**1**	**0**
All Wabash R. Sites	Total number of species	**> 20**	**10-20**	**<10**	**0**
All Wabash R. Sites	Percent large river species as individuals	**> 56.6%**	**28.3-56.6%**	**<28.3%**	**0**
All Wabash R. Sites	Number of centrarchid species	**≥ 5**	**3-4**	**≤ 2**	**0**
All Wabash R. Sites	Number of round-bodied sucker species	**≥ 5**	**2-4**	**< 2**	**0**
All Wabash R. Sites	Number of sensitive species	**≥ 8**	**4-7**	**≤ 3**	**0**
All Wabash R. Sites	Percent tolerant species as individuals	**< 43.3%**	**43.3-71.6%**	**> 71.6%**	
All Wabash R. Sites	Percent omnivore species as individuals	**< 36.7%**	**36.7-68.3%**	**>68.3%**	
All Wabash R. Sites	Percent insectivore species as individuals	**> 50%**	**25-50%**	**< 25%**	**0**
All Wabash R. Sites	Percent carnivore species as individuals	**>20-<30%**	**10-20 and 30-40%**	**< 10% or >40%**	**0**
All Wabash R. Sites	Catch Per Unit Effort- gizzard shad (=number of individuals)	**>1,200**	**600-1,200**	**< 600**	**0**
All Wabash R. Sites	Percent simple lithophilic spawning as individuals	**> 30%**	**15-30%**	**<15%**	**0**
All Wabash R. Sites	Percent DELT anomalies as individuals	**< 0.1%**	**0.1-1.3%**	**> 1.3%**	

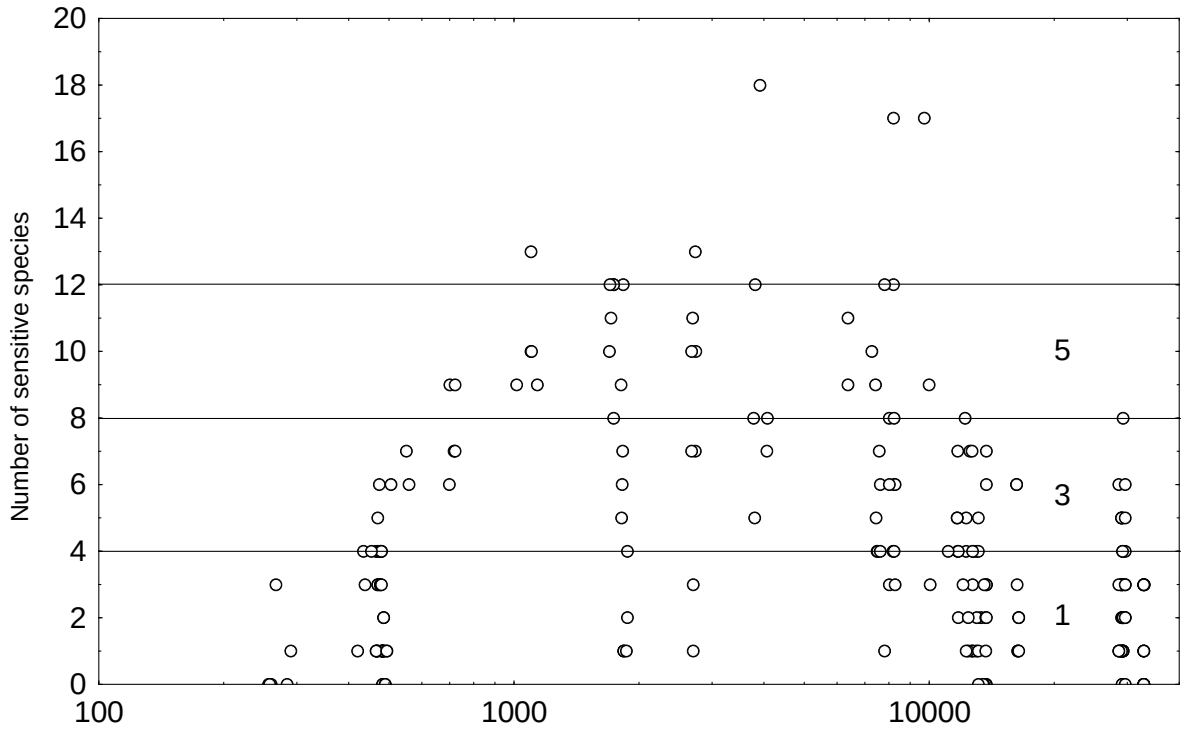
Scoring modification are made when less than 50 (without gizzard shad) or 100 (with gizzard shad) individuals are collected. NOTE: Scoring modifications include scoring all percentage metrics "1".

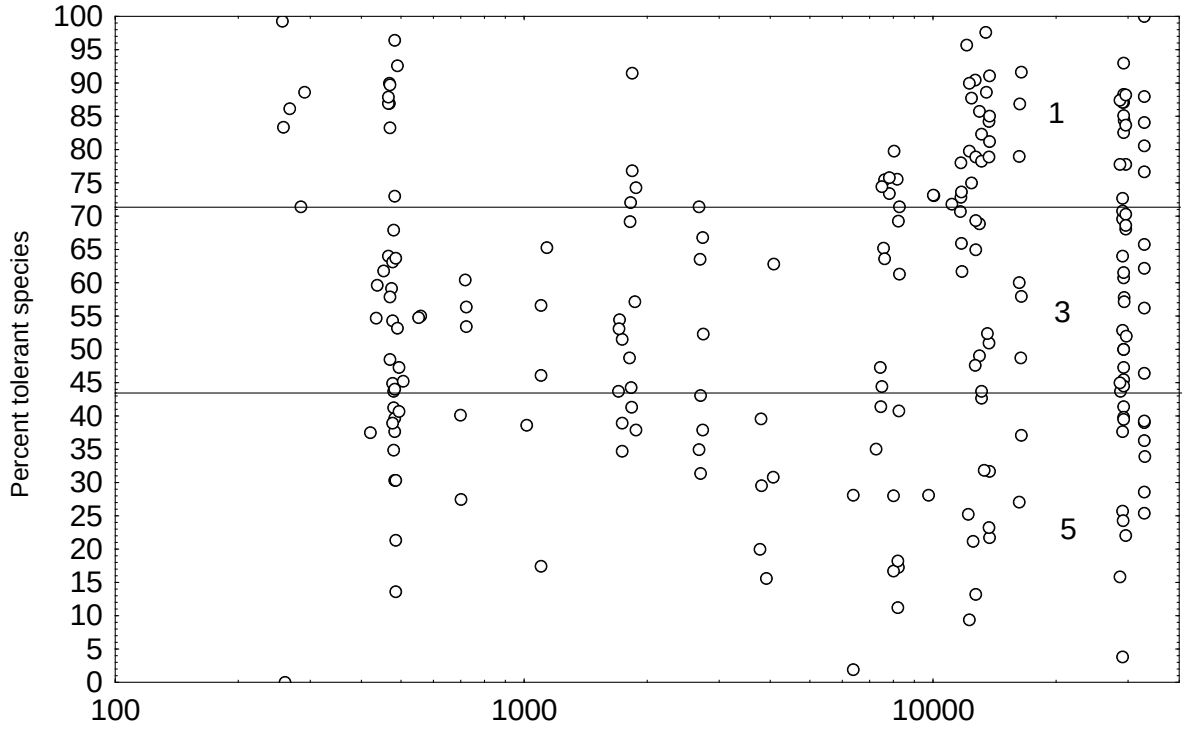

Number of species
48
46
44
42
40
38
36
34
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
100
1000
10000
5
3
1

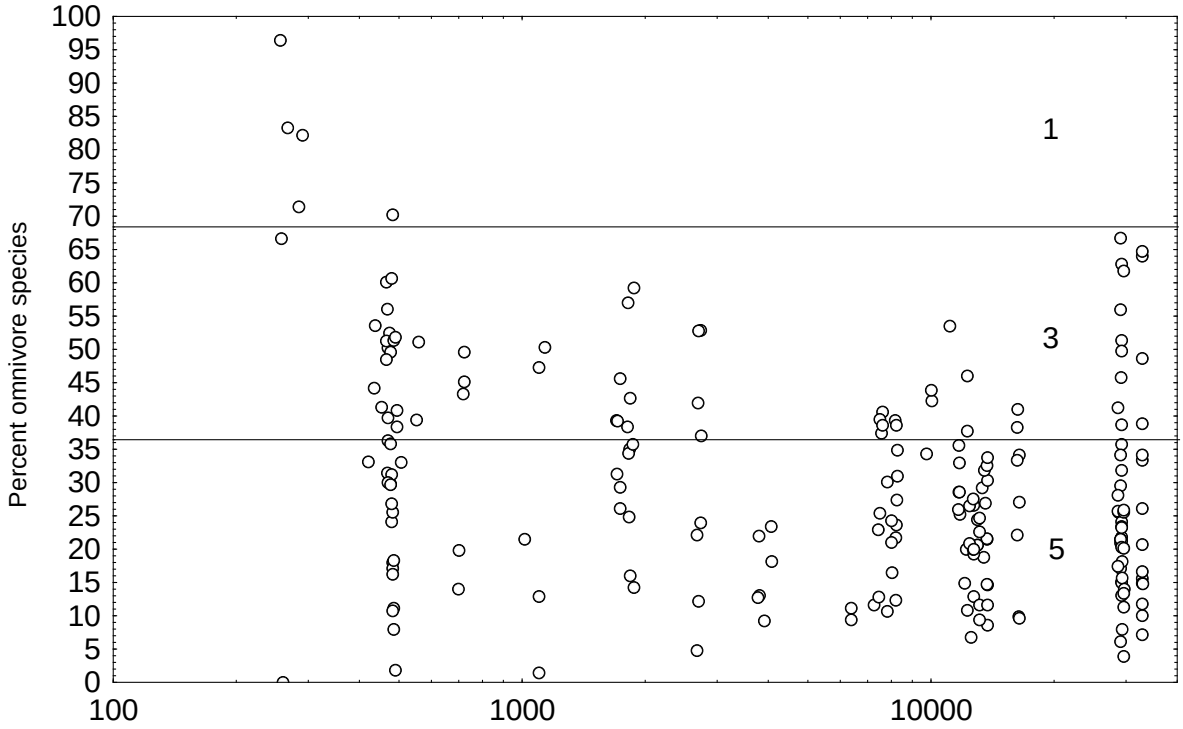

Percent large river species
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
100
1000
10000
5
3
1

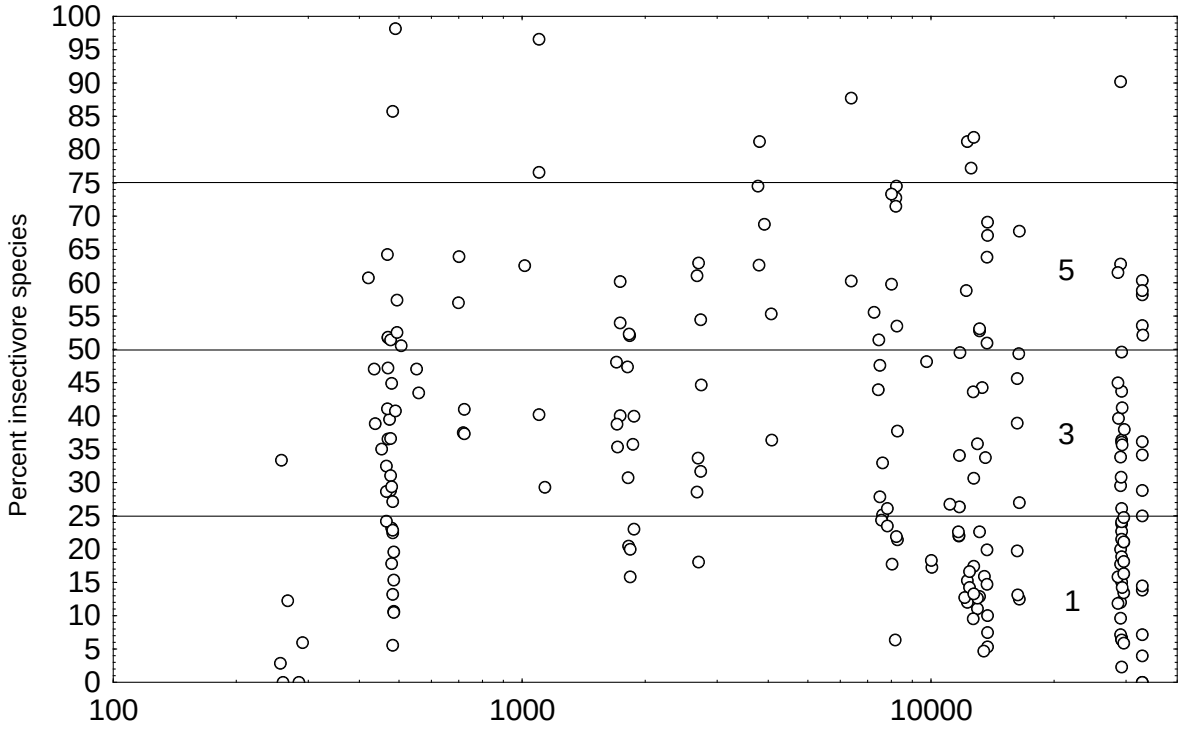

Number of centrarchid species
10
8
6
4
2
0
100
1000
10000
5
3
1

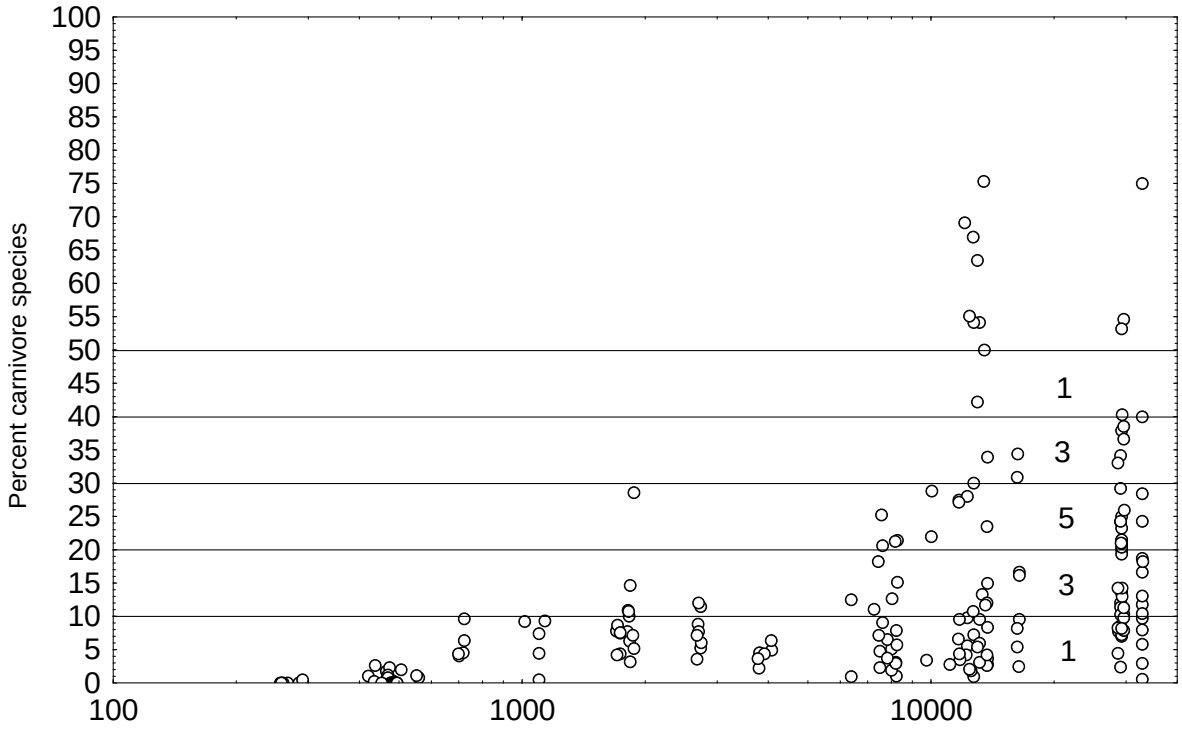

Number of round bodied suckers
10
8
6
4
2
0
100
1000
10000
5
3
1

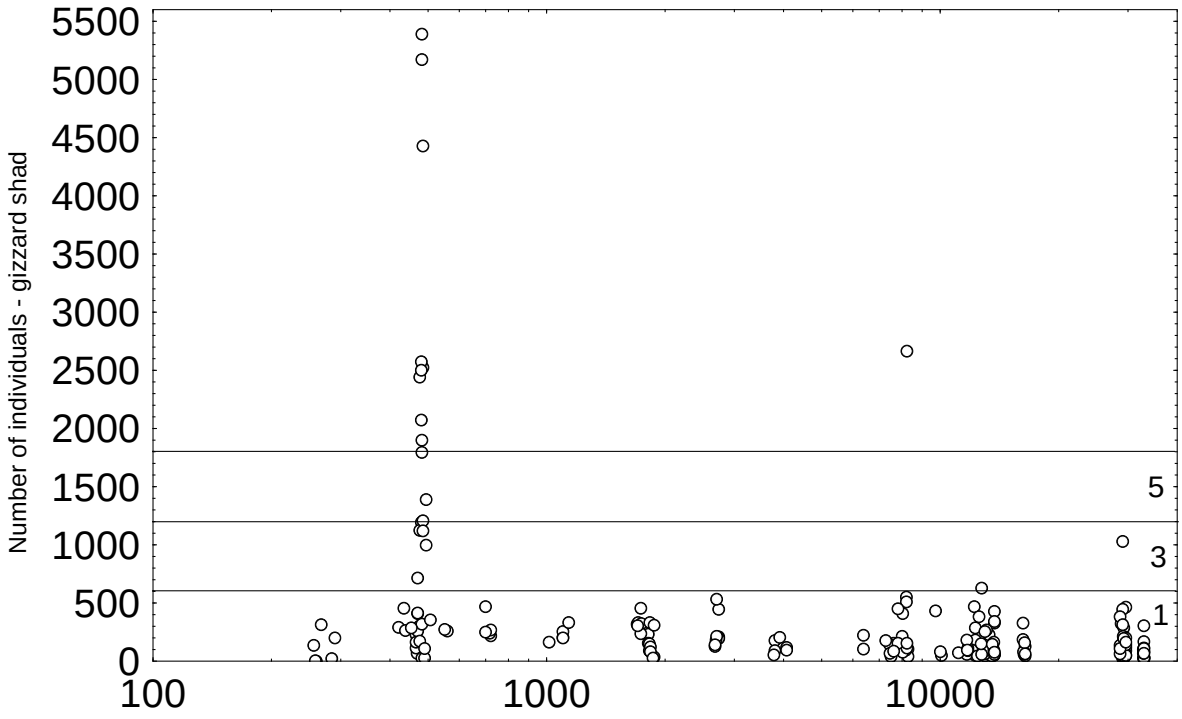

Number of sensitive species
20
18
16
14
12
10
8
6
4
2
0
100
1000
10000
5
3
1

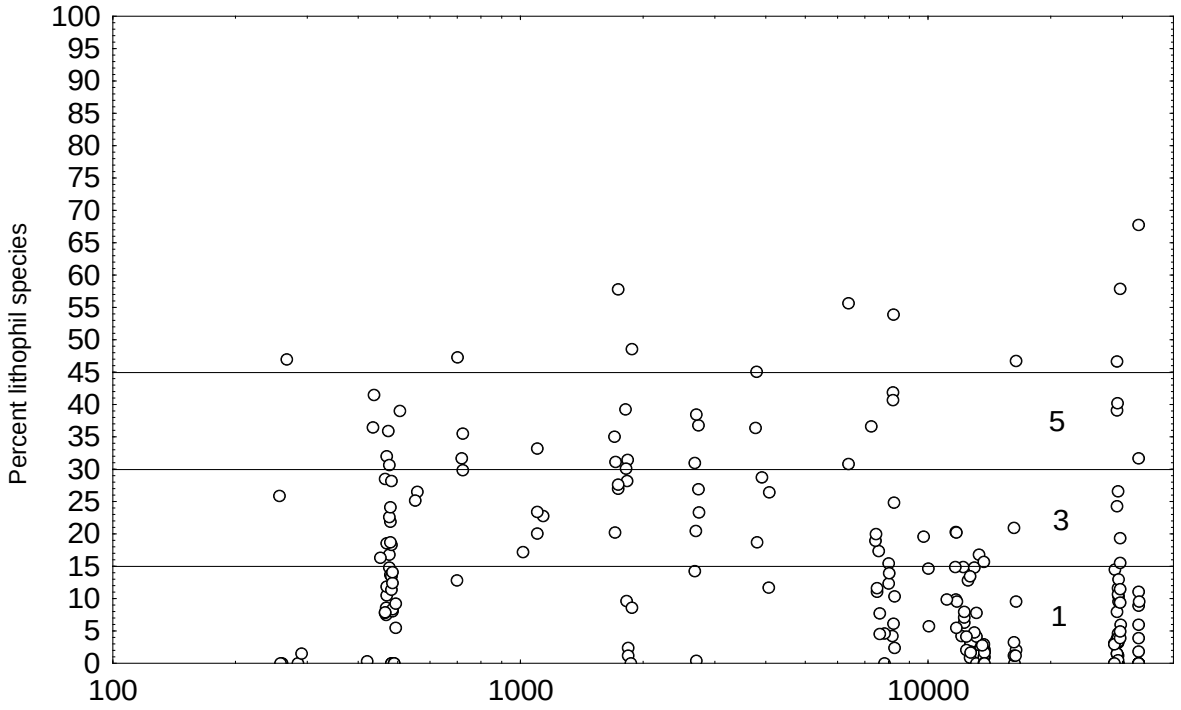

Percent tolerant species
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
100
1000
10000
1
3
5

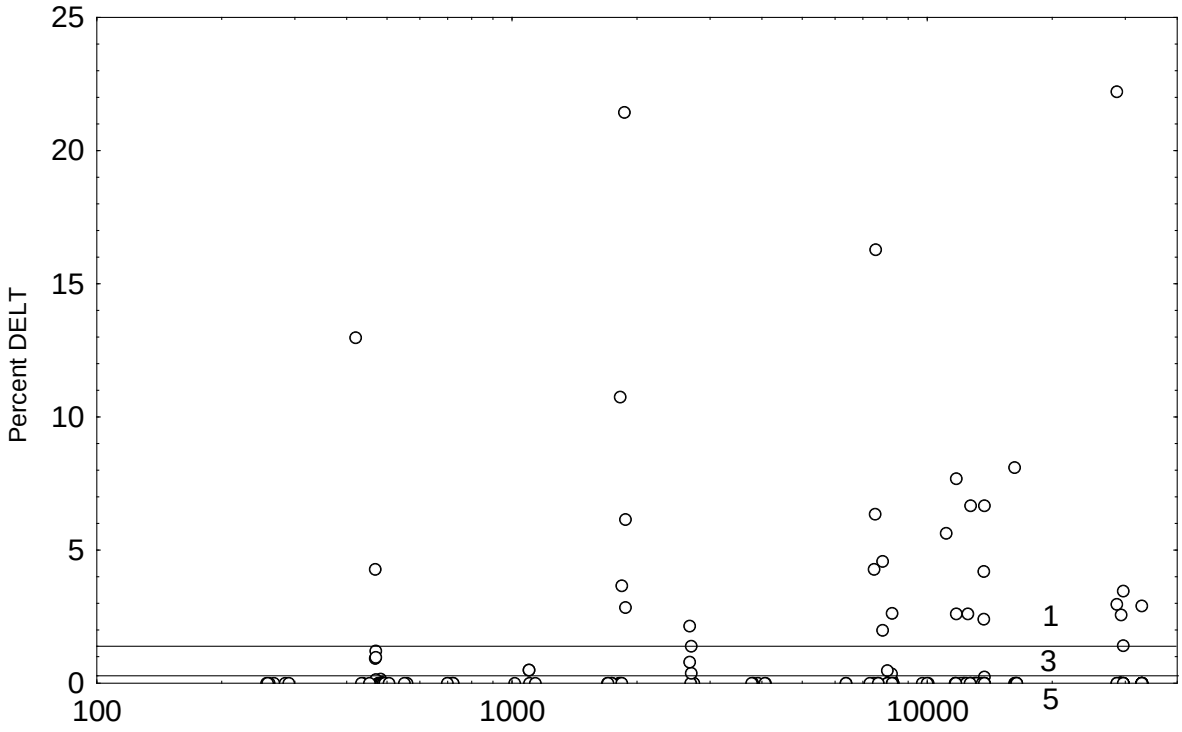

Percent omnivore species
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
100
1000
10000
1
3
5


Percent insectivore species
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
100
1000
10000
5
3
1


Percent carnivore species
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
100
1000
10000
1
3
5
3
1


Number of individuals - gizzard shad
5500
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
100
1000
10000
5
3
1


Percent lithophil species
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
100
1000
10000
5
3
1


Percent DELT
25
20
15
10
5
0
100
1000
10000
1
3
5

Ohio River Metrics

These series of metrics are developed for use on the Ohio River and are based on the study by Emery *et al*., 2003. This index can be applied to all Ohio River sites along the Indiana shoreline. Rkm = Ohio River kilometer. Guild assignments for the ORFiN are included in Appendix 1 of Emery *et al.,* 2003..

Location	Metric	1	3	5
all Ohio River sites	Total number of species (excludes nonindigeneous species & hybrids)	X ≤ (-0.0046* rkm) + 48.28)*0.33	(-0.0046* rkm) + 48.28)* 0.33 < X< (-0.0046*(rkm) + 48.28) * 0.66	X ≥ (-0.0046* (rkm) + 48.28) * 0.66
all Ohio River sites	Number of sucker spp.	X≤ (-0.0035*(rkm) + 14.48)*0.33	(-0.0035 * (rkm) + 14.48) * 0.33 < X <(-0.0035*(rkm) + 14.48) * 0.66	X ≥ (-0.0035* (rkm) + 14.48) * 0.66
all Ohio River sites	Number of centrarchid species	X < 3	3 ≤ X < 6	X ≥ 6
all Ohio River sites	Number of great river species	X < 2	2 ≤ X ≤ 3	X > 3
all Ohio River sites	Number of intolerant species	X ≤ (-0.004* (rkm) + 12.87) * 0.33	(-0.004 * (rkm) + 12.87) * 0.33 < X <(-0.004*(rkm) + 12.87) * 0.66	X ≥ (-0.004* (rkm) + 12.87) * 0.66
all Ohio River sites	Percent tolerant species as individuals	X > 6.66	3.33 < X ≤ 6.66	X ≤ 3.33
all Ohio River sites	Percent simple lithophilic spawning as individuals	X ≤ (-0.0237* (rkm) + 105.09) * 0.33	(-0.0237 * (rkm) + 105.09) * 0.33 < X <(-0.0237*(rkm) + 105.09)* 0.66	X ≥ (-0.0237 * (rkm) + 105.09) * 0.66
all Ohio River sites	Percent Nonnative species as individuals	X> 8.58	4.3 < X ≤ 8.58	X ≤ 4.3
all Ohio River sites	Percent detritivore species as individuals	X ≥ (-0.006* (rkm) + 51.49) * 0.66	(-0.006* (rkm) + 51.49) * 0.33 <X<(-0.006* (rkm) + 51.49) * 0.66	X ≤ (-0.006* (rkm) + 51.49) * 0.33
all Ohio River sites	Percent invertivore species as individuals	X ≤ (-0.0335* (rkm) + 138.4) * 0.33	(-0.0335* (rkm) + 138.4) * 0.33 <X< (-0.0335* (rkm) + 138.4) * 0.66	X ≥ (-0.0335* (rkm) + 138.4) * 0.66
all Ohio River sites	Percent piscivore species as individuals	X ≤ (-0.0047* (rkm) + 96.56) * 0.33	(-0.0047* (rkm) + 96.56) * 0.33 <X< (-0.0047* (rkm) + 96.56) * 0.66	X ≥ (-0.0047* (rkm) + 96.56) * 0.66
all Ohio River sites	Number of DELT anomalies	X ≥ 4	2 ≤ X < 4	X < 2
all Ohio River sites	Catch Per Unit Effort *	X ≤ (-0. 018* (rkm) + 740.29) * 0.33	(-0.018* (rkm) + 740.29) * 0.33 <X <(-0.0018*(rkm) + 740.29) * 0.66	X ≥ (-0.018*(rkm) + 740.29) * 0.66

NOTE: Large numbers of a single species can often "swamp" certain metrics making it difficult to assess site status. Therefore, it is essential to remove gizzard shad (*Dorosoma cepedianum*) and emerald shiner from this particular set of data prior to IBI calculations. CPUE is based on the relative number of individuals collected using a standard sampling technique removing species designated as tolerant, non-indigenous (including both alien and non-indigenous species), and hybrids. Scoring modification are made when less than 50 (without gizzard shad and emerald shiner, non-indigenous species, and hybrids) or 100 (with gizzard shad and emerald shiner) individuals are collected. Scoring modifications include scoring all percentage metrics "1".

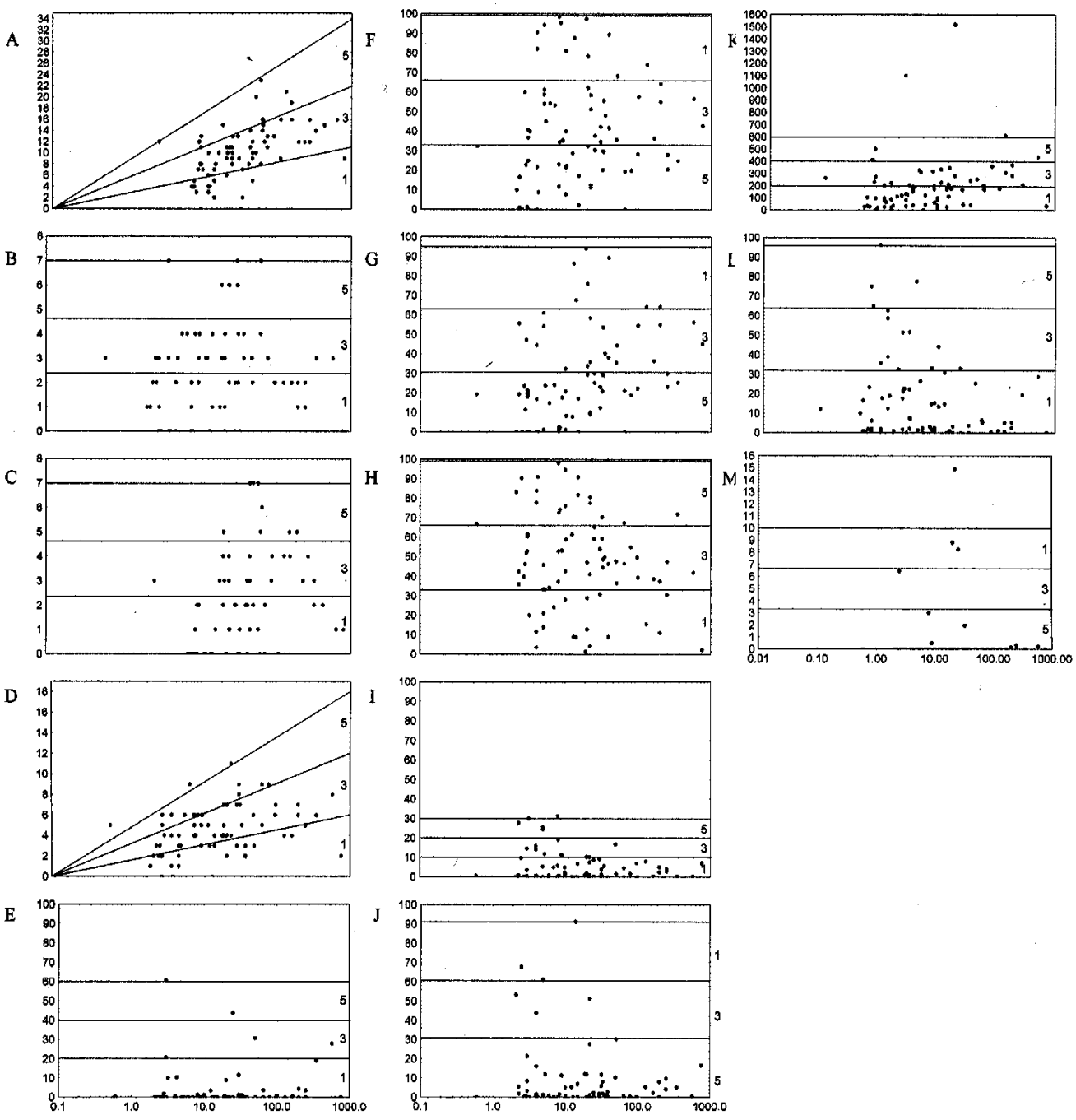
In 2008 ORSANCO developed an approach for improving upon an existing multimetric index that included keeping the original metrics, but moving from a discrete (1-3-5) to a continuous (0-100) scoring approach, scaling metrics to catchment area, and calibrating the index for five discrete classes of habitat as identified based on a combination of substrate composition and depth (modified ORFIN). Overall, these modifications allow for a more predictive approach to establishing baseline expectations for the revised index, and are expected to result in more accurate assessments as natural variability has been reduced. MORfin scores of less than the 25th percentile may be inferred as having an adverse biological community response to an impact. The Ohio River is another example of the diversity of water body types that need special consideration in site specific demonstration study design. Applicants whose discharge is to the Ohio River will follow ORSANCO's MORFin methodology for habitat classification, fish sampling, and ORFin scaling.

Lake Michigan Nearshore Metrics

These series of metrics are developed for use on Lake Michigan nearshore habitats and is based on the study by Simon (2004b). This index can be applied to all Lake Michigan nearshore sites along the Indiana shoreline.

Category	Metric	5	3	1
B	Total number of species	**See**	**Fig A**	
B	Number of centrarchid species (Fig B)	**≥ 5**	**3-4**	**≤ 2**
B	Number Lake Michigan obligate species (Fig C)	**≥ 5**	**3-4**	**≤2**
B	Number lake habitat species	**See**	**Fig D**	
B	Percent individuals intolerant species (Fig E)	**< 20%**	**20-40%**	**> 40%**
B	Percent individuals tolerant species (Fig F)	**≤33%**	**34-66%**	**≥ 67%**
B	Percent individuals as detritivores (Fig G)	**≤33%**	**34-66%**	**≥ 67%**
B	Percent individuals as insectivores (Fig H)	**≥ 67%**	**34-66%**	**≤33%**
B	Percent individuals as carnivores (Fig I)	**> 20%**	**10-20%**	**< 10%**
B	Percent individuals as exotic or non-native species (Fig J)	**≤ 32%**	**33-61%**	**≥ 62%**
B	Catch Per Unit Effort-gizzard shad (=number of individuals) (Fig K)	**≥401**	**201-400**	**≤ 200**
B	Percent individuals as phytophils (Fig L)	**≥ 67%**	**34-66%**	**≤33%**
B	Percent individuals with DELT anomalies (Fig M)	**≤ 3.2%**	**3.3-6.9%**	**≥ 7%**

NOTE: Large numbers of a single species can often "swamp" certain metrics making it difficult to assess site status. Therefore, it is essential to remove gizzard shad (*Dorosoma cepedianum*) from this particular set of data prior to IBI calculations (see metric CPUE – gizzard shad). Scoring modification are made when less than 50 (without gizzard shad) or 100 (with gizzard shad) individuals are collected. Scoring modifications include scoring all percentage metrics "1".

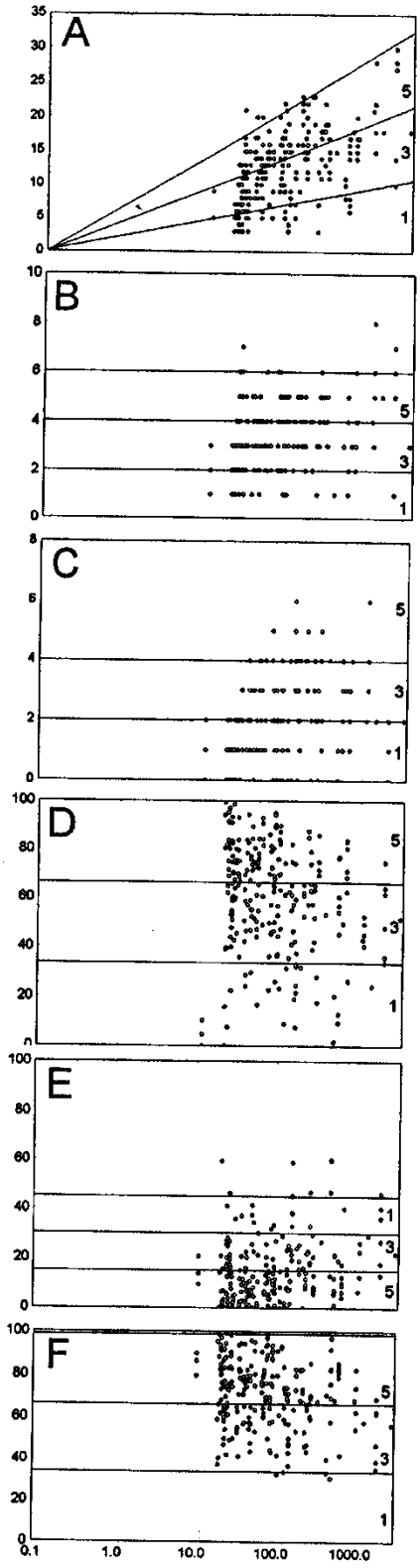

A
B
C
D
E
F
G
H
I
J
K
L
M
WETTED WETLAND WIDTH (m)

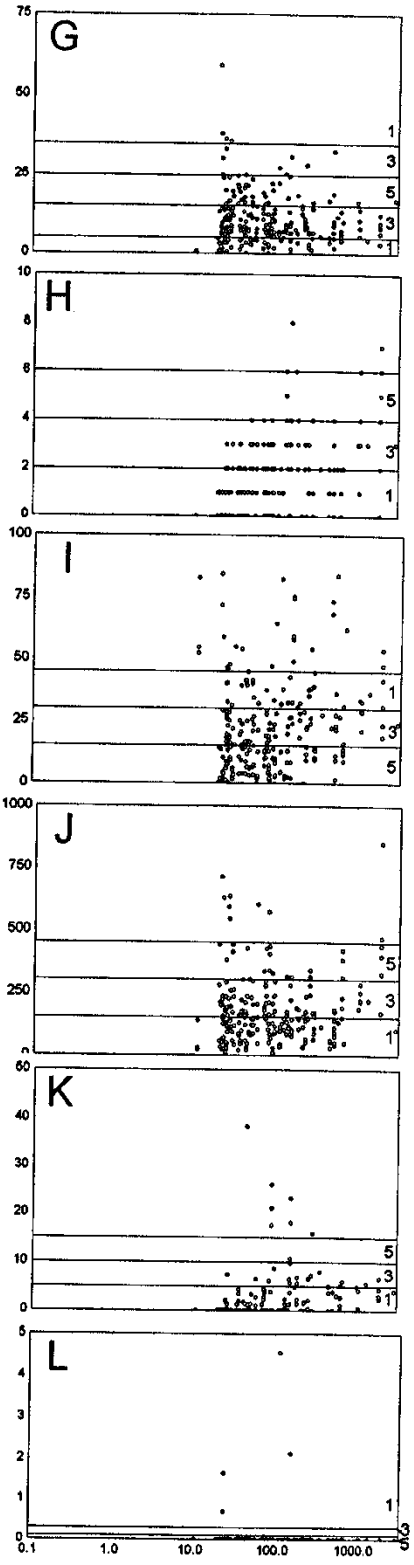
Natural Lake and Reservoir Metrics (Central Corn Belt Plain, Northern Indiana Till Plain, Huron-Erie Lake Plain, Eastern Corn Belt Plain Ecoregions)

These series of metrics are developed for use on natural lake and reservoir metrics in four ecoregions in northern Indiana. These metrics are based on the study by Simon, 2001. This index can be applied to all lake sites (> 20 ha) in the four Indiana ecoregions.

Category	Metric	5	3	1
B	Total number of species	**See**	**Fig A**	
B	Number of centrarchid species (Fig B)	**≥ 5**	**3-4**	**≤ 2**
B	Number of native minnow species (Fig C)	**≥ 5**	**3-4**	**≤2**
B	Percent individuals as lake obligate species (Fig D)	**≥ 67%**	**34-66%**	**≤ 33%**
B	Percent individuals as omnivores (Fig E)	**< 15%**	**15-30%**	**> 30%**
B	Percent individuals as insectivores (Fig F)	**≥ 67%**	**33-66%**	**<33%**
B	Percent individuals as carnivores (Fig G)	**>15%-25%**	**> 5-15% or >25-≤35%**	**≤5% or > 35%**
B	Number of sensitive species (Fig H)	**≥ 5**	**3-4**	**≤2**
B	Percent individuals as tolerant species (Fig I)	**< 15%**	**15-30%**	**> 30%**
B	Catch Per Unit Effort–gizzard shad (=number of individuals) (Fig J)	**> 300**	**150-300**	**<150**
B	Percent individuals simple lithophils (Fig K)	**>10%**	**5-10%**	**<5%**
B	Percent individuals DELT anomalies (Fig L)	**< 0.1%**	**0.1-0.3%**	**> 0.3%**

NOTE: Large numbers of a single species can often "swamp" certain metrics making it difficult to assess site status. Therefore, it is essential to remove gizzard shad (*Dorosoma cepedianum*) from this particular set of data prior to IBI calculations (see metric CPUE – gizzard shad). Scoring modification are made when less than 50 (without gizzard shad) or 100 (with gizzard shad) individuals are collected. Scoring modifications include scoring all percentage metrics "1".


A
B
C
D
E
F
0.1
1.0
10.0
100.0
1000.0
SURFACE AREA (ha)

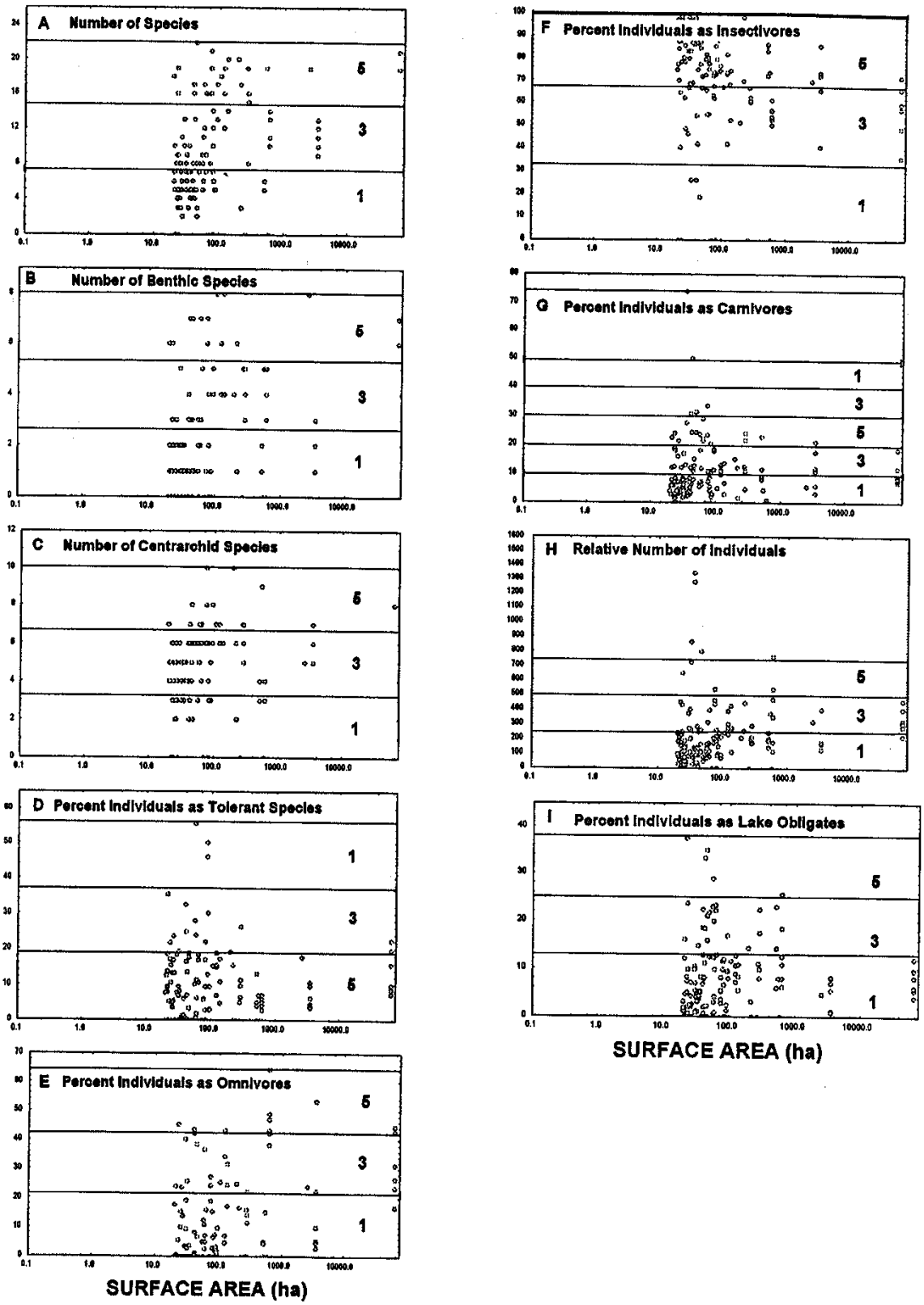

G
H
I
J
K
L
0.1
1.0
10.0
100.0
1000.0
SURFACE AREA (ha)

Oxbow Lake and Reservoir Metrics
(Interior River Lowland and Interior Plateau)

These series of metrics are developed for use on lakes larger than 20 ha surface area and are based on the study by Simon, 2002. This index can be applied to all Interior River Lowland and Interior Plateau lakes within these Ecoregions.

Category	Metric	5	3	1
B	Total number of species (Fig A)	**≥ 15**	**8-14**	**≤7**
B	Number of benthic species (Fig B)	**≥ 6**	**3-5**	**≤ 2**
B	Number of centrarchid species (Fig C)	**≥ 7**	**4-6**	**≤ 3**
B	Percent individuals as tolerant species (Fig D)	**≤19**	**20-37%**	**> 37%**
B	Percent individuals as detritivores (Fig E)	**< 22%**	**22-42%**	**> 42%**
B	Percent individuals as insectivores (Fig F)	**> 66%**	**33-66%**	**<33%**
B	Percent individuals as carnivores (Fig G)	**>20-<30%**	**10-20 or 30-40%**	**<10% or >40%**
B	Catch Per Unit Effort)-gizzard shad (=number of individuals (Fig H)	**> 500**	**250-500**	**<250**
B	Percent individuals as lake obligate species (Fig I)	**> 24%**	**12-24%**	**< 12%**
B	Percent individuals with DELT anomalies	**< 0.1%**	**0.1-0.3%**	**> 0.3%**

NOTE: Large numbers of a single species can often "swamp" certain metrics making it difficult to assess site status. Therefore, it is essential to remove gizzard shad (*Dorosoma cepedianum*) from this particular set of data prior to IBI calculations (see metric CPUE – gizzard shad). Scoring modification are made when less than 50 (without gizzard shad) or 100 (with gizzard shad) individuals are collected. Scoring modifications include scoring all percentage metrics "1".


A Number of Species
B Number of Benthic Species
C Number of Centrarchid Species
D Percent Individuals as Tolerant Species
E Percent Individuals as Omnivores
F Percent Individuals as Insectivores
G Percent Individuals as Carnivores
H Relative Number of Individuals
I Percent Individuals as Lake Obligates
SURFACE AREA (ha)

APPENDIX M

Office of Water Quality Modified Version (2010) of the Qualitative Habitat Evaluation Index (QHEI) for Flowing Waters Based on Rankin (1995).

Fish Collection Data Sheet

OWQ Biological Studies QHEI (Qualitative Habitat Evaluation Index)

Sample #	bioSample #	Stream Name	Location

Surveyor	Sample Date	County	Macro Sample Type	☐ Habitat Complete	QHEI Score:

1] ***SUBSTRATE*** Check ONLY Two predominant substrate TYPE BOXES; estimate % and check every type present

BEST TYPES

PREDOMINANT P R — PRESENT P R — TOTAL %

☐☐ BLDR/SLABS [10] ☐☐ ____
☐☐ BOULDER [9] ☐☐ ____
☐☐ COBBLE [8] ☐☐ ____
☐☐ GRAVEL [7] ☐☐ ____
☐☐ SAND [6] ☐☐ ____
☐☐ BEDROCK [5] ☐☐ ____

NUMBER OF BEST TYPES: ☐ 4 or more [2] ☐ 3 or less [0]

OTHER TYPES

PREDOMINANT P R — PRESENT P R — TOTAL %

☐☐ HARDPAN [4] ☐☐ ____
☐☐ DETRITUS [3] ☐☐ ____
☐☐ MUCK [2] ☐☐ ____
☐☐ SILT [2] ☐☐ ____
☐☐ ARTIFICIAL [0] ☐☐ ____

(Score natural substrates; ignore sludge from point-sources)

ORIGIN Check ONE (Or 2 & average)

☐ LIMESTONE [1]
☐ TILLS [1]
☐ WETLANDS [0]
☐ HARDPAN [0]
☐ SANDSTONE [0]
☐ RIP/RAP [0]
☐ LACUSTRINE [0]
☐ SHALE [-1]
☐ COAL FINES [-2]

QUALITY

SILT
☐ HEAVY [-2]
☐ MODERATE [-1]
☐ NORMAL [0]
☐ FREE [1]

EMBEDDEDNESS
☐ EXTENSIVE [-2]
☐ MODERATE [-1]
☐ NORMAL [0]
☐ NONE [1]

Substrate ☐ Maximum 20

Comments

2] ***INSTREAM COVER*** Indicate presence 0 to 3 and estimate percent: **0**–Absent; **1**–Very small amounts or if more common of marginal quality; **2**-Moderate amounts, but not of highest quality or in small amounts of highest quality; **3**-Highest quality in moderate or greater amounts (e.g., very large boulders in deep or fast water, large diameter log that is stable, well developed root wad in deep/fast water, or deep, well-defined, functional pools.)

% Amount		% Amount		% Amount	
___ __	UNDERCUT BANKS [1]	___ __	POOLS > 70cm [2]	___ __	OXBOWS, BACKWATERS [1]
___ __	OVERHANGING VEGETATION [1]	___ __	ROOTWADS [1]	___ __	AQUATIC MACROPHYTES [1]
___ __	SHALLOWS (IN SLOW WATER) [1]	___ __	BOULDERS [1]	___ __	LOGS OR WOODY DEBRIS [1]
___ __	ROOTMATS [1]				

AMOUNT Check ONE (Or 2 & average)

☐ EXTENSIVE > 75% [11]
☐ MODERATE 25 - 75% [7]
☐ SPARSE 5 - < 25% [3]
☐ NEARLY ABSENT < 5% [1]

Cover ☐ Maximum 20

Comments

3] ***CHANNEL MORPHOLOGY*** Check ONE in each category (Or 2 & average)

SINUOSITY	DEVELOPMENT	CHANNELIZATION	STABILITY
☐ HIGH [4]	☐ EXCELLENT [7]	☐ NONE [6]	☐ HIGH [3]
☐ MODERATE [3]	☐ GOOD [5]	☐ RECOVERED [4]	☐ MODERATE [2]
☐ LOW [2]	☐ FAIR [3]	☐ RECOVERING [3]	☐ LOW [1]
☐ NONE [1]	☐ POOR [1]	☐ RECENT OR NO RECOVERY [1]	

Channel ☐ Maximum 20

Comments

4] ***BANK EROSION AND RIPARIAN ZONE*** Check ONE in each category for EACH BANK (Or 2 per bank & average)

River right looking downstream

EROSION (L R)

☐☐ NONE/LITTLE [3]
☐☐ MODERATE [2]
☐☐ HEAVY/SEVERE [1]

RIPARIAN WIDTH (L R)

☐☐ WIDE > 50m [4]
☐☐ MODERATE 10-50m [3]
☐☐ NARROW 5-10m [2]
☐☐ VERY NARROW [1]
☐☐ NONE [0]

FLOOD PLAIN QUALITY (L R)

☐☐ FOREST, SWAMP [3]
☐☐ SHRUB OR OLD FIELD [2]
☐☐ RESIDENTIAL, PARK, NEW FIELD [1]
☐☐ FENCED PASTURE [1]
☐☐ OPEN PASTURE, ROWCROP [0]

(L R)

☐☐ CONSERVATION TILLAGE [1]
☐☐ URBAN OR INDUSTRIAL [0]
☐☐ MINING /CONSTRUCTION [0]

Indicate predominant land use(s) past 100m riparian.

Riparian ☐ Maximum 10

Comments

5] ***POOL/GLIDE AND RIFFLE/RUN QUALITY***

MAXIMUM DEPTH Check ONE (ONLY!)

☐ > 1m [6]
☐ 0.7 - < 1m [4]
☐ 0.4 - < 0.7m [2]
☐ 0.2 - < 0.4m [1]
☐ < 0.2m [0]

CHANNEL WIDTH Check ONE (Or 2 & average)

☐ POOL WIDTH > RIFFLE WIDTH [2]
☐ POOL WIDTH = RIFFLE WIDTH [1]
☐ POOL WIDTH < RIFFLE WIDTH [0]

CURRENT VELOCITY Check ALL that apply

☐ TORRENTIAL [-1] ☐ SLOW [1]
☐ VERY FAST [1] ☐ INTERSTITIAL [-1]
☐ FAST [1] ☐ INTERMITTENT [-2]
☐ MODERATE [1] ☐ EDDIES [1]

Indicate for reach – pools and riffles.

Recreation Potential (Circle one and comment on back)

☐ Primary Contact
☐ Secondary Contact

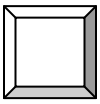
Pool / Current ☐ Maximum 12

Comments

Indicate for functional riffles; Best areas must be large enough to support a population of riffle-obligate species:

☐ NO RIFFLE [metric = 0]

RIFFLE DEPTH **RUN DEPTH** **RIFFLE / RUN SUBSTRATE** (Check ONE (Or 2 & average)) **RIFFLE / RUN EMBEDDEDNESS**

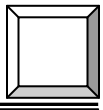
☐ BEST AREAS > 10cm [2]	☐ MAXIMUM > 50cm [2]	☐ STABLE (e.g., Cobble, Boulder) [2]	☐ NONE [2]	Riffle / Run
☐ BEST AREAS 5 - 10cm [1]	☐ MAXIMUM < 50cm [1]	☐ MOD. STABLE (e.g., Large Gravel) [1]	☐ LOW [1]	
☐ BEST AREAS < 5 cm [metric = 0]		☐ UNSTABLE (e.g., Fine Gravel, Sand) [0]	☐ MODERATE [0]	
			☐ EXTENSIVE [-1] Maximum	

Fish Collection Data Sheet

Comments 8

6] *GRADIENT* (ft / mi) ☐ VERY LOW - LOW [2 – 4] ☐ MODERATE [6 - 10] **% POOL:** **GLIDE:** ent Maximum

DRAINAGE AREA (mi^2) ☐ HIGH - VERY HIGH [10 - 6] **% RUN:** **FLE:**



IDEM 07/06/10

Fish Collection Data Sheet

OWQ Biological Studies QHEI (Qualitative Habitat Evaluation Index)

COMMENT _____

A-CANOPY

- ☐ > 85% - Open
- ☐ 55% - < 85%
- ☐ 30% - < 55%
- ☐ 10% - < 30%
- ☐ < 10% - Closed

B-AESTHETICS

- ☐ Nuisance algae
- ☐ Invasive macrophytes
- ☐ Excess turbidity
- ☐ Discoloration
- ☐ Foam / Scum
- ☐ Oil sheen
- ☐ Trash / Litter
- ☐ Nuisance odor
- ☐ Sludge deposits
- ☐ CSOs / SSOs / Outfalls

C-RECREATION

Area Depth ☐ Public ☐ Private

Pool: ☐ > 100 ft^2 ☐ > 3 ft

D-MAINTENANCE

☐ Active ☐ Historic

Succession: ☐ Young ☐ Old

☐ Spray ☐ Islands ☐ Scoured

Snag : ☐ Removed ☐ Modified

Leveed: ☐ One sided ☐ Both banks

☐ Relocated ☐ Cutoffs

Bedload: ☐ Moving ☐ Stable

☐ Armoured ☐ Slumps

☐ Impounded ☐ Desiccated

☐ Flood control ☐ Drainage

E-ISSUES

☐ WWTP ☐ CSO ☐ NPDES

☐ Industry ☐ Urban

☐ Hardened ☐ Dirt & Grime

☐ Contaminated ☐ Landfill

BMPs: ☐ Construction ☐ Sediment

☐ Logging ☐ Irrigation ☐ Cooling

Erosion: ☐ Bank ☐ Surface

☐ False bank ☐ Manure ☐ Lagoon

☐ Wash H_2O ☐ Tile ☐ H_2O Table

Mine: ☐ Acid ☐ Quarry

Flow: ☐ Natural ☐ Stagnant

☐ Wetland ☐ Park ☐ Golf

☐ Lawn ☐ Home

☐ Atmospheric deposition

Looking upstream (> 10m, 3 readings; < 10m, 1 reading in middle) ; Round to the nearest whole percent

	Left	Middle	Right	Total Average
% open	%	%	%	%

Stream Drawing:

APPENDIX N

Quality Assurance and Quality Control Quick Reference for Evaluating QHEI Scoring.

QHEI
Qualitative Habitat Evaluation Index

QA/QC
Quick Reference

Note:

- The maximum total score allowed for the QHEI is 100.
- Only one box per column should be checked. However, when two or more boxes per column are checked, an average score for that column is used in the calculation.
- Metric and total scores are whole numbers.
- Round to the nearest whole number (if the number ends in 0.5, round up to the nearest whole number).
- If a category has been left blank try to ask the individual who completed the form. If unavailable, calculate the metric as is.
- All scoring summations should be checked by a person who did not fill out the form.
- When in doubt, ask!

APPENDIX O

Application for Alternative Thermal Effluent Limitations (ATEL) and Thermal Mixing Zone

APPLICATION FOR ALTERNATIVE THERMAL EFFLUENT LIMITATIONS (ATEL) AND THERMAL MIXING ZONE

The following information MUST be submitted to IDEM upon completion of the Detailed Demonstration:

1. A quantitative description and rationale for the proposed ATEL,

2. The Absence of Prior Appreciable Harm assessment or RIS assessment supporting the proposed ATEL,

3. All of the thermal and biological data collected during the Demonstration in its most detailed form, provided in Microsoft Excel® or Microsoft Access® format. Summarized data and data compilations will NOT be accepted,

3. Executive Summary of Study Findings,

4. Request for Thermal Mixing Zone. The Thermal Mixing Zone request must specify the temperature within and at the edge of the Zone of Initial Dilution (ZID), the temperature at the edge of the chronic mixing zone (the point at which the temperature stabilizes) and the proposed sizes of the mixing zones as applicable,

5. Any other information deemed necessary and developed by the discharger for the demonstration,

6. A delineation/model of the thermal plume under representative flow conditions based on in-stream temperature monitoring data, and with the proposed point of compliance for the proposed thermal limits, and

7. Any additional studies conducted since the last Demonstration was completed and an analysis of any changes from the previous assessments and conclusions.

The application must be signed by an appropriate signatory as defined in 327 IAC 5-2-22 to be valid. The signature attests to the following:

"I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are

significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations."

_____	_____
(Printed Name)	(Title)
_____	_____
(Signature)	(Date Signed)