Field Methods for Evaluating Primary Headwater Streams in Ohio (Version 4.1)


Spring Creek, Cuyahoga County

Division of Surface Water
May 2020

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Notices:

Ohio EPA has developed this manual to provide standardized assessment methodologies for primary headwater streams. The methods provided in this manual are used to discern the actual and expected biological conditions in primary headwater streams. The use of the procedures in this manual is particularly relevant in the context of Section 401 water quality certifications and antidegradation reviews.

This manual replaces prior documents made available to the public on standardized sampling in primary headwater habitat streams (Davic, 1996; Anderson et al. 1999; Ohio EPA, 2002a; Ohio EPA, 2009; Ohio EPA, 2012). Questions regarding Ohio EPA water quality standard regulations and aquatic life use designations should be directed to the Division of Surface Water, PO Box 1049, Columbus Ohio 43216-1049 [(614) 644-2001]. Ohio EPA maintains a primary headwater web page, accessible at http://www.epa.ohio.gov/dsw/wqs/headwaters/index.aspx that contains this field manual as well as related documents and information.

All addresses for access to internet sites for sources of information referenced in this manual were accurate at the time of publication. Over time it can be expected that these links may become outdated. However, the Ohio EPA maintains copies of all documents referenced in this manual that can be obtained by contacting the Ohio EPA Division of Surface Water.

The proper citation for this document is as follows:

Ohio EPA. 2020. Field Methods for Evaluating Primary Headwater Streams in Ohio. Version 4.1. Ohio EPA Division of Surface Water, Columbus, Ohio. 130 pp.

Acknowledgments:

The original version of this manual was authored by Robert Davic, Paul Anderson and Steve Tuckerman. This 2020 revision of the manual was edited by Chris Skalski, Ohio EPA Division of Surface Water. Technical questions regarding the procedures described in this manual should be directed to Chris Skalski at: (614) 644-2144; Ohio EPA Division of Surface Water, 50 West Town Street, Suite 700, Columbus, Ohio 43216-1049; or via e-mail: chris.skalski@epa.ohio.gov. Lead investigators for the Ohio EPA primary headwater stream assessment program were: Paul Anderson, Mike Bolton, Robert Davic, and Steve Tuckerman; under the direction of project coordinators Dan Dudley, Bill Schumacher, and Chris Skalski. Other members of the Ohio EPA primary headwater stream work-group who contributed technical review and/or field data were: Jim Grow, Joe Loucek, MaryAnne Mahr, Ed Moore, Louise Snyder, Ric Queen, Ed Rankin, Hugh Trimble, and Chris Yoder. We acknowledge the significant efforts of numerous Ohio EPA summer interns as well as Matt Scharver and Chad Edgar of the Lake Soil and Water Conservation District for their contribution in the collection of data. We also thank members of the Ohio Academic Panel that was convened by Dr. Gene Willeke of Miami University in Oxford, Ohio for their valuable technical comments on sampling procedures contained in the original version of this manual.

Conversions:

Throughout this manual various metric and English measurement units are cited due to different protocols established in the engineering and basic sciences. Some useful conversions are given below:

To covert	into	Multiply by or use formula
Square mile	hectare	259
Square mile	square kilometer	2.590
Feet	meters	0.3048
Inches	centimeters	2.540
Miles	kilometers	1,609
Hectares	acres	2.471
Celsius	Fahrenheit	(1.8 * °C) + 32
Fahrenheit	Celsius	5/9 * (°F - 32)

List of Acronyms:

7Q10	Minimum seven-day average flow with a ten-year recurrence interval (see USGS, 2001 for Ohio data).
CWA	Clean Water Act (Public Law 92-500, October 18, 1972)
CWH	Coldwater Habitat (OAC Chapter 3745-1)
DQO	Data quality objective
EPT Taxa	Benthic macroinvertebrates from the Ephemeroptera, Plecoptera, and Trichoptera (mayflies, stoneflies, and caddisflies, respectively)
EWH	Exceptional Warmwater Habitat (OAC Chapter 3745-1)
GIS	Geographic Information System
GPS	Geographic Positioning System
HHEI	Headwater Habitat Evaluation Index
HMFEI	Headwater Macroinvertebrate Field Evaluation Index
IBI	Index of Biotic Integrity
ICI	Invertebrate Community Index
MWH	Modified Warmwater Habitat (OAC Chapter 3745-1)
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service (formerly SCS)
OAC	Ohio Administrative Code (state administrative rules)
Ohio EPA	State of Ohio Environmental Protection Agency
ODNR	State of Ohio Department of Natural Resources
ORC	Ohio Revised Code (state law)
PHW	Primary Headwater
QHEI	Qualitative Habitat Evaluation Index
SCS	Soil Conservation Service (now NRCS)
SWCD	Soil and Water Conservation District
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WWH	Warmwater Habitat (OAC Chapter 3745-1)

Preface to Version 1.0 (Ohio EPA, 2002):

The Federal Clean Water Act provides for "maintaining the biological integrity of the nation's waters", from the mouths to the headwaters. In carrying out the regulatory responsibilities for streams in the State of Ohio, there is a need for a methodology that deals with proposed activities in the extreme headwaters areas, what Ohio EPA calls "primary headwater habitat" (PHWH) streams. It is well established in the scientific literature that headwater streams of the kind addressed in this manual are important to the quality of water and biological communities in larger streams to which these primary headwater streams are tributary.

The primary headwater streams addressed in this manual are quite small, less than 1.0 mi^2 drainage area. Many of them would not show up as blue lines on USGS 1:24,000 quadrangle maps, although almost all of them would be visible and marked on county soil maps. These streams are not often defined or assigned beneficial uses in Ohio water quality standards. The sampling methods, and concurrent biological and habitat indices now used by OEPA to classify waterways for existing water quality (e.g., IBI, ICI, QHEI) are oriented toward larger streams. Because these "index of biotic integrity" assessment systems are watershed size dependent, they often cannot be used to identify the well-being of the native fauna that survive and reproduce in small headwater stream ecosystems.

In the absence of comparable measures of stream quality for extreme headwaters, government agencies responsible for protection of water resource integrity may appear to be arbitrary if they seek to approve or deny a permit or certification application to lower water quality in primary headwater streams. The stream classification methodology presented in this manual helps to fill that void, in a manner similar to the Ohio EPA (ORAM) sampling methods now being used to classify jurisdictional wetlands. This primary headwater stream manual outlines a predictable three-tiered protocol that can be used to conduct rapid assessment of headwater stream quality. The lowest level of field effort is a relatively rapid habitat evaluation procedure known as the “Headwater Habitat Evaluation Index” (HHEI). It is based on three physical measurements that have been found to correlate well with biological measures of stream quality. Two levels of biological assessment, one at an order-family level of taxonomic identification, the second to genus-species, provide flexibility in reaching a final decision on the appropriate aquatic life use designation needed to protect the native fauna of any primary headwater stream.

The great number of primary headwater streams in Ohio, their diverse ecological functions, and their value to the well-being of the larger rivers, lakes, and wetlands to which they are tributary underscores the importance of their proper classification and protection.

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A Quick Guide to the Primary Headwater (PHW) Stream Assessment Process

The following sequence of tasks summarizes the various steps involved in a PHW stream assessment.

Desktop Preparation (Section 2.0)

Step 1 Develop a study plan for conducting the PHW stream assessment. Identify the data quality objectives for the study, personnel to be involved and the equipment and supplies to be used for the study. (Sections 2.0 and 2.1)

Step 2 Obtain the NRCS county soil map, the USGS 7.5 minute topographic map, or other suitable mapping resource for the watershed area under investigation. (Section 2.2.1)

Step 3 Delineate the boundaries for the PHW assessment on the site map. Determine the total linear distance (feet or meters) of all potential PHW streams.

Step 4 Select the site(s) to be assessed using the guidelines in Section 3.0. Determine the total watershed area for each PHW stream to be assessed at the most downstream location of the property boundary or assessment area using the USGS STREAMSTATS web page, the USGS topographic map, the NRCS soil map, or other mapping tools at the appropriate scale. (Section 2.2.2)

Step 5 Prepare to conduct an on-site PHW stream evaluation if the watershed area is less than 1 mi^2 (259 ha). Prepare to conduct a QHEI/WWH stream evaluation if the watershed area is greater than 1 mi^2 (259 ha) (Section 3.2).

> Note: Where determined to be appropriate by a qualified biologist, a PHW evaluation can be conducted in streams with watershed areas greater than 1 mi^2 (259 ha), or a QHEI/WWH evaluation can be conducted in streams with watershed areas less than 1 mi^2 (259 ha) (see Section 3.2).

Field Reconnaissance and Sampling

Step 6 Determine if the streams in question are at or near base flow for the period of the year that the survey is being conducted (Section 2.3). If **NO**, do not proceed with evaluation. If **YES**, proceed with the assessment. In addition, determine if severe drought conditions exist or if stream flows in the vicinity of the study area are below the 7Q10 using USGS stream flow information. If the area is under drought conditions or stream flows in the vicinity of the study area are less than 7Q10 flow, the PHW stream assessment should not be conducted (see Section 2.3).

Step 7 Delineate (with flags or flag taping) 200 ft (60m) stream reach sections for each mainstem PHW stream. Begin stream reach delineation starting at the most downstream point of interest and continue in an upstream direction following the thalweg of the channel. Tributaries of the mainstem with channel lengths greater than 200 ft (60 m) should be evaluated as separate PHW streams. Very small seepage areas can be assessed as being part of the associated 200 ft (60 m) PHW stream reach. (Section 3.0)

Step 8 Record observational data on the PHW Form (Attachment 1) regarding the physical characteristics of the stream corridor including the stream flow condition, riparian zone land use and buffer width, channel modification category, etc. (Section 5.0). Take photographs and index them for later association with the appropriate data sheet. (Section 5.9.4)

Step 9 If water chemistry sampling is going to be conducted, do so before walking in the stream water and adding turbidity, or, collect samples from an undisturbed area. (Section 5.9.4)

Step 10 **If conducting a biological survey (Level 2 or Level 3 Assessment)**; begin by sampling for amphibians (salamanders), then fish, and finally benthic macroinvertebrates. Collect voucher specimens where appropriate. The sequence of sampling from vertebrates to invertebrates is important because it is much easier to conduct a visual search for aquatic salamander larvae when the water is clear. However, clear water is also conducive to the observation and collection of fish and benthic macroinvertebrate. Thus, you must wait until the water is clear to conduct these surveys unless site-specific conditions preclude this. Record all biological data on appropriate PHW biological field data sheets. (Section 6.0)

Step 11 **Complete the HHEI assessment for all sites (Level 1 Assessment).** Measure the bankfull width, maximum pool depth, and substrate composition as directed in this manual. Record all data on pages 1 and 2 of the PHW Field Form. Be sure to complete the entire PHW Form in Attachment 1. (Section 5.0)

Step 12 Optional habitat measures for parameters such as gradient (surveyed), flood prone width, and quantitative pebble counts may now be conducted if deemed necessary. (Section 5.3.1, Attachment 4)

Final Report

Step 13 Use data from the HHEI evaluation (Attachment 1) **and** the results of the biological survey (if conducted) to determine the PHW stream classification. Use the decision-making flowchart in Figure 18 when using the HHEI information in the absence of a biological survey. Use the guidelines from Section 7.0 and Figures 20 through 22 of this manual when using biological data to classify the stream reach.

Results from the biological survey take precedence over results from a HHEI survey unless there is reason to believe that chemical stressors are present which could limit the presence of biological communities (i.e., warm water resulting from the lack of riparian cover, toxic levels of heavy metals, elevated ammonia-N, low dissolved oxygen, high TDS (Total Dissolved Solids), low pH, excessive stream bed siltation, etc.). Where chemical stressors are shown to be present, the results from the HHEI survey can be used to identify the biological potential of the stream.

Summarize the results of the field evaluation and write a report describing the PHW stream assessment results of the stream(s) investigated.

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1.0 Introduction and Rationale

The term "headwaters" has been operationally defined by the Agency for nearly three decades as those streams having a drainage area of <20 mi^2. For the purposes of this manual, a stream is defined as a water body having a channel with well-defined bed and banks, either natural or artificial, that confines and conducts continuous or periodical flowing water. See Section 1.4 for additional details. The methods in this manual are calibrated to provide data necessary to assess and differentiate "primary" headwater streams in Ohio. The term primary headwater stream is used herein to communicate and describe a specific subset of headwater streams to which the methods and tools described in this manual were developed and are intended to be applied.

While many different names can generally be descriptive of Primary Headwater (PHW) streams (e.g, creek, brook, run, spring, ravine, hollow) the majority of these streams lack specific official names and are often referred to by Ohio EPA as "unnamed tributary" in association with the specific waterbody and river mile location into which it flows. A river mile (RM) refers to the lineal distance from the downstream terminus (i.e., mouth is RM 0.0) and moving in an upstream direction.

PHW streams are those headwater streams that occupy the very uppermost reaches of a watershed. They are characterized by having a low stream order, generally 1st up to perhaps 3rd order, and having a total drainage area of ~1.0 mi^2 or less. Another physical hallmark of these smallest of headwater streams is their limited pool depth, with most of the natural pool depths below 40 cm during baseflow conditions. The position of PHW streams in the landscape and their resulting physical characteristics support unique aquatic biological communities that are often not well-suited to all the traditional approaches that may be used for measuring the biological integrity of larger streams.

Streams are complex and can vary widely depending on many factors such as geological setting, ecoregion and gradient, to name a few. As such, a single method or manual cannot be expected to describe every possible scenario without becoming so cumbersome as to jeopardize its utility, while still not fully describing the complete array of possible variation. The practitioner must exercise good judgement founded upon solid skills and experience in both using the methods presented herein and in making decisions to use alternative or additional assessment tools.

Primary headwater streams are often the origin of larger water bodies in the state. The chemical, physical, and biological quality in larger streams and lakes are closely connected to the overall health of headwater streams and their watersheds (Alexander et al., 2007;

Meyer et al., 2007; Peterson et al., 2001; Wipfli, 2005). Primary headwater streams provide important economic and ecological functions through the retention of sediment, water, and organic matter; nutrient reduction; and by providing corridors for wildlife dispersal (Ohio EPA, 2003; Meyer and Wallace, 2001; Peterson et al., 2001). They may harbor a unique native fauna of vertebrates and benthic macroinvertebrates that are adapted to specific stream flow patterns or thermal conditions found in PHW streams (Davic, Anderson, and Tuckerman, 2013). These small streams are a natural and vital part of the stream continuum (Figure 1), which identifies how larger streams in a watershed are dependent on chemical and biological processes that occur in the smaller streams that flow into them. Headwater streams provide important spawning habitat for fish species in the spring and are critical for sustaining fish, fisheries, and ecosystem services (Colvin at al., 2019). Degradation of the physical, hydrological, chemical or biological conditions present in headwater streams not only can have direct and substantial negative consequences to the headwater stream itself, but can cumulatively have substantial negative consequences on downstream waters, invoking the idiom “death by a thousand cuts”.

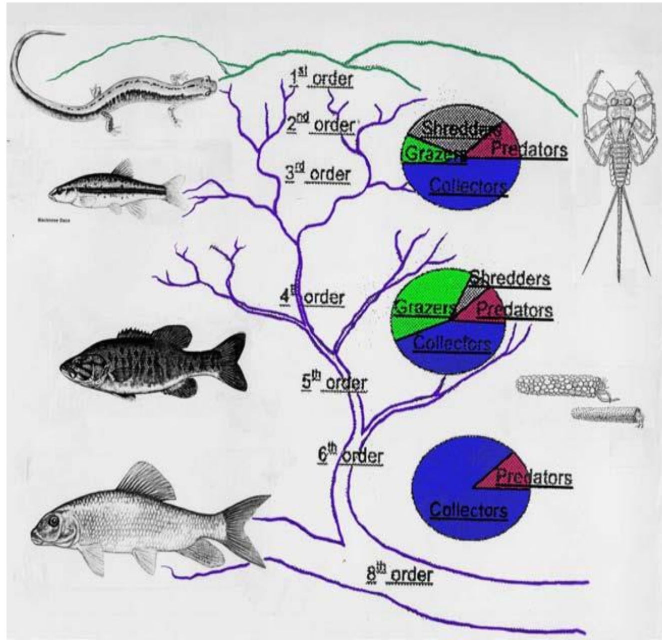
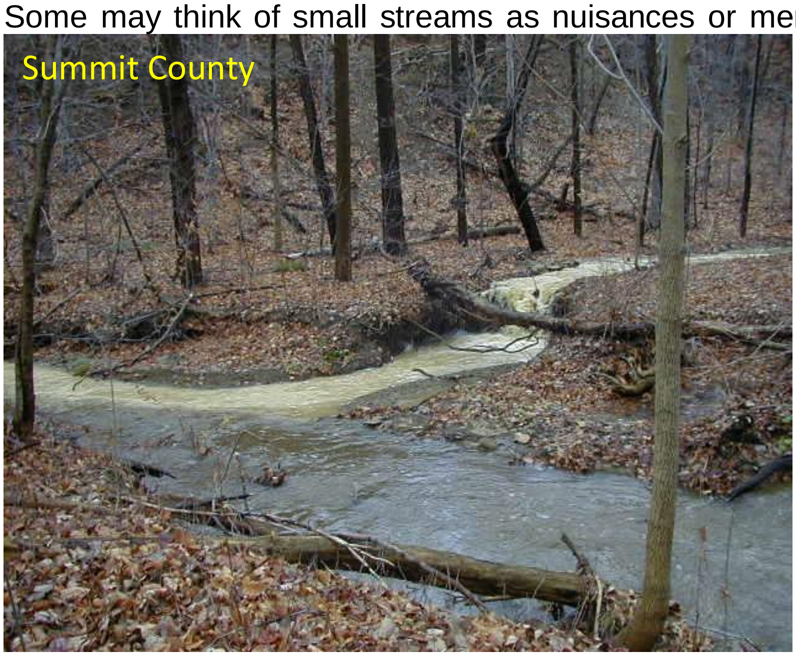


Figure 1. The river continuum concept and its relationship to biological communities found in primary headwaters (after Vannote *et. al*, 1980).

Some may think of small streams as nuisances or merely storm water conveyances. The concept that the conditions present in these seemingly insignificant streams can cumulatively have substantial consequences on downstream water quality is not always recognized by the general public.



The primary objective of the federal Clean Water Act (CWA, Sec. 101(a) is “to... restore and maintain the chemical, physical, and biological integrity of the nation's waters”, a goal that clearly applies not only to large rivers but also to the smaller headwater streams of the nation's watersheds. In Ohio, PHW streams that connect to other flowing waters are defined as “waters of the state” in the Ohio

Revised Code (ORC 6111.01). Discharges from point sources into small streams and drainage channels are regulated by National Pollutant Discharge Elimination System (NPDES) permits as discharges to waters of the state.

In Ohio, water quality standards contain both chemical and biological criteria (OAC Chapter 3745-1). Biological water quality criteria include the Index of Biotic Integrity (IBI) for fish and the Invertebrate Community Index (ICI) for macroinvertebrates. However, experience in the use of these indices over the past 30+ years has found that these standardized sampling methods, which work well in most larger streams, are not always suitable assessment tools for the smallest streams in Ohio. Their physical size and presence within the upper-most reaches of the watershed network often exerts a natural limitation on the stream's ability to fully support a well-balanced and diverse fish community as defined by existing biological criteria. Yet, these streams often have suitable flow, habitat and water quality to support diverse assemblages of aquatic life. The expression "use the right tool for the job" is applicable here. Just as a plumber would be expected to carry and use a different set of tools to repair a faucet than those used to install a new hot water tank, a biologist assessing the Ohio River won't employ the same tools or methods to assess a small creek.

Research has shown that there are strong relationships between hydrology, geomorphology, and the biotic potential of PHW streams. Conservation and management of these resources requires a watershed perspective which acknowledges the continuum of water quality from headwaters to larger streams and rivers as well as the natural variation inherent in small streams present in the landscape.

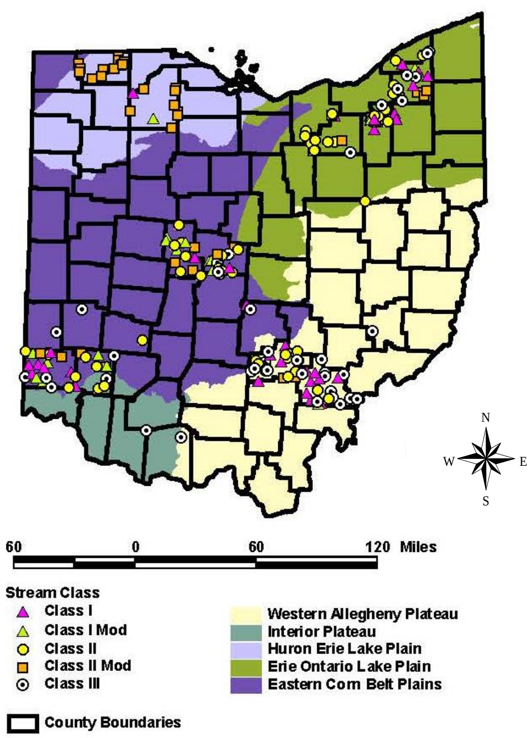


Figure 2. Ohio EPA PHW sampling locations, 1999-2001.

Recognizing the limitations of the biological assessment methods used in larger streams, a study was conducted to develop assessment methodologies at the small watershed scale. From 1999 to 2001 Ohio EPA conducted a statewide biological, chemical, and physical habitat evaluation of PHW streams located within four of the major ecoregions of Ohio (Figure 2). This evaluation was a continuation of a PHW stream assessment initiative that Ohio EPA has made available to the public since the 1990's (Davic, 1996; Anderson, et al, 1999; Ohio EPA, 2002a; Ohio EPA, 2009).

Fifty-nine PHW streams were surveyed in 1999 with an additional 215 streams randomly sampled in 2000 from 5 rapidly developing areas in 10 Ohio counties. In 2001, 18 streams were sampled for seasonal trends (benthic macroinvertebrates), and additional data were collected from select counties. Detailed information on the results of these surveys is available in separate technical reports (Ohio EPA, 2002b; Ohio EPA, 2002c; Ohio EPA, 2002d). The results of these studies were used to develop a system capable of defining the aquatic life potential of PHW streams in Ohio.

1.1 Classes of PHW Streams

Headwater streams support different types of aquatic biological communities that are a reflection their chemical, physical, and hydrological characteristics including the flow regime, water source, the underlying geology and substrate composition, stream thermal characteristics, water quality, riparian quality, and land use within its watershed. The statewide sampling effort revealed three general types of PHW streams based upon the biological communities present. These include the following:

1.1.1 Class I PHW Streams

Class I streams are ephemeral streams that have limited or no aquatic life potential, except seasonally when flowing water is present for short time periods following precipitation or snow melt. These streams may be typified by one or more of the following characteristics:

- well defined channel;
- no significant habitat for aquatic fauna;
- no significant aquatic wildlife use;
- limited or no potential to achieve higher PHW biological functions.

1.1.2 Class II PHW Streams

These streams are normally intermittent, but some may have perennial flow derived from shallow groundwater in which case the ambient stream temperature remains relatively warm during the summer and fluctuates to a greater degree seasonally compared to the more stable thermal regime associated with Class III PHW streams. The Class II PHW stream may exhibit moderately diverse communities of warm water adapted native fauna present either seasonally or year-round. The native fauna is characterized by species of vertebrates (temperature facultative species of amphibians or pioneering species of fish) or benthic macroinvertebrates. Pool depth and water volume are normally insufficient to fully support the biological criteria associated with other sub-categories of aquatic life described in OAC 3745-1-07. Prevailing temperature conditions in intermittent streams prevent establishment of biological communities present in perennial streams associated with colder water derived from deeper groundwater.

1.1.3 Class III PHW Streams

The prevailing flow and temperature conditions of these streams are influenced by groundwater. They exhibit moderately diverse to highly diverse communities of cold water adapted native fauna present year-round. Pool depth and water volume are normally insufficient to fully support the biological criteria associated with other sub-categories of aquatic life described OAC 3745-1-07. Depending on the strength of the groundwater connection and other factors as outlined in section 1.1 above, subtypes of perennial headwater streams may be recognizable based on the fauna (e.g., macroinvertebrates, salamanders, or fish) present. Class III PHW streams may be further divided into two sub-types as follows. Definitive identification of the sub-types is usually based upon a detailed and complete evaluation of the aquatic faunal community.

Class IIIA PHW:

These are perennial streams that exhibit diverse communities of native fauna. The native fauna is characterized by:

- reproducing populations of one or more of these salamander species (sub-species): The Northern Two-Lined Salamander (*Eurycea bislineata bislineata*), the Southern Two-Lined Salamander (*Eurycea bislineata cirrigera*), the Northern Longtail Salamander (*Eurycea longicauda*); or
- benthic macroinvertebrates, including four or more cold water macroinvertebrate taxa

Class IIIB PHW:

These are perennial streams that exhibit superior species composition or diversity of native fauna. The native fauna is characterized by:

- a reproducing population of one or more cold-water adapted vertebrates or
- a macroinvertebrate community consisting of at least four cold water taxa and having two or more of the following attributes:
    - six or more cold water (see macroinvertebrates Attachment 3);

- seven or more taxa from the insect orders Ephemeroptera, Plecoptera and Trichoptera;
- seven or more sensitive macroinvertebrate taxa.

NOTE TO USERS: A list of cold water indicator macroinvertebrate taxa is identified in Attachment 3 to this manual. The list of sensitive macroinvertebrate taxa, defined as pollution intolerant and moderately pollution intolerant macroinvertebrate taxa is also included in Attachment 3.

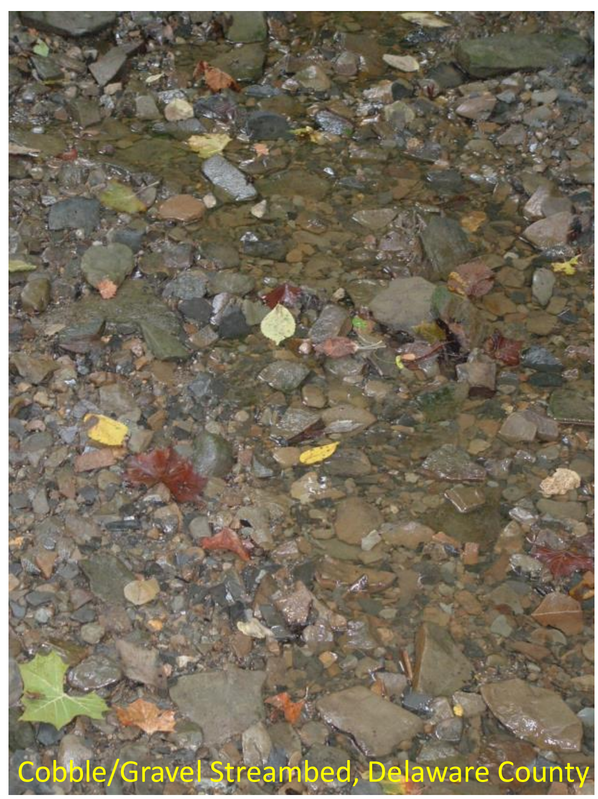
THE THREE BASIC TYPES OF PRIMARY HEADWATER STREAMS IN OHIO:

1. **<u>Class I PHW Streams</u> where flow is temporary and in direct response to precipitation or snow melt; otherwise normally a dry channel. Very limited to no aquatic fauna.**

2. **<u>Class II PHW streams</u> where flow is primarily derived from surface runoff, or if perennial, derived from shallow groundwater such that the ambient stream temperature is warm in the summer. Thermal regime is more responsive to seasonal changes in ambient air temperatures. Supports warm water adapted fauna.**

3. **<u>Class III PHW streams</u> where flow is primarily derived from deeper groundwater and remains cool in the summer. Thermal regime is more resistant to seasonal changes in ambient air temperatures. Supports cold water adapted fauna.**


Northern Red Salamander, Geauga County


Cobble/Gravel Streambed, Delaware County

1.2 Modified PHW Streams

Some PHW streams in Ohio are channelized, often with significant or complete removal of riparian vegetation. Channelization leads to changes in stream hydrology, physical habitat degradation, and sedimentation problems that are recognized among the leading causes of impairment of Ohio's surface waters (Ohio EPA, 2018). Channelization or other forms of drainage enhancement are often seen as essential for agricultural production, especially in northwestern, western and portions of central Ohio. These practices, along with riparian removal, can contribute to the runoff and export of nutrients downstream which in turn can stimulate the production of harmful algal blooms in Lake Erie, the Ohio River, and other inland lakes. In general, projects that result in the placement of fill material into streams or wetlands often require a federal permit (CWA Section 404) and state water quality certification (CWA Section 401).

The identification of channels with relatively permanent anthropogenic habitat disturbance is explained in additional detail in Section 5.2 and Table 3 of this manual.

Modified channels may include those streams that:

- are historically channelized watercourses as defined in ORC 6111.01;
- have permanent structures that impound free-flowing water; or
- have other human induced channel modifications that are of long-lasting duration.

There are cases where highly modified stream channels have been documented to support Class III PHW biological communities. However, these types of streams are rarely encountered and their presence is difficult to predict using rapid habitat assessment methodologies alone. Inevitably, these systems are linked to stream segments further upstream where groundwater contribution to the stream flow is significant and where refugia exist that are capable of supporting reproducing populations of cold water adapted fauna. Where these situations arise, the stream segment should be treated as a Class III PHW stream.

1.3 Physical Characteristics of PHW Streams

The primary physical habitat distinction between a Class I and Class II PHWH stream is the presence of flowing water or isolated pools for extended periods of time in the latter during dry periods of the year that are absent in the former. The primary biological distinction is that Class I PHW streams either have no species of aquatic life present, or if present, the biological community is of relatively low diversity.

During the years 1999-2001, biological sampling and accompanying measurements of numerous physical habitat attributes was conducted at 274 PHW stream locations following field methods described in Anderson, et al. (1999). The purpose of this sampling was to determine the feasibility of using a rapid assessment of physical habitat variables to predict, with a high degree of statistical confidence, the biological characteristics of a PHW stream. Using methodologies similar to those employed to develop the Qualitative Habitat Evaluation Index (QHEI) (Rankin, 1989; Rankin, 1995), a Headwater Habitat Evaluation Index (HHEI), was constructed. The HHEI can be used to score physical habitat features that have been found to be statistically important determinants of biological community structure in PHW streams with drainage area less than 1 mi^2 (259 ha).

The HHEI assessment is similar to, but different from, the "Habitat Suitability Index" approach used by the U.S. Fish and Wildlife Service to predict ecological habitat requirements for specific wildlife species (U.S. Fish and Wildlife Service, 1981). The Habitat Suitability Index (HSI) uses measures of habitat variables to predict life history characteristics of individual species of wildlife. In contrast, the primary design objective of the HHEI approach is to use measures of habitat variables to predict the presence or absence of cold water adapted vertebrates (fish and/or lungless salamanders) and benthic macroinvertebrate assemblages associated with a Class III PHW stream. The secondary objective was to determine scoring parameters for use in predicting biological communities associated with Class II and Class I primary headwater streams.

Statistical analysis of a large number of physical habitat measurements showed that three habitat variables (channel substrate composition, bankfull width, and maximum pool depth) are sufficient to statistically distinguish and predict the biological potential of PHW streams. Assigning positive and negative weighted scores to these three habitat variables results in the formation of a final composite HHEI score. The HHEI rapid assessment tool is most predictive when "modified" channels (e.g., channels modified by relocation, channelization, dredging) are separated from "natural" channels (those with little or no evidence of historical channel modification, or where the channel has recovered from such impacts). Thus indirectly, the final HHEI scoring process incorporates many more aspects of the geomorphology and hydrology of small stream channels (i.e., entrenchment, degree of sinuosity, etc.) than the limited set of three variables that require quantitative measurement.

The headwater stream network of watersheds is complex, and the proportion of the three PHWH stream classes varies among the ecoregions in Ohio (OSU, 2001). The average stream miles of the different classes of streams estimated in Ohio are shown in Table 1. Some waterways without a defined stream bed and bank (non-stream waterways), constituting 18.4% of the total PHW drainage network in Ohio, fall outside the concept of a headwater "stream" (Figure 3). These statistics were derived from data collected by Ohio

EPA in 2001 using a random survey of PHW streams in various ecoregions. Man-made roadside ditches that are not a continuation of a natural stream channel (“captured streams”) are also included in the non-stream waterway category (see Section 1.4 for further discussion).

Table 1. Summary of estimated miles of flowing waterways in Ohio. Stats from OSU (2001).

Waterway Type	Length in Miles	Percent of Total
Named Streams		
(ODNR, USGS blue lines)	21,028	12.61%
Unnamed Streams*		
Class I PHW Streams	36,405	21.80%
Class II PHW Streams	51,250	30.69%
Class III PHW Streams	27,551	16.51%
Unnamed Waterways		
Non-stream waterways[#]	30,708	18.39%
Total of all types: mean	166,962	100%
95% Upper CL of mean	250,636	

*A random site selection statistical approach was used to estimate the total length of “unnamed stream” miles. This value would include intermittent blue lines on USGS topographic 7.5 min. series maps.
[#]Non-stream waterways do not have a well-defined bed and bank and thus they do not meet the concept of a “Primary Headwater stream”. However, these waters do meet the definition of “waters of the state” in Ohio Revised Code, Section 6111.

Many different hydrological terms relate to the three classes of PHW streams described in this manual. Terms such as perennial, permanent, continuous, intermittent, temporary, interrupted, and ephemeral are routinely used to describe the type of flow present in stream channels. The relationship between hydrology and potential PHW stream class is summarized in the box below (see also Figure 4 and Table 2). For example, a perennial flowing PHW stream may have either Class III (cold) or Class II (warm) type of biology present, with the primary difference being water temperature rather than flow regime.

Perennial flow (continuous, permanent)	**=**	**either Class III or Class II**
Interstitial flow (interrupted)	**=**	**either Class III of Class II**
Intermittent flow (temporary, summer-dry)	**=**	**Class II**
Ephemeral flow	**=**	**Class I**

The type of biological community found in PHW streams can shift abruptly from one PHW stream class to another, such as when cold spring-fed groundwater flow intercepts a dry stream channel (e.g., Class I stream becomes a Class III stream). Other changes in species composition are gradual (e.g., when a cold Class III stream is sequentially diluted by contributions of warmer surface runoff or when incident sunlight warms the stream where shading is reduced). Yet other PHW streams maintain the same type of biological community throughout their length. Terms that relate hydrology to the different types of PHW streams are provided in Table 2, and in Figure 4.

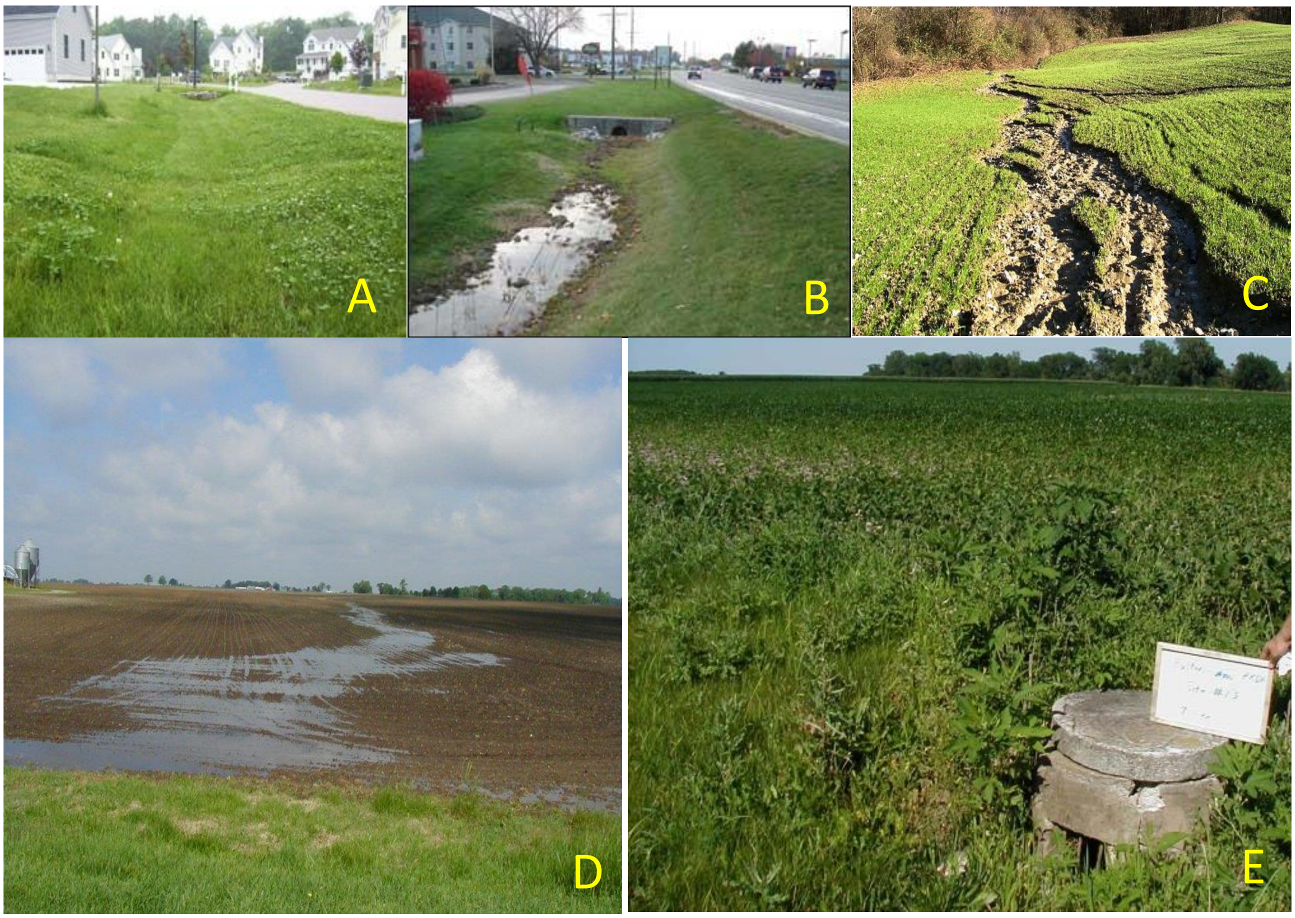


Figure 3. Examples of some **non**-PHW features: A) grass swale; B) roadside ditch; C) erosion rills; D) field water way; E) field tile.

Users should note that the flow regime descriptions used in this manual are presented to describe the underlying physical characteristics that result in the different types of biological communities present in PHW streams. These descriptions may or may not be synonymous with definitions for stream types used by federal regulatory agencies. For the purposes of PHW stream assessment, it is the biological condition, not the perceived flow condition which is definitive in determining the PHW stream class.

Table 2. Terminology used to identify different types of hydrology associated with biological communities and types of primary headwater streams in Ohio. See also Figure 4.

"**Continuous flow**". Water that flows permanently in a stream channel. Also referred to as "**perennial**" or "**permanent**" flow. There are two general types of continuous flowing primary headwater streams:

"**Suprafacial flow**"**. Streams with continuous flow over the surface of the stream bed substrate. Streams with suprafacial flow maintain surface flowing water at most times of the year (except for years of extreme drought) due to constant infiltration of surface runoff and/or groundwater recharge from subsurface aquifers. These streams may have either a Class II PHW fauna (if warm in summer) or a Class III PHW fauna (if cold-cool in summer).

"Interstitial flow". Streams with continuous flow that occurs seasonally under the surface of the stream bed within the interstitial spaces of course substrate, or cracks in bedrock. Also called "**interrupted flow**". Streams with interstitial flow have visually dry stream beds with isolated pools of water that are hydraulically connected by slowly moving water. At times of sustained drought, this type of stream may only have water flowing within the subsurface alluvium. The perennial flow is maintained by either deep groundwater recharge from the water table, or from surface wetlands. These streams can maintain either a Class II (if warm in summer) or Class III fauna (if cold-cool in summer) present within the isolated pools of water, or in the interstitial spaces of the subsurface hyporheic zone, depending on the origin of the flowing water. The biology in warm water interstitial streams tends to resemble that of the intermittent stream type during sustained drought.

"**Periodical flow**". Water that stops flowing along the stream channel during periods of no precipitation and/or groundwater recharge. There are two general types of periodical flow:

"**Intermittent flow**". Also called "**temporary flow**", or "**summer-dry**" type of stream. These streams have flow for extended periods of time seasonally, but gradually reach a state where there are either isolated pools of water that are not hydraulically connected by sub-surface flow, or a dry channel. Biology may be present in wet hyporheic subsurface substrate. Usually have a Class II type of fauna present from roughly October to June.

"**Ephemeral flow**". These streams are normally dry and only flow during and after precipitation runoff **(episodic flow)**. These streams normally have a dry stream channel with no evidence of isolated pools of water. May have Class I aquatic fauna present seasonally in the spring.

** Note: The roots of the term "suprafacial flow" are: **supra**=above or surface; and **facial**=on the face of.

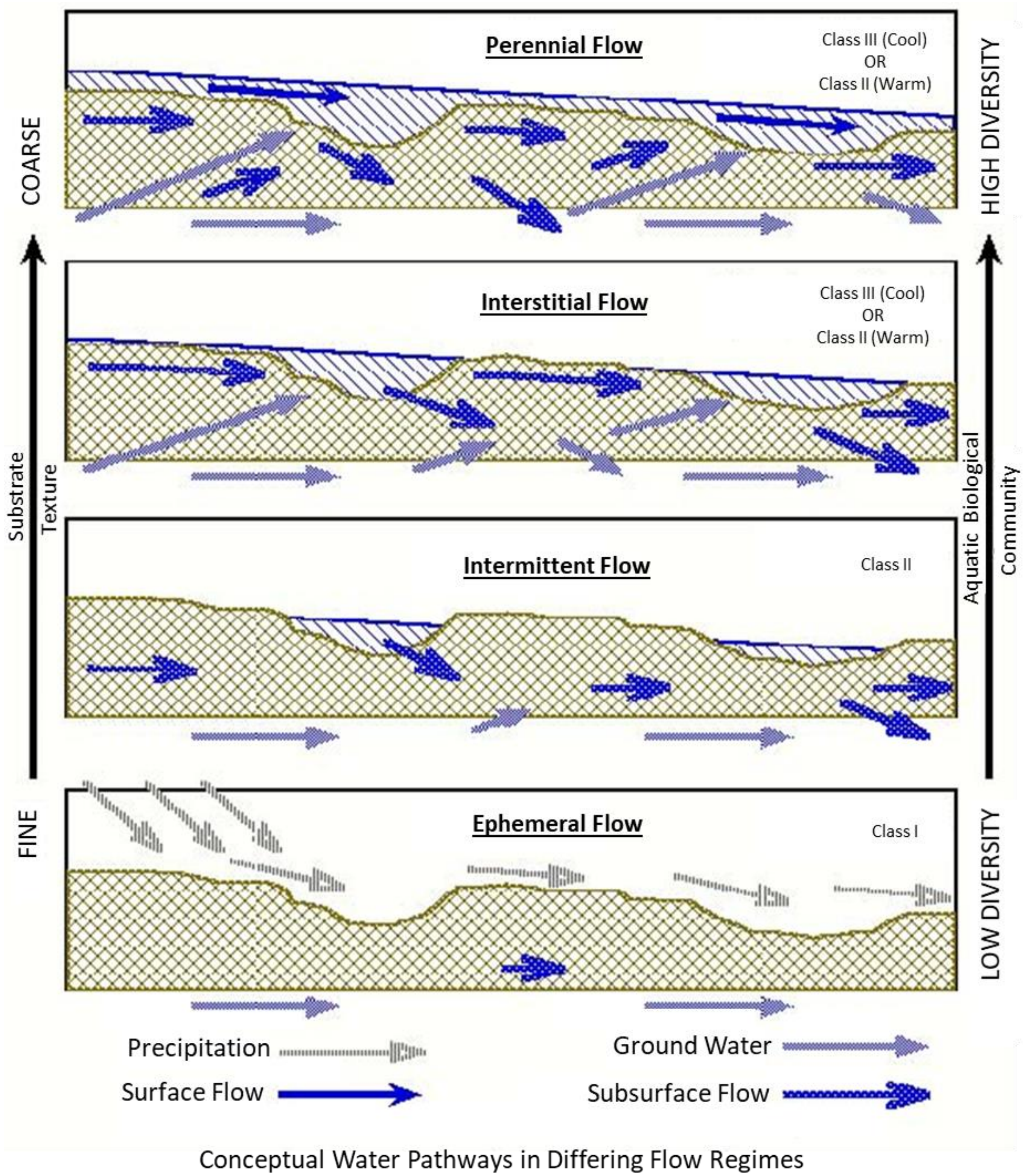


Figure 4. Conceptual water pathways in different types of PHW streams.

1.4 Assessment Overview for PHW Streams

The methods in this manual are based upon measurement of biological, chemical, and physical (HHEI) habitat characteristics that can be used to differentiate between various PHW stream types that exist on the landscape. A PHW assessment should only be conducted after the following determinations have been made:

- The water body meets the definition of a stream. For the purposes of this manual, a stream is defined as a water body having a channel with well-defined bed and banks, either natural or artificial, that confines and conducts continuous or periodical flowing water. The term “stream” includes captured streams, which are those portions of an existing stream that lie within or have been relocated to lie within a roadway right-of-way; and
    - It excludes roadside ditches, which are drainage features adjacent to or within a right of way along private or public roads, railroads or other similar development features that have been constructed or modified and serve to collect and transport water draining from the development feature or the right of way.
    - It also excludes grass swale waterways and other temporary channel-like features on the land surface created by water erosion such as rills; and

- The stream is not specifically assigned to another aquatic life use [i.e., Warmwater Habitat (WWH), Exceptional Warmwater Habitat (EWH), Coldwater Habitat (CWH), or Modified Warmwater Habitat (MWH)] in OAC rules 3745-1-08 to 3745-1-32; and

- The stream does not support a well-balanced fish community as measured by the IBI as the result of natural habitat features and watershed characteristics that rule out other aquatic life use designations found in OAC Chapter 3745-1.

In general, any stream with a watershed area greater than 1.0 mi^2 (259 ha), <u>or</u> where the maximum depths of natural pools within the stream are *predominantly* over 40 cm, should first be evaluated using the QHEI and biological sampling methods consistent with the WWH, EWH, CWH, or MWH aquatic life use designations (Ohio EPA, 1989; Rankin, 1989; Rankin, 1995; Ohio EPA, 2006a). It is sometimes appropriate to use the PHW methodologies for streams with drainage areas greater than 1.0 mi^2 based upon the watershed characteristics. Conversely, some streams having drainage areas within the PHW range that are capable of supporting well-balanced fish communities may be best described using aquatic life designations such as WWH or EWH. This manual provides guidance to identify situations where these exceptions exist and to adjust the assessment methodology to provide the most accurate analysis.

1.4.1 Levels of PHW Assessment

Three assessment methodologies are provided within this manual to evaluate PHW streams:

- Level 1 Assessment (Section 5.0) consists of a physical assessment of the habitat using the HHEI. The result of the HHEI analysis is used as a predictor of the biological condition of the stream using protective statistical relationships.

- Level 2 Assessment (Section 6.0) combines qualitative biological sampling results with the Level 1 Assessment to provide a higher degree of certainty regarding the biological condition of the PHW stream.

- Level 3 Assessment (Section 6.0) consists of a definitive biological assessment of the vertebrate and macroinvertebrate communities present in the PHW stream in which all taxa are evaluated to the lowest practicable taxonomic level.

Level 1 and Level 2 Assessment protocols are rapid assessment methodologies as that term is defined by the U.S. Environmental Protection Agency (USEPA) (USEPA, 1989). As with the QHEI for larger streams, the use of the HHEI and qualitative biological evaluations, when used in the proper context can accurately predict the biological potential of a PHW stream. However, the structure of the biological community, as determined by a Level 3 Assessment is the final arbiter of a PHW evaluation. Exceptions to this tenet are cases where profound effects caused by drought conditions, in-stream toxicity, or pollution stress exist which prevent the stream from meeting its biological potential. In these situations, the evaluation of the stream should be based upon a determination of the potential for the stream to support the biological communities associated with the various types of PHW streams. This determination should be based upon a weight-of-evidence approach using all available data, particularly the HHEI, to determine the type of community that could reasonably exist if the pollution stress was reduced or eliminated.

1.4.2 Documentation and Responsible Practices

All field observations and physical and biological data collected during PHW assessments should be recorded on the Ohio EPA PHW Stream Evaluation Form included as Attachment 1 of this manual. Where stream assessments are conducted using the protocols designed for larger streams in Ohio, the appropriate field forms for these methodologies should be used (e.g., the QHEI form). An overview of the sequence of tasks involved in a PHW stream evaluation is found in the “Quick Guide to the PHW Assessment Process” located in the front of this manual.

Field personnel conducting PHW assessments should obtain permission from property owners to gain access to the streams. In addition, users should make certain to obtain any necessary local, state or federal permits for conducting biological collections prior to carrying out PHW assessments.

2.0 Preparation for PHW Surveys

The use of the procedures described in this manual will be most efficient when field studies are well planned prior to engaging in field sampling and assessment. Field activities should be guided through the preparation of a written study plan that includes: information regarding the area to be sampled; the stream resources of interest; the methods to be used; lists of involved personnel including the levels of training required; a list of necessary equipment and supplies; safety precautions to be taken; and other relevant information. The study plan should also describe quality assurance and quality control procedures that will be followed to ensure that the data quality objectives of the field study will be met. All personnel involved in the study must have the proper training to collect the data required or be supervised by personnel who can ensure that sampling and data recording are conducted properly.

2.1 Data Quality Objectives

The establishment of Data Quality Objectives (DQOs) for PHW stream evaluations is necessary to specify how "good" data must be to support decision making, including the level of uncertainty that is acceptable. Study plans should always be developed prior to going out into the field so that the appropriate data can be collected to support the DQO's for PHW assessments. Ohio EPA strongly encourages the use of a weight-of-evidence approach that combines the assessment of the physical and biological characteristics of a stream to make final conclusions regarding the PHW stream classification. This approach will result in the highest level of confidence that the PHW stream classification decisions are accurate.

It is up to the investigator for any individual project to assign the DQO's for PHW assessments. Survey plans for PHW streams should be constructed with an understanding of the balance between level of effort and the degree of certainty necessary to achieve the goals of the project. Confidence in PHW evaluations will improve as the level of effort increases. Level 1 Assessments using only the HHEI for determination of the PHW stream type will sometimes result in conservative predictions of the in-stream biological community (i.e., Level 1 Assessments have a tendency to over-predict rather than under-predict Class I and Class II streams in some situations). However, the addition of some biological sampling to the HHEI scoring reduces the level of uncertainty in the evaluation. Level 2 Assessments (qualitative biology) can significantly improve the assessment outcome and are often definitive. Level 3 Assessment of the stream will result in definitive conclusions under almost all circumstances.

DQOs specify:

- the problem to be resolved;
- the decision to be made;
- the inputs to the decision;
- the boundaries of the study;
- the decision rule; and
- the acceptable limits of uncertainty*.

*It is important to note that DQOs are the user-defined target values for data quality and are not necessarily criteria for the acceptance or rejection of data by Ohio EPA.

Data from a PHW stream evaluation is usually used to determine the stream classification. Two example approaches for such evaluations include:

- If the purpose of the evaluation is to generally inventory or categorize the type(s) of PHW stream(s) in a given area or at a particular site, data from a Level 1 or Level 2 Assessment is usually sufficient)*.

  *Note: For Level 1 assessments where the resulting classification is Class III PHWH, it is assumed that the stream is a Class IIIB PHWH stream unless a Level 2 Assessment or Level 3 Assessment (full biological survey) is conducted to indicate or prove otherwise.

- If the purpose of the evaluation is to determine the type of PHW stream while tracking potential changes in the stream biota (for purposes, such as restoration, enforcement, management efforts, etc.), a more thorough assessment strategy must often be taken from the outset. Under this scenario, a Level 3 analysis including a detailed taxonomic evaluation of the fish, benthic macroinvertebrate, and salamander communities must often be conducted.

To ensure scientific credibility and study repeatability, all project activities associated with the PHW evaluation need to be adequately documented. These activities include (if appropriate) adherence to sampling protocols, equipment calibration, use of standardized field sampling methods, review of data sheets, the use of field notes, data quality assessment, data analyses, and data interpretation.

2.2 Desktop Evaluation

Prior to going into the field, a desktop evaluation of the potential PHW resources should be conducted in order to direct the field activities. This exercise includes identification of the potential PHW stream(s) of interest, gathering of metadata regarding the stream location and access points for field surveys, and the calculation of the upstream drainage area(s) of the stream(s) to be sampled. The user is encouraged to utilize all desktop resources available within a particular locale to identify the presence of potential PHW streams prior to conducting field surveys.

2.2.1 Mapping Resources

The potential location of a PHW stream in the landscape can be identified using the USDA, National Resources Conservation Service (NRCS, formerly SCS) soil survey maps that are available for each of the 88 counties in Ohio (Figure 5). Different terminology is used in the various county soil surveys to identify potential PHW streams. Terms such as “drainage”, “stream-perennial”, “stream-intermittent”, “stream-unclassified”, “ditches”, “springs”, “drainage end”, “alluvial fan”, etc. are used to identify small watercourses on these county soil maps. Each of these watercourses that connect to downstream surface waters of the state is a potential PHW stream. County soil survey maps can be obtained at: https://www.nrcs.usda.gov/wps/portal/nrcs/surveylist/soils/survey/state/?stateId=OH. Paper copies of the maps can also be obtained at county Soil and Water Conservation District

(SWCD) offices or borrowed at many local and university libraries. All counties in Ohio now have digitized soil maps available for Geographic Information System (GIS) interfaces. However, these resources may be of limited use statewide since many counties have not digitized the hydrologic drainage information along with the soils distribution information. A directory of contact information for Ohio SWCD's can be found on the ODA Division of Soil and Water Conservation web page at: https://agri.ohio.gov/wps/portal/gov/oda/divisions/soil-and-water-conservation/.

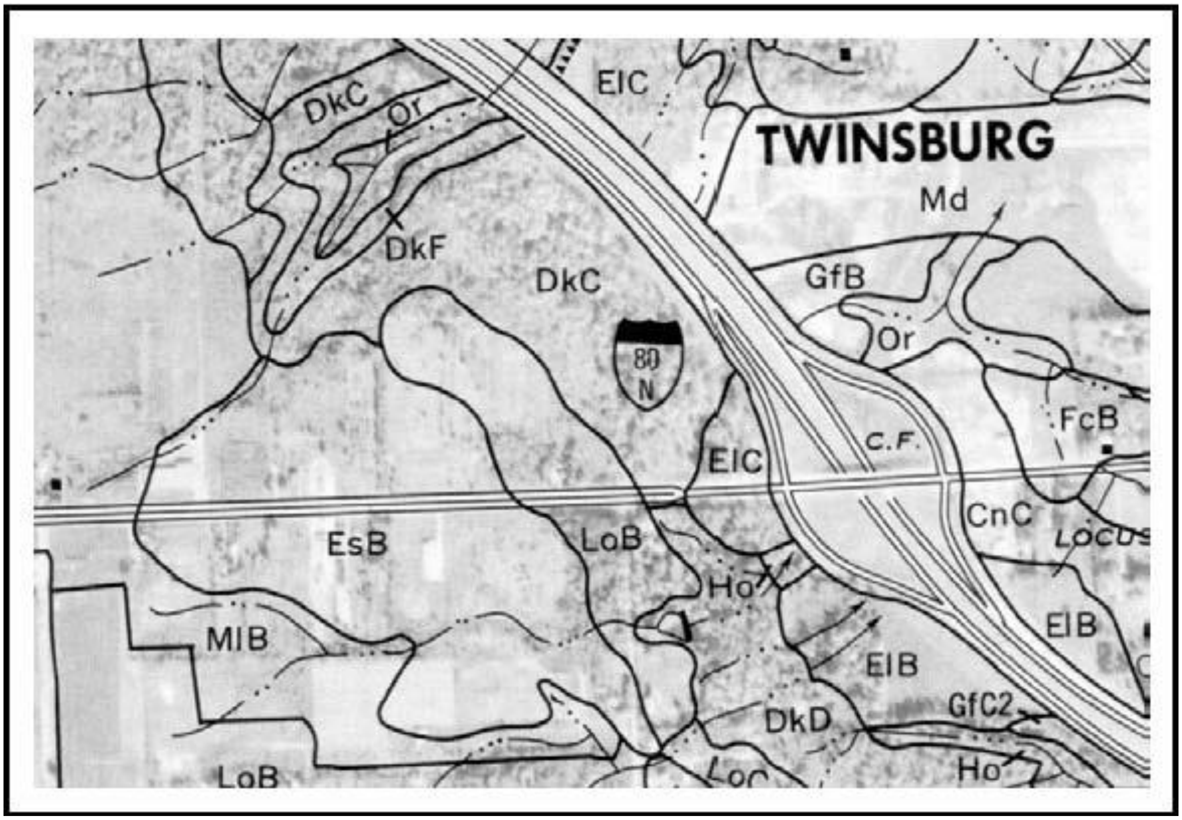


Figure 5. Representative NRCS (aka SCS) County Soil Map showing location of PHW streams in a local watershed. First order PHW streams are those primary streams at the uppermost limits of the drainage network. Two first order PHW streams merge to form a second order stream and so on until the drainage empties into a larger stream that has a specific designated use. Streams in Ohio with assigned designated uses are found in OAC Chapter 3745-1. Total area shown in this figure is about 0.63 mi^2 (163 ha).

The NRCS mapping scale represents the most detailed knowledge of the distribution and abundance of potential primary headwater streams in Ohio. A common soil mapping scale is 1:15,840, but others do exist. Because the field and aerial survey data shown on many county soil survey maps were collected prior to 1970, a field assessment of a property may show that a potential PHW stream has been relocated or placed in a drainage culvert. In some rare cases, a PHW stream observed to be present during a site visit will not be shown on a county soil map but may be shown on a U.S. Geologic Survey (USGS) topographic map. Thus, both NRCS and USGS maps should be consulted to determine if any PHW streams are potentially present.

Many Ohio counties have also developed other mapping resources such as high resolution aerial photography, small scale topographic maps (including maps of "derived" streams determined using topography), and drainage mapping resources in GIS formats that are readily available.

2.2.2 Determination of Upstream Drainage Area

Drainage areas of the watershed upstream of the PHW stream reaches to be evaluated can be determined in a number of different ways including the use of a planimeter over a topographic map on which the watershed boundaries have been determined. Computer aids using GIS software can also be used to accurately calculate upstream drainage areas. A very useful on-line resource developed by USGS in cooperation with other federal and state agencies for determining watershed areas is the USGS STREAMSTATS web page (https://streamstats.usgs.gov/ss/). The STREAMSTATS web page uses an interactive mapping tool to delineate drainage basins and provide data regarding watershed areas and available flow and land use data (Figures 6 and 7). Although the mapping scale varies somewhat across various regions in Ohio, in many locales the scale of the underlying stream layer is suitable for the PHW universe.

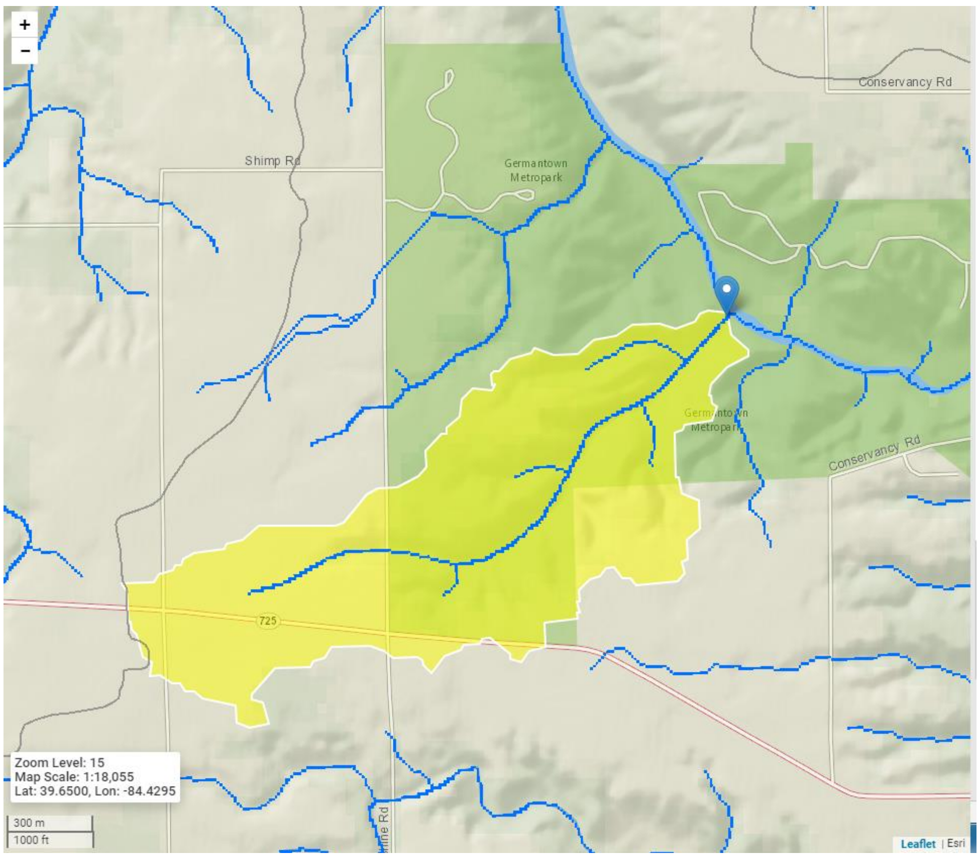
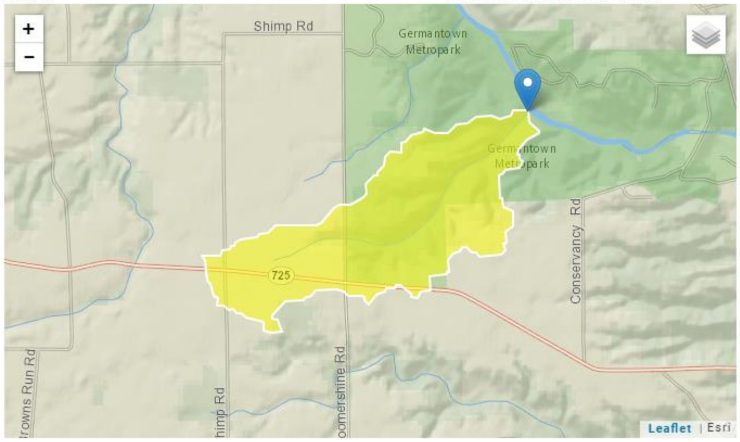


Figure 6. Example watershed delineation from the Ohio STREAMSTATS web page.

StreamStats Report

Region ID:	OH
Workspace ID:	OH20180613135217417000
Clicked Point (Latitude, Longitude):	39.63879, -84.41674
Time:	2018-06-13 09:52:33 -0400



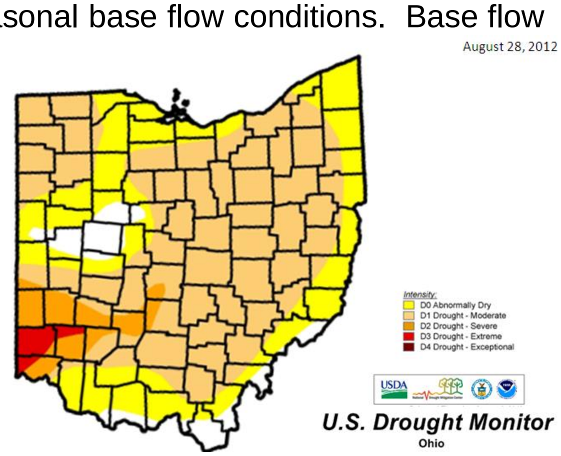
Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
DRNAREA	Area that drains to a point on a stream	0.58	square miles
FOREST	Percentage of area covered by forest	46.4	percent
LC11DEV	Percentage of developed (urban) land from NLCD 2011 classes 21-24	7.37	percent
LC11IMP	Average percentage of impervious area determined from NLCD 2011 impervious dataset	0.85	percent
CSL1085LFP	Change in elevation divided by length between points 10 and 85 percent of distance along the longest flow path to the basin divide, LFP from 2D grid	121	feet per mi

Figure 7. Example of basin data provided from the STREAMSTATS web page following a watershed delineation.

2.3 When to Sample

A biological or physical habitat (HHEI) assessment can be conducted at any time of the year but must be conducted when the stream is under seasonal base flow conditions. Base flow conditions in small headwater streams recover quickly after rain events, usually within 24 hours. Evidence of elevated flows due to runoff consists of observation of surface runoff draining into the stream, stream water depths near or above the bankfull depth (see Section 5.3.3), and elevated turbidity.



Biological sampling during drought conditions and for up to one year following drought conditions can also result in misidentification of biotic potential. Two methods, the Palmer Drought Condition Index (Palmer, 1965) and the minimum seven-day average flow with a ten-year recurrence interval (7Q10), can be used to determine if drought conditions exist within a specific geographical area. "Drought" is defined for the purposes herein as the condition of severe or extreme soil dryness as measured by values of minus 3.0 (-3.0) or less on the Palmer Drought Severity Index published weekly by the National Oceanic and Atmospheric Administration (NOAA). Consult NOAA drought monitoring data for current and historic Palmer Drought Severity Index data before any biological sampling is performed. This information can be accessed at http://www.cpc.ncep.noaa.gov/products/monitoring_and_data/drought.shtml.

Lacking other information, the 7Q10 value from the nearest hydrologic unit as reported by the USGS can be used to estimate critical low flow on the date of assessment (Straub, 2001). The 7Q10 flow is used in OAC 3745-2-05(A) to protect the aquatic life potential of surface waters in Ohio from chronic stressors. Real time flow data from USGS gage stations in Ohio can be found at: http://waterdata.usgs.gov/oh/nwis/rt. Gage data from the nearest USGS gage station can be compared to the historic stream flow characteristics (available at http://oh.water.usgs.gov/reports/wrir/wrir01-4140.pdf). In situations where the flow conditions at the nearest local stream gages indicate that stream flows are below the 7Q10 for the area of interest, biological data may not be indicative of PHW stream potential.

Evaluations using the HHEI (Level 1 Assessments) can be done at any time of the year to determine the biological potential of PHW streams. This statement is made with the understanding that: 1) reasonable and appropriate sampling conditions prevail at the time of the assessment; and 2) that the HHEI metrics have been selected, and weights adjusted, to allow for statistical protection of Class III PHW streams during the summertime low-flow period of the year. The sampling period of June through September will most accurately distinguish the various classes of PHW streams relative to other times of the year. For dry stream channels, the minimum level of documentation required is a habitat evaluation using the HHEI after the stream has been thoroughly evaluated to determine that interstitial perennial flow or permanent pools are not present.

Vertebrates that live in cold spring-fed PHW streams are present throughout the year because they are adapted to permanent flow conditions. For amphibians, it is the gilled larvae that are most sensitive to stream desiccation. This life stage may therefore be present in some streams in the spring and early summer but be later excluded from the stream when the local groundwater table drops during the dryer months of the year. See Section 6.2.1 for a further discussion of issues relating to seasonality with respect to salamander assessments.

Biological assessments using Level 2 or Level 3 methodologies for macroinvertebrates can also be conducted at any time of the year as long as limitations in data interpretation resulting from seasonal effects are borne in mind. Again, these assessments are more representative during the summer sampling period (June through September). When sampling is conducted outside of this index period, it should be recognized that there is generally an increase in the number of macroinvertebrate taxa present in many PHW streams associated with spring-emerging taxa (January through May). In addition, special precautions should be used when sampling from October through December after leaf-fall has occurred. Accumulated leaf litter present in small streams at this time of the year will often mask stream substrate conditions and make it difficult to visually locate stream dwelling vertebrates.

When multiple physical measurements or biological samples are collected at the same location at different times of the year, the measurements taken during the June through September time period are used to distinguish different PHW stream classes. When multiple samples are collected within the June through September time period, a weight of evidence approach should be used to determine the stream classification. Other than the exceptions outlined in this manual, greatest weight should always be given to biological sampling results (Level 2 or 3 Assessments) in determining the type of PHW stream over Level 1 Assessments, regardless of the time of year that the data was collected.

2.4 Equipment Check List

An equipment checklist for conducting chemical, physical and biological measurements is included as Attachment 2 of this manual.

2.5 Reference Materials

Additional references that may prove useful to aid in conducting physical stream measurements used in this manual can be found in Rosgen (1996), Rankin (1989), and the most recent field manual for the QHEI methodology (Ohio EPA, 2006a). Field chemical sampling procedures are described in "Surface Water Field Sampling Manual for Water Quality Parameters and Flows (Ohio EPA, 2019). Recommended general reference materials for macroinvertebrate taxonomic identifications are Merritt et al. (2008), Smith (2001), Voshell (2002), and Bouchard (2004). References for the identification of macroinvertebrates to the lowest taxonomic level are listed in the Ohio EPA guidance manual for conducting biological assessments (Ohio EPA, 2006b; Ohio EPA, 2015).

Fish should be identified using Trautman (1981), "The Fishes of Ohio", or other appropriate taxonomic keys. More recently, "A Naturalist's Guide to the Fishes of Ohio" (Rice and Zimmerman, 2019) was published. This book provides updated species distribution maps, field identification tips, habitat information and color photos of Ohio's fish species. The ODNR field guide "Stream Fishes of Ohio" (ODNR, 2017) is a handy reference for field applications. See: http://wildlife.ohiodnr.gov/portals/wildlife/pdfs/publications/ID%20guides/pub5127.pdf. Salamanders should be identified to the species level consulting one or more of the following references: "The Salamanders of Ohio" (Pfingsten and Downs, 1989), "Amphibians of Ohio (Pfingsten et. al. 2013), "Salamanders of the United States and Canada" (Petranka, 1998). These references have keys for adults and larvae with numerous photographs of various life stages of salamanders found in Ohio. Other useful references for Ohio amphibians are the Field Guide to Reptiles and Amphibians by Conant and Collins (1998) and a guide to Ohio amphibians developed by the ODNR Division of Wildlife (ODNR, 2012), available in print and at: https://wildlife.ohiodnr.gov/portals/wildlife/pdfs/publications/id%20guides/pub348.pdf. ODNR also provides an on-line guide to amphibians that provides life history and identification information at the following link: http://wildlife.ohiodnr.gov/species-and-habitats/species-guide-index/amphibians. Pfingsten (1998), Pfingsten and Matson (2003) and Pfingsten et. al. (2013) provide updated range distribution maps, by county, for amphibians in Ohio. Davic (2005) provides tips for differentiating Two-lined and Northern

Dusky larval salamanders from one another. This is a key skill to acquire as these species are indicators of two different PHW classes (Class II and Class III).

3.0 Stream Reach Delineation and Site Selection

The PHW stream evaluation process consists of a combination of physical, chemical, and biological characterization of a **PHW stream reach**. A PHW stream reach is defined as a stream with a continuous channel bed up to 200 ft (61 m) in length, a modification of the stream reach concept adopted by the Government of British Columbia (1998). Stream reaches for a PHW assessment may be shorter than 200 ft in situations where tributaries have a junction with mainstem PHW streams or where features within the stream channel (either natural or artificial) warrant restricting the evaluation reach to a distance less than 200 feet of channel length. Such tributaries will usually be "first order" streams at the NRCS county soil mapping scale (see Figure 5). Where deemed appropriate, these first order tributaries can be evaluated as being part of the larger mainstem PHW stream. The mainstem of a PHW stream drainage network is the channel with the longest length that forms a junction with a larger named stream (see Figure 8).

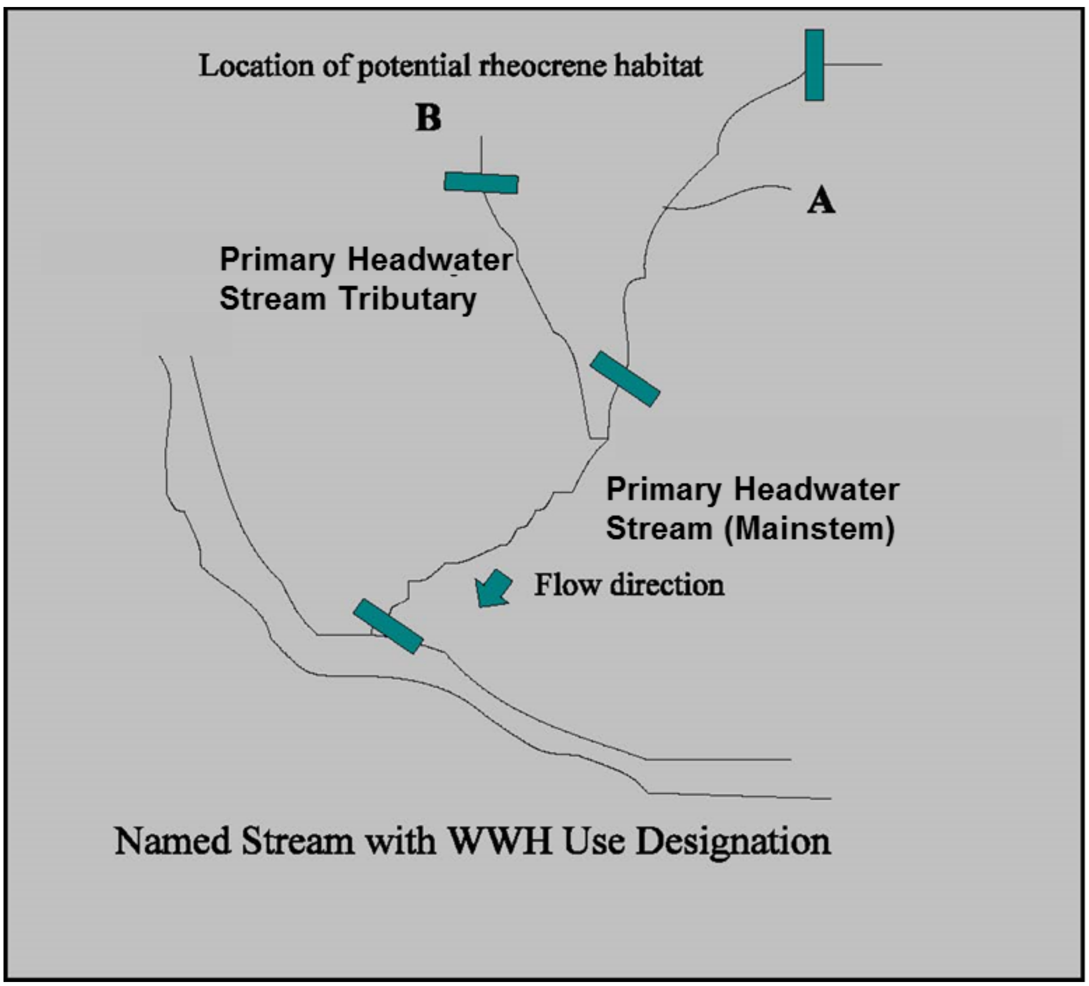


Figure 8. Hypothetical relationship of the PHW stream reach concept, showing 200 ft (61 m) upper and lower reach boundaries (dark rectangles). Delineation always begins at the lowest

downstream location (or the lower property boundary) and proceeding upstream following the thalweg of the channel (see photo below). Total length of PHW stream mainstem in this example is 430 ft (131 m). Small tributary (A) in upper zone of the PHW mainstem may be included in assessment of that stream reach, or it may require its own assessment if it differs significantly from the mainstem conditions. PHW tributary (B) receives its own 200 ft (61 m) stream reach assessment. The small section above the upper reach boundary for (B) may be included in the assessment of the lower 200 ft (61 m) section. The stream section near (B) would represent the potential location of a “rheocrene” habitat. The river mile (RM) where PHW mainstem empties into the WWH designated stream should be recorded, as well as the RM location where PHW tributary (B) empties into the PHW mainstem.

It must be noted that the use of data for stream reaches that are less than 200 ft may be suspect since the PHW methodology is calibrated for this length, especially the physical measurements related to the HHEI.

Discrete stream reach boundaries are used to divide the stream channel into consecutive watercourse units for standardized assessment. At the headwaters of a watercourse, the location of the upper boundary of the uppermost stream reach is the location where the first (or last, depending on direction of travel) evidence is found of scour through the mineral substrate or alluvial deposition (Government of British Columbia, 1998). A 200 ft (61 m) distance was selected because this was the distance used to calibrate the association between biological and habitat variables during the 1999 and 2000 calibration survey. This length of stream allows for a complete assessment of the natural scale of habitat variability that is present in these types of headwater streams.

Following the desktop evaluation to map and identify stream reach features and to delineate watershed boundaries, the physical, chemical, and biological characteristics of the stream can be determined in the field. Marked variability in land use or channel character observed within a stream reach should be noted during the site visit. The stream delineation always begins at the most downstream location, or the lower limits of a property boundary, as shown in Figure 8. If a stream reach is dissected by natural geological features such as a bedrock outcropping, the length of the stream reach for assessment can be adjusted accordingly.

3.1 Site Selection

Sampling of PHW streams will occur for a variety of reasons, including but not limited to, the following examples:

1. to delineate the total number, and total linear feet, of different types of PHW streams present within a specified property boundary (for example, as part of a CWA Section 401 water quality certification application);

2. to delineate the relative number and percentage of PHW stream types that may be impacted by extensive road building, pipeline, or power line projects that may affect numerous PHW streams;

3. to determine the relative quality, biological condition, or type of PHW as may be needed when considering NPDES permit applications or CWA Section 401 water quality certifications;

4. to determine if a wastewater discharge, or other environmental alteration/stressor, is having a significant impact on the chemistry and/or biology of a PHW stream;

5. as a standardized evaluation protocol used in association with land use planning, storm water management, or scientific surveys related to PHW streams;

6. to survey and catalog aquatic resources within protected areas such as parks, preserves, and wildlife areas;

7. to ascertain the success of PHW stream mitigation projects.

In example 1 above, all PHW streams in the assessment area should be mapped and delineated using 200 ft (61 m) stream reach assessments. In example 2, photographs and HHEI evaluations at discrete locations where PHW stream channels will be crossed can be used to quickly estimate the relative percentage of different types of PHW streams that will potentially be impacted by various project routes across the landscape. In example 3, a multiple number (3-5) of discrete 200 ft (61 m) stream reach assessments should be conducted along the length of the mainstem PHW channel. Areas of recent habitat modification should be avoided in these types of PHW stream assessments. In example 4, 200 ft (61 m) stream reaches should be identified upstream (reference site) and downstream from the proposed wastewater discharge, or source of impact. Potential chemical impacts should be evaluated against the applicable water quality criteria found in OAC Chapter 3745-1. Potential biological impacts should be evaluated using the sample methods found in this manual. In the final three examples, study plans should incorporate sufficient coverage of streams to accomplish the DQO's and scale of resolution necessary to meet the goals of the study in question.

3.2 QHEI vs. HHEI Evaluation in Headwater Streams

If the watershed size is greater than 1.0 mi^2 ***or*** if the ***predominant*** natural pools are greater than 40 cm in depth regardless of watershed size, a Qualitative Habitat Evaluation Index (QHEI) evaluation should be completed in accordance with standard Ohio EPA procedures (Rankin, 1989; Ohio EPA, 2006a). The QHEI evaluation can be used to determine if the stream has potential to support a WWH community of fish and has been used when assigning aquatic life use designations for streams with drainage areas greater than 1.0 mi^2. The decision-making flow chart found in Figures 15 and 16 of Rankin (1989) should be used to determine if the stream has WWH potential using the QHEI technique. The stream length for a QHEI evaluation in a headwater stream should extend a minimum distance of 100 m and should incorporate the entire 200 ft PHW stream reach.

If deemed appropriate by a qualified biologist, a HHEI habitat evaluation can also be conducted in conjunction with the QHEI evaluation in streams where watershed area is less than 1.0 mi^2, but pools where are greater than 40 cm in depth, to ensure the aquatic life use potential is accurately characterized. This is particularly relevant in high gradient, step-pool streams. In these systems the energy within the stream will often create pools greater than 40 cm in depth. Where these systems exist on the landscape and the watershed area is less than 1 mi^2, it is important to determine whether these streams are capable of supporting a well-balanced fish community or whether the stream would be more appropriately characterized as some type of PHW using the assessment tools provided within this manual. These types of decisions are best left to a biologist trained in the use of both the QHEI and HHEI evaluation methods.

The HHEI should be used with caution to make PHW stream classification decisions in rheocrene habitats (see discussion in Section 4.0 of this manual), and in streams with drainage areas greater than 1.0 mi^2 (even if the stream is ephemeral), since the index was not calibrated using sufficient data for these types of habitats.

4.0 Rheocrene Habitats and Seepage Areas

Where deep groundwater (saturated zone) suddenly emerges to the land surface from an underground aquifer, a “spring” type aquatic habitat is formed. There are three general types of springs: (1) those that form a well-defined channel (rheocrene); (2) those that form small pools or basins (limnocrene); and (3) those that form a marsh or swamp (helocrene). Springs are unique freshwater ecosystems because their thermal, physical and chemical environments are usually more stable. In Ohio, persistent springs are generally of cold groundwater origin, maintain relatively constant temperatures throughout the year, and have exceptional chemical water quality. They are warmer in winter and colder in summer than surface water recharge streams. Hot springs are not known to exist in Ohio. The type of biology present in springs will vary according to the type of spring that is formed (i.e., rheocrene, limnocrene, helocrene). Helocrene habitats are best evaluated using Ohio EPA wetland monitoring techniques (Mack, 2001; Micacchion, 2002), which are available online at: http://epa.ohio.gov/dsw/401/ecology.

For the purposes of a PHW stream assessment, the potential location of a “rheocrene” type of habitat will be identified if the stream under investigation has constant flowing water, forms a defined bed-bank, and has a watershed size less than 0.1 mi^2 (25.9 ha). In many cases, the HHEI cannot reliably be used as an indicator to predict the biological community present in rheocrene habitats and should not be used as the sole evaluation methodology in these situations (see Section 5.4 and Figure 18). A biological survey using Level 3 Assessment methods for amphibians and benthic macroinvertebrates (Section 6.0) must be conducted in potential rheocrene habitats when the watershed area is less than 0.1 mi^2 (25.9 ha), the stream is flowing, the HHEI score for the site is greater than 30 points and less than 50 points, and the percent of large substrates (boulder, bedrock, and cobble) is less than 10% of the total substrate composition.

In instances where a rheocrene is found to be impacted by pollution, it may not be possible to accurately predict the biological condition of the stream using either the HHEI or the methods outlined in this manual. In these instances, it is recommended that a search be made for similar, unaffected channels within the vicinity of the stream of interest that can serve as a local reference to predict the stream's ecological potential in the absence of pollution. Where the assessment is being conducted for regulatory purposes, the selection of appropriate reference streams should be made in consultation with Ohio EPA.

Final determinations concerning waterways meeting the definition of a rheocrene habitat will usually be based on the types of vertebrate and benthic macroinvertebrate species present. Evaluation of these habitats should usually be conducted using the biological methods outlined in Section 6.0 of this manual. Seepage areas adjacent to and hydraulically connected to the main stream channel (e.g., within ravines) may also be included as part of the assessment of the receiving stream for purposes of biological evaluation. Seepage areas with diffuse flow that have wide and very shallow drainage ways lacking a defined bed and bank fall outside the assessment methods of this manual. However, this type of habitat may meet the definition of a wetland, and Ohio EPA wetland assessment methods (Mack, 2001; Micacchion, 2002) may apply in these situations.

The habitat comprising the zone of saturated sediments beneath and adjacent to an active stream channel that is available for aquatic organisms is called the hyporheic zone. This zone is the biologically and chemically active interface or ecotone among the atmosphere, land, surface waters and ground waters. This manual does not address sampling techniques to be used in hyporheic habitats. However, users should be aware of zones of interstitial flow within stream systems that should be evaluated as part of both the physical and biological evaluation process for PHW streams.

5.0 Level 1 PHW Assessment: Conducting a HHEI Evaluation

If the watershed size is less than 1.0 mi^2 (259 ha), and most of the natural deep pools are less than 40 cm, a PHW stream evaluation must be completed. A copy of the form to be used to record data is provided in Attachment 1 and is referred to as the "PHW Form" throughout this manual. This section of the manual provides instructions for collecting the essential data needed to complete the PHW Form. The PHW Form is to be used to record all field measures and observations for physical (i.e., HHEI), and biological assessments. The PHW Form is divided into four (4) pages. Detailed instructions for completion of pages 1 and 2 (the HHEI evaluation) of the form are described in this section and constitute a Level 1 Assessment for PHW streams. Pages 3 and 4 of the PHW form are used for recording the results of biological sampling (Level 2 and 3 Assessments). Biological assessment methods are described in Section 6.0.

PHW FORM - PAGE 1

5.1 General Stream Information

Ohio Environmental Protection Agency

Headwater Habitat Evaluation Index Field Form

HHEI Score (sum of metrics 1+2+3)

SITE NAME/LOCATION __________

SITE NUMBER _____ RIVER BASIN _____ RIVER CODE _____ DRAINAGE AREA (mi^2) _____

LENGTH OF STREAM REACH (ft) _____ LAT _____ LONG _____ RIVER MILE _____

DATE _____ SCORER _____ COMMENTS _____

- Complete the site descriptive information found at the top of the first page of the PHW Form. Information should be provided with enough specifics to allow for return visits to the same location. Observations of landmarks, etc. are important for relocation of the same site at a later time.

- The river basin represents the major basin in the stream network that the PHW stream ultimately flows into. River code information is specific to the Ohio EPA data tracking system and can be left blank for non-Ohio EPA users.

- Latitude and longitude can be determined using a Global Positioning System (GPS) unit in the field, estimated from a 7.5 min. series USGS topographic map using standardized measurement tools, or from one of the many internet based topographic mapping sites such as Google Earth, Terra Server, Topozone, Streamstats etc. The latitude and longitude should be identified from the center point of the 200 ft reach and should be reported on the PHW Form in decimal degrees with negative values reported for west latitude values in a dd.ddddd, -ddd.ddddd format.

Example conversions:

$$N\ 41^\circ\ 45'\ 23.2'' = 41 + (45 \div 60) + (23.2 \div 3600) = 41 + 0.75 + 0.00644$$

$$= \mathbf{41.75644}$$

$$W\ 80^\circ\ 25'\ 13.1'' = -1 \times [80 + (25 \div 60) + (13.1 \div 3600)] = -1 \times (80 + 0.41667 + 0.00364)$$

$$= \mathbf{-80.42031}$$

- Determine the upstream drainage area of the PHW stream segment under investigation (see Section 2.2.2). Note that it is likely that many PHW streams will not be identified at the USGS 1:24,000 mapping scale.

- Record the date of the assessment and the name of the scorer(s) in the space provided at the top of the PHW Form.

5.2 Channel Modification Category Determination

STREAM CHANNEL MODIFICATIONS: ☐ NONE / NATURAL CHANNEL ☐ RECOVERED ☐ RECOVERING ☐ RECENT OR NO RECOVERY

The PHW field evaluation process for a stream reach begins with a determination of whether or not the stream channel has been modified by channelization. A determination must be made as to the extent the channel geomorphology has been modified and sinuosity reduced as well as the degree of recovery that has occurred over time resulting in re-naturalization from past channel modifications. Guidelines to determine the proper channel modification category are listed in Table 3 and are further described in the Ohio EPA QHEI guidance (Ohio EPA, 2006a – see discussion for Metric 3: Channel Morphology). Streams in the "NONE/NATURAL CHANNEL" and the "RECOVERED" categories are considered **"natural"** channels when using the HHEI flow chart (Figure 18), while those in the "RECOVERING" and the "RECENT OR NO RECOVERY" categories are considered **"modified"** channels.

On the front of the PHW Form, determine the proper level of channel modification and check the appropriate box in the area provided next to the heading "Stream Channel Modifications". Research regarding historical land use patterns of an area is often helpful in properly completing this portion of the form for the stream reach under evaluation. In addition, the degree of natural features which should be present in any given stream reach must be taken into account in light of the watershed characteristics, flow patterns and geologic setting of the evaluated reach when assigning the stream channel modification category. Photo documentation of channel morphology should be made (Figures 9 and 10) as part of the assessment.

Table 3. Guidelines for the determination of the stream channel modification category for the HHEI form.

Stream Channel Modification Category	Narrative Description
NONE/NATURAL CHANNEL	No obvious historical relocation or alteration of the stream channel is evident. The stream channel is characterized by the presence of riffles and pools, heterogeneous substrate deposition, the presence of point bars or other evidence of floodplain sediment deposition, appropriate stream channel sinuosity for the setting of the stream in the landscape, varied water depths and current velocity (when flowing), no obvious evidence of current or past bank shaping or armoring activities is present. Natural wooded or wetland riparian vegetation dominates the stream margin.
RECOVERED	Visual evidence is present of historical channel alteration, channel relocation, bank shaping, or armoring. However, the stream has fully recovered many of the natural characteristics as listed above. Wooded or wetland riparian vegetation in either a natural condition or exhibiting significant recovery along most of the stream margin.
RECOVERING	Visual evidence is present of historical channel alteration, channel relocation, bank shaping, or armoring. The stream is in the process of adjustment but has not fully recovered the natural characteristics listed above. Stream channel sinuosity may be less than appropriate for the setting of the stream in the landscape. Wooded or wetland riparian vegetation may be present along the stream margins but is in the early stages of re-growth.
RECENT OR NO RECOVERY	Visual evidence of stream channel relocation or alteration (including bank shaping and/or armoring) exists where few if any of the natural stream characteristics listed above are present. Typical appearance of the stream channels in this condition reveals obvious signs of channel straightening, bank alteration, floodplain alterations, riparian vegetation removal, entrenchment, and trapezoidal channel geometry. Highly modified streams tend to have uniform depths, over-wide channels, homogeneous substrate types, high levels of substrate embeddedness, and low sinuosity.

Figure 9. Examples Illustrating Varying Degrees of Channel Modification.

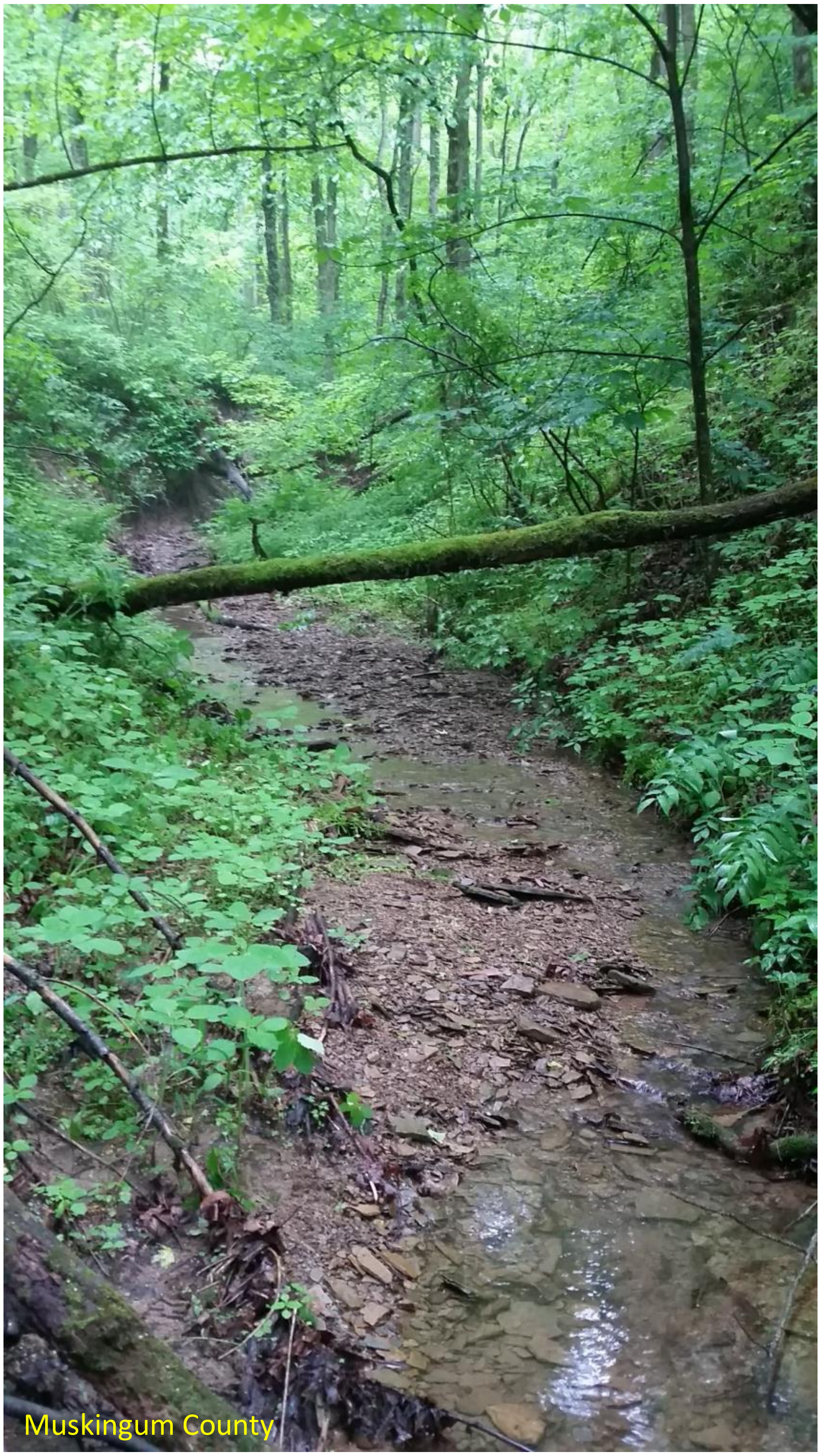


Figure 10. Some features associated with a natural PHW stream channel: A) well-defined riffles and pools in sequence; B) heterogeneous substrate and sorting of bed materials; C) stream channel sinuosity; D) varied water depths and flow velocities; E) stream banks natural with no abnormal bank erosion evident; F) wooded riparian zone composed of natural vegetation layers including tree canopy, understory layer, and herbaceous vegetation; G) clean substrates devoid of embeddedness and interstitial spaces between individual pieces abundant.

5.3 Calculation of the HHEI Score

The HHEI is a multi-parameter rapid assessment of the physical habitat that can be used to predict the biological potential of most PHW streams. The HHEI is calibrated to streams with watershed size less than 1.0 mi^2 (259 ha) where the deepest pools of water are predominantly less than 40.0 cm and should only be used with extreme caution outside of these limitations (see Sections 3 and 4 of this manual). All HHEI measurements are to be made within the 200 ft (61 m) stream reach zone. On the front of the PHW Form, within the large box, are three field measurements that must be taken to calculate a final HHEI score. Information obtained from the HHEI scoring is then used to determine the biological potential of the PHW stream following the HHEI decision-making flowchart in Figure 18.

5.3.1 HHEI Metric # 1: Stream Channel Substrate

1. **SUBSTRATE (Estimate percent of every type present).** Check *ONLY* two predominant substrate *TYPE* boxes. (Max of 32). Add total number of significant substrate types found (Max of 8). Final metric score is sum of boxes A & B

TYPE		PERCENT	TYPE		PERCENT
☐☐	BLDR SLABS **[16 pts]**	______	☐☐	SILT **[3 pt]**	______
☐☐	BOULDER (>256 mm) **[16 pts]**	______	☐☐	LEAF PACK/WOODY DEBRIS **[3 pts]**	______
☐☐	BEDROCK **[16 pts]**	______	☐☐	FINE DETRITUS **[3 pts]**	______
☐☐	COBBLE (65-256 mm) **[12 pts]**	______	☐☐	CLAY or HARDPAN **[0 pt]**	______
☐☐	GRAVEL (2-64 mm) **[9 pts]**	______	☐☐	MUCK **[0 pts]**	______
☐☐	SAND (<2 mm) **[6 pts]**	______	☐☐	ARTIFICIAL **[3 pts]**	______

Total of Percentages of Bldr Slabs, Boulder, Cobble, Bedrock ______

SCORE OF TWO MOST PREDOMINATE SUBSTRATE TYPES: (A) ☐ **TOTAL NUMBER OF SUBSTRATE TYPES: (B)** ☐

HHEI Metric Points
Substrate Max = 40
☐
A + B

Aside from water temperature and an adequate supply of water, the composition of the substrate found in the stream channel is the most important feature that predicts biological potential. Acting in conjunction with other physical characteristics of the stream channel, the substrate composition is indicative of stream hydrology, the dynamics of sediment transport to downstream water bodies, and the type of biology present. The faunal composition of Class III PHW streams is seldom dominated by fine grained or monotonous substrate types. This metric is calibrated to separate Class III PHW streams from all other types of primary headwater streams.

The characterization of the channel substrate includes a visual assessment of the 200 ft (61 m) stream reach using a reasonably detailed evaluation of both the dominant types of substrate, and the total number of substrate types present. For flowing streams, the substrate evaluation is restricted to the **wetted channel only** (locales where obligate aquatic organisms can survive). For dry stream channels, the substrate evaluation includes the **entire** channel bottom within the bounds of the bankfull width.

Use the following protocol to complete the substrate scoring section of the PHW Form:

- Estimate and record the presence and percentage of all the substrate types observed that are potentially biologically significant (i.e., provide usable habitat for obligate aquatic fauna) in the blanks included in the “PERCENT” column of the form. As a general practice, this will usually, but not necessarily always, be limited to substrate types estimated to cover 1% or greater of the stream channel. A detailed estimate of the percent coverage of each substrate type is required in order to complete the HHEI decision flowchart found in Figure 18. Ensure that the substrate percentages add up to 100% when entry of the substrate metric information is complete.

- Record the two most dominant substrate types by checking the appropriate two boxes in the “TYPE” column adjacent to the names of the substrate types estimated to be dominant in the evaluated reach. Note that only two substrate type boxes can be checked on the form and that only these two substrate types are used to calculate the score entered in Box A of the substrate metric. If it is determined that one type of substrate completely dominates the stream channel within the reach (based upon one substrate type exceeding 90% of the coverage and no other type exceeding 5%), check both substrate type boxes next to the appropriate substrate type and check no other boxes in the “TYPE” column.

- Add the scores associated with the two dominant substrate types and record the sum in Box A of the substrate metric section (note: if there is only one dominant substrate type, the score in Box A equals two times the score associated with the substrate type).

- Count the number of substrate types observed (those for which percentages are estimated) and enter the result in Box B of the substrate metric section. Box B has a maximum possible score of 8 points, even if more than 8 functional substrate types are present.

- Add the score in Box A to the score in Box B and enter the result in the Substrate metric box on the right-hand side of the PHW Form. [Note that the substrate metric score cannot exceed 40 points, see previous bullet]

- Add the percent coverage of Bedrock, Boulders, Boulder Slabs, and Cobble and record the sum as a percentage in the space provided to the left of Box A in the substrate metric section of the PHW form. This estimate may be important when categorizing the stream using the decision flow chart (Figure 18).

An example of a properly completed substrate metric section of the PHW form is provided in Figure 11.

1. SUBSTRATE (Estimate percent of every type present). Check *ONLY* two predominant substrate *TYPE* boxes. (Max of 32). Add total number of significant substrate types found (Max of 8). Final metric score is sum of boxes A & B

TYPE		PERCENT	TYPE		PERCENT	HHEI Metric Points
☐ ☐	BLDR SLABS **[16 pts]**		☐ ☐	SILT **[3 pt]**	5	Substrate Max = 40
☐ ☐	BOULDER (>256 mm) **[16 pts]**	5	☐ ☐	LEAF PACK/WOODY DEBRIS **[3 pts]**	10	
☐ ☐	BEDROCK **[16 pts]**		☐ ☐	FINE DETRITUS **[3 pts]**	5	
☒ ☐	COBBLE (65-256 mm) **[12 pts]**	30	☐ ☐	CLAY or HARDPAN **[0 pt]**		28
☐ ☒	GRAVEL (2-64 mm) **[9 pts]**	35	☐ ☐	MUCK **[0 pts]**		
☐ ☐	SAND (<2 mm) **[6 pts]**	15	☐ ☐	ARTIFICIAL **[3 pts]**		A + B

Total of Percentages of Bldr Slabs, Boulder, Cobble, Bedrock: 35

SCORE OF TWO MOST PREDOMINATE SUBSTRATE TYPES: (A) 21

TOTAL NUMBER OF SUBSTRATE TYPES: (B) 7

Figure 11. An example of a completed Substrate Metric section from page 1 of the PHW Form. Note that only two substrate types are checked under the "TYPE" column and that these scores are added to produce the score in Box A. The percentage estimates for observed substrate types are entered in the "PERCENT" column, and the total percentages of boulder slabs, boulders, bedrock and cobble are added and recorded in the space to the left of Box A. The total number of substrate types is counted and the result entered in Box B. Scores from Box A and Box B are added to obtain the Substrate Metric score and the result is recorded in the box provided in the "HHEI Metric Points" column on the right-hand side of the form.

Although not required, pebble-counts can be used to quantify the percentages of the most common substrate types. However, the user should note that substrate types that are visually observed and deemed to be biologically available habitat within the evaluated reach must <u>always</u> be counted toward the scoring for the number of substrate types present regardless of whether or not that substrate type was encountered during a pebble count analysis. The HHEI substrate metric was calibrated based upon use of the visual estimation method.

Experience among Ohio EPA field staff has shown that pebble count analyses often miss one or more substrate types that can be visually observed and which are available to aquatic organisms. In addition, it has also been observed that pebble count analyses tend to under-estimate the percent composition of large substrates in PHW stream evaluations. Therefore, extreme care should be taken to ensure that the minimum number of observations made during pebble counts is sufficient to capture the true variability of the substrate in the evaluated stream and that these data are verified by cross checking with visual observations. Pebble-count data can be recorded on the field form provided in Attachment 4 or other published sources. For further information regarding conducting, recording, and interpreting pebble count data, the following references can be consulted: Bevenger and King (1995); Kondolf (1995); Kondolf and Li (1992); Rosgen (1996); and Wolman (1954). A stream mapping and qualitative substrate evaluation form used by Ohio EPA field staff is also provided as Attachment 5 to this manual. Use of this optional form can provide a standardized, semi-quantitative aid for determining substrate composition for use in scoring the Substrate Metric of the HHEI.

The measurement of substrate particles during an HHEI assessment is conducted with the use of a small metric ruler with gradations in millimeters. Measurements and size classifications are based upon the length of the intermediate axis of the particle (Figure 12). The intermediate axis is always perpendicular to the long axis of the particle. Care should be taken to measure the longest point on the particle that is perpendicular to the long axis. For particles determined to meet the definition of a boulder, the ratio of the measurement of the intermediate axis to the short axis is used to distinguish between boulders and boulder-slabs (see definitions below).

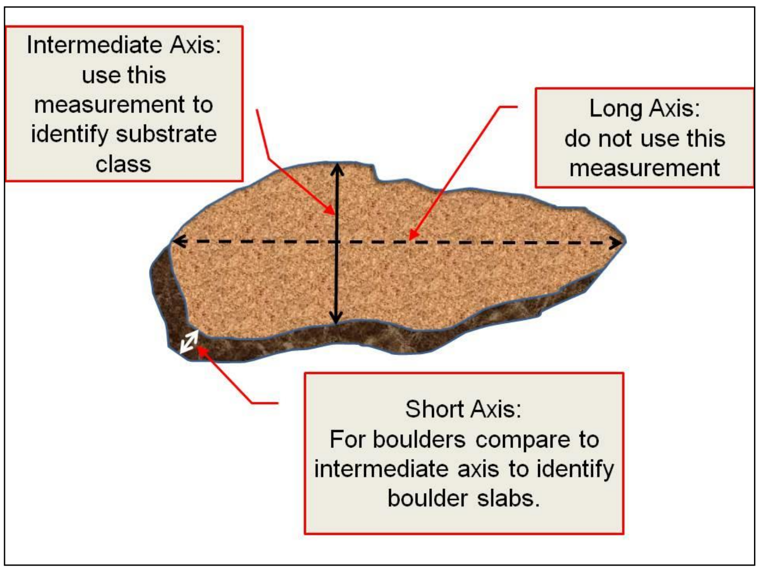


Figure 12. A stylized representation of a substrate particle indicating the proper axes used to determine the particle size category for classification in HHEI scoring.

A summary of definitions for the nine major substrate types that apply to the HHEI evaluation follows:

Bedrock Substrates: Streambed characterized by the presence of monolithic bedrock outcropping. May be fractured, and often associated with boulder and cobble substrates. Since PHW streams with bedrock substrate are often associated with the surface discharge of groundwater, a high degree of association was found at these sites with the presence of cold water adapted native fauna including obligate salamanders and benthic macroinvertebrates (e.g., Class III PHW stream biology).

Boulder Substrates: These substrate types provide excellent habitat for obligate aquatic salamanders, fish, and benthic macroinvertebrates because of their inherent stability. They are separated into two types:

Boulder Slabs: Greater than 256 mm, flat instead of round (see Figure 12: ratio of intermediate axis length to the short axis length >2).

Boulders: Greater than 256 mm, round, (see Figure 12: ratio of intermediate axis length to the short axis length ≤ 2).

Cobble Substrates: Stones with intermediate axis lengths greater than 64 mm and less than 256 mm. This substrate type has a strong association with Class III PHW streams.

Gravel Substrates: Particles 64 mm or less, but at least 2 mm in size along the intermediate axis. This substrate type is neutral in its ability to differentiate PHW streams but is often a secondary component of Class III PHW streams.

Sand Substrates: Particles less than 2 mm in size along the intermediate axis, gritty texture when rubbed between fingers. This substrate type is often a secondary component of Class III PHW streams.

Silt Substrates: Substrate particles less than 0.6 mm in size, exhibiting a greasy texture when rubbed between the fingers. Silt is most often a conglomerate of eroded clays and very fine organic matter which has deposited in the stream channel. There is a negative association of silt with Class III PHW streams, but silts can be present in limited amounts in natural channels with low energy dynamics.

Clay or Hardpan Substrates: This substrate type is typically found when the stream bed has eroded to a depositional clay layer within the underlying sub-soil. This substrate is typically hard and gummy and is difficult to penetrate. Unlike silts, this substrate type is not deposited in the stream channel by recent fluvial processes. It provides a poor habitat for most native fauna.

Muck Substrates: Muck consists of decayed organic matter with little or no clay content. Muck differs from silt in that it is almost entirely organic in nature, less dense, and more odorous. Muck differs from detritus in that it is partially decayed and not coarse or readily identifiable as to the material of origin. This substrate type is strongly associated with Class II PHW streams. Caution should be taken to ensure that the material is not actually sludge deposited downstream of a discharge from a failing wastewater treatment system or animal management operation. In such cases, the sludge is ignored and the underlying substrate is identified and used for scoring.

Detritus Substrates: Detritus refers to the presence of partially decayed or un-decayed sticks, wood, leaves or other plant material deposited in the stream channel. The allochthonous input of organic matter is the primary energy resource for the biological community of PHW streams. Two categories are recognized:

Leaf Pack/Woody Debris: The presence of leaf packs and woody debris provides an energy resource as well as habitat for colonization of plants and animals. Although this substrate type was found to be neutral in its ability to separate different types of PHW streams from one another, it is often found as a secondary component of Class III PHW streams with heterogeneous substrates. It provides potential microhabitat and is the primary food source for benthic macroinvertebrates that are in turn prey for fish and obligate aquatic salamanders. This substrate type is also positively associated with the presence of salamander larvae.

NOTE: Users should be aware that assessments conducted during the period of leaf fall (September through November) may temporarily overwhelm the stream channel with leaf litter. These conditions should be noted on the HHEI form and adjustments made to the substrate score to accurately represent the stream substrates under normal stream conditions.

Fine Detritus: This substrate type refers to fine, partially decomposed plant material that has accumulated within the stream channel as a precursor to the development of muck deposits. These materials are subject primarily to microbial decomposition processes. Fine particulate organic matter may be correlated with the presence of macroinvertebrate fauna that "collect" fine organic matter as a food source.

Artificial Substrates: "Artificial" substrate types include all man-made or engineered materials in the stream channel whether or not they have been intentionally placed in the stream. Artificial substrates include materials such as crushed stone (rip-rap or aggregate), concrete, bricks, lumber, trash, asphalt, metal, etc. that have either been placed in or found their way into the stream. Where engineered structures or substrates have been placed in the stream for the purposes of stream restoration, a trained biologist who determines that the placed materials are functioning as viable habitat for aquatic fauna may categorize these substrates into the appropriate substrate category associated with natural substrates (e.g., boulder, cobble, gravel, woody debris, etc.) and score the substrate metric accordingly.

5.3.2 HHEI Metric #2: Maximum Pool Depth

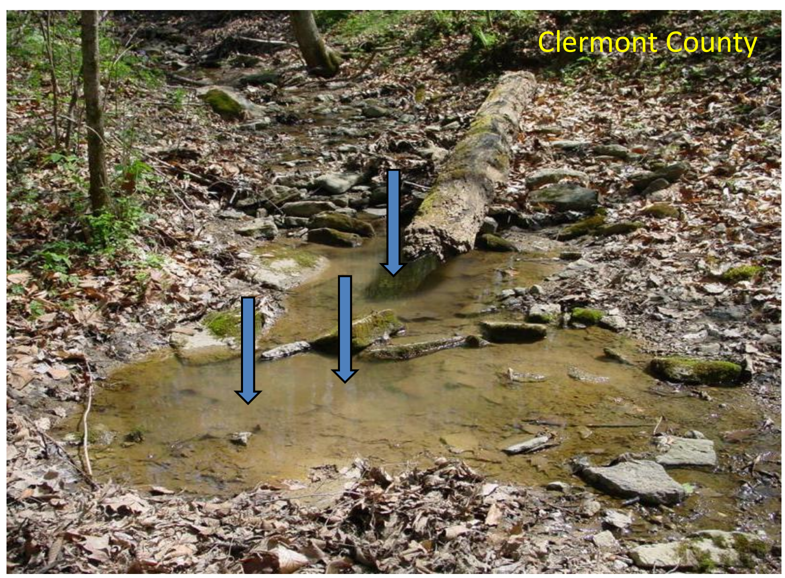
2. **Maximum Pool Depth (*Measure the maximum pool depth within the 61 meter (200 feet)*** evaluation reach at the time of evaluation. Avoid plunge pools from road culverts or storm water pipes) (Check *ONLY* one box):

		Pool Depth Max = 30
☐ > 30 centimeters **[20 pts]**	☒ 5 cm - 10 cm **[15 pts]**	15
☐ > 22.5 - 30 cm **[30 pts]**	☐ < 5 cm **[5pts]**	
☐ > 10 - 22.5 cm **[25 pts]**	☐ NO WATER OR MOIST CHANNEL **[0pts]**	

COMMENTS ______ **MAXIMUM POOL DEPTH (centimeters):** 10

The maximum pool depth within the stream reach is important since it is a key indicator of whether the stream can support a well-balanced fish community. Streams where most of the natural pools are less than 40 cm in depth during the critical low flow period of the year are less likely to have well-balanced WWH fish communities (see Figure 16 in Rankin, 1989), and thus are more likely to have dense populations of lungless salamanders. Maximum pool depth is also related to the type of flow present in the stream channel (i.e., continuous, intermittent, interstitial), and thus serves as a good discriminator of the various types of PHW streams. Scoring of the Pool Metric is based upon the maximum pool depth within the 200 ft (61 m) stream reach. In the field, several depth measurements should be taken within each pool in order to verify that the deepest point(s) have been measured.

To complete this section of the PHW Form, check the appropriate box for the maximum pool depth observed and record the corresponding Pool Depth metric score in the box in the right-hand column of the form. If no water can be found within the evaluated reach, the Pool Metric score is zero (0). The maximum pool depth observed should be recorded to the nearest centimeter. Individual pool depth measurements may be recorded in the comments space as they are made.



Care should be taken to avoid measurements in plunge pools located on the downstream ends of road culverts or other man-made structures as these depths are not characteristic of overall stream morphology. Evaluation reaches should be selected to exclude these features whenever possible. In addition, it is important to ensure that the stream is under seasonal base flow conditions (see Section 2.3) in order to properly score the Pool Metric. Since the

HHEI was calibrated based upon evaluations conducted during critical low flow periods of the year (June-September), assessments conducted during high flow periods of the year may result in higher overall HHEI scores based solely upon differences in the Pool Metric score.

5.3.3 HHEI Metric #3: Average Bankfull Width

3. **BANK FULL WIDTH (Measured as the average of 3 - 4 measurements) (Check *ONLY* one box):**

- [X] > 4.0 meters (> 13') **[30 pts]**
- [ ] > 3.0 m - 4.0 m (> 9' 7"- 13') **[25 pts]**
- [ ] > 1.5 m - 3.0 m (> 4' 8" - 9' 7") **[20 pts]**
- [ ] > 1.0 m - 1.5 m (> 3' 3" - 4' 8") **[15 pts]**
- [ ] ≤ 1.0 m (≤ 3' 3") **[5 pts]**

COMMENTS ______________________ **AVERAGE BANKFULL WIDTH (meters)** 4.2

Bankfull Width Max=30: 30

Bankfull width is a morphological characteristic of streams that is determined by the energy dynamics related to water discharge. The bankfull width of the stream therefore relates strongly to its annual flow condition and has been found to be a strong discriminator of the three classes of PHW streams in Ohio. The bankfull width of a stream channel should be measured in straight sections of the stream (riffle, run, or glide). Pools and bends in the stream or other areas where the stream width is affected by the deposition of debris, fallen trees, log jams, etc. should be avoided. For the purposes of this manual, the bankfull width is defined as the elevation on the stream banks where the flow is at the bankfull discharge. The bankfull discharge is defined as follows:

> "... the discharge at which channel maintenance is the most effective, that is, the discharge at which moving sediment, forming or removing bars, forming or changing bends and meanders, and generally doing work that results in the average morphologic characteristics of channels." Dunne and Leopold (1978).

The elevation of bankfull discharge may not be at the top of the stream bank in incised or entrenched streams. Rosgen (1996) gives several suggestions for determining bankfull width in streams:

- "a break in slope of the banks and/or a change in the particle size distribution (since finer material is associated with deposition by overflow, rather than the deposition of coarser material within the active channel)";
  [*Note: the highest elevation of gravel and/or sand bars ("point bars") is an excellent indicator of the bankfull discharge elevation*]
- "evidence of an inundation feature such as small benches";
- "staining of rocks"; and/or
- "exposed root hairs below an intact soil layer indicating exposure to erosive flow."

The boundary elevation on the stream bank where terrestrial vegetation begins along the stream margin can also indicate the edge of the bankfull width (Figures 13 through 16). This indicator can be extremely helpful when used in combination with other indicators mentioned above. However, caution must be taken when evaluations are conducted under drought conditions when pioneering terrestrial vegetation may temporarily invade the stream channel.

Further guidance, including a series of training videos relating to the determination of bankfull stage, can be accessed through the USDA Forest Service web page via the following link: https://www.fs.fed.us/biology/nsaec/products-videoswebinars.html. Users of this manual are highly encouraged to review this video training series to develop competence at identifying bankfull stage elevation.

Following the measurement of 3-4 bankfull widths along the evaluated stream reach, the average bankfull width (in meters) is entered into the appropriate box in the Bankfull Width Metric section on page one of the PHW Form. The bankfull width category for the reach is checked and the corresponding metric score is entered in the box in the right-hand column of the form. Individual bankfull width measurements may be recorded in the comments space as they are made.

In the field it will often be possible to determine the bankfull stage on only one bank of the stream. However, this point can be used as a reference to determine the bankfull elevation on the opposite bank by creating a level line across the stream from the identified bankfull elevation perpendicular to the stream flow (see Figures 13 through 16). The following procedure can then be used to determine the bankfull width:

- mark the bankfull elevation with a stake;
- connect a length of string to the stake at the bankfull elevation;
- place bubble type line level on measuring string (Figure 17);
- suspend the measuring string perpendicular to the stream flow from the staked location to the opposite bank;
- pull string taut and manipulate up and down until the line level indicates that the string is level. Mark the location where the string intersects the opposite bank;
- measure the distance between the marked bankfull locations on either bank of the stream; then
- repeat the procedure to result in 3-4 measurements throughout the 200 ft (61 m) stream reach and record each measurement.
- Calculate an average bankfull width for the stream segment. Record the average bankfull width on the PHW Form in the space provided.

Line levels are readily available at home improvement and hardware stores at a reasonable cost. Ohio EPA has also had good success using carpenter's laser levels placed at the bankfull elevation to shoot the bankfull elevation of the opposing bank along a level plane.

These types of laser levels may be ineffective on sunny days along streams with little forest canopy or where the stream is very wide. For very narrow streams (widths less than 1 meter at bankfull) with highly visible bankfull indicators on both banks, the use of levels to mark the bankfull elevations may be unnecessary to get an accurate measurement.

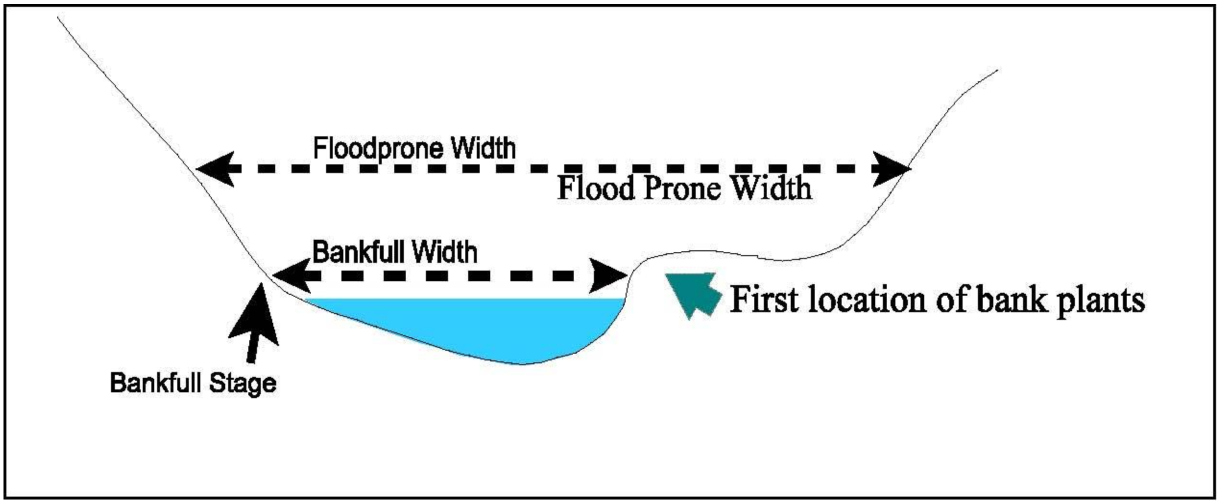


Figure 13. Schematic representation of the relationship between bankfull and floodprone stream widths.

Figure 14. Measuring bankfull width of an incised PHW stream. Note that the bankfull indicators are below the top of the bank in this incised channel.

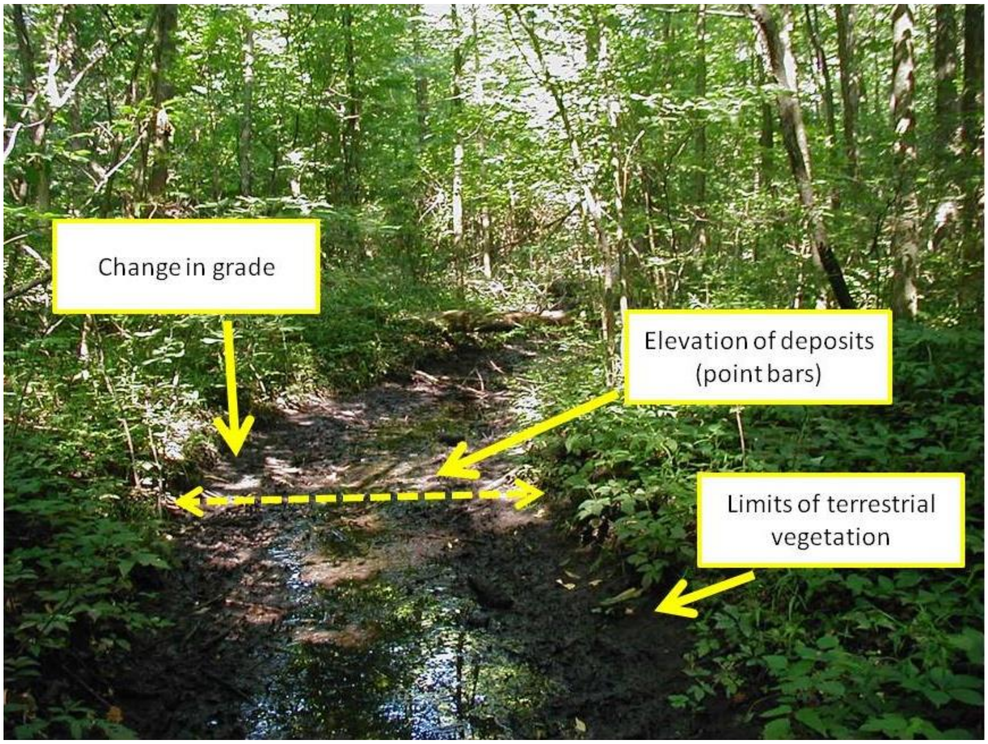


Figure 15. Bankfull indicators noted for a PHW stream in Fulton County, Ohio. The dashed line represents the bankfull width for this location.

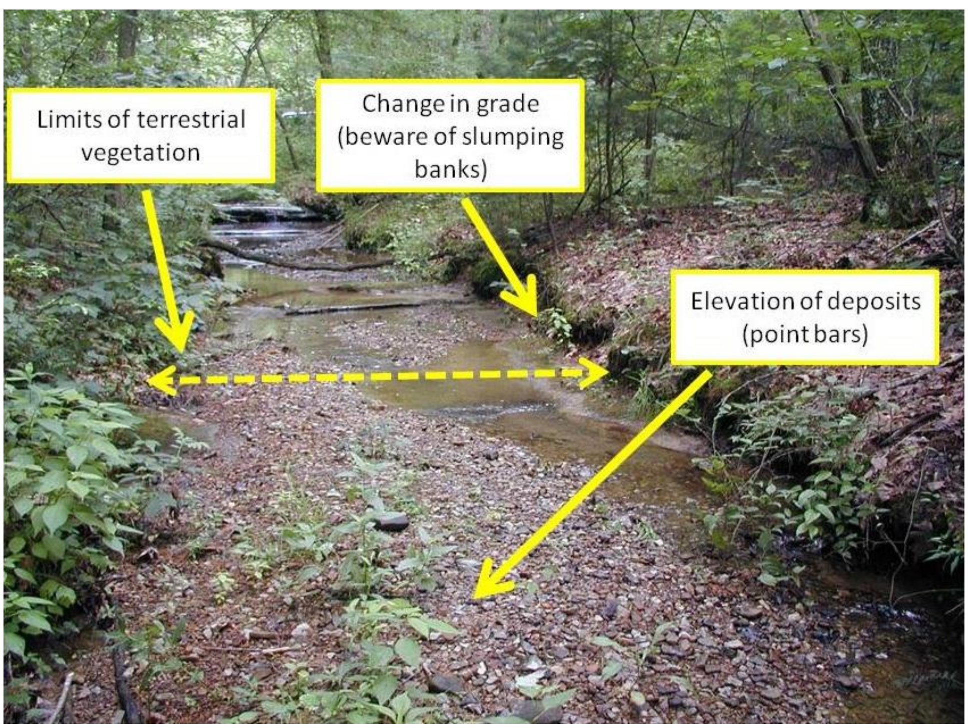


Figure 16. Bankfull indicators noted for a PHW stream in Hocking County, Ohio. The dashed line represents the bankfull width for this location.

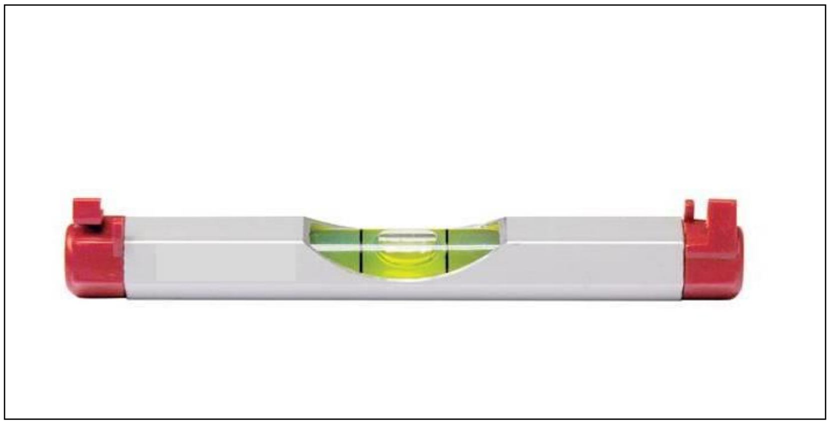


Figure 17. A line level. The instrument is hung from a taut string suspended between a known bankfull elevation to determine the bankfull elevation on the opposite stream bank.

5.3.4 Total HHEI Score

The total HHEI score is derived by adding the three metric scores (substrate + pool depth + bankfull width). The resulting value is then entered into the "HHEI Score" box located in the upper right hand corner of page one of the PHW Form.

5.4 Using the HHEI Assessment to Differentiate Between PHW Stream Types

The Ohio EPA currently uses a rapid habitat assessment tool, the QHEI, to assess the biological potential of larger streams in Ohio. As a rule of thumb, if multiple QHEI assessments along a stream corridor have an average QHEI score greater than 60 points, this information can be used to assign a WWH aquatic life use designation to an undesignated stream with deep pools greater than 40 cm (see Figures 15 and 16 in Rankin, 1989). However, a QHEI less than 60 points does not necessarily suggest that a WWH use cannot be obtained unless the QHEI score is significantly degraded due to a high number of modified metrics (see Rankin, 1989 for guidance).

In a manner similar to use of the QHEI, it is possible to use the HHEI to determine the biological potential of PHW streams in Ohio. Whereas the QHEI is calibrated to the presence of a well-balanced fish assemblage, the HHEI is calibrated to the presence or absence of salamander species with obligate aquatic multi-year larval periods. These species often replace fish as the top vertebrate predator in perennial headwater streams. Neither the QHEI nor the HHEI are primarily calibrated to the presence or absence of well-balanced or cold water adapted benthic macroinvertebrate communities. However, the HHEI can be used to predict the presence of cold water adapted species of macroinvertebrates where they are strongly associated with the presence of reproducing obligate aquatic salamander species.

The flowchart found in Figure 18 **must** be used to assign the classification to a PHW stream when the stream classification is based solely on a HHEI assessment. This flowchart allows for both natural and modified PHW stream channels to be placed into one of six potential PHW stream types:

- Rheocrene
- Class I (natural channel)
- Class I (modified channel)
- Class II (natural channel)
- Class II (modified channel)
- Class III

When the results of both a biological assessment and a habitat assessment using the HHEI are available, the data from the biological assessment are used to classify the PHW stream. Users should note that the HHEI evaluation process does not provide sufficient data needed to differentiate between Class IIIA and Class IIIB streams. In cases where the HHEI assessment indicates that a stream is Class III, it is assumed that the aquatic fauna within the stream is a Class IIIB fauna until sufficient biological data is collected to show otherwise. See Sections 6.0 and 7.0 of this manual for further guidance regarding the appropriate level of biological data collection necessary to differentiate between the two subtypes of aquatic fauna associated with Class III streams.

The exceptions to the use of biological data to definitively classify PHW streams without reference to the HHEI data are cases where drought conditions exist (Section 2.3) or there is reason to suspect that chemical toxicity or another pollution source (typically organic or nutrient enrichment or sedimentation) is limiting the full biological potential of the stream. If degraded water quality resulting in toxicity, enrichment, or sedimentation is present, the HHEI assessment should be used to determine the potential aquatic life use that would be present once the chemical pollution problem is eliminated. A similar approach is used in larger streams with the QHEI evaluation, which is used by Ohio EPA to determine if a stream has the potential to attain a WWH fish community in the absence of chemical toxicity. Chemical-physical parameters that could affect headwater stream biology include ammonia-N, low dissolved oxygen, dissolved solids (salts), excessive siltation, heavy metals from mine drainage, pH, and excessive increases in water temperature.

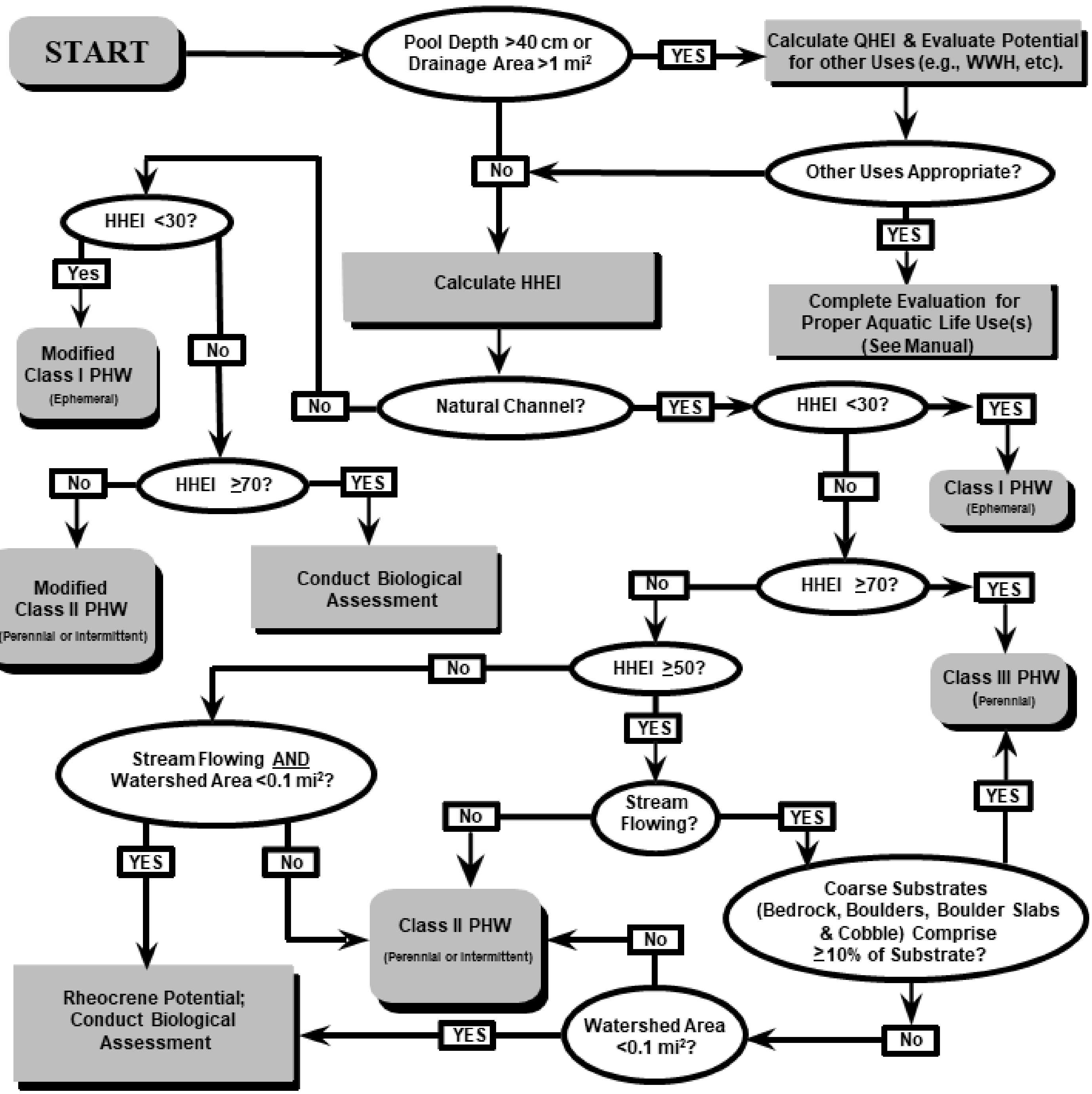
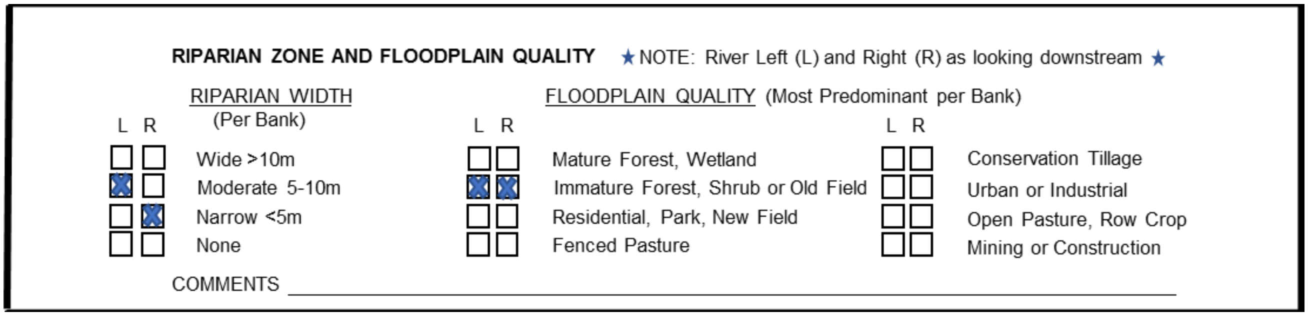


Figure 18. The HHEI Flow Chart.

5.5 Riparian Zone and Floodplain Quality



RIPARIAN ZONE AND FLOODPLAIN QUALITY ★NOTE: River Left (L) and Right (R) as looking downstream ★

L	R	RIPARIAN WIDTH (Per Bank)	L	R	FLOODPLAIN QUALITY (Most Predominant per Bank)	L	R	
☐	☐	Wide >10m	☐	☐	Mature Forest, Wetland	☐	☐	Conservation Tillage
☒	☐	Moderate 5-10m	☒	☒	Immature Forest, Shrub or Old Field	☐	☐	Urban or Industrial
☐	☒	Narrow <5m	☐	☐	Residential, Park, New Field	☐	☐	Open Pasture, Row Crop
☐	☐	None	☐	☐	Fenced Pasture	☐	☐	Mining or Construction

COMMENTS ______

The riparian ecotone between the flowing water of a stream and the adjacent flood plain is critical for the fauna that lives in PHW streams. The riparian stream margin provides the primary source of food in the form of fallen leaves (detritus) for the benthic macroinvertebrate food web. Physical structure in the form of leaf litter and decayed logs provide shelter for amphibians and other animals. The shading provided by a well-formed canopy of woody vegetation helps to maintain cool water temperatures in the summer months in spring-fed PHW streams. The riparian zone is also an important migratory corridor for many forms of wildlife including mammals, reptiles, amphibians, and birds.

The "Riparian Width" and "Floodplain Quality" check boxes on the PHW Form are completed by checking the appropriate selection for the riparian width and land use(s) for each bank. The riparian width refers to the overall average distance from the stream bank that is vegetated by woody vegetation (mature trees and shrubs). The right and left banks (a.k.a.,"river right" and "river left") are determined looking in the downstream direction. In cases where the riparian width or land use varies significantly along one or both stream banks within the stream reach being evaluated, the two most appropriate selections should be checked. It may also be of interest to record the type of plant community found in the riparian corridor of the stream reach under investigation. This information should be recorded in the comments section.

[NOTE: the term "mature forest" in the PHW context does not have the same meaning as used in wetlands assessments using the Ohio Rapid Assessment Method (ORAM). For PHW stream assessments, relatively mature second or third growth forest cover (20+ year trees) should be counted as "mature forest".]

5.6 Flow Regime

FLOW REGIME *(At Time of Evaluation)* (Check *ONLY* one box):

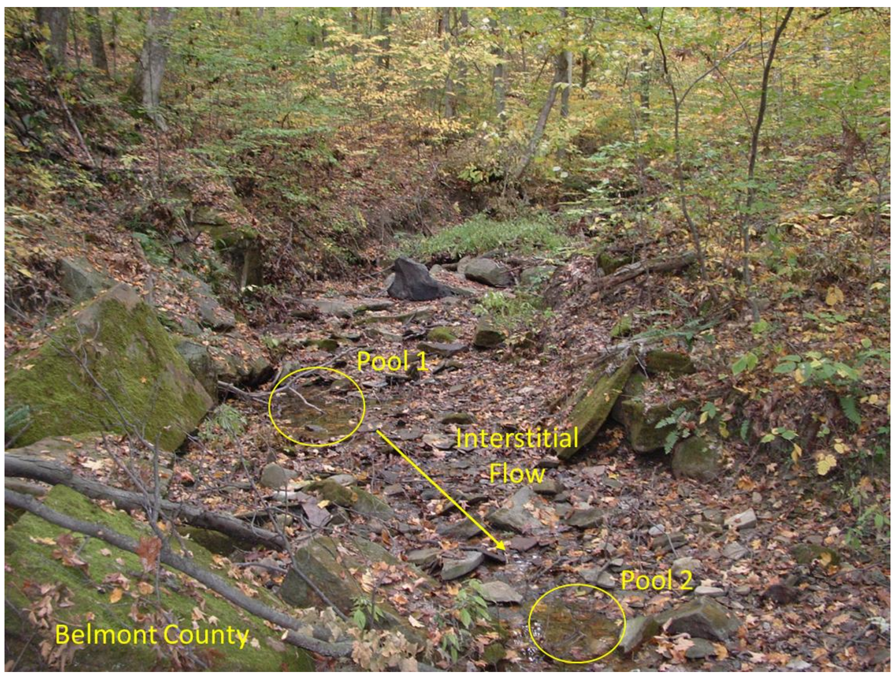
- [ ] Stream Flowing
- [x] Subsurface flow with isolated pools (interstitial)
- [ ] Moist Channel, isolated pools, no flow (intermittent)
- [ ] Dry channel, no water (ephemeral)

COMMENTS ______________________________

For purposes of completing an evaluation of PHW streams, the following are definitions used to describe the apparent flow characteristics at the time of the evaluation:

Stream Flowing: Flowing water present at time of assessment.

Interstitial Flow with Isolated Pools: Flowing water is present in isolated pools (often widely spaced), which remain connected by subsurface flows. Dye testing may be needed to document pool connection. Alternatively, a test can be made for interstitial flow by digging away the substrate in a "dry" portion of the stream (preferably in the thalweg) to see if the substrates are saturated (i.e. water fills the hole). If the water in the hole clears of suspended silts quickly, or obvious stream flow is present, and/or the water is at temperatures indicating groundwater contribution (temperatures ≤ 20°C in the summer), interstitial flow through the channel substrates is indicated.



Moist Channel, Isolated Pools, No Flow: Moist substrate and/or water present in isolated pools, but no visual evidence that the water in the pools is flowing.

Dry Channel, No Water: A completely dry channel for the entire 200 ft (61 m) stream reach. No pools, moist substrates or interstitial flow present.

Record the flow condition at the time of evaluation in the space provided on the PHW Form. This information can be very useful in making a final PHW classification decision. If it is believed that low flow conditions would be significantly different than that observed at the time of the evaluation, this can be confirmed by either:

1) waiting until the stream is at seasonal low flow conditions, or
2) by conducting a biological evaluation of the stream.

NOTE: Temporal and seasonal variations in the flow condition of PHW streams are common and should be expected. Base flow conditions present during an evaluation should be verified as typical (not drought related) based upon an analysis of the drought index and critical low flow data for the area in question as discussed in Section 2.3. If drought conditions exist, the results of the HHEI evaluation may be suspect and determination of the PHW stream type should be delayed until normal flow conditions resume in the area. Where drought conditions are suspected, or where the stream channel is dry, the Palmer Drought Severity Index value for the area should be recorded in the "comments" section in the "Flow Regime" section of the PHW Form. Information regarding local flow conditions from nearby USGS stream gages can also be recorded in this area of the form.

5.7 Sinuosity

SINUOSITY (Number of bends per 61 m (200 ft) of channel) (Check ONLY one box):

☐ None	☐ 1.0	☒ 2.0	☐ 3.0
☐ 0.5	☐ 1.5	☐ 2.5	☐ >3

Although not determined to be a significant discriminator of PHW stream types, the sinuosity of a stream may be related to channel modification, which is one of the primary factors used in the HHEI assessment flow chart to differentiate various PHW stream types (Figure 19). Determine the number of complete and well-defined outside bends in the 200 ft (61m) stream reach (Figure 19) and record on the PHW Form (Attachment 1). Incomplete bends not fully included in the evaluation reach should be counted as half bends at the discretion of the observer. Indicators that can be helpful to determine the sinuosity pattern in the field are steep and eroded banks on outside bends and the presence of point bars on the inside of the bend. For recovering and recovered channels (stream modification category – Section 5.2), sinuosity of the wetted channel and thalweg may form before the stream banks have fully adjusted laterally and vertically following a disturbance of the stream channel. The user may wish to document this forming stream pattern as sinuosity on the form, using caution and noting this alternative interpretation.

The method of estimating sinuosity presented in this manual differs from the more quantitative stream geomorphology technique typically used in stream geomorphology studies [e.g., Rosgen (1996)]. This more technical approach is based on the ratio of the channel length to valley length to define a unit-less sinuosity coefficient (K).

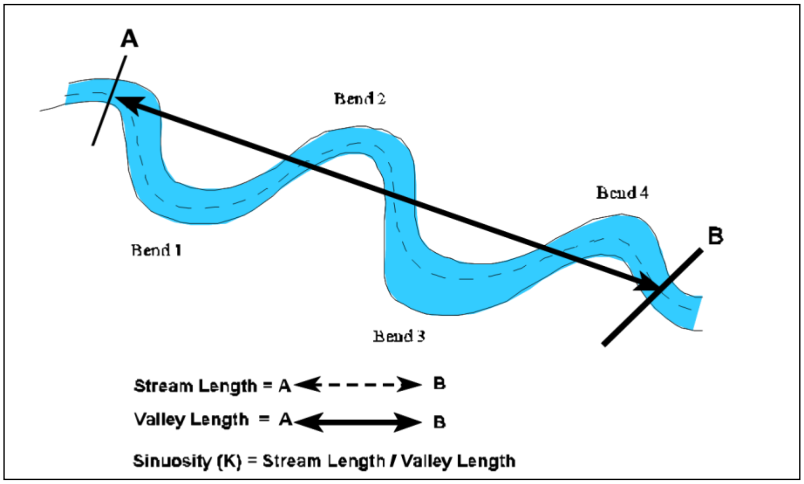


Figure 19. Diagram indicating the method for determining sinuosity as recorded on the PHW Form. Note that points "A" and "B" represent the limits of the 200 ft (61 m) PHW evaluation reach. This particular example has four complete bends and would be entered as ">3" on the PHW form.

5.8 Stream Gradient

STREAM GRADIENT ESTIMATE
☐ Flat (0.5 ft/100 ft) ☒ Flat to Moderate ☐ Moderate (2 ft/100 ft) ☐ Moderate to Severe ☐ Severe (10 ft/100 ft)

Stream gradient was not determined to be a significant overall discriminator of PHW stream class. However, stream gradient was found to be suitable for separating Class III PHW streams from all other types. In general, Class III PHW streams typically have a moderate gradient of 2% slope (0.02 feet/foot) and are rarely greater than 10% slope (0.10 feet/foot). Both very high gradient streams and sluggish streams do not provide optimal flow hydrology for the types of biological communities adapted for life in Class III PHW streams. On the front of the PHW Form, check the box with the best visual estimate of stream gradient for the stream reach.

Although several methods are available to accurately measure stream gradient using surveying techniques, these methods are often time consuming and require the use of expensive equipment. An excellent visual estimation method to accurately estimate the gradient without the need for specialized equipment is as follows:

1. stand at the mid-point of the 200 ft (61 m) evaluation zone and look upstream at the marker indicating the upstream limit of the zone;

2. estimate the height (in feet) at which a level line extending from the upstream marker would be at the mid-point of the zone;

3. this height gives the gradient of the stream equivalent to the units provided on the PHW Form (ft/100 ft).

If the stream gradient is markedly different between the upstream and downstream halves of the zone, the same procedure can be repeated by observing from the downstream limit of the zone and looking upstream to the mid-point of the zone. In this case, record the average of the readings or check both boxes and provide explanatory notes on the form regarding the differences within the evaluated reach.

5.9 PHW FORM - PAGE 2

5.9.1 QHEI Assessment

Check the appropriate box as to whether or not a QHEI evaluation was performed. If yes, attach a copy of the final QHEI sheet. See Section 3.2 for a discussion regarding how to determine whether a QHEI assessment is necessary when assessing a potential PHW stream.

5.9.2 Downstream Designated Uses(s)

If known, mark the box which indicates the downstream designated uses (within two river miles). Check a box only if the stream segment feeds to a wetland or to a stream with a known use designation. If the downstream segments are undesignated, check no boxes, but describe downstream characteristics in the space provided.

Please be specific in responses to this item. Information provided in this section can be used to evaluate potential beneficial uses of the water body and to evaluate potential impacts on downstream uses. A description of the drainage hierarchy downstream of the segment being analyzed to the nearest named stream should be provided if possible.

5.9.3 Location Information

Attach a copy of both the USGS topographic map and the NRCS county soil map with the watershed areas of the PHW streams clearly identified. Enter information regarding the maps on which the evaluated reach lies on the PHW Form in the spaces provided. Also identify the county and township or municipality where the site is located.

A useful feature of the STREAMSTATS web tool for the delineation of watershed areas is a feature for exporting the watershed map in an electronic format. For users with GIS software, a shape file of the watershed, superimposed upon the USGS topographic map can be uploaded from the STREAMSTATS web page (see Section 2.2.2).

5.9.4 Miscellaneous Information

Several items on page 2 of the PHW Form are provided for entering miscellaneous information about the evaluated stream reach and its condition on the day the survey. They include:

- A space to indicate whether or not the stream was at base flow conditions for the season of the year when the field evaluation was conducted. Two additional pieces of information are recorded in this portion of the form that can be helpful in making this determination, the date and quantity of the last local precipitation (if known) and whether or not the turbidity of the water is elevated on the day of the site visit. If there has been significant rainfall or snow melt within the previous 48 hours and the turbidity of the stream is high, the PHW evaluation should be postponed until the stream returns to base flow conditions.

- Information regarding photographs taken of the assessed stream reach can be recorded in this section of the PHW Form. It is highly recommended that enough photographs be taken to fully document the conditions and the habitat present at the time of the evaluation. Provide information on the form that will allow for later identification of the photos.

- A space is provided to record an estimate of the percent openness of the overhanging tree canopy over the stream reach. The amount of open area in the tree canopy should be estimated as that which would be experienced at the time of maximum leaf cover. In most situations, a visual estimate of the percent openness of the canopy is sufficient, although quantitative estimates can be obtained using a leaf densiometer. Information regarding the amount of shading of the stream can be helpful when making a final determination regarding the type of PHW stream under investigation.

- Spaces are provided to record field measurements for dissolved oxygen, pH, water temperature, and conductivity using standard Ohio EPA quality control methods (Ohio EPA, 2019). If no field monitoring equipment is available, at a minimum, the water temperature of the stream (if water is present) should be recorded during each PWH assessment. Water temperature in summer months can be used to verify potential Class III PHW streams. In general, Class III PHW streams will have a daily average summer water temperature below 20°C, with values less than 18°C near the spring source. Water in Class III PHW streams can have daily maximum summer water temperatures higher than 20°C well downstream from their spring source(s), but average daily temperatures will rarely be above 23°C (see Ohio EPA 2002b).

- A space is provided to record whether water samples were collected for laboratory analyses. Water samples for analyses in addition to the field parameters listed above do not need to be routinely collected to classify PHW streams. However, in the event that upstream chemical pollution of the water is suspected, a sample should be collected for analysis in order to ensure that site biology is not affected by water chemistry. If a sample is collected, provide the sample identification information and provide copies of the analytical report. Under these circumstances, analyses should be conducted for nutrient parameters (ammonia-N, nitrate+nitrite-N, total phosphorus), COD, chlorides, heavy metals, dissolved solids and *E. coli* bacteria. Where mine drainage impacts are suspected, include samples for iron, manganese, and sulfates. The Water Quality Standards found in OAC Chapter 3745-1 should be consulted in order to determine if any applicable standards are exceeded.

5.9.5 Biological Evaluation Summary

If a biological evaluation is conducted, complete the information in this section of the form as indicated. A detailed summary of biological data should be recorded on pages 3 and 4 of the PHW Form (see Section 6.0) in the space provided.

Even in cases where a detailed biological evaluation (Level 2 or Level 3 Assessment) is not conducted, cursory observations of the in-stream biology noted during the HHEI evaluation process can often be extremely helpful in interpreting the habitat data. Fish, amphibians, macroinvertebrates or some combination of these groups are often observed while completing the field measurements associated with conducting the HHEI analysis. It is therefore highly advisable that observations of the aquatic fauna be made and recorded in conjunction with the HHEI.

5.9.6 Drawing and PHW Stream Reach Narrative Description

In the space provided on the HHEI form or using the Qualitative Substrate Evaluation Form included as Attachment 5, make a drawing of the evaluated PHW stream reach. Include the following information on the map: important landmarks, habitat features, notations regarding substrate distribution, bankfull width measurement locations, pools and pool depths, riffles, the direction of water flow, a north arrow, and any other features of interest such as springs, seeps, or nearby wetlands. Also include information regarding any road crossings or points for access. The drawing should include comments on the type of riparian zone and land use adjacent to the stream reach, and any observations regarding seepage areas or confluences with other tributary channels. The stream drawing is a critical component of the assessment process and is extremely useful to document the condition of the evaluated reach on the day of the site evaluation. **The PHW evaluation process should not be deemed to be complete unless the stream sketch is completed.**

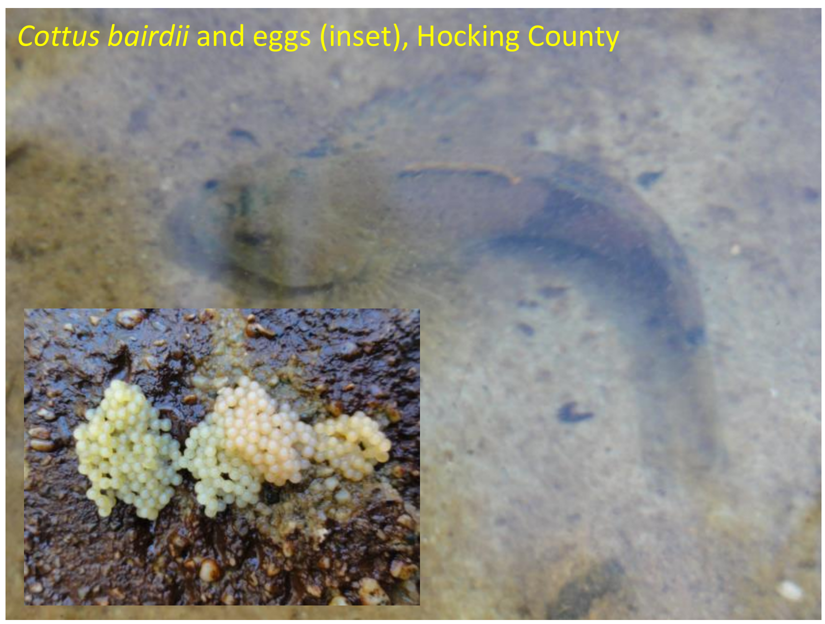
PHW FORM - PAGES 3-5

6.0 Level 2 and Level 3 Assessments: Biological Sampling

Differentiation of PHW streams is based upon the communities of aquatic life that are, or have the potential to be, supported within the stream. Therefore, proper use of biological sampling is critical to provide the data necessary to properly identify the stream(s) being assessed relative to the different types of PHW streams existing on the landscape. The following sections provide information on the different types of biological communities found in PHW streams. Standardized methods to be used in the collection and preservation of biological specimens are also described. All data collected for biological assessments should be recorded on pages 3 and 4 of the PHW Form (Attachment 1).

Some general notes apply for all the biological sampling techniques described in this manual. It is extremely important that the flow conditions of the stream are appropriately understood prior to committing resources toward the collection of biological samples. Elevated stream flows as well as drought can both create stream conditions that are unsuitable for the assessment of the in-stream biology (see Section 2.3). In addition, extra precautions must be taken when sampling during times of leaf fall because of the interference that the leaves cause in searching for organisms. The time allocated for collecting fish, salamanders, or benthic macroinvertebrates may have to be lengthened significantly to account for the additional effort needed to properly sort through the detritus to capture organisms. Similar cautions also apply for times of year when streams are frozen, since the physical conditions will interfere with access to the various habitat types within the stream and limit collection efficiency. In short, common sense should prevail in determining whether the stream conditions are suitable for conducting valid biological assessments.

6.1 Fish in PHW Streams


Cottus bairdii and eggs (inset), Hocking County

Many PHW streams contain fish that are classified by Ohio EPA (Ohio EPA, 1989) into one of three major categories: (1) cold water adapted (e.g., Redside Dace); (2) pioneering species (e.g., Creek Chub), or (3) headwater adapted species (e.g., Blacknose Dace). All three of these categories of fish species have been collected in PHW streams. A list of all species of fish collected from PHW streams by Ohio EPA in 1999 and 2000 is provided in Table 4. The Creek Chub was the most common species, collected in 32.8% of all samples, with Bluntnose Minnow (19.4%), and Blacknose Dace (10.4%) next in frequency of occurrence (see also Ohio EPA, 2002c).

Although many different species of fish may be present in PHW streams as shown in Table 4, it becomes increasing less likely that a <u>well-balanced</u> fish community, as measured by the IBI, can be supported as watershed size approaches and falls below 1.0 mi^2 (259 ha). Limitations to the establishment of well-balanced fish communities in PHW streams can result from the lack of suitable habitat or forage, barriers to migration (natural or artificial), or the lack of refugia during low and zero flow conditions. The lack of permanent nursery areas for young-of-the-year fish also may preclude the establishment of well-balanced fish communities in PHW systems. Therefore, many fish species may be only temporally resident as they move in and out of PHW streams to exploit seasonally available food resources. There often exists in natural watersheds a lower limit in watershed size and stream scale where fish are no longer observed but are replaced by salamanders as the dominant vertebrate predator (see Figure 1).

The presence of fish species adapted to cooler water is a definitive indicator that the stream is a Class IIIB PHW. A Class II PHW stream may be indicated by the presence of warm water

adapted populations of fish in the absence of any cold water indicator taxa. If the maximum depth of the predominant pools is greater than 40 cm, then the Ohio EPA QHEI habitat evaluation should be conducted, and the stream should be evaluated for potential to attain the WWH or EWH use designations according to established agency procedures (Rankin, 1989; see also Section 3.2).

Sampling methods to collect fish in PHW streams can include electro-fishing techniques (i.e., long-line or backpack methods), use of a 10 ft seine, or collection with a fine mesh benthic invertebrate net. If assessing the stream for potential WWH, CWH, or EWH use designations, standard procedures using electro-fishing techniques must be followed (Ohio EPA, 1989).

For a PHW stream survey, fish must be collected for at least 15 minutes throughout the 200 ft (61 m) stream reach under investigation. Focus on pools, undercut banks, and other deep cover features such as larger rocks, boulders and boulder slabs within the stream reach. These are areas used as refuge for fish when the stream is disturbed. All fish collected should be identified to species. Record all species collected and their total numbers on page 3 of the PHW form (Attachment 1). Record in minutes the total time spent searching for fish.

Voucher specimens should be collected for each species that cannot be positively identified in the field and preserved in a solution consisting of one part buffered formalin and nine parts water. If voucher specimens are to be held longer than 2-3 weeks, the specimens should be transferred to a 70% ethanol preservative solution using the methods described in the Ohio EPA methods manual (Ohio EPA, 1989). Place a field tag in and on the jar which includes date, collector name, county, township, and stream identification as listed on the HHEI field evaluation form (see Attachment 6).

Table 4. Fish species observed/collected in Primary Headwater streams in Ohio, 1999-2000. Fish were captured in 67 of the 215 streams sampled. Fish species in **bold** represent PHW stream indicator species based upon habitat preference. Species listed in *italics* indicate cold water adapted indicator species "Yes" indicates that the species is associated with the listed ecological category by Ohio EPA. (Ohio EPA, 1989).

Species (common name)	Percent Occurrence	Pioneering Species	IBI-Headwater Species	Coldwater Species
Creek Chub	32.8	Yes	---	---
Bluntnose Minnow	19.4	Yes	---	---
Blacknose Dace	10.4	---	Yes	---
Rainbow Darter	7.5	---	---	---
Bluegill Sunfish	4.5	---	---	---
Johnny Darter	4.5	Yes	---	---
Stoneroller Minnow	4.5	---	---	---
Largemouth Bass	2.9	---	---	---
Fantail Darter	2.9	---	Yes	---
Greenside Darter	2.9	---	---	---
White Sucker	2.9	---	---	---
Green Sunfish	2.9	Yes	---	---
Redside Dace	1.5	---	Yes	Yes
Mottled Sculpin	1.5	---	Yes	Yes
Brook Trout (native)	1.5	---	---	Yes
Goldfish*	1.5	---	---	---
Central Mudminnow	1.5	---	---	Yes
Orangethroat Darter	1.5	Yes	---	---
Fish Species expected to occur in PHW streams in Ohio but not observed during 1999 and 2000 surveys				
Creek Chubsucker	-	Yes	---	---
Southern Redbelly Dace	-	---	Yes	Yes
Rosyside Dace	-	---	Yes	---
Silverjaw Minnow	-	Yes	---	---
Fathead Minnow	-	Yes	---	---
Brook Stickleback	-	---	Yes	Yes
Yellow Bullhead	-	---	---	---

Redside dace, *Clintostomus elongatus*, from Clark County

6.2 Salamanders in PHW Streams

In the headwaters of some watersheds, aquatic to semi-aquatic salamander species replace fish as the primary aquatic vertebrate predator functional group (Figure 1). These amphibians are distributed throughout Ohio except for the counties in the northwest part of the state. Detailed maps showing the distribution of salamanders in Ohio by county are given in Pfingsten and Downs (1989), Pfingsten (1998), and Pfingsten and Matson (2003) and Pfingsten et. al. (2013). Three assemblages of salamander species have been identified in headwater streams throughout the state based on the results of studies conducted by Ohio EPA in 1999 and 2000, which are summarized in Table 5, and discussed in detail below.

Class III PHW Salamander Assemblage (perennial flow; egg and larval development dependent upon year-round presence of flowing water, usually with greater than 12-month larval period)

This salamander assemblage is represented by species of obligate aquatic species that have larvae resident in the stream channel on a year-round basis. Most of these species have larval stages that last for at least two years based on available literature, with a maximum span between 4-5 years (Petranka, 1998; Pfingsten and Downs, 1989; Pfingsten et. al., 2013). These species also require flowing water for egg deposition, with females usually laying eggs in habitats saturated with flowing water. The larvae of these species also require perennial flow conditions throughout their larval development, during which time they reside within the stream channel. Salamander species associated with Class III PHW stream types in Ohio are taxonomically related, all classified within the Tribe Hemidactyliini, Subfamily Plethodontinae, of the Family Plethodontidae. The presence of Class III indicator salamander species in PHW streams is also highly associated with the presence of cold water adapted species of benthic macroinvertebrates.

The Class III salamander taxa may be further sub-divided into two groupings. Although the presence of reproducing populations of any Class III indicator species is indicative of perennial flow conditions, those included as Class IIIA indicator species are separated from the Class IIIB indicator species based upon life history and thermal tolerances as described below and in Tables 5 and 6.

1. Class IIIA PHW Salamander Assemblage

Three species, the Northern Two-lined Salamander (*Eurycea bislineata*), the Southern Two-lined Salamander (*Eurycea cirrigera)*, and the Long-tailed Salamander, *Eurycea longicauda* are recognized as indicator species of Class IIIA PHW streams in Ohio (Tables 5 and 6). The Northern Two-lined Salamander and the Southern Two-lined Salamander were the most common species collected from PHW streams in Ohio. These two species also have the widest geographic distribution ranges of all the salamander indicator species found in Ohio's perennial headwater streams. Similar to other Class III indicator salamanders, the Two-lined salamander species have larval periods extending well beyond 12 months (Table 6) where the presence of flowing water is necessary for survival and life cycle completion. The exception to this general characteristic is the Long-tailed Salamander, which may or may not have a larval period greater than 12 months in Ohio.


Northern Two-lined Salamander, Geauga County

Class IIIA indicator salamander species are separated from Class IIIB indicator species based upon the thermal requirements for survival. Reproducing populations of Class IIIA species can commonly be found in streams with warmer thermal regimes compared to the Class IIIB indicator salamander species. In addition, reproducing populations of the Northern Two-lined Salamander and the Southern Two-lined salamander can commonly be found in larger, non-PHW streams in Ohio, where Class IIIB indicator species are generally restricted to smaller catchments associated with springs.

The presence of a reproducing population of one or more Class IIIA salamander species is conclusive evidence that the PHW is a Class III PHW stream. Furthermore, they are also indicative of a Class IIIA PHW in the absence of other indicator taxa including (salamanders, fish, or macroinvertebrates) that are associated with and satisfy the conditions of a Class IIIB PHW as outlined in this manual. It is only possible to definitively discern a Class IIIA PHW stream from a Class IIIB PHW stream following a complete assessment of the benthic macroinvertebrate, fish and salamander community that is present in the stream during which all organisms are identified to the lowest taxonomic level (i.e., Level 3 PHW assessment). The exception to this statement occurs if Class IIIB indicators are observed during a Level 2 PHW assessment, which results in a definitive Class IIIB classification for the stream.


Long-tailed Salamander, Montgomery County

2. Class IIIB PHW Salamander Assemblage

Six species or subspecies from the genera *Eurycea*, *Gyrinophilus*, and *Pseudotriton* are recognized as Class IIIB indicator taxa (also see Tables 5 and 6 of this manual). Two of these species, the Cave Salamander (*Eurycea lucifuga*), and the Midland Mud Salamander (*Pseudotriton montanus*) are listed as endangered and threatened, respectively, in ORC 1531.25. Observations of reproducing populations of one or more of these species is definitive evidence that the PHW stream is a Class IIIB.


Northern Spring Salamander, Belmont County

Class II Salamander Assemblage (intermittent flow warm water adapted; larvae present in the stream seasonally, less than 12-month larval period)

The second assemblage of salamanders found in PHW streams in Ohio are distinguished from the Class III obligate aquatic salamander assemblage by having a larval period of less than 12 months (Tables 5 and 6). These indicator species can be associated with a continuum of permanent to intermittent flow conditions. These non-obligate aquatic salamander species are taxonomically different from the obligate salamander assemblage, being classified within the Subfamily Desmognathinae of the Family Plethodontidae, the Family Ambystomatidae, and the rarely encountered species *Hemidactylium scutatum* (Four-Toed Salamander). Although salamanders from this non-obligate group may be found coexisting with obligate salamander species, these non-obligate aquatic species have life history traits that do not require residence in flowing water on a year-round basis due to their shorter larval life stage.


Northern Dusky Salamander, Hocking County

Salamanders in Ohio from the genus *Desmognathus* do not require flowing water for egg clutch deposition, but instead lay eggs in stream bank habitats, usually under rocks, moss, or logs; although seepage areas may also be utilized. Species from the genus *Ambystoma*, which may lay eggs within the flowing water of a PHW stream channel, have short larval periods. They tend to be found in streams that become intermittent or completely dry during summer months. A third aquatic salamander genus, *Hemidactylium*, is largely found in sphagnum bogs, but may migrate to headwater streams that connect to these bogs. The presence of species of salamanders from this non-obligate aquatic assemblage can be used to identify the presence of a warm water Class II PHW stream type.


N. Dusky Salamander guarding egg clutch, Belmont County

Two species from this second group, the Blue-Spotted Salamander (*Ambystoma laterale*) and the Four-Toed Salamander (*Hemidactylium scutatum*), are listed as endangered and special concern, respectively, in ORC 1531.25.


Streamside Salamander larvae, Warren County

Other Salamanders in PHW Streams (taxa with no aquatic larval development stage; adults may forage in dry channels in search of food).


Red-backed Salamander, Pickaway County

The third group of salamander species that may be encountered in PHW streams consists of species that are adapted for life in terrestrial forest habitats. These species often migrate into PHW stream corridors, usually during wet periods, to forage for food. This group includes species from the genus *Plethodon* [examples include the Redback Salamander, (*P. cinereus*) the Ravine Salamander (*P. richmondi)*, and the Slimy Salamander (*P. glutinosus*). These salamander species have terrestrial modes of existence and lack aquatic larval stages, but they are an important component of the food web structure of second growth forests in Ohio. *Plethodon* species are good bio-indicators of various stages of forest succession, with preference for old growth forest seral stages. They are common in Beech-Maple associations that once were dominant throughout Ohio. *Plethodon* salamanders live in burrows and under decaying logs, bark, rocks and leaf litter in forested areas throughout the state. While the presence or absence of these species is not used in the PHW assessment, notations of their presence, when observed, should be noted.

6.2.1 Sampling Methods for Salamanders in PHW Streams

The goal when assessing the salamander community in PHW streams is to document the presence or absence of reproducing populations of species from the various indicator groups discussed above. Two techniques for assessing salamanders in PHW streams are presented in this manual. The qualitative technique described in Section 6.2.1.1 is a Level 2 Assessment that is typically suitable for differentiating different types of PHW streams. Oftentimes, the use of this technique will provide sufficient documentation to definitively discriminate PHW stream types and relative quality. However, this technique cannot be used exclusively to rule out the presence of reproducing populations of Class IIIB indicator species when Class IIIA salamander species have been identified from the stream, or when only a single life stage of a Class IIIB indicator species is documented. Only evidence of reproduction (eggs, larvae, or a mixture of juveniles and adults) can be used to discern the PHW stream classification based on salamanders. The semi-quantitative visual encounter survey (VES) technique described in Section 6.2.1.2 is considered a Level 3 Assessment method. The VES method should always be accompanied by the qualitative sampling described in Section 6.2.1.1. Results of a Level 3 salamander survey are definitive for determining the PHW stream classification based on this organism group and for differentiating between Class IIIA and Class IIIB salamander assemblages.

Table 5. Species of salamanders that can be used as bio-indicators of Class III (cooler water, perennial flow) and Class II (warmer water, intermittent flow) PHW streams in Ohio.

Species adapted to Perennial Flow, with Larval Periods >12 Months (Class III PHW Indicators)

Family Plethodontidae (Lungless Salamanders)

Subfamily Plethodontinae; Tribe Hemidactyliini

Eurycea bislineata (Northern Two-lined Salamander)

Eurycea cirrigera (Southern Two-lined Salamander)

Eurycea longicauda (Long-tailed Salamander)
[Some populations may have shorter larval periods]

Eurycea lucifuga (Cave Salamander)**

Gyrinophilus porphyriticus porphyriticus (Northern Spring Salamander)

Gyrinophilus porphyriticus duryi (Kentucky Spring Salamander)

Pseudotriton montanus diasticus (Midland Mud Salamander)**

Pseudotriton ruber ruber (Northern Red Salamander)

Species Adapted to Survive Intermittent Flow, with Larval Periods <12 months (Class II PHW Indicators)

Family Ambystomatidae (Mole Salamanders)

Ambystoma barbouri (Streamside Salamander)

Other *Ambystoma spp.* (Such as Jefferson, Smallmouth Salamander, Tiger Salamander)

Family Plethodontidae (Lungless Salamanders)

Subfamily Desmognathinae

Desmognathus fuscus (Northern Dusky Salamander)

Desmognathus ochrophaeus (Allegheny Mountain Dusky Salamander)

Subfamily Plethodontinae; Tribe Hemidactyliini

Hemidactylium scutatum (Four-Toed Salamander)**
[This species is uncommon in headwater streams]

** Note: The salamander species, *Eurycea luifuga* (Cave Salamander), *Ambystoma laterale* (Blue-Spotted Salamander), and *Aneides aeneus* (Green Salamander) are listed as “endangered” species in Ohio (ORC 1531.25). The species *Pseudotriton montanus diasticus* (Midland Mud Salamander) is listed as a “threatened” species and *Hemidactylium scutatum* (Four-Toed Salamander) is listed as a species of “special concern” in ORC 1531.25.

Adapted from “Salamanders of the United States and Canada”, 1998. James W. Petranka.
Smithsonian Institution Press, Washington, DC.

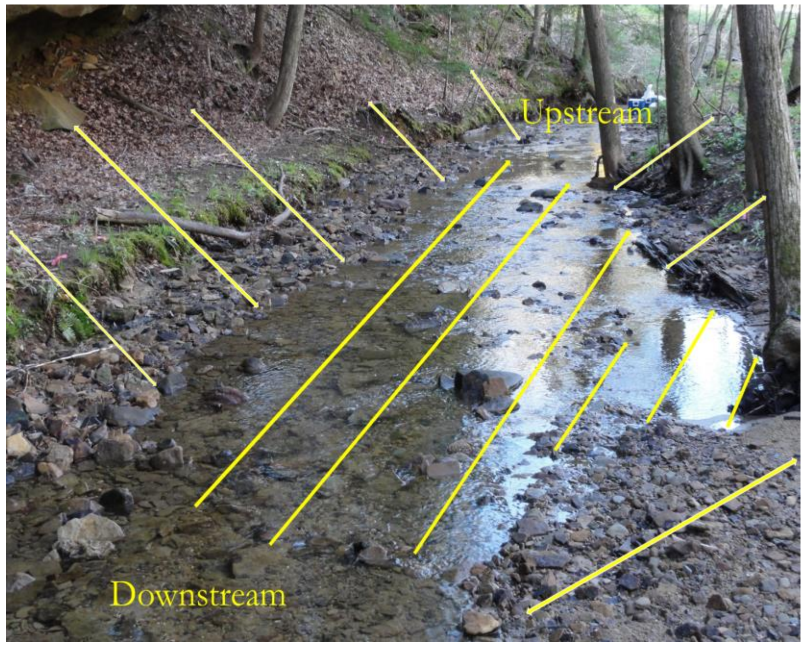
Table 6. List of salamander species in Ohio that use primary headwater stream corridors as a habitat for egg deposition (oviposition) and larval growth. Species ordered from shortest length of larval period to longest. Life history data from personal observations of R.D. Davic (formerly Ohio EPA), Harding (1997), Pfingsten and Downs (1989), Petranka (1998), Hulse et al. (2001). *Plethodon* and *Aneides* species with direct development are not included in this table. When multiple species are observed in the same stream segment, the most obligate aquatic species is used to indicate the PHW stream type **Only evidence of reproduction (eggs, larvae, or mixture of juveniles & adults) is used to determine PHW stream class.**

Species	Micro-habitat and Season for Egg Clutch Deposition and <u>PHW Stream Class Indicator</u>	Length/Season of Larval Period
Four-Toed Salamander (*Hemidactylium scutatum*)	Found in bog habitats, eggs usually found in moss (sphagnum) from March to May. Eggs may be found in slow moving headwater streams associated with bog habitat. Adults are terrestrial. **<u>If evidence of reproduction found, a Class II indicator species.</u>** Protected as a Special Interest species in ORC, Section 1531.25.	1-2 months (May to June) Pond type larval development
Streamside Salamander (*Ambystoma barbouri*)	SW Ohio only. Oviposition from January to March in headwater streams with few fish. Stream usually becomes intermittent during summer. Often in limestone type geology. Eggs found in water under rocks from December to March. **<u>If evidence of reproduction found, a Class II PHW indicator species.</u>**	2-3 months (March to May)
Allegheny Mountain Dusky Salamander (*Desmognathus ochrophaeus*)	Extreme NE Ohio only. Oviposition near seepage areas, mostly from August to October. Known to breed in sub-surface habitats. Stream may become intermittent in summer. Adults will forage in riparian areas. **<u>If evidence of reproduction found, a Class II PHW indicator species.</u>** May also be found in some Class III stream habitats.	1-3 months. Most common in September to November but may occur in March-April in some Ohio populations.
Northern Longtail Salamander (*Eurycea longicauda*)	Statewide except northwest and north-central Ohio. Oviposition over winter in streams and seepage areas associated with rock outcrops or in sub-surface areas. Often in limestone or shale geology, around caves. **<u>If evidence of reproduction found, a Class IIIA PHW indicator species.</u>**	4-5 months, (March to July) but may extend to 12-14 months in local populations. Larval period not well known for Ohio.
Northern Dusky Salamander (*Desmognathus fuscus*)	Statewide except northwest and north-central Ohio. Oviposition in stream bank microhabitats or seepage areas, outside flowing water (June to August). Eggs not in flowing water, but located streamside under rocks, logs, moss with brooding female. **<u>If evidence of reproduction found, a Class II PHW indicator species</u>.** May also be found in Class III stream habitats.	9-10 months (September to May) No larvae in late June-early August. Young and old larvae may be found along stream banks outside of flowing water.
Cave Salamander (*Eurycea lucifuga*)	Extreme southwest counties of Ohio (Butler and Hamilton Counties) and in southern Adams County; Ohio at northern edge of geographic range. Oviposition from September to February within caves and subterranean habitats. **<u>If evidence of reproduction found, a Class IIIB PHW indicator species.</u>** Very rare, listed as an Endangered Species in Ohio (ORC 1531.25).	Mostly 14-18 months with two larval age classes common in Indiana populations. Larval period not well known for Ohio

Table 6 (cont). List of salamander species in Ohio that use primary headwater stream corridors as a habitat for egg deposition (oviposition) and larval growth. Species ordered from shortest length of larval period to longest. Life history data from personal observations of R.D. Davic (formerly Ohio EPA), Harding (1997), Pfingsten and Downs (1989), Petranka (1998), Hulse et al. (2001). *Plethodon* and *Aneides* species with direct development are not included in this table. When multiple species are observed in the same stream segment, the most obligate aquatic species is used to indicate the PHW stream type. **Only evidence of reproduction (eggs, larvae or mixture of juveniles & adults) is used to determine PHW stream class.**

Species	**Micro-habitat and Season for Egg Clutch Deposition and <u>PHW Stream Indicator Type</u>**	**Length/Season of Larval Period**
Midland Mud Salamander (*Pseudotriton montanus*)	Extreme south-central Ohio. Oviposition in autumn, embryos hatch in winter. Common in burrows; egg nests in cryptic underground sites. **<u>If evidence of reproduction found a Class IIIB PHW indicator species.</u>**	15 to 30 months, larval period not well known for Ohio populations
Northern Two-Lined Salamander (*Eurycea bislineata*)	North Central to North East Ohio. Common in perennial flowing PHW streams. Oviposition from April to May, in shallow running water under flat rocks. May be found in dry streams with interstitial sub-surface flow. **<u>If evidence of reproduction found, a Class III A indicator species</u>.** Known to migrate into higher order streams.	24 to 36 months in Ohio. Three distinct larval age classes observed in some populations.
Southern Two-Lined Salamander (*Eurycea cirrigera*)	Southern portion of Ohio, considered a sub-species of E. bislineata by Petranka (1998). Same behavior as northern two-lined salamander. **<u>If evidence of reproduction found, a Class IIIA PHW indicator species.</u>**	24 to 36 months in Ohio. Three distinct larval age classes in summer.
Red Salamander (*Pseudotriton ruber*)	Eastern portions of state, north to south. Oviposition from October to February, usually in sub-surface areas. Adults migrate away from streams in spring-summer but overwinter in headwater springs. Associated with sandstone geology. **<u>If evidence of reproduction found, a Class IIIB PHW indicator species.</u>**	24 to 36 months, may overwinter to a fourth year as larvae.
Spring Salamander complex (*Gyrinophilus p. porphyriticus, and G. p. duryi*)	East to east-central and southern portions of the state. Oviposition in summer months, in sub-surface areas. Adults may forage away from streams. This species has a propensity for a subterranean mode of life in cold-cool headwater springs. May be associated with caves. **<u>If evidence of reproduction found, a Class IIIB PHW indicator species</u>.**	36 to > 48 months.

The general collection and handling techniques for salamanders are similar for both Level 2 and Level 3 Assessment methods described in the sub-sections below. Because salamanders are most active during the night in response to predation by other vertebrates, they are found during the daylight hours hiding under different types of microhabitat cover including rocks, logs, leaves, moss, bark, burrows, etc. Thus, efforts to collect salamanders along a stream corridor must include an effort to sample all the different types of micro-habitat cover available in the stream reach under investigation. Emphasis should be placed on sampling both within the stream channel and at least 1-2 meters (3-7 ft) from the wetted channel along the stream margins in order to maximize the potential to capture salamanders from all life stages. The presence of salamander larvae is the best predictor that the salamander population is resident in the stream on a continual basis. However, it is also extremely important to document the presence or absence of juvenile and mature salamanders at a site since this also indicates that a population is using the stream channel for reproduction.



An ordinary metal strainer, bent to a triangular shape, or a fine mesh aquatic invertebrate net is recommended for the collection of salamanders, especially the small slippery and elusive larvae. Flat edge insect nets can also be used. Brine shrimp nets can also be effective sampling tools for the capture of larval salamanders. Due to high oxygen demand, gilled, pre-metamorphic larvae are restricted to the flowing water of the stream. They are often found hiding under cover objects such as rocks, leaves, and woody material as a protection from possible predators. Deposits of loose gravel should also be searched thoroughly as larvae sometimes find this habitat to be a safe refuge from predators.

As the collection effort moves upstream, first place the net tightly against the bottom substrate and then lift cover objects in front of the net. To capture larval salamanders, position the net in front of the salamander's head, and gently touch the tail; more often than not they will move forward into the net. Replace cover objects that are lifted to their original position to minimize habitat disturbance. Another technique used to capture salamander larvae is to attach a 200 ml suction bulb to a small rubber tube of sufficient diameter to allow salamander larvae to enter. Place the tube near the larvae and use the suction bulb to capture the larvae in the tube. This method is useful in areas of the stream where larvae are hiding in such a way that nets and strainers will not work, such as within bedrock crevices. A high intensity head light may be helpful in some headwater streams due to low light conditions under tree canopy.

Spring Salamanders (*Gyrinophilus spp.*) are often found at the terminal limits of a PHW stream, near the ground water source. These salamanders are known to bury into gravel substrate as adults, although larvae can be located under rocks throughout the stream channel. When searching for salamanders near a ground water source, extra time should be spent digging into any gravel substrate that may be present. Gently but thoroughly disturbing the gravel to a depth of several inches with a small hand rake can expose hidden salamanders. Wait for any turbidity to be swept away or settle and continue to watch in and around the disturbed area as the turbidity clears for any exposed salamanders as they seek to re-establish their seclusion. You may need to repeat the process several times depending upon the extent of the habitat.

All captured salamanders should be placed into a plastic container with a vented lid or a sealable bag (double) so that species can be identified and the total number of each type counted. Great care should be taken to ensure the captured salamanders cannot escape prior to identification and enumeration. Many salamanders are accomplished climbers and should never be placed unattended into an open container or escape is likely. Larger salamanders such as adult or larger larval forms of Spring and Red salamanders should not be placed into the same containers as smaller larvae of any species as predation may occur of smaller collected specimens. Take note of any salamanders that escape capture and include those in the total tally if they can be positively identified. The stream margin should be searched within at least 1-2 m (3-7 ft) on each side of the wetted stream channel for juvenile and adult salamanders, including any seepage zones along the stream. This search zone may need to be widened to be sufficiently thorough dependent upon site-specific conditions. These age classes often migrate away from the water in search of food or places to hide from predators.

To identify the captured specimens, place all captured salamanders into a white sorting tray with a small amount of water. Gills on the head of the larvae will be visible against the white background to allow them to be identified. Record the total number of each salamander species collected on page 3 of the PHW Form. Include in the tally the total number of salamanders observed but that escaped capture. It is highly recommended that any salamanders that cannot be positively identified and larvae from each identifiable taxon be vouchered for positive identification in the laboratory. After voucher specimens are taken (Section 6.2.2), return all remaining salamanders into the stream from which they were collected.

Sampling for salamanders is best conducted during the spring and summer months. Spring sampling (April and May) will often provide the best overall assessment of in-stream reproduction, as this is the period of the year when stream-obligate salamander species will be laying eggs in the stream. Sampling in the summer months will provide the best overall capture probabilities for larvae (often multiple year classes will be present), juveniles, and adults. Larvae from species with short larval development periods (e.g., Dusky Salamanders and Longtail Salamanders) will often only be observed in the flowing stream in the late spring to early summer (May – June). Sampling during the fall months is often much more difficult, as the level of effort must be intensified due to the presence of heavy leaf litter in many PHW streams. Wintertime sampling will seldom, if ever, result in the capture of adult salamanders, since the adults hibernate and will be very difficult to find. Larvae of the obligate aquatic indicator species will continue to reside in the stream during the winter months, as they require flowing water for survival. Therefore, the presence of larvae alone in a PHW stream during the winter months is considered evidence of a reproducing population for that species since the larvae must have hatched in the stream and survived through the critical low-flow period of the year.

For both salamander sampling protocols, the same procedures are used to document the results: 1) collect the salamanders; 2) identify all individuals to species and life stage (larvae, juveniles, and adults); and 3) tally the results on Page 3 of the PHW Form (Attachment 1). Be sure to record on the page the sampling method(s) used to collect the salamanders, and the time (in minutes) that was spent actively searching the stream. Compare the results to the criteria presented in Tables 5, and 6 and the protocols described in Section 7.0 to determine the type of PHW stream.

6.2.1.1 Level 2 Assessment: Qualitative Salamander Evaluations

A variety of collection methods and tools can be used to qualitatively survey a PHW stream reach for salamanders. The techniques described in Section 6.2.1 above can be carried out throughout the stream reach in areas of suitable salamander habitat. In addition, salamanders are often captured when seining or shocking for fish (Section 6.1), or when kick-net or dip-net sampling for macroinvertebrates (Section 6.3). Additional time should always be allocated to specifically search for salamanders beyond the efforts for other organism groups. A diligent search for salamanders, thoroughly searching all available micro-habitats and the stream margins should detect whether populations are present. In most cases this assessment will provide sufficient information to determine the full array of indicator species present to sufficiently determine the PHW classification based upon the salamander species assemblage.

6.2.1.2 Level 3 Assessment: Salamander Visual Encounter Survey

A Level 3 Assessment for salamanders is conducted in situations where a definitive classification is needed to discern between Class IIIA and Class IIIB PHW stream communities or where semi-quantitative data is needed to meet the DQO's for a study of PHW streams. The Level 3 Assessment utilizes a technique that is a modification of a Visual Encounter Survey (VES) as described by Heyer, et al. (1994). Although a VES survey is semi-quantitative, more vigorous sampling techniques can be utilized to quantify salamander densities if required. Examples include the 4 m^2 quantitative sampling method as described by Rocco and Brooks (2000), or the placement of artificial substrates such as flat boards, leaf bags or other artificial substrates. These types of quantitative estimates of salamander abundance have not been specifically calibrated for this PHW manual.

Begin the salamander VES by selecting **TWO** 30 ft (9.1 m) sections of stream within the 200 ft (61 m) stream reach under investigation. Choose each sample zone where an optimal number and size of cobble type microhabitat substrate is present (64 to 128 mm length), even over bedrock. This substrate size class has been shown to be a good predictor of the presence of obligate aquatic salamander species. If both a salamander VES and benthic invertebrate sampling is to be conducted at the same time by two people, place the salamander sample zones upstream from the initial macroinvertebrate survey to eliminate problems with water turbidity caused by kick net sampling. Sampling for salamanders within the VES zone utilizes the general sampling techniques described in Section 6.2.1 above, with a meticulous downstream to upstream search of all available micro-habitats within the 30 ft (9.1 m) zone and associated stream margins. If no salamanders are observed in the first 30 ft (9.1 m) sample zone, repeat the process for the second zone. At least 30 minutes should be spent actively engaged in searching for and collecting salamanders, and the entire 30 ft (9.1 m) zone should be thoroughly searched during the survey.

Within each 30 ft (9.1 m) sample zone, salamander abundance can be estimated using the VES technique as described by Heyer et al. (1994). Time is expressed as the number of person-hours of searching within the 30 ft (9.1 m) zone. Record the exact amount of time expended in searching for salamanders to the minute on the PHW Form. A VES can be used to determine the salamander species richness of a stream segment, and to estimate the relative abundances of species on a time basis. Because turbidity can greatly affect the results of a VES, this type of monitoring should only be conducted when water is clear. Extra care must be taken if the sampling occurs during leaf fall in September through November of the year as the leaves will make searching more difficult.

6.2.2 Salamander Voucher Specimens

Collect voucher specimens and transport them live to the laboratory for proper preservation. Place adult and juvenile salamanders into double plastic bags (or plastic containers with air holes) with some moist leaf litter or moss. Remember to keep larger predatory salamanders separate from smaller specimens that may be preyed upon in transit. Larvae should be transported in stream water (typically in a sealable plastic bag) in order to keep them alive. Use a cooler with block ice for transport to the lab for preparation of scientific voucher specimens. At least five larvae and two juvenile-adults should be preserved for each species type observed in the field, if possible.

At the lab, salamanders should be euthanized as quickly and humanely as possible in a way that leaves them in a relaxed position. Salamanders may be euthanized by placing the individuals in a shallow pan and immersing them in a weak (15%-20%) ethanol solution. It may be necessary to straighten the organism several times prior to death in order to ensure that they are not fixed in a curled position. Once dead, the specimen is fixed by placing in a tray lined with white paper towel soaked with 10% formalin. The individual should be laid out straight with the limbs pointing forward parallel to the body. The toes should be spread with the palmar surface facing down. Cover with a second paper towel and add 10% formalin to the tray to a depth of 1 cm. Cover the tray to stop formalin odors and place the tray in a well-ventilated place, preferably under a fume hood. The salamanders should harden somewhat within 2 hours. Specimens should then be transferred to a jar of 10% formalin for shipment or short-term storage. Place a field tag in/on the jar which includes date, collector name, county, township, and stream identification as listed on the field evaluation form (see Attachment 6 to this manual). For long-term storage, run the formalin preserved salamanders through a series of first distilled water, then 15% ethanol, 30% ethanol, and finally 70% ethanol. Salamanders should stay in each solution for 24 hours.

6.3 Benthic Macroinvertebrates in PHW Streams

As presented in Section 1.1, there are a variety of different types of PHW streams that are found on Ohio's landscape based upon the biological communities that they can support. The benthic macroinvertebrate community is one of the definitive biological indicators that can be used to differentiate the types of PHW streams from one another. Based upon collections conducted by the Ohio EPA, three distinct macroinvertebrate assemblages have been identified in PHW streams (Ohio EPA, 2002d). These communities are defined based upon the following characteristics: the number of cold water indicator taxa present; the number of taxa from the Orders Ephemeroptera, Plecoptera, and Trichoptera (EPT taxa); and the number of sensitive taxa found at a surveyed location. Macroinvertebrate taxa having one or more of these characteristics are listed in Attachment 3 of this manual.

The benthic macroinvertebrate community assemblages for PHW streams are described in Ohio EPA (2002d) and are summarized in Table 7. Note that when evaluating macroinvertebrate assemblages to determine whether the community is consistent with the characteristics of a Class IIIB PHW, an individual taxon may count under multiple categories (e.g., sensitive, EPT, cold water). Also note that some EPT taxa are neither cold water indicators nor are sensitive taxa and thus are not listed in Attachment 3. However, these EPT taxa are still counted toward the total number of EPT taxa present at the site.

6.3.1 Benthic Macroinvertebrate Sampling Methods

Benthic macroinvertebrates are to be collected following the standard qualitative macroinvertebrate collection techniques used by Ohio EPA for all stream types (Ohio EPA, 2015). All potential habitats (riffles, runs, pools, and along stream margins) should be thoroughly searched for macroinvertebrates. Visually scan the stream bottom for organisms and their retreats. Pick up and examine numerous larger substrates such as rocks, woody debris, and leaf packs. Place a small net (about 10 inches wide with a curved or flexible rim) with small mesh size downstream from substrates when they are disturbed to capture dislodged specimens. Wash small amounts of fine particle sized substrates through the net and examine the contents with a white pan. Use the white pan to sort through the rocks and debris and to help identify and keep track of the taxa collected. Special care must be given to searching for the very small and often cryptic midge larvae of the Chironomidae. Many indicator taxa that are associated with Class III streams belong to this taxonomic group.

Collect aquatic macroinvertebrates for at least 30 minutes from all available habitats and thereafter until no new taxa are found. Extend the collection period as necessary when new taxa continue to be found or if conditions warrant (e.g., heavy accumulation of detritus or leaves in the stream or high habitat diversity). Record the total time spent collecting and sorting organisms in the field on Page 4 of the PHW Form (Attachment 1).

Record the presence and relative abundance (i.e., rare, common, abundant) of all major taxa collected within the sampling area on Page 4 of the PHW Form (Attachment 1). For the EPT taxa, record the total number of field-identifiable taxa observed for each group. This determination is typically at the Family taxonomic level and can often be made based on body shape and size. Record the EPT family names collected at the site on the HMFEI form.

Table 7. Summary of benthic macroinvertebrate community characteristics associated with PHW stream classes.

Class III	Streams with four or more cold water adapted taxa present. Class III PHW streams can be further divided into two subcategories:
Class IIIA	Class IIIA PHW streams are those that have no cohabitating cold water vertebrates and where the benthic macroinvertebrates do not exhibit the characteristics of a Class IIIB community.
Class IIIB	Class IIIB PHW streams have one or more of the following characteristics: • Streams with cohabitating cold water vertebrate species; • Streams where two of the following three characteristics are present within the benthic macroinvertebrate community: ✓ six or more cold water adapted benthic macroinvertebrate taxa; ✓ seven or more EPT taxa; ✓ seven or more sensitive taxa.
Class II	The macroinvertebrate communities in these PHW streams are characterized by a composition of primarily warm water adapted macroinvertebrates of moderate to high diversity. Three or fewer cold water adapted taxa are present.
Class I	Macroinvertebrate communities may be non-existent due to ephemeral flow conditions or may have reproducing populations of native short lived, primarily springtime macroinvertebrate assemblages with low diversity.

6.3.1.1 Level 2 Assessment: The Headwater Macroinvertebrate Field Evaluation Index (HMFEI)

The methodology developed for PHW streams is referred to as the Headwater Macroinvertebrate Field Evaluation Index (HMFEI). The HMFEI is a rapid bio-assessment field sampling method designed by former Ohio EPA biologist Mike Bolton. This index has been documented to be a good predictor of the various classes of PHW streams in Ohio. The HMFEI is designed for use in the field but does require the taxonomic expertise to distinguish taxa to the Family level in many cases. Although the HMFEI can be a useful rapid assessment tool, it is inferior to a more detailed identification of benthic macroinvertebrates as obtained through analysis of a voucher sample identified to the lowest practical taxonomic level back at the laboratory (see Section 6.3.1.2).

The HMFEI uses field level identification at the Family or Order level of taxonomy to classify different assemblages of benthic macroinvertebrates found in primary headwater streams. The HMFEI is designed to be calculated in the field. However, if it is calculated from a voucher sample, care should be taken that the same level of identification possible in the field is used. Field identification of the EPT taxa is usually possible only at the family level.

Three scoring categories are used for benthic macroinvertebrate taxa to derive the HMFEI score (Table 8). Scoring values are assigned to the macroinvertebrate categories based upon the correlation of each taxa group to Class III biological communities. The final HMFEI is calculated as follows: for Taxa Groups 1 and 2 each taxa group present at the site is multiplied by the appropriate scoring value; for Taxa Group 3, the scoring protocol is identical except for the EPT taxa, where each field-recognizable family belonging to these groups is multiplied by the scoring value of three points. Use Page 4 of the PHW Form to record the information needed to calculate a final HMFEI score.

An example of a HMFEI scoring procedure is given below. In this example, a 200 ft (61 m) PHW stream reach was sampled and the nine (9) major Taxa Groups shown below were collected. A voucher sample was collected for each of the major taxa observed as follows:

==

Taxa Group	Group Type:	Metric Scores:
Turbellaria (aquatic worm)	1	1
Mayflies: 2 taxa	3	2 x 3 = 6
Corydalidae (fishfly)	3	3 x 1 = 3
Caddisflies: 3 taxa	3	3 x 3 = 9
Tipulidae	3	3
Blackflies (other Diptera)	1	1
Midges	1	1
Snails	1	1
Crayfish	2	2

Total HMFEI Score= 27

Based on a final HMFEI score of 27, the stream reach described above has a benthic macroinvertebrate assemblage associated with vertebrates found in a Class III PHW stream.

Table 8. Headwater Macroinvertebrate Field Evaluation Index (HMFEI) scoring categories for use in assessing primary headwater streams in Ohio.

Group 1 Taxa (Scoring Value = 1)	**Group 2 Taxa (Scoring Value = 2)**	**Group 3 Taxa (Scoring Value = 3)**
Sessile Animals (Porifera, Cnidaria, Bryozoa)	Crayfish (Decapoda)	Mayfly Nymphs[1] (Ephemeroptera)
Aquatic Worms (Turbellaria, Oligochaeta, Hirudinea)	Dragonfly Nymphs (Anisoptera)	Stonefly Nymphs[1] (Plecoptera)
Sow Bugs (Isopoda)	Riffle Beetles (Dryopidae, Elmidae, Ptilodactylidae)	Caddisfly Larvae[1] (Trichoptera)
Scuds (Amphipoda)	 *Heptageniidae*, Belmont County	Fishfly Larvae (Corydalidae)
Water Mites (Hydracarina)		Water Penny Beetles (Psephenidae)
Damselfly Nymphs (Zygoptera)		Cranefly Larvae (Tipulidae)
Alderfly Larvae (Sialidae)	 *Peltoperlidae* from Rheocrene, Belmont County	
Other Beetles (Coleoptera)		
Midges (Chironomidae)		
Larvae of Other Flies (Diptera)		
Snails (Gastropoda)		
Clams (Bivalvia)		

Note: Hemiptera (True Bugs) do not receive any points in the HMFEI.

[1] Note: Each identified family of Ephemoptera, Plecoptera, and Trichoptera (EPT taxa) receives three points under the HMFEI scoring system.

The HMFEI is reasonably good at separating Class III stream benthos from Class II benthic macroinvertebrate species groups. A HMFEI score of greater than or equal to 20 provides separation between these two types of streams at approximately the 75th percentile level. Because the HMFEI is designed to be used with a level of taxonomy that is inferior to the identification of organisms to the lowest practical level at the laboratory, it is crucial that the biologist conducting the survey have the Family level of taxonomic expertise. Although it is not required in all circumstances, it is highly recommended that HMFEI analyses be conducted by a biologist who has been qualified as a Level 2 Qualified Data Collector for benthic macroinvertebrates under the Ohio Credible Data Program (http://www.epa.ohio.gov/dsw/credibledata/index). The HMFEI can be conducted any time of the year. However, for the most representative results it is recommended that it be conducted during the summer (June through September) in order to avoid the increase in the number of taxa present during the spring time (January through May) and the sampling difficulty associated with leaf fall in the fall (October through December).

The HMFEI may also be used to differentiate between the two subtypes of Class III PHW streams (Class IIIA and Class IIIB), based upon the composition of the macroinvertebrate community. However, identification of the macroinvertebrate community to the lowest practical taxonomic level (Section 6.3.1.2 below) becomes definitive for this differentiation (with regard to the benthic macroinvertebrate community) and may be used to verify or refute the findings of a Level 2 macroinvertebrate assessment. A detailed summary of the correct interpretation of biological results from PHW surveys is provided in Section 7.0 of this manual.

The following table is used to identify the PHW stream classification based on a Level 2 macroinvertebrate assessment and resulting HMFEI score:

IF Final HMFEI Score is 27 or more, then **Class IIIB** PHW Stream

IF Final HMFEI Score is 20 thru 26, then **Class IIIA** PHW Stream

IF Final HMFEI Score is 7 thru 19, then **Class II** PHW Stream

IF Final HMFEI Score is 0 thru 6, then **Class I** PHW Stream

6.3.1.2 Level 3 Assessment: Lowest Taxonomic Level Analysis for Benthic Macroinvertebrates

Definitive macroinvertebrate evaluations of a PHW stream consist of identification of taxa down to the lowest practical level. The lowest practical level is typically to genus but may require positive identification to the species level in some cases. The Ohio EPA biocriteria documents (Ohio EPA 2006b; Ohio EPA, 2015) fully detail the methodologies for sample collection, handling and identification. Lists of cold water indicator taxa and sensitive macroinvertebrate taxa are provided as Attachment 3 of this manual. Identification of macroinvertebrates to the lowest practical level typically requires both training and experience to a degree where the biologist is eligible for qualification as a Level 3 Qualified Data Collector under the Ohio Credible Data Program (http://www.epa.ohio.gov/dsw/credibledata/index).

Bryozoa under rock (circled), pictured with Two-lined salamander eggs and embryos

6.3.2 Benthic Macroinvertebrate Voucher Specimens

It is recommended that voucher samples of macroinvertebrates be collected and retained for all assessments where biological sampling is conducted. A voucher is a complete inventory of the macroinvertebrate taxa found at a site. Special effort should be made to collect and retain multiple specimens of taxa where the lowest practical level of identification cannot be achieved in the field with certainty, especially EPT taxa and midges. For assessments conducted in conjunction with permit applications to the Ohio EPA, a voucher sample must be retained in order to be considered valid. Organisms are preserved in a 4-ounce sample collection jar filled with 95% ethyl alcohol (ETOH). Standard lab preservative is 70% alcohol but Ohio EPA uses 95% ETOH for field collections since a fair amount of dilution water and fluids are inadvertently added during sampling. Place a field tag in the jar which includes: date, collector name, county, township, and stream identification as listed on the PHW form.

7.0 Summary of the Criteria Used to Differentiate PHW Streams

The following steps outline a sequential protocol using the various assessment tools described within this manual to identify PHW streams in Ohio and the different types found on the landscape. The sequence presented is in rank order of techniques beginning with those that are least costly and time consuming (Level 1 Assessment) and progressing to those that are progressively more resource intensive (Level 2 and 3 Assessments).

The information presented within this section assumes that the stream in question meets the definition of a PHW (see Section 1.1). In addition, it is assumed that the PHW stream is being assessed under the appropriate conditions to provide reliable data for determination of stream classification (see Section 2.3). During periods when drought or high flow conditions exist, PHW evaluations should not be conducted. If they are, appropriate notes of conditions must be made and should be considered during data interpretation.

Level 1 Assessments consist of classifying PHW streams based solely upon the use of the HHEI (Figure 20). The flowchart found in Figure 20 for Level 1 Assessments should be used in conjunction with the HHEI decision flow chart (Figure 18) when evaluating the PHW stream data. It should be noted that a Level 1 Assessment does not provide sufficient data needed to differentiate between Class IIIA Class IIIB PHW streams. When a PHW stream is determined to be a Class III stream based on a Level 1 Assessment, it is assumed to support a biological community consistent with that of a Class IIIB until a biological survey is conducted to show otherwise (conduct Level 2 or 3 Assessment).

A biological survey (Level 2 or Level 3 Assessment) must be conducted in the following situations:

- when the HHEI is insufficient to correctly predict the PHW stream type based upon the lack of adequate calibration data (e.g., rheocrene streams, see Section 5.4 and Figure 18);
- when observations in the field lead the investigator(s) to believe that data is necessary to refute or affirm a decision based upon HHEI and/or HMFEI scoring; and as stated above;

- when the data quality objectives require the differentiation of Class IIIA versus Class IIIB stream sub-types.

Biological evaluations will not produce reliable results where there is evidence of profound pollution impacts that have overwhelmed the local biological communities in the stream (see Section 5.4). In cases where these conditions are discovered to exist, the Level 1 Assessment should be used to describe the type of PHW stream (See Section 4.0 in the event of profound pollution occurring in a rheocrene). This analysis will provide the best description of the aquatic life potential of the stream.

If there is reason to question the HHEI assessment results, study-specific DQO's are not met, or additional data is necessary to verify the PHW classification (e.g., rheocrene streams), then perform a Level 2 rapid biological assessment of the vertebrate and benthic macroinvertebrate communities (Figure 21). Apply the HMFEI scoring criteria from Section 6.3.1.1 (Page 4 of Attachment 1). A HMFEI of 27 or greater is predictive of a Class IIIB PHW stream whereas a HMFEI that is <27 but ≥20 is predictive of a Class IIIA PHW. A HMFEI score <20 but ≥7 is predictive of a Class II PHW while streams having a HMFEI score <7 are assigned as Class I PHW streams. Apply the salamander criteria found in Tables 5 and 6 (Section 6.2.1.1). The presence of a reproducing population of cold water salamander species or the presence of cold water fish indicator species (Table 4) is definitive that the stream is a Class IIIB PHW stream. If there is evidence of reproducing populations of Two-lined or Long-tailed salamanders in the absence of cold water vertebrate species, or if the HMFEI is greater than ≥20 but less than 27, then a Class IIIA PHW is indicated. If there is evidence of only warm water fish species or reproducing populations of non-obligate salamanders, and the HMFEI score is ≥7 but less than 20, then a Class II PHW stream is indicated. If fish and reproducing populations of salamanders are absent and the HMFEI score is <7, then a Class I PHW stream is indicated.

Level 3 Assessments consist of identification of the vertebrate and benthic macroinvertebrate taxa to the lowest taxonomic level (Figure 22). A Level 3 Assessment is typically necessary in the following circumstances:

- there is reason to question the PHW stream classification using the HMFEI based upon site-specific observations, resulting in a need to verify or refute the Level 2 Assessment;
- there is evidence of the presence of Class III indicator salamanders, but the data are inconclusive as to whether reproducing populations are present;
- data are necessary to positively and definitely differentiate between Class IIIA and Class IIIB PHW communities; or
- the project DQO's specify the collection of data meeting the Level 3 Assessment protocols.

A Level 3 Assessment consists of performing a VES for salamanders (Section 6.2.1.2) and identification of the macroinvertebrates in the voucher collection to the lowest taxonomic level (Section 6.3.1.2). For Level 3 Assessments, if there are cold water adapted fish present, or reproducing populations of Class IIIB obligate aquatic salamanders (Table 6 in Section 6.2), or a macroinvertebrate community with ≥4 cold water indicator taxa meeting the conditions described in Sections 1.1.3 and 6.3 and Table 7, then a Class IIIB PHW is indicated. If the macroinvertebrate community consists of ≥4 cold water macroinvertebrate taxa but falls short of the conditions described in Sections 1.1.3, 6.3, and Table 7 or if there is evidence of reproducing populations of Two-lined or Long-tailed salamanders in the absence of other cold water vertebrates, then a Class IIIA PHW is indicated. If there are <4 cold water macroinvertebrate taxa present, only warm water adapted fish, if present at all, (as described in Section 6.1) or a reproducing population of non-obligate salamander species is present (Table 6), then a Class II stream is indicated. If none of these conditions exist and the HMFEI score is <7 then a Class I PHW stream is indicated.

Ohio EPA strongly recommends that a weight-of-evidence approach, combining physical, chemical and biological measurements, be used to classify PHW streams. Except where in-stream toxicity resulting from water pollution is present, detailed biological evaluations are definitive for determining the PHW stream classification. Judicious use of the HHEI in conjunction with qualitative biological sampling (rapid assessment tools) and/or detailed biological evaluations will provide the greatest degree of certainty for classifications. Users should be aware when designing PHW survey plans that the HHEI is based upon metrics designed to minimize the potential to misidentify Class III PHW streams. Therefore, by design, determinations of the PHW stream classification based solely upon use of HHEI scoring alone can sometimes result in the misclassification of the stream (e.g., indicating Class II for a stream that is actually Class I or indicating Class III for a stream that is actually Class II).

If using a biological assessment to evaluate a PHW stream, the following criteria must be followed:

7.1 Determination of a Class I PHW Stream (Ephemeral Flow)

A PHW stream that lacks any evidence of obligate aquatic vertebrate aquatic life or has a benthic macroinvertebrate HMFEI score less than 7, has a very high probability of becoming ephemeral. These types of headwater streams represent the highest percentage of all PHW streams in Ohio [about 45 to 50% of all headwater streams with watershed area 1.0 mi^2 (259 ha) or less]. Adult salamanders of the genera *Plethodon* and *Ambystoma* may be found in Class I stream corridors, but reproduction of indicator species within them is not supported.

7.2 Determination of a Class II PHW Stream (Warm Water Adapted Community)

A Class II PHW stream is characterized by the presence of warm water adapted species of vertebrates (fish, amphibians, or both) and/or by the presence of warm water species of benthic macroinvertebrates resulting in a community having a HMFEI score of 7 through 19. Lists of warm water adapted vertebrate species characteristic of these warmer PHW streams are found in Tables 4, 5, and 6. Class II streams have fewer (<4), if any, cold-water adapted macroinvertebrate taxa present.

7.3 Determination of a Class III PHW Stream (Cold Water Adapted Community)

A Class III PHW stream is characterized by the presence of one or more species of fish adapted to cold water **or** by the presence of reproducing populations of one of the eight species (subspecies) of obligate aquatic salamander species from the genera *Eurycea*, *Pseudotriton*, or *Gyrinophilus* as listed in Tables 5 and 6.

A Class III stream can also be identified based on a detailed taxonomic evaluation of the benthic macroinvertebrate community using the cold water species list found in Attachment 3. The presence of four or more species of cold water benthic invertebrates from this list is indicative of Class III streams.


Riffle in PHW stream, Licking County

As an alternative to a detailed laboratory identification of cold water macroinvertebrate taxa, the qualitative Headwater Macroinvertebrate Field Evaluation Index (HMFEI) method, can be used to identify a Class III stream as detailed on Page 4 of the PHW Form (Attachment 1). Where data regarding the presence of both cold water adapted taxa and HMFEI data are available, the more detailed taxonomic approach to genus-species level of taxonomy is used to establish the PHW classification.

Distinction between Class IIIA and Class IIIB biological communities found is based upon the presence-absence of cold water adapted vertebrates as well as the characteristics of the macroinvertebrate community. A Level 3 Assessment, in the absence of water pollution, is always definitive between these two community types.


Perlidae, Ashland County


S. Two-lined Salamander embryos, Adams County


Cave Salamander, Hamilton County


Brook Trout, Geauga County


Pickaway County


Cuyahoga County

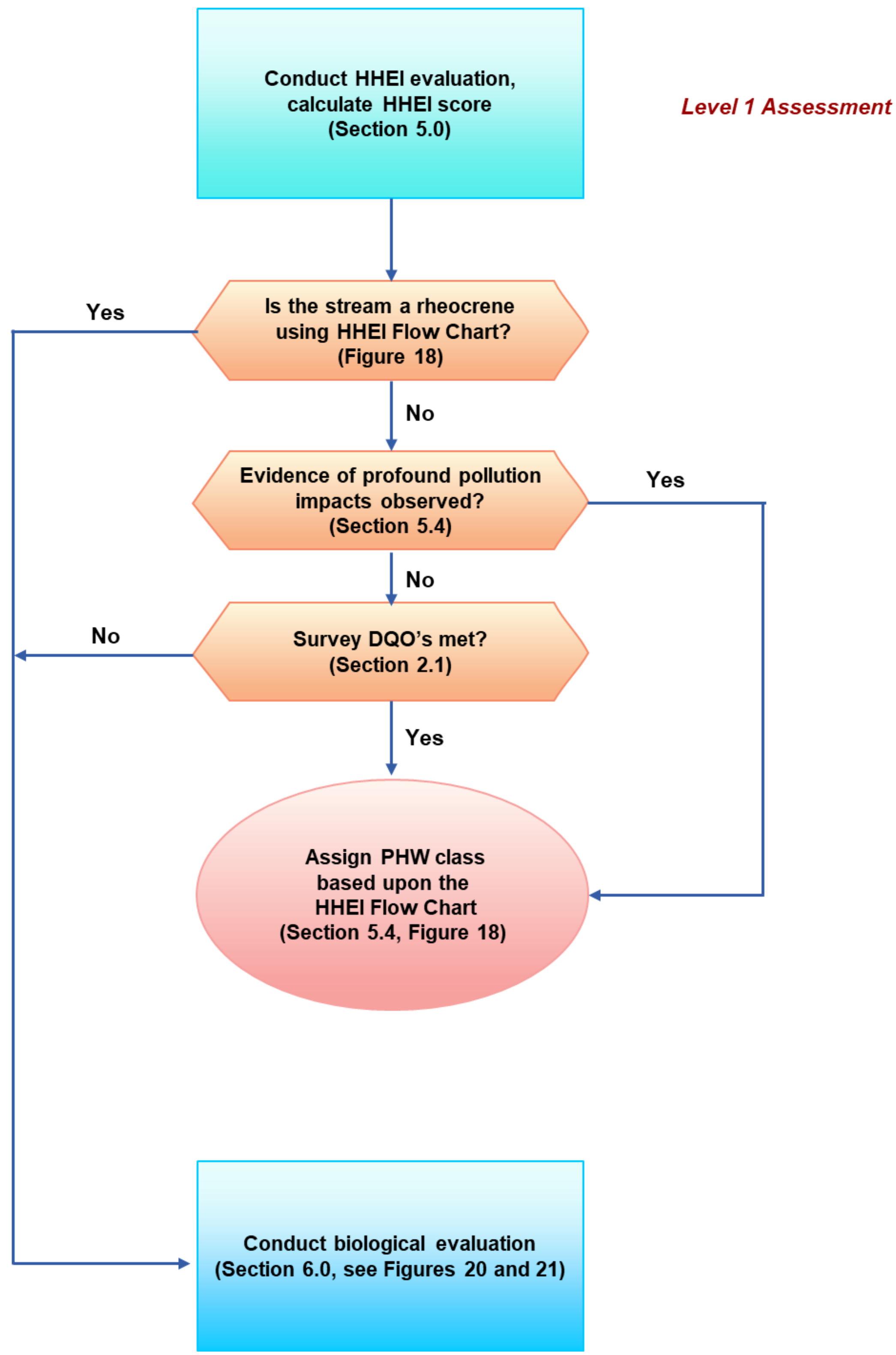


Figure 20. Level 1 PHW stream assessment flow chart.

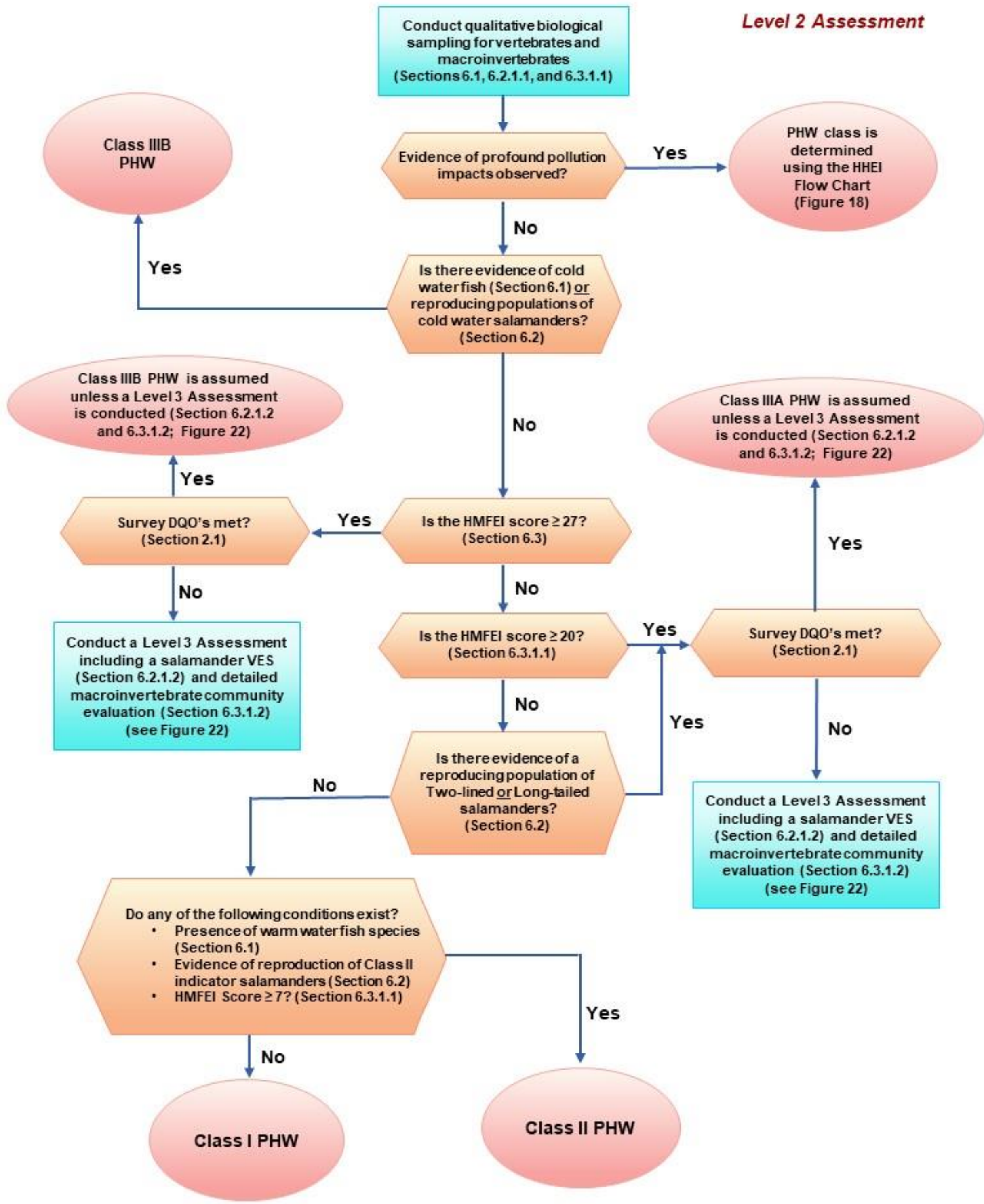


Figure 21. Level 2 PHW stream assessment flow chart.

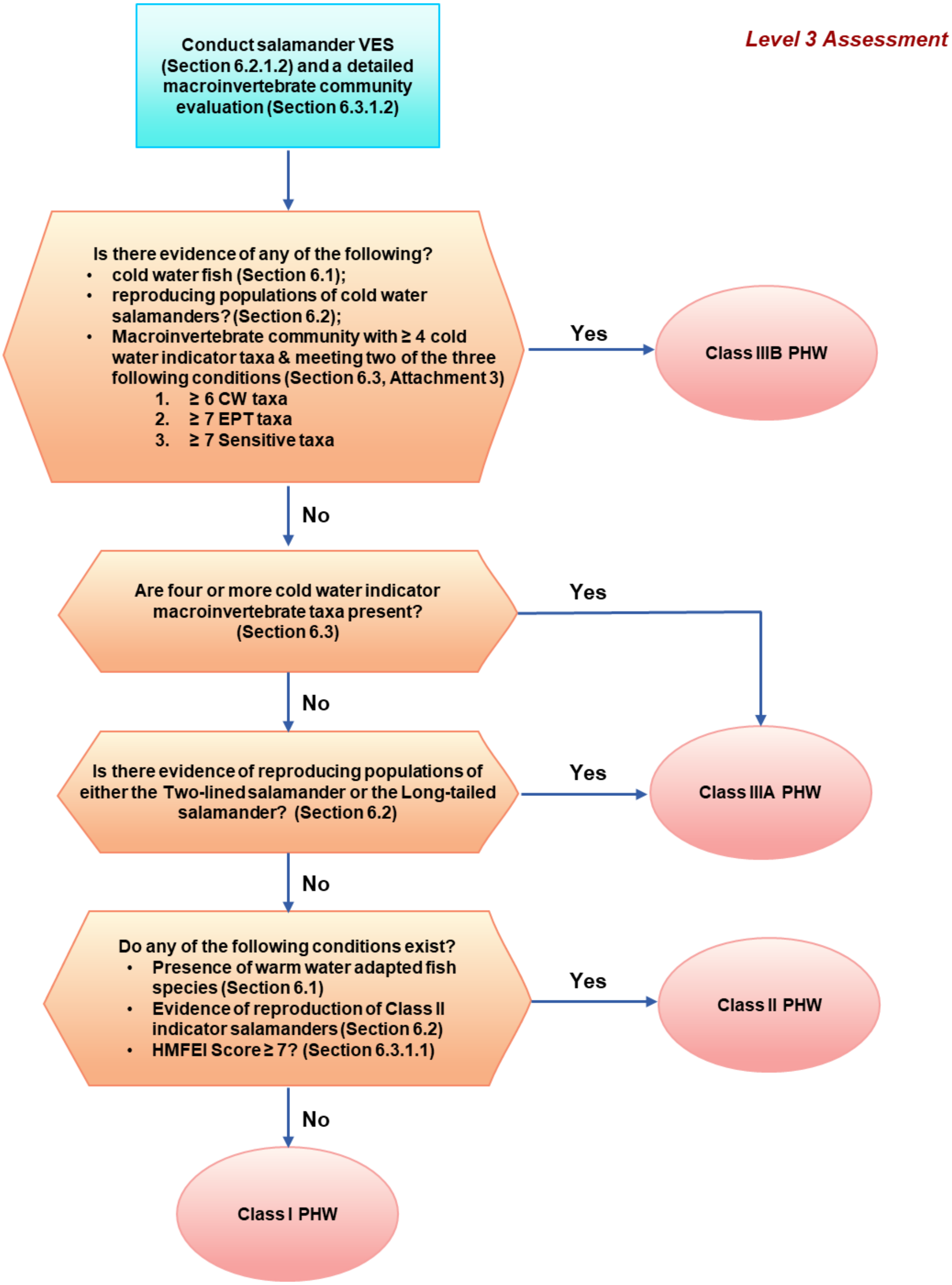


Figure 22. Level 3 PHW stream assessment flow chart.

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Attachment 1

The Ohio EPA Primary Headwater Field Evaluation Form

(PHW Field Form)

Note: The PHW Field Evaluation Forms can be downloaded at the following URL:

http://www.epa.ohio.gov/dsw/wqs/headwaters/index

Headwater Habitat Evaluation Index Field Form

HHEI Score (sum of metrics 1+2+3) [ ]

SITE NAME/LOCATION ____________

SITE NUMBER ______ RIVER BASIN ______ RIVER CODE ______ DRAINAGE AREA (mi²) ______

LENGTH OF STREAM REACH (ft) ______ LAT ______ LONG ______ RIVER MILE ______

DATE ______ SCORER ______ COMMENTS ______

NOTE: Complete All Items On This Form - Refer to "Headwater Habitat Evaluation Index Field Manual" for Instructions

STREAM CHANNEL MODIFICATIONS: ☐ NONE / NATURAL CHANNEL ☐ RECOVERED ☐ RECOVERING ☐ RECENT OR NO RECOVERY

HHEI Metric Points

1. SUBSTRATE (Estimate percent of every type present). Check *ONLY* two predominant substrate *TYPE* boxes. (Max of 32). Add total number of significant substrate types found (Max of 8). Final metric score is sum of boxes A & B

TYPE		PERCENT	TYPE		PERCENT
☐ ☐	BLDR SLABS **[16 pts]**	______	☐ ☐	SILT **[3 pt]**	______
☐ ☐	BOULDER (>256 mm) **[16 pts]**	______	☐ ☐	LEAF PACK/WOODY DEBRIS **[3 pts]**	______
☐ ☐	BEDROCK **[16 pts]**	______	☐ ☐	FINE DETRITUS **[3 pts]**	______
☐ ☐	COBBLE (65-256 mm) **[12 pts]**	______	☐ ☐	CLAY or HARDPAN **[0 pt]**	______
☐ ☐	GRAVEL (2-64 mm) **[9 pts]**	______	☐ ☐	MUCK **[0 pts]**	______
☐ ☐	SAND (<2 mm) **[6 pts]**	______	☐ ☐	ARTIFICIAL **[3 pts]**	______

Total of Percentages of Bldr Slabs, Boulder, Cobble, Bedrock ______ **(A)**

SCORE OF TWO MOST PREDOMINATE SUBSTRATE TYPES: [ ]

(B) TOTAL NUMBER OF SUBSTRATE TYPES: [ ]

Substrate Max = 40 [ ] **A + B**

2. Maximum Pool Depth (*Measure the maximum pool depth within the 61 meter (200 feet)* evaluation reach at the time of evaluation. Avoid plunge pools from road culverts or storm water pipes) (Check *ONLY* one box):

- ☐ > 30 centimeters **[20 pts]**
- ☐ > 22.5 - 30 cm **[30 pts]**
- ☐ > 10 - 22.5 cm **[25 pts]**
- ☐ 5 cm - 10 cm **[15 pts]**
- ☐ < 5 cm **[5pts]**
- ☐ NO WATER OR MOIST CHANNEL **[0pts]**

COMMENTS ______ **MAXIMUM POOL DEPTH (centimeters):** [ ]

Pool Depth Max = 30 [ ]

3. BANK FULL WIDTH (Measured as the average of 3 - 4 measurements) (Check *ONLY* one box):

- ☐ > 4.0 meters (> 13') **[30 pts]**
- ☐ > 3.0 m - 4.0 m (> 9' 7" - 13') **[25 pts]**
- ☐ > 1.5 m - 3.0 m (> 4' 8" - 9' 7") **[20 pts]**
- ☐ > 1.0 m - 1.5 m (> 3' 3" - 4' 8") **[15 pts]**
- ☐ ≤ 1.0 m (≤ 3' 3") **[5 pts]**

COMMENTS ______ **AVERAGE BANKFULL WIDTH (meters)** [ ]

Bankfull Width Max=30 [ ]

This information must also be completed

RIPARIAN ZONE AND FLOODPLAIN QUALITY ★ NOTE: River Left (L) and Right (R) as looking downstream★

L R	RIPARIAN WIDTH (Per Bank)	L R	FLOODPLAIN QUALITY (Most Predominant per Bank)	L R	
☐ ☐	Wide >10m	☐ ☐	Mature Forest, Wetland	☐ ☐	Conservation Tillage
☐ ☐	Moderate 5-10m	☐ ☐	Immature Forest, Shrub or Old Field	☐ ☐	Urban or Industrial
☐ ☐	Narrow <5m	☐ ☐	Residential, Park, New Field	☐ ☐	Open Pasture, Row Crop
☐ ☐	None	☐ ☐	Fenced Pasture	☐ ☐	Mining or Construction

COMMENTS ______

FLOW REGIME *(At Time of Evaluation)* (Check *ONLY* one box):

- ☐ Stream Flowing
- ☐ Subsurface flow with isolated pools (interstitial)
- ☐ Moist Channel, isolated pools, no flow (intermittent)
- ☐ Dry channel, no water (ephemeral)

COMMENTS ______

SINUOSITY (Number of bends per 61 m (200 ft) of channel) (Check ONLY one box):

☐ None	☐ 1.0	☐ 2.0	☐ 3.0
☐ 0.5	☐ 1.5	☐ 2.5	☐ >3

STREAM GRADIENT ESTIMATE

☐ Flat (0.5 ft/100 ft) ☐ Flat to Moderate ☐ Moderate (2 ft/100 ft) ☐ Moderate to Severe ☐ Severe (10 ft/100 ft)

ADDITIONAL STREAM INFORMATION (This Information Must Also be Completed):

QHEI PERFORMED? ☐ Yes ☐ No QHEI Score ___________ (If Yes, Attach Completed QHEI form)

DOWNSTREAM DESIGNATED USE(S)

☐ WWH Name: ______________________________ Distance from Evaluated Stream ___________

☐ CWH Name: ______________________________ Distance from Evaluated Stream ___________

☐ EWH Name: ______________________________ Distance from Evaluated Stream ___________

MAPPING: ATTACH COPIES OF MAPS, INCLUDING THE ENTIRE WATERSHED AREA. CLEARLY MARK THE SITE LOCATION.

USGS Quadrangle Name: ____________________ NRCS Soil Map Page: ________ NRCS Soil Map Stream Order: _______

County: ______________________________ Township/City: ______________________________

MISCELLANEOUS

Base Flow Conditions? (Y/N): _______ Date of last precipitation: ________________ Quantity: ___________

Photo-documentation Notes: ____

Elevated Turbidity? (Y/N): _________ Canopy (% open): __________

Were samples collected for water chemistry? (Y/N): _______ Lab Sample # or ID (attach results): _______________

Field Measures: Temp (°C) ______ Dissolved Oxygen (mg/l) _________ pH (S.U.) ________ Conductivity (umhos/cm) __________

Is the sampling reach representative of the stream (Y/N) _____ If not, explain: ______________________________

____

Additional comments/description of pollution impacts: ______________________________

____

BIOLOGICAL OBSERVATIONS

(Record all observations below)

Fish Observed? (Y/N) ______ Species observed (if known): ______________________________

Frogs or Tadpoles Observed? (Y/N) ______ Species observed (if known): ______________________________

Salamanders Observed? (Y/N) ______ Species observed (if known): ______________________________

Aquatic Macroinvertebrates Observed? (Y/N) ______ Species observed (if known): ______________________________

Comments Regarding Biology: ______________________________

____

DRAWING AND NARRATIVE DESCRIPTION OF STREAM REACH (This must be completed)

Include important landmarks and other features of interest for site evaluation and a narrative description of the stream's location

FLOW

Stream Salamander Assessment Field Data Sheet

Ohio Environmental Protection Agency

SITE NAME/LOCATION ______________________________

SITE NUMBER __________ RIVER BASIN ______________ RIVER CODE __________ DRAINAGE AREA (mi²) __________

STREAM LENGTH ASSESSED (ft)__________ LAT ______________ LONG ______________ RIVER MILE __________

DATE ______________ SAMPLE METHOD ______________________________

VOUCHER SPECIMENS RETAINED? (circle) Y or N VOUCHER NUMBER ______________ WATER TEMP __________

COLLECTOR #1 ______________ TIME SPENT (min) _____ COLLECTOR #2 ______________ TIME SPENT (min) _____

COMMENTS ______________________________

Species	# Larvae	# Juveniles/Adults	Total Number
Mountain Dusky *(Desmognathus ochrophaeus)*			
Northern Dusky *(Desmognathus fuscus)*			
Two-lined *(Eurycea bislineata)*			
Long-tailed *(Eurycea longicauda)*			
Cave *(Eurycea lucifuga)*			
Red *(Pseudotriton ruber)*			
Mud *(Pseudotriton montanus)*			
Spring *(Gyrinophilus porphyriticus)*			
Mole spp. *(Ambystoma spp.)*			
Four-toed *(Hemidactylium scutatum)*			
Other (record species)			
Total			

May 2020 Revision

PHW Fish Data Sheet

SITE NAME/LOCATION ____________________

SITE NUMBER ________ RIVER BASIN ____________ RIVER CODE ________ DRAINAGE AREA (mi²) ________

STREAM LENGTH ASSESSED (ft)________ LAT ____________ LONG ____________ RIVER MILE ________

DATE ____________ SAMPLE METHOD ____________________

VOUCHER SPECIMENS RETAINED? (circle) Y or N VOUCHER NUMBER ____________ WATER TEMP ________

COLLECTOR #1 ____________ TIME SPENT (min) _____ COLLECTOR #2 ____________ TIME SPENT (min) _____

COMMENTS ____________________

Species	Number Captured	Notes
Total		

Headwater Macroinvertebrate Field Evaluation Index (HMFEI) Scoring Sheet

Indicate abundance of each taxa above each box using the key
Record HMFEI scoring value points within each box
For EPT taxa, indicate the different families present

KEY: V=Very Abundant (>50); A=Abundant (10-50); C=Common (3-9); R=Rare (<3)

Sessile Animals (**Porifera, Cnidaria, Bryozoa**) HMFEI pts=1	Crayfish (**Decapoda**) HMFEI pts=2	Fishfly Larvae (**Corydalidae**) HMFEI pts=3
Aquatic Worms (**Turbellaria, Oligochaeta, Hirudinea**) HMFEI pts=1	Dragonfly Nymphs (**Anisoptera**) HMFEI pts=2	Water Penny Beetles (**Psephenidae**) HMFEI pts=3
Sow Bugs (**Isopoda**) HMFEI pts=1	Riffle Beetles (**Dryopidae, Elimidae, Ptilodactylidae**) HMFEI pts=2	Cranefly Larvae (**Tipulidae**) HMFEI pts=3
Scuds (**Amphipoda**) HMFEI pts=1	Larvae of other Flies (**Diptera**) Name: HMFEI pts=1	Mayfly Nymphs (**Ephemeroptera**) Families Present: HMFEI pts= [# Families x 3]
Water Mites (**Hydracarina**) (HMFEI pts=1)	Midges (**Chironomidae**) HMFEI pts=1	
Damselfly Nymphs (**Zygoptera**) (HMFEI pts=1)	Snails (**Gastropoda**) HMFEI pts=1	Stonefly Nymphs (**Plecoptera**) Families Present: HMFEI pts= [# Families x 3]
Alderful Larvae (**Sialidae**) (HMFEI pts=1)	Clams (**Bivalvia**) HMFEI pts=1	
Other Beetles (**Coleoptera**) (HMFEI pts=1)	Other Taxa:	Caddisfly Larvae (**Trichoptera**) Families Present: HMFEI pts= [# Families x 3]
Other Taxa:	Other Taxa:	

Voucher Sample ID ____________ Time Spent Collecting (minutes) ____________ Total Number of EPT Families = ___________

Notes on Macroinvertebrates (Predominant Organisms, Other Common Organisms, Diversty Estimates) ____________________________

Final HMFEI Calculated Score (Sum of all Individual Taxa Scores in Boxes Above) =

If Final HMFEI Score is >26, then a Class IIIB PHW Stream is Indicated
If Final HMFEI Score is 20-26, then a Class IIIA PHW Stream is Indicated
If Final HMFEI Score is 7-19, then a Class II PHW Stream is Indicated
If Final HMFEI Score is <7, then a Class I PHW Stream is Indicated

Attachment 2

Field Check List for Primary Headwater Stream Sampling

Applicable for all Sampling:

PHW field data forms (waterproof paper recommended), clip board, pencil
100' tape measure, flexible cloth to measure sampling zone(s)
3 color flag markers (used to mark sample zones)
Flagging tape
Stop watch
Digital camera
Equipment bag/backpack
GPS unit for lat/long
Hip waders, chest waders or knee boots (knee boots may be insufficient at some sites)
Mosquito repellant, sunscreen

Physical-Chemical Sampling:

Meter stick (wood recommended)
Ruler (in/cm) (wood recommended)
30 ft of string to measure bankfull width, with two metal stakes
Bubble type carpenter's line level or carpenter's laser level
Guarded thermometer or field meter [temperature, dissolved oxygen, pH, conductivity]
Containers for potential water samples for nutrients, coliform bacteria, and/or metals

Biological Sampling:

Fine mesh kick net for invertebrate sampling
White sorting pans (2 or more)
Fine tip forceps (2 or more)
Large bore pipettes (2 or more)
Hand lens/Jeweler's eye loupe magnifying lens
Specimen jars: 70% alcohol for invertebrates; formalin solution for fish voucher samples
Large tea strainer or fine mesh small handle invertebrate net for salamanders
Hard plastic containers with air holes in lid for salamander collection
Heavy duty plastic bags (4) for transport of salamanders to lab
Small cooler with ice or block ice for salamander transport and water samples
10' fish seine, dip nets, or long-line/backpack shocking unit for fish sampling
Optional: High intensity head lamp

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Attachment 3. Temperature and Pollution Sensitivity of Benthic Macroinvertebrate Indicator Taxa found in Ohio Primary Headwater Streams.

Family/ Subfamily	**Taxon Name**	**Cold Water Taxon**	**Sensitive Taxon**	**Common Name**
Phylum Ectoprocta				(Bryozoa, Moss Animals)
Lophopodidae				
	Lophopodella carteri		**X**	
Paludicellidae				
	Paludicella articulata		**X**	
Plumatellidae				
	Hyalinella punctata		**X**	
Phylum Entoprocta				(Banded Moss Animals)
Barentsiidae				
	Urnatella gracilis		**X**	
Phylum Arthropoda				
Class Crustacea				
Order Amphipoda				(Scuds, Amphipods)
Gammaridae				
	Gammarus minus	**X**		
Order Decapoda				
Cambaridae				(Crayfish)
	Cambarus (Cambarus) sciotensis		**X**	
Class Insecta				(Insects)
Order Ephemeroptera				(Mayflies)
Ameletidae				(Ameletid Minnow Mayflies)
	Ameletus sp.	**X**	**X**	
Baetidae				(Small Minnow Mayflies)
	Acentrella sp.		**X**	
	Acentrella nadineae		**X**	
	Acentrella rallatoma		**X**	
	Acentrella turbida		**X**	
	Acerpenna sp.		**X**	
	Acerpenna macdunnoughi		**X**	
	Acerpenna pygmaea		**X**	
	Plauditus sp.		**X**	
	Acentrella parvula		**X**	
	Anafroptilum minor group sp. 1		**X**	
	Anafroptilum minor group sp. 2		**X**	
	Baetis brunneicolor	**X**		
	Baetis tricaudatus	**X**	**X**	
	Iswaeon anoka		**X**	

Family/ Subfamily	**Taxon Name**	**Cold Water Taxon**	**Sensitive Taxon**	**Common Name**
	Labiobaetis sp.		**X**	
	Labiobaetis dardanum		**X**	
	Labiobaetis frondale		**X**	
	Labiobaetis propinquum		**X**	
	Plauditus cestus		**X**	
	Plauditus dubius		**X**	
	Plauditus dubius or *P. virilis*		**X**	
	Plauditus gloveri		**X**	
	Plauditus punctiventris		**X**	
	Plauditus virilis		**X**	
	Centroptilum sp. (w/o hindwing pads)		**X**	
	Procloeon sp (formerly in *Centroptilum)*		**X**	
	Diphetor hageni		**X**	
	Heterocloeon (H.) sp.		**X**	
	Paracloeodes sp.		**X**	
	Paracloeodes fleeki		**X**	
	Paracloeodes minutus		**X**	
	Procloeon sp.		**X**	
	Procloeon sp. (w/ hindwing pads)		**X**	
	Procloeon sp. (w/o hindwing pads)		**X**	
	Procloeon viridoculare		**X**	
	Acentrella sp. or *Plauditus* sp. (formerly in *Pseudocloeon)*		**X**	
Isonychiidae				(Brushlegged Mayflies)
	Isonychia sp.		**X**	
Heptageniidae				(Flatheaded Mayflies)
	Epeorus sp.	**X**	**X**	
	Heptagenia flavescens		**X**	
	Heptagenia marginalis		**X**	
	Leucrocuta sp.		**X**	
	Leucrocuta hebe		**X**	
	Leucrocuta maculipennis		**X**	
	Nixe sp.		**X**	
	Nixe inconspicua		**X**	
	Nixe perfida		**X**	
	Rhithrogena manifesta		**X**	
	Maccaffertium sp.		**X**	
	Maccaffertium exiguum		**X**	
	Maccaffertium ithaca	**X**	**X**	
	Maccaffertium mediopunctatum		**X**	
	Maccaffertium mexicanum integrum		**X**	

Family/ Subfamily	**Taxon Name**	**Cold Water Taxon**	**Sensitive Taxon**	**Common Name**
	Maccaffertium modestum	X	X	
	Maccaffertium pulchellum group		X	
	Maccaffertium pulchellum		X	
	Maccaffertium terminatum		X	
	Maccaffertium vicarium		X	
Leptophlebiidae				(Prong-gilled Mayflies)
	Choroterpes sp.		X	
	Habrophlebia vibrans	X	X	
	Habrophlebiodes sp.	X	X	
Ephemerellidae				(Spiny Crawler Mayflies)
	Ephemerellidae		X	
	Dannella simplex	X	X	
	Eurylophella sp.		X	
	Teloganopsis sp.		X	
	Teloganopsis deficiens		X	
Tricorythidae				(Little Stout Crawler Mayflies)
	Tricorythodes sp.		X	
Caenidae				(Small Squaregill Mayflies)
	Sparbarus sp.		X	
	Sparbarus lacustris		X	
Baetiscidae				(Armored Mayflies)
	Baetisca sp.		X	
	Baetisca lacustris		X	
Potamanthidae				(Hacklegill Mayflies)
	Anthopotamus sp.		X	
Ephemeridae				(Common Burrower Mayflies)
	Ephemera sp.		X	
	Ephemera blanda		X	
	Ephemera guttulata		X	
	Ephemera simulans		X	
	Ephemera varia		X	
	Litobrancha recurvata	X	X	
Polymitarcyidae				(Pale Burrower Mayflies)
	Ephoron sp.		X	
	Ephoron album		X	
	Ephoron leukon		X	
Order Odonata				
Anisoptera				(Dragonflies)
Aeshnidae				(Darner Dragonflies)
	Boyeria grafiana	X	X	

Family/ Subfamily	**Taxon Name**	**Cold Water Taxon**	**Sensitive Taxon**	**Common Name**
Gomphidae				(Clubtail Dragonflies)
	Gomphurus sp.		X	
	Gomphurus externus		X	
	Lanthus sp.	X	X	
	Lanthus parvulus	X	X	
	Ophiogomphus sp.		X	
	Ophiogomphus rupinsulensis		X	
	Ophiogomphus carolus		X	
	Stylogomphus albistylus		X	
	Stylurus sp.		X	
	Stylurus notatus		X	
	Stylurus spiniceps		X	
Corduliidae				(Emerald Dragonflies)
	Neurocordulia obsoleta		X	
	Neurocordulia yamaskanensis		X	
Macromiidae				(River and Stream Cruiser Dragonflies)
	Macromia sp.		X	
Order Plecoptera				(Stoneflies)
Pteronarcyidae				(Giant Stoneflies)
	Pteronarcys sp.		X	
	Pteronarcys biloba		X	
Peltoperlidae				(Roachlike Stoneflies)
	Peltoperla sp.	X	X	
Nemouridae				(Nemourid Stoneflies)
	Amphinemura sp.	X	X	
	Ostrocerca sp.		X	
	Prostoia sp.		X	
	Soyedina sp.	X	X	
Leuctridae				(Rolledwinged Stoneflies)
	Leuctra sp.	X	X	
	Paraleuctra sp.		X	
Perlidae				(Common Stoneflies)
	Acroneuria sp.		X	
	Acroneuria abnormis		X	
	Acroneuria carolinensis		X	
	Acroneuria frisoni		X	
	Acroneuria internata		X	
	Acroneuria lycorias		X	
	Eccoptura xanthenes	X	X	
	Neoperla sp.		X	

Family/ Subfamily	Taxon Name	Cold Water Taxon	Sensitive Taxon	Common Name
	Paragnetina sp.		X	
	Paragnetina media		X	
	Perlinella sp.		X	
	Perlinella drymo		X	
	Agnetina sp.		X	
	Agnetina capitata		X	
	Agnetina flavescens		X	
Perlodidae				(Perlodid Stoneflies)
	Clioperla clio	X	X	
	Diploperla sp.	X	X	
	Diploperla robusta	X	X	
	Isoperla sp.		X	
	Isoperla burksi		X	
	Isoperla decepta		X	
	Isoperla montana		X	
	Isoperla transmarina		X	
	Malirekus iroquois	X	X	
Chloroperlidae				(Green Stoneflies)
	Alloperla sp.		X	
	Haploperla brevis	X	X	
	Sweltsa sp.	X	X	
Order Megaloptera				(Dobsonflies, Hellgrammites)
Corydalidae				
	Corydalus cornutus		X	
	Nigronia fasciata	X	X	
Order Trichoptera				(Caddisflies)
Philopotamidae				(Fingernet Caddisflies)
	Chimarra sp.		X	
	Chimarra aterrima		X	
	Chimarra obscura		X	
	Chimarra socia		X	
	Dolophilodes sp.	X	X	
	Dolophilodes distinctus	X	X	
	Wormaldia sp.	X	X	
	Wormaldia moesta	X	X	
	Wormaldia shawnee		X	
Psychomyiidae				(Tube-making Caddisflies)
	Lype diversa		X	
	Psychomyia flavida		X	
Polycentropodidae				(Trumpet-net Caddisflies)

Family/ Subfamily	**Taxon Name**	**Cold Water Taxon**	**Sensitive Taxon**	**Common Name**
	poss. Cernotina sp. or *Polycentropus* sp.		**X**	
	Neureclipsis sp.		**X**	
	Nyctiophylax sp.		**X**	
	Polycentropus sp.		**X**	
Hydropsychidae				(Common Netspinner Caddisflies)
	Diplectrona sp.	**X**		
	Diplectrona metaqui	**X**	**X**	
	Diplectrona modesta	**X**		
	Ceratopsyche sp.		**X**	
	Ceratopsyche morosa group		**X**	
	Ceratopsyche morosa		**X**	
	Ceratopsyche slossonae	**X**	**X**	
	Ceratopsyche ventura	**X**	**X**	
	Homoplectra doringa	**X**	**X**	
	Hydropsyche aerata		**X**	
	Hydropsyche bidens		**X**	
	Hydropsyche bidens or *H. orris*		**X**	
	Hydropsyche dicantha		**X**	
	Hydropsyche frisoni		**X**	
	Hydropsyche hageni		**X**	
	Hydropsyche orris		**X**	
	Hydropshche phalerata		**X**	
	Hydropsyche simulans		**X**	
	Hydropsyche valanis		**X**	
	Hydropsyche venularis		**X**	
	Macrostemum sp.		**X**	
	Macrostemum zebratum		**X**	
	Parapsyche sp.	**X**	**X**	
	Parapsyche apicalis	**X**	**X**	
	Potamyia flava		**X**	
Rhyacophilidae				(Primitive, Free-living Caddisflies)
	Rhyacophila sp. (excluding *R. lobifera*)	**X**	**X**	
	Rhyacophila minor	**X**	**X**	
	Rhyacophila carolina	**X**	**X**	
	Rhyacophila fenestra or *R. ledra*	**X**	**X**	
	Rhyacophila glaberrima	**X**	**X**	
	Rhyacophila torva	**X**	**X**	
	Rhyacophila invaria complex	**X**	**X**	
Glossosomatidae				(Saddlecase Maker Caddisflies)
	Agapetus sp.	**X**	**X**	

Family/ Subfamily	Taxon Name	Cold Water Taxon	Sensitive Taxon	Common Name
	Glossosoma sp.	X	X	
	Protoptila sp.		X	
Hydroptilidae				(Micro Caddisflies)
	Leucotrichia pictipes		X	
	Mayatrichia ayama		X	
	Ochrotrichia sp.		X	
	Ochrotrichia confusa group		X	
	Stactobiella sp.		X	
Phryganeidae				(Giant Case Maker Caddisflies)
	Oligostomis pardalis	X		
Brachycentridae				(Humpless Case Maker Caddisflies)
	Brachycentrus sp.		X	
	Brachycentrus nigrosoma		X	
	Brachycentrus numerosus		X	
Goeridae				
	Goera sp.	X	X	
Limnephilidae				(Northern Case Maker Caddisflies)
	Frenesia sp.	X	X	
	Hydatophylax sp.		X	
	Hydatophylax argus		X	
	Limnephilus sp.		X	
	Pycnopsyche sp.		X	
Uenoidae				(Uenoid Case Maker Caddisflies)
	Neophylax sp.		X	
Lepidostomatidae				(Lepidostomid Case Maker Caddisflies)
	Lepidostoma sp.	X	X	
Odontoceridae				(Strongcase Maker Caddisflies)
	Psilotreta indecisa	X	X	
	Psilotreta rufa	X	X	
Molannidae				
	Molanna sp.	X	X	
Helicopsychidae				(Snailcase Maker Caddisflies)
	Helicopsyche borealis		X	
Leptoceridae				(Longhorned Case Maker Caddisflies)
	Ceraclea sp.		X	
	Ceraclea ancylus		X	
	Ceraclea flava complex		X	
	Ceraclea maculata		X	
	Ceraclea spongillovorax		X	
	Mystacides sp.		X	

Family/ Subfamily	**Taxon Name**	**Cold Water Taxon**	**Sensitive Taxon**	**Common Name**
	Mystacides sepulchralis		**X**	
	Nectopsyche sp.		**X**	
	Nectopsyche candida		**X**	
	Nectopsyche diarina		**X**	
	Nectopsyche exquisita		**X**	
	Nectopsyche pavida		**X**	
	Oecetis avara		**X**	
	Oecetis persimilis		**X**	
	Triaenodes sp.		**X**	
	Triaenodes ignitus		**X**	
	Triaenodes injustus		**X**	
	Triaenodes melaca		**X**	
	Triaenodes perna		**X**	
Order Lepidoptera				(Butterflies and Moths)
Crambidae				(Aquatic Moths)
	Parapoynx sp.		**X**	
	Petrophila sp.		**X**	
Order Coleoptera				(Beetles)
Psephenidae				(Water Pennies)
	Psephenus herricki		**X**	
Elmidae				(Riffle Beetles)
	Microcylloepus pusillus		**X**	
	Optioservus sp.		**X**	
	Optioservus ampliatus		**X**	
	Optioservus fastiditus		**X**	
	Optioservus trivittatus		**X**	
Ptilodactylidae				(Toe-winged Beetles)
	Anchytarsus bicolor	**X**	**X**	
Lutrochidae				(Travertine Beetles)
	Lutrochus laticeps		**X**	
Order Diptera				(True Flies)
Tanyderidae				(Primitive Crane Flies)
	Protoplasa fitchii		**X**	
Tipulidae				(Crane Flies)
	Antocha sp.		**X**	
	Dicranota sp.	**X**	**X**	
	Hexatoma sp.		**X**	
	Hexatoma cinerea		**X**	
	Limnophila sp.	**X**	**X**	
	Molophilus sp.		**X**	

Family/ Subfamily	**Taxon Name**	**Cold Water Taxon**	**Sensitive Taxon**	**Common Name**
	Pedicia sp.	X		
	Pseudolimnophila sp.		X	
Psychodidae				(Moth Flies/Sand Flies)
	Pericoma albitarsis		X	
Ptychopteridae				(Phantom Crane Flies)
	Ptychoptera sp.		X	
Thaumaleidae				(Solitary Midges)
	Protothaumalea americana	X	X	
Dixidae		X		(Meniscus Midges)
	Dixa sp.	X		
Simuliidae				(Black Flies)
	Prosimulium sp.	X	X	
Chironomidae				(Non-biting Midges)
Tanypodinae				
	Apsectrotanypus johnsoni	X	X	
	Brundiniella eumorpha	X	X	
	Krenopelopia sp.		X	
	Macropelopia sp.	X	X	
	Meropelopia sp.	X		
	Paramerina sp 1		X	
	Radotanypus florens	X	X	
	Rheopelopia acra		X	
	Rheopelopia paramaculipennis		X	
	Telopelopia okoboji		X	
	Trissopelopia ogemawi	X	X	
	Zavrelimyia (Z.) sp.	X		
Diamesinae				
	Diamesa sp.	X		
	Pagastia orthogonia	X		
	Potthastia gaedii group		X	
	Potthastia longimanus		X	
	Sympotthastia sp.		X	
Prodiamesinae				
	Odontomesa ferringtoni	X		
	Prodiamesa olivacea	X		
Orthocladiinae				
	Brillia parva	X	X	
	Cardiocladius obscurus		X	
	Chaetocladius piger	X	X	
	Corynoneura ascensa	X	X	

Family/ Subfamily	**Taxon Name**	**Cold Water Taxon**	**Sensitive Taxon**	**Common Name**
	Corynoneura floridaensis		**X**	
	Corynoneura sp. 12		**X**	
	Cricotopus (Isocladius) absurdus		**X**	
	Cricotopus (C.) politus		**X**	
	Epoicocladius sp. 3 (sensu Jacobsen, 1992)		**X**	
	Eukiefferiella brehmi group		**X**	
	Eukiefferiella devonica group	**X**		
	Eukiefferiella gracei group		**X**	
	Heleniella sp.	**X**	**X**	
	Heterotrissocladius sp.		**X**	
	Heterotrissocladius marcidus	**X**	**X**	
	Lopescladius sp.		**X**	
	Metriocnemus sp.	**X**	**X**	
	Metriocnemus eurynotus	**X**	**X**	
	Nanocladius (Plecopteracoluthus) downesi		**X**	
	Orthocladius (Symposiocladius) lignicola		**X**	
	Parachaetocladius sp.	**X**	**X**	
	Parakiefferiella n.sp. 5		**X**	
	Parametriocnemus sp.	**X**		
	Parametriocnemus sp. A (sensu Sæther, 1969)		**X**	
	Paratrichocladius sp.		**X**	
	Psilometriocnemus triannulatus	**X**	**X**	
	Rheocricotopus (R.) eminellobus	**X**	**X**	
	Thienemanniella taurocapita		**X**	
	Thienemanniella boltoni	**X**	**X**	
	Thienemanniella similis		**X**	
	Tvetenia bavarica group		**X**	
	Tvetenia sp.		**X**	
	Tvetenia discoloripes group		**X**	
	Xylotopus par		**X**	
Chironominae				
	Demicryptochironomus sp.		**X**	
	Gillotia alboviridis		**X**	
	Glyptotendipes (Heynotendipes) chelonia		**X**	
	Lipiniella sp.		**X**	
	Microtendipes "caelum" (sensu Simpson & Bode, 1980)		**X**	
	Microtendipes rydalensis		**X**	
	Parachironomus pectinatellae		**X**	

Family/ Subfamily	**Taxon Name**	**Cold Water Taxon**	**Sensitive Taxon**	**Common Name**
	Paracladopelma nais		**X**	
	Paracladopelma undine		**X**	
	Polypedilum (P.) n.sp. 1		**X**	
	Polypedilum (P.) albicorne	**X**		
	Polypedilum (Uresipedilum) aviceps	**X**	**X**	
	Polypedilum (P.) laetum group		**X**	
	Polypedilum (Cerobregma) ontario		**X**	
	Robackia demeijerei		**X**	
	Cladotanytarsus vanderwulpi		**X**	
	Cladotanytarsus vanderwulpi group sp. 3		**X**	
	Cladotanytarsus vanderwulpi group sp. 4		**X**	
	Cladotanytarsus vanderwulpi group sp. 5		**X**	
	Micropsectra sp.	**X**		
	Neozavrelia sp. 1	**X**	**X**	
	Paratanytarsus longistilus	**X**	**X**	
	Rheotanytarsus pellucidus		**X**	
	Stempellina sp.		**X**	
	Stempellina sp. 2		**X**	
	Stempellina johannsenii		**X**	
	Stempellina poss. subglabripennis		**X**	
	Stempellinella sp.		**X**	
	Stempellinella leptocelloides		**X**	
	Stempellinella boltoni	**X**	**X**	
	Stempellinella fimbriata		**X**	
	Sublettea coffmani		**X**	
	Neostempellina reissi	**X**	**X**	
	Tanytarsini genus A *Ekrem*	**X**	**X**	
	Zavrelia aristata	**X**	**X**	
Athericidae				(Aquatic Snipe Flies)
	Atherix lantha		**X**	
Empididae				(Dance Flies)
	Neoplasta sp.	**X**	**X**	
	Clinocera sp.	**X**	**X**	
	Trichoclinocera sp.		**X**	
Phylum Mollusca				
Class Gastropoda				(Snails)
Pleuroceridae				
	Elimia sp.		**X**	
	Pleurocera sp.		**X**	
Class Bivalvia				(Mussels, Clams)

Family/ Subfamily	**Taxon Name**	**Cold Water Taxon**	**Sensitive Taxon**	**Common Name**
Unionidae				(Freshwater Mussels)
	Utterbackia imbecillis		**X**	
	Strophitus undulatus		**X**	
	Alasmidonta marginata		**X**	
	Alasmidonta viridis		**X**	
	Lasmigona complanata		**X**	
	Lasmigona compressa		**X**	
	Lasmigona costata		**X**	
	Megalonaias nervosa		**X**	
	Tritogonia verrucosa		**X**	
	Theliderma cylindrica		**X**	
	Theliderma metanevra		**X**	
	Cyclonaias pustulosa		**X**	
	Quadrula quadrula		**X**	
	Amblema plicata		**X**	
	Fusconaia flava		**X**	
	Cyclonaias tuberculata		**X**	
	Pleurobema clava		**X**	
	Pleurobema cordatum		**X**	
	Pleurobema sintoxia		**X**	
	Eurynia dilatata		**X**	
	Ptychobranchus fasciolaris		**X**	
	Obliquaria reflexa		**X**	
	Cyprogenia stegaria		**X**	
	Actinonaias ligamentina		**X**	
	Ellipsaria lineolata		**X**	
	Obovaria subrotunda		**X**	
	Truncilla donaciformis		**X**	
	Truncilla truncata		**X**	
	Leptodea fragilis		**X**	
	Potamilus alatus		**X**	
	Potamilus ohiensis		**X**	
	Ligumia nasuta		**X**	
	Ligumia recta		**X**	
	Villosa fabalis		**X**	
	Villosa iris		**X**	
	Lampsilis fasciola		**X**	
	Lampsilis siliquoidea		**X**	
	Lampsilis cardium		**X**	
	Epioblasma triquetra		**X**	

NOTE TO USERS: The taxa list presented above represents a complete list of macroinvertebrate taxa identified as cold water indicator or sensitive taxa (pollution intolerant or moderately pollution intolerant) by the Ohio EPA at the time of publication of this manual (October 2018). Where genera are listed in the table (e.g. "*genus sp.*") as meeting one or both of these categories, it should be assumed that the applicable categorizations apply to any new species from that genus encountered in PHW macroinvertebrate collections.

Definitions:

Cold water macroinvertebrates are taxa that primarily inhabit streams that generally maintain average summer water temperatures below approximately 20°C. Cold water taxa have been in part chosen by analysis of the 50th percentile statistic of the number of cold water taxa at a taxon's collection sites during the summer collection period (June 15 through September 30). Cold water taxa are identified as those present in circumstances where the 50th percentile of the number of known cold water taxa cohabitating sites where a taxon is found is greater than or equal to three. Information in the published scientific literature was also considered when assigning taxa to this list.

Some species emerge in the spring and their larvae are not present during the summer collection period. For these taxa, the nature of the collection sites was taken into account along with an analysis of the associated taxa and a review of the scientific literature to determine if a particular taxon should be included on this taxa list. Percentile breakdowns for each cool water taxon and literature references relevant to the assessment process noted above are available upon request from the Ohio EPA (Ohio EPA 2006b).

Sensitive macroinvertebrate taxa are defined as taxa that are considered by the Ohio EPA to be pollution intolerant or moderately pollution intolerant. These taxa are primarily found at stream monitoring stations that have minimal anthropogenic pollution or physical habitat alterations. This condition is usually associated with relatively high qualitative sample diversity for taxa from the Orders Ephemeroptera, Plecoptera, and Trichoptera (EPT taxa). Therefore, the number of qualitative EPT taxa present at stream monitoring stations is used as the surrogate for anthropogenic disturbance. Pollution tolerance categories are based upon a statistical evaluation of the occurrence of qualitative EPT taxa cohabiting stations where each macroinvertebrate taxon has been found. The results of this analysis for each sensitive taxon and data relevant to the assessment process noted above are available upon request from the Ohio EPA.

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Attachment 4 – PHW Manual Version 4.0

River Code:______________ River/Stream:___________________________________ RM:________
Date:______________ Location:____
Investigator:___________________________________ Rosgen Channel Type: _________________

Zig/Zag Pebble Count

Particle Size Range (mm)	Total (Dry) Channel	Total (Wetted Channel) Riffle	Run	Pool	Glide	%	Cum%
Silt							
Sand (< 2)							
V Fine Gravel (2-3.9)							
Fine Gravel (4-7.9)							
Medium Gravel (8-15)							
Coarse Gravel (16-31)							
V Coarse Gravel (32-63)							
Small Cobble (64-127)							
Large Cobble (128-255)							
Small Boulder (256-511)							
Medium Boulder (512-1023)							
Large Boulder (> 1024)							
Bedrock							
Clay Hardpan							

Bank Full Width: ________ Bankfull Max Depth: ________ Channel Slope ________

Bank Full Mean Depth ________ Flood Prone Area Width: ________ Valley Slope: ________

Width/Depth Ratio ________ Entrenchment Ratio ________ Sinuosity ________

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Attachment 5: Qualitative Substrate Evaluation Form

Site:________________________________ **Date:**______________________ **Evaluator:**______________

Stream Drawing: use the grid below to draw the stream channel. Note habitat features and reference points for notes. Include landmarks.

Scale = 5 ft grid.

Place North Arrow in circle:

Use the following codes to complete the station chart below:

Substrate Types:

Bedrock:	BD	Silt:	ST
Boulder Slab:	BS	Leaf Pack/Woody Debris:	W
Boulder:	B	Fine Detritus:	D
Cobble:	C	Muck:	M
Gravel:	G	Clay/Hardpan:	H
Sand:	S	Artificial:	A

Substrate Prevalence Codes (at station):

Absent:	blank	Trace (functional)	X
<10%	1	10%-25%	2
25%-49%:	3	50%-75%::	4
75%-99%:	5	100%:	6

Habitat Types:

Pool:	P	Run:	RN
Riffle:	R	Glide:	G
Dry:	D	Stagnant:	S

	Substrate Types (enter code)							
Station/ Habitat								
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
23								
24								
25								
26								
27								
28								
29								
30								
Tally:								

Use back of form for notes.

Bedrock Exposed? Y / N Type:______________________

Attachment 5: Qualitative Substrate Evaluation Form Instructions

1) Make a drawing of the evaluated PHW stream reach in the grid provided on this attachment. A scale of 5 feet per grid unit is assumed unless an alternative scale is noted on the form.

   Include the following information on the map (note that suggested abbreviations for notations are provided on the form for habitat and substrate types):

   - important landmarks,
   - habitat features,
   - notations regarding substrate distribution,
   - bankfull width measurement locations,
   - pools and pool depths,
   - riffles,
   - the direction of water flow,
   - a north arrow, and
   - any other features of interest.

   Also include information regarding any road crossings or access points. The drawing should include comments on the type of riparian zone and land use adjacent to the stream reach, and any observations regarding springs, seepage areas, adjacent wetlands or confluences with other tributary channels. The stream drawing is a critical component of the assessment process and is extremely useful to document the condition of the evaluated reach on the day of the site evaluation.

2) To semi-quantitatively assess the percentages of the substrate types present, a tally table is provided to record both the types of substrate present and the relative prevalence of each substrate type at various points within the PHW reach. It is helpful to identify each assessment point on the stream map by numbering them with the corresponding number on the tally sheet.
   - Note that the prevalence ratings use percent ranges that apply for a particular assessment point within the reach.
   - For stream reaches with normal substrate heterogeneity, it is recommended that at least 20 points be assessed for relative substrate distribution. For complex sites, additional assessment points may be needed. For sites with simple or monotonic substrate distribution patterns, fewer points may be sufficient.

3) Use an averaging approach (total tally ÷ number of assessment points) to determine the relative distribution of each of the substrate types. The relative scores can then be used to estimate the percent distribution for entry onto the HHEI form. A count of all of the substrate types observed within the stream reach can also be tallied to score sub-metric B of the substrate metric on the HHEI form.

NOTES: ____

____

____

Collection ID #: ______________________

Ohio EPA
Headwater Stream Salamander Voucher Data Sheet

Date Collected: ________________________________ Time: ___________________________
Site Name: ____
Location: ____
Tributary of: ____
County: _______________________________; Township: ____________________________
County Soil Map Page: __________________________; USGS Topo Map: _________________
Road/Bridge: ____
Latitude: _______________________ N; Longitude _______________________ W
Average Bankfull Width (meters): _____________; Maximum Pool Depth (cm): ____________
Two Dominant Stream Bed Substrate Types: ____________________; _____________________
Riparian Vegetation Description: ____
____
Temp (°C) ________; DO (mg/l) _________; pH __________; Cond (umhos/cm)___________
Stream Gradient Estimate (% Slope in ft/100 ft): _______________ within 200 ft stream reach
Watershed Area: (sq mi) _____________; (km) ______________; (ha) ________________
Were fish present? (Y) _____; (N) ______; Species: _________________, ________________,
_________________, ____________________, ____________________, _________________
Water Type: Spring-seep near source_____ ; Headwater Stream _____; Other: ______________
Type of Flow: Complete Surface Flow _____; Interstitial Flow _____; Isolated Pools-Moist Soil
but not Flowing (Intermittent)______; Dry Channel Entire Length: ______

Collectors: ____

Salamander Species Collected:	Age Class:	
______________________________________	______________________	Number ( )
______________________________________	______________________	Number ( )
______________________________________	______________________	Number ( )
______________________________________	______________________	Number ( )
______________________________________	______________________	Number ( )
______________________________________	______________________	Number ( )
______________________________________	______________________	Number ( )

Tentative Identifications by: ____

***** Upon completion, this form can be copy reduced to fit inside the voucher container *****