Appendix C:

Methods for Assessing Habitat in Flowing Waters: Using the Qualitative Habitat Evaluation Index (QHEI)

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Introduction

This document summarizes the methodology for completing a general evaluation of macrohabitat, generally done by the fish field crew leader while sampling each location using the Ohio EPA Site Description Sheet - Fish (Appendix 1). This form is used to tabulate data and information for calculating the Qualitative Habitat Evaluation Index (QHEI). The following guidance should be used when completing the site evaluation form.

Header/Geographical Information

Complete site identification information is critical to making field data useful. Figure 1 illustrates the location information required for the QHEI.

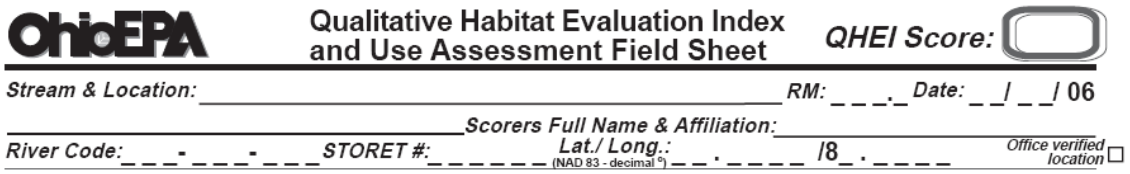

Figure 1. Header of Ohio EPA QHEI Sheet

1) Stream & Location, River Mile (RM), Date. The official stream name may be found in the Gazetteer of Ohio Streams (Ohio DNR 2001) or on USGS 7.5 minute topographic maps. If the stream is unnamed, a name and stream code is assigned by the Ohio ECOS Database Coordinator. Usually the name of a nearby landmark is used for the stream name. The River Mile (RM) designations used are found on 7.5 minute topo maps stored at the Ohio EPA, Division of Surface Water, Lazarus Government Center, Front Street (PEMSO RMI maps), one of five Ohio EPA District offices (maps for that district), and the Ohio EPA, Ecological Assessment Section at Grove City. These maps should soon be available as Adobe PDF files. A brief description of the sampling location should include proximity to a local landmark such as a bridge, road, discharge outfall, railroad crossing, park, tributary, dam, etc.

2) QHEI Scorers Full Name/Institution. The full name of the person who filled out the sheet are listed, along with the institution, company etc. QHEI information is to be completed someone who has successfully completed the QHEI training (e.g., crew leader). Ohio EPA will track the level of qualifications for each scorer. Level 2 QHEI practitioners have completed the two day training and successfully scored an additional site in a manner similar to EPA staff; Level 3 practitioners have additional training and have submitted three sites scored independently which will be verified as similar to EPA staff.

3) River Code, STORET, and Lat/Long. The River Code is Ohio EPA river code (PEMSO system) and the STORET # is the official unique Station Identifier used to link all data collected at a given "site" or "station" deemed to be similar for assessment purposes within a certain spatial area.

Habitat Characteristics: QHEI Metrics

The Qualitative Habitat Evaluation Index (QHEI) is a physical habitat index designed to provide an empirical, quantified evaluation of the general lotic macrohabitat characteristics that are important to fish communities. A detailed analysis of the development and use of the QHEI is available in Rankin (1989) and Rankin (1995). The QHEI is composed of six principal metrics each of which are described below. The maximum possible QHEI site score is 100. Each of the metrics are scored individually and then summed to provide the total QHEI site score. This is completed at least once for each sampling site during each year of sampling. An exception to this convention would be when substantial changes to the macrohabitat have occurred between sampling passes. Standardized definitions for pool, run, and riffle habitats, for which a

variety of existing definitions and perceptions exist, are essential for accurately using the QHEI. For consistency the following definitions are taken from Platts et al. (1983). It is recommended that this reference also be consulted prior to scoring individual sites.

Riffle and Run Habitats:

Riffle - areas of the stream with fast current velocity and shallow depth; the water surface is visibly broken.

Figure 2. Riffle cross-section.

Figure 3. Run cross-section.

Run - areas of the stream that have a rapid, non-turbulent flow; runs are deeper than riffles with a faster current velocity than pools and are generally located downstream from riffles where the stream narrows; the stream bed is often flat beneath a run and the water surface is not visibly broken.

Pool and Glide Habitats:

Pool - an area of the stream with slow current velocity and a depth greater than riffle and run areas; the stream bed is often concave and stream width frequently is the greatest; the water surface slope is nearly zero.

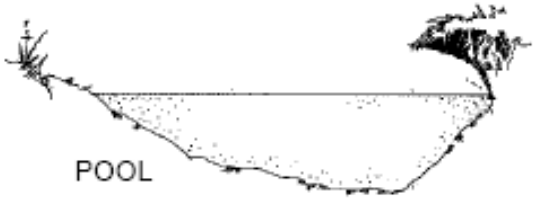

Figure 4. Pool cross-section.

Figure 5. Glide cross-section.

Glide - this is an area common to most modified stream channels that do not have distinguishable pool, run, and riffle habitats; the current and flow is similar to that of a canal; the water surface gradient is nearly zero. HINT: These habitat types typically grade into one another. For example a run gradually changes into a pool. When measuring typical depths of these features take measurements where the feature is clearly of that type, not where they are grading from one type to another. The following is a description of each of the six QHEI metrics and the individual metric components. Guidelines on how to score each is presented. Generally, metrics are scored by checking boxes. In certain cases the biologist completing the QHEI sheet may interpret a habitat characteristic as being intermediate between the possible choices; in cases where this is allowed (denoted by the term "Double-Checking") two boxes may be checked and their scores averaged.

Metric 1: Substrate (Figure 6).

This metric includes two components, substrate type[1] and substrate quality. **Substrate type** Check the two most common substrate types in the stream reach. If one substrate type predominates (greater than approximately 75- 80% of the bottom area OR what is clearly the most functionally predominant substrate) then this substrate type should be checked twice. **DO NOT CHECK MORE THAN TWO BOXES**. Note the category for artificial substrates. Spaces are provided to note the presence (by check marks, or estimates of % if time allows) of all substrate types present in pools (includes pools and glides) and riffles (includes riffles and runs) that each comprise sufficient quantity to support species that may commonly be associated with

[1] We suggest that QHEI practitioners should conduct some pebble count assessments which help calibrate an investigators ability to identify predominant substrates.

that substrate type. This section must be filled out completely to permit future analyses of this metric. If there are more than four or more high quality substrate types in the zone that are present in sufficient amounts (see above) then check the appropriate box for number of best types. This metrics award points to those sites with a diversity of high quality substrate types. Substrate origin refers to the parent material from which the substrate type(s) originated. This can be double-checked if two origin types are common (e.g., tills & limestone). See end of this section for some definitions.

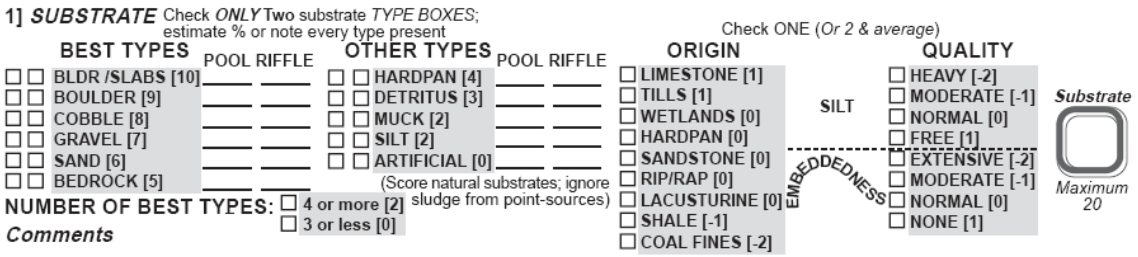

Figure 6. QHEI substrate metric.

Substrate quality.

Substrate origin refers to the "parent" material that the stream substrate is derived from. Check ONE box under the substrate origin column unless the parent material is from multiple sources (e.g., limestone and tills).

Embeddedness is the degree that cobble, gravel, and boulder substrates are surrounded, impacted in, or covered by fine materials (sand and silt). Substrates should be considered embedded if >50% of surface of the substrates are embedded in fine material. Embedded substrates cannot be easily dislodged. This also includes substrates that are concreted or "armor-plated". Naturally sandy streams are not considered embedded; however, a sand predominated stream that is the result of anthropogenic activities that have buried the natural coarse substrates is considered embedded.

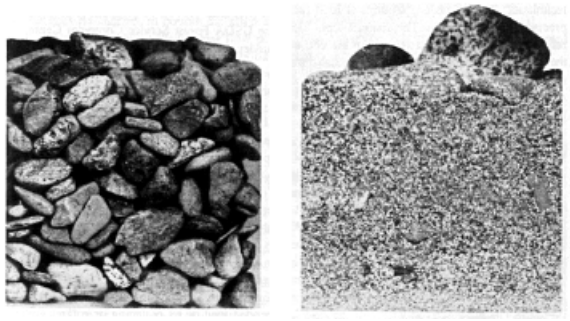

Figure 7. Side view of clearly un-embedded and embedded substrates.

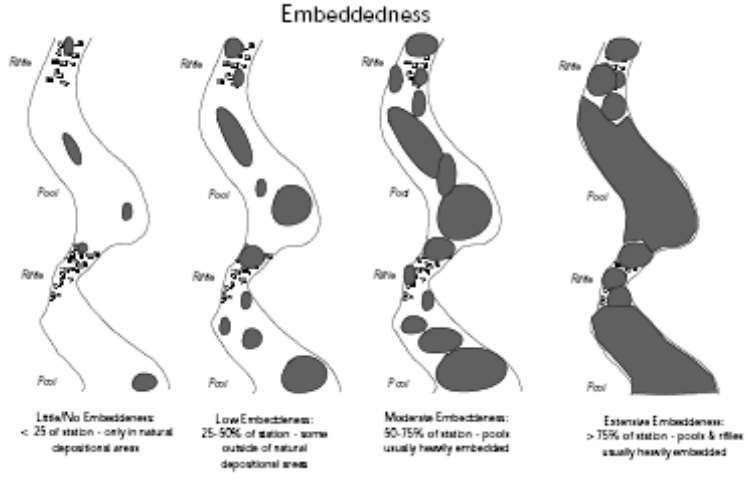

Figure 8. Illustration of example of degrees of pervasiveness of embeddedness for this QHEI component.

This can be very difficult to perceive. One help is to examine fresh point bars and look at the most common large materials that have been recently moved. According to Kappesser (1993), for gravel-bed rivers, the median of these large pieces should be equivalent to the median of the pieces on a riffle (based on a Wolman pebble count). If the riffles are finer than this, then sediment is aggrading in the reach and is evidence of embedded conditions. In some cases one can dig though the fine surface materials and fine coarser materials buried below. In this metric we are estimating the

pervasiveness of embedded conditions through-out a station. Boxes are checked for extensiveness (*i.e.*, pervasiveness throughout the area of the sampling zone) of the embedded substrates as follows: Extensive – > 75% of site area, Moderate – 50-75%, Normal[2] – 25-50%, None[3] – < 25%.

Silt Cover is the extent that substrates are covered by a silt layer (*i.e.*, a 1 inch thick or obviously affecting aquatic habitats). Silt cover differs from the embeddedness metric in that it only considers the fine silt size particles whereas fine gravels, sands, and other fines are considered in assessing embedded conditions. **Silt Heavy** means that nearly the entire stream bottom is layered with a deep covering of silt. (pool/glides and all but the fastest areas of riffle/runs). **Moderate** means extensive covering by silts, but with some areas of cleaner substrate (*e.g.*, riffles). **Normal** silt cover includes areas where silt is deposited in small amounts along the stream margin or is present as a "dusting" that appears to have little functional significance. If substrates are exceptionally clean the **Silt Free** box should be checked.

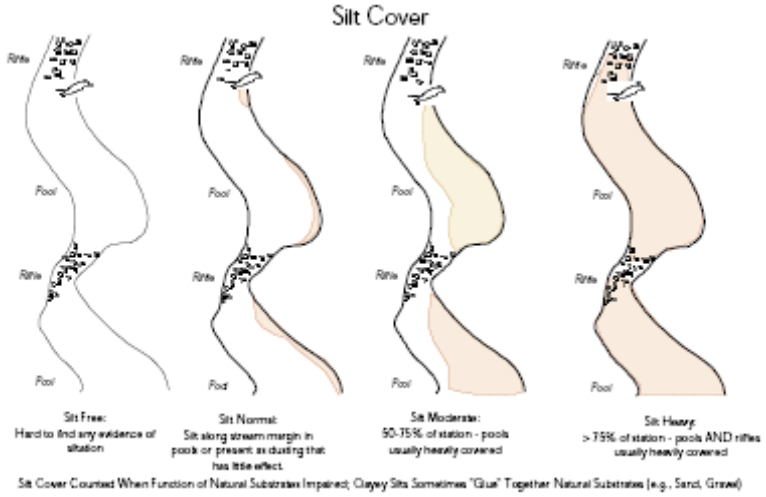

Figure 9. Illustration of example of degrees of pervasiveness of silt cover.

Substrate types are defined as:
a) **Bedrock** - solid rock forming a continuous surface.
b) **Boulder** - rounded stones over 256 mm in diameter (10 in.) or large "slabs" more than 256 mm in length (Boulder slabs)[4].
c) **Cobble** - stones from 64- 256 mm (2 1/2 - 10 in.) in diameter.
d) **Gravel** - mixture of rounded course material from 2-64 mm (1/12 - 2 1/2 in.) in diameter. Note the wide range of sizes included under gravel. In the riffle metric we distinguish between large and fine gravels
e) **Sand** - materials 0.06 - 2.0 mm in diameter, gritty texture when rubbed between fingers.
f) **Silt** - 0.004 - 0.06 mm in diameter, generally this is fine material which feels "greasy" when rubbed between fingers.
g) **Hardpan** - particles less than 0.004 mm in diameter, usually clay, which forms a dense, gummy surface that is difficult to penetrate.
h) **Marl** - calcium carbonate; usually grayish-white; often contains fragments of mollusk shells.
i) **Detritus** - dead, unconsolidated organic material covering the bottom which could include sticks, wood and other partially or un-decayed coarse plant material.
j) **Muck** - black, fine, flocculent, completely decomposed organic matter (does not include sewage sludge).
k) **Artificial** - substrates such as rock baskets, gabions, bricks, trash, concrete etc., placed in the stream for reasons OTHER than habitat mitigation.

Sludge is defined as a thick layer of organic matter that is decidedly of human or animal origin. NOTE: SLUDGE THAT ORIGINATES FROM POINT SOURCES IS NOT INCLUDED; THE SUBSTRATE SCORE IS BASED ON THE UNDERLYING MATERIAL. This scenario is rare today and was done to prevent underestimating stream habitat potential affect by discharges.

Substrate Metric Score: Although the sum of the individual metric scores can be greater than 20 the maximum substrate core allowed for this metric is 20 points.

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[2] In some earlier training materials "normal" was described as "low" (e.g., see Figure 7).
[3] In some earlier training materials "None" was described as "little-no" (e.g., see Figure 7).
[4] A version of the QHEI used in Maine distinguishes large boulders.

Example of stream with heavily embedded substrates.

Example of spongy deposits of fine gravels and sands from recent erosion activities.

Substrate Origin Identification Tips:

- Limestone: Often contains fossils, easily scratched with knife, usually bedrock or flat boulders and cobbles
- Tills: Sediments deposited by glaciers; particles often rounded. Can be carried into non-glaciated areas
- Wetlands: Usually organic muck and detritus
- Hardpan: Clay – smooth, usually slippery
- Sandstone: Contains rounded fragment of sand "cemented" together
- Rip/Rap: Artificial boulders
- Lacustrine: Old lake bed sediments
- Shale: "Claystone," sedimentary rock made of silt/clay, soft and cleaves easily
- Coal Fines: Black fragments of coal, generally SE Ohio only

We suggest that QHEI practitioners gain some experience in pebble count procedures. Conducting Wolman or Zig-Zag pebble counts helps to improve the ability to visually estimate predominant substrate sizes and size categories.

Stream characterized by cobble and boulder-size substrates.

2] *INSTREAM COVER* Indicate presence 0 to 3: **0**-Absent; **1**-Very small amounts or if more common of marginal quality; **2**-Moderate amounts, but not of highest quality or in small amounts of highest quality; **3**-Highest quality in moderate or greater amounts (e.g., very large boulders in deep or fast water, large diameter log that is stable, well developed rootwad in deep / fast water, or deep, well-defined, functional pools.

AMOUNT
Check ONE (*Or 2 & average*)
- ☐ EXTENSIVE >75% [11]
- ☐ MODERATE 25-75% [7]
- ☐ SPARSE 5-<25% [3]
- ☐ NEARLY ABSENT <5% [1]

____ UNDERCUT BANKS [1]	____ POOLS > 70cm [2]	____ OXBOWS, BACKWATERS [1]	
____ OVERHANGING VEGETATION [1]	____ ROOTWADS [1]	____ AQUATIC MACROPHYTES [1]	
____ SHALLOWS (IN SLOW WATER) [1]	____ BOULDERS [1]	____ LOGS OR WOODY DEBRIS [1]	
____ ROOTMATS [1]			

Comments

Cover Maximum 20

Figure 10. Instream cover (structure) metric.

Metric 2: Instream Cover (Figure 10).

This metric scores presence of instream cover types and amount of overall instream cover. Ohio EPA has been phasing in an alternative scoring system for this metric, but for this 2006, the total scoring still follows the existing methods. The changes will be discussed later.

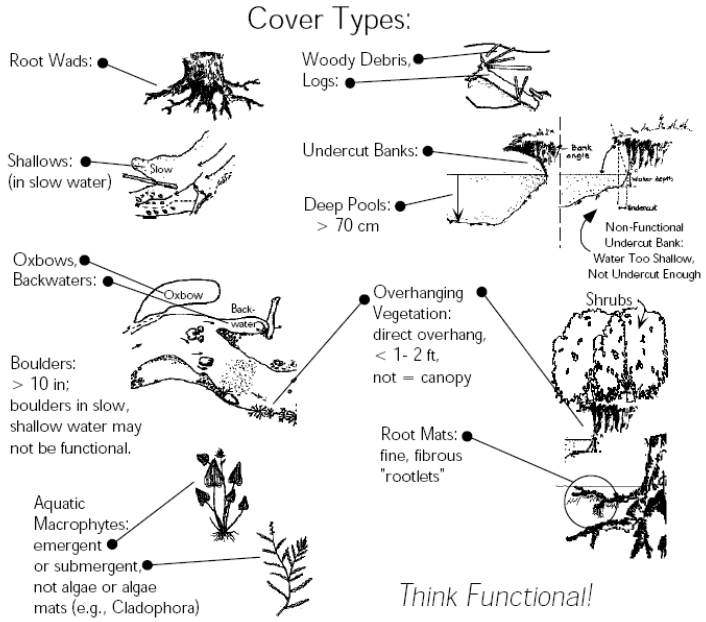


Figure 11. Examples of major cover/structure types measured with QHEI.

Existing Scoring Method:

Each cover type that is present in an amount occurs in sufficient quantity to support species that may commonly be associated with the habitat type should be scored.[5] Cover should not be counted when it is in areas of the stream with insufficient depth (usually < 20 cm) to make it useful. For example a logjam in 5 cm of water contributes very little, if any cover, and at low flow may be dry. Other cover types with limited function in shallow water include undercut banks and overhanging vegetation, boulders, and rootwads. Under amount, one or two boxes may be checked. Extensive cover is that which is present throughout the sampling area, generally greater than about 75% of the stream reach sampled. Cover is moderate when it occurs over 25- 75% of the sampling area. Cover is sparse when it is present in less than 25% of the stream margins (sparse cover usually exists in one or more isolated patches). Cover is nearly absent when no large patch of any type of cover exists anywhere in the sampling area. This situation is usually found in recently channelized streams or other highly modified reaches (e.g. ship channels). If cover is thought to be intermediate in amount between two categories, check two boxes and average their scores. For wide streams cover amount is estimated along the swath of stream sampled (or that would be sampled) with an electrofisher. In smaller streams

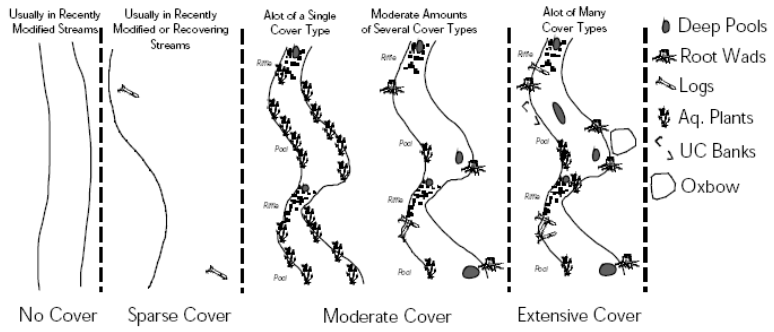


Figure 12. Illustration of the four categories of cover amounts.

[5] We had mentioned a 5% rule of thumb for an amount threshold if biological experience is low – this would be as a linear, not an areal amount.

(smaller wadeable and headwater streams) this generally covers most of the stream width. If a single type of cover is extensive and others are absent or uncommon then the total is scored as moderate because of the low diversity of types.

A desire to investigate and measure variation in amount and quality of individual cover types lead to a change in scoring of this metric. Over the next year or so the existing scoring method (each cover type scored on an presence/absence rating and a cumulative cover amount score) will be replaced with the following scoring method that focuses on scoring each cover type on a gradient of amount and quality. Each cover type would receive a score of 0-3 where:

> 0 - Absent;
> 1 - Very small amounts or if more common of marginal quality;
> 2 - Moderate amounts, but not of highest quality or in small amounts of highest quality;
> 3 - Highest quality in moderate or greater amounts (e.g., very large boulders in deep or fast water, large diameter logs that are stable, well developed rootwads in deep/fast water, or deep, well-defined, functional pools.

The cover ratings have been collected for about the last five years and an assessment of their relation to biological measures will be used to adjust a final scoring for this metric. At present, continue scoring these as present/absent and use the overall cover metric score. Cover types include: 1) undercut banks, 2) overhanging vegetation, 3) shallows (in slow water)[6], 4) logs or woody debris, 5) deep pools (> 70 cm), 6) oxbows, backwaters, or side channels, 7) boulders, 8) aquatic macrophytes, and 9) rootwads (tree roots that extend into stream). Do not check undercut banks AND rootwads unless undercut banks exist along with rootwads as a major component. Although the theoretical maximum score is > 20 the maximum score assigned for the QHEI for the instream cover metric is limited to 20 points.

High quality logs and woody debris in deep water.

High quality rootwad in deep, fast water.

[6] Shallows are habitats that provide nursery areas for small fish.

Example of good quality shallow habitat with aquatic macrophyte bed that acts as nursery habitat.

High quality boulder in fast water

Root Mats

Importance of logs and woody debris in large rivers.

Functional overhanging vegetation

Metric 3: Channel Morphology (Figure 13)

This metric emphasizes the quality of the stream channel that relates to the creation and stability of macrohabitat. It includes channel sinuosity (i.e. the degree to which the stream meanders), channel development, channelization, and channel stability. One box under each should be checked unless conditions are considered to be intermediate between two categories; in these cases check two boxes and average their scores.

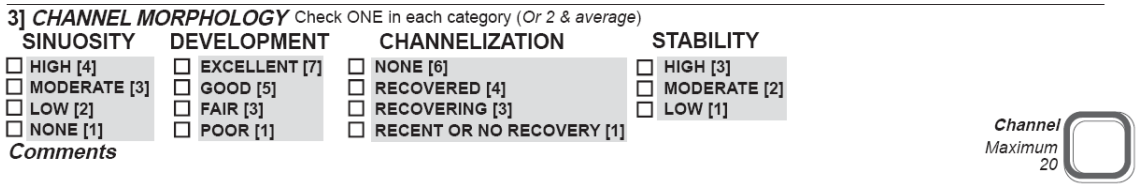


Figure 13. Channel morphology metric.

a) *Sinuosity* - **No sinuosity** is a straight channel. **Low sinuosity** is a channel with only 1 or 2 poorly defined outside bends in a sampling reach, or perhaps slight meandering within modified banks. **Moderate sinuosity** is more than 2 outside bends, with at least one bend well defined. **High sinuosity** is more than 2 or 3 well defined outside bends with deep areas outside and shallow areas inside. Sinuosity may be more conceptually described by the ratio of the stream distance between two points on the channel of a stream and the straight-line distance between these same two points, taken from a topographic map. This metric measures the formation of pools and increased habitat area as the primary "functions" of sinuosity as related to aquatic life. Check one box or select two and average.

b) *Development* - This refers to the development of riffle/pool complexes. **Poor** means riffles are absent, or if present, shallow with sand and fine gravel substrates; pools, if present are shallow. Glide habitats, if predominant, receive a **Poor** rating. **Fair** means riffles are poorly developed or absent; however, pools are more developed with greater variation in depth. **Good** means better defined riffles present with larger substrates (gravel, rubble or boulder); pools have variation in depth and there is a distinct transition between pools and riffles. **Excellent** means development is similar to the **Good** category except the following characteristics must be present: pools must have a maximum depth of >1 m and deep riffles and runs (>0.5 m) must also be present. In streams sampled with wading methods, a sequence of riffles, runs, and pools must occur more than once in a sampling zone. Check one box or check two and average.

Table 1: Scoring criteria for pool/riffle development metric.

	Excellent	Good	Fair	Poor
Pool	> 1 m deep, well defined	0.7-1.0 m deep, well defined	Some depth variation	Shallow, if present
Glide	Not common	Not common	Common	Predominant
Riffle	Deep, well defined riffles, large substrates	Defined riffles, large substrates	Poorly defined riffles or riffles absent	Absent of shallow with fine substrates
Run	> 0.5 m deep, well defined	Deep, well defined	Usually absent	Absent

This metric can be double-checked. For situations, for example where riffles are excellent and pools are only fair, it is advantageous to check the excellent and the fair box rather than checking the good box as an average to keep information on the variance in quality.

Note how well defined (i.e., distinct) the riffle and pool are in this high quality headwater stream pictured on the left. Also note the large tree in the riparian

c) *Channelization* - This refers to anthropogenic channel modifications. **Natural** refers to no obvious direct moving or alteration of the channel and a natural appearance. **Recovered** refers to streams that have been channelized in the past, but which have recovered most of their natural channel characteristics. **Recovering** refers to channelized streams which are still in the process of regaining their former, natural however, these habitats are still degraded. This category also applies to those streams, especially in the Huron/ Erie Lake Plain ecoregion (NW Ohio), that were channelized long ago and have a riparian border of mature trees, but still have Poor channel characteristics. **Recent** or **No Recovery** refers to streams that were recently channelized or those that show no significant recovery of habitats (e.g. drainage ditches, grass lined or rock rip-rap banks, etc.). The specific type of habitat modification is checked in the last two columns but not scored.

A channelized stream channel starting to revert towards more natural channel features.

Unstable channel features and low stability.

d) *Stability* - This refers to channel stability. Artificially stable (concrete) stream channels receive a High score. Even though they generally have a negative influence on fish assemblages, the negative effects are related to features other than their stability. Channels with **Low stability** are usually characterized by fine substrates in riffles that often change location, have unstable and severely eroding banks, and a high bedload that slowly creeps downstream. Sometimes these unstable riffles form diagonally across the channel (see figure, right). Channels with **Moderate stability** are those that appear to maintain stable riffle/ pool and channel characteristics, but which exhibit some symptoms of instability, e.g. high bedload, eroding or false banks, or shows the effects of wide fluctuations in water level. Channels with **High stability** have stable banks and substrates, and little or no erosion and bedload. e) *Modifications/Other* - Check the appropriate box if impounded, islands present, or leveed (these are not included in the QHEI scoring) as well as the appropriate source of habitat modifications. The maximum QHEI metric score for Channel Morphology is 20 points.

Metric 4: Riparian Zone and Bank Erosion (Figure 14)

This metric emphasizes the quality of the riparian buffer zone and quality of the floodplain vegetation. This includes riparian zone width, floodplain quality, and extent of bank erosion. Each of the three components requires scoring the left and right banks (looking downstream). The average of the left and right banks is taken to derive the component value. One box per bank should be checked unless conditions are considered to be intermediate between two categories; in these cases check two boxes and average their scores.

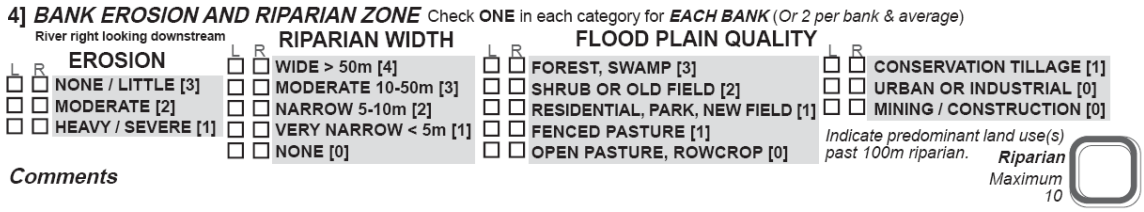


Figure 14. Bank erosion and riparian zone metric.

Severe bank erosion.

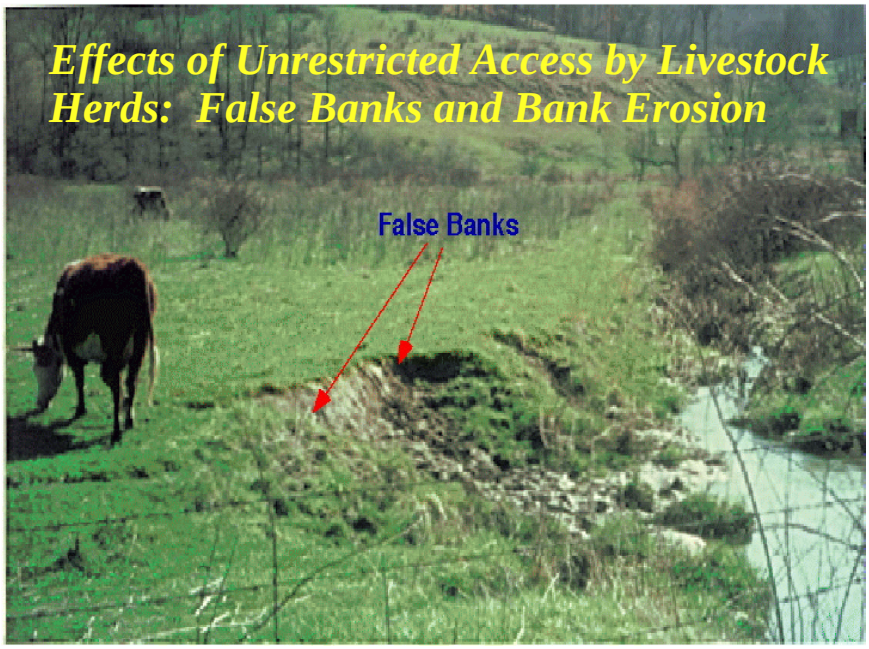
a) *Bank Erosion* – A modified Streambank Soil Alteration Ratings from Platts et al. (1983) is used here; check one box for each side of the stream and average the scores. False banks are used in the sense of Platts et al. (1983) to mean banks that are no longer adjacent to the normal flow of the channel but have been moved back into the floodplain most commonly as a result of livestock trampling. 1) **None** - streambanks are stable and not being altered by water flows or animals (e.g. livestock) - Score 3. 2) **Little** - streambanks are stable, but are being lightly altered along the transect line; less than 25% of the streambank is receiving any kind of stress, and if stress is being received it is very light; less than 25% of the streambank is false, broken down or eroding - Score 3. 3) **Moderate** - streambanks are receiving moderate alteration along the transect line; at least 50 percent of the streambank is in a natural stable condition; less than 50% of the streambank is false, broken down or eroding; false banks are rated as altered - Score 2. 4) **Heavy** - streambanks have received major alterations along the transect line; less than 50% of the streambank is in a stable condition; over 50% of the streambank is false, broken down, or eroding - Score 1. 5) **Severe** - streambanks along the transect line are severely altered; less than 25% of the streambank is in a stable condition; over 75% of the streambank is false, broken down, or eroding - Score 1

b) *Riparian Width* - This is the width of the riparian (stream side) vegetation. Width estimates are only done for **forest, shrub, swamp,** and **old field vegetation** if it has **woody** components (*e.g.*, willows). Old field refers to a fairly mature successional field that has stable, woody plant growth; this generally does not include weedy urban or industrial lots that often still have high runoff potential. Two boxes, one each for the left and right bank (looking downstream), should be checked and then averaged.

c) *Floodplain Quality* - The two most predominant floodplain quality types should be checked, one each for the left and right banks (includes urban, residential, etc.), and then averaged. By floodplain we mean the areas immediately outside of the riparian zone or greater than 100 meters from the stream, whichever is wider on each side of the stream. The concept is to identify land uses that might deliver harmful runoff to the stream. These are areas adjacent to the stream that can have direct runoff and erosion effects during normal wet weather. This is considered a ground truthing exercise and we suggest those interested in estimating of the effects of adjacent or riparian land uses use now well-developed GIS approaches. We do not limit it to the riparian zone and it is much less encompassing than the stream basin.

The maximum score for Riparian Zone and Erosion metric is 10 points.

Estimating riparian zone width.



Example of un-restricted livestock access and the formation of "false" banks.

Metric 5: Pool/Glide and Riffle-Run Quality (Figure 15)

This metric emphasizes the quality of the pool, glide and/or riffle-run habitats. This includes pool depth, overall diversity of current velocities (in pools and riffles), pool morphology, riffle-run depth, riffle-run substrate, and riffle-run substrate quality.

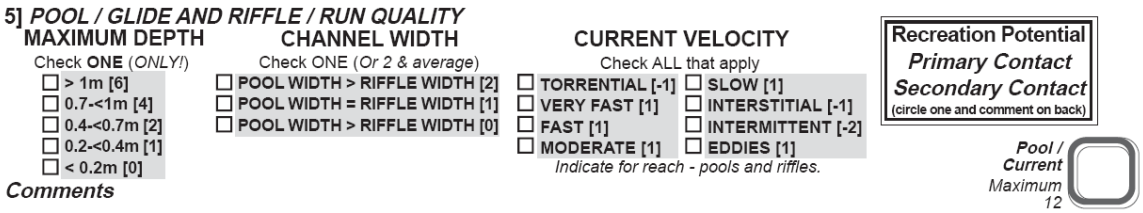


Figure 15. Pool/glide and riffle/run metric

A) Pool/Glide Quality

1) *Maximum depth* of pool or glide; check one box only (Score 0 to 6). Pools or glides with maximum depths of less than 20 cm are considered to have lost their function and the total metric is scored a 0. No other characteristics need be scored in this case.

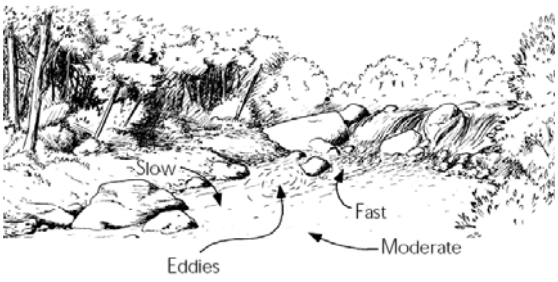


Figure 16. Typical locations of various current velocity types in a stream.

2) *Current Types* - check each current type that is present in the stream (including riffles and runs; score -2 to 4), definitions are: **Torrential** - extremely turbulent and fast flow with large standing waves; water surface is very broken with no definable, connected surface; usually limited to gorges and dam spillway tailwaters. **Very Fast** – turbulent flow that may make it difficult to stand and creates pulsating effect again leg. **Fast** - mostly non-turbulent flow with small standing waves in riffle/run areas; water surface may be partially broken, but there is a visibly connected surface. Fast current has sufficient energy to flow forcefully <u>over</u> objects. Sharp drop evident on depth rod. **Moderate** - non-turbulent flow that is detectable and visible (i.e. floating objects are readily transported downstream); water surface is visibly connected. With moderate current water flows around rather than over objects. Little drop around depth rod. **Slow** - water flow is perceptible, but very sluggish. **Eddies** - small areas of circular current motion usually formed in pools immediately downstream from riffle-run areas. **Interstitial** - water flow that is perceptible only in the interstitial spaces between substrate particles in riffle-run areas. **Intermittent** - no flow is evident anywhere leaving standing pools that are separated by dry areas. The role of bank erosion in sediment delivery to streams is often underestimated. Higher gradient stream showing typical locations of fast, moderate, and slow areas and eddies.

4) *Morphology* - Check **Wide** if pools are wider than riffles, **Equal** if pools and riffles are the same width, and **Narrow** if the riffles are wider than the pools (Score 0 to 2, see Figure 17). If the morphology varies throughout the site average the types. If the entire stream area (including areas outside of the sampling zone) is pool or riffle, then check riffle = pool.

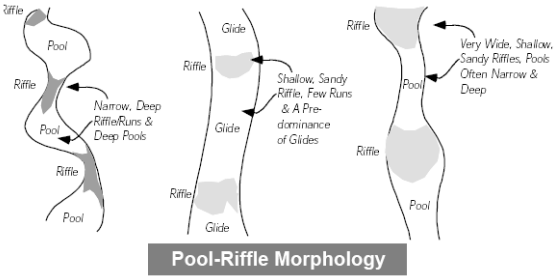


Figure 17. Pool morphology metric categories.

Although the theoretical maximum score for the pool metric is greater than 12 the maximum score assigned for the QHEI for the Pool Quality metric is limited to 12 points.

Illustration of the importance of pool depth to aquatic life

Estimating current velocity, Sharp drop from front to back of rod and boot indicates fast current velocities.

B) Riffle-Run Quality (Figure 18)

This entire metric is scored 0 if no riffles are present.

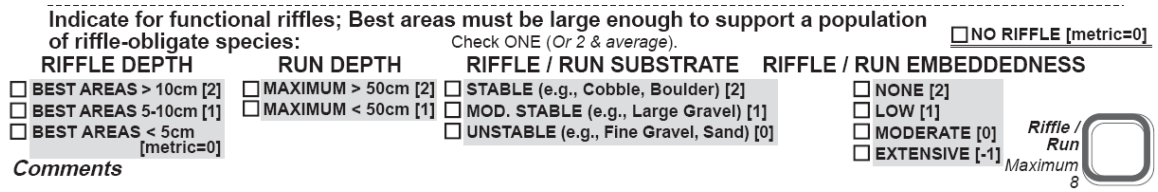


Figure 18. Riffle-run metric.

1)Riffle - select one box that most closely describes the depth characteristics of the best riffle in the zone (Score 0 to 2). The best riffle is selected because we want to identify bottlenecks during harsh periods (*e.g.*, drought). Estimate depths in areas that are clearly riffle, not transitional between a riffle and a run. If the riffle is generally less than 5 cm in depth, riffles are considered to have loss their function and the entire riffle metric is scored a 0.

2) Run Depth - select one box that most closely describes the depth characteristics of the runs (Score 0 to 2). Estimate depth in areas that are clearly run, not transitional between a pool and a run or a riffle and a run.

3) *Riffle/Run Substrate Stability*— select one box from each that best describes the substrate type and stability of the riffle habitats (Score 0 to 2).

4) *Riffle/Run Embeddedness*— Embeddedness is the degree that cobble, gravel, and boulder substrates are surrounded or covered by fine material (sand, silt); here in the riffle/runs only. We consider substrates embedded if >50% of surface of the substrates are embedded in fine material—these substrates cannot be easily dislodged. This also includes substrates that are concreted. Boxes are checked for pervasiveness of (riffle/ run area of sampling zone) embedded substrates: **Extensive** — > 75% of stream area, **Moderate** — 50-75%, **Sparse** — 25- 50%, **Low** — < 25%. The maximum score assigned for the QHEI for the Riffle/Run Quality metric is 8 points.

Metric 6: Map Gradient

Local or map gradient is calculated from USGS 7.5 minute topographic maps by measuring the elevation drop through the sampling area. This is done by measuring the stream length between the first contour line upstream and the first contour line downstream of the sampling site and dividing the distance by the contour interval. If the contour lines are closely "packed" a minimum distance of at least one mile should be used. Some judgment may need to be exercised in certain anomalous areas (e.g. in the vicinity of waterfalls, impounded areas, etc.) and this can be compared to an infield, visual estimate which is recorded next to the gradient metric on the front of the sheet. Scoring for ranges of stream gradient takes into account the varying influence of gradient with stream size, preferably measured as drainage area in square miles or stream width. Gradient classifications (Table V-4-3) were modified from Trautman (p 139, 1981) and scores were assigned, by stream size category, after examining scatter plots of IBI vs. natural log of gradient in feet/mile (see Rankin 1989). Scores are listed in Table 2. The maximum QHEI metric score for Gradient is 10 points

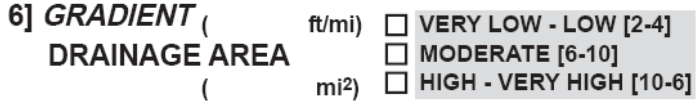


Figure 19. QHEI Stream gradient metric.

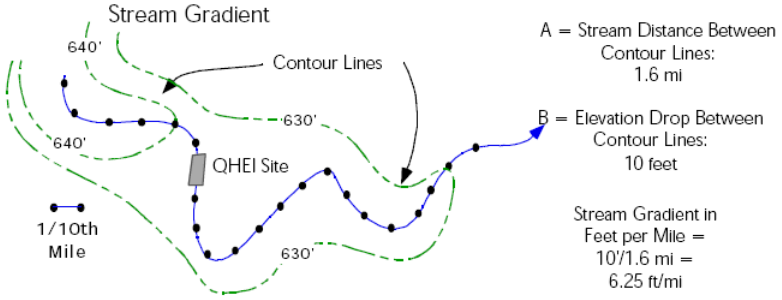


Figure 20. Illustration of methodology for determining stream gradient from topographic maps.

Table 2 Classification of stream gradients for Ohio by stream size. Modified from Trautman (p 139, 1981). Scores were derived from plots of IBI versus stream gradient for each stream size category.

Stream Width	Drainage Area (sq mi)	Gradient (feet/mile)						
		Very Low	Low	Low-Moderate	Moderate	Moderate-High	High	Very High[1]
≤ 4.7	< 9.2	0 - 1.0 **2**	1.1 - 5.0 **4**	5.1 - 10.0 **6**	10.1 - 15.0 **8**	15.1 - 20 **10**	20.1 - 30 **10**	30.1 - 40 **8**
4.8 - 9.2	9.2 - 41.6	0 - 1.0 **2**	1.1 - 3.0 **4**	3.1 - 6.0 **6**	6.1 - 12.0 **10**	12.1 - 18 **10**	18.1 - 30 **8**	30.1 - 40 **6**
9.3 - 13.8	41.7 - 103.7	0 - 1.0 **2**	1.1 - 2.5 **4**	2.6 - 5.0 **6**	5.1 - 7.5 **8**	7.6 - 12 **10**	12.1 - 20 **8**	20.1 - 30 **6**
13.9 - 30.6	103.8 - 622.9	0 - 1.0 **4**	1.1 - 2.0 **6**	2.1 - 4.0 **8**	4.1 - 6.0 **10**	6.1 - 10 **10**	10.1 - 15 **8**	15.1 - 25 **6**
> 30.6	> 622.9		0 - 0.5 **6**	0.6 - 1.0 **8**	1.1 - 2.5 **10**	2.6 - 4.0 **10**	4.1 - 9 **10**	> 9 **8**

[1]Any site with a gradient greater than the upper bound of the "very high" gradient classification is assigned a score of 4.

Computing the Total QHEI Score: To compute the total QHEI score, add the components of each metric to obtain the metric scores and then sum the metric scores to obtain the total QHEI score. The QHEI metric scores cannot exceed the Metric Maximum Score indicated below.

Narrative ranges of QHEI scores

For communicating general habitat quality to the public general narrative categories have been assigned to QHEI scores. Habitat influences on aquatic life, however, occur at multiple spatial scales and these narrative ranges are general and not always definitely predictable of aquatic assemblages are any given site.

Table 2. General narrative ranges assigned to QHEI scores. Ranges vary slightly in headwater (≤ 20 sq mi) vs. larger waters.

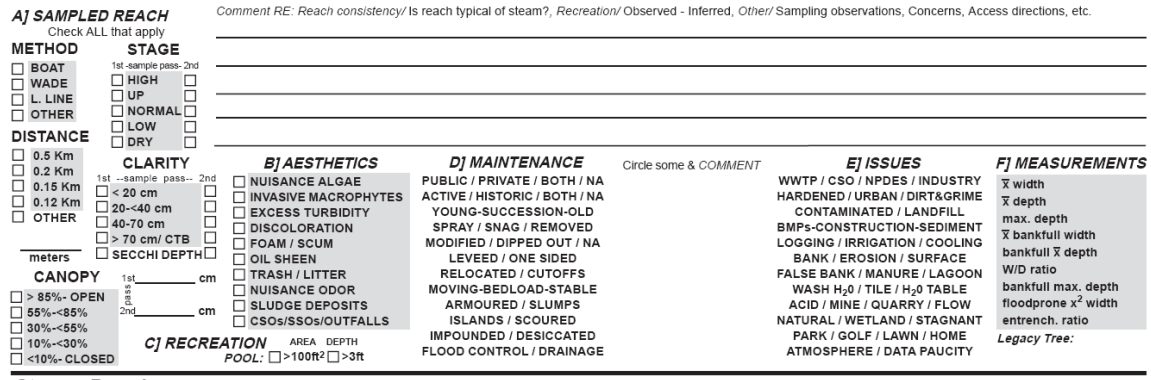
Narrative Rating	QHEI Range	
	Headwaters	Larger Streams
Excellent	≥ 70	≥ 75
Good	55- to 69	60 to 74
Fair	43 to 54	45 to 59
Poor	30 to 42	30 to 44
Very Poor	< 30	< 30

QHEI SCORING (Maximum = 100)

QHEI Metric	Metric Component	Component Scoring Range	Metric Max. Score
1) Substrate	a) Type b) Quality	0 to 21 -5 to 3	20
2) Instream Cover	a) Type b) Amount	0 to 10 1 to 11	20
3) Channel Morphology	a) Sinuosity b) Development c) Channelization d) Stability	1 to 4 1 to 7 1 to 6 1 to 3	20
4) Riparian Zone	a) Width b) Quality c) Bank Erosion	0 to 4 0 to 3 1 to 3	10
5a) Pool Quality	a) Max. Depth b) Current c) Morphology	0 to 6 -2 to 4 0 to 2	12
5b) Riffle Quality	a) Depth b) Substr Stab. c) Substr Embd.	0 to 4 0 to 2 -1 to 2	8
6) Gradient		2 to 10	10

Additional Information/Back of QHEI Sheet

Additional information is recorded on the reverse side of the Site Description Sheet. Several versions of the reverse of the QHEI sheet have been produced over the past 10 years, but this description is based on the most recent revision of the Ohio EPA sheet (Figure 21).



A – Sampling Characteristics

1) *Methods Used* – A series of check boxes to record the type of sampling completed in the reach.

2) *Distance* – Distance assessed for the QHEI and/or fish assessment.

3) *Stage* – Estimate of flow stage during assessment. Since some sites are sampled twice, a box is included for each sampling effort.

4) *Clarity* – Estimate of water clarity during assessment. Since some sites are sampled twice, a box is included for each sampling effort. There are also two places to record Secchi depths, if taken.

5) *Canopy* – Estimate of average width of canopy

B. Aesthetics

1) Check all of the boxes that apply in terms of aesthetic characteristics of the site

C. Recreation

1) Record whether there exists, within the area, greater than 100 ft^2 of water greater than three feet in depth. This is used to estimate whether full body immersion is possible or likely.

D. Maintenance

1) Record what types of stream maintenance activities or special features occur in the sampling zone. Some of this information was previously on the front of the sheet and is used as an aid when determining aquatic life uses (e.g., existing on ongoing channel maintenance).

E. Issues

1) Record various potential sources of impact that may occur in or near the site.

F. Measurements

1) If some quantitative measurements of stream channel characteristics are collected they may be recorded here. It is likely, however, that more detailed stream measurements (e.g., geomorphic assessment) will be recorded on separate forms.

G) *Stream Maps and Diagram*

Stream maps for each site can be very important. The act of drawing a map usually helps to identify habitat types scored with the QHEI. It can also help later samples identify sampling sites and determine whether changes have occurred. The level of detail of the drawings will likely vary with the objective. For example, sites assessed for 401 purposes should have as much detail as possible to help in later decisions of habitat limitations or high potential. Two or three cross-sections of the stream can provide useful information on the stream bank, stream bottom, stream channel, and floodplain characteristics.

QHEI Pool/Riffle Development Metric

Excellent Pool/Riffle Development:

Pools - > 1 m Deep
Glides - Only Transitional Habitats
Runs - > 0.5 m Deep
Riffles - Deep, Large Substrates
Morphology - All Habitats Easily Definable, Riffles Narrow and Deep, Pools Wide with Deep and Shallow Sections

Good Pool/Riffle Development:

Pools - > 0.7 m Deep
Glides - Mostly Transitional Habitats
Runs - Deep, but < 0.5 m
Riffles - Some Deep Areas, Large Substrates (At Least Large Gravels)
Morphology - All Habitats Fairly Well Definable, Riffles Typically Narrower Than Most Pools

Fair Pool/Riffle Development:

Pools - Show Some Depth Variation
Glides - Common
Runs - Typically Absent
Riffles - Poorly Defined, Shallow
Morphology - Habitat Types Not As Distinct, Glides Typically Difficult to
Separate From Pools and Riffles

Poor Pool/Riffle Development:

Pools - Shallow if Present
Glides - Predominant
Runs - Absent
Riffles - Absent, Or if Present Unstable and Shallow With Fine Substrates
Morphology - Mostly Glide Characteristics, Riffles Ephemeral if Present

Qualitative Habitat Evaluation Index and Use Assessment Field Sheet

OhioEPA

QHEI Score: ____

Stream & Location: _____ RM: _ _ _._ Date: _ _/ _ _/ 06

Scorers Full Name & Affiliation: _____

River Code:_ _ _- _ _ _- _ _ _ STORET #:_ _ _ _ _ _ Lat./ Long.: (NAD 83 - decimal °) _ _ . _ _ _ _ /8_ . _ _ _ _ Office verified location ☐

1] SUBSTRATE

Check *ONLY* **Two** substrate *TYPE BOXES*; estimate % or note every type present

BEST TYPES	POOL	RIFFLE	OTHER TYPES	POOL	RIFFLE
☐ ☐ BLDR /SLABS [10]	____	____	☐ ☐ HARDPAN [4]	____	____
☐ ☐ BOULDER [9]	____	____	☐ ☐ DETRITUS [3]	____	____
☐ ☐ COBBLE [8]	____	____	☐ ☐ MUCK [2]	____	____
☐ ☐ GRAVEL [7]	____	____	☐ ☐ SILT [2]	____	____
☐ ☐ SAND [6]	____	____	☐ ☐ ARTIFICIAL [0]	____	____
☐ ☐ BEDROCK [5]	____	____			

(Score natural substrates; ignore sludge from point-sources)

NUMBER OF BEST TYPES: ☐ 4 or more [2] ☐ 3 or less [0]

Check ONE (*Or 2 & average*)

ORIGIN
- ☐ LIMESTONE [1]
- ☐ TILLS [1]
- ☐ WETLANDS [0]
- ☐ HARDPAN [0]
- ☐ SANDSTONE [0]
- ☐ RIP/RAP [0]
- ☐ LACUSTURINE [0]
- ☐ SHALE [-1]
- ☐ COAL FINES [-2]

EMBEDDEDNESS

SILT
- ☐ HEAVY [-2]
- ☐ MODERATE [-1]
- ☐ NORMAL [0]
- ☐ FREE [1]

QUALITY
- ☐ EXTENSIVE [-2]
- ☐ MODERATE [-1]
- ☐ NORMAL [0]
- ☐ NONE [1]

Substrate ____ Maximum 20

Comments

2] INSTREAM COVER

Indicate presence 0 to 3: **0**-Absent; **1**-Very small amounts or if more common of marginal quality; **2**-Moderate amounts, but not of highest quality or in small amounts of highest quality; **3**-Highest quality in moderate or greater amounts (e.g., very large boulders in deep or fast water, large diameter log that is stable, well developed rootwad in deep / fast water, or deep, well-defined, functional pools.

____ UNDERCUT BANKS [1]	____ POOLS > 70cm [2]	____ OXBOWS, BACKWATERS [1]
____ OVERHANGING VEGETATION [1]	____ ROOTWADS [1]	____ AQUATIC MACROPHYTES [1]
____ SHALLOWS (IN SLOW WATER) [1]	____ BOULDERS [1]	____ LOGS OR WOODY DEBRIS [1]
____ ROOTMATS [1]		

AMOUNT

Check ONE (*Or 2 & average*)
- ☐ EXTENSIVE >75% [11]
- ☐ MODERATE 25-75% [7]
- ☐ SPARSE 5-<25% [3]
- ☐ NEARLY ABSENT <5% [1]

Comments

Cover Maximum 20 ____

3] CHANNEL MORPHOLOGY

Check ONE in each category (*Or 2 & average*)

SINUOSITY
- ☐ HIGH [4]
- ☐ MODERATE [3]
- ☐ LOW [2]
- ☐ NONE [1]

DEVELOPMENT
- ☐ EXCELLENT [7]
- ☐ GOOD [5]
- ☐ FAIR [3]
- ☐ POOR [1]

CHANNELIZATION
- ☐ NONE [6]
- ☐ RECOVERED [4]
- ☐ RECOVERING [3]
- ☐ RECENT OR NO RECOVERY [1]

STABILITY
- ☐ HIGH [3]
- ☐ MODERATE [2]
- ☐ LOW [1]

Comments

Channel Maximum 20 ____

4] BANK EROSION AND RIPARIAN ZONE

Check **ONE** in each category for *EACH BANK* (*Or 2 per bank & average*)

River right looking downstream

L	R	EROSION
☐	☐	NONE / LITTLE [3]
☐	☐	MODERATE [2]
☐	☐	HEAVY / SEVERE [1]

L	R	RIPARIAN WIDTH
☐	☐	WIDE > 50m [4]
☐	☐	MODERATE 10-50m [3]
☐	☐	NARROW 5-10m [2]
☐	☐	VERY NARROW < 5m [1]
☐	☐	NONE [0]

L	R	FLOOD PLAIN QUALITY
☐	☐	FOREST, SWAMP [3]
☐	☐	SHRUB OR OLD FIELD [2]
☐	☐	RESIDENTIAL, PARK, NEW FIELD [1]
☐	☐	FENCED PASTURE [1]
☐	☐	OPEN PASTURE, ROWCROP [0]

L	R	
☐	☐	CONSERVATION TILLAGE [1]
☐	☐	URBAN OR INDUSTRIAL [0]
☐	☐	MINING / CONSTRUCTION [0]

Indicate predominant land use(s) past 100m riparian.

Comments

Riparian Maximum 10 ____

5] POOL / GLIDE AND RIFFLE / RUN QUALITY

MAXIMUM DEPTH

Check **ONE** (*ONLY!*)
- ☐ > 1m [6]
- ☐ 0.7-<1m [4]
- ☐ 0.4-<0.7m [2]
- ☐ 0.2-<0.4m [1]
- ☐ < 0.2m [0]

CHANNEL WIDTH

Check ONE (*Or 2 & average*)
- ☐ POOL WIDTH > RIFFLE WIDTH [2]
- ☐ POOL WIDTH = RIFFLE WIDTH [1]
- ☐ POOL WIDTH > RIFFLE WIDTH [0]

CURRENT VELOCITY

Check ALL that apply
- ☐ TORRENTIAL [-1]
- ☐ VERY FAST [1]
- ☐ FAST [1]
- ☐ MODERATE [1]
- ☐ SLOW [1]
- ☐ INTERSTITIAL [-1]
- ☐ INTERMITTENT [-2]
- ☐ EDDIES [1]

Indicate for reach - pools and riffles.

Recreation Potential
Primary Contact
Secondary Contact
(circle one and comment on back)

Comments

Pool / Current Maximum 12 ____

Indicate for functional riffles; Best areas must be large enough to support a population of riffle-obligate species: Check ONE (*Or 2 & average*). ☐ NO RIFFLE [metric=0]

RIFFLE DEPTH
- ☐ BEST AREAS > 10cm [2]
- ☐ BEST AREAS 5-10cm [1]
- ☐ BEST AREAS < 5cm [metric=0]

RUN DEPTH
- ☐ MAXIMUM > 50cm [2]
- ☐ MAXIMUM < 50cm [1]

RIFFLE / RUN SUBSTRATE
- ☐ STABLE (e.g., Cobble, Boulder) [2]
- ☐ MOD. STABLE (e.g., Large Gravel) [1]
- ☐ UNSTABLE (e.g., Fine Gravel, Sand) [0]

RIFFLE / RUN EMBEDDEDNESS
- ☐ NONE [2]
- ☐ LOW [1]
- ☐ MODERATE [0]
- ☐ EXTENSIVE [-1]

Comments

Riffle / Run Maximum 8 ____

6] GRADIENT

DRAINAGE AREA (ft/mi) (mi²)

- ☐ VERY LOW - LOW [2-4]
- ☐ MODERATE [6-10]
- ☐ HIGH - VERY HIGH [10-6]

%POOL: ____ %GLIDE: ____

%RUN: ____ %RIFFLE: ____

Gradient Maximum 10 ____

A] SAMPLED REACH

Check ALL that apply

METHOD

- ☐ BOAT
- ☐ WADE
- ☐ L. LINE
- ☐ OTHER

STAGE

1st -sample pass- 2nd	
☐ HIGH	☐
☐ UP	☐
☐ NORMAL	☐
☐ LOW	☐
☐ DRY	☐

DISTANCE

- ☐ 0.5 Km
- ☐ 0.2 Km
- ☐ 0.15 Km
- ☐ 0.12 Km
- ☐ OTHER

_____ meters

CLARITY

1st --sample pass-- 2nd	
☐ < 20 cm	☐
☐ 20-<40 cm	☐
☐ 40-70 cm	☐
☐ > 70 cm/ CTB	☐
☐ SECCHI DEPTH	☐

CANOPY

- ☐ > 85%- OPEN
- ☐ 55%-<85%
- ☐ 30%-<55%
- ☐ 10%-<30%
- ☐ <10%- CLOSED

pass 1st _____ cm

pass 2nd _____ cm

C] RECREATION

POOL: ☐ >100ft² ☐ >3ft (AREA / DEPTH)

Comment RE: Reach consistency/ Is reach typical of steam?*, Recreation/* Observed - Inferred, *Other/* Sampling observations, Concerns, Access directions, etc.

B] AESTHETICS

- ☐ NUISANCE ALGAE
- ☐ INVASIVE MACROPHYTES
- ☐ EXCESS TURBIDITY
- ☐ DISCOLORATION
- ☐ FOAM / SCUM
- ☐ OIL SHEEN
- ☐ TRASH / LITTER
- ☐ NUISANCE ODOR
- ☐ SLUDGE DEPOSITS
- ☐ CSOs/SSOs/OUTFALLS

D] MAINTENANCE

Circle some & *COMMENT*

PUBLIC / PRIVATE / BOTH / NA
ACTIVE / HISTORIC / BOTH / NA
YOUNG-SUCCESSION-OLD
SPRAY / SNAG / REMOVED
MODIFIED / DIPPED OUT / NA
LEVEED / ONE SIDED
RELOCATED / CUTOFFS
MOVING-BEDLOAD-STABLE
ARMOURED / SLUMPS
ISLANDS / SCOURED
IMPOUNDED / DESICCATED
FLOOD CONTROL / DRAINAGE

E] ISSUES

WWTP / CSO / NPDES / INDUSTRY
HARDENED / URBAN / DIRT&GRIME
CONTAMINATED / LANDFILL
BMPs-CONSTRUCTION-SEDIMENT
LOGGING / IRRIGATION / COOLING
BANK / EROSION / SURFACE
FALSE BANK / MANURE / LAGOON
WASH H_20 / TILE / H_20 TABLE
ACID / MINE / QUARRY / FLOW
NATURAL / WETLAND / STAGNANT
PARK / GOLF / LAWN / HOME
ATMOSPHERE / DATA PAUCITY

F] MEASUREMENTS

- $\bar{x}$ width
- $\bar{x}$ depth
- max. depth
- $\bar{x}$ bankfull width
- bankfull $\bar{x}$ depth
- W/D ratio
- bankfull max. depth
- floodprone x^2 width
- entrench. ratio

Legacy Tree:

Stream Drawing: