Fish data collection protocols for lotic waters in Minnesota

Sample collection, sample processing, and calculation of indices of biotic integrity

Minnesota Pollution Control Agency

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Contents

Introduction

This document describes the protocols for sampling fish from lotic waters (e.g., streams, rivers, and ditches), processing samples, and calculating index of biotic integrity (IBI) scores. These methods must be followed for the data to be used as part of 1) assessment of aquatic life (Class 2) beneficial uses as part of the intensive watershed monitoring program, 2) data supplementation to aid the stressor identification process, 3) development of regional biological criteria, and 4) calibration of biological criteria. The use of biological data for determining attainment or nonattainment of beneficial uses, including the use of IBIs, is described in Minn. R. 7050.0150, subp. 6. A description of how biological information is used for assessment of beneficial uses is described in the 2016 Guidance Manual for Assessing the Quality of Minnesota Surface Waters for Determination of Impairment 305(b) Report and 303(d) List (MPCA 2016). Before using these standard operating proceedures (SOPs), field crews, sample processors, and others involved in the collection of fish data should familiarize themselves with these protocols.

Fish community sampling protocol for stream monitoring sites

This section describes the methods used by the Minnesota Pollution Control Agency's (MPCA) Biological Monitoring Program to collect fish community information at stream monitoring sites for the purpose of assessing water quality and developing biological criteria. This procedure applies to all monitoring sites for which an integrated assessment of water quality is to be conducted. An integrated assessment involves the collection of biological (fish and macroinvertebrate communities), physical habitat, and chemical information to assess stream condition.

Sites may be selected for monitoring for a number of reasons including, but not limited to: 1) sites selected for condition monitoring as part of Intensive Watershed Monitoring (IWM), 2) sites randomly selected as part of the Environmental Monitoring and Assessment Program (EMAP), 3) sites selected for the development and calibration of biological criteria, and 4) sites selected for stressor identification. Although the reasons for monitoring a site vary, the fish community sampling protocol described in this document applies to all monitoring sites, unless otherwise noted.

Fish community sampling is conducted in conjunction with the water chemistry and physical habitat assessment protocols (see the following SOPs: MPCA 2014c [Water Chemistry Assessment Protocol for Stream Monitoring Sites] and; MPCA 2014d [MPCA Stream Habitat Assessment (MSHA) Protocol for Stream Monitoring Sites]. An additional protocol that may be used during a site visit includes: MPCA 2012 [Stream Condition and Stressor Identification (SCSI) protocol for Stream Monitoring Sites]). Fish sampling should occur after water chemistry collection so as not to disrupt the sediments prior to collecting water samples. However, the fish sampling should be conducted prior to any physical habitat assessment so as not to disturb the fish community prior to sampling.

Requirements

Qualifications of crew leaders: The crew leader must be a professional aquatic biologist with a minimum education of a Bachelor of Science degree in aquatic biology or closely related specialization. He or she must have a minimum of six months field experience in fish community sampling methodology and fish taxonomy. Field crew leaders should also possess excellent map reading skills and a demonstrated proficiency in the use of a GPS (Global Positioning System) receiver and orienteering compass.

Qualifications of field technicians/interns: A field technician/intern must have at least one year of college education and coursework in environmental and/or biological science.

General qualifications: All personnel conducting this procedure must have the ability to perform rigorous physical activity. It is often necessary to wade through streams and/or wetlands, canoe, or hike for long distances to reach a sampling site

Responsibilities

Field crew leader: Implement the procedures described in this section and ensure that the data generated meets the standards and objectives of the Biological Monitoring Program.

Technicians/interns: Implement the procedures described in this section, including maintenance and stocking of equipment, data collection and recording.

Quality assurance and quality control

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

In addition to adhering to the specific requirements of this sampling protocol and any supplementary site specific procedures, the minimum Quality Assurance (QA) and/or Quality Control (QC) requirements for this activity are as follows:

A. Control of deviations: Deviations shall be sufficiently documented to allow repetition of the activity as performed.
B. QC samples: Five to ten percent of sites sampled in any given year are re-sampled as a means of determining sampling error and temporal variability.
C. Verification: The field crew leader will conduct periodic reviews of field personnel to ensure that technical personnel are following procedures in accordance with this SOP.

Training

A. All inexperienced personnel will receive instruction from a trainer designated by the program manager. Major revisions in this protocol require that all personnel be re-trained in the revised protocol by experienced personnel.
B. The field crew leader will provide instruction in the field and administer a field test to ensure personnel can execute this procedure.

Fish sampling proceedures

A. Equipment check list

Verify that all necessary items are present before commencement of this procedure (Table 1).

Table 1. Equipment Check List – This table identifies all equipment needed in the field in order to implement the sampling protocol as described.

√	*Item and purpose*
	Electrofisher – for sampling the fish community, use appropriate gear type (includes control box, generator, anode(s), and cathode)
	Nets – for collection of fish; 1/8" mesh, fiberglass handles

√	***Item and purpose***
	Rubber gloves – for safety during electrofishing; electrically rated
	Holding tank – for holding fish during electrofishing; of sufficient size to minimize stress
	Wet containers – for holding fish during processing; of sufficient size and number to minimize stress
	Balance or spring scales – for weighing fish
	Measuring board – for measuring total length of fish
	Waders – for safety during electrofishing
	Polarized sunglasses – for aid in capturing fish
	Clipboard – to store forms and record data
	Forms – for recording data
	Pencil – for filling out forms
	Permanent marker – for labeling voucher bottle
	Taxonomic key – to assist in identifying fish
	Voucher bottle – for storing preserved specimens
	Formalin – for preserving voucher specimens
	Labels – to label voucher jars
	Camera – to document fish species collected that are too large to preserve

B. Data collection method

The location and length of the sampling reach is determined during site reconnaissance (see MPCA 2014b [Reconnaissance Procedures for Initial Visit to Stream Monitoring Sites]). The reach length, 35 times the mean stream width (MSW), is based on the distance necessary to capture a representative and repeatable sample of the fish community within a stream segment (Lyons 1992). Reach lengths are a minimum of 150 meters and a maximum of 500 meters. Sampling is conducted during daylight hours within the summer index period of mid-June through mid-September. Sampling should occur when streams are at or near base-flow because flood or drought events can have a profound effect on fish community structure and sampling efficiency.

For wadeable streams, fish community sampling is conducted in conjunction with the physical habitat assessment protocol (see SOP--"Quantitative Physical Habitat Assessment Protocol for Wadeable Stream Monitoring Sites or MPCA Stream Habitat Assessment (MSHA) Protocol for Stream Monitoring Sites"). Fish sampling should be conducted before the physical habitat assessment so as not to disturb the fish community prior to sampling. Sample all habitat types available to fish within the reach in the approximate proportion that they occur. An effort is made to collect all fish observed. Fish < 25 mm in total length are not counted as part of the catch.

All fish that are alive after processing should be immediately returned to the stream, unless they are needed as voucher specimens. Considerable effort should be expended to minimize handling mortality, such as using a live well, quickly sorting fish into numerous wet containers, and replacing their water supply.

Fish survey results are recorded on the Fish Survey Record data sheet (Appendix A). Guidelines for filling out this data sheet are described in the following pages.

C. Fish survey record data sheet

This data sheet summarizes the location, sampling characteristics, and fish community composition of the sampling site (see Appendix A). The variables recorded are as follows:

C.1. Location and sampling characteristics

A. Field Number – A seven-digit code that uniquely identifies the station. The first two digits identify the year of sampling, the second two identify the major river basin, and the last three are numerically assigned in sequential order (example 02UM001).

B. Stream Name – The name of the stream as shown on the most recent USGS 7.5” topographic map. Include all parts of the name (i.e. “North Branch,” “Creek,” “River,” “Ditch,” etc.).

C. Date – The date fish sampling is conducted in month/day/year format (MM/DD/YYYY).

D. Crew – The personnel who conducted fish community sampling.

E. Gear Type – The specific type of electrofisher utilized for fish collection. The MPCA’s Biological Monitoring Program utilizes four electrofishing gear types. Care is taken to select the gear type that will most effectively sample the fish community. Gear selection is dictated by stream width, depth, and accessibility. General guidelines for determining the appropriate gear type and their use are as follows:

Backpack: Generally used in small, wadeable streams (typically < 8 m MSW and < 50 mi^2 drainage area). A single electrofishing run is conducted in an upstream direction. In very small streams (<2 m wide) it is possible to sample most of the available habitat, but in larger streams it is often necessary to meander between habitat types. Two personnel are necessary - one to carry the unit and operate the anode, and another to collect the fish. In most small streams, a minimum of 1200 seconds of electrofishing should be conducted to collect a representative sample. Indicate the type of backpack electrofisher utilized by circling the appropriate option, Smith-Root generator, LR-24, or Halltech model.

Double Backpack: Used in larger wadeable streams and rivers (typically > 8 m MSW and 50-500 mi^2 drainage area) where access limits the ability to use the stream electrofisher. This electrofishing method is considered last, and typically is only utilized on randomly selected sites where access is very difficult or in wide, shallow, riffle and boulder strewn reaches. A single electrofishing run is conducted in an upstream direction using two backpack units simultaneously. Four personnel are necessary - two to carry the units and operate the anodes, and two personnel to net and carry the fish. Total time fished is determined by adding the times of both electrofishing units. Indicate the type of backpack electrofisher utilized.

Stream-electrofisher: Used in larger, wadeable streams and rivers (typically > 8 m MSW and 50-500 mi^2 drainage area). The stream-electrofisher is a towable unit that can effectively sample larger streams because it has additional power capabilities and employs two anodes, thus increasing the electrified zone. Five personnel are required for operation - one to control the electrofisher, two to direct the anodes, and two to net and carry the fish. A single electrofishing run is conducted in an upstream direction weaving between habitat types. The amount of time electrofished is variable due to differences in reach length, stream width, and habitat complexity; however, most circumstances would require a minimum of 2000 seconds of electrofishing to be conducted. In rare instances, when stream-electrofisher access is too difficult or the site is a wide, shallow riffle prohibiting utilization of a tote barge, it may be necessary to sample larger streams utilizing two backpack electrofishers simultaneously.

Mini-boom: Used in non-wadeable streams and rivers that are either too small or do not afford the access necessary to utilize a boom-electrofisher. The mini-boom electrofisher is a jon-boat that is light enough to be portaged, yet provides a stable work platform. Personnel consist of one person to operate the boat, monitor the control box, and ensure the safety of a single fish collector on the bow. In most cases, a minimum of 3000 seconds of electrofishing should be conducted to collect a representative sample. A single electrofishing run is conducted in a downstream direction weaving between habitat types, both stream banks, and mid-channel areas ensuring that the entire reach is thoroughly sampled. In larger streams (500 m reach lengths), the sampling effort should essentially equate to electrofishing the entire left bank, right bank, and mid-channel as prescribed in the boom-electrofisher protocol.

Boom-electrofisher: Used in large, accessible rivers. Three electrofishing runs are made in a downstream direction, one each along the right bank, left bank, and mid-channel. Personnel consist of one person to drive the boat, monitor the control box, and ensure the safety of the two fish collectors on the bow. Each electrofishing run is typically at least 1200 seconds of effort, or a minimum of 3600 seconds for all three passes combined.

F. Channel Position – If the site is sampled with a boom-electrofisher, circle the appropriate channel position of the electrofishing run (determined while facing downstream); right bank, left bank, or mid-channel. A separate Fish Survey Record data sheet is used for each of the three runs.

G. Distance – The length of stream sampled for fish, measured to the nearest meter following the center of the stream channel. If the entire reach is electrofished, the distance sampled for fish is the same as the station length recorded on the Visit Summary data sheet (see SOP--"Physical Habitat and Water Chemistry Assessment Protocol for Wadeable Stream Monitoring Sites"). In the event the entire station cannot be electrofished, measure the portion of the reach that was not sampled and subtract this distance from the station length to calculate the distance sampled for fish. Possible explanations include the occurrence of a culvert or beaver impoundment within the reach.

H. Time Fished – The number of seconds electrofished. Reset the timer on the electrofisher before each sampling event.

I. Identified By – The person(s) whose field identified the fish collected, must meet the minimum requirements of a field crew leader described previously.

J. Visit Comments – Record any additional information about the fish sampling visit in the space provided.

C.2. Fish community composition

A. Species – The common name of each fish species collected during the electrofishing run. If a fish cannot be identified to species with certainty, identify to the lowest possible taxon (e.g., to genus) and voucher for later lab identification.

B. Length Range – The minimum and maximum length for each fish species collected (fish < 25 mm are excluded). Measure to the nearest millimeter using Maximum Total Length protocol: the distance from the anterior-most part of the fish to the posterior-most tip of the caudal fin while it is being compressed. If only one individual of a fish species is captured, record the length as both the minimum and maximum total length.

C. Weight – The total wet weight of each fish species collected. Together, weigh all individuals of the same species to the nearest 0.5 gram. Multiple batch weights may be necessary if scale capacity is exceeded; these can be recorded on the back of the data sheet in the space provided. Only species totals should be recorded here.

D. Number – The total number of individuals of each fish species.

E. Anomalies or YOY – Record the total number and type of anomalies observed on all individuals of a fish species. Recognized anomalies and their codes are located on the bottom of the Fish Survey Record data sheet. In addition, instances in which young of year (YOY) trout species are collected note the total number of YOY individuals.

F. Voucher – The number of specimens of each fish species retained for verification and deposition in the Minnesota Bell Museum of Natural History. For fish that are identified with certainty to species level, several individuals of each species should be preserved in 10% formalin solution (37% formaldehyde: water) in the "A-jar." For each species of fish, document the number of individuals preserved in this data field. The person recording the fish information is in charge of the voucher bottle, and specimens will only be added to the voucher bottle upon the recorder's approval, to ensure accuracy of numbers. All fish that could not be identified to the species level should be preserved in a separate container (B-jar) in 10% formalin solution. Record the number preserved.

Voucher containers should be labeled externally and internally. On the outside of the jar, write the field number, sampling date, and jar identification (A or B) with a permanent marker. Place a label inside each jar identifying the field number, sampling date, stream name, jar identification, county, gear type, and collectors. Write this information on an index weight label in pencil or a solvent proof marker. If an "A" and "B" jar are used they should be taped together.

For specimens that are too large to preserve, a photograph may be taken to serve as a voucher. Place a card with the site field number and sampling date visibly into the picture frame with the fish positioned in a manner that allows key characteristics to be identified. Indicate that a photograph was taken by writing "photo" in the voucher column.

C.3. Individual or batch measurements

Often times it is necessary to weigh large fish individually or conduct multiple batch weights for a species of fish. These measurements can be recorded in this section of the data sheet. The data fields are the same as those described above. After fish processing is complete, combine the information for fish of the same species so that only species totals are recorded in the previous section.

Calculation of Minnesota stream fish Index of Biotic Integity

The IBI is used by the MPCA to determine if streams are meeting their aquatic life use goals. Calculation of an IBI involves synthesis of fish community information into a numerical expression of stream health. In order to apply the MPCA stream Fish IBI (FIBI), it is essential that all data is collected using MPCA standard operating procedures (see protocols described above). A complete description of the development of FIBIs can be found in MPCA (2014a).

Stream types

Prior to determining the FIBI score, the sampling location must be categorized into a stream type. MPCA has stratified Minnesota streams into nine types corresponding to regional patterns in the composition of stream fishes; a unique FIBI and biocriterion have been developed for each type. Stream type is differentiated by geographic region, contributing drainage area, reach-scale gradient, and thermal regime. Classification criteria are described in the following paragraphs and a step-by-step classification approach is outlined in Appendix B.

Geographic Region: The FIBI stream typology framework divides Minnesota into two regions (North and South). Regionalization largely follows major watershed boundaries and reflects significant post-glacial barriers to fish migration (e.g., St. Anthony Falls) (Figure 1). The "northern" FIBI region includes the Lake Superior basin, Rainy River basin, the portion of the Upper Mississippi River basin upstream of St. Anthony Falls, the portion of the St. Croix River basin upstream of Taylor's Falls, and the portion of the Red River basin lying outside of the Glacial Lake Agassiz Basin level 4 ecoregion. The "southern" FIBI region includes the entirety of the Minnesota River, Lower Mississippi River, Des Moines and Cedar River basins, the portion of the Upper Mississippi River basin below St. Anthony Falls, the portion of the St. Croix River basin below Taylor's Falls, and the portion of the Red River basin lying within the Glacial Lake Agassiz Basin level 4 ecoregion.

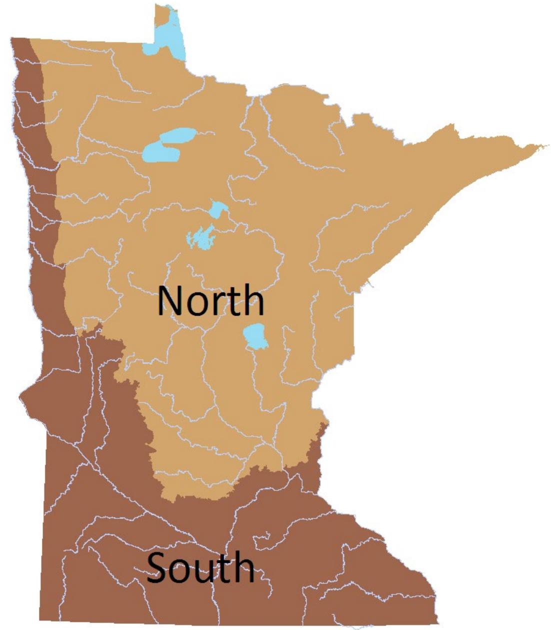

Figure 1. Regional framework for FIBI development and application.

Drainage area: Contributing drainage area (square miles) must be determined for all stream fish sampling locations. Drainage area is used for classification purposes and, in some cases, the metric scoring process.

Gradient: Reach-scale gradient (meters/kilometer) is required for most stream fish sampling locations. Gradient is used for classification purposes and, in some cases, the metric scoring process. MPCA recommends determining reach-scale gradient based on the endpoint elevations of a 1000 meter stream segment that brackets the midpoint of the fish sampling reach.

Temperature – For the purposes of FIBI classification, MPCA recognizes two temperature types: coldwater (2A) and non-coldwater (2B). Thermal classifications for Minnesota streams can be found in Minn. R. 7050.0470 and 7050.0430.

Fish community data

Stream fish data must be collected using MPCA protocols (see protocols described above) and identified to the lowest feasible taxonomic level (typically species). MPCA has utilized a variety of published and non-published sources to assign trophic, reproductive, habitat, tolerance, and life history traits to fish species known to inhabit Minnesota's rivers and streams. These species-level attributes should be used to calculate FIBI metric values, and are listed in Appendix C.

In some cases, a species-level taxonomic determination may not be feasible and individual fish may be identified at a coarser taxonomic level (e.g., immature redhorse may be identified as *Moxostoma spp*.). For the purposes of taxa richness and taxa percentage metrics, the determination of whether to "count" these individuals as a unique taxon depends on whether other members of the same taxonomic group are present and identified at a finer taxonomic resolution. For example, if the only redhorse collected in a sample are immature and cannot be identified to the species level, the genus *Moxostoma* should be considered a unique taxon. However, if other redhorse individuals in the same sample can be identified to the species level, the immature specimens should not be considered a unique taxon.

Calculating metric values

Metric values are the raw numerical expression of taxonomic or autecological information at the community level. Fish IBI metrics fall into three general categories: taxa richness, taxa percentage, and relative abundance (Table 2). Appendix D provides information regarding each FIBI and associated metrics.

Table 2. Metric types used in FIBI.

Metric Type	Description	Example
Taxa Richness	The number of unique taxa observed in a sample that share a common attribute	Number of piscivorous taxa
Taxa Percentage	The number of taxa observed in a sample that share a common attribute divided by the total number of unique taxa in the sample	Proportion of piscivorous taxa among all taxa in the sample
Relative Abundance	The number of individuals observed in a sample that share a common attribute divided by the total number of individuals in the sample	Proportion of piscivorous individuals among all individuals in the sample

Taxa Richness — Taxa richness metrics represent the number of taxa sharing a common ecological or taxonomic attribute. As described above, only “unique” taxa should contribute to taxa richness metrics.

Example: Piscivorous Taxa (number of piscivorous taxa): if there are 4 unique piscivorous taxa in a sample, the “Piscivore” taxa richness metric value would be 4.

Taxa Percentage – Taxa percentage metrics represent the proportion of taxa sharing a common ecological or taxonomic attribute, relative to the total number of taxa in the sample. As described above, only “unique” taxa should contribute to taxa percentage metrics.

Example: Piscivore_TxPct (percent piscivorous taxa): if there are 4 unique piscivorous taxa in a sample of 20 total unique taxa, the “Piscivore_TxPct” metric value would be 20% (4/20).

Relative abundance – Relative abundance metrics represent the abundance of a individuals sharing a common taxonomic or ecological attribute, relative to the total number of individuals in the sample. When calculating relative abundance, all individuals that meet the group criteria should be included, not only those that are considered “unique” taxa (as with taxa richness and taxa percent metrics).

Example: Piscivore_Pct (relative abundance of piscivorous individuals): if there are 20 piscivorous individuals in a sample of 100 total individuals, the “Piscivore_Pct” metric value would be 20% (20/100).

Calculating metric scores

In some cases, transformations are used to reduce skew in metric value distributions. Metric values should be transformed as indicated in Appendix D. In other cases, metrics are known to be correlated with natural gradients (e.g., drainage area, reach gradient), which may amplify, reduce, or otherwise obscure a metric response to anthropogenic disturbance. In these cases, a “corrected” metric value is obtained by calculating a residual from an ordinary least squares (OLS) regression, and using that residual value as the new metric value. Metric values should be corrected for natural gradients as indicated in Appendix D. “Corrected” metric values are calculated as follows:

Corrected metric value = *(metric value) - ((([slope]*(Log([natural gradient value]))+([Constant]))*

Most metrics are scored on a continuous scale from 0 to 10. Metric scores are derived using different equations, depending on the directionality of each metric’s response to disturbance. Metrics that respond negatively to disturbance (“positive metrics”) will have metric scores positively correlated with metric values. Metrics that respond positively to disturbance ("negative metrics") will have metric scores inversely related to metric values.

Metric scores are interpolated linearly between minimum and maximum metric values.

Formula for calculating positive metric scores: $metric\ score = \frac{metric\ value - 5th\ percentile\ value}{95th\ percentile\ value - 5th\ percentile\ value} * 10$

Formula for calculating negative metric scores: $metric\ score = \frac{95th\ percentile\ value - metric\ value}{95th\ percentile\ value - 5th\ percentile\ value} * 10$

To limit the influence of extreme metric values, the 5^{th} and 95^{th} percentile values are treated as *de facto* "maximum values" for each metric. For positive metrics, values less than the 5th percentile (minimum) are assigned the minimum score of 0, while those with values greater than the 95^{th} percentile (maximum) are assigned the maximum score of 10. For negative metrics, values less than the 5th percentile (minimum) are given the maximum score of 10, while those with values greater than the 95^{th} percentile (maximum) are given the minimum a score of 0. Upper and lower limits for each metric are documented in Appendix D.

Discrete scoring is used in cases where metric score distributions remain heavily skewed following transformation and implementation of the continuous scoring process. Discretely-scored metrics receive a score of 0, 5, or 10 based on breakpoints in metric score distributions. Discretely-scored metrics and associated breakpoints are documented in Appendix D.

Very low catch rates, either in terms of number of individuals or number of taxa, are generally indicators of severe degradation in permanent, warm and coolwater Minnesota streams. In these cases, the presence of a few individuals may artificially inflate the FIBI score and possibly mask a serious impairment. This is particularly concerning for proportional metrics (individual percentage and taxa percentage), where very low counts of "non-tolerant" individuals may result in extremely high metric scores for negative metrics. To address this issue, MPCA utilizes "low end scoring" criteria, under which individual percentage metrics in non-coldwater IBIs receive a score of 0 when fewer than 25 individuals were captured, and taxa richness and taxa percentage receive a score of 0 when fewer than 6 taxa were captured. Low end scoring taxa richness and taxa percentage metric adjustments are applied to the Southern Rivers, Southern Streams, Northern Rivers and Northern Streams FIBIs. Because fish assemblages of small, perennial headwaters may be relatively depauperate under natural conditions, the low end scoring threshold for taxa richness and taxa percentage metrics in Northern Headwaters, Southern Headwaters, and Low Gradient IBIs is reduced to fewer than 4 taxa. Low End Scoring criteria are not applied to Southern Coldwater and Northern Coldwater IBIs because these systems may exhibit extremely low taxa richness or number of individuals under natural, undisturbed conditions.

The composite IBI score is the sum of metric scores, scaled to a 0-100 range. The formula for scaling IBI scores is as follows:

$$IBI\ score = sum\ of\ metric\ scores * \frac{10}{\#\ metrics\ in\ IBI}$$

References

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Appendix A. Fish survey field sheets

FISH SURVEY RECORD MPCA

Field Number:	Stream Name:
Date (mm/dd/yyyy):	Crew:

Gear Type (circle one): Backpack* Stream-electrofisher Boom-electrofisher Mini-Boom

*Type of Backpack (circle one): Generator LR-24 Halltech

Channel Position: Right Bank Mid-Channel Left Bank
(circle one if boom-electrofisher site)

Distance (m):	Time Fished (sec):	Identified By:

Visit Comments:

Species (common name)	Length Range (mm)	Weight (g)	Number	Anomalies or YOY	Voucher Number	Voucher Pics
1.						
2.						
3.						
4.						
5.						
6.						
7.						
8.						
9.						
10.						
11.						
12.						
13.						
14.						
15.						
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25.						
26.						
27.						
28.						

Anomalies: **A**-anchor worm; **B**-black spot; **C**-leeches; **D**-deformities; **E**-eroded fins; **F**-fungus; **G**-yellow grub; **L**-lesions; **N**-blind; **P**=parasites; **PL**-parasite lesion; **Y**-popeye; **S**-emaciated; **W**-swirled scales; **T**-tumors; **Z**-other. (Heavy [**H**] or Light [**L**] code may be combined with above codes).

(Cont.)

Species (common name)	Length Range (mm)	Weight (g)	Number	Anomalies or YOY	Voucher Number	Voucher Pics
29.						
30.						
31.						
32.						
33.						
34.						
35.						
36.						
37.						
38.						

INDIVIDUAL OR BATCH MEASUREMENTS

Species (common name)	Length Range (mm)	Weight (g)	Number	Anomalies or YOY	Voucher Number	Voucher Pics
1.						
2.						
3.						
4.						
5.						
6.						
7.						
8.						
9.						
10.						
11.						
12.						
13.						
14.						
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19.						
20.						
21.						
22.						
23.						
24.						
25.						
26.						
27.						
28.						
29.						
30.						
31.						
32.						

(Revised May 2015)

Appendix B. Classification criteria for determining the appropriate FIBI for a Minnesota stream or river.

1a. Northern.............5
1b. Southern.............2

Southern

2a. coldwater....................**Southern Coldwater**
2b. warmwater................3

3a. Drainage area >300 sq mi......................**Southern Rivers**
3b. Drainage area <300 sq mi......................4

4a. Drainage area >30 sq mi.............. **Southern Streams**
4b. Drainage area <30 sq mi..............5

5a. Gradient >0.50 m/km............**Southern Headwaters**
5b. Gradient <0.50 m/km............**Low-Gradient**

Northern

5a. coldwater..................**Northern Coldwater**
5b. warmwater..............6

6a. Basin = Red.............7
6b. Basin = other..............8

7a. Drainage area >350 sq mi..........................**Northern Rivers**
7b. Drainage area <350 sq mi..........................9

8a. Drainage area >500 sq mi..................**Northern Rivers**
8b. Drainage area <500 sq mi.................9

9a. Drainage area >50....................**Northern Streams**
9b. Drainage area <50.................10

10a. Gradient >0.50 m/km......**Northern Headwaters**
10b. Gradient <0.50 m/km......**Low-Gradient**

Appendix C. Taxon attributes used to calculate FIBI metrics.

Taxon	BenInsect-Tol	Coldwater	CWIntolerant	CWSensitive	CWTol	DarterSculp	DetNWQ	Exotic	Generalist	Headwater	Herbv	InsectCyp	Insect-Tol	Intolerant	MA<2	MA>3	Minnows-Tol	NativeCold	NestNoLith	Omnivore	Percfm	Pioneer	Piscivore	Sdet	Sensitive	SLithop	SLvd	SSpn	Tol	Vtol	Wetland
alewife								X								X															
American brook lamprey			X	X						X				X		X									X						
American eel																							X								
Atlantic salmon		X						X								X							X								
banded darter	X					X							X		X						X				X	X		X			
banded killifish													X		X													X			
bighead carp					X			X								X								X				X	X	X	
bigmouth buffalo									X							X				X				X					X	X	
bigmouth shiner					X							X			X									X			X	X	X	X	
black buffalo							X		X											X				X							
black bullhead					X				X											X				X					X	X	X
black crappie																			X		X		X								
black redhorse	X			X									X	X		X									X	X					
blackchin shiner												X	X	X	X		X							X	X			X			
blacknose dace									X	X					X											X	X		X		
blacknose shiner												X	X	X	X		X								X		X				
blackside darter	X					X							X		X						X					X					
blackstripe topminnow													X		X													X			
blue catfish																			X				X								
blue sucker	X												X	X											X	X					
bluegill													X		X				X		X							X			
bluntnose darter	X					X							X																		
bluntnose minnow					X		X		X						X				X			X		X			X	X	X	X	
bowfin																X							X								
brassy minnow					X		X				X				X									X			X		X		
brook silverside													X		X										X		X				
brook stickleback										X					X				X								X		X		X
brook trout		X	X	X										X		X		X					X		X						
brown bullhead									X										X	X				X				X			X
brown trout		X		X				X								X							X		X						
bullhead minnow									X						X		X		X									X			
burbot														X		X							X		X	X					
carmine shiner							X					X	X		X		X								X	X	X				
central mudminnow					X										X														X	X	X
central stoneroller					X						X																		X		
channel catfish																X			X				X	X							
channel shiner												X	X		X		X								X		X				

Taxon	BenInsect-Tol	Coldwater	CWIntolerant	CWSensitive	CWTol	DarterSculp	DetNWQ	Exotic	Generalist	Headwater	Herbv	InsectCyp	Insect-Tol	Intolerant	MA<2	MA>3	Minnows-Tol	NativeCold	NestNoLith	Omnivore	Percfm	Pioneer	Piscivore	Sdet	Sensitive	SLithop	SLvd	SSpn	Tol	Vtol	Wetland
chestnut lamprey														X		X							X		X						
chinook salmon		X						X								X							X								
coho salmon		X						X								X							X								
common carp					X		X	X	X						X					X				X					X	X	
common shiner									X						X		X							X		X					
creek chub									X						X							X							X		
crystal darter	X					X							X	X	X						X				X	X	X	X			
deepwater sculpin	X					X							X	X		X									X						
emerald shiner												X	X		X		X							X		X	X				
Fam: gars																							X								
Fam: lamprey																									X						
Fam: mooneyes													X																		
Fam: pikes																							X								
Fam: sturgeons	X												X													X					
fantail darter	X			X		X				X			X		X						X				X			X			
fathead minnow					X		X		X						X				X	X		X		X			X	X	X	X	X
finescale dace				X						X		X	X		X		X								X			X			X
flathead catfish																X			X				X								
flathead chub												X	X		X		X											X			
freshwater drum													X			X					X										
Gen: buffalos									X											X											
Gen: bullheads									X											X											X
Gen: carpsuckers									X											X											
Gen: Catostomus																										X					
Gen: common sunfishes													X																		
Gen: crappies																							X								
Gen: Etheostoma	X					X							X																		
Gen: madtoms	X												X																		
Gen: Micropterus																							X								
Gen: Notropis																	X														
Gen: Percina	X					X							X													X					
Gen: Phoxinus										X																					
Gen: redhorses	X												X													X					
Gen: Rhinichthys																										X					
Gen: Sander																							X			X					
Gen: sculpins	X	X		X		X							X					X							X						
Gen: stonerollers											X						X														
Gen: topminnows													X																		
ghost shiner							X					X	X	X	X		X								X			X			

Taxon	BenInsect-Tol	Coldwater	CWIntolerant	CWSensitive	CWTol	DarterSculp	DetNWQ	Exotic	Generalist	Headwater	Herbv	InsectCyp	Insect-Tol	Intolerant	MA<2	MA>3	Minnows-Tol	NativeCold	NestNoLith	Omnivore	Percfm	Pioneer	Piscivore	Sdet	Sensitive	SLithop	SLvd	SSpn	Tol	Vtol	Wetland
gilt darter	X					X							X	X	X						X				X	X					
gizzard shad															X									X				X			
golden redhorse	X												X			X								X		X					
golden shiner									X						X		X											X			X
goldeye													X			X															
goldfish					X			X	X							X				X				X				X	X	X	
grass carp					X			X			X				X									X					X		
gravel chub	X											X	X	X	X		X							X	X	X	X				
greater redhorse	X												X	X		X									X	X					
green sunfish					X				X						X				X		X	X							X	X	
highfin carpsucker							X		X							X				X				X	X						
hornyhead chub												X	X		X		X							X	X			X			
hybrid sunfish					X																								X		
ide					X			X								X													X		
Iowa darter	X					X							X		X						X				X		X				X
johnny darter	X					X							X		X				X		X	X									
kokanee								X															X								
lake chub			X	X								X	X	X		X	X								X	X					
lake herring																X															
lake sturgeon	X												X	X		X									X	X					
lake trout		X														X		X					X								
lake whitefish													X			X															
lamprey ammocoete														X											X						
largemouth bass																			X		X		X								
largescale stoneroller											X				X		X							X							
least darter	X					X							X	X	X						X				X		X	X			
logperch	X					X							X	X	X						X				X	X					
longear sunfish													X	X	X				X		X				X						
longnose dace	X		X	X								X	X	X			X								X	X					
longnose gar																X							X					X			
longnose sucker	X		X	X									X	X		X									X	X					
mimic shiner												X	X	X			X							X	X		X	X			
Mississippi silvery minnow											X			X			X								X						
mooneye													X												X						
mottled sculpin	X	X		X		X				X			X		X			X							X						
mud darter	X					X							X		X						X				X		X				
muskellunge														X		X							X		X						
ninespine stickleback													X		X				X												

Taxon	BenInsect-Tol	Coldwater	CWIntolerant	CWSensitive	CWTol	DarterSculp	DetNWQ	Exotic	Generalist	Headwater	Herbv	InsectCyp	Insect-Tol	Intolerant	MA<2	MA>3	Minnows-Tol	NativeCold	NestNoLith	Omnivore	Percfm	Pioneer	Piscivore	Sdet	Sensitive	SLithop	SLvd	SSpn	Tol	Vtol	Wetland
northern brook lamprey			X	X										X		X									X						
northern hogsucker	X												X			X								X	X	X					
northern pike															X								X								X
northern redbelly dace										X	X				X		X								X		X	X			X
orangespotted sunfish					X										X						X							X	X	X	
Ozark minnow											X			X	X		X							X	X	X					
paddlefish														X		X									X	X					
pallid shiner												X	X	X			X								X						
pearl dace				X						X		X	X		X		X							X	X						X
pink salmon		X						X															X								
pirate perch													X		X																
plains topminnow													X		X										X		X				
pugnose minnow							X					X	X	X	X		X		X					X	X		X	X			
pugnose shiner							X				X			X		X	X								X		X				
pumpkinseed													X		X				X		X										
pygmy whitefish													X																		
quillback							X		X							X				X				X							
rainbow darter	X			X		X							X		X						X				X	X		X			
rainbow smelt								X															X					X			
rainbow trout		X		X				X								X							X		X						
red shiner					X				X						X												X	X	X		
redfin shiner												X	X		X		X								X		X				
redside dace			X	X						X		X	X	X	X		X								X	X					
river carpsucker							X		X							X				X				X							
river darter	X					X							X	X	X						X				X	X	X				
river redhorse	X												X	X		X									X	X					
river shiner												X	X		X		X							X		X	X				
rock bass																X			X		X		X		X						
round goby								X								X			X				X					X			
round whitefish													X			X															
ruffe					X			X							X													X	X		
sand shiner					X		X					X			X									X			X	X	X		
sauger																X					X		X			X					
saugeye																					X		X			X					
sea lamprey							X	X								X							X								
shoal chub	X											X	X		X		X								X		X				
shorthead redhorse	X												X			X								X		X					
shortjaw cisco																X															
shortnose gar																X							X								

Taxon	BenInsect-Tol	Coldwater	CWIntolerant	CWSensitive	CWTol	DarterSculp	DetNWQ	Exotic	Generalist	Headwater	Herbv	InsectCyp	Insect-Tol	Intolerant	MA<2	MA>3	Minnows-Tol	NativeCold	NestNoLith	Omnivore	Percfm	Pioneer	Piscivore	Sdet	Sensitive	SLithop	SLvd	SSpn	Tol	Vtol	Wetland
shovelnose sturgeon	X												X			X										X					
silver carp					X			X																					X	X	
silver chub	X											X	X		X		X														
silver lamprey																X							X		X						
silver redhorse	X												X			X								X		X					
skipjack herring																							X								
slender madtom	X						X						X	X											X						
slenderhead darter	X					X							X		X						X				X	X					
slimy sculpin	X	X	X	X		X				X			X	X		X		X							X						
smallmouth bass														X		X			X		X		X		X						
smallmouth buffalo									X						X					X				X							
southern brook lamprey			X	X			X							X		X									X						
southern redbelly dace										X	X				X		X							X		X	X	X			
splake		X													X			X					X								
spoonhead sculpin	X					X							X	X	X										X						
spotfin shiner							X					X	X		X		X							X				X			
spottail shiner												X	X		X		X								X						
spotted sucker	X												X	X		X								X	X	X					
starhead topminnow													X	X	X										X			X			X
stonecat	X												X			X									X			X			
SubFam: buffalo/carpsuckers									X											X											
SubFam: salmonids																							X								
suckermouth minnow	X											X	X		X		X							X		X		X			
tadpole madtom	X												X		X				X									X			X
threespine stickleback					X			X							X				X								X		X		
tiger musky																							X								
tiger trout		X																					X								
Topeka shiner										X		X	X	X	X		X								X		X				
trout-perch	X												X		X												X				
tubenose goby								X					X																		
walleye																X					X		X			X					
warmouth															X						X		X								
weed shiner							X				X			X	X		X							X	X		X	X			
western sand darter	X					X							X	X	X						X				X	X	X	X			
white bass															X						X		X								
white crappie															X				X		X		X								
white perch								X					X			X					X										
white sucker							X		X							X				X				X		X			X		

Taxon	BenInsect-Tol	Coldwater	CWIntolerant	CWSensitive	CWTol	DarterSculp	DetNWQ	Exotic	Generalist	Headwater	Herbv	InsectCyp	Insect-Tol	Intolerant	MA<2	MA>3	Minnows-Tol	NativeCold	NestNoLith	Omnivore	Percfm	Pioneer	Piscivore	Sdet	Sensitive	SLithop	SLvd	SSpn	Tol	Vtol	Wetland
yellow bass																X					X		X								
yellow bullhead									X										X	X				X				X			X
yellow perch													X			X					X										

Appendix D. FIBI metrics and scoring criteria.

Table D1. Metric information for the Southern Rivers FIBI

Metric	Type	Description	Category	Response	Scoring	Floor	Ceiling	Notes
Insectivore-Tol_Pct	IndPct	Percent insectivorous individuals (excludes tolerant species)	Tr	P	C	12.01	82.00	
SimpleLithophil	Richness	Number of simple lithophilic taxa, scoring adjusted for gradient	R	P	C	-6.71	2.59	slope=3.945 intercept=11.187
GeneralistFeeder_Pct	IndPct	Percent generalist feeder individuals	Tr	N	C	5.64	64.72	
VeryTolerant_TxPct	TXPct	Percent very tolerant taxa	To	N	C	5.04	33.33	
SerialSpawner_TxPct	TXPct	Percent serial spawner taxa	R	N	C	14.40	38.04	
Tolerant_Pct	IndPct	Percent tolerant individuals	To	N	C	5.38	82.30	
ShortLived_Pct	IndPct	Percent short-lived individuals	LH	N	C	0.83	60.10	
Sensitive_TxPct	TXPct	Percent sensitive taxa, scoring adjusted for gradient	To	P	C	-23.59	15.82	slope=16.042 intercept=33.5
Detritivore_TxPct	TXPct	Percent detritivorous taxa	Tr	N	C	15.38	41.62	
Piscivore	Richness	Number of piscivorous taxa	Tr	P	C	1.00	7.90	
DominanceTwoTaxa_Pct	IndPct	Combined relative abundance of the two most abundant taxa	Comp	N	C	30.39	75.00	
FishDELT_Pct*	IndPct	Percent of individuals with Deformities, Eroded fins, Lesions, Tumors	Comp	N	D			≥4% = -10 ≥2% = -5

*FishDELT_Pct metric is a negative adjustment applied (if applicable) after calculating the composite (0-100 scale) FIBI score

Table D2. Metric information for the Southern Streams FIBI

Metric	Type	Description	Category	Response	Scoring	Floor	Ceiling	Notes
BenthicInsectivore-Tol_TxPct	TXPct	Percent benthic insectivore taxa (excludes tolerant species)	Tr	P	C	0.00	40.00	
Sensitive_TxPct	TXPct	Percent sensitive taxa	To	P	C	0.00	45.11	
Detritivore_TxPct	TXPct	Percent detritivorous taxa	Tr	N	C	14.13	46.38	
ShortLived	Richness	Number of short-lived taxa	LH	N	C	1.00	7.00	
Tolerant_TxPct	TXPct	Percent tolerant taxa	To	N	C	27.99	84.81	
MatureAge<2_Pct	IndPct	Percent early-maturing individuals	R	N	C	29.68	97.68	
Tolerant_Pct	IndPct	Percent tolerant individuals	To	N	C	27.93	75.00	
DominanceTwoTaxa_Pct	IndPct	Combined relative abundance of the two most abundant taxa	Comp	N	C	34.00	75.00	
FishDELT_Pct*	IndPct	Percent of individuals with Deformities, Eroded fins, Lesions, Tumors	Comp	N	D			≥4% = -10 ≥2% = -5

*FishDELT_Pct metric is a negative adjustment applied (if applicable) after calculating the composite (0-100 scale) FIBI score

Table D3. Metric information for the Southern Headwaters FIBI

Metric	Type	Description	Category	Response	Scoring	Floor	Ceiling	Notes
Sensitive	Richness	Number of sensitive taxa	To	P	C	0.00	4.00	
Detritivore_TxPct	TXPct	Percent detritivorous taxa	Tr	N	C	0.00	50.00	
GeneralistFeeder_TxPct	TXPct	Percent generalist feeder taxa	Tr	N	C	31.92	76.53	
SerialSpawner_Pct	IndPct	Percent serial spawner individuals	R	N	C	0.00	76.92	
VeryTolerant_TxPct	TXPct	Percent very tolerant taxa	To	N	C	0.00	58.71	
ShortLived_Pct	IndPct	Percent short-lived individuals	LH	N	C	0.14	98.73	
FishDELT_Pct*	IndPct	Percent of individuals with Deformities, Eroded fins, Lesions, Tumors	Comp	N	D			≥4% = -10 ≥2% = -5

*FishDELT_Pct metric is a negative adjustment applied (if applicable) after calculating the composite (0-100 scale) FIBI score

Table D4. Metric information for the Northern Rivers FIBI

Metric	Type	Description	Category	Response	Scoring	Floor	Ceiling	Notes
Sensitive_TxPct	TXPct	Percent sensitive taxa, scoring adjusted for gradient	To	P	C	-16.39	7.04	slope=11.902 intercept=43.121
Sensitive_Pct	IndPct	Percent sensitive individuals, scoring adjusted for gradient	To	P	C	-33.70	17.75	slope=22.503 intercept=51.121
Detritivore_Pct	IndPct	Percent detritivorous individuals	Tr	N	C	0.39	46.93	
VeryTolerant_TxPct	TXPct	Percent very tolerant taxa	To	N	C	0.00	20.00	
Exotic_Pct	IndPct	Percent exotic individuals	Comp	N	D			≥10% = 0 ≥5% = 5 <5% = 10
SerialSpawner_TxPct	TXPct	Percent serial spawner taxa	R	N	C	8.70	29.22	
Insectivore-Tol_Pct	IndPct	Percent insectivorous individuals (excludes tolerant species)	Tr	P	C	28.94	74.99	
NonLithophilicNester_Pct	IndPct	Percent non-lithophilic nest-building individuals	R	N	C	8.74	46.14	
SimpleLithophil_TxPct	TXPct	Percent simple lithophilic taxa	R	P	C	26.28	48.32	
DominanceTwoTaxa_Pct	IndPct	Combined relative abundance of the two most abundant taxa	Comp	N	C	34.86	50.00	
FishDELT_Pct*	IndPct	Percent of individuals with Deformities, Eroded fins, Lesions, Tumors	Comp	N	D			≥4% = -10 ≥2% = -5

*FishDELT_Pct metric is a negative adjustment applied (if applicable) after calculating the composite (0-100 scale) FIBI score

Table D5. Metric information for the Northern Streams FIBI

Metric	Type	Description	Category	Response	Scoring	Floor	Ceiling	Notes
Sensitive_TxPct	TXPct	Percent sensitive taxa	To	P	C	5.69	44.00	
Intolerant_Pct	IndPct	Percent intolerant individuals	To	P	C	0.00	41.98	
Insectivore-Tol_TxPct	TXPct	Percent insectivorous taxa (excludes tolerant species)	Tr	P	C	26.12	50.50	
MatureAge>3-Tol_Pct	IndPct	Percent late-maturing individuals (excludes tolerant species)	R	P	C	0.00	34.09	
GeneralistFeeder	Richness	Number of generalist taxa	Tr	N	C	2.20	7.00	
SerialSpawner_TxPct	TXPct	Percent serial spawner taxa	R	N	C	6.25	33.33	
Detritivore_Pct	IndPct	Percent detritivorous individuals	Tr	N	C	1.01	38.98	
VeryTolerant	Richness	Number of very tolerant taxa	To	N	C	1.00	5.00	
DarterSculpinSucker_TxPct	TXPct	Percent darter, sculpin, and sucker taxa	Comp	P	C	6.42	27.78	
SimpleLithophil_Pct	IndPct	Percent simple lithophilic individuals	R	P	C	3.11	67.34	
DominanceTwoTaxa_Pct	IndPct	Combined relative abundance of the two most abundant taxa	Comp	N	C	37.64	50.00	
FishDELT_Pct*	IndPct	Percent of individuals with Deformities, Eroded fins, Lesions, Tumors	Comp	N	D			≥4% = -10 ≥2% = -5

*FishDELT_Pct metric is a negative adjustment applied (if applicable) after calculating the composite (0-100 scale) FIBI score

Table D6. Metric information for the Northern Headwaters FIBI

Name	Type	Description	Category	Response	Scoring	Floor	Ceiling	Notes
Sensitive	Richness	Number of sensitive taxa	To	P	C	0.00	4.00	
Minnow-Tol_Pct	IndPct	Percent cyprinid individuals (excludes tolerant species)	Comp	P	C	0.00	51.48	
Insectivore-Tol_TxPct	TXPct	Percent insectivorous taxa (excludes tolerant species)	Tr	P	C	0.00	42.87	
NumPerMeter-Tol	CPUE	Number of fish per meter (excludes tolerant species)	Comp	P	C	0.01	1.82	
InsectivorousCyprinid_Pct	IndPct	Percent insectivorous cyprinid individuals	Tr	P	C	0.00	20.85	
HeadwaterSpecialist-Tol	Richness	Number of headwater taxa (excludes tolerant taxa)	H	P	C	0.00	3.00	
DarterSculpin	Richness	Number of darter and sculpin taxa	Comp	P	C	0.00	2.00	
SimpleLithophil	Richness	Number of simple lithophilic taxa	R	P	C	0.00	4.28	
Tolerant_TxPct	TXPct	Percent tolerant taxa	To	N	C	33.33	80.00	
Pioneer_TxPct	TXPct	Percent pioneer taxa	LH	N	C	10.00	33.33	
FishDELT_Pct*	IndPct	Percent of individuals with Deformities, Eroded fins, Lesions, Tumors	Comp	N	D			≥4% = -10 ≥2% = -5

*FishDELT_Pct metric is a negative adjustment applied (if applicable) after calculating the composite (0-100 scale) FIBI score

Table D7. Metric information for the Low Gradient FIBI

Name	Type	Description	Category	Response	Scoring	Floor	Ceiling	Notes
Minnow-Tol_Pct	IndPct	Percent cyprinid individuals (excludes tolerant species)	Comp	P	C	0.00	52.29	
Wetland-Tol	Richness	Number of wetland taxa (excludes tolerant species)	H	P	C	0.00	4.10	
Sensitive	Richness	Number of sensitive taxa	To	P	C	0.00	4.00	
NumPerMeter-Tol	CPUE	Number of fish per meter (excludes tolerant species)	Comp	P	C	0.00	1.89	
HeadwaterSpecialist-Tol_Pct	IndPct	Percent headwater individuals (excludes tolerant species)	H	P	C	0.00	34.77	
SimpleLithophil	Richness	Number of simple lithophilic taxa	R	P	C	0.00	4.00	
Ominivore_TxPct	TXPct	Percent omnivorous taxa	Tr	N	C	0.00	40.00	
Tolerant_TxPct	TXPct	Percent tolerant taxa	To	N	C	33.33	85.80	
Pioneer_TxPct	TXPct	Percent pioneer taxa	LH	N	C	0.00	35.71	
FishDELT_Pct*	IndPct	Percent of individuals with Deformities, Eroded fins, Lesions, Tumors	composition	N	D			≥4% = -10 ≥2% = -5

*FishDELT_Pct metric is a negative adjustment applied (if applicable) after calculating the composite (0-100 scale) FIBI score

Table D8. Metric information for the Southern Coldwater FIBI

Name	Type	Description	Category	Response	Scoring	Floor	Ceiling	Notes
ColdwaterNative_Pct	IndPct	Percent native, coldwater individuals	H	P	C	0.00	1.96	(log10 +1) transformation of values prior to scoring
SensitiveColdwater_Pct	IndPct	Percent sensitive individuals (specific to coldwater streams, adjusted for drainage area)	To	P	C	-76.14	17.59	slope = -27.382 intercept = 114.322
Detritivore_TxPct (SDet_TxPct)	TXPct	Percent taxa that consume detritus as part of their diet (adjusted for drainage area)	Tr	N	C	-14.35	28.09	slope = 16.211 intercept = -5.276
TolerantColdwater	Richness	Number of tolerant taxa (specific to coldwater streams, adjusted for drainage area)	To	N	C	-1.04	4.24	slope = 1.089 intercept = -0.827
Pioneer_Pct	IndPct	Percent pioneer individuals	LH	N	C	0.00	55.02	
Herbivore_Pct	IndPct	Percent herbivorous individuals	Tr	N	D			≥8.06% = 0 ≥3.07% = 5 <3.07% = 10
ColdwaterNative_TxPct	TXPct	Percent native, coldwater taxa (adjusted for drainage area)	H	P	C	-32.45	28.48	slope = -24.242 intercept = 54.017
FishDELT_Pct*	IndPct	Percent of individuals with Deformities, Eroded fins, Lesions, Tumors	Comp	N	D			≥4% = -10 ≥2% = -5

*FishDELT_Pct metric is a negative adjustment applied (if applicable) after calculating the composite (0-100 scale) FIBI score

Table D9. Metric information for the Northern Coldwater FIBI

Metric	Type	Description	Category	Response	Scoring	Floor	Ceiling	Notes
Coldwater	Richness	Coldwater taxa	H	P	C	0.00	2.00	
IntolerantColdwater_Pct	IndPct	Percent intolerant individuals (specific to coldwater	To	P	C	0.00	83.65	
SensitiveColdwater_TxPct	TXPct	Percent sensitive taxa (specific to coldwater streams, adjusted for gradient)	To	P	C	-27.66	25.90	slope = 23.788 intercept = 24.437
TolerantColdwater_Pct	IndPct	Percent tolerant individuals (specific to coldwater streams)	To	N	C	0.00	1.49	(log10 +1) transformation of values prior to scoring
NonLithophilicNester_Pct	IndPct	Percent non-lithophilic nest-building individuals	R	N	C	0.00	1.68	(log10 +1) transformation of values prior to scoring
Ominivore_TxPct	TXPct	Percent omnivorous taxa	Tr	N	C	0.00	20.00	
Pioneer_TxPct	TXPct	Percent pioneer taxa	LH	N	C	0.00	33.33	
Perciformes_Pct	IndPct	Percent of individuals belonging to Order Perciformes	Comp	N	C	0.00	1.52	(log10 +1) transformation of values prior to scoring
FishDELT_Pct*	IndPct	Percent of individuals with Deformities, Eroded fins, Lesions, Tumors	Comp	N	D			≥4% = -10 ≥2% = -5

*FishDELT_Pct metric is a negative adjustment applied (if applicable) after calculating the composite (0-100 scale) FIBI score

Attachment 4

Macroinvertebrate data collection protocols for lotic waters in Minnesota

Sample collection, sample processing, and calculation of indices of biotic integrity for qualitative multihabitat samples

Minnesota Pollution Control Agency

March 2017

Contents

Introduction

This document describes the protocols for sampling macroinvertebrates from lotic waters (e.g., streams, rivers, and ditches), processing samples, and calculating index of biotic integrity (IBI) scores. These methods must be followed for the data to be used as part of 1) assessment of aquatic life (Class 2) beneficial uses as part of the intensive watershed monitoring program, 2) data supplementation to aid the stressor identification process, 3) development of regional biological criteria, and 4) calibration of biological criteria. The use of biological data for determining attainment or nonattainment of beneficial uses, including the use of IBIs, is described in Minn. R. 7050.0150, subp. 6. A description of how biological information is used for assessment of beneficial uses is described in the 2016 Guidance Manual for Assessing the Quality of Minnesota Surface Waters for Determination of Impairment 305(b) Report and 303(d) List (MPCA 2016). Before using these standard operating procedures (SOPs), field crews, sample processors and others involved in the collection of macroinvertebrate data should familiarize themselves with these protocols.

Macroinvertebrate community sampling protocol for stream monitoring sites

This section describes the methods used by the Minnesota Pollution Control Agency's (MPCA) Biological Monitoring Program to collect macroinvertebrate community information at stream monitoring sites for the purpose of assessing water quality and developing biological criteria. This procedure applies to all wadeable and non-wadeable monitoring sites in which stream macroinvertebrates are to be collected for the development of biological criteria or the assessment of water quality.

Definitions

Integrated monitoring: A stream monitoring technique to assess water quality using chemical, biological and physical indicators.

Biological Criteria: Narrative expressions or numerical values that describe the reference biological integrity of a specified habitat. Biological criteria are the benchmarks for judging the condition of aquatic communities.

Qualitative Multi-habitat Sample (QMH): A method of sampling macroinvertebrates which involves sampling a variety of macroinvertebrate habitats, including the following: rocky substrates, including riffles and runs, submerged and emergent aquatic vegetation, undercut banks, overhanging vegetation, woody debris, and leaf packs.

Intensive Watershed Monitoring: A watershed monitoring plan designed to assess the aquatic health of major watersheds through intensive biological and water chemistry sampling. This intensive approach allows assessment of watersheds for aquatic life, aquatic recreation, and aquatic consumption use support of the state's streams in each of the state's 80 major watersheds on a rotating 10-year cycle.

Requirements

Qualifications of crew leaders: The crew leader must be a professional aquatic biologist with a minimum of a Bachelor of Science degree in biology with an aquatic entomology, invertebrate zoology, fisheries, or closely related specialization, or equivalent experience in a related field. Additionally, they should have previous professional experience working as a field biologist, including sampling macroinvertebrates, and conducting habitat assessments. Field crew leaders must possess excellent map reading skills, have a demonstrated proficiency in the use of a GPS (Global Positioning System), and have good interpersonal skills for communicating with landowners and other interested stakeholders.

Qualifications of field technicians/interns: A field technician/intern must have at least one year of college education and had coursework in environmental and/or biological science.

General qualifications: All personnel conducting this procedure must have the ability to perform rigorous physical activity. It is often necessary to wade through streams and/or wetlands, canoe, or hike for long distances to reach a sampling site.

Responsibilities

Field crew leader: Ensures that data generated using this procedure meet the standards and objectives of the integrated stream monitoring program and carries out the procedures outlined in this section.

Technicians/interns: Carries out the procedures outlined in this section, including maintenance and stocking of equipment, data collection and recording.

Quality Assurance and Quality Control

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

In addition to adhering to the specific requirements of this sampling protocol and any supplementary site specific procedures, the Quality Assurance (QA) and Quality Control (QC) requirements for this protocol are as follows:

1. Control of Deviations: Deviations from the procedure shall be sufficiently documented to allow repetition of the activity as actually performed.
2. QC Samples: 5-10 percent of all sites sampled in any given year are resampled as a means of determining sampling variability.
3. Verification: The field crew leader will conduct periodic reviews of field personnel to ensure that technical personnel are following the procedures according to this SOP.

Training

All personnel, including experienced staff, will receive annual instruction from a trainer designated by the program manager. Major revisions in this protocol require that all personnel be re-trained in the revised protocol by experienced personnel. Training activities will include instruction in the field, as well as a field test to ensure that personnel can implement this procedure. The field crew leader will provide instruction in the field to untrained personnel, such as interns and technicians, to ensure they can effectively execute this procedure.

Macroinvertebrate sampling procedures

A. Equipment list

Verify that all necessary items are present before commencement of this procedure (Table 1).

Table 1. Equipment List – This table identifies all equipment needed in the field in order to implement the sampling protocol as described.

√	*Item and purpose*
	Two D-frame dipnets with 500 micron mesh nets, equivalent to Wildco, turtox design – for collection of inverts
	Two sieve buckets with 500 micron sieves – for reducing debris in sample
	Stream Invertebrate Visit Form – for recording data
	Stream Verification Form (electronic or hardcopy) – for navigating to sampling station
	Maps of stream reach (aerial imagery & 1:24,000 USGS topographical map) – for navigating to sampling station
	Minnesota Atlas and Gazetteer (Delorme) – for navigating to sampling station
	Pencils – for filling out forms
	Permanent/Alcohol proof marker – for labeling jar and voucher tags
	Internal and External macroinvertebrate sample identification labels – to label sample containers
	100% reagent alcohol, (adequate volume to preserve 4 days of samples, ca. 10-15 gallons) – for preserving sample specimens
	Waterproof notebook – for making observations
	Chest waders – for safety during sampling
	Rain-gear – for comfort during sampling during inclement weather
	Camera – to document site conditions
	Plastic Sample Jars; wide-mouth, minimum 1 L capacity – for storing preserved specimens
	Box or crate - to store sample jars
	Canoe or Kayak if needed – for access to sampling station
	Backpack – carry equipment to and from a site

B. Data collection method

The location and length of the sampling reach is determined during site reconnaissance (see MPCA 2014b [Reconnaissance Procedures for Initial Visit to Stream Monitoring Sites]). The reach length, 35 times the mean stream width (MSW), is based on the distance necessary to capture a representative and repeatable sample of the fish community within a stream segment (Lyons 1992). Reach lengths are a minimum of 150 meters and a maximum of 500 meters. Sampling is conducted during daylight hours within the summer index period of late-July through October. Sampling should occur when streams are at or near base-flow because flood or drought events can have an effect on macroinvertebrate community structure and sampling efficiency.

Macroinvertebrate community sampling is conducted in conjunction with the water chemistry and physical habitat assessment protocols (see MPCA 2014c [Water Chemistry Assessment Protocol for Stream Monitoring Sites] and MPCA 2014d [MPCA Stream Habitat Assessment (MSHA) Protocol for Stream Monitoring Sites]). Additional protocols that may be used during a site visit include: MPCA 2012 [Stream Condition and Stressor Identification (SCSI) protocol for Stream Monitoring Sites] and MPCA 2014e [Channel Condition and Stability Index (CCSI): MPCA protocol for assessing the Geomorphic

Condition and Stability of Low-Gradient Alluvial Streams]. Macroinvertebrate sampling should occur after water chemistry collection so as not to disrupt the sediments prior to collecting water samples. However, the macroinvertebrate sampling should be conducted prior to any physical habitat assessment so as not to disturb the macroinvertebrate community prior to sampling.

C. Assessing stream habitats

Before sampling can begin, the crew leader and field technician must determine which habitats are present in the reach. This should be a cooperative effort. This is done by walking the sample reach and determining which productive habitats dominate the stream reach. A site visit form should be filled out during this process or immediately following sample collection. Ideally the stream should be viewed from the top of the stream bank, but this is generally the exception rather than the rule. For this reason, care should be taken to walk along the stream edge or any streamside exposed areas. If this is not possible, stay to one side of the stream so as to disturb as little substrate as possible.

NOTE

Sampling should be conducted in a downstream to upstream fashion, it will save time to start the initial visual inspection of the stream from the upstream end of the sampling reach and walk downstream. This will allow you to start sampling at the downstream end of the reach as soon the inspection is completed.

The multi-habitat method entails collecting a composite sample from up to five different habitat types. The goal of this method is to get a sample representative of the macroinvertebrate community of a particular sampling reach, it is also to collect and process that sample in a time and cost effective manner. For that reason, the habitats described below are relatively non-specific, being chosen to represent broad categories rather than microhabitats. Every broad category includes numerous microhabitats, some of which will not be sampled. It is to the discretion of the sampler which microhabitats are most representative of a reach. As a general rule, sample in a manner that reflects the most common microhabitat of any given broad habitat category. The habitats to be sampled include:

Hard bottom (riffle/cobble/boulder)

This category is intended to cover all hard, rocky substrates, not just riffles. Runs and wadeable pools often have suitable "hard" substrates, and should not be excluded from sampling. The surfaces of large boulders and areas of flat, exposed bedrock are generally quite unproductive, avoid including these habitats in the sampling area if possible. This is a general rule, if a particular stream has productive exposed bedrock, or boulder surfaces, those habitats should be considered sampleable.

Aquatic macrophytes (submerged/emergent vegetation)

Any vegetation found at or below the water surface should be considered in this category. Emergent vegetation is included because all emergent plants have stems that extend below the water surface, serving as suitable substrate for macroinvertebrates. Do not sample the emergent portion of any plant.

Undercut banks (undercut banks/overhanging vegetation)

This category is meant to cover in-bank or near-bank habitats, shaded areas away from the main channel that typically are buffered from high water velocities.

Snags (snags/rootwads)

Snags include any piece of large woody debris found in the stream channel. Logs, tree trunks, entire trees, tree branches, large pieces of bark, and dense accumulations of twigs should all be considered snags. Rootwads are masses of roots extending from the stream bank into the water.

Leaf packs

Leaf packs are dense accumulations of leaves typically present in the early spring and late fall They are found in deposition zones, generally near stream banks, around logjams, or in current breaks behind large boulders.

It can be difficult to estimate total stream coverage of certain habitats due to their appearance as linear or two dimensional features. Undercut banks and overhanging vegetation can appear as linear features despite their depth, while snags, woody debris, vegetation mats, and emergent vegetation can appear flat despite their three dimensional nature. For these reasons, best professional judgment must be used to determine what level of effort is adequate to equal one "sample effort" for any given substrate. Keep in mind that this method is considered qualitative, rulers and grids are not necessary to effectively implement this procedure.

D. Sampling macroinvertebrates

After the number of productive sampleable habitats have been determined, the sampling team should proceed in a downstream to upstream manner, sampling the habitats present. Sampling consists of dividing 20 sampling efforts equally among the dominant, productive habitats present in the reach. If 2 habitats are present, each habitat should receive 10 sampling efforts. If 3 habitats are present, each habitat should receive 7 sampling efforts. If a productive habitat is present in a reach but not in great enough abundance to receive an equal proportion of sampling efforts, it should be thoroughly sampled and the remaining samples should be divided among the remaining habitat types present.

NOTE

In order to get complete samples, the contents of the D-net should be emptied into a sieve bucket frequently. This prevents the back flow of water resulting from a clogged net. In larger streams, it is convenient for each sampler to have a sieve bucket. This allows samplers to sample independent of each other, avoiding frequent stream crossings, which can alter the stream bed.

A sample effort is defined as taking a single dip or sweep in a common habitat. A sweep is taken by placing the D-net on the substrate and disturbing the area directly in front of the net opening equal to the net width, ca. 1 ft^2. The net should be swept several times over the same area to ensure that an adequate sample is collected. Each effort should cover approximately 0.09 m^2 of substrate. Total area sampled is ca. 1.8 m^2. The following describes how to sample each habitat:

Hard bottom

Riffles and rocky runs are basically two dimensional areas, and should be thought of as such when trying to determine how dominant the riffle habitat is in a stream. It must be kept in mind that riffles are often the most productive and diverse habitat in the reach, relatively speaking.

The field personnel must be careful to not oversample riffles. The purpose of this method is to get a representative sample. Sampling in this habitat type is relatively simple. The D-net should be placed firmly and squarely on the substrate downstream of the area to be sampled. If the water is shallow enough, the area directly in front of the net should be disturbed with the hands, taking care to wash large rocks off directly into the net. If the water is too deep for this, kicking the substrate in front of the net is adequate. Watch for stoneflies and mayflies trying to crawl out of the net.

Vegetation

Aquatic vegetation is either completely submerged, mostly submerged and partially floating on the water's surface, or partially submerged and mostly extended above the water's surface. Things like pondweed, coontail, and milfoil tend to clump and float at the water's surface. These types of plants should be sampled with an upward sweep of the net. If the net fills with weeds, the weeds should be hand washed vigorously or jostled in the net for a few moments and then discarded. Emergent plants such as reed canary grass and various plants in the rush family, should be sampled with horizontal and vertical sweeps of the net until it is felt that the area being swept has been adequately sampled. Plants like floating bur reed and water celery tend to float in long strands with the current. They can be floating on the surface or completely submerged. These plants should be sampled as emergent plants with horizontal and vertical sweeps in a downstream to upstream motion.

Undercut banks/Overhanging vegetation

Undercut banks and overhanging vegetation follow the line of the stream bank. Undercut banks can vary in how undercut they are. An additional problem is that many banks appear undercut, but when investigated prove not to be. For these reasons, banks should be prodded to determine how deeply they are undercut. Overhanging vegetation should be treated the same way. Sampling should consist of upward thrusts of the net, beating the undercut portion of the bank or the overhanging vegetation, so as to dislodge any clinging organisms.

Snags

Snags and rootwads can be large or small, long or wide, simple or twisted masses of logs or twigs that do not have any consistent shape. Best professional judgment must be used to determine what a “sampling effort” is. Approximating the amount of sampleable surface area is a sensible method with larger tree trunks or branches. Masses of smaller branches and twigs must be estimated. Given their variable nature, there is not one best method for sampling snags. Using something like a toilet brush or kitchen brush works well for large pieces of wood, whereas kicking and beating with the net works best for masses of smaller branches.

Leaf packs

One square foot of leaf pack surface area that has two cubic feet of leaf underneath should be sampled near the surface, whereas a shallow leaf pack can be sampled in its entirety. Sweeping to the bottom of every leaf pack could create a disproportionately large amount of sample volume being collected for relatively small sample area. In most situations leaf packs will not be dominate enough to be included in a sample. If leaf packs are sampled, it is suggested that time be spent streamside washing macroinvertebrates off of leaves and discarding the leaves, as a leaf pack sample can easily become overwhelmingly large.

NOTE

While sampling, it may become necessary to clean the sample of muddy, fine sediment. This can be done by filling the sieve bucket with clean water and allowing the resulting mucky water to drain. Care must be taken not twist and turn the bucket too much, as this can damage some macroinvertebrates.

E. Preserving the sample

Once sampling is complete, the sample material should be preserved as quickly as possible. Transfer the sample material from the sieve bucket to the sample containers. Sample containers should contain no more than 30% of their volume as wet weight. Fill sample containers with 100% reagent alcohol to a level that ensures a final alcohol concentration of at least 70%. Be sure to thoroughly clean the bucket and sampling nets of all macroinvertebrates. The use of forceps might be necessary to dislodge some of the smaller organisms.

F. Labeling the sample

Fill out internal and external sample labels for each sample container using preprinted sample labels (see Appendix A). Be sure to use water and alcohol proof writing medium.

G. Stream invertebrate visit form

The "Stream Invertebrate Visit Form" should be filled out during the streamside survey, or notes should be taken on field note books and transferred to visit forms.

Macroinvertebrate sample processing and Quality Assurance/Quality Control procedures

These procedures are used for the processing and identification of freshwater macroinvertebrates. The procedures may be used by any person who has received training in processing samples. A laboratory staff member qualified to perform QC checks must be present when samples are processed by an inexperienced staff member, or when QC checks are needed for an experienced sorter's samples. This staff person is qualified by achieving a mean sorting efficiency of at least 90% over the previous 6 months.

Different sample processing methods may be used for different sample types or for different projects. The SOPs described in this document are for the sampling of lotic waters for the assessment of aquatic life beneficial uses (as described in 7050.0222, subparts 2c, 2d, 3c, 3d, 4c, and 4d). These macroinvertebrate samples use a 300 count subsample (tolerance of +/- 10%) with a Large/Rare search. For all methods described, some organisms are picked from the sample, but not counted (e.g., copepods and cladocerans). In addition, only aquatic and semiaquatic taxa are counted as part of the sample. The list of macroinvertebrates that are counted are listed in Appendix E.

Sample cleaning and preparation for subsampling

A. Equipment list

Verify that all necessary items are present before commencement of this procedure (Table 2).

Table 2. Sample preparation materials list.

√	*Item*
	Caton screen(s)
	plastic holding tray(s) for Caton screen(s)
	1000 ml Nalgene jars
	ethanol
	scissors
	scoops
	spoons
	spatula
	latex gloves
	assorted scrapers
	3x lighted magnifier

√	*Item*
	500 micron soil sieve
	sample splitting pan (for samples with large volumes)

NOTE

Be sure that all sorting equipment is thoroughly cleaned and free of organisms before beginning the preparation procedure.

B. General preparation procedure

1. Gently mix each sample in its jar(s).
2. Decant alcohol while pouring the sample out of each jar, using the 500 micron soil sieve (US #35) and the plastic Caton holding tray or 5 gallon bucket in the rinsing sink. If the sample is contained in several jars, empty and wash each jar one at a time. If the alcohol is not excessively stained or diluted, retain it for reuse as preservative for unsorted portion of sample, otherwise, discard the alcohol down the rinsing sink drain.
3. Pour the sample out into the 500 micron sieve, and retrieve all internal sample labels. Rinse all debris and organisms from the labels into the sieve.
4. Retrieve and save all labels. Check to make sure that the internal labels correspond with the bench sheet and the inventory. Labels are to be stapled to the back lower left of bench sheet once they are dried.
5. Gently rinse the sample jar, retaining all contents on the sieve.
6. Using the 500 micron sieve, gently wash the sample, running cold tap water over it to remove any fine material.
7. Transfer the sieve contents onto the Caton screen. If there are several sample jars, empty each onto the Caton screen as rinsing proceeds.
8. Rinse the sieve onto the Caton screen to collect any organisms or debris that may have been retained in the sieve. Inspect the sieve with the 3x lighted magnifier. Be sure the sieve is clean to prevent cross contamination between samples. Place all organisms retrieved from the sieve onto the Caton screen.
9. Place the Caton screen into the plastic holding tray. Add enough water to spread the sample evenly over the Caton screen. (Note: the water level should be close to the top of the plastic tray.) Move the sample into the corners of the pan using your hands, forceps, or other equipment. Agitate the tray and screen to help spread the sample. If the sample is composed of different types of material, be sure that there is thorough mixing of all types.
10. Remove large objects (sticks, stones, etc.) and examine them, using the 3x lighted magnifier when necessary. If organisms are found on these items, remove them and add them to the sample material on the Caton screen.
11. Lift the Caton screen out of the plastic tray to drain. Pour off the water from the plastic tray and set the screen back into the tray. Add just enough water to the tray so that it barely covers the screen while it is in the tray. Be careful not to add so much water that the sample material floats around.

C. Procedure precautions and exceptions

1. Never allow a sample to dry out during any stage of preparation or sorting.
2. Before beginning sample preparation, and after completion of preparation, be sure to examine sieves, Caton screens, spatulas, spoons, scoops, and all other materials to make sure that no organisms or sample residues are adhering to surfaces. These precautions prevent cross-contamination between samples.
3. Sample preparation and sorting is often complicated by the materials present in the samples. In every case, your goal is to mix materials as thoroughly as possible and randomly distribute mixed

materials over the Caton screen. Do not keep disparate materials separate. Consider cutting materials with scissors before distributing them.

4. Woody chunks often appear clean, but if you crack them open, they often have macroinvertebrates that have burrowed into them.
5. Be aware of stony caddisfly cases, which can be very small.
6. If a sample is to be fully-picked, you do not need to distribute the sample as carefully as when a random sub-sample is needed.
7. If the ADAPTATION FOR LARGE VOLUMES, ADAPTATION FOR SMALL VOLUMES, or ELUTRIATION procedures are used, you must carefully document this on the bench sheet, and give accurate characterizations of the number of grids sorted (out of a total of 30) or the proportion of sample used.

D. Adaptation for large sample volumes

When the sample is contained in more than three jars, or is made up of an unusually large volume of material (the goal is to reduce the volume of material from a selected grid such that it will fit in a petri dish), use the following procedure to split the sample:

1. Rinse the contents of each jar one at a time, using the 500 micron sieve.
2. Empty the sieve contents into the splitting pan; repeat until all jars have been sieved, rinsed, and emptied into the splitting pan.
3. Using your hands or any other suitable equipment, mix the sample thoroughly in the splitting pan. Ensure that the sample is mixed well and evenly distributed in the splitting pan. If the sample is composed of different types of material, be sure that there is thorough mixing of all types. If necessary, add water to the sample to facilitate mixing, but don't overdo it, since too much water will make the sample difficult to split.
4. Once the sample is thoroughly mixed and evenly distributed, divide the sample in half using the spatula. You may need to use scissors as well for this step. Move material to the left and right of a line down the middle of the sample material.
5. Using the spatula and scissors if necessary, split the halves of the sample into quarters.
6. Using spoons and scoops, return three of the quarters to three separate jars. Carefully label these jars and keep them at your work station, away from other samples or archive material.
7. Pour the remaining quarter of the sample into the Caton screen, and spread it evenly using the General Preparation Procedures.
8. Carefully rinse the splitting pan and the 500 micron sieve to prevent contamination of the next sample.

NOTE
When samples are split in this way, each grid you remove during sorting procedures constitutes 1 of 120 grids, or ¼ of a grid when the 30 grid standard is used. Use of this procedure must be documented on the bench sheet (Appendix B). The "number of grids sorted" and/or the "sample proportion used" calculations must be accurately described, to document how much of the sample was used to produce the required subsample size.

E. Adaptation for small sample volume

When the sample contains very small amounts of material (especially Surber or Hess samples that are not composites):

1. Rinse the sample in the 500 micron sieve, transfer the sample onto the Caton screen, and rinse the sieve as for the General Preparation Procedures.
2. Place the Caton screen into the plastic tray, and add just enough water to "float" the sample material above the screen.
3. Using scoops, spatulas, or other appropriate equipment, move the sample material into half of the Caton screen, or, if necessary, into a quarter of the screen.

Note

When samples are condensed in this way, each grid you remove during sorting procedures constitutes a multiple number of grids when the 30 grid standard is used. For example, a single grid from half of the Caton tray must be recorded as 2 grids. Use of this procedure must be documented on the bench sheet (Appendix B). The "number of grids sorted" and/or the "sample proportion used" calculations must be accurately described, to document how much of the sample was used to produce the required subsample size.

Sorting and subsampling

A. Equipment list

Verify that all necessary items are present before commencement of this procedure (Table 3).

Table 3. Sample sorting and subsampling materials list.

√	*Item*
	Caton screen and plastic holding tray, with mixed and randomly distributed sample material prepared with the procedures above
	Caton cookie-cutter and other appropriate grid delineation equipment
	An assortment of tweezers and forceps
	Dissecting needles
	Caton scoops, spoons, spatulas, and other appropriate equipment to lift sample materials out of the Caton screen
	Ethanol and water in labeled wash bottles
	Petri dishes
	Dissecting microscope (10x – 30x) with fiberoptic illuminator
	Vials and caps or stoppers
	Labels for each vial and jar
	Vial rack
	Correctly selected bench sheet
	Pencil
	Mechanical counters
	Magnifying lamp
	Jar(s) for sorted substrate
	Jar(s) for unsorted substrate

B. Rules for picking and counting organisms

ALL organisms should be removed from the sample substrate using the following rules:

1. Cladocerans and copepods *are not to be counted* AND if they are very abundant, they may be left behind in the substrate. If the sample is processed this way, record it on the bench sheet (Appendix B), and name the organisms that have been left behind.
2. Even organisms that are probably too small for definitive identification must be removed from the substrate. These organisms are to be placed in the vial(s) for the taxonomists.
3. As long as the head of an organism is present, it is to be picked for the taxonomists.
4. Do not pick or count fragments such as legs, antennae, gills, etc. if the head of the organism is not present. Do not pick or count obviously empty snail or clam shells or insect exuvia.
5. For worms, attempt to remove and count only whole organisms and fragments that include the head; do not pick or count fragments that do not include the head.
6. Organisms should be sorted into appropriate groups and each group placed in its own vial.
7. All vials should be labeled using pre-printed labels available for each project. In addition, the "picked but not counted" organism vial should be identified as such.

C. Sample sorting procedure

1. Use a random number generator, such as a pair of dice, to select a grid for sorting.
2. Use the Caton cookie-cutter device to delineate the selected grid, moving the sample material very slightly to push the material in the selected grid together, in order to make it easier to remove it from the tray.
3. Using a scoop, scraper, spoon, or other appropriate equipment, lift the grid contents into a petri dish, and add water from a wash bottle to the sample material to avoid desiccation and to disperse the material in the petri dish. Depending on the consistency of the sample material, it may be necessary to use scissors during these steps.
4. Examine the Caton screen for any remaining organisms. Use the following rules when dealing with organisms that lie on the line between two grids:
    a. An organism belongs to the grid where its head is.
    b. If you cannot determine where the head is, the organism belongs to the grid containing most of its body.
    c. If part of an organism's head is on either side of the line, pick the organism if the line is on the "top" of the grid or the right side of the grid.
5. Examine the sample material in the petri dish under the microscope, and determine as closely as possible whether there are a large number of macroinvertebrates present. Estimate as closely as possible whether ¼ or more of the target number of organisms would be picked if the sample material from the selected grid were picked in its entirety.
    d. If there are clearly less than ¼ of the target number, proceed to pick through this sample material: go to step 6.
    e. If there are clearly more than ¼ of the target number, use the "Sorting Procedure for High Organism Density" below.

NOTE
If you determine that there are very few organisms in the initial grid, more than one grid can be removed from the Caton screen before sorting. Place the materials from each randomly selected grid in separate petri dishes with water. Be sure not to let these sample fractions dry out or get spilled. Place a label in each petri dish to properly identify each grid. It is also acceptable to combine the contents of several grids for sorting if you determine that the density of organisms is low and that combining grids will not result in sorting more organisms than the target.

6. Remove the macroinvertebrates from the sample material in each grid, using forceps. Place organisms for identification in the taxonomy vial(s). Place organisms that are to be excluded (not included in the taxonomic targets list [Appendix E]) in a separate vial. Sort through the substrate material thoroughly.
7. Using mechanical counters, keep a running count of the total number of organisms picked, as well as a separate count of the number of chironomids and the number of worms.
8. When the substrate from the first grid has been completely picked, empty the sorted substrate into a labeled jar and preserve this material with recycled ethanol. This material will be used for quality control checks.
9. Continue random selection and sorting of grids until the target number of organisms is attained. This includes a specific target of 300 organisms AND a complete pick of the final grid. To accomplish this, proceed as follows:
    a. If completion of a grid results in a number that falls within the target tolerance, you are finished.
    b. If completion of the final grid will apparently result in a number that exceeds the target tolerance, place the organisms picked from the final grid into a separate vial. You must randomly remove organisms from this group so that the tolerance is not exceeded. Use the following procedure to **ADJUST THE TOTAL COUNT TO CONFORM TO TARGET AND TOLERANCE**:
        i. Completely pick the final grid and place all of the organisms from this grid together into their own vial.
        ii. Place the substrate from the final grid into the QC jar containing sorted substrate from all other grids.
        iii. Using a petri dish scribed with “pie slices,” pour out the organisms from the final grid, and distribute them evenly in the petri dish. Use an appropriate petri dish, that is, one scribed with a number of pie slices appropriate to the number of organisms that are to be removed from the total number.
        iv. Randomly select a pie slice by using a random number generator, such as dice, and remove all of the organisms from the associated pie slice, counting the removed organisms as you go. Continue random selection of pie slices and removal of organisms until the number of organisms in the final subsample will be within the protocol tolerance for the project.
        v. Place all removed organisms back into the unsorted substrate.
        vi. Sort or place all organisms left in the petri dish in to the labeled vial(s) for taxonomy.
10. To complete the sample sorting, all unsorted substrate should be re-preserved in the original sample jar(s). Use recycled alcohol for re-preservation, and make sure that the jar is appropriately labeled. Store the unsorted substrate in the area reserved for unsorted substrate for the project.
11. Sorted substrate should be properly labeled and placed on the shelf reserved for sorting QAs.
12. Vials for taxonomists should all be appropriately labeled and banded together. Indicate on the bench sheet (Appendix B) the number of vials you have used for the sample. Place the vials in the

section of the tech refrigerator reserved for samples that have been sorted but not yet QA'd. These samples should not go to the taxonomy department until the sorted substrate QA is completed and the recovered organisms included with the taxonomy vials.

13. The bench sheet should be filled out during and after sample processing. Include the following information on the bench sheet in the spaces provided:
    - f. Initials of the sorting technician.
    - g. Date of sorting.
    - h. The number of hours (to the nearest ¼ hour) spent doing the entire sorting procedure, including rectification of a failed QA.
    - i. The number of grids sorted, and the number of grids occupied by the entire sample.
    - j. A preliminary count of the total number of picked and counted organisms, a count of the number of picked chironomids, and a count of the number of picked worms.
    - k. An analysis of the components of substrate encountered in the whole sample (i.e., before sieving and rinsing).
    - l. Information about special sample handling. For example, you should record things such as whether the sample was split, or whether large amounts of material (e.g., grasses, cobbles, etc.) were removed before the sample was placed in the Caton tray.
    - m. Difficulties encountered during sample processing, such as spills, rotten organisms, inappropriate sample odors or substrate components, etc.

D. Sorting procedure for high organism density

When the sample material in the first randomly selected grid contains more than ¼ of the target number of organisms:

1. In the petri dish, divide the sample material from the first grid into quarters, using a spatula, scraper, or other appropriate equipment.
2. Make a random selection of one of the quarters, and lift it into a separate petri dish. Place the remaining 3 quarters into the jar for unsorted substrate.
3. Proceed to pick the organisms from the selected quarter grid.
4. Make a random selection of another grid from the Caton tray and proceed as above.
5. If the first quarter grid contains the target number of organisms, you should select and sort a second quarter grid. This will likely result in exceedance of the target and tolerance. Use the procedure for "**ADJUST THE TOTAL COUNT TO CONFORM TO TARGET AND TOLERANCE"** above.
6. If using the ADAPTATION FOR LARGE SAMPLE VOLUMES (see the section **Sample cleaning and preparation for subsampling** above): there will be sample fractions in jars as a result of the initial sample splitting procedure. If the target number of organisms is not attained by fully sorting the contents of the first Caton tray, empty and disperse a second sample quarter onto the Caton screen, and proceed using the General Preparation Procedure above. If necessary, use the third and fourth sample quarters in sequence until the target is reached, or the entire sample is sorted.

E. Sorting procedures precautions and exceptions

1. Do not re-disperse the sample across the Caton screen after removing any portion of the sample.
2. AT ***ALL*** TIMES, PREVENT DESICCATION OF ALL SAMPLE FRACTIONS (i.e., Caton tray contents, contents of all petri dishes and vials). Also prevent contamination of the sample by organisms such as fruit and house flies.
3. The number of grids sorted must be clearly recorded on the bench sheet (Appendix B). If a special procedure was used, i.e., for large sample volumes or small sample volumes, the proportion of

sample used must be calculated using the appropriate correction factors for partial grids or multiple grids.

4. Although partial sorting is typically necessary, it should be avoided if possible. Ideally, samples should be finished the same day they are begun. Sample sorting by multiple technicians should also be avoided. If it is necessary to store a partially sorted sample, it is important to stabilize the substrate material on the Caton screen so that the grids selected and removed remain distinct. The Caton tray should be completely covered and preservative or water adjusted so that sample desiccation does not occur. (The threat of sample desiccation is another reason why it is important to split large volume samples so that they "fit" into a Caton tray without being "top heavy."). The covered Caton tray must be refrigerated until sorting is completed. A label with the date and time that the sample was placed in the refrigerator should be attached to the covered tray such that it is clearly visible. Keep the bench sheet at your work station, but clearly indicate where the bench sheet is. For example, if you store bench sheets in a drawer, place a permanent label on the drawer indicating that you keep them there. A partially sorted sample should remain in the refrigerator for as little time as possible; generally no more than 24 – 36 hours. Technicians should check the dates on stored samples, and if a sample has been stored for more than 36 hours, the water or preservative in the Caton tray should be checked and adjusted if necessary.
5. You should always record the total number of grids on the bench sheet, being especially careful to note when the sorted "grids" are actually fractions of a regular Caton grid. Also record special procedures that you may have followed, such as the procedure for high organism density. The total number of grids you record must accurately reflect the proportion of the total sample volume you sorted to obtain the target number of organisms.
6. Before checking out another sample to work on, be sure that your work station has been cleared of all materials related to the prior sample. There should be no jars, vials, labels, or other materials related to any other sample at your workstation before you bring another sample there.

F. Large/rare search

The MPCA sorting procedure includes a Large/Rare search. Use the following general procedure, unless the project specifications call for a different procedure.

The goal of the Large/Rare search is to add organisms which may not have been collected in the random subsampling procedure:

1. It may be useful to review the organisms collected during the random subsampling procedure before doing the Large/Rare search.
2. Once sorting and subsampling procedures are finished, the remaining unsorted substrate should be searched, using the magnifying lamp, for 5 to 10 minutes.
3. Organisms that did not occur in the random subsampling should be collected and placed in a vial, appropriately labeled with the sample identifier numbers, but also labeled "L/R," so that it is not confused with the organisms collected during the random subsampling procedure.
4. It may be difficult to differentiate between organisms already collected in the random subsampling and those found in the Large/Rare search. If there is doubt about whether an organism has already been collected, it should be included in the Large/Rare vial just to be safe.
5. It is only necessary to collect a single specimen of a Large/Rare organism, even if it is found to occur more than once in the unsorted substrate. However, try to collect the best possible specimens.
6. If a sample has been split because of large sample volume, all of the unsorted substrate must be included in the Large/Rare search. Sample fractions may be searched one at a time, or all together in

separate Caton screens. For large volume samples, the Large/Rare search may need more than 5-10 minutes.

7. Count the Large/Rare specimens as they are placed in the vial, and record the number of organisms included in the appropriate place on the bench sheet (Appendix B).
8. If the sorting QA/QC procedures have not yet been done on the sample, the number of L/R organisms is not to be included in the calculation of sorting efficiency.

Quality assurance for sorting and subsampling

These procedures are used to check sorting efficiency. This should be tracked for each technician and for each project. The procedures may be used by a laboratory staff member qualified to perform quality control (QC) checks. This staff person is qualified by achieving a mean sorting efficiency of at least 90% over the previous 6 months. All sorted samples should be checked for sorting efficiency as soon as possible after sorting has taken place:

1. Equipment and materials:
   a. Similar to General Preparation Procedure and Sorting Procedure above.
2. All of the sorted substrate from the selected sample is poured out and evenly distributed in the Caton screen, using the General Preparation Procedure methods.
3. Twenty percent of the sorted substrate will be examined under the dissecting scope by the QC technician. Lift the contents of the appropriate number of randomly selected grids into petri dishes and carefully examine the substrate for missed organisms.
4. Any missed organisms should be enumerated and placed into a separate, labeled vial for taxonomy. Record the number of recovered organisms on the bench sheet (Appendix B). This number is added to the final sorted count of the sample.
5. Sorting efficiency is calculated using the following basic formula:

   $$\text{Percent sorting efficiency} = (A / A + B) \times 100$$

   where: A is the number of organisms found by the sorting technician, and B is the number of missed organisms found by the QC technician

   Since during sample processing, only 20% of the sorted substrate is typically examined, the basic formula must be adapted to account for this proportion. For example, if 20% of the sample was resorted, 20% of the actual total number of organisms picked for the subsample is calculated and reported by the sorting technician. This number is used for A in the formula above.
6. A sample passes the QC check if the sorting efficiency equals or exceeds 90%.
7. If a sample fails the QC check, the failure must be rectified: the sorting technician must resort all of the substrate remaining in the Caton tray. Place recovered organisms into labeled vials for taxonomy.
8. If the addition of recovered organisms results in exceedance of the tolerance for the target number, the sample must be reduced in size using the ADJUSTMENT OF TOTAL COUNT TO CONFORM TO TARGET AND TOLERANCE above.
9. The QA technician should record QA check information in the appropriate spaces on the sample bench sheet (Appendix B). Recorded information should include:
   a. The initials of the tech performing the QA check.
   b. The proportion of the sorted substrate examined for the QA check (usually this is 20%, but may differ from this proportion in some circumstances).

c. The number of organisms recovered from the examined substrate, and the percentage of total organisms this represents (this percentage is the sorting efficiency). This calculation is based on the proportion of sorted substrate examined and an equal proportion of the number of organisms picked by the sorting technician.
d. A “pass” or “fail” determination based on the results of the above calculation.
e. Whether or not rectification was performed, if a “fail” results.
f. The amount of time, to the nearest ¼ hour, spent on the QA procedure (not including rectification).

Macroinvertebrate identification and enumeration

A. Taxonomist requirements

Identification of macroinvertebrates needs to be performed by trained taxonomists. This includes a lead taxonomist and other taxonomists that fulfill the following roles and have with the following qualifications:

1. LEAD TAXONOMIST

a. Roles: Provides identification, taxonomic oversight, internal QC, and problem specimen identification.
b. Qualifications: Must have at least one year’s experience with fauna from the Midwestern United States; Masters Degree or Ph.D. in one of the following areas: Water Resources Science; Zoology; Biology or Ecology; 10 Years of taxonomic experience working with aquatic macroinvertebrates; Certifications: Society for Freshwater Science (SFS) Genus-level, Chironomidae EAST, EPT Genera EAST.

2) TAXONOMIST

a. Roles: Provides identification of macroinvertebrate samples.
b. Qualifications: Must have at least one year’s experience with fauna from the Midwestern United States; B.A. or B.S. in Biological Area (i.e., Biology, Ecology, Environmental Studies); 1 Year of taxonomic experience working with aquatic macroinvertebrates; Certifications: Society for Freshwater Science (SFS) Genus-level, Chironomidae EAST, EPT Genera EAST

B. Equipment list

Verify that all necessary items are present before commencement of this procedure (Table 4).

Table 4. Macroinvertebrate identification and enumeration materials list.

√	*Item*
	Waterproof paper labels and water/solvent proof marker
	80 percent ethanol
	Squeeze bottles (for ethanol and water)
	4 oz. jars, with plastic or foam-line cap
	Dissecting scope with a 10x minimum power
	Fine tipped forceps, watchmaker type
	Vials, with polyseal caps -2,4, and 8 dram

C. General sample identification procedure

1. Empty contents of the taxonomy vial(s) into a petri-dish.
2. To facilitate identification, sort organisms according to major taxonomic groups (i.e., Plecoptera, Trichoptera, or Coleoptera). Different groups can be placed in separate, 60mm petri-dishes or kept separate in several larger petri-dishes.
3. Identify organisms to the target taxonomic level (see Appendix E for taxonomic targets). The desired level is genus for many taxa, although this varies depending on the feasibility and need for finer taxonomic resolution.
4. Organisms should be counted as they are identified, and removed to another dish or placed back in the sample vial to avoid miscounting.

Note

Final identifications are to be made by experienced taxonomists. Preliminary identifications made by interns, or inexperienced taxonomists must be verified by a staff member whose name appears on the macroinvertebrate QC list. When making identifications, the taxonomist should refer to taxonomic reference materials. Many taxonomic references contain high quality pictures, but identifications are never to be made using pictures alone. The proper way to make an identification includes taking a specimen through a dichotomous key, checking range distribution, checking habitat preference, and checking for seasonal emergence and growth patterns. If any questions remain about the identity of a specimen, consult another staff taxonomist, or a regional or taxonomic group specialist.

5. When large numbers of individual taxa are present, a laboratory counter should be used to keep a running total. Counters should be labeled to avoid confusion if using more than one counter.
6. If an organism is encountered for the first time in the laboratory, remove it to its own vial for inclusion in the voucher collection. Make a note of this on the Invertebrate Identification and Enumeration Sheet (Appendix B).

D. Large/rare sample identification

1. The Large/Rare sample should be identified and enumerated separate from the main sub-sample.
2. Sort organisms according to major taxonomic groups (i.e., Plecoptera, Trichoptera, or Coleoptera)
3. Different groups can be placed in separate, 60-mm petri dishes or kept separate in several larger petri-dishes.
4. Identify organisms to the lowest practical taxonomic level (see Appendix E for taxonomic targets). The desired level is genus for many taxa, although this varies depending on the feasibility and need for finer taxonomic resolution.
5. Organisms should be counted as they are identified, and removed to another dish or placed back in the sample vial to avoid miscounting.
6. Record numbers of Large/Rare organisms in the Large/Rare column of the macroinvertebrate identification bench sheet (Appendix B).

Note

It is imperative that organisms which are a part of the Large/Rare sample are kept separate from the multihabitat subsample and quantitative sample. Large/Rare organisms are only used in taxa richness measures, so it is most important that their presence is noted.

Quality Assurance/Quality Control procedure for macroinvertebrate identification

It is required that 10% of all samples are sent to an external lab for an additional check on taxonomy. The goal of this additional step is to ensure that the lab is following updated taxonomic rules, to improve on lab taxonomy, and correct any persistent taxonomic errors.

Calculation of Minnesota Macroinvertebrate IBIs

The Index of Biotic Integrity (IBI) is one of the primary tools used by the Minnesota Pollution Control Agency (MPCA) to determine if streams are meeting their aquatic life use goals. Calculation of an IBI involves the synthesis of macroinvertebrate community information into a numerical expression of stream health. In order to apply the MPCA Macroinvertebrate IBI (MIBI) to a macroinvertebrate dataset, it is essential that all data is collected using MPCA field and laboratory protocols (See protocols above). This section details the process for calculating the Minnesota MIBIs from raw macroinvertebrate samples.

Summary of MIBI development

To account for natural differences in macroinvertebrates communities in Minnesota, streams are assigned to different stream types. These stream types use different MIBI models and biocriteria to determine the condition of the macroinvertebrate assemblage and their attainment or nonattainment of the aquatic life beneficial use. The MPCA stratified Minnesota streams into nine macroinvertebrate stream types based on the expected natural composition of stream macroinvertebrates (Table 5). Stream type is differentiated by drainage area, geographic region, thermal regime, and gradient. These stream types are used to determine thresholds (i.e., biocriteria) that interpret the calculated MIBI as meeting or exceeding the aquatic life use goal. MIBIs were developed from five individual macroinvertebrate stream groups, with large rivers, wadeable high gradient and wadeable low gradient stream types each being combined for the purposes of metric testing and evaluation. A complete description of the development of MIBIs can be found in MPCA (2014a).

Table 5. List of MIBI groups, stream types, and stream type descriptions.

MIBI Group	Stream Type	Stream Type Geographic Description	Drainage Area
Large Rivers	1 - Northern Forest Rivers	Rivers in the Laurentian Mixed Forest Province	>=500 Sq. Miles
	2 - Prairie and Southern Forest Rivers	Rivers in the Eastern Broadleaf Forest, Prairie Parklands, and Tall Aspen Parklands ecological provinces	>=500 Sq. Miles
Wadeable High-Gradient Streams (RR)	3 - Northern Forest Streams RR	High Gradient streams in the Laurentian Mixed Forest ecological province, excluding streams in HUC 07030005	<500 Sq. Miles
	5 - Southern Streams RR	High Gradient Streams in the Eastern Broadleaf Forest, Prairie Parklands, and Tall Aspen Parklands ecological provinces, as well as streams in HUC 07030005	<500 Sq. Miles
Wadeable	4 - Northern Forest Streams GP	Low Gradient streams in the Laurentian Mixed Forest ecological province, excluding streams in HUC 07030005	<500 Sq. Miles

MIBI Group	Stream Type	Stream Type Geographic Description	Drainage Area
Low-Gradient Streams (GP)	6 - Southern Forest Streams GP	Low Gradient Streams in the Eastern Broadleaf Forest, as well as streams in HUC 07030005	<500 Sq. Miles
	7 - Prairie Streams GP	Low Gradient Streams in the Prairie Parklands, and Tall Aspen Parklands ecological provinces	<500 Sq. Miles
Northern Coldwater Streams	8 - Northern Coldwater	Coldwater Streams in northern portions of Minnesota, characterized by the Laurentian Mixed Forest ecological province. Excluding streams in HUC 07030005	N/A
Southern Coldwater Streams	9 - Southern Coldwater	Coldwater Streams in southern portions of Minnesota, characterized by the Eastern Broadleaf Forest, Prairie Parkland, and Tall Aspen Parklands ecological provinces. Including streams in HUC 07030005	N/A

Determining stream type

Prior to calculating an MIBI score for a given sampling location, the stream reach must be categorized into a macroinvertebrate stream type. This requires a determination of the drainage area, geographic region, thermal regime, and gradient for a stream site. Determination of each of these stream characteristics is described below and a dichotomous key for stream type determination is provided in Appendix C.

Drainage area - Drainage area must be determined for all stream reaches sampled. There is one large river MIBI applied to rivers greater than 500 square miles (although determination of the applicable biocriterion also requires determination of region membership). All other stream types apply to streams less than 500 square miles.

Region – The macroinvertebrate stream types follow a geographic framework based on the Minnesota Department of Natural Resources Ecological Classification system. The only exception is the portion of the Laurentian Mixed Forest which falls in the St. Croix River – Stillwater watershed (HUC 07030005) and is grouped with southern stream types. Figure 1 shows the geographic framework used for the purpose of assessment and biocriteria development.

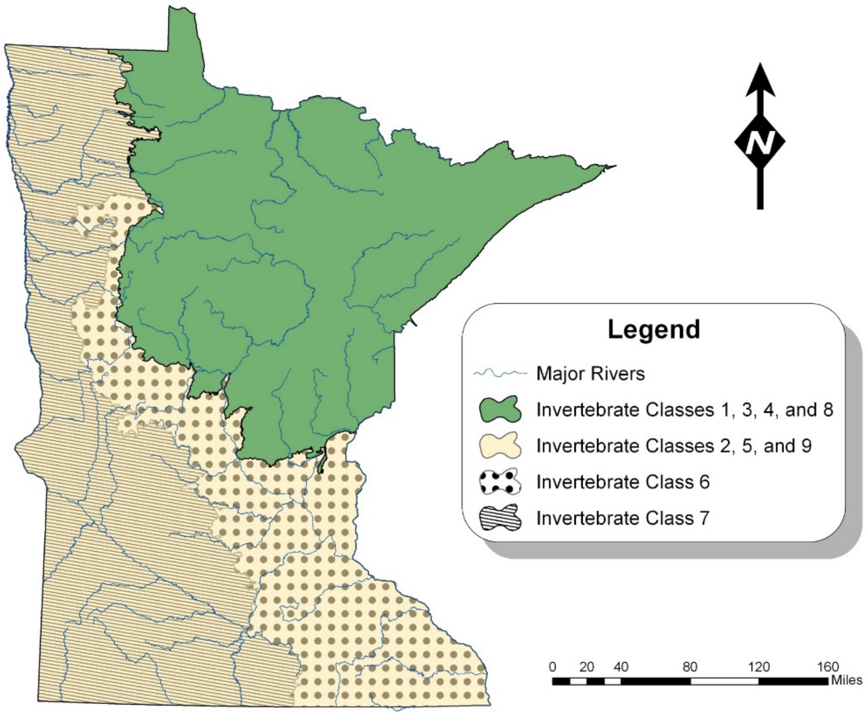

Figure 1. Map of ecological provinces associated with MPCA macroinvertebrate indices of biological integrity (MIBIs).

Temperature – For purposes of the application of stream water quality standards, the MPCA recognizes two temperature stream types: 1) warmwater/coolwater (Classes 2Bd, 2B, and 2C) and 2) coldwater (Class 2A). Similarly, temperature regime was a primary factor in the development of stream types used for MIBI development. The determination of a stream's coldwater designation can be found in Minn. R. 7050.0470.

Gradient – Two of the five MIBI stream groups are categorized using stream gradient. Gradient is determined based on flow conditions and the presence of riffles. If a stream reach includes riffles as representative habitat, and has flow adequate to create an environment supportive of riffle dwelling organisms, then a stream would be considered as high gradient, or riffle/run (RR). If these conditions are not met, then a stream is considered low gradient, or glide/pool (GP). Table 6 outlines criteria used by the MPCA to determine gradient category.

Table 6. Dichotomous key for determining stream type membership.

Riffle/Run (RR) vs. Glide Pool (GP) Designation Guidance		
Criteria	Yes	No
1. Has the sampler indicated on the stream visit form that 'riffle/run' is the 'Dominant invertebrate habitat in reach'?	**RR**	**#2**
2. In the mulithabitat sample, was any portion collected from riffles or rocky runs?	**go to #3**	**GP**
3. Was there a riffle present in the sample reach?	**go to #4**	**GP**
4. Flow over riffle perceptible?	**go to #5**	**GP**
5. # 'Riffle/run, rocky substrate' samples > 4?	**RR**	**go to #6**
6. Use a weight of evidence approach pulling in comments from macroinvertebrate visit form, habitat data from fish visit, sample reach photos, aerial photos, and geomorphology GIS layer to address the following:		
	RR	**GP**
Extent of riffle in sample reach (%)	≥ 5%	< 5%
Gradient of sample reach	> 1	≤ 1
Evidence from site photos or aerial photos of obvious high-gradient stream segments.		

Data collection and organization

In order to calculate a Minnesota MIBI score for a macroinvertebrate sample, data must be collected and processed using MPCA protocols (see protocol sections above). In order to calculate metric values it is necessary to use the same taxonomic targets and taxonomic attributes used by the MPCA. These attributes have been assigned using a variety of external sources, as well internally calculated tolerance values (Appendix D). Attributes used in the calculation of metric values include taxonomy, functional feeding group, tolerance related to general disturbance, tolerance related to thermal regime, habitat, and longevity.

Counting taxa: In order to correctly calculate the value of richness or relative richness metrics, taxa must be counted in a consistent manner. The target taxonomic level of determination is genus for the majority of organisms that will be encountered in a typical stream sample. Appendix E includes a table with the taxonomic target for organisms used in calculating the metrics that comprise the Minnesota MIBIs. In the process of identifying a sample, it is common to have organisms identified to multiple levels within a taxonomic group, i.e., distinct family, genus and species level identifications for organisms within the same family. When this happens, only organisms at the highest level (typically genus) should be considered when counting distinct taxa. If species-level identifications are made, they must be grouped at the genus level for the purpose of metric calculation. Likewise, if individuals are left at the family level due to poor condition or early instar, while individuals within the family are identified to a higher level, .e.g., genus, the family-level identification should not be counted.

Calculating metric and IBIs scores

Metric values are the raw numeric expression of taxonomic or autecological information at either the community or individual level. Metric values are derived for each target metric group as explained in the Metric Type descriptions below. The tables in Appendix F detail the metrics for each metric group, including the information needed to calculate each metric value.

Metric types

Richness — Richness metrics are calculated based on the taxonomic richness of the target group identified for the metric. When calculating, richness only taxa determined to be countable, as described above, are to be considered. Richness groups can be defined by taxonomy, tolerance, life habit, functional feeding group, or other meaningful autecological classifications. Example metric – Intolerant Taxa: if there are 20 countable intolerant taxa in a sample, the "Intolerant Taxa" metric value would be 20.

Relative richness (percent taxa) – Relative richness metrics are calculated based on the taxonomic richness of the target group identified for the metric, relative to total taxonomic richness in the sample. When calculating, relative richness only taxa determined to be countable, as described above, are to be considered. The groups can be defined by taxonomy, tolerance, life habitat, functional feeding group, or other meaningful autecological classifications. Example metric – Clinger Percent Taxa: if there are 6 countable clinger taxa in a sample with 24 total countable taxa, the "Clinger % Taxa" metric value would be 25% (6/24).

Relative abundance – Relative abundance metrics are calculated based on the abundance of the target group identified for the metric, relative to total sample abundance. When calculating relative abundance, all individuals that meet the group criteria are to be tallied, not only those that are considered countable, as with richness metrics. The groups can be defined by taxonomy, tolerance, life habit, functional feeding group, or other meaningful autecological classifications. Example metric – Percent Plecoptera: if there are 50 Plecoptera individuals in a sample with 350 total individuals, the "Percent Plecoptera" metric value would be 14.3% (50/350).

Ratio – Ratio metrics represent the ratio of one group to another. The ratio can be an expression of richness or abundance. The only ratio metric calculated for a Minnesota MIBI, is the Chironomidae:Diptera ratio metric. This metric is the ratio of Chironomidae abundance to total Diptera abundance. Example metric – Chironomidae:Diptera: if there are 50 Chironomidae individuals in a sample with 65 total Diptera individuals, the "Chironomidae:Diptera" metric value would be 0.77 (50/65).

Biotic index – A biotic index is calculated by determining the abundance weighted average of the tolerance values of each taxon present in a sample that has been assigned a tolerance value. When calculating a biotic index, abundances should be summed up to the highest level to which a tolerance value is assigned, i.e., if a tolerance value is not assigned to a taxon identified to a higher taxonomic resolution it should be summed with the next lowest taxonomic group. There are two Biotic Index metrics calculated for Minnesota MIBIs, the Minnesota Hilsenhoff Biotic Index and the Minnesota Coldwater Biotic index. The tolerance values used in these calculations were derived from data collected as part of the MPCA biomonitoring effort, and supplemented with other national or regional tolerance values where necessary. The tolerance values can be found in the table in Appendix D.

Calculating metric scores

Metric scores are derived from metric values. Metric scores range from 0 to 10, and their derivation is as follows:

Step 1 – Metric value transformation. Transformation is applied to correct skewed metrics. If indicated in the metric table for the relevant MIBI (Appendix F), the metric value should be transformed using the indicated transformation.

Step 2 – Drainage area correction. Drainage area correction is applied to remove a metrics relationship with drainage area. Drainage area corrected metrics are only tabulated for the Southern Coldwater MIBI. If indicated in Appendix F, Table 5 the metric value should be corrected using the drainage area for the sample location, and the slope and constant provided. The correction is calculated as follows:

Corrected metric value = (metric value)-(((slope)*$\log_{10}$(drainage area))+constant)

Step 3 – Scaling metric values from 0 to 10 points. Each metric is scored on a continuous scale from 0 to 10. There are two ways to score a metric, depending on the metrics predicted response to disturbance (Appendix F). Metrics that respond negatively to disturbance will have metrics scores positively correlated with metric values (positive metrics). Metrics that respond positively to disturbance will have metric scores inversely related to metric values (negative metrics). In order to limit the effect of extreme values when deriving metric scoring criteria, upper and lower limits were established by determining the 5^{th} and 95^{th} percentiles of each metric. These limits are documented in Appendix F. For positive metrics, values less than the 5th percentile (minimum) are given a score of 0, those with values greater than the 95^{th} percentile (maximum) are given a score of 10, and metric scores in between are interpolated linearly. For negative metrics, values less than the 5th percentile (minimum) are given a score of 10, those with values greater than the 95^{th} percentile (maximum) are given a score of 0, and metric scores in between are interpolated linearly. The formulas for calculating metric scores are as follows:

Formula for calculating positive metric scores: $$metric\ score = \frac{metric\ value - 5th\ percentile\ value}{95th\ percentile\ value - 5th\ percentile\ value} * 10$$

Formula for calculating negative metric scores: $$metric\ score = \frac{95th\ percentile\ value - metric\ value}{95th\ percentile\ value - 5th\ percentile\ value} * 10$$

Calculating IBI scores

Calculation of the MIBI score for a stream sample is done by summing the metric scores and scaling the summed scores to maximum score of 100. The formula for scaling IBI scores is as follows:

Formula for scaling summed metrics score to 100: $$IBI\ score = sum\ of\ metric\ scores * \frac{10}{\#\ metrics\ in\ IBI}$$

References

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Appendix A: Field visit form and field data labels for collecting macroinvertebrates from Minnesota streams

Attachment 4

MPCA Stream Monitoring Program

STREAM INVERTEBRATE VISIT FORM

Stream Name:		**Date:**
Field Number:	**County:**	**Crew:**

Water Chemistry	Tape Down: ___.____ (1/100ths ft) Location: ____________________

Time: (24 hr) ___:___ Air Temp:______ (ºC) Water Temp:______ (ºC) Conductivity: __________ (umhos@25ºC)

DO: __________(mg/L) DO % Saturation:____________ pH:__________ Secchi -Tube: __________ (cm)

Water Level: Normal Below _______ (m) Above _______ (m) Color _______________ (pcu)

If Flagging is not found or if establishing a new site, fill out GPS info

Coordinates	LATITUDE	LONGITUTDE	Time:
Field GPS:	_____._________	_____._________	**Name:**

Notes:

Stream Classification Information

Flow	Flow over riffle(s)	High / Med / Low / NA	Channel	Excavated, trapezoidal channel	%
Flow	Flow at reach constriction	High / Med / Low / NA	Channel	Shallow excavation, channelized wetland	%
Flow	Flow over run	High / Med / Low / NA	Channel	Natural channel	%
Flow	General flow pattern	High / Med / Low / NA	Vegetation	Emergent, aquatic vegetation in channel	Ext / Mod / Sparse / NA
Flow	Intermittent sections	Yes / No	Vegetation	Emergent, aquatic vegetation along bank	Ext / Mod / Sparse / NA
Habitat	Riffle (with flow) present in reach c		Vegetation	Floating or submerged aquatic vegetation	Ext / Mod / Sparse / NA
Habitat	Riffle (with flow) present outside of reach c (riffles do not include riprap associated with bridges or bank stabilization)		Vegetation	Loosely attached filamentous algae	Ext / Mod / Sparse / NA
			Vegetation	Firmly attached algae or submerged veg	Ext / Mod / Sparse / NA
Habitat	Dominant invertebrate habitat (circle two) Riffle | Rocky Run-Pool | Aquatic Macrophyte | Bank-Overhanging Veg | Wood | Leaf				

Substrate	Dominant Run Substrate	bedrock / boulder / cobble / gravel / sand / silt
Substrate	Dominant Pool Substrate	bedrock / boulder / cobble / gravel / sand / silt
Substrate	Dominant Substrate receiving flow	bedrock / boulder / cobble / gravel / sand / silt
Substrate	Dominant Substrate in reach	bedrock / boulder / cobble / gravel / sand / silt

c	Stream displays a typical riffle-run pool morphology c adequate flow to maintain riffle organisms c inadequate flow to maintain riffle organisms
c	Stream has adquate flow to maintain riffle organism, but does not have suitable coarse substrate to support these assemblages (riffles, rock substrate in runs or pools)
c	Stream has adquate flow to maintain riffle dwelling organism, woody debris has replaced rocks as primary coarse substrate
c	Stream is low gradient, stream bed is predominately fine substrate, inadequate flow to maintain riffle organisms

Invertebrate Sample Information

Qualitative Multi-Habitat Sample (QMH)

Divide 20 samples equally among habitat types present in the reach. If three habitat types are present take 7 samples in each of the three dominant habitats (for a total of 21). If a habitat is present, but not in abundance to sample in equal proportion to other habitats, sample as much as possible and divide the remaining samples between the dominant habitat types.

a	Habitat			#Samples
c	rock riffle/run	Flow adequate to carry insects into net		
c	rock substrate	Artificial flow needed to carry insect into net		
c	aquatic macrophyte			
c	undercut bank, overhanging veg			
c	snag, woody debris, root wad			
c	leaf pack			

Number of multihabitat containers: _____

Additional Biological Information

Presence of freshwater sponge ----------- yes / no

Presence of exotic species ---------------- yes / no

Name of exotic(s) if present:

(voucher a specimen if not present in sample)

Presence of mussels ----------------------yes / no

Description of mussel density and/or mussel bed location:

Notes

Pictures #: __ DD __ DU __ MD __ MU __ UD __ UU

Stream Sample External Label:

MPCA Bioassessment – Invertebrate Sample
Sample Preservative - 100% reagent alcohol / 10% formalin
Sample Type: QMH / RTH
Sample Composition: Riffle / Bank / Wood / Veg
Date ____/____/20___ (mm/dd/yyyy)
Station Name ___________________________
Station ID __________________
Site Visit 1 / 2 Sample Jar ___ of ___
Collectors ____________________________

Stream Sample Internal Label:

Invertebrate Sample – sample type __________
Site Name:______________________________
Field Number____________________________
Date:_____/_____/_____ Bottle No. _____of____
Collected by: ____________________________
____

Appendix B: Examples of macroinvertebrate sorting and identification bench sheets

Macroinvertebrate Sample Sorting Bench Sheet

Field Number	Sample Date	Sample Type *	# Sample Bottles	Sample Sorting Date		# Organisms Picked	# Squares Picked**	L/R (y/n)	Chiro toVial (y/n)
				Begin	End				

* QMH, QR, HD, WTL

** Applies only to samples being subsampled

-MPCA Biological Monitoring Program- **Attachment 4**

Macroinvertebrate Sorting QC Form

Sample Field Number	Sampling Date	Sample Type	Initials of QC Sorter	# Organisms found in QC	# Organisms originally found in sample	Sorting Efficiency	Date QC Sort Completed

-MPCA Biological Monitoring Program- **Attachment 4**

Macroinvertebrate Identification Lab Bench Sheet

Field Number	**Sample Date**
Site Name	**Taxonomist:**
Sample Type QMH* QR HD other____________	**Date of Sample ID:** _____/_____/_____

*A processed QMH sample consists of 2 parts, the subsample(ss) and large/rare (l/r), both parts must be identified

Order/Family	Genus	Species/Notes	ss	l/r
Ephemeroptera				
Baetiscidae	Baetisca			
Caenidae	Bracycercus			
	Caenis			
Ephemerellidae	Attenella			
	Ephemerella			
	Serratella			
Ephemeridae	Ephemera			
	Hexagenia			
Leptohyphidae	Tricorythodes			
Leptophlebiidae	Leptophlebia			
	Paraleptophlebia			
Polymitarcidae	Ephoron			
Potamanthidae	Anthopotamus			
Heptageniidae	Epeorus			
	Heptagenia			
	Stenacron			
	Stenonema			
Isonychiidae	Isonychia			
Ametropodidae	Ametropus			
Baetidae	Acerpenna			
	Baetis			
	Callibaetis			
	Heterocloeon			
notes/additional taxa				
Plecoptera				
Leuctridae				
Taeniopterygidae				
Perlidae	Acroneuria			
	Agnetina			
	Attaneuria			
	Neoperla			
	Paragnetina			
	Perlinella			
Perlodidae				
Pteronarcyidae	Pteronarcys			
notes/additional taxa				
Lepidoptera				
Pyralidae	Paraponyx			
	Petrophila			
notes/additional taxa				
Megaloptera				
Corydalidae	Chauliodes			
	Corydalus			
	Nigronia			
Sialidae	Sialis			
notes/additional taxa				
Isopoda				
Asselidae	Asselus			
notes/additional taxa				

Order/Family	Genus	Species/Notes	ss	l/r
Odonata				
Calopterygidae	Calopteryx			
	Hetaerina			
Coenagrionidae	Argia			
	Enallagma			
	Nehalennia			
Lestidae	Lestes			
Aeshnidae	Aeschna			
	Anax			
	Basiaeschna			
	Boyeria			
Cordulegastridae	Cordulegaster			
Corduliidae	Cordulia			
	Dorocordulia			
	Epitheca			
	Somatochlora			
Gomphidae	Dromogomphus			
	Gomphurus			
	Gomphus			
	Hagenius			
	Ophiogomphus			
	Phanogomphus			
	Progomphus			
notes/additional taxa				
Hemiptera				
Belostomatidae	Belstoma			
	Corixidae			
Corixidae	Hesperocorixa			
	Sigara			
	Trichocorixa			
Nepidae	Ranatra			
Notonectidae	Buenoa			
	Notonecta			
notes/additional taxa				
Amphipoda				
Talitridae	Hyallela	azteca		
Gammaridae	Gammarus			
notes/additional taxa				
Decapoda				
Cambaridae	Cambarus			
	Orconectes			
	Procambarus			
notes/additional taxa				
Pelecypoda				
Sphaeriidae				
Corbiculidae				
Unionidae				
notes/additional taxa				

entered into DataInverts by______ --- (initials) date_________

Order/Family	Genus	Species/Notes	ss	l/r
Trichoptera				
Dipseudopsidae	Phylocentropus			
Hydropsycidae	Ceratopsyche			
	Cheumatopsyche			
	Diplectrona			
	Hydropsyche			
	Potamyia			
Philopotamidae	Chimarra			
	Dolophilodes			
Polycentropodidae	Cernotina			
	Cyrnellus			
	Neureclipsis			
	Paranyctiophylax			
	Polycentropus			
Psychomyiidae	Lype			
	Psychomyia			
Glossosomatidae	Agapetus			
	Glossosoma			
	Protoptila			
Hydroptilidae	Hydroptila			
	Leucotrichia			
	Mayatrichia			
	Oxyethira			
	Orthotrichia			
Rhyacophilidae	Rhyacophila			
Brachyecentridae	Brachycentrus			
	Micrasema			
Helicopsychidae	Helicopsyche			
Lepidostomatidae	Lepidostoma			
Leptoceridae	Ceraclea			
	Leptocerus			
	Mystacides			
	Nectopsyche			
	Oecetis			
	Trianodes			
Limnephilidae	Limnephilus			
	Hydatophylax			
Molannidae	Molanna			
Phryganeidae	Phryganea			
	Ptilostomis			
Sericostomatidae	Agarodes			

notes/additional taxa

Order/Family	Genus	Species/Notes	ss	l/r
Gastropoda				
Ancylidae	Ferrissia			
Planorbidae	Helisoma			
	Promentus			
	Planorbula			
	Gyraulus			
Vivaparidae	Campeloma			
Lymnaeidae	Lymnaea			
	Bulimnea			
	Fossaria			
Hydrobiidae	Amnicola			
Pleuroceridae	Pleurocera			
Physidae	Physa			

notes/additional taxa

Order/Family	Genus	Species/Notes	ss	l/r
Diptera				
Ceratopogonidae	Alluaudomyia			
	Atrichopogon			
	Bezzia			
	Ceratopogon			
	Culicoides			
	Nilobezzia			
	Palpomyia			
	Probezzia			
	Sphaeromias			
Chironomidae	G.			
Dixidae	Dixa			
	Dixella			
Simuliidae	Simulium			
Tipulidae	Antocha			
	Dicranota			
	Hexatoma			
	Limnophila			
	Limonia			
	Pilaria			
	Tipula			
Athericidae	Atherix			
Empididae	Hemerodromia			
Tabanidae	Chrysops			
	Tabanus			

notes/additional taxa

Order/Family	Genus	Species/Notes	ss	l/r
Coleoptera				
Dytiscidae	Agabus			
	Laccophilus			
	Liodessus			
Gyrinidae	Dineutus			
	Gyrinus			
Elmidae	Ancyronyx			
	Dubiraphia			
	Macronychus			
	Optioservus			
	Stenelmis			
Hydrophilidae	Berosus			
	Helocombus			
	Laccobius			
	Sperchopsis			
	Tropisternus			
Annelida	Oligochaeta			
	Hirudinea			

notes/additional taxa

Order/Family	Genus	Species/Notes	ss	l/r
Hydracarina (trombidoformes, acarina)				
Nematoda				

notes/additional taxa

entered into DataInverts by______ --- (initials) date__________

-MPCA Biological Monitoring Program-

Macroinvertebrate Identification QC Form

Field Number	Sample Date	Identifiers' Initials		Discrepancies		Comments	Total # of Conflicts	Total # of Taxa	Precision	
		Original ID	QC ID	Original Identification	QC Identification				Original ID	QC ID

Appendix C: Dichotomous key for determining macroinvertebrate stream type membership

1a. Drainage area >500 mi^2 .... Rivers 2
1b. Drainage area <500 mi^2 .... Streams 3

Rivers

2a. Sampling site located in the Laurentian Mixed Forest Province .... **Northern Forest Rivers**
2b. Sampling site located in the Eastern Broadleaf Forest, Prairie Parklands, or Tall Aspen Parklands province .... **Prairie and Southern Forest Rivers**

Streams

3a. Sampling site is in a designated coldwater stream (Class 2A) .... Coldwater Streams 4
3b. Sampling site is in a designated warm/cool waters stream (Class 2Bd, 2B, 2C) .... Warmwater and Coolwater Streams 5

Coldwater Streams

4a. Sampling site is in the Laurentian Mixed Forest ecological province (excluding streams in HUC 07030005) .... **Northern Coldwater Streams**
4b. Sampling site is in the Eastern Broadleaf Forest, Prairie Parkland, or Tall Aspen Parklands province (including streams in HUC 07030005) .... **Southern Coldwater Streams**

Warmwater and Coolwater Streams

5a. Sampling site is high gradient (riffle/run; see Table 6) .... High Gradient Streams 6
5b. Sampling site is low gradient (glide/pool; see Table 6) .... Low Gradient Streams 7

High Gradient (RR) Streams

6a. Sampling site is in the Laurentian Mixed Forest ecological province (excluding streams in HUC 07030005) .... **Northern Forest Streams RR**
6b. Sampling site is in the Eastern Broadleaf Forest, Prairie Parkland, or Tall Aspen Parklands province (including streams in HUC 07030005) .... **Southern Streams RR**

Low Gradient (GP) Streams

7a. Sampling site is in the Laurentian Mixed Forest ecological province (excluding streams in HUC 07030005) .... **Northern Forest Streams GP**
7b. Sampling site is in the Eastern Broadleaf Forest province (including streams in HUC 07030005) .... **Southern Forest Streams GP**
7c. Sampling site is in the Prairie Parkland or Tall Aspen Parklands province .... **Prairie Streams GP**

Appendix D: Taxonomic trait information

The following table includes a list of the macroinvertebrate taxa in the MPCA database and their associated taxonomic traits. The taxonomic traits in this database are derived from several sources including: Merritt and Cummins (1996), Barbour et al. (1999), Poff et al. (2006) and the Freshwater Biological Traits Database (https://www.epa.gov/risk/freshwater-biological-traits-database-traits). The Minnesota Tolerance and Coldwater Tolerance values are Minnesota specific and were developed using Minnesota's biological monitoring database. The fields in this table are as follows:

TSN (Taxonomic Serial Number): The TSN is a unique identifier that for a scientific name that does not include information on the status, rank, or taxonomic position of the organism. See the Integrated Taxonomic Information System (ITIS) (https://www.itis.gov/) for more information.

Name1: This field includes the scientific name of the taxon. Depending on the taxon, this field can include any taxonomic level from genus to phylum.

Name2: This field includes the species name if available.

FFG (Functional Feeding Group): This field classifies aquatic macroinvertebrates by their method of food acquisition and functional role in aquatic food webs. Abbreviations: cf = collector-filterer, cg = collector-gatherer, hb = herbivore, pa = parasite, pr = predator, sc = scraper, and sh = shredder.

Habit: This field refers to how a macroinvertebrate moves in the aquatic environment and where they find food. Abbreviations: burr = burrower, clim = climber, skat = skater, spra = sprawler, and swim = swimmer.

MN Tolerance: Tolerance values were calculated using the weighted average of a general disturbance measure where taxa relative abundance was the weighting factor. The general disturbance measure was the first principal component of a principal components analysis of six disturbance variables including Minnesota's Human Disturbance Score (HDS), the Minnesota Stream Habitat Assessment score, total phosphorus, total suspended solids, NH_4, and nitrate/nitrite.

Coldwater Tolerance: Coldwater sensitivity values were calculated using the weighted average of stream temperatures where taxa relative abundance was the weighting factor.

LongLived: These are macroinvertebrates that are relatively long-lived with a life cycle of more than 1 year (i.e., semivoltine).

Some fields in this table are blank due to a lack of autecological information on the taxa or in the case of the "MN Tolerance" and Coldwater Tolerance" metrics, an insufficient number of occurrences of these taxa to calculate these values. In some cases, the attributes for lower taxonomic units (e.g., species) are derived from higher taxonomic units due to the lack of the information at finer taxonomic resolutions.

TSN	Name1	Name2	FFG	Habit	MN Tolerance	Coldwater Tolerance	LongLived
-65	*Acentrella*	*rallatoma*	cg	swim		20.96	FALSE
-64	*Kloosia*		cg	burr	6.00		FALSE
-63	*Anafroptilum*		cg	swim	4.29		FALSE
-62	*Kribiodorum*	*perpulchra*	cg	burr			FALSE
-61	*Allocladius*		cg	spra			FALSE
-51	*Neostempellina*	*reissi*	cf	burr			FALSE
-49	*Kribiodorum*	*perpulchrum*	cg	burr			FALSE
-48	*Kribiodorum*		cg	burr			FALSE
-47	*Radotanypus*		pr	spra			FALSE
-45	*Pericoma / Telmatoscopus*		cg	burr	4.00		FALSE
-36	*Thienemannimyia Gr.*		pr		7.90	20.07	FALSE
-20	*Bezzia/Palpomyia*		pr	spra	6.00	19.10	FALSE
-19	*Odontomyia /Hedriodiscus*		cg	clim			FALSE
-8	*Phanogomphus*		pr	burr	5.00		TRUE
48739	Hydrozoa		pr				FALSE
50844	Hydridae		pr		9.36	21.03	FALSE
50845	Hydra		pr		9.25	22.02	FALSE
53964	Turbellaria		pr	spra	4.00		FALSE
57577	*Prostoma*		pr				FALSE
59490	Nematoda		pr		5.00		FALSE
64183	Nematomorpha		pr	burr	5.00		FALSE
64357	Annelida						FALSE
68422	Oligochaeta		cg	burr	6.00		FALSE
68440	Lumbriculidae		cg	burr	6.00		FALSE
68441	*Lumbriculus*		cg	burr	6.00		FALSE
68450	*Stylodrilus*		cg	burr			FALSE
68531	*Enchytraeus*		cg	burr	6.00		FALSE
68541	*Henlea*		cg	burr			FALSE
68544	*Mesenchytraeus*		cg	burr	6.00		FALSE
68638	*Limnodrilus*		cg	burr	6.00		FALSE
68679	*Aulodrilus*		cg	burr	6.00		FALSE
68779	*Bothrioneurum*	*vejdovskyanum*	cg	burr			FALSE
68780	*Spirosperma*		cg	burr	6.00		FALSE
68794	*Quistadrilus*	*multisetosus*	cg	burr	6.00		FALSE
68839	*Rhyacodrilus*		cg	burr	6.00		FALSE
68854	Naididae		cg	burr	6.00		FALSE
68856	*Slavina*	*appendiculata*	cg	burr	6.00		FALSE
68871	*Stylaria*		cg	burr	6.00		FALSE
68872	*Stylaria*	*lacustris*	cg	burr			FALSE
68876	*Pristina*		cg	burr	6.00		FALSE
68898	*Dero*		cg	burr	6.00		FALSE

TSN	Name1	Name2	FFG	Habit	MN Tolerance	Coldwater Tolerance	LongLived
68934	*Chaetogaster*		cg	burr	6.00		FALSE
68946	*Nais*		cg	burr	6.00		FALSE
68995	*Ophidonais*		cg	burr	6.00		FALSE
68996	*Ophidonais*	*serpentina*	cg	burr	6.00		FALSE
69021	*Bratislavia*		cg	burr	6.00		FALSE
69168	Branchiobdellida		cg	clim			FALSE
69169	Branchiobdellidae		cg	clim	9.00	21.85	FALSE
69180	*Branchiobdella*		cg	burr			FALSE
69290	Hirudinea		pr	swim	10.00		FALSE
69357	Glossiphoniidae		pr	clim	6.19	20.20	FALSE
69363	*Placobdella*		pr	clim	6.00		FALSE
69366	*Placobdella*	*ornata*	pr	clim	6.00		FALSE
69367	*Placobdella*	*multilineata*	pr	clim	6.00		FALSE
69369	*Placobdella*	*hollensis*	pr	clim	6.00		FALSE
69380	*Glossiphonia*		pr	clim			FALSE
69381	*Glossiphonia*	*complanata*	pr	clim			FALSE
69389	*Alboglossiphonia*	*heteroclita*	pr	clim			FALSE
69396	*Helobdella*		pr	clim	6.30	20.10	FALSE
69397	*Helobdella*	*elongata*	pr	clim	6.30	20.10	FALSE
69398	*Helobdella*	*stagnalis*	pr	clim	6.30	20.10	FALSE
69403	*Helobdella*	*papillata*	pr	clim	6.30	20.10	FALSE
69407	Hirudinidae		pr	swim	7.00		FALSE
69408	*Haemopis*		pr	swim			FALSE
69438	Erpobdellidae		pr	swim	4.19	18.12	FALSE
69444	*Erpobdella*		pr	swim		19.12	FALSE
69455	*Nephelopsis*		pr	swim	6.06	17.05	FALSE
69456	*Nephelopsis*	*obscura*	pr	swim	6.06	17.05	FALSE
69459	Gastropoda		sc		7.00		FALSE
70304	Viviparidae		sc	clim	1.56	20.23	FALSE
70305	*Viviparus*		sc	clim	1.00		FALSE
70311	*Campeloma*		sc	clim	2.47	18.49	TRUE
70312	*Campeloma*	*decisum*	sc	clim	2.47	18.49	TRUE
70328	*Cipangopaludina*		sc	clim			FALSE
70345	Valvatidae		sc	clim	6.78	22.49	TRUE
70346	*Valvata*		sc	clim	6.80	22.50	TRUE
70354	*Valvata*	*tricarinata*	sc	clim	6.80	22.50	TRUE
70359	*Valvata*	*lewisi*	sc	clim	6.80	22.50	TRUE
70493	Hydrobiidae		sc	clim	4.56	20.81	FALSE
70505	*Probythinella*		sc	clim			FALSE
70605	*Fontigens*		sc	clim			FALSE
70736	*Pomatiopsis*		sc	clim			FALSE

TSN	Name1	Name2	FFG	Habit	MN Tolerance	Coldwater Tolerance	LongLived
70747	*Amnicola*		sc	clim	2.98	21.28	FALSE
70794	*Bithynia*	*tentaculata*	sc	clim			FALSE
71541	Pleuroceridae		sc	clim	5.00		FALSE
71542	*Goniobasis*		sc	clim			FALSE
71549	*Pleurocera*		sc	clim	3.70		TRUE
71550	*Pleurocera*	*acuta*	sc	clim	3.70		TRUE
76483	Lymnaeidae		sc	clim	9.59	20.14	FALSE
76484	*Lymnaea*		sc	clim	7.16		FALSE
76487	*Lymnaea*	*stagnalis*	sc	clim	7.16		TRUE
76497	*Fossaria*		sc	clim	6.36	19.88	FALSE
76528	*Pseudosuccinea*		sc	clim	9.41	20.89	FALSE
76529	*Pseudosuccinea*	*columella*	sc	clim	9.41	20.89	FALSE
76532	*Bulimnaea*		sc	clim			FALSE
76533	*Bulimnaea*	*megasoma*	sc	clim			FALSE
76534	*Stagnicola*		sc	clim	10.00	19.80	FALSE
76568	Ancylidae		sc	clim	7.07	20.97	FALSE
76569	*Ferrissia*		sc	clim	7.07	20.97	FALSE
76577	*Laevapex*	*fuscus*	sc	clim			FALSE
76591	Planorbidae		sc	clim	8.17	20.33	FALSE
76592	*Gyraulus*		sc	clim	8.21	19.72	FALSE
76599	*Helisoma*		sc	clim	7.36	21.16	TRUE
76600	*Helisoma*	*anceps*	sc	clim	7.36	21.16	FALSE
76621	*Promenetus*		sc	clim	6.83	18.70	FALSE
76622	*Promenetus*	*exacuous*	sc	clim	6.83	18.70	FALSE
76625	*Promenetus*	*umbilicatellus*	sc	clim	6.83	18.70	FALSE
76626	*Menetus*		sc	clim	5.48		FALSE
76629	*Planorbula*		sc	clim	9.11	20.12	FALSE
76630	*Planorbula*	*armigera*	sc	clim	9.11	20.12	FALSE
76643	*Micromenetus*		sc	clim			FALSE
76654	*Planorbella*		sc	clim	10.00	20.84	FALSE
76658	*Planorbella*	*campanulata*	sc	clim	10.00	20.84	TRUE
76671	*Planorbella*	*trivolvis*	sc	clim	10.00	20.84	FALSE
76676	Physidae		sc	clim	10.00	20.35	FALSE
76677	*Physa*		sc	clim	10.00	20.35	FALSE
76683	*Physa*	*integra*	sc	clim	10.00	20.35	FALSE
76695	*Aplexa*		sc	clim			FALSE
76697	*Aplexa*	*elongata*	sc	clim			FALSE
76698	*Physella*		sc	clim	8.00		FALSE
79118	Bivalvia		cf		8.00		TRUE
79913	Unionidae		cf	burr	1.13		TRUE
79951	*Elliptio*		cf	burr	8.00		FALSE

TSN	Name1	Name2	FFG	Habit	MN Tolerance	Coldwater Tolerance	LongLived
79986	*Lampsilis*		cf	burr			TRUE
80170	*Proptera*		cf	burr			FALSE
80297	*Elliptoideus*		hb	burr			FALSE
81339	*Dreissena*	*polymorpha*	cf	clng			FALSE
81381	Corbiculidae		cf	burr	6.00		FALSE
81388	Pisidiidae		cf	burr	7.82	20.46	FALSE
81391	*Sphaerium*		cf	burr	4.70		FALSE
81400	*Pisidium*		cf	burr	4.60		FALSE
84195	Ostracoda		cg		8.00		FALSE
85257	Copepoda		cg				FALSE
92120	Isopoda		cg		8.00		FALSE
92657	Asellidae		cg	spra	7.69	19.42	FALSE
92658	*Asellus*		cg	spra	6.49	19.88	FALSE
92666	*Lirceus*		cg	spra	8.00		FALSE
92686	*Caecidotea*		cg	spra	8.23	19.19	FALSE
93294	Amphipoda		cg	spra	4.00		FALSE
93745	Gammaridae		cg		6.05	17.00	FALSE
93773	*Gammarus*		cg	spra	6.05	17.00	FALSE
93790	*Gammarus*	*pseudolimnaeus*	cg	spra	6.05	17.00	FALSE
94025	*Hyalella*		cg	spra	7.30	21.43	FALSE
94026	*Hyalella*	*azteca*	cg	spra	7.30	21.43	FALSE
95081	*Crangonyx*		cg	spra	5.26	19.98	FALSE
95599	Decapoda		sh		8.00		TRUE
97336	Cambaridae		cg	spra	9.85	20.66	TRUE
97337	*Cambarus*		cg	spra	6.00		TRUE
97338	*Cambarus*	*diogenes*	cg		6.00		TRUE
97421	*Orconectes*		cg	spra	9.41	20.85	TRUE
97424	*Orconectes*	*rusticus*	cg		9.41	20.85	TRUE
97425	*Orconectes*	*virilis*	cg		9.41	20.85	TRUE
97446	*Orconectes*	*immunis*	cg		9.41	20.85	TRUE
97490	*Procambarus*		cg	spra	6.00		TRUE
99237	Collembola		cg				FALSE
99246	*Isotomurus*		cg	skat			FALSE
99643	*Entomobryidae*		cg	skat			FALSE
100502	Ephemeroptera		cg		4.00		FALSE
100504	Heptageniidae		sc	clng	7.63	20.78	FALSE
100507	*Stenonema*		sc	clng	6.94	21.06	FALSE
100516	*Stenonema*	*femoratum*	sc	clng	6.94	21.06	FALSE
100548	*Stenonema*	*vicarium*	sc	clng	6.94	21.06	FALSE
100572	*Rhithrogena*		pr	clng	0.00	17.61	FALSE
100602	*Heptagenia*		sc	clng	9.46	20.07	FALSE

TSN	Name1	Name2	FFG	Habit	MN Tolerance	Coldwater Tolerance	LongLived
100626	*Epeorus*		cg	clng	0.00	19.11	FALSE
100649	*Epeorus*	*vitreus*	cg	clng	0.00	19.11	FALSE
100676	*Leucrocuta*		sc	clng	8.46	20.67	FALSE
100692	*Nixe*		pr	clng	0.00		FALSE
100713	*Stenacron*		cg	clng	7.25	20.47	FALSE
100714	*Stenacron*	*interpunctatum*	cg	clng	7.25	20.47	FALSE
100742	*Stenacron*	*minnetonka*	cg	clng	7.25	20.47	FALSE
100744	*Macdunnoa*		sc	clng			FALSE
100749	*Raptoheptagenia*		pr	swim			FALSE
100755	Baetidae		cg	swim	7.19	19.44	FALSE
100771	*Pseudocloeon*		sc	swim	8.96	20.55	FALSE
100794	*Heterocloeon*		sc	swim	0.18		FALSE
100796	*Heterocloeon*	*curiosum*	sc	swim	0.18		FALSE
100800	*Baetis*		cg	swim	6.78	18.29	FALSE
100801	*Acentrella*		cg	swim	8.46	20.96	FALSE
100808	*Baetis*	*intercalaris*	cg	clng	6.78	18.29	FALSE
100817	*Baetis*	*tricaudatus*	cg	spra	6.78	18.29	FALSE
100825	*Baetis*	*brunneicolor*	cg	clng	6.78	18.29	FALSE
100835	*Baetis*	*flavistriga*	cg	clng	6.78	18.29	FALSE
100873	*Centroptilum*		cg	swim	6.06	20.64	FALSE
100899	*Paracloeodes*		sc	swim	5.87	22.75	FALSE
100901	*Paracloeodes*	*minutus*	sc	swim	5.87	22.75	FALSE
100903	*Callibaetis*		cg	swim	10.00	21.68	FALSE
100951	Siphlonuridae		cg	swim	7.00		FALSE
100953	*Siphlonurus*		cg	swim	7.00		FALSE
100987	*Acanthametropus*		pr	swim	1.00		FALSE
100996	*Ameletus*		sc	swim	0.00		FALSE
101041	*Isonychia*		cf	swim	8.47	21.44	FALSE
101045	*Isonychia*	*bicolor*	cf	swim	8.47	21.44	FALSE
101057	*Isonychia*	*rufa*	cf	swim	8.47	21.44	FALSE
101062	*Isonychia*	*sicca*	cf	swim	8.47	21.44	FALSE
101078	Metretopodidae		pr	swim	1.00	19.80	FALSE
101079	*Siphloplecton*		cg	swim	1.00	19.80	FALSE
101084	*Siphloplecton*	*interlineatum*	cg	swim	1.00	19.80	FALSE
101095	Leptophlebiidae		cg	clng	3.27	19.91	FALSE
101096	*Traverella*		pr	clng			FALSE
101108	*Choroterpes*		cg	clng	2.00		FALSE
101122	*Habrophlebiodes*		sc	swim	6.00		FALSE
101148	*Leptophlebia*		cg	swim	3.36	20.40	FALSE
101153	*Leptophlebia*	*cupida*	cg	swim	3.36	20.40	FALSE
101183	*Habrophlebia*		cg	swim	1.00		FALSE

TSN	Name1	Name2	FFG	Habit	MN Tolerance	Coldwater Tolerance	LongLived
101187	*Paraleptophlebia*		cg	swim	3.80	19.77	FALSE
101232	Ephemerellidae		cg	clng	1.00	19.75	FALSE
101233	*Ephemerella*		cg	clng	0.26	18.69	FALSE
101241	*Ephemerella*	*subvaria*	cg	clng	0.26	18.69	FALSE
101255	*Ephemerella*	*aurivillii*	cg	clng	0.26	18.69	FALSE
101276	*Ephemerella*	*excrucians*	cg	clng	0.26	18.69	FALSE
101282	*Ephemerella*	*invaria*	cg	clng	0.26	18.69	FALSE
101317	*Timpanoga*		cg	clng	7.00		FALSE
101324	*Eurylophella*		cg	clng	1.34	20.68	FALSE
101326	*Eurylophella*	*temporalis*	cg	clng	1.34	20.68	FALSE
101332	*Eurylophella*	*funeralis*	cg	clng	1.34	20.68	TRUE
101334	*Eurylophella*	*bicolor*	cg	clng	1.34	20.68	FALSE
101338	*Attenella*		cg	spra	0.00		FALSE
101340	*Attenella*	*attenuata*	cg	clng	0.00		FALSE
101360	*Dannella*		cg	swim			FALSE
101395	*Serratella*		cg	clng	0.56	18.97	FALSE
101405	*Tricorythodes*		cg	spra	8.81	21.87	FALSE
101429	*Leptohyphes*		pr	clng	4.00		FALSE
101461	*Neoephemera*		cg	clng			FALSE
101466	*Neoephemera*	*bicolor*	cg	clng			FALSE
101467	Caenidae		cg	spra	8.80	21.47	FALSE
101468	*Brachycercus*		cg	spra	7.40		FALSE
101478	*Caenis*		cg	spra	8.79	21.47	FALSE
101479	*Caenis*	*tardata*	cg	spra	8.79	21.47	FALSE
101483	*Caenis*	*diminuta*	cg	spra	8.79	21.47	FALSE
101486	*Caenis*	*hilaris*	cg	burr	8.79	21.47	FALSE
101488	*Caenis*	*latipennis*	cg	spra	8.79	21.47	FALSE
101494	*Baetisca*		cg	swim	7.36	20.77	FALSE
101504	*Baetisca*	*lacustris*	cg	spra	7.36	20.77	FALSE
101505	*Baetisca*	*laurentina*	cg	spra	7.36	20.77	FALSE
101525	Ephemeridae		cg	burr	9.39	21.08	FALSE
101526	*Ephemera*		cg	burr	3.87	20.47	TRUE
101530	*Ephemera*	*simulans*	cg	burr	3.87	20.47	TRUE
101535	*Ephemera*	*varia*	cg	burr	3.87	20.47	TRUE
101537	*Hexagenia*		cg	burr	9.78	21.31	FALSE
101538	*Hexagenia*	*bilineata*	cg	burr	9.78	21.31	FALSE
101552	*Hexagenia*	*limbata*	cg	burr	9.78	21.31	TRUE
101566	*Litobrancha*			burr			FALSE
101569	Polymitarcyidae		cg	burr	7.35	21.03	FALSE
101570	*Ephoron*		cg	burr	7.38	21.09	FALSE
101571	*Ephoron*	*album*	cg	burr	7.38	21.09	FALSE

TSN	Name1	Name2	FFG	Habit	MN Tolerance	Coldwater Tolerance	LongLived
101593	Odonata		pr	clim			FALSE
101594	Anisoptera		pr		6.00		FALSE
101596	Aeshnidae		pr	clim	7.38	19.64	TRUE
101597	*Anax*		pr	clim	8.13	21.55	TRUE
101598	*Anax*	*junius*	pr	clim	8.13	21.55	TRUE
101603	*Aeshna*		pr	clim	7.99	19.17	TRUE
101605	*Aeshna*	*umbrosa*	pr	clim	7.99	19.17	TRUE
101607	*Aeshna*	*verticalis*	pr	clim	7.99	19.17	TRUE
101609	*Aeshna*	*constricta*	pr	clim	7.99	19.17	TRUE
101634	*Gomphaeschna*		pr	clim	4.00		TRUE
101635	*Gomphaeschna*	*furcillata*	pr	clim	4.00		TRUE
101645	*Boyeria*		pr	clim	5.33	19.35	TRUE
101646	*Boyeria*	*grafiana*	pr	clim	5.33	19.35	TRUE
101647	*Boyeria*	*vinosa*	pr	clim	5.33	19.35	TRUE
101648	*Basiaeschna*		pr	clim	6.00	21.80	TRUE
101649	*Basiaeschna*	*janata*	pr	clim	6.00	21.80	TRUE
101653	*Nasiaeschna*		pr	clim	4.00		TRUE
101664	Gomphidae		pr	burr	3.75	20.66	TRUE
101665	*Gomphus*		pr	burr	7.11	21.09	TRUE
101666	*Stylurus*		pr	burr			TRUE
101672	*Gomphus*	*viridifrons*	pr	burr	7.11	21.09	TRUE
101685	*Gomphus*	*lividus*	pr	burr	7.11	21.09	TRUE
101700	*Gomphus*	*graslinellus*	pr	burr	7.11	21.09	TRUE
101718	*Progomphus*		pr	burr	1.00		TRUE
101725	*Erpetogomphus*		pr	burr	5.00		TRUE
101726	*Erpetogomphus*	*designatus*	pr	burr	5.00		FALSE
101730	*Dromogomphus*		pr	burr	3.00		TRUE
101734	*Hagenius*		pr	spra	1.00		TRUE
101735	*Hagenius*	*brevistylus*	pr	burr	1.00		TRUE
101738	*Ophiogomphus*		pr	burr	0.00	19.65	TRUE
101740	*Ophiogomphus*	*rupinsulensis*	pr	burr	0.00	19.65	TRUE
101745	*Ophiogomphus*	*carolus*	pr	burr	0.00	19.65	TRUE
101755	*Ophiogomphus*	*colubrinus*	pr	burr	0.00	19.65	TRUE
101770	*Arigomphus*		pr	burr	6.00		TRUE
101797	Libellulidae		pr	spra	7.17	21.38	FALSE
101803	*Perithemis*		pr	spra	6.85		FALSE
101808	*Plathemis*		pr	spra	8.00		FALSE
101809	*Plathemis*	*lydia*	pr	spra	8.00		FALSE
101851	*Didymops*		pr	spra	4.00		TRUE
101852	*Didymops*	*transversa*	pr	spra	4.00		TRUE
101854	*Dorocordulia*		pr	spra	5.00		TRUE

TSN	Name1	Name2	FFG	Habit	MN Tolerance	Coldwater Tolerance	LongLived
101856	*Dorocordulia*	*libera*	pr	spra	5.00		TRUE
101885	*Leucorrhinia*		pr	clim	9.00		FALSE
101893	*Libellula*		pr	spra	9.00		FALSE
101896	*Libellula*	*quadrimaculata*	pr	spra	9.00		FALSE
101918	*Macromia*		pr	spra	0.82	19.60	TRUE
101921	*Macromia*	*illinoiensis*	pr	spra	0.82	19.60	TRUE
101922	*Macromia*	*taeniolata*	pr	spra	0.82	19.60	TRUE
101934	*Neurocordulia*		pr	clim	3.54	19.19	TRUE
101936	*Neurocordulia*	*molesta*	pr	clim	3.54	19.19	TRUE
101937	*Neurocordulia*	*yamaskanensis*	pr	clim	3.54	19.19	TRUE
101940	*Neurocordulia*	*xanthosoma*	pr	clim	3.54	19.19	TRUE
101947	*Somatochlora*		pr	spra	5.14	20.46	TRUE
101955	*Somatochlora*	*elongata*	pr	spra	5.14	20.46	TRUE
101958	*Somatochlora*	*minor*	pr	spra	5.14	20.46	TRUE
101960	*Somatochlora*	*walshii*	pr	spra	5.14	20.46	TRUE
101976	*Sympetrum*		pr	spra	10.00		FALSE
101978	*Sympetrum*	*corruptum*	pr	spra	10.00		FALSE
101979	*Sympetrum*	*vicinum*	pr	spra	10.00		FALSE
101981	*Sympetrum*	*obstrusum*	pr	spra	10.00		FALSE
101990	*Sympetrum*	*semicinctum*	pr	spra	10.00		FALSE
102014	*Cordulia*		pr	spra			TRUE
102015	*Cordulia*	*shurtleffi*	pr	spra			TRUE
102020	Corduliidae		pr	clim	3.88	19.87	TRUE
102026	Cordulegastridae		pr	burr	0.00		TRUE
102027	*Cordulegaster*		pr	burr	0.00		TRUE
102029	*Cordulegaster*	*erronea*	pr	burr	0.00		TRUE
102031	*Cordulegaster*	*maculata*	pr	burr	0.00		TRUE
102035	*Epitheca*		pr	clim	4.13		TRUE
102036	*Epitheca*	*canis*	pr	clim	4.13		TRUE
102043	Calopterygidae		pr	clim	5.85	20.60	FALSE
102048	*Hetaerina*		pr	clim	7.85	22.55	FALSE
102049	*Hetaerina*	*titia*	pr	clim	7.85	22.55	FALSE
102050	*Hetaerina*	*americana*	pr	clim	7.85	22.55	FALSE
102052	*Calopteryx*		pr	clim	5.03	20.42	TRUE
102055	*Calopteryx*	*maculata*	pr	clim	5.03	20.42	TRUE
102056	*Calopteryx*	*aequabilis*	pr	clim	5.03	20.42	TRUE
102058	Lestidae		pr	clim	9.00		FALSE
102059	*Archilestes*		pr	clim	7.00		FALSE
102061	*Lestes*		pr	clim	9.00		FALSE
102069	*Lestes*	*inaequalis*	pr	clim	9.00		FALSE
102077	Coenagrionidae		pr	clim	9.73	21.66	FALSE

TSN	Name1	Name2	FFG	Habit	MN Tolerance	Coldwater Tolerance	LongLived
102078	*Ischnura*		pr	clim	9.99	21.56	FALSE
102079	*Ischnura*	*verticalis*	pr	clim	9.99	21.56	FALSE
102082	*Ischnura*	*posita*	pr	clim	9.99	21.56	FALSE
102093	*Amphiagrion*		pr	clim	9.00		FALSE
102095	*Amphiagrion*	*saucium*	pr	clim	9.00		FALSE
102102	*Enallagma*		pr	clim	9.17	21.85	FALSE
102108	*Enallagma*	*divagans*	pr	clim	9.17	21.85	FALSE
102115	*Enallagma*	*signatum*	pr	clim	9.17	21.85	FALSE
102122	*Enallagma*	*civile*	pr	clim	9.17	21.85	FALSE
102124	*Enallagma*	*cyathigerum*	pr	clim	9.17	21.85	FALSE
102125	*Enallagma*	*basidens*	pr	clim	9.17	21.85	FALSE
102133	*Chromagrion*		pr	clim	2.12		FALSE
102134	*Chromagrion*	*conditum*	pr	clim	2.12		FALSE
102135	*Nehalennia*		pr	clim	7.00		FALSE
102139	*Argia*		pr	clim	10.00	21.30	FALSE
102140	*Argia*	*apicalis*	pr	clng	10.00	21.30	FALSE
102143	*Argia*	*fumipennis*	pr	clng	10.00	21.30	FALSE
102155	*Coenagrion*		pr	clim	8.00		FALSE
102467	Plecoptera		pr	clng	8.00		FALSE
102470	Pteronarcidae		sh	clng	5.83	18.98	TRUE
102471	*Pteronarcys*		sh	clng	5.83	18.98	TRUE
102517	Nemouridae		sh	clng	1.00		FALSE
102540	*Amphinemura*		sh	spra	3.00		FALSE
102556	*Soyedina*		sh	spra	0.00		FALSE
102567	*Malenka*		sh	spra			FALSE
102643	Capniidae		sh	spra	0.15	16.30	FALSE
102788	Taeniopterygidae		sh	spra	2.52	21.05	FALSE
102789	*Taeniopteryx*		sh	spra	2.67	21.56	FALSE
102804	*Paracapnia*		sh	spra	0.33		FALSE
102840	Leuctridae		sh	clng	0.02	18.56	FALSE
102844	*Leuctra*		sh	spra	0.00		FALSE
102887	*Paraleuctra*		sh	spra	0.00		FALSE
102914	Perlidae		pr	clng	2.88	20.09	TRUE
102917	*Acroneuria*		pr	clng	2.40	20.07	TRUE
102918	*Acroneuria*	*lycorias*	pr	clng	2.40	20.07	TRUE
102919	*Acroneuria*	*abnormis*	pr	clng	2.40	20.07	TRUE
102922	*Acroneuria*	*carolinensis*	pr	clng	2.40	20.07	TRUE
102942	*Neoperla*		pr	clng	2.02		FALSE
102945	*Neoperla*	*stewarti*	pr	clng	2.02		FALSE
102954	*Attaneuria*		pr	clng	1.00		TRUE
102955	*Attaneuria*	*ruralis*	pr	clng	1.00		TRUE

TSN	Name1	Name2	FFG	Habit	MN Tolerance	Coldwater Tolerance	LongLived
102962	*Paragnetina*		pr	clng	3.29	19.56	TRUE
102968	*Paragnetina*	*media*	pr	clng	3.29	19.56	TRUE
102975	*Agnetina*		pr	clng	4.24	21.40	TRUE
102979	*Agnetina*	*capitata*	pr	clng	4.24	21.40	TRUE
102994	Perlodidae		pr	clng	2.68	18.75	FALSE
102995	*Isoperla*		pr	clng	4.17	18.90	FALSE
103124	*Isogenoides*		pr	clng	0.00		FALSE
103202	Chloroperlidae		pr	clng	1.00		FALSE
103203	*Alloperla*		pr	clng	0.00		FALSE
103212	*Alloperla*	*usa*	pr	clng	0.00		FALSE
103244	*Perlinella*		pr	clng	1.00		FALSE
103246	*Perlinella*	*dryma*	pr	clng	1.00		FALSE
103251	*Perlesta*		pr	clng	6.81	19.76	FALSE
103273	*Sweltsa*		pr	clng	1.00		FALSE
103359	Hemiptera		pr	clim			FALSE
103364	Corixidae		pr	swim	8.68	21.38	FALSE
103369	*Sigara*		hb	swim	7.74	21.00	FALSE
103382	*Sigara*	*grossolineata*	hb	swim	7.74	21.00	FALSE
103402	*Sigara*	*lineata*	hb	swim	7.74	21.00	FALSE
103403	*Sigara*	*trilineata*	hb	swim	7.74	21.00	FALSE
103423	*Trichocorixa*		pr	swim	10.00	21.34	FALSE
103444	*Hesperocorixa*		hb	swim	4.53	21.42	FALSE
103460	*Hesperocorixa*	*kennicotti*	hb	swim	4.53	21.42	FALSE
103484	*Corisella*		pr	swim			FALSE
103491	*Palmacorixa*		pr	swim	9.48	22.66	FALSE
103501	*Cenocorixa*		pr	swim	8.00		FALSE
103514	*Callicorixa*		pr	swim	4.33		FALSE
103517	*Callicorixa*	*audeni*	pr	swim	4.33		FALSE
103525	*Cymatia*		pr	swim	9.00		FALSE
103526	*Cymatia*	*americana*	pr	swim	9.00		FALSE
103557	Notonectidae		pr	swim	6.57	21.40	FALSE
103558	*Notonecta*		pr	swim	6.77	21.22	FALSE
103583	*Buenoa*		pr	swim	7.00		FALSE
103602	Pleidae		pr	swim	8.90	21.83	FALSE
103603	*Neoplea*		pr	swim	8.92	21.85	FALSE
103604	*Neoplea*	*striola*	pr	swim	8.92	21.85	FALSE
103665	*Pelocoris*		pr	clim	7.00		FALSE
103683	Belostomatidae		pr	clim	9.33	20.96	FALSE
103684	*Belostoma*		pr	clim	9.34	20.96	FALSE
103689	*Belostoma*	*flumineum*	pr	clim	9.34	20.96	FALSE
103699	*Lethocerus*		pr	clim	6.87		TRUE

TSN	Name1	Name2	FFG	Habit	MN Tolerance	Coldwater Tolerance	LongLived
103709	*Lethocerus*	*americanus*	pr	clim	6.87		TRUE
103748	*Ranatra*		pr	clim	10.00	21.05	FALSE
103765	*Nepa*		pr	clim	7.00		FALSE
103766	*Nepa*	*apiculata*	pr	clim	7.00		FALSE
103801	Gerridae		pr	skat	7.26	19.44	FALSE
103802	*Rheumatobates*		pr	skat	6.02	19.71	FALSE
103811	*Trepobates*		pr	skat	8.00		FALSE
103829	*Gerris*		pr	skat	6.89	20.17	FALSE
103857	*Metrobates*		pr	skat	6.00		FALSE
103872	*Limnoporus*		pr	skat	5.41		FALSE
103882	*Neogerris*	*hesione*	pr	skat			FALSE
103885	Veliidae		pr	skat	5.68	20.15	FALSE
103886	*Rhagovelia*		pr	skat	4.79	20.92	FALSE
103900	*Microvelia*		pr	skat	3.90	20.31	FALSE
103939	*Hydrometra*		pr	skat			FALSE
103954	*Mesovelia*		pr	skat	9.29	20.83	FALSE
103964	Hebridae		pr	clim			FALSE
103983	*Merragata*		pr	skat			FALSE
103990	Macroveliidae		pr	clim			FALSE
104063	Saldidae		pr	clim	10.00		FALSE
104140	*Saldula*		pr	clim			FALSE
109191	Aphididae		hb				FALSE
109216	Coleoptera		pr				FALSE
111857	Haliplidae		hb	clng	8.52	20.87	FALSE
111858	*Haliplus*		sh	clim	8.66	20.80	FALSE
111883	*Haliplus*	*immaculicollis*	sh	swim	8.66	20.80	FALSE
111923	*Peltodytes*		sh	clim	8.02	21.10	FALSE
111963	Dytiscidae		pr	swim	7.70	21.13	FALSE
111966	*Agabus*		pr	swim	5.15	18.68	FALSE
112072	*Agabetes*		pr	swim			FALSE
112074	*Acilius*		pr	swim			FALSE
112086	*Rhantus*		pr	swim	5.00		FALSE
112109	*Thermonectus*		pr	swim	5.00		FALSE
112118	*Dytiscus*		pr	swim	5.00		FALSE
112145	*Desmopachria*		pr	swim	10.00	23.72	FALSE
112148	*Desmopachria*	*convexa*	pr	swim	10.00	23.72	FALSE
112165	*Graphoderus*		pr	swim			FALSE
112172	*Hydaticus*		pr	swim	5.00		FALSE
112181	*Ilybius*		pr	swim	5.08	18.79	FALSE
112200	*Hygrotus*		pr	swim	10.00	21.71	FALSE
112278	*Laccophilus*		pr	swim	8.88	24.08	FALSE

TSN	Name1	Name2	FFG	Habit	MN Tolerance	Coldwater Tolerance	LongLived
112314	*Oreodytes*		sh	swim	5.00		FALSE
112364	*Cybister*		pr	swim			FALSE
112371	*Coptotomus*		pr	swim	7.40	20.07	FALSE
112379	*Colymbetes*		pr	swim	5.00		FALSE
112390	*Hydroporus*		pr	swim	7.56	19.82	FALSE
112561	*Copelatus*		pr	swim	5.00		FALSE
112575	*Uvarus*		pr	swim	7.21		FALSE
112580	*Liodessus*		pr	swim	6.18	21.34	FALSE
112653	Gyrinidae		pr	swim	5.28	20.17	FALSE
112654	*Gyrinus*		pr	swim	5.31	19.98	FALSE
112711	*Dineutus*		pr	swim	5.00		FALSE
112756	Hydraenidae		pr	clng	5.06	20.15	FALSE
112757	*Hydraena*		pr	clng	4.41	20.03	FALSE
112777	*Ochthebius*		sc	clng	9.79	20.39	FALSE
112811	Hydrophilidae		pr	swim	8.50	20.62	FALSE
112812	*Berosus*		hb	swim	5.03	21.32	FALSE
112858	*Laccobius*		hb		3.88	20.32	FALSE
112878	*Anacaena*			burr	6.02	20.11	FALSE
112909	*Paracymus*		pr	clng	8.16	20.78	FALSE
112931	*Sperchopsis*		cg	clng	5.00		FALSE
112932	*Sperchopsis*	*tessellata*	cg	clng	6.00		FALSE
112938	*Tropisternus*		pr	clim	9.42	20.98	FALSE
112973	*Enochrus*		cg	burr	10.00	21.19	FALSE
113017	*Cymbiodyta*		cg	burr	5.00		FALSE
113106	*Helophorus*		sh	swim	10.00	19.93	FALSE
113148	*Helocombus*		cg	clng			FALSE
113150	*Helochares*		cg				FALSE
113166	*Hydrochus*		sh	clim	9.25	21.91	FALSE
113190	*Hydrochara*		cg	swim			FALSE
113196	*Hydrobius*		pr	clim	5.94	20.56	FALSE
113204	*Hydrophilus*		pr	swim			FALSE
113220	*Crenitis*		pr	burr	4.34	19.37	FALSE
113265	Staphylinidae		pr	clng	8.00		FALSE
113576	*Stenus*		pr	skat	8.00		FALSE
113835	Lampyridae				0.00		FALSE
113924	Scirtidae		sc	clim	8.52	21.66	FALSE
113929	*Scirtes*		sh	clim	8.22	21.44	FALSE
113948	*Cyphon*		sc	clim	9.97	21.63	FALSE
113999	Dryopidae		sc	clng	7.38	18.52	TRUE
114006	*Helichus*		sh	clng	7.38	18.53	TRUE
114069	Psephenidae		sc	clng	0.00	20.25	TRUE

TSN	Name1	Name2	FFG	Habit	MN Tolerance	Coldwater Tolerance	LongLived
114087	*Ectopria*		sc	clng	0.00	20.25	TRUE
114093	Elmidae		cg	clng	8.16	20.93	TRUE
114095	*Stenelmis*		sc	clng	8.30	21.83	TRUE
114102	*Stenelmis*	*crenata*	cg	clng	8.30	21.83	TRUE
114126	*Dubiraphia*		cg	clng	9.26	21.06	TRUE
114146	*Microcylloepus*		cg	clng	3.00		TRUE
114147	*Microcylloepus*	*pusillus*	cg	clng	3.00		TRUE
114177	*Optioservus*		sc	clng	3.08	19.22	TRUE
114190	*Optioservus*	*fastiditus*	sc	clng	3.08	19.22	TRUE
114194	*Ancyronyx*	*variegatus*	cg	clng	5.01	20.48	TRUE
114212	*Macronychus*		cg	clng	7.21	20.80	TRUE
114213	*Macronychus*	*glabratus*	cg	clng	7.21	20.80	TRUE
114509	Chrysomelidae		sh	clng	6.00		FALSE
114666	Curculionidae		sh	clng	6.00		FALSE
114690	*Listronotus*		sh	clng			FALSE
114838	*Lixus*		sh	clng			FALSE
114999	Neuroptera		pr				FALSE
115001	Sialidae		pr	burr	5.65	19.72	TRUE
115002	*Sialis*		pr	burr	5.65	19.72	TRUE
115023	Corydalidae		pr	clng	2.92	19.90	TRUE
115024	*Chauliodes*		pr	clng	5.80	20.11	TRUE
115028	*Nigronia*		pr	clng	0.41	19.47	TRUE
115033	*Corydalus*		pr	clng	6.00		TRUE
115085	Sisyridae		pr	clim	5.00		FALSE
115086	*Climacia*		pr	clim	8.00		FALSE
115087	*Climacia*	*areolaris*	pr		8.00		FALSE
115090	*Sisyra*		pr	clim			FALSE
115095	Trichoptera		un				FALSE
115097	*Rhyacophila*		pr	clng	0.00	16.70	FALSE
115099	*Rhyacophila*	*angelita*	pr		0.00	16.70	FALSE
115133	*Rhyacophila*	*fuscula*	cg	clng	0.00	16.70	FALSE
115147	*Rhyacophila*	*minor*	pr	clng	0.00	16.70	FALSE
115150	*Rhyacophila*	*invaria*	pr	clng	0.00	16.70	FALSE
115221	*Protoptila*		pr	clng	1.40	21.56	FALSE
115257	Philopotamidae		cf	clng	0.00	20.01	FALSE
115273	*Chimarra*		cf	clng	0.00	20.31	FALSE
115276	*Chimarra*	*obscura*	cf	clng	0.00	20.31	FALSE
115278	*Chimarra*	*aterrima*	cf	clng	0.00	20.31	FALSE
115279	*Chimarra*	*socia*	cf	clng	0.00	20.31	FALSE
115319	*Dolophilodes*		cf	clng	0.00	17.40	FALSE
115322	*Dolophilodes*	*distinctus*	cf	clng	0.00	17.40	FALSE

TSN	Name1	Name2	FFG	Habit	MN Tolerance	Coldwater Tolerance	LongLived
115334	Psychomyiidae		cg	clng	3.90	19.53	FALSE
115335	*Psychomyia*		cg	clng	4.14	20.33	FALSE
115341	*Psychomyia*	*flavida*	cg	clng	4.14	20.33	FALSE
115361	*Phylocentropus*		cf	clng	1.24		FALSE
115364	*Phylocentropus*	*placidus*	cf	clng	1.24		FALSE
115373	*Cernotina*		pr	clng	1.04	17.98	FALSE
115391	*Lype*		sc	burr	3.10	18.51	FALSE
115392	*Lype*	*diversa*	sc	spra	3.10	18.51	FALSE
115398	Hydropsychidae		cf	clng	7.55	20.26	FALSE
115399	*Diplectrona*		cf	clng	0.00		FALSE
115402	*Diplectrona*	*modesta*	cf	clng	0.00		FALSE
115408	*Cheumatopsyche*		cf	clng	8.05	20.59	FALSE
115453	*Hydropsyche*		cf	clng	7.81	21.21	FALSE
115454	*Hydropsyche*	*betteni*	cf	clng	7.81	21.21	FALSE
115458	*Hydropsyche*	*bidens*	cf	clng	7.81	21.21	FALSE
115461	*Hydropsyche*	*cuanis*	cf	clng	7.81	21.21	FALSE
115465	*Hydropsyche*	*dicantha*	cf	clng	7.81	21.21	FALSE
115468	*Hydropsyche*	*frisoni*	cf	clng	7.81	21.21	FALSE
115469	*Hydropsyche*	*hageni*	cf	clng	7.81	21.21	FALSE
115471	*Hydropsyche*	*incommoda*	cf	clng	7.81	21.21	FALSE
115477	*Hydropsyche*	*phalerata*	cf	clng	7.81	21.21	FALSE
115480	*Hydropsyche*	*scalaris*	cf	clng	7.81	21.21	FALSE
115481	*Hydropsyche*	*simulans*	cf	clng	7.81	21.21	FALSE
115482	*Hydropsyche*	*valanis*	cf	clng	7.81	21.21	FALSE
115487	*Hydropsyche*	*placoda*	cf	clng	7.81	21.21	FALSE
115551	*Potamyia*		cf	clng	8.53	22.07	FALSE
115552	*Potamyia*	*flava*	cf	clng	8.53	22.07	FALSE
115556	*Parapsyche*		cf	clng	1.00		FALSE
115557	*Parapsyche*	*apicalis*		clng			FALSE
115570	*Ceratopsyche*		cf	clng	6.61	19.32	FALSE
115571	*Ceratopsyche*	*alternans*	cf	clng	6.61	19.32	FALSE
115575	*Ceratopsyche*	*vexa*		clng	6.61	19.32	FALSE
115577	*Ceratopsyche*	*bronta*	cf	clng	6.61	19.32	FALSE
115580	*Ceratopsyche*	*morosa*	cf	clng	6.61	19.32	FALSE
115586	*Ceratopsyche*	*slossonae*	cf	clng	6.61	19.32	FALSE
115589	*Ceratopsyche*	*sparna*	cf	clng	6.61	19.32	FALSE
115592	*Ceratopsyche*	*walkeri*	cf	clng	6.61	19.32	FALSE
115596	*Ceratopsyche*	*alhedra*	cf	clng	6.61	19.32	FALSE
115603	*Macrostemum*		cf	clng	0.35	23.17	FALSE
115606	*Macrostemum*	*zebratum*	cf	clng	0.35	23.17	FALSE
115629	Hydroptilidae		hb	clim	6.47	20.69	FALSE

TSN	Name1	Name2	FFG	Habit	MN Tolerance	Coldwater Tolerance	LongLived
115630	*Leucotrichia*		sc	clng	0.75	21.48	FALSE
115631	*Leucotrichia*	*pictipes*	sc	clng	0.75	21.48	FALSE
115635	*Agraylea*		cf	clim	8.00		FALSE
115641	*Hydroptila*		hb	clng	7.58	20.65	FALSE
115714	*Ochrotrichia*		cg	clng	10.00	23.88	FALSE
115779	*Oxyethira*		cg	clim	1.37	20.50	FALSE
115811	*Mayatrichia*		sc	clng	7.97	22.89	FALSE
115812	*Mayatrichia*	*ayama*	sc	clng	7.97	22.89	FALSE
115817	*Stactobiella*		sh	clim	2.00		FALSE
115823	*Ithytrichia*		pr	clng			FALSE
115824	*Ithytrichia*	*clavata*	sc	clng			FALSE
115826	*Dibusa*		pr	clng	6.00		FALSE
115828	*Orthotrichia*		hb	clng	6.00		FALSE
115833	*Neotrichia*		sc	clng	9.00		FALSE
115867	Phryganeidae		sh	clim	3.93	19.98	FALSE
115868	*Ptilostomis*		sh	clng	4.40	19.50	FALSE
115882	*Agrypnia*		sh	clim			FALSE
115888	*Fabria*	*inornatus*					FALSE
115892	*Phryganea*		sh	clim	1.61	22.02	FALSE
115900	*Oligostomis*		pr	clim	2.00		FALSE
115911	*Banksiola*		sh	clim			FALSE
115933	Limnephilidae		sh	clim	3.45	19.19	FALSE
115934	*Goeridae*		sc	clng		17.03	FALSE
115935	*Apatania*		pr	clng	1.00		FALSE
115956	*Anabolia*		sh	spra			FALSE
115974	*Psychoglypha*		sh	spra	1.00		FALSE
115981	*Psychoglypha*	*subborealis*	cg	spra	2.00		FALSE
115989	*Pseudostenophylax*		sh	spra			FALSE
115995	*Hydatophylax*		sh	spra	2.63	19.44	FALSE
115997	*Hydatophylax*	*argus*	sh	spra	2.63	19.44	FALSE
116001	*Hesperophylax*		sh	spra	2.67	13.03	FALSE
116008	*Hesperophylax*	*designatus*		spra	2.67	13.03	FALSE
116030	*Glyphopsyche*		sh	clng	3.31	18.53	FALSE
116031	*Glyphopsyche*	*irrorata*		clng	3.31	18.53	FALSE
116046	*Neophylax*		sc	clng	3.15	19.76	FALSE
116047	*Neophylax*	*concinnus*	sc	clng	3.15	19.76	FALSE
116049	*Neophylax*	*fuscus*	sc	clng	3.15	19.76	FALSE
116050	*Neophylax*	*mitchelli*	sc	clng	3.15	19.76	FALSE
116053	*Neophylax*	*aniqua*	sc	clng	3.15	19.76	FALSE
116057	*Neophylax*	*oligius*	sc	clng	3.15	19.76	FALSE
116069	*Limnephilus*		sh	spra	3.71	17.32	FALSE

TSN	Name1	Name2	FFG	Habit	MN Tolerance	Coldwater Tolerance	LongLived
116221	*Asynarchus*			clim			FALSE
116304	*Frenesia*	*missa*					FALSE
116407	*Platycentropus*		sh	clim			FALSE
116409	*Pycnopsyche*		sh	spra	4.55	21.70	FALSE
116423	*Goera*		sc	clng	0.00		FALSE
116426	*Goera*	*stylata*	sc	clng	0.00		FALSE
116432	*Nemotaulius*		sh	spra	5.50	22.41	FALSE
116434	*Nemotaulius*	*hostilis*	sh	spra	5.50	22.41	FALSE
116473	Molannidae		sc	spra	1.81	20.04	FALSE
116474	*Molanna*		sc	spra	2.40	20.18	FALSE
116496	Odontoceridae		sc	spra	0.00		FALSE
116503	*Psilotreta*	*indecisa*					FALSE
116547	Leptoceridae		cg	clim	6.78	21.43	FALSE
116548	*Setodes*		cg	spra	0.13		FALSE
116565	*Triaenodes*		sh	swim	5.61	22.17	FALSE
116598	*Mystacides*		cg	spra	3.08	20.97	FALSE
116607	*Oecetis*		pr	clng	4.31	20.78	FALSE
116608	*Oecetis*	*avara*	pr	clng	4.31	20.78	FALSE
116609	*Oecetis*	*cinerascens*	pr		4.31	20.78	FALSE
116631	*Oecetis*	*nocturna*	pr	spra	4.31	20.78	FALSE
116636	*Oecetis*	*persimilis*	pr	swim	4.31	20.78	FALSE
116644	*Oecetis*	*immobilis*	pr		4.31	20.78	FALSE
116651	*Nectopsyche*		sh	clim	9.93	21.99	FALSE
116659	*Nectopsyche*	*exquisita*	sh	clim	9.93	21.99	FALSE
116661	*Nectopsyche*	*candida*	sh	clim	9.93	21.99	FALSE
116663	*Nectopsyche*	*diarina*	sh	clim	9.93	21.99	FALSE
116677	*Leptocerus*		sh	swim	4.00		FALSE
116678	*Leptocerus*	*americanus*	sh	swim	4.00		FALSE
116684	*Ceraclea*		cg	clng	2.45	20.30	FALSE
116793	Lepidostomatidae		sh	clim	0.12	18.43	FALSE
116794	*Lepidostoma*		sh	clim	0.12	18.42	FALSE
116905	Brachycentridae		cf	clng	4.68	18.04	FALSE
116906	*Brachycentrus*		cf	clng	5.14	17.78	FALSE
116910	*Brachycentrus*	*numerosus*	cf	clng	5.14	17.78	FALSE
116912	*Brachycentrus*	*americanus*	cf	clng	5.14	17.78	FALSE
116918	*Brachycentrus*	*occidentalis*	cf		5.14	17.78	FALSE
116958	*Micrasema*		sh	clng	0.67	18.83	FALSE
116961	*Micrasema*	*rusticum*	cg	clng	0.67	18.83	FALSE
116964	*Micrasema*	*sprulesi*	sh	clng	0.67	18.83	FALSE
116965	*Micrasema*	*rickeri*	cg	clng	0.67	18.83	FALSE
116969	*Micrasema*	*gelidum*	sh	clng	0.67	18.83	FALSE

TSN	Name1	Name2	FFG	Habit	MN Tolerance	Coldwater Tolerance	LongLived
116982	Sericostomatidae		sh	spra	0.00	20.50	FALSE
116983	*Agarodes*		sh	spra	0.00	19.73	FALSE
116984	*Agarodes*	*distinctus*	sh	spra	0.00	19.73	FALSE
117015	Helicopsychidae		sc	clng	2.69	20.78	FALSE
117016	*Helicopsyche*		sc	clng	2.61	20.78	FALSE
117020	*Helicopsyche*	*borealis*	sc	clng	2.61	20.78	FALSE
117043	Polycentropodidae		cf	clng	3.01	20.30	FALSE
117044	*Polycentropus*		pr	clng	3.20	20.45	FALSE
117091	*Cyrnellus*		cf	clng	8.00		FALSE
117092	*Cyrnellus*	*fraternus*	cf	clng	8.00		FALSE
117095	*Neureclipsis*		cf	clng	1.13	20.21	FALSE
117104	*Nyctiophylax*		pr	clng	4.38	21.53	FALSE
117120	Glossosomatidae		sc	clng	1.29	17.12	FALSE
117121	*Agapetus*		sc	clng	0.00		FALSE
117159	*Glossosoma*		sc	clng	1.14	17.12	FALSE
117162	*Glossosoma*	*intermedium*	sc	clng	1.14	17.12	FALSE
117164	*Glossosoma*	*nigrior*		clng	1.14	17.12	FALSE
117196	*Glossosoma*	*lividum*	sc	clng	1.14	17.12	FALSE
117232	Lepidoptera		sh		6.00		FALSE
117297	Arctiidae		sh		5.00		FALSE
117318	Noctuidae		sh	burr	6.00		FALSE
117641	Pyralidae		sh	spra	7.69	21.06	FALSE
117642	*Paraponyx*		sh	clng	1.54	20.51	FALSE
117654	*Synclita*		sh	clim			FALSE
117659	*Nymphula*		sh	clim			FALSE
117665	*Elophila*		sh				FALSE
117672	*Munroessa*		sh	clim	2.30		FALSE
117682	*Petrophila*		sc	clim	2.23	21.66	FALSE
117714	*Parapoynx*		sh	clim			FALSE
117741	*Acentria*		sh	clim	1.00		FALSE
118746	*Nepticula*		sh	burr			FALSE
118831	Diptera		un		7.00		FALSE
118840	Tipulidae		sh	burr	5.80	19.05	FALSE
118890	*Holorusia*		sh	burr			FALSE
119008	*Prionocera*		sh	burr	3.00		FALSE
119037	*Tipula*		sh	burr	6.29	20.09	FALSE
119654	Limoniinae		cg		5.00		FALSE
119656	*Antocha*		cg	clng	4.07	18.13	FALSE
119690	*Helius*		cg	burr	4.00		FALSE
119704	*Limonia*		sh	burr	6.87	18.27	FALSE
120094	*Hexatoma*		pr	burr	8.07	20.49	FALSE

TSN	Name1	Name2	FFG	Habit	MN Tolerance	Coldwater Tolerance	LongLived
120164	*Limnophila*		pr	burr	7.30	17.07	FALSE
120335	*Pilaria*		pr	burr	5.31	17.90	FALSE
120365	*Pseudolimnophila*		pr	burr	2.00		FALSE
120387	*Ulomorpha*			burr			FALSE
120488	*Cryptolabis*		sh	burr	3.00		FALSE
120503	*Erioptera*		cg	burr	5.08	17.74	FALSE
120640	*Gonomyia*		cg	burr	3.00		FALSE
120732	*Hesperoconopa*		cg	burr	1.00		FALSE
120830	*Ormosia*		cg	burr	6.50		FALSE
121027	*Dicranota*		pr	burr	3.98	18.31	FALSE
125351	Psychodidae		cg	burr	9.06	18.97	FALSE
125468	*Psychoda*		cg	burr	8.41	19.19	FALSE
125514	*Pericoma*		cg	burr	7.59	19.26	FALSE
125763	Ptychopteridae		cg	burr	4.51		FALSE
125765	*Bittacomorpha*		cg	burr	7.00		FALSE
125786	*Ptychoptera*		cg	burr	4.51		FALSE
125799	Tanyderidae		cg	spra	5.00		FALSE
125809	Dixidae		cg	swim	4.51	19.03	FALSE
125810	*Dixa*		cg	clim	5.20	17.82	FALSE
125854	*Dixella*		cg	swim	4.27	19.47	FALSE
125886	Chaoboridae		pr	spra	8.22	19.41	FALSE
125888	*Eucorethra*		pr	swim	7.00		FALSE
125893	*Mochlonyx*		pr				FALSE
125904	*Chaoborus*		pr	spra	8.45	19.37	FALSE
125930	Culicidae		cg	swim	7.96	20.69	FALSE
125956	*Anopheles*		cf	swim	8.06	20.57	FALSE
126234	*Aedes*		cf	swim	6.39	20.67	FALSE
126424	*Coquillettidia*		cf				FALSE
126429	*Culiseta*		cg	swim			FALSE
126455	*Culex*		cf	swim	8.22	22.23	FALSE
126575	*Uranotaenia*		cf	swim			FALSE
126580	*Uranotaenia*	*sapphirina*	cf				FALSE
126621	*Ochlerotatus*		cf				FALSE
126640	Simuliidae		cf	clng	6.38	18.79	FALSE
126648	Prosimuliini						FALSE
126774	*Simulium*		cf	clng	6.37	18.76	FALSE
126838	*Simulium*	*luggeri*	cf	clng	6.37	18.76	FALSE
126903	*Simulium*	*vittatum*	cf	clng	6.37	18.76	FALSE
127076	Ceratopogonidae		pr	spra	5.68	20.33	FALSE
127112	Forcipomyiinae		pr	spra	6.00	22.00	FALSE
127113	*Atrichopogon*		cg	clng	7.76	20.82	FALSE

TSN	Name1	Name2	FFG	Habit	MN Tolerance	Coldwater Tolerance	LongLived
127152	*Forcipomyia*		sc	burr	7.12	21.35	FALSE
127278	*Dasyhelea*		cg	spra	5.68	20.85	FALSE
127338	Ceratopogoninae		pr	burr	6.00	20.00	FALSE
127340	*Culicoides*		pr	burr	5.68	20.53	FALSE
127533	*Alluaudomyia*		pr	burr	6.00		FALSE
127564	*Ceratopogon*		pr	burr	6.12	18.35	FALSE
127575	*Monohelea*		pr	burr			FALSE
127614	*Serromyia*		pr	burr	5.90	20.50	FALSE
127619	*Stilobezzia*		pr	spra			FALSE
127649	*Clinohelea*		pr	burr			FALSE
127702	*Mallochohelea*		pr	burr	6.62	21.94	FALSE
127720	*Nilobezzia*		pr	burr	6.00		FALSE
127729	*Probezzia*		pr	burr	2.53	20.07	FALSE
127761	*Sphaeromias*		pr	burr	3.78	19.26	FALSE
127778	*Bezzia*		pr	spra	5.21	20.36	FALSE
127859	*Palpomyia*		pr	burr	6.00		FALSE
127917	Chironomidae		cg		7.80	20.14	FALSE
127962	*Lasiodiamesa*		cg,sc	spra			FALSE
127994	Tanypodinae		pr	burr	6.00	21.00	FALSE
127996	*Clinotanypus*		pr	burr	3.30	20.95	FALSE
128021	*Apsectrotanypus*		pr	burr	2.00		FALSE
128034	*Macropelopia*		pr	spra	7.00		FALSE
128037	*Macropelopia*	*decedens*	pr	spra	7.00		FALSE
128048	*Psectrotanypus*		pr	spra	8.10		FALSE
128070	*Natarsia*		pr	spra	2.84	19.91	FALSE
128079	*Ablabesmyia*		pr	spra	7.38	20.72	FALSE
128130	*Conchapelopia*		pr	spra	8.67	19.36	FALSE
128131	*Helopelopia*		pr	spra			FALSE
128161	*Guttipelopia*		pr	spra	2.94	18.01	FALSE
128170	*Krenopelopia*		pr	spra			FALSE
128173	*Labrundinia*		pr	spra	9.88	20.37	FALSE
128174	*Labrundinia*	*becki*	pr	spra	9.88	20.37	FALSE
128183	*Larsia*		pr	spra	7.69	21.98	FALSE
128202	*Nilotanypus*		pr	spra	5.63	20.98	FALSE
128207	*Paramerina*		pr	spra	7.35	19.21	FALSE
128215	*Pentaneura*		pr	spra	4.61	21.96	FALSE
128226	*Rheopelopia*		pr	spra	3.00		FALSE
128234	*Telopelopia*	*okoboji*	pr	burr			FALSE
128236	*Thienemannimyia*		pr	spra	5.91		FALSE
128245	*Thienemannimyia*	*senata*	pr	spra	5.91		FALSE
128249	*Hayesomyia*	*sonata*	pr	spra			FALSE

TSN	Name1	Name2	FFG	Habit	MN Tolerance	Coldwater Tolerance	LongLived
128251	*Trissopelopia*		pr	spra	0.19	17.10	FALSE
128252	*Trissopelopia*	*ogemawi*	pr	spra	0.19	17.10	FALSE
128259	*Zavrelimyia*		pr	spra	8.02	18.33	FALSE
128271	*Djalmabatista*		pr	spra	9.00		FALSE
128277	*Procladius*		pr	spra	7.49	20.66	FALSE
128324	*Tanypus*		pr	spra	10.00	23.83	FALSE
128341	Diamesinae		cg	spra	5.00		FALSE
128355	*Diamesa*		cg	spra	5.00		FALSE
128401	*Pagastia*		cg	spra	5.14	14.05	FALSE
128408	*Potthastia*		cg	spra	5.12	20.09	FALSE
128416	*Pseudodiamesa*		cg	spra			FALSE
128440	*Monodiamesa*		cg				FALSE
128446	*Odontomesa*		cg	spra	6.51	17.01	FALSE
128452	*Prodiamesa*		cg	spra	5.76	14.74	FALSE
128457	Orthocladiinae		cg	burr	5.00	20.00	FALSE
128463	*Acricotopus*		cg	spra	4.05	20.16	FALSE
128477	*Brillia*		sh	burr	8.01	18.62	FALSE
128511	*Cardiocladius*		pr	burr	2.69	22.12	FALSE
128520	*Chaetocladius*		cg	spra	6.00		FALSE
128563	*Corynoneura*		cg	spra	6.70	19.42	FALSE
128575	*Cricotopus*		sh	clng	8.52	20.11	FALSE
128583	*Cricotopus*	*bicinctus*	cg	burr	8.52	20.11	FALSE
128670	*Diplocladius*		cg	spra	8.87	22.89	FALSE
128671	*Diplocladius*	*cultriger*	cg	spra	8.87	22.89	FALSE
128680	*Doncricotopus*		cg	spra		17.78	FALSE
128681	*Doncricotopus*	*bicaudatus*	cg	spra		17.78	FALSE
128682	*Epoicocladius*		cg		9.87	24.35	FALSE
128689	*Eukiefferiella*		cg	spra	5.13	16.02	FALSE
128695	*Eukiefferiella*	*devonica*	cg	spra	5.13	16.02	FALSE
128707	*Euryhapsis*						FALSE
128718	*Gymnometriocnemus*		cg	burr			FALSE
128730	*Heleniella*		pr	spra	0.00	17.65	FALSE
128737	*Heterotrissocladius*		cg	spra	5.46	15.28	FALSE
128750	*Hydrobaenus*		sc	spra	8.98	20.69	FALSE
128771	*Krenosmittia*		cg	spra	0.00		FALSE
128776	*Limnophyes*		cg	spra	8.38	18.52	FALSE
128811	*Lopescladius*		cg	burr	0.00	20.12	FALSE
128821	*Metriocnemus*		cg	spra	4.52		FALSE
128844	*Nanocladius*		cg	spra	7.77	20.33	FALSE
128874	*Orthocladius*		cg	spra	7.31	19.13	FALSE
128877	*Symposiocladius*		pr	spra	6.00		FALSE

TSN	Name1	Name2	FFG	Habit	MN Tolerance	Coldwater Tolerance	LongLived
128878	*Orthocladius*	*annectens*	cg	spra	7.31	19.13	FALSE
128951	*Parachaetocladius*		cg	spra	7.00		FALSE
128956	*Paracladius*		cg	spra			FALSE
128962	*Paracricotopus*		cg	spra	10.00		FALSE
128968	*Parakiefferiella*		cg	spra	10.00	19.66	FALSE
128978	*Parametriocnemus*		cg	spra	5.15	18.38	FALSE
128989	*Paraphaenocladius*		cg	spra	9.34	18.57	FALSE
129018	*Psectrocladius*		cg	spra	2.60	19.59	FALSE
129052	*Pseudorthocladius*		cg	spra	0.00		FALSE
129071	*Pseudosmittia*		cg	spra	7.48	19.98	FALSE
129083	*Psilometriocnemus*		cg	spra			FALSE
129086	*Rheocricotopus*		cg	spra	6.64	20.35	FALSE
129107	*Rheosmittia*		cg	burr	0.00		FALSE
129110	*Smittia*		cg	burr	2.00		FALSE
129152	*Stilocladius*		cg	spra	4.72	20.55	FALSE
129161	*Synorthocladius*		cg	spra	0.29	20.32	FALSE
129182	*Thienemanniella*		cg	spra	7.95	19.60	FALSE
129197	*Tvetenia*		cg	spra	4.98	17.54	FALSE
129206	*Unniella*		cg	burr	0.66		FALSE
129209	*Xylotopus*	*par*	cg	burr	2.21	19.37	FALSE
129213	*Zalutschia*		sh	spra	7.00		FALSE
129228	Chironominae		cg	burr	7.00		FALSE
129229	Chironomini		cg	burr	6.00	21.00	FALSE
129236	*Axarus*		cg	spra	2.00		FALSE
129249	*Chernovskiia*		cg	spra	6.00		FALSE
129254	*Chironomus*		cg	burr	8.64	18.97	FALSE
129350	*Cladopelma*		cg	burr	7.08	22.80	FALSE
129368	*Cryptochironomus*		pr	spra	9.13	20.13	FALSE
129394	*Cryptotendipes*		cg	burr	8.01	20.76	FALSE
129421	*Demicryptochironomus*		cg	burr	1.96	19.01	FALSE
129428	*Dicrotendipes*		cg	burr	8.19	20.08	FALSE
129459	*Einfeldia*		cg	burr	9.00		FALSE
129470	*Endochironomus*		sh	clng	8.52	22.08	FALSE
129483	*Glyptotendipes*		sh	burr	9.07	23.13	FALSE
129516	*Kloosia/Harnischia*		cg	burr	8.00		FALSE
129520	*Hyporhygma*		cg	burr	0.00		FALSE
129521	*Hyporhygma*	*quadripunctatus*	cg	burr	0.00		FALSE
129522	*Kiefferulus*		cg	burr	10.00		FALSE
129525	*Lauterborniella*		cg	clng	0.00	20.67	FALSE
129526	*Lauterborniella*	*agrayloides*	cg	clng	0.00	20.67	FALSE
129532	*Microchironomus*		cg	burr	0.00		FALSE

TSN	Name1	Name2	FFG	Habit	MN Tolerance	Coldwater Tolerance	LongLived
129535	*Microtendipes*		cf	clng	4.70	19.71	FALSE
129548	*Nilothauma*		cg	burr	0.63	22.05	FALSE
129556	*Omisus*		cg		4.00		FALSE
129561	*Pagastiella*		cg	spra	0.00		FALSE
129564	*Parachironomus*		pr	spra	9.40	21.26	FALSE
129597	*Paracladopelma*		cg	spra	7.29	19.61	FALSE
129616	*Paralauterborniella*		cg	burr	7.62	19.10	FALSE
129619	*Paralauterborniella*	*nigrohalterale*	cg	burr	7.62	19.10	FALSE
129623	*Paratendipes*		cg	burr	8.47	20.02	FALSE
129637	*Phaenopsectra*		sc	clng	6.46	19.74	FALSE
129657	*Polypedilum*		sh	clim	8.57	20.78	FALSE
129730	*Robackia*		cg	burr	6.31		FALSE
129735	*Saetheria*		cg	burr	10.00	20.27	FALSE
129746	*Stenochironomus*		cg	burr	6.49	21.02	FALSE
129785	*Stictochironomus*		cg	burr	10.00	19.41	FALSE
129820	*Tribelos*		cg	burr	2.45	19.88	FALSE
129837	*Xenochironomus*		pr	burr	4.26	20.34	FALSE
129838	*Xenochironomus*	*xenolabis*	pr	burr		20.34	FALSE
129850	Pseudochironomini		cg				FALSE
129851	*Pseudochironomus*		cg	burr	3.10	21.54	FALSE
129872	Tanytarsini		cf	burr	6.00	20.00	FALSE
129873	*Cladotanytarsus*		cg	clim	8.04	20.99	FALSE
129884	*Constempellina*		cg	clim	5.51		FALSE
129890	*Micropsectra*		cg	clim	7.75	17.99	FALSE
129935	*Paratanytarsus*		cg	clng	8.98	20.55	FALSE
129952	*Rheotanytarsus*		cf	clng	6.21	20.22	FALSE
129962	*Stempellina*		cg	clim	0.35	18.90	FALSE
129969	*Stempellinella*		cg	clim	2.24	20.07	FALSE
129975	*Sublettea*		cg	spra	6.98	19.74	FALSE
129976	*Sublettea*	*coffmani*	cg	spra	6.98	19.74	FALSE
129978	*Tanytarsus*		cf	clng	5.04	20.30	FALSE
130038	*Zavrelia*		cg	swim	6.00		FALSE
130040	*Zavreliella*		cg	burr	5.45	25.21	FALSE
130042	*Neozavrelia*						FALSE
130046	*Endotribelos*		cg	burr	2.84	21.24	FALSE
130150	Stratiomyidae		cg	spra	10.00	21.47	FALSE
130160	*Allognosta*		cg	spra			FALSE
130409	*Caloparyphus*		cg	spra	7.00		FALSE
130436	*Euparyphus*		cg	spra	8.00		FALSE
130461	*Oxycera*		sc	spra			FALSE
130573	*Odontomyia*		cg	spra	10.00	21.75	FALSE

TSN	Name1	Name2	FFG	Habit	MN Tolerance	Coldwater Tolerance	LongLived
130627	*Stratiomys*		cg	spra			FALSE
130694	*Nemotelus*		cg	spra	4.00		FALSE
130929	*Atherix*		pr	spra	3.73	20.33	FALSE
130932	*Atherix*	*variegata*	pr	spra	3.73	20.33	FALSE
130934	Tabanidae		pr	spra	5.91	19.95	FALSE
131078	*Chrysops*		pr	spra	5.15	19.76	FALSE
131321	*Hybomitra*		pr	spra	7.00		FALSE
131527	*Tabanus*		pr	spra	5.00		FALSE
135830	Empididae		pr	spra	5.61	20.25	FALSE
135844	Clinocerinae		pr	clng			FALSE
135849	*Clinocera*		pr	clng	2.99		FALSE
135871	*Dolichocephala*		pr	clng			FALSE
135893	*Roederiodes*		pr	clng			FALSE
135903	*Trichoclinocera*		pr	clng			FALSE
135920	*Wiedemannia*		pr	clng			FALSE
136290	Hemerodromiinae		pr	spra			FALSE
136305	*Chelifera*		cg	spra	6.67	17.75	FALSE
136327	*Hemerodromia*		pr	spra	5.38	20.53	FALSE
136352	*Neoplasta*		pr	spra	7.11	18.95	FALSE
136377	*Oreogeton*		pr	spra			FALSE
136824	Dolichopodidae		pr	burr	1.04	21.30	FALSE
138921	Phoridae		cg	burr	6.00		FALSE
139621	Syrphidae		cg	burr	10.00		FALSE
140904	*Eristalis*		cg	burr	10.00		FALSE
144653	Sciomyzidae		pr	burr	9.85	19.66	FALSE
144898	*Sepedon*		pr	burr			FALSE
146893	Ephydridae		cg	burr	9.46	19.84	FALSE
147117	*Hydrellia*		cg	burr			FALSE
150025	Muscidae		pr	spra	7.72	22.13	FALSE
150730	*Limnophora*		pr	burr	6.00		FALSE
152741	Hymenoptera		pr		8.00		FALSE
185976	*Serratella*	*serrata*	cg	clng	0.56	18.97	FALSE
185979	*Aeshna*	*interrupta*	pr	clim	7.99	19.17	TRUE
185987	*Epitheca*	*spinigera*	pr	clim			TRUE
186372	*Deronectes*	*griseostriatus*	pr				FALSE
189328	*Zavreliella*	*marmorata*	cg	burr		25.21	FALSE
193637	*Gymnochthebius*				2.98	21.34	FALSE
204785	*Fridericia*		cg	burr	6.00		FALSE
206620	*Acerpenna*	*pygmaea*	cg	swim	2.68	20.86	FALSE
206622	*Procloeon*		cg	swim	3.80	21.09	FALSE
206655	*Apedilum*		cg		6.00		FALSE

TSN	Name1	Name2	FFG	Habit	MN Tolerance	Coldwater Tolerance	LongLived
563956	*Nemata*						FALSE
568515	*Cricotopus (Isocladius)*		sh	clng	7.00		FALSE
568523	*Orthocladius (Symposiocladius)*		cg	spra			FALSE
568545	Leptohyphidae		cg				FALSE
568546	*Acerpenna*		cg	swim	2.68	20.86	FALSE
568550	*Diphetor*		cg	clim			FALSE
568551	*Fallceon*		sh	swim	10.00	22.54	FALSE
568552	*Labiobaetis*		cg	swim	6.00		FALSE
568553	*Plauditus*			swim	4.67	21.50	FALSE
568554	*Pseudocentroptiloides*		cg	clng			FALSE
568556	*Cercobrachys*		cg	spra			FALSE
568559	*Anthopotamus*		cg	burr	8.95	22.27	FALSE
568560	*Barbaetis*		cg	clng	7.47		FALSE
568574	*Acentrella*	*turbida*	cg	swim		20.96	FALSE
568598	*Diphetor*	*hageni*	cg	clim			FALSE
568601	*Fallceon*	*quilleri*	sh	swim		22.54	FALSE
568604	*Labiobaetis*	*dardanus*	cg	swim	6.00		FALSE
568605	*Labiobaetis*	*propinquus*	cg	swim	6.00		FALSE
568623	*Amercaenis*	*ridens*	cg	spra			FALSE
568627	*Caenis*	*youngi*	cg	spra		21.47	FALSE
568668	*Labiobaetis*	*frondalis*	cg	swim	6.00		FALSE
568671	*Acerpenna*	*macdunnoughi*	sh	swim	2.68	20.86	FALSE
568680	*Pseudocloeon*	*dardanum*	sc	swim		20.55	FALSE
568681	*Pseudocloeon*	*propinquum*	sc	swim		20.55	FALSE
568685	*Leptophlebia*	*bradleyi*	cg	swim		20.40	FALSE
568757	Uenoidae		sc	clng	0.00		FALSE
568817	*Ceratopsyche*	*ventura*	cf	clng	6.61	19.32	FALSE
568826	*Stictotarsus*		pr				FALSE
568954	*Desserobdella*	*picta*	pr	clim			FALSE
591727	Macromiinae		pr	spra			TRUE
592856	*Gomphus*	*fraternus*	pr	burr	6.00	21.09	TRUE
598162	Limnephiloidea						FALSE
598372	*Ylodes*		sh	swim			FALSE
603100	*Oecetis*	*furva*	pr		4.31	20.78	FALSE
603269	*Oecetis*	*testacea*	pr		4.31	20.78	FALSE
609530	*Acentrella*	*parvula*	cg	swim		20.96	FALSE
609583	*Pseudocentroptiloides*	*usa*	cg	clng			FALSE
609591	*Cercobrachys*	*etowah*	cg	spra			FALSE
609660	*Anthopotamus*	*myops*	cf	burr	8.95	22.27	FALSE
609662	*Anthopotamus*	*verticis*	cf	burr	8.95	22.27	FALSE

TSN	Name1	Name2	FFG	Habit	MN Tolerance	Coldwater Tolerance	LongLived
678385	Sphaeriusidae		hb				FALSE
678801	Donaciinae		sh	clng	6.00		FALSE
678851	Dytiscinae		pr	swim			FALSE
693963	Crambidae		sh		6.87	23.47	FALSE
697957	*Maccaffertium*		sc	clng	6.77	21.48	FALSE
698057	*Labiobaetis*	*longipalpus*	cg	swim	6.00		FALSE
698216	*Maccaffertium*	*exiguum*	sc	clng	6.77	21.48	FALSE
698222	*Maccaffertium*	*luteum*	sc	clng	6.77	21.48	FALSE
698232	*Maccaffertium*	*modestum*	sc	clng	6.77	21.48	FALSE
698241	*Maccaffertium*	*pulchellum*	sc	clng	6.77	21.48	FALSE
698255	*Maccaffertium*	*vicarium*	sc	clng	6.77	21.48	FALSE
698469	*Maccaffertium*	*mediopunctatum*	sc	clng	6.77	21.48	FALSE
698470	*Maccaffertium*	*mexicanum*	sc	clng	6.77	21.48	FALSE
698471	*Maccaffertium*	*terminatum*	sc	clng	6.77	21.48	FALSE
698515	*Maccaffertium*	*integrum*	sc	clng	6.77	21.48	FALSE
717547	*Aquarius*		pr	skat			FALSE
722295	*Sperchopsis*	*tessellata*					FALSE
728212	Agabinae		pr	swim			FALSE
728241	*Platambus*		pr	swim			FALSE
728249	*Heterosternuta*		pr	swim	7.82	20.13	FALSE
728251	*Nebrioporus*		pr	swim			FALSE
728252	*Neoporus*		pr	swim	10.00	20.50	FALSE
728253	*Sanfilippodytes*		pr	swim			FALSE
733321	Acari		pr	clng	7.00		FALSE
776922	*Sparbarus*		cg	spra			FALSE
776928	*Iswaeon*					21.29	FALSE
776935	*Acentrella*	*nadineae*	cg	swim		20.96	FALSE
776969	*Sparbarus*	*maculatus*	cg	spra			FALSE
776981	*Teloganopsis*	*deficiens*	cg	clng	3.00		FALSE
914204	Trepaxonemata						FALSE
974284	Naidinae		cg	burr	6.00		FALSE
974289	Tubificinae		cg	burr			FALSE

Appendix E: Taxonomic targets

The taxonomic targets vary by group depending on the feasibility and need for finer taxonomic resolution. There are two target levels currently used by the MPCA. The "IBI Taxonomic Target" is the taxonomic resolution needed for calculating the IBIs described in this document. The second is the "Current Taxonomic Target" and the taxonomic resolution currently used by the MPCA. Although not required for the IBIs in this document, subsequent revisions to the IBI models may require this finer taxonomic resolution. In addition, the finer resolution of the "Current Taxonomic Target" can be useful for other efforts such as stressor identification and thermal condition reviews.

Classification Group	Order	IBI Taxonomic Target	Current Taxonomic Target
Bivalvia		Genus	Genus
Gastropoda		Genus	Genus
Hydrozoa		Class	Class
Oligochaeta		Class	Family
Crustacea	Amphipoda	Genus	Genus
Branchiobdellida	Branchiobdellida	Order	Order
Coleoptera	Coleoptera	Genus	Genus
Crustacea	Decapoda	Genus	Genus
Insecta	Diptera	Genus	Genus
Insecta	Ephemeroptera	Genus	Species
Insecta	Hemiptera	Genus	Genus
Insecta	Hymenoptera	Genus	Genus
Isopoda	Isopoda	Genus	Genus
Insecta	Lepidoptera	Genus	Genus
Insecta	Neuroptera	Genus	Genus
Insecta	Odonata	Genus	Species
Insecta	Plecoptera	Genus	Species
Insecta	Trichoptera	Genus	Species
Nematoda		Phylum	Phylum
Nematomorpha		Phylum	Phylum
Acari		Subclass	Subclass
Hirudinea		Genus	Genus
Trepaxonemata		Class	Class

Appendix F: Macroinvertebrate IBI metric information

Table E1 – Metric information for Large River MIBI, stream types 1 and 2.

Metric Name	Metric Type	Target Group	Metric Calculation Description	Response	Transformation	Drainage Correction	Ceiling	Floor
Percent (%) Dominant Five Taxa	Relative Adundance	5 most abundant taxa	Relative abundance (%) of dominant five taxa in subsample (Chironomid genera treated individually)	increase	none	none	41.7	82.3
Hilsenhoff Biotic Index, MN TVs	Biotic Index	MN Tolerance, All Taxa	Abundance weighted average of each taxon using MN derived tolerance values.	increase	none	none	5.5	8.3
Intolerant Taxa	Richness	MN Tolerance <=4	Taxa richness of countable macroinvertebrates with tolerance values less than or equal to 4, using MN derived tolerance values	decrease	none	none	18.2	0
Odonata Taxa	Richness	Odonata Taxa	Taxa richness of countable Odonata taxa	decrease	none	none	5	0
Predator Taxa	Richness	FFG = Predator	Taxa richness of countable predator taxa	decrease	none	none	18.3	3.5
Total Taxa	Richness	All Taxa	Total taxa richness of all countable macroinvertebrates	decrease	none	none	57.6	24
Percent (%) Trichoptera-Hydropsychidae	Relative Adundance	Trichoptera, excluding Hydropsychidae	Relative abundance (%) of non-Hydropsychidae Trichoptera individuals in subsample	decrease	log10(x+1)	none	22.8	0
Percent (%) VeryTolerant	Relative Adundance	MN Tolerance >=8	Relative abundance (%) of macroinvertebrate individuals in subsample with tolerance values equal to or greater than 8, using MN derived tolerance values	increase	none	none	12.8	78.7

Table E2 – Metric Information for High Gradient Stream MIBI, stream types 3 and 5.

Metric Name	Metric Type	Target Group	Metric Calculation Description	Response	Transformation	Drainage Correction	Ceiling	Floor
Climber Taxa	Richness	Habit = Climber	Taxa richness of countable climber taxa	decrease	none	none	12.0	2.7
Clinger Taxa %	Relative Richness	Habit = Clinger	Relative richness of countable taxa adapted to cling to substrates in swift flowing water	decrease	none	none	46.0	20.0
Percent (%) Dominant Five Taxa	Relative Abundance	5 most abundant taxa	Relative abundance (%) of dominant five taxa in subsample (chironomid genera treated individually)	increase	none	none	38.2	78.2
Hilsenhoff Biotic Index, MN TVs	Biotic Index	MN Tolerance, All Taxa	Abundance weighted average of each taxon using MN derived tolerance values.	increase	none	none	4.9	8.3
Insect Taxa %	Relative Richness	Insect Taxa	Relative richness of countable insect taxa	decrease	arcsin(sqrt(x))	none	93.6	72.5
Odonata Taxa	Richness	Odonata Taxa	Taxa richness of countable Odonata taxa	decrease	log10(x+1)	none	5.0	0.0
Plecopotera Taxa	Richness	Plecoptera Taxa	Taxa richness of countable Plecoptera taxa	decrease	log10(x+1)	none	3.0	0.0
Predator Taxa	Richness	FFG = Predator	Taxa richness of countable predator taxa	decrease	none	none	16.0	3.0
Tolerant %	Relative Richness	MN Tolerance >=6	Relative richness (%) of macroinvertebrate individuals in subsample with tolerance values equal to or greater than 6, using MN derived tolerance values	increase	none	none	93.7	47.1
Trichoptera Taxa	Richness	Trichoptera Taxa	Taxa richness of countable Trichoptera taxa	decrease	noen	none	12.0	2.0

Table E3 – Metric information for Low Gradient Stream MIBI, stream types 4, 6, and 7.

Metric Name	Metric Type	Target Group	Metric Calculation Description	Response	Transformation	Drainage Correction	Ceiling	Floor
Climber Taxa	Richness	Habit = Climber	Taxa richness of countable climber taxa	Decrease	none	none	17.0	2.0
Percent (%) Collector-filterers	Relative Abundance	FFG = Filterer	Relative abundance (%) of collector-filterer individuals	Decrease	none	none	37.9	0.3
Percent (%) Dominant Five Taxa	Relative Abundance	5 most abundant taxa	Relative abundance (%) of dominant five taxa in subsample (chironomid genera treated individually)	Increase	none	none	43.2	90.8
Hilsenhoff Biotic Index, MN TVs	Biotic Index	MN Tolerance, all taxa	Abundance weighted average of each taxon using MN derived tolerance values.	Increase	none	none	5.8	8.8
Very Intolerant Taxa Richness	Richness	MN Tolerance <=2	Taxa richness of countable macroinvertebrates with tolerance values less than or equal to 2, using MN TVs	Decrease	log10(x+1)	none	3.0	0.0
POET Taxa	Richness	Plecoptera, Odonata, Ephemeroptera, and Trichoptera	Combined richness of countable taxa within the orders Plecoptera, Odonata, Ephemeroptera, & Trichoptera, with all Baetidae taxa treated at the family level	Decrease	none	none	16.0	2.0
Predator Taxa	Richness	FFG = Predator	Taxa richness of countable predator taxa	Decrease	none	none	18.0	4.0
Total Taxa	Richness	All taxa	Total taxa richness of all countable macroinvertebrates	Decrease	none	none	53.0	19.0
Trichoptera %	Relative Richness	Trichoptera Taxa	Relative richness of countable Trichoptera taxa	Decrease	none	none	16.4	0.0
Percent (%) Trichoptera-Hydropsy	Relative Abundance	Trichoptera, excluding Hydropsychidae	Relative abundance (%) of non-Hydropsychidae Trichoptera individuals in subsample	Decrease	log10(x+1)	none	10.8	2.0

Table E4 – Metric Information for Northern Coldwater Stream MIBI, stream type 8.

Metric Name	Metric Type	Target Group	Metric Description	Response	Transformation	Drainage Correction	Ceiling	Floor
Collector-Gatherer Taxa %	Relative Richness	FFG = Gatherer	Relative richness of countable collector-gatherer taxa	Increase	none	none	22.1	41.90
Hilsenhoff Biotic Index, MN TVs	Biotic Index	MN Tolerance, all taxa	Abundance weighted average of each taxon using MN derived tolerance values.	Increase	none	none	4.22	7.03
Very Intolerant Taxa Richness	Richness	MN Tolerance <=2	Taxa richness of countable macroinvertebrates with tolerance values less than or equal to 2, Using MN TVs	Decrease	none	none	12	0.00
Long-lived Taxa %	Relative Richness	LongLived = True	Relative richness of countable long-lived taxa	Decrease	none	none	26	6.00
Non-insect Taxa %	Relative Richness	Non-insect taxa	Relative richness of countable non-insect taxa	Increase	none	none	2.47	20.79
Odonata Taxa %	Relative Richness	Odonata Taxa	Relative richness of countable odonata taxa	Decrease	none	none	9.5	0.00
POET Taxa	Richness	Plecoptera, Odonata, Ephemeroptera, and Trichoptera	Combined richness of countable taxa within the orders Plecoptera, Odonata, Ephemeroptera, & Trichoptera, with all Baetidae taxa treated at the family level	Decrease	none	none	29	8.00
Predator Taxa Richness (excludes genus level Chironomidae)	Richness	FFG = Predator	Taxa richness of countable predator taxa (excluding Chironomidae predator taxa at the genus level)	Decrease	none	none	16	5.00
Very Tolerant Taxa %	Relative Richness	MN Tolerance >=8	Relative richness of countable taxa with tolerance values equal to or greater than 8, using MN TVs.	Increase	none	none	9.2	32.50

Table E5 – Metric Information for Southern Coldwater Stream MIBI, stream type 9.

Metric Name	Metric Type	Target Group	Metric Description	Response	Transformation	Drainage Correction	Ceiling	Floor
Coldwater Biotic Index	Biotic Index	CW Tolerance	Coldwater Biotic Index score based on coldwater tolerance values derived from Minnesota taxa/temperature data.	increase	none	slope = 0.579 constant = 17.923	-0.69	1.41
Chiro:Diptera	Ratio	Diptera taxa	Ratio of Chironomidae abundance to total Dipteran abundance.	increase	none	slope = 9.428 constant = 45.12	-40.33	37.59
Percent (%) Collector – Filterers	Relative Abundance	FFG = filterers	Relative abundance (%) of collector-filterer individuals in a subsample	decrease	none	none	53.41	7.36
Hilsenhoff Biotic Index, MN TVs	Biotic Index	MN Tolerance, all taxa	Abundance weighted average of each taxon using MN derived tolerance values.	increase	none	slope = 0.375 constant = 6.046	-0.58	1.04
Very intolerant Taxa Richness	Richness	MN Tolerance <=2	Taxa richness of macroinvertebrates with tolerance values less than or equal to 2, using MN TVs	decrease	none	none	3	0.00
Trichoptera Taxa %	Relative Richness	Trichoptera Taxa	Relative richness of countable trichoptera taxa	Decrease	none	none	23.74	6.27
Percent (%) Very Tolerant	Relative Abundance	MN Tolerance >=8	Relative abundance (%) of macroinvertebrate individuals in subsample with tolerance values equal to or greater than 8, using MN TVs.	increase	none	slope = 4.239 constant = 7.249	-10.28	35.77

Calibration of the biological condition gradient in Minnesota streams: a quantitative expert-based decision system

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Abstract: The Biological Condition Gradient (BCG) is a conceptual model that describes changes in aquatic communities with increasing levels of anthropogenic stress. The gradient represented by the BCG has been divided into 6 levels of condition that biologists consider readily discernible in most areas of North America. We developed quantitative BCG models for 7 warm-water stream types in Minnesota for both fish and macroinvertebrates. Panels of aquatic biologists calibrated the general BCG model to Minnesota streams by assigning test samples (271 macroinvertebrate and 288 fish samples) to BCG Levels 1 to 6. From the panelists' descriptions of their criteria for assigning sites to levels, a set of quantitative operational rules was developed for performing the same task. We developed a decision model based on fuzzy-set theory to account for discontinuities and to identify when BCG assignments might be intermediate between adjacent levels. This model captures the consensus professional judgment of the panel and uses panel-derived rules. Decisions based on the quantitative model for macroinvertebrates exactly matched 77% of the panel decisions, 89% within ½ BCG level, and 100% within 1 BCG level. Decisions based on the quantitative fish model exactly matched 70% of the panel decisions, 86% within ½ BCG level, and 99% within 1 BCG level. The BCG provides a tool to interpret aquatic biological condition along a gradient of naturalness and is consistent across stream types and political boundaries. It includes documentation of baselines to prevent inadvertent shifting, and the BCG logic rules are transparent, a desirable property for communicating condition, management goals, and water-quality criteria.

Key words: Biological Condition Gradient, decision model, fuzzy logic, expert system, Minnesota, benthic macroinvertebrates, fish, water quality management, streams

In many nations, policies developed to protect and maintain water quality include the concepts of biological and ecological quality, which are assessed on the basis of the ecological structure and function of living aquatic communities. The US Clean Water Act of 1972 (CWA) has the long-term objective of restoration and protection of chemical, physical, and biological integrity (US Code title 33, §1251 [a]; USEPA 2011). In the European Union (EU), the Water Framework Directive (WFD) has the similar objective of restoration and maintenance of 'good' or better ecological quality (e.g., Hering et al. 2010, EU Commission 2015). Both the US Environmental Protection Agency (EPA) and the EU have made efforts to define what was meant by 'biological integrity' (USA) and 'high', 'good', 'fair', 'poor', and 'bad' condition (EU). In the USA, biological integrity has come to mean "The ability of an aquatic ecosystem to support and maintain a balanced, integrated and adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of natural habitats within a region" (Frey 1977, Karr and Dudley 1981). In the EU, high ecological quality is defined as the ecological condition occurring under "no or very low human pressure" and is accepted as the reference condition (EU Commission 2015). Good through bad condition are

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defined as successively increasing deviation from high or reference status (Hering et al. 2010). Both systems use natural condition with no or minimal human influence as a benchmark.

To meet the goals of the CWA and WFD, ecologically consistent interpretations of biological condition are needed to allow definition of thresholds of condition for assessment, restoration, and management. The definitions must be specific, well-defined, and must allow for waters of different natural quality and different desired uses. In the USA, the EPA developed a conceptual model—the Biological Condition Gradient (BCG)—that describes ecological changes from pristine to severely degraded that occur in flowing waters with increased anthropogenic degradation (Davies and Jackson 2006). The BCG was designed to provide a way to map different indicators on a common scale of biological condition to facilitate comparisons among programs and across jurisdictional boundaries. The original BCG is a conceptual, narrative model that describes how biological attributes of aquatic ecosystems change along a gradient of increasing anthropogenic stress (Fig. 1) and provides a framework for understanding current conditions relative to natural, undisturbed conditions (Davies and Jackson 2006, USEPA 2016).

US states, EU member states, and academics and environmental agencies worldwide have developed technical approaches and indexes to assess the biological condition of water bodies. In recent years, most approaches have been variations on the multimetric Index of Biotic Integrity (IBI; Karr et al. 1986, Whittier et al. 2007, Pont et al. 2009) or multivariate interpolations of reference-site species composition (River Invertebrate Prediction and Classification System; RIVPACS; e.g., Hawkins et al. 2000, Simpson and Norris 2000, Wright 2000). These indexes rely on empirical, present-day reference conditions quantified from existing reference sites to anchor their measurement systems. They require 'minimally disturbed' reference sites that are representative of biological integrity (Stoddard et al. 2006). However, in practice, most reference site data sets consist of 'least-disturbed' sites, which are the best remaining sites. The distinction between minimally disturbed and least-disturbed is important: minimally disturbed denotes fully natural biological conditions indistinguishable from pre-industrial or pre-European settlement, whereas least-disturbed denotes an upper quantile of contemporary conditions (Stoddard et al. 2006). Most indexes are built from a statistically adequate sample of least-disturbed (best available) reference sites, so that 1 or 2 minimally disturbed (near-pristine) sites in a reference data set may be treated as statistical outliers and may have little influence on index scoring. In the situation where no reference sites meet minimally disturbed criteria, the best score of this index would be similar to the moderately disturbed reference sites and could be substantially degraded from the natural condition. This situation is an example of the 'shifting baseline syndrome', such that the ideal reference or condition changes over generations as memory of previous baselines is lost (e.g., Pauly 1995, Dayton et al. 1998).

Part of the BCG process is to build a description of a fixed baseline based on either minimally disturbed conditions (Stoddard et al. 2006) or a fixed, agreed-upon point in time. The initial description is based on professional judgment, but as the BCG approach becomes accepted, the professional judgment should be replaced or enhanced

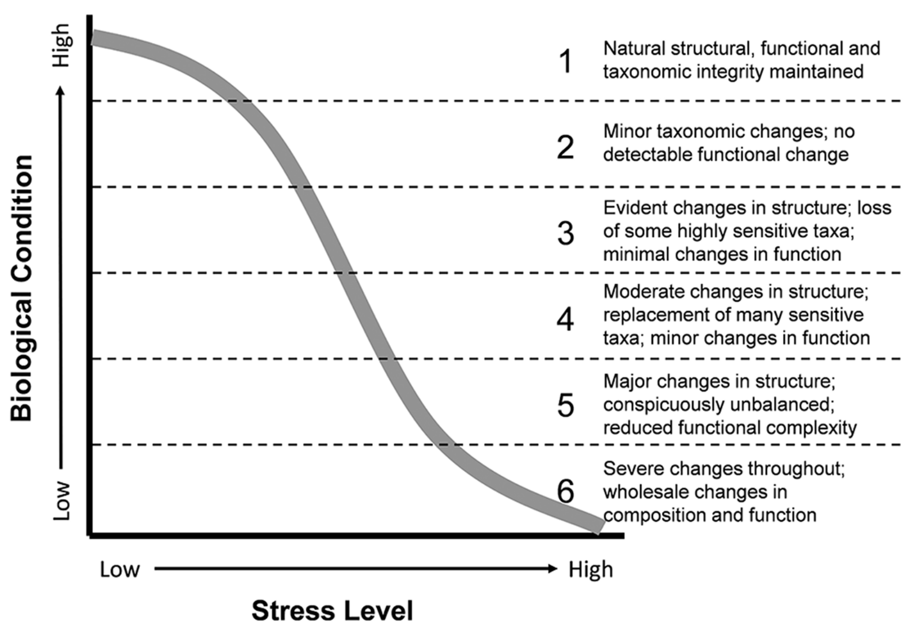

Figure 1. Graphic representation of the Biological Condition Gradient conceptual model (modified from Davies and Jackson 2006).

with documented information: historical descriptions, paleo investigations, museum records, and information from documented minimally disturbed sites. The description of minimally disturbed is necessarily incomplete, but its documentation is a defense against future inadvertent baseline shifts. Careful use of the BCG would identify a natural or historic baseline that could be used to guard against shifting baseline syndrome. For regions or situations where all information on natural baseline is irretrievably lost, the BCG could assist in identifying an 'Anthropocene baseline' for restoration and management (Kopf et al. 2015).

The quantitative BCG development was published by the USEPA (2016) based on case studies from the preceding decade. The methods have matured and experience gained has shown that a quantitative BCG has several desirable properties for use in water-quality management:

1. *Universal interpretive scale based on biologically meaningful changes* The original intent of the BCG was to create a scale with uniform interpretation across political and administrative jurisdictions (Davies and Jackson 2006). This intent was in response to the risk that use of different biological indexes and thresholds might result in contrary interpretations among states, wherein one state might call a cross-border stream impaired, but a neighboring state might not.
2. *Documented defense against shifting baselines* BCG values and thresholds are designed to defend against shifting baselines by including a description of undisturbed conditions. Any index or assessment method can include a documented baseline, but many indexes have been built empirically with data from 'least-stressed' reference sites (Stoddard et al. 2006). The BCG is independent of sometimes arbitrary percentiles of empirical reference populations. In the USA, management criteria consisting of the 50th, 25th, 10th, 5th, and 0th percentiles of reference distributions have all been proposed by states and advocacy groups.
3. *A transparent decision system with stated rules* The quantitative BCG method consists of documented decision rules and, therefore, is transparent. Rules can be changed, but changes are conscious and deliberate and cannot result from additions or deletions in a database. The decision system provides a bridge between ecological science and value-based management. BCG levels can be adopted directly as management goals, restoration goals, or regulatory (protective) criteria.
4. *Flexibility* A quantitative BCG model can be used as a stand-alone assessment index, or cross-walked to other existing indexes to provide ecological interpretation and identify management thresholds (Bouchard et al. 2016).

Here, we explain the calibration of a quantitative assessment model in the framework of the BCG. We use as an example the development of the model for warm-water streams and rivers of the state of Minnesota, USA, for benthic macroinvertebrate and fish assemblages (original report: Gerritsen et al. 2013).

METHODS

BCG primer

Biologists from across the USA developed the BCG conceptual model and agreed that a similar sequence of biological alterations occurs in streams in response to increasing stress, even in different geographic regions (Davies and Jackson 2006). The BCG is divided into 6 levels of biological condition along the stressor–response curve. Levels range from observable biological conditions found at no or low levels of stress (Level 1) to those found at the highest levels of stress (Level 6) (Fig. 1, Table 1). The 6 levels of the BCG are convergent with the 5 ecological status conditions defined in the EU WFD. The BCG levels were described in greater detail by Davies and Jackson (2006).

The BCG uses 10 attributes of aquatic ecosystems that change in response to increasing levels of stress along the gradient to describe the 6 levels (Table 2). The attributes include aspects of community structure, organism condition, ecosystem function, spatial and temporal attributes of stream size, and connectivity and are used as indicators of condition. The BCG was developed originally based on forested streams of eastern North America as examples (Davies and Jackson 2006), but the model has been applied to other regions and water bodies by calibrating it to local conditions on the basis of specific expertise and local data. Several US states, tribes, and territories are calibrating BCG-based indexes based on the first 7 attributes that characterize the biotic community, primarily tolerance to stressors, presence/absence of native and nonnative species, and organism condition (Table 2). BCG models have been developed for streams, lakes, estuaries, and coral reefs and biological assemblages including fish, benthic macroinvertebrates, and diatoms (summarized by USEPA 2016; Gerritsen and Leppo 2005, Stamp and Gerritsen 2012, Hausmann et al. 2016, Santavy et al., in press).

Approach

Our approach for BCG model development is based on professional judgment and development of consensus. Professional consensus has a long pedigree in the medical field, including the National Institutes of Health (NIH) Consensus Development Conferences to recommend best practices for diagnosis and treatment of diseases (http://consensus.nih.gov/). The NIH consensus meetings were a "hybrid of . . . judicial decision-making, scientific conferences and the town hall meeting" (Nair et al. 2011). Other researchers, institutes, and countries also develop medical consensus statements using NIH methods (Nair et al. 2011).

Table 1. Descriptions of Biological Condition Gradient levels (modified from Davies and Jackson 2006).

BCG level	Description
Level 1: Natural or native condition	Native structural, functional, and taxonomic integrity is preserved; ecosystem function is preserved within the range of natural variability. Level 1 represents biological conditions as they existed (or may still exist) in the absence of measurable effects of stressors.
Level 2: Minimal changes in structure of the biotic community and minimal changes in ecosystem function	Virtually all native taxa are maintained with some changes in biomass or abundance; ecosystem functions are fully maintained within the range of natural variability. Level 2 represents the earliest changes in densities, species composition, and biomass that occur as a result of slight elevation in stressors (such as increased temperature regime or nutrient enrichment).
Level 3: Evident changes in structure of the biotic community and minimal changes in ecosystem function	Evident changes in structure caused by loss of some highly sensitive native taxa; shifts in relative abundance of taxa but sensitive-to-ubiquitous taxa are common and abundant; ecosystem functions are fully maintained through redundant attributes of the system. Level 3 represents readily observable changes that, e.g., can occur in response to organic enrichment or increased temperature.
Level 4: Moderate changes in structure of the biotic community with minimal changes in ecosystem function	Moderate changes in structure caused by replacement of some intermediate-sensitive taxa by more tolerant taxa, but reproducing populations of some sensitive taxa are maintained; overall balanced distribution of all expected major groups; ecosystem functions largely maintained through redundant attributes.
Level 5: Major changes in structure of the biotic community and moderate changes in ecosystem function.	Sensitive taxa are markedly diminished; conspicuously unbalanced distribution of major groups from those expected; organism condition shows signs of physiological stress; ecosystem function shows reduced complexity and redundancy; increased build-up or export of unused materials. Changes in ecosystem function (as indicated by marked changes in foodweb structure and guilds) are critical in distinguishing between Levels 4 and 5.
Level 6: Severe changes in structure of the biotic community and major loss of ecosystem function	Extreme changes in structure; wholesale changes in taxonomic composition; extreme alterations from normal densities and distributions; organism condition is often poor; ecosystem functions are severely altered. Level 6 systems are taxonomically depauperate (low diversity or reduced number of organisms) compared to the other levels.

Experts define BCG levels in the context of the conceptual model (Davies and Jackson 2006). They determine the attributes and the changes in those attributes that characterize distinct BCG levels and signal shifts to a different level (Tables 1, 2). The BCG consensus approach asks the experts to make judgments on the biological significance of changes in the attributes. Thus, a fundamental assumption of this approach is that consensus professional judgment is the best current estimate of biological condition. The outcome of the process is a multiple-attribute decision model that mimics the consensus decisions based on a set of quantitative rules. The logic train of the decision model and the experts' documented reasoning create a transparent decision system for review, modification, and water-quality management.

Index calibration begins with the assembly and analysis of biological monitoring data and identification of stress–response relationships for individual taxa. During one or more calibration workshops, experts familiar with local conditions and biota use the data to develop narrative decision rules for assigning sites to a BCG level. Panelists assign relevant taxa to BCG attributes (Table 2). Next, they examine biological data from selected sites, describe the native aquatic assemblages under natural conditions, and assign the samples to Levels 1 to 6 of the BCG. The intent is to achieve consensus and to identify rules that experts use to make their assignments. Experts' opinions are elicited and documented to assist in quantitative rule development.

Over the long term, reconvening the same group of experts for every new sample is impractical. Thus, use of a quantitative BCG in routine monitoring and assessment requires a way to automate the consensus expert judgment. The decision criteria are codified into a quantitative decision model, which is a transparent, formal, and testable method for documenting and validating expert knowledge.

For over a decade, the Minnesota Pollution Control Agency (MPCA) has been using fish and benthic macroinvertebrate assemblage data to assess water resource quality. Until recently, biological indexes in Minnesota were developed for individual drainage basins (e.g., Niemela et al. 1999). The MPCA used data from 2285 fish and 1502 macroinvertebrate samples to develop statewide fish and macroinvertebrate IBIs following the approach published by Whittier et al. (2007). Descriptions of these IBIs can be found in MPCA (2014b, c). The BCG calibration we describe here relies heavily on the knowledge and experience gained from Minnesota's IBI developments, and addresses MPCA's ob-

Table 2. Attributes used to characterize the Biological Condition Gradient (BCG) (modified from Davies and Jackson 2006).

Attribute	Description
	Attributes I–V: Native structure and composition
I. Historically documented, sensitive, long-lived, or regionally endemic taxa	Taxa known to have been supported according to historical, museum, or archeological records, or taxa with restricted distribution (occurring only in a locale as opposed to a region), often because of unique life-history requirements (e.g., sturgeon, American Eel, pupfish, unionid mussel species)
II. Highly sensitive (typically uncommon) taxa	Taxa that are highly sensitive to pollution or anthropogenic disturbance; tend to occur in low numbers, and many are specialists for habitats and food type; the first to disappear with disturbance or pollution (e.g., most stoneflies, Brook Trout [in the eastern USA], Brook Lamprey)
III. Intermediate sensitive and common taxa	Common taxa that are ubiquitous and abundant in relatively undisturbed conditions but are sensitive to anthropogenic disturbance/pollution; have a broader range of tolerance than attribute II taxa and can be found at reduced density and richness in moderately disturbed sites (e.g., many mayflies, many darter fish species)
IV. Taxa of intermediate tolerance	Ubiquitous and common taxa that can be found under almost any conditions, from undisturbed to highly stressed sites; broadly tolerant but often decline under extreme conditions (e.g., filter-feeding caddisflies, many midges, many minnow species)
V. Highly tolerant taxa	Taxa that typically are uncommon and of low abundance in undisturbed conditions but increase in abundance in disturbed sites; opportunistic species able to exploit resources in disturbed sites; the last survivors (e.g., tubificid worms, Black Bullhead)
VI. Nonnative or intentionally introduced species	Any species not native to the ecosystem (e.g., Asiatic clam, Zebra Mussel, carp, European Brown Trout); in addition, many fish native to one part of North America introduced elsewhere
VII. Organism condition	Anomalies of the organisms; indicators of individual health (e.g., deformities, lesions, tumors)
VIII. Ecosystem function	Processes performed by ecosystems, including primary and secondary production, respiration, nutrient cycling, decomposition, their proportion/dominance, and what components of the system carry the dominant functions (e.g., shift of lakes and estuaries to phytoplankton production and microbial decomposition under disturbance and eutrophication)
IX. Spatial and temporal extent of detrimental effects	The spatial and temporal extent of cumulative adverse effects of stressors (e.g., groundwater pumping in Kansas led to change in fish composition from fluvial-dependent to sunfish)
X. Ecosystem connectivity	Access or linkage (in space/time) to materials, locations, and conditions required for maintenance of interacting populations of aquatic life; the opposite of fragmentation (e.g., levees restrict connections between flowing water and floodplain nutrient sinks, dams impede fish migration, spawning)

jective to develop statewide biological criteria for streams within Minnesota.

Aquatic biologists familiar with Minnesota streams met as a work group to develop the ecological attributes and rules for assigning sites to levels. Their expertise included aquatic ecology, benthic macroinvertebrate sampling and monitoring, water quality, and fisheries biology. We summarize here the results of BCG calibration for warm-water streams in Minnesota (Gerritsen et al. 2013. A 2nd multi-state and multi-tribal effort to develop a BCG calibration for cold water streams of the Upper Midwest was reported by Gerritsen and Stamp (2013).

Data

When the models were developed, the MPCA had collected >3800 fish and >2800 macroinvertebrate samples from warm-water streams (1996–2011). Minnesota's biological assessment program was assessed in 2015 (USEPA 2013) and was deemed sufficient to support development and implementation of biological monitoring tools (MBI 2015).

A fish sampling reach is defined as 35× mean stream width. This length is sufficient to capture a representative and repeatable sample of the fish assemblage in a stream segment (Lyons 1992, MPCA 2014d). Sampling is conducted during daylight hours in the summer index period (mid-June–mid-September). Streams are sampled during or near base flow because floods or droughts can affect fish assemblage structure and sampling efficiency. All habitat types within the sampling reach are sampled in approximate proportion to their occurrence to capture fish ≥25 mm in total length. Four electrofishing methods are used: backpack electrofisher in small headwater streams; towed stream electrofisher in larger wadeable streams; mini-boom electrofisher (2-person jon boat) in small, nonwadeable streams;

and a boat-mounted boom electrofisher in large streams and rivers. For detailed fish sampling methods see MPCA (MPCA 2014d). Fish sampling is repeated at 10% of the sample reaches during the index period to estimate measurement error.

A multihabitat method is used to obtain a representative sample of the macroinvertebrate assemblage of a reach. Habitats sampled include hard bottom (riffle/cobble/boulder), aquatic macrophytes (submerged/emergent vegetation), undercut banks (undercut banks/overhanging vegetation), snags (snags/rootwads), and leaf packs. Twenty D-frame dipnet (500-µm mesh) sweeps are divided equally among the dominant, productive habitats present in the reach. Each sweep covers ~0.09 m^2 of substrate for a total area sampled of ~1.8 m^2. Collections are randomly subsampled to a target subsample of 300 individuals and identified to genus. Macroinvertebrate collection standard operating procedures (SOPs) were described fully by the MPCA (MPCA 2014e). Macroinvertebrate sampling is repeated at 10% of the sample reaches on the same day to estimate measurement error.

Measurement error (sample variability) was not estimated as part of this project, but Minnesota's sampling and analysis methods are comparable to those used by EPA in national aquatic surveys (e.g., Stoddard et al. 2008). Other studies of similar methods have shown variability of indexes to be low and consistent for repeated samples within and among years (e.g., Hose et al. 2004, Barbour and Gerritsen 2006, Huttunen et al. 2012).

Classification

Classification of aquatic habitats is necessary to account for natural variability so that the experts can place a stream in context of its setting. Panelists involved in some early attempts to develop a quantitative BCG struggled in the absence of a classification scheme understood by the panel and appropriate for the data set (USEPA 2016). Most panels have preferred a primarily typological classification (e.g., ecoregions), but continuous classifiers, such as catchment area, stream gradient, and elevation, have been used successfully.

The MPCA developed a classification system for natural stream communities to support the development of typological IBI models (MPCA 2014b, c). The stream types were based on distributions of species among classification variables that are not influenced by anthropogenic effects. The classification system for warm-water streams was developed with the same data set used to develop the IBIs and consisted >2200 fish and 1500 macroinvertebrate samples collected from 1996 through 2008. Biological communities and predictive variables were identified with the aid of several tools including: hierarchical cluster analysis, nonmetric multidimensional scaling, and Mean Similarity Analysis (Van Sickle 1998, Van Sickle and Hughes 2000). This process resulted in 7 warm-water stream types each for the fish and the benthic macroinvertebrate communities based on: 1) ecoregion, 2) sampling method, 3) drainage area, and 4) stream gradient (Table 3). Fish and macroinvertebrate stream types follow a similar regional pattern, but they do not match. For example, invertebrate riffle–run and glide–pool habitats may occur in both wadeable and headwater streams as defined for fish sampling. Geographic delineations included northern or southern Minnesota and forest or prairie. The remaining classes were defined by sampling method (e.g., riffle–run vs glide–pool for macroinvertebrates).

Preliminary analysis: stress–response and BCG attributes

The MPCA developed a disturbance index called the Human Disturbance Score (HDS) based on the degree of human activity in the upstream watershed and at the reach level for biological monitoring sites (Bouchard et al. 2016, MPCA 2016). The HDS includes 8 primary metrics, which consist of measures of watershed land use, stream alteration, riparian condition, and known permitted discharges.

Table 3. Final Minnesota Pollution Control Agency (MPCA) classifications of warm-water stream types for fish and macroinvertebrates, and number of samples with valid data in each. The 2 river classes correspond between fish and macroinvertebrates, but the wadeable stream classes do not correspond.

Fish stream type		Macroinvertebrate stream type	
Name	*N*	Name	*N*
Northern rivers	358	Northern forest rivers	125
Southern rivers	525	Prairie and southern forest rivers	155
Northern streams	523	Northern forest streams, high-gradient	271
Northern headwaters	706	Northern forest streams, low-gradient	425
Southern streams	665	Southern streams, high-gradient	445
Southern headwaters	638	Southern forest streams, low-gradient	396
Low-gradient streams	313	Prairie streams, low-gradient	617

HDS scores can range from 1 (heavily altered watersheds) to 81 (nearly pristine watersheds).

Stress-response models

BCG composition attributes II through V (Table 2) are familiar tolerance designations (e.g., Merritt et al. 2008) applied in many IBI and multimetric indexes. Published tolerance values are often 'received wisdom' originally estimated from different regions (Carlisle et al. 2007), so we augmented the published values with analysis of the MPCA data to estimate tolerances from the local data. We used general linear models (GLMs) to estimate the probability of observing a particular taxon across the HDS score. The optimum of the model (maximum probability) yielded the tolerance value. We plotted the capture probabilities over the range of the disturbance gradient (Figs 2–5).

Assign taxa to attributes

Assignments of taxa to attributes relied on a combination of the empirical data analysis (Figs 2, 3A, B, 4A, B, 5A, B), published values, and professional experience of the expert panels (Tables 4, 5). HDS is not a perfect measurement of stressors in a stream reach because it is a general predictor of disturbance. It provided an a priori general stressor gradient that is associated with taxon abundance and probability of occurrence to assist the panel in assigning the BCG attributes. The use of empirical data, published tolerances, ecological theory, and professional experience minimizes the effect of noise in the HDS during BCG development.

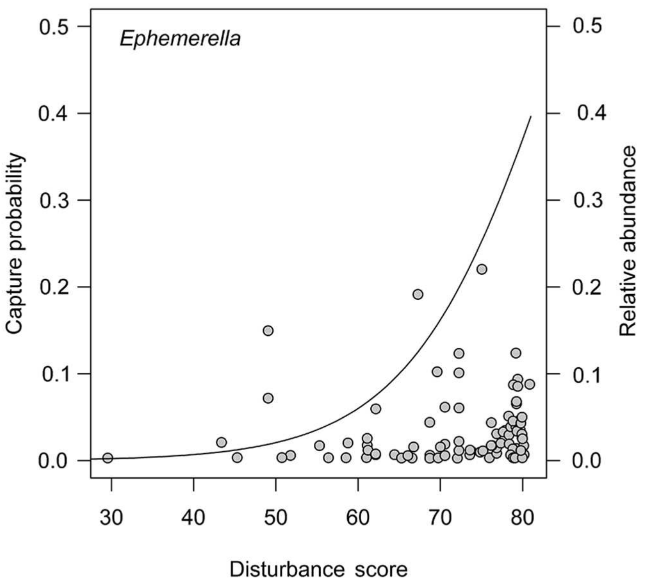

Figure 2. Disturbance score and *Ephemerella* occurrence in stream samples. Circles show observations and relative abundance of *Ephemerella* (right axis); curve shows probability of occurrence (left axis; maximum likelihood). *Ephemerella* was assigned to Biological condition Gradient (BCG) attribute II (highly sensitive taxa), as shown by its high abundance and high probability of occurrence in minimally disturbed sites (disturbance score 81). See Table 2 for BCG attributes.

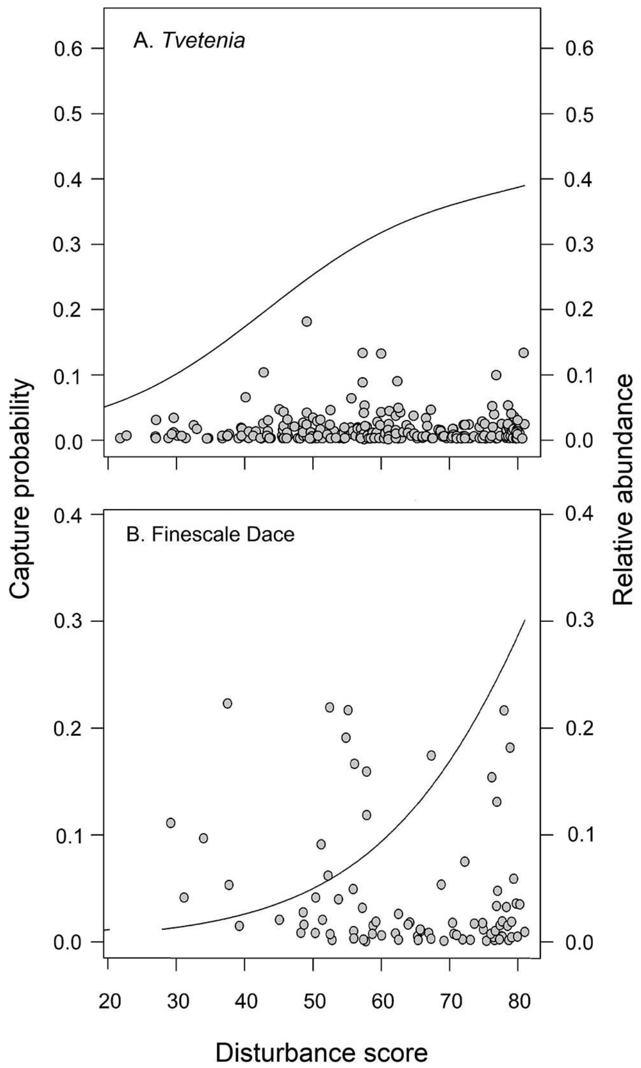

Figure 3. Examples of Biological Condition Gradient (BCG) attribute III taxa *Tvetenia* (A) and Finescale Dace (B). These species occur throughout the disturbance gradient, but with higher probability in better sites. Final attribute assignment was based on these plots and on professional judgment of the panel. See Table 2 for BCG attributes.

For taxa with a sufficient sample, the capture probabilities and, to a lesser extent, the observed abundances followed the expectations given by the attribute descriptions (Table 2, Figs 2, 3A, B, 4A, B, 5A, B). In cases of disagreement, the panel relied on consensus professional opinion unless contradicted by an overwhelming response in the data analysis.

The fish panel identified 2 additional subclasses of the attributes 'tolerant species' and 'nonnative species'. They identified highly tolerant native species (attribute Va) as the last survivors in a degraded stream and divided the

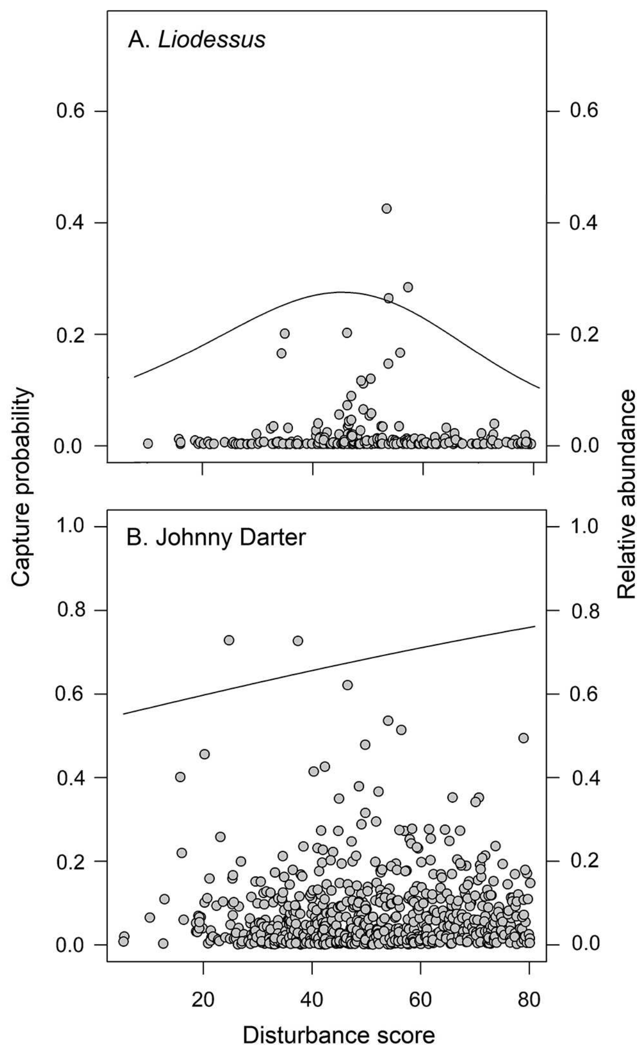

Figure 4. Examples of intermediate tolerant, Biological Condition Gradient (BCG) attribute IV taxa *Liodessus* (A) and Johnny Darter (B). These species occur throughout the disturbance gradient with roughly equal probability throughout or with a peak in the middle of the disturbance range. See Table 2 for BCG attributes.

nonnative group into sensitive nonnative species (attribute VI, e.g., nonnative salmonids) and tolerant nonnatives (attribute VIa; e.g., Common Carp, Ruffe; Table 5).

Assign sites to BCG levels

The panels examined data from selected monitoring sites and assigned the sites to levels of the BCG based on the taxa present in the sample and the generic descriptions of BCG levels (Table 1). The data included lists of taxa and abundances, BCG attribute groups assigned to the taxa, summary metrics, and limited site information, such as stream type and ecoregion, sampling method, and substrate. Stream location, water quality, and MPCA's disturbance score were not revealed to panel members because doing so might have biased assignments. Panel members discussed the species composition, what they expected to see for each level of the BCG, and then assigned samples to BCG levels. The work groups examined macroinvertebrate data from 271 samples (7 stream types), and fish data from 288 samples (7 stream types).

Quantitative description

In the discussions of BCG assignments, facilitators elicited panelist's reasoning for their decision; e.g., "I expect to see more stonefly taxa in a BCG Level-2 site." The reasoning formed the basis to formalize the expert knowledge by codifying level descriptions into a set of rules (e.g., Droesen 1996).

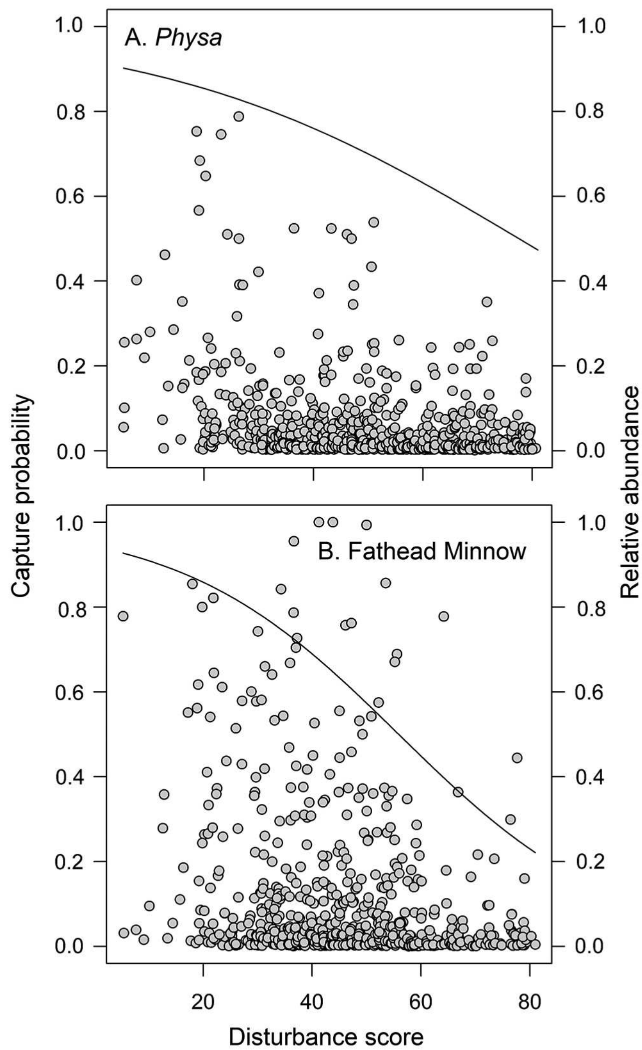

Figure 5. Examples of tolerant taxa, *Physa* (Biological Condition Gradient [BCG] attribute V; tolerant) (A) and Fathead Minnow (BCG attribute Va; highly tolerant) (B). These species occur throughout the disturbance gradient, but with higher probability of occurrence and higher abundances in more stressed sites. See Table 2 for BCG attributes.

Table 4. Examples of macroinvertebrate taxa by Biological Condition Gradient (BCG) attribute group. Assignment to attribute varied between habitats (glide–pool and riffle–run) for some taxa, so number of taxa represents the range of the number of genera assigned to the attribute group among glide–pool and riffle–run stream types.

BCG attribute	Number of taxa	Example taxa
I Endemic, rare	1	*Goera*
II Highly Sensitive	29–41	*Stempellina*, *Heleniella*, *Ephemerella*, *Paraleuctra*, *Ophiogomphus*, *Parapsyche*, *Diplectron*,, *Lepidostoma*, *Dolophilodes*, *Rhyacophila*
III Intermediate Sensitive	107–148	*Diamesa*, *Tvetenia*, *Hexatoma*, *Plauditus*, *Parapoynx*, *Isoperla*, *Boyeria*, *Amphinemura*, *Pycnopsyche*, *Brachycentrus*, *Limnephilus*
IV Intermediate Tolerant	201–231	Dytiscidae, Ceratopogonidae, *Polypedilum*, *Limonia*, *Perlesta*, *Heptagenia*, *Libellula*, *Hydropsyche*, *Sphaerium*, *Planorbella*
V Tolerant	25–41	Erpobdellidae, *Cricotopus*, *Pseudocloeon*, Corixidae, *Enallagma*, *Caecidotea*, Physidae
VI Nonnative	1	*Corbicula*
x Unassigned	20	Family identifications or unusual taxa; *Chaoborus*, *Zavrelia*, *Didymops*, Nemata

Rule development required discussion and documentation of BCG-level assignment decisions and the reasoning behind the decisions. During this discussion, we recorded: 1) each participant's decision ('vote') for the site; 2) the critical or most important information for the decision, e.g., the number of taxa of a certain attribute, the abundance of an attribute, the presence of indicator taxa; and 3) confounding or conflicting information and how the conflict was resolved for the eventual decision.

After initial site assignment and rule development, we estimated descriptive statistics of the attributes and other biological indicators for each BCG level determined by the panel. These descriptions assisted in review of the rules and their iteration for testing and refinement. The first 2 panel sessions were in-person, 3-d workshops, and subsequent panel sessions were by webinar. The initial panel decisions comprised a preliminary set of decision rules. We quantified the rules in Excel® (versions 2003–2013; Microsoft, Redmond, Washington) workbooks, and calculated BCG level assignments for each sample. We evaluated model performance by comparing model-assigned BCG levels to the panel assignments. Following the initial development phase, the panel tested the draft rules with new data to ensure that new sites were assessed in the same way. Any remaining ambiguities and inconsistencies from the first iterations were resolved.

Table 5. Examples of fish taxa by Biological Condition Gradient (BCG) attribute group. Assignment to attribute varied among stream types for some species, so number of taxa represents the range of the number of species assigned to the attribute group among 7 stream types.

BCG attribute	Number species	Example species
I Endemic, rare	1–9	Blue Sucker, Crystal Darter, Gilt Darter, Greater Redhorse, Lake Sturgeon, Pugnose Shiner, River Redhorse, Shovelnose Sturgeon, Topeka Shiner
II Highly sensitive	6–17	American Brook Lamprey, Blackchin Shiner, Brook Trout, Southern Brook Lamprey, Western Sand Darter
III Intermediate sensitive	15–35	Blacknose Shiner, Burbot, Golden Redhorse, Hornyhead Chub, Shorthead Redhorse, Smallmouth Bass
IV Intermediate tolerant	26–43	Common Shiner, Gizzard Shad, Johnny Darter, Northern Pike, Spotfin Shiner, White Sucker[a]
V Tolerant	5–18	Creek Chub, Brassy Minnow, Brook Stickleback, Central Stoneroller, Sand Shiner
Va Highly tolerant	7–8	Bigmouth Shiner, Bluntnose Minnow, Fathead Minnow, Green Sunfish
VI Sensitive nonnative	3	Brown Trout, Rainbow Trout, Chinook Salmon
VIa Tolerant nonnative	4	Common Carp, Goldfish, Ruffe, Threespine Stickleback
x unassigned	2	Unidentified fish, hybrids

[a] White Sucker is identified tolerant (attribute V) in wadeable streams only.

BCG inference models

The decision models calculated BCG levels directly from the quantified rules by applying fuzzy logic (Zadeh 1965, 2008). Instead of a statistical prediction of expert judgment, this approach directly and transparently converts the expert consensus to automated site assessment. Fuzzy logic is "a precise logic of imprecision and approximate reasoning" (Zadeh 2008). It is directly applicable to environmental assessment and has been used extensively in engineering and environmental applications worldwide (e.g., Castella and Speight 1996, Ibelings et al. 2003, Demicco and Klir 2004, Cheung et al. 2005, Joss et al. 2008).

Fuzzy logic and set theory allows degrees of truth, in contrast to binary truth in classical logic and set theory. For example, one can compare how classical set theory and fuzzy-set theory treat classification of sediment, where sand is defined as particles ≤2.0 mm diameter and gravel is >2.0 mm (Klir 2004). In classical 'crisp' set theory, a particle with diameter = 2.00 mm is classified as sand, and one with diameter = 2.01 mm is classified as gravel. In fuzzy-set theory, both particles have nearly equal membership in both classes (Klir 2004). Measurement error as small as 0.005 mm greatly increases the uncertainty of classification in classical set theory, but in fuzzy-set theory a particle near the boundary would have nearly equal membership in both sets (sand and gravel). Thus, fuzzy sets retain the understanding and knowledge of measurements close to a set boundary, which is lost in classical sets. For further explanation of fuzzy logic, see Klir (2004) or any online tutorial.

To develop the fuzzy inference model, each linguistic variable (e.g., high taxon richness) is defined quantitatively as a fuzzy set (e.g., Klir 2004). A fuzzy set has a membership function in the range of 0 to 1 that determines whether an object is in the set or not in the set. Example membership functions of different sets of taxon richness are shown in Fig. 6A, B. We used piecewise linear functions (i.e., functions consisting of line segments) to assign membership values. If the number of taxa is less than or equal to the lower threshold it has membership of 0, if the number of taxa is greater than or equal to an upper threshold it has membership of 1, and if the number of taxa is between the thresholds, the membership is assigned using a linear interpolation between the lower and upper thresholds. For example, a sample with 30 total taxa would have a membership of ~0.5 in the set 'Moderate number of taxa' and a membership of 0.5 in the set 'High number of taxa' (Fig. 6A).

Assigning membership on the basis of fuzzy-set theory is different from doing so on the basis of classical set theory. Suppose 2 rules determine whether a water body is BCG Level 3: 1) the number of total taxa is high and 2) the number of sensitive taxa is moderate or higher (shaded areas in Fig. 6A, B). If both rules must be true, they are combined with the Boolean AND operator. In fuzzy-set theory, the Boolean AND operator is equivalent to the minimum membership given by each rule: Level 3 = MIN (total taxa is high, sensitive taxa is moderate or higher). For 32 total taxa and 7 sensitive taxa, fuzzy membership in total taxa is high = 0.6 (Fig. 6A), and fuzzy membership in sensitive taxa is low-moderate to moderate = 0.4 (Fig. 6B). Membership of BCG Level 3 is then 0.4, indicating that the site is "somewhat like Level 3 sites, but not overwhelmingly"; i.e., it is borderline. In the fuzzy-set case, a single additional sensitive taxon raises the membership in BCG Level 3 from 0.4 to 0.6, indicating it is somewhat more like Level 3, but still borderline. In classical set theory, the boundaries of the categories in Fig. 6A, B would be vertical lines. A sample with 7 sensitive taxa would be deemed not in Level 3, but a sample with 8 sensitive taxa would be deemed in Level 3.

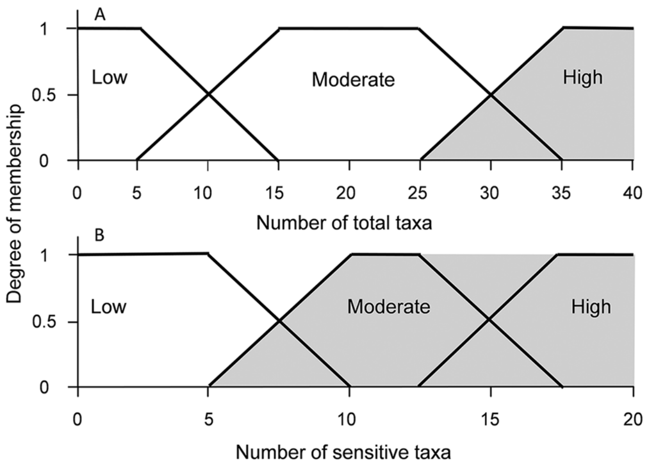

Figure 6. Fuzzy-set membership functions assigning linguistic values to defined ranges for total taxa (A) and sensitive taxa (B). Shaded regions correspond to example rules for Biological Condition Gradient Level 3: "number of total taxa is high" and "number of sensitive taxa is moderate or greater."

If the 2 rules are combined with an OR operator, then either can be true for a site to meet BCG Level 3. In words, we would say, "BCG Level is 3 if total taxa are high OR sensitive taxa are moderate or higher." Classical set theory now yields a value of 'true' if total taxa = 32 and sensitive taxa = 7 (total taxa > 32, therefore, it is true). Fuzzy-set theory yields a membership of 0.6 (maximum of 0.4 and 0.6). In practice, the OR operator is specified only occasionally, when the panel wishes to set up alternative criteria for a certain decision.

In the decision model, rules work as a logical cascade from BCG Level 1 to Level 6. A sample is first tested against the BCG Level 1 rules. If a required rule fails, then the level fails, and the assessment moves down to BCG Level 2, and so on. Required rules are combined with AND operators (i.e., all must be true), and alternate rules are combined with OR operators. Membership in any BCG Level ranges from 0 to 1, and the model requires all membership values to sum to 1. The highest membership is taken as the nominal level, although memberships within 0.2 of each other are considered ties. For example, if the membership of BCG Level 2 is 0.5 and Level 3 is 0.4, then the site is considered to be intermediate between Levels 2 and 3. The output of the model is the nominal BCG level and its membership value and the 2nd (runner-up) BCG level and its membership value.

Because MPCA intended to use the BCG to develop meaningful thresholds for its IBI indexes, the BCG scores were compared to IBI scores from all available biological visits. This analysis consisted of examining box plots and outliers (e.g., sites with high IBI scores, but BCG scores indicating an altered community). The intent of this analysis was not to identify individual visits and bring them in alignment with BCG expectations, but to identify groups of similar communities that were not part of the calibration or test data sets and might require changes to both BCG and IBI models. This effort was parsimonious because too much modification to the models could lead to over-fitting or altering the model from the intent of the panel.

RESULTS

Stress-response relationships and BCG taxa attributes

We examined stress-response scatterplots and estimated maximum likelihood models for taxon occurrence for all taxa with >20 occurrences in the data set (Figs 2, 3A, B, 4A, B, 5A, B, S1, S2). HDS scores were not evenly distributed with relatively few sites with scores <40 (highly altered). An apparent reduction in point density at low-disturbance scores reflects the fact that few sites in the database had such low scores and not necessarily the response of the taxa. The capture probability curve takes the distribution of disturbance scores into account and shows which taxa are tolerant or thrive under disturbed conditions (Figs 2, 3A, B, 4A, B, 5A, B, S1, S2).

Scatterplots that combined abundances of individual taxa on the disturbance gradient with the maximum likelihood models were deemed to be the most useful for identifying attribute groups (Tables 4, 5, Figs 2, 3A, B, 4A, B, 5A, B). Fish species were assigned to attributes separately for each of the 7 fish stream types and macroinvertebrates were assigned separately to 2 groups: glide–pool and riffle–run streams. Only a few taxa differed in assigned attribute among stream types.

Fish experts identified 2 additional subattributes related to highly tolerant taxa (Table 5). An additional very tolerant classification was created (attribute Va). Separation of the highly tolerant attribute Va fish from the merely tolerant attribute V fish was based on the collective professional experience and judgment of the fish panel. The nonnative fish taxa attribute (VI) was similarly divided into sensitive nonnative salmonids (attribute VI; e.g., Brown Trout and Rainbow Trout) and highly tolerant nonsalmonid, nonnative species (attribute VIa; e.g., Ruffe, Sea Lamprey, Common Carp).

In total, 133 fish taxa and 516 macroinvertebrate taxa were assigned to BCG taxonomic attributes (Tables S1, S2). An additional 53 fish species occurred in MDNR's species list, but were absent from the stream data set and were left unclassified, and 10 fish taxa in the data were left unclassified (family- or genus-level identifications or hybrids considered uninformative). Twenty invertebrate taxa were left unassigned because participants thought information on the taxa was insufficient, or they were relatively unusual in the data set.

Site assignments to BCG levels

The panel was able to reach a majority opinion on the BCG level assignments for all sites reviewed. Some sites required discussion and resolution of disagreement on which of 2 adjacent BCG levels to assign the site. These sites were considered intermediate, with characteristics of both adjacent BCG levels.

The panels were able to distinguish 6 BCG levels (BCG Levels 1–6), but sites that fit Levels 1 (nearly pristine) and 6 (extreme degradation) were rare. The fish panel identified 9 BCG Level 1 sites, but the macroinvertebrate panel identified none. In general, macroinvertebrate experts felt that BCG Level 1 and Level 2 sites were not distinguishable based on macroinvertebrate data only, in part because rare and endemic taxa are poorly identified, their historic distributions are poorly known, and macroinvertebrate sampling methods are inefficient at finding rare and endemic species. Further examination may be necessary to decide whether any sites meet criteria for minimally disturbed (Stoddard et al. 2006). The macroinvertebrate panel identified 9 and the fish panel identified 8 BCG Level 6 samples.

Attributes and BCG levels

We derived metrics (e.g., taxon richness, % taxa, % individuals, dominance) based on BCG attributes and taxonomic groupings (see examples in Figs 7A–F, 8A–F, 9A–D, 10A–E). These box plots were used to help with the selection of metrics for initial model development and for panel review of metrics and rules during subsequent iterations. We developed the BCG using only taxonomic information (attributes I–VI; USEPA 2016) because MPCA's monitoring program does not require collection of information on the other attributes. If available, information from attributes VII–X could be incorporated into the BCG models to improve their performance.

BCG rule development

Panelists followed the descriptions of the BCG levels (Table 1) and gave their reasoning during the deliberations for assigning sites to levels. Rules and reasoning of the panel, whether quantitative or qualitative, were compared to data summaries of the panel decisions (Figs 7A–F,

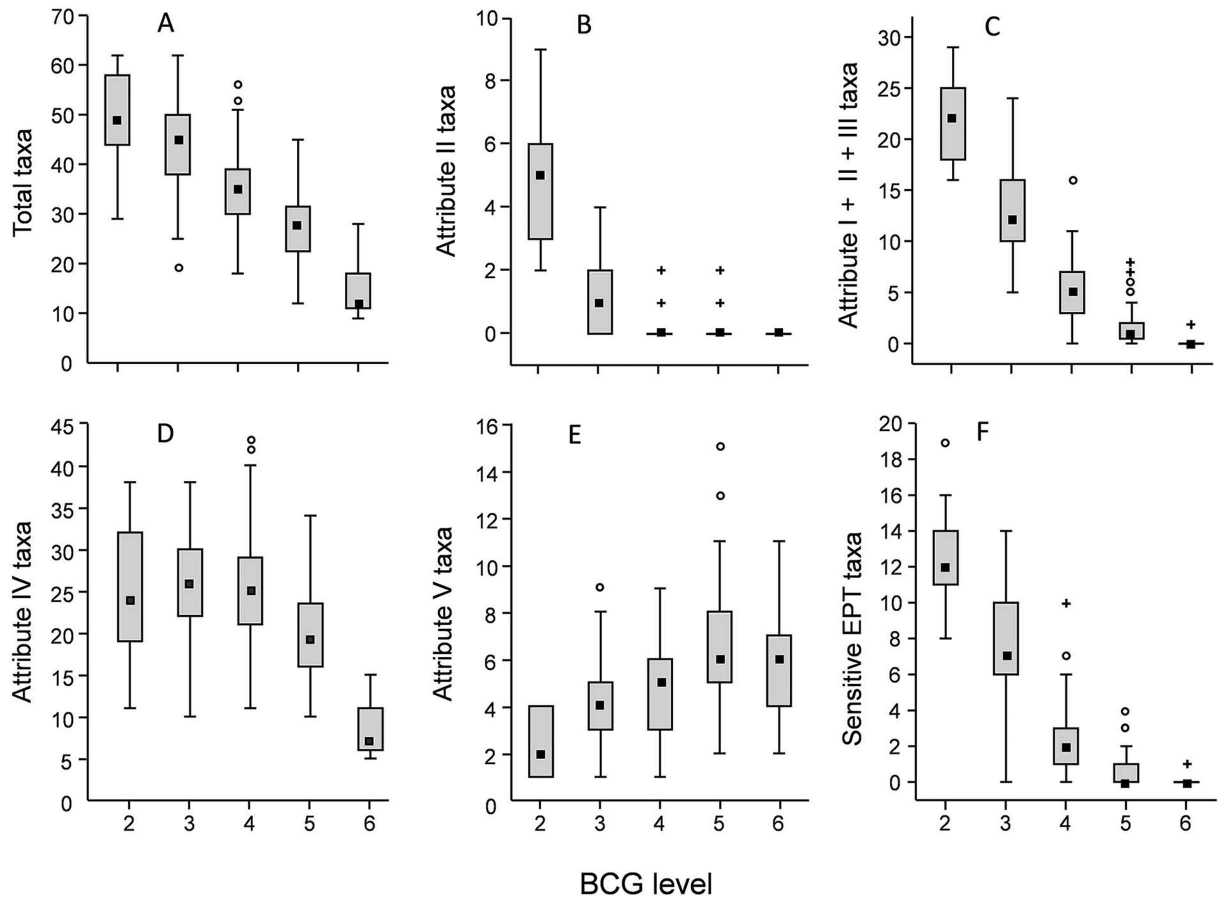

Figure 7. Box-and-whisker plots for the total (A), attribute II (B), attributes I, II, and III (C), attribute IV (D), attribute V (E), and sensitive Ephemeroptera, Plecoptera, Trichoptera (EPT) (F) number of benthic macroinvertebrate taxa by Biological Condition Gradient (BCG) level. Squares in boxes are medians, boxes are interquartile range (IQR), whiskers are to 1.5 × IQR, circles are outliers up to 3 IQR, and crosses show extreme values > 3 IQR.

8A–F, 9A–D, 10A–E). For example, if the panel identified a moderate number of sensitive taxa for BCG Level 3, then we examined the number of sensitive taxa in samples the panel assigned to BCG Level 3. We then selected a reasonable minimum of the distribution of sensitive taxa in BCG Level 3, say the minimum or a 10th quantile, as the decision threshold. This process was repeated for all rules and attributes identified by the panel as being important to their decisions. Sample sizes for the highest and lowest levels (BCG Levels 1, 2, and 6) were small, and required increased professional judgment from the panel to develop rules.

For a particular attribute or metric, the threshold identified by the panel typically was the 50% membership value in a fuzzy membership function. For example, if the panel identified ">10" sensitive taxa as a requirement for BCG Level 3 (Fig. 7A–F), then 10 taxa would correspond to 50% membership, 5 taxa might correspond to 0% membership, and 15 taxa to 100%. Because number of taxa is always a whole number, this membership function is not continuous. Some rules are non-fuzzy: if a rule requires "≥1" or "presence," then presence receives a membership of 100% and absence receives 0%. Final rules for all 14 assessed stream types are in Tables S3–S8. We include 2 sets of rules here for illustration: riffle–run invertebrate samples (Table 6) and wadeable stream fish samples (Table 7).

Panelists preferred to use taxon richness within the sensitive attributes as the most important criteria for setting site BCG level assignments. Thus, the number of sensitive taxa was most often used to distinguish BCG Level 2 from Level 3 sites. BCG Level 2 should have several highly sensitive taxa (attribute II), but their richness may be reduced or absent in BCG Level 3. All of the BCG Level 1 fish samples had ≥2 attribute I taxa (rare or endemic taxa). Higher BCG levels (1–3) all required some minimum relative abundance or relative richness of sensitive taxa (attributes I–III). In addition, for a site to be considered in Level 1 to Level 3, participants often placed upper limits on the abundance and dominance of tolerant taxa, especially attributes V and Va (for fish). Going further down the gradient, BCG Level 4 typically had a fairly low minimum requirement for sensi-

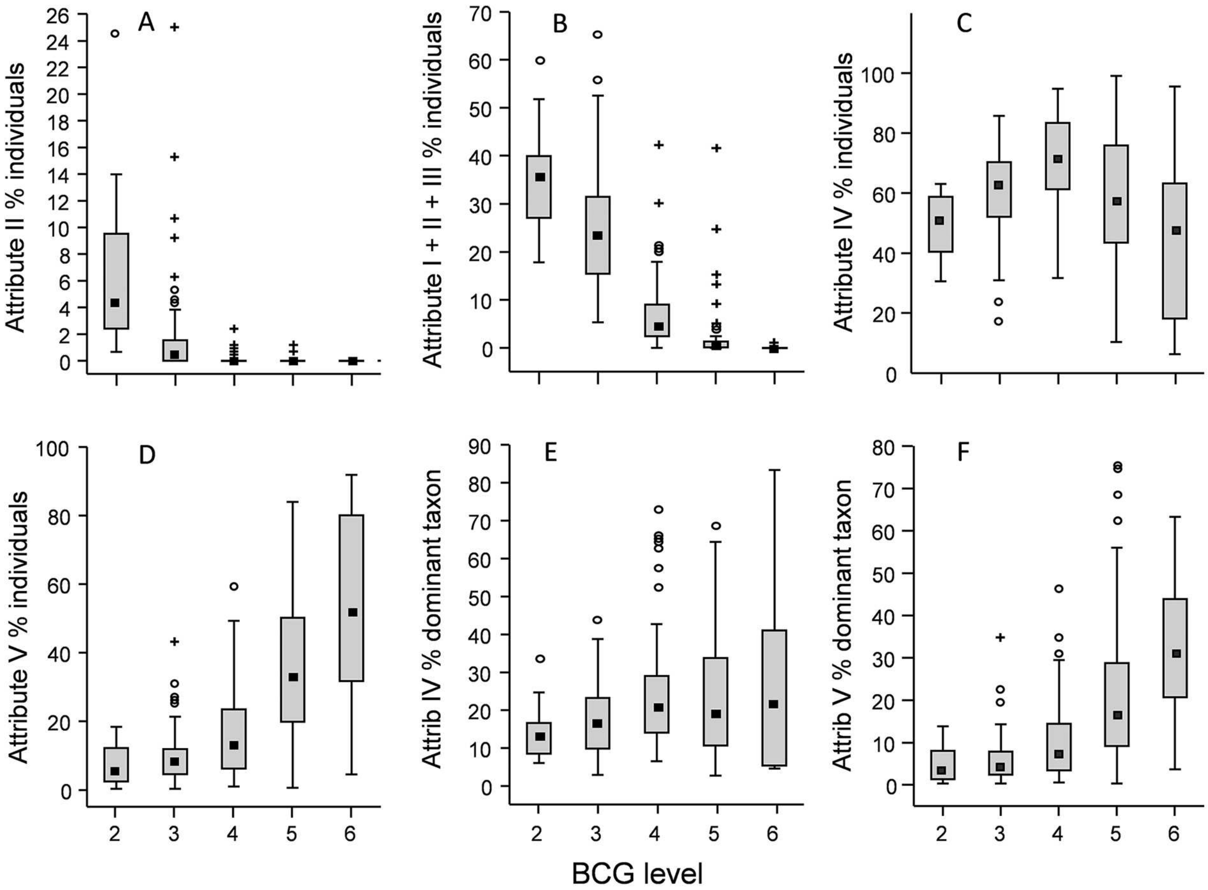

Figure 8. Box-and-whisker plots for the % attribute II (A), attributes I, II, and III (B), attribute IV (C), attribute V (D) individuals and % dominance of attribute IV (E) and attribute V (F) genera of benthic macroinvertebrates by Biological Condition Gradient (BCG) level. See Fig. 7 for explanation of plots.

tive taxa (attribute III), sufficient to show they had not disappeared. BCG Level 5 usually had only requirements of minimum overall richness, and often a maximum dominance (not to be exceeded) of a tolerant taxon. Failure of Level 5 rules result in an assessment of Level 6. The decision patterns described here are consistent with those developed in other states and regions by other panels for invertebrates and fish (see case studies in USEPA 2016).

Rules (Tables 6, 7, S3–S8) were expressed as an inequality, a midpoint, and a range: e.g., ≥20 (15–25). The first number is the midpoint, and the range is in parentheses, where the range describes the linear fuzzy membership function as it increases from 0 to 1 for '≥' and decreases from 1 to 0 for '≤'. Thus, for a rule expressed as ≥20% (15–25), the given membership is 0 at a metric value ≤15%; rises linearly to 1 at a metric value of 25%; and remains 1 for values >25%. The membership is 0.5 at the midpoint of 20%.

Some rule sets included alternatives; i.e., 2 or 3 alternative rules may exist for a certain BCG level (e.g., BCG Level 3 in Table 6, Levels 4 and 5 in Table 7). At least one of the alternatives must be true for the site to be assigned to that level. Alternatives usually reflected a trade-off specified by the panel. For example, a high number of total taxa could offset a low proportion of sensitive taxa, and vice versa. Rules *within* each alternative are joined by AND operators, and the 2 or 3 alternatives are then joined by OR operators to assign level.

Model performance

To evaluate the performance of the quantitative decision model, we assessed the number of samples where the BCG decision model's nominal level exactly matched the panel's median (exact match) and the number of samples where the model predicted a BCG level that differed from the median expert opinion (mismatch samples). For the mismatched samples, we examined the size of the difference between the BCG level assignments.

The model output is in terms of relative membership (0–100%) of a site among BCG levels, where memberships of all levels must sum to 100%. Model output could yield ties between adjacent levels, or a majority could be assigned to 1 level over ≥1 other levels. As with the quanti-

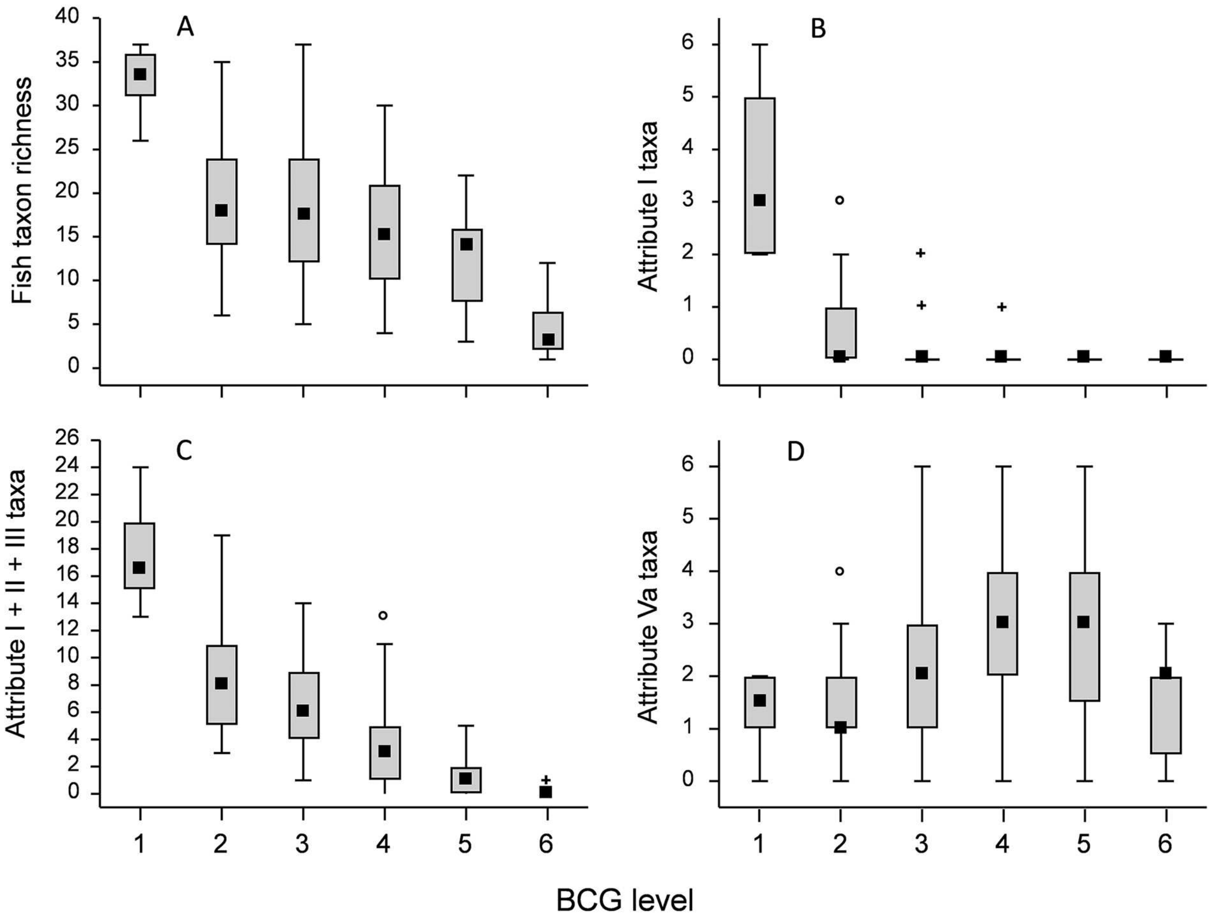

Figure 9. Box-and-whisker plots for the total (A), attribute I (B), attributes I, II, and III (C), and attribute Va (D) number of fish taxa by Biological Condition Gradient (BCG) level. See Fig. 7 for explanation of plots.

tative model, panelists' site ratings could be split among BCG levels.

To estimate concurrence between the quantitative model and the panel, we assigned scores as clear majority or ties and near-ties based on the panelists' votes and the model membership outcomes. We assigned ties and near-ties where either the model or the panel was divided. For model ties, nearly equal membership was present in 2 BCG levels (e.g., membership of 0.4–0.6 in BCG Level 2 and membership of 0.6–0.4 in BCG Level 3). Panelist ties were site ratings where a single vote could have flipped the decision (e.g., 4–4 or 5–4 decisions).

If either the BCG model assigned a tie that did not match with the panelist consensus, or vice-versa, we assigned a difference of ½ BCG level. For example, if the model assignment was a BCG Level 2–3 tie and panelist consensus was BCG Level 2, the model was considered to be off by ½ BCG level; more specifically, the model rating was a ½ BCG level worse than the panelists' consensus. To avoid cutting the differences too finely, we considered mismatches by units of only ½ BCG level. These units were: match (i.e., both panel and model a clear majority for the same level or the same tie); ≤½ level (i.e., panel and model mismatch by ≤½ BCG level); ≤1 level (i.e., panel and model mismatch ½ but ≤1 BCG level); and so on.

Model performance is summarized in Tables 8 and 9, which show the number and % model assessments compared to panel assessments. The panel did not consider a ½-level mismatch with their consensus to be a meaningfully different assessment, and a ½ level was similar to the spread in ratings among panel members. Thus, the panel was unwilling to adjust ratings or to modify rules for small mismatches. On average, the macroinvertebrate models were 89% accurate in replicating the panel assessments within ½ BCG level, and the fish models were 86% accurate. The fish model had 2 mismatches >1 BCG level.

We compared BCG model performance on all sites to IBI models, which had been developed independently. Neither IBI model nor BCG model was regarded as objective truth. Rather, the comparison was used to identify situations where, in the expert opinion of the panel, either or both models might need modifications. Overall, the IBI and BCG models corresponded to each other, but interquartile ranges did overlap between adjacent BCG levels

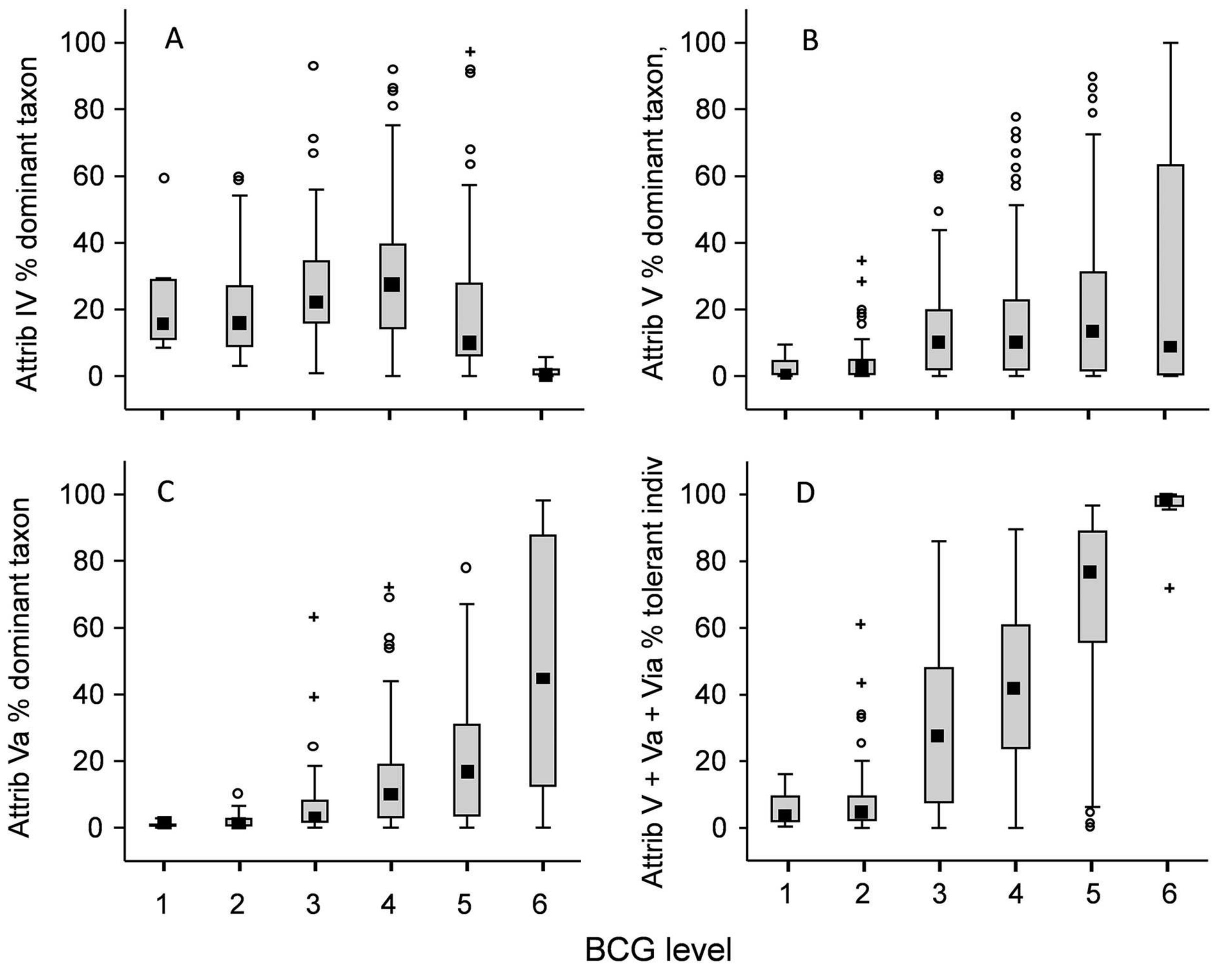

Figure 10. Box-and-whisker plots for the % dominance of attribute II (A), attribute V (B), and attribute Va (C) fish, and % tolerant (attributes V, Va, and VIa) individuals (D) by Biological Condition Gradient (BCG) level. See Fig. 7 for explanation of plots.

(Figs 11A–G, 12A–G). In some stream types, the distribution of IBI scores for BCG Level 6 appeared anomalous. Differences between the 2 models often were the result of differences in the scoring approaches. For example, with the IBIs, a biological sample might score extremely poorly for a single metric, but because the final score is a sum of multiple metric scores, the final score could still be high or intermediate if other metrics score high, a phenomenon known as "eclipsing" (Suter 1993).

The exercise also identified situations where the panel thought the BCG rules were too stringent, and the rules subsequently were relaxed. These changes included modifying the thresholds for some metric criteria or, in some cases, addition of alternate criteria (e.g., BCG Level 3 in Table 6). The alternate criteria provide multiple paths to a higher BCG level score for a sample and account for the diversity of healthy communities within a stream type. The rule changes improved the applicability of the BCG models beyond the population of the sites used in the model development and testing efforts. This exercise also indicated where changes should be made to the IBI models. The process identified a small number of samples with poorly scoring biological communities in relatively undisturbed watersheds. These streams were often wetland-influenced streams, and new IBI and BCG models are needed to measure biological condition appropriately for this type of stream.

Fish-invertebrate assemblage comparison

An issue of interest to managers is whether fish and macroinvertebrate assemblages yield the same results, and whether both must be monitored. We examined BCG assessments by the panel for a set of sites with both fish and benthic macroinvertebrate samples that were sampled in the same calendar year (typically within 1–3 mo). The maximum difference found was 3 BCG levels in 2 rivers where the fish were rated Level 2 but the invertebrates were rated Level 5. Both assemblages were rated at ≤1 BCG

Table 6. Decision rules for macroinvertebrate assemblages in high-gradient streams (riffle–run habitat). Rules show the midpoint and ranges (in parentheses) of fuzzy membership functions (see Fig. 6). *N* is the number of sites at the indicated Biological Condition Gradient (BCG) level and stream type in the calibration data set. 'Alt' designation in rules identifies alternative rule sets for a particular stream type and BCG Level (see text for details). EPT = Ephemeroptera, Plecoptera, Trichoptera; '= Alt 1' indicates the rule is the same as given under Alt 1 for this metric; n/a = not applicable.

	Northern forest streams, high-gradient		Southern streams, high-gradient	
Metric	Alt 1	Alt 2	Alt 1	Alt 2
BCG Level 2	$N = 2$		$N = 0$[a]	
Total taxa	≥40 (35–45)	n/a	≥40 (35–45)	n/a
Attribute I+II taxa	>3 (2–5)	n/a	>3 (2–5)	n/a
Attribute I+II+III % taxa	≥50% (45–55)	n/a	≥50% (45–55)	n/a
Attribute I+II+III % individuals	≥30% (25–35)	n/a	≥30% (25–35)	n/a
Attribute V % individuals	≤10% (7–13)	n/a	≤10% (7–13)	n/a
Sensitive EPT taxa	>11 (9–14)	n/a	>11 (9–14)	n/a
BCG Level 3	$N = 17$		$N = 8$	
Total taxa	≥30 (25–35)	≥45 (40–50)	≥30 (25–35)	≥45 (40–50)
Attribute I+II+III % taxa	≥20% (15–25)	≥15% (10–20)	≥20% (15–25)	≥10% (7–13)
Attribute I+II+III % individuals	≥10% (7–13)	≥5% (3–7)	≥15% (10–20)	≥5% (3–7)
Attribute IV dominance	≤25% (20–30)	= Alt 1	n/a	n/a
Attribute V % individuals	n/a	n/a	≤20% (15–25)	= Alt 1
Attribute V dominance	≤35% (30–40)	= Alt 1	≤10% (7–13)	= Alt 1
Sensitive EPT taxa	>3 (2–5)	= Alt 1	>3 (2–5)	= Alt 1
BCG Level 4	$N = 9$		$N = 19$	
Total taxa	≥20 (16–24)	n/a	≥20 (16–24)	≥30 (25–35)
Attribute I+II+III % taxa	≥10% (7–13)	n/a	≥5% (3–7)	Present
Attribute I+II+III % individuals	Present	n/a	≥5% (3–7)	Present
Attribute V % individuals	≤25% (30–40)	n/a	≤25% (30–40)	≤40% (35–45)
Attribute V dominance	≤25% (20–30)	n/a	≤20% (15–25)13	= Alt 1
Sensitive EPT	Present	n/a	Present	= Alt 1
BCG Level 5	$N = 2$		$N = 20$	
Total taxa	>13 (11–16)	≥20 (16–24)	>13 (11–16)	≥20 (16–24)
Attribute II+III+IV % taxa	n/a	n/a	n/a	≥50% (45–55)
Attribute V % taxa	≤40% (35–45)	≤50% (45–55)	≤40% (35–45)	n/a
Attribute V dominance	≤60% (55–65)	= Alt 1	≤60% (55–65)	n/a
BCG Level 6	$N = 0$		$N = 0$	

[a] BCG rules for southern streams, high-gradient Level 1 provisionally set to same criteria as northern forest streams, high-gradient

level apart in 83% of the sample sets (Table 10). The macroinvertebrate panel was slightly more stringent than the fish panel: no invertebrate samples were rated BCG Level 1, and slightly fewer Levels 2 and 3 ratings were given by the macroinvertebrate panel than by the fish panel. More large differences of ≥2 levels (Table 10) occurred at river than at wadeable stream sites. Fish and invertebrates were rated at ≥2 BCG levels apart in 40% of large river sites (non-wadeable; drainage area > 1300 km^2) but in only 9% of wadeable sites. The 2 assemblages respond to different stressors, so we would not expect a perfect correlation between ratings based on macroinvertebrates and on fish. Both assemblages are sampled and assessed because of their different responses.

DISCUSSION

Recent developments of environmental assessment using professional judgment have shown that experts are highly concordant in their ratings of marine benthic macroinvertebrates (Weisberg et al. 2008, Teixeira et al. 2010), marine sediment quality (Bay et al. 2007, Bay and Weisberg 2010), and fecal contamination (Cao et al. 2013). In the pilot BCG studies (USEPA 2016), aquatic biologists have

Table 7. Decision rules for fish assemblages in wadeable streams. Rules show the midpoint and ranges (in parentheses) of fuzzy membership functions (see Fig. 6). *N* is the number of sites at the indicated Biological Condition Gradient (BCG) level and stream type in the calibration data set. 'Alt' designation in rules identifies alternative rule sets for a particular stream type and BCG level (see text for details). '= Alt 1' indicates the rule is the same as given under Alt 1 for this metric; n/a = not applicable.

	Southern streams			Northern streams	
Metric	Alt 1	Alt 2	Alt 3	Alt 1	Alt 2
BCG Level 1		$N = 0^a$		$N = 0^a$	
Total taxa	≥30 (25–35)	n/a	n/a	≥30 (25–35)	n/a
Attribute I endemic taxa	Present	n/a	n/a	Present	n/a
Attribute I+II taxa	>3 (2–5)	n/a	n/a	>3 (2–5)	n/a
Attribute I+II+III % taxa	≥50% (45–55)	n/a	n/a	≥50% (45–55)	n/a
Attribute I+II+III % individuals	≥30% (25–35)	n/a	n/a	≥30% (25–35)	n/a
Tolerant % individuals (V+Va+VIa)	≤5% (3–7%)	n/a	n/a	≤5% (3–7%)	n/a
BCG Level 2		$N = 1$		$N = 8$	
Total taxa	≥20 (16–24)	n/a	n/a	>13 (11–16)	n/a
Attribute I+II+III total taxa	≥8 (6–10)	n/a	n/a	n/a	n/a
Attribute I+II+III % taxa	≥40% (35–45)	n/a	n/a	≥30% (25–35)	n/a
Attribute I+II+III % individuals	≥10% (7–13)	n/a	n/a	≥10% (7–13)	n/a
Attribute Va or VIa dominance	–	n/a	n/a	≤10% (7–13)	n/a
Tolerant % individuals (V+Va+VIa)	–	n/a	n/a	≤35% (30–40)	n/a
Highly tolerant % individuals (Va+VIa)	≤20% (15–25)	n/a	n/a	n/a	n/a
BCG Level 3		$N = 4$		$N = 10$	
Total taxa	>13 (11–16)	n/a	n/a	>13 (11–16)	n/a
Attribute I+II+III % taxa	≥10% (7–13)	n/a	n/a	≥25% (20–30)	n/a
Attribute I+II+III % individuals	≥5% (3–7)	n/a	n/a	≥5% (3–7)	n/a
Attribute Va or VIa dominance	≤20% (15–25)	n/a	n/a	≤10% (7–13)	n/a
Highly tolerant % individuals (Va+VIa)	≤40% (35–45)	n/a	n/a	≤20% (15–25)	n/a
BCG Level 4		$N = 10$		$N = 15$	
Total taxa	≥8 (6–10)	≥20 (16–24)	n/a	≥8 (6–10)	= Alt 1
Attribute I+II+III % taxa	Present	n/a	n/a	≥5% (3–7)	n/a
Attribute 1+ 2+3 % individuals	≥0.5% (0–1)	n/a	n/a	Present	n/a
I+II+III+IV % individuals	n/a	n/a	n/a	n/a	≥70% (65–75)
Attribute I+II+III+IV % taxa	n/a	n/a	n/a	n/a	≥50% (45–55)
Attribute Va or VIa dominance	≤50% (45–55)	= Alt 1	n/a	≤30% (25–35)	≤20% (15–25)
Tolerant % individuals (V+Va+VIa)	≤70% (65–75)	= Alt 1	n/a	n/a	n/a
Highly tolerant % individuals (Va+VIa)	≤60% (55–65)	= Alt 1	n/a	≤60% (55–65)	n/a
BCG Level 5		$N = 18$		$N = 4$	
Total taxa	≥5 (3–7)	>13 (11–16)	≥20 (16–24)	≥3 (1–5)	n/a
Attribute I+II+III % taxa	n/a	Present	n/a	n/a	n/a
Attribute I+II+III+IV % taxa	≥10% (7–13)	n/a	≥20% (15–25)	≥15% (10–20)	n/a
Attribute Va or VIa dominance	≤50% (45–55)	n/a	n/a	<65–75%	n/a
Highly tolerant % individuals (Va+VIa)	≤70% (65–75)	n/a	n/a	n/a	n/a
BCG Level 6		$N = 2$		$N = 0$	

[a] BCG rules for Level 1 provisionally set to same criteria as Prairie Rivers (Table S4).

come to very tight consensus on the descriptions of individual levels of the BCG and on the BCG level assigned to individual sites. The Minnesota BCG reported here confirms the concordance among experts.

The conceptual model of the BCG was derived from experience of working aquatic ecologists from across the US (Davies and Jackson 2006). Development of the quantitative BCG requires quantitative mapping of biological infor-

Table 8. Performance of Biological Condition Gradient (BCG) quantitative macroinvertebrate models. 'Better' and 'worse' indicate model assessment of stream condition compared to panel (e.g., 'better' if model assessed BCG Level 2, but panel assessed BCG Level 3). N = number of comparisons in category, % = % of comparisons in category.

		Quantitative model performance					
Invertebrate stream type	Type	1 better	0.5 better	Match	0.5 worse	1 worse	Total
Northern forest rivers	*N*	2	2	26	2	5	37
	%	5%	5%	70%	5%	14%	
Prairie rivers	*N*	0	4	21	3	1	29
	%	0%	14%	72%	10%	3%	
Northern forest riffle–run	*N*	1	1	27	3	5	37
	%	3%	3%	73%	8%	14%	
Northern forest glide–pool	*N*	2	1	28	2	2	35
	%	6%	3%	80%	6%	6%	
Southern riffle–run	*N*	1	2	35	5	2	45
	%	2%	4%	78%	11%	4%	
Southern hardwood glide–pool	*N*	2	1	29	3	1	36
	%	6%	3%	81%	8%	3%	
Prairie glide–pool	*N*	3	2	44	0	3	52
	%	6%	4%	85%	0	6%	
Total	*N*	11	13	210	18	19	271
	%	4%	5%	77%	7%	7%	

mation into the conceptual and theoretical model. The BCG is calibrated using a data set, but also requires ecological considerations with wide expert agreement from biologists familiar with the resources. The result is intended to be more general than a regression analysis of biological response to stressors. The BCG uses universal attributes (in this application, only the taxonomic attributes I–VI) that are intended to apply in all regions. Specifics of the attributes (taxon membership, attribute groups indicating good, fair, poor, etc.) do vary across regions and stream types, but the attributes themselves and their importance are consistent. The BCG requires descriptions of the levels from pristine to degraded. Documentation of the rationale for making BCG level determinations (i.e., the rules) provides the foundation for building a robust quantitative model and ensures that future information and discoveries can be related back to the level descriptions.

The approach requires substantial time and effort from the expert panel, but does it also require a rich database? We think the BCG calibration itself can be done with a smaller data set. Stress–response analysis benefits from a large database because we generally require a minimum of 20 occurrences of a taxon to develop the stress–response model. Other sources of tolerances for attribute assignments in the absence of stress–response analysis include existing literature and panelists' experience with the taxa. Early BCG calibrations were successful with 50 to 100 sites assessed by the panel, and stress–response was not used in those efforts (e.g., case studies in USEPA 2016). As a general rule, ≥30 sites in each stream type and perhaps as few as 20 is sufficient for rule development.

In a critique of ecosystem health and indexes, Suter (1993) pointed out technical weakness of common indexes. Weaknesses include: 1) *ambiguity*: one cannot tell why an index value is high or low (although individual metric values will reveal it); 2) *eclipsing*: a high metric value balances a low metric value, with a resulting inappropriate score (site is better or worse than its score indicates); and 3) *arbitrary combining functions*: most multimetric indexes (and observed/expected taxon ratios) are the sum of the component metrics (or component reference taxa), with no weighting or other combining function, nor consideration of why or why not to do so (Suter 1993). Eclipsing is one consequence of arbitrary equal weighting and summing. In the BCG rule-based method, weighting and combining functions are stated and not arbitrary. For example, a rule for a BCG level may require a certain number of sensitive taxa. If a site has too few sensitive taxa, it will be rated at a lower level because the sensitive taxa rule failed. Rules prevent ambiguity (i.e., we know why it failed), eclipsing (i.e., a high value in another attribute or metric does not change the decision, unless a rule specifically allows it), and the combining function for the rules is not arbitrary (i.e., transparent and established by the panel).

We do not suggest that the BCG is a panacea for all current issues in bioassessment. It has distinct disadvantages in development and acceptance. For example, the BCG is labor-intensive to develop, requires a panel of experts who are knowledgeable about local water bodies and biota. It can-

Table 9. Performance of Biological Condition Gradient (BCG) quantitative fish models. 'Better' and 'worse' indicate model assessment of stream condition compared to panel (e.g., 'better' if model assessed BCG Level 2, but panel assessed BCG Level 3). N = number of comparisons in category, % = % of comparisons in category.

		Quantitative model performance								
Fish stream type	Type	1.5 better	1 better	0.5 better	Match	0.5 worse	1 worse	1.5 worse	2 worse	Total
Northern forest rivers	N	0	4	2	36	4	1	0	0	47
	%	0%	9%	4%	77%	9%	2%	0	0%	
Prairie rivers	N	0	5	4	52	10	4	0	0	75
	%	0%	7%	5%	69%	13%	5%	0	0%	
Northern wadeable	N	1	1	3	22	8	1	0	1	37
	%	3%	3%	8%	59%	22%	3%	0	3%	
Northern headwaters	N	0	2	4	19	2	3	0	0	30
	%	0%	7%	13%	63%	7%	10%	0	0%	
Southern wadeable	N	0	4	1	23	2	5	0	0	35
	%	0%	11%	3%	66%	6%	14%	0	0%	
Southern headwaters	N	0		1	25	3	3	0	0	32
	%	0%	0%	3%	78%	9%	9%	0	0%	
Wetland influenced	N	0	2	1	26	1	2	0	0	32
	%	0%	6%	3%	81%	3%	6%	0	0%	
Total	N	1	18	16	203	30	19	0	1	288
	%	0.3%	6%	6%	70%	10%	7%	0	0%	

not be developed and calibrated by an individual with a data set and a computer. Broad acceptance of the BCG may be problematic. Many scientists and managers sometimes implicitly assume that continuous, quantitative models are somehow better than expert consensus. We contend that this assumption is untested, and may be an unfounded personal bias.

Decision analysis

To develop the fuzzy decision analysis system, we needed a set of rules to which we could apply fuzzy logic. The greatest single strength of the fuzzy-model approach may be development of a set of transparent rules that can, in principle, be followed by anyone making a decision on a site. Fuzzy-model rules may seem exotic to those not familiar with the approach, but they are fully laid out and are not hidden in a statistical model or in artificial machine learning. Experts can describe the classes of the BCG in a very general way, but without the specific rules and their combination, their decisions cannot be replicated and the rules cannot be modified effectively as new knowledge is gained.

The fuzzy-rule model replicates expert judgment by direct application of rules. It is only as good as the rules themselves. Experts also make errors, so an iterative process is required for rule development to correct inconsistencies, elicit hidden rules, or recalibrate incorrect membership functions. The fuzzy model does not require a statistical model to predict the expert panel decisions. If one accepts the expert consensus and rules of the BCG, then a fuzzy-model approach is the best way we know to automate it.

The rules have no requirement for linearity or monotonicity of metrics or attributes. For example, a linguistic rule that captures subsidy–stress (e.g., Odum et al. 1979) is permissible, such as "If taxon richness is high and abundance is high, then BCG level is ≤3." Moderate taxon richness may indicate very good conditions and fair or poor conditions and could be problematic in monotonic applications of taxon richness to condition. Most biotic indexes (e.g., IBI and RIVPACS models; e.g., Barbour et al. 1999) require monotonic responses of component metrics.

Like the BCG, a fuzzy-decision analysis approach has a disadvantage in acceptance. For example, an unfounded linguistic bias exists among American English-speakers against the term "fuzzy" in any scientific context. This bias has resulted in slower acceptance of fuzzy logic systems in English-speaking countries, especially in the USA, than elsewhere because the word 'fuzzy' has colloquial meaning in the USA (fuzzy thinking, warm and fuzzy). Prominent English-speaking scientists revealed their linguistic bias when criticizing fuzzy theory (see quotes in Zadeh 2008). In continental Europe and Japan, fuzzy logic systems are widely used in engineering and decision analysis, including ecological applications (e.g., Ibelings et al. 2003), because

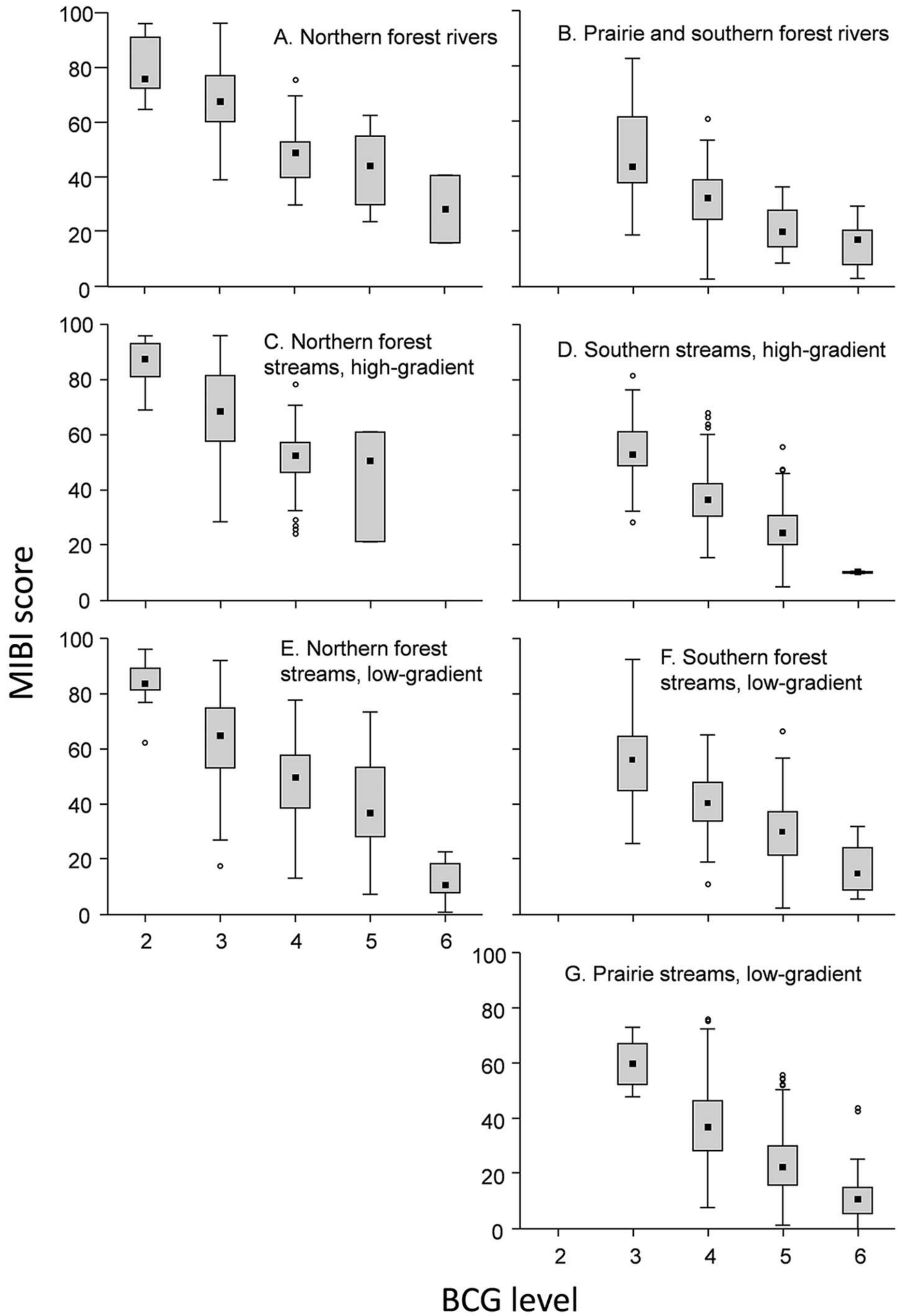

Figure 11. Frequency distributions of Macroinvertebrate Index of Biological Integrity (MIBI) scores by Biological Condition Gradient (BCG) level for northern forest rivers (A), prairie rivers (B), high- (C) and low-gradient (E) gradient northern forest streams, high- (D) and low-gradient (F) southern forest streams, and low-gradient prairie streams (G) in Minnesota at sites sampled from 1996–2011. See Fig. 7 for explanation of plots.

of greater economy of development with respect to nonlinear responses, and because the English word fuzzy has no colloquial connotations in other languages.

We measure things on continuous scales (e.g., pH) or as whole numbers (e.g., counts of taxa), but most interpretations and decisions are binary or categorical. Management and public communication require assessments such as 'no impact', 'slight impact', or 'severe impact'; or decisions such as 'no action' or 'reduce phosphorus by 50%'. Statements such as '5.8 mg/L O_2' or '29 insect species' are neither decisions nor interpretations. Fuzzy-decision systems are an explicit and transparent bridge between continuous

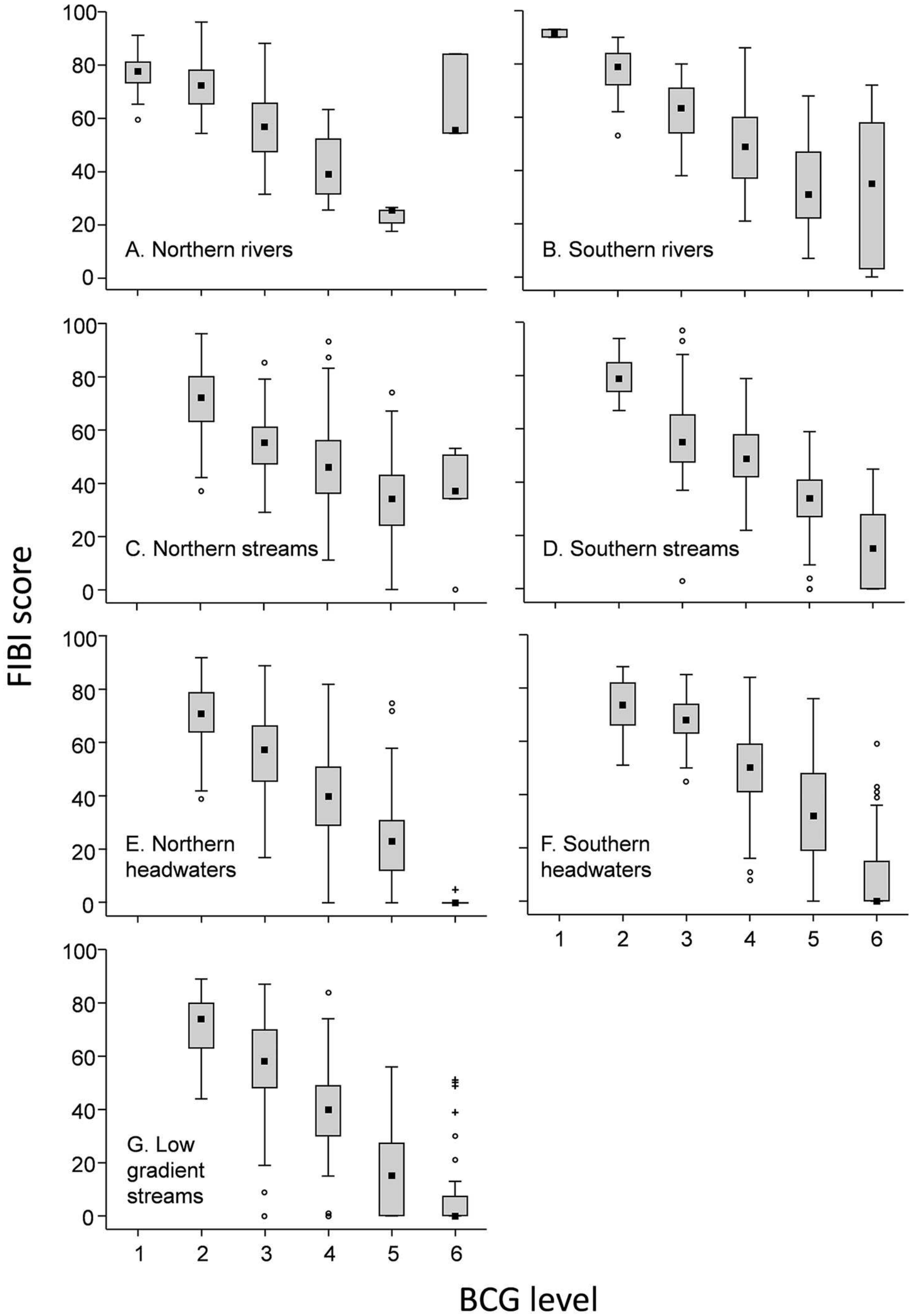

Figure 12. Frequency distributions of Fish Index of Biological Integrity (FIBI) scores by Biological Condition Gradient (BCG) level for northern rivers (A), southern rivers (B), northern streams (C), southern streams (D), northern headwaters (E), southern headwaters (F), and low-gradient streams (G) in Minnesota at sites sampled from 1996–2011. See Fig. 7 for explanation of plots.

measurements and interpretation and management decisions that are categorical (Silvert 2000).

BCG and multimetric IBIs

The BCG and IBI (Figs 10, 11) results were similar, which was not unexpected because they use the same field data sets. Moreover, the fundamental concept of both is that aquatic systems deviate from natural conditions (embodying biological integrity) with increasing anthropogenic stress. However, the development process differed for the models and, therefore, they do not produce identical results. The BCG concept and methods address some issues that multimetric IBI models cannot. The BCG categorizes biological communities in terms of naturalness, whereas the full range of multimetric IBI scores may reflect only avail-

Table 10. Differences in assessment of Biological Condition Gradient (BCG) level for fish and invertebrate communities at sites where both assemblages were sampled in the same calendar year and assessed by the panels ($N = 76$).

Variable	Fish more natural			Same	Invertebrates more natural		
BCG difference	3	2	1	0	1	2	3
N	2	9	22	25	16	2	0

able conditions. The BCG weights metrics and rules according to the panel's judgments, whereas multimetric IBI indexes weight all metrics equally in the total score. The BCG allows for nonlinear or modal responses in the attributes whereas multimetric IBI metrics are monotonic.

Management: aquatic life uses

The Minnesota BCG models are promising as a basis for developing decision criteria or biological criteria for Aquatic Life Uses (ALUs). In the USA, the terms 'Use', 'Designated Uses', and 'Aquatic Life Use' have specific meanings for water-quality management in the context of the CWA. A state defines the uses for its waters and develops physical, chemical, and biological criteria to protect those uses. Designated Uses are the water-quality goals for a specific water body and identify the functions and activities that are supported by a state-defined level of water quality. Water-quality standards are reviewed periodically based on new information that may indicate change in appropriateness of use and changes in what might have been considered irreversible.

Designated Uses also include potential quality or condition that may not be attained currently, but could be attained with appropriate controls or restoration. Thus, ALUs can be set according to the biological potential of water bodies, rather than their current condition. For example, infrastructure is not always irreversible, but it can be modified to reduce stresses on water bodies. The BCG may be more robust than current indexes because it allows for nonlinear responses, and has requirements for combinations of metric values in the condition levels.

The BCG models have been used to refine Minnesota's designated uses known as Tiered Aquatic Life Uses (TALUs; Bouchard et al. 2016, MPCA 2014a). TALUs are refined ALUs that articulate the goal for a water body better than a single one-size-fits-all ALU (e.g., Yoder and Rankin 1995, Bouchard et al. 2016). In Minnesota, the BCG was used to develop biological criteria for TALUs and to address differences in the current condition of streams across the state (Bouchard et al. 2016). For example, the prairie regions in Minnesota have been highly altered, resulting in few if any sites that meet the requirements for minimally disturbed reference sites. This situation poses challenges when the typical reference condition approach is used because minimally disturbed streams are needed to establish benchmarks (i.e., biological criteria) for ALUs.1 The BCG was used as a universal yardstick to set consistent and protective biological criteria across a diverse landscape (Bouchard et al. 2016). It also aligned biological criteria with the narrative language established by the CWA with the proposed TALU narratives. Levels of the BCG are not a priori equivalent to TALUs or water-quality criteria, although a given criterion could be set to a level of the BCG as a policy decision. The BCG is a measurement yardstick, and it does not express policy decisions and breakpoints for designated uses.

The BCG provides a powerful approach for an operational monitoring and assessment program, for communicating resource condition to the public, and for management decisions to protect or remediate water resources. If formalized properly, any person with data can follow the rules to obtain the same level assignments as the group of experts. This property makes the actual decision criteria transparent to stakeholders. Description of BCG Levels 1 and 2 in the BCG process establishes a fixed natural reference (which may no longer exist) to prevent shifting baselines. Understanding of the natural baseline may be modified with new and better information on historic conditions, but both original and modified baselines are documented and not simply a present-day sample. The levels of the BCG are biologically recognizable stages in condition of stream water bodies. They can inform a biological basis for biological criteria and regulation of water bodies. Development of quantitative BCG models yield the technical tools for protecting the highest quality waters through TALU and for developing realistic restoration goals for waters affected by legacy activities (e.g., ditching, impoundments). The BCG allows practical and operational implementation of ALUs in a state's water-quality criteria and standards.

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RECONNAISSANCE PROCEDURES FOR INITIAL VISIT TO STREAM MONITORING SITES

I. PURPOSE

To describe the methods used by the Minnesota Pollution Control Agency's (MPCA) Biological Monitoring Program to determine the location of stream monitoring sites for the purpose of assessing water quality and developing biological criteria.

II. SCOPE/LIMITATIONS

This procedure applies to all initial site visits for which an integrated assessment of water quality is to be conducted. An integrated assessment involves the collection of biological (fish and macroinvertebrate communities), physical habitat, and chemical information to assess stream condition. Reconnaissance procedures must be implemented before any sampling can be conducted.

III. GENERAL INFORMATION

Sites may be selected for monitoring for a number of reasons including: 1) sites selected for condition monitoring as part of Intensive Watershed Monitoring (IWM), 2) sites randomly selected as part of the Environmental Monitoring and Assessment Program (EMAP), 3) sites selected for the development and calibration of biological criteria, and 4) sites selected for stressor identification. Although the reasons for monitoring a particular site vary, the reconnaissance procedures described in this document apply to all monitoring sites unless otherwise noted.

IV. REQUIREMENTS

A. Qualifications of crew leaders: The crew leader must be a professional aquatic biologist with a minimum of a Bachelor of Science degree in aquatic biology or closely related specialization. Field crew leaders should also possess excellent map reading skills and a demonstrated proficiency in the use of a GPS (Global Positioning System) receiver and orienteering compass.

B. Qualifications of field technicians/student interns: A field technician/student intern must have at least one year of college education and coursework in environmental and/or biological science.

C. General qualifications: All personnel conducting this procedure must have the ability to perform rigorous physical activity. It is often necessary to wade through streams and/or wetlands, canoe, or hike for long distances to reach a sampling site.

V. RESPONSIBILITIES

A. Field crew leader: Implement the procedures outlined in the action steps and ensure that the data generated meets the standards and objectives of the Biological Monitoring Program.

B. Technicians/interns: Implement the procedures outlined in the action steps, including maintenance and stocking of equipment, data collection and recording.

VI. QUALITY ASSURANCE AND QUALITY CONTROL

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

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

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

B. QC samples: Quality control samples are not required for this procedure.

C. Verification: The field crew leader will conduct periodic reviews of field personnel to ensure that technical personnel are following procedures in accordance with this SOP.

VII. TRAINING

A. All inexperienced personnel will receive instruction from a trainer designated by the program manager. Major revisions in this protocol require that all personnel be re-trained in the revised protocol by an authorized trainer.

B. The field crew leader will provide instruction in the field and administer a field test to ensure personnel can execute this procedure.

VIII. ACTION STEPS

A. Equipment List: Verify that all necessary items are present before commencement of this procedure (Table 1).

B. Method: Depending on the type of site being sampled (random, biocriteria development, etc.); reconnaissance activities may begin with the collection of preliminary information in the office or take place entirely in the field.

1) Latitude and longitude coordinates (x-site) are provided by the EPA's Environmental Monitoring and Assessment Program (EMAP) for all randomly selected condition monitoring sites. A stream information sheet is supplied for each site which contains locational information and a stream trace, making it possible to determine the approximate location of the site on a USGS 7.5" topographic map and the state DeLorme atlas. Record the site location on the topographic map and make a copy of the appropriate section. Also record the location on the state atlas to aid in vehicular navigation to the site.

   It is often advantageous to begin landowner determination prior to site reconnaissance. County Plat maps, courthouse records, and county websites on the internet can be used to determine ownership and provide contact information for landowners. GIS mapping programs on individual county websites are the most accurate tool with recently updated ownerships. If a site is accessible only via private land, it is essential to obtain access permission from the landowner before visiting the site. Under no circumstances should field personnel knowingly trespass on private property to access a sampling site. For each site an information packet is compiled containing the Stream Verification Form (see below), the stream information sheet provided by EPA, the topographic map copy, and any additional maps that may be useful (Platte map, aerial photos, land use coverage, etc.).

   Consult the state atlas, topographic map, Plat map, aerial photos, etc. to navigate as close as possible to the site by vehicle. Navigate from the vehicle to the target location (x-site), as identified on the EMAP stream information sheet, utilizing available maps, a compass, and a GPS receiver (consult GPS manual for operating instructions). In remote areas, it is recommended that a GPS waypoint be taken at the vehicle to aid in returning from the site. Considerable effort should be expended to identify and record an access route that minimizes access problems for sampling crews returning at a later date.

2) For targeted sites (i.e. latitude and longitude are unknown prior to initial site reconnaissance) it is up to the investigator to determine what, if any, preliminary information should be obtained before field reconnaissance activities are conducted. It is often beneficial to gather information about the stream and its watershed (e.g. reference condition, above or below point sources, and watershed land use) to help achieve the monitoring objectives. Prior to field reconnaissance activities there may be many candidate sites considered for sampling, however, completion of the Stream Verification Form is necessary only for those sites that meet the monitoring objectives and are determined *sampleable*.

While selection of the sampling reach and determination of the x-site (mid-point of the sampling reach) are at the discretion of the principal investigator, it is important to consider local influences that may affect the fish or macroinvertebrate community. Unless your objective is to evaluate a specific local influence, an effort should be made to avoid sampling within 1 mile of a lake, dam, or stream confluence that is three or more stream orders larger. Establishing sampling reaches under bridges, through culverts, or within their associated scour holes should also be avoided.

For all sites the station length is 35 times the mean stream width, which is based on the distance necessary to capture a representative and repeatable sample of the fish community (following: Lyons, J. 1992. The length of stream to sample with a towed electrofishing unit when fish species richness is estimated. North American Journal of Fisheries Management. 16:241-256.). This approach provides progressively longer stations with increasing stream size.

The information obtained during initial site reconnaissance is recorded on the Stream Verification Form. A copy is attached and guidelines for filling out this data sheet are described in the following pages.

C. Stream Verification Form

This form provides locational, stream status, and reach length information. The form is completed after location or determination of the downstream, X-midpoint and upstream station coordinates are established. For sites in which a predetermined latitude and longitude is not provided, it will be necessary for the investigator to determine the station location. Record the following information in the space provided:

C.1. Stream Documentation

1) *Field Num* – A seven-digit code that uniquely identifies the station. The first two digits identify the year the station was established, the second two identify the major river basin, and the last three are numerically assigned in sequential order (example 02UM001). Assign the station an appropriate field number. For EMAP sites the last three digits should correspond to the sequential number provided by EPA for each site.

2) *Stream Name* – The name of the stream as shown on the most recent USGS 7.5" topographic map. Include all parts of the name (i.e. "North Branch", "Creek", "River", "Ditch", etc.).

3) *Project* – The purpose behind sampling of the site (i.e. "IWM", "Class7", "stressor ID", etc.).

4) *Watershed* – The name of the 8 Digit HUC that the site is located in.

5) *Visit Date* – The date initial site reconnaissance is conducted in month/day/year format (MM/DD/YY).

6) *DNR Office* – The DNR area office whose jurisdiction the site is located within.

7) *Crew* – The personnel who conducted the reconnaissance procedures.

8) *Invasive Presence* – The invasive species that are known to be present in the area, based on DNR map coverage. Species specific measures to prevent spreading invasive species between sites should be taken.

9) *GPS File Name US, DS, X* – The unique identifier of a waypoint file assigned by the GPS unit. When the upstream (US), downstream (DS), and mid-point (X) locations are determined, GPS files are taken to document the locations. Waypoint averaging should be utilized with a minimum of 100 waypoints collected, if possible the GPS coordinates should be taken mid-channel at these locations. The appropriate GPS file naming convention for the upstream location is the field number of the sampling site followed by the suffix US (i.e. 13UM001US). The appropriate GPS file naming convention for the downstream location is the field number of the sampling site followed by the suffix DS (i.e. 13UM001DS). The appropriate GPS file naming convention for the mid-point (X) location is the field number of the sampling site followed by the suffix X (i.e. 13UM001X). Consult the GPS user's manual for additional guidance on GPS operation.

10) *GPS Date US, DS, X* – The date that each GPS file is taken in month/day/year format (MM/DD/YY).

11) *GPS Time US, DS, X* – The time of day (24-hour clock) that each GPS file is taken.

12) *Lat: US, DS, X* – The angular distance north or south of the equator. Record the latitude of US, DS, and X as displayed on the GPS receiver in decimal degrees format with a map datum type of WGS84.

13) *Long: US, DS, X* – The angular distance east or west of the prime meridian. Record the longitude of US, DS, and X locations as displayed on the GPS receiver in decimal degrees format with a map datum type of WGS84.

14) *Unit* – Record which biological monitoring unit the station is located within.

15) *IWM/SID Lead* – Record the staff member who is the IWM Biological Monitoring lead for the station, if the station is a stressor ID project then record the name of the stressor ID staff who requested that station location.

C.2. <u>Stream Status</u>: A determination of the stations sampleability. Determine if the station is *sampleable* or *non-sampleable* for biological monitoring; check the box that best describes the status of the station.
Note – sampling stations selected as part of separate monitoring projects may have different protocol regarding their sampling status. For example, a stream that is intermittent at the time of sampling may be *sampleable* following EMAP protocol but generally is considered *non-sampleable* following other project protocol including Intensive Watershed Monitoring (IWM).

1) *Habitat* – Check this box to indicate if a quantitative habitat assessment should be conducted during the sampling visit to the site.

2) *TL* – Check this box to indicate if a temperature logger should be placed at the site.

3) *Recon Result* – A Sampleable or Non-Sampleable checkbox to determine if the site is or is not sampleable.

4) *Recon Result Reason* – Sites where a representative sample can be taken are considered sampleable. Reasons for declaring a site *sampleable* include:

   Perennial: A stream that flows continuously throughout the year. It is often difficult to distinguish between small, headwater perennial streams and intermittent streams (a stream which carries water a considerable portion of the time, but which ceases to flow occasionally during very dry periods). For this reason any stream that contains flowing water throughout the stream channel at the time of sampling and did not go dry at any point in the year prior to sampling - should be considered a perennial, *sampleable* stream.

   Intermittent (EMAP only): Flow of water is not continual at the site but the stream channel is defined and greater than 50% of the sampling reach contains water.

   Other (Explain in Comments): If a site is determined to be *sampleable* for a reason other than one of those described above, note and explain in the comments.

5) *Non-Sampleable* Reason – Circumstances where a representative sample of stream biological communities may not be taken at a site. Reasons for declaring a site *non-sampleable* include:

   No Channel or Waterbody Present: Examination of the x-site revealed no waterbody or stream channel.

   Impounded: The stream is submerged under a lake or pond due to man-made or natural (e.g. beaver dam) impoundments. An impounded site can be declared *sampleable* if it maintains a defined channel and more than half of the reach can be effectively sampled for fish.

   Wetland: The site contains water but does not have a definable stream channel. In cases in which riparian wetland vegetation surrounds a defined stream channel, classify the site as *sampleable* and restrict sampling to the defined channel.

Insufficient Flow: Project specific, for most monitoring projects including IWM defined as: portions of the stream channel are dry, and/or emergent vegetation throughout the stream channel, and/or stream flow is considerably lower than normal summer base flow. For EMAP sampling stations defined as: a discernible stream channel is present but less than half of the sampling reach contains water. If the channel is completely dry, note in comments.

Access Permission Denied: The field crew is denied permission to access the site by the landowner.

Inaccessible: The site cannot be sampled safely or effectively because it is not possible to access the site with the necessary sampling gear or the nature of the stream makes it unsafe to sample (e.g. rapids or waterfalls).

5) *Gear Type* – Determine the type of electrofishing gear that will most effectively sample the fish community given the width, depth, and accessibility of the stream, and check the appropriate box. The MPCA's Biological Monitoring Program utilizes four electrofishing gear types. General guidelines for determining the appropriate gear type are as follows:

BP (Backpack): Generally used in small, wadeable streams (typically < 8 m MSW and < 50 mi^2 drainage area).

BPx2: Used in larger streams that don't allow for efficient sampling with stream-shocker, usually wide shallow riffles with numerous large boulders, using this method both units are used simultaneously.

SS (Stream-shocker): Used in larger, wadeable streams and rivers (typically > 8 m MSW and 50-500 mi^2 drainage area). The stream-shocker is a towable unit that can effectively sample larger streams because it has additional power capabilities and employs two anodes, thus increasing the electrified zone. When stream-shocker access is too difficult or the site is a wide, shallow riffle it may be necessary to sample larger streams utilizing two backpack electrofishers.

BP/SS: Used in situations where conditions at recon visit did not allow for easy determination of gear type needed, although conditions do indicate it would be best sampled by BP or SS depending on flow variability.

MB (Mini-boom): Used in non-wadeable streams and rivers that are either too small or that do not afford the access necessary to utilize a boom-shocker. The mini-boom electrofisher is a jon-boat that is light enough to be portaged, yet provides a stable work platform.

SS/MB: Used in situations where conditions at recon visit did not allow for easy determination of gear type needed, although conditions do indicate it would be best sampled by SS or MB depending on flow variability.

BS (Boom-shocker): Used in large rivers with available boat access.

7) *Desktop Channel Condition* – Indicates if the channel appeared to be Natural or Channelized using Aerial imagery, etc. during the desktop review process.

8) *Recon Channel Condition* – Indicate if the channel is Natural or Channelized during the initial site visit.

9) *Desktop Recon Comments* – Record any desktop recon information about the station in the space provided, such as the possible access locations or physical obstacles seen on aerials.

C.3. <u>Stream Reach Determination</u>: To obtain the reach length multiply the mean stream width (MSW) by 35, round to the nearest meter. Divide by 2 to determine the distance to proceed upstream and downstream from the x-site. The x-site will serve as the mid-point of the sampling reach. The minimum and maximum reach length is 150 m and 500 m, respectively.

Mark the reach with flagging at the x-site, downstream end, and upstream end of the station. It is important that the flagging be visible from as great a distance as possible. It is preferable to tie the flagging on nearby vegetation as high as possible to ensure that high water conditions do not wash it away. Write on the flagging in permanent marker which reach boundary is being marked.

For EMAP sites there are some circumstances which permit "sliding" the stream reach in order to meet the minimum sampling distance (≥ 50% of the reach is sampleable). Do not advance upstream into a lower order stream or downstream into a higher order stream when laying out the stream reach. Similarly, do not proceed if you encounter a lake, impoundment, or wetland while establishing the reach. If such a confluence is reached, note the distance and flag the confluence as the reach end. As long as ≥ 50% of the reach is sampleable, the station is considered sufficient and target for EMAP purposes. If establishment of the minimum reach length is prohibited due to the occurrence of the confluence, you may compensate for the loss of reach length by moving ("sliding") the x-site up to a maximum of 28 m in order to obtain the minimum reach length. Do not slide the reach to avoid man-made features such as bridges, culverts, rip-rap, or channelization. If ≥ 50% of the reach cannot be sampled, the station is *non-sampleable*.

1) *Est. DA* – The estimated drainage area using the preliminary station coordinates of the subwatershed's polygon using GIS methods.

2) *County* – The county which the station falls within.

3) *Mean Stream Width (m)* – The average stream width (m) used to determine the reach length of the sampling site. Determine the MSW by measuring with a tape measure the wetted width of the stream channel at the x-site and a minimum of three other representative cross sections, such as a riffle, run, and pool. Average the measurements and record to the nearest half-meter. If initial site reconnaissance is conducted during high water conditions, it may be necessary to "adjust" the MSW downward to account for the narrower stream widths that would be encountered while sampling. To the degree possible, the reach length should be 35 times the normal summer base flow MSW.

4) *Upstream Length (m)* – The length, measured to the nearest half meter, of the upstream portion of the sampling reach. From the x-site, measure the appropriate distance upstream with a tape measure, avoid rounding off bends or diverging too far from the stream channel.

5) *Downstream Length (m)* – The length, measured to the nearest half meter, of the downstream portion of the sampling reach. From the x-site, measure the appropriate distance downstream with a tape measure, avoid rounding off bends or diverging too far from the stream channel.

6) *Total Length (m)* – The length of the sampling reach. To obtain, add the upstream and downstream lengths, should correspond to the MSW.

7) *Length Accuracy* – Record the accuracy of the total reach length by checking the Yes/No box. If the reach was measured in the stream or in the immediate riparian zone and incorporates all bends, the reach length is accurate. If the stream reach was measured away from the immediate riparian zone and does not incorporate all bends, the reach length is not accurate, and should be re-measured prior to sampling.

C.4. Location/Access: Provide a comprehensive description of your access route to guide sampling crews returning at a later date. Use the top line for naming the nearby road crossing and describing location of the station pertaining to that road crossing(Upstream or Downstream), also include the distance in miles to the nearest town. In the larger box below include driving instructions, where to park and access, major landmarks, trail info, etc. It is critical that the reconnaissance crew does a thorough job identifying and documenting the easiest access route to the site in order to minimize the difficulty experienced by the sampling crews.

C.5. Landowner Information: Provide pertinent landowner information for the upstream and downstream landowners including name, address, and phone number. Also include the County Plat name and section number. If the landowner is interested in a fish list record, providing the address will make the site easier to find.

1) *US* – Record pertinent information for the landowner upstream of the road crossing including name, address, phone number, nearby relatives (if available) and which landowner granted permission including who at that household gave permission. Also include Township name and section number for the area immediately upstream of the road crossing for a point of reference. Add landowner specific requests involving access to this box as well.

2) *DS* – Record pertinent information for the landowner downstream of the road crossing including name, address, phone number, nearby relatives(if available) and which landowner granted permission including who at that household gave permission. Also include Township name and section number for the area immediately downstream of the road crossing for a point of reference. Add landowner specific requests involving access to this box as well.

3) *Fish List Request (Name*) – Record landowner(s) name that requested fish list.

4) *Fish List Given* – Check this box if fish list was given to the landowner immediately following sampling visit.

C.6. Flagging Information: Record information about flagging placement. Flags should be placed at the downstream, mid-point, and upstream sections of the reach in an area that will be visible throughout the summer. Mark the flags with the appropriate section of the reach. Describe in detail the location of the flagging tape including what side of the bank the flagging is on, what the flagging is tied to, etc..

C.7. Tape Down Location/Description: Record information about tape down location. This should include what the reference mark was(e.g. blue arrow, blue arrow with line), upstream or downstream of road crossing, where on culvert or bridge deck the reference mark was made, and which culvert if multiple culverts exists.

Table 1. Equipment List – This table identifies all equipment needed in order to implement the initial site reconnaissance procedure as described.

Stream information sheet – for location of x-site, provided by EPA (needed only for EMAP sites)

1:24,000 USGS topographical maps – for navigation to and from the sampling site

County Platte maps – for determining land ownership

Aerial photographs – for navigation to and from the sampling site

DeLorme atlas – for vehicular navigation to and from the sampling site

Stream Verification Form – for recording initial site reconnaissance information

Measuring tape (m) – for measuring distances

GPS receiver – to locate and document sampling location

Compass – for navigation to and from the sampling site

Flagging – to mark the boundaries of the sampling reach

Pencil – for filling out forms

Permanent marker – to label flagging

Clipboard – to store forms/maps and record data

Waders – because it may be necessary to enter the stream during site reconnaissance

Cellular telephone – to contact landowners, to communicate between field crews, and for safety

STREAM VERIFICATION FORM

Unit: | IWM/SID Lead: | **MPCA**

STREAM DOCUMENTATION

Sample Year 2013

FieldNum:		Stream Name:	
Project:		Watershed:	
Visit Date (mm/dd/yy):		DNR Office:	
Crew:		Invasive Presence:	

GPS X		UP		Down	
File_Name:		File_Name:		File_Name:	
Date:	Lat:	Date:	Lat:	Date:	Lat:
Time:	Long:	Time:	Long:	Time:	Long:

STREAM STATUS

Habitat	TL
☐	☐

TL Serial Number

Clear Recon Result

Recon Result

- ☐ Sampleable
- ☐ Non-Sampleable

Recon Result Reason Clear ReconResReason

- ☐ Non-sampleable: Access permission denied
- ☐ Non-sampleable: Impounded
- ☐ Non-sampleable: Inaccessible
- ☐ Non-sampleable: Insufficient flow
- ☐ Non-sampleable: No channel or water body present
- ☐ Non-sampleable: Wetland
- ☐ Sampleable: Intermittent (EMAP only)
- ☐ Sampleable: Other (explain in comments)
- ☐ Sampleable: Perennial

Clear Gear Type

Gear Type

- ☐ BP
- ☐ BP/SS
- ☐ BPx2
- ☐ BS
- ☐ MB
- ☐ SS
- ☐ SS/MB

Clear DesktopChan

Desktop Channel Condition

- ☐ NA
- ☐ OC

Clear Recon Chan

Recon Channel Condition

- ☐ NA
- ☐ OC

DesktopRecon Comments:

STREAM REACH DETERMINATION

Est. DA:	Mean Stream Width (m)	Upstream Length (m)	Downstream Length (m)	Total Length (m)	Length Accuracy
County:					☐ Yes ☐ No, remeasure

Clear Length Accuracy

LOCATION/ACCESS

Fish List Request: (Name)

LANDOWNER INFORMATION

☐ Fish List Given

US

DS

FLAGGING INFORMATION

Midwest Biodiversity Institute

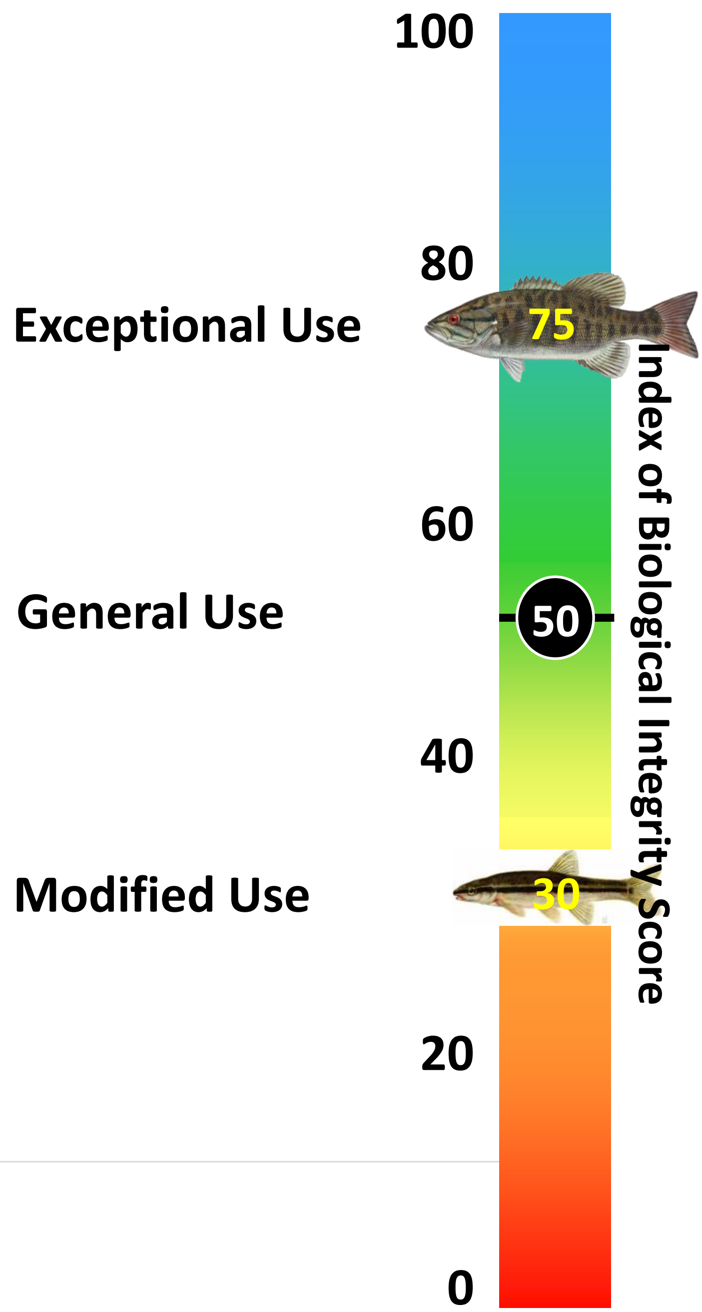
Minnesota Pollution Control Agency

A Framework for Conducting Use Attainability Analyses (UAA) for Aquatic Life Uses


West Branch Little Knife River


Little Cedar River


Judicial Ditch No. 7



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A Framework for Conducting Use Attainability Analyses (UAA) for Aquatic Life Uses

December 31, 2016

MBI Technical Report MBI/2016-6-4

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Minnesota Pollution Control Agency
Water Quality Standards Unit
Environmental Analysis and Outcomes Division
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A Framework for Conducting Use Attainability Analyses (UAA) for Aquatic Life Uses

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Introduction

The goal of the Clean Water Act (CWA) is to *". . . protect, maintain and restore the biological, chemical and physical integrity of the Nation's waters"* (Section 101[a]). At the same time Congress recognized that fully realizing the goals of the CWA was uncertain and provided for interim goals such as *". . . wherever attainable an interim goal of water quality which provides for the protection and propagation of fish, shellfish, and wildlife and recreation in and on the water . . ."* (Section 101[a][2]). The Section 101[a][2] provision has become known as the "swimmable and fishable" goal for surface waters providing the basis for developing and implementing designated uses. This provision also recognized that the interim goals may not be attainable at all times and in all places as affirmed by the *"wherever attainable"* qualifier to the 101[a][2] goal.

U.S. EPA regulations adopted in 1975 provided the policy framework that includes the general criteria for conducting a Use Attainability Analysis (UAA; 40 CFR Part 131[g]). A UAA is defined as *". . . a structured scientific assessment of the factors affecting the attainment of the use which may include physical, chemical, biological, and economic factors as described in §131.10[g]."* This framework, however, lacks sufficient specificity to actually know when or how to conduct a UAA with regard to the structure of state WQS and the data and information needs. These issues are addressed in the U.S. EPA Water Quality Standards Handbook (U.S. EPA 1994), but this too is insufficient in terms of critical details about state WQS and monitoring and assessment.

This report emphasizes the application of UAAs to designated aquatic life uses. Aquatic life uses and criteria are commonly the principal determinant of water quality requirements for management decision-making and they apply to *all* jurisdictional waters. As a result aquatic life is a universally relevant determinant of water quality management options and responses. The conduct of UAAs for aquatic life uses has been overshadowed by a focus on UAAs for recreational uses. As stated above the federal regulations and guidance offered by U.S. EPA are alone insufficient to assure that UAAs can be implemented in a consistent and cost-effective manner and, more importantly, to assure a credible outcome. Simply put the federal regulations and EPA guidance lack important specifics about what types of indicators, criteria, and monitoring data are needed to execute UAAs in a credible and cost-effective manner. As such the States have been left to fill in the important details and some have done it successfully for many years.

Water Quality Standards

The CWA directs states to adopt Water Quality Standards (WQS) that consist of three parts:

1. Use designations that serve as the goal statements for all waters;
2. Water quality criteria that consist of numeric and/or narrative descriptions for substances (e.g., pollutants) and conditions (e.g., nuisance growths, biological assemblages) that are consistent with attainment of the designated use narratives; and,
3. An antidegradation policy that deals with protecting waters that are of "better" quality than the minimum established by designated use criteria.

The federal WQS regulations of 1975 (40 CFR Part 131) generally defined the concept of attainability of uses and specified when a use may be removed (or reduced) due to factors that preclude attainment of the CWA 101[a][2] goal uses. Such factors include the influence of natural factors, irretrievability of legacy impacts, technological limitations, and socio-economic consequences. However, the regulations also placed a high burden of proof with sound scientific rationale being necessary to result in the removal of a 101[a][2] designated use.

Designated Aquatic Life Uses

Designated uses were initially very broadly defined based on categorical uses of water for water supply (public, agricultural, and industrial), recreation (swimming, boating), and aquatic life (propagation of fish, shellfish, and wildlife) and with general narrative criteria being assigned to each. This became the template for required designated uses in state WQS and later on incorporating national water quality criteria. For aquatic life most states implemented a "one-size-fits-all" approach that was in keeping with the knowledge and technology that was available in the early 1970s (NAS 1973; U.S. EPA 1976). Distinctions were sometimes made between warm water and cold water fisheries that emphasized game fish attributes. In the 1980s a few states developed refinements that are termed "tiered aquatic life uses" ("TALUs") where multiple subclasses are defined within the general context of a warm water and cold water classification scheme and measured biologically using biological criteria or "biocriteria". Biocriteria include additional classification strata such as ecoregions, catchment size, elevation and temperature within the calibration and derivation processes. Furthermore, TALUs are based on the attributes of the *entirety* of the biological assemblages rather than being restricted to game fish components. U.S. EPA adopted national guidance in 1990 (U.S. EPA 1990) and draft methods document that details the underlying principles of TALUs, how to initiate a framework for TALU development and implementation, and case examples of TALU applications in water quality management (U.S. EPA 2005). The details about the developmental and implementation history of two state programs that were the first to formally adopt TALU frameworks in their WQS (Maine and Ohio) are included in this document[1]. A major theme of this report is that a certain level of specificity of the TALUs and an adequate set of monitoring tools are essential to assure credible UAA outcomes. This is further assured by the development and implementation of a TALU-based approach[2] to WQS and monitoring and assessment.

Use Attainability Analysis (UAA)

A Use Attainability Analysis (UAA) is defined in the federal water quality regulations (40 CFR Part 131) as:

". . . a structured scientific assessment of the factors affecting the attainment of the use which may include physical, chemical, biological, and economic factors as described in §131.10[g]."

The factors are described at 40 CFR Part 131.10[g] as follows:

"States may remove a designated use which is not an existing use, as defined in Section 131.3, or establish sub-categories of a use if the State can demonstrate that attaining the designated use is not feasible because:

1) *Naturally occurring pollutant concentrations prevent the attainment of the use; or*
2) *Natural, ephemeral, intermittent or low flow conditions or water levels prevent the attainment of the use, unless these conditions may be compensated for by the discharge of sufficient volume of effluent discharges without violating State water conservation requirements to enable uses to be met; or*
3) *Human caused conditions or sources of pollution prevent the attainment of the use and cannot be remedied or would cause more environmental damage to correct than to leave in place; or*
4) *Dams, diversions or other types of hydrologic modifications preclude the attainment of the use, and it is not feasible to restore the water body to its original condition or to operate such modification in a way that would result in the attainment of the use; or*
5) *Physical conditions related to the natural features of the water body, such as the lack of a proper substrate, cover, flow, depth, pools, riffles, and the like, unrelated to water quality, preclude attainment of aquatic life protection uses; or*

[1] The draft 2005 document was not finalized by U.S. EPA - it is available at: http://www.midwestbiodiversityinst.org/.
[2] The "TALU based approach" includes tiered aquatic life uses (TALU) based on numeric biological criteria and implementation via an adequate monitoring and assessment program that includes biological, chemical, and physical measures, parameters, indicators and a process for stressor identification.

6) *Controls more stringent than those required by sections 301(b) and 306 of the Act would result in substantial and widespread economic and social impact."*

U.S. EPA UAA Guidance
The currently available EPA guidance for conducting UAAs is described in the 1994 Water Quality Standards Handbook (U.S. EPA 1994):

As defined in the Water Quality Standards Regulation (40 CFR 131.3) a Use Attainability Analysis (UAA) is ". . . a structured scientific assessment of the factors affecting the attainment of a use which may include physical, chemical, biological, and economic factors as described in section 131.10[g]." The evaluations conducted in a UAA will determine the attainable uses for a water body.

The physical, chemical, and biological factors affecting the attainment of a use are evaluated through a water body survey and assessment. The guidance on water body survey and assessment techniques that appears in this Handbook is for the evaluation of fish, aquatic life, and wildlife uses only (EPA has not developed guidance for assessing recreational uses). Water body surveys and assessments conducted by the States should be sufficiently detailed to answer the following questions:

- *What are the aquatic use(s) currently being achieved in the water body?*
- *What are the causes of any impairment of the aquatic uses?*
- *What are the aquatic use(s) that can be attained based on the physical, chemical, and biological characteristics of the water body?*

While this guidance provides the series of steps that a state might take to address use attainability, it does not address the baseline infrastructure of standards and monitoring that is required of the states to execute UAAs with a reasonable degree of reliability and accuracy.

Issues with Current UAA Practice
It is largely the "unsatisfactory outcome" of regulatory actions that has been the primary stimulus for UAAs conducted by non-TALU states. The NPDES program stimulated a number of UAAs in the 1970s and 1980s, particularly in response to water quality based permitting that was sometimes perceived as overprotective of aquatic resources in small or highly modified receiving streams. Novotny et al. (1997) reviewed UAAs across the U.S. and found that most were indeed "issue" driven (e.g., CSOs, effluent dominance, etc.). Early difficulties with water quality based permitting in effluent dominated receiving waters frequently resulted in revising WQS to accommodate the current effluent treatment technology of that time period (e.g., secondary treatment). Some states lowered instream water quality criteria to accommodate existing effluent loadings on a case-by-case basis and sometimes under a

use subcategory that did not meet the 101[a][2] goal both with and without a UAA. Ohio attempted the latter approach in 1978 by developing a Limited Warmwater Habitat (LWH) use subcategory that allowed varied water quality criteria to accommodate existing effluent quality on a waterbody specific basis which was summarily disapproved by U.S. EPA. This less than 101[a][2] goal subcategory was addressed via structured UAA process the first of which resulted in a landmark ruling that upheld the TALU-based approach developed by Ohio in the 1980s[3]. In other cases the water quality criteria were lowered within what was claimed to be a 101[a][2] use. Some of these were disapproved by U.S. EPA, but others were accepted with no follow-up about the root cause of the perceived need to downgrade a use, the water quality criteria, or both. In many of these instances it was the lack of specificity in the aquatic life use itself that led to flawed outcomes. More recently the spate of TMDLs in the late 1990s and early 2000s generated a renewed interest in UAAs as one way of resolving the status of "questionable" impaired waters listings. Once again this exposed the inadequacy of one-size-fits-all general aquatic life uses and reaffirmed the need for refined use subcategories and a more consistent and rigorous UAA process (NRC 2001).

While the majority of the UAAs described above were performed to remove a designated use, a more complete approach would also consider when a more protective use subcategory is needed resulting in an "upgraded" use and consistent with *existing use* (40 CFR Part 131.3[e] and 131.1[i]). A subsequent U.S. EPA, Office of Water memorandum distributed to the EPA regions affirmed that UAA outcomes can also result in use designation upgrades (King 2006). While upgrading to a use subcategory that meets Section 101[a][2] does not require a UAA (40 CFR Part 131.1[k]), it certainly helps to prove the need for such within a consistent data collection and analytical process. Among the states that have actually accomplished the routine execution of numerous UAAs, Maine and Ohio have further distinguished their approaches by making the use designation determination the primary outcome of their monitoring and assessment. This constitutes a proactive approach that is in stark contrast to the reactionary uses of UAAs in the 1970s, 1980s, and 1990s. With an increased interest in TALUs by additional states the merits of a monitoring driven approach to UAAs is now more widely appreciated.

Current Status of State UAAs

The current practice and usage of UAAs among a selection of 14 states varies widely (Table 1). Information was compiled by reviewing state-specific information and reports and the results of state program reviews conducted per U.S. EPA (2013). Table 1 describes the structure of the aquatic life uses including how subcategories are defined, biological criteria (narrative or numeric, in WQS or not), the level of rigor as defined in U.S EPA (2013) for the states that have been reviewed, which biological assemblages are used, what type of habitat assessment is accomplished, is UAA guidance available, how

[3] NEORSD vs. Shank No. 89-1554, Supreme Court of Ohio, Feb. 27, 1991.

Table 1. *Summary of selected U.S. states Aquatic Life Use (AQLU) Attainability Analysis (UAA) frameworks including aquatic life use structure, use subcategories, biological criteria, and key aspects of any UAA type of process including physical habitat, biological indicators, availability of UAA methods, and frequency of UAAs, UAA method references, and reference for recent UAA applications.*

State	Aquatic Life Use Structure	AQL Subcategories	Biological Criteria?	Level of Rigor	UAA Requirements and Documentation					
					Biological Data?	Habitat Data?	UAA Methods Defined?	Frequency of UAAs	UAA References	Example UAA(s)
California	General Uses	Warm & Cold Water	Narrative Translator (by Method)	L3 (2009)	Macros, Fish	[a]RBP[4], [b]HSI[5], [b]PHab[6]	No	Some	None	Tetratech (2004)
Idaho	Fishery Uses	Warm/Cold Water, Modified	Narrative Translator (by Method)	NA	Macros, Fish	[a/b]SHI[7], [a/b]HI[8]	Yes	Few	Grafe et al. (2002)	Idaho DEQ (2015)
Illinois	General Use	General and Limited	Narrative Translator (by Method)	L3- (2013)	Macros, Fish	[a]QHEI,[9] [a]SHAP[10], [a]MMHI[11]	No	Few	None Found	Novotny et al. (2007)
Iowa	Fishery Uses	Warm/Cold Water, Limited	Narrative Translator (by Method)	L3- (2010)	Macros and/or Fish	[b]GFHI[12] [b]EFHI[13]	Yes	Many	Iowa DNR (2006)	Iowa DNR (2009)

[a]Visual Habitat Assessment Protocol; [b]Measurement or Transect Based Habitat Assessment Protocol.

[4] RBP – Rapid Bioassessment Protocols – Barbour et al. (1999).
[5] HSI – Habitat Suitability Indices.
[6] PHab – Physical Habitat assessment.
[7]SHI – Stream Habitat Index - Idaho DEQ (2015).
[8] HI – Habitat, Intensive - Hayslip, G. A. (editor). 1993. EPA Region 10 In-stream Biological Monitoring Handbook (wadeable streams in the Pacific Northwest). EPA-910/9-92-013. U. S. EPA, Region 10.
[9] QHEI – Qualitative Habitat Evaluation Index – Rankin (1989, 1999), Ohio EPA (2006).
[10] SHAP –Stream Habitat Assessment Protocol.
[11] MMHI – Multimetric Habitat Index.
[12] GFHI - General Fish Habitat Index – Iowa DNR (2015).
[13] EFHI - Ecoregional Fish Habitat Index – Iowa DNR (2015).

Table 1. continued.										
State	**Aquatic Life Use Structure**	**AQL Subcategories**	**Biological Criteria?**	**Level of Rigor**	**UAA Requirements and Documentation**					
					Biological Data?	**Habitat Data?**	**UAA Methods Defined?**	**Frequency of UAAs**	**UAA References**	**Example UAA(s)**
Kansas	Fishery Uses	Warm/Cold-water, Limited Uses	Narrative Translator (by Method)	NA	Macros, Mussels	[a]HDI[14]	Yes	Few	KDHE (2001)	No Recent UAAs
Maine	Tiered AQLUs	AA, A, B, C	Numeric (DFM Models)	L4 (2010)	Macros, Periphyton	No	Yes	Numerous (Routine)	Davies et al. (2016)	Davies et al. (2016)
Minnesota	Tiered AQLUs (Proposed)	Exceptional, General, Modified, Coldwater Class 7	Numeric (IBI type indices)	L4 (2015)	Macros, Fish	[a]MSHA[15]	Yes	Pending (Routine)	MPCA (2015)	In Prepara-tion
Missouri	Fishery Uses	Warm/Cold-water, Limited	Narrative Translator (by Method)	L2 (2008)	Macros	[a/b]MO SHAP[16]	Yes	Few	MODNR (2013 draft)	None Found
Ohio	Tiered AQLUs	Exceptional, Warmwater, Modified, Coldwater	Numeric (IBI type indices)	L4 (2010)	Macros, Fish (Amphibians)	[a]QHEI[6] [a]HHEI[17]	Yes	Numerous (Routine)	Ohio EPA (1987, 1989, 2015)	Ohio EPA (2007)

[a]Visual Habitat Assessment Protocol; [b]Measurement or Transect Based Habitat Assessment Protocol.

[14] HDI – Habitat Development Index -
[15] MSHA – Minnesota Stream Habitat Assessment.
[16] MO SHAPP – Missouri Stream Habitat Assessment Project Procedure – MO DNR (2010).
[17] HHEI – Headwater Habitat Evaluation Index – Ohio EPA (2013).

***Table 1**. continued.*

State	Aquatic Life Use Structure	AQL Subcategories	Biological Criteria?	Level of Rigor	UAA Requirements and Documentation					
					Biological Data?	Habitat Data?	UAA Methods Defined?	Frequency of UAAs	UAA References	Example UAA(s)
Oklahoma	Fish and Wildlife Uses	Warmwater, Coolwater, Habitat Limited	Narrative Translator (by Method)	L2 (2014)	Macros, Fish	[a]RBP[1]	Yes	Few	OKWRB (2001)	OKWRB (2012)
Oregon	Fishery Uses	Core Coldwater, Coolwater, Warmwater, Fishery-based[18]	Narrative Translator (by Method)	NA	Macros	[b]PHab[19] [b]Rosgen[20] [b]AHI[21]	Yes	Few	ODEQ (2007)	ODEQ (2012)
Texas	Tiered AQLUs[22]	Exceptional, High, Intermediate, Limited, Minimal	Narrative Translator (by Method)	L3+ (2014)	Macros, Fish	TCEQ [b]HQI[23]	Yes	Many (D.O. focus)	TCEQ (2007)	TCEQ (2012)
Vermont	Tiered AQLUs	A,B,C	Numeric (IBI type indices)	L4 (2010)	Macros, Fish	[a]RHA[24]	Yes	Pending	Pending	Pending
Washington	Fishery Uses	Warm/Cold Water	Narrative Translator (by Method)	NA	Macros, Fish	[b]ISEMP[25]	Yes	Few	WA Dept. Ecology (2005)	CH2M Hill (2004)

[a]Visual Habitat Assessment Protocol; [b]Measurement or Transect Based Habitat Assessment Protocol.

[18] Specific Aquatic Life Uses in Oregon: Salmon/Steelhead Spawning, Core Coldwater Habitat, Salmon/Trout Rearing/Migration, Migration Corridor, Lahontan Cutthroat/Redband Trout, Bull Trout Spawning/Juvenile Rearing, Coolwater Species, Borax Lake Chub, Coldwater Aquatic Life, Coolwater Aquatic Life, Warmwater Aquatic Life, Modified Aquatic Life.
[19] PHab – Physical Habitat transect data (Peck et al. 2006).
[20] Rosgen – Rosgen stream geomorphology assessment method.
[21] AHI – Aquatic Habitat Inventory (ODFW 2010).
[22] TALU for D.O. only; biocriteria not fully developed.
[23] HQI – Habitat Quality Index – TCEQ (2007).
[24] RHA – Reach Habitat Assessment – VT ANR (2008).
[25] ISEMP - Integrated Status and Effectiveness Monitoring Program – ISEMP (2014).

frequently UAAs are conducted, and references to specific UAAs and the attendant process. Out of the 14 states examined in Table 1 aquatic life UAAs were considered routine in only two, Maine, Ohio, and pending in Minnesota with the recent development of TALUs and a process for the routine determination of the specific TALU tier as the primary outcome of their monitoring assessment program (MPCA 2014, 2015). Each of these state programs also function at Level 4 (U.S. EPA 2013) which is a technical necessity for supporting the adoption and implementation of TALUs in WQS and executing a TALU-based approach that supports all water quality management programs. The breadth of this type of program support is in contrast to the Level 2 states that produce general condition assessments as their principal monitoring and assessment (M&A) output. Two other states in Table 1, Texas and Iowa, have conducted numerous UAAs, but these are either focused on a single pollutant (e.g., D.O. in Texas) or have comparatively simple endpoints (e.g., the presence or absence of game fish in Iowa). Both of these programs, however, would have a shorter path to a more complete UAA process than the remaining states in Table 1 assuming the requisite technical rigor is attained.

Improving the UAA Process

The primary purpose of this document is to describe a framework for conducting UAAs for aquatic life uses (ALUs) and how the process functions within a TALU based approach. Non-aquatic life designated uses such as recreation or public water supply are not considered specifically herein, but many the same principles could be applied to these uses. The more effective and accurate conduct of UAAs is contingent on having:

1. The development and adoption of tiered aquatic life uses and biocriteria and their adoption in the WQS;
2. Specific language in the WQS about the designated use narratives and the response to non-attainment of 101[a][2] use subcategories including the options for responding to or reconciling an impairment, the latter including a UAA option; and,
3. The implementation of a TALU-based approach to monitoring and assessment (M&A) which includes a stressor identification process.

TALUs provide a regionally indexed and sufficiently refined framework within which aquatic life uses can be predictably assigned following the general definitions and policy set forth by the 1975 EPA water quality regulations (40 CFR Part 131). Adequate M&A (Yoder 1998; Yoder and Rankin 1998) provides the essential data *and* a sufficiently rigorous assessment process by which existing condition can be accurately and proportionately determined and impairments diagnosed by a stressor identification process which assures that all limiting factors are proportionately delineated.

The key advantages of conducting UAAs within a TALU-based WQS and M&A framework are that they are doable, protective, and *routine*. Attempting UAAs outside of a TALU-based framework is prone to inaccuracies, the commission of both type I and Type II errors, and is more costly on a per capita basis due to the greater burden of scientific uncertainty and the degree of proof that are required. As a result, UAAs have the reputation of being too costly, time consuming, and contentious to bother with. As a result, comparatively few UAAs have been attempted for aquatic life uses outside of the two states that have TALUs in their WQS. This generally occurs where:

1. "One-size-fits-all" use designations are the rule;
2. M&A programs are under-developed, immature, lack sufficiently developed biocriteria, and which are focused solely on general status assessments; and,
3. The designation of uses is by default and when modifications are attempted they are reactionary.

In stark contrast are the state examples where UAAs are a routine outcome of integrated M&A with literally 100s of use changes being accomplished within a rotating basin approach.[26] TALU-based M&A fosters the fundamental integration between M&A and WQS, the latter of which include biologically based uses. Conducting UAAs within an adequate M&A program that includes sufficiently rigorous bioassessment (U.S. EPA 2013) and TALUs produces UAAs that are sound, doable, protective, and routine.

Adequate Monitoring for TALUs and UAAs

Some of the contemporary efforts to revitalize and better define the role of monitoring and assessment in state and federal programs and the emergence of biological criteria concepts offer important details on what is termed here as "adequate" monitoring and assessment (Yoder 1998; Yoder and Rankin 1998). The term "adequate" was chosen as a theme on which to base the template for revitalizing state M&A programs. It was a deliberate attempt to avoid the term "minimum" which is what U.S. EPA has at least tacitly accepted from the states. The term "comprehensive" was also avoided because it carries with it the negative connotation of doing more than is necessary to achieve the basic goals and objectives of a sound and robust M&A program.

An important prerequisite to achieving an adequate M&A approach is the incorporation of fundamental concepts about the development of the indicators and criteria that operationally determine the status of aquatic resources, designated uses, causal diagnosis, and the effectiveness of water quality management. Indicators and endpoints are appropriately detailed and directly support refined criteria and standards that guide management programs and measure their effectiveness. This approach addresses two of the principal issues identified by the National Research Council (NRC 2001) in their review of the role of science in the TMDL process; 1) a lack of adequate monitoring and assessment, and 2) the need for appropriately refined and detailed

[26] A current example can be found at http://epa.ohio.gov/dsw/dswrules.aspx.

water quality standards (WQS) including the need for a better approach to UAAs. Adequate monitoring includes the following key attributes and principles:

- Indicator development, position, and selection adhere to accepted theoretical concepts (i.e., Karr's five factors; NRC Position of the Standard [NRC 2001]);
- Indicators are comprehensive, yet cost-effective to develop and use;
- Indicators are used within their *most appropriate* roles as indicators of stress, exposure, *or* response – elevating stress and exposure indicators as proxies for response is prohibited;
- Indicators are directly tied to a state's WQS via designated uses and numerical criteria;
- Measurement and data quality objectives (MQO/DQO) are defined in the WQS and are adequate to assure accurate assessments and perform diagnostic functions;
- The M&A program can adapt quickly to improved science and technology;
- The M&A program is supported by adequate resources, facilities, and professionalism;
- The spatial design matches the scale at which management is applied thus minimizing the over-extrapolation of M&A results; and,
- The end outcome is an integrated assessment, not just the output of data.

The technical rigor of a state program is equally important to its content for determining if a state is capable of assigning appropriate and attainable use designations, accurately delineating impairments, diagnosing all stressors, and measuring changes over time. These are the major objectives of TALU based M&A and in their sequential order of need and importance.

Judging Adequacy in State Programs

The technical capabilities needed to develop and implement a TALU-based framework are the same as that needed to conduct UAAs and a lack of rigor in any technical element can introduce error and uncertainty into the UAA process. An important observation from the 25 state program reviews conducted since 2002 (U.S. EPA 2013) is that the use of M&A data by Level 2 programs[27] is focused primarily on statewide and regional assessments of condition in support of 305[b] reporting and 303[d] listing. This is the primary M&A output and there is little if any additional "reach" of that information into the primary water quality management programs (WQS, NPDES permitting, TMDLs, 404/401, etc.). Singular "one-size-fits-all" use attainment thresholds consisting of method-based numeric translators are another characteristic of Level 2 programs. In effect, Level 2 programs execute an indirect "hand-off" of M&A information and results to the management programs. While Level 3+ and 4 programs also complete the same baseline 305[b] and 303[d] tasks, they extend the reach of M&A

[27] The state program review process (U.S. EPA 2013) rates state bioassessment programs as Levels 1-4 with Level 4 being the highest level of technical development.

by providing direct support to the primary water quality management programs on a stream and river-specific scale. This includes direct assessments of sources that are linked to measured impairments thus extending the "reach" of the M&A program beyond pass/fail status assessment. If UAAs are done they are reactionary and generally in response to the perception of a type I assessment error. In some cases UAAs can become time consuming, expensive, and inconclusive in the end. By contrast UAAs done within Level 3+/4 programs will avoid these outcomes because the first task of the M&A program is to determine the appropriate and attainable use. By meeting the requirements of adequate M&A spatially adequate data about specific stream and river reaches supports a more complete assessment of causes and sources of impairments. For states with TALUs in their WQS the derivation and establishment of biological criteria will have already been vetted via the public participation process and would have engaged stakeholder interests, each of which are key components of a UAA (Michael and Moore 1997). For these states especially, getting the use designation resolved as a first step provides "up front" support for the management programs by resolving WQS related questions prior to the development of regulatory and management actions. This eliminates the need for reactionary UAAs based on unsatisfactory regulatory outcomes and less than adequate M&A support.

Essential Steps for Aquatic Life UAAs

Besides what has already been described about adequate M&A and programmatic rigor the essential steps for the routine and credible application of a UAA type of approach within a TALU-based framework include:

1. The appropriate and attainable use subcategory is determined *first* via a bioassessment and an attendant habitat assessment tool (the latter providing evidence of attainability when the biocriteria are not attained);

2. The status of the stream or river is determined with the biocriteria at each sampling site;

3. All causes associated with observed biological impairments are delineated; and,

4. Changes over time are documented and assessed for relevance to any management actions with the trajectory of change documented whenever possible.

The focus of step 1 above is to determine the appropriate and attainable use subcategory within a TALU framework. MPCA has developed a TALU structure and the M&A to support it with adoption of the TALU subcategories and numeric biocriteria in 2017. The structure, content, and implementation is similar to what both Ohio (Appendix A) and Maine (Appendix B) have accomplished over the past 35+ years. The key steps and options for determining TALUs for Minnesota warmwater streams and rivers are summarized in Table 2. For the General warmwater use subcategories the default for all warmwater streams and rivers in Minnesota is the current Class 2B, thus this is the starting point for a determination of the appropriate and attainable use subcategory going forward. If sufficient monitoring data demonstrates the biological attainment of the proposed General use subcategory, then that is the appropriate and attainable use. If the biocriteria for the General use are not met, then the habitat assessment that is conducted as part of site-specific M&A is used to determine the potential to meet the General use. This emphasizes the critical role that a robust habitat assessment and affiliated tool calibrated to the use subcategories (MPCA 2014) plays in the implementation of TALUs.

***Table 2**. Tiered aquatic life use options based on evaluation of the default 2B use currently in the Minnesota WQS and under a proposed framework of tiered aquatic life uses (TALUs).*

Current Designated Aquatic Life Use	Monitoring Results	Attains Designated Use?	Management Options Under New TALU-Based Approach
General[28]	**General Use Attainment**	YES	Retain General designation because biocriteria demonstrate attainability.
General	**General Use Non-attainment**	NO	If habitat assessment indicates General is attainable, then retain General use; OR If habitat is impaired & due to 40 CFR 131[g] factors, change use to Modified.
General	**Exceptional Attainment**	YES	Revise use to Exceptional based on attainment of Exceptional biocriteria by *both* assemblages.

The implementation and content of the steps outlined above are generally similar to those outlined in the U.S. EPA (1994) WQS Handbook, but with some very important exceptions. The order of the key UAA tasks within a TALU based approach is different with reconciling the designated use being the first step and the assessment of attainment status the second step. This is done to avoid the pitfall of basing a finding of impairment (or attainment) on the wrong goal, i.e., the designated use which can trigger

[28] General – General Warmwater; subcategories for the Cold Water use designation are also proposed.

a cascade of unproductive pursuits including inappropriate 303[d] listings. The TALU-based approach coupled with the need to have a sufficient level of program rigor is not addressed by U.S. EPA guidance, but is nonetheless a critical part of the credible conduct of UAAs. The third step is to perform the attendant causal analysis as this clarifies which factors need to be addressed to restore impaired uses that were defined in step two. Not only does this affirm if a UAA is needed, it exposes the causes of impairment that are directly regulated by CWA programs which must be resolved outside of the UAA process. Step four is done when sufficient data over time are available which allows the trajectory of the biological indicators to be examined. This is especially important where the improvements are incremental, i.e., they still fall short of the biocriteria for the applicable TALU tier. For some categories of stressors, especially those with complex interactions of pollutants and non-pollutants, the trajectory of the biocriteria is uniquely informative about the prognosis for eventual use attainment.

MPCA has demonstrated a preparedness to implement a TALU-based approach by developing and preparing to adopt biocriteria and TALUs in their WQS (MPCA 2016). The technical rigor sufficient to support all aspects of this approach is the result of a nearly 10-year long developmental process. The routine conduct of UAAs for aquatic life has been planned for and as outlined in the MPCA technical guidance (MPCA 2015).

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Appendix A: Ohio Template for Designating Use Subcategories

Case Study A: Development and Implementation of Tiered Aquatic Life Uses for Ohio Rivers and Streams

Ohio has used biological assessment information in conjunction with chemical water quality and physical habitat assessments to support water quality management since the late 1970s. While the Ohio ALU classification framework pre-dated the BCG by 25 years, it is based on concepts that are parallel to the BCG, highlighting the relationship between biology, habitat, and the potential for water quality improvements. Ohio's approach contributed both technical and implementation "lessons learned" to conceptualization of the BCG (Davies and Jackson 2006). The state's biological monitoring and assessment program has provided timely information about the status of water bodies and the data to support water quality management program information needs for more than 35 years. This includes when biological conditions improve and when revisions of designated uses are warranted. A systematic process to determine which use(s) is (are) appropriate and attainable for a stream or river has been and remains the key first step in using biological assessment data to support water quality management.

Background

A major aspect of the development of the Ohio biological assessment program and tiered ALU framework is the experience gained through the sustained development of systematic biological assessments beginning in the late 1970s and through the 1980s. This is where the methods, concepts, and theories were tested, applied, and refined, resulting in a tractable system for measuring biological quality at appropriate spatial scales and through time. Qualitative, narrative guidelines were initially used to assess biological status via systematic watershed monitoring and assessment. The data and experiences gained in this early assessment process provided the raw materials for incorporating the concepts of biological integrity that emerged later. Further refinements were also made to the biological assessment tools and the tiered uses including how they are assigned and assessed. Keys to the success of this approach were the initial decisions about indicator assemblages and methods. These have remained stable through time with no major modifications that could have resulted in disconnections within the statewide database that is more than 35 years old.

Ohio EPA formally adopted numeric biological criteria into the Ohio Water Quality Standards (Ohio WQS; Ohio Administrative Code 3745-1) in 1990. The biological criteria have been used to guide and enhance water quality management programs and assess their environmental outcomes. As a result, the state refined definitions of some ALUs, adopted new ones, and added numerical biological criteria to support a tiered approach to water quality management within the Ohio WQS (Table A-1). The numeric biological criteria are an outgrowth of an existing framework of TALUs and narrative biological assessment criteria that had been in place since the late 1970s (Tables 2 and 3). Ohio's approach to biological assessment evolved from an initial reliance on best professional judgment guided by the narrative biological criteria for determining the quality of fish and macroinvertebrate assemblages to a more quantitative and independent approach based on calibrated indices and numeric biological criteria. While the early narrative descriptions of four levels of quality ranging from excellent to poor (Tables A-2 and A-3) predated the BCG, the narrative attributes and the rating of multiple levels of condition are consistent with the attributes and scaling of the current BCG. These concepts were retained and further refined with the development of the fish IBI and invertebrate community integrity index (ICI) and the derivation of numeric biological criteria for the current Ohio TALUs (Figure A-1) which were mapped to the BCG as part of the early BCG development workshops hosted by EPA (Figure A-2).

Table A-1. Descriptive summary of Ohio's tiered aquatic life use designations

Aquatic Life Use	Key Attributes	Why a Water body Would Be Designated	Practical Impacts (compared to a baseline of WWH)
Warmwater Habitat (WWH)	Balanced assemblages of fish/invertebrates comparable to least impacted *regional* reference condition	Either supports biota consistent with numeric biological criteria for that ecoregion **or** exhibits the habitat potential to support recovery of the aquatic fauna	Baseline regulatory requirements consistent with the CWA "fishable" and "protection & propagation" goals; criteria consistent with EPA guidance with state/regional modifications as appropriate
Exceptional Warmwater Habitat (EWH)	Unique and/or diverse assemblages; comparable to upper quartile of *statewide* reference condition	Attainment of the EWH biological criteria demonstrated by both organism groups	More stringent criteria for DO, temperature, ammonia, and nutrient targets; more stringent restrictions on dissolved metals translators; restrictions on nationwide dredge & fill permits; may result in more stringent wastewater treatment requirements
Coldwater Habitat (CWH)	Sustained presence of Salmonid or non-salmonid coldwater aquatic organisms; bonafide trout fishery	Biological assessment reveals coldwater species as defined by Ohio EPA (2014); put-and-take trout fishery managed by Ohio Department of Natural Resources	Same as above except that common metals criteria are more stringent; may result in more stringent wastewater treatment requirements
Modified Warmwater Habitat (MWH)	Warmwater assemblage dominated by species tolerant of low DO, excessive nutrients, siltation, and/or habitat modifications	Impairment of the WWH biological criteria; existence and/or maintenance of hydrological modifications that cannot or will not be reversed or abated In the foreseeable future so that WWH biological criteria can be attained; a UAA is required	Less stringent criteria for DO, ammonia, and nutrient targets; less restrictive applications of dissolved metals translators; Nationwide permits apply without restrictions or exception; may result in less restrictive wastewater treatment requirements
Limited Resource Waters (LRW)	Highly degraded assemblages dominated exclusively by tolerant species; *should not* reflect acutely toxic conditions	Extensive physical and hydrological modifications that cannot be reversed, are essentially irretrievable and which preclude attainment of higher uses; a UAA is required	Chemical criteria are based on the prevention of acutely lethal conditions; may result in less restrictive wastewater treatment requirements

Table A-2. Narrative biological criteria (fish) for determining ALU designations and attainment of CWA goals (November, 1980; after Ohio EPA 1981)

Evaluation Class Category	"Exceptional" Class I (EWH)	"Good" Class II (WWH)	"Fair" Class III	"Poor" Class IV
1.	Exceptional or unusual assemblage of species	Usual association of expected species	Some expected species absent, or in very low abundance	Most expected species absent
2.	Sensitive species abundant	Sensitive species present	Sensitive species absent, or in very low abundance	Sensitive species absent
3.	Exceptionally high diversity	High diversity	Declining diversity	Low diversity
4.	Composite index > 9.0–9.5	Composite index > 7.0–7.5; < 9.0–9.5	Composite index > 4.5–5.0; < 7.0–7.5	Composite index < 4.0–4.5
5.	Outstanding recreational Fishery		Tolerant species increasing, beginning to dominate	Tolerant species dominate
6.	Rare, endangered, or threatened species present			

Conditions: Categories 1, 2, 3, and 4 (if data are available) must be met and 5 or 6 must also be met in order to be

Table A-3. Narrative biological criteria (macroinvertebrates) for determining ALU designations and attainment of CWA goals (November 1980; after Ohio EPA 1981)

Evaluation Class Category	"Exceptional" Class I (EWH)	"Good" Class II (WWH)	"Fair" Class III	"Poor" Class IV designated in a particular class.
1.	Pollution sensitive species abundant	Pollution sensitive species present in moderate numbers	Pollution sensitive species present in low numbers	Pollution sensitive species absent
2.	Intermediate species present in low numbers	Intermediate species present in moderate numbers	Intermediate species abundant	Intermediate species present in low numbers or absent
3.	Tolerant species present in low numbers	Tolerant species present in low numbers	Tolerant species present in moderate numbers	Tolerant species abundant (all types may be absent if extreme toxic conditions exist)
4.	Number of taxa > 30[1]	Number of taxa 25–30	Number of taxa 20–25	Number of taxa < 20
5.	Exceptional diversity Shannon index < 3.5	High diversity Shannon index 2.9–3.5	Moderate diversity Shannon index 2.3–2.9	Low diversity Shannon index < 2.3

[1]Number of quantitative taxa from artificial substrates.

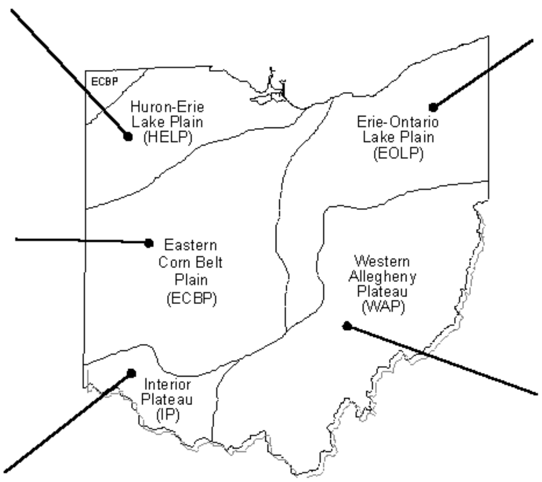
Ohio Biological Criteria: Adopted May 1990 (OAC 3745-1-07; Table 7-14)

Huron Erie Lake Plain (HELP)

Use	Size	IBI	MIwb	ICI
WWH	H	28	NA	34
	W	32	7.3	34
	B	34	8.6	34
MWH-C	H	20	NA	22
	W	22	5.6	22
	B	20	5.7	22
MWH-I	B	30	5.7	NA

Erie Ontario Lake Plain (EOLP)

Use	Size	IBI	MIwb	ICI
WWH	H	40	NA	34
	W	38	7.9	34
	B	40	8.7	34
MWH-C	H	24	NA	22
	W	24	6.2	22
	B	24	5.8	22
MWH-I	B	30	6.6	NA



Eastern Corn Belt Plains (ECBP)

Use	Size	IBI	MIwb	ICI
WWH	H	40	NA	36
	W	40	8.3	36
	B	42	8.5	36
MWH-C	H	24	NA	22
	W	24	6.2	22
	B	24	5.8	22
MWH-I	B	30	6.6	NA

Western Allegheny Plateau (WAP)

Use	Size	IBI	MIwb	ICI
WWH	H	44	NA	34
	W	44	8.4	34
	B	40	8.6	34
MWH-C	H	24	NA	22
	W	24	6.2	22
	B	24	5.8	22
MWH-A	H	24	NA	30
	W	24	5.5	30
	B	24	5.5	30
MWH-I	B	30	6.6	NA

Interior Plateau (IP)

Use	Size	IBI	MIwb	ICI
WWH	H	40	NA	30
	W	40	8.1	30
	B	38	8.7	30
MWH-C	H	24	NA	22
	W	24	6.2	22
	B	24	5.8	22
MWH-I	B	30	6.6	NA

Statewide Exceptional Criteria

Use	Size	IBI	MIwb	ICI
EWH	H	50	NA	46
	W	50	9.4	46
	B	48	9.6	46

Figure A-1. Numeric biological criteria adopted by Ohio EPA in 1990, showing stratification of biological criteria by biological assemblage, index, site type, ecoregion for warmwater and modified warmwater habitat (WWH and MWH, respectively), and statewide for the exceptional warmwater habitat (EWH) use designations.

Developed and adopted by Ohio EPA in 1978, the original tiered aquatic life use narratives represented a major revision to a general use framework that was adopted in 1974. Ohio's tiered uses recognized the different types of warmwater aquatic assemblages that corresponded to the mosaic of natural features of the landscape and nearly two centuries of human-induced changes. The eventual development of more refined tiered uses and numeric biological criteria that are in place today was the result of sustained state support to develop a biological monitoring and assessment program with technical capability to discriminate incremental changes in biological condition with increasing stress. The empirical evidence used to develop the initial concepts for tiered uses can be found in comprehensive works on the natural history and zoogeography of the Midwest such as *Fishes of Ohio* (Trautman 1957, 1981). This and other natural history texts documented the natural and human-caused variations in the distribution, composition, and abundance of biological assemblages over space and through time including before and after European settlement. Trautman (1957) not only provides a detailed narrative of Ohio's natural history, but describes the biological evidence that was used to formulate the initial concepts about biological integrity that emerged in the late 1970s and early 1980s and which were later incorporated in the BCG. Such works also described the key features of the landscape that influence and determine the potential aquatic fauna of water bodies and were the forerunners of the regionalization frameworks that appeared soon after. As an alternative to a "one-size-fits-all" approach, these provided an important foundation for the development of Ohio's tiered uses. The articulation of a practical definition of biological integrity by Karr and Dudley (1981) provided a theoretical framework for the development of Ohio's numeric biological criteria (Figure A-2). Key components of this framework are: (1) using biological assemblages as a direct measure of ALU attainment status (Herricks and Schaeffer 1985; Karr et al. 1986), (2) the development and use of IBIs as assessment tools (Karr 1981; Karr et al. 1986), (3) derivation of regional reference condition to determine appropriate and attainable ALU goals and assessment endpoints (Hughes et al. 1986), and (4) systematic monitoring and assessment of the state's rivers and streams using a pollution survey design. These represented a major advancement over previous attempts (Ballantine and Guarria 1975) to define and develop a workable framework to address the concept of biological integrity. Embedded in this framework is the recognition that water quality management must be approached from an ecological perspective that is grounded in sound ecological theory *and* which is validated by empirical observation. This means developing monitoring and assessment and WQS to encompass the five factors that determine the integrity of a water resource (Karr et al. 1986).

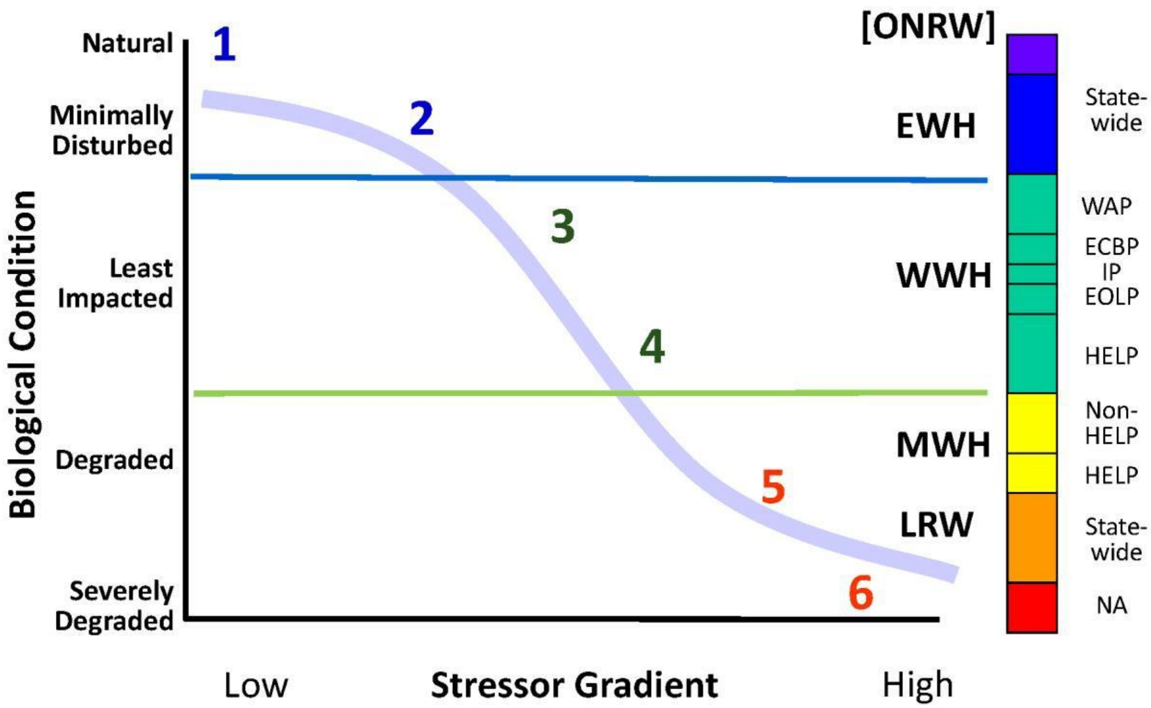
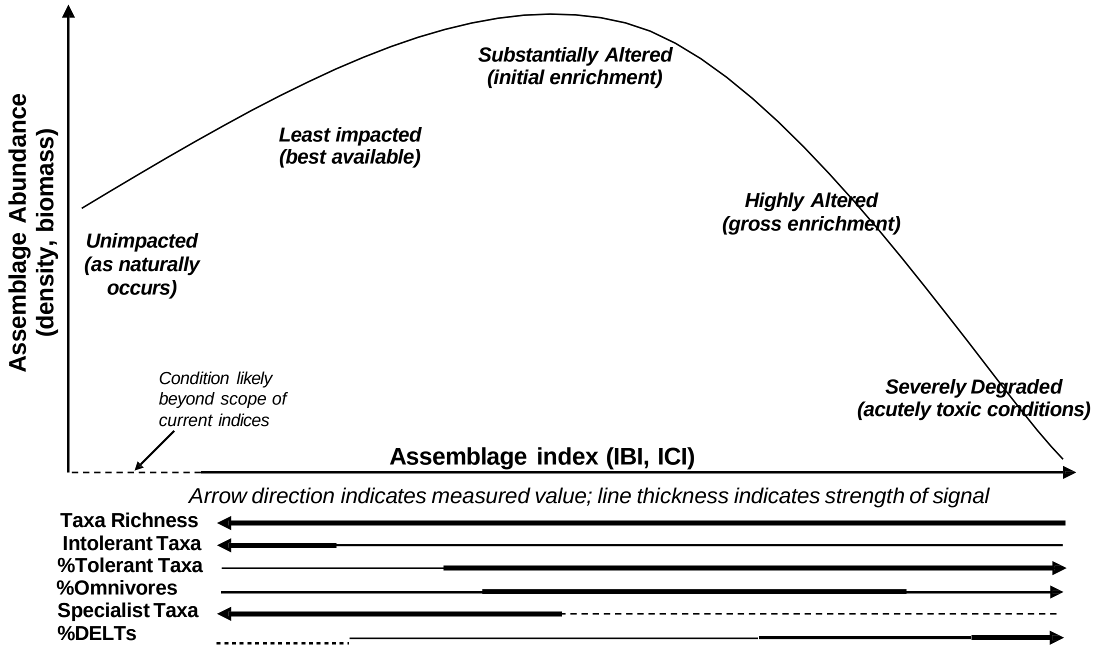


Figure A-2. An initial mapping of the Ohio TALUs to the BCG relating descriptions of condition along the y1-axis and ranges of condition encompassed by the numerical biological criteria for each of four tiered use subcategories and the highest antidegradation tier (ONRW) along the y2-axis. ONRW – Outstanding National Resource Waters; EWH – Exceptional Warmwater Habitat; WWH – Warmwater Habitat; MWH – Modified Warmwater Habitat; LRW – Limited Resource Waters.

The understanding of fish and macroinvertebrate assemblage responses to stressor gradients ranging from minimally disturbed to severely altered conditions was affirmed by repeated empirical observations of assemblage responses which are depicted in Figure A-3. This graphic represents measured assemblage abundance (y-axis) against assemblage indices (fish IBI, macroinvertebrate ICI; x-axis) with the response of selected metrics and other assemblage attributes at increments along what



Biological and Stressor Gradient Descriptors

"As Naturally Occurs" *(Pristine)*	**"Least Impacted"** *(Exceptional)*	**"Initial Enrichment"** *(Good)*	**"Moderate Enrichment"** *(Fair)*	**"Gross Enrichment"** *(Poor)*	**"Severely Degraded"** *(Very Poor)*
		Assemblage Characteristics			
Native assemblages; no symptoms of stress	"Best of what's left" assemblages; high richness; intolerants, specialists predominate	"Typical" assemblages; good richness; emerging symptoms of stress in selected metrics	"Impaired" assemblages; tolerants & generalists predominate numbers/bio-mass; loss of intolerants	"Degraded"; highly tolerant taxa pre-dominate; reduced abundance; anomalies increasing	"Severely degraded"; very low numbers; few taxa; very high % anomalies; toxic signatures
		Chemical Water Quality Condition			
As natural; no human-made compounds present	"Best reference" quality; toxics < detection;high D.O.,low nutrients	"Background reference" quality; toxics < chronic; adequate D.O.,nutrients = reference	*"Enriched" quality; toxics < chronic; marginal D.O. regime,nutrients > reference*	*"Degraded" quality; toxics > chronic; low D.O., nutrients* **>>** *reference*	*"Extremely poor" quality; toxics ≥ acute; very low D.O., nutrients* **>>** *reference; contaminated sediments*
		Physical Habitat & Flow Regime			
Natural habitat and flow regime; no human-made modifications	Excellent quality habitat & flow regime; recovered from human-made modifications	Good quality habitat & flow regime; *de minimis* human modifications	Fair quality habitat & flow regime; active human modifi-cations; incomplete recovery	Poor quality habitat & flow regime; active human modifi-cations; no recovery	Severe modifi-cations; ephemeral flows; active human modifications; no recovery potential
		Examples of Sources and Activities			
No effects of human activity are evident	Point sources present, do not dominate flows; NPS impacts buffered by extensive riparian system	Point sources may dominate flows; NPS impacts buffered by good riparian zones	PS/NPS enrich-ment impacts; NPS unbufferd; channel modifi-cations; im-poundments	Gross PS/NPS enrichment impacts inc. CSOs; NPS unbufferd; chan-nel modifications; urbanization	Severe PS/NPS toxic impacts; extreme channel modifications; urbanization; acid mine drainage, severe thermal

Figure A-3. Response of fish and macroinvertebrate metrics and attributes to a quality gradient and levels of stressors in Midwestern U.S. rivers and streams (modified from Ohio EPA 1987 and Yoder and Rankin 1995b).

is in reality a continuum. Biological descriptions correspond to the six levels of the then emerging BCG model and include descriptions of key assemblage characteristics, chemical water quality conditions, physical habitat and flow regime, and sources of stress that are typically associated with each. This was modified from the original conceptual model of Ohio EPA (1987a) and Yoder and Rankin (1995b), and it includes the probable upper limits of Ohio's fish and macroinvertebrate indices. It demonstrates that understanding the relationship between assemblage responses and stressors is a fundamental aspect of using biological assessments to support condition assessments *and* water quality management programs. It also demonstrates the pre-BCG concepts that eventually merged in the formal development and description of the current BCG.

Determining Appropriate Levels of Protection

By merging the ALU framework with systematic monitoring and assessment, Ohio has been able to determine attainable levels of condition for streams and rivers and also to set protection levels for high quality waters. This framework is consistently applied within a rotating basin sequence of "biological surveys" that address the following questions:

1) Is the current designated ALU appropriate and attainable and if not, what is the appropriate use for a water body?
2) Are the biological criteria for the most appropriate and attainable use tier attained?
3) Have there been any changes through time and what do they portend for water quality management?

The scale of monitoring and assessment is sufficiently detailed so that designations of individual water bodies or segments of a water body can be made based on scientific information and data. Getting this task done correctly affects everything that follows including assessments of condition and which WQS will guide water quality management actions such as permitting and TMDLs. The data gathered by a biological survey is processed, evaluated, and synthesized in a biological and water quality report. The report serves as the rationale for justifying recommended changes to a currently assigned ALU. The report also identifies sources of pollutants and/or pollution contributing to impairment(s) of the recommended designated uses. The recommendations for use designation revisions are a direct output of the biological and water quality assessment. Recommended revisions to the WQS are based on a UAA framework that emphasizes the demonstrated *potential* to attain a particular use tier based on the following information (and in order of importance):

1) Attainment of the numeric biological criteria for WWH[38] or EWH results in designation of that use; or,
2) If the WWH biological criteria are not attained, the habitat determined by the Qualitative Habitat Evaluation Index (QHEI; Rankin 1995) based on an assessment of habitat attributes is used to determine the *potential* to attain WWH.

[38] WWH – Warmwater Habitat is the minimum condition that meets the 101[a][2] goal of the Clean Water Act under the Ohio WQS. A UAA is required to designate a river or stream to a lower use (e.g., MWH or LRW).

For uses below WWH (i.e., MWH or LRW), a UAA is performed and includes consideration of the restorability of the water body and of the factors that may preclude WWH attainment. This process requires the following information:

1) The current attainment status of the water body based on a biological assessment performed in accordance with the requirements of the biological criteria, the Ohio WQS, and the Five-Year Monitoring Strategy;
2) A habitat assessment to evaluate the potential to attain WWH; and,
3) A reasonable relationship between the impaired status and the precluding human-caused activities based on an assessment of multiple indicators used in their most appropriate indicator roles and a demonstration consistent with 40 CFR Part 131.10[g].

Since 1978 Ohio EPA has used a consistent process to validate and, if necessary, revise uses in the Ohio WQS. The codified uses for approximately 2,000 streams and rivers have been revised using this process (Figure A-4) and information from a biological and water quality assessment. This became a routine practice once the assessment criteria and decision making process for UAAs were established in the mid-1980s. It required the parallel development of reliable tools, particularly for determining status, assessing habitat, and determining causal associations, all of which is part of the developmental process described in several documents and publications (Ohio EPA 1987; 2006; Rankin 1989; 1995; Yoder 1995). The terms "upgrade" and "downgrade" are used only as descriptions of the direction of change from the current codified use to that derived from systematic monitoring and assessment. The vast majority of these changes are from the baseline of original designations that were made in 1978 without the benefit of systematic monitoring and assessment data, numerical biological criteria, and refinements in the process that occurred in the mid-1980s. Hence, these original designations are merely being replaced by the most appropriate use designation based on consistently applied criteria and assessments. Undesignated streams are almost always smaller watersheds of < 5–10 mi^2 drainage area that were missed by the default stream naming format that was employed when stream and river specific designations were originally adopted in 1985. Prior to that time, smaller tributaries were "automatically" assigned the use tier of the parent mainstem river or stream, a practice that resulted in numerous erroneous use designations. The more frequent monitoring of these smaller streams and watersheds in the 1990s and 2000s was partially the result of a shift in emphasis to watershed based TMDLs which resulted in numerous undesignated streams being monitored and hence designated for the first time. A detailed fact sheet is prepared for each use designation rulemaking to communicate the types of proposed changes to the WQS, the rationale for the changes, and which rivers and streams are affected by the proposed changes. When use designation rulemakings are underway, fact sheets specific to affected river basins can be found on Ohio EPA's website.[1]

[1] See http://epa.ohio.gov/dsw/dswrules.aspx#120473212-early-stakeholder-outreach. Accessed February 2016.

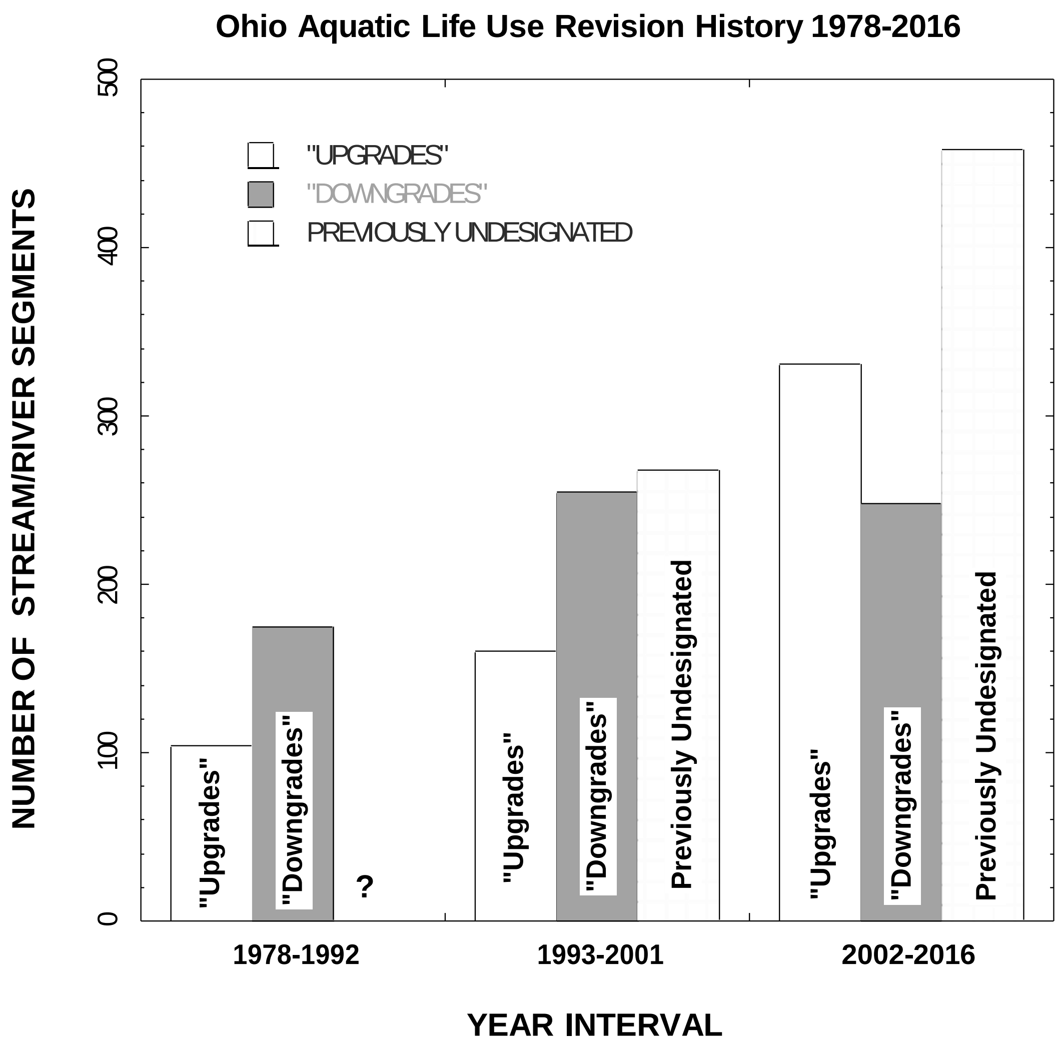


Figure A-4. The number of individual stream and river segments in which ALU designations were revised during 1978–1992, 1993–2001, and 2002–2016. Cases where the use was revised to a higher use are termed "upgrades" and cases where a lower use was assigned are termed "downgrades." Previously undesignated refers to streams that were not listed in the 1985 WQS, but which were added as each was designated as a result of systematic monitoring and assessment. The number of waters previously undesignated in the first interval is unknown.

The Ohio tiered use and biological criteria framework and their application to Ohio rivers and streams were first tested in the Ohio court system in 1989 and were validated by a lower court and upheld in appeals up to, and including, the Ohio Supreme Court (NEORSD vs. Shank No. 89-1554, Supreme Court of Ohio, Feb. 27, 1991). The application of the biological criteria to justify additional pollution controls in response to a biological impairment was likewise validated by a lower court and upheld in subsequent appeals (City of Salem vs. Korleski No. 09AP-620, Tenth District Court of Appeals, March 23, 2010; Ohio Supreme Court 2010-0818; appeal not accepted, August 25, 2010).

Setting Attainable Goals

Ecologically-based tiered uses, a systematic approach to monitoring and assessment, and a tractable UAA process can provide substantial benefits for water quality management programs related to guiding efforts to improve conditions and assessing the effectiveness of those efforts in protecting and restoring an ALU. The identification of the recovery potential for aquatic life in a water body using a systematic approach can help set attainable goals for improvements and support evaluation of environmental risks. The Ohio case example illustrates the role of tiered ALUs using a BCG approach for interpretation of conditions, systematic monitoring and assessment, and a consistent process for conducting UAAs in support of TMDLs. The UAA process is routinely applied as a result of the systematic monitoring and assessment of Ohio rivers and streams (Figure A-5). The data are used to support recommendations for revisions to the Ohio WQS on an annual basis.

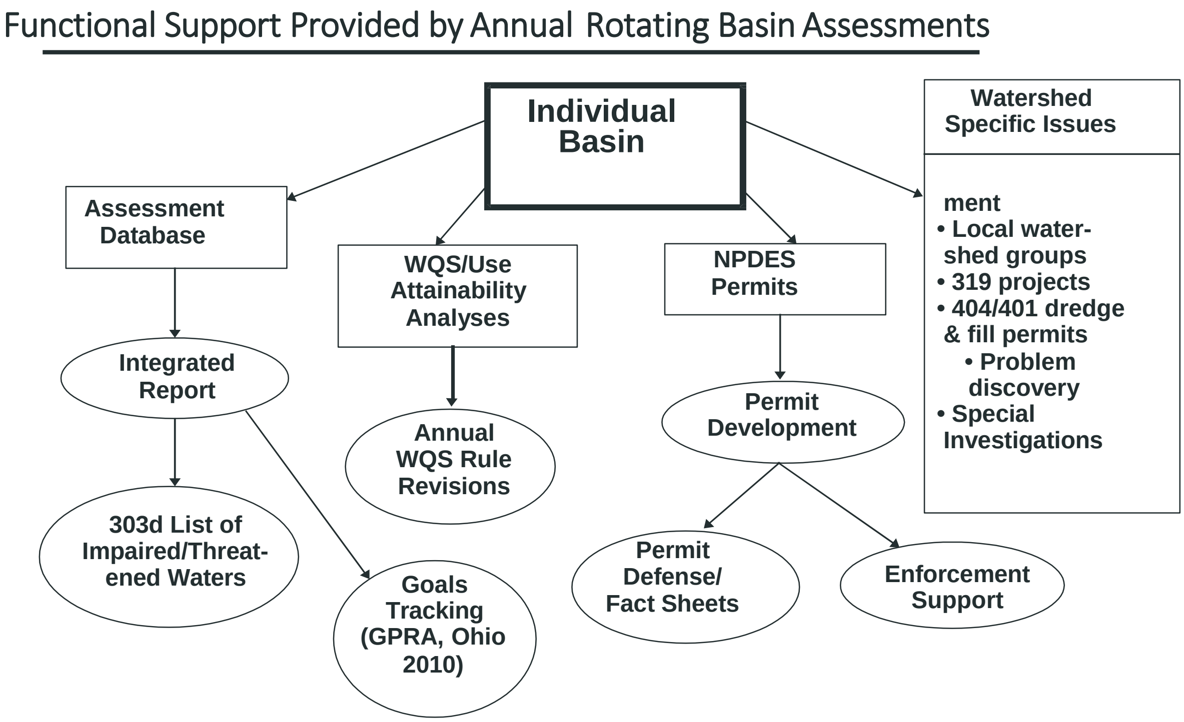


Figure A-5. The flow of information from biological and water quality assessments to support for major water quality management programs in Ohio.

Ohio's tiered ALU designation procedures were incorporated into the TMDL process beginning in 1999 (Figure A-6; Ohio EPA 1999). Figure A-6 illustrates the steps for validating the most appropriate tiered ALU and then basing a TMDL on the criteria embodied by that use tier and the attendant assessment of the receiving streams and rivers. It also illustrates the delineation of the severity and extent of impairments, the most probable causes of the impairments, and follow-up assessments to validate TMDL effectiveness. Because the Ohio EPA monitoring and assessment strategy includes chemical, physical, and biological indicators which are used in their most appropriate roles as indicators of stress, exposure, and response (Yoder and Rankin 1998), support for the development of TMDLs can go beyond addressing singular pollutants to addressing the combination of pollution and pollutants that impair an ALU.

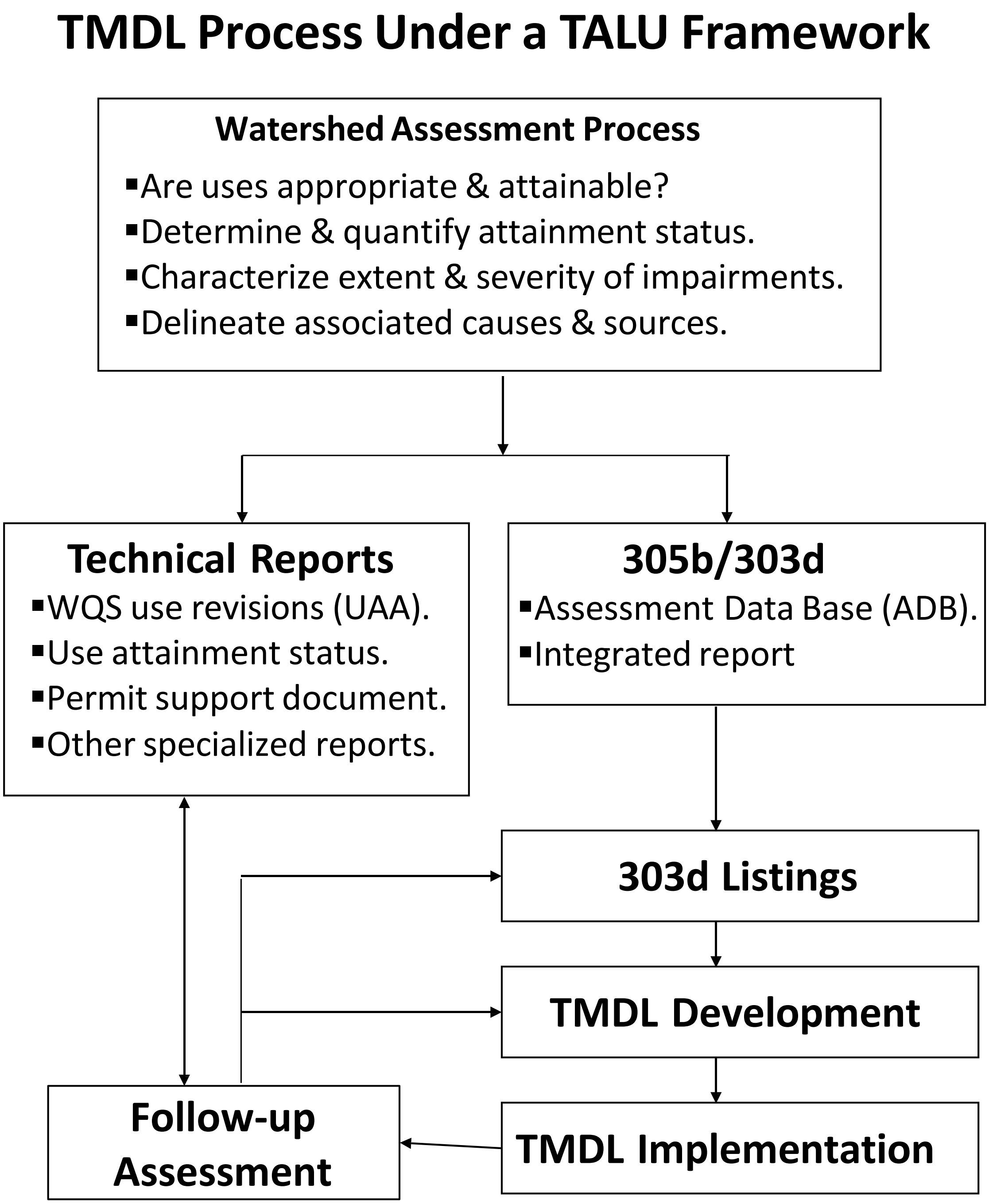


Figure A-6. Key steps showing how a TALU based framework can be used to organize and guide a TMDL development and implementation process.

Protecting High Quality Water Bodies

Ohio's antidegradation rule (Ohio Administrative Code 3745-1-05) incorporates levels of protection between the minimum required under the CWA and the maximum protection afforded by federal regulations. The most stringent application of antidegradation is to disallow any lowering of water quality in waters listed as ONRWs. The minimum requirement allows for a lowering of water quality to the minimum WQS applicable to the water body if a determination is made that lowering water quality is necessary to accommodate important social and economic development. However, lowering of water quality below that which is necessary to protect an existing use is prohibited. Ohio has two intermediate levels of protection for certain ecologically important water bodies that permanently reserve a portion of the unused pollutant assimilative capacity, thereby assuring maintenance of a water quality that is better than that prescribed by the prevailing designated use tier. The two intermediate levels are: (1) Outstanding State Water (OSW; Figure A-7), and (2) Superior High Quality Water (SHQW) which fall in between ONRW and General High Quality Waters (GHQWs; Figure 8). High quality water bodies are valued public resources because of their ecological and human benefits. Their biological components act as an early warning system that can indicate potential threats to human health, degradation of aesthetic values, reductions in the quality and quantity of recreational opportunities, and other ecosystem

Figure A-7. The Mohican River in northeastern Ohio—a candidate for OSW classification because of its high quality ecological and recreational attributes.

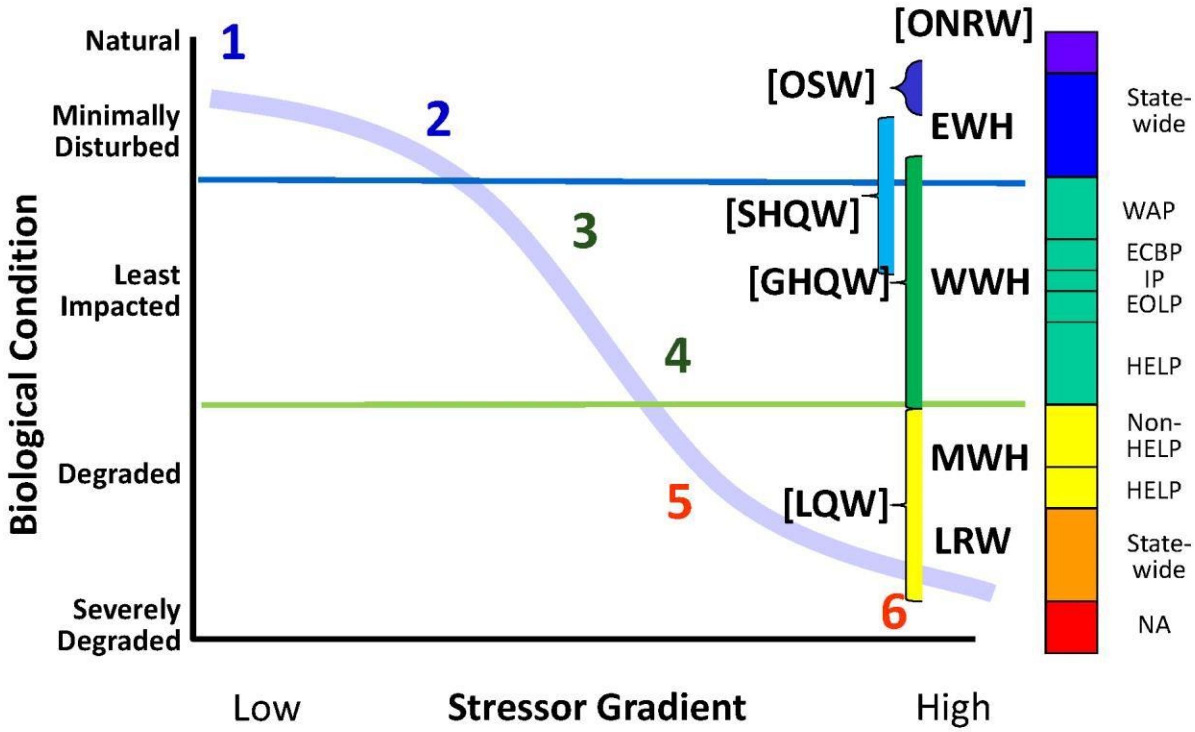


Figure A-8. Mapping the Ohio antidegradation tiers to the BCG relating descriptions of condition along the y1-axis and ranges of condition encompassed by the numerical biological criteria for each of four tiered use subcategories and the four antidegradation tiers along the y2-axis. ONRW – Outstanding National Resource Waters; OSW – Outstanding State Waters; SHQW – Superior High Quality Waters; GHQW – Generally High Quality Waters; LQW – Low Quality Waters; EWH – Exceptional Warmwater Habitat; WWH – Warmwater Habitat; MWH – Modified Warmwater Habitat; LRW – Limited Resource Waters.

benefits, or services. The ability of streams and rivers to provide these beneficial services and to act as environmental sentinels is reduced whenever their integrity is degraded. Under the Ohio antidegradation rule, a portion of the remaining assimilative capacity is reserved for water bodies classified as OSW or SHQW in order to preserve an already existing high quality.

Ohio uses a number of biological and physical attributes to place river and stream segments into the OSW, SHQW, and GHQW antidegradation tiers (Table A-4). Included are the presence of state or federally listed endangered and threatened species, declining fish species (as defined in the antidegradation rules), the fish and macroinvertebrate assemblage indices (IBI and ICI), the QHEI, the vulnerability of the river or stream to increased stressors, the relative abundance of fish species sensitive to pollution and habitat destruction, and the accumulation of multiple attributes. Adjustments are also made for the Lake Erie drainage to account for the fewer endemic fish and mussel species. Additional considerations include other designations, such as state and national scenic river status, outstanding biodiversity among all aquatic assemblages, exceptionally high quality habitat, and the presence of unique landforms along geological and geomorphological boundaries.

Table A-4. General guidelines for nominating OSW, SHQW, and GHQW categories in Ohio. Attributes are considered both singly and in the aggregate.

Attribute	OSW	SHQW	GHQW
Endangered & Threatened Species	Multiple species; large populations; include the most vulnerable species	Present, smaller populations; may include less vulnerable species	Absent or, if present, small populations or of low vulnerability
Declining Fish Species	> 4 declining fish species/segment; large populations	2–4 declining fish species/segment; moderate populations	< 2 declining fish species/segment; typically small populations
IBI and ICI	High mean scores; very high max scores (> 56)	Lower mean scores; fewer high max scores or, if more high scores, few other attributes	Lower mean scores; few or no very high max scores
QHEI	High percentage of QHEI scores ≥ 80	Fewer QHEI scores ≥ 80, many above 70	Few or no QHEI scores ≥ 80, fewer above 70
Vulnerability	Little wastewater effluent; high vulnerability	May be more wastewater effluent; moderate vulnerability	Lower vulnerability; for vulnerable components, antidegradation application may still be denied
Relative Abundance of Fish Species Sensitive to Pollution and Habitat Destruction	Relative abundance is ≥ 3 standard deviations compared to statewide collections of similar sized streams	Relative abundance is ≥ 2 standard deviations compared to statewide collections of similar sized streams	Relative abundance is < 2 standard deviations compared to statewide collections of similar sized streams
Multiple Attributes	High co-occurrence of above attributes	Lower co-occurrence of above attributes or individual attributes more marginal	Little co-occurrence of above attributes, individual attributes often marginal if present

Conclusion

The Ohio approach to classifying waters based on current ecological condition and potential for improvement provides a direct linkage to the CWA biological Integrity objective and ALU goals. This direct linkage enables more effective communication with stakeholders and water quality management decision makers on current conditions and likelihood for improvements. The BCG-like approach enables Ohio EPA to account for biological expectations relative to ecoregion and drainage area and provides a numeric value that synthesizes everything that is being experienced by the biota that can be tracked, monitored, and compared over time to determine if conditions are improving, stabilizing, or deteriorating. As chemical, physical, and biological monitoring has been coordinated and the database expanded, critical information for investigating cause and source of biological impairments has been built and has enabled water quality managers to target sources of stressors and their mechanism of action on the aquatic ecosystem. Because of this database, the state has been able to develop water quality goals for some parameters less well-suited to the classic dose-response relationship for DO and many toxicants. Ohio's ecologically-based approach to classifying waters combined with a robust monitoring program has provided a scientifically defensible method to categorize waters into designated uses and antidegradation tiers. The process has generated UAAs and justification documents as an accepted and routine rulemaking process, primarily resulting in incremental upgrades as controls and BMPs were implemented and improvements observed.

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Appendix B: Maine Template for Designating Use Subcategories

Maine Case Study B: Development of Condition Classes and Biological Criteria to Support Water Quality Management Decision Making

Clear, technically rigorous goal statements have provided Maine with an effective framework to improve biological condition of streams and rivers. Maine has established four ALU classes (Classes AA/A/B/C) with different ecological expectations. The classes span the range from Maine's interpretation of the CWA interim goal to the ultimate CWA objective "to restore and maintain chemical, physical and biological integrity" (Class AA/A). All rivers and streams in Maine are assigned to one of the four classes in Maine's WQS for planning and management purposes. These TALUs and numeric biological criteria have enabled Maine to inject critical biological information into all aspects of water quality management. Along with the practical experience and scientific advancements demonstrated by other states with strong biological assessment programs, Maine's approach to classification and biological criteria development provided the template for the conceptual BCG (Davies and Jackson 2006). In turn, Maine continues to strengthen and develop its biological assessment program to address other water bodies and include measures of the algal communities in its assessments. The BCG is being incorporated as part of its "toolbox" to accomplish these tasks.

Background

Since the 1960s, prior to adoption of the CWA, Maine water quality law has had a tiered structure based on observations of gradients of water quality conditions. In 1986, Maine revised its water classification law and added TALUs to maintain and restore the structure, function, and biological integrity of aquatic life communities. Maine's TALUs were based on concepts of John Cairns, H.T. Odum, and others who observed declines in biological condition in response to gradients of increasing stressors (Ballentine and Guarraia 1977; Odum et al. 1979, Cairns et al. 1993; Karr and Chu 2000). The four narrative TALU standards in Maine's water classification law describe conditions across a biological gradient ranging from "as naturally occurs" (Classes AA and A) to "maintenance of structure and function" (Class C). Class C is the lowest ALU designation allowed in the state and consistent with Maine's interpretation of the CWA fishable/swimmable interim goal (Table 35; M.R.S.A Title 38 Article 4-A § 464-466). Maine's TALUs for fresh surface waters apply to streams, rivers, and wetlands. Maine has similar TALUs for coastal marine waters (SA, SB, SC). Maine has established a single class for lakes that is equivalent to Class A. Maine's TALUs are based on tiers of biological condition along observed human disturbance gradients. Such stressor-response relationships are also the foundation of the later development of the BCG.

Maine's TALUs are supported by ecologically-based definitions in the law. The narrative definitions in Maine law establish the biological characteristics that are required to attain the standards of each class (Table B-1). Class AA and Class A have the same "*as naturally occurs*" aquatic life goals and will hereafter be referred to as Class AA/A; Class AA is more restrictive in allowable permitted activities. For example, no dams or discharges are allowed in Class AA waters. Maine's assessed streams and rivers are predominantly classified as either Class AA/A or B waters, 48.6% and 51%, respectively. Class A/AA waters have been interpreted by Maine as comparable to BCG levels 1 and 2 and class B waters are equivalent to BCG level 3. Less than 1% of Maine's streams and rivers are classified as Class C waters, which have been deemed as comparable to BCG level 4. These waters are primarily in urbanizing areas or downstream of significant point sources. Figure B-1 summarizes relationships between Maine's narrative biological, chemical, and physical standards and shows Maine's TALUs in relation to the BCG.

Table B-1. Criteria for Maine river and stream classifications and relationship to antidegradation policy

Class	DO criteria	Bacteria criteria	Habitat narrative criteria	Aquatic life narrative criteria*** and management limitations/restrictions	2012 Percentage of Maine waters designated in class ****	Corresponding federal antidegradation policy tiers
AA	As naturally occurs	As naturally occurs	Free-flowing and natural	As naturally occurs**; no direct discharge of pollutants; no dams or other flow obstructions.	3.6%	3 (Outstanding National Resource Water [ONRW])
A	7 ppm; 75% saturation	As naturally occurs	Natural**	Discharges permitted only if the discharged effluent is of equal to or better quality than the existing quality of the receiving water; before issuing a discharge permit the Department shall require the applicant to objectively demonstrate to the department's satisfaction that the discharge is necessary and that there are no reasonable alternatives available. Discharges into waters of this class licensed before 1/1/1986 are allowed to continue only until practical alternatives exist.	45%	2 ½
B	7 ppm; 75% saturation	64/100 mg (g.m.) or 236/100 ml (inst.)*	Unimpaired**	Discharges shall not cause adverse impact to aquatic life** in that the receiving waters shall be of sufficient quality to support all aquatic species indigenous** to the receiving water without detrimental changes to the resident biological community.**	51%	2 to 2 ½
C	5 ppm; 60% saturation; and 6.5 ppm (monthly avg.) when temperature is ≤ 24 °C	125/100 mg (g.m.) or 236/100 (inst.)*	Habitat for fish and other aquatic life	Discharges may cause some changes to aquatic life**, provided that the receiving waters shall be of sufficient quality to support all species of fish indigenous** to the receiving waters and maintain the structure** and function** of the resident biological community. **	0.4%	1 to 2

Source: Maine DEP (modified). http://www.maine.gov/dep/water/monitoring/classification/index.html.

Notes:

* g.m. = geometric mean; inst. = instantaneous level.

** Terms are defined by statute (Maine Revised Statutes Title 38, §466).

*** Numeric biological criteria in Maine regulation Chapter 579, Classification Attainment Evaluation Using Biological Criteria for Rivers and Streams http://www.maine.gov/dep/water/rules/index.html.

**** Source: 2012 Maine Integrated Water Quality Report, http://www.maine.gov/dep/water/monitoring/305b/2012/report-final.pdf.

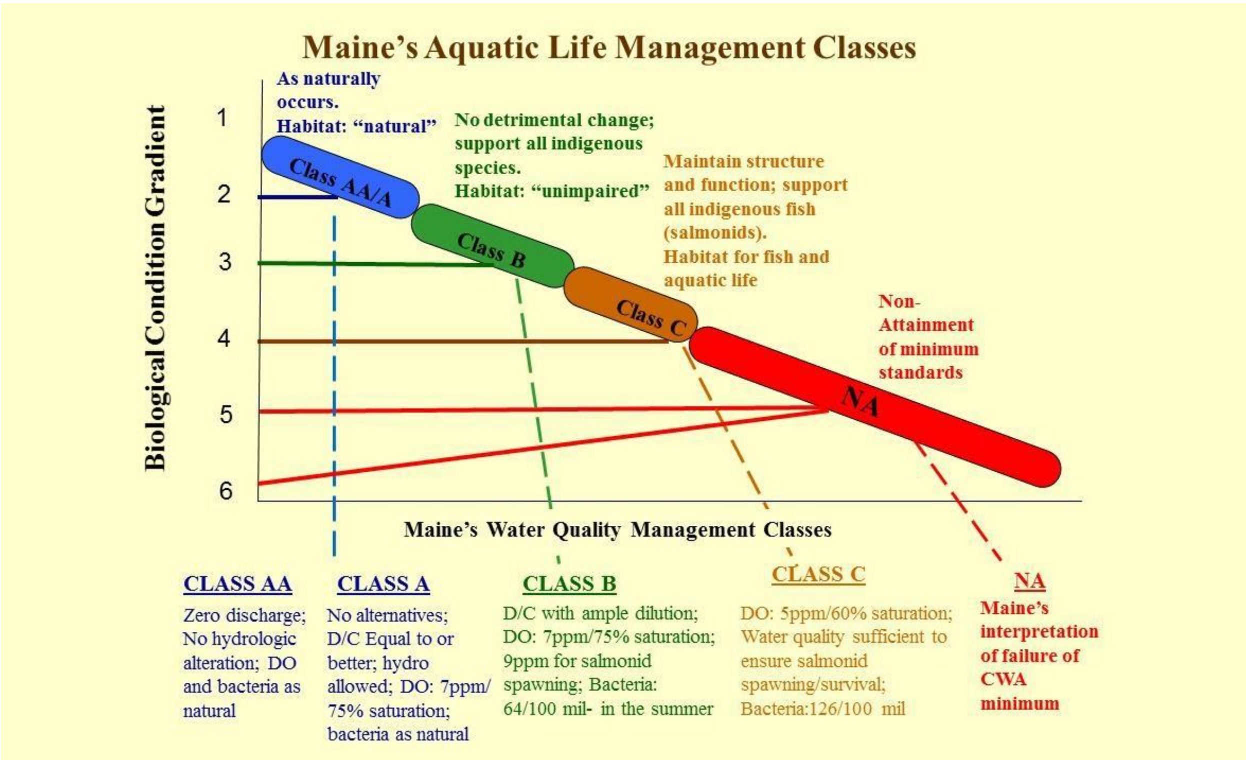


Figure B-1. Relation between Maine TALUs, the BCG, and Maine's other water quality standards and criteria. Class AA/A is approximately equivalent to BCG levels 1 and 2. Classes B and C approximate BCG levels 3 and 4, respectively. Non-attainment conditions below Class C are approximately equivalent to BCG levels 5 and 6.

Maine's Numeric Biological Criteria and Tiered Aquatic Life Uses

In 2003, Maine adopted numeric biological criteria in rule for rivers and streams, based on assessment of benthic macroinvertebrates (State of Maine 2003; Shelton and Blocksom 2004; Davies et al. In press). Technical details describing development of the statistical biological criteria models are found in Chapter 4 of this document and in Davies et al. (In press). In short, MEDEP utilized expert consensus to establish four *a priori* groups corresponding to Maine's TALUs, and developed and tested a linear discriminant model (LDM) to predict the probability of a sample attaining ALU goal conditions (Class AA/A, Class B, and Class C). The fourth group, termed "non-attainment" (NA) represents samples that are in poorer condition than Class C. The LDM and accompanying provisions for application are codified in rule and constitute Maine's numeric biological criteria.[1] When confirmed (e.g., by re-sampling and review of data results) that a stream reach fails to attain its assigned water quality goal, the water body segment is listed as impaired on the state's 303(d) list (Table B-2). State law requires that water bodies be considered for upgrade to a higher class if they are found to be consistently attaining the standards of that higher classification.

[1] http://www.maine.gov/dep/water/rules/index.html. Accessed February 2016.

Table B-2. Examples of how numeric biological criteria results determine whether or not a water body attains designated ALUs in Maine

Legislative Class	Monitoring Result	Attains Class?	Next Step
A	A	Yes	--
C	B	Yes	Review for upgrade
A	B	No	303(d) list as impaired if confirmed
B	NA	No	303(d) list as impaired if confirmed

MEDEP also conducts biological assessments of stream algal, wetland macroinvertebrate, and wetland phytoplankton and epiphytic algal assemblages (Danielson et al. 2011, 2012). MDEP used Maine's narrative biological criteria and the BCG as the foundation of biological assessment models for stream algae and wetland macroinvertebrates. A first step in model-building was to empirically compute tolerance values for algal and macroinvertebrate species that had been collected in Maine's monitoring program. After computing tolerance values, the species were grouped into the BCG framework's sensitive, intermediate, and tolerant attribute groups. MEDEP then modified the BCG framework for stream macroinvertebrates for stream algae and wetland macroinvertebrates, describing how those assemblages empirically respond to anthropogenic stressor gradients. MEDEP used the BCG and tolerance metrics along with the narrative biological criteria and other metrics to build predictive biological assessment models for the additional assemblages. MEDEP has completed LDM statistical models to predict TALU attainment for both stream algal and wetland macroinvertebrate community data. These models currently are used to help interpret narrative biological criteria. Following adequate testing and standard public review protocols, MEDEP intends to amend the Maine Biological Criteria Rule[2] to include the stream algal and wetland macroinvertebrate models as numeric biological criteria.

In summary, numeric biological assessment models, when codified in the MEDEP biological criteria rule (as for stream macroinvertebrates), or when used as an objective corroboration of expert judgment (as for stream algae and wetlands), provide a transparent and standardized quantitative means for determining attainment of TALUs in Maine WQS. Numeric biological criteria have enabled Maine to use biological information to support multiple water quality management information needs and decision making. Examples of applications follow.

Goal-based Management Planning to Optimize Aquatic Life Conditions

As described in the previous section, the Maine State Legislature revised Maine's WQS and classification law in 1986 (M.R.S.A Title 38 Article 4-A § 464-466) establishing narrative biological criteria for four ALU classes for rivers and streams. This law set in motion a process involving the public, the state environmental agency, and the Maine legislature to assign all Maine waters to an appropriate goal classification. All available monitoring data and information about then-current biological and/or water quality conditions were used to initially propose the statutory classes for stream and river segments for the 1986 law. Many waters that lacked current monitoring data retained their previous water quality goals (generally Class B, except for some urban or industrialized areas, which were Class C) until monitoring data or other evidence was found to recommend a different (and in most cases higher) class.

[2] See Code of Maine Rules, MEDEP, Chapter 579, http://www.maine.gov/dep/water/rules/index.html. Accessed February 2016.

Maps spanning the period between 1987 (Figure B-2) and 2012 (Figure B-3) show the past and present distribution of water quality classifications. Approximately 99% of Maine's rivers and streams have been designated for classes of protection equal to or higher than Maine's interpretation of the CWA Interim Goal (i.e., Class C). Reclassification upgrades have been implemented with strong public and legislative support. The state has designated water bodies into higher classes to protect waters currently demonstrating high quality and to retain improvements in lower quality waters that had been restored to higher conditions due to wastewater treatment successes. During the nearly three decades since 1987, the Maine State Legislature has assigned 13,955 river and stream miles to a Class A or Class AA management goal, an increase of 25.5%[3]. Numeric biological criteria and articulation of the gradient of aquatic life management classes facilitated the recognition of both the presence of high quality waters and improvements in condition due to remediation. These classification upgrades have mostly been drawn from Class B and Class C waters where biological monitoring data demonstrated either the potential, or the actual achievement of the standards of Class A or Class AA. Without their ALU classification approach, TALUs, and criteria, these gains in condition would likely have gone un-detected and unprotected. Additionally, the state's ecologically descriptive condition classes have enhanced public understanding of existing conditions, problems, and restorable target conditions. They provide an important tool in building public and stakeholder support for the often substantial investment that is required to restore aquatic resources.

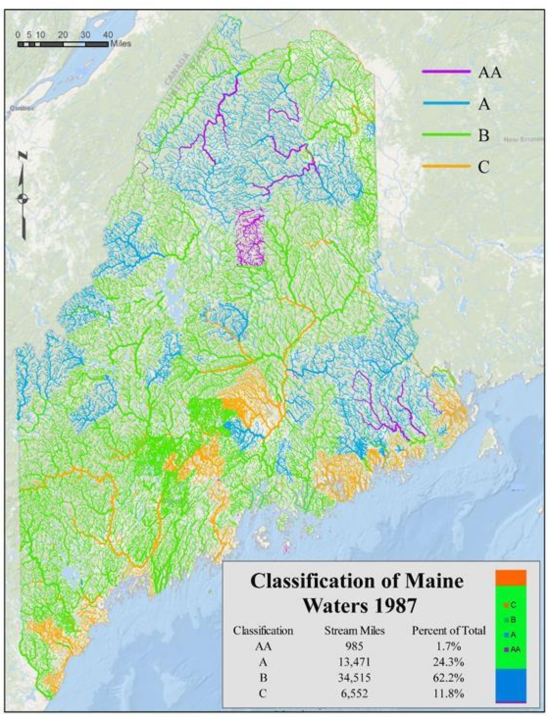


Figure B-2. Distribution of Maine water quality classifications in 1987 prior to WQS revisions.

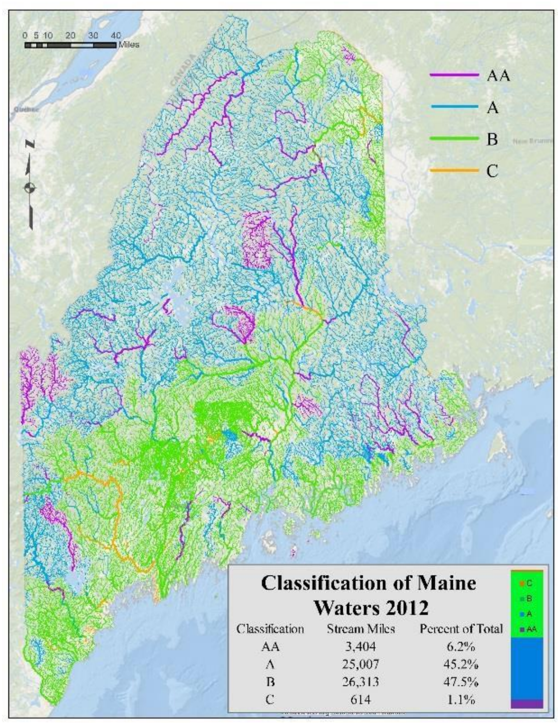


Figure B-3. Distribution of Maine water quality classifications in 2012 following 25 years of water quality improvements and classification upgrades.

[3] See State of Maine Water Quality Standards Docket, http://www.maine.gov/dep/water/wqs/docket/index.html and USEPA, State Tribal and Territorial Standards http://water.epa.gov/scitech/swguidance/standards/wqslibrary/me_index.cfm.

Early Detection and Management of an Emerging Problem

When Maine's Biological Monitoring Program was initiated, a primary concern was management of point source discharges. Implementation of Best Available Technology for point sources eliminated many of these causes of biological impairment with the result that the aquatic life in receiving waters throughout the State rebounded to significantly improved conditions (Davies et al. 1999; Davies et al. In press). More recently, however, biological assessment of smaller streams has revealed impairment caused by changes in physical stream conditions (e.g., increased impervious surfaces in the watershed, hydrologic and stream channel shape alteration). Chemical assessments in these smaller streams have documented increased nutrients and toxic constituent concentrations, salt runoff, increased temperature, and decreased DO.

In 2006, Maine became one of the first states to issue TMDLs based on the percent of a stream watershed covered by impervious surfaces such as roads and parking lots (% IC) (Meidel and MEDEP 2006a, 2006b). Narrative and numeric biological criteria in Maine's WQS were used as the TMDL end point, goal, and ultimate numeric water quality compliance measure for the impaired portions of the streams in order to address non-attainment of ALUs. The restoration pathway described in the TMDL focused on realistic approaches to minimizing the biological, physical, and chemical *effects* of impervious cover, rather than direct elimination of IC. Expanding on the success of the 2006 % IC TMDL, in 2012, MEDEP completed a statewide % IC TMDL for 30 urban impaired streams and 5 associated wetlands (MEDEP 2012). As in 2006, the 2012 TMDL also included aquatic life restoration targets based on the relationship of % IC in the stream watersheds and target improvements in macroinvertebrate community condition.

In 2015, MEDEP conducted a fine-scale geospatial analysis of % IC in watersheds upstream of algal and macroinvertebrate biological assessment sites and determined attainment of TALU for each assemblage at those sites (Danielson et al. In press). Watershed % IC estimates were computed in ArcMap with 1- meter, high-resolution spatial data from 2004 and 2007. Results, shown in Figure B-4, revealed that in general, streams become vulnerable to no longer attaining Class AA/A biological criteria when % IC in upstream watersheds is in the range of 1%–3% IC. The risk of not attaining Class B biological criteria increases in the range of 3%–6% IC. Finally, the transition from low risk to high risk of attaining Class C criteria is in the range of 10%–15% IC.

The % IC study revealed that small streams are at risk of impairment at lower levels of watershed % IC than previously recognized. Recognizing the difficulty, expense, and extended lag times associated with urban stream restoration, environmental managers and urban planners in Maine increasingly realize the importance and cost-effectiveness of *preventing* impairment of urban streams. TALU and BCG concepts, along with rigorous biological assessment data, helped MDEP raise awareness about the vulnerability of biological assemblages to urbanization and other human-caused stressors. This information is used in Maine at both the state and local level to inform water quality management decisions and local land use planning and design of development.

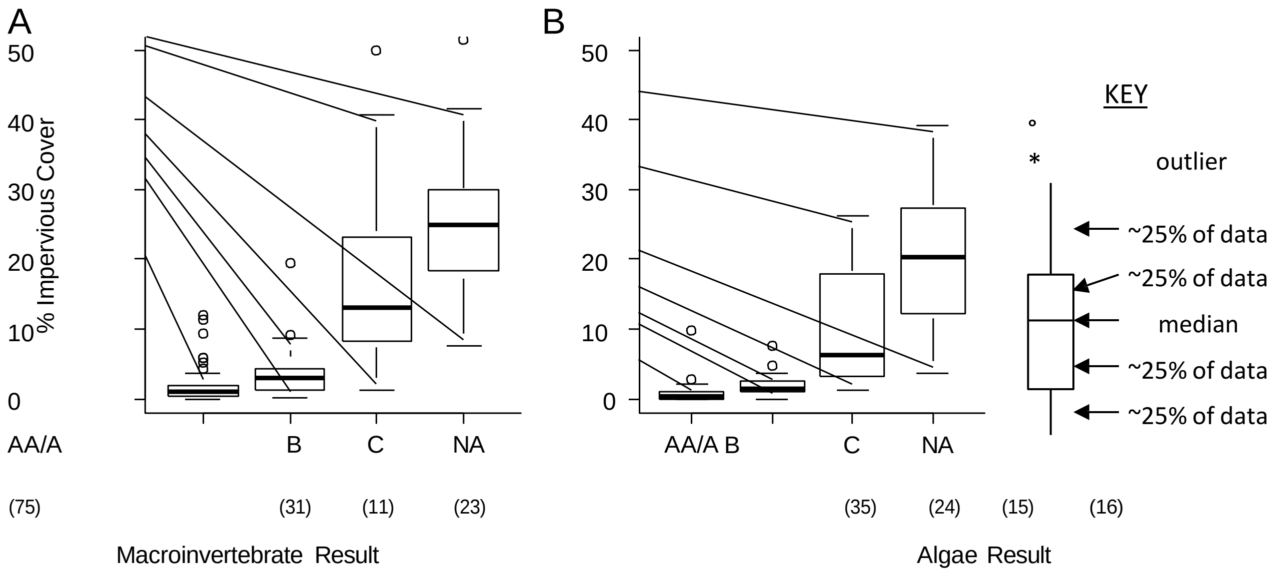
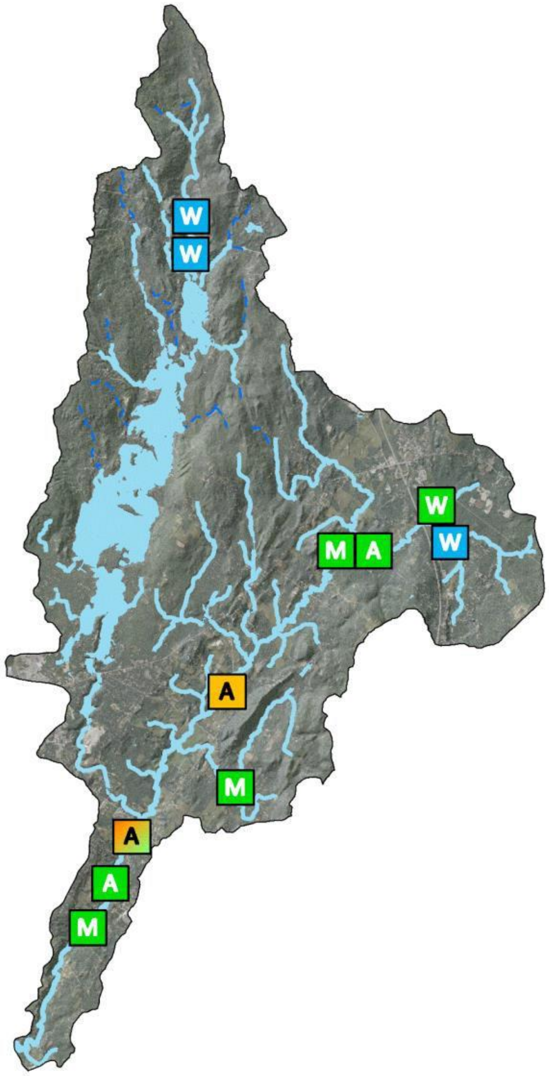


Figure B-4. Box-and-whisker plot of % IC of samples grouped by biological assessment results for (A) macroinvertebrates and (B) algae with number of samples in parentheses. The NA group includes samples that do not attain biological criteria for Classes AA/A, B, or C (Source: Danielson et al. In press).

Monitoring and Assessment to Determine Current Condition: Using Biological Condition Gradient Concepts to Integrate Biological Information from Multiple Assemblages and Water Body Types



	WATERBODY	ASSEMBLAGE	CLASS	BCG LEVEL
W	WETLAND	MACROINVERTEBRATE	A	2
W	WETLAND	MACROINVERTEBRATE	B	3
M	STREAM	MACROINVERTEBRATE	B	3
A	STREAM	ALGAE	B	3
A	STREAM	ALGAE	B/C	3/4
A	STREAM	ALGAE	C	4

Figure B-5. Pleasant River sites with attained water quality class and BCG level for different assemblages and water body

BCG concepts provide Maine with a common assessment framework for comparing biological integrity among different types of water bodies (wetlands, rivers, and streams), regardless of the assemblage assessed or the sampling methods used. This enables MEDEP to evaluate condition and threats to aquatic resources on a watershed basis. The integrated assessment also contributes important information for design of remediation activities, even in the absence of formally promulgated numeric biological criteria. For example, MEDEP evaluated the condition of the Pleasant River watershed using multiple biological assessment models, water quality class attainment, expert judgment, the BCG, and supporting chemical and physical information. Located in southern Maine, the Pleasant River watershed is primarily forested with some agriculture, as well as increasing amounts of urbanization in the downstream portions of the watershed. The Pleasant River has a TALU goal of Class B. MEDEP sampled algae and macroinvertebrates in several locations on the Pleasant River and sampled macroinvertebrates in several headwater wetlands (MEDEP 2006, 2009, 2014; Danielson et al. 2011). Biological assessment showed that the headwater stream and wetland samples attained Class A or B biological criteria using macroinvertebrate data (Figure B-5).

However, further downstream, the stream macroinvertebrate samples attained Class B biological criteria, but stream algal samples were mixed, attaining Class B or C. MEDEP used water chemistry data, habitat evaluations, diagnostic algal and macroinvertebrate metrics, expert judgment, and the BCG concept to determine that nutrient pollution was the probable stressor to which the algal community was responding. A watershed survey identified potential sources of nutrients in the lower part of the watershed. The combination of biological assessments for two water body types and taxonomic groups allowed MEDEP to complete a more holistic and meaningful evaluation of the Pleasant River watershed than what could have been accomplished with only one biological assessment method. MEDEP now has a tool to detect early signals of nutrient pollution before the full aquatic community is detrimentally impacted.

Findings from biological assessments of multiple assemblages and water body types have also been used to improve and strengthen Maine's statewide impervious cover TMDL report.[4] For example, in Maine's 2010 Integrated Water Quality Report, Capisic Brook in Portland and Westbrook, Maine was 303(d)- listed for stream benthic macroinvertebrate impairment based on MEDEP's numeric biological criteria rule. Although numeric biological criteria for Maine wetlands had not yet been formally promulgated, Capisic Pond was also listed for wetland macroinvertebrate impairments based on interpretation of quantitative data showing that narrative ALUs were not attained. The state's multivariate biological assessment models for wetland macroinvertebrates and stream algae enabled results to be compared to Maine's TALU classes and macroinvertebrate numeric biological criteria. Stream algal and wetland macroinvertebrate biological assessments helped biologists determine that Capisic Pond and Capisic Brook were not attaining narrative biological criteria, resulting in biological impairment listing for multiple causes.

Using Maine's Tiered Aquatic Life Uses and Biological Assessment Methods to Evaluate Wetland Condition

The MEDEP Biological Monitoring Program assesses the health of inundated emergent and aquatic bed freshwater wetlands. Samples consist of aquatic macroinvertebrates, planktonic and epiphytic algae, and physical and chemical data related to trophic state and habitat condition (MEDEP 2006; MEDEP 2009). Sampling typically occurs in freshwater marshes and fringing wetlands associated with rivers, streams, lakes, and ponds. The biological assessment statistical model for wetlands provides an objective means of assessing condition.

Maine has found that wetland biological assessment provides a complementary approach to assessments of wetland function and value. Under the definitions established by the USEPA *Wetland Core Elements of an Effective State and Tribal Wetlands Program*[5] Maine conducts a "level 3" biological assessment of wetlands. According to EPA, "level 3 or intensive site assessments provide a more thorough and rigorous measure of wetland condition by gathering direct and detailed measurements of biological taxa and/or hydro-geomorphic functions." Maine's wetland macroinvertebrate biological assessment program can detect incremental differences in aquatic resource condition utilizing a locally calibrated statistical model consistent with the BCG concepts (MDEP 2006; MDEP 2009). Additional applications of wetland biological assessments include determining whether wetlands attain designated ALUs, tracking trends over time, and, in conjunction with chemical and physical assessments, diagnosing stressors, and assessing impacts or threats related to land use practices (e.g., point source discharges, toxic contaminants, hydropower, and water withdrawal projects).

In 2013, the MEDEP Biological Monitoring Program evaluated the biological condition of wetland compensatory mitigation projects using wetland biological assessment methods (DiFranco et al. 2013).

[4] See http://www.maine.gov/dep/water/monitoring/tmdl/tmdl2.html. Accessed February 2016.

[5] See http://water.epa.gov/grants_funding/wetlands/cefintro.cfm. Accessed February 2016.

Mitigating adverse environmental impacts of development is an integral part of Maine's Natural Resources Protection Act,[6] a state law regulating land use activities and administered by MEDEP. The State of Maine or federal agencies administering resource protection regulations might require appropriate and practicable compensatory mitigation as a condition of granting a permit to alter or destroy wetlands. Compensation is defined in the NRPA as "replacement of a lost or degraded wetland function with a function of equal or greater value." If ecologically appropriate compensation is not available or otherwise practicable, a permit applicant may request to pay an *in-lieu* compensation fee to be used for the purpose of restoring, enhancing, creating or preserving other resource functions or values that are environmentally equal or preferable to the functions and values being lost. Upon authorization the In-Lieu Fee is placed in a "Natural Resource Mitigation Fund" administered by The Nature Conservancy's (TNC's) Maine office.

For this study, MEDEP wanted to determine whether compensatory mitigation projects supported aquatic life communities comparable to minimally disturbed reference sites. The MEDEP Biological Monitoring Program evaluated quantitative biological data, biological assessment model results, expert judgment, and the BCG, to compare the biological condition of 9 wetland compensation sites to that of 51 minimally disturbed reference sites. The mitigation sites in the study represented a cross section of available Maine "permittee-responsible" compensation projects that used restoration, creation, enhancement, and preservation techniques, and were completed between 1995 and 2007. The compensation projects varied in age and encompassed a range of freshwater wetland types, including forested, scrub-shrub, emergent, wet meadow, aquatic bed, and open water marsh.

Figure B-6 illustrates comparisons of reference and mitigation sites for sensitive versus tolerant taxa metrics using box and whisker plots and quantile (cumulative distribution) plots. In general, mitigation sites had fewer numbers and types of sensitive taxa and a higher proportion of eurytopic taxa (i.e., taxa that are adapted to a wide range of environmental conditions). Table B-3 shows estimated BCG condition based on data analysis, expert judgment and the provisional wetland biological assessment model (DiFranco et al. 2013). Results of this study indicated that community structure is significantly different between a set of 51 reference wetlands and nine mitigation wetlands based on taxa tolerance metrics and BCG level. This type of information can improve monitoring and assessment of mitigation sites.

[6] See NRPA, http://www.maine.gov/dep/land/nrpa/index.html (Accessed February 2016), 38 M.R.S.A. § 480 A–BB.

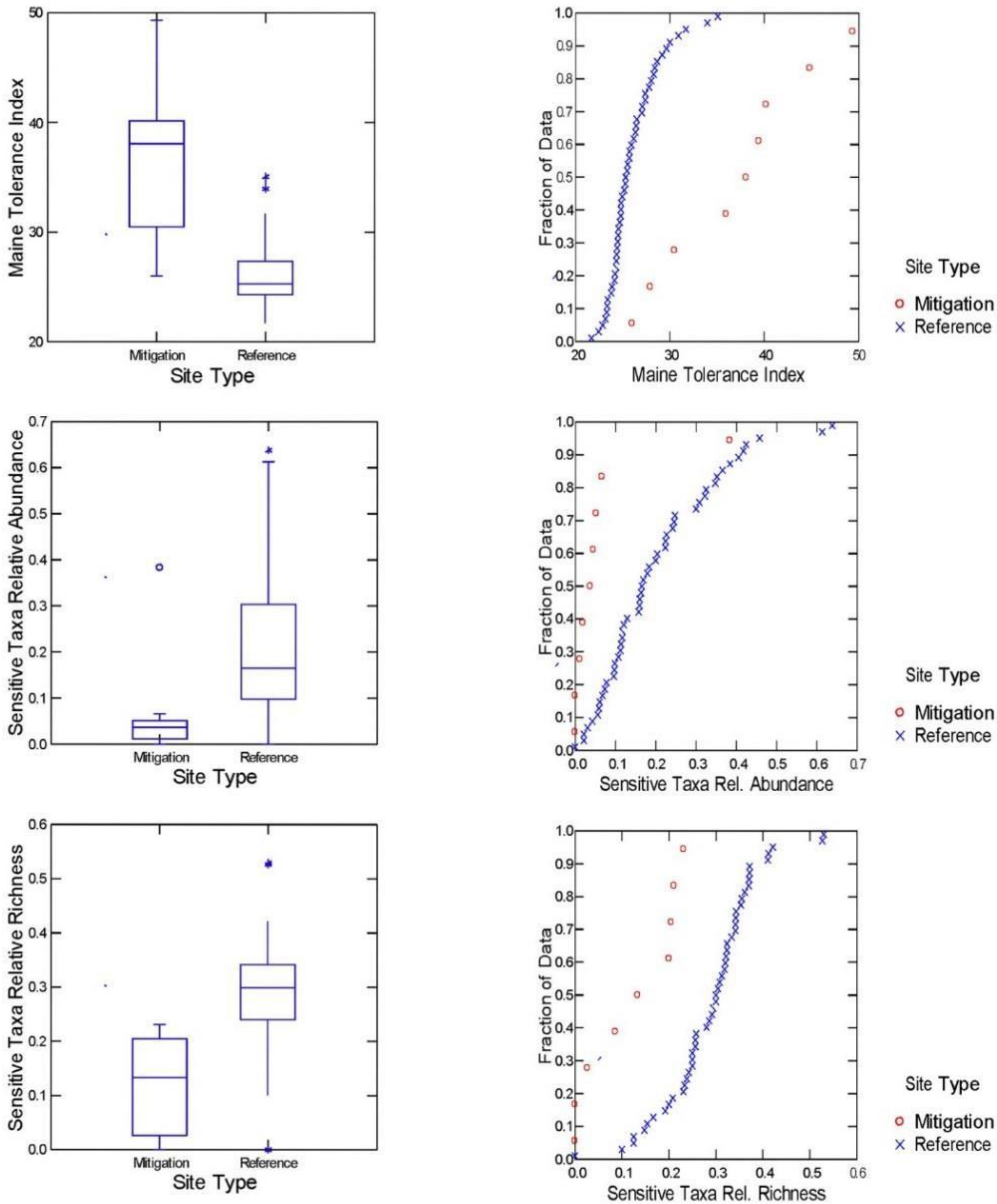


Figure B-6. Comparison of reference and mitigation sites for the Maine Tolerance Index and sensitive/tolerant taxa metrics (reference site N=51; mitigation site N=9) (DiFranco et al. 2013).

Table B-3. Measured values of chemical and watershed stressors, attained water quality classes, and corresponding BCG levels of reference wetlands and mitigation wetlands (DiFranco et al. 2013)

Mitigation Site Station Number	Specific Conductance µS/cm	Total Phosphorus (mg/L)	MEDEP Human Disturbance Score	Watershed Alteration	Assigned Legislative Class	BCG Level
Reference site range	**9–95**	**.005–.097**	**1–10**	**0–5.5**		**2.5–4.5**
Reference site mean	**30.6**	**.017**	**5**	**1.9**		**2.8**
W-171	98	0.15	26	24.1	B	5.2[3]
W-173	141	0.22	20	74.7	B	5.5
W-174	57	0.071	10	37.6	C	4.2
W-175	25	0.013	23	16.7	B	4.2
W-179	265	0.051	23	84.0	B	5.5
W-180	76	0.032	22	21.9	B	4.2
W-181	163	0.091	24	39.9	C	4.8
W-182	1120	0.069	40	100	B	4.5
W-184	234	0.027	22	73.3	B	4.5

[1] Reference site classification attainment: Class AA/A or Class B: 78%; Class C: 8%; Non-attainment: 0

[2] Non-attainment of Class C (i.e., lower than the lowest Maine ALU standards)

[3] MEDEP assigns BCG scores utilizing digits to the right of the decimal point to indicate the strength of association, e.g., level 3.2 means "Leans toward level 2"; level 3.5 means "Solid level 3", level 3.8 means "Leans toward level 4".

Conclusion

For Maine, their approach to classifying waters based on current ecological condition provides a direct linkage to CWA biological integrity objectives and ALU goals. This direct linkage facilitates effective communication with stakeholders and water quality management decision makers on current conditions and the likelihood for improvements. As sustained and significant improvements in biological condition were observed based on systematic monitoring of streams, these improvements were documented and class assignments for specific streams were upgraded (e.g., Class C to B; Class B to A as appropriate). As Maine further develops and applies biological assessment tools and data to water bodies other than streams (e.g., wetlands, estuaries, lakes, large rivers), the BCG is included as part of their toolbox.

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Attachment 8

AUTHENTICATED U.S. GOVERNMENT INFORMATION GPO

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Part IV

Environmental Protection Agency

40 CFR Part 131

Water Quality Standards Regulatory Revisions; Final Rule

ENVIRONMENTAL PROTECTION AGENCY

40 CFR Part 131

[EPA–HQ–OW–2010–0606; FRL–9921–21–OW]

RIN 2040–AF16

Water Quality Standards Regulatory Revisions

AGENCY: Environmental Protection Agency (EPA).

ACTION: Final rule.

SUMMARY: EPA updates the federal water quality standards (WQS) regulation to provide a better-defined pathway for states and authorized tribes to improve water quality and protect high quality waters. The WQS regulation establishes a strong foundation for water quality management programs, including water quality assessments, impaired waters lists, and total maximum daily loads, as well as water quality-based effluent limits in National Pollutant Discharge Elimination System (NPDES) discharge permits. In this rule, EPA is revising six program areas to improve the WQS regulation's effectiveness, increase transparency, and enhance opportunities for meaningful public engagement at the state, tribal and local levels. Specifically, in this rule EPA: Clarifies what constitutes an Administrator's determination that new or revised WQS are necessary; refines how states and authorized tribes assign and revise designated uses for individual water bodies; revises the triennial review requirements to clarify the role of new or updated Clean Water Act (CWA) section 304(a) criteria recommendations in the development of WQS by states and authorized tribes, and applicable WQS that must be reviewed triennially; establishes stronger antidegradation requirements to enhance protection of high quality waters and promotes public transparency; adds new regulatory provisions to promote the appropriate use of WQS variances; and clarifies that a state or authorized tribe must adopt, and EPA must approve, a permit compliance schedule authorizing provision prior to authorizing the use of schedules of compliance for water quality-based effluent limits (WQBELs) in NPDES permits. In total, these revisions to the WQS regulation enable states and authorized tribes to more effectively address complex water quality challenges, protect existing water quality, and facilitate environmental improvements. The final rule also leads to better understanding and proper use of available CWA tools by promoting transparent and engaged public participation. This action finalizes the WQS regulation revisions initially proposed by EPA on September 4, 2013.

DATES: This final rule is effective on October 20, 2015.

ADDRESSES: EPA has established a docket for this action under Docket ID No. EPA–HQ–OW–2010–0606. All documents in the docket are listed on the *http://www.regulations.gov* Web site. Although listed in the index, some information is not publicly available, *e.g.*, confidential business information or other information whose disclosure is restricted by statute. Certain other material, such as copyrighted material, is not placed on the Internet and will be publicly available only in hard copy form. Publicly available docket materials are available either electronically through *http://www.regulations.gov* or in hard copy at the Office of Water Docket Center, EPA/DC, William Jefferson Clinton West Building, Room 3334, 1301 Constitution Ave. NW., Washington, DC 20004. The Public Reading Room is open from 8:30 a.m. to 4:30 p.m., Monday through Friday, excluding legal holidays. The telephone number for the Public Reading Room is (202) 566–1744, and the telephone number for the Office of Water Docket Center is (202) 566–2426. To view docket materials, call ahead to schedule an appointment. Every user is entitled to copy 266 pages per day before incurring a charge. The Docket Center may charge $0.15 for each page over the 266-page limit, plus an administrative fee of $25.00.

FOR FURTHER INFORMATION CONTACT: Janita Aguirre, Standards and Health Protection Division, Office of Science and Technology (4305T), Environmental Protection Agency, 1200 Pennsylvania Ave. NW., Washington DC 20460; telephone number: (202) 566–1860; fax number: (202) 566–0409; email address: *WQSRegulatoryClarifications@epa.gov*.

SUPPLEMENTARY INFORMATION: The supplementary information section is organized as follows:

Table of Contents

I. General Information

A. Does this action apply to me?

The entities potentially affected by this rule are shown in the table below.

Category	Examples of potentially affected entities
States and Tribes.	States and authorized tribes responsible for administering or overseeing water quality programs.[1]
Industry	Industries discharging pollutants to waters of the United States.
Municipalities.	Publicly owned treatment works or other facilities discharging pollutants to waters of the United States.

This table is not exhaustive, but rather it provides a guide for entities that may be directly or indirectly affected by this action. Citizens concerned with water quality and other types of entities may also be interested in this rulemaking, although they might not be directly impacted. If you have questions

[1] Hereafter referred to as ''states and authorized tribes.'' ''State'' in the CWA and this document refers to a state, the District of Columbia, the Commonwealth of Puerto Rico, the U.S. Virgin Islands, Guam, American Samoa, and the Commonwealth of the Northern Mariana Islands. ''Authorized tribes'' refers to those federally recognized Indian tribes with authority to administer a CWA WQS program.

regarding the applicability of this action to a particular entity, consult the person listed in the preceding **FOR FURTHER INFORMATION CONTACT** section.

B. What is the statutory and regulatory history of the federal WQS regulation?

The Clean Water Act (CWA or the Act)—initially enacted as the Federal Water Pollution Control Act Amendments of 1972 (Pub. L. 92–500) and subsequent amendments—determined the basic structure in place today for regulating pollutant discharges into waters of the United States. The objective of the CWA is ''to restore and maintain the chemical, physical, and biological integrity of the Nation's waters,'' and to achieve ''wherever attainable, an interim goal of water quality which provides for the protection and propagation of fish, shellfish, and wildlife and provides for recreation in and on the water'' (CWA sections 101(a) and 101(a)(2)).

The CWA establishes the basis for the water quality standards (WQS or standards) regulation and program. CWA section 303 addresses the development of state and authorized tribal WQS that serve the CWA objective for waters of the United States. The core components of WQS are designated uses, water quality criteria that support the uses, and antidegradation requirements. Designated uses establish the environmental objectives for a water body and water quality criteria [2] define the minimum conditions necessary to achieve those environmental objectives. The antidegradation requirements provide a framework for maintaining and protecting water quality that has already been achieved.

CWA section 301 establishes pollutant discharge restrictions for point sources. Specifically, it provides that ''the discharge of any pollutant by any person shall be unlawful'' except in compliance with the terms of the Act, including industrial and municipal effluent limitations specified under CWA sections 301 and 304 and ''any more stringent limitation, including those necessary to meet water quality standards, treatment standards, or schedule of compliance, established pursuant to any [s]tate law or regulations.''

The CWA gives states and authorized tribes discretion on how to control pollution from nonpoint sources. Although the CWA includes specific requirements for the control of pollution from certain discharges, state and authorized tribal WQS established pursuant to CWA section 303 apply to the water bodies themselves, regardless of the source(s) of pollution/pollutants. Thus, the WQS express the desired condition and level of protection for a water body, regardless of whether a state or authorized tribe chooses to place controls on nonpoint source activities, in addition to point source activities required to obtain permits under the CWA. Section 303(c) of the Act also requires that states and authorized tribes hold a public hearing to review their standards at least once every three years (*i.e.*, triennial review), and that EPA review and approve or disapprove any new or revised state and authorized tribal standards. Furthermore, if EPA disapproves a state's or authorized tribe's WQS under CWA sections 303(c)(3) and 303(c)(4)(A), or if the Administrator makes a determination under CWA section 303(c)(4)(B) that a new or revised WQS is necessary, EPA must propose and promulgate federal standards for a state or authorized tribe, unless the state or authorized tribe develops and EPA approves its own WQS first.

EPA established the core of the WQS regulation in a final rule issued in 1983. That rule strengthened provisions that had been in place since 1977 and codified them as 40 CFR part 131.[3] In support of the 1983 regulation, EPA issued a number of guidance documents, such as the *Water Quality Standards Handbook* (WQS Handbook),[4] that provide guidance on the interpretation and implementation of the WQS regulation and on scientific and technical analyses that are used in making decisions that would impact WQS. EPA also developed the *Technical Support Document for Water Quality-Based Toxics Control* [5] that provides additional guidance for implementing state and authorized tribal WQS.

EPA modified the 40 CFR part 131 regulation twice since 1983. First, in 1991 pursuant to section 518 of the Act, EPA added §§ 131.7 and 131.8 which extended to Indian tribes the opportunity to administer the WQS program and outlined dispute resolution mechanisms.[6] Second, in 2000, EPA finalized § 131.21(c)–(f), commonly known as the ''Alaska Rule,'' which specifies that new and revised standards adopted by states and authorized tribes and submitted to EPA after May 30, 2000, become applicable standards for CWA purposes only when approved by EPA.[7]

In 1998, EPA issued an Advance Notice of Proposed Rulemaking (ANPRM) to discuss and invite comment on over 130 aspects of the federal WQS regulation and program, with the goal of identifying specific changes that might strengthen water quality protection and restoration, facilitate watershed management initiatives, and incorporate evolving water quality criteria and assessment science into state and authorized tribal WQS programs.[8] Although EPA chose not to move forward with a rulemaking after the ANPRM, EPA identified a number of high priority issue areas for which the Agency developed guidance, provided technical assistance, and continued further discussion and dialogue to ensure more effective program implementation. This action is part of EPA's ongoing effort to clarify and strengthen the WQS program.

C. What environmental issues do the final changes to the federal WQS regulation address?

Since EPA first established the WQS regulation in 1983, the regulation has acted as a powerful force to prevent pollution and improve water quality by providing a foundation for a broad range of water quality management programs. Since 1983, however, diverse and complex challenges have arisen, including new types of contaminants, pollution stemming from multiple sources, extreme weather events, hydrologic alteration, and climate change-related impacts. These challenges necessitate a more effective, flexible and practicable approach for the implementation of WQS and protecting water quality. Additionally, extensive experience with WQS implementation by states, authorized tribes, and EPA revealed a need to update the regulation to help meet these challenges.

This rulemaking revises the requirements in six program areas: (1) Administrator's determination that new or revised WQS are necessary, (2) designated uses, (3) triennial reviews, (4) antidegradation, (5) WQS variances, and (6) permit compliance schedule authorizing provisions.

The provisions related to designated uses help states and authorized tribes restore and maintain resilient and

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[2] Under CWA section 304(a), EPA publishes recommended water quality criteria guidance that consists of scientific information regarding concentrations of specific chemicals or levels of parameters in water that protect aquatic life and human health. CWA section 303(c) refers to state and authorized tribal water quality criteria that are subject to EPA review and approval or disapproval.

[3] 54 FR 51400 (November 8, 1983).

[4] First edition, December 1983; second edition, EPA 823–B–94–005a, August 1994.

[5] First edition, EPA 440/4–85–032, September 1985; revised edition, EPA 505/2–90–001, March 1991.

[6] 56 FR 64893 (December 12, 1991).

[7] 65 FR 24641 (April 27, 2000).

[8] 63 FR 36742 (July 7, 1998).

robust ecosystems by requiring that states and authorized tribes evaluate and adopt the highest attainable use when changing designated uses. The rule provides clearer expectations for when an analysis of attainability of designated uses is or is not required. Such clarity allows for better and more transparent communication among EPA, states, authorized tribes, stakeholders and the public about the designated use revision process, and the appropriate level of protection necessary to meet the purposes of the CWA.

This rule ensures better protection and maintenance of high quality waters that have better water quality than minimally necessary to support propagation of fish, shellfish, and wildlife, and recreation in and on the water. Through protection of habitat, water quality, and aquatic community structure, high quality waters are better able to resist stressors, such as atmospherically deposited pollutants, emerging contaminants, severe weather events, altered hydrology, or other effects resulting from climate change. This rule strengthens the evaluation used to identify and manage high quality waters and increases the opportunities for the public and stakeholders to be involved in the decision-making process. Specifically, there must be a transparent, public, robust evaluation before any decision is made to allow lowering of high quality water. Thus, this rule will lead to better protection of high quality waters.

The rule addresses WQS variances and permit compliance schedules, which are two CWA tools which can be used where WQS are not being attained. The provisions related to WQS variances allow states and authorized tribes to address water quality challenges in a transparent and predictable way. The rule also includes provisions for authorizing the use of permit compliance schedules to ensure that a state or authorized tribal decision to allow permit compliance schedules includes public engagement and transparency. These two tools help states and authorized tribes focus on making incremental progress in improving water quality, rather than pursuing a downgrade of the underlying water quality goals through a designated use change, when the current designated use is difficult to attain.

Lastly, the Administrator's determination and triennial review provisions in this rule promote public transparency and allow for effective communication among EPA, states, authorized tribes, and stakeholders to ensure WQS continue to be consistent with the CWA and EPA's implementing regulation. Meaningful and transparent involvement of the public is an important component of triennial review when making decisions about whether and when criteria will be adopted or revised to protect designated uses. The rule provides more clearly defined and transparent requirements, so that states and authorized tribes consider the latest science as reflected in the CWA section 304(a) criteria recommendations, and the public understands the decisions made.

D. How was this final rule developed?

In developing this rule, EPA considered the public comments and feedback received from stakeholders. EPA provided a 120-day public comment period after the proposed rule was published in the **Federal Register** on September 4, 2013.[9] In addition, EPA held two public webinars, a public meeting, and a tribal consultation to discuss the contents of the proposed rule and answer clarifying questions in order to allow the public to submit well-informed comments.

Over 150 organizations and individuals submitted comments on a range of issues. EPA also received 2,500 letters from individuals associated with mass letter writing campaigns. Some comments addressed issues beyond the scope of the proposed rulemaking. EPA did not expand the scope of the rulemaking or make regulatory changes to address the substance of these comments. In each section of this preamble, EPA discusses certain public comments so that the public is fully aware of its position. For a full response to these and all other comments, see EPA's Response to Comments document in the official public docket.

In addition, EPA met with all stakeholders who requested time to discuss the contents of the proposed rule. Such discussions occurred with members of state and tribal organizations and the environmental community. Records of each meeting are included in the official public docket.

E. When does this action take effect?

This regulation is effective October 20, 2015. For judicial review purposes, this rule is promulgated as of 1 p.m. EST (Eastern Standard Time) on the effective date, which will be 60 days after the date of publication of the rule in the **Federal Register**.

States and authorized tribes are subject to the requirements of this final rule on the effective date of the rule. EPA's expectation is that, where a new or revised requirement necessitates a change to state or authorized tribal WQS, such revisions will occur within the next triennial review that the state or authorized tribe initiates after publication of the rule.

As a general matter, when EPA reviews new or revised state or authorized tribal WQS it reviews the provisions to determine whether they are consistent with the CWA and regulation applicable at the time of EPA's review. However, for a short period of transition, EPA will review the provisions and approve or disapprove based on whether they are consistent with the CWA and the relevant part 131 regulation that is in effect prior to the final rule's effective date if (1) they were submitted before the effective date of this final rule or (2) if a state or authorized tribe has held its public hearing(s) and the public comment period has closed before the effective date of this rule and the state or authorized tribe has submitted the new or revised WQS within nine months of the effective date of this final rule. This approach is reasonable for the transition period because EPA recognizes that states and authorized tribes may have invested a significant amount of resources drafting new or revised WQS for the public to comment on without the benefit of knowing EPA's final rule requirements and the state or authorized tribe may not have had sufficient notice to alter the WQS prior to submission to EPA. It would be inefficient and unfair for the state or authorized tribe to have to re-propose and re-start the rulemaking process when it can address the issue in the next triennial review consistent with the final rule. In addition, changing the applicable federal standards that will be basis of EPA's review after the public has put in the effort to provide constructive comments to the state or authorized tribe would be inefficient and could render the comments obsolete. Nine months is a reasonable timeframe to accommodate states and authorized tribes that have legislative processes such that new or revised WQS cannot be submitted to EPA until the legislature has passed the regulation at its soonest legislative session after close of the public comment period. Except for the circumstances outlined in this paragraph regarding the transition period, EPA will work with states and authorized tribes to ensure that new or revised WQS meet the requirements of the final rule.

In the event that a court sets aside any portion of this rule, EPA intends for the remainder of the rule to remain in effect.

[9] See Water Quality Standards Regulatory Clarifications, 78 FR 54517 (September 4, 2013).

II. Rule Revisions Addressed in This Rule

EPA provides a comparison document showing the revisions made by this final rule, and a second document showing the revisions made between the proposed and final rule. EPA has posted both documents at *http://water.epa.gov/lawsregs/lawsguidance/wqs_index.cfm*.

A. Administrator's Determinations That New or Revised WQS Are Necessary

What does this rule provide and why?

Open communication among states, tribes and EPA facilitates the sharing of information to ensure that WQS continue to adequately protect waters as new challenges arise. However, the public has occasionally mistaken such communication from EPA for a ''determination'' by the Administrator that new or revised WQS are necessary under CWA section 303(c)(4)(B) (hereafter referred to as ''Administrator's determination'').[10]

With the clarification provided by this rule, stakeholders and the public can readily distinguish Administrator's determinations from routine EPA communications on issues of concern and recommendations regarding the scope and content of state and authorized tribal WQS. This rule minimizes the potential for stakeholders to misunderstand EPA's intent with its communications and allows EPA to provide direct and transparent feedback. It will also preserve limited resources that would otherwise be spent resolving the confusion through litigation.

An Administrator's determination is a powerful tool, and this rule ensures that it continues to be used purposefully and thoughtfully. This rule contains two requirements related to an Administrator's determination at § 131.22(b). The first requirement provides that, in order for a document to constitute an Administrator's determination, it must be signed by the Administrator or duly authorized delegate. The second requirement is that such a determination must include a statement that the document is an Administrator's determination for purposes of section 303(c)(4)(B) of the Act. This requirement makes clear that this provision applies to Administrator's determinations made under CWA section 303(c)(4)(B) rather than determinations made under CWA section 303(c)(4)(A).

Section 303(c)(4) of the Act provides two different scenarios under which the Administrator has the authority to ''promptly prepare and publish proposed regulations setting forth a revised or new water quality standard for the navigable waters involved'' following some sort of determination. Section 303(c)(4)(A) of the Act gives EPA the authority to propose regulations where states or authorized tribes have submitted new or revised WQS that the Administrator ''determines'' are not consistent with the Act. In this instance, EPA disapproves new or revised WQS and specifies the changes necessary to meet CWA requirements. If a state or authorized tribe fails to adopt and submit the necessary revisions within 90 days after notification of the disapproval determination, EPA must promptly propose and promulgate federal WQS as specified in CWA section 303(c)(4)(A) and 40 CFR 131.22(a). This action does not address or affect this authority.

Absent state or authorized tribal adoption or submission of new or revised WQS, section 303(c)(4)(B) of the CWA gives EPA the authority to determine that new or revised WQS are necessary to meet the requirements of the Act. Once the Administrator makes such a determination, EPA must promptly propose regulations setting forth new or revised WQS for the waters of the United States involved, and must then promulgate such WQS, unless a state or authorized tribe adopts and EPA approves such WQS first.

Commenters expressed concern that the proposed rule was not clear with respect to which of these authorities was addressed in this rule. EPA's final rule makes clear that these requirements only refer to Administrator's determinations under CWA section 303(c)(4)(B).

Based on comments, EPA reviewed the use of the term ''states'' throughout the regulation and found that, in § 131.22(b), this term did not accurately describe the scope of waters for which the CWA provides authority to the EPA Administrator. Thus, consistent with CWA section 303(c)(4), this rule provides that the Administrator may propose and promulgate a regulation applicable to one or more ''navigable waters,'' as that term is defined in CWA section 502(7) after determining that new or revised WQS are necessary to meet the requirements of the CWA. Consistent with the statute's plain language, this authority applies to all navigable waters located in any state or in any area of Indian country.[11]

What did EPA consider?

EPA considered finalizing the revision to § 131.22(b) as proposed. However, EPA decided it was important to clarify that this provision only addresses Administrator's determinations made pursuant to section 303(c)(4)(B) of the Act, which was not clear given the comments received. EPA also considered foregoing revisions to § 131.22(b) altogether. However, this option would not meet EPA's policy objective, described previously, which many commenters supported.

What is EPA's position on certain public comments?

Some commenters requested that EPA clarify whether this revision will affect the petition process under section 553(e) of the Administrative Procedure Act (APA) (5 U.S.C. 553(e)). This action does not affect the public's ability to petition EPA to issue, amend, or repeal a rule. Nor does this action affect the Agency's obligations for responding to an APA petition or the ability of a petitioner to challenge the Agency for unreasonable delay in responding to a petition. In the event that the Administrator grants a petition for WQS rulemaking and makes an Administrator's determination that new or revised WQS are necessary, this provision does not affect the obligation the Agency has to promptly propose and promulgate federal WQS.

Some commenters requested that EPA clarify how the Administrator delegates authority. The laws, Executive Orders, and regulations that give EPA its authority typically, but not always, indicate that ''the Administrator'' shall or may exercise certain authorities. In order for other EPA management officials to act on behalf of the Administrator, the Administrator must delegate the authority granted by Congress or the Executive Branch. The Administrator may do so by regulation or through the Agency's delegation process by signing an official letter that is then maintained as a legal record of authority.

B. Designated Uses

What does this rule provide and why?

CWA section 303(c)(2)(A) requires that new or revised WQS shall consist

[10] A listing of Administrator's determinations that new or revised WQS are necessary to meet the requirements of the CWA pursuant to section 303(c)(4)(B) can be found at: *http://water.epa.gov/scitech/swguidance/standards/wqsregs.cfm#federal* under the heading ''Federal Clean Water Act Determinations that New or Revised Standards Are Necessary.'' EPA intends to post future Administrator's determinations pursuant to CWA section 303(c)(4)(B) to its Web site.

[11] Indian country is defined at 18 U.S.C. 1151. A prior example of federally promulgated WQS in Indian country can be found at 40 CFR 131.35, federally promulgated WQS for the Colville Confederated Tribes Indian Reservation (54 FR 28625, July 6, 1989).

of designated uses and water quality criteria based on such uses. It also requires that such WQS shall protect the public health or welfare, enhance the quality of the water, and serve the purposes of the Act. Section 101(a) of the CWA provides that the ultimate objective of the Act is to restore and to maintain the chemical, physical, and biological integrity of the Nation's waters. The national goal in CWA section 101(a)(2) is water quality that provides for the protection and propagation of fish, shellfish, and wildlife and for recreation in and on the water ''wherever attainable.'' EPA's WQS regulation at 40 CFR part 131, specifically §§ 131.10(j) and (k), interprets and implements these provisions through requirements that WQS protect the uses specified in CWA section 101(a)(2) unless states and authorized tribes show those uses are unattainable through a use attainability analysis (UAA) consistent with EPA's regulation, effectively creating a rebuttable presumption of attainability.[12] This underlying requirement remains unchanged by this rule. EPA discussed the 1983 requirements and the rebuttable presumption in the preamble to the proposed rule as background discussion of the existing regulatory requirements. The revisions to § 131.10 establish the additional requirement to adopt the highest attainable use (HAU) after demonstrating that CWA section 101(a)(2) uses are not attainable.

CWA section 303(c)(2)(A) also requires states and authorized tribes to establish WQS ''taking into consideration their use and value'' for a number of purposes, including those addressed in section 101(a)(2) of the Act. EPA's final 1983 regulation at § 131.10(a) implements this provision by requiring that the ''[s]tate must specify appropriate water uses to be achieved and protected'' and that the ''classification of the waters of the [s]tate must take into consideration the use and value of water for public water supplies, protection and propagation of fish, shellfish and wildlife, recreation in and on the water, agricultural, industrial, and other purposes including navigation.''

The revisions to the designated use requirements improve the process by which states and authorized tribes designate and revise uses to better help restore and maintain resilient water quality and robust aquatic ecosystems. The revisions reduce potential confusion and conflicting interpretations of the regulatory requirements for establishing designated uses that can hinder environmental progress. Designated uses drive state and authorized tribal criteria development and water quality management decisions. Therefore, clear and accurate designated uses are essential in maintaining the actions necessary to restore and protect water quality and to meet the goals and objectives of the CWA.

The CWA distinguishes between two broad categories of uses: uses specified in section 101(a)(2) of the Act and uses specified in section 303(c)(2) of the Act. For the purposes of this final rule, the phrase ''uses specified in section 101(a)(2) of the Act'' refers to uses that provide for the protection and propagation of fish,[13] shellfish, and wildlife, and recreation in and on the water, as well as for the protection of human health when consuming fish, shellfish, and other aquatic life. A ''sub-category of a use specified in section 101(a)(2) of the Act'' refers to any use that reflects the subdivision of uses specified in section 101(a)(2) of the Act into smaller, more homogenous groups for the purposes of reducing variability within the group.[14] A ''non-101(a)(2) use'' is a use that is not related to the protection or propagation of fish, shellfish, wildlife or recreation in or on the water. Non-101(a)(2) uses include those listed in CWA section 303(c)(2), but not those listed in CWA section 101(a)(2), including use for public water supply, agriculture, industry, and navigation.

For uses specified in section 101(a)(2) of the Act, this rule clarifies when a UAA is and is not required. This rule also makes clear that once a state or authorized tribe has rebutted the presumption of attainability by demonstrating through a required UAA that a use specified in section 101(a)(2) of the Act is not attainable, it must adopt the HAU, as defined in this rule. The HAU requirement supports adoption of states' and authorized tribes' WQS to enhance the quality of the water and to serve the purposes of the Act, including ensuring water quality that provides for uses described in CWA section 101(a)(2) where attainable and to restore and maintain the chemical, physical and biological integrity of the Nation's waters.

For non-101(a)(2) uses, this rule provides that a UAA is not required when a state or authorized tribe removes or revises a non-101(a)(2) use, but clarifies that states and authorized tribes must still submit documentation consistent with CWA section 303(c)(2)(A) to support the state or authorized tribe's action. This requirement recognizes that states' and authorized tribes' decisions about non-101(a)(2) uses must be consistent with the statute and transparent to the public and EPA. This rule also provides a regulatory definition for a non-101(a)(2) use at § 131.3(q). Non-101(a)(2) uses are separate and distinct from uses specified in CWA section 101(a)(2) and sub-categories of such uses.

To clarify when a UAA is and is not required, this rule revises § 131.10(g) and (j) so that when the provisions are read together, it is clear that the factors at § 131.10(g) are only required to be considered when the state or authorized tribe must conduct a UAA under § 131.10(j). In addition, this rule revises § 131.10(k) into new § 131.10(k)(1) and (2) to eliminate a possible contradiction with § 131.10(j)(2), as described in the preamble to the proposed rule.[15]

Section 131.10(j) describes when a UAA is required. Section 131.10(k) specifies when a UAA is not required. Further, the definition of a UAA at § 131.3(g) says that a UAA ''is a structured scientific assessment of the factors affecting the attainment of the use which may include physical, chemical, biological, and economic factors as described in § 131.10(g).'' Section 131.10(g) provides that states and authorized tribes may remove a designated use if they can demonstrate that attaining a designated use is not feasible because of one of six specified factors.

EPA revises § 131.10(j)(1) to clarify that a UAA is required whenever a state or authorized tribe designates uses for the first time that do not include the uses specified in section 101(a)(2) of the Act. Section 131.10(j)(1) also clarifies that a UAA is required where a state or authorized tribe has previously designated uses that do not include the

[12] EPA's 1983 regulation and ''the rebuttable presumption stemming therefrom'' have been upheld as a ''permissible construction of the statute'' (*Idaho Mining Association* v. *Browner*, 90 F. Supp. 2d 1078, 1097–98 (D. Idaho 2000)).

[13] To achieve the CWA's goal of ''wherever attainable . . . protection and propagation of fish . . . '' all aquatic life, including aquatic invertebrates, must be protected because they are a critical component of the food web.

[14] A sub-category of a use specified in section 101(a)(2) of the Act is not necessarily less protective than a use specified in section 101(a)(2) of the Act. For example, a cold water aquatic life use is considered a use sub-category, but provides ''for the protection and propagation of fish, shellfish and wildlife,'' consistent with CWA section 101(a)(2). On the other hand, a secondary contact recreation use (*i.e.*, a use, such as wading or boating, where there is a low likelihood of full body immersion in water or incidental ingestion of water) is considered a use sub-category, but does not provide ''for recreation in and on the water,'' consistent with CWA section 101(a)(2).

[15] See 78 FR 54525 (September 4, 2013).

uses specified in section 101(a)(2) of the Act.[16] EPA revises § 131.10(j)(2) to clarify that a UAA is required when removing or revising a use specified in section 101(a)(2) of the Act as well as when removing or revising a sub-category of such a use. These revisions also clarify that when adopting a sub-category of a use specified in section 101(a)(2) of the Act with less stringent criteria, a UAA is only required when the criteria are less stringent than the previously applicable criteria. EPA made corresponding revisions to § 131.10(g) to explicitly reference § 131.10(j). This rule also includes editorial changes to § 131.10(g) that are not substantive in nature. Lastly, EPA establishes a new § 131.10(k)(1) and (2) to explain when a UAA is not required.

To ensure that states and authorized tribes adopt WQS that continue to serve the Act's goal of water quality that provides for the uses specified in section 101(a)(2) of the CWA to the extent attainable and enhance the quality of the water, this rule revises § 131.10(g) to provide that where states and authorized tribes adopt new or revised WQS based on a required UAA, they must adopt the HAU as defined at § 131.3(m). These new requirements make clear that states and authorized tribes may remove unattainable uses, but they must retain and designate the attainable use(s). The final regulation does not prohibit states and authorized tribes from removing a designated use specified in CWA section 101(a)(2) or a sub-category of such a use, altogether, where demonstrated to be unattainable. For example, a state or authorized tribe may remove an aquatic life use if it can demonstrate through a UAA that no aquatic life use or sub-category of aquatic life use is attainable. EPA expects such situations to be rare; however to clarify that this outcome is possible, EPA adds a sentence to the definition of HAU at § 131.3(m) to make explicit that where the state or authorized tribe demonstrates the relevant use specified in section 101(a)(2) of the Act and sub-categories of such a use are not attainable, there is no required HAU to be adopted. If a state or authorized tribe removes the designated use, altogether, and in the same action adopts another designated use in a different broad use category (*e.g.*, agricultural use, recreational use), it may appear as though the state or authorized tribe intends the newly adopted use to be the HAU. In fact, this is a separate state or tribal decision in the same rulemaking.

The concept of HAU is fundamental to the WQS program. Adopting a use that is less than the HAU could result in the adoption of water quality criteria that inappropriately lower water quality and could adversely affect aquatic ecosystems and the health of the public recreating in and on such waters. For example, a state or authorized tribe may be able to demonstrate that a use supporting a particular class of aquatic life is not attainable. However, if some less sensitive aquatic organisms are able to survive at the site under current or attainable future conditions, the state's or authorized tribe's WQS are not continuing to serve the goals of the CWA by removing the aquatic life use designation and applicable criteria altogether without adopting an alternate CWA section 101(a)(2) use or sub-category of such a use that is feasible to attain, and the criteria that protect that use. EPA's regulation at §§ 131.5(a)(2), 131.6(c), and 131.11(a) explicitly requires states and authorized tribes to adopt water quality criteria that protect designated uses.

Commenters expressed concern that the proposed definition of HAU used overly subjective terminology that would make it difficult for states and authorized tribes to adopt an HAU that would not be challenged by stakeholders. The definition of HAU at § 131.3(m) includes specific terms to ensure that the resulting HAU is clear to states, authorized tribes, stakeholders and the public.

First, the word ''modified'' makes clear that when adopting the HAU, the state or authorized tribe is adopting a different use within the same broad CWA section 101(a)(2) use category, if any such use is attainable. For example, if a state or authorized tribe removes a warm water aquatic life use, then the HAU is a modified version of the warm water aquatic life use, such as a ''limited warm water aquatic life use.'' The definition makes clear that states and authorized tribes are not required to determine whether one broad use category is better than another (*e.g.*, to determine that a recreation use is better than an aquatic life use).

Second, EPA adds the phrase ''based on the evaluation of the factor(s) in § 131.10(g) that preclude(s) attainment of the use and any other information or analyses that were used to evaluate attainability'' to the final HAU definition to be clear that the HAU is the attainable use that results from the process of determining what is not attainable. For example, where the state or authorized tribe demonstrates that a use cannot be attained due to substantial and widespread economic and social impacts, the state or authorized tribe may then determine the HAU by considering the use that is attainable without incurring costs that would cause a substantial and widespread economic and social impact consistent with § 131.10(g)(6). Although the definition continues to include the terms ''highest'' and ''closest to,'' which some commenters said were subjective terms, the new definition does not necessarily mean that the use with the most numerically stringent criteria must be designated as the HAU. The CWA does not require states and authorized tribes to adopt designated uses to protect a level beyond what is naturally occurring in the water body. Therefore, a state's or authorized tribe's determination of the HAU must take into consideration the naturally expected condition for the water body or waterbody segment. For example, Pacific Northwest states provide specific levels of protection for different life stages of salmonids. While the different life stages require different temperature criteria, the designated use with the most numerically stringent temperature criterion may not be required under § 131.11(a) to protect the HAU, if the life stage that temperature criterion protects does not naturally occur in that water body or waterbody segment.

When conducting a UAA and soliciting input from the public, states and authorized tribes need to consider not only what is currently attained, but also what is attainable in the future after achievable gains in water quality are realized. EPA recommends that such a prospective analysis involve the following:

· Identifying the current and expected condition for a water body;

· Evaluating the effectiveness of best management practices (BMPs) and associated water quality improvements;

· Examining the efficacy of treatment technology from engineering studies; and

· Using water quality models, loading calculations, and other predictive tools.

The preamble to the proposed rule also provided several examples of how states and authorized tribes can articulate the HAU. These examples include using an existing designated use framework, adopting a new statewide sub-category of a use, or adopting a new sub-category of a use that uniquely recognizes the limiting condition for a specific water body (*e.g.*, aquatic life limited by naturally high levels of copper).

One example of where a state adopted new statewide sub-categories to protect

[16] This provision includes situations where a state or authorized tribe adopts for the first time, or previously designated, only non-101(a)(2) uses.

the highest attainable use was related to a class of waters the state defines as ''effluent dependent waters.'' The state conducted a UAA to justify the removal of the aquatic life use in these waters. It was not feasible for these waters to attain the same aquatic life assemblage expected of waters assigned the statewide aquatic life use. The state identified the highest attainable aquatic life use for these waters and created two new sub-categories (effluent-dependent fisheries and effluent-dependent non-fish bearing waters) with criteria that are sufficiently protective of these uses. These EPA-approved sub-categories reflect the aquatic life use that can be attained in these waters, while still protecting the effluent dependent aquatic life.

Some commenters expressed concern with the difficulty of articulating a specific HAU because doing so may require additional analyses. Where this may be the case, an alternative method of articulating the HAU can be for a state or authorized tribe to designate for a water body a new or already established, broadly defined HAU (*e.g.*, limited aquatic life use) and the criteria associated with the best pollutant/parameter levels attainable based on the information or analysis the state or authorized tribe used to evaluate attainability of the designated use. This is reasonable because the state or authorized tribe is essentially articulating that the HAU reflects whatever use is attained when the most protective, attainable criteria are achieved.

One example where a state used this alternative method involved adoption of a process by which the state can tailor site-specific criteria to protect the highest attainable use as determined by a UAA. EPA approved the state's adoption of a broad ''Limited Use'' and the subsequent adoption of a provision to allow the development of site-specific criteria for certain pollutants to protect that use. The ''Limited Use'' shares the same water quality criteria as the state's full designated use for recreation and fish and wildlife protection ''except for any site-specific alternative criteria that have been established for the water body.'' Such site-specific criteria are limited to numeric criteria for nutrients, bacteria, dissolved oxygen, alkalinity, specific conductance, transparency, turbidity, biological integrity, or pH. The state restricts application of the ''Limited Use'' to waters with human induced physical or habitat conditions that prevent attainment of the full designated use for recreation and fish and wildlife protection, and to either (1) wholly artificial waters, or (2) altered water bodies dredged and filled prior to November 28, 1975. Through this process, the state is able to articulate the HAU by identifying the most protective, attainable criteria that can be achieved.

Where a state or authorized tribe does not already have a statewide use in their regulation that is protective of the HAU, the state or authorized tribe will need to find an approach that meets the requirements of the CWA and § 131.10(g). States and authorized tribes are not limited by the examples described in this section and can choose a different approach that aligns with their specific needs, as long as their preferred approach is protective of the HAU and is consistent with the CWA and § 131.10.[17]

As an example of how a UAA informs the identification of the HAU, consider a state or authorized tribe with a designated aquatic life use and associated dissolved oxygen criterion. The state or authorized tribe determines through a UAA that a particular water body cannot attain its designated aquatic life use due to naturally occurring dissolved oxygen concentrations that prevent attainment of the use (*i.e.*, the use is not attainable pursuant to § 131.10(g)(1)). Such an analysis also shows that the low dissolved oxygen concentrations are not due to anthropogenic sources, but rather due to the bathymetry of the water body. The state or authorized tribe then evaluates what level of aquatic life use is attainable in light of the naturally low dissolved oxygen concentration, as well as any data that were used to evaluate attainability (*e.g.*, biological data). The state or authorized tribe concludes that the naturally low dissolved oxygen concentration precludes attainment of the full aquatic life use, and requires an alternative dissolved oxygen criterion that protects the ''highest'' but limited aquatic life that is attainable. Once this analysis is complete and fully documented in the UAA, the state or authorized tribe would then designate the HAU and adopt criteria to protect that use.

To clarify what is required when a state or authorized tribe adopts new or revised non-101(a)(2) uses, this rule finalizes a new paragraph (3) at § 131.10(k) to specify that states and authorized tribes are not required to conduct a UAA whenever they wish to remove or revise a non-101(a)(2) use, but must meet the requirements in § 131.10(a). This rule defines a non-101(a)(2) use at § 131.3(q) as: ''any use unrelated to the protection and propagation of fish, shellfish, wildlife or recreation in or on the water.'' While the CWA specifically calls out the protection and propagation of fish, shellfish, and wildlife and recreation in and on the water as the national goal, wherever attainable, this does not mean that non-101(a)(2) uses are not important. This rule revises § 131.10(a) to be explicit that where a state or authorized tribe is adopting new or revised designated uses other than the uses specified in section 101(a)(2) of the Act, or removing designated uses, it must submit documentation justifying how its consideration of the use and value of water for those uses listed in § 131.10(a) appropriately supports the state's or authorized tribe's action. EPA refers to this documentation as a ''use and value demonstration.'' These requirements are consistent with EPA's previously existing regulation at §§ 131.10(a)[18] and 131.6.[19] A UAA can also be used to satisfy the requirements at § 131.10(a).

EPA encourages states and authorized tribes to work closely with EPA when developing a use and value demonstration. States and authorized tribes must consider relevant provisions in § 131.10, including downstream protection (§ 131.10(b)) and existing uses of the water (§ 131.10(h)(1)). EPA recommends states and authorized tribes also consider a suite of other factors, including, but not limited to:

· Relevant descriptive information (*e.g.*, identification of the use that is under consideration for removal, location of the water body/waterbody

[17] Section 131.10(c) provides that states and authorized tribes ''*may* adopt sub-categories of a use. . .'' (emphasis added). This provision generally allows states and authorized tribes to adopt sub-categories of the uses specified in the CWA. This rule is finalizing revisions to § 131.10(g) to specify that when a state or authorized tribe conducts a UAA required by § 131.10(j), and the state or authorized tribe revises its WQS to something other than a use specified in section 101(a)(2) of the Act, the state or authorized tribe must adopt the highest attainable modified aquatic life, wildlife, and/or recreation use (*i.e.*, a sub-category of an aquatic life, wildlife, and/or recreation use). Where a UAA is not required by § 131.10(j), the state or authorized tribe retains discretion to choose whether to adopt sub-categories of uses per § 131.10(c).

[18] Section 131.10(a) already provided that states and authorized tribes ''must specify appropriate water uses to be achieved and protected'' and that the ''classification of the waters of the [s]tate must take into consideration the use and value of water for public water supplies, protection and propagation of fish, shellfish and wildlife, recreation in and on the water, agricultural, industrial, and other purposes including navigation'').

[19] Section 131.6(a) and (b) already provided that states and authorized tribes must submit to EPA for review ''use designations consistent with the provisions of sections 101(a)(2) and 303(c)(2) of the Act'' and ''[m]ethods used and analyses conducted to support WQS revisions.''

segment, overview of land use patterns, summary of available water quality data and/or stream surveys, physical information, information from public comments and/or public meetings, anecdotal information, etc.),

· Attainability information (*i.e.*, the § 131.10(g) factors as described previously, if applicable),

· Value and/or benefits (including environmental, social, cultural, and/or economic value/benefits) associated with either retaining or removing the use, and

· Impacts of the use removal on other designated uses.

As an example of what a use and value demonstration for a non-101(a)(2) use can look like, consider a small water body that a state or authorized tribe generically designated as a public water supply as part of a statewide action. The state or authorized tribe decides there is no use and value in retaining such a use for that water body. The state or authorized tribe could provide the public and EPA with documentation that public water supply is not an existing use (*e.g.*, there is no evidence that the water body was used for this purpose and the water quality does not support this use); the nearby population uses an alternative drinking water supply; and projected population trends suggest that the current supply is sufficient to accommodate future growth. States and authorized tribes must make this documentation available to the public prior to any public hearing, and submit it to EPA with the WQS revision.

What did EPA consider?

In developing this rule, EPA considered foregoing the revisions to § 131.10(g), (j), and (k), but this option would not clarify when a UAA is or is not required and thus not accomplish the Agency's objectives. EPA considered finalizing the revisions to § 131.10(g), (j), and (k)(1) and (2) as proposed; however, in response to comments received, EPA made revisions to better accomplish its objectives.

EPA considered foregoing the HAU requirement at § 131.10(g), but this option would not support the adoption of WQS that continue to serve the purposes of the Act and enhance the quality of the water. EPA also considered finalizing the requirement as proposed but not finalizing a regulatory definition; however, the absence of a regulatory definition could lead to confusion and hinder environmental protection.

EPA considered not specifying what is required when removing or revising a non-101(a)(2) use in the final rule; however, multiple commenters indicated that EPA's proposed rule only specified that a UAA is not required to remove or revise a non-101(a)(2) use and did not specify what is required. Given the confusion about existing requirements, EPA decided to make the requirement explicit in § 131.10(a) and (k)(3).

What is EPA's position on certain public comments?

Numerous commenters disagreed with EPA's position that the consumption of aquatic life is a use specified in section 101(a)(2) of the Act and requested that EPA document the rationale for this position. Based on the CWA section 303(c)(2)(A) requirement that WQS protect public health, EPA interprets the uses under section 101(a)(2) of the Act to mean that not only can fish and shellfish thrive in a water body, but when caught, they can also be safely eaten by humans.[20]

EPA first articulated this interpretation in the 1992 National Toxics Rule.[21] For example, EPA specified that all waters designated for even minimal aquatic life protection (and therefore a potential fish and shellfish consumption exposure route) are protected for human health. EPA also described its interpretation in the October 2000 Human Health Methodology.[22] Consistent with this interpretation, most states have adopted human health criteria as part of their aquatic life uses, as the purpose of the criteria is to limit the amount of a pollutant in aquatic species prior to consumption by humans. However, states and authorized tribes may also choose to adopt human health criteria as part of their recreational uses, recognizing that humans will consume fish and shellfish after fishing, which many states consider to be a recreational use. EPA leaves this flexibility to states and authorized tribes as long as the waters are protecting humans from adverse effects of consuming aquatic life, unless the state or authorized tribe has shown that consumption of aquatic life is unattainable consistent with EPA's regulation.

EPA also received comments requesting clarification on existing uses. EPA notes that in addressing these comments, EPA is not reopening or changing the regulatory provision at § 131.10(h)(1). The proposed change to § 131.10(g) simply referred back to the requirement that is housed in § 131.10(h)(1) and was not intended to change requirements regarding existing uses. This is also the case in the final rule. The WQS regulation at § 131.3(e) defines an existing use as ''those uses actually attained in the water body on or after November 28, 1975, whether or not they are included in the water quality standards.'' EPA provided additional clarification on existing uses in the background section of the proposed preamble,[23] as well as in a September 2008 letter from EPA to the State of Oklahoma.[24] Specifically, EPA explained that existing uses are known to be ''actually attained'' when the use has actually occurred *and* the water quality necessary to support the use has been attained. EPA recognizes, however, that all the necessary data may not be available to determine whether the use actually occurred or the water quality to support the use has been attained. When determining an existing use, EPA provides substantial flexibility to states and authorized tribes to evaluate the strength of the available data and information where data may be limited, inconclusive, or insufficient regarding whether the use has occurred and the water quality necessary to support the use has been attained. In this instance, states and authorized tribes may decide that based on such information, the use is indeed existing.

Some commenters expressed concern that this interpretation supports the removal of a designated use in a situation where the use has actually occurred but the water quality necessary to protect the use has never been attained, as well as in a situation where the water quality has been attained but the use has not actually occurred. Such an interpretation may be contrary to a state's or authorized tribe's environmental restoration efforts or water quality management goals. For example, a state or authorized tribe may designate a highly modified water body for primary contact recreation even though the water quality has never been attained to support such a use. In this situation, if the state or authorized tribe exercises its discretion to recognize such an existing use, then consistent with EPA's regulation the designated use may not be removed.

[20] *http://water.epa.gov/scitech/swguidance/standards/upload/2000_10_31_standards_shellfish.pdf.*

[21] 57 FR 60859 (December 22, 1992). See also 40 CFR 131.36.

[22] *http://water.epa.gov/scitech/swguidance/standards/criteria/health/methodology/index.cfm; Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health*, see pages 4–2 and 4–3.

[23] 78 FR 54523 (September 4, 2013).

[24] *http://water.epa.gov/scitech/swguidance/standards/upload/Smithee-existing-uses-2008-09-23.pdf.*

If a state or authorized tribe chooses not to recognize primary contact recreation as an existing use in this same situation, the state or authorized tribe still must conduct a UAA to remove the primary contact use. The state or authorized tribe may only remove the primary contact recreation use if the use is not an existing use or if more stringent criteria are being added; the use cannot be attained by implementing effluent limits required under sections 301(b) and 306 of the Act and by implementing cost-effective and reasonable best management practices for nonpoint source control (§ 131.10(h)(1) and(2)); and the state or authorized tribe can demonstrate that one of the factors listed at § 131.10(g) precludes attainment of the primary contact recreation use. The combination of all the requirements at § 131.10 ensures that states and authorized tribes designate uses consistent with the goals of the Act unless the state or authorized tribe has demonstrated that such a use is not attainable. It also requires states and authorized tribes to maintain uses that have actually been attained.

C. Triennial Reviews

What does this rule provide and why?

The CWA and EPA's implementing regulation require states and authorized tribes to hold, at least once every three years, a public hearing for the purpose of reviewing applicable WQS (*i.e.* a triennial review). The CWA creates a partnership between states and authorized tribes, and EPA, by assigning states and authorized tribes the primary role of adopting WQS (CWA sections 101(b) and 303), and EPA the oversight role of reviewing and approving or disapproving state and authorized tribal WQS (CWA section 303(c)). Consistent with this partnership, the statute also assigns EPA the role of publishing national recommended criteria to assist states and authorized tribes in establishing water quality criteria in their WQS (CWA section 304(a)(1)). States and authorized tribes have several options for developing and adopting chemical, physical and biological criteria. They may use EPA's CWA section 304(a) criteria recommendations, modify EPA's CWA section 304(a) criteria recommendations to reflect site-specific conditions, or establish criteria using other scientifically defensible methods. Ultimately, states and authorized tribes must adopt criteria that are scientifically defensible and protective of the designated use to ensure that WQS continue to ''protect the public health or welfare, enhance the quality of water and serve the purposes of'' the Act (CWA section 303(c)(2)(A)).

In some cases, states and authorized tribes do not transparently communicate with the public their consideration of EPA's CWA section 304(a) criteria recommendations when deciding whether to revise their WQS. As a result, the public may be led to believe that states and authorized tribes are not considering some of the latest science that is reflected in EPA's new or updated CWA section 304(a) criteria recommendations. To ensure public transparency and clarify existing requirements, the final rule contains two revisions to the triennial review requirements at 40 CFR 131.20(a). First, the rule requires that if states and authorized tribes choose not to adopt new or revised criteria during their triennial review for any parameters for which EPA has published new or updated criteria recommendations under CWA section 304(a), they must explain their decision when reporting the results of their triennial review to EPA under CWA section 303(c)(1) and 40 CFR 131.20(c). Second, the rule clarifies the ''applicable water quality standards'' that states and authorized tribes must review triennially.

The first revision addresses the role of EPA's CWA section 304(a) criteria recommendations in triennial reviews. While states and authorized tribes are not required to adopt EPA's CWA section 304(a) criteria recommendations, they must consider them. EPA continues to invest significant resources to examine evolving science for the purpose of updating existing and developing new CWA section 304(a) criteria recommendations to help states and authorized tribes meet the requirements of the Act. Those recommendations are based on data and scientific judgments about pollutant concentrations and environmental or human health effects.[25]

EPA's proposed rule, requiring states and authorized tribes to ''consider'' EPA's new or updated CWA section 304(a) criteria recommendations, raised several commenter questions and concerns about how states and authorized tribes were to ''document'' such consideration.

Commenters also expressed concern that EPA was overstepping its authority by dictating how states and authorized tribes conduct their triennial reviews and by requiring states and authorized tribes to adopt EPA's CWA section 304(a) criteria recommendations. This rule focuses on how a state or authorized tribe explains its decisions to EPA (and the public) rather than on how the state or authorized tribe conducts its review. The CWA section 304(a) criteria are national recommendations, and states or authorized tribes may wish to consider site-specific physical and/or chemical water body characteristics and/or varying sensitivities of local aquatic communities. While states and authorized tribes are not required to adopt the CWA section 304(a) criteria recommendations, they are required under the Act and EPA's implementing regulations to adopt criteria that protect applicable designated uses and that are based on sound scientific rationale. Since EPA revises its CWA section 304(a) recommendations periodically to reflect the latest science, it is important that states and authorized tribes consider EPA's new or updated recommendations and explain any decisions on their part to not incorporate the latest science into their WQS.

An important component of triennial reviews is meaningful and transparent involvement of the public and intergovernmental coordination with local, state, federal, and tribal entities. Communication with EPA (and the public) about these decisions provides opportunities to assist states and authorized tribes in improving the scientific basis of its WQS and can build support for state and authorized tribal decisions. Such coordination ultimately increases the effectiveness of the state and authorized tribal water quality management processes. Following this rulemaking, when states and authorized tribes conduct their next triennial review they must provide an explanation for why they did not adopt new or revised criteria for parameters for which EPA has published new or updated CWA section 304(a) criteria recommendations since May 30, 2000.[26] During the triennial reviews that follow, states and authorized tribes must do the same for criteria related to parameters for which EPA has published CWA section 304(a) criteria recommendations since the states' or authorized tribes' most recent triennial review. This requirement applies regardless of whether new or updated CWA section 304(a) criteria recommendations are

[25] EPA's compilation of national water quality criteria recommendations, published pursuant to CWA section 304(a), can be found at: *http://water.epa.gov/scitech/swguidance/standards/criteria/current/index.cfm.*

[26] WQS adopted and submitted to EPA by states and authorized tribes on or after May 30, 2000, must be approved by EPA before they become effective for CWA purposes, including the establishment of water quality-based effluent limits or development of total maximum daily loads (40 CFR 131.21, 65 FR 24641, April 27, 2000).

more stringent or less stringent than the state's or authorized tribe's applicable criteria because all stakeholders should know how the state or authorized tribe considered the CWA section 304(a) criteria recommendations when determining whether to revise their own WQS following a triennial review. A state's or authorized tribe's explanation may be situation-specific and could involve consideration of priorities and resources. EPA will not approve or disapprove this explanation pursuant to CWA section 303(c) nor will the explanation be used to disapprove new or revised WQS that otherwise meet the requirements of the CWA. Rather, it will inform both the public and EPA of the state's or authorized tribe's plans with respect to adopting new or revised criteria in light of the latest science. EPA strongly encourages states and authorized tribes to include their explanation on a publically accessible Web site or some other mechanism to inform the public of their decision.

The second revision addresses confusion expressed in public comments regarding the meaning of § 131.20(a) so that states, authorized tribes and the public are clear on the scope of WQS to be reviewed during a triennial review. By not addressing this issue directly in the proposal, EPA may have inadvertently created ambiguity by implying that the only criteria states and authorized tribes need to re-examine during a triennial review are those criteria related to the parameters for which EPA has published new or updated CWA section 304(a) criteria recommendations. However, EPA's intent was not to qualify the initial sentence in § 131.20(a) regarding ''applicable water quality standards'' (which are all WQS either approved or promulgated by EPA for a state or tribe) but to supplement it by adding more detail regarding the triennial review of any and all existing criteria established pursuant to 40 CFR 131.11. Thus, the final rule clarifies what the regulation means by ''applicable water quality standards.'' [27]

When conducting triennial reviews, states and authorized tribes must review all applicable WQS adopted into state or tribal law pursuant to §§ 131.10–131.15 [28] and any federally promulgated WQS.[29] Applicable WQS specifically include designated uses (§ 131.10), water quality criteria (§ 131.11), antidegradation (§ 131.12), general policies (§ 131.13), WQS variances (§ 131.14), and provisions authorizing the use of schedules of compliance for WQBELs in NPDES permits (§ 131.15).[30] If, during a triennial review, the state or authorized tribe determines that the federally promulgated WQS no longer protect its waters, the state or authorized tribe should adopt new or revised WQS. If EPA approves such new or revised WQS, EPA would withdraw the federally promulgated WQS because they would no longer be necessary.

Some states and authorized tribes target specific WQS during an individual triennial review to balance resources and priorities. The final rule does not affect states' or authorized tribes' discretion to identify such priority areas for action. However, the CWA and EPA's implementing regulation require the state or authorized tribe to hold, at least once every three years, a public hearing [31] for the purpose of reviewing applicable WQS, not just a subset of WQS that the state or authorized tribe has identified as high priority. In this regard, states and authorized tribes must still, at a minimum, seek and consider public comment on all applicable WQS.

What did EPA consider?

EPA considered finalizing the revision to § 131.20(a) as proposed. However, given public commenters' confusion and concerns, as discussed previously, EPA ultimately rejected this option. EPA also considered foregoing revisions to § 131.20(a) altogether. However, this option would not ensure that states and authorized tribes adopt criteria that reflect the latest science, and thus EPA rejected it.

What is EPA's position on certain public comments?

One commenter requested a longer period than three years for states and authorized tribes to consider new or updated CWA section 304(a) criteria recommendations because it was neither reasonable nor feasible to conduct a comprehensive review and rulemaking in this timeframe, including the public participation component. Other commenters suggested that EPA allow triennial reviews to occur ''periodically,'' while some suggested that nine or 12 years would be a more appropriate frequency of review.

Although EPA acknowledges the challenges (*e.g.*, the legal and administrative processes, resource constraints) that states and authorized tribes may experience when conducting triennial reviews, the three-year timeframe for triennial review comes directly from CWA section 303(c)(1). EPA has no authority to provide a longer timeframe for triennial reviews.

D. Antidegradation

One of the principal objectives of the CWA is to ''*maintain* the chemical, physical and biological integrity of the Nation's waters.'' [32] Congress expressly affirmed this principle of ''antidegradation'' in the Water Quality Act of 1987 in CWA sections 101(a) and 303(d)(4)(B). EPA's WQS regulation has included antidegradation provisions since 1983. In particular, 40 CFR 131.12(a)(2) includes a provision that protects ''high quality'' waters (*i.e.*, those with water quality that is better than necessary to support the uses specified in section 101(a)(2) of the Act.)

Maintaining high water quality is critical to supporting economic and community growth and sustainability. Protecting high water quality also provides a margin of safety that will afford the water body increased resilience to potential future stressors, including climate change. Degradation of water quality can result in increased public health risks, higher treatment costs that must be borne by ratepayers and local governments, and diminished aquatic communities, ecological diversity, and ecosystem services. Conversely, maintaining high water quality can lower drinking water costs, provide revenue for tourism and recreation, support commercial and recreational fisheries, increase property values, create jobs and sustain local communities.[33] While preventing degradation and maintaining a reliable source of clean water involves costs, it can be more effective and efficient than

[27] EPA published the *What is a New or Revised Water Quality Standard Under CWA 303(c)(3) Frequently Asked Questions* (EPA–820–F–12–017, October 2012) to consolidate EPA's interpretation (informed by the CWA, EPA's implementing regulation at 40 CFR part 131, and relevant case law) of what constitutes a new or revised WQS that the Agency has the CWA section 303(c)(3) authority and duty to approve or disapprove (*http://water.epa.gov/scitech/swguidance/standards/upload/cwa303faq.pdf*).

[28] Definitions adopted by states and authorized tribes are considered WQS when they are inextricably linked to provisions adopted pursuant to §§ 131.10–131.15.

[29] Any WQS that EPA has promulgated for a state or tribe are found in 40 CFR part 131, subpart D. See also: *http://water.epa.gov/scitech/swguidance/standards/wqsregs.cfm#proposed*.

[30] This rule finalizes § 131.14 (WQS Variances) and § 131.15 (Provisions Authorizing the Use of Schedules of Compliance for WQBELs in NPDES permits). For detailed discussion about these sections, see sections II.E and II.F of this document, respectively.

[31] For detailed discussion about this final rule for § 131.20(b), related to public participation, see section II.G of this document.

[32] See CWA section 101(a) (emphasis added).

[33] *http://water.epa.gov/polwaste/nps/watershed/upload/economic_benefits_factsheet3.pdf; Economic Benefits of Protecting Healthy Watersheds* (EPA 841–N–12–004, April 2012).

investing in long-term restoration efforts or remedial actions.

This rule revises the antidegradation regulation to enhance protection of high quality waters and to promote consistency in implementation. The new provisions require states and authorized tribes to follow a more structured process when making decisions about preserving high water quality. They also increase transparency and opportunities for public involvement, while preserving states' and authorized tribes' decision-making flexibility. The revisions meet the objectives of EPA's proposal, although EPA made some changes to the regulatory language after further consideration of the Agency's policy objectives and in response to public comments.

This rule establishes requirements in the following areas: Identification of high quality waters, analysis of alternatives, and antidegradation implementation methods. In addition to the substantive changes described in the following section, this rule also includes editorial changes that are not substantive in nature. For a detailed discussion of EPA's CWA authority regarding antidegradation, see the preamble to the proposed rule at 78 FR 54526 (September 4, 2013).

Identification of Waters for High Quality Water (Tier 2) Protection

What does this rule provide and why?

Tier 2 refers to a decision-making process by which a state or authorized tribe decides how and how much to protect water quality that exceeds levels necessary to support the uses specified in Section 101(a)(2) of the Act. The final rule at § 131.12(a)(2)(i) provides that states and authorized tribes may identify waters for Tier 2 protection on either a parameter-by-parameter or a water body-by-water body basis. The rule also specifies that, where states and authorized tribes identify waters on a water body-by-water body basis, states and authorized tribes must involve the public in any decisions pertaining to when they will provide Tier 2 protection, and the factors considered in such decisions. Further, states and authorized tribes must not exclude water bodies from Tier 2 protection solely because water quality does not exceed levels necessary to support all of the uses specified in CWA section 101(a)(2). This rule requires that states' and authorized tribes' antidegradation policies be consistent with these new requirements.

States and authorized tribes typically use one of two approaches to identify high quality waters consistent with the CWA. States and authorized tribes using a parameter-by-parameter approach generally identify high quality waters at the time an entity proposes the activity that would lower water quality. Under this approach, states and authorized tribes identify parameters for which water quality is better than necessary to support the uses specified in CWA section 101(a)(2) and provide Tier 2 protection for any such parameters. Alternatively, states and authorized tribes using a water body-by-water body approach generally identify waters that will receive Tier 2 protection by weighing a variety of factors, in advance of any proposed activity. States and authorized tribes can identify some waters using a parameter-by-parameter approach and other waters using a water body-by-water body approach.

The 1983 WQS regulation did not specify which approach states and authorized tribes must use to identify waters for Tier 2 protection. In the 1998 ANPRM, EPA articulated that either approach, when properly implemented, is consistent with the CWA, and described advantages and disadvantages to both approaches. A parameter-by-parameter approach can be easier to implement, can be less susceptible to challenge, and can result in more waters receiving some degree of Tier 2 protection. The ANPRM also articulated: ''[t]he water body-by-water body approach, on the other hand, allows for a weighted assessment of chemical, physical, biological, and other information (*e.g.*, unique ecological or scenic attributes). In this regard, the water body-by-water body approach may be better suited to EPA's stated vision for the [WQS] program . . . This approach also allows for the high quality water decision to be made in advance of the antidegradation review . . ., which may facilitate implementation. A water body-by-water body approach also allows [s]tates and [t]ribes to focus limited resources on protecting higher-value [s]tate or [t]ribal waters. The water body-by-water body approach can . . . preserve high quality waters on the basis of physical and biological attributes, rather than high water quality attributes alone.''

Because the original WQS regulation did not provide specific requirements regarding use of the water body-by-water body approach, it was possible for states and authorized tribes to identify high quality waters in a manner inconsistent with the CWA and the intent of EPA's implementing regulation. In some cases, states and authorized tribes have used the water body-by-water body approach without documenting the factors that inform the decision or informing the public. For example, some states or authorized tribes have excluded waters from Tier 2 protection entirely based on the fact that the water was included on a CWA section 303(d) list for a single parameter without allowing an opportunity for the public to provide input.

This rule reaffirms EPA's support for both approaches. The new regulatory requirements included at § 131.12(a)(2)(i) only apply to the water body-by-water body approach because they are unnecessary for the parameter-by-parameter approach. States and authorized tribes using the parameter-by-parameter approach provide Tier 2 protection to all chemical, physical, and biological parameters for which water quality is better than necessary to protect the uses specified in CWA section 101(a)(2). Because the identification of waters that are high quality with respect to relevant parameters would occur in the context of allowing a specific activity, the level of protection is already subject to any public involvement required for that activity. For example, an NPDES permit writer calculating WQBELs would use available data and information about the water body to determine whether assimilative capacity exists for the relevant parameters. The state or authorized tribe would then provide Tier 2 protection for all parameters for which assimilative capacity exists. The draft permit would reflect the results of the Tier 2 review, hence providing an opportunity for public involvement.

The requirement at § 131.12(a)(2)(i) regarding public involvement increases the transparency of and accountability for states' and authorized tribes' water quality management decisions. The final rule is consistent with the CWA and the WQS regulation's emphasis on the public's role in water quality protection. A key part of a state's or authorized tribe's antidegradation process involves decisions on how to manage high water quality, a shared public resource. Commenters expressed concern that the proposed rule did not require states and authorized tribes to engage the public on decisions when implementing a water body-by-water body approach. Consequently, the public would not know the factors a state or authorized tribe considered in deciding that the water body did not merit Tier 2 protection, which would limit the public's ability to provide constructive input during the permit's public notice and comment period.

To provide for well-informed public input and to aid states and authorized tribes in making robust decisions, EPA recommends states and authorized tribes document their evaluation of the Tier 2 decision, including the factors considered and how those factors were weighed. The case of *Ohio Valley Envtl. Coalition* v. *Horinko* demonstrates why it is important for states and authorized tribes to articulate the rationale for their decisions.[34] In this case, the U.S. District Court for the Southern District of West Virginia considered whether the record contained sufficient evidence to justify EPA's approval of the state's exclusion of particular water bodies from Tier 2 protection. The state had classified some CWA section 303(d) listed waters as waters to receive Tier 2 protection, while it had excluded other similar waters with similar impairments from Tier 2 protection. The Court found the administrative record insufficient to support EPA's decision to approve the state's classification because the state's CWA section 303(d) listing was the only evidence related to the water quality of those river segments. The Court did not opine on whether, in a different factual situation, categorically excluding waters from Tier 2 protection based on CWA section 303(d) impairments would be consistent with the CWA.

To minimize the administrative processes associated with this rule, EPA uses the phrase ''opportunity for public involvement'' rather than ''public participation.'' ''Public participation'' at 40 CFR 131.20(b)[35] refers to a state or authorized tribe holding a public hearing for the purpose of reviewing WQS. With this rule, EPA provides states and authorized tribes the flexibility to engage the public in a way that suits the state or authorized tribe and the public. For example, a state or authorized tribe could develop lists of waters that will and will not receive Tier 2 protection along with descriptions of the factors considered in making each of those decisions and post that information on its Web site. To obtain public input, the state or authorized tribe could share these lists during a triennial review and/or during revision of antidegradation implementation methods. Such an approach has the advantage of streamlining both the decision-making and public involvement processes. As another example, a state could use the NPDES process to engage the public at the time it drafts a permit that would allow a lowering of water quality. The state would document the relevant information related to its decision in the permit fact sheet provided to the public and specifically request comment on its Tier 2 protection decision.

States and authorized tribes can provide additional avenues for public involvement by providing structured opportunities for the public to initiate antidegradation discussions. For example, a state or authorized tribe could provide a petition process in which citizens request Tier 2 protection for specific waters, and those citizens could provide data and information for a state's or authorized tribe's consideration. Also, states and authorized tribes can establish a process to facilitate public involvement in identifying waters as Outstanding National Resource Waters (ONRWs).

An additional requirement at § 131.12(a)(2)(i) provides that states and authorized tribes must not exclude a water body from the protections in § 131.12(a)(2) solely because water quality does not exceed levels necessary to support all of the uses specified in CWA section 101(a)(2). For a discussion on why such an approach is inconsistent with the Act, see the preamble to the proposed rule at 78 FR 54527 (September 4, 2013). Thus, when considering whether to exclude waters from Tier 2 protection, states and authorized tribes must consider the overall quality of the water rather than whether water quality is better than necessary for individual chemical, physical, and biological parameters to support all the uses specified in CWA section 101(a)(2). The rule provides for a decision-making process where states and authorized tribes consider water quality and reasons to protect water quality more broadly. This can lead to more robust evaluations of the water body, and potentially more waters receiving Tier 2 protection. To make a decision to exclude a water body from Tier 2 protection, states and authorized tribes must identify the factors considered which should include factors that are rooted in the goals of the CWA, including the chemical, physical, and biological characteristics of a water body. Where states and authorized tribes wish to consider CWA section 303(d) listed impairments, it would be important that they also consider all other relevant available data and conduct an overall assessment of a water's characteristics. It would also be important that states and authorized tribes consider the public value of the water. This includes the water's impact on public health and welfare, the existing aquatic and recreational uses, and the value of retaining ecosystem resilience against the effects of future stressors, including climate change. For additional information on this overall assessment, see the preamble to the proposed rule at 78 FR 54527 (September 4, 2013).

This requirement is consistent with the proposed rule. However, to accurately articulate the requirement, and to remain consistent with § 131.12(a)(2), the final rule text reflects that for a water to have available assimilative capacity for which to provide Tier 2 protection, the water quality must ''exceed'' the levels necessary (*i.e.*, be better than necessary) to support the uses specified in CWA section 101(a)(2). Commenters stated that some members of the public could misinterpret the phrase ''high quality waters'' in the proposal to include waters that *meet* but do not *exceed* the water quality necessary to support the uses specified in CWA section 101(a)(2). The final rule replaces ''high quality waters'' with the phrase ''waters for the protections described in (a)(2) of this section.'' The final rule also says waters cannot be excluded from Tier 2 protection solely ''because water quality does not exceed levels necessary to support all of the uses specified in section 101(a)(2) of the Act'' instead of ''because not all of the uses specified in CWA section 101(a)(2) are attained,'' as stated in the proposal.

Where water quality is better than necessary to support all of the uses specified in CWA section 101(a)(2), § 131.12(a)(2) requires states and authorized tribes to provide Tier 2 protection. Where water quality is not better than necessary to support all of the uses specified in CWA section 101(a)(2), the final rule does not require states and authorized tribes to provide Tier 2 protection for the water body. However, in instances where states and authorized tribes lack data and information on the water quality to make individual water body conclusions, EPA recommends that they provide all or a subset of their waters with Tier 2 protection, by default. Doing so will increase the probability that these waters will maintain a level of resiliency to future stressors.

This rule requires states' and authorized tribes' antidegradation policies (which are legally binding state and authorized tribal provisions subject to public participation) to be consistent with the new requirements related to identifying waters for Tier 2 protection. Since states and authorized tribes must provide for public participation on their antidegradation policies, placing their requirements for identification of high quality waters in their antidegradation policies increases accountability and transparency. The proposed rule

[34] *Ohio Valley Envtl. Coal.* v. *Horinko,* 279 F. Supp. 2d 732, 746–50 (S.D. W. Va. 2003).

[35] See section II.G for more information on the final rule change related to public participation.

articulated that states and authorized tribes must design their implementation methods to achieve the requirements for identifying high quality waters. Commenters questioned whether the proposed requirement for identifying high quality waters was mandatory, since the proposal did not require states and authorized tribes to adopt the requirement into their legally binding policies. Some commenters suggested requiring states and authorized tribes to adopt all implementation methods into binding provisions. While some states and authorized tribes find adoption of their implementation methods to be helpful, others view it as burdensome. EPA determined that while adopting implementation methods increases accountability and transparency, states and authorized tribes could still provide this accountability and transparency for identification of waters for Tier 2 protection without a requirement to adopt implementation methods. Therefore, the final rule requires antidegradation policies to be consistent with the provision at § 131.12(a)(2)(i). States and authorized tribes have the discretion and flexibility to adopt antidegradation provisions that address other aspects of antidegradation that are not specifically addressed in § 131.12(a). Where a state or authorized tribe chooses to include antidegradation implementation methods in non-binding guidance, the methods must be consistent with the applicable state or authorized tribal antidegradation requirements that EPA has approved. Consistent with § 122.44(d)(1)(vii)(a), permits must derive from and comply with all applicable WQS. Otherwise, EPA could have a basis to object to the permits.

What did EPA consider?

EPA considered not revising § 131.12(a)(2) and continuing to provide no new regulatory requirements for identification of waters for Tier 2 protection. EPA also considered prohibiting the water body-by-water body approach. Providing no regulatory requirements would continue to allow states and authorized tribes to implement a water body-by-water body approach that is potentially inconsistent with the CWA, while prohibiting the water body-by-water body approach would limit states' and authorized tribes' flexibility to prioritize their waters for Tier 2 protection. EPA rejected these options in favor of a more balanced approach by placing conditions on how states and authorized tribes use their discretion to better ensure protection of high quality waters.

EPA considered finalizing the rule as proposed, without a requirement for public involvement in decisions about whether to provide Tier 2 protection to a water body; however, EPA found that public involvement is critical for increasing accountability and transparency and included the requirement in the final rule. EPA also considered providing for an EPA approval or disapproval action under CWA section 303(c) of states' and authorized tribes' decisions on whether to provide Tier 2 protection to each water. EPA ultimately decided not to include such a requirement because of concern that it would add more administrative and rulemaking burden for states and authorized tribes than EPA determined was necessary to ensure public involvement. EPA considered specifying precisely which waters must receive Tier 2 protection. However, EPA did not include such specificity in the rule because there are multiple ways that states and authorized tribes can make well-reasoned decisions on Tier 2 protection based on case-specific facts.

Analysis of Alternatives

What does this rule provide and why?

The final rule at § 131.12(a)(2)(ii) provides that before allowing a lowering of high water quality, states and authorized tribes must find, after an analysis of alternatives, that such a lowering is necessary to accommodate important economic or social development in the area in which the waters are located. That analysis must evaluate a range of non-degrading and less degrading practicable alternatives. For the purposes of this requirement, the final rule at § 131.3(n) defines "practicable" to mean "technologically possible, able to be put into practice, and economically viable." When an analysis identifies one or more such practicable alternatives, states and authorized tribes may only find that a lowering is necessary if one such alternative is selected for implementation. This rule requires that states' and authorized tribes' antidegradation policies must be consistent with these new requirements.

Section 131.12(a)(2)(ii) requires a structured analysis of alternatives, which will increase transparency and consistency in states' and authorized tribes' decisions about high water quality. The new requirement makes the analysis of alternatives an integral part of a state's or authorized tribe's finding that degradation of high quality water is "necessary." Such an analysis provides states and authorized tribes with a basis to make informed and reasoned decisions, assuring that degradation only occurs where truly necessary. This rule refers to "analysis of alternatives" rather than "alternatives analysis" as in the proposal. This makes clear that the analysis required in § 131.12(a)(2)(ii) is distinct from the "alternatives analysis" required in other programs, such as the National Environmental Policy Act and CWA section 404 permitting.

Section 131.12(a)(2)(ii) is consistent with the proposed rule, but makes clear that states' and authorized tribes' findings that a lowering is necessary depends on both an analysis of alternatives and an analysis related to economic or social development. Commenters were concerned that the proposed rule seemed to remove the requirement at § 131.12(a)(2) for states and authorized tribes to consider whether a lowering of water quality will "accommodate important economic or social development in the area in which the waters are located."

This rule preserves states' and authorized tribes' discretion to decide the order in which they satisfy these requirements. A state or authorized tribe can choose to first review an analysis of economic or social development. If it finds that the proposed lowering of water quality would accommodate important economic or social development, it can then require an analysis of alternatives to see if the lowering could be prevented or lessened. If, on the other hand, a state or authorized tribe finds that the proposed lowering of water quality would not accommodate important economic or social development, it could choose to disallow lowering of water quality and terminate the Tier 2 review without ever requiring an analysis of alternatives. Similarly, a state or authorized tribe could first choose to require an analysis of alternatives and then examine an analysis of economic or social development. In this case, if a non-degrading alternative is selected for implementation, the state or authorized tribe does not need to proceed with an analysis of economic or social development.

Although states and authorized tribes are responsible for making a finding to allow a lowering of water quality based on a reasonable, credible, and adequate analysis of alternatives, states and authorized tribes themselves need not conduct the analysis of alternatives or select the alternative to be implemented. Commenters expressed concern that the proposed rule language implied that states and authorized tribes must perform the analysis themselves, when other entities may be best positioned to analyze the alternatives. The final rule language allows states and authorized tribes to rely on analyses prepared by third parties (*e.g.*, a permit applicant). This preserves appropriate flexibility for states' and authorized tribes' decision-makers, and can bring additional resources and expertise to the analysis. States and authorized tribes remain ultimately responsible for making findings to allow degradation and for basing their decisions on adequate analyses. If the state or authorized tribe deems an initial analysis of alternatives insufficient to support a finding that a lowering of high water quality is "necessary," it can request additional analyses of alternatives from the permit applicant or other entities. A state or authorized tribe can also obtain information on common practicable alternatives appropriate for a proposed activity from additional existing resources.[36]

The final rule specifies that states and authorized tribes must analyze "practicable alternatives that would prevent or lessen the degradation," rather than "non-degrading and minimally degrading practicable alternatives that have the potential to prevent or minimize the degradation," as proposed. While non-degrading or minimally degrading alternatives preserve high water quality to a greater extent, in cases where no minimally-degrading alternatives exist, a less degrading alternative will still provide a margin of protection for the high quality water. The final rule requires a broader, more complete analysis.

To enhance clarity and provide for consistency in implementation, this rule finalizes a definition of the word "practicable." The definition embodies a common sense notion of practicability—*i.e.*, an alternative that can actually be implemented under the circumstances. Because "practicable" appears in other contexts related to water quality, the definition at § 131.3(n) is only applicable for § 131.12(a)(2)(ii). This definition is consistent with the one articulated in the preamble to the proposed rule,[37] but eliminates redundancy and omits "at the site in question" in response to commenters' concern that relocation of a proposed activity may be a less degrading alternative that the state or authorized tribe can consider.

Section 131.12(a)(2)(ii) provides for preservation of high water quality by requiring a less degrading practicable alternative to be selected for implementation, if available, before states and authorized tribes may find that a lowering of water quality is necessary. This requirement applies even if the analysis identifies only one alternative. States and authorized tribes must still make a finding that a lowering is necessary if the analysis does not identify any practicable alternatives that lessen degradation. On the other hand, if the analysis results in choosing an alternative that avoids degradation, a state or authorized tribe need not make a finding. Regardless of the number of alternatives identified, the analysis should document a level of detail that reflects the significance and magnitude of the particular circumstances encountered, to provide the public with the necessary information to understand how the state or authorized tribe made its decision.

EPA chose not to require implementation of the least degrading practicable alternative to allow states and authorized tribes the flexibility to balance multiple considerations. Some alternatives to lowering water quality can have negative environmental impacts in other media (*e.g.*, air, land). For example, incinerating pollutants rather than discharging the pollutants to surface waters could adversely impact air quality and energy use, and land application of pollutants could have adverse terrestrial impacts. EPA recommends that states and authorized tribes consider cross-media impacts and, where possible, seek alternatives that minimize degradation of water quality and also minimize other environmental impacts.

The final rule requires states' and authorized tribes' antidegradation policies (which are legally binding provisions subject to public participation) to be consistent with the new requirements related to analysis of alternatives. As with the provision on identification of waters for Tier 2 protection at § 131.12(a)(2)(i), EPA determined that antidegradation policies must be consistent with the federal regulation on analysis of alternatives at § 131.12(a)(2)(ii) to increase accountability and transparency.

What did EPA consider?

EPA considered finalizing the proposed rule without alteration. EPA did not choose this option in light of commenters' suggestions to clarify the language in order to avoid confusion as to who is responsible for conducting the analysis. EPA also rejected an option to forego any revisions related to an analysis of alternatives, as this would not provide clarification regarding what type of analysis supports states' or authorized tribes' decisions that a lowering of water quality is "necessary," thus risking a greater loss of water quality.

Antidegradation Implementation Methods

What does this rule provide and why?

The rule at § 131.12(b) requires states' and authorized tribes' antidegradation implementation methods (whether or not those methods are adopted into rule) to be consistent with their antidegradation policies and with § 131.12(a). This rule also requires states and authorized tribes to provide an opportunity for public involvement during the development and any subsequent revisions of antidegradation implementation methods, and to make the methods available to the public.

Finally, this rule adds § 131.5(a)(3) to explicitly specify that EPA has the authority to determine whether the states' and authorized tribes' antidegradation policies and any adopted antidegradation implementation methods[38] are consistent with the federal antidegradation requirements at § 131.12. This revision does not expand EPA's existing CWA authority, rather it ensures § 131.5 is consistent with §§ 131.6 and 131.12.

The public involvement requirement at § 131.12(b) increases transparency, accountability, and consistency in states' and authorized tribes' implementation. EPA proposed a requirement that implementation methods be publicly available. As EPA discussed in the preamble to the proposed rule, CWA section 101(e) provides that "public participation in the development, revision, and enforcement of any regulations, standard, effluent limitation, plan, or program established . . . under this Act shall be provided for, encouraged, and assisted . . ." Thus, this rule also provides for public involvement during development or revision of implementation methods. A state or authorized tribe may decide to offer more than one opportunity to most effectively engage the public. States and authorized tribes can use various mechanisms to provide such

[36] E.g., EPA's Municipal Technologies Web site, which presents technology fact sheets to assist in the evaluation of different technologies for wastewater (*http://water.epa.gov/scitech/wastetech/mtb_index.cfm*).

[37] See 78 FR 54528 (September 4, 2013).

[38] See *http://water.epa.gov/scitech/swguidance/standards/cwa303faq.cfm. What is a New or Revised Water Quality Standard Under CWA 303(c)(3) Frequently Asked Questions* (EPA–820–F–12–017, October 2012).

opportunities, including a public hearing, a public meeting, a public workshop, and different ways of engaging the public via the Internet, such as webinars and Web site postings. If a state or authorized tribe adopts antidegradation implementation methods as part of its WQS or other legally binding provisions, the state's or authorized tribe's own public participation requirements and 40 CFR part 25 and § 131.20(b) of the federal regulation, will satisfy this requirement.

Section 131.5(a)(3) makes explicit EPA's authority to review states' and authorized tribes' antidegradation policies and any adopted antidegradation implementation methods and to determine whether those policies and methods are consistent with § 131.12. EPA recommends states and authorized tribes adopt binding implementation methods to provide more transparency and consistency for the public and other stakeholders and to increase accountability. States and authorized tribes may find that the Continuing Planning Process provisions described at CWA section 303(e) and § 130.5 can facilitate the state's or authorized tribe's establishment and maintenance of a process for WQS implementation consistent with the requirements of the final rule.

Here, EPA clarifies the terms ''antidegradation policy'' and ''antidegradation implementation methods.'' For the purposes of § 131.12, states' and authorized tribes' ''antidegradation policies'' must be adopted in rule or other legally binding form, and must be consistent with the requirements of § 131.12(a). EPA originally promulgated this requirement in 1983. ''Antidegradation implementation methods'' refer to any additional documents and/or provisions in which a state or authorized tribe describes methods for implementing its antidegradation policy, whether or not the state or authorized tribe formally adopts the methods in regulation or other legally binding form. If a state or authorized tribe does not choose to adopt the entirety of its implementation methods, EPA recommends, at a minimum, adopting in regulation or other legally binding form any antidegradation program elements that substantively express the desired instream level of protection and how that level of protection will be expressed or established for such waters in the future.

What did EPA consider?

EPA considered not adding § 131.5(a)(3). EPA rejected this option in light of commenters' suggestions to clarify the extent of EPA's authority. EPA also considered not adding § 131.12(b) or establishing § 131.12(b), as proposed. However, public involvement in the development and implementation of states' and authorized tribes' antidegradation implementation methods is fundamental to meeting the CWA requirements to restore and maintain water quality. EPA considered revising the rule to require that all states and authorized tribes adopt the entirety of their antidegradation implementation methods in regulation to improve accountability and transparency, as some commenters suggested. EPA did not make this change because it would limit states' and authorized tribes' ability to easily revise their implementation methods in order to adapt and improve antidegradation protection in a timely manner. Some states and authorized tribes have difficulty adopting their methods because of resource constraints, state or tribal laws, or complex rulemaking processes. Instead of requiring adoption of implementation methods, the final rule achieves more accountability by establishing specific requirements for states' and authorized tribes' antidegradation policies regarding two key aspects of Tier 2 implementation.

What is EPA's position on certain public comments?

Commenters requested clarification concerning whether states and authorized tribes must change their approaches to antidegradation to be consistent with the final rule. Where a state or authorized tribe already has established antidegradation requirements consistent with this rule, EPA does not anticipate the need for further changes.

Many commenters requested clarification concerning whether the proposed rule affects states' and authorized tribes' ability to use *de minimis* exclusions. Some states and authorized tribes use *de minimis* exclusions to prioritize and manage limited resources by excluding activities from Tier 2 review if they view the activity as potentially causing an insignificant lowering of water quality. This allows states and authorized tribes to use their limited resources where it can have the greatest environmental impact. Although EPA did not propose any revisions related to defining or authorizing *de minimis* exclusions, some commenters requested that EPA finalize a rule that explicitly accepts them, and others asked EPA to prohibit them. Section 131.12—including the revisions in this rule—does not address *de minimis* exclusions. States and authorized tribes can use *de minimis* exclusions, as long as they use them in a manner consistent with the CWA and § 131.12.

The DC Circuit explained in *Ala. Power* v. *Costle* that under the *de minimis* doctrine, ''[c]ategorical exemptions may also be permissible as an exercise of agency power, inherent in most statutory schemes, to overlook circumstances that in context may fairly be considered *de minimis*.'' [39] The Court went on to explain that the authority to create a *de minimis* provision ''is not an ability to depart from the statute, but rather a tool to be used in implementing the legislative design.'' [40] The Sixth Circuit has also explained that *de minimis* provisions are created through an ''administrative law principle which allows an agency to create unwritten exceptions to a statute or rule for insignificant or '*de minimis*' matters.'' [41]

States and authorized tribes have historically defined ''significant degradation'' in a variety of ways. Significance tests range from simple to complex, involve qualitative or quantitative measures or both, and may vary depending upon the type of pollution or pollutant (*e.g.*, the approach may be different for highly toxic or bioaccumulative pollutants). EPA does not endorse one specific approach to identifying what constitutes insignificant degradation, though EPA does recognize that one potential way a state or authorized tribe could describe its *de minimis* methodology would be to identify a ''significance threshold'' as percentage of assimilative capacity loss for a parameter or lowering of water quality that would be considered ''insignificant.'' EPA has not found a scientific basis to identify a specific percentage of loss of assimilative capacity or lowering of water quality that could reasonably be considered insignificant for all parameters, in all waters, at all times, for all activities. Depending on the water body's chemical, physical, and biological characteristics and the circumstances of the lowering of water quality, even very small changes in water quality could cause significant effects to the water body.

Courts have explained that the implied *de minimis* provision authority is ''narrow in reach and tightly bounded by the need to show that the situation

[39] *Ala. Power.* v. *Costle*, 636 F.2d. 323, 360 (D.C. Cir. 1979).

[40] *Id.*

[41] *Ky. Waterways Alliance* v. *Johnson*, 540 F.3d 466, 483 (6th Cir. 2008).

is genuinely *de minimis* or one of administrative necessity.'' [42] Accordingly, this authority only applies ''when the burdens of regulation yield a gain of trivial or no value.'' [43] Finally, a ''determination of when matters are truly *de minimis* naturally will turn on the assessment of particular circumstances, and the agency will bear the burden of making the required showing.'' [44]

Unless a state or authorized tribe can provide appropriate technical justification, it should not create categorical exemptions from Tier 2 review for specific types of activities based on a general finding that such activities do not result in significant degradation. States and authorized tribes should also consider the appropriateness of exemptions depending on the types of chemical, physical, and biological parameters that would be affected. For example, if a potential lowering of water quality contains bioaccumulative chemicals of concern, a state or authorized tribe should not apply a categorical *de minimis* exclusion because even extremely small additions of such chemicals could have a significant effect. For such pollutants, it could be possible to apply a *de minimis* exclusion on a case by case basis, but the state or authorized tribe should carefully consider any such proposed lowering prior to determining that it would be insignificant. States and authorized tribes should also consider the potential effects of cumulative impacts on the same water body to ensure that the cumulative degradation from multiple activities each considered to have a *de minimis* impact will not cumulatively add up to a significant impact. Finally, if a state or authorized tribe intends to use *de minimis* exclusions, then EPA recommends that it describe how it will use *de minimis* in its antidegradation implementation methods. This guarantees that states and authorized tribes will inform the public ahead of time about how they will use *de minimis* exemptions.

EPA also encourages states and authorized tribes to consider other ways to help focus limited resources where they may result in the greatest environmental protection. A state or authorized tribe should consider whether it will require more effort and resources to justify a *de minimis* exemption than it would take to actually complete a Tier 2 review for the activity. EPA encourages states and authorized tribes to develop ways to streamline Tier 2 reviews, rather than seeking to exempt activities from review entirely.

E. WQS Variances

What does this rule provide and why?

This rule establishes an explicit regulatory framework for the adoption of WQS variances that states and authorized tribes can use to implement adaptive management approaches to improve water quality. States and authorized tribes can face substantial uncertainty as to what designated use may ultimately be attainable in their waters. Pollutants that impact such waters can result from large-scale land use changes, extreme weather events, or environmental stressors related to climate change that can hinder restoration and maintenance of water quality. In addition, pollutants can be persistent in the environment and, in some cases, lack economically feasible control options. WQS variances are customized WQS that identify the highest attainable condition applicable throughout the WQS variance term. For a discussion of why it is important for states and authorized tribes to include the highest attainable condition, see the preamble to the proposed rule at 78 FR 54534 (September 4, 2013). States and authorized tribes could use one or more WQS variances to require incremental improvements in water quality leading to eventual attainment of the ultimate designated use.

While EPA has long recognized WQS variances as an available tool, the final rule provides regulatory certainty to states and authorized tribes, the regulated community, and the public that WQS variances are a legal WQS tool. The final rule explicitly authorizes the use of WQS variances and provides requirements to ensure that WQS variances are used appropriately. Such a mechanism allows states and authorized tribes to work with stakeholders and assure the public that WQS variances facilitate progress toward attaining designated uses. When all parties are engaged in a transparent process that is guided by an accountable framework, states and authorized tribes can move past traditional barriers and begin efforts to maintain and restore waters. As discussed in the preamble to the proposed rule at 78 FR 54531 (September 4, 2013), a number of states have not pursued WQS variances. For WQS variances submitted to EPA between 2004 and 2015, 75% came from states covered by the ''Water Quality Guidance for the Great Lakes System'' rulemaking at 40 CFR part 132. EPA attributes the Region 5 states' success in adopting and submitting WQS variances to the fact that the states and their stakeholders have had more specificity in regulation regarding WQS variances than the rest of the country. This final rule is intended to provide the same level of specificity nationally.

EPA's authority to establish requirements for WQS variances comes from CWA sections 101(a) and 303(c)(2). This rule reflects this authority by explicitly recognizing that states and authorized tribes may adopt time-limited WQS with a designated use and criterion reflecting the highest attainable condition applicable throughout the term of the WQS variance, instead of pursing a permanent [45] revision of the designated use and associated criteria. WQS variances serve the national goal in section 101(a)(2) of the Act and the ultimate objective of the CWA to restore and maintain the chemical, physical, and biological integrity of the Nation's waters because WQS variances are narrow in scope and duration and are designed to make progress toward water quality goals. When a WQS variance is in place, all other applicable standards not addressed in the WQS variance continue to apply, in addition to the ultimate water quality objectives (*i.e.*, the underlying WQS). Also, by requiring the highest attainable condition to be identified and applicable throughout the term of the WQS variance, the final rule provides a mechanism to make incremental progress toward the ultimate water quality objective for the water body and toward the restoration and maintenance of the chemical, physical, and biological integrity of the Nation's waters.

This rule adds a new regulatory section at § 131.14 that explicitly authorizes the use of WQS variances when the applicable designated uses are not attainable in the near-term but may be attainable in the future. The rule clarifies how WQS variances relate to other CWA programs and specifies the information that the state and authorized tribe must adopt in any WQS variance, including the highest attainable condition. States and authorized tribes must submit to EPA supporting documentation that demonstrates why the WQS variance is

[42] *Id.* (quoting *Ala. Power.* v. *Costle,* 636 F.2d. 323, 361 (D.C. Cir. 1979)).

[43] *Id.* (quoting *Greenbaum* v. *U.S. Envtl Prot. Agency,* 370 F.3d 527, 534 (6th Cir. 2004)).

[44] *Id.* (quoting *Greenbaum* v. *U.S. Envtl Prot. Agency,* 370 F.3d 527, 534 (6th Cir. 2004)).

[45] ''Permanent'' is used here to contrast between the time-limited nature of WQS variances and designated use changes. In accordance with 40 CFR 131.20, waters that ''do not include the uses specified in section 101(a)(2) of the Act shall be re-examined every 3 years to determine if new information has become available. If such new information indicates that the uses specified in section 101(a)(2) of the Act are attainable, the [s]tate shall revise its standards accordingly.''

needed and justifies the term and interim requirements. Finally, the rule requires states and authorized tribes to reevaluate WQS variances longer than five years on an established schedule with public involvement. The changes from the proposed rule respond to public comments and remain consistent with the Agency's clearly articulated policy objectives in the proposed rule. This rule also includes editorial changes that are not substantive in nature.

First, to provide clarity, this rule includes a new section at § 131.14 to explicitly authorize states and authorized tribes to adopt WQS variances. States and authorized tribes may adopt WQS variances for a single discharger, multiple dischargers, or a water body or waterbody segment, but it only applies to the permittee(s) or water body/waterbody segment(s) specified in the WQS variance. The rule defines a WQS variance at § 131.3(o) as a time-limited designated use and criterion for a specified pollutant(s), permittee(s), and/or water body or waterbody segment(s) that reflects the highest attainable condition applicable throughout the specified time period. The rule further specifies that a WQS variance is a new or revised WQS subject to EPA review and approval or disapproval,[46] requires a public process, and must be reviewed on a triennial basis. All other applicable standards not specifically addressed by the WQS variance remain applicable. This rule adds § 131.5(a)(4) to explicitly specify that EPA has the authority to determine whether any WQS variances adopted by a state or authorized tribe are consistent with the requirements at § 131.14. A WQS variance shall not be adopted if the designated use and criterion can be achieved by implementing technology-based effluent limits required under sections 301(b) and 306 of the Act.

To make incremental water quality improvements, it is important that states' and authorized tribes' WQS continue to reflect the ultimate water quality goal. This rule, therefore, requires states and authorized tribes to retain the underlying designated use and criterion in their standards to apply to all other permittees not addressed in the WQS variance, and for identifying threatened and impaired waters under CWA section 303(d), and for establishing a Total Maximum Daily Load (TMDL).[47] For further clarity, this rule also specifies that once EPA approves a WQS variance, including the highest attainable condition, it applies for purposes of developing NPDES permit limits and requirements under 301(b)(1)(C). WQS variances can also be used by states, authorized tribes, and other certifying entities when issuing certifications under CWA section 401. If EPA disapproves a WQS variance, the state or authorized tribe will have an opportunity to revise and re-submit the WQS variance for approval. Until EPA approves the re-submitted WQS variance, the underlying designated use and criteria remain applicable for all CWA purposes. This rule reinforces the requirements at § 122.44(d)(1)(vii)(A) by specifying that any limitations and requirements necessary to implement the WQS variance must be included as enforceable conditions of the implementing NPDES permit.

Second, to provide public transparency, this rule requires states and authorized tribes to include specific information in the WQS variance. States and authorized tribes must specify the pollutant(s) or water quality parameter(s) and the water body/waterbody segment(s) to which the WQS variance applies. A state or authorized tribe must also identify the discharger(s) subject to a discharger-specific WQS variance. As an alternative to identifying the specific dischargers at the time of adoption of a WQS variance for multiple dischargers, states and authorized tribes may adopt specific eligibility requirements in the WQS variance. This will make clear what characteristics a discharger must have in order to be subject to the WQS variance for multiple dischargers. It is EPA's expectation that states and authorized tribes that choose to identify the dischargers in this manner will subsequently make a list of the facilities covered by the WQS variance publicly available (*e.g.*, posted on the state or authorized tribal Web site). It may be appropriate for a state or authorized tribe to adopt one WQS variance that applies to multiple dischargers experiencing the same challenges in meeting their WQBELs for the same pollutant so long as the WQS variance is consistent with the CWA and § 131.14.[48] A multiple discharger WQS variance may not be appropriate or practical for all situations and can be highly dependent on the applicable pollutants, parameters, and/or permittees.

States and authorized tribes must also specify the term of any WQS variance to ensure that WQS variances are time-limited. States and authorized tribes have the flexibility to express the WQS variance term as a specific date (*e.g.*, expires on December 31, 2024) or as an interval of time after EPA-approval (*e.g.*, expires 10 years after EPA approval), as long as it is only as long as necessary to achieve the highest attainable condition. If, at the end of the WQS variance, the underlying designated use remains unattainable, the state or authorized tribe may adopt a subsequent WQS variance(s), consistent with the requirements of § 131.14.

To ensure that states and authorized tribes use WQS variances that continue to make water quality progress, the rule does not allow a WQS variance to lower currently attained ambient water quality, except in circumstances where a WQS variance will allow short-term lowering necessary for restoration activities consistent with § 131.14(b)(2)(i)(A)(*2*). Moreover, states and authorized tribes must specify in the WQS variance itself the interim requirements reflecting the highest attainable condition. Where a permittee cannot immediately meet the WQBEL derived from the terms of a WQS variance, the permitting authority can decide whether to provide a permit compliance schedule (where authorized) so the permittee can remain in compliance with its NPDES permit.[49] (See CWA section [502(17)] for a definition of ''Schedules of compliance'' and 40 CFR 122.47).[50] Any such compliance schedule must include a final effluent limit based on the applicable highest attainable condition and must require compliance with the permit's WQBEL ''as soon as possible.'' If the compliance schedule exceeds one year, the permitting authority must include interim requirements and the dates for their achievement.

For example, if the underlying criterion requires an NPDES WQBEL of 1 mg/L for pollutant X, but the permittee's current effluent quality is at 10 mg/L, the state or authorized tribe could adopt the highest attainable condition of 3 mg/L to be achieved at the end of 15 years and obtain EPA approval if they have met the requirements of § 131.14. Once approved by EPA, the highest attainable condition of 3 mg/L is the applicable

[46] For this reason, states and authorized tribes are not required to adopt specific authorizing provisions into state or authorized tribal law before using WQS variances consistent with the federal regulation.

[47] See 78 FR 54533 (September 4, 2013).

[48] EPA has developed a list of Frequently Asked Questions addressing when a multiple discharger WQS variance may be appropriate and how a state or authorized tribe can develop a credible rationale for this type of WQS variance. *Discharger-specific Variances on a Broader Scale: Developing Credible Rationales for Variances that Apply to Multiple Dischargers*, EPA–820–F–13–012, March 2013.

[49] As an alternative to a permit compliance schedule, there may be other available mechanisms such as an administrative order.

[50] 78 FR 54532 (September 4, 2013).

criterion for purposes of deriving the NPDES WQBEL and developing the NPDES permit limits and requirements for the facility covered by the WQS variance. For this example, assume the permitting authority is developing the NPDES permit without allowing dilution (*i.e.*, applying the criterion end of pipe). In this case, the facility will need 15 years to implement the activities necessary to meet the limit based on the 3 mg/L. The permitting authority could include a 15 year compliance schedule with a final effluent limit based on 3 mg/L and an enforceable sequence of actions that the permitting authority determines are necessary to achieve the final effluent limit. As discussed later in this section, the documentation that a state or authorized tribe provides to EPA justifying the term of the WQS variance informs the permitting authority when determining the enforceable sequence of actions.

This rule requires states and authorized tribes to provide a quantifiable expression of the highest attainable condition. This requirement is an important feature of a WQS variance that facilitates development of NPDES permit limits and requirements and allows states, authorized tribes, and the public to track progress. This rule provides states and authorized tribes the flexibility to express the highest attainable condition as numeric pollutant concentrations in ambient water, numeric effluent conditions, or other quantitative expressions of pollutant reduction, such as the maximum number of combined sewer overflows that is achievable after implementation of a long-term control plan or a percent reduction in pollutant loads.

The final rule at § 131.14(b)(1)(ii) provides states and authorized tribes with different options to specify the highest attainable condition depending on whether the WQS variance applies to a specific discharger(s) or to a water body or waterbody segment. For a discharger(s)-specific WQS variance, the rule allows states and authorized tribes to express the highest attainable condition as an interim criterion without specifying the designated use it supports. EPA received comments suggesting that identifying both an interim use and interim criterion for a WQS variance is unnecessary. EPA agrees that the level of protection afforded by meeting the highest attainable criterion in the immediate area of the discharge(s) results in the highest attainable interim use at that location. Therefore, the highest attainable interim criterion is a reasonable surrogate for both the highest attainable interim use and interim criterion when the WQS variance applies to a specific discharger(s). For similar reasons, as explained in the preamble to the proposed rule, states and authorized tribes may choose to articulate the highest attainable condition as the highest attainable interim effluent condition.[51] Neither of these options, however, is appropriate for a WQS variance applicable to a water body or waterbody segment. Such a WQS variance impacts the water body or waterbody segment in a manner that is similar to a change in a designated use and, therefore, must explicitly articulate the highest attainable condition as the highest attainable interim designated use and interim criterion. A state's or authorized tribe's assessment of the highest attainable interim designated use and interim criterion for this type of WQS variance necessarily involves an evaluation of all pollutant sources.

Where the state or authorized tribe cannot identify an additional feasible pollutant control technology, this rule provides options for articulating the highest attainable condition using the greatest pollutant reduction achievable with optimization of currently installed pollutant control technologies and adoption and implementation of a Pollutant Minimization Program (PMP). The rule makes this option available for a WQS variance that applies to a specific discharger(s) as well as a WQS variance applicable to a water body or waterbody segment. EPA defines PMP at § 131.3(p) as follows: ''*Pollutant Minimization Program*, in the context of § 131.14, is a structured set of activities to improve processes and pollutant controls that will prevent and reduce pollutant loadings . . . .'' Pollutant control technologies represent a broad set of pollutant reduction options, such as process or raw materials changes and pollution prevention technologies, practices that reduce pollutants prior to entering the wastewater treatment system, or best management practices for restoration and mitigation of the water body. This option requires states and authorized tribes to adopt the PMP along with other elements that comprise the highest attainable condition. As part of the applicable WQS, the permitting authority must use the PMP (along with the quantifiable expression of the ''greatest pollutant reduction achievable'') to derive NPDES permit limits and requirements.

As discussed later in this section, states and authorized tribes must reevaluate WQS variances on a regular and predictable schedule. To ensure that a WQS variance reflects the highest attainable condition throughout the WQS variance term, states and authorized tribes must adopt a provision specifying that the applicable interim WQS shall be either the highest attainable condition initially adopted, or a higher attainable condition later identified during any reevaluation. The rule requires such a provision only for WQS variances longer than five years. This provision must be self-implementing so that if any reevaluation yields a more stringent attainable condition, that condition becomes the applicable interim WQS without additional action. Upon permit reissuance, the permitting authority will base the WQBEL on the more stringent interim WQS consistent with the NPDES permit regulation at § 122.44(d)(vii)(A). Where the reevaluation identifies a condition less stringent than the highest attainable condition, the state or authorized tribe must revise the WQS variance consistent with CWA requirements and obtain EPA approval of the WQS variance before the permitting authority can derive a WQBEL based on that newly identified highest attainable condition.

Third, to ensure EPA has sufficient information to determine whether the WQS variance is consistent with EPA's WQS regulation, states and authorized tribes must provide documentation to justify why the WQS variance is needed, the term for the WQS variance, and the highest attainable condition. For a WQS variance to a designated use specified in CWA section 101(a)(2) and sub-categories of such uses, states and authorized tribes must demonstrate that the use and criterion are not feasible to attain on the basis of one of the factors listed in § 131.10(g) or on the basis of the new restoration-related factor in § 131.14(b)(2)(i)(A)(*2*). EPA added this new factor for when states and authorized tribes wish to obtain a WQS variance because they expect a time-limited exceedance of a criterion when removing a dam or during significant wetlands, lake, or stream reconfiguration/restoration efforts. EPA includes ''lake'' in the regulatory language for this factor, on the basis of public comments suggesting that the rule also apply to lake restoration activities. States and authorized tribes may only use this factor to justify the time necessary to remove the dam or the length of time in which wetland, lake, or stream restoration activities are actively on-going. Although such a WQS

[51] 78 FR 54534 (September 4, 2013).

variance might not directly impact an NPDES permittee or the holder of a federal license or permit, states and authorized tribes could rely on the WQS variance when deciding whether to issue a CWA section 401 certification in connection with an application for a federal license or permit. The central feature of CWA section 401 is the state or authorized tribe's ability to grant, grant with conditions, deny or waive certification for federally licensed or permitted activities that may discharge into navigable waters. Many states and authorized tribes rely on CWA section 401 certification to ensure that federal projects do not cause adverse water quality impacts. By adopting a WQS variance, the state or authorized tribe lays the groundwork for issuing a certification (possibly with conditions, as per CWA section 401(d)) that allows a federal license or permit to be issued. Without a WQS variance, the state or authorized tribe's only options might be to deny certification which prevents issuance of the federal license or permit, or waive certification and allow the license or permit to be issued without conditions. If a state or authorized tribe issues a CWA certification based on a WQS variance, EPA recommends that the state or tribe consider whether to include the applicable interim requirements from the WQS variance as conditions of its certification.

For WQS variances to non-101(a)(2) uses, this rule specifies that states and authorized tribes must document and submit a use and value demonstration consistent with § 131.10(a) (see section II.B for additional discussion on use and value demonstrations). EPA's proposed rule would have required that a ''[s]tate must submit a demonstration justifying the need for a WQS variance'' and the preamble to the proposed rule noted that the demonstrations for uses specified in CWA section 101(a)(2) and non-101(a)(2) may differ. EPA received comments questioning the requirements for WQS variances to non-101(a)(2) uses and this rule explicitly makes clear that the documentation requirement for removing or adopting new or revised designated uses in §§ 131.10(a) and 131.6 also applies to non-101(a)(2) WQS variances. States and authorized tribes may also use the factors at § 131.14(b)(2)(i)(A) to justify how their consideration of the use and value appropriately supports the WQS variance.

States and authorized tribes must justify the term of any WQS variance on the basis of the information and factors evaluated to justify the need for the WQS variance. States and authorized tribes must also describe the pollutant control activities, including those identified through a PMP, that the state or authorized tribe anticipates implementing throughout the WQS variance term to achieve the highest attainable condition. During its review of the WQS variance, EPA will evaluate this description of activities which must reflect only the time needed to plan activities, implement activities, or evaluate the outcome of activities. Explicitly requiring the state or authorized tribe to document the relationship between the pollutant control activities and the WQS variance term ensures that the term is only as long as necessary to achieve the highest attainable condition and that water quality progress is achieved throughout the entire WQS variance term. The pollutant control activities specified in the supporting documentation serve as milestones for the WQS variance and inform the permitting authority when developing the enforceable terms and conditions of the NPDES permit necessary to implement the WQS variance, as required at 40 CFR 122.44(d)(1).

The degree of certainty associated with pollutant control activities and pollutant reductions will inform EPA's review and evaluation of whether the state's or authorized tribe's submission sufficiently justifies the need and the term of WQS variances. There can be instances where a state or authorized tribe has information to determine that the underlying designated use and criterion cannot be attained for a particular period of time, but does not have sufficient information to identify the highest attainable condition that would be achieved in that same period of time. In such cases, EPA anticipates that a state or authorized tribe will adopt a shorter WQS variance reflecting the highest attainable condition that is supported by the available information, including the pollutant control activities identified in the WQS submission. States and authorized tribes could then determine the appropriate mechanism to continue making progress towards the underlying designated use and criterion, which may include adoption of subsequent WQS variances as more data are gathered and additional pollutant control activities are identified.

This rule also includes two additional requirements to ensure states and authorized tribes use all relevant information to establish a WQS variance for a water body or waterbody segment. States and authorized tribes must identify and document cost-effective and reasonable BMPs for nonpoint sources, and provide for public notice and comment on that documentation. States and authorized tribes must also document whether and to what extent BMPs were implemented and the water quality progress achieved during the WQS variance term to justify a subsequent WQS variance. Nonpoint sources can have a significant bearing on whether the designated use and associated criteria for the water body are attainable. It is essential for states and authorized tribes to consider how controlling these sources through application of cost-effective and reasonable BMPs could impact water quality before adopting such a WQS variance. Doing so informs the highest attainable condition, the duration of the WQS variance term, and the state's or authorized tribe's assessment of the interim actions that may be needed to make water quality progress.

Fourth, to ensure that states and authorized tribes thoroughly reevaluate each WQS variance with a term longer than five years, this rule requires states and authorized tribes to specify, in the WQS variance, the reevaluation frequency and how they plan to obtain public input on the reevaluation. Additionally, they must submit the results of the reevaluation to EPA within 30 days of completion. States and authorized tribes may specify the frequency of reevaluations to coincide with other state and authorized tribal processes (*e.g.*, WQS triennial reviews or NPDES permit reissuance), as long as reevaluations occur at least every five years. Although EPA does not review and approve or disapprove the results of a WQS variance reevaluation, the results could inform whether the Administrator exercises his or her discretion to determine that new or revised WQS are necessary. The rule also requires states and authorized tribes to adopt a provision specifying that the WQS variance will no longer be the applicable WQS for CWA purposes if they do not conduct the required reevaluation or do not submit the results of the reevaluation within 30 days of completion. If a state or authorized tribe does not reevaluate the WQS variance or does not submit the results to EPA within 30 days, the underlying designated use and criterion become the applicable WQS for the permittee(s) or water body specified in the WQS variance without EPA, states or authorized tribes taking an additional WQS action. In such cases, subsequent NPDES WQBELs for the associated permit must be based on the underlying designated use and criterion rather than the highest attainable condition, even if the originally specified variance term has not expired. As discussed earlier in this section, states and authorized tribes must also adopt a provision that ensures the WQS variance reflects the highest attainable condition initially adopted or any more stringent highest attainable condition identified during a reevaluation that is applicable throughout the WQS variance term.

EPA proposed a maximum allowable WQS variance term of 10 years to ensure that states and authorized tribes reevaluate long-term WQS challenges at least every 10 years before deciding whether to continue with a WQS variance. EPA explained in the preamble to the proposed rule that the purpose of this maximum WQS variance term was as follows: ''Establishing an expiration date will ensure that the conditions of a [WQS] variance will be thoroughly reevaluated and subject to a public review on a regular and predictable basis to determine (1) whether conditions have changed such that the designated use and criterion are now attainable; (2) whether new or additional information has become available to indicate that the designated use and criterion are not attainable in the future (*i.e.*, data or information supports a use change/refinement); or (3) whether feasible progress is being made toward the designated use and criterion and that additional time is needed to make further progress (*i.e.*, whether a [WQS] variance may be renewed).'' [52]

Some commenters suggested that 10 years is too long and does not provide adequate assurance that the state or authorized tribe will periodically reevaluate a WQS variance in a publicly transparent manner. Other commenters suggested that 10 years is too short because states often adopt WQS variances through conventional rulemaking processes and that such a maximum term would result in unnecessary rulemaking burden where it is widely understood that long-term pollution challenges require more time to resolve. A 10-year maximum could also discourage the use of WQS variances.

In response, EPA concludes that establishing specific reevaluation requirements for WQS variances longer than five years is the best way to achieve EPA's policy objective of active, thorough, and transparent reevaluation by states and authorized tribes while minimizing rulemaking burden. The reevaluation requirements in this rule eliminate the need to specify a maximum WQS variance term because they ensure the highest attainable condition is always the applicable WQS throughout the WQS variance term, thus driving incremental improvements toward the underlying designated use. These requirements also ensure the public has an opportunity to provide input throughout the WQS variance term. EPA chose five years as the maximum interval between reevaluations because five years is the length of a single NPDES permit cycle, allowing the reevaluation to inform the permit reissuance process. Although this rule does not specify a maximum WQS variance term, states and authorized tribes must still identify the WQS variance term and provide documentation demonstrating that the term is only as long as necessary to achieve the highest attainable condition. EPA will use this information to determine whether to approve or disapprove the WQS variance submitted for review, based on the requirements in § 131.14.

WQS variances remain subject to the triennial review and public participation requirements specified in § 131.20. The final rule requirements ensure that the public has the opportunity to work with states and authorized tribes in a predictable and timely manner to search for new or updated data and information specific to the WQS variance that could indicate a more stringent highest attainable condition exists than the state or authorized tribe originally adopted. ''New or updated data and information'' include, but are not limited to, new information on pollutant control technologies, changes in pollutant sources, flow or water levels, economic conditions, and BMPs that impact the highest attainable condition. Where there is an EPA-approved WQS variance, the permitting authority must refer to the reevaluation results when reissuing NPDES permits to ensure the permit implements any more stringent applicable WQS that the reevaluation provides. States and authorized tribes can facilitate this coordination by publishing and making accessible the results of reevaluations.

While this rule only requires reevaluations of WQS variances with a term longer than five years, states and authorized tribes must review all WQS variances during their triennial review. If a state or authorized tribe synchronizes a WQS variance reevaluation with permit reissuance, the reevaluation must occur on schedule even if there is a delay in the permit reissuance.

EPA previously promulgated specific variance procedures when EPA established federal WQS for Kansas (§ 131.34(c)) and Puerto Rico (§ 131.40(c)). To provide national consistency, this rule authorizes the Regional Administrator to grant WQS variances in Kansas and Puerto Rico in accordance with the provisions of § 131.14.

What did EPA consider?

In addition to considering the option EPA proposed, EPA considered options that provide a maximum WQS variance term more than or less than 10 years. EPA rejected these options because retaining a maximum term of any duration does not accomplish EPA's goal of a balanced approach that ensures both flexibility and accountability as effectively as requiring periodic reevaluations of the WQS variance. Additionally, on the basis of commenters' suggestions, EPA considered requiring identification and documentation of cost-effective and reasonable BMPs for nonpoint sources for all WQS variances and not just for WQS variances applicable to a water body or waterbody segment. To achieve EPA's policy objectives, EPA chose instead to add a requirement for all WQS variances that states and authorized tribes describe the pollutant control activities to achieve the highest attainable condition (see § 131.14(b)(2)(ii)).

What is EPA's position on certain public comments?

EPA received comments that suggested confusion between WQS variances and NPDES permit compliance schedules. WQS variances can be appropriate to address situations where it is known that the designated use and criterion are unattainable today, but progress could be made toward attaining the designated use and criterion. Typically, a permit authority grants a permit compliance schedule when the permittee needs additional time to modify or upgrade treatment facilities in order to meet its WQBEL based on the applicable WQS (*i.e.*, designated use and criterion). After the effective date of this rule, a permit authority could also grant a permit compliance schedule when the permittee needs additional time to meet its WQBEL based on the applicable WQS variance (*i.e.*, highest attainable condition) such that a schedule and resulting milestones will lead to compliance with the effluent limits derived from the WQS variance ''as soon as possible.'' If a WQS variance is about to expire and a state or authorized tribe concludes the underlying designated use is now attainable, it is not appropriate for the state or authorized tribe to adopt a subsequent

[52] 78 FR 54536 (September 4, 2013).

WQS variance. However, if a permittee is unable to immediately meet a WQBEL consistent with the now attainable WQS, and the permitting authority can specify an enforceable sequence of actions that would result in achieving the WQBEL, the permitting authority could grant a permit compliance schedule consistent with § 122.47. If the underlying designated use is still not attainable, the state or authorized tribe can adopt a subsequent WQS variance.

EPA also received comments questioning how a WQS variance works with a TMDL and CWA section 303(d) impaired waters listing(s). These comments suggested the proposed rule creates a conflict in how the NPDES permitting regulation requires permitting authorities to develop WQBELs. Section 122.44(d)(1)(vii)(A) specifies that all WQBELs in an NPDES permit must derive from and comply with all applicable WQS. Section 122.44(d)(1)(vii)(B) specifies that the WQBEL of any NPDES permit must be consistent with the assumptions and requirements of any *available* (emphasis added) waste load allocation (WLA) in an EPA-approved or EPA-established TMDL. Because the WLA of the TMDL is based on the underlying designated use and criterion (and not the highest attainable condition established in the WQS variance), then the WLA in the TMDL is not available to the permittee covered by the WQS variance for NPDES permitting purposes while the WQS variance is in effect. The permitting authority must develop WQBELs for the permittees subject to the WQS variance based on the interim requirements specified in the WQS variance. Upon termination of the WQS variance, the NPDES permit must again derive from and comply with the underlying designated use and criterion and be consistent with the assumptions and requirements of the WLA (as it is again ''available'').

Some commenters questioned what would happen if a state or authorized tribe does not coordinate a WQS variance term with the expiration date of an NPDES permit. If information is available to the permitting authority indicating that the term of a WQS variance will end during the permit cycle, the permitting authority must develop two WQBELs: one WQBEL based on the highest attainable condition applicable throughout the WQS variance term, and another WQBEL based on the underlying designated use and criterion to apply after the WQS variance terminates. Including two sets of WQBELs that apply at different time periods in the permit ensures that the permit will derive from and comply with WQS throughout the permit cycle. If the state or authorized tribe adopts and EPA approves a subsequent WQS variance during the permit term to replace an expiring WQS variance, the new WQS variance would constitute ''new regulations'' pursuant to § 122.62(a)(3)(i), and the permitting authority could modify the permit to derive from and comply with the subsequent WQS variance. At the request of the permittee, the permitting authority can also utilize the Permit Actions condition specified in § 122.41(f) to modify a permit and revise the WQBEL to reflect the new WQS variance.

Some commenters questioned whether states and authorized tribes must modify WQS variances that states and authorized tribes adopted before the effective date of the final rule. States and authorized tribes must meet the requirements of this rule on the effective date of the final rule. As with any WQS effective for CWA purposes, WQS variances are subject to the triennial review requirements at § 131.20(a). When a state or authorized tribe reviews a WQS variance that was adopted before § 131.14 becomes effective, EPA strongly encourages the state or authorized tribe to ensure the WQS variance is consistent with this rule. EPA encourages the public to engage in triennial reviews and request revisions to WQS variances that states and authorized tribes adopted and EPA approved prior to the effective date of the final rule so that the public can provide information supporting the need to modify the WQS variances. Some states and authorized tribes may also have adopted binding WQS variance policies and/or procedures. Such policies and procedures are not required by EPA's regulation before utilizing WQS variances, however, where state and authorized tribes have them and they are inconsistent with this rule, those states and authorized tribes must revise such policies and/or procedures prior to, or simultaneously with, adopting the first WQS variance after the effective date of the final rule.

A state or authorized tribe may be able to streamline its WQS variance process in several ways. As discussed earlier in this section, one way is to adopt multiple discharger WQS variances. In justifying the need for a multiple discharger WQS variance, states and authorized tribes should account for as much individual permittee information as possible. A permittee that cannot qualify for an individual WQS variance cannot qualify for a multiple discharger WQS variance. EPA recommends that states and authorized tribes provide a list of the dischargers covered under the WQS variance on their Web sites or other publicly available sources of state or authorized tribal information, particularly when using multiple discharger WQS variances.

A second way is to adopt an administrative procedure that fulfills the WQS submittal and review requirements and specifies that if the state or authorized tribe follows the procedure, the WQS variance is legally binding under state or tribal law. A state or authorized tribe could submit such an administrative procedure for a WQS variance, as a rule, to EPA for review and approval under § 131.13. Once approved, the state or authorized tribe can follow this administrative procedure and develop a final document for each WQS variance. Because the state or tribal law specifies this WQS variance document is legally binding, there is no need for the state or authorized tribe to do a separate rulemaking for each individual WQS variance. Rather, the state or authorized tribe could submit each resulting WQS variance document, with an Attorney General or appropriate tribal legal authority certification, and EPA could take action under CWA section 303(c).

Some commenters questioned how this rule affects states and authorized tribes under the 1995 Great Lakes Water Quality Guidance (GLWQG) [53] because those requirements are different than the WQS variance requirements in the final rule. For waters in the Great Lakes basin, states and authorized tribes must meet the requirements of both 40 CFR parts 131 and 132. The practical effect of this requirement is that, where regulations in 40 CFR parts 131 and 132 overlap, the more stringent regulation applies. In some cases, the flexibilities and requirements in the national rule will not be applicable to waters in the Great Lakes basin. For example, the GLWQG limits any WQS variance to a maximum term of five years (with the ability to obtain a subsequent WQS variance). Therefore, any WQS variance on waters that are subject to the GLWQG cannot exceed five years even though the final rule in 40 CFR part 131 does not specify a maximum term. On the other hand, because GLWQG WQS variances cannot exceed five years, the requirements in the final rule that pertain to conducting reevaluations (for WQS variances greater than five years) are not applicable.

[53] See 60 FR 15366 (March 23, 1995); 40 CFR part 132.

Finally, some commenters questioned the level of ''scientific rigor'' required for a WQS variance as compared to a UAA required for changes to 101(a)(2) uses. Section 40 CFR 131.5(a)(4) provides that EPA's review under section 303(c) involves a determination of whether the state's or authorized tribe's ''standards which do not include the uses specified in section 101(a)(2) of the Act are based upon appropriate technical and scientific data and analyses. . . .'' Because WQS variances are time-limited designated uses and criteria, this requirement applies to WQS variances. States and authorized tribes must adopt WQS variances based on appropriate technical and scientific data and analyses. Therefore, the level of rigor required for a WQS variance is no different than for a designated use change. That said, the appropriate technical and scientific data required to support a designated use change and WQS variance can vary depending on the complexity of the specific circumstances. EPA recognizes that the data and analyses often needed to support adoption of a WQS variance could be less complex and require less time and resources compared to removing a designated use because many WQS variances evaluate only one parameter for a single permittee for a limited period of time. The level of effort a state or authorized tribe needs to devote to a WQS variance will in large part be determined by the complexity of the water quality problem the state or authorized tribe seeks to address.

F. Provisions Authorizing the Use of Schedules of Compliance for WQBELs in NPDES Permits

What does this rule provide and why?

In 1990, EPA concluded that before a permitting authority can include a compliance schedule for a WQBEL in an NPDES permit, the state or authorized tribe must affirmatively authorize its use in its WQS or implementing regulations.[54] EPA approval of the state's or authorized tribe's permit compliance schedule authorizing provision as a WQS ensures that any NPDES permit WQBEL with a compliance schedule derives from and complies with applicable WQS as required by § 122.44(d)(1)(vii)(A). Because the state's or authorized tribe's approved WQS authorize extended compliance, any delay in compliance with a WQBEL pursuant to an appropriately issued permit compliance schedule is consistent with the statutory implementation timetable in CWA section 301(b)(1)(C).

The use of legally-authorized permit compliance schedules by states and authorized tribes provides needed flexibility for many dischargers undergoing facility upgrades and operational changes designed to meet WQBELs in their NPDES permits. This flexibility will become increasingly important as states and authorized tribes adopt more stringent WQS, including numeric nutrient criteria, and address complex water quality problems presented by emerging challenges like climate change.

Some states have adopted compliance schedule authorizing provisions but have not submitted them to EPA for approval as WQS pursuant to CWA section 303(c). Other states have not yet adopted compliance schedule authorizing provisions. A permit could be subject to legal challenge where a state and authorized tribe decide to authorize permit flexibility using permit compliance schedules, but do not have a compliance schedule authorizing provision approved by EPA as a WQS.

Section 131.15 in this final rule requires that if a state or authorized tribe intends to authorize the use of compliance schedules for WQBELs in NPDES permits, it must first adopt a permit compliance schedule authorizing provision. The authorizing provision must be consistent with the CWA and is subject to EPA review and approval as a WQS. This rule adds § 131.5(a)(5) to explicitly specify that EPA has the authority to determine whether any provision authorizing the use of schedules of compliance for WQBELs in NPDES permits adopted by a state or authorized tribe is consistent with the requirements at § 131.15. This rule also includes a number of non-substantive editorial changes.

By expressly requiring that the state or authorized tribe adopt a permit compliance schedule authorizing provision, the first sentence of the final regulation at § 131.15 ensures that the state or authorized tribe has expressly made a determination that, under appropriate circumstances, it can be lawful to delay permit compliance. Formal adoption as a legally binding provision ensures public transparency and facilitates public involvement.

Some commenters expressed concern that the proposed regulatory language regarding state and authorized tribal adoption could be interpreted to refer to permit compliance schedules themselves, rather than their authorizing provisions. To address that concern, the final rule refers to ''the use of'' schedules of compliance. The phrase ''the use of'' indicates that the mere adoption of an authorizing provision, by itself, does not extend the date of compliance with respect to any specific permit's WQBEL; rather, its adoption allows the state or authorized tribe *to use* schedules of compliance, as appropriate, on a case-by-case basis in individual permits.

The second sentence of the final regulation at § 131.15 provides that states' and authorized tribes' authorizing provisions must be consistent with the CWA and are WQS subject to EPA review and approval. By incorporating the authorizing provision into the state's or authorized tribe's approved WQS, the state or authorized tribe ensures that a permitting authority can then legally issue compliance schedules for WQBELs in NPDES permits that are consistent with CWA section 301(b)(1)(C). Only the permit compliance schedule authorizing provisions are WQS subject to EPA approval; individual permit compliance schedules are not. The final rule provides flexibility for a state or authorized tribe to include the authorizing provision in the part of state or tribal regulations where WQS are typically codified, in the part of state or tribal regulations dealing with NPDES permits, or in other parts of the state's or authorized tribe's implementing regulations. Regardless of where the authorizing provision is codified, as long as the provision is legally binding, EPA will take action on it under CWA section 303(c). If a state or authorized tribe has already adopted an authorizing provision that is consistent with the CWA, it need not readopt the provision for purposes of satisfying the final rule. Instead, the state or authorized tribe can submit the provision to EPA with an Attorney General or appropriate tribal legal authority certification. Moreover, consistent with § 131.21(c), any permit compliance schedule authorizing provision that was adopted, effective, *and submitted* to EPA before May 30, 2000, is applicable for purposes of § 131.15.

This final rule does not change any permit compliance schedule requirements at § 122.47.

Other judicial and administrative mechanisms issued pursuant to other authorities, such as an enforcement order issued by a court, can delay the need for compliance with WQBELs. This rule does not address those other mechanisms.

What did EPA consider?

EPA considered finalizing § 131.15, as proposed. Given the comments

[54] *In the Matter of Star-Kist Caribe, Inc.* 3 EAD 172 (April 16, 1990).

indicating that ambiguity in the proposed language could lead to confusion over whether the requirements to adopt and submit for EPA approval applied directly to permit compliance schedules themselves, EPA did not select this option. Instead, EPA added clarifying language to address the commenters' concern and streamlined the text of the proposed rule without making substantive changes. EPA also considered foregoing the addition of § 131.15. Many commenters, however, supported adding § 131.15 as a useful clarification of the need and process for states and authorized tribes to adopt compliance schedule authorizing provisions.

What is EPA's position on certain public comments?

Some commenters said that the following proposed regulatory language—''authorize schedules of compliance *for water quality-based effluent limits (WQBELs)* in NPDES permits''—could have the effect of narrowing the universe of NPDES permits and permit requirements for which permitting authorities can include permit compliance schedules. The regulation does not narrow that universe, nor does it preclude other appropriate uses of permit compliance schedules as provided for in § 122.47. The new § 131.15 requirements only apply to the authorization of compliance schedules *for WQBELs* in NPDES permits. Such WQBELs are designed to meet WQS established by the state or authorized tribe and approved by EPA under CWA section 303(c).[55] Adding this new provision to the WQS regulation will ensure that the state or authorized tribe takes the necessary steps to ensure that any NPDES permit with a permit compliance schedule for a WQBEL is consistent with the state's or authorized tribe's applicable WQS. The requirement in § 131.15 does not preclude, or apply to, use of compliance schedules for permit limitations or conditions that are not WQBELs. A permitting authority can grant a permit compliance schedule for non-WQBEL NPDES permit limits or conditions without an EPA-approved authorizing provision, provided the permit compliance schedule is consistent with the CWA, EPA's permitting regulation, especially §§ 122.2 and 122.47, and any applicable state or tribal laws and regulations. Permitting authorities can include such permit compliance schedules without an EPA-approved permit compliance schedule authorizing provision because such limits and conditions are not themselves designed to implement the state's or authorized tribe's approved WQS.

G. Other Changes

What does this rule provide and why?

Regulatory provisions can only be effective if they are clear and accurate. Even spelling and grammar mistakes, and inconsistent terminology can cause confusion. This rule, therefore, corrects these types of mistakes and inconsistencies in the following 11 regulatory provisions: §§ 131.2, 131.3(h), 131.3(j), 131.5(a)(1), 131.5(a)(2), 131.10(j), 131.10(j)(2), 131.11(a)(2), 131.11(b), 131.12(a)(2), and 131.20(b). The rule finalizes eight of the provisions, as proposed. However, based on public comments, EPA revised how it is correcting §§ 131.5(a)(2), 131.12(a)(2), and 131.20(b). EPA notes that in correcting these minor pre-existing errors, it did not re-examine the substance of these regulatory provisions. Thus EPA did not reopen these regulatory provisions.

With regard to the revision at § 131.5(a)(2), the final rule adds a reference to § 131.11 and ''sound scientific rationale'' to make the link clear. Commenters expressed concern that ''sound scientific rationale'' was an ambiguous and subjective point of reference and may interfere with the ability of states and authorized tribes to use narrative criteria. By linking the two regulatory sections, this rule makes clear that this provision does not contradict the requirements and flexibilities provided in § 131.11.

This rule at § 131.12(a)(2) correctly cites to the CWA language and makes no other changes. EPA proposed revising ''assure'' to ''ensure,'' however, the final rule does not include this change. Commenters raised the question of whether the revision changed the meaning of the provision. Although both ''assure'' and ''ensure'' mean ''to make sure,'' EPA recognizes that the context surrounding the word is important. While ''ensure'' is used in § 131.10(b), in this context, the states and authorized tribes can ''make sure'' their WQS meet the regulatory requirements. However, § 131.12(a)(2), addresses water quality, not WQS. While states and authorized tribes have control over their WQS, they do not have the same control over the resulting water quality as it can be affected by many other factors. So use of the word ''ensure'' would not be appropriate in this provision.

This rule clarifies four points related to public hearings. First, it clarifies that 40 CFR part 25 is EPA's public participation regulation that sets the minimum requirements for public hearings and removes the nonexistent citation to ''EPA's water quality management regulation (40 CFR 130.3(b)(6)).'' Second, it clarifies that holding one public hearing may satisfy the legal CWA requirement although states and authorized tribes may hold multiple hearings. The purpose of this revision is to provide consistency with the language of CWA section 303(c)(1) and § 131.20(a), not to create a requirement that states and authorized tribes must hold multiple hearings when reviewing or revising WQS. Third, EPA's corresponding change in § 131.5(a)(6) clarifies that EPA's authority in acting on revised or new WQS includes determining whether the state or authorized tribe has followed the ''applicable'' legal procedures. Applicable legal procedures include those required by the CWA and EPA's implementing regulations. In particular, states and authorized tribes must comply with the requirement in § 131.20(b) to hold a public hearing in accordance with 40 CFR part 25 when reviewing or revising WQS. The purpose of the § 131.20(b) requirements is to implement the CWA and provide an opportunity for meaningful public input when states or authorized tribes develop WQS, which is an important step to ensure that adopted WQS reflect full consideration of the relevant issues raised by the public. Finally, § 131.20(b) and EPA's corresponding deletion of § 131.10(e) clarify that a public hearing is required when (1) reviewing WQS per § 131.20(a); (2) when revising WQS as a result of reviewing WQS per § 131.20(a); and (3) whenever revising WQS, regardless of whether the revision is a result of triennial review per § 131.20(a). EPA reviewed the use of the phrase ''an opportunity for a public hearing'' used in § 131.10(e) and found that such language contradicts the CWA and § 131.20(b). Therefore, EPA is deleting this provision as a conforming edit to its clarifications in § 131.20(b). As suggested by commenters, EPA replaced its proposed language of ''reviewing or revising'' to ''reviewing as well as when revising'' to make clear that public participation is required in all of these circumstances.

What is EPA's position on certain public comments?

A commenter requested that EPA further revise the regulation to allow states and authorized tribes to gather public input in formats other than public hearings (*e.g.*, public meetings, webinars). Although EPA acknowledges

[55] 40 CFR 122.44(d)(1); 122.44(d)(1)(vii)(A).

the challenges that states and authorized tribes may experience when planning and conducting a public hearing, the requirement to hold hearings for the purposes of reviewing, and as appropriate, modifying and adopting WQS comes directly from CWA section 303(c)(1). Further, meaningful involvement of the public and intergovernmental coordination with local, state, federal, and tribal entities with an interest in water quality issues is an important component of the WQS process. States and authorized tribes have discretion to use other outreach efforts in addition to fulfilling the requirement for a public hearing.

A ''public hearing'' may mean different things to different people. At a minimum, per § 131.20(b), states and authorized tribes are required to follow the provisions of state or tribal law and EPA's public participation regulations at 40 CFR part 25. EPA's public participation regulation, at 40 CFR 25.5, sets minimum requirements for states and authorized tribes to publicize a hearing at least 45 days prior to the date of the hearing; provide to the public reports, documents, and data relevant to the discussion at the public hearing at least 30 days before the hearing; hold the hearing at times and places that facilitate attendance by the public; schedule witnesses in advance to allow maximum participation and adequate time; and prepare a transcript, recording, or other complete record of the hearing proceedings. See 40 CFR 25.5 for the actual list of federal public hearing requirements. State and tribal law may include additional requirements for states and authorized tribes to meet when planning for and conducting a hearing. In addition to meeting the requirements of state and tribal law and 40 CFR part 25, states and authorized tribes may also choose to gather public input using other formats, such as public meetings and webinars.

III. Economic Impacts on State and Authorized Tribal WQS Programs

EPA evaluated the potential incremental administrative burden and cost that may be associated with the final rule, beyond the burden and cost of the WQS regulation already in place. EPA's estimate is higher than the estimate of the proposed rule for two reasons unrelated to any substantive change in requirements. First, EPA obtained more precise estimates of burden and costs. EPA received many comments suggesting that EPA underestimated the burden and cost of the proposed rule. States specifically requested to meet with EPA to provide additional information for EPA to consider. EPA engaged the states and incorporated the information provided into the final economic analysis. The higher estimate is also partly due to EPA using known data to extrapolate burden and costs to states, territories and authorized tribes where data were unavailable. EPA describes the method of extrapolation in detail in the full economic analysis available in the docket of the final rule. EPA's economic analysis focuses on the potential administrative burden and cost to all 50 states, the District of Columbia, five territories, the 40 authorized tribes with EPA-approved WQS, and to EPA. While this rule does not establish any requirements directly applicable to regulated point sources or nonpoint sources of pollution, EPA acknowledges that this rule may result in indirect costs to some regulated entities as a result of changes to WQS that states and authorized tribes adopt based on the final rule. EPA is unable to quantify indirect costs and benefits since it cannot anticipate precisely how the rule will be implemented by states and authorized tribes and because of a lack of data. States and authorized tribes always have the discretion to adopt new or revised WQS independent of this final rule that could result in costs to point sources and nonpoint sources. EPA's economic analysis and an explanation for how EPA derived the cost and burden estimates are documented in the *Economic Analysis for the Water Quality Standards Regulatory Revisions (Final Rule)* and can be found in the docket for this rule.

EPA assessed the potential incremental burden and cost of this final rule using the same basic methodology used to assess the potential incremental burden and cost of EPA's proposed rule, including: (1) Identifying the elements of the final rule that could potentially result in incremental burden and cost; (2) estimating the incremental number of labor hours states and authorized tribes may need to allocate in order to comply with those elements of the final rule; and (3) estimating the cost associated with those additional labor hours.

EPA identified four areas where differences between the proposed and final rules affected burden and cost estimates. First, when states and authorized tribes submit the results of triennial reviews to EPA, they must provide an explanation when not adopting new or revised water quality criteria for parameters for which EPA has published new or updated CWA section 304(a) criteria recommendations. Second, when developing or revising antidegradation implementation methods and when deciding which waters would receive Tier 2 antidegradation protection under a water body-by-water body approach, states and authorized tribes must provide an opportunity for public involvement. States and authorized tribes must also document and keep in the public record the factors they considered when making those decisions. Third, the final rule no longer includes a maximum WQS variance duration of 10 years and thus eliminates the burden and cost associated with renewing a WQS variance when the state or authorized tribe can justify a longer term. Fourth, the final rule requires states and authorized tribes to proactively reevaluate WQS variances that have a term longer than five years no less frequently than every five years and to submit the results of each reevaluation to EPA within 30 days of completion. EPA also revised certain economic assumptions based on additional information obtained independently by EPA and in response to stakeholder feedback.

The potential incremental burden and cost of the final rule include five categories: (1) One-time burden and cost associated with state and authorized tribal rulemaking activities when some states and authorized tribes may need to adopt new or revised provisions into their WQS (*e.g.*, review currently adopted water quality standards to determine if the new requirements necessitate revisions, such as modifying antidegradation policy, revising WQS variance procedures if the state or authorized tribe has chosen to adopt such a procedure, or adopting a permit compliance schedule authorizing provision); (2) recurring burden and cost associated with removing uses specified in CWA section 101(a)(2) because states and authorized tribes must identify the HAU; (3) recurring burden and cost associated with triennial reviews whereby states and authorized tribes must prepare and submit an explanation when not adopting new or revised water quality criteria for parameters for which EPA has published new or updated CWA section 304(a) criteria recommendations; (4) recurring burden and cost associated with antidegradation requirements, including providing the opportunity for public involvement when developing and subsequently revising antidegradation implementation methods; providing the opportunity for public involvement when deciding which waters will receive Tier 2 antidegradation protection when using a water body-by-water body approach; documenting and keeping in the public record the factors the state or authorized tribe considered when deciding which waters will receive Tier 2 antidegradation protection; and performing/evaluating more extensive and a greater number of antidegradation reviews; and (5) recurring burden and cost associated with developing and documenting WQS variances for submission to EPA, and reevaluating WQS variances with a term longer than five years no less frequently than every five years. EPA did not estimate potential cost savings associated with a provision in the final rule that a UAA is not required when removing a non-101(a)(2) use because states and authorized tribes continue to have the discretion to conduct a UAA when removing such uses.

Estimates of the potential incremental burden and cost of this final rule are summarized in the following tables.

SUMMARY OF POTENTIAL INCREMENTAL BURDEN AND COST TO STATES AND AUTHORIZED TRIBES

Provision	One-time activities			Recurring activities	
	Burden (hours)	Cost (2013$ millions)	Annualized cost (2013$ millions/ year) [1]	Burden (hours/year)	Cost (2013$ millions/ year)
Rulemaking Activities	48,000–96,000	$2.35–$4.70	$0.16–$0.32	—	—
Designated Uses	—	—	—	2,250–4,500	$0.11–$0.22
Triennial Reviews	—	—	—	4,320–21,600	0.21–1.06
Antidegradation	6,450–12,900	0.32–0.63	0.02–0.04	48,015–143,400	2.37–7.02
WQS Variances	—	—	—	51,840–233,280	2.54–11.43
National Total	54,450–108,900	2.67–5.34	0.18–0.36	106,425–402,780	5.24–19.73

'—' = not applicable

Note: Individual annual cost estimates do not add to the total because of independent rounding.

[1] Although EPA expects one-time rulemaking activity costs to be incurred over an initial three-year period, it annualized costs at a three percent discount rate over 20 years for comparative purposes. See the *Economic Analysis for the Water Quality Standards Regulatory Revisions (Final Rule)* for the potential incremental burden and cost using a seven percent discount rate.

SUMMARY OF POTENTIAL INCREMENTAL BURDEN AND COST TO EPA [1]

One-time activities				Recurring activities		
Cost to the agency (2013$ million) [2]	Annualized cost to the agency (2013$ million per year) [3]	Burden		Cost to the agency (2013$ million per year) [6]	Burden	
		Hours [4]	FTEs [5]		Hours per year [4]	FTEs per year [5]
$0.53–$1.07	$0.04–$0.07	7,080–14,150	3.4–6.8	$1.05–$3.95	13,900–52,320	6.7–25.2

[1] Assuming that the incremental burden and costs to EPA are equal to 20 percent of the burden and costs to states and authorized tribes.

[2] $0.53 million ($2.67 million ´ 20 percent) to $1.07 million ($5.34 million ´ 20 percent)

[3] Although EPA expects these one-time costs to be incurred over an initial three-year period, the costs are annualized at three percent discount rate over 20 years for comparative purposes. See the *Economic Analysis for the Water Quality Standards Regulatory Revisions (Final Rule)* for the potential incremental burden and cost using a seven percent discount rate.

[4] Total costs to the Agency divided by hourly wage rate ($75.41 per hour).

[5] Burden hours to the Agency divided by hours worked by full-time equivalent (FTE) employees per year (2,080 hours per year).

[6] $1.05 million ($5.24 million ´ 20 percent) to $3.95 million ($19.73 million ´ 20 percent).

COMBINED SUMMARY OF POTENTIAL INCREMENTAL BURDEN AND COST TO STATES, AUTHORIZED TRIBES, AND EPA

Entities	One-time activities			Recurring activities	
	Burden (hours)	Cost (2013$ millions)	Annualized cost (2013$ million/ year) [1]	Burden (hours/year)	Cost (2013$ millions/ year)
States and Authorized Tribes	54,450–108,900	$2.67–$5.34	$0.18–$0.36	106,425–402,780	$5.24–$19.73
Agency	7,080–14,150	0.53–1.07	0.04–0.07	13,900–52,320	1.05–3.95
Total	61,530–122,050	3.20–6.40	0.22–0.43	120,325–455,100	6.29–23.68

Note: Individual annual cost estimates do not add to the total because of independent rounding.

[1] Although EPA expects states and authorized tribes to incur rulemaking costs over an initial three-year period, it annualized one-time costs at a three percent discount rate over 20 years for comparative purposes. See the *Economic Analysis for the Water Quality Standards Regulatory Revisions (Final Rule)* for the potential incremental burden and cost using a seven percent discount rate.

To estimate the total annual cost of this rule which includes both one-time cost and recurring cost, EPA annualized the one-time cost over a period of 20 years. Using a 20-year annualization period and a discount rate of three percent, EPA estimates the total annual cost for this final rule to range from $6.51 million per year ($0.22 million per year + $6.29 million per year) to $24.11 million per year ($0.43 million per year + $23.68 million per year).[56]

[56] See the *Economic Analysis for the Water Quality Standards Regulatory Revisions (Final Rule)* for the potential incremental burden and cost for this final rule using a seven percent discount rate.

EPA also evaluated the potential benefits associated with this rule. States and authorized tribes will benefit from these revisions because the WQS regulation will provide clear requirements to facilitate the ability of states and authorized tribes to effectively and legally utilize available regulatory tools when implementing and managing their WQS programs. Although associated with potential administrative burden and cost in some areas, this rule has the potential to partially offset these burdens by reducing regulatory uncertainty and increasing overall program efficiency. Use of these tools to improve establishment and implementation of state and authorized tribal WQS, as discussed throughout the preamble to this rule, provides incremental improvements in water quality and a variety of economic benefits associated with these improvements, including the availability of clean, safe, and affordable drinking water sources; water of adequate quality for agricultural and industrial use; and water quality that supports the commercial fishing industry and higher property values. Nonmarket benefits of this rule include greater recreational opportunities and the protection and improvement of public health. States, authorized tribes, stakeholders and the public will also benefit from the open public dialogue that results from the additional transparency and public participation requirements included in this rule. Because states and authorized tribes implement their own WQS programs, EPA could not reliably predict the control measures likely to be implemented and subsequent improvements to water quality, and thus could not quantify the resulting benefits.

IV. Statutory and Executive Order Reviews

Additional information about these statutes and Executive Orders can be found at *http://www2.epa.gov/laws-regulations/laws-and-executive-orders*.

A. Executive Order 12866: Regulatory Planning and Review and Executive Order 13563: Improving Regulation and Regulatory Review

This action is a significant regulatory action that was submitted to the Office of Management and Budget (OMB) for review. Any changes made in response to OMB recommendations have been documented in the docket. EPA prepared an analysis of the potential costs and benefits associated with this action. This analysis, *Economic Analysis for the Water Quality Standards Regulatory Revisions (Final Rule)*, is summarized in section III of the preamble and is available in the docket.

B. Paperwork Reduction Act (PRA)

The information collection activities in this rule have been submitted for approval to OMB under the PRA. The Information Collection Request (ICR) document that EPA prepared has been assigned EPA ICR number 2449.02. You can find a copy of the ICR in the docket for this rule, and it is briefly summarized here. The information collection requirements are not enforceable until OMB approves them.

The core of the WQS regulation, established in 1983, requires EPA to collect certain information from states and authorized tribes and has an approved ICR (EPA ICR number 988.11; OMB Control number 2040–0049). This rule requires states and authorized tribes to submit certain additional information to EPA. This mandatory information collection ensures EPA has the necessary information to review WQS and approve or disapprove consistent with the rule. The goals of the rule can only be fulfilled by collecting this additional information. Due to the nature of this rule, EPA assumes that all administrative burden associated with this rule, summarized in section III, is associated with information collection.

Respondents/affected entities: The respondents affected by this collection activity include the 50 states, the District of Columbia, five territories, and 40 authorized tribes that have EPA-approved WQS. The respondents are in NAICS code 92411 ''Administration of Air and Water Resources and Solid Waste Management Programs,'' formerly SIC code #9511.

Respondent's obligation to respond: The collection is required pursuant to CWA section 303(c), as implemented by the revisions to 40 CFR part 131.

Estimated number of respondents: A total of 96 governmental entities are potentially affected by the rule.

Frequency of response: The CWA requires states and authorized tribes to review their WQS at least once every three years and submit the results to EPA. In practice, some states and authorized tribes choose to submit revised standards for portions of their waters more frequently.

Total estimated burden: EPA estimates a total annual burden of 124,575–439,080 hours and 3,176 to 5,096 responses per year. Burden is defined at 5 CFR 1320.3(b). A ''response'' is an action that a state or authorized tribe would need to take in order to meet the information collection request provided in the rule (*e.g.*, documentation supporting a WQS variance). See also the ''Information Collection Request for Water Quality Standards Regulatory Revisions (Final Rule)'' in the docket for this rule.

Total estimated cost: Total estimated annual incremental costs range from $6.13 million to $21.51 million.

An agency may not conduct or sponsor, and a person is not required to respond to, a collection of information unless it displays a currently valid OMB control number. The OMB control numbers for EPA's regulations in 40 CFR are listed in 40 CFR part 9. When OMB approves this ICR, the Agency will announce the approval in the **Federal Register** and publish a technical amendment to 40 CFR part 9 to display the OMB control number for the approved information collection activities contained in this final rule.

C. Regulatory Flexibility Act (RFA)

I certify that this action will not have a significant economic impact on a substantial number of small entities under the RFA. State and authorized tribal governments responsible for administering or overseeing water quality programs may be directly affected by this rulemaking, as states and authorized tribes may need to consider and implement new provisions, or revise existing provisions, in their WQS. Small entities, such as small businesses or small governmental jurisdictions, are not directly regulated by this rule. This rule will not impose any requirements on small entities.

D. Unfunded Mandates Reform Act (UMRA)

This rule does not contain a federal mandate that may result in expenditures of $100 million or more for state, local, and tribal governments, in the aggregate, or the private sector in any one year. EPA estimates total annual costs to states and authorized tribes to range from $5.24 million to $19.73 million per year. Thus, this rule is not subject to the requirements of sections 202 or 205 of UMRA.

This rule is also not subject to the requirements of section 203 of UMRA because it contains no regulatory requirements that might significantly or uniquely affect small governments.

E. Executive Order 13132: Federalism

This rule does not have federalism implications. It will not have substantial direct effects on the states, on the relationship between the national government and the states, or on the distribution of power and responsibilities among the various levels of government. The rule finalizes regulatory revisions to provide clarity and transparency in the WQS regulation that may require state and local officials to reevaluate or revise their WQS. However, the rule will not impose substantial direct compliance costs on state or local governments, nor will it preempt state law. Thus, Executive Order 13132 does not apply to this action.

Keeping with the spirit of Executive Order 13132 and consistent with EPA's policy to promote communications between EPA and state and local governments, EPA consulted with state and local officials early in the process and solicited their comments on the proposed action and on the development of this rule.

Between September 2013 and June 2014, EPA consulted with representatives from states and intergovernmental associations at their request, to hear their views on the proposed regulatory revisions and how commenters' suggested revisions would impact implementation of their WQS programs. Some participants expressed concern that the proposed changes may impose a resource burden on state and local governments, as well as infringe on states' flexibility in the areas included in the proposed rule. Some participants urged EPA to ensure that states with satisfactory regulations in these areas are not unduly burdened by the regulatory revisions.

F. Executive Order 13175: Consultation and Coordination With Indian Tribal Governments

This action may have tribal implications. However, it will neither impose substantial direct compliance costs on tribal governments, nor preempt tribal law. Thus, Executive Order 13175 does not apply to this action. To date, 50 Indian tribes have been approved for treatment in a manner similar to a state (TAS) for CWA sections 303 and 401. Of the 50 tribes, 40 have EPA-approved WQS in their respective jurisdictions. All of these authorized tribes are impacted by this regulation. However, this rule might affect other tribes with waters adjacent to waters with federal, state, or authorized tribal WQS.

EPA consulted and coordinated with tribal officials consistent with EPA's Policy on Consultation and Coordination with Indian Tribes early in the process of developing this regulation to allow them to provide meaningful and timely input into its development. In August 2010, November 2013, and October 2014, EPA held tribes-only consultation and coordination sessions to hear their views and answer questions of all interested tribes on the targeted areas EPA considered for regulatory revision. Tribes expressed the need for additional guidance and assistance in implementing the proposed rulemaking, specifically for development of antidegradation implementation methods and determination of the highest attainable use. EPA considered the burden to states and authorized tribes in developing this rule and, when possible, has provided direction and flexibility that allows tribes to address higher priority aspects of their WQS programs. EPA also intends to release updated guidance in a new edition of the WQS Handbook. A summary of the consultation and coordination is available in the docket for this rule.

G. Executive Order 13045: Protection of Children From Environmental Health Risks and Safety Risks

This action is not subject to Executive Order 13045, because it is not economically significant as defined in Executive Order 12866, and because the EPA does not believe the environmental health risks or safety risks addressed by this action present a disproportionate risk to children.

H. Executive Order 13211: Actions Concerning Regulations That Significantly Affect Energy Supply, Distribution, or Use

This action is not a ''significant energy action'' because it is not likely to have a significant adverse effect on the supply, distribution, or use of energy.

I. National Technology Transfer and Advancement Act

This rulemaking does not involve technical standards.

J. Executive Order 12898: Federal Actions To Address Environmental Justice in Minority Populations and Low-Income Populations

EPA has determined that this rule will not have disproportionately high and adverse human health or environmental effects on minority or low-income populations, because it does not adversely affect the level of protection provided to human health or the environment. This rule does not directly establish WQS for a state or authorized tribe and, therefore, does not directly affect a specific population or a particular geographic area(s).

K. Congressional Review Act (CRA)

This action is subject to the CRA, and EPA will submit a rule report to each House of the Congress and to the Comptroller General of the United States. This action is not a ''major rule'' as defined by 5 U.S.C. 804(2).

List of Subjects in 40 CFR Part 131

Environmental protection, Indians—lands, Intergovernmental relations, Reporting and recordkeeping requirements, Water pollution control.

Dated: August 5, 2015.

Gina McCarthy,

Administrator.

For the reasons stated in the preamble, EPA amends 40 CFR part 131 as follows:

PART 131—WATER QUALITY STANDARDS

■ 1. The authority citation for part 131 continues to read as follows:

Authority: 33 U.S.C. 1251 *et seq.*

Subpart A—General Provisions

■ 2. In § 131.2, revise the first sentence to read as follows:

§ 131.2 Purpose.

A water quality standard defines the water quality goals of a water body, or portion thereof, by designating the use or uses to be made of the water and by setting criteria that protect the designated uses. * * *

* * * * *

■ 3. In § 131.3:

■ a. Revise paragraphs (h) and (j).

■ b. Add paragraphs (m), (n), (o), (p), and (q).

The revisions and additions read as follows:

§ 131.3 Definitions.

* * * * *

(h) *Water quality limited segment* means any segment where it is known that water quality does not meet applicable water quality standards, and/or is not expected to meet applicable water quality standards, even after the application of the technology-based effluent limitations required by sections 301(b) and 306 of the Act.

* * * * *

(j) *States* include: The 50 States, the District of Columbia, Guam, the Commonwealth of Puerto Rico, Virgin Islands, American Samoa, the Commonwealth of the Northern Mariana Islands, and Indian Tribes that EPA determines to be eligible for purposes of the water quality standards program.

* * * * *

(m) *Highest attainable use* is the modified aquatic life, wildlife, or recreation use that is both closest to the uses specified in section 101(a)(2) of the

Act and attainable, based on the evaluation of the factor(s) in § 131.10(g) that preclude(s) attainment of the use and any other information or analyses that were used to evaluate attainability. There is no required highest attainable use where the State demonstrates the relevant use specified in section 101(a)(2) of the Act and sub-categories of such a use are not attainable.

(n) *Practicable*, in the context of § 131.12(a)(2)(ii), means technologically possible, able to be put into practice, and economically viable.

(o) A *water quality standards variance* (WQS variance) is a time-limited designated use and criterion for a specific pollutant(s) or water quality parameter(s) that reflect the highest attainable condition during the term of the WQS variance.

(p) *Pollutant Minimization Program*, in the context of § 131.14, is a structured set of activities to improve processes and pollutant controls that will prevent and reduce pollutant loadings.

(q) *Non-101(a)(2) use* is any use unrelated to the protection and propagation of fish, shellfish, wildlife or recreation in or on the water.

■ 4. In § 131.5:

■ a. Revise paragraphs (a)(1) and (2).

■ b. Redesignate paragraphs (a)(3) through (5) as paragraphs (a)(6) through (8).

■ c. Add paragraphs (a)(3) through (5).

■ d. Revise newly designated paragraph (a)(6).

■ e. Revise paragraph (b).

The revisions and additions read as follows:

§ 131.5 EPA authority.

(a) * * *

(1) Whether the State has adopted designated water uses that are consistent with the requirements of the Clean Water Act;

(2) Whether the State has adopted criteria that protect the designated water uses based on sound scientific rationale consistent with § 131.11;

(3) Whether the State has adopted an antidegradation policy that is consistent with § 131.12, and whether any State adopted antidegradation implementation methods are consistent with § 131.12;

(4) Whether any State adopted WQS variance is consistent with § 131.14;

(5) Whether any State adopted provision authorizing the use of schedules of compliance for water quality-based effluent limits in NPDES permits is consistent with § 131.15;

(6) Whether the State has followed applicable legal procedures for revising or adopting standards;

* * * * *

(b) If EPA determines that the State's or Tribe's water quality standards are consistent with the factors listed in paragraphs (a)(1) through (8) of this section, EPA approves the standards. EPA must disapprove the State's or Tribe's water quality standards and promulgate Federal standards under section 303(c)(4), and for Great Lakes States or Great Lakes Tribes under section 118(c)(2)(C) of the Act, if State or Tribal adopted standards are not consistent with the factors listed in paragraphs (a)(1) through (8) of this section. EPA may also promulgate a new or revised standard when necessary to meet the requirements of the Act.

* * * * *

Subpart B—Establishment of Water Quality Standards

■ 5. In § 131.10:

■ a. Revise paragraphs (a), (g) introductory text, (j), and (k).

■ b. Remove and reserve paragraph (e).

The revisions read as follows:

§ 131.10 Designation of uses.

(a) Each State must specify appropriate water uses to be achieved and protected. The classification of the waters of the State must take into consideration the use and value of water for public water supplies, protection and propagation of fish, shellfish and wildlife, recreation in and on the water, agricultural, industrial, and other purposes including navigation. If adopting new or revised designated uses other than the uses specified in section 101(a)(2) of the Act, or removing designated uses, States must submit documentation justifying how their consideration of the use and value of water for those uses listed in this paragraph appropriately supports the State's action. A use attainability analysis may be used to satisfy this requirement. In no case shall a State adopt waste transport or waste assimilation as a designated use for any waters of the United States.

* * * * *

(e) [Reserved]

* * * * *

(g) States may designate a use, or remove a use that is *not* an existing use, if the State conducts a use attainability analysis as specified in paragraph (j) of this section that demonstrates attaining the use is not feasible because of one of the six factors in this paragraph. If a State adopts a new or revised water quality standard based on a required use attainability analysis, the State shall also adopt the highest attainable use, as defined in § 131.3(m).

* * * * *

(j) A State must conduct a use attainability analysis as described in § 131.3(g), and paragraph (g) of this section, whenever:

(1) The State designates for the first time, or has previously designated for a water body, uses that do not include the uses specified in section 101(a)(2) of the Act; or

(2) The State wishes to remove a designated use that is specified in section 101(a)(2) of the Act, to remove a sub-category of such a use, or to designate a sub-category of such a use that requires criteria less stringent than previously applicable.

(k) A State is not required to conduct a use attainability analysis whenever:

(1) The State designates for the first time, or has previously designated for a water body, uses that include the uses specified in section 101(a)(2) of the Act; or

(2) The State designates a sub-category of a use specified in section 101(a)(2) of the Act that requires criteria at least as stringent as previously applicable; or

(3) The State wishes to remove or revise a designated use that is a non-101(a)(2) use. In this instance, as required by paragraph (a) of this section, the State must submit documentation justifying how its consideration of the use and value of water for those uses listed in paragraph (a) appropriately supports the State's action, which may be satisfied through a use attainability analysis.

■ 6. In § 131.11, revise paragraphs (a)(2) and (b) introductory text to read as follows:

§ 131.11 Criteria.

(a) * * *

(2) *Toxic pollutants*. States must review water quality data and information on discharges to identify specific water bodies where toxic pollutants may be adversely affecting water quality or the attainment of the designated water use or where the levels of toxic pollutants are at a level to warrant concern and must adopt criteria for such toxic pollutants applicable to the water body sufficient to protect the designated use. Where a State adopts narrative criteria for toxic pollutants to protect designated uses, the State must provide information identifying the method by which the State intends to regulate point source discharges of toxic pollutants on water quality limited segments based on such narrative criteria. Such information may be included as part of the standards or may be included in documents generated by the State in response to the Water

Quality Planning and Management Regulations (40 CFR part 130).

(b) *Form of criteria:* In establishing criteria, States should:

* * * * *

■ 7. In § 131.12:

■ a. Revise the section heading and paragraphs (a) introductory text and (a)(2).

■ b. Add paragraph (b).

The revisions and additions read as follows:

§ 131.12 Antidegradation policy and implementation methods.

(a) The State shall develop and adopt a statewide antidegradation policy. The antidegradation policy shall, at a minimum, be consistent with the following:

* * * * *

(2) Where the quality of the waters exceeds levels necessary to support the protection and propagation of fish, shellfish, and wildlife and recreation in and on the water, that quality shall be maintained and protected unless the State finds, after full satisfaction of the intergovernmental coordination and public participation provisions of the State's continuing planning process, that allowing lower water quality is necessary to accommodate important economic or social development in the area in which the waters are located. In allowing such degradation or lower water quality, the State shall assure water quality adequate to protect existing uses fully. Further, the State shall assure that there shall be achieved the highest statutory and regulatory requirements for all new and existing point sources and all cost-effective and reasonable best management practices for nonpoint source control.

(i) The State may identify waters for the protections described in paragraph (a)(2) of this section on a parameter-by-parameter basis or on a water body-by-water body basis. Where the State identifies waters for antidegradation protection on a water body-by-water body basis, the State shall provide an opportunity for public involvement in any decisions about whether the protections described in paragraph (a)(2) of this section will be afforded to a water body, and the factors considered when making those decisions. Further, the State shall not exclude a water body from the protections described in paragraph (a)(2) of this section solely because water quality does not exceed levels necessary to support all of the uses specified in section 101(a)(2) of the Act.

(ii) Before allowing any lowering of high water quality, pursuant to paragraph (a)(2) of this section, the State shall find, after an analysis of alternatives, that such a lowering is necessary to accommodate important economic or social development in the area in which the waters are located. The analysis of alternatives shall evaluate a range of practicable alternatives that would prevent or lessen the degradation associated with the proposed activity. When the analysis of alternatives identifies one or more practicable alternatives, the State shall only find that a lowering is necessary if one such alternative is selected for implementation.

* * * * *

(b) The State shall develop methods for implementing the antidegradation policy that are, at a minimum, consistent with the State's policy and with paragraph (a) of this section. The State shall provide an opportunity for public involvement during the development and any subsequent revisions of the implementation methods, and shall make the methods available to the public.

■ 8. Add § 131.14 to read as follows:

§ 131.14 Water quality standards variances.

States may adopt WQS variances, as defined in § 131.3(o). Such a WQS variance is subject to the provisions of this section and public participation requirements at § 131.20(b). A WQS variance is a water quality standard subject to EPA review and approval or disapproval.

(a) *Applicability*. (1) A WQS variance may be adopted for a permittee(s) or water body/waterbody segment(s), but only applies to the permittee(s) or water body/waterbody segment(s) specified in the WQS variance.

(2) Where a State adopts a WQS variance, the State must retain, in its standards, the underlying designated use and criterion addressed by the WQS variance, unless the State adopts and EPA approves a revision to the underlying designated use and criterion consistent with §§ 131.10 and 131.11. All other applicable standards not specifically addressed by the WQS variance remain applicable.

(3) A WQS variance, once adopted by the State and approved by EPA, shall be the applicable standard for purposes of the Act under § 131.21(d) through (e), for the following limited purposes. An approved WQS variance applies for the purposes of developing NPDES permit limits and requirements under 301(b)(1)(C), where appropriate, consistent with paragraph (a)(1) of this section. States and other certifying entities may also use an approved WQS variance when issuing certifications under section 401 of the Act.

(4) A State may not adopt WQS variances if the designated use and criterion addressed by the WQS variance can be achieved by implementing technology-based effluent limits required under sections 301(b) and 306 of the Act.

(b) *Requirements for Submission to EPA*. (1) A WQS variance must include:

(i) Identification of the pollutant(s) or water quality parameter(s), and the water body/waterbody segment(s) to which the WQS variance applies. Discharger(s)-specific WQS variances must also identify the permittee(s) subject to the WQS variance.

(ii) The requirements that apply throughout the term of the WQS variance. The requirements shall represent the highest attainable condition of the water body or waterbody segment applicable throughout the term of the WQS variance based on the documentation required in (b)(2) of this section. The requirements shall not result in any lowering of the currently attained ambient water quality, unless a WQS variance is necessary for restoration activities, consistent with paragraph (b)(2)(i)(A)(*2*) of this section. The State must specify the highest attainable condition of the water body or waterbody segment as a quantifiable expression that is one of the following:

(A) For discharger(s)-specific WQS variances:

(*1*) The highest attainable interim criterion; or

(*2*) The interim effluent condition that reflects the greatest pollutant reduction achievable; or

(*3*) If no additional feasible pollutant control technology can be identified, the interim criterion or interim effluent condition that reflects the greatest pollutant reduction achievable with the pollutant control technologies installed at the time the State adopts the WQS variance, and the adoption and implementation of a Pollutant Minimization Program.

(B) For WQS variances applicable to a water body or waterbody segment:

(*1*) The highest attainable interim use and interim criterion; or

(*2*) If no additional feasible pollutant control technology can be identified, the interim use and interim criterion that reflect the greatest pollutant reduction achievable with the pollutant control technologies installed at the time the State adopts the WQS variance, and the adoption and implementation of a Pollutant Minimization Program.

(iii) A statement providing that the requirements of the WQS variance are either the highest attainable condition identified at the time of the adoption of the WQS variance, or the highest attainable condition later identified during any reevaluation consistent with paragraph (b)(1)(v) of this section, whichever is more stringent.

(iv) The term of the WQS variance, expressed as an interval of time from the date of EPA approval or a specific date. The term of the WQS variance must only be as long as necessary to achieve the highest attainable condition and consistent with the demonstration provided in paragraph (b)(2) of this section. The State may adopt a subsequent WQS variance consistent with this section.

(v) For a WQS variance with a term greater than five years, a specified frequency to reevaluate the highest attainable condition using all existing and readily available information and a provision specifying how the State intends to obtain public input on the reevaluation. Such reevaluations must occur no less frequently than every five years after EPA approval of the WQS variance and the results of such reevaluation must be submitted to EPA within 30 days of completion of the reevaluation.

(vi) A provision that the WQS variance will no longer be the applicable water quality standard for purposes of the Act if the State does not conduct a reevaluation consistent with the frequency specified in the WQS variance or the results are not submitted to EPA as required by (b)(1)(v) of this section.

(2) The supporting documentation must include:

(i) Documentation demonstrating the need for a WQS variance.

(A) For a WQS variance to a use specified in section 101(a)(2) of the Act or a sub-category of such a use, the State must demonstrate that attaining the designated use and criterion is not feasible throughout the term of the WQS variance because:

(*1*) One of the factors listed in § 131.10(g) is met, or

(*2*) Actions necessary to facilitate lake, wetland, or stream restoration through dam removal or other significant reconfiguration activities preclude attainment of the designated use and criterion while the actions are being implemented.

(B) For a WQS variance to a non-101(a)(2) use, the State must submit documentation justifying how its consideration of the use and value of the water for those uses listed in § 131.10(a) appropriately supports the WQS variance and term. A demonstration consistent with paragraph (b)(2)(i)(A) of this section may be used to satisfy this requirement.

(ii) Documentation demonstrating that the term of the WQS variance is only as long as necessary to achieve the highest attainable condition. Such documentation must justify the term of the WQS variance by describing the pollutant control activities to achieve the highest attainable condition, including those activities identified through a Pollutant Minimization Program, which serve as milestones for the WQS variance.

(iii) In addition to paragraphs (b)(2)(i) and (ii) of this section, for a WQS variance that applies to a water body or waterbody segment:

(A) Identification and documentation of any cost-effective and reasonable best management practices for nonpoint source controls related to the pollutant(s) or water quality parameter(s) and water body or waterbody segment(s) specified in the WQS variance that could be implemented to make progress towards attaining the underlying designated use and criterion. A State must provide public notice and comment for any such documentation.

(B) Any subsequent WQS variance for a water body or waterbody segment must include documentation of whether and to what extent best management practices for nonpoint source controls were implemented to address the pollutant(s) or water quality parameter(s) subject to the WQS variance and the water quality progress achieved.

(c) *Implementing WQS variances in NPDES permits.* A WQS variance serves as the applicable water quality standard for implementing NPDES permitting requirements pursuant to § 122.44(d) of this chapter for the term of the WQS variance. Any limitations and requirements necessary to implement the WQS variance shall be included as enforceable conditions of the NPDES permit for the permittee(s) subject to the WQS variance.

■ 9. Add § 131.15 to read as follows:

§ 131.15 Authorizing the use of schedules of compliance for water quality-based effluent limits in NPDES permits.

If a State intends to authorize the use of schedules of compliance for water quality-based effluent limits in NPDES permits, the State must adopt a permit compliance schedule authorizing provision. Such authorizing provision is a water quality standard subject to EPA review and approval under section 303 of the Act and must be consistent with sections 502(17) and 301(b)(1)(C) of the Act.

Subpart C—Procedures for Review and Revision of Water Quality Standards

■ 10. In § 131.20, revise paragraphs (a) and (b) to read as follows:

§ 131.20 State review and revision of water quality standards.

(a) *State review.* The State shall from time to time, but at least once every 3 years, hold public hearings for the purpose of reviewing applicable water quality standards adopted pursuant to §§ 131.10 through 131.15 and Federally promulgated water quality standards and, as appropriate, modifying and adopting standards. The State shall also re-examine any waterbody segment with water quality standards that do not include the uses specified in section 101(a)(2) of the Act every 3 years to determine if any new information has become available. If such new information indicates that the uses specified in section 101(a)(2) of the Act are attainable, the State shall revise its standards accordingly. Procedures States establish for identifying and reviewing water bodies for review should be incorporated into their Continuing Planning Process. In addition, if a State does not adopt new or revised criteria for parameters for which EPA has published new or updated CWA section 304(a) criteria recommendations, then the State shall provide an explanation when it submits the results of its triennial review to the Regional Administrator consistent with CWA section 303(c)(1) and the requirements of paragraph (c) of this section.

(b) *Public participation.* The State shall hold one or more public hearings for the purpose of reviewing water quality standards as well as when revising water quality standards, in accordance with provisions of State law and EPA's public participation regulation (40 CFR part 25). The proposed water quality standards revision and supporting analyses shall be made available to the public prior to the hearing.

* * * * *

■ 11. In § 131.22, revise paragraph (b) to read as follows:

§ 131.22 EPA promulgation of water quality standards.

* * * * *

(b) The Administrator may also propose and promulgate a regulation, applicable to one or more navigable waters, setting forth a new or revised standard upon determining such a standard is necessary to meet the requirements of the Act. To constitute an Administrator's determination that a new or revised standard is necessary to meet the requirements of the Act, such determination must:

(1) Be signed by the Administrator or his or her duly authorized delegate, and

(2) Contain a statement that the document constitutes an Administrator's determination under section 303(c)(4)(B) of the Act.

* * * * *

Subpart D—Federally Promulgated Water Quality Standards

■ 12. In § 131.34, revise paragraph (c) to read as follows:

§ 131.34 Kansas.

* * * * *

(c) *Water quality standard variances.* The Regional Administrator, EPA Region 7, is authorized to grant variances from the water quality standards in paragraphs (a) and (b) of this section where the requirements of § 131.14 are met.

■ 13. In § 131.40, revise paragraph (c) to read as follows:

§ 131.40 Puerto Rico.

* * * * *

(c) *Water quality standard variances.* The Regional Administrator, EPA Region 2, is authorized to grant variances from the water quality standards in paragraphs (a) and (b) of this section where the requirements of § 131.14 are met.

[FR Doc. 2015–19821 Filed 8–20–15; 8:45 am]
BILLING CODE 6560–50–P

3745-1-12 **Sandusky river drainage basin.**

(A) The water bodies listed in table 12-1 of this rule are ordered from downstream to upstream. Tributaries of a water body are indented. The aquatic life habitat, water supply and recreation use designations are defined in rule 3745-1-07 of the Administrative Code. The state resource water use designation is defined in rule 3745-1-05 of the Administrative Code. The most stringent criteria associated with any one of the use designations assigned to a water body will apply to that water body.

(B) Figure 1 of the appendix to this rule is a generalized map of the Sandusky river drainage basin. A generalized map of Ohio outlining the twenty-three major drainage basins and listing associated rule numbers in ~~Chapter 3745-1 of the Administrative Code~~this chapter is in figure 1 of the appendix to rule 3745-1-08 of the Administrative Code.

(C) RM, as used in this rule, stands for river mile and refers to the method used by the Ohio environmental protection agency to identify locations along a water body. Mileage is defined as the lineal distance from the downstream terminus (i.e., mouth) and moving in an upstream direction.

(D) The following symbols are used throughout this rule:

* Designated use based on the 1978 water quality standards~~;~~.

\+ Designated use based on the results of a biological field assessment performed by the Ohio environmental protection agency~~;~~.

o Designated use based on justification other than the results of a biological field assessment performed by the Ohio environmental protection agency~~; and~~.

~~L An L in the warmwater habitat column signifies that the water body segment is designated limited warmwater habitat.~~

Table 12-1. Use designations for water bodies in the Sandusky river drainage basin.

Water Body Segment	Use Designations													Comments
		Aquatic Life Habitat						Water Suppl			Recreation			
	SRW	WWH	EWH	MWH	SSH	CWH	LRW	PWS	AWS	IWS	BW	PCR	SCR	
| | | | | | | |														
Muddy creek		+							+	+		+		
Little Muddy creek		+							+	+		+		
Fishing creek		+							+	+		+		
Gries ditch		+							+	+			+	
North		+							*	*		*		
branch		+							*	*		*		
South branch		+						o	+	+		+		PWS intakes - Fremont (RM 18.02), Tiffin (RM 41.08), Upper Sandusky (RMs 82.9 and 83.15), and Bucyrus (RM 115.45)
Sandusky river - at RMs 18.02, 41.08, 82.9, 83.15 and 115.45														
		~~+~~							~~+~~	~~+~~		~~+~~		
~~- upstream Roger Young memorial park (RM 16.8) to Muskellunge creek (RM 9.37)~~		~~+~~							~~+~~	~~+~~		~~+~~		
~~- Ella st. dam (RM 42.1) to RM 19.0 (upstream from Fremont)~~				+					+	+		+		ECBP ecoregion - impounded
- RM 45.0 to Ella st. dam (RM 42.1)		~~+~~							~~+~~	~~+~~		~~+~~		
~~- headwaters to RM 45.0~~		*~~+~~							*~~+~~	*~~+~~		*~~+~~		
- all other		*							*	*		*		
segments Yellow slough						+			+	+		+		Native fauna
Green creek - confluence with Beaver creek (RM 20.4) to st. rte. 20 (RM 10.1)		+							+	+		+		
- all other segments		*							*	*		*		

Table 12-1. Use designations for water bodies in the Sandusky river drainage basin.

Water Body Segment	Use Designations													Comments
		Aquatic Life Habitat						Water Suppl			Recreation			
	SRW	WWH	EWH	MWH	SSH	CWH	LRW	PWS	AWS	IWS	BW	PCR	SCR	
Beaver creek - at RM2.88		+						o	+	+		+		PWS intake - Clyde
- all other segments		+							+	+		+		
Owl creek		*							*	*		*		
Emerson creek		+							+	+		+		
Royer ditch		+							+	+		+		
Westerhouse ditch		+							+	+		+		
Albright ditch		*							*	*		*		
Noel ditch		*							*	*		*		
Bark creek		+							+	+		+		
Muskellunge		+							+	+		+		
creek Indian creek		*							*	*		*		
Wolf creek		*							*	*		*		
East branch		*							*	*		*		
Snuff creek		*							*	*		*		
East branch		*							*	*		*		
Middle branch		*							*	*		*		
John Smith ditch (East branch Wolf cr. RM 20.37)							+		*	*			+	Small drainageway maintenance
Michael Gruss ditch (John Smith ditch RM 3.97)							+		*	*			+	Small drainageway maintenance.

Table 12-1. Use designations for water bodies in the Sandusky river drainage basin.

Water Body Segment	Use Designations													Comments
		Aquatic Life Habitat						Water Suppl			Recreation			
	SRW	WWH	EWH	MWH	SSH	CWH	LRW	PWS	AWS	IWS	BW	PCR	SCR	
| | | | | | | |														
Sugar creek		*							*	*		*		
Spicer creek		*							*	*		*		
Morrison creek – headwaters to CR 43 (RM 7.9)		*		+					*+	*+		*		ECBP ecoregion – channel modification
- CR 43 (RM 7.9) to the mouth		+							+	+		*		
Willow creek		*		+					*+	*+		*+		ECBP ecoregion – channel modification
Unnamed tributary (Willow creek RM 0.88)							o						o	Small drainageway maintenance.
Rock creek		+							+	+		+		
East branch		*+							*+	*+		*+		
Armstrong & Beighly ditch		*							*	*		*		
Carpenter ditch		*							*	*		*		
Gibson creek		*+							*+	*+		*+		
Bells run		*+							*+	*+		*+		
Honey creek – headwaters to Scott road (RM 37.3)		+							+	+		+		
- Scott road (RM 37.3) to State Route 4 (RM 28.35)				+					+	+		+		ECBP ecoregion – channel modification
~~Honey creek -~~ at RM 28.35		*+						o	*+	*+		*+		PWS intake - Attica
- State Route 4 (RM 28.35) to co. rte. 19 (RM 1.1)		+							+	+		+		
- co. rte. 19 (RM 1.1) to the mouth				+					+	+		+		~~HELP~~ECBP ecoregion - impounded
~~- all other segments~~		*							*	*		*		

Table 12-1. Use designations for water bodies in the Sandusky river drainage basin.

Water Body Segment	Use Designations	Aquatic Life Habitat						Water Suppl			Recreation			Comments
	SRW	WWH	EWH	MWH	SSH	CWH	LRW	PWS	AWS	IWS	BW	PCR	SCR	
Van Meter creek (Honey creek RM 3.69) – headwaters to Infirmary road (RM 1.7)				+					+	+		+		ECBP ecoregion – channel modification
- Infirmary road (RM 1.7) to the mouth		*							*	*		*		
Buckeye creek		+							+	+		+		
Silver creek – headwaters to Brillhart road (RM 8.7)		*					+		*+	*+		*		Small drainageway maintenance
- Brillhart road (RM 8.7) to the mouth		+							+	+		*		
Slee ditch (Silver creek RM 0.72)		+							+	+		+		
~~Eicholtz~~Aicholtz ditch – headwaters to CR 12 (RM 2.8)		*		+					*+	*+		*+		ECBP ecoregion – channel modification
- CR 12 (RM 2.8) to the mouth		+							+	+		+		
Kagy ditch		*							*	*		*		
Bolinger ditch		*							*	*		*		
Hedden ditch		*							*	*		*		
Hooper ditch		*							*	*		*		
Schaaf ditch		*							*	*		*		
Brokenknife creek – headwaters to Seneca/Crawford co. line (RM 3.2)		*		+					*+	*+		*+		ECBP Ecoregion – channel modification
- Seneca/Crawford co. line (RM 3.2) to the mouth		+							+	+		+		
Kibler ditch (Brokenknife creek RM 5.27)							+		*	*			+	Small drainageway maintenance
Unnamed tributary (Brokenknife creek RM 5.50) - at RM 2.15								o						PWS intake - New Washington
Mile run		+							+	+		+		

Table 12-1. Use designations for water bodies in the Sandusky river drainage basin.

Water Body Segment	Use Designations													Comments
		Aquatic Life Habitat						Water Suppl			Recreation			
	SRW	WWH	EWH	MWH	SSH	CWH	LRW	PWS	AWS	IWS	BW	PCR	SCR	
Sycamore creek – headwaters to state route 19 (RM 17.8)		+		+					+	+		+		ECBP ecoregion – channel modification
- State route 19 (RM 17.8) to the mouth		+							+	+		+		
Greasy run		*+							*+	*+		*+		
Spring creek (Sycamore creeek RM 12.92)		+							+	+		+		
Taylor run		*+							*+	*+		*+		
West branch (Taylor run RM 2.49)				+					+	+		+		ECBP ecoregion – channel modification
Thorn run		*+							*+	*+		*+		
Tymochtee creek – headwaters to Cramer road (RM 51.8)		+					+		+	+		+		Small drainageway maintenance
- Cramer road (RM 51.8) to the mouth		+							+	+		+		
Spring run		*+							*+	*+		*+		
Poverty run		+							+	+		+		
No. 32 ditch		*+							*+	*+		*+		
Little Tymochtee creek – headwaters to CR 108 (RM 9.1)		*					+		*+	*+		*		Small drainageway maintenance
- CR 108 (RM 9.1) to the mouth		+							+	+		*		
Hart ditch		*							*	*		*		
Browns run		*							*	*		*		
Veith ditch		*							*	*		*		
Lick run		*+							*+	*+		*+		

Table 12-1. Use designations for water bodies in the Sandusky river drainage basin.

Water Body Segment	Use Designations													Comments
		Aquatic Life Habitat						Water Suppl			Recreation			
	SRW	WWH	EWH	MWH	SSH	CWH	LRW	PWS	AWS	IWS	BW	PCR	SCR	
Baughman run		*							*	*		*		
Blake ditch		*							*	*		*		
Perkins run		*							*	*		*		
Oak run Sugar		*							*	*		*		
run		*+							*+	*+		*+		
Warpole creek		*		+					*+	*+		*+		ECBP ecoregion – channel modification
St. James run		*							*	*		*		
Unnamed tributary (Tymochtee creek RM 40.30)				+					+	+			+	HELP ecoregion - channel modification.
Little Tymochtee creek – headwaters to CR 205 (RM 8.63)		*		+					*+	*+		*+		ECBP ecoregion – channel modification
- CR 205 (RM 8.63) to the mouth		+							+	+		+		
Reevhorn run		*							*	*		*		
Pawpaw run		*							*	*		*		
Pawpaw run		+							+	+		+		
Unnamed tributary (Pawpaw run RM 4.17)				+					+	+			+	HELP ecoregion - channel modification.
Carroll ditch				+					+	+			+	HELP ecoregion - channel modification.
Enoch creek		+							+	+		+		
Blood run		+							+	+		+		
Prairie run		+							+	+		+		

Table 12-1. Use designations for water bodies in the Sandusky river drainage basin.

Water Body Segment	Use Designations	Aquatic Life Habitat						Water Suppl			Recreation			Comments
	SRW	WWH	EWH	MWH	SSH	CWH	LRW	PWS	AWS	IWS	BW	PCR	SCR	
Thompson ditch				+					+	+			+	HELP ecoregion - channel modification.
Layton ditch		*+							*+	*+		*+		
Sugar run		+							+	+		+		
Negro run		+							+	+		+		
Spring branch		+							+	+		+		
Kiser run		*							*	*		*		
Porcupine creek		*							*	*		*		
Cranberry run		*							*	*		*		
Rock run		+							+	+		+		
Little Sandusky river		+							+	+		+		
Honey run		*+							*+	*+		*+		
Unnamed tributary (little Sandusky river RM 8.93)				+					+	+			+	HELP ecoregion - channel modification.
Broken Sword creek		+							+	+		+		
Indian run – headwaters to state route 231 (RM 1.7)		*		+					*+	*+		*+		ECBP ecoregion – channel modification
- State route 231 (RM 1.7) to the mouth		+							+	+		+		
Brandywine creek – headwaters to Temple road (RM 1.6)		*					+		*+	*+		*		Small drainageway maintenance
- Temple road (RM 1.6) to the mouth		*							+	+		+		
Unnamed tributary (Broken Sword creek RM 28.04)		+							+	+		+		

Table 12-1. Use designations for water bodies in the Sandusky river drainage basin.

Water Body Segment	Use Designations													Comments
		Aquatic Life Habitat						Water Suppl			Recreation			
	SRW	WWH	EWH	MWH	SSH	CWH	LRW	PWS	AWS	IWS	BW	PCR	SCR	
| | | | | | | |														
Red run		*_					+		*+	*+		*		Small drainageway maintenance
Grass run – headwaters to Marion Melmore road (RM 6.0)		*_		+					*+	*+		*+		ECBP ecoregion – channel modification
- Marion Melmore road (RM 6.0) to the mouth		+							+	+		+		
Gray Eye run		+							+	+		+		
West north Robinson run (Sandusky river RM 121.19)		+							+	+		+		
East north Robinson run (Sandusky river RM 122.09)		+							+	+		+		
Loss creek		+							+	+		+		
South fork		+							+	+		+		
Paramour creek		+							+	+		+		
~~Crestline STP tributary (~~Westerly creek ~~/~~(Paramour creek RM 1.92)		*+							*+	*+		*+		
East Crestline tributary (~~West Crestline tributary /~~ Paramour creek RM 2.88)		*+							*+	*+		*+		
PPG tributary (Paramour creek RM 5.13)		+							+	+			+	
Allen run		+							+	+		+		
South creek		+							+	+		+		
Raccoon creek - at RM 13.1		+						+	+	+		+		PWS intake - Clyde (formerly)
- all other segments		+							+	+		+		
Little Raccoon creek		+							+	+			+	

Table 12-1. Use designations for water bodies in the Sandusky river drainage basin.

Water Body Segment	Use Designations													Comments
		Aquatic Life Habitat						Water Suppl			Recreation			
	SRW	WWH	EWH	MWH	SSH	CWH	LRW	PWS	AWS	IWS	BW	PCR	SCR	
Buck creek		+							+	+		+		
Pickerel creek		+							+	+		+		
Strong		*							*	*		*		
creek Fuller		*							*	*		*		
creek						+			+	+		+		Inland trout stream
Little Pickerel creek						+			+	+		+		Inland trout stream
Cold creek - Blue Hole (RM 4.28) to confluence with Lake Erie		*							*	*		*		
- all other segments						*			*	*		*		
Cold creek tributaries downstream of Blue Hole		+							+	+		+		
Mills creek		+							+	+		+		
Caswell ditch (Mills creek RM 3.95)				+				o	+	+			+	HELP ecoregion - channel modification; PWS intakes - Bellevue.
Snyders ditch - at RMs 5.0 and 5.5				+					+	+			+	HELP ecoregion - channel modification.
- all other segments		+							+	+		+		
Pipe creek		*							*	*		*		
Plum brook		+							+	+		+		

SRW = state resource water; WWH = warmwater habitat; EWH = exceptional warmwater habitat; MWH = modified warmwater habitat; SSH = seasonal salmonid habitat; CWH = coldwater habitat; LRW = limited resource water; PWS = public water supply; AWS = agricultural water supply; IWS = industrial water supply; BW = bathing water; PCR = primary contact recreation; SCR = secondary contact recreation.

Effective:

Five Year Review (FYR) Dates: 11/29/2016

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Certification

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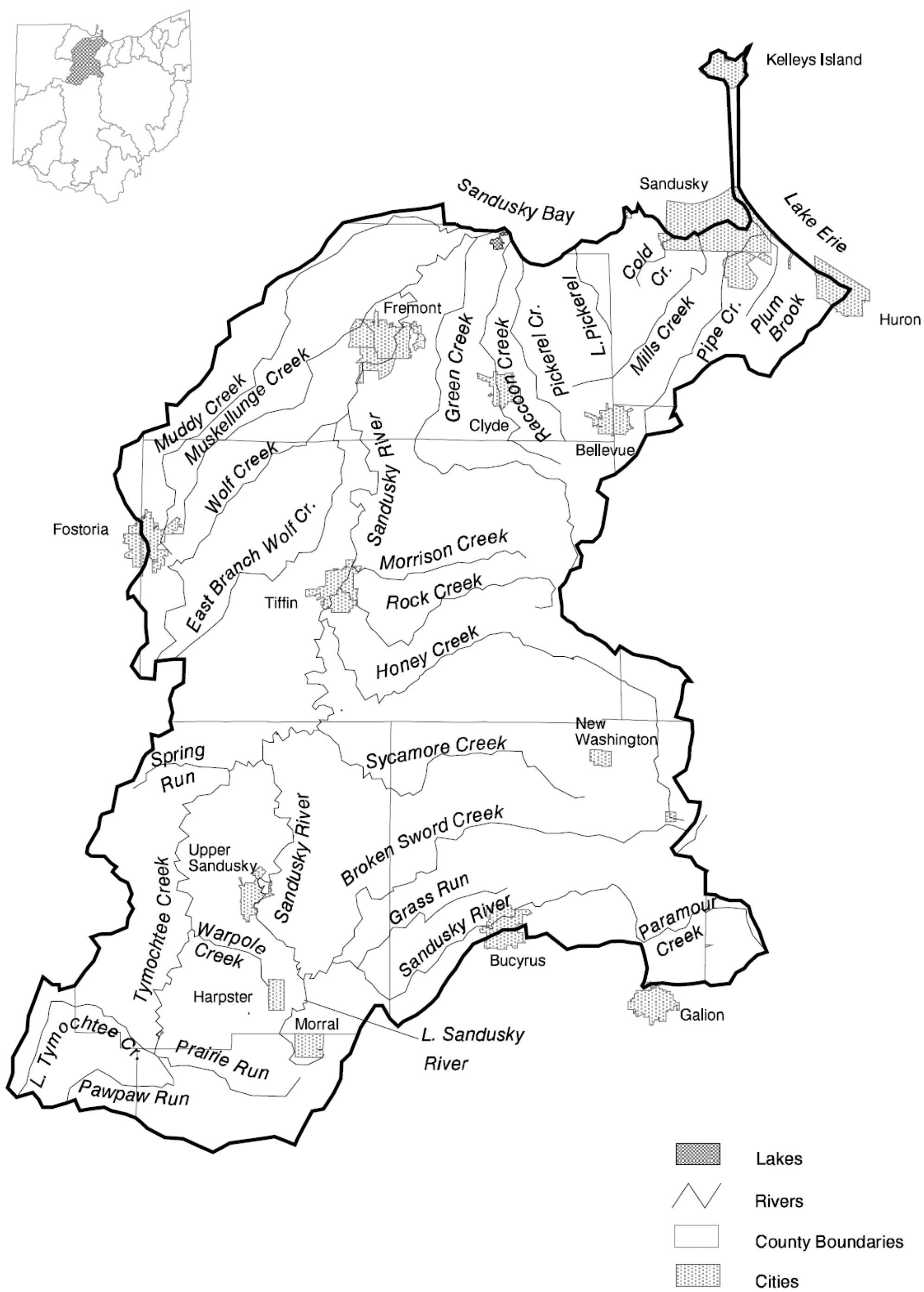
Date

Promulgated Under:	119.03
Statutory Authority:	6111.041
Rule Amplifies:	6111.041
Prior Effective Dates:	4/4/1985, 8/19/1985, 7/28/1986, 4/21/1992, 4/26/1997, 7/31/1998, 7/21/2002, 4/1/2007, 6/16/2011

Appendix

Figure 1. Sandusky river drainage basin.



Attachment 10

List of minor errors in the Tiered Aquatic Life Uses Statement of Need and Reasonableness (December 15, 2016)

March 17, 2017

The following is a list of minor errors in the Tiered Aquatic Life Uses (TALU) Statement of Need and Reasonableness (SONAR) (December 15, 2016) published at the start of the public comment period on December 19, 2016. All corrections are minor and do not impact the conclusions in the SONAR. These corrections will be introduced into the rulemaking record as part of the response to comments on March 17, 2017.

p. 43: change “Draft” to “Proposed”
p. 82: change “30” to “29” (2 occurrences)
p. 85: change “1) Municipal Separate Storm Sewer System (MS4) cities;” to “1) stormwater;”
p. 85: change “MS4 cities” to “Stormwater Permits”
p. 85: change “MS4” to “stormwater”
p. 85: change “MS4 NPDES/SDS city discharger” to “stormwater permittee”
p. 85: change “30” to “29”
p. 90: change “MS4 cities” to “stormwater”
p. Appendix 4: change “Ridgley” to “Ridgely”
pp. Appendix 10 to Appendix 83: Change all 112 instances of “40 CFR § 131.10(g)(3)” to “40 CFR § 131.10(g)(4)”
p. Appendix 56: change “Ridgley” to “Ridgely”
p. Appendix 68: change “Ridgley” to “Ridgely” (2 occurrences)
p. Appendix 69: change “Ridgley” to “Ridgely”

Division of Surface Water
November 2016

Proposed Rules – Beneficial Use Designations

Water Quality Standards Use Designations (OAC Chapter 3745-1)

What does OAC Chapter 3745-1 cover?

Ohio Administrative Code (OAC) Chapter 3745-1 contains Ohio's standards for water quality. Water quality standards are state regulations or rules that protect lakes, rivers, streams and other surface water bodies from pollution. These rules contain: beneficial use designations such as warmwater aquatic life habitat, public water supply and primary contact recreation; numeric levels and narrative statements (water quality criteria) protective of the beneficial use designations; and procedures for applying the water quality criteria to wastewater discharges. This rulemaking involves water body beneficial use designations.

What are beneficial use designations?

A goal of the Clean Water Act is to achieve fishable and swimmable conditions in water bodies, wherever attainable. The fishable and swimmable goals equate to the warmwater habitat (WWH) and primary contact recreation (PCR) use designations in Chapter 3745-1 of the OAC. The use designations are defined in rule 3745-1-07 of the OAC and are briefly discussed below. The water quality criteria and values protective of the designated uses are found within Chapter 3745-1 of the OAC.

Beneficial use designations are the water quality goals for lakes, rivers, streams and other water bodies. Designations include such uses as aquatic life habitats (warmwater, coldwater, etc.), recreation (bathing waters, primary contact, secondary contact) and water supplies (public, agricultural, industrial).

Beneficial use designations are assigned to specific water bodies in Chapter 3745-1 of the OAC. Each of the 23 major drainage basins or watersheds in the state is assigned a rule in Chapter 3745-1. Specific water quality criteria are associated with each beneficial use and are the minimum specific target conditions to be maintained in the water bodies. Together the uses and criteria may be the basis for permit limits in wastewater discharge permits and conditions in Section 401 water quality certifications. Changes to designated uses are adopted as water quality standard rule revisions.

Which water quality standards rules are under review at this time?

This rulemaking includes review of beneficial use designation rules for the Maumee River (3745-1-11), Sandusky River (3745-1-12), Great Miami River (3745-1-21), Portage River (3745-1-23), and Muskingum (3745-1-24) watersheds.

Will use designation changes made in watersheds in the Western Lake Erie basin affect efforts to reduce nutrient pollution?

No. The narrative water quality criteria that are the basis of any regulatory actions (NPDES permits, TMDLS) are not part of this rulemaking and those criteria apply to all waters regardless of the assigned use designation in the rules currently under review.

What changes are being proposed?

State law and the federal Clean Water Act require Ohio EPA to periodically update rules to reflect the latest scientific information. The Agency has evaluated information regarding beneficial use designations for the five drainage basins listed above. Three broad types of changes are being proposed:

1) Changing beneficial use designations for specific water bodies;
2) Adding water bodies that are currently undesignated to the rules; and
3) Verifying existing beneficial use designations already listed in the rules.

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Changes, additions and verifications of existing beneficial use designations are based upon the findings of biological, habitat, and water quality surveys. Other available pertinent information is also consulted, including information and comments from interested persons. The paragraphs below explain the changes in more detail.

Aquatic Life Use Designation Changes

The current aquatic life habitat use designations for 145 stream segments are proposed for revision. Some of the revisions are highlighted below. The proposed revisions are summarized by drainage basin in Table 1, while specific details are listed in Table 2. Supporting documents containing data and information to support the proposed revisions are available on the Division of Surface Water web page at: ***epa.ohio.gov/dsw/dswrules.aspx#120473215-proposed-rules***.

- Twenty-five waterbodies within the lower Muskingum River drainage basin and four water body segments of tributaries within the Great Miami River basin currently designated Exceptional Warmwater Habitat (EWH) are proposed to be redesignated WWH based on the biological assessment that was conducted revealing the presence of a WWH community. Most of these water bodies were designated EWH as part of the original designations assigned to water bodies in the State, before the development of Ohio's biological assessment program and biological criteria. While the vast majority of original designations made in the 1970s and early 1980s was for the WWH use designation, a number of streams were assigned either the EWH or the Coldwater Habitat (CWH) designation. The reassignment of the aquatic life habitat use designation to these water bodies, while at first glance may appear to be a "downgrade" actually represents the first scientific assessment of these streams. Most of these streams are small and located in the sparsely populated rural hills of southeastern Ohio.
- Thirteen water bodies currently designated WWH were found to fully attain the EWH biocriteria and thus are proposed to be redesignated the EWH aquatic life habitat use designation.
- Eight water bodies currently designated WWH are proposed for redesignation to CWH. Surveys of the biological communities within these streams demonstrated the presence of both cold water adapted fish and benthic macroinvertebrates. In addition, twelve water bodies currently designated EWH are proposed to be redesignated from EWH to CWH because while these streams did not attain the EWH biocriteria, they were found to possess coldwater adapted fish and macroinvertebrates. Five water bodies currently designated EWH were found to fully attain the EWH biocriteria, thus affirming the EWH designation and are also proposed to be designated CWH due to the presence of both coldwater fish and macroinvertebrates.
- Forty-seven water bodies currently designated WWH are proposed to be redesignated Modified Warmwater Habitat (MWH). Most of these water bodies (41) are located in northwest Ohio and are heavily channelized to maintain drainage to accommodate row crop agriculture and as a result, the habitat quality is insufficient to support a WWH biological community. These water bodies lack functional pools and riffles, have minimal to no riparian corridors, have poor substrate quality, and lack stream energy (flow) due to very low gradient. In addition, one water body and portions of four additional water bodies within the Sandusky River drainage basin currently designated WWH are under proposed to be redesignated Limited Resource Water (LRW) due to degraded habitat conditions associated with small drainageway maintenance activities. Biological surveys of these streams/stream segments had not previously been conducted.
- A 20.4 mile stretch of the Auglaize River is proposed for redesignation to MWH-I (impounded) to account for the riverine impoundment resulting from the Defiance Power Dam located at river mile 5.8 on the Auglaize River in Defiance County. While previously considered an inland reservoir, resumption of power generation at the EGS facility at the dam has reduced reservoir retention time considerably such that this stretch of the river ecologically functions as an impounded stream rather than a run-of-river reservoir. The free-flowing conditions in the rest of the river support a WWH community. Small segments of two other water bodies are also proposed to be redesignated from WWH to MWH due to impounded conditions.
- Nineteen water bodies currently designated Limited Warmwater Habitat (LWH) are proposed for redesignation to WWH. Biological assessments of these water bodies were conducted for the first time and found to support or have the potential to fully support the WWH designation. Biological assessments conducted of five additional water bodies currently designated LWH were found not to support, or have the potential to support, the WWH use due to pervasive impacts associated with historic coal mining. These five streams are proposed to be designated MWH use (mine affected) or limited resource water (acid mine drainage).

Proposed Rules – Beneficial Use Designations
November 2016

Recreational Use Designation Changes

Most water bodies in the state are designated Primary Contact Recreation (PCR), defined as suitable for full-body contact recreation. The PCR designation represents the "swimmable" goals of the Clean Water Act. Some water bodies are designated Secondary Contact Recreation (SCR), defined as suitable for partial body contact. The determination of whether a water body should be designated PCR or SCR is based on a suite of factors such as the size of the water body, accessibility, and potential for use by children. The only numeric water quality criteria applicable to the recreational use designations are for *E. coli* bacteria.

As part of the 5-year basin biological survey cycle, Ohio EPA field staff occasionally sample streams that are in fact too small and too isolated to support the PCR use. In these cases, a recommendation is made to redesignate the water body SCR to reflect the recreational potential based upon field observations and data gathered during the stream survey.

In this rulemaking, forty-eight currently undesignated water bodies are proposed for PCR based upon field observations of the water body and consideration of the factors mentioned above. There are no water bodies proposed to be designated SCR.

Designations Specifically Assigned for the First Time

Only about one-third of surface water bodies in the state are listed in the water quality standards rules. Those water bodies that are not listed are generally small, unnamed tributaries. As these unlisted water bodies are surveyed and appropriate use designations are determined, they are added to the rules.

With the exception of the biological criteria, the water quality criteria applicable to water bodies that are not specifically listed in the rules are the same as those criteria associated with the WWH use designation.

Twenty-eight currently undesignated water body segments are proposed to be designated WWH, and seven currently undesignated water bodies are proposed to be designated EWH (four of these would also carry the CWH designation). The specific designation of these water bodies will result in use-specific chemical criteria and biological criteria.

Eleven undesignated water bodies located within the Maumee and Sandusky watershed are proposed to be designated MWH as a result of extensive habitat modification resulting from agricultural drainage maintenance, the continuation of which precludes attainment of the WWH goals. The designation of MWH will result in less stringent biological criteria and less stringent chemical criteria for ammonia and dissolved oxygen.

All forty-six of the water body segments proposed to be designated an aquatic life use for the first time, as described above, are also proposed to be designated PCR. The recreational water quality criteria applicable to water bodies that are not specifically listed in rules are the same as those criteria associated with the PCR use designation.

The Agricultural Water Supply (AWS) and Industrial Water Supply (IWS) use designations are also proposed for the forty-six water bodies that are proposed to be designated an aquatic life use for the first time as described above.

The AWS use designation is for the prevention of adverse effects occurring from use of surface waters to irrigate crops or to water livestock. There are AWS water quality criteria for fourteen chemicals, mostly heavy metals. The designation of water bodies as AWS will result in the application of those water quality criteria.

A modification to the AWS designation that currently applies to the lower 4.15 miles of Dicks Creek in Middletown is proposed. This modification is based upon a ***study and information*** provided by the AK Steel Corporation documenting that this segment of the stream is not currently used for livestock watering and has not been subject to this use since at least 1975. This revision would result in a change to the applicable fluoride criterion from 2 mg/l to 15 mg/l, which remains protective of the irrigation component of the AWS designation that will be maintained. In addition, numeric chemical criteria to protect aquatic life, human health and recreational uses will be maintained.

The IWS use designation is for the protection against adverse effects of the water on industrial processes. There are no specific IWS water quality criteria. Therefore, the designation of water bodies as IWS will not result in any changes to applicable water quality criteria.

Verification of Existing Use Designations

Proposed Rules – Beneficial Use Designations November 2016

As part of the stream survey process, the use designations identified in the water quality standards rules for many water bodies are verified to be correct. In this rulemaking, verifications of existing designated uses (typically WWH, AWS, IWS and PCR uses) are proposed for 291 water bodies. For these water bodies, the symbols identifying the use designations in the water quality standards rules will change from asterisks to plus signs to indicate that they are based on the results of stream surveys.

A list of stream designations proposed for verification is in Table 3 at the end of this fact sheet. Verifying stream designations does not result in any changes to applicable water quality criteria.

Where does the new information come from?

The new information supporting the changes being proposed comes from water body surveys. Ohio EPA has an ongoing 5-year basin monitoring schedule that rotates monitoring efforts across the state. The monitoring program consists of surveying the chemical, physical and biological characteristics of selected water bodies throughout the state each year, following the 5-year basin cycle. The purposes of these surveys include determining the present health and uses of the water bodies and predicting the potential health and uses of the water bodies if additional pollution controls were imposed. These proposed rule revisions, incorporating the results of a water body surveys conducted in the past several years, reflect the Agency's responsibility to assign beneficial water uses.

Although the Agency has used the water body survey approach to determine applicable use designations for over 25 years, many water bodies have still not been surveyed.

In the 1978 water quality standards rules, only a small number of water bodies were listed with their use designations, determined from information available at the time. All other surface water bodies were assigned the WWH and PCR use designations by default (consistent with baseline goals of the Clean Water Act).

The 1985 water quality standards rules listed all water bodies identified in the Ohio Department of Natural Resources Gazetteer of Ohio Streams and clearly identified their assigned use designations. For most water bodies, the WWH and PCR default use designations were carried over. The 1985 water quality standards rules and subsequent rulemakings included use designations resulting from water body surveys.

Since 1985, the water quality standards rules have distinguished between use designations carried over from the 1978 water quality standards (indicated by asterisks) and those based on the results of water body surveys (indicated by plus signs).

For information on the current conditions of Ohio water bodies and trends in water quality, see the Ohio EPA Integrated Water Quality Monitoring and Assessment Report. It is available on the web at ***epa.ohio.gov/dsw/tmdl/OhioIntegratedReport.aspx***.

How many water bodies are involved with these rule revisions?

Results of water body surveys, conducted in past years, indicate that additions/changes in the current beneficial use designations are needed for 191 water body segments in five drainage basins. In addition, verifications of existing designations are included for 291 water body segments in five drainage basins.

Table 1 lists the rules and identifies the types of changes being proposed. Figure 1 shows the particular areas within the drainage basins for which changes are being proposed. Specific use designation changes for each water body being proposed for revisions and for verifications are listed in Tables 2 and 3, respectively, at the end of this fact sheet.

What changes were made to the July 2016 draft rule revisions?

Several changes were made to the draft rules as a result of comments and additional review. Most of these changes were in the Maumee (OAC 3745-1-11) and Sandusky (OAC 3745-1-12) basin rules. No changes were made to OAC 3745-1-24 (Muskingum River basin). Most of the changes involve either retaining the current WWH designation for the stream (six streams) or for a portion of the stream (five streams) rather than the MWH designation that was under consideration in the draft version of the rules. In addition, the MWH designation that was being considered for five undesignated streams is deferred pending the collection of additional information to support a designation. These streams would remain undesignated. Per OAC 3745-1, the chemical criteria associated with the protection of the WWH use designation will remain in place for these undesignated water bodies. All of the changes from the draft version of these rules are described in the ***response to comments*** document and are also summarized ***here***.

How will the changes affect controls placed on water pollution?

Some of these revisions will bring about more stringent controls, other changes may allow less stringent controls. The assigned use designation governs the levels of chemical water quality criteria that apply to protect the use designation. The coldwater and exceptional warmwater habitat uses bring about stricter chemical criteria, as does the replacement of a limited warmwater habitat or limited resource water use with a warmwater habitat use. In these cases, where higher use designations result in the application of more stringent chemical criteria, lower effluent limits for wastewater dischargers may be required.

When a water body's use designation becomes less stringent, existing dischargers must continue the same treatment as before. However, if an existing facility expands its operation or a new facility commences discharging, less stringent pollution controls may be needed to meet the water quality standards for the less stringent use designations.

Detailed information regarding the differences between chemical criteria that apply to various use designations can be viewed in Ohio's water quality standards, available on the at ***epa.ohio.gov/dsw/rules/3745_1.aspx*** as well as on tables summarizing aquatic life and human health criteria, available on the web at ***epa.ohio.gov/dsw/wqs/criteria.aspx.***

Overall, there should be no impact as a result of the water body use designation changes, verifications and additions associated with this rulemaking on water pollution controls based upon a review of existing dischargers to these stream segments. This is based on either a lack of change to the criteria that already apply to most of these water bodies, a lack of regulated discharges to water bodies where more stringent criteria would apply, or less stringent criteria that would apply for water bodies where the MWH or LRW aquatic life habitat use is proposed.

What additional information is the Agency seeking?

The Agency wants to hear from interested stakeholders (public, local officials, and National Pollutant Discharge Elimination System [NPDES] permit holders, industry sectors, other state agencies, consultants and environmental organizations) who may be impacted by these use designation revisions and additions. General comments and specific factual information are welcome. Data on resident fish and macroinvertebrate communities and the physical habitat conditions of the water body are most pertinent to assignment of the proper aquatic life use designation. Data collection must be consistent with acceptable quality assurance protocols to be considered valid.

How are the amendments formatted in the proposed rules?

Text that is proposed for deletion is identified in strikeout font; new text is underlined.

What is the rulemaking schedule?

A public hearing on the proposed rules will be held to consider public comments in accordance with Section 119.03 of the Ohio Revised Code. This hearing will be held at the Ohio EPA Conference Center, Room A, 50 West Town Street, Suite 700, in Columbus, Ohio at 10:30 a.m. on January 5, 2017. The purpose of the public hearing is to give interested persons the opportunity to present oral or written comments on the proposed rules.

At the close of the public comment period, the Agency will review the comments, make any necessary changes to the rules, and then adopt the rules. This is roughly a two-month process from the close of the comment period. A responsiveness summary will be prepared and sent to everyone who comments on the proposed rules. Final rules could be adopted in winter 2017.

Attachment 11

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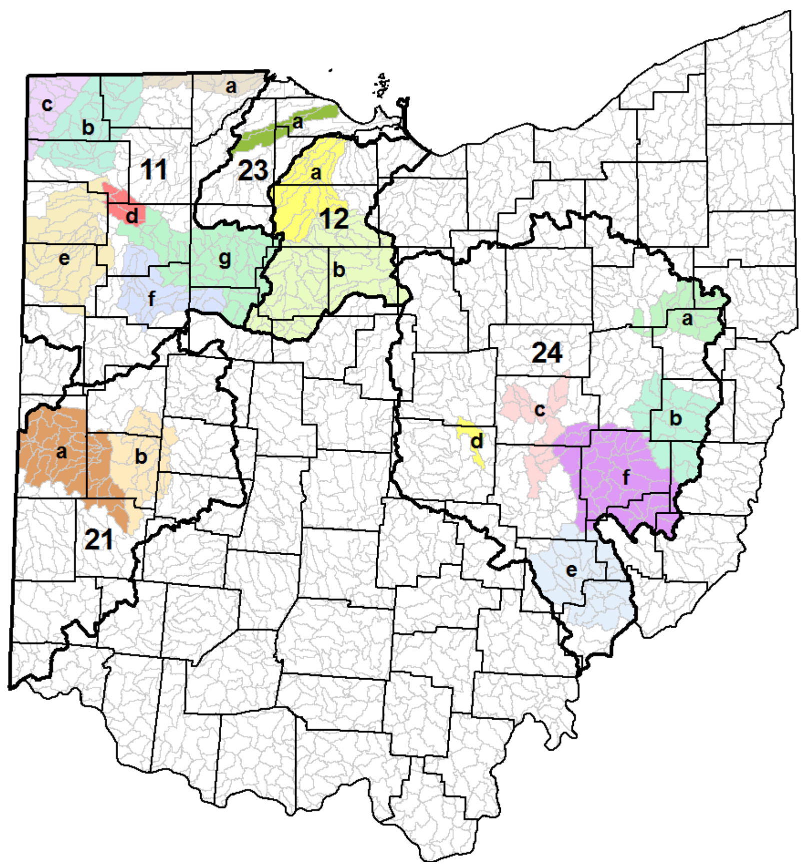
Table 1. Reasons for Rule Revisions

Rule #	Drainage Basin	New Additions	Use Designation Changes	Use Designation Verifications	# Water Body Segments Added/Changed/Verified
3745-1-11	Maumee River Basin	X	X	X	19/31/75
3745-1-12	Sandusky River Basin	X	X	X	4/16/38
3745-1-21	Great Miami River Basin	X	X	X	8/8/12
3745-1-23	Portage River Basin	X	X	X	1/1/1
3745-1-24	Muskingum River Basin	X	X	X	14/89/165
				Totals	46/145/291

Figure 1. Rules and Associated Drainage Basins where Proposed Revisions are Located

- 2011 Ottawa River/Tenmile Creek basin survey (11a)
- 2013 Tiffin River basin survey (11b)
- 2013 St. Joseph River basin survey (11c)
- 2013 Powell Creek basin survey (11d)
- 2014 Lower Auglaize River bain survey (11e)
- 2010 Ottawa River basin survey (11f)
- 2005 Blanchard River basin survey (11g)
- 2012-13 Lye Creek survey (11g)
- 2012-13 Maumee R. & Auglaize R. mainstem survey
- 2009 Lower Sandusky River basin survey (12a)
- 2001 Sandusky River basin survey (12b)
- 2013 Broken Sword Creek basin survey (12b)
- 2013 Stillwater River basin survey (21a)
- 2009 Middle Great Miami R. basin survey (21b)
- 2003 Toussaint River basin survey (23a)
- 2010 Sandy Creek basin survey (24a)
- 2012 Stillwater Creek basin survey (24b)
- 2010 Walhonding River basin survey (24c)
- 2008 Licking River basin survey (24d)
- 2012-2013 Lower Muskingum River tributaries basin survey (24e)
- 2014 Wills Creek basin survey (24f)



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How can I comment on the proposed rules?

Please submit your comments in one of the following ways:

- By email: ***dsw_rulecomments@epa.ohio.gov***
- By fax: (614) 644-2745
- By postal mail:
  Rule Coordinator
  Ohio EPA, Division of Surface Water
  P.O. Box 1049
  Columbus, OH 43216-1049

Comments on the proposed rules must be received no later than 5:00 p.m. January 5, 2017.

How can I get more information?

Copies of this fact sheet, CSI form and the proposed rules are on the Division of Surface Water website at ***epa.ohio.gov/dsw/dswrules.aspx***. For additional background information on water quality standards and beneficial uses, please visit the Water Quality Standards Program web page at: ***epa.ohio.gov/dsw/wqs/index.aspx***. The existing rules in OAC Chapter 3745-1 are available at: ***epa.ohio.gov/dsw/rules/3745_1.aspx***. The biological and water quality studies upon which the rule revisions are based are available at: ***epa.ohio.gov/dsw/document_index/psdindx.aspx***.

For more information about these proposed rules, please contact:

Dan Dudley
(614) 644-2876
daniel.dudley@epa.ohio.gov

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Table 2. Summary of Proposed Revisions

Page #*	Water Body Segment	Existing Designated Uses**	Proposed Changes
Maumee River Drainage Basin, OAC 3745-1-11 (2011 Ottawa River/Tenmile Creek basin survey)			
2	Raisin Creek	WWH, AWS, IWS, PCR	Delist – not in Ohio
2	Hill Ditch (Ottawa River RM 11.81)	LRW-SDM, AWS, IWS, SCR	Designate MWH-CM in lieu of LRW-SDM
2	Zink Ditch (Heldman ditch RM 5.96)	None	Designate MWH-CM, AWS, IWS, PCR
3	Prairie Ditch (Tenmile Creek RM 6.02)	WWH, AWS, IWS, PCR	Designate MWH-CM in lieu of WWH
3	Detwiler Ditch	None	Designate MWH-CM, AWS, IWS, PCR
Maumee River Drainage Basin, OAC 3745-1-11 (2012 Maumee/Auglaize River mainstem survey)			
7	Auglaize River – Blanchard River (RM 26.2) to the Defiance power dam at RM 5.8	WWH, AWS, IWS, PCR	Designate MWH-I in lieu of WWH
Maumee River Drainage Basin, OAC 3745-1-11 (2013 Powell Creek basin survey)			
7	Unnamed tributary (North Powell Creek RM 4.25)	None	Designate WWH, AWS, IWS, PCR
8	Unnamed tributary (North Powell Creek RM 6.0)	None	Designate WWH, AWS, IWS, PCR
Maumee River Drainage Basin, OAC 3745-1-11 (2014 Lower Auglaize River basin survey)			
8	Sixmile Creek	WWH, AWS, IWS, PCR	Designate MWH-CM in lieu of WWH
8	Little Flatrock Creek - headwaters to State Route 637 (RM 2.2)	WWH, AWS, IWS, PCR	Designate MWH-CM in lieu of WWH
8	Flatrock Creek – headwaters to Kings Church Road (RM 51.68)	WWH, AWS, IWS, PCR	Designate MWH-CM in lieu of WWH
8	Snyder ditch (Auglaize River RM 12.98)	None	Designate WWH, AWS, IWS, PCR
9	Bobenmyer ditch (Auglaize River RM 13.17)	None	Designate WWH, AWS, IWS, PCR
9	Upper Prairie Creek – headwaters to Middle Creek (RM 0.33)	WWH, AWS, IWS, PCR	Designate MWH-CM in lieu of WWH
9	Middle Creek (Upper Prairie Creek RM 0.33)	None	Designate MWH-CM, AWS, IWS, PCR
10	Big Run	None	Designate WWH, AWS, IWS, PCR
Maumee River Drainage Basin, OAC 3745-1-11 (2005 Blanchard River basin survey)			
11	Deer Creek – headwaters to State Route 115 (RM 1.57)	WWH, AWS, IWS, PCR	Designate MWH-CM in lieu of WWH
11	Bear Creek – headwaters to unnamed tributary at RM 3.63	WWH, AWS, IWS, PCR	Designate MWH-CM in lieu of WWH
11	Caton ditch (Blanchard River RM 13.23)	WWH, AWS, IWS, PCR	Designate MWH-CM in lieu of WWH
11	Cranberry Creek – headwaters to upstream Little Cranberry Creek (RM 17.05)	WWH, AWS, IWS, PCR	Designate MWH-CM in lieu of WWH
11	Little Cranberry Creek	None	Designate MWH-CM, AWS, IWS, PCR

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Page #*	Water Body Segment	Existing Designated Uses**	Proposed Changes
12	Riley Creek – headwaters to Little Riley Creek (upper) (RM 20.63)	WWH, AWS, IWS, PCR	Designate MWH-CM in lieu of WWH
12	Cranberry Run – headwaters to Riley Township Road 7L (RM 2.95)	WWH, AWS, IWS, PCR	Designate MWH-CM in lieu of WWH
12	Marsh Run (Riley Creek RM 15.61)	WWH, AWS, IWS, PCR	Designate MWH-CM in lieu of WWH
12	Dutch Run – headwaters to upstream Bassinger ditch (RM 5.26)	WWH, AWS, IWS, PCR	Designate MWH-CM in lieu of WWH
13	Moffitt ditch – headwaters to unnamed tributary at RM 0.37	WWH, AWS, IWS, PCR	Designate MWH-CM in lieu of WWH
13	Tiderishi Creek – headwaters to upstream Norfolk and Western RR (RM 2.90)	WWH, AWS, IWS, PCR	Designate MWH-CM in lieu of WWH
13	Aurand Run	None	Designate WWH, AWS, IWS, PCR
14	Stahl ditch	WWH, AWS, IWS, PCR	Designate MWH-CM in lieu of WWH
14	Unnamed tributary at Blanchard River RM 79.75	None	Designate MWH-CM, AWS, IWS, PCR
14	Unnamed tributary at Blanchard River RM 80.53	None	Designate MWH-CM, AWS, IWS, PCR
14	Unnamed tributary at Blanchard River RM 100.38	None	Designate MWH-CM, AWS, IWS, PCR
Maumee River Drainage Basin, OAC 3745-1-11 (2010 Ottawa River basin survey)			
15	Unnamed tributary at Ottawa River RM 0.70	None	Designate WWH, AWS, IWS, PCR
15	Plum Creek – confluence of Sycamore Creek and unnamed tributary at Plum Creek RM 15.8) to Township Road 14L (RM 5.2)	WWH, AWS, IWS, PCR	Designate MWH-CM in lieu of WWH
15	Unnamed tributary at Plum Creek RM 7.30	None	Designate WWH, AWS, IWS, PCR
15	Sycamore Creek	WWH, AWS, IWS, PCR	Designate MWH-CM in lieu of WWH
15	Sugar Creek – headwaters to downstream Stewart Road (RM 20.0)	WWH, AWS, IWS, PCR	Designate MWH-CM in lieu of WWH
15	Rattlesnake Creek	WWH, AWS, IWS, PCR	Designate MWH-CM in lieu of WWH
16	Beaver Run (Ottawa River RM 21.16)	None	Designate WWH, AWS, IWS, PCR
16	Honey Run – headwaters to Billy Mack Road (RM 1.1)	WWH, AWS, IWS, PCR	Designate MWH-CM in lieu of WWH
16	Little Ottawa River – headwaters to upstream of CS&T railroad bridge (RM 5.54)	WWH, AWS, IWS, PCR	Designate MWH-CM in lieu of WWH
16	Lost Creek – headwaters to High Street (RM 0.35)	WWH, AWS, IWS, PCR	Designate MWH-CM in lieu of WWH
16	Unnamed tributary at Lost Creek RM 1.15	None	Designate MWH-CM, AWS, IWS, PCR
16	Grass Creek (Hog Creek RM 10.07)	WWH, AWS, IWS, PCR	Designate MWH-CM in lieu of WWH
16	Number 28 Ditch (Hog Creek RM 10.38)	WWH, AWS, IWS, PCR	Designate MWH-CM in lieu of WWH

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17	Fitzhugh Ditch (Hog Creek RM 11.45)	WWH, AWS, IWS, PCR	Designate MWH-CM in lieu of WWH
17	Lord Ditch (Hog Creek RM 12.79)	WWH, AWS, IWS, PCR	Designate MWH-CM in lieu of WWH
17	Unnamed tributary at Hog Creek RM 13.71	None	Designate MWH-CM, AWS, IWS, PCR
17	Unnamed tributary at Little Hog Creek RM 0.47	None	Designate WWH, AWS, IWS, PCR
Maumee River Drainage Basin, OAC 3745-1-11 (2013 Tiffin River basin survey)			
18	Tiffin River – U.S. Route 24 (RM 1.3) to the mouth	WWH, AWS, IWS, PCR	Designate MWH-I in lieu of WWH
20	Bean Creek	WWH, AWS, IWS, PCR	Designate EWH in lieu of WWH
Sandusky River Drainage Basin, OAC 3745-1-12 (2001 basin survey)			
4	Morrison Creek – headwaters to CR 43 (RM 7.9)	WWH, AWS, IWS, PCR	Designate MWH-CM in lieu of WWH
4	Willow Creek	WWH, AWS, IWS, PCR	Designate MWH-CM in lieu of WWH
4	Honey Creek – Scott Road (RM 37.3) to State Route 4 (RM 28.3)	WWH, AWS, IWS, PCR	Designate MWH-CM in lieu of WWH
5	Van Meter Creek (Honey Creek RM 3.69) – headwaters to Infirmary Road (RM 1.7)	None	Designate MWH-CM, AWS, IWS, PCR
5	Van Meter Creek (Honey Creek RM 3.69) – Infirmary Road (RM 1.7) to the mouth	None	Designate WWH, AWS, IWS, PCR
5	Silver Creek – headwaters to Brillhart Rd (RM 8.7)	WWH, AWS, IWS, PCR	Designate LRW-SDM in lieu of WWH
5	Aicholtz Ditch – headwaters to CR 12 (RM 2.8)	WWH, AWS, IWS, PCR	Designate MWH-CM in lieu of WWH
5	Brokenknife Creek – headwaters to Seneca/Crawford County line (RM 3.2)	WWH, AWS, IWS, PCR	Designate MWH-CM in lieu of WWH
6	Sycamore Creek – headwaters to State Route 19 (RM 17.8)	WWH, AWS, IWS, PCR	Designate MWH-CM in lieu of WWH
6	West Branch Taylor Run (Taylor Run RM 2.49)	None	Designate MWH-CM, AWS, IWS, PCR
6	Tymochtee Creek – headwaters to Cramer Road (RM 51.8)	WWH, AWS, IWS, PCR	Designate LRW-SDM in lieu of WWH
6	Little Tymochtee Creek – headwaters to CR 108 (RM 9.1)	WWH, AWS, IWS, PCR	Designate LRW-SDM in lieu of WWH
7	Warpole Creek	WWH, AWS, IWS, PCR	Designate MWH-CM in lieu of WWH
7	Little Tymochtee Creek– headwaters to CR 205 (RM 8.63)	WWH, AWS, IWS, PCR	Designate MWH-CM in lieu of WWH
8	Broken Sword Creek – headwaters to Eaton Road (RM 21.4)	WWH, AWS, IWS, PCR	Designate MWH-CM in lieu of WWH
8	Indian Run – headwaters to State Route 231 (RM 1.7)	WWH, AWS, IWS, PCR	Designate MWH-CM in lieu of WWH

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Page #*	Water Body Segment	Existing Designated Uses**	Proposed Changes
8	Brandywine Creek – headwaters to Temple Road (RM 1.6)	WWH, AWS, IWS, PCR	Designate LRW-SDM in lieu of WWH
9	Unnamed tributary at Broken Sword Creek RM 28.04	None	Designate WWH, AWS, IWS, PCR
9	Red Run	WWH, AWS, IWS, PCR	Designate LRW-SDM in lieu of WWH
9	Grass Run – headwaters to Marion Melmore Road (RM 6.0)	WWH, AWS, IWS, PCR	Designate MWH-CM in lieu of WWH
Great Miami River Drainage Basin, OAC 3745-1-21 (Middle GMR 2009 basin survey)			
2	Great Miami River - SR 66 (RM 116.7) to upper limit of Piqua Dam Pool at Main Street (RM 115.15)	WWH, AWS, IWS, PCR	Designate EWH in lieu of WWH
18	Honey Creek – headwaters to Indian Creek (RM 3.68)	EWH, AWS, IWS, PCR	Designate WWH in lieu of EWH
18	Pleasant Run – headwaters to Elizabeth Road (RM 0.85)	None	Designate WWH, AWS, IWS, PCR
18	Pleasant Run – Elizabeth Road (RM 0.85) to the mouth	None	Designate EWH, CWH, AWS, IWS, PCR
18	Indian Creek – Unnamed tributary at RM 2.4 to the mouth	WWH, AWS, IWS, PCR	Designate CWH in lieu of WWH
19	Lost Creek - Headwaters to East Branch (RM 10.8)	EWH, AWS, IWS, PCR	Designate WWH in lieu of EWH
19	Lost Creek - East Branch (RM 10.8) to Knoop Road (RM 4.3)	WWH, AWS, IWS, PCR	Designate CWH in lieu of EWH
19	Lost Creek - Knoop Road (RM 4.3) to mouth	EWH, AWS, IWS, PCR	Designate WWH in lieu of EWH
19	Little Lost Creek – headwaters to unnamed tributary at RM 2.2	None	Designate WWH, AWS, IWS, PCR
19	Little Lost Creek – unnamed tributary at RM 2.2 to the mouth	None	Designate EWH, CWH, AWS, IWS, PCR
19	Middle Branch Lost Creek	None	Designate WWH, AWS, IWS, PCR
19	East Branch Lost Creek – headwaters to Loy Road (RM 2.0)	EWH, AWS, IWS, PCR	Designate WWH in lieu of EWH
19	East Branch Lost Creek – Loy Road (RM 2.0) to the mouth	EWH, AWS, IWS, PCR	Designate CWH in lieu of EWH
19	West Branch Lost Creek	None	Designate WWH, AWS, IWS, PCR
19	Boone Creek (Great Miami River RM 103.87)	None	Designate WWH, AWS, IWS, PCR
19	Peters Creek (Boone Creek RM 0.2)	None	Designate WWH, AWS, IWS, PCR
Portage River Drainage Basin, OAC 3745-1-23 (Toussaint River 2003 basin survey)			

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Page #*	Water Body Segment	Existing Designated Uses**	Proposed Changes
3	Rushaw Creek	WWH, AWS, IWS, PCR	Designate MWH-CM in lieu of WWH
3	Martin Ditch	None	Designate WWH, AWS, IWS, PCR
Muskingum River Drainage Basin, OAC 3745-1-24 (Lower Muskingum River tributaries 2013 basin survey)			
3	Second Creek	None	Designate WWH, AWS, IWS, PCR
3	Cat Creek	WWH, AWS, IWS, PCR	Designate EWH in lieu of WWH
3	Right Branch	WWH, AWS, IWS, PCR	Designate EWH in lieu of WWH
3	Big Run	WWH, AWS, IWS, PCR	Designate EWH in lieu of WWH
3	Straight Run	WWH, AWS, IWS, PCR	Designate EWH in lieu of WWH
4	Cushing Run	LWH, AWS, IWS, PCR	Designate WWH in lieu of LWH
4	Wolf Creek	SRW, EWH, AWS, IWS, PCR	Designate WWH in lieu of EWH
4	Hayward Run	SRW, EWH, AWS, IWS, PCR	Designate WWH in lieu of EWH
4	Duck Creek	SRW, EWH, AWS, IWS, PCR	Designate WWH in lieu of EWH
4	Boseman Run	SRW, EWH, AWS, IWS, PCR	Designate WWH in lieu of EWH
4	Flint Run	SRW, EWH, AWS, IWS, PCR	Designate WWH in lieu of EWH
4	South Branch Wolf Creek	SRW, EWH, AWS, IWS, PCR	Designate WWH in lieu of EWH
4	Plumb Run	None	Designate WWH, AWS, IWS, PCR
4	Painter Run	SRW, EWH, AWS, IWS, PCR	Designate WWH in lieu of EWH
4	Southwest Fork	SRW, EWH, AWS, IWS, PCR	Designate WWH in lieu of EWH
4	South Fork	SRW, EWH, AWS, IWS, PCR	Designate WWH in lieu of EWH
4	Browns Run	SRW, EWH, AWS, IWS, PCR	Designate WWH in lieu of EWH
4	Turkeyhen Run	SRW, EWH, AWS, IWS, PCR	Designate WWH in lieu of EWH
5	Horse Run	SRW, EWH, AWS, IWS, PCR	Designate WWH in lieu of EWH
5	Halfway Run	SRW, EWH, AWS, IWS, PCR	Designate WWH in lieu of EWH
5	Chainey Run	SRW, EWH, AWS, IWS, PCR	Designate CWH in lieu of EWH
5	Lucas Run	SRW, EWH, AWS, IWS, PCR	Designate WWH in lieu of EWH
5	Whitewater Creek	SRW, EWH, AWS, IWS, PCR	Designate WWH in lieu of EWH
5	Shrader Run	SRW, EWH, AWS, IWS, PCR	Designate CWH in lieu of EWH
5	North Branch Coal Run	SRW, EWH, AWS, IWS, PCR	Designate CWH in addition to EWH
5	Mile Run (Coal Run RM 8.37)	SRW, EWH, AWS, IWS, PCR	Designate WWH in lieu of EWH
5	Walnut Run	None	Designate EWH, AWS, IWS, PCR
5	Scott Run	SRW, EWH, AWS, IWS, PCR	Designate CWH in lieu of EWH
5	Lick Run	SRW, EWH, AWS, IWS, PCR	Designate WWH in lieu of EWH

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Page #*	Water Body Segment	Existing Designated Uses**	Proposed Changes
5	McPherson Run	SRW, EWH, AWS, IWS, PCR	Designate CWH in lieu of EWH
6	Browns Run	SRW, EWH, AWS, IWS, PCR	Designate WWH in lieu of EWH
6	Little Wolf Creek	SRW, EWH, AWS, IWS, PCR	Designate CWH in lieu of WWH
6	Chaneyville Run – headwaters to unnamed tributary at RM 0.33	SRW, EWH, AWS, IWS, PCR	Designate CWH in lieu of EWH
6	Chaneyville Run – Unnamed tributary at RM 0.33 to the mouth	SRW, EWH, AWS, IWS, PCR	Designate WWH in lieu of EWH
6	Unnamed tributary at West Branch Wolf Creek RM 33.33	None	Designate EWH, AWS, IWS, PCR
6	Buck Run	SRW, EWH, AWS, IWS, PCR	Designate WWH in lieu of EWH
6	Pleasant Run	SRW, EWH, AWS, IWS, PCR	Designate WWH in lieu of EWH
6	Hedgehog Creek	SRW, EWH, AWS, IWS, PCR	Designate WWH in lieu of EWH
6	Kickapoo Creek	SRW, EWH, AWS, IWS, PCR	Designate WWH in lieu of EWH
6	Peeper Run	SRW, EWH, AWS, IWS, PCR	Designate CWH in lieu of EWH
6	Cow Run	SRW, EWH, AWS, IWS, PCR	Designate CWH in addition to EWH
6	Elk Run	SRW, EWH, AWS, IWS, PCR	Designate CWH in lieu of EWH
6	Little Olive Green Creek	SRW, EWH, AWS, IWS, PCR	Designate CWH in addition to EWH
6	Scott Run	SRW, EWH, AWS, IWS, PCR	Designate CWH in lieu of EWH
6	Allen Run	SRW, EWH, AWS, IWS, PCR	Designate CWH in lieu of EWH
7	Stony Creek	SRW, EWH, AWS, IWS, PCR	Designate CWH in lieu of EWH
7	Reasoners Run	SRW, EWH, AWS, IWS, PCR	Designate WWH in lieu of EWH
7	Taylor Fork	None	Designate EWH, CWH, AWS, IWS, PCR
7	Shrivers Fork	None	Designate EWH, CWH, AWS, IWS, PCR
7	Limestone Run	SRW, EWH, AWS, IWS, PCR	Designate CWH in addition to EWH
7	Sharon Fork	SRW, EWH, AWS, IWS, PCR	Designate WWH in lieu of EWH
7	Meigs Creek – Morgan County line (RM 17.9) to the mouth	WWH, AWS, IWS, PCR	Designate EWH in lieu of WWH
7	Onion Run	WWH, AWS, IWS, PCR	Designate EWH in lieu of WWH
7	Perry Run	WWH, AWS, IWS, PCR	Designate CWH in lieu of WWH
7	Fourmile Run	WWH, AWS, IWS, PCR	Designate EWH in lieu of WWH
8	Mans Fork - headwaters to Bear Run (RM 1.25)	WWH, AWS, IWS, PCR	Designate EWH in lieu of WWH
8	Mill Run	WWH, AWS, IWS, PCR	Designate CWH in lieu of WWH
9	Doudna Run	WWH, AWS, IWS, PCR	Designate CWH in lieu of WWH
9	Bell Creek	None	Designate WWH, AWS, IWS, PCR

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Page #*	Water Body Segment	Existing Designated Uses**	Proposed Changes
Moxahala Creek Sub-basin (2014 survey)			
12	Twomile Run	LWH, AWS, IWS, PCR	Designate WWH in lieu of LWH
13	Dry Run – all segments listed	LWH, AWS, IWS, PCR, (PWS at RM 2.23)	Designate LRW-AMD in lieu of LWH
Licking River Sub-basin (2008 basin survey)			
15	Painter Run	WWH, AWS, IWS, PCR	Designate EWH in lieu of WWH
Wills Creek Sub-basin (2014 basin survey)			
20	White Eyes Creek	LWH, AWS, IWS, PCR	Designate WWH in lieu of LWH
20	Unnamed tributary at White Eyes Creek RM 4.50	None	Designate WWH, AWS, IWS, PCR
20	Brush Run	LWH, AWS, IWS, PCR	Designate WWH in lieu of LWH
21	Marlatt Run (Wills Creek RM 23.49)	None	Designate WWH, AWS, IWS, PCR
21	Unnamed tributary at Johnson Fork RM 1.04	None	Designate WWH, AWS, IWS, PCR
21	Unnamed tributary at Wills Creek RM 34.43	None	Designate WWH, AWS, IWS, PCR
22	Turkey Run	WWH, AWS, IWS, PCR	Designate EWH and CWH in lieu of WWH
22	Jackson Run	LWH, AWS, IWS, PCR	Designate MWH-MA in lieu of LWH
22	Peters Creek	LWH, AWS, IWS, PCR	Designate WWH in lieu of LWH
22	Bobs Run	LWH, AWS, IWS, PCR	Designate WWH in lieu of LWH
22	North Crooked Creek	LWH, AWS, IWS, PCR	Designate WWH in lieu of LWH
23	Fox Creek – headwaters to US Route 22 (RM 0.9)	LWH, AWS, IWS, PCR	Designate MWH-MA in lieu of LWH
23	Fox Creek – US Route 22 (RM 0.9) to the mouth	LWH, AWS, IWS, PCR	Designate WWH in lieu of LWH
23	Dare Run	LWH, AWS, IWS, PCR	Designate MWH-CM in lieu of LWH
23	Shannon Run	LWH, AWS, IWS, PCR	Designate WWH in lieu of LWH
24	North Fork (Skin Creek)	WWH, AWS, IWS, PCR	Designate EWH in lieu of WWH
25	Buffalo Creek	LWH, AWS, IWS, PCR	Designate WWH in lieu of LWH
25	North Fork Buffalo Creek	LWH, AWS, IWS, PCR	Designate MWH-MA in lieu of LWH
25	South Fork	LWH, AWS, IWS, PCR	Designate WWH in lieu of LWH
25	Little Buffalo Creek	LWH, AWS, IWS, PCR	Designate WWH in lieu of LWH
Stillwater Creek Sub-basin (2012 basin survey)			
27	Stillwater Creek – headwaters to confluence with Brushy Fork (RM 25.82)	LWH, AWS, IWS, PCR	Designate WWH in lieu of LWH
28	Unnamed tributary at Little Stillwater Creek RM 7.60	None	Designate WWH, AWS, IWS, PCR
29	Skull Fork	LWH, AWS, IWS, PCR	Designate WWH in lieu of LWH

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Page #*	Water Body Segment	Existing Designated Uses**	Proposed Changes
29	Millers Fork	LWH, AWS, IWS, PCR	Designate WWH in lieu of LWH
29	Unnamed tributary at Skull Fork RM 13.87	None	Designate WWH, AWS, IWS, PCR
29	Boggs Fork – Holloway (RM 6.35) to the confluence with Stillwater Creek	LWH, AWS, IWS, PCR	Designate WWH in lieu of LWH
30	Plum Run	LWH, AWS, IWS, PCR	Designate WWH in lieu of LWH
30	Trail Run	LWH, AWS, IWS, PCR	Designate WWH in lieu of LWH
Sandy Creek Sub-basin (2010 basin survey)			
35	Bear Run	WWH, AWS, IWS, PCR	Designate MWH-CM in lieu of WWH
37	Still Fork - headwaters to Arbor Road (RM 3.9)	WWH, AWS, IWS, PCR	Designate MWH-CM in lieu of WWH
37	Still Fork – Arbor Road (RM 3.9) to the mouth	WWH, AWS, IWS, PCR	Designate MWH-I in lieu of WWH
37	Muddy Fork – headwaters to Stony Hollow (RM 3.0)	WWH, AWS, IWS, PCR	Designate MWH-CM in lieu of WWH
37	Reeds Run	WWH, AWS, IWS, PCR	Designate MWH-CM in lieu of WWH
37	Pipes Fork	WWH, AWS, IWS, PCR	Designate MWH-CM in lieu of WWH
37	Friday Creek	WWH, AWS, IWS, PCR	Designate MWH-CM in lieu of WWH
Walhonding River Sub-basin (2010 basin survey)			
40	Turkey Run	EWH, AWS, IWS, PCR	Designate CWH in addition to EWH
40	Beards Run	LWH, AWS, IWS, PCR	Designate WWH in lieu of LWH
43	Beaver Run – headwaters to unnamed tributary at RM 2.53	WWH, AWS, IWS, PCR	Designate CWH in lieu of WWH
43	Mohawk Creek	WWH, AWS, IWS, PCR	Designate EWH in lieu of WWH
43	Unnamed tributary at Mohawk Creek RM 2.93	None	Designate EWH, AWS, IWS, PCR
43	Dutch Run	WWH, AWS, IWS, PCR	Designate CWH in lieu of WWH
48	Fleming Falls Creek	WWH, AWS, IWS, PCR	Typographical correction: This is a direct trib of Black Fork at RM 25.16 (not Rocky Fork) in the Mohican River basin.

* The page numbers listed in the table refer to page numbers in the amended rules.
** As indicated in OAC 3745-1-08 through OAC 3745-1-30.

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Index of Acronyms Used

The following acronyms are used in this table. Designated uses are defined in OAC 3745-1-05 and OAC 3745-1-07.

AWS = Agricultural Water Supply
CWH = Coldwater Habitat
EWH = Exceptional Warmwater Habitat
IWS = Industrial Water Supply
LWH = Limited Warmwater Habitat
LRW-AMD = Limited Resource Water-Acid Mine Drainage
LRW-SDM = Limited Resource Water-Small Drainageway Maintenance
MWH-CM = Modified Warmwater Habitat – Channel Modification
MWH-I = Modified Warmwater Habitat - Impounded
PCR = Primary Contact Recreation
PWS = Public Water Supply
SCR = Secondary Contact Recreation
SRW = State Resource Water
WWH = Warmwater Habitat

RM = River Mile. The river mile is a point location describing the lineal distance from the downstream terminus (i.e., mouth) and moving in an upstream direction.

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Table 3. Summary of Existing Use Designations Proposed for Verification

Page #*	Water Body Segment	Existing Designations Proposed for Verification**
Rule 3745-1-11 Maumee River Drainage Basin (2011 Ottawa/Tenmile Cr survey)		
2	Bear Creek	WWH, AWS, IWS, PCR
2	Halfway Creek	WWH, AWS, IWS, PCR
2	Ottawa River	AWS, IWS
3	Tenmile Creek	AWS, IWS, PCR
3	North Branch Tenmile Creek	AWS, IWS, PCR
3	Prairie Ditch	AWS, IWS, PCR
Rule 3745-1-11 Maumee River Drainage Basin (2012 Maumee/Auglaize R. survey)		
3	Maumee River – I-75 (RM 7.1) to confluence with Maumee Bay	WWH, AWS, IWS, PCR
3	Maumee River – at RM 23.16 and RM 65.84	WWH, AWS, IWS, PCR
4	Maumee River – all other segments	WWH, AWS, IWS, PCR
7	Auglaize River – Defiance power dam (RM 5.8) to the mouth	WWH, AWS, IWS, PCR
7	Auglaize River – Blanchard River (RM 26.2) to the Defiance power dam at RM 5.8)	AWS, IWS, PCR
Rule 3745-1-11 Maumee River Drainage Basin (2013 Powell Creek basin survey)		
7	Powell Creek	WWH, AWS, IWS, PCR
7	Wagner Run	WWH, AWS, IWS, PCR
7	North Powell Creek	WWH, AWS, IWS
7	Hogback Run	WWH, AWS, IWS, PCR
8	South Powell Creek	WWH, AWS, IWS
Rule 3745-1-11 Maumee River Drainage Basin (2014 Lower Auglaize R. survey)		
8	Threemile Creek	WWH, AWS, IWS, PCR
8	Jackson Ditch (Auglaize River RM 5.60)	WWH, AWS, IWS, PCR
8	Fivemile Creek	WWH, AWS, IWS, PCR
8	Eagle Creek	WWH, AWS, IWS, PCR
8	Sixmile Creek	AWS, IWS, PCR
8	Little Flatrock Creek – headwaters to State Route 637 (RM 2.2)	AWS, IWS, PCR
8	Little Flatrock Creek – State Route 637 (RM 2.2) to the mouth	WWH, AWS, IWS, PCR
8	Wildcat Creek	WWH, AWS, IWS, PCR
9	Barcer Run	WWH, AWS, IWS, PCR
9	Upper Prairie Creek - headwaters to Middle Creek (RM 0.33)	AWS, IWS, PCR
Rule 3745-1-11 Maumee River Drainage Basin (2005 Blanchard River survey)		
11	Deer Creek - headwaters to State Route 115 (RM 1.57)	AWS, IWS, PCR
11	Bear Creek - headwaters to unnamed tributary at RM 3.63	AWS, IWS, PCR
11	Caton Ditch	AWS, IWS, PCR
11	Cranberry Creek – all segments	PCR

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Page #*	Water Body Segment	Existing Designations Proposed for Verification**
12	Pike Run	WWH, AWS, IWS, PCR
12	Cranberry Run – headwaters to Riley Twp Road 7L (RM 3.05)	AWS, IWS, PCR
12	Cranberry Run – Riley Township Rd 7L (RM 3.05) to the mouth	WWH, AWS, IWS, PCR
12	Marsh Run (Riley Creek RM 15.61)	AWS, IWS, PCR
12	Little Riley Creek (upper) (Riley Creek RM 20.63)	WWH, AWS, IWS, PCR
12	Dutch Run - headwaters to upstream Bassinger ditch (RM 5.26)	AWS, IWS, PCR
12	Dutch Run - upstream Bassinger ditch (RM 5.26) to the mouth	WWH, AWS, IWS, PCR
13	Dukes Run	WWH, AWS, IWS, PCR
13	Moffitt ditch - headwaters to unnamed tributary at RM 0.37	AWS, IWS, PCR
13	Tederishi Creek - headwaters to upstream Norfolk and Western RR (RM 2.90)	AWS, IWS, PCR
13	Tederishi Creek – all other segments	WWH, AWS, IWS, PCR
13	Eagle Creek	PCR
13	Flat Branch	WWH, AWS, IWS, PCR
14	Lye Creek	WWH, AWS, IWS, PCR
14	Silver Creek	WWH, AWS, IWS, PCR
14	Potato Run	PCR
14	Ripley Run	WWH, AWS, IWS, PCR
14	The Outlet (upper) (Blanchard River RM 90.94)	WWH, AWS, IWS, PCR
14	Cessna Creek	WWH, AWS, IWS, PCR
Rule 3745-1-11 Maumee River Drainage Basin (2010 Ottawa River basin survey)		
15	Sycamore Creek	AWS, IWS, PCR
15	Sugar Creek – headwaters to Stewart Road (RM 20.5)	AWS, IWS, PCR
15	Sugar Creek – Stewart Road (RM 20.5) to the mouth	WWH, AWS, IWS, PCR
15	Rattlesnake Creek	AWS, IWS, PCR
15	Leatherwood Ditch	WWH, AWS, IWS, PCR
16	Honey Run – headwaters to Billy Mack Road (RM 1.1)	AWS, IWS, PCR
16	Honey Run – Billy Mack Road (RM 1.1) to the mouth	WWH, AWS, IWS, PCR
16	Dug Run	WWH, AWS, IWS, PCR
16	Lost Creek – headwaters to High Street (RM 0.35)	AWS, IWS, PCR
16	Lost Creek – High Street (RM 0.35) to the mouth	WWH, AWS, IWS, PCR
16	Grass Creek	AWS, IWS, PCR
16	Number 28 Ditch	AWS, IWS, PCR
17	Fitzhugh Ditch	AWS, IWS, PCR
17	Lord Ditch	AWS, IWS, PCR
17	Mud Run	WWH, AWS, IWS, PCR
Rule 3745-1-11 Maumee River Drainage Basin (2013 Tiffin River basin survey)		

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Page #*	Water Body Segment	Existing Designations Proposed for Verification**
19	Buckskin Creek	WWH, AWS, IWS, PCR
19	Dry Creek	WWH, AWS, IWS, PCR
19	Dotty Creek (Doty Run)	WWH, AWS, IWS, PCR
19	Owl Creek	WWH, AWS, IWS, PCR
20	Flat Run	WWH, AWS, IWS, PCR
Rule 3745-1-11 Maumee River Drainage Basin (2013 St. Joseph R. basin survey)		
21	Big Run	WWH, AWS, IWS, PCR
21	Eagle Creek	WWH, AWS, IWS, PCR
21	North Branch Eagle Creek	WWH, AWS, IWS, PCR
21	Nettle Creek	WWH, AWS, IWS, PCR
21	East Branch St. Joseph River	WWH, AWS, IWS, PCR
21	Clear Fork	WWH, AWS, IWS, PCR
Rule 3745-1-12 Sandusky River Drainage Basin (2001 survey)		
2	Sandusky River – Muskellunge Creek (RM 9.37) to the mouth	WWH, AWS, IWS, PCR
2	Sandusky River – RM 16.8 to RM 19.0	WWH, AWS, IWS, PCR
4	Morrison Creek – headwaters to CR 43 (RM 7.9)	AWS, IWS
4	Morrison Creek – CR 43 (RM 7.9) to the mouth	WWH, AWS, IWS, PCR
4	Willow Creek	AWS, IWS, PCR
4	East Branch Rock Creek	WWH, AWS, IWS, PCR
4	Gibson Creek	WWH, AWS, IWS, PCR
4	Bells Run	WWH, AWS, IWS, PCR
4	Honey Creek – RM 37.3 (Scott Rd) to RM 28.3 (SR4)	AWS, IWS, PCR
4	Honey Creek – all other segments	WWH, AWS, IWS, PCR
5	Silver Creek – headwaters to Brillhart Road (RM 8.7)	AWS, IWS
5	Silver Creek – Brillhart Road (RM 8.7) to the mouth	WWH, AWS, IWS, PCR
5	Aicholtz ditch – headwaters to CR 12 (RM 2.8)	AWS, IWS, PCR
5	Aicholtz ditch – CR 12 (RM 2.8) to the mouth	WWH, AWS, IWS, PCR
5	Brokenknife Creek – headwaters to Seneca/Crawford County Line (RM 3.2)	AWS, IWS, PCR
5	Brokenknife Creek – RM 3.2 to the mouth	WWH, AWS, IWS, PCR
6	Greasy Run	WWH, AWS, IWS, PCR
6	Taylor Run	WWH, AWS, IWS, PCR
6	Thorn Run	WWH, AWS, IWS, PCR
6	Spring Run	WWH, AWS, IWS, PCR
6	No. 32 ditch	WWH, AWS, IWS, PCR
6	Little Tymochtee Creek – headwaters to CR 108 (RM 9.1)	AWS, IWS
6	Little Tymochtee Creek – CR 108 (RM 9.1) to the mouth	WWH, AWS, IWS, PCR

Attachment 11

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Page #*	Water Body Segment	Existing Designations Proposed for Verification**
7	Lick Run	WWH, AWS, IWS, PCR
7	Warpole Creek	AWS, IWS, PCR
7	Little Tymochtee Creek – headwaters to CR 205 (RM 8.63)	AWS, IWS, PCR
7	Little Tymochtee Creek – CR 205 (RM 8.63) to the mouth	WWH, AWS, IWS, PCR
8	Layton ditch	WWH, AWS, IWS, PCR
8	Honey Run	WWH, AWS, IWS, PCR
8	Indian Run – headwaters to State Route 231 (RM 1.7)	AWS, IWS, PCR
8	Indian Run – State Route 231 (RM 1.7) to the mouth	WWH, AWS, IWS, PCR
8	Brandywine Creek – headwaters to Temple Road (RM 1.6)	AWS, IWS
9	Brandywine Creek – Temple Road (RM 1.6) to the mouth	AWS, IWS, PCR
9	Red Run	AWS, IWS
9	Grass Run – headwaters to Marion Melmore Road (RM 6.0)	AWS, IWS, PCR
9	Grass Run – Marion Melmore Road (RM 6.0) to the mouth	WWH, AWS, IWS, PCR
9	Westerly Creek (Paramour Creek RM 1.92)	WWH, AWS, IWS, PCR
9	East Crestline tributary (Paramour Creek RM 2.88)	WWH, AWS, IWS, PCR
Rule 3745-1-21 Great Miami River Drainage Basin (Stillwater River 2013 survey)		
15	Canyon Run	WWH, AWS, IWS, PCR
Rule 3745-1-21 Great Miami River Drainage Basin (Middle GMR 2009 survey)		
18	Indian Creek – headwaters to unnamed tributary at RM 2.4	WWH, AWS, IWS, PCR
18	Indian Creek – Unnamed tributary at RM 2.4 to the mouth	AWS, IWS, PCR
18	Dry Creek	WWH, AWS, IWS, PCR
18	West Fork	WWH, AWS, IWS, PCR
19	East Fork	WWH, AWS, IWS, PCR
19	East Branch	AWS, IWS, PCR
19	Rush Creek	WWH, AWS, IWS, PCR
21	Mill Branch	WWH, AWS, IWS, PCR
21	Tawawa Creek (all segments listed)	PCR
21	Mosquito Creek	WWH, AWS, IWS, PCR
21	Leatherwood Creek	WWH, AWS, IWS, PCR
Rule 3745-1-23 Portage River Drainage Basin (Toussaint River 2013 survey)		
3	Rushaw Creek	AWS, IWS, PCR
Rule 3745-1-24 Muskingum River Drainage Basin Muskingum River mainstem (2006 survey)		
3	Muskingum River – all listed segments	WWH, AWS, IWS, PCR
Rule 3745-1-24 Muskingum River Drainage Basin Lower Muskingum Tributaries Sub-basin (2013 survey)		
3	Indian Run	WWH, AWS, IWS, PCR

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Page #*	Water Body Segment	Existing Designations Proposed for Verification**
3	Devol Run	WWH, AWS, IWS, PCR
3	Rainbow Creek	WWH, AWS, IWS, PCR
3	Bear Creek	WWH, AWS, IWS, PCR
3	Cat Creek	AWS, IWS, PCR
3	Right Branch	AWS, IWS, PCR
3	Big Run	AWS, IWS, PCR
3	Straight Run	AWS, IWS, PCR
4	Cushing Run	AWS, IWS, PCR
4	Congress Run	WWH, AWS, IWS, PCR
4	Wolf Creek	AWS, IWS, PCR
4	Hayword Run	AWS, IWS, PCR
4	Duck Creek	AWS, IWS, PCR
4	Boseman Run	AWS, IWS, PCR
4	Flint Run	AWS, IWS, PCR
4	South Branch Wolf Creek	AWS, IWS, PCR
4	Painter Run	AWS, IWS, PCR
4	Southwest Fork	AWS, IWS, PCR
4	South Fork	AWS, IWS, PCR
4	Browns Run	AWS, IWS, PCR
4	Turkeyhen Run	AWS, IWS, PCR
5	Horse Run	AWS, IWS, PCR
5	Halfway Run	AWS, IWS, PCR
5	Chainey Run	AWS, IWS, PCR
5	West Branch	EWH, AWS, IWS, PCR
5	Lucas Run	AWS, IWS, PCR
5	Whitewater Creek	AWS, IWS, PCR
5	Laurel Run	EWH, AWS, IWS, PCR
5	Coal Run	EWH, AWS, IWS, PCR
5	Shrader Run	AWS, IWS, PCR
5	North Branch	EWH, AWS, IWS, PCR
5	Buckeye Run	EWH, AWS, IWS, PCR
5	Mile Run (Coal Run RM 8.37)	AWS, IWS, PCR
5	Aldridge Run	EWH, AWS, IWS, PCR
5	Scott Run	AWS, IWS, PCR
5	Lick Run	AWS, IWS, PCR
5	McPherson Run	AWS, IWS, PCR
5	Goshen Run	EWH, AWS, IWS, PCR

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Page #*	Water Body Segment	Existing Designations Proposed for Verification**
6	Browns Run	AWS, IWS, PCR
6	Little Wolf Creek	AWS, IWS, PCR
6	Chaneyville Run – entire length	AWS, IWS, PCR
6	Buck Run	AWS, IWS, PCR
6	Pleasant Run	AWS, IWS, PCR
6	Hedgehog Creek	AWS, IWS, PCR
6	Kickapoo Creek	AWS, IWS, PCR
6	Peeper Run	AWS, IWS, PCR
6	Olive Green Creek	EWH, AWS, IWS, PCR
6	Cow Run	EWH, AWS, IWS, PCR
6	Elk Run	AWS, IWS, PCR
6	Little Olive Green Creek	EWH, AWS, IWS, PCR
6	Scott Run	AWS, IWS, PCR
6	Allen Run	AWS, IWS, PCR
7	Stony Creek	AWS, IWS, PCR
7	Reasoners Run	AWS, IWS, PCR
7	Keith Fork	EWH, AWS, IWS, PCR
7	Limestone Run	EWH, AWS, IWS, PCR
7	Sharon Fork	AWS, IWS, PCR
7	Dinner Fork	EWH, AWS, IWS, PCR
7	Meigs Creek – headwaters to Morgan County line (RM 17.9)	WWH, AWS, IWS, PCR
7	Meigs Creek – Morgan County line (RM 17.9) to the mouth	AWS, IWS, PCR
7	Onion Run	AWS, IWS, PCR
7	Perry Run	AWS, IWS, PCR
7	Fourmile Run	AWS, IWS, PCR
7	Dyes Fork	WWH, AWS, IWS, PCR
7	Horse Run	WWH, AWS, IWS, PCR
8	Mans Fork – headwaters to Bear Run (RM 1.25)	AWS, IWS, PCR
8	Mans Fork – Bear Run (RM 1.25) to the mouth	WWH, AWS, IWS, PCR
8	Bear Run	WWH, AWS, IWS, PCR
8	Guyst Fork	WWH, AWS, IWS, PCR
8	Mill Run	AWS, IWS, PCR
8	Bald Eagle Run	EWH, AWS, IWS, PCR
9	Doudna Run	AWS, IWS, PCR
9	Oilspring Run	WWH, AWS, IWS, PCR
Walhonding/Muskingum tributaries Sub-basin (2010 survey)		
18	Mill Run	WWH, AWS, IWS, PCR

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Page #*	Water Body Segment	Existing Designations Proposed for Verification**
18	Blount Run	WWH, AWS, IWS, PCR
18	Blunt Run	AWS, IWS, PCR
18	Symmes Creek	WWH, AWS, IWS, PCR
18	North Branch	WWH, AWS, IWS, PCR
18	South Branch	WWH, AWS, IWS, PCR
25	Robinson Run	WWH, AWS, IWS, PCR
40	Beards Run	AWS, IWS, PCR
40	Crooked Run	WWH, AWS, IWS, PCR
43	Simmons Run	WWH, AWS, IWS, PCR
43	Flint Run	WWH, AWS, IWS, PCR
43	Darling Run	WWH, AWS, IWS, PCR
43	Mohawk Creek	AWS, IWS, PCR
43	Dutch Run	AWS, IWS, PCR
44	Honey Run	AWS, IWS, PCR
Wills Creek Sub-basin (2014 survey)		
20	White Eyes Creek	AWS, IWS, PCR
20	Brush Run	AWS, IWS, PCR
20	Bacon Run	WWH, AWS, IWS, PCR
21	Center Creek	WWH, AWS, IWS, PCR
21	Twomile Run	WWH, AWS, IWS, PCR
21	Birds Run	WWH, AWS, IWS, PCR
21	Johnson Fork	WWH, AWS, IWS, PCR
21	Indian Camp Run	WWH, AWS, IWS, PCR
22	Sarchett Run	WWH, AWS, IWS, PCR
22	Crooked Creek	PCR
22	Jackson Run	AWS, IWS, PCR
22	Peters Creek	AWS, IWS, PCR
22	Bobs Run	AWS, IWS, PCR
22	North Crooked Creek – all listed segments	AWS, IWS, PCR
23	Fox Creek – all listed segments	AWS, IWS, PCR
23	Dare Run	AWS, IWS, PCR
23	Leatherwood Creek – all listed segments	PCR
23	Infirmary Run	WWH, AWS, IWS, PCR
23	Shannon Run	AWS, IWS, PCR
23	Seneca Fork	WWH, AWS, IWS, PCR
24	Opossum Run	WWH, AWS, IWS, PCR
24	Beaver Creek	WWH, AWS, IWS, PCR

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Page #*	Water Body Segment	Existing Designations Proposed for Verification**
24	Glady Run	WWH, AWS, IWS, PCR
24	South Fork Seneca Fork	WWH, AWS, IWS, PCR
24	North Fork Seneca Fork (Skin Creek)	AWS, IWS, PCR
24	Buffalo Fork	AWS, IWS, PCR
24	Yoker Creek	AWS, IWS, PCR
25	Collins Fork	AWS, IWS, PCR
25	Miller Creek	AWS, IWS, PCR
25	Rannells Creek	AWS, IWS, PCR
25	Buffalo Creek	AWS, IWS, PCR
25	North Fork Buffalo Creek	AWS, IWS, PCR
25	South Fork Buffalo Creek	AWS, IWS, PCR
25	Little Buffalo Creek	AWS, IWS, PCR
Stillwater Creek Sub-basin (2012 survey)		
27	Stillwater Creek – headwaters to Brushy Fork	AWS, IWS, PCR
27	Stillwater Creek – at RM 7.05	WWH, AWS, IWS, PCR
27	Stillwater Creek – all other segments	WWH, AWS, IWS, PCR
27	Little Stillwater Creek – Plum Run (RM 8.77) to Dennison (RM 3.3)	PCR
27	Little Stillwater Creek – at RM 14.55	WWH, AWS, IWS, PCR
27	Little Stillwater Creek – all other segments	WWH, AWS, IWS, PCR
28	Plum Run	WWH, AWS, IWS, PCR
28	Clear Fork	WWH, AWS, IWS, PCR
28	Standingstone Fork	WWH, AWS, IWS, PCR
28	Crooked Creek	WWH, AWS, IWS, PCR
28	Laurel Creek	WWH, AWS, IWS, PCR
28	Watson Creek	WWH, AWS, IWS, PCR
28	Fallen Timber Creek	WWH, AWS, IWS, PCR
28	Weaver Run	WWH, AWS, IWS, PCR
28	Hitchcock Run	WWH, AWS, IWS, PCR
28	Brushy Fork	WWH, AWS, IWS, PCR
29	Elk Run	WWH, AWS, IWS, PCR
29	Atkinson Run	WWH, AWS, IWS, PCR
29	Craborchard Creek	WWH, AWS, IWS, PCR
29	Skull Fork	AWS, IWS, PCR
29	Millers Fork	AWS, IWS, PCR
29	Boggs Fork – headwaters to Holloway (RM 6.35)	AWS, IWS, PCR
29	Boggs Fork – Holloway (RM 6.35) to the confluence with Stillwater Creek	AWS, IWS, PCR
30	Plum Run	AWS, IWS, PCR

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Page #*	Water Body Segment	Existing Designations Proposed for Verification**
30	Trail Run	AWS, IWS, PCR
30	Spencer Creek	WWH, AWS, IWS, PCR
Sandy Creek Sub-basin (2010 survey)		
35	Bear Run	AWS, IWS, PCR
35	Limestone Creek	WWH, AWS, IWS, PCR
36	Indian Run	WWH, AWS, IWS, PCR
36	Little Sandy Creek	WWH, AWS, IWS, PCR
36	Black Run	WWH, AWS, IWS, PCR
36	Middle Run	WWH, AWS, IWS, PCR
37	Armstrong Run	WWH, AWS, IWS, PCR
37	Pipe Run	WWH, AWS, IWS, PCR
37	Hugle Run	WWH, AWS, IWS, PCR
37	Muddy Fork – headwaters to Stony Hollow (RM 3.0)	AWS, IWS, PCR
37	Muddy Fork – Stony Hollow (RM 3.0) to the mouth	WWH, AWS, IWS, PCR
37	Reeds Run	AWS, IWS, PCR
37	Pipes Fork	AWS, IWS, PCR
37	Friday Creek	AWS, IWS, PCR
37	Middle Branch Sandy Creek	WWH, AWS, IWS, PCR
37	Conser Run (Conservation Run)	WWH, AWS, IWS, PCR

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