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.

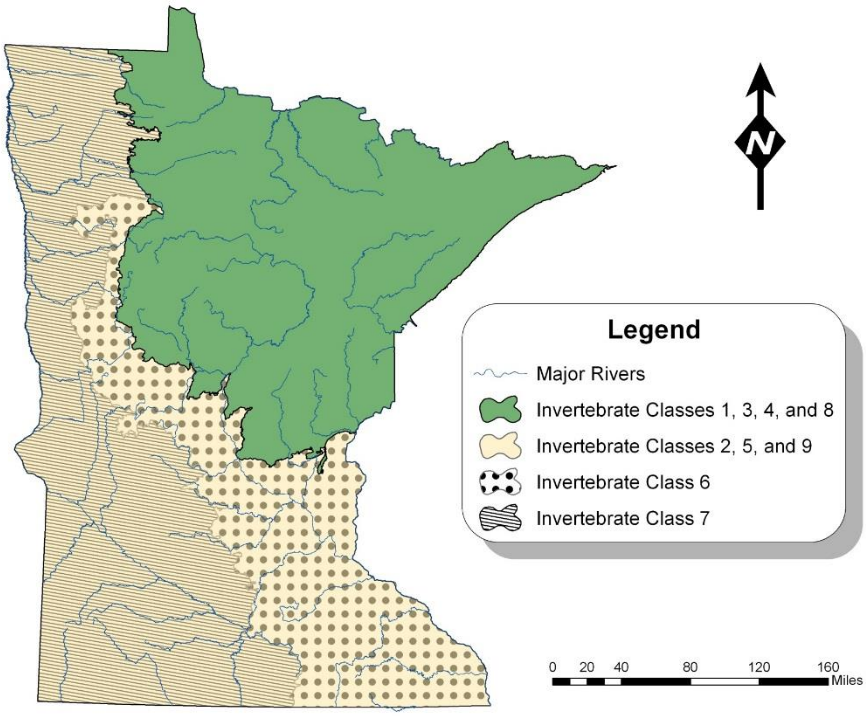

Figure 1. Map of ecological provinces associated with MPCA macroinvertebrate indices of biological integrity (MIBIs).

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 (%)	$\geq$ 5%	< 5%
Gradient of sample reach	> 1	$\leq$ 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 as ceiling and floor values in Appendix F. The documented limits reflect the limits of the metric value; for the purposes of scoring, the limits must be treated similar to the metric value if a needed transformation is indicated. 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: $IBI\ score = sum\ of\ metric\ scores * \frac{10}{\#\ metrics\ in\ IBI}$

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