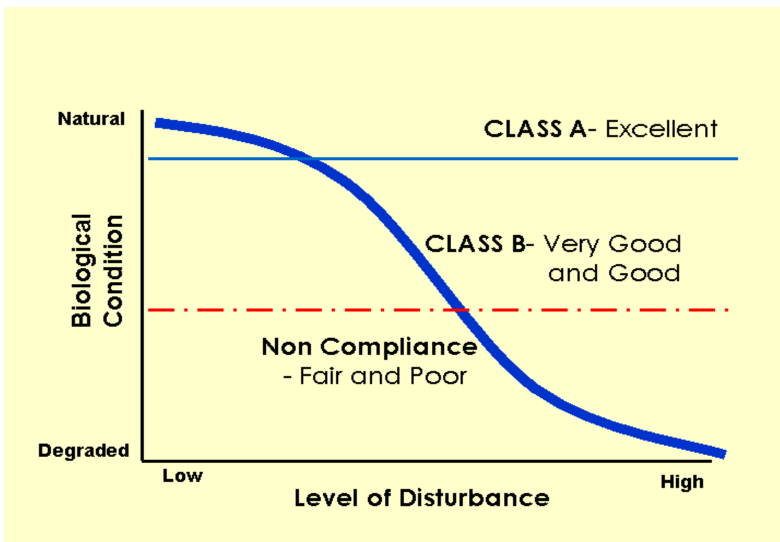
Biocriteria for Fish and Macroinvertebrate Assemblages in Vermont Wadeable Streams and Rivers

-Implementation Phase-



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Biomonitoring and Aquatic Studies Section

Vermont Department of Environmental Conservation
Waterbury, Vermont

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Biocriteria for Fish and Macroinvertebrate Assemblages in Vermont Wadeable Streams and Rivers

-Implementation Phase-

(Methods for Determining Aquatic Life Use Status in Selected Wadeable Streams Pursuant to Applicable Water Quality Management Objectives and Criteria for Aquatic Biota Found in Vermont Water Quality Standards (VWQS) Chapter 3 §3-01, as Well as Those Specified in 3-02(A1 and B3), 3-03(A1 and B3), and 3-04(A1 and B4:a-d)).

1. Summary

These methods describe the methods that the Vermont Department of Environmental Conservation employs for determining aquatic life use support pursuant to applicable management objectives and criteria contained in Chapter 3 of the Vermont Water Quality Standards (VWQS), effective date July 2, 2000. These methods apply only to the evaluation of fish and aquatic macroinvertebrate assemblages in selected wadeable streams. These methods discuss numerical indices descriptive of biological assemblage characteristics and describe how the Vermont Department of Environmental Conservation (VTDEC) uses these indices to determine the status of aquatic biota (fish and macroinvertebrates) in relation to applicable designated uses for aquatic life. Standard operating procedures (SOPs) for fish and macroinvertebrate sampling are described and referenced. Methods for calculating eight aquatic macroinvertebrate metrics and two fish assemblage Indices of Biotic Integrity are described. The general approach for establishing biological criteria is to identify and describe an applicable reference condition and to measure deviation from the reference condition consistent with narrative language in the VWQS's. Guidelines for determining applicable reference conditions are described. Much of the background material for this document is presented in *"Biocriteria for Fish and Macroinvertebrate Assemblages in Vermont Wadeable Streams and Rivers – Development Phase"*, VTDEC 11/14/01 updated 2/10/04.

2. Definitions

Applicable water quality criteria means all criteria specified in §§3-01 of the VWQS, as well as those specified in §§'s 3-02(B), 3-03(B), and 3-04(B) that are applicable to the classification and Water Management Type of the waters in question.

Aquatic biota means all organisms that, as part of their natural life cycle, live in or on waters.

Aquatic habitat means the physical, chemical, and biological components of the water environment.

Aquatic life use support determination means a finding by VTDEC regarding the status of a particular waterbody in regard to its designated uses related to aquatic biota.

Biological integrity means the ability of an aquatic ecosystem to support and maintain, when consistent with reference conditions, a community of organisms that is not dominated by any particular species or functions (balanced), is fully functional (integrated), and is resilient to change or impact (adaptive), and which has the expected species composition, diversity, and functional organization.

Classification means the water quality classification designated for a specific body of water in accordance with the provisions of 10 V.S.A. §§1253.

Evaluation Site means a site on a waterbody at which a determination of aquatic life use support will be made.

Full support of uses, or fully support uses means the achievement of the level of water quality necessary to consistently maintain and protect existing and designated uses.

Functional component of the aquatic ecosystem means a portion of the aquatic biological community identified by its role in the processing of energy within the aquatic ecosystem (e.g., primary producers, predators, detrivores, etc.).

Intolerant aquatic organisms means those organisms which are particularly sensitive to, and likely to be adversely affected by, the stress of pollution, flow modification or habitat alteration (e.g., mayflies and stoneflies).

Natural condition means the condition representing chemical, physical, and biological characteristics that occur naturally with only minimal effects from human influences

Reference condition means the range of chemical, physical, and biological characteristics of waters minimally affected by human influences. In the context of an evaluation of biological indices, or where necessary to perform other evaluations of water quality, the reference condition establishes attainable chemical, physical, and biological conditions for specific water body types against which the condition of waters of similar water body type is evaluated.

Taxonomic component of the aquatic ecosystem means a portion of the biological community identified by a hierarchical classification system for identifying biological organisms that uses physical and biological characteristics (e.g., Insecta: Plecoptera: Perlidae: *Agnetina capitata*).

Tolerant aquatic organisms means organisms (e.g., midges and annelids) that, although they may be affected by the stress of pollution, flow modification or habitat alteration, are less sensitive and less likely to be adversely affected than are intolerant aquatic organisms.

Waters include all rivers, streams, creeks, brooks, reservoirs, ponds, lakes, springs and all bodies of surface waters, artificial or natural, which are contained within, flow through or border upon the State or any portion of it.

3. General Provisions of the Vermont Water Quality Standards - Biological Criteria:

The Vermont Water Quality Standards (adopted June 10, 1999; effective date July 2, 2000) provide the authority and the basis for macroinvertebrate and fish community biocriteria. §§ 3-01 authorizes the Secretary of the Vermont Agency of Natural Resources to "establish and apply numeric biological indices to determine whether there is full support of aquatic biota and aquatic habitat uses" and to "establish procedures that employ standard sampling and analytical methods to characterize the biological integrity of the appropriate reference condition", as well as to measure deviation from the range of reference conditions. §§'s 3-02, 3-03, and 3-04 identify three levels of management objectives and narrative standards for biological integrity based on allowable change from the reference condition. Narrative standards for aquatic biota related to fish and macroinvertebrate assemblages are summarized below:

> *Class A Ecological* - "...within the range of the natural condition"
>
> *Class B Water Management Type I* - "... Limited to minor changes *(from the reference condition)* in the relative proportions of taxonomic and functional components; relative proportions of tolerant and intolerant components are within the range of the reference condition."
>
> *Class A Water Supply and Class B Water Management Types II and III* - "... Limited to moderate changes (*from the reference condition)* in the relative proportions of tolerant, intolerant, taxonomic, and functional components."
>
> *All other Class B Waters* - "... no change from the reference condition that would have an undue adverse effect on the composition of the aquatic biota."

Water Management Types within Class B will require formal designation by the Vermont Water Resources Board. Until such time that Class B Water Management Types have been designated, VTDEC shall interpret the term "undue adverse effect on the composition of the aquatic biota" as being equivalent to the narrative criterion for Class B, Water Management Type II/III waters: "Limited to moderate changes (*from the reference condition)* in the relative proportions of tolerant, intolerant, taxonomic, and functional components " Therefore, subsequent to July 2, 2000, it is the intent of VTDEC to implement biological criteria for fish and macroinvertebrates, as described here, for all Class B waters in a manner equivalent to proposed implementation for Water Management Type II/III waters for aquatic life use. This will provide consistency with historical use of biocriteria and will provide for a consistent transition when water management types become designated.

4. Appropriate Uses of Biological Assessment and Biological Criteria.

Methods for aquatic biota evaluations described here are used to make decisions about the degree to which a wadeable stream water body supports its designated aquatic life uses. Findings of aquatic biota evaluations are most appropriately used to describe ambient, or existing, conditions in relation to the reference condition. Biological evaluations are less useful in establishing permit or activity limits since there are no established predictive tools that are able to characterize, with the needed level of specificity and precision, the effect of a disturbance or perturbation on the specific measures of biological community health typical of biological criteria. Findings of biological aquatic life use assessments may be used to identify types and sources of perturbation, establish baseline conditions, as well as to identify water bodies exceeding their minimal designated aquatic life use criteria, and as such, are potential candidates for reclassification to a higher designated use classification. The following describes the general strengths and weaknesses of biocriteria implementation:

> *Planning*: Biological criteria establish goals for biological integrity in specific classes of water. Assessment of biological integrity using biocriteria provides a means of measuring attainment or progress towards the attainment of those goals. Biological criteria create a valuable tool to provide interactive feedback into water quality planning and management activities, which are implemented with specific objectives related to biological integrity. Biological monitoring and assessment should be an integral part of any watershed management plan. Biomonitoring and biological criteria are an integral component of TMDL process of impairment identification and performance evaluation.
>
> *Assessment:* Biological assessment and the application of biological criteria provide information regarding the attainment of water quality goals and objectives related to biological integrity. Assessment data can measure the success or failure of single or cumulative water quality management activities to restore or enhance biological integrity. Assessment information can provide valuable feedback for evaluating program activities and priorities.
>
> *Permitting:* Biological assessment and biocriteria provide a means of evaluating the performance of restrictions placed on regulated activities (e.g. permit limits, best management practices). Biological assessment information can, in combination with other information, provide feedback to the critical review of regulatory practices. Biological assessment data have limited value for *a priori* permitting decisions, such as setting permit limits, due to the complexity of biological communities and the aquatic habitat in which they live and the unpredictability of biological community response to perturbation or management activities.
>
> *Enforcement:* Biological assessment and biocriteria implementation applied independently can provide clear information regarding site-specific biological impacts. When used in conjunction with additional monitoring activities aimed at identifying with a high degree of certainty a specific discharge or activity causing the observed biological impacts, probable cause can be established and appropriate enforcement action taken.

5. Interaction with Other Water Quality Criteria

All applicable water quality standards and criteria are applied independently. Biological assessment can stand independently as an indicator of impairment for a specific water body. A biological finding of non-impairment, however, does not preclude a finding of water body aquatic life use impairment based on any other applicable water quality standards or criteria. In addition to the macroinvertebrate and fish community criteria presented here, VTDEC may consider additional information related to the support of Aquatic Biota, Wildlife, and Aquatic Habitat consistent with the narrative criteria in §§ 3-02B(3), 3-03B(3), 3-04B(4) of the VWQS's.

6. Sampling

Representative sampling of aquatic macroinvertebrate and fish communities are required for the application of the methods described here. VTDEC staff is the primary source of aquatic life use support data. VTDEC may consider data gathered by qualified non-VTDEC personnel. When conducting biological assessments for the purpose of applying biological criteria as described here, the following shall apply at all times:

A. Sampling Methods. All samples shall be collected following Vermont Department of Environmental Conservation (VTDEC) standard operating procedures (Attachments A and B). These procedures are summarized as follows:

- macroinvertebrate sampling uses a timed kick net method in riffle habitats; all macroinvertebrate sampling for aquatic life use determinations using these specific biocriteria must be conducted during the late summer to early fall index period;

- fish sampling involves electro-shocking over a representative reach of stream; sampling for aquatic life use determinations using these specific biocriteria must be conducted during the late summer to early fall period;

B. Laboratory Methods. All sample processing and analysis shall follow VTDEC standard operating procedures as presented in Attachments A and B and summarized below:

- macroinvertebrate samples shall be preserved in the field and picked, sorted, and identified in the laboratory; sub-sampling must include a minimum of 300 organisms AND a minimum of 25 per cent of the total sample; taxonomy is to the lowest practicable level consistent with VTDEC standard operating procedures.

- fish samples will be processed in the field with specimens released back into the stream; taxonomy is to the species level consistent with VTDEC standard operating procedures.

C. Personnel Qualifications. Sampling, data processing, and data analysis shall be conducted only by qualified personnel. VTDEC staff shall be primarily responsible for all aspects of aquatic life use determinations made according to these methods. Non-DEC personnel who gather, process, and analyze data for aquatic life use determinations pursuant to these methods must provide DEC with an appropriate demonstration of quality assurance prior to submitting data for determinations. An "appropriate demonstration" shall be determined on a case-by-case basis with the goal of providing assurance that information of adequate representativeness, precision, and accuracy can be generated. All data used for making aquatic life use determinations pursuant to these methods must be approved by the VTDEC (see *Sections 10 and 11*).

D. Use of Non-compliant Assessment Data. Macroinvertebrate and fish community monitoring data that are not gathered in a manner entirely consistent with the considerations in A-C above shall not preclude the VTDEC from using those data to evaluate aquatic life use support status. Situations, which may require such an evaluation, include, but are not limited to, short-term impacts related to catastrophic events such as spills or accidental releases of toxic materials, which occur outside the sampling index period requiring rapid response. Findings related to aquatic life use support shall be based on the establishment of a compelling weight-of-evidence argument derived from monitoring data and best professional judgement. Such evaluations shall be conducted in a manner consistent with established principles of water pollution biology and shall be fully documented.

7. Determining the Reference Condition.

The criteria presented in these methods were derived from descriptions of the range of reference conditions for macroinvertebrate and fish communities inhabiting certain categories of wadeable streams. The range of reference conditions have been determined using monitoring data collected and analyzed by VTDEC from minimally impacted wadeable stream sites representing a variety of stream and watershed physical and chemical characteristics (VTDEC, 2/10/04a).

A. *Reference Condition for Three Macroinvertebrate Community Stream Categories* (The descriptive statistics presented here refer to average values within the reference streams evaluated by VTDEC for each category - see **Table 1**).

1. Small High Gradient Streams (SHG) – Small, first to third order headwater streams, typically over 1500 ft elevation, and highly canopied (83% average canopy cover). They are high in gradient, and as a result, their substrate is dominated by gravel/cobble/boulder with generally only about 3% fines. The drainage areas average 10 km^2, and the water chemistry is relatively soft, with alkalinity averaging less than 20 mg/l.

2. Medium-size High Gradient Streams (MHG) -Medium-sized streams in the third to fourth order range, typically found at moderate elevations averaging 814 ft, with an average of 50% canopy. The gradient is high with the substrate dominated by gravel/cobble/boulder averaging 6% fines. The drainage areas average 88 km^2, and the water chemistry is usually moderate in alkalinity averaging 48 mg/l.

3. Warmwater Medium Gradient Streams and Rivers (WWMG) - Larger streams, fourth to sixth order in size OR small streams within the Champlain Valley, all at lower elevations averaging 369 ft. Typically more open, averaging 30% canopy cover, and warmer based on the dominant species. Gradients are moderate with substrates dominated by gravel/cobble/boulder, and averaging 7% fines. The drainage areas can range widely but are often quite large (with the exception of Champlain Valley streams with small watersheds) with an average size of 480 km^2. Alkalinities are typically high, averaging 70 mg/l.

Macroinvertebrate criteria have been developed by the VTDEC that are stream category specific. Other macroinvertebrate stream categories have been identified but current data are insufficient to adequately describe the range of reference conditions for macroinvertebrate communities. The criteria presented here shall be applicable to all streams that can be appropriately designated as one of the three macroinvertebrate stream categories described above.

B. *Reference Condition for Two Stream Categories for Fish Community Metrics*. The reference condition for fish communities in wadeable streams has been established for two stream categories through the development of two biological indices for Vermont wadeable streams. The Cold Water Index of Biological Integrity (CWIBI) is applied to small coldwater streams. The Mixed Water Index of Biological Integrity (MWIBI) is applied to warmwater and medium-sized coldwater sites. In developing these indices, VTDEC has utilized monitoring data from minimally impacted (reference) stream sites to calibrate the community measurements that make up each index. Prior to using an IBI for evaluating aquatic life use support, the applicable IBI for the site being evaluated must be identified as described in *Section 11* of this document.

8. Determination of Macroinvertebrate Community Stream Category and Criteria Applicability Evaluation

The macroinvertebrate methods for evaluating aquatic life use support described here will be applicable only in situations where the evaluation site has been properly identified as belonging to one of the three macroinvertebrate stream categories described above: SHG, MHG, or WWMG. VTDEC shall make determinations of site categorization by comparing site chemical and physical characteristics with the range of comparable conditions found in reference streams. When making a site categorization evaluation, VTDEC shall include, but not be limited to, consideration of the following factors (see **Table 1**): elevation; drainage area; stream order/size; stream gradient and substrate composition; pH and alkalinity; specific conductance; unique characteristics of the site. Certain characteristics of a site may affect the ability of the Department to place a site into one of the three categories with a high degree of confidence. Examples which may influence categorization/applicability determinations include, but are not limited to: lake outlets; sites where chemical and/or physical attributes are well beyond the range of the described reference condition (e.g. extremely small drainage area, extremely high elevation).

A site categorization evaluation by VTDEC, with consideration to the factors listed above, shall result in a finding that:

> A.- the site belongs to one of three macroinvertebrate stream categories. The site will be assigned by VTDEC to its most probable macroinvertebrate stream category and the appropriate criteria will be applicable to aquatic life use support evaluations of the site. VTDEC shall use a weight of evidence approach in assigning water bodies to their appropriate category.
>
> OR
>
> B.- the site cannot be placed into any of the three macroinvertebrate stream categories with a high degree of confidence These methods and criteria may not be applicable entirely or in part to aquatic life use support evaluations of a stream site. The VTDEC will use alternative analyses to make determinations of aquatic life use support. In developing alternative analyses, the VTDEC shall give full consideration to identifying appropriate biological communities to evaluate, and to describing the appropriate reference condition for evaluating those communities. In evaluating appropriate reference conditions, VTDEC must describe the range of chemical, physical, and biological characteristics of waters minimally affected by human influences that reasonably establish attainable chemical, physical, and biological conditions for the specific water body under evaluation. When describing the appropriate reference condition, VTDEC may include, but not be limited to, consideration of the following:
>
> - historical monitoring data from the same, adjacent, or similar water body;
> - regional reference sites;
> - site-specific reference sites (e.g. new data gathered from similar water bodies upstream of or adjacent to the evaluation site);
> - paleo-ecological data (eg evidence of historical ecological conditions preserved in sediments)
> - quantitative models developed from field, historical, and experimental laboratory data;

VTDEC stream categorization decisions will be based on a weight of evidence approach determining the most probable categorization and criterion applicability. Because the criteria presented in this document are derived from a range of reference sites with known physical and chemical characteristics, as summarized in **Table 1**, these criteria shall not be generally applicable to sites that exhibit characteristics that are not represented in the reference data base.

Findings related to aquatic life use support in non-categorized waterbodies shall be based on the establishment of a compelling weight-of-evidence argument derived from monitoring data and best professional judgement. Such evaluations shall be conducted in a manner consistent with established principles of freshwater ecology and water pollution biology, and shall be fully documented.

Table 1. Physico-chemical attributes of the three macroinvertebrate community categories. Data reported as the mean and minimum- maximum. Stream community types with the same letter are not significantly different ($p<0.05$; Kruskall-Wallis non-parametric ANOVA and the Dunn's's multiple comparison test).

Parameter/ Community Type	SHG n=23	MHG n=43	WWMG n=18
Drainage area (km^2)	10.5 0.6-95 A	87.5 1-513 B	480 10-1781 C
Elevation (ft)	1535 840-2500 A	814 290-1624 B	369 140-900 C
% Canopy Cover	82.6 30-100 A	45 10-90 B	29 10-80 B
% Fines (sand/silt)	3.2 0-12 A	5.9 0-15 AB	7.2 3-12 B
Dominant Substrate Size Category*	5.1 3-6 A	5.0 4-6 A	5.0 5-6 A
Velocity ft/sec	1.4 0.75-2.8 A	1.4 0.8-2.3 A	1.5 0.5-2.0 A
Order	1.5 1-3 A	2.8 1-4 B	3.6 1-5 C
pH	7.09 6.29-8.07 A	7.59 6.46-8.38 B	7.93 6.95-8.41 B
Alkalinity (mg/l)	18 3-99 A	48 2.8-127 B	69 10-154 B
Conductivity (umhos)	56 19-206 A	127 22-293 B	209 53-450 BC

* The Dominant Substrate size was assigned a ranking from 1-6. 1=silt, 2=sand, 3=gravel, 4=coarse gravel, 5=cobble, 6=boulder.

9. Determination of the Applicability of a Fish Index of Biotic Integrity (IBI)

The fish community methods for evaluating aquatic life use support described here will be applicable only in situations where the most appropriate IBI for the evaluation site has been properly identified with a reasonable level of confidence.

A. *The Cold Water Index of Biotic Integrity (CWIBI)* should only be applied to coldwater streams with the potential to support two to four native, naturally reproducing species of fish.

B. *The Mixed Water Index of Biotic Integrity (MWIBI)* should be applied to all other streams with the potential to support five or more native, naturally reproducing species of fish.

C. For warmwater sites without the potential to support five or more native, naturally reproducing species and cold water sites without the potential to support two or more native, naturally reproducing species, *neither the CWIBI nor the MWIBI* can be applied, and alternative analyses, as described in *Section 8* of this document, will be used to evaluate aquatic life use support.

For the purposes of IBI applicability, in the absence of clear and convincing evidence to the contrary, all sites above 500 feet in elevation and all sites in the Connecticut River drainage (excluding the main stem of the Connecticut River and lower reaches of the West River) shall be considered cold water; all sites below 500 feet in elevation shall be considered warm water unless shown to support cold water species. Guidelines for IBI application are outlined in **Attachment A – Fish Community Methods**.

10. Macroinvertebrate Methods and Criteria for Three Categories of Wadeable Streams.

A. *Measures of the Biological Integrity*. Eight macroinvertebrate community metrics have been selected to evaluate aquatic life use support in each of the three macroinvertebrate community stream categories. For each measure, or metric, the range of values found in the reference data base and in a set of impacted streams for each stream category have been determined. These distributions have been used to select values which represent the range of the reference condition as well as “minor” and “moderate changes from the reference condition” pursuant to the VWQS’s. The eight metrics and the method of calculating them are described below (more detail regarding the calculation of each metric is provided in **Attachment B - Macroinvertebrate Community Methods**). The metrics have been selected to measure a variety of macroinvertebrate community characteristics, including: tolerance and intolerance; taxonomic structure; and functional structure.

1. Density (general indicator of community viability and productivity) - Density is the relative abundance of animals in a sample (density per unit sampling effort).

2. Richness (indicator of taxonomic structure) - Species richness is the number of species in a sample unit. Richness is calculated as the total number of distinct taxa identified in a sample (calculated as the mean if multiple replicates are evaluated).

3. EPT Index (indicator of taxonomic structure and tolerance/intolerance) - The EPT index is a subset of the above richness measure. EPT is calculated as the number of distinct taxa from the generally more environmentally sensitive insect orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) identified in a sample unit (calculated as the mean if multiple replicates are evaluated).

4. Percent Model Affinity of Orders -PMA-O (indicator of taxonomic structure)- PMA-O is a measure of order-level similarity to a model based on the reference streams (Novak and Bode, 1992). PMA-O is calculated by determining the percent composition for each major group - Coleoptera, Diptera, Ephemeroptera, Plecoptera, Trichoptera, Oligochaeta, Other - at the assessment site and comparing them to the mean percent composition values from the reference condition (model developed by VTDEC for each stream category). The model order percentages are then arrayed with the assessment site order percentages. The sum of the lower of the two values for each order is the PMA-O.

$$\text{PMA-O} = 3 \ \min (X_a \text{ or } X_r)$$

Where:
- X_a = the percent composition of order X from the assessment site;
- X_r = the percent composition of order X from the appropriate reference condition;

5. Hilsenhoff Biotic Index- HBI 0-10 (indicator of tolerance/intolerance) - The BI is a measure of the macroinvertebrate assemblage tolerance toward organic (nutrient) enrichment (Hilsenhoff, 1987). The BI is calculated by multiplying the number of individuals of each taxon in a sample by its assigned tolerance (bioindex) value (as assigned by VTDEC after Hilsenhoff 1987, Bode 1996); the total of all these taxon/tolerance value products divided by the total number of individuals of all taxa assigned a tolerance value is the BI value.

$$\text{HBI} = 3 \ \frac{n_i a_i}{N}$$

Where: "n" is the number of individuals of the "i"th taxon;
"a" is the index value of that taxon;
N is the total number of individuals in the sample;

6. Percent Oligochaeta (indicator of tolerance/intolerance) - The percent Oligochaeta is a measure of the percent of the macroinvertebrate community made up of the order Oligochaeta. Percent Oligochaeta is calculated by dividing he number of individuals (abundance) of the order Oligochaeta by the total number of animals in the sample.

7. EPT/EPT + Chironomidae (indicator of taxonomic structure and tolerance/intolerance) - EPT/EPT + C is a measure of the ratio of the abundance of the intolerant EPT orders to the generally tolerant Diptera family Chironomidae. EPT/EPT + C is calculated by dividing the number (relative abundance) of animals from the orders Ephemeroptera, Trichoptera and Plecoptera, by the above plus the number (relative abundance) of animals of the order Chironomidae in the sample.

8. Pinkham-Pearson Coefficient of Similarity - Functional Groups - (PPCS-F - indicator of functional structure) - The PPCS-F is a measure of functional feeding group similarity to a model based on the reference streams. It is similar in concept to the PMA-O above, however, it measures functional feeding group changes instead of taxonomic changes to the macroinvertebrate assemblage. PPCS-F is calculated by first determining the percent composition of the six major functional groups (collector gatherer, collector filterer, predator, shredder-detritus, shredder-herbivore, scraper) as assigned by VTDEC after Merrit and Cummins (1996) and Bode (1996) at the assessment site. For each functional group determine the quotient of min/max between the assessment site and the reference model (as developed by VTDEC) for the stream category. The sum of these quotients divided by six (# of functional groups) is the PPCS-F.

$$\text{PPCS-F} = 1/k \sum_{I=1}^{K} \text{minimum}(xia, xib)/\text{maximum}(xia, xib)$$

Where: k = the number of comparisons between stations (6);
xi = the number of individuals in functional group I;
a, b = site a, site b;

B. Threshold Criteria for Macroinvertebrate Metrics. **Table 2** identifies threshold values for each macroinvertebrate metric for each management objective for each macroinvertebrate stream category. These threshold values were derived from the distribution of metrics within reference and impacted data sets with minor adjustments based on best professional judgement of VTDEC staff. These threshold values will form the basis for evaluating aquatic life use support using macroinvertebrate community data. The threshold values appearing in **Table 2** represent a single point in a continuum of values reflecting change from reference condition. These numbers are not intended to be used as absolute discriminators of aquatic life use support status. These values are to be used in the context of a general weight of evidence decision process incorporating factors such as: sampling and natural variability of the test data; data quality; representativeness of the data; other relevant information (such as historical chemical, physical, or biological data) available for the evaluation site. These values have been selected with the intent of minimizing the potential for making incorrect decisions regarding aquatic life use support status at evaluation sites and to be as consistent as possible with historical biocriteria implementation.

1. The *Class A* criteria were initially set to include at least the upper 75th percentile of the reference site distribution for those metrics which decrease with impairment or lower 25th percentile value for those metrics which increase with impairment for each stream type. The criteria were then slightly adjusted based on the best professional judgement of VTDEC staff.

2. The *Class B WMT 1* threshold criteria were initially set to include at least the upper 95th percentile of the reference site distribution for those metrics which decrease with impairment or lower 5th percentile value for those metrics which increase with impairment for each stream category. The criteria were then slightly adjusted based on the best professional judgement of VTDEC staff.

3. The *Class A-Water Supply and Class B-WMT 2, -WMT 3* threshold criteria were generally set outside the 95th/5th percentiles or range (depending on the nature of the outliers) of the reference site distribution for each stream type. The criteria were then adjusted based on the median, and 10th / 90th percentiles from sites known to be impaired plus best professional judgment of VTDEC staff.

4. Not all metrics will demonstrate impairment at a site known to be impaired. Different pollutant types will often only effect certain aspects of macroinvertebrate community structure or function, and is the reason why a number of metrics are used independently to ensure the protection of both the structural and functional integrity of the community.

C. *Considerations for Evaluating Macroinvertebrate Monitoring Data:* The following considerations will be used when evaluating monitoring data to assess aquatic life use support status in applicable wadeable stream categories as described herein pursuant to the Vermont Water Quality Standards:

1. *Determination of Applicable Stream Category.* The chemical and physical attributes of the evaluation site will be assessed in order to determine which if any of the three wadeable stream macroinvertebrate categories are applicable. In making this determination, VTDEC will evaluate the primary variables that best describe the stream categories. These variables include: site elevation, drainage area, temperature, pH/alkalinity, specific conductance, stream order, percent canopy, and substrate composition.

2. *Data Quality Evaluation.* Prior to being used for making determinations of aquatic life use support, VTDEC will evaluate the quality of the data. The threshold criteria presented here are derived from data gathered according to specific methodologies. Therefore, these threshold criteria cannot be reasonably applied to data gathered in a manner other than those specified in these methods. In assessing data quality, VTDEC shall consider the following:

a. Personnel qualifications: individuals submitting data to VTDEC for assessment pursuant to these methods shall be required to provide to VTDEC a demonstration of their qualifications for review by VTDEC.

b. Consistency with standard operating procedures: VTDEC must verify that all data collection, sample processing, and sample analysis methods are consistent with VTDEC standard operating procedures.

c. Sample representativeness: VTDEC must confirm the absence of circumstances surrounding the collection and analysis of the data that could result in findings that are not representative of the average conditions at the evaluation site. Such circumstances could include: extreme hydrological, meteorological, or other cataclysmic events prior to sampling; sampling errors.

d. Sample variability: samples with excessive sampling variability will be rejected for further analysis. In general, abundance estimates with a percent standard error of forty of less (%SE =<40%) will be acceptable. Variability in exceedence of 40% will be evaluated on a case-by-case basis to determine acceptability. In general, abundance estimates with a percent standard error in excess of 75% will be rejected.

Table 2. Macroinvertebrate assemblage biocriteria thresholds for three macroinvertebrate community stream categories, and associated WQ Classes or Management Types in Vermont. Extreme departures from the criteria thresholds indicate either a very poor biological condition or an assemblage of exceptionally high value.

	Small-size High Gradient Streams (SHG)			Medium-size High Gradient Streams (MHG)			Warm Water Medium Gradient Streams and Rivers (WWMG)		
WQ Class	A1 (ecological)	B - WMT1	B B - WMT 2-3 A2 (water supply)	A1 (ecological)	B - WMT 1	B B - WMT 2-3 A2 (water supply)	A1 (ecological)	B - WMT 1	B B - WMT 2-3 A2 (water supply)
Metric	Reference Condition	Minimal Change from the Reference Condition	Moderate Change from the Reference Condition (undue adverse effect)	Reference Condition	Minimal Change from the Reference Condition	Moderate Change from the Reference Condition (undue adverse effect)	Reference Condition	Minimal Change from the Reference Condition	Moderate Change from the Reference Condition (undue adverse effect)
Richness	> 35	> 31	> 27	> 43	> 39	> 30	> 40	> 35	>30
EPT	> 21	>19	> 16	> 24	> 22	> 18	> 21	> 19	> 16
PMA-O	>65	> 55	> 45	> 65	> 55	> 45	> 65	> 55	> 45
BI	< 3.00	< 3.50	< 4.50	< 3.50	< 4.00	<5.00	< 4.25	< 4.75	< 5.40
% Oligo	< 2	< 5	< 12	< 2	< 5	< 12	< 2	< 5	< 12
EPT/ EPT+C	> 0.65	> 0.55	> 0.45	> 0.65	> 0.55	> 0.45	> 0.65	> 0.55	> 0.45
PPCS-FG	> 0.50	> 0.45	> 0.40	> 0.50	> 0.45	> 0.40	> 0.50	> 0.45	> 0.40
Density	>500	>400	>300	>500	>400	>300	>500	>400	>300

3. *Data Rejection Alternatives:* If evaluation data are rejected under any of considerations a-d above, the VTDEC may require re-sampling of the test site following the development of an appropriate Sampling and Quality Assurance Plan. VTDEC may issue an interim aquatic life use support finding until completion of acceptable re-sampling. Interim findings will be weight-of-evidence based on evaluation of all known chemical, physical, and biological data available for the test site. Macroinvertebrate community monitoring data that are not gathered in a manner entirely consistent with the considerations in a-d above may be considered by the VTDEC on a situational basis for the purpose of evaluating aquatic life use support. Situations which may require such an evaluation include but are not limited to short term impacts related to catastrophic events such as spills or accidental releases of toxic materials, or unanticipated enforcement or performance evaluations requiring rapid response. Findings related to aquatic life use support shall be based on the establishment of a compelling weight-of-evidence argument derived from monitoring data and best professional judgement. Such evaluations shall be conducted in a manner consistent with established principles of water pollution biology and shall be fully documented.

4. *Determination of Support Status:* Following a determination of data acceptability, the macroinvertebrate community metrics described in *Section 10* of this document are calculated, VTDEC will make an aquatic life use support determination. Such a determination shall take into consideration the following **Tables 3-5** and procedural guidelines as outlined in D below.

*D. Guidelines for Using **Tables 3-5** to Evaluate Macroinvertebrate Monitoring Data When Making Determinations of Aquatic Life use Support.*

1. The indeterminate range represents a method error bar around the threshold values from **Table 2**. The range represents sampling and analytical error and is estimated by applying plus or minus the mean relative standard error (%SE) as calculated from 546 replicate kick net samples to the threshold value. Mean %SE's for the metrics are: Density - 13%; Richness - 5.5%; EPT - 7.7%; BI - 3.5%; ept/ept+Chiro - 3.5%; PMA-O - (est 10%); % Oligo - 20-50%; PPCS-F - (est.10%);

2. The total number of *pass*, *fail*, and *indeterminate* scores will form the basis of determining aquatic life use support status based on macroinvertebrate community analysis. The DEC will make one of the following findings: The site 1) "supports" aquatic life use; 2) does "not support" aquatic life use; 3) "support" status is indeterminate with tendency toward "support" or "non-support". While considerable best professional judgement must be applied when determining status, the following guidelines will be generally applied.

a) Aquatic life use is *"fully supported*" when:

1. Five or more metrics are scored *pass* AND no metrics are *below* the threshold values;

b.) Aquatic Life Use is *"not supported"* when:

1. One or more metrics are scored *fail*;

c.) In situations where neither of the conditions in a) and b) above are met, DEC will make an *"indeterminate"* finding, indicating "stress" and require further assessment. *Indeterminate* findings may be qualified by a *plus* or *minus* designation, indicating a tendency toward support or non-support status. These tendency indicators will be considered by the Department when evaluating data. An "indeterminate" finding may be modified to full support" or "non-support" findings based on convincing additional weight-of-evidence evaluation by VTDEC.

E. Aquatic Life Use Support Data Evaluation - Case Examples

The following three case examples are intended to demonstrate how VTDEC evaluates macroinvertebrate monitoring data and utilizes the threshold criteria in **Table 2** to make appropriate decisions regarding the support of aquatic life uses. The three examples illustrate the three endpoints described above: 1) non-support (Joiner Brook); 2) full support (Batten Kill); and 3) indeterminate (stress) (Lamoille River).

Example Support Status Determination - Macroinvertebrates, Joiner Brook Tributary: Class B Water Classification

Data were collected on a tributary to Joiner Brook following a report of erosion from a logging site entering the stream and potentially causing a violation of water quality standards. The intent of the sampling was to determine aquatic life use support status in the area affected by sediment from the logging operation. Macroinvertebrates were sampled in accordance with applicable methods and protocols. The following example demonstrates the process of analyzing macroinvertebrate data for the purpose of determining aquatic life use support.

1. *Stream Category Determination* - the characteristics of this site , including drainage area, elevation, substrate composition, stream order and size, alkalinity and specific conductance indicate a small high gradient stream. There are no unusual characteristics that would suggest site uniqueness. Therefore, *most probable stream category is Small High Gradient (SHG).*

2. *Data Quality Evaluation* - Data were collected by VTDEC using all applicable sampling and analytical methods. Percent standard error of density estimate less than 40%. Precedent hydrological and meteorological conditions normal. *Data quality acceptable.*

3. *Aquatic Life Use Support Determination* - The eight criteria metrics were calculated and are presented in **Table 3a** below. These metric scores are compared to the appropriate table values (**Table 3**) for stream category (SHG) and stream classification (Class B = WMT 2-3). Six metrics are in the pass range, none in the indeterminate range, and two metrics fall into the fail range. The failure of two metrics, particularly density and the low diversity of intolerant taxa (EPT), indicate that a finding of non-support would be appropriate.

4. An evaluation of these data in relation to higher classification criteria provides information regarding the degree of impact at this site. Three additional metrics - % Oligochaete, EPT/EPT & Chironomid, and functional similarity (PPCS-F) - become “indeterminate” when compared to WMT1 criteria; no metrics indicate “full support” of Class A aquatic life uses. This suggests that whatever is impacting this site is affecting the macroinvertebrate community both structurally and functionally, with the most significant effects on overall density and intolerant organisms with secondary effects on functionality.

5. The non-support status is relatively marginal. VTDEC commonly uses a qualitative descriptor to characterize finding. On the non-support scale of fair, poor or very poor, this site would rank as fair, based on criteria performance.

Table 3 a-b. Macroinvertebrate Scoring Guidelines - Wadeable Stream Category Small High Gradient (SHG). Case example: Data from a tributary to Joiner Brook near Bolton, VT (**Table 3a**) are scored here as a case example. Joiner Brook tributary is presently a Class B water and would be required to meet the Class B-2,3 WQ management scoring guidelines. Biocriteria threshold values (from **Table 2**) are in italics. If a metric value falls very near the threshold value, between the pass and fail it is scored as Indeterminate + or **-** . The score for each metric for each water class or management type is marked in bold in **Table 3a**. **Table 3b** presents the Joiner Brook metric values, resulting scores, and summary of scores for each WQ management class in the far right column. For example, in the Class A-1 classification, no metrics pass, 3 are indeterminate 1+ , 2-, and five metrics fail. For Class B, Water Management Type 1, three metrics pass, three are indeterminate 2+,1-, and two fail.

For Classes B-2,3 and A-2, six metrics pass and two metrics fail. The resulting determination is non-support (fair aquatic life support.

Table3a

WQ Class (SHG)	Scoring Guidelines	Density	Richness	EPT	PMA-O	B.I.	%Oligo	EPT/ EPT&c	PPCS-F
A-1	Full Support	>605	>36	>22	>70	<2.70	<1	>0.67	>0.55
	Threshhold Indet +-	*500*	*35*	*21*	***65***	***3.00***	*2*	*0.65*	***0.50***
	Non-Support	**<450**	**<34**	**<20**	<60	>3.30	**>3**	**<0.63**	<0.45
B-WMT1	Full Support	>450	**>32**	>20	**>60**	**<3.35**	<3.5	>0.57	>0.50
	Threshhold Indet +-	*400*	*31*	*19*	*55*	*3.50*	***5***	***0.55***	***0.45***
	Non-Support	**<350**	<30	**<18**	<50	>3.65	>6.5	<0.53	<0.40
B-WMTT2, 3 & A2	Full Support	>350	**>28**	>17	**>50**	**<4.35**	**<9.5**	**>0.47**	**>0.45**
	Threshhold, Indet +-	*300*	*27*	*16*	*45*	*4.50*	*12*	*0.45*	*0.40*
	Non-Support	**<250**	<26	**<15**	<40	>4.65	>14.5	<0.43	<0.35

Table 3b

River/ Support Status	WQ-Class	Density	Richness	EPT	PMA-O	B.I.	%Oligo	EPT/EPT&c	PPCS-F	Scoring Total		
										S	I(+,-)	NS
Joiner Brook Trib 0.4	B	160	33	14	62.9	2.87	4	0.54	0.48			
	A-1	NS	NS	NS	I-	I+	NS	NS	I-	0	1+,2-	5
	B-1	NS	S	NS	S	S	I+	I-	I+	3	2+,1-	2
Non-Support (Fair)	**B, B-2&3 A2**	**NS**	**S**	**NS**	**S**	**S**	**S**	**S**	**S**	**6**	**0**	**2**

Example Support Status Determinations - Macroinvertebrates, Batten Kill near Arlington, VT: Class B Water Classification

Data were collected from the Batten Kill near Arlington, VT. The Batten Kill is a high quality natural (populations of salmonids not augmented by stocking) cold water fishery. While there is some development in the watershed, including a small waste water treatment facility, the site is presumed to be only slightly impacted by human activity. Recent declines in brown trout populations in the Kill have stimulated interest in evaluating the biological health of the river. Macroinvertebrates were sampled in accordance with applicable methods and protocols. The following example demonstrates the process of analyzing macroinvertebrate data for the purpose of determining aquatic life use support.

1. *Stream Category Determination* - the characteristics of this site , including drainage area, elevation, substrate composition, stream order and size, alkalinity and specific conductance indicate a medium-size high gradient stream. There are no unusual characteristics that would suggest site uniqueness. Therefore, *most probable stream category is medium high gradient (MHG).*

2. *Data Quality Evaluation* - Data were collected by VTDEC using all applicable sampling and analytical methods. Per cent standard error of density estimate less than 40%. Precedent hydrological and meteorological conditions normal. *Data quality acceptable*.

3. *Aquatic Life Use Support Determination* - The eight criteria metrics were calculated and presented in the **Table 4a** below. These metric scores are compared to the appropriate table values (**Table 4**) for stream category (MHG) and stream classification (Class B = WMT 2-3). All eight metrics score well into the pass range; this site supports its aquatic life use designation.

4. The data also indicate that the Batten Kill supports a biological condition, as measured by macroinvertebrate community metrics, of higher biological integrity than its current classification (Class B) designated use for aquatic biota, very likely supporting the Class A designated use characteristics (within the range of the natural condition).

Table 4 a-b. Macroinvertebrate Scoring Guidelines - Wadeable Stream Category ***Medium High Gradient (MHG)***.
Case example: Data from The Batten Kill (**Table 4a**) are scored here as a case example. The Batten Kill is presently a WQ Management Class B water and would be required to meet the Class B-2,3 WQ management scoring guidelines. Biocriteria threshold values (from **Table 2**) are in italics. If a metric value falls very near the threshold value, between the pass and fail, it is scored as Indeterminate + or **-** . The score for each metric for each water class or management type is marked in bold in **Table 4a. Table 4b** presents the Batten Kill metric values, resulting scores, and summary of scores for each WQ management class in the far right column. For example, in the Class A-1 classification, 6 metrics Pass, 2 metrics Indeterminate +. For Class B,Water Management Type 1, all 8 metrics Pass.

For Classes B-2,3 and A-2, all 8 metrics pass. The resulting determination is Full Support well above its present WQ management class (Very Good-Excellent aquatic life support).

Table4a

WQ Class (MHG)	Scoring Guidelines	Density	Richness	EPT	PMA-O	B.I.	%Oligo	EPT/ EPT&c	PPCS-F
A-1	Full Support	**>605**	**>45**	>26	**>70**	**<3.35**	<1	**>0.67**	**>0.55**
	Threshhold Indet +-	*500*	*43*	***24***	*65*	*3.50*	***2***	*0.65*	*0.50*
	Non-Support	<450	<41	<22	<60	>3.80	>3	<0.63	<0.45
B-T1	Full Support	**>450**	**>41**	**>24**	**>60**	**<3.85**	**<3.5**	**>0.57**	**>0.50**
	Threshhold Indet +-	*400*	*39*	*22*	*55*	*4.00*	*5*	*0.55*	*0.45*
	Non-Support	<350	<37	<20	<50	>4.15	>6.5	<0.53	<0.40
B-T2,3 & A2	Full Support	**>350**	**>32**	**>20**	**>50**	**<4.85**	**<9.5**	**>0.47**	**>0.45**
	Threshhold, Indet +-	*300*	*30*	*18*	*45*	*5.00*	*12*	*0.45*	*0.40*
	Non-Support	<250	<28	<16	<40	>5.15	>14.5	<0.43	<0.35

Table 4b

River/ Support Staus	WQ-Class	Density	Richness	EPT	PMA-O	B.I.	%Oligo	EPT/EPT&c	PPCS-F	Scoring Total		
										S	I(+,-)	NS
Batten Kill 34.9	B	2206	54	25.5	84	3.35	1.1	0.82	0.70			
	A-1	S	S	I+	S	S	I+	S	S	6	2+	0
	B-1	S	S	S	S	S	S	S	P	8	0	0
Full Support (very good-excellent)	**B, B-2&3 A2**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**8**	**0**	**0**

Example Support Status Determinations - Macroinvertebrates, Lamoille River near Georgia, VT: Class B Water Classification

Data were collected from the Lamoille River near Georgia, VT, just upstream of Arrowhead Mountain Reservoir. The Lamoille River is a relatively large river supporting a mixed-water fishery. The intent of the sampling was to determine aquatic life use support status. There were no known sources of significant impact affecting this site. Macroinvertebrates were sampled in accordance with applicable methods and protocols. The following example demonstrates the process of analyzing macroinvertebrate data for the purpose of determining aquatic life use support.

1. *Stream Category Determination* - the characteristics of this site , including drainage area, elevation, substrate composition, stream order and size, alkalinity and specific conductance indicate a warmwater medium gradient stream. There are no unusual characteristics that would suggest site uniqueness. Therefore, *most probable stream category is Warmwater Medium Gradient (WWMG).*

2. *Data Quality Evaluation* - Data were collected by VTDEC using all applicable sampling and analytical methods. Percent standard error of density estimate less than 40%. Precedent hydrological and meteorological conditions normal. *Data quality acceptable.*

3. *Aquatic Life Use Support Determination* - The eight criteria metrics were calculated and are presented in **Table 5a**. These metric scores are compared to the appropriate table values (**Table 5**) for stream category (WWMG) and stream classification (Class B = WMT 2-3). Seven metrics score into the full support range and one metric (PPCS-F) in the indeterminate range with tendency toward fail. No metrics fail - the site does not categorically fail to support aquatic life use. Because the indeterminate metric falls below the threshold criterion (mid-point of the range) the site does not categorically fully support aquatic life use. This site would merit an indeterminate finding with continued assessment needed. (Note: A return sample the following year showed all metrics in the "full support" range for a finding of full support.)

4. These data do not indicate that the Lamoille River at this location is supporting a biological condition, as measured by macroinvertebrate community characteristics, of higher biological integrity than its current designated use for aquatic biota. Overall impacts are greater than seen in the Batten Kill but less than those observed in the Joiner Brook Tributary.

Table 5 a-b. Macroinvertebrate Scoring Guidelines - Wadeable Stream Category ***Warm Water Medium Gradient (WWMG)***.
Case example: Data from the Lamoille River (**Table 5a**) are scored here as a case example. The Lamoille River is presently aWQ Management Class B water and would be required to meet the Class B-2,3 WQ management scoring guidelines. Biocriteria threshold values (from **Table 2**) are in italics. If a metric value falls very near the threshold value, between the pass and fail, it is scored as Indeterminate + or **-** . The score for each metric for each water class or management type is marked in bold in **Table 5a**. **Table 5b** presents the Lamoille River metric values, resulting scores, and summary of scores for each WQ management class in the far right column. For example, in the Class A-1 classification, 5 metrics pass, 1 indeterminate +, 2 metrics fail. For Class B, Water Management Type 1, 6 metrics pass, 1 indeterminate +, and 1 metric fails.

For Classes B-2,3 and A-2, 7 metrics pass, 1 indeterminate – and no metrics fail. The resulting determination is probable full support, passed on "best professional judgement", continued monitoring recommended every five years.

Table5a

WQ Class (WWMG)	Scoring Guidelines	Density	Richness	EPT	PMA-O	B.I.	%Oligo	EPT/ EPT&c	PPCS-F
A-1	Full Support	>605	>42	**>22**	**>70**	**<4.10**	<1	**>0.67**	>0.55
	Threshhold Indet +-	*500*	*40*	*21*	*65*	*4.25*	***2***	*0.65*	*0.50*
	Non-Support	<450	**<38**	<20	<60	>4.40	>3	<0.63	**<0.45**
B-T1	Full Support	>450	>37	**>20**	**>60**	**<4.60**	**<3.5**	**>0.57**	>0.50
	Threshhold Indet +-	*400*	***35***	*19*	*55*	*4.75*	*5*	*0.55*	*0.45*
	Non-Support	<350	<33	<18	<50	>4.90	>6.5	<0.53	**<0.40**
B-T2,3 & A2	Full Support	>350	**>32**	**>17**	**>50**	**<5.35**	**<9.5**	**>0.47**	>0.45
	Threshhold, Indet +-	*300*	*30*	*16*	*45*	*5.40*	*12*	*0.45*	***0.40***
	Non-Support	<250	<28	<15	<40	>5.65	>14.5	<0.43	<0.35

Table 5b

River/ Support Staus	WQ-Class	Densit y	Richness	EPT	PMA-O	B.I.	%Oligo	EPT/EPT&c	PPCS-F	Scoring Total		
										S	I(+,-)	NS
Lamoille River 15.7	B	1694	33.5	23.5	71	4.05	1.3	0.96	0.37			
	A-1	S	NS	S	S	S	I+	S	NS	5	1+	2
	B-1	S	I-	S	S	S	S	S	NS	6	1+	1
Stressed-Full Support (Good)	**B, B-2&3 A2**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**I-**	**7**	**1-**	**0**

11. Fish Biocriteria for Wadeable Streams

The VTDEC has developed two indices of biological integrity based on fish assemblage characteristics: The Cold Water Index of Biotic Integrity (CWIBI) and the Mixed Water Index of Biotic Integrity (MWIBI). These indices will be used by VTDEC to evaluate the aquatic life use status of applicable wadeable streams in Vermont. These indices are comprised of multiple measures of fish assemblage structure, function, and condition that are combined to provide a single numerical index that is representative of the overall biological integrity of the fish assemblage being evaluated. VTDEC has used data from reference sites and impaired sites to assign index values that are consistent with the narrative biological criteria in the VWQS's; they are: reference condition; minor deviation from the reference condition; and moderate deviation from the reference condition.

The CWIBI is shown in **Table 6**. The CWIBI consists of six metrics which are scored 1.5, 4.5, or 7.5 with the sum of the scores being the site CWIBI score. The individual metric scores for the CWIBI (six metrics) are converted so that final IBI scores will be comparable to the MWIBI (nine metrics) scores. The MWIBI is shown in **Table 7**. The MWIBI consists of nine metrics which are scored 1, 3, or 5 with the sum of the scores being the site MWIBI score.

A. *Considerations for Evaluating Fish Monitoring Data:*

1. *Determination of applicable Index of Biotic Integrity*: VTDEC must verify that appropriate guidance has been followed when determining the applicable IBI. General considerations are listed below. Further guidance is provided in **Attachment B**.

a. The CWIBI should only be applied to cold water streams with the potential to support two to four native, naturally reproducing species of fish.

b. The MWIBI should be applied to all other streams with the potential to support five or more native, naturally reproducing species of fish.

c. For warmwater sites without the potential to support five or more native, naturally reproducing species and cold water sites without the potential to support two or more native, naturally reproducing species, *neither the CWIBI nor the MWIBI can be applied*, and alternative analyses will be used to evaluate aquatic life use support.

d. For the purposes of IBI applicability, all sites above 500 feet in elevation and all sites in the Connecticut River drainage (excluding the main stem of the Connecticut River and lower reaches of the West River) shall be considered cold water; all sites below 500 feet in elevation shall be considered warm water unless shown to support naturally-reproducing coldwater species. Guidelines for IBI application are outlined in **Attachment A**.

2. *Calculation of IBI:* The VTDEC must verify that metric and IBI calculations are consistent with IBI calculation guidance provided in **Attachment A**.

3. *Data quality evaluation:*

a. Personnel qualifications: individuals submitting data to VTDEC for assessment pursuant to these methods shall be required to provide to VTDEC a demonstration of their qualifications for review by VTDEC. Among the skills which will be considered are fish sampling experience and taxonomic expertise.

b. Consistency with standard operating procedures: VTDEC must verify that all data collection (including collection technique, site selection, and section length), sample processing, and sample analysis methods are consistent with VTDEC standard operating procedures for fish assemblages (**Attachment B**).

c. Sample representativeness: VTDEC must confirm that physical conditions at the time of sample-taking were representative of those encountered during a "normal" year, and do not reflect extreme hydrological, meteorological, or other cataclysmic events prior to, or during sampling. Additionally, unacceptable sampling error or unique or unusual biological assemblages would qualify for a "non-representative" sample to be declared.

B. *Data Rejection Alternatives:* If evaluation data are rejected under any of the data quality evaluation considerations a-c above, the VTDEC may require re-sampling of the test site following the development of an appropriate Sampling and Quality Assurance Plan. In cases where the relative precision of a sample is in question, a re-sample may be taken at a later date within the same season. It is preferable that the re-sample would be collected on a different stream section. Less desirable, is re-sampling the same section. If the re-sample were to be taken at the same section, it should not be collected sooner than three weeks from when the initial sample was taken. The VTDEC may issue an interim aquatic life use support finding until completion of acceptable re-sampling. Interim findings will be weight-of-evidence based on evaluation of all known chemical, physical, and biological data available for the test site. Fish community monitoring data that are not gathered in a manner entirely consistent with the determination of applicable index considerations (*Section 11:A-1*) may be considered by the VTDEC on a situational basis for the purpose of evaluating aquatic life use support. Situations which may require such an evaluation include but are not limited to: short term impacts related to catastrophic events such as spills or accidental releases of toxic materials; unanticipated enforcement or performance evaluations requiring rapid response. Findings related to aquatic life use support shall be based on the establishment of a compelling weight-of-evidence argument derived from monitoring data and best professional judgement. Such evaluations shall be conducted in a manner consistent with established principles of water pollution biology and shall be fully documented.

C. *Application of IBI Scores to Designated Aquatic Life Use Support:* Following a determination of data acceptability, the appropriate IBI is calculated following **Tables 6 and 7** and the more detailed IBI implementation guidance presented in **Attachment A**.

1. **Table 8** shows IBI score ranges and the corresponding class-specific water quality standard. Certain scores require some interpretation in order to determine the aquatic life use support status. If the evaluation site IBI score is 29 or 31, the biologist will determine whether or not the site meets class B2-3 criteria using best professional judgment. Similarly, if the IBI score is 35 or 39, best professional judgement is required to assign the score its appropriate aquatic life use support status. The selection of these "indeterminate" scores was based on the variability of IBI scoring as evaluated by VTDEC. Estimated variability in scoring, based on both within and

between year sampling , is " 2-3 points. For the CWIBI, intermediate scoring ranges which require biologist interpretations of aquatic life use support status are 30 and 39. When an index score falls into one of the intermediate ranges, the biologist may consider the following factors in assessing the final site evaluation:

a.) raw metric values and how close each was to the scoring criteria limits;

b.) relative importance of IBI metrics (weigh the relative importance of scores from the individual metrics);

c.) sampling efficiency; the relative precision of the sample. Where a sample was collected from two electro-fishing passes, the "catchability" (p) for each species will be examined;

Table 6: An Index of Biotic Integrity for small Vermont coldwater streams (CWIBI).

For coldwater streams naturally supporting from two to four native species	5	3	1
1. Number of intolerant species (one exotic trout species may be substituted for brook trout)	2	1	0
2. Proportion of individuals as coldwater stenotherms	> 75%	50-75%	< 50%
3. Proportion of individuals as generalist feeders	< 5%	5-9%	> 9%
4. Proportion of individuals as top carnivores	> 35%	25-35%	< 25%
5. Brook trout density (#s/100 m^2-1 pass)	>4.0	2.0-4.0	<2.0
6. Brook trout age class structure (young-of-the-year = < 100mm, adult=>100mm)	yoy and adults present	yoy only	yoy absent

<u>Metric Scores</u>

Excellent	42-45
Very Good	36
Good	33
Fair	27
Poor	<27

<u>Conditions for Use</u>

1. Only fishes over 25 mm in length should be considered
2. Only naturally reproducing salmonids are to be considered
3. Only species represented by more than a single individual will be entered into metrics 1 and 6

Table 7. Mixed Waters Index of Biotic Integrity (MWIBI) for the fish communities of wadeable Vermont streams.

For streams naturally supporting more than four native fish species			Scoring Criteria 5	3	1
Species Richness and Composition					
1.	Total number of native fish species		Follows maximum species richness lines (Attachment E)		
2.	Number and identity of native, intolerant species (*A non-native trout may be substituted for brook trout when absent*)	[Site Elevation >400 ft.]-	>1	1	0
		[Site Elevation <400 ft.]-	>0	-	0
3.	Number and identity of native benthic insectivores	[Site Elevation <400 ft. with site drainage <25 km^2]	>0	-	0
		All other sites	>1	1	0
4.	Proportion of individuals as white suckers and creek chubs		<11%	11-30%	>30%
Trophic Composition					
5.	Proportion of individuals as generalist feeders	[Site Elevation >500 ft.]-	<20%	20-45%	>45%
		[Site Elevation <500 ft.]-	<30%	30-60%	>60%
6.	Proportion of individuals as water column and benthic insectivores *(score a "1" if blacknose dace is >60% of total assemblage or 100% of insectivores)*	[Site Elevation >500 ft.]-	>65%	30-65%	<30%
		[Site Elevation <500 ft.]-	>55%	20-55%	<20%
7.	Proportion of individuals as top carnivores (*Nonnative trouts included)*	[cold water assemblage] -	>15%	5-15%	<5%
		[warm water assemblage with site drainage >25 km^2.] -	>10%	3-10%	<3%
		[warm water assemblage with site drainage <25 km^2.] -	$0	-	-
Fish Abundance and Condition					
8.	Proportion of individuals with Deformities. fin erosion, lesions or tumors		<1%	1-4%	>4%
9.	Abundance in Sample (one pass - #100m^2) *(Nonnative species included)*	[Site Elevation <500 ft].	>20	10-20	<10*
		[Site Elevation >500 ft].			
		[Alk. >9 mg/l]	>10	7-10	<7*
		[Alk. <9 mg/l]	>6	3-6	<3*

*site scores "poor"

1 All sites within the Connecticut River drainage are to be scored as > 500 elevation

Metric Scores

Excellent	41-45
Very good	37
Good	33
Fair	27
Poor	<27

Conditions for Use

1. For wadeable streams only.
2. Site should naturally support at least five native species.
3. Only individuals more than 25mm TL are to be entered into the determination.
4. Only species with more than one individual captured are entered in metrics 2 and 3.
5. Stocked fish are not considered in determinations.

Table 8: All possible scores for Coldwater and Mixed-water IBI's and the corresponding water quality classification contained in the VT WQS effective July 2, 2000. Scores range from 9 (very poor) to 45 (excellent).

WQS Classification	Range	Possible Scores	
		CWIBI	MWIBI
A-1 *Minimal* impacts, biological integrity within the range of natural condition	41 - 45	42, 45	41, 43, 45
Best professional judgement determines placement into A-1 or B1 designated use criteria	39	39	39
B-1 *Minor* changes in relative proportions of taxonomic and functional components. Proportions of tolerant and intolerant components within range of reference condition	36-37	36	37
Best professional judgement determines placement into B1 or A2, B2-3 designated use criteria	35		35
A-2, B-2, B-3 *Moderate* changes in the relative proportions of tolerant, intolerant taxonomic and functional components	33	33	33
Best professional judgement determines placement into Class B-2,3 or Non-Support	29- 31	30	31, 29
Non-Support Class B, Class B2-3, Class A2	< 29	27, 24, 21, 18, 15, 12, 9	27, 25, 23, 21, 19, 17, 15, 13, 11, 9

Attachment A
Fish Community Methods For Wadeable Streams

A. Sampling Protocols and Considerations. Both the CWIBI and MWIBI are intended for use on wadeable streams. Wadeable streams are defined as any stream or river that at some time during the year can be sampled by an individual wading into the thalweg of the channel. "Wadeable" is a function of depth, velocity, and, to a lesser extent, investigator size and strength. Non-wadeable streams are simply deeper than wadeable streams and include the lower portions of many of the larger rivers in Vermont.

1. *Collection Technique*. The method of collection will be by electrofishing. Generally streams less than 5-6 m wide can be effectively shocked using a single back-pack unit. Collections in wider (larger) streams and rivers should be made using a stream or bank-side generator with two or more electrodes and supporting crews, or with multiple back-pack units. All stunned fish are to be collected. The section should be sampled in a systematic fashion beginning at the downstream margin and continuing upstream to the head in the section. Block nets should be used on the up-stream end of the section if there is no physical barrier to constrain fish at that point. A downstream block net is recommended if a population size estimate is to be made. For screening purposes, a single electrofishing run will suffice to calculate an IBI. Where density is a particular concern, or where a specific impact is being evaluated, two or three runs should be conducted. Where multiple runs are conducted, a removal population estimate method should be calculated for each species. Any specimen captured which cannot be identified in the field should be preserved and submitted to the VTDEC for positive identification. All fishes collected, should be released within the section upon completion of the specimen identifications.

2. *Site selection.* The stream section to be sampled should be representative of the habitat present in the overall stream reach in which it is located. As an example, if the stream reach containing the section fished is of high gradient with a predominance of riffles, then the section sampled should reflect this character by including a predominance of riffles. This is an important step in fish assemblage assessment since assemblage composition is strongly associated with habitat type. It is also important to include all habitat types within a section that are present in the reach in order to maximize the chances of collecting all species present in a particular reach. When comparing results from an evaluation site to a control site, the habitat composition of the two sites should be made as similar as possible. This minimizes effects on fish assemblage composition caused by differences in habitat structure.

3. *Section length*. The length of stream fished should be great enough to provide a representative sub-sample of the overall stream reach. Generally the wider a river or steam is, the longer the sampled section will need to be. The minimum section length to be fished in wadeable streams should never be less than 75 m. The sampled section may also be dependent on the expected density of fishes. Longer sections should be sampled at unproductive coldwater sites where numbers of fish are suspected to be low. Productive cool and warmwater sites can be sampled at lengths closer to the minimum standards in shown in **Table A-1**.

Table A-1. Minimum fish section lengths for wadeable Vermont streams by stream width.

Stream Width (m)	3 or less	4 - 5	6 - 8	9 -11	12-14	15+
Minimum Section Length Sampled	75	100	120	140	160	180+

B. *Rules for Applying and Scoring the IBIs.*

1. *Species number requirements for applying the appropriate IBI:* It is sometimes difficult to place a site into one of the three categories in **Table A-2**, with a high degree of confidence, without first sampling the site. While there are general trends in physico-chemical parameters that are associated with each IBI type, too much overlap in these parameters exists between the three options to clearly determine which IBI option to use. The preferred approach is to simply sample the site and apply the appropriate option based on the number of species collected. In cases where an impairment may be suspected to have caused a reduction in total species number, two approaches may be applied in specifying the appropriate IBI. The first would be to sample an upstream control station out of the influence of the impact of concern. This site would necessarily be located as near to the site being evaluated as possible. The second approach is to use best professional judgement. Factors to consider would include species lists from adjacent streams in the same drainage as well as site physico-chemical factors.

Table A-2. Species richness criteria for applying the correct IBI for wadeable Vermont streams.

Number of species	IBI used
Coldwater sites with two to four native, naturally-reproducing species	CWIBI
Warmwater sites with five or more native, naturally-reproducing species	MWIBI
Warmwater sites with fewer than five species and coldwater sites with one species	No IBI can be applied

C. *Species size requirements.* Since electrofishing efficiency is low for smaller fish, only fish that are at least one inch in length will be considered in IBI calculations.

D. *Species included in IBI computations.*

1. Salmonids

a) Only salmonids that are naturally reproducing are entered into calculations. Stocked individuals should not be included in the computation of any metric. Because stocked individuals have not been subject to the stream conditions throughout their lives, as are residents, they are not to be considered as valid indicators of stream conditions. The presence of stocked fish reflects more a fisheries management distribution policy than stream biological integrity. Fish and Wildlife Department stocking records can be consulted to determine whether a stream has been stocked. Additionally, stocked fish may sometimes be differentiated from naturally reproducing fish by abnormalities in dorsal fin rays. All adults without obvious hatchery-related physical anomalies will be considered native if young of the year fish (not stocked) are collected in the section, regardless of whether the section has been stocked with adults.

b). Atlantic salmon are not considered in any of the metric value determinations. Since natural reproduction of this species is rare or non-existent in Vermont rivers, this species will be considered as hatchery supported. The presence of this species however, will weigh *positively* where best professional judgement is being applied to a site evaluation.

c). Brown and rainbow trout may be considered for the "number of intolerant species" metrics (#2 in MWIBI and #1 in CWIBI) *only* if brook trout are absent from the sample. If both brown and rainbow trout are present in a sample, then only *one* may be substituted for brook trout in these two metrics. For other computations, naturally reproducing brown and rainbow trout are considered as other native species except for the MWIBI species richness metric, where just native species are considered.

2. *Non-salmonids*

a). Nonnative, non-salmonid fishes are not considered in the calculation of the species richness ("Number of...") metrics, but will enter computations for all of the proportional ("Proportion of...") metrics and the total abundance metric of the MWIBI. Non-native in this context is defined as non-native to state *and* the watershed in which the sampled section lies (see **Table A-4**). Nonnative, non-salmonid species are most always tolerant generalists. Most gain a foothold on their new environment only when habitat quality has been impacted (the mere presence of nonnative species is considered by many, in itself, a form of degradation). The inclusion of these species then, into the proportional metrics will increase the raw value of the generalist feeder metric, thereby decreasing the insectivore and top carnivore raw metric values. All of this will have the appropriate effect of *lowering* the IBI score. If, in the very unlikely event, that the nonnative, non-salmonid is a top carnivore or insectivore (which would lead to *positive* scoring), it would then be dropped from all calculations.

b). Species (native or nonnative) which are non-residents, such as lake species originating from upstream standing waters, will not be considered in the scoring of any metric.

The species considerations discussed above are summarized in **Table A-3**.

E. *Minimum Number of Individuals to Consider in Meeting Criteria.* For metrics 2 and 3 in the MWIBI and metrics 1 and 6 in the CWIBI, at least two individuals must be recorded to constitute the presence of that species.

Table A-3: Summary of scoring rules for species considerations for both MWIBI and CWIBI.

Species or species group	Scoring rule
Naturally reproducing, nonnative salmonids (wild brown and rainbow trout)	a. Enter into MWIBI total abundance metric and all proportional[1] metrics; b. Not entered into species richness [2] metrics except for "...intolerant species" metrics - only when brook trout are absent (maximum of one species only);
1. Stocked species, including Atlantic salmon 2. All fish less than 25 mm 3. All non-resident species 4. All non-naturally reproducing species	Not entered into any metric calculations;
Nonnative non-salmonid species	a. Enter into total abundance metric and all proportional metrics; b. Not entered in species richness metrics;

1. Proportional metrics are 4, 5, 6, 7 and 8 in MWIBI and 2, 3 and 4 in CWIBI.
2. Species richness metrics are 1, 2 and 3 in MWIBI and 1 in CWIBI.

F. *Special Scoring Conditions: MWIBI*

1. *The determination cold or warmwater assemblage type for metric 7.* For the purposes of applying an IBI, all *wadeable* streams in Vermont located at elevations of over 500 feet will be designated as cold water. All streams below 500 feet are classified as warmwater streams unless naturally-reproducing coldwater species are present. A few non-Connecticut drainage coldwater streams occur below 500 feet in the Champlain Valley. These sites will be identified by their species composition. If a salmonid species, slimy sculpin or longnose sucker are present, the site should be classified as coldwater. Additionally, any wadeable site located within the Connecticut River drainage should also be considered as coldwater. As a result of human activities, some naturally coldwater sites are populated by species common to warm waters. These sites should also be considered as coldwater.

2. *The 500 foot criterion for metrics for metrics 5 and 6.* Differences observed in the raw values of these two metrics between cold and warmwater assemblages prompted different expectations for metric criteria scoring. This elevation was selected as the best discriminator between warm and cold water sites (coldwater $<$500 ft., warmwater $>$500 ft.). It is meant to be a guide for metric scoring and not intended to be strictly adhered to in all cases. Since a few coldwater stream reaches may occur below 500 feet, site species data should be consulted (as above) in the final determination of which elevation group to select. All sites in the Connecticut River drainage should be scored in the over 500 feet elevation group in metrics 5 and 6.

3. *The blacknose dace modification to metric 6.* While blacknose dace can be classified as an insectivore, they have generalist feeding tendencies and are tolerant to a wide range of perturbations. Without this condition for metric 6, a degraded assemblage, dominated by blacknose dace, could (inappropriately) score a 5 for this metric.

4. *If the density for all fish combined (metric 9) falls below the levels stipulated for the three stream types, then the site MWIBI score will be 9 (poor).* This condition was instituted to insure index sensitivity to toxic impacts. This type of impact often leaves the relative trophic proportions and species richness elements of the fish assemblage intact, while severely reducing the abundance. Since only the abundance metric may be potentially de-scored in this instance, the final index score would therefore not reflect the extent of the actual impact. Providing a special abundance condition which pushes the total IBI value to the minimum score insures the sensitivity of the index to this particular type of degradation.

5. *Awarding pluses ("+'s") or minuses ("- 's") for metric scores.* Occasionally a raw metric value will fall close to the criterion for a particular metric score. If this value falls just over or just under the criterion the metric score, a "+" or "-" will be applied to the metric score respectively. If two metrics score "-" or "+", then 2 points will be subtracted from or added to, the index score. The "+" and " -" designations are additive, e.g. four "+'s" will add four points to the index score. Plus's and minus's can cancel each other out as well. As an example, two "+'s: and one "- " will result in no change in the index score. **Table A-5** shows the threshold values which trigger the "+" and "-" designations for each metric. Plus's and minus's are not applied to scores which exceed the minimum criteria for a 5 score.

Table A-4 : Native-non-native status for Vermont fishes for purposes of IBI calculations.

The following species are considered to be native in Vermont only to elevations below 600 feet in the Champlain drainage. If found outside this range these species will be considered as non-native.

Northern brook lamprey	*Ichthyomyzon fossor*	Channel catfish	*Ictalurus punctatus*
Silver lamprey	*Ichthyomyzon unicuspis*	Stonecat	*Noturus flavus*
Lake sturgeon	*Acipenser fulvescens*	Northern pike	*Esox lucius*
Bowfin	*Amia calva*	Muskellunge	*Esox masquinongy*
Mooneye	*Hiodon tergisus*	Central mudminnow	*Umbra limi*
Brassy minnow	*Hybognathus hankinsoni*	Cisco / Lake herring	*Coregonus artedi*
Emerald shiner	*Notropis atherninoides*	Trout-perch	*Percopsis omiscomaycus*
Blackchin shiner	*Notropis heterodon*	Brook stickleback	*Culaea inconstans*
Blacknose shiner	*Notropis heterolepis*	Bluegill	*Lepomis macrochirus*
Rosyface shiner	*Notropis rubellus*	Rock bass	*Ambloplites rupestris*
Sand shiner	*Notropis stramineus*	Smallmouth bass	*Micropterus dolomieu*
Mimic shiner	*Notropis volucellus*	Largemouth bass	*Micropterus salmoides*
Northern redbelly dace	*Phoxinus eos*	Black crappie	*Pomoxis nigromaculatus*
Finescale dace	*Phoxinus neogaeus*	Walleye	*Stizostedion vitreum*
Bluntnose minnow	*Pimephales notatus*	Sauger	*Stizostedion canadense*
Fathead minnow	*Pimephales promelas*	Fantail darter	*Etheostoma flabellare*
Silver redhorse	*Moxostoma anisurum*	Channel darter	*Percina copelandi*
Shorthead redhorse	*Moxostoma macrolepidotum*	Logperch	*Percina caprodes*_
Greater redhorse	*Moxostoma valenciennesi*	Eastern sand darter	*Ammocrypta pellucida*
Yellow bullhead	*Ameiurus natalis*	Freshwater drum	*Aplodinotus grunniens*

These species are considered as native statewide for all waters for purposes of scoring the IBIs.

Sea lamprey	*Petromyzon marinus*	Blacknose dace	*Rhinichthys atratulus*
American brook lamprey	*Lampetra appendix*	Longnose dace	*Rhinichthys cataractae*
American eel	*Anguilla rostrata*	Spotfin shiner	*Cyprinella spiloptera*
American shad	*Alosa sapidissima*	Quillback	*Carpiodes cyprinus*
Longnose gar	*Lepisosteus osseus*	Longnose sucker	*Catostomus catostomus*
Rainbow smelt	*Osmerus mordax*	White sucker	*Catostomus commersoni*
Brook trout	*Salvelinus fontinalis*	Brown bullhead	*Ameiurus nebulosus*
Lake trout	*Salvelinus namaycush*	Burbot	*Lota lota*
Lake whitefish	*Coregonus clupeaformis*	Redfin pickerel	*Esox americanus americanus*
Round whitefish	*Prosopium cylindraceum*	Chain pickerel	*Esox niger*
Cutlips minnow	*Exoglossum maxillingua*	Banded killifish	*Fundulus diaphanus*
E. Silvery minnow	*Hybognathus regius*	Pumpkinseed	*Lepomis gibbosus*
Bridle shiner	*Notropis bifrenatus*	Redbreast sunfish	*Lepomis auritus*
Fallfish	*Semotilus corporalis*	Yellow perch	*Perca flavescens*
Lake chub	*Couesius plumbeus*	Tessellated darter	*Etheostoma olmstedi*
Common shiner	*Luxilus cornutus*	Slimy sculpin	*Cottus cognatus*
Pearl dace	*Margariscus margarita*	Mottled sculpin	*Cottus bairdi*
Golden shiner	*Notemigonus crysoleucas*	Striped bass	*Morone saxatilis*
Spottail shiner	*Notropis hudsonius*	Creek chub	*Semotilus atromaculatus*

The following species considered non-native to the state of Vermont and thereby should not be included in IBI calculations for any Vermont stream site.

Alewife	*Alosa pseudoharengus*	White crappie	*Pomoxis annularis*
Gizzard shad	*Dorosoma cepedianum*	Redear sunfish	*Lepomis microlophus*
Blueback herring	*Alosa aestivalis*	White perch	*Morone americana*
Goldfish	*Carassius auratus*	Brown trout[1]	Salmo trutta
Carp	*Cyprinus carpio*	Rainbow trout[1]	Oncorhynchus mykiss
Rudd	*Scardinius erythrophthalmus*		
Brook silverside	*Labidesthes sicculus*		

1. See **Table A-3** for explanation

Table A-5. Metric values which trigger a "+" or "-" to be applied to the metric score for the MWIBI. Using metric 4 as an example, the "5" criterion is; <11%. A raw metric value of 10% would give a score of "5 -" ; a raw value of 12% would give a score of "3+".

MWIBI Metric	Value That Triggers " + " or " - " on Score
1. Total number of native fish species	1 species above or below a criterion
2. Number and identity of native intolerant species *and* 3. Number and identity of native benthic insectivores	a. An intolerant species represented by only 2 individuals scores a "-" b. An intolerant species represented by only 1 individual scores a "+"
4 .Proportion of individuals as white suckers and creek chubs	" 1 % points or less of each criterion
5. Proportion of individuals as generalist feeders *and* 6. Proportion of individuals as water column and benthic insectivores	" 2 % points or less of each criterion
7. Proportion of individuals as top carnivores	" 1 % points or less of each criterion
8. Proportion of individuals with Deformities. fin erosion, lesions or tumors	" 0.5% points or less of each criterion
9. Abundance in Sample (one pass - # /100m^2)	" 1 / 100m^2

G. Special Conditions: CWIBI

1. If the density for all fish combined does not meet the criteria for metric 9 of the MWIBI for sites >500 ft. then the site score will be 9 (poor).

2. Awarding "+'s" or "-'s" for metric scores. See **Table A-6** and discussion in *Section F-5* of **Attachment A**.

Table A-6: The metric values that trigger a "+" or "-" to be added to a metric score for the metrics of the CWIBI. As an example of use; for metric 2, the criteria for metric scoring are: <50% =1, 50-75%=3 and >75%=5. If the raw value calculated for a sample is 47 to 49 (-3% points or less from 50) then the final metric score will be 1+. If a metric score is 50-53 the metric score will be 3-. Similarly a 3+ for this metric would equate to 72-75 % and a 5- would represent a raw value of 76-78%.

CWIBI Metric	Value That Triggers " + " or " - " on Score
1. Number of intolerant species	none
2. Proportion of individuals as coldwater stenotherms	within " 3 % points or less of each criterion
3. Proportion of individuals as generalist feeders	" 1 % points or less of each criterion
4. Proportion of individuals as top carnivores	" 2 % points or less of each criterion
5. Brook trout density	0.5 or less trout/100m^2
6. Brook trout age class structure	none

H. Applying IBI scores to the designated use criteria in the Vermont Water Quality Standards. **Table 9** in *Section 11* of this document shows IBI score ranges and the corresponding class/water management type - specific water quality criterion. Certain scores require some interpretation in order to determine the aquatic life use support status. For example, if the evaluation site IBI score is 29 or 31, the biologist will determine whether or not the site meets Class B, Water Management Type 2 and 3 criteria using best professional judgment. Similarly, if the IBI score is 35 or 39, best professional judgement is required to assign the score its appropriate aquatic life use support status. The selection of these "indeterminate" scores was based on the variability of IBI scoring as evaluated by VTDEC. Estimated variability in scoring, based on both within and between year sampling is " 2-3 points. The biologist may consider the following factors in assessing the final site evaluation:

1. raw metric values and how close each was to the scoring criteria limits;

2. relative importance of IBI metrics (weigh the relative importance of scores from the metrics);

3. sampling efficiency; the relative precision of the sample; where a sample was collected from two electro-fishing passes the "catchability" (p) for each species will be examined.

In cases where the relative precision of a sample is in question, a re-sample may be taken at a later date within the same season. It is preferable that the re-sample would be collected on a different stream reach. If the re-sample were to be taken at the same stream reach, it should not be collected sooner than 3 weeks after the initial sample was collected.

Attachment B
<u>Macroinvertebrate Community Methods</u>
Wadeable High to Moderate Gradient Streams

Sample collections: All macroinvertebrate samples are collected during the late-Summer, early fall index period, from September to mid-October. A two-person field crew selects a representative riffle section in the steam reach to be sampled. Physical characteristics recorded at the selected each site include: stream width; depth; water velocity; water temperature; specific conductance; weather conditions; substrate composition; substrate embeddedness (riffle sites only); canopy cover; stream bank condition and immediate upstream land use. All data are entered onto a field sheet with appropriate site and sampling event identifiers, along with additional comments that may be pertinent to the site evaluation. A water sample is collected for pH and alkalinity determination and placed on ice for return to the laboratory.

Samples are collected using an 18 inch wide x 12 inch high D-frame net with a 500 F mesh size. The net is placed in the riffle at an appropriate location and an area immediately upstream of the net is thoroughly disturbed by hand, ensuring that all pieces of substrate are moved and rubbed clean of attached organisms. Moving up-stream, this is repeated at 4 to 5 different locations within the riffle, representing a range of velocity and substrate type characteristic of that riffle. Each specific location is actively sampled until all the substrate in about an 18" x 18" square in front of net has been disturbed this generally takes about 30 seconds, and active sampling is terminated at the end of two minutes. Time spent relocating to a new location within the riffle is not counted as part of the two minutes. The contents of the net are washed into a quart mason jar and preserved with 75% ethanol. The process is repeated, being careful to avoid areas previously disturbed. This "composite" sampling methodology effectively collects samples representative of the macroinvertebrate community of that riffle. This sampling protocol is most comparable to the riffle-run sampling portion of Rapid Bioassessment Protocol III (RBPIII) as described in Plafkin et al. (1989).

Laboratory methods: Samples are washed of ETOH through a #30 sieve and spread evenly over a white gridded tray (minimum of 24 grids or squares) by adding a small amount of water to allow the sample to be evenly spread, but not so much as to cause the macroinvertebrates to float freely around the tray. All animals from one quarter (6 squares) of tray are picked. The six squares are randomly selected (a single random number from 1-24 is picked and the next five numbers are added) and isolated from the rest of the sample using an appropriate divider (VTDEC uses rectangular granite blocks). If, after six squares, 300 animals have not been encountered, additional grids are then selected, isolated, and picked until a minimum of 300 animals have been picked. The total number of grids (squares) picked is recorded so that sample density or relative abundance can be calculated. Animals are then sorted into major groups, and preserved in 75% ETOH. All macroinvertebrates are then identified to genus/species except for the Oligochaeta, which are identified to family.

Calculation of metrics:

1. Density- Is the relative abundance of animals in a sample unit (# per unit effort).

Calculation: Number of animals in subsample / proportion of sample processed.

Example: 300 animals picked / 0.25 (or one quarter of sample picked) = 1200 animals/sample unit

2. Richness- Species richness is the number of species in a sample unit.

Calculation: Richness is the total number of distinct taxa identified in a sample unit. With multiple sample units (replicates) this number is the mean of all repicates. Note: an immature larva identified to family or genus is not considered a distinct new taxon if a genus or species identification is determined within its group.

Example :

Taxon	# orgs Rep 1	# orgs Rep 2
Ephemerellidae Ephemerella sp	2	0
Ephemerellidae Ephemerella dorothea	3	4
Ephemerellidae Ephemerella invaria	0	2
Richness =	1	2
Mean Richness =	3) 2 = 1.5	

3. EPT Index- The EPT index is a subset of the above richness measure. It is the number of species of the generally more environmentally sensitive orders Ephemeroptera, Plecoptera, and Trichoptera in the sample unit.

Calculation: The number of distinct taxa identified in a sample from the insect orders Ephemeroptera, Plecoptera, Trichoptera. Note: same rules apply as above for replicates and determining number of distinct taxa.

4. EPT/EPT & Chironomidae - Is a measure of the ratio of the abundance of the intolerant EPT orders to the generally tolerant Diptera family Chironomidae.

Calculation: The number (relative abundance) of animals from the orders Ephemeroptera, Trichoptera and Plecoptera, divided by the above plus the number of Chironomidae.

5. % Oligochaeta - Is a measure of the percent of the macroinvertebrate community made up of the Order Oligochaeta.

Calculation: The number (relative abundance) of Oligochaeta divided by the total number of animals in sample unit.

6. Percent Model Affinity of Orders - (PMA-O) - Is a measure of order level similarity to a model based on the reference streams (Novak and Bode, 1992).

Calculation: Determine the percent composition for each major group - Coleoptera, Diptera, Ephemeroptera, Plecoptera, Trichoptera, Oligochaeta, Other. Compare to the "Model" for the appropriate stream community (see below), then add up the lower of the two values for each of the groups (assessment site vs Model), This is the PMA-O for the assessment site.

PMA-O = 3 min (X_a or X_r)

Where: X_a = the percent composition of order X from the assessment site;
X_r = the percent composition of order X from the appropriate reference condition;

Example:

Percent Composition Major Groups	Assessment Site % Composition	Model for MHG Macroinvertebrate Stream Type
Coleoptera	20	**6**
Diptera	55	**18**
Ephemeroptera	**10**	34
Plecoptera	**2**	8
Trichoptera	**3**	33
Oligocheata	10	**0.5**
Other	**0**	0.5
PMA-Orders =	**39.5 rounded = 40.0**	

7. Hilsenhoff Biotic Index- BI (0-10) - Is a measure of the macroinvertebrate assemblage tolerance toward organic (nutrient) enrichment Hilsenhoff (1987). In many ways this index is both an indicator taxa metric and functional group metric, since those taxa which become more dominant in moderately enriched streams are those which are taking advantage of shifts in the available food base in the stream.

Calculation : Multiply the number of individuals of a taxon by its assigned tolerance value, see VTDEC BI values, modified from Hilsenhoff 1987, and Bode 1996. Total all these products, and divide by the total number of individuals of each taxon assigned a tolerance value. This is the Bio Index value.

$$HBI = \sum \frac{n_i a_i}{N}$$

Where:
- "n" is the number of individuals of the "i"th taxon;
- "a" is the index value of that taxon;
- N is the total number of individuals in the sample assigned a Bio Index Value

Example :

Taxon	Count	BI Tolerance Value	Subtotal Ct × BI
Ephemerellidae imm	(10)	NA	NA
Ephemerella sp	10	4	40
Ephemerella needhami	10	1	10
Plecoptera Leuctridae imm	20	0	0
Diptera Cricotopus bisinctus	5	6	30
Trichoptera Symphitopsyche alhedra	10	3	30
Trichoptera Symphitopsyche sp	5	5	25
Totals	*60*		*145*
Site Bio Index Value =	145 ÷ 60 = *2.42*		

8. **Pinkham-Pearson Coefficient of Similarity - Functional Groups - (PPCS-F) -** Is a measure of functional feeding group similarity to a model based on the reference streams. It is similar in concept to the PMA-O in that a site is compared to a reference condition model of the composition of the functional feeding groups as opposed to order level taxonomic changes. Also the Pinkham-Pearson Coefficient of Similarity (Pinkham1976) was used as the similarity index.

Calculation: At the assessment site determine the percent composition of the six major functional groups (Collector Gatherer, Collector Filterer, Predator, Shredder-Detritus, Shredder-Herbivore, Scraper) as assigned by VTDEC after Merrit and Cummins 1996, Bode 1996. For each functional group determine the product (min/max) between the assessment site vs the Model for the stream community sampled. Add these products and divide by six (# of functional groups). This is the PPCS-F.

$$\text{PPCS-F} = 1/k \sum_{I=1}^{K} \text{minimum}(xia, xib)/\text{maximum}(xia, xib)$$

Where:
- k = the number of comparisons between stations (6)
- xi = the number of individuals in functional group I
- a, b = site a, site b

Example :

Functional Group	Assessment Site % Comp	"Model" for MHG macroinvertebrate stream type	Product (min/max)
Collector .Gatherer	68	32	0.47
Collector Filterer	10	30	0.33
Predator	2	13	0.15
Shredder - Detritus	0	4	0.00
Shredder - Herbaceous	16	1	0.06
Scraper	2	13	0.15
TOTAL			1.16
PPCS-F =	**1.16) 6 = 0.19**		

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Attachment C: VTDEC macroinvertebrate taxa list for biocriteria determinations of wadeable high gradient stream communities water quality class determinations. This table lists taxonomic level required if possible, and the associated Vermont Bio Index value (0-10), and functional group for each taxa. Note 1- If taxon does not occur on list the VTDEC should be consulted for proper coding. 2- This list and associated values may be updated periodically.

Order	Genera	Species	BI (0-10)	Function	BugRefID
COLEOPTERA	DRYOPIDAE	unid	5	SCR	7
	DRYOPIDAE	imm	5	SCR	7
	HELICHUS	sp	5	SCR	46
	HELICHUS	basilus	5	SCR	46
	HELICHUS	lithophilus	5	SCR	46
	HELICHUS	fastigiatus	5	SCR	46
	ANCYRONYX	sp	6	CG	7
	ANCYRONYX	variegata	6	CG	46
	DUBIRAPHIA	sp	6	CG	7
	DUBIRAPHIA	bivittata	8	CG	32
	DUBIRAPHIA	quadrinotata	5	CG	32
	DUBIRAPHIA	vittata	6	CG	32
	DUBIRAPHIA	minima	5	CG	38
	MACRONYCHUS	sp	5	SRD	7
	MACRONYCHUS	glabratus	5	SRD	32
	MICROCYLLOEPUS	sp	4	SHR	7
	MICROCYLLOEPUS	pusillus	4	SHR	32
	OPTIOSERVUS	sp	4	SCR	7
	OPTIOSERVUS	fastiditus	4	SCR	32
	OPTIOSERVUS	trivittatus	4	SCR	32
	OPTIOSERVUS	ovalis	3	SCR	32
	OPTIOSERVUS	immunis	4	SCR	32
	OPTIOSERVUS	sandersoni	4	SCR	32
	OULIMNIUS	sp	3	SCR	7
	OULIMNIUS	latiusculus	3	SCR	32
	PROMORESIA	sp	2	SCR	7
	PROMORESIA	elegans	2	SCR	32
	PROMORESIA	tardella	2	SCR	32
	STENELMIS	sp	5	SCR	7
	STENELMIS	bicarinata	5	SCR	32
	STENELMIS	concinna	5	SCR	32
	STENELMIS	crenata	5	SCR	32
	STENELMIS	humerosa	5	SCR	32
	STENELMIS	mirabilis	5	SCR	32
COLEOPTERA	STENELMIS	musgravei	5	SCR	32

	STENELMIS	sandersoni	5	SCR	32
	STENELMIS	mera	5	SCR	32
	STENELMIS	quadrimaculata	5	SCR	32
	STENELMIS	humer/sinuata	6	SCR	32
	STENELMIS	species a	5	SCR	32
	STENELMIS	species b	5	SCR	32
	PSEPHENIDAE	unid	4	SCR	7
	PSEPHENIDAE	imm	4	SCR	7
	ECTOPRIA	sp	5	SCR	7
	ECTOPRIA	leechi	4	SCR	38
	ECTOPRIA	nervosa	5	SCR	32
	PSEPHENUS	sp	4	SCR	7
	PSEPHENUS	herricki	4	SCR	38
	SCIRTIDAE	unid	5	SRD	46
	CYPHON	sp	5	SHR	46
	SCIRTES	sp	5	SRD	46
DIPTERA	ATHERIX	sp	2	PRD	7
	BLEPHAROCERA	sp	0	SCR	7
	CERATOPOGONIDAE	unid	6	PRD	7
	ALLUAUDOMYIA	sp	6	PRD	7
	ATRICHOPOGON	sp	1	CG	7
	BEZZIA	sp	6	PRD	7
	CERATOPOGON	sp		PRD	7
	CLINOHELIA	sp		PRD	7
	CULICOIDES	sp	10	PRD	7
	DASYHELEA	sp	8	CG	7
	FORCIPOMYIA	sp	6	SCR	7
	HETEROMYIA	sp		PRD	7
	JOHANNSENOMYIA	sp		PRD	7
	MALLOCHOHELEA	sp		PRD	7
	PALPOMYIA	sp	6	PRD	7
	PROBEZZIA	sp	6	PRD	7
	SERROMYIA	sp		PRD	7
	SPHAEROMIAS	sp	6	PRD	7
	CHAOBORIDAE	unid	8	PRD	7
	CHAOBORUS	sp	8	PRD	7
	CHAOBORUS	punctipennis	8	PRD	61
	CHAOBORUS	flavescens	8	PRD	61
	EUCORETHRA	sp	8	PRD	7

DIPTERA	MOCHLONYX	sp	8	PRD	7
	MOCHLONYX	cinctipes	8	PRD	7
	ABLABESMYIA	sp	8	PRD	52
	ACRICOTOPUS	sp	10	CG	52
	ARCTOPELOPIA	sp		PRD	56
	AXARUS	sp	8	CG	52
	BRILLIA	sp	5	SRD	52
	CHAETOCLADIUS	sp	6	CG	52
	CARDIOCLADIUS	sp	5	PRD	52
	CHIRONOMUS	sp	10	CG	52
	CHIRONOMUS	decorus grp	10	CG	77
	CHIRONOMUS	riparius grp	10	CG	77
	CHIRONOMUS	tentans grp	10	CG	71
	CHIRONOMUS	plumosus grp	10	CG	77
	CLADOTANYTARSUS	sp	6	CG	52
	CLINOTANYPUS	sp	8	PRD	52
	COELOTANYPUS	sp	4	PRD	52
	CLADOPELMA	sp	9	CG	52
	CONCHAPELOPIA	sp	6	PRD	52
	CONSTEMPELLINA	sp	4	CG	52
	CORYNONEURA	sp	4	CG	52
	CORYNONEURA	celeripes	4	CG	77
	CORYNONEURA	taris	4	CG	77
	CRICOTOPUS	sp	7	SHR	52
	CRICOTOPUS	bisinctus	7	SHR	52
	CRICOTOPUS	intersectus	7	SHR	77
	CRICOTOPUS	sylvestris	7	SHR	77
	CRICOTOPUS	tremulus	7	SHR	77
	CRICOTOPUS	trifascia	6	SHR	52
	CRICOTOPUS	reversus gr	7	SHR	78
	CRICOTOPUS	flavocinctus		SHR	188
	CRICOTOPUS	cylindraceus		SHR	188
	CRYPTOCHIRONOMUS	sp	8	PRD	52
	CRYPTOTENDIPES	sp	6	CG	52
	DEMICRYPTOCHIRONOMUS	sp	8	CG	52
	DIAMESA	sp	5	CG	52
	DICROTENDIPES	sp	8	CG	52
	DICROTENDIPES	neomodestus	8	CG	77
	DICROTENDIPES	nervosus	8	CG	77

DIPTERA	DIPLOCLADIUS	sp	8	CG	52
	DJALMABATISTA	sp	3	PRD	52
	EINFELDIA	sp	9	CG	52
	ENDOCHIRONOMUS	sp	10	SHR	52
	EPOICOCLADIUS	sp	4	CG	52
	EUKIEFFERIELLA	sp	6	CG	52
	EUKIEFFERIELLA	devonica	6	CG	51
	EUKIEFFERIELLA	brehmi	4	CG	51
	EUKIEFFERIELLA	similis	4	CG	51
	EUKIEFFERIELLA	gracei	4	CG	51
	EUKIEFFERIELLA	cyanea	4	CG	51
	EUKIEFFERIELLA	pseudomontana	8	CG	51
	EUKIEFFERIELLA	brevicalar	2	CG	51
	EUKIEFFERIELLA	claripennis	8	CG	51
	EUKIEFFERIELLA	rectangularis	4	CG	51
	EUKIEFFERIELLA	coerulescens	4	CG	51
	EUORTHOCLADIUS	sp	6	CG	52
	GLYPTOTENDIPES	sp	10	SHR	52
	GOELDICHIRONOMUS	sp	8	CG	52
	GRACEUS	sp		CG	56
	GUTTIPELOPIA	sp	5	PRD	52
	GYMNOMETRIOCNEMUS	sp		CG	52
	HARNISCHIA	sp	8	CG	52
	HETEROTRISSOCLADIUS	sp	4	CG	52
	HYDROBAENUS	sp	8	CG	52
	KIEFFERULUS	sp	10	CG	52
	KRENOPELOPIA	sp	4	PRD	52
	KRENOSMITTIA	sp	1	CG	52
	LABRUNDINIA	sp	7	PRD	52
	LARSIA	sp	6	PRD	52
	LASIODIAMESA	sp		CG	52
	LAUTERBORNIELLA	sp		CG	52
	LIMNOPHYES	sp	8	CG	52
	MACROPELOPIA	sp		PRD	52
	MESOCRICOTOPUS	sp		CG	56
	METRIOCNEMUS	sp	4	CG	52
	MICROTENDIPES	sp	6	CG	52
	MONODIAMESA	sp	7	CG	52
	MONOPELOPIA	sp		PRD	52

DIPTERA	NANOCLADIUS	sp	3	CG	52
	NATARSIA	sp	8	PRD	52
	NILOTANYPUS	sp	6	PRD	52
	NILOTHAUMA	sp	2	CG	52
	ODONTOMESA	sp	4	CG	52
	ORTHOCLADIUS	sp	7	CG	52
	ORTHOCLADIUS	annectans	7	CG	77
	PAGASTIA	sp	4	CG	52
	PARABOREOCHLUS	sp	1	CG	52
	PARACHAETOCLADIUS	sp	2	CG	52
	PARACHIRONOMUS	sp	10	PRD	52
	PARACLADOPELMA	sp	7	CG	52
	PARACRICOTOPUS	sp	1	CG	52
	PARAKIEFFERIELLA	sp	4	CG	52
	PARALAUTERBORNIELLA	sp	8	CG	52
	PARAMERINA	sp	4	PRD	52
	PARAMETRIOCNEMUS	sp	5	CG	52
	PARAPHAENOCLADIUS	sp	4	CG	52
	PARATANYTARSUS	sp	6	CG	52
	PARATENDIPES	sp	8	CG	52
	PARATRICHOCLADIUS	sp		CG	56
	PAROCHLUS	sp	4	CG	56
	PARORTHOCLADIUS	sp		CG	52
	PEDIONEMUS	sp		CG	56
	PENTANEURA	sp	6	PRD	52
	PHAENOPSECTRA	sp	7	CG	52
	POLYPEDILUM	sp	6	CG	52
	POLYPEDILUM	fallax	7	CG	54
	POLYPEDILUM	illionoense	7	CG	54
	POLYPEDILUM	convictum	6	CG	54
	POLYPEDILUM	scalaenum	7	CG	54
	POLYPEDILUM	aviceps	5	CG	54
	POLYPEDILUM	halterale	7	CG	54
	POLYPEDILUM	nubeculosum	6	CG	54
	POLYPEDILUM	laetum	6	CG	54
	POLYPEDILUM	ophioides	7	SHR	54
	POTTHASTIA	sp	2	CG	52
	POTTHASTIA	gaedii	2	CG	52
	POTTHASTIA	longimana	2	CG	52

DIPTERA	PROCLADIUS	sp	9	PRD	52
	PRODIAMESA	sp	3	CG	52
	PROTANYPUS	sp		CG	52
	PSECTROCLADIUS	sp	8	CG	52
	PSECTROTANYPUS	sp	10	PRD	52
	PSEUDOCHIRONOMUS	sp	5	CG	52
	PSEUDODIAMESA	sp	4	CG	52
	PSEUDORTHOCLADIUS	sp	3	CG	52
	PSILOMETRIOCNEMUS	sp	4	CG	52
	RHEOCRICOTOPUS	sp	6	CG	52
	RHEOPELOPIA	sp	4	PRD	52
	RHEOTANYTARSUS	sp	6	CF	52
	RHEOTANYTARSUS	distinctissimus	6	CF	77
	RHEOTANYTARSUS	exiguus	6	CF	77
	SMITTIA	sp	6	CG	52
	STEMPELLINA	sp	2	CG	52
	STEMPELLINELLA	sp	4	CG	52
	STENOCHIRONOMUS	sp	5	CG	52
	STICTOCHIRONOMUS	sp	9	CG	52
	SUBLETTEA	sp	4	CG	52
	SYMPOTTHASTIA	sp	3	CG	52
	SYNORTHOCLADIUS	sp	2	CG	52
	TANYPUS	sp	10	PRD	52
	TANYTARSUS	sp	6	CF	52
	TANYTARSUS	glabnescens	6	CF	77
	THIENEMANNIELLA	sp	5	CG	52
	THIENEMANNIELLA	fusca	5	CG	77
	THIENEMANNIELLA	xena	5	CG	77
	THIENEMANNEMYIA	sp	6	PRD	52
	TRIBELOS	sp	5	CG	52
	TRICHOTANYPUS	sp		CG	52
	TRISSOPELOPIA	sp	4	PRD	52
	TVETENIA	sp	5	CG	52
	TVETENIA	discoloripes	6	CG	51
	TVETENIA	bavarica	4	CG	51
	WIRTHIELLA	sp		CG	56
	XENOCHIRONOMUS	sp	0	PRD	52
	ZALUTSCHIA	sp	4	SRD	52
	ZAVRELIA	sp	4	CF	52

DIPTERA	ZAVRELIMYIA	sp	8	PRD	52
	CRICOTOPUS/ORTHOCLAD	sp	7	SHR	52
	MICROPSECTRA	sp	6	CG	52
	MICROPSECTANYTARSUS	unid	6	CG	52
	SYMPOSIOCLADIUS	sp	5	CG	52
	SAETHERIA	sp	4	CG	52
	ROBACKIA	sp		CG	52
	XYLOTOPOS	sp	2	CG	52
	BRUNDINIELLA	sp	2	PRD	52
	LENZIELLA	sp		CG	56
	APSECTROTANYPUS	sp		PRD	52
	LOPESCLADIUS	sp	2	CG	52
	ASHEUM	sp	5	CG	52
	TELOPELOPIA	sp	6	PRD	52
	BOREOCHLUS	sp	2	CG	52
	ALOTANYPUS	sp	6	PRD	52
	DEMEIJEREA	sp	8	CG	52
	MICROCHIRONOMUS	sp	6	CG	52
	CYPHOMELLA	sp		CG	52
	HYPORHYGMA	sp		SHR	52
	DIXA	sp	1	CG	52
	DIXELLA	sp		CG	52
	DOLICHOPODIDAE	unid	4	PRD	52
	EMPIDIDAE	unid	6	PRD	52
	CHELIFERA	sp	6	PRD	52
	CLINOCERA	sp	6	PRD	52
	DOLICHOCEPHALA	sp	6	PRD	52
	HEMERODROMIA	sp	6	PRD	52
	OREOGETON	sp	6	PRD	52
	ROEDERIODES	sp	6	PRD	52
	WIEDEMANNIA	sp	6	PRD	52
	EPHYDRINAE	unid	6	SHR	52
	EPHYDRINAE	sp	6	SHR	52
	NOTIPHILINAE	sp	6	CG	52
	PARYDRINAE	sp	6	CG	52
	PSILOPINAE	sp	6	CG	52
	MUSCIDAE	unid	6	PRD	52
	LIMNOPHORA	sp		PRD	52
	PSYCHODIDAE	unid	10	CG	52

DIPTERA	PERICOMA	sp	6	CG	52
	PSYCHODA	sp	10	CG	52
	PSYCHODA	spa		CG	52
	PSYCHODA	spb		CG	52
	THRETICUS	sp	9	CG	52
	NYMPHOMYIIDAE	unid		SCR	52
	BITTACOMORPHA	sp		CG	52
	BITTACOMORPHELLA	sp	3	CG	52
	PTYCHOPTERA	sp		CG	52
	SIMULIDAE	unid		CF	52
	CNEPHIA	sp	1	CF	83
	CNEPHIA	mutata	1	CF	83
	ECTEMNIA	sp	1	CF	83
	METACNEPHIA	sp	2	CF	83
	PROSIMULIUM	sp	2	CF	83
	PROSIMULIUM	fontanum	2	CF	83
	PROSIMULIUM	fuscum	2	CF	83
	PROSIMULIUM	fuscum/mixtum	2	CF	83
	PROSIMULIUM	magnum	2	CF	83
	PROSIMULIUM	mixtum	3	CF	83
	PROSIMULIUM	vernale	5	CF	83
	SIMULIUM	sp	5	CF	83
	SIMULIUM	aestivum	4	CF	83
	SIMULIUM	aureum	7	CF	83
	SIMULIUM	corbis	2	CF	83
	SIMULIUM	croxtoni	2	CF	83
	SIMULIUM	decorum	5	CF	83
	SIMULIUM	fibrinflatum	5	CF	83
	SIMULIUM	furculatum	4	CF	83
	SIMULIUM	jenningsi	4	CF	83
	SIMULIUM	latipes	4	CF	83
	SIMULIUM	quebecense	4	CF	83
	SIMULIUM	tubersom	4	CF	83
	SIMULIUM	vittatum	7	CF	83
	SIMULIUM	parnassum	4	CF	83
	SIMULIUM	venustum	4	CF	83
	SIMULIUM	gouldingi	3	CF	83
	SYRPHIDAE	unid	10	CG	52
	CHRYSOGASTER	sp	10	CG	52

DIPTERA	ERISTALIS	sp	10	CG	52
	HELOPHILUS	sp	10	CG	52
	TABANIDAE	unid	5	PRD	52
	ATYLOTUS	sp		PRD	52
	CHRYSOPS	sp	6	CG	52
	DIACHLORUS	sp		PRD	52
	GONIOPS	sp		PRD	52
	HAEMATOPOTA	sp		PRD	52
	HYBOMITRA	sp	5	PRD	52
	TABANUS	sp	5	PRD	52
	THAUMALEA	sp	4	CG	52
	ANTOCHA	sp	3	CG	52
	DICRANOTA	sp	3	PRD	52
	ERIOPTERA	sp	7	CG	52
	HELIUS	sp	4	CG	52
	HEXATOMA	sp	2	PRD	52
	HEXATOMA	spa	2	PRD	52
	LIMNOPHILA	sp	3	PRD	52
	LIMONIA	sp	6	SHR	52
	LIPSOTHRIX	sp		SHR	52
	PEDICIA	sp	4	PRD	52
	PHALACROCERA	sp		SHR	52
	PSEUDOLIMNOPHILA	sp	2	PRD	52
	TIPULA	sp	6	SRD	52
	TIPULA	spa	6	SRD	52
	TIPULA	spb	6	SRD	52
	TIPULA	spc	6	SRD	52
	GONOMYIA	sp	4	CG	52
	ORMOSIA	sp	4	CG	52
	MOLOPHILUS	sp	4	CG	52
	BRACHYPREMNA	sp	6	SHR	52
	STRATIOMYIDAE	unid	7	CG	52
	SCIOMYZIDAE	unid		PRD	52
	GLUTOPS	sp		PRD	81
EPHEMEROPTERA	BAETIDAE	unid		CG	96
	BAETIDAE	imm		CG	96
	BAETIS	sp	6	CG	96
	BAETIS	brunneicolor	4	CG	102
	BAETIS	frondalis	5	CG	102

EPHEMEROPTERA	BAETIS	flavistriga	5	CG	102
	BAETIS	hageni	5	CG	102
	BAETIS	intercalaris	6	CG	102
	BAETIS	propinquus	6	CG	102
	BAETIS	pluto	6	CG	102
	BAETIS	tricaudatus	6	CG	102
	BAETIS	sp a	6	CG	96
	BAETIS	sp b	6	CG	96
	CALLIBAETIS	sp	9	CG	96
	CENTROPTILUM	sp	2	CG	96
	CLOEON	stephans	4	CG	96
	HETEROCLOEON	sp	2	SCR	96
	HETEROCLOEON	curiosum	2	SCR	99
	ACENTRELLA	sp	4	SCR	99
	ACENTRELLA	cingulatum	4	SCR	99
	ACENTRELLA	sp a	4	SCR	96
	ACENTRELLA	sp b	4	SCR	96
	ACENTRELLAPLAUDITUS	sp	4	SCR	194
	PLAUDITUS	sp	5	SCR	193
	PLAUDITUS	dubium	4	SCR	193
	PLAUDITUS	punctiventrus	5	SCR	193
	ACERPENNA	sp	6	SCR	194
	ACERPENNA	pygmaeus	4	SCR	194
	ACERPENNA	macdonnoughi	6	SCR	194
	PROCLOEON	sp	4	SCR	194
	BAETISCA	sp	4	CG	96
	BRACHYCERUS	sp	3	CG	96
	BRACHYCERUS	nitidus	3	CG	195
	BRACHYCERUS	maculatus	3	CG	195
	BRACHYCERUS	lacustris	3	CG	195
	BRACHYCERUS	flavus	3	CG	195
	CAENIS	sp	7	CG	96
	CAENIS	latipennis	7	CG	189
	CAENIDAE	unid	7	CG	189
	ATTENELLA	sp	1	CG	96
	ATTENELLA	attenuata	1	CG	96
	DANNELLA	sp	2	CG	88
	DANNELLA	lita	2	CG	88
	DANNELLA	simplex	2	CG	88

EPHEMEROPTERA	DRUNELLA	sp	0	SCR	89
	DRUNELLA	lata	0	SCR	89
	DRUNELLA	cornutella	0	SCR	89
	DRUNELLA	cornuta	0	SCR	89
	DRUNELLA	walkeri	0	SCR	89
	EPHEMERELLA	sp	4	CG	91
	EPHEMERELLA	aurivillii	0	CG	91
	EPHEMERELLA	dorothea	1	CG	91
	EPHEMERELLA	excrucians	1	CG	91
	EPHEMERELLA	invaria	4	CG	91
	EPHEMERELLA	needhami	1	CG	91
	EPHEMERELLA	subvaria	4	CG	91
	EPHEMERELLA	rotunda	5	CG	91
	EPHEMERELLA	septentrionalis	2	CG	91
	EPHEMERELLA	sub/inv/rot/gr	4	CG	91
	EPHMERELLA	minimella	2	CG	91
	EPHEMERELLA	sp a	4	CG	91
	EPHEMERELLA	sp b	4	CG	91
	EURYLOPHELLA	sp	2	CG	92
	EURYLOPHELLA	bicolor	1	CG	92
	EURYLOPHELLA	funeralis	0	SHR	92
	EURYLOPHELLA	lutulenta	6	CG	92
	EURYLOPHELLA	temporalis	5	CG	92
	SERRATELLA	sp	2	CG	90
	SERRATELLA	deficiens	2	CG	90
	SERRATELLA	sordida	2	CG	90
	SERRATELLA	serrata	2	CG	90
	SERRATELLA	serratoides	2	CG	90
	SERRATELLA	sp a	2	CG	90
	SERRATELLA	sp b	2	CG	90
	EPHEMERA	sp	2	CG	96
	HEXAGENIA	sp	6	CG	96
	HEXAGENIA	limbata	6	CG	96
	LITOBRANCHA	sp	5	CG	96
	LITOBRANCHA	recurvata	5	CG	96
	ARTHROPLEA	sp	5	CF	96
	ARTHROPLEA	bipunctata	5	CF	96
	CINYGMULA	sp	2	SCR	96
	CINYGMULA	subaequalis	2	SCR	96

EPHEMEROPTERA	EPEORUS	sp	0	CG	96
	HEPTAGENIA	sp	4	SCR	96
	RHITHROGENA	sp	0	CG	96
	STENACRON	sp	7	SCR	96
	STENACRON	interpunctatum	7	SCR	7
	STENONEMA	sp	3	SCR	96
	STENONEMA	femoratum	5	SCR	93
	STENONEMA	ithaca	3	SCR	93
	STENONEMA	mediopunctatum	3	SCR	93
	STENONEMA	modestum	1	SCR	93
	STENONEMA	pudicum	1	SCR	93
	STENONEMA	pulchellum	3	SCR	93
	STENONEMA	terminatum	4	SCR	93
	STENONEMA	vicarium	2	SCR	93
	STENONEMA	luteum	3	SCR	93
	STENONEMA	sp a	3	SCR	96
	STENONEMA	sp b	3	SCR	96
	NIXE	sp	2	SCR	97
	LEUCROCUTA	sp	1	SCR	97
	CHOROTERPES	sp	2	CG	96
	HABROPHLEBIA	vibrans	4	CG	96
	HABROPHLEBIODES	sp	6	SCR	96
	LEPTOPHLEBIA	sp	4	CG	96
	PARALEPTOPHLEBIA	sp	1	CG	96
	METRETOPODIDAE	unid	2	CG	97
	METRETOPUS	sp	2	CG	97
	METRETOPUS	borealis	2	CG	97
	SIPHLOPLECTON	sp	2	CG	97
	ISONYCHIA	sp	3	CF	96
	EPHORON	sp	2	CG	96
	EPHORON	leukon	2	CG	96
	POTAMANTHIDAE	unid	4	CG	96
	ANTHOPOTAMUS	sp	4	CG	96
	AMELETUS	sp	0	CG	96
	SIPHLONURUS	sp	7	CG	96
	TRICORYTHIDAE	unid	5	CG	96
	TRICORYTHODES	sp	5	CG	96
TRICHOPTERA	BRACHYCENTRIDAE	unid	1	CF	170
	BRACHYCENTRIDAE	imm	1	CF	170
TRICHOPTERA	ADICROPHLEPS	sp	2	SHR	169

	ADICROPHLEPS	hitchcochi	2	SHR	169
	BRACHYCENTRUS	sp	1	CF	169
	BRACHYCENTRUS	americanus	1	CF	151
	BRACHYCENTRUS	lateralis	1	CF	151
	BRACHYCENTRUS	numerosus	1	CF	151
	BRACHYCENTRUS	occidentalis	1	CF	151
	BRACHYCENTRUS	incanus	0	CF	151
	MICRASEMA	sp	2	SHR	169
	MICRASEMA	kluane	1	SHR	151
	MICRASEMA	rusticum	2	SHR	151
	MICRASEMA	wataga	2	SHR	151
	CALAMOCERATIDAE	unid		SRD	169
	HETEROPLECTRON	sp	0	SRD	169
	HETEROPLECTRON	americanum	0	SRD	169
	GLOSSOSOMATIDAE	unid		SCR	169
	GLOSSOSOMATIDAE	imm		SCR	169
	AGAPETUS	sp	0	SCR	169
	GLOSSOSOMA	sp	0	SCR	169
	PROTOPTILA	sp	1	SCR	169
	CULOPTILA	sp	1	SCR	169
	HELICOPSYCHE	sp	3	SCR	169
	HELICOPSYCHE	borealis	3	SCR	169
	HYDROPSYCHIDAE	unid		CF	169
	HYDROPSYCHIDAE	imm		CF	169
	ARCTOPSYCHE	sp	1	CF	169
	ARCTOPSYCHE	ladogensis	1	CF	145
	CHEUMATOPSYCHE	sp	6	CF	169
	DIPLECTRONA	sp	0	CF	169
	DIPLECTRONA	modesta	0	CF	158
	HYDROPSYCHE	sp	5	CF	169
	HYDROPSYCHE	betteni	7	CF	161
	HYDROPSYCHE	dicantha	2	CF	161
	HYDROPSYCHE	frisoni	4	CF	160
	HYDROPSYCHE	phalerata	1	CF	160
	HYDROPSYCHE	cuanis	6	CF	160
	HYDROPSYCHE	venularis	4	CF	161
	HYDROPSYCHE	scalaris	2	CF	160
	HYDROPSYCHE	valanis	6	CF	160
TRICHOPTERA	HYDROPSYCHE	bidens	4	CF	160

	MACRONEMA	sp	5	CF	169
	MACRONEMA	carolina	5	CF	158
	MACRONEMA	zebrutum	5	CF	158
	PARAPSYCHE	sp	0	CF	169
	PARAPSYCHE	apicalis	0	CF	158
	POTAMYIA	sp	5	CF	169
	POTAMYIA	flava	5	CF	158
	SYMPHITOPSYCHE	sp	5	CF	169
	SYMPHITOPSYCHE	bifida gr	6	CF	159
	SYMPHITOPSYCHE	bronta	5	CF	159
	SYMPHITOPSYCHE	morosa	6	CF	159
	SYMPHITOPSYCHE	alhedra	3	CF	159
	SYMPHITOPSYCHE	riola	3	CF	161
	SYMPHITOPSYCHE	slossonae	4	CF	159
	SYMPHITOPSYCHE	sparna	4	CF	159
	SYMPHITOPSYCHE	macleodi	2	CF	159
	SYMPHITOPSYCHE	ventura	2	CF	159
	SYMPHITOPSYCHE	etnieri	3	CF	159
	SYMPHITOPSYCHE	bif/mor/bro	6	CF	159
	SYMPHITOPSYCHE	alh/slo/spa	4	CF	159
	SYMPHITOPSYCHE	sp b	5	CF	169
	SYMPHITOPSYCHE	sp c	5	CF	169
	APHROPSYCHE	sp		CF	169
	ARCTOPARAPSYCHE	imm	1	CF	158
	HYDROPTILIDAE	unid			169
	AGRAYLEA	sp	8	SHR	169
	ALISOTRICHIA	sp	6	SCR	169
	DIBUSA	sp	5	SCR	169
	HYDROPTILA	sp	6	PRH	169
	ITHYTRICHIA	sp	6	SCR	169
	ITHYTRICHIA	clavata	6	SCR	158
	LEUCOTRICHIA	sp	6	SCR	169
	LEUCOTRICHIA	pictipes	6	SCR	158
	MAYATRICHIA	sp	6	SCR	169
	NEOTRICHIA	sp	2	SCR	169
	OCHROTRICHIA	sp	4	CG	169
	ORTHOTRICHIA	sp	6	PRH	169
	OXYETHIRA	sp	3	PRH	169
TRICHOPTERA	PALAEGAPETUS	sp	1	SRD	169

	PALAEGAPETUS	celsus	4	SRD	158
	STACTOBIELLA	sp	2	SHR	169
	LEPIDOSTOMA	sp	1	SRD	169
	THELIOPSYCHE	sp	0	SRD	169
	CERACLEA	sp	3	CG	169
	LEPTOCERUS	sp	4	SHR	169
	LEPTOCERUS	americanus	4	SHR	169
	MYSTACIDES	sp	4	CG	169
	MYSTACIDES	sepulchralis	4	CG	158
	MYSTACIDES	longicornis	4	CG	158
	NECTOPSYCHE	sp	3	SHR	169
	NECTOPSYCHE	albida	3	SHR	158
	OECETIS	sp	4	PRD	169
	OECETIS	avara	4	PRD	158
	OECETIS	inconspicua	4	PRD	158
	SETODES	sp	2	CG	169
	TRIAENODES	sp	6	SHR	169
	TRIAENODES	injusta	4	SHR	158
	TRIAENODES	aba	4	SHR	158
	TRIAENODES	tarda		SHR	158
	LIMNEPHILIDAE	unid			169
	LIMNEPHILIDAE	imm			169
	ANABOLIA	sp	5	SRD	169
	APATANIA	sp	3	SCR	169
	ASYNARCHUS	sp	6	SRD	169
	FRENESIA	sp	0	SRD	169
	GLYPHOPSYCHE	sp	1	SRD	169
	GOERA	sp	0	SCR	169
	GOERITA	sp		SCR	169
	HESPEROPHYLAX	sp	3	SRD	169
	HYDATOPHYLAX	sp	2	SRD	169
	IRONOQUIA	sp	3	SHR	169
	LIMNEPHILUS	sp	3	SRD	169
	NEMOTAULIUS	sp	3	SRD	169
	ONOCOSMOECUS	sp	2	SCR	169
	PLATYCENTROPUS	sp	4	SRD	169
	PSEUDOSTENOPHYLAX	sp	0	SCR	169
	PSYCHOGLYPHA	sp	0	CG	169
TRICHOPTERA	PYCNOPSYCHE	sp	4	SRD	169

	GRAMMOTAULIUS	sp		SHR	169
	GRENSIA	sp	2	SRD	169
	MOLANNA	sp	6	SCR	169
	MOLANNA	tryphena	6	SCR	162
	MOLANNA	uniophila	6	SCR	162
	MOLANNA	blenda	6	SCR	162
	PSILOTRETA	sp	0	SCR	169
	MARILIA	sp	1	SCR	169
	CHIMARRA	sp	4	CF	169
	CHIMARRA	aterrima	4	CF	158
	CHIMARRA	obscura	4	CF	158
	CHIMARRA	socia	0	CF	158
	CHIMARRA	feria	1	CF	158
	DOLOPHILODES	sp	0	CF	169
	WORMALDIA	sp	0	CF	169
	AGRYPNIA	sp	7	SRD	169
	AGRYPNIA	improba	7	SRD	166
	AGRYPNIA	vestita	7	SRD	166
	BANKSIOLA	sp	6	SHR	169
	BANKSIOLA	crotchi	6	SHR	166
	BANKSIOLA	smithi	6	SHR	166
	HAGENELLA	canadensis	0	SHR	166
	OLIGOSTOMIS	sp	2	PRD	169
	PHRYGANEA	sp	8	SHR	169
	PTILOSTOMIS	sp	5	SRD	169
	PTILOSTOMIS	ocellifera	5	SRD	158
	CYRNELLUS	sp	8	CF	169
	CYRNELLUS	fraternus	8	CF	150
	NEURECLIPSIS	sp	7	CF	169
	NYCTIOPHYLAX	sp	5	PRD	169
	PHYLOCENTROPUS	sp	5	CF	169
	POLYCENTROPUS	sp	6	PRD	169
	POLYCENTROPUS	glacialis	6	PRD	158
	POLYCENTROPUS	cinereus	6	PRD	158
	POLYCENTROPUS	centralis	6	PRD	158
	POLYCENTROPUS	interruptus	6	PRD	158
	CERNOTINA	sp	4	PRD	158
	LYPE	sp	2	SCR	169
TRICHOPTERA	LYPE	diversa	2	SCR	158

	PSYCHOMYIA	sp	2	CG	169
	RHYACOPHILA	sp	1	PRD	169
	RHYACOPHILA	fuscula	2	PRD	149
	RHYACOPHILA	melita	4	PRD	149
	RHYACOPHILA	carolina	0	PRD	149
	RHYACOPHILA	torva	0	PRD	149
	RHYACOPHILA	nigrita	0	PRD	149
	RHYACOPHILA	manistee	0	PRD	149
	RHYACOPHILA	vibox	0	PRD	149
	RHYACOPHILA	fenestra	0	PRD	149
	RHYACOPHILA	minora	0	PRD	149
	RHYACOPHILA	atrata	0	PRD	149
	RHYACOPHILA	carpenteri	1	PRD	149
	RHYACOPHILA	invaria	1	PRD	149
	RHYACOPHILA	invaria spa	1	PRD	149
	RHYACOPHILA	invaria spb	1	PRD	149
	RHYACOPHILA	carolina spa	1	PRD	149
	RHYACOPHILA	carolina spb	1	PRD	149
	RHYACOPHILA	sp a	1	PRD	149
	RHYACOPHILA	glaberrima	1	PRD	149
	RHYACOPHILA	acropedes	1	PRD	149
	RHYACOPHILA	acutiloba	1	PRD	149
	AGARODES	sp	3	SRD	169
	NEOPHYLAX	sp	3	SCR	169
	NEOPHYLAX	nacatus	2	SCR	147
	NEOPHYLAX	ornatus	2	SCR	147
PLECOPTERA	CAPNIIDAE	unid	3	SRD	7
	CAPNIIDAE	imm	3	SRD	7
	ALLOCAPNIA	sp	3	SRD	7
	CAPNIA	sp	2	SRD	7
	NEMOCAPNIA	sp	2	SRD	7
	PARACAPNIA	sp	1	SRD	7
	CHLOROPERLIDAE	unid	0	PRD	7
	CHLOROPERLIDAE	imm	0	PRD	7
	ALLOPERLA	sp	0	CG	7
	CHLOROPERLA	sp	0	PRD	7
	HASTAPERLA	sp	1	SCR	7
	RASVENA	sp	0	CG	7
PLECOPTERA	SUWALLIA	sp	0	PRD	7
	SWELTSA	sp	0	PRD	7

	UTAPERLA	sp	0	SRD	7
	LEUCTRIDAE	unid	0	SRD	7
	LEUCTRIDAE	imm	0	SRD	7
	LEUCTRA	sp	0	SRD	7
	LEUCTRA	maria	0	SHR	7
	PARALEUCTRA	sp	0	SRD	7
	ZEALEUCTRA	sp	0	SRD	7
	NEMOURIDAE	unid	2	SRD	7
	NEMOURIDAE	imm	2	SRD	7
	AMPHINEMURA	sp	2	SRD	7
	AMPHINEMURA	wui	2	SRD	7
	AMPHINEMURA	nigritta	2	SRD	7
	NEMOURA	sp	1	SRD	7
	OSTROCERCA	sp	1	SRD	7
	PARANEMOURA	sp	2	SRD	7
	PROSTOIA	sp	0	SRD	7
	SHIPSA	sp	1	SRD	7
	SOYEDINA	sp	0	SRD	7
	ZAPADA	sp	0	SRD	7
	PODMOSTA	sp	0	SRD	7
	PELTOPERLIDAE	unid	0	SRD	7
	PELTOPERLA	sp	0	SRD	7
	TALLAPERLA	sp	0	SRD	7
	PERLIDAE	unid	3	PRD	7
	PERLIDAE	imm	3	PRD	7
	ACRONEURIA	sp	0	PRD	7
	ACRONEURIA	carolinesis	0	PRD	7
	ACRONEURIA	abnormis	0	PRD	7
	ACRONEURIA	lycorias	0	PRD	7
	ACRONEURIA	internata	0	PRD	7
	ACRONEURIA	georgiana	0	PRD	7
	ACRONEURIA	filicis	1	PRD	7
	ATTANEURIA	ruralis	1	PRD	7
	NEOPERLA	sp	1	PRD	138
	NEOPERLA	clymene	1	PRD	7
	PARAGNETINA	sp	1	PRD	7
	PARAGNETINA	media	1	PRD	7
PLECOPTERA	PARAGNETINA	immarginata	1	PRD	7

	PERLESTA	sp	5	PRD	7
	PERLESTA	placida	5	PRD	7
	PERLINELLA	sp	1	PRD	7
	AGNETINA	sp	2	PRD	7
	AGNETINA	capitata	2	PRD	7
	BELONEURIA	sp	0	PRD	7
	BELONEURIA	georgiana	0	PRD	7
	PERLODIDAE	unid	2	PRD	7
	PERLODIDAE	imm	2	PRD	7
	ARCYNOPTERYX	sp	0	PRD	7
	CULTUS	sp	3	PRD	7
	DIPLOPERLA	sp	2	PRD	7
	HELOPICUS	sp	2	PRD	7
	ISOGENOIDES	sp	0	PRD	7
	ISOGENOIDES	hansoni	2	PRD	7
	ISOGENOIDES	doratus	2	PRD	7
	ISOGENOIDES	frontalis	0	PRD	7
	ISOGENOIDES	olivaceous	0	PRD	7
	ISOPERLA	sp	2	PRD	7
	ISOPERLA	bilineata	4	PRD	7
	ISOPERLA	clio	1	PRD	131
	ISOPERLA	dicala	2	PRD	7
	ISOPERLA	frisoni	0	PRD	7
	ISOPERLA	lata	0	PRD	7
	ISOPERLA	marlynia	4	PRD	7
	ISOPERLA	holochlora	1	PRD	7
	ISOPERLA	nana	5	PRD	7
	ISOPERLA	namata	1	PRD	7
	ISOPERLA	orata	2	PRD	7
	ISOPERLA	signata	2	PRD	7
	ISOPERLA	similis	1	PRD	7
	ISOPERLA	slossonae	2	PRD	7
	ISOPERLA	cotta	1	PRD	7
	ISOPERLA	francesca	1	PRD	7
	ISOPERLA	gibbsae	1	PRD	7
	ISOPERLA	richardsoni	2	PRD	7
	ISOPERLA	transmarina	0	PRD	7
	ISOPERLA	burksi	2	PRD	7
PLECOPTERA	MALIREKUS	sp	2	PRD	7

	MALIREKUS	hastatus	2	PRD	7
	REMENUS	sp	2	PRD	7
	CLIOPERLA	sp	1	PRD	7
	DIURA	sp	2	PRD	138
	PTERONARCYS	sp	0	SRD	138
	PTERONARCYS	biloba	0	SRD	138
	PTERONARCYS	proteus	0	SRD	138
	PTERONARCYS	dorsata	0	SRD	138
	TAENIOPTERYGIDAE	unid	3	SRD	7
	TAENIOPTERYGIDAE	imm	3	SRD	7
	OEMOPTERYX	sp	1	SCR	7
	STROPHOPTERYX	sp	3	SRD	7
	TAENIOPTERYX	sp	3	SHR	7
	TAENIOPTERYX	burksi	1	SHR	7
	TAENIOPTERYX	nivalis	1	SHR	7
	TAENIOPTERYX	maura	3	SHR	7
	TAENIONEMA	sp	1	SRD	7
	BRACHYPTERA	grp	1	SRD	134
ODONATA	AESHNIDAE	unid	5	PRD	126
	AESHNIDAE	imm	5	PRD	126
	AESHNA	sp	5	PRD	126
	AESHNA	interrupta	5	PRD	126
	AESHNA	tuberculifera	5	PRD	126
	AESHNA	umbrosa	5	PRD	126
	AESHNA	eremita	5	PRD	126
	AESHNA	venticalis	5	PRD	126
	AESHNA	juncea	5	PRD	126
	ANAX	sp	8	PRD	126
	BASIAESHNA	sp	6	PRD	126
	BASIAESCHNA	janta	6	PRD	126
	BOYERIA	sp	2	PRD	126
	BOYERIA	vinosa	2	PRD	126
	BOYERIA	grafiana	2	PRD	126
	NASIAESCHNA	pentacantha	2	PRD	126
	EPIAESCHNA	sp	2	PRD	126
	GOMPHAESCHNA	sp	4	PRD	126
	CALOPTERYGIDAE	unid	7	PRD	126
	CALOPTERYGIDAE	imm	7	PRD	126
ODONATA	CALOPTERYX	sp	6	PRD	126
	HETAERINA	sp	6	PRD	126

	COENAGRIONIDAE	unid	8	PRD	7
	COENAGRIONIDAE	imm	8	PRD	7
	AMPHIAGRION	sp	9	PRD	7
	ARGIA	sp	6	PRD	7
	ARGIA	moesta	6	PRD	7
	ARGIA	tibialis	6	PRD	7
	ARGIA	violacea	6	PRD	7
	CHROMAGRION	sp	4	PRD	7
	CHROMAGRION	conditum	4	PRD	7
	COENAGRION	sp	8	PRD	7
	ENALLAGMA	sp	8	PRD	7
	ISCHNURA	sp	9	PRD	7
	ANOMALAGRION	sp	7	PRD	7
	NEHALLENIA	sp	7	PRD	7
	CORDULEGASTRIDAE	unid	3	PRD	126
	CORDULEGASTRIDAE	imm	3	PRD	126
	CORDULEGASTER	sp	3	PRD	126
	CORDULEGASTER	maculatus	3	PRD	126
	TAENIOGASTER	sp	2	PRD	126
	ZORAENA	sp	2	PRD	126
	CORDULIIDAE	imm	3	PRD	126
	EPICORDULIA	sp	3	PRD	126
	EPICORDULIA	princeps	3	PRD	126
	HELOCORDULIA	sp	3	PRD	126
	NEUROCORDULIA	sp	2	PRD	126
	SOMATOCHLORA	sp	1	PRD	126
	TETRAGONEURIA	sp	3	PRD	126
	TETRAGONEURIA	cynasura	3	PRD	126
	TETRAGONEURIA	spinigera	3	PRD	113
	CORDULIA	sp	3	PRD	126
	GOMPHIDAE	unid	5	PRD	126
	GOMPHIDAE	imm	5	PRD	126
	ARIGOMPHUS	sp	6	PRD	126
	DROMOGOMPHUS	sp	4	PRD	126
	GOMPHURUS	sp	6	PRD	126
	GOMPHUS	sp	5	PRD	126
	HAGENIUS	sp	1	PRD	126
ODONATA	HAGENIUS	brevistylus	6	PRD	126

	HYLOGOMPHUS	sp	3	PRD	126
	LANTHUS	sp	5	PRD	126
	LANTHUS	parvulus	5	PRD	126
	LANTHUS	albistylus	5	PRD	126
	OPHIOGOMPHUS	sp	1	PRD	126
	OPHIGOMPHUS	anomalus	1	PRD	126
	PROGOMPHUS	sp	6	PRD	126
	STYLOGOMPHUS	sp	0	PRD	126
	STYLURUS	sp	4	PRD	126
	LESTES	sp	9	PRD	7
	DIDYMOPS	sp	4	PRD	126
	DIDYMOPS	transversa	4	PRD	126
	MACROMIA	sp	2	PRD	126
	LIBELLULIDAE	unid	8	PRD	126
	LIBELLULIDAE	imm	8	PRD	126
	CELITHEMIS	sp	8	PRD	126
	ERYTHEMIS	sp	8	PRD	126
	LADONA	sp	8	PRD	126
	LADONA	julia	8	PRD	126
	LEUCORRHINIA	sp	9	PRD	126
	LEUCORRHINIA	frigida	9	PRD	126
	LEUCORRHINIA	glacilis	9	PRD	126
	LEUCORRHINIA	proxima	9	PRD	126
	LEUCORRHINIA	hudsonica	9	PRD	126
	LIBELLULA	sp	9	PRD	126
	NANNOTHEMIS	bella	8	PRD	126
	PACHYDIPLAX	longipennis	8	PRD	126
	PLATHEMIS	sp	8	PRD	126
	PLATHEMIS	lydia	8	PRD	126
	SYMPETRUM	sp	10	PRD	126
	SYMPETRUM	vicinum	10	PRD	126
MEGALOPTERA	CHAULIODES	sp	4	PRD	122
	CORYDALUS	sp	5	PRD	122
	NEOHERMES	sp		PRD	122
	NIGRONIA	sp	0	PRD	122
	SIALIS	sp	6	PRD	122
LEPIDOPTERA	UID		5	SHR	119
	ACENTRIA	sp	5	SHR	119
LEPIDOPTERA	CRAMBUS	sp	5	SHR	119
	NEOCATACLYSTA	sp	5	SHR	119

	NYMPHULA	sp	7	SHR	119
	PARARGYRACTIS	sp	5	SCR	119
	PARAPONXY	sp	5	SHR	119
	PETROPHILA	sp	5	SCR	119
	TORTRICIDAE	unid	5	SHR	119
	ARCHIPS	sp	5	SHR	119
	BACTRA	sp	5	SHR	119
	NEPTICULIDAE	sp	5	SHR	119
AMPHIPODA	GAMMARUS	sp	6	CG	13
	GAMMARUS	fasciatus	6	CG	13
	GAMMARUS	pseudolimnaeus	4	CG	13
	GAMMARUS	lacustris	4	CG	13
	CRANGONYX	sp	8	CG	13
	CRANGONYX	pseudogracilis	8	CG	13
	CRANGONYX	richmondensis	8	CG	13
	STYGONECTES	sp	4	SCR	13
	STYGOBROMUS	borealis	4	SCR	15
	HYALLELA	sp	8	CG	13
	HYALLELA	azteca	8	CG	13
ISOPODA	ASELLIDAE	unid	8	CG	13
	ASELLUS	sp	8	CG	13
	ASELLUS	communis	8	CG	13
	ASELLUS	racovitzai	8	CG	13
	LIRCEUS	sp	8	CG	13
DECAPODA	UNID		6	CG	13
	CAMBARIDAE	unid	6	CG	13
	CAMBARUS	sp	6	CG	13
	CAMBARUS	bartoni	4	CG	13
	ORONECTES	sp	6	CG	13
	ORONECTES	immunes	6	CG	13
	ORONECTES	limosus	6	CG	13
	ORONECTES	obscurus	6	CG	13
	ORONECTES	propinquus	6	CG	13
	ORONECTES	rusticus	6	CG	13
	ORONECTES	virilis	6	CG	13
GASTROPODA	HYDROBIIDAE	unid	8	SCR	30
	AMNICOLA	sp	8	SCR	30
	AMNICOLA	limosa	8	SCR	30
GASTROPODA	AMNICOLA	walkeri	8	SCR	30

	AMNICOLA	grana	8	SCR	30
	CINCINNATIA	sp	8	SCR	30
	LYOGYRUS	sp	8	SCR	30
	LYOGYRUS	pupoidea	8	SCR	30
	MARSTONIA	decepta	8	SCR	30
	PROBITHINELLA	sp	8	SCR	30
	PYRGULOPSIS	sp	8	SCR	30
	PYRGULOPSIS	lustrica	8	SCR	30
	BITHYNIA	sp	8	SCR	30
	BITHYNIA	tentaculata	8	SCR	30
	PLEUROCERIDAE	unid	8	SCR	30
	GONIOBASIS	sp	6	SCR	30
	GONIOBASIS	livescens	6	SCR	30
	PLEUROCERA	sp	6	SCR	30
	LEPTOXIS	sp	6	SCR	30
	LEPTOXIS	carinata	6	SCR	30
	VALVATA	sp	6	SCR	30
	VALVATA	tricarinata	8	SCR	30
	VIVIPARIDAE	unid	6	SCR	30
	CAMPELOMA	decisa	6	SCR	30
	CIPANGOPALUDINA	sp	6	SCR	30
	CIPANGOPALUDINA	chinensis	6	SCR	30
	CIPANGOPALUDINA	japonica	6	SCR	111
	LIOPLAX	sp	6	SCR	30
	VIVIPARUS	georgianus	6	CG	30
	ANCYLIDAE	unid	6	SCR	30
	FERRISSIA	californica	6	SCR	30
	FERRISSIA	rivularis	6	SCR	30
	FERRISSIA	parallela	6	SCR	30
	FERRISSIA	sp	6	SCR	30
	LAEVAPEX	fuscus	6	SCR	30
	LYMNAEIDAE	unid	6	CG	30
	ACELLA	haldemani	6	SCR	30
	FOSSARIA	sp	6	CG	30
	FOSSARIA	galbana	6	CG	30
	FOSSARIA	obrussa grp	6	SCR	30
	FOSSARIA	rusticus	6	SCR	111
	FOSSARIA	modicella	6	SCR	111
GASTROPODA	FOSSARIA	parva	6	SCR	111

	FOSSARIA	obrussa	6	SCR	111
	LYMNAEA	sp	6	CG	30
	LYMNAEA	stagnicola	6	CG	30
	PSEUDOSUCCINEA	sp	6	CG	30
	PSEUDOSUCCINEA	columella	6	CG	30
	RADIX	sp	6	CG	30
	STAGNICOLA	sp	6	CG	30
	STAGNICOLA	emarginata	6	CG	30
	STAGNICOLA	catascopium	6	CG	30
	STAGNICOLA	elodes	6	CG	30
	PHYSIDAE	unid	8	CG	30
	APLEXA	sp	8	CG	30
	APLEXA	elongata	8	SCR	30
	PHYSA	sp	8	CG	30
	PHYSA	heterostropha	8	SCR	30
	PHYSA	integra	8	CG	30
	PHYSELLA	sp	8	CG	30
	PHYSELLA	ancillaria	8	SCR	30
	PHYSELLA	gyrina	8	CG	30
	PLANORBIDAE	unid	8	SCR	30
	GYRAULUS	sp	8	SCR	30
	GYRAULUS	circumstriatus	8	SCR	30
	GYRAULUS	parvus	8	SCR	30
	GYRAULUS	deflectus	8	SCR	30
	GYRALUS	crista	8	SCR	30
	HELISOMA	sp	6	SCR	30
	HELISOMA	anceps	6	SCR	30
	HELISOMA	campanulata	6	SCR	30
	HELISOMA	trivolvis	6	SCR	30
	HELISOMA	pilsbryi	6	SCR	105
	MICROMENETUS	sp	6	SCR	30
	MICROMENETUS	dilatus	6	SCR	30
	PLANORBULA	sp	6	SCR	30
	PLANORBULA	armigera	6	SCR	30
	PROMENETUS	sp	6	SCR	30
	PROMENETUS	exacuous	6	SCR	30
BIVALVIA	UNID		8	CF	30
	CORBICULA	sp	8	CF	30
BIVALVIA	SPHAERIIDAE	unid	8	CF	30

	MUSCULIUM	sp	8	CF	30
	MUSCULIUM	securis	8	CF	27
	MUSCULIUM	partumeium	8	CF	27
	MUSCULIUM	transversum	8	CF	27
	MUSCULIUM	lacustre	8	CF	27
	PISIDIUM	sp	8	CF	30
	PISIDIUM	casertanum	8	CF	27
	PISIDIUM	henslowanum	8	CF	27
	PISIDIUM	punctatum	8	CF	27
	PISIDIUM	ventricosum	8	CF	27
	PISIDIUM	walkeri	8	CF	27
	PISIDIUM	compressum	8	CF	27
	PISIDIUM	fallax	8	CF	27
	PISIDIUM	amnicum	8	CF	27
	PISIDIUM	adamsi	6	CF	27
	PISIDIUM	nitidium	8	CF	27
	PISIDIUM	ferrugineum	8	CF	27
	PISIDIUM	dubium	8	CF	27
	PISIDIIDAE	unid	8	CF	27
	PISIDIUM	variabile	8	CF	16
	SPHAERIUM	sp	8	CF	30
	SPHAERIUM	corneum	8	CF	27
	SPHAERIUM	occidetale	8	CF	27
	SPHAERIUM	rhomboideum	8	CF	27
	SPHAERIUM	simule	8	CF	27
	SPHAERIUM	striatum	8	CF	27
	MARGARITIFERA	sp	6	CF	30
	UNIONIDAE	unid	6	CF	30
	ALASMIDONTA	sp	6	CF	30
	ALASMIDONTA	vericosa	6	CF	30
	ALASMIDONTA	undulata	6	CF	30
	ALASMIDONTA	heterodon	6	CF	30
	PYGANODON	sp	6	CF	30
	PYGANODON	grandis	6	CF	30
	PYGANODON	cataracta	6	CF	30
	ANODONTOIDES	ferussacianus	6	CF	30
	ANODONTA	implicata	6	CF	30
	ELLIPTIO	sp	8	CF	30
BIVALVIA	ELLIPTIO	complanata	8	CF	30

	LAMPSILIS	sp	6	CF	30
	LAMPSILIS	radiata	6	CF	30
	LAMPSILIS	ovata	6	CF	30
	LASMIGONA	sp	6	CF	30
	LASMIGONA	compressa	6	CF	30
	LASMIGONA	costata	6	CF	30
	LEPTODEA	fragilis	6	CF	30
	LIGUMIA	recta	6	CF	30
	PROPTERA	alata	6	CF	30
	STROPHITUS	undulatus	6	CF	30
	DREISSENA	polymorpha	8	CF	179
TRICLADIDA	UNID		6	PRD	8
	DUGESIA	sp	6	PRD	8
	CURA	sp	6	PRD	8
	CURA	foremanii	6	PRD	8
	PLANARIA	sp	6	PRD	8
	HYMANELLA	sp	6	PRD	8
	HYMANELLA	retenuova	6	PRD	8
	PHAGOCATA	sp	6	PRD	8
	PHAGOCATA	gracilis	6	PRD	8
	PROCOTYLA	fluviatilis	6	PRD	8
OLIGOCHAETA	BRANCHOBDELLIDAE	unid		CG	23
	NAIDIDAE	unid		CG	23
	TUBIFICIDAE	unid		CG	23
	LUMBRICULIDAE	unid		CG	23
	ENCHYTRAEIDAE	unid		CG	23
	LUMBRICINA	unid		CG	23
HIRUDINEA	GLOSSIPHONIIDAE	unid	6	CG	20
	ACTINOBDELLA	sp	6	CG	20
	ALBOGLOSSIPHONIA	sp	6	CG	20
	ALBOGLOSSIPHONIA	heteroclita	6	CG	20
	BATRACOBDELLA	sp	6	CG	20
	BATRACOBDELLA	phalera	6	CG	20
	BATRACOBDELLA	picta	6	CG	20
	BATRACOBDELLA	cryptobranchii	6	CG	20
	GLOSSIPHONIA	sp	6	CG	20
	GLOSSIPHONIA	complanata	6	CG	20
	HELOBDELLA	sp	6	CG	20
HIRUDINEA	HELOBDELLA	elongata	8	CG	20
	HELOBDELLA	fusca	6	CG	20

	HELOBDELLA	papillata	6	CG	20
	HELOBDELLA	stagnalis	6	CG	20
	HELOBDELLA	triseralis	8	CG	20
	PLACOBDELLA	sp	6	CG	20
	PLACOBDELLA	montifera	6	CG	20
	PLACOBDELLA	multilineata	6	CG	20
	PLACOBDELLA	ornata	6	CG	20
	PLACOBDELLA	papillifera	6	CG	20
	PLACOBDELLA	parasitica	6	PAR	20
	PLACOBDELLA	translucens	6	PRC	20
	PLACOBDELLA	hollensis	6	CG	20
	OLIGOBDELLA	sp	6	PAR	20
	OLIGOBDELLA	biannulata	6	PAR	20
	BOREOBDELLA	verrucata	6	CG	20
	HIRUDINIDAE	unid	6	CG	20
	HAEMOPIS	sp	6	CG	20
	HAEMOPIS	grandis	6	CG	20
	HAEMOPIS	kingi	6	CG	20
	HAEMOPIS	marmorata	6	CG	20
	MACROBDELLA	sp	6	PRD	20
	ERPOBDELLIDAE	unid	6	CG	20
	DINA	sp	6	CG	20
	ERPOBDELLA	sp	6	CG	20
	ERPOBDELLA	punctata	6	CG	20
	MOOREOBDELLA	microstoma	6	PRD	20
NEUROPTERA	CLIMACIA	sp	5	PRD	122
	SISYRA	sp	4	PRD	122
HYDRACHNIDIA	UID		6	PRD	116

Functional Abbreviations: PRD = Predator; CG = Collector/Gatherer; CF = Collector/Filterer; PAR = Parasite; SCR = Scraper; SRD = Shredder/Detritus; SHR = Shredder/Herbaceous

Attachment D: VTDEC list of identification references for all macroinvertebrate taxa - July, 2000
Table lists the VTDEC reference number, and associated reference. References may be added as taxonomic associations change periodically.

Ref #	Author	Title	Publication
1	Borrow, D.J., C.A. Triplehorn & N.F. Johnson. 1989	An intro. to the study of insects. 6th ed.	Harcourt Brace Jovanovich College Publ., NY. 875p
2	Fiske, S. and J.Byrne. 1987	Key to Freshwat. macroinv. fauna of New Eng.	River watch network, Montpelier, VT. 42p
3	Hilsenhoff, W.L. 1979	Aqu. insects of WI. Keys to WI genera & notes of bio, dist, & spp	Natural Hist. Council, Madison, WI. 60p
4	Lehmkuhl, D.M. 1979	How to know the aqu. insects	WM. C. Brown Co. Publ. Univ. of Saskatchewan. 168p
5	McCafferty, W.P. 1981	Aquatic entomology	Jones & Bartlett Publ. Inc. 448p
6	Merrit, R.W. & K.W. Cummins (eds) 1997	An intro to aqu. insects of N. Amer. 3rd Ed.	Kendall/Hunt, Dubuque, IA. 862p
7	Peckarsky, B.L. 1990	Freshwat. macroinv. of northeastern N. Amer.	Cornell Univ. Press, Ithaca, NY. 442p
8	Pennak, R.W. 1978	Freshwat. inverts. of the U.S. 2nd ed.	John Wiley & Sons Inc., NY. 803p
9	Peterson, A. 1960	Larvae of insects. An intro. to nearctic spp. Part II.	Edward Bros. Inc., Ann Arbor, MI 416p
10	Stehr, F.W. (ed) 1991	Immature insects (vol II)	Kendall/Hunt Publ. Co., Dubuque, IA. 975p
11	Usinger, R.I. (ed) 1956	Aqu. insects of California	Univ. of Cal. Press. 508p
12	Ward, H.B. & G.C. Whipple 1959	Freshwat. Bio. 2nd ed.	John Wiley & sons, Inc., NY. 1248p
13	Bell, R.T. 1971	Handbook of malacost. of VT & neighboring regions.	UVM, Burlington, VT. 65p
14	Bousfield, E.L. 1973	Shallow-water gammaridean Amphipoda of New Eng.	Cornell Univ. Press., Ithaca, NY. 312p
15	Holsinger, J.R. 1972	The Freshwat. Amphipod crustaceans (Gammeridae) of N. Amer	US EPA 18050ELD. Ident. manual no. 5. 89p
16	Smith, D.G. 1988	Key to the Freshwat. macroinv. of MA (no. 3) Crustacea Malacostraca	Div of water Poll. Control Publ. no. 15,236-61-250-2-88cr. Westborough, MA 58p

17	Brinkhurst, R.O. 1986	Guide to the freshwat. aqu. microdile oligochaetes of N. Amer	Dept. Fish & Oceans, Ottawa, Canada. 259p
18	Foster, N. 1972	Freshwat. Polychaetes (Annelida) of N. Amer.	US EPA 18050ELD. Ident. manual no. 4. 15p
19	Klemm, D.J. 1972	Freshwat. leeches (Annelida: Hirudinea) of N. Amer.	US EPA 18050ELD. Ident. manual no. 8. 53p
20	Klemm, D.J. 1982	Leeches (Annelida: Hirudinea) of N. Amer.	US EPA-600/3-82-025. Cincinnati, OH. 177p
21	Klemm, D.J. 1990	Hirudinea. ch 19. In Peckarsky. Freshwat. macroinv. of NE N. Amer.	Cornell Univ. Press., Ithaca, NY. 442p
22	Stimpson, K.S., D.J. Klemm & J.K. Hiltunen. 1982	A guide to the freshwat. tubificidae of N. Amer.	US EPA-600/3-82-033. 61p
23	Strayer, D. 1990	Aqu. Oligochaeta. ch. 18. In Peckarsky. Freshwat. macroinv. of NE N. Amer.	Cornell Univ. Press., Ithaca, NY. 442p
24	Burch, J.B. 1975	Freshwat. Unionacean clams (Molluska: Pelecypoda)	Malacological Publ., Hamburg, MI. 95p
25	Burch, J.B. 1975b	Freshwat. Sphaeriacean clams (Molluska: Pelecypoda)	Malacological Publ., Hamburg, MI. 96p
26	Clarke, A.H. 1981	The freshwat. mollusks of Canada	Nat'l museums of Canada, Ottawa. 436p
27	Mackey, G.L., D.S. White & T.W. Zdeba. 1980	A guide to the freshwat. mollusks of Laurentian Great Lakes with special emph. on Pisidium	US EPA-600/3-80-068. Duluth, MN. 133p
28	Smith, D.G. 1986	Key to the freshwat. macroinv. of MA (no. 1) Molluska Pelecypoda	Div. of Water Poll. Cont. Publ. no. 14676-56-300-12-86-cr
29	Strayer, D. 1984	Annotated keys to the freshwat. mollusks of NY state with notes on zoogeo. & spp dist.	NY. botanical gardens, Box AB, Millbrook, NY. 52p
30	Strayer, D. 1990	Freshwat. Mollusks. ch 17. In Peckarsky. Freshwat. macroinv of NE N. Amer.	Cornell Univ. Press., Ithaca, NY. 442p
31	Barr, C.B. & J.B. Chapin. 1988	The aqu. Dryopoidea of LA.	Tulane studies in zoology & botany. 26(2):164p
32	Brown, H.P. 1972	Aqu. Dryopoid beetles (Coleoptera) of the U.S.	US EPA ident. manual no. 6. Water Poll. Cont. Res. Ser. 82p
33	Brown, H.P. & C.M. Murvosh. 1972	A revision of the genus Psephenus (water-	Trans. Amer. Ent. Soc. 100:289-340p

		penny beetles) of the US & Can.	
34	Brown, H.P. & D.S. White. 1978	Notes on separation & ident. of N. Amer. riffle beetles	Ent. News. 89(1,2):1-12p
35	Finni, G.R. & B.A. Skinner. 1975	The Elmidae & Dryopidae of IN.	J. Kansas Entomol. Soc. 48(3):388-395p
36	Hilsenhoff, W.L. 1973	Notes of Dubiraphia w/ desc. of 5 new spp.	Ann. Entomol. Soc. Amer. 66(1):55-61p
37	Hilsenhoff, W.L. & W.U. Brigham. 1978	Crawling water beetles of WI.	The Great Lakes Entomol. 11(1):11-22p
38	Hilsenhoff, W.L. & K.L. Schmude. 1992	Riffle beetles of WI. w/ notes on dist., hab. & ident.	The Great Lakes Entomol. 25:191-213p
39	Hilsenhoff, W.L. 1992	Dytiscidae & Noteridae of WI. (Coleoptera) I...Spec. of Agabetinae, Laccophilinae,Noterida	The Great Lakes Entomol. 25:57-69p
40	Hilsenhoff, W.L. 1993	Dytiscidae & Noteridae of WI. (Coleoptera) II...Spec. of Dytiscinae	The Great Lakes Entomol. 26:35-53p
41	Hilsenhoff, W.L. 1993	Dytiscidae & Noteridae of WI. (Coleoptera) III...Spec. of Colymbetinae, Except Agabini	The Great Lakes Entomol. 26:121-136p
42	Hilsenhoff, W.L. 1993	Dytiscidae & Noteridae of WI. (Coleoptera) IV...Spec. of Agabini (Colymbetinae)	The Great Lakes Entomol. 26:173-197p
43	Lawrence, J.F. et. al. 1991	Order Coleoptera. ch 34. In Stehr. Immature insects (vol II).	Kendall/Hunt Publ. Co., Dubuque, IA. 975p
44	Thompson, R.T. 1992	Observ. on the morph. & class. of weevils w/ a key to major grps.	J. Natural Hist. 26:835-891p
45	White, D.S. 1978	A revision of the nearctic Optioservus w/ descrip. of new spp.	System. Entomol. 3:59-74p
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47	Christiansen, K.A. & R.J. Snider. 1984	Aqu. Collembola. ch 9. In Merritt & Cummins. An intro to aqu insects of N. Amer (2nd ed).	Kendall/Hunt Publ. Co., Dubuque, IA. 772p

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50	Beck, E.C. & W.M. Beck, Jr. 1969	Chironomidae of FL. III. The Harnischia complex.	FL. State Museum Bull. (5):277-313p
51	Bode, R.W. 1983	Larvae of N. Amer. Eukiefferiella & Tvetenia.	NY. State Museum Bull. Albany, NY. 452:40p
52	Bode, R.W. 1990	Chironomidae. ch 14. In Peckarsky. Freshwat. macroinv. of NE N. Amer.	Cornell Univ. Press., Ithaca, NY. 442p
53	Boesel, M.W. 1972	The early stages of Ablabesmyia annulata (Say).	The OH. J. of Sci. 72(3):170-173p
54	Boesel, M.W. 1985	A brief review of gen. Polypedilum in OH. w/ keys to spp in NE U.S.	OH. Acad. Sci. 0030-0950/85/0005-0245. Oxford, OH.
55	Byers, G.W. 1984	Tipulidae. ch 22. In Merritt & Cummins. An intro. to the aqu. insects of N. Amer (2nd ed).	Kendall/Hunt Publ. Co., Dubuque, IA. 722p
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58	Doughman, J.S. 1985a	Ann. keys to the gen. of the tribe Diamesini.	Inst. Wat. Res./Eng. Exp. Station, Univ. of AK.-Fairbanks. 37p
59	Doughman, J.S. 1985b	Sympotthastia pagast, an update based on larv. from NC.	Brimleyana. 11:39-53p
60	Foote, B.A. et. al. 1991	Order Diptera. ch 37. In Stehr. Immat. insects (vol II).	Kendall/Hunt Publ. Co., Dubuque, IA. 975p
61	Johannsen, O.A. 1970	Aqu. Diptera.	Reprint by Entomol. reprt. specialists. Los Angeles, CA.
62	Mason, P.G. 1985	The larvae of Tventenia vitracies (Saether).	Proc. Entomol. Soc. Wash. 87(2):418-420p
63	Merritt, R.W. & E.I. Schlinger. 1984	Adults of aqu. Diptera (part II). ch 21. In Merritt & Cummins. Intro to aqu insects of N.A	Kendall/Hunt Publ. Co., Dubuque, IA. 722p

64	Newson, H.D. 1984	Culicidae. ch 23. In Merritt & Cummins. An intro. to the aqu. insects of N.A.	Kendall/Hunt Publ. Co., Dubuque, IA. 722p
65	Oliver, D.R. 1977	Bincinctus-Grp. of gen. Cricotopus in the nearctic w/ desc. of a new sp.	J. Fish. Res. Bd. Can. 34(1):98-104p
66	Oliver, D.R. & M.E. Dillon. 1988	Review of Cricotopus of the nearctic arctic zone w/ desc. of 2 new spp.	Can. Ent. 120:463-496p
67	Oliver, D.R. & M.E. Roussel. 1982	The larvae of Pagastia oliver w/ desc. of 3 nearctic spp. Potthastia iberica.	Can. Ent. 114:849-854p
68	Oliver, D.R. & M.E. Roussel. 1983	Redesc. of Brillia kieffer w/ desc. of nearctic spp.	Can. Ent. 115:257-279p
69	Peterson, B.V. 1970	Keys to the subgen. & spp. of Prosimulium of Can. & Ak. In the Prosimulium of Can & Ak.	Mem. Ent. Soc. of Can. 69:11-213p
70	Peterson, B.V. 1984	Simulidae. ch 23. In Merritt & Cummins. An intro. to the aqu. insects of N. Amer. (2nd ed)	Kendall/Hunt Publ. Co., Dubuque, IA. 722p
71	Roback, S.S. 1957	The imm. Tendipedids of the Philadelphia area.	Monogr. Acad. of Natur. Sci., Philadelphia, PA. 9:148p
72	Roback, S.S. 1982	Identity of Ablabesmyia sp., Roback, Bereza and Vidrine (1980)	Ent. News. 1:9-11p
73	Roback, S.S. 1985	The imm. chironomids of the eastern U.S. (VI). Pentaneurini-genus Abalabesmyia	Proc. Acad. Natur. Sci., Philadelphia, PA. 137(2):153-212p
74	Saether, O.A. 1971	Nomenclature & phylogeny of the genus Harniscilla	Can. Ent. 103:347-362p
75	Saether, O.A. 1975	Two new spp. of Protanypus kieffer, w/ keys to nearctic & palearctic spp of???????	J. Fish. Res. Bd. Can. 32(3):367-388p
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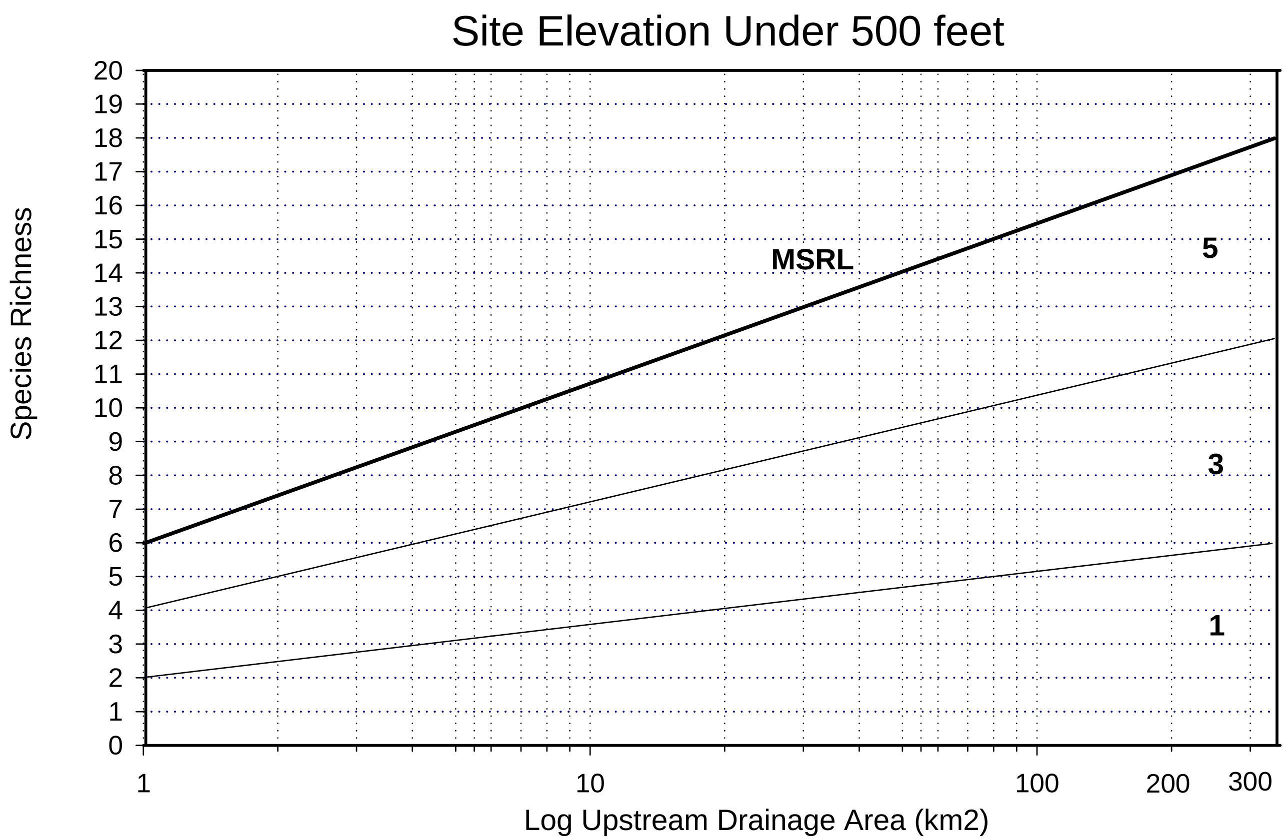
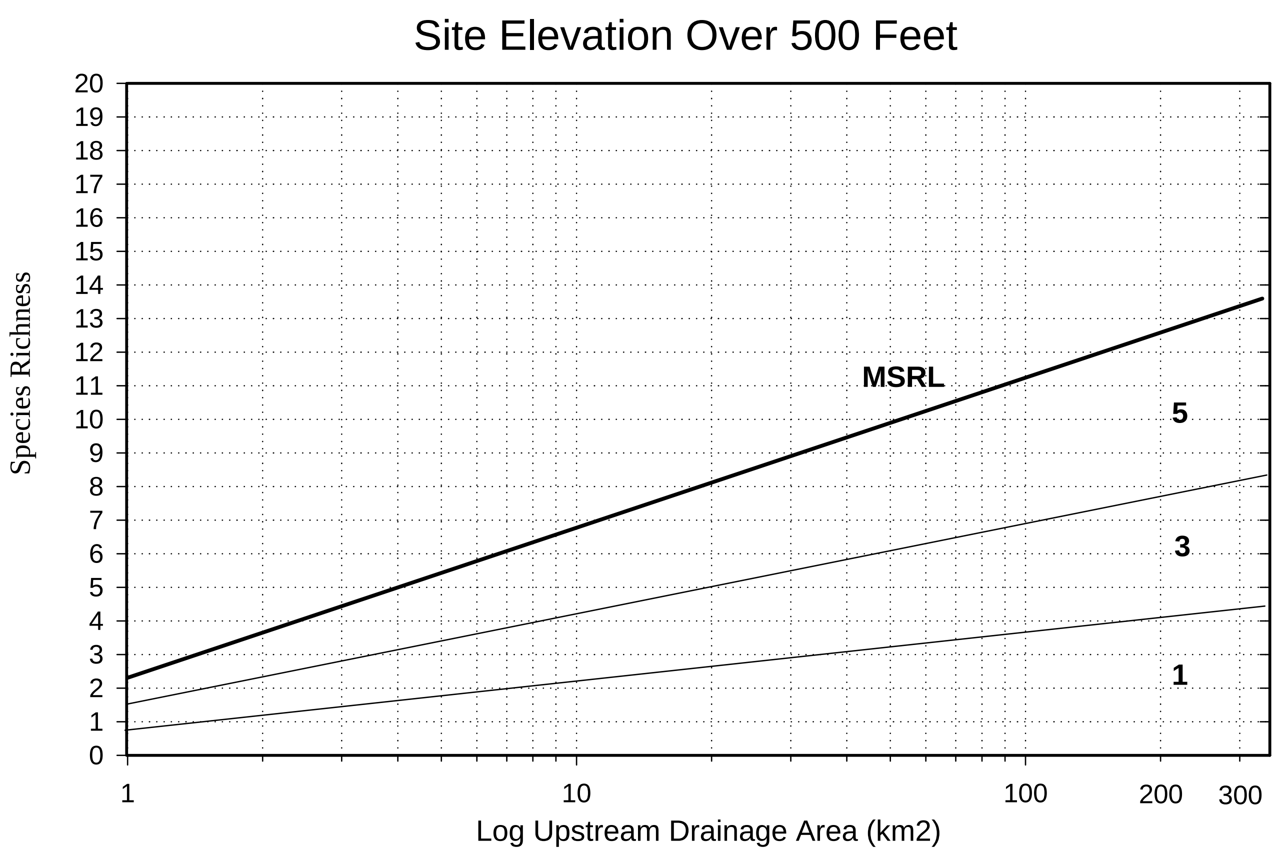
Attachment E. Maximum Species Richness Line (MSRL) for fish for sites from two elevation ranges.





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