

## 4. Biological Monitoring Program (BioMon)

### (1) Program Description

Biological monitoring using benthic macroinvertebrates is an invaluable tool for evaluating the overall, temporally integrated effects of the water and sediment quality in streams and rivers. Benthic macroinvertebrates are invertebrate organisms such as insects, crustaceans, snails or worms that are large enough to be seen with the naked eye, and that live on the bottom of streams and rivers. Benthic macroinvertebrate communities indicate water quality, integrated over time and among the effects of different pollution stressors, thus providing a measure of their collective impact, including antagonism and/or synergism among chemical and physical pollutants. Because of their sedentary nature, macroinvertebrates are good indicators of localized conditions. Most species have a complex life cycle of one year or more and, therefore integrate the effects of fluctuations in water quality over time, which periodic, conventional water quality surveys may miss. In essence, benthic macroinvertebrates are considered to be virtual “living recorders” of water quality conditions over time. The structure and functioning of macroinvertebrate communities are also extremely sensitive, and may exhibit responses to water quality parameters for which specific criteria or standards have not been defined, for which chemical analyses are not normally performed, or for which biological tolerance is below chemical detection limits.

VADEQ’s biological monitoring program examines over 150 stations annually. Reasons for bioassessments include, but are not limited to: targeted monitoring, probabilistic monitoring, tracking local pollution events, TMDL monitoring, and follow-up on waters of concern identified through volunteer citizen monitoring. Data from the biological monitoring program are used in the periodic review and assessment of state waters as required by Section 305(b) of the Clean Water Act. Benthic macroinvertebrate monitoring is used in assessing the designated use of state waters established in 9 VAC 25-260-10 A that states in part that “All state waters, including wetlands, are designated for the following uses:...the propagation and growth of a balanced, indigenous population of aquatic life, including game fish, which might reasonably be expected to inhabit them...” . Results of benthic macroinvertebrate assessments are used in DEQ’s biennial 305(b)/303(d) Reports to the U.S. EPA and Congress.

The VADEQ uses two bioassessment indices to assess the biotic integrity in non-tidal freshwater streams and rivers in Virginia. For non-coastal streams in the Piedmont and Mountain regions of the state, biological assessment of the benthic macroinvertebrate community is based on the methods of the Virginia Stream Condition Index (VSCI). The VSCI was developed for Virginia freshwater non-coastal streams by USEPA’s contractor Tetra Tech, Inc., using historical data collected in Virginia at reference and stressed streams from 1994 to 1998, and was tested against additional data collected from 1999 to 2002. This review has resulted in the development of the Virginia Stream Condition Index (VSCI) for use in assessing wadeable, non-coastal streams. In September of 2003, Tetra Tech produced a final written report, titled “[A Stream Condition Index for Virginia Non-Coastal Streams](#)” [III-B-4c.pdf], a copy of which is linked to this document. The report describes the details related to the development of this index, up to that time. The development of this index has continued to evolve. An Academic Advisory Committee (AAC) was subsequently assembled to review the technical merits of its development, to ensure the applicability of the VSCI, and to provide recommendations toward the further testing of the index over the ensuing years. A final report on the subsequent testing and validation of the VSCI was completed in November of 2006: “[Using Probabilistic Monitoring Data to Validate the Non-Coastal Virginia Stream Condition Index](#)” [III-B-4d.pdf] and has been reviewed and approved by the USEPA. The validation study using probabilistic biological data has confirmed that the VSCI works well to discriminate between sites with acceptable water quality and habitat versus sites with degraded water quality and habitat.

In the Coastal Plain, which is characterized by low gradient streams east of the fall line, DEQ uses the Coastal Plain Macroinvertebrate Index (CPMI). This multimetric bioassessment index was developed in 1997 by the Mid-Atlantic Coastal Streams (MACS) workgroup (USEPA 1997, Maxted et al. 2000). The CPMI was calibrated for low gradient Coastal Plain streams, which exhibit different expected benthic macroinvertebrate communities from non-coastal streams. The CPMI was originally developed for use with genus level taxonomy but with assistance from the USEPA, the CPMI was adjusted for metric scoring at the family level.

The VSCI and CPMI are based upon recent advances in bioassessment methods contained in the U.S. EPA document “Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates, and Fish, 2<sup>nd</sup> Edition” (Barbour et al. 1999). This document is available at <http://www.epa.gov/owow/monitoring/rbp>. The VSCI, a multimetric calculation of benthic integrity converted into a single numerical score, resulted in a single reference condition for the entire non-coastal portion of the Commonwealth against which all future benthic samples will be compared. The CPMI is similar to the VSCI in that it uses a single reference condition but one that represents the Coastal Plain. The development of these indices is considered a significant step in the advancement of the biomonitoring program to address a wide range of monitoring and assessment needs.

The DEQ Biological Monitoring Program initiated the Freshwater Probabilistic Monitoring module in the spring of 2001 (see Section III-B-2 Probabilistic Monitoring Network - Free-flowing Freshwaters, above). Since that time, the agency has been sampling 40 to 50 new wadeable probabilistic freshwater sites each year. Thirty additional sites were randomly selected as probabilistic trend sites. Fifteen sites of the thirty sites are sampled each year. In the freshwater resource class, the distribution of site selection among stream sizes has been chosen to ensure approximately equal representation among five sampling strata: streams of the 1st, 2nd, 3rd, 4th, and  $\geq$ 5th Strahler Orders. In wadeable streams, DEQ collects biological samples and measures conventional field parameters (temperature, dissolved oxygen, pH and conductivity) during separate spring and fall visits to each site. This provides for the evaluation of seasonal variations at the site and ensures that field parameters and biological information are collected during two critical periods for the principal groups of water quality parameters of interest. For sites in this resource class, spring and fall sampling coincides with high- and low-flow periods, respectively, providing evaluations of worst-case and best-case NPS scenarios, as well as two different phases of benthic organism life cycles. In non-wadeable streams, the randomly selected sites are visited in the spring and the fall, but larger boatable river sites are only sampled in the fall. Beginning in 2013, monthly water quality stations have been established near selected freshwater probabilistic sites where conditions are appropriate, to collect additional information on highly variable parameters such as bacteria and nutrients.

In addition to providing unbiased physical, chemical, and biological characterizations with well-defined statistical confidence intervals for Virginia’s free-running, freshwater streams and rivers, the randomly selected biological monitoring sites provide valuable insight for the subsequent definition of regional “best attainable” and “reference” biological communities. The accumulation of such information, over time, will also provide additional data for the refinement of the VSCI and CPMI. This will assure the continued improvement of DEQ’s Biological Monitoring Program.

The agency piloted the probabilistic program from 2001 to 2005 and has committed to make this activity a permanent part of our monitoring strategy. The state monitoring design has been integrated into the 2013-2014 National Stream and River Assessment survey (NSRA) and the agency also plans on participating in the 2018-2019 and subsequent NSRA projects.

## **(2) Purpose**

The purpose of these biological evaluations is to assess the water quality and biological health of Virginia's freshwater streams, through the analysis of the structure and function of benthic macroinvertebrate communities. These organisms are important to water quality studies for several reasons. In addition to being the major intermediate constituent of the aquatic food web, benthic macroinvertebrates are considered to be virtual "living recorders" of past, as well as present water quality conditions. This is due to their relative immobility and their variable responses to the diverse contaminants introduced into streams. No two groups of benthic organisms have the same limiting factor(s) and/or tolerance(s) for the various chemical and physical constituents encountered in the aquatic ecosystem. An evaluation of the community structure of these organisms thus provides the basis for the biological analysis of water quality.

Biological monitoring data are consequently used to assess whether the current water quality of surface waters of the Commonwealth supports the designated aquatic life uses specified in the Clean Water Act and the Virginia Water Quality Standards regulations for that water body.

## **(3) Quality Assurance**

Quality Assurance components of the biomonitoring program are an ongoing and evolving portion of the program. DEQ's updated "[Biological Monitoring Quality Assurance Project Plan for Wadeable Streams and Rivers](#)" [III-B-4f.pdf] was approved by the USEPA in 2008 and contains current Standard Operating Procedures and quality control measures for both field and laboratory methods. Updated quality assurance measures include sample sorting efficiency, taxonomic identification efficiency and field audits. While DEQ currently uses family level benthic macroinvertebrate taxonomy, all biologists have earned genus level certification of benthic macroinvertebrate identification from the Society for Freshwater Science.

## **(4) Data Management**

All biological data (taxonomy, habitat assessment, etc.) are recorded in an Ecological Data Application System (EDAS) database. This database is capable of calculating VSCI and CPMI scores.

The EDAS database provides information that is summarized in the Agency's biennial 305(b) Water Quality Assessment Report. Results are also submitted to EPA under DEQ's Section 106 agreement. All impaired stream segments are listed on the 303(d) list of waters prioritized for TMDL development and remediation activities.

## **(5) Plan and Schedule**

On the average, DEQ resources are sufficient to allow for the monitoring of approximately 200 sites annually for biological impairment. However, further testing of the VSCI and CPMI, anticipated increased involvement of biological staff with TMDL investigations, identification of benthic macroinvertebrates to genus level and the possibility of adding periphyton and fish sampling to the monitoring network for the development of additional biological indices, will require additional resources for the Biological Monitoring Program.

Long-term goals for the Virginia Biological Monitoring Program include:

- (a) Further refinement of the VASCI and CPMI assessment methodologies,
- (b) Consideration of the adoption of an enhanced narrative Biological Water Quality Standard or of adopting numerical biological criteria,

- (c) Expansion of the program to include additional aquatic communities such as algae and/or fish.
- (d) Incorporating genus level macroinvertebrate taxonomy into VSCI and CPMI.

DEQ biologists conducted a self assessment of the Biological Monitoring Program in 2008 to gain a better understanding of what the program needs to move forward in the future. The document “[Benthic Biomonitoring Program Self-Assessment 2009](#)” [III-B-4e] was created to provide focus and direction to biological monitoring in Virginia for the next several years. DEQ Central Office and Regional Office staff met from February 2008 through March 2009, to identify needed guidance and data management tools related to the Biological Monitoring Program. The DEQ Self-Assessment found that the Coastal Plain Macroinvertebrate Index (CPMI) needed improvement in its discrimination power between unimpaired and impaired low gradient coastal streams. That need has already been addressed and the Coastal Plain workgroup has already submitted a draft of “[Evaluation of Virginia's Coastal Plain Macroinvertebrate Index](#)” [III-B-4e-2.doc] for EPA and agency review. Once comments have been received and responded to, the final report will be released, perhaps in June 2013. DEQ expects to use the refined CPMI in the 2014 Integrated Report.

The program also needs to address monitoring strategies in non-wadeable streams and rivers. These and other intended additions to/adaptations of the Biological Monitoring Program will result in some profound changes that will require time, effort and adequate staff to transition from old to new procedures and to handle increased workloads.

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