**Ambient Biomonitoring Network**
**Bioassessments of Flowing Waters in Vermont**
**Quality Assurance Project Plan**

**Vermont Department of Environmental Conservation**
**Watershed Management Division**

**June 26, 2018**

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## A. Project Management

### *A1. Project Organization*

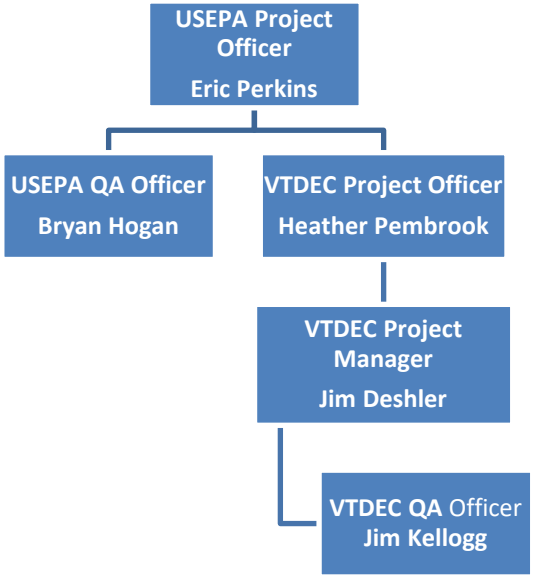
The present Quality Assurance Project Plan (QAPP) is written with a five-year timeframe. Minor revisions to protocols and procedures employed by the Biomonitoring and Aquatic Studies Section (BASS) during the five-year period will be reflected in updated versions as necessary.

**Figure 1** presents the organizational chart for staff involved in the Bioassessment of Flowing Waters in Vermont. The USEPA QA Officer is responsible for reviewing this QAPP and serves as the primary contact with the USEPA and the Vermont Department of Environmental Conservation (VTDEC) Project Officer. The VTDEC Watershed Management Division (WSMD), Monitoring Assessment and Planning Program (MAPP), Biomonitoring and Aquatic Studies Section (BASS) has primary responsibility for developing and implementing river and stream biological monitoring and assessment activities related to water management programs under the jurisdiction of the VTDEC. Heather Pembrook, BASS Section Chief, serves as the Project Officer and is responsible for general oversight and supervision and serves as the primary USEPA contact. Jim Deshler, Environmental Scientist with BASS, serves as VTDEC Project Manager and has primary responsibility for the overall management of monitoring activities. Jim Kellogg, Environmental Scientist with BASS, serves as Water Chemistry Quality Assurance Officer. In this capacity, he coordinates activities with the QA Officer for the Vermont Agriculture and Environmental Laboratory (VAEL).

The VAEL is responsible for the bulk of water and sediment analyses conducted in conjunction with BASS monitoring activities. Individual analytical chemists under the direction of the Laboratory Director, Dr. Guy Roberts, are responsible for internal QA/QC procedures and the initial data validation for samples analyzed by VAEL. Final data validation prior to sample authorization is the responsibility of the Laboratory Director. Upon authorization, the results are forwarded to the Project Manager and QA Officer for further review before the results are considered valid. A series of internal procedural checks are conducted on each sample including anion/cation balances, conductivity checks, comparisons to expectations with previously collected site samples, results in consideration of flow, as well as a complete review of all collected QC samples. Once a QAPP is finalized within MAPP and prior to submission to EPA, VTDEC QAPPs are reviewed by the VAEL QA Officer to validate the information pertaining to the QA objectives and methods described in the VAEL Quality Systems Manual (VAEL 2016). The VAEL QA/QC Officer is independent of the VTDEC. Section 4.2 of the VAEL QSM details the responsibilities of VAEL staff.

Occasionally, special projects require contracts with outside laboratories to process samples using methods VAEL is not certified or equipped to perform. In these cases, the internal QA/QC procedures are the responsibility of the contracted laboratory. Selection of outside contract laboratories includes determining that a comprehensive QA/QC procedure is in place is the responsibility of VAEL. The Project Officer will be notified, and changes will be made to the QAPP to reflect any modification.

**Figure 1. Project Organizational Chart of the Vermont Biological Assessment Program**




The principal data users include: VTDEC WSMD program managers and staff (stormwater, 305(b) reporting, 303(d) listing, aquatic nuisance control permitting, monitoring and assessment, TMDL, water quality standards development, non-point sources; watershed planning;); VTDEC Wastewater Management Program managers and staff (NPDES, Indirect Discharge Regulations); VTDEC Waste Management and Prevention Division managers and staff (CERCLA, RCRA, hazardous sites management); Vermont Agency of Natural Resources (VTANR) Compliance and Enforcement Division; VTANR Land Use Planning Office (Act 250); USEPA (National Surveys, Regional and National special projects and grants); consultants and other external data generators and users.

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## *A2. Background*

The VTDEC has been conducting river and stream monitoring of macroinvertebrate communities, water chemistry and physical habitat since the early 1970s in a manner that has retained a high level of methodological consistency throughout this period. With the addition of fish community assessments in 1982, the Ambient Biomonitoring Network (ABN) was established to: 1) monitor long-term trends in water quality as revealed by changes in the ambient aquatic biological communities; 2) evaluate potential and real impacts on lotic biological communities from permitted direct and indirect discharges, Act 250 (10 V.S.A. 151) projects, nonpoint sources, spills, acidification and other disturbances affecting water resources; and 3) establish a reference database to facilitate the generation of Vermont-specific biological criteria for water quality classification and use attainment

determinations. The primary purpose of this program is to regularly provide or supplement data necessary to assess the biological aquatic life use designation. This information is used to support the status of Vermont rivers and streams and identify the primary factors affecting that condition. This is accomplished through the systematic monitoring of chemical, physical and biological components of river and stream ecosystems throughout Vermont. More recently, comprehensive statewide assessments using probability-based sampling designs have been implemented.

Since 1985, the VTDEC has used standardized methods for sampling fish and macroinvertebrate communities, processing samples, and analyzing and evaluating data. The program has led to the development of both a cold-water and a mixed water fish community Indexes of Biotic Integrity (IBI). The two fish IBIs were specifically designed for Vermont's streams and rivers. For macroinvertebrates, VTDEC uses two IBI's for low gradient streams and three sets of multi-metric biocriteria for high and moderate gradient streams. Guidelines have been developed to determine water quality standards attainment using both the fish community IBI, and the macroinvertebrate community metrics and IBI's (VTDEC 2004). Information on Vermont's low gradient IBI for macroinvertebrates can be found in the 2016 revision of Vermont's Water Quality Standards (VTDEC 2017).

Fish assemblages are assessed at between 50-70 sites annually. Macroinvertebrate assemblages are assessed at approximately 120-140 sites per year. Physical and chemical habitat measures and observations are collected at least once at the time of biological assessment. Chemical water quality measures include alkalinity, pH, conductivity, hardness, temperature, dissolved oxygen, chloride, total nitrogen, total phosphorus calcium, magnesium, sodium, potassium, aluminum and other turbidity, and metals. Physical habitat and other field measurements including bankfull and wetted width, substrate composition, embeddedness, silt/sediment rating, woody debris, leaf pack accumulation, riparian condition, canopy cover, the percent and type of three periphyton cover types, and approximate velocity and depth are routinely recorded. These and other site-descriptive meta-data are collected at each site on standardized electronic field sheets using electronic tablets. The data is saved while the tablet is offline, and later verified and uploaded directly to the VTDEC Watershed Data Portal database. The full electronic field sheet can be found in **Appendix 1**.

Macroinvertebrate and fish populations of rivers and streams are assessed by comparing a series of biometrics which measure community structure and function to a set of criteria that represent the biological potential for the stream type. "Biological potential" is defined as pre-European colonization and is represented by data from sites that are least disturbed by human activity, sites that are commonly referred to as reference sites. The biological potential for various sites is established through long-term reference site monitoring. Information from this program element also serves to refine existing biocriteria and indicate any broad trends or conditions related to annual variability and year-specific conditions. Biocriteria thresholds have been developed in a manner consistent with biologic condition and disturbance gradient theory and narrative tiered uses included in the Vermont Water Quality Standards. (VTDEC 2017)

## *A3. Project Description*

Monitoring activities can be roughly categorized as 1) water management program ambient assessments; 2) regulatory compliance and enforcement; 3) long term reference/ sentinel site monitoring and 4) special projects.

Assessing the water management program is the largest activity for ambient biological assessments of flowing waters. For routine ambient biomonitoring monitoring associated with VTDEC water management programs, Vermont presently subscribes to a rotating basin assessment approach, as described in the Vermont Surface Water Assessment Methodology and the Water Quality Monitoring Program Strategy (VTDEC 2015).

Special projects are generally associated with a specific funding source such as a research grant or technical assistance grant. These require the development of adherence to a project-specific QAPP. Assessment strategies can vary depending upon project-specific goals and objectives. These projects vary from year to year in their scope and scale. Recent examples include the New England Regional Methods Comparability and Bio Condition Gradient Development for Rivers and Streams, and The Vermont Agency of Natural Resources Reach Habitat Assessment Project.

Enforcement activities are generally conducted on an as need basis in support of water and waste management regulatory programs. Some examples include assessments of impacts related to an illegal discharge of ammonia from an industrial facility, landfill leachate, manure, or sediment related discharges.

There are 17 drainages in Vermont, with 15 basin plans. With the rotational approach, waterbodies in each watershed are targeted for assessment once every five years (**Figure 2**). During the year prior to monitoring within a rotational basin, a variety of input is solicited from other Monitoring, Assessment and Planning Program (MAPP) staff (program managers, basin planners), Waste Water Program staff, Waste Management Division staff and other stakeholders including local watershed groups with interests in the targeted basin regarding the identification of sites or reaches in need of assessment. A list of candidate sites is compiled and prioritized by BASS staff with input from MAPP program managers and staff. Generally, sites with regulatory implications, such as those associated with NPDES, a TMDL, state permitting, impaired and threatened waters lists, and technical assistance to assess environmental conditions adjacent to CERCLA super-fund sites are given highest priority. All high priority sites are targeted for assessment. Lower priority sites are assessed as resources and time allows. Stream reaches found to be biologically impaired during the initial rotational year are routinely followed up the next year with greater longitudinal coverage, and additional stressor identification work.

Additionally, to estimate the condition of all Vermont's waters, a randomly selected set of sites is assessed. Currently up to 15 sites are sampled each year using USEPA National Flowing Water Assessment oversample list and are coordinated with the state rotational basins to the greatest extent possible. Following a five-year rotational cycle, a minimum of 65 random sites are pooled to obtain a statewide probabilistic estimate of river and stream biological condition. The most recent reporting of these data is found in the report entitled Assessing the Biological Condition of Vermont's Wadeable Streams 2008-2012: Results of a Statewide Probability-Based Survey (VTDEC 2014).

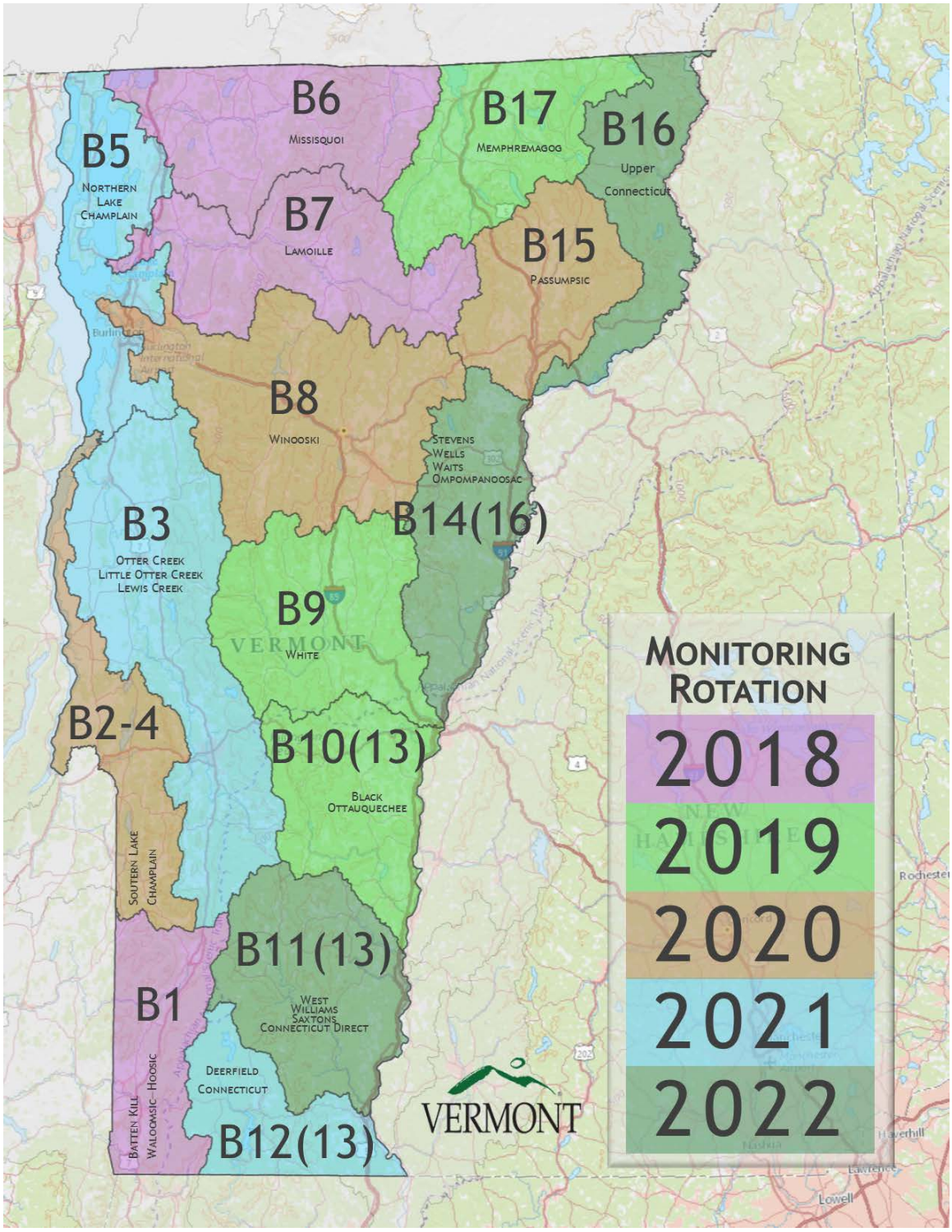
Long term reference, or sentinel site monitoring is conducted at 12 fixed stream reaches each year. These sites are assessed to allow for an annual baseline of the biological expectation of reference sites in Vermont, and to give a better understanding of how the biological condition of reference streams are changing over time due to extraneous factors.

Biological assessments generally involve a single visit during the late summer-fall index period (late August to mid-October). Sampling within a certain time of year minimizes variability in population structure and density. The rationale for sampling during this period is to (1) target conditions following the most stressful low flow period in the summer, (2) the capture of many later-instar macroinvertebrate forms which facilitates identification, and (3) collect a greater proportion of fishes, because the young of the year have attained a minimum length for vulnerability to the electric field. A variety of chemical, physical and biological data are collected during that single visit.

Routine biological samples are collected, processed, identified and analyzed by BASS staff. All routine chemistry samples are analyzed by VAEL. All data management is conducted using VTDEC relational databases developed with Microsoft Access applications.

| Basin Number | Basin Name | Next Year to be Assessed |
|---|---|---|
| 1 | Hoosic, Walloomsac Rivers | 2018 |
| 2 | Poultney-Mettawee Rivers | 2020 |
| 3 | Otter Creek | 2021 |
| 4 | Southern Lake Champlain Direct | 2020 |
| 5 | Northern Lake Champlain Direct | 2021 |
| 6 | Missisquoi River | 2018 |
| 7 | Lamoille River | 2018 |
| 8 | Winooski River | 2020 |
| 9 | White River | 2019 |
| 10 | Black, Ottauquechee Rivers | 2019 |
| 11 | Saxton's, West, Williams Rivers | 2022 |
| 12 | Deerfield River | 2021 |
| 13 | Lower Direct Connecticut River | 2019 |
| 14 | Stevens Wells, Waits, Ompompanoosuc Rivers | 2022 |
| 15 | Passumpsic River | 2020 |
| 16 | Upper Direct Connecticut River | 2022 |
| 17 | Memphremagog Tributaries | 2019 |

**Figure 2. Vermont's Major Basins with the 5-Year Rotational Assessment Schedule.**




*A4. Quality Objectives and Criteria*

The overall objective for VTDEC biomonitoring activities is to generate high quality and defensible chemical, physical and biological data necessary to support and direct implementation of VTDEC Watershed Management Division programs. The data generated will provide feedback to management activities that supports adaptive management in protecting or restoring the biological integrity of Vermont's surface waters.

### A4.1: Chemistry Analyses

Measurement performance criteria are calculated following methods provided by the VAEL Quality Assurance Plan (VAEL 2016). Precision is assessed based on the calculated relative percent differences (RPD) of field and laboratory duplicates. Accuracy is assessed based on calculated percent matrix spike recoveries or bias for analytical analyses. Representativeness is assured by sampling the same segment of each river (centroid of flow) under similar climatic conditions, low/baseline flows, and season of the year. Completeness is assessed as the percent of samples successfully analyzed. The Quality Assurance Plan referenced above provides specific details.

### A4.2: Macroinvertebrate Analyses

*Completeness and Accuracy*

The measurement quality objective (MQO) for completeness by an individual picker is termed Percent Picking Efficiency (PPE). The PPE target is 90% or greater of the animals within the targeted subsample area. It is achieved by having all samples picked and then the sample is rechecked by a second certified biologist or technician. Both the primary sample picker and the checker initial the Benthos Laboratory Sheet (Appendix 2) and fill out the information regarding how the sample was picked. The sample sorter then transcribes this information to the Benthos Excel Data Sheet (**Appendix** 3), where taxonomists enter their taxonomic data as the sample is processed. Ten percent of the samples are then checked by a third biologist / technician to determine the PPE of a sample. At least one sample from each biologist is triple checked using this process. The PPE is calculated using the following formula.

$$(n_o / n_o + n_r) \times 100$$

$n_o$ = *original no. of organisms found by picker*
$n_r$ = *no. of organisms missed and found by QC checker (recoveries)*

If a sample is found to have >10% of the total density remaining after processing the sample is accepted with the additional animals added. The QA/QC officer identifies and documents the cause of the violation. Causes may include tendency to overlook a cryptic animal, too much detritus or sand in the picking tray, too much water in tray, and or incorrect use of subsample blocks in the picking tray. A follow-up QA/QC check on the processor is immediately performed to insure corrective actions are employed and the 10% criterion is being met.

Taxonomic accuracy is achieved using standard taxonomic keys for all identifications. An identification confidence level is assigned to each determination by the taxonomist following the recommendation of USEPA BIOS. A reference collection of all identified taxa is maintained in house assuring consistent identifications. Once a BASS staff member has demonstrated consistent proficiency in correctly identifying aquatic macroinvertebrates to an experienced BASS staff member, they are then cleared to independently conduct identifications. Two biologists are responsible for each taxonomic group for in-house identification verifications as necessary. BASS staff keep current

with taxonomic changes regularly by consulting the Integrated Taxonomic Identification System (ITIS), participating in the regional annual NEAEB conferences, and pursue taxonomic certifications through the Society for Freshwater Science when possible. Finally, all samples are permanently archived by sample log-in identification number and major taxonomic groupings to insure a long-term record. All archived specimens are curated by BASS in locked fire proof storage cabinets located at the Dewey Building on the National Life Group Campus in Montpelier, VT.

*Precision*

Sampling method precision is determined by calculating the percent relative difference (PRD) between duplicates, with the MQO maximum set at 40% for macroinvertebrate density, and 20% for total richness. Macroinvertebrate sample duplicates are collected under identical field conditions from the same riffle or sweep (low gradient) habitats. A minimum of 10% of all sites are targeted for laboratory processing. Descriptive statistics of density and richness are determined for each duplicate and reported in the yearly. Sites which fail to meet Vermont's expected precision guidelines may only be used in assessment with extreme caution.

$$\textit{Relative Percent Difference (RPD)} = |x_1 - x_2| / [(x_1 + x_2) / 2] \times 100$$

$x_1$ = *value calculated from primary sample*
$x_2$ = *value calculated from secondary sample*

Taxonomic precision is quantified for both taxonomic enumeration and identification on 5% of the benthic samples processed each year internally or by sending to a second laboratory.

*Enumeration*

Precision of counts is determined by calculating the Percent Difference in Enumeration (PDE) as follows:

$$PDE = (n_1 - n_2 / n_1 + n_2) \times 100$$

$n_1$ = *no. of organisms counted in sample by 1st taxonomist*
$n_2$ = *no. of organisms counted by 2nd taxonomist or laboratory*

The MQO for enumeration is 95%. Corrective action for exceedance of MQO would include reviewing counting rules; when to identify specimens, and handling of specimens at the bench.

*Taxonomy*

Precision of taxonomy is determined by samples being re-identified by the laboratory/taxonomist and comparing the results between the taxonomist or laboratories by counting the number of agreements from which a Percent Taxonomic Agreement (PTA) is calculated**:**

$$PTA = [\text{Comp}_{pos} / N)] \times 100$$

$\text{Comp}_{pos}$ = *number of agreements (positive comparisons)*
$N$ = *total number of specimens in the larger of the 2 counts*

The higher the PTA value, the greater the overall taxonomic precision, indicating relative consistency in sample treatment. The MQO for the precision of taxonomy is 85%. If disagreements affect specimens in either single or multiple samples throughout the entire data set, then those samples can be isolated and evaluated further for corrective re-identifications. Most disagreements are hierarchical in taxonomic level and do not affect the biological assessment outcome. The corrective action is to

establish what critical taxonomic characteristics are necessary to determine the lowest practical taxonomic level and come to an agreement between laboratories. Finally, all samples are archived by sample ID number and major taxonomic groupings to insure a long-term record.

*Representativeness*
Representativeness is achieved by having all samples collected from habitat specific reaches with the preferred habitat being riffle habitats or from reaches with velocities greater than 0.2 feet/second and depths less than 1 meter. Samples are collected in a standard manner within a habitat type to assure that the true biological condition for a site is represented by each sample as outlined in the Water Quality Field Methods Manual (VTDEC 2012, Section 6.4.1).

*Comparability*
Comparability is achieved because all sampling and analytical methods have been standardized and defined in the in the Water Quality Field Methods Manual (VTDEC 2012). For example, the lotic semi-quantitative benthic survey method is used for collection in riffle habitats.

**A4.3: Fish Community Assessment**

*Completeness and Accuracy*
Completeness is achieved by applying standard methods for sampling and sampled section location. By selecting a representative sample stream section of appropriate length for the stream site drainage area coupled with the use of similar electrofishing technique, variation in sampling effort and catchability are minimized.

Taxonomic identification of fish specimens is carried out in the field for all but a few individuals that are harder to identify. Where identifications cannot be firmly established in the field, individuals are preserved and taken back to the laboratory for microscopic examination.

There are no established precision objectives for fish population data. It is generally impractical to collect a true field replicate of a fish population sample since repeated sampling at the same site in a short time period affects catchability and numbers captured of each subsequent sample. At sites where two or more electrofishing passes are conducted, population estimates with associated 95% confidence intervals estimate of standard error of the population size can be generated. This permits an evaluation of relative precision to be made.

The overall precision and accuracy of the data is dependent on several factors, all of which are controlled by the biologists conducting the sampling. While accuracy can be estimated from data generated from two or more electrofishing runs through calculation of standard formulae for 95% confidence limits, most of the evaluation of data quality is determined from the "best professional judgment" by the sampling biologist. All BASS staff and additional crew members that participate in fish sampling have been trained by the Project Officer in proper fish sampling technique and safety procedures.

*Representativeness*
Stream sections selected for sampling are judged to contain pool/riffle ratios and substrate composition representative of the reach in which the section lies. For site specific impact assessments, the impact and control sites must be physically similar to each other to facilitate meaningful comparison. Sections sampled are longer at stream sites with larger drainages (greater wetted width).

*Comparability*

Fish collections are conducted using standard electrofishing methods. Taxonomic identifications are based on standard taxonomic manuals. Population density can be converted from an areal to a linear basis as required. For all samples, the Project Officer or a trained biologist determines site location, section length, conducts the collection and identifies specimens in the field or laboratory.

### *A5. Training and Certification*

All project staff are familiarized annually with the methods and procedures used to conduct chemical and biological collections and to perform habitat evaluations. They possess the general knowledge and experience to perform all field aspects of this project. Individual staff members are trained in specialized skills related to certain components of the project: e.g. benthic taxonomy; fish and algal identifications and physical/habitat assessments. The Project Manager is responsible for training staff technicians and biologists in field collections and laboratory log-in procedures. Specialized skills are acquired through mentoring among scientific staff. Most field staff maintain a current CPR/AED certification and VTDEC Laboratory safety training. Staff are encouraged to participate in professional development and training opportunities, when resources allow.

### *A6. Documents and Records*

The Project Officer is responsible for providing project personnel with the most current and approved QAPP. The QAPP is updated when there are any changes or modifications to the program or the project objectives. As this project conforms to the VAEL QAPP, analytical method changes are addressed through routine updates and approval of that QAPP.

The primary records objective of the project is to have all field and laboratory data and information entered into the biomonitoring database and fully screened for accuracy and completeness. This primary database is used to access information and develop objective-specific assessment reports dependent upon the needs of the end user of the information. The database creates several event and site-specific summary reports. Project reports are generated on an as need basis. All sample site locations are available to the public on the department web site.

All electronic field forms remain stored within the online Watershed Data Portal, laboratory bench sheets are transcribed to the Excel data sheets and saved on the VTDEC internal drive. The Laboratory Information Management System (LIMS) number is provided by VAEL and recorded on the field sheets for reference and retrieval.

## B. Data Generation and Acquisition

### *B1. Sampling Design*

The overall goal of the sampling design is to develop and implement an annual sampling plan that makes the most efficient use of available resources to address water quality assessment priorities related to the WSMD programs. To this end, a five-year rotational monitoring strategy directs annual effort toward a specific area of the state. This strategy allows for a focused effort in a limited geographical area. Some assessments related to special projects and some regulatory programs require that some assessment resources be applied outside of the rotational scenario. Assessment sites are identified on an annual basis from a list of "priority" sites identified by a variety of stakeholders in the target watersheds. Top priority sites include: those downstream of all NPDES discharges; water

bodies currently on the 303(d) impaired waters list for aquatic life use; water bodies on the VTDEC 303(d) C list, "waters in need of further assessment", probability sites, sentinel sites, and waters that need additional data to be reclassified under the Vermont Water Quality Standards.

### *B2. Sampling Methods*

All field sampling methods for chemical, physical and biological measurements and parameters are documented in the Vermont Water Quality Division Field Methods Manual (VTDEC 2012).

*Water*
Grab samples are collected from a well-mixed area of the stream channel. This is usually the centroid of flow. For routine project purposes, samples are representative of low-flow conditions when possible (or otherwise as dictated by project-specific requirements). When collecting samples downstream of discharges, particular consideration is given to mixing characteristics. For parameters requiring filtration, such as chloride, filtration is done in the field. Field filtrations are accomplished by collecting a sample using a 60-ml plastic syringe which has been triple rinsed with ambient water. The sample is then filtered through a Millipore Swinnex™ filter holder that houses a Pall Supor-450™ 0.45 μm filter. A small amount of ambient water is passed through the filter to rinse the filter prior to discharging the sample in to the container. All containers (except for total phosphorus and dissolved phosphorus) and filtering equipment are triple rinsed with ambient water prior to filling. Some parameters, such as pH, specific conductance, turbidity, dissolved oxygen and temperature may be collected in the field using a Hydrolab multiprobe data sonde. Details regarding container, preservation, holding time and analytical method references are provided in **Table 1**.

*Biota*
Samples of biota are collected in a manner consistent with the site characteristics, which are outlined below and the appropriate field method described in Water Quality Division Field Methods Manual (VTDEC, 2012)

Macroinvertebrates: Sample Collection: For most wadeable streams, macroinvertebrate samples are collected using a 500 μm mesh kick net (KN) in riffle habitat following the Method 6.4.1 described in VTDEC (2012). Four KN net samples are collected in a designated riffle area (two kicks in a high velocity area and two kicks in a moderate velocity area) and composited in an appropriate container (i.e. 1-quart glass jar) and covered with 75% ethanol (ETOH). For low gradient streams dominated by sand/silt bottoms the KN is used in a sweeping fashion and samples are identified as sweep net (SW) samples (Method 6.4.2. in VTDEC 2007). The targeted habitat within the reach includes large woody debris, overhanging vegetation and root wads. Four areas of this targeted habitat within the reach are sweep netted and composited for a sample. For each site sampled, a standardized habitat assessment sheet is used to record the physical/chemical conditions at the site. See **Appendix 1 for habitat measures collected on field data sheets** and the Water Quality Division Field Methods Manual Section 6.4.3 for physical habitat methods (VTDEC 2012)

Macroinvertebrates: Sample Processing: Following methods described in 6.6 (VTDEC 2007), 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 a 24-grid tray) of the tray are picked, additional grids are then picked until a minimum of 300 animals have been picked. Samples are picked with the aid of a 2x magnifier. 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 mature instars of aquatic macroinvertebrates are then identified to genus/species except for the Oligochaeta and immature instars which are identified to family. All subsampling and

taxonomic identifications are recorded on a lab bench sheet and transcribed to the Excel benthos lab sheet. See **Appendices** 2 and 3.

Fish: Fish populations are sampled as described in (VTDEC 2012) section 6.5.1 using a backpack electrofishing gear in the pulsed DC mode. Typically, sampled stream sections are 75 to 150m in length. Longer sections are fished in larger rivers. Stream sections to be fished must be wadeable over most or all of the section. The section sampled must contain habitat types in proportion to the surrounding stream reach. Each site should contain at least two pool/riffle cycles if the reach is characterized by these habitat types. For larger rivers where pool/riffle cycles are long, only one cycle is sampled. All fish are collected during sampling and released following identification and examination for exterior anomalies. When fish are not able to be identified in the field, voucher specimens are preserved and returned to the laboratory for identification.

Physical Site Characteristics: Physical characteristics and event information are recorded on appropriate electronic field sheets. Substrate composition and algal cover may be estimated either by observation or by semi-quantitative methods, such as a pebble count. The crew members completing the physical site characteristics data collection as well as collecting other parameters are indicated by checking the box next to their name on the electronic field sheet.

### *B3. Sample Handling and Custody*

All water samples are collected by BASS staff and remain in their custody until delivered to VAEL. Water samples and associated tests are immediately entered in to the LIMS system by project staff. Samples are typically logged in the day of collection unless an overnight sampling trip occurs. In that case, the samples are logged in as soon as possible. Chain of custody procedures are only employed when samples are intended to be used for enforcement purposes. Table 1 lists the field analytical collection method, equipment, sample containers, preservation, and holding times. The VAEL QAPP (VAEL 2016) describes the log in procedures and custody procedures in detail.

Once samples are logged into the Laboratory Information Management System (LIMS), they are then preserved and/or refrigerated depending on the parameter to be analyzed (**Table 2**). Individual chemists take the containers to analyze for their respective parameters. Samples are submitted to the VAEL within two days of collection unless a non-routine parameter with a shorter holding time is sampled in special circumstances (such as turbidity or dissolved oxygen). This allows samples to be analyzed within the holding time specified in **Table 1**. **Table 3** cites the analytical methods and method references used to process samples. In instances where an earlier version of the VTDEC QAPP does not agree with the methods cited below, the latest VTDEC QAPP takes precedent. Any changes in the methodologies employed by VAEL will be updated in the next update of this QAPP.

*B4. Analytical Methods*

**Table 1**. Field analytical collection method, equipment, sample containers, preservation, and holding times.

| Parameter | Field Collection Method/Equipment | Container | Preservative | Holding Time |
|---|---|---|---|---|
| Alkalinity | Grab-Titration pH Meter Orion Model 720A | P, 250 ml square | Cool, 4º C | 14 days |
| Chloride | Grab-Dionex IC Model IC25 | P, 50 ml cylindrical | Cool, 4º C | 28 days |
| Dissolved Organic Carbon | Shimadzu TOC Analyzer | P, 125 ml cylindrical | Cool, 4º C | 14 days |
| Nitrate+ Nitrite | Grab-Latchet Quik Chem 8000 | P, 50 ml cylindrical | Cool, 4º C $H_2SO_4$ to pH ≤ 2 | 28 days |
| Phosphorus, Dissolved | Grab-Persulfate digestion Lachat Quik Chem 8000 | G, 75 ml test tube | None | 28 days |
| Phosphorus, Total | Grab-Persulfate digestion Lachat Quik Chem 8000 | G, 75 ml test tube | None | 28 days |
| Total Nitrogen | Grab-Lachat Quik Chem 8000 | P, 50 ml cylindrical | Cool, 4º C $H_2SO_4$ to pH ≤ 2 | 28 days |
| Sulfate | Grab-Dionex IC Model IC25 | P, 50 ml cylindrical | Cool, 4º C | 28 days |
| Aluminum | Grab-Thermo-Elemental X Series ICP-MS | P, 125 ml cylindrical | Filter* Cool, 4º C $HNO_3$ to pH ≤ 2 | 6 months |
| Calcium | Grab-Thermo-Elemental X Series ICP-MS | P, 125 ml cylindrical | Filter* Cool, 4º C $HNO_3$ to pH ≤ 2 | 6 months |
| Magnesium | Grab-Thermo-Elemental X Series ICP-MS | P, 125 ml cylindrical | Filter* Cool, 4º C $HNO_3$ to pH ≤ 2 | 6 months |
| Potassium | Grab-Thermo-Elemental X Series ICP-MS | P, 125 ml cylindrical | Filter* Cool, 4º C $HNO_3$ to pH ≤ 2 | 6 months |
| Sodium | Grab-Thermo-Elemental X Series ICP-MS | P, 125 ml cylindrical | Filter* Cool, 4º C $HNO_3$ to pH ≤ 2 | 6 months |
| Iron | Grab-Thermo-Elemental X Series ICP-MS | P, 125 ml cylindrical | Filter* Cool, 4º C $HNO_3$ to pH ≤ 2 | 6 months |
| Manganese | Grab-Thermo-Elemental X Series ICP-MS | P, 125 ml cylindrical | Filter* Cool, 4º C $HNO_3$ to pH ≤ 2 | 6 months |
| Hardness | Calculated | NA | Cool, 4º C | 6 months |

| Parameter | Field Collection Method/Equipment | Container | Preservative | Holding Time |
|---|---|---|---|---|
| Specific Conductivity, field | Hydrolab MiniSonde 4/4A and Surveyor 4/4a. In-situ measurements at centroid of flow. Calibrated with 100 µmhos and 1000 µmhos standards. | NA | None | Analyze immediately |
| Specific Conductivity, field | YSI Sonde. In-situ measurements at centroid of flow. Calibrated with 100umhos and 1000umhos standards. | NA | None | Analyze immediately |
| pH, field | Hydrolab MiniSonde 4/4A and Surveyor 4/4a. In-situ measurements at centroid of flow. Calibrated with either buffers 4 and 7, or 7 and 10. | NA | None | Analyze immediately |
| Temperature, field | Hydrolab MiniSonde 4/4A and Surveyor 4/4a. In-situ measurements at centroid of flow. Calibrated using a lab grade thermometer. | NA | None | Analyze immediately |
| TSS | Grab-Filtration and gravimetry Method #2540-D | P, 1L | Cool, 4º C | 7 days |
| Turbidity | Grab-Turbidity Meter. Scientific, INC. Micro 100 | P, 250 ml | Cool, 4º C | 48 hours |
| Turbidity, field | Hydrolab MiniSonde 4/4A and Surveyor 4/4a. In-situ measurements at centroid of flow. Calibrated with distilled water and 0.3 NTU turbidity standards. | NA | None | Analyze immediately |
| Oxygen, dissolved, field | Hydrolab MiniSonde 4/4A and Surveyor 4/4a. In-situ measurements at centroid of flow. Calibrated on site with barometric pressure. | NA | None | Analyze immediately |
| Apparent Color | Orbeco-Hellige Model 611-A Aqua Tester | P, 50 ml | Cool 4º C | 48 hours |

**Table 2**. Laboratory analytical methods.
Refer to VAEL's Quality Systems Manual Table 5.1 for most recent update of analytical methods.

| Parameter | Method | Method Reference |
|---|---|---|
| Alkalinity | Grab-Titration pH Meter Orion Model 720A | Method 2320B. Standard Methods for the Examination of Water and Wastewater_ 21tstEd. 2005 |
| Chloride | Grab-Dionex IC Model IC25 | Method 300.0. USEPA Methods for the Determination of Inorganic Substances in Environmental Samples. A/600/R-93/100 |
| Nitrate + Nitrite | Grab-Latchet Quik Chem 8000 | Method 4500 NO3-I. Standard Methods for the Examination of Water and Wastewater; 21tstEd. 2005 |
| Phosphorus, Dissolved | Grab-Persullfate digestion Lachat Quik Chem 8000 | Method 4500-P H. Standard Methods for the Examination of Water and Wastewater; 21tstEd. 2005 |
| Phosphorus, Total | Grab-Persulfate digestion Lachat Quik Chem 8000 | Method 4500-P H. Standard Methods for the Examination of Water and Wastewater; 21tstEd. 2005 |
| Total Nitrogen | Grab-Lachat Quik Chem 8000 | Method 4500-N C-modified. Standard Methods for the Examination of Water and Wastewater; 21tstEd. 2005 |
| Sulfate | Grab-Dionex IC Model IC25 | Method 300.0. USEPA Methods for the Determination of Inorganic Substances in Environmental Samples. A/600/R-93/100 |
| Aluminum | Grab- Thermo-Scientific iCAP 6000 Series ICP Spectrometer. | Method 6010C. Test Methods for Evaluating Solid Wastes, (SW846). |
| Calcium | Grab- Thermo-Scientific iCAP 6000 Series ICP Spectrometer. | Method 6010C. Test Methods for Evaluating Solid Wastes |
| Magnesium | Grab- Thermo-Scientific iCAP 6000 Series ICP Spectrometer. | Method 6010C. Test Methods for Evaluating Solid Wastes |
| Potassium | Grab- Thermo-Scientific iCAP 6000 Series ICP Spectrometer. | Method 6010C. Test Methods for Evaluating Solid Wastes |
| Sodium | Grab- Thermo-Scientific iCAP 6000 Series ICP Spectrometer. | Method 6010C. Test Methods for Evaluating Solid Wastes |
| Iron | Grab- Thermo-Scientific iCAP 6000 Series ICP Spectrometer. | Method 6010C. Test Methods for Evaluating Solid Wastes |
| Manganese | Grab- Thermo-Scientific iCAP 6000 Series ICP Spectrometer. | Method 6010C. Test Methods for Evaluating Solid Wastes |
| Conductivity, field | Hydrolab MiniSonde 4/4a and Surveyor 4/4a. In-situ measurements at centroid of flow. Calibrated with 10 µmhos and 100 µmhos standards. | Hydrolab Inc. 2002 |
| pH, field | Hydrolab MiniSonde 4/4A and Surveyor 4/4a. In-situ measurements at centroid of flow. Calibrated with either buffers 4 and 7, or 7 and 10. | Hydrolab Inc. 2002 |

| Parameter | Method | Method Reference |
|---|---|---|
| Temperature, field | Hydrolab MiniSonde 4/4A and Surveyor 4/4a. In-situ measurements at centroid of flow. Calibrated using a lab grade thermometer. | Hydrolab Inc. 2002 |
| TSS | Grab-Filtration and gravimetry Method #2540-D | Method 2540-D. Standard Methods for the Examination of Water and Wastewater; 21tstEd. 2005 |
| Turbidity | Grab-Turbidity Meter. Scientific, INC. Micro 100 | Method 180.1. Methods for the Determination of Inorganic Substances in Environmental Samples; EPA/600/R-93/100. |
| Apparent Color | Orbeco-Hellige Model 611-A Aqua Tester | APHA, 2005 2120B |

*VAEL Quality Systems Manual, 2016.

### *B5. Quality Control for Chemical Parameters*

This section defines quality control procedures that are necessary to develop information which can be used to evaluate the quality of analytical data. Quality control (QC) terms are defined and an explanation of how, when and why QC samples are taken or analyzed is provided. Much of this section is taken from the VAEL Quality Systems Manual (VAEL 2016). It is included here to enable quick reference by the BASS staff.

Field Quality Control Samples - Field quality control samples are logged into the LIMS by Laboratory users and assigned a Laboratory ID number. These include equipment blanks, field blanks, field duplicates, analytical duplicates and spikes. Field Quality Control Samples are collected as deemed necessary by the Project QA Officer.

Equipment Blanks are used to determine if contamination has been introduced through contact with sampling equipment or to verify effectiveness of equipment cleaning (VAEL 2016). Deionized water (or analyte-free) water is transported to the sampling site and processed through the sampling device, preserved if necessary and returned to the laboratory for analysis. Fresh analyte-free water is obtained weekly from the laboratory. Equipment blanks should be processed whenever contamination is suspected. Corrective action for contamination detected in equipment blanks is addressed by the Project QA Officer.

Field Blanks are used to determine if method analytes or other interferences are present in the field environment. This would include contamination from sample bottles, storage, transport and sample preparation. A field blank is usually laboratory deionized water that is transported to the sampling site, opened to the contaminated environment, and processed as a sample (filtration, preservation, etc.). One field blank should be submitted whenever contamination is suspected. Contamination detected in field blanks would need to be evaluated by both the Project QA Officer and VAEL personnel. Blank results are evaluated against practical quantitation limits provided in VAEL (2016).

Field Duplicates provide a measure of the reproducibility of the sampler and sampling techniques. They are collected independently of the sample to measure the precision of the sampling method. A field duplicate should be submitted for every 10th sample and are treated as independent samples.

Analytical Duplicates are split samples from the same collected aliquot. Results give a measure of the precision associated with preservation and storage as well as with laboratory procedures. Analytical duplicates may be taken as deemed necessary by the Project QA Officer.

Spikes determine the accuracy of a measurement by determining the closeness of a result compared to the value of a known value. Spikes are taken from the same sample collection, after thoroughly mixing or compositing the sample.

### *B6. Analytical Quality Control Samples, Solutions and Routines*

See the VAEL Quality Systems Manual for a detailed description of the sample analyses. EPA certified laboratories with current EPA approved laboratory QAPPs are selected for any parameters that needs to be contracted outside of the VAEL facilities.

The parameter practical quantitation levels (PQL) and corresponding quality assurance objectives for precision and accuracy are outlined in **Table 3**. This includes practical quantitation levels (PQLs) and corresponding quality assurance objectives for precision and accuracy for chemical analyses. The VAEL reports to a Practical Quantitation Limit (PQL) for all appropriate parameters. PQLs are approximately two to five times the calculated Method Detection Limit (MDL). Parameter range, resolution and accuracy for in-situ field readings made with Hydrolab MiniSonde 4a or DS5 and Surveyor units are outlined in **Table 4**. Refer to VAEL's QSM for most recent QA objectives.

**Table 3.** Reporting criteria and quality assurance objectives.

| Parameter | Units | PQL[1] | Precision, Relative Percent Difference | Accuracy (% Recovery) | Completeness |
|---|---|---|---|---|---|
| Alkalinity | mg/l $CaCO_3$ | <1 | 5 (>20mg/l)<br>15 (<20mg/l) | | 90% |
| Chloride | mg/l | 2 | 5% | 85-110% | 90% |
| Nitrate | mg/l | 0.02 | 5% | 90-110% | 90% |
| Phosphorus, Dissolved | µg/l | 5 | 15% | 85-115% | 90% |
| Phosphorus, Total | µg/l | 5 | 15% | 85-115% | 90% |
| Sulfate | mg/l | 0.5 | 5% | 90-110% | 90% |
| Calcium | mg/l | 0.1 | 5% | 80-120% | 90% |
| Magnesium | mg/l | 0.01 | 5% | 80-120% | 90% |
| Potassium | mg/l | 0.1 | 5% | 80-120% | 90% |
| Sodium | mg/l | 0.1 | 5% | 80-120% | 90% |
| Iron | µg/l | 50 | 7.5% | 80-120% | 90% |
| Manganese | µg/l | 5 | 7.5% | 80-120% | 90% |
| Hardness | mg/l | 0.29 | 5% | 80-120% | 90% |
| Specific Conductance, field | µS/cm | < 10 - 1000 | 5% | -- | 90% |
| pH, field | standard units | <2 - 14 | 5% | -- | 90% |

| Parameter | Units | PQL[1] | Precision, Relative Percent Difference | Accuracy (% Recovery) | Completeness |
|---|---|---|---|---|---|
| Temperature, field | °C | <1 – 30 | -- | -- | 90% |
| Total Nitrogen | mg/l | 0.1 | 10% | 85-115% | 90% |
| TSS | mg/l | 1.0 | 15% | 80-120% | 90% |
| Turbidity | NTU's | 0.2 | 15% | -- | 90% |

[1]Practical quantitation limit taken from VAEL Quality Systems Manual 2016, except for field parameters, which are reported as operational ranges. It is rare that specific conductance values exceed 1000µS/cm.

[2] Hydrolab parameter precision are expressed as 95th percentile of RPD for 180 duplicate measurements collected by Hydrolab between 1998 and 2003.

**Table 4**. Multiprobe (Hydrolab) Parameter Specifications

| Parameter | Calibration Range | Ambient range | Accuracy | Resolution | Minimum VT Water Quality Criterion |
|---|---|---|---|---|---|
| Temperature | 0º to 30°C | 0º to 30°C | ±0.10°C | 0.01°C | Class-dependent – typically expressed as a minimum 1o change |
| Conductivity | 10 to 500 mS/cm | 0 to 500 mS/cm | ±5% of reading ±0.01 mS/cm | 4 digits | n/a |
| pH | 4 to 10 units | <4 to >10 units | ±0.2 units | 0.01 units | <6.5, >8.5 |
| Dissolved Oxygen | <0.5 to saturation | 0 to >14 mg/L | ±0.2mg/L | 0.01mg/L | 5 |
| ORP | -999 to 999 mV | -20 – 700 mV | ±20mV | 1mV | n/a |
| Depth/0-100m | 0 to 100m | | ±0.3m | 0.1m | n/a |
| Chlorophyll a | 0.02µg/l to 50 µg/l | 0.02µg/l to >50 µg/l | 0.02 µg/L1 | 0.01 µg/L | n/a |
| Turbidity | 0 to 100 | 0-3000 NTU | ±1% (<100NTU) ±3% (100-400 NTU) | 0.1 NTU | <10 NTU |
| Barometric Pressure | 500 to 850 mmHg | | ±10 mmHg | 0.1 mmHg | n/a |

*B7. Instrument/Equipment Testing, Inspection and Maintenance*

VAEL small instruments are tested and serviced by an outside contractor (Q.C. Services, Inc.) once a year. All other instruments are maintained according to VAEL Quality Systems Manual (VAEL 2016)

Field sampling equipment is inspected prior to use to assure excellent working condition.

### *B8. Instrument/Equipment Calibration and Testing*

The Hydrolab multiprobes are calibrated by BASS staff according to the Field Methods Manual (VTDEC 2012). Typically, the pH, redox, chlorophyll-a and conductivity probes are calibrated at the beginning of each sampling day, and checked at the end of the day. The dissolved oxygen and depth sensors are calibrated at the start of sampling at each lake as well. A standard operating procedure for Hydrolab maintenance and calibration is provided in Appendix A of VTDEC (2012).

The Project Coordinator keeps a log of the calibration records for the field equipment. Calibration failures and drift are recorded in the log, so that the data from the affected parameters can be flagged or deleted in the database accordingly. Summarized in **Table 4** are the calibration schedules, procedures, standards and acceptance criteria for the field measurements.

All calibration standards used for calibrating the Hydrolab field instrument are vendor certified. They are used directly from the vendor without dilution or further preparation. Between standards, deionized water is used to rinse sensors and calibration cup. Sensors and calibration cup are air dried and/or rinsed with the calibration standard prior to calibration with a standard. Standards are used for two consecutive calibrations before being discarded. The 4.75 pH 3rd point check sample is made from reagent grade 0.02 N $H_2SO_4$ stock standards certified by the vendor and deionized water. This check sample is only used as a 3rd point check when it has been made within the last 2 weeks.

Readings are verified at the end of each sampling day. If the calibrations have drifted, field data will be qualified.

### *B9. Inspection/Acceptance of Supplies and Consumables*

Individual VTDEC Laboratory analysts are responsible for inspecting and accepting supplies and consumables. Analysts maintain quality documentation on reagents and standards. Reagent preparation, documentation and storage procedures follow VAEL Quality Systems Manual.

The Project Coordinator is responsible for inspecting and accepting supplies and consumables related to the field instruments and field sampling effort. For purchased standards/reagents the date opened is marked on the container and vendor recommendations on storage procedures are followed. Expired standards/reagents are given to the appropriate VAEL personnel for disposal. Once a solution is prepared it is labeled with the solution name or description, concentration or normality, and preparation dates and initials of preparer. Stock standards used for calibration can be used for six months if properly preserved and stored, unless otherwise specified by the vendor.

### *B10. Data Management*

Upon return to VAEL all water samples are immediately logged into the LIMS using a unique alphanumeric code to distinguish the sample identity. This 20-character code identifies the stream, station, and location name. The LIMS then issues an eight-digit number the chemists use for sample tracking. Data Management procedures including data reduction, validation, reporting and storage follow VAEL (2016).

Once the samples have been authorized by the VAEL laboratory director, the results are released to a Project QA Officer where they undergo further data validation procedures as discussed in Section D1 of this document.

The Biomonitoring database is maintained within the VTANR network. VTANR has a Microsoft Windows network consisting of Windows servers and Windows computers. The LIMS data resides on the main DEC-SQL server. A full back-up of the DEC-SQL server, which holds both the LIMS and VLTM database, occurs every night Sunday – Saturday. The Friday night back-up includes verification. The DEC-SQL server is stored indefinitely. The daily tapes for Monday through Thursday are stored in the room in which the server is located. The weekly Friday tapes are stored in a fireproof file cabinet in a different building. Every fourth Friday a monthly tape is prepared and stored in a third building in a fireproof cabinet located in a locked room. All rooms used for storing the tapes are temperature controlled. In the case of a security breach, the last back-up would be used to restore data. See VAEL (2016) of the VTDEC QAPP for a full description of data storage for the LIMS system (VTDEC 2010).

Fish sampling data is entered electronically in the field, then uploaded into a Microsoft Access data base, where it is assigned a unique event ID number, site ID, date and time.

Macroinvertebrate samples are returned to the laboratory. Each sample container, labeled with the date, time, sampler and location, is manually entered into a log-in spreadsheet with site location, date and field personnel and assigned a unique lab ID number, which is marked on the container with permanent marker. This sample ID number is used to track all further sample processing. Sample containers are stored in the laboratory pending further processing. A laboratory bench sheet and Excel sheet is established for each sample ID number. As the sample progresses through picking, sorting and taxonomic processing, data are recorded manually on the bench sheet. Once sample processing is complete, data are-entered into Microsoft Access data base.

## C. Assessment and Oversight

### *C1. Assessments and Response Actions*

BASS has been audited by the Region 1 Office of Environmental Measurements and Evaluation (OEME) Biological Laboratory Services Section of the USEPA. This on-site audit has not in been conducted on a regularly scheduled basis in recent years. However, in the summer of 2008, a field operations audit was conducted by OEME as part of a review of our activities associated with the National Rivers and Stream Assessment Program (NRSAP). An audit of our NRSAP macroinvertebrate laboratory procedures was performed in the summer and fall of 2009.

VAEL analyses all non-ambient chemistry samples collected by BASS. VAEL is accredited by the National Environmental Laboratory Accreditation Conference (NELAC). This accreditation requires an on-site audit every two years. USEPA Region 1 OEME participates in the NELAC audit of the

laboratory as a member of the New Hampshire Environmental Laboratory Accreditation Program (NHELAP) auditing team. NHELAP is the National Environmental Laboratory Program's (NELAP) accrediting authority for VAEL. The USEPA Region 1 recognizes NELAP and accepts NELAC accreditation. The last audit was conducted in May 2009. This review, and all internal and external components of the performance and systems audits, are described in VAEL (2016) Corrective actions are initiated as a result of problems identified through a systems audit, performance audit or interlaboratory comparison study (VAEL 2016). A review of all Internal Performance Evaluations is addressed in VAEL QAPP. Evaluation results are available upon request from the VTDEC QA Officer. Quality Assurance Irregularity Report forms are issued to the analyst by the VTDEC QA Officer when QA proficiency results exceed acceptable limits.

The project managers and/or QA Officers will conduct regularly scheduled field audits to assure compliance with this QAPP. Section A4.2 of this QAPP describes the QA steps BASS undertakes with the macroinvertebrate analyses.

### *C2. Reports to Management*

The VAEL QA Officer communicates data quality problems in the laboratory to a Project QA Officer as soon as possible. Corrective actions are taken and documented by the VTDEC Laboratory QA Officer. Appropriate data flags are appended to the laboratory results in the LIMS. Project field staff notifies a Project QA Officer where problems exist with data collection techniques or the multiprobe-based data. Project managers are informed of data quality problems when samples are intended for legal purposes.

Select individual site reports are authored by the program managers for upper management and other VTDEC staff.

## D. Data Validation and Usability

### *D1. Data Review, Verification and Validation*

All chemical data generated by the VTDEC Laboratory are validated by the individual chemist as well as revalidated by a second analyst prior the authorization by the VTDEC Laboratory Supervisor. After internal laboratory approval, the results are released to a Project QA Officer for further validation prior to release to the Project Managers and subsequent electronic entry in to the biomonitoring ambient database. A full description of data validation and reporting is presented in VAEL (2016). **Table 3** provides the required practical reporting levels, within laboratory relative precision, accuracy (bias) limits, completeness, and reporting units for each parameter.

On occasion, chemical and biological contract laboratories may be used to facilitate the processing of samples. For contract laboratory data, QC information is requested from the laboratories and reviewed relative to the intent and goals of the QAPP. QA objectives are discussed with the prospective laboratories prior to the laboratory being retained in order to ensure that target QA objectives of this QAPP can be met. Specifically, the quality of macroinvertebrate biometrics will be assessed by comparison of biometrics across duplicate collections.

### *D2. Verification and Validation Methods*

Information in this section relates to data generated from both the VTDEC Laboratory and contract laboratories. Final data validation is the responsibility of the Project Manager before reporting. Results of blanks and duplicates are tracked during the sampling season by a QA Officer to identify potential field-related contamination problems. If there are unacceptable differences in duplication or blanks, the data for the corresponding run of samples is evaluated to ensure its quality. Poor replication or contaminated blanks may be cause for rejecting an entire run of samples, although this is rarely necessary.

At the close of the field season, the mean value for blanks is calculated, mean recoveries are reviewed and, relative percent differences or relative standard deviations (for replicate sets) are calculated. All data quality metrics are compared to data quality objectives established in **Table 3**. The practical quantitation limits shown in those tables form the basis for blank criteria.

Once the VAEL validates and authorizes the results to a project QA Officer, the values are thoroughly vetted. Additional validation checks include the following: (1) an anion vs. cation balance; (2) a comparison of measured vs. calculated conductance and; (3) comparison with previous year's data when available, (4) a determination if each reported value is a potential outlier. If an outlier is found, the sample is checked to determine the cause. The sample is checked to determine if the outlier resulted from a transcription error. Field sheets are reviewed to rule out any field elements or perturbations that could be the cause of a problem. In some cases, parameters are reanalyzed. The Project QA Officer, in consultation with the Project Manager tags or deletes the outlier from the final database. A Project QA Officer works with the VAEL QA Officer and the appropriate analytical staff to identify the source of any problems prior to any data rejection.

### *D3. Reconciliation and User Requirements*

The data requirements for VRSBAP vary according to the type of sampling involved, and data are reconciled with their intended uses accordingly. Where data are intended to be used in enforcement actions or to verify legal impairment, their quality must meet all data quality objectives without exception. Where data are used for routine assessment, individual data points which marginally pass data quality objectives are acceptable, so long as no specific problems have been identified during the data validation process. Where data are of lesser quality, they are so flagged, and the waterbody may be scheduled for follow-up verification sampling. Data that blatantly fail data quality objectives will not be retained. A summary of data flags is presented in **Table 5**.

**Table 5**. VAEL data flags or remark codes used to qualify project data

| Data flag | Description |
|---|---|
| < | True value is less than value reported |
| > | True value is greater than value reported |
| BH | Reported value may be biased high. |
| BL | Reported value may be biased low. |
| D | Dilution resulted in instrument concentration below PQL. |
| E | Estimated Value |
| H | Hold time exceeded. |
| I | Matrix Interference |
| N | Not processed or processed but results not reported. |
| O | Outside calibration range, estimated value. |
| OL | Outside limit |
| P | Preservation of sample inappropriate, value may be in error. |
| S | Surrogate recovery outside acceptance limits. |
| T | Time not provided |
| W | Sample warm on arrival, no evidence cooling has begun. |

## References


1. Vermont Department of Environmental Conservation (VTDEC). (2017) *Vermont Water Quality Standards.* http://dec.vermont.gov/sites/dec/files/documents/wsmd_water_quality_standards_2016.pdf

2. Vermont Department of Environmental Conservation. (2004) *Wadeable Stream Biocriteria Development and Implementation Methods for Fish and Macroinvertebrate Assemblages in Vermont Wadeable Streams and Rivers.* http://dec.vermont.gov/watershed/map/monitor/biomonitoring#How%20to%20use%20biomonitoring

3. Vermont Department of Environmental Conservation. (2015) *Water Quality Monitoring Program Strategy: 2011-2020.* http://dec.vermont.gov/content/water-quality-monitoring-program-strategy-2011-2020

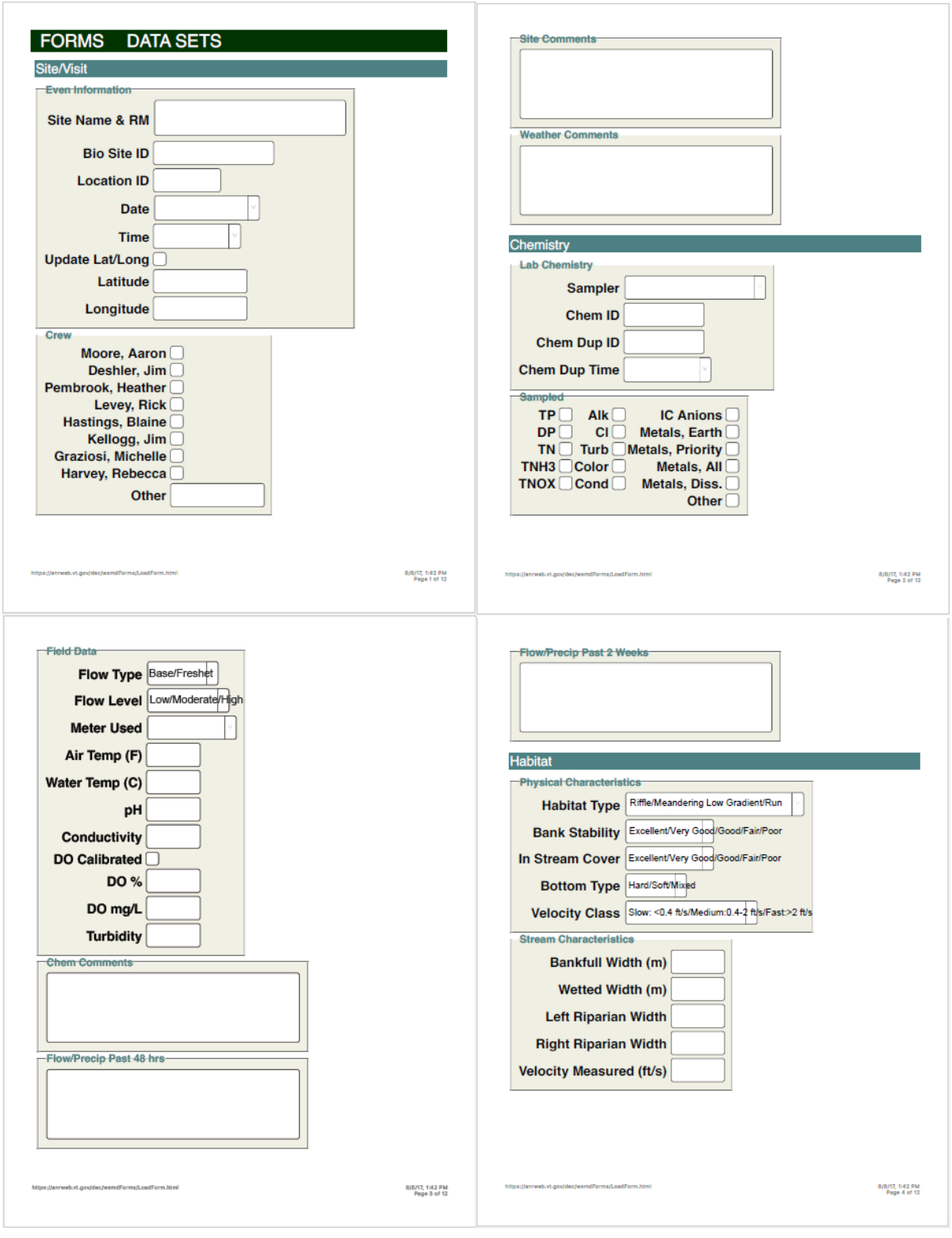
4. Vermont Department of Environmental Conservation. (2012) *Water Quality Division Field Methods Manual.* http://dec.vermont.gov/sites/dec/files/wsm/mapp/docs/bs_fieldmethodsmanual.pdf

5. Vermont Department of Environmental Conservation. (2014) *Assessing the Biological Condition of Vermont's Wadeable Streams 2008-2012: Results of a Statewide Probability-Based Survey.* *http://dec.vermont.gov/sites/dec/files/wsm/mapp/docs/WSMD_mapp_nrsa_prob2008_2012.pdf*

6. Vermont Agriculture and Environmental Laboratory (VAEL). (2016) *VAEL Quality Systems Manual.* http://agriculture.vermont.gov/sites/ag/files/pdf/lab/VAEL%20QSM%20%20-%202016.pdf

7. Vermont Department of Environmental Conservation.(2017) *Vermont Surface Water Management Strategy.* http://dec.vermont.gov/watershed/map/strategy

## Appendix 1: Benthos Electronic Field Form



FORMS DATA SETS

Site/Visit

Even Information

Site Name & RM

Bio Site ID

Location ID

Date

Time

Update Lat/Long

Latitude

Longitude

Crew

Moore, Aaron

Deshler, Jim

Pembrook, Heather

Levey, Rick

Hastings, Blaine

Kellogg, Jim

Graziosi, Michelle

Harvey, Rebecca

Other

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Site Comments

Weather Comments

Chemistry

Lab Chemistry

Sampler

Chem ID

Chem Dup ID

Chem Dup Time

Sampled

TP Alk IC Anions

DP Cl Metals, Earth

TN Turb Metals, Priority

TNH3 Color Metals, All

TNOX Cond Metals, Diss.

Other

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Field Data

Flow Type Base/Freshet

Flow Level Low/Moderate/High

Meter Used

Air Temp (F)

Water Temp (C)

pH

Conductivity

DO Calibrated

DO %

DO mg/L

Turbidity

Chem Comments

Flow/Precip Past 48 hrs

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Flow/Precip Past 2 Weeks

Habitat

Physical Characteristics

Habitat Type Riffle/Meandering Low Gradient/Run

Bank Stability Excellent/Very Good/Good/Fair/Poor

In Stream Cover Excellent/Very Good/Good/Fair/Poor

Bottom Type Hard/Soft/Mixed

Velocity Class Slow: <0.4 ft/s/Medium:0.4-2 ft/s/Fast:>2 ft/s

Stream Characteristics

Bankfull Width (m)

Wetted Width (m)

Left Riparian Width

Right Riparian Width

Velocity Measured (ft/s)

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**Vegetation**

| | |
|---|---|
| Softwood Overstory % | |
| Hardwood Overstory % | |
| Shrub Understory % | |
| Herbaceous Understory % | |
| Grass Understory % | |
| Canopy % | |

**Substrate**

| | |
|---|---|
| Embeddedness Est. % | |
| Silt Rating (0-5) | |
| CPOM Rating (0-5) | |
| Iron Precipitates % | |
| Calcareous Deposits % | |
| Large Woody Debris #/100m | |



**Periphyton Cover**

| | |
|---|---|
| Diatom % | |
| Filamentous Green % | |
| Blue Green % | |
| Moss % | |
| Green % | |
| Other Peri % | |
| Macrophyte % | |

**Habitat Comments**

## Estimated Substrate



**Estimated Substrate**

| | |
|---|---|
| Ledge % | |
| Boulder % | |
| Cobble % | |
| Coarse Gravel % | |
| Gravel % | |
| Sand % | |
| Silt % | |
| Clay % | |

## Pebble Counter

Show/Hide Didymo | Show/Hide Iron

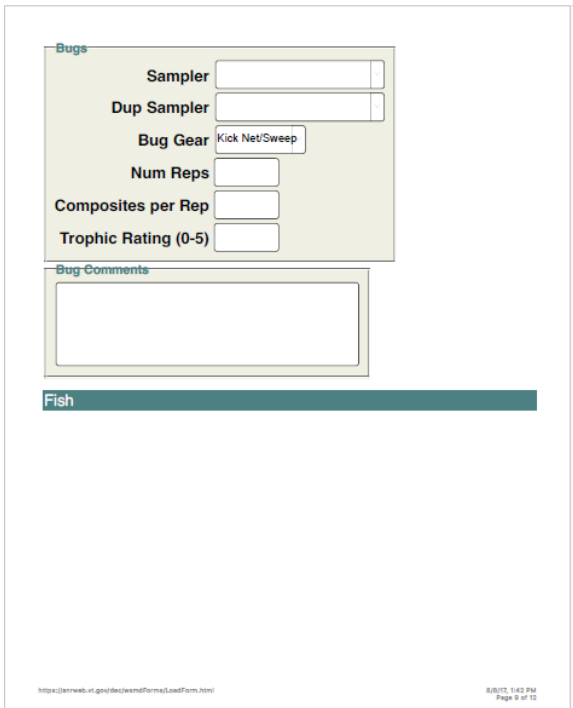
| Pebble Type | Moss | Macro Algae | Micro Algae | Didymo | Iron |
|---|---|---|---|---|---|
| Ledge | 0 0% | 0 0% | 0 none | 0 none | 0 none |
| Boulder | 1 <5% | 1 <5% | 1 slimy | 1 <5% | 1 <5% |
| Cobble | 2 5 to 25% | 2 5 to 25% | 2 draw line | 2 5 to 25% | 2 5 to 25% |
| Coarse Gravel | 3 >25% | 3 >25% | 3 0.5 to 1 mm | 3 25 to 75% | 3 25 to 75% |

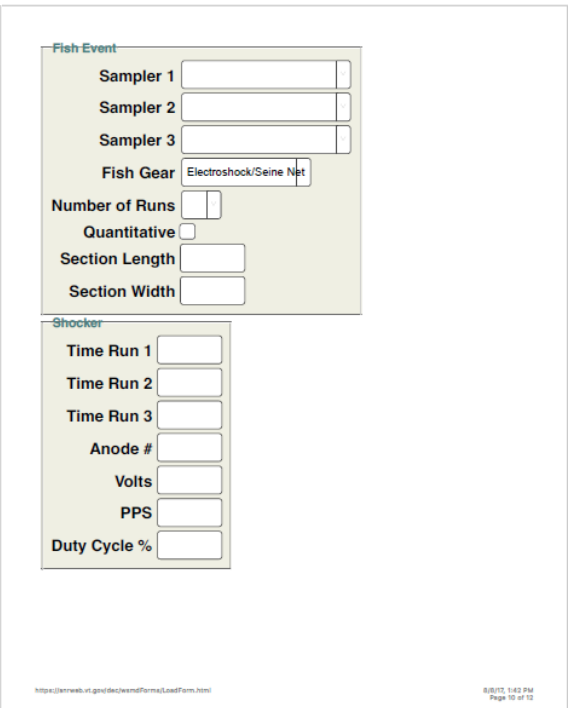


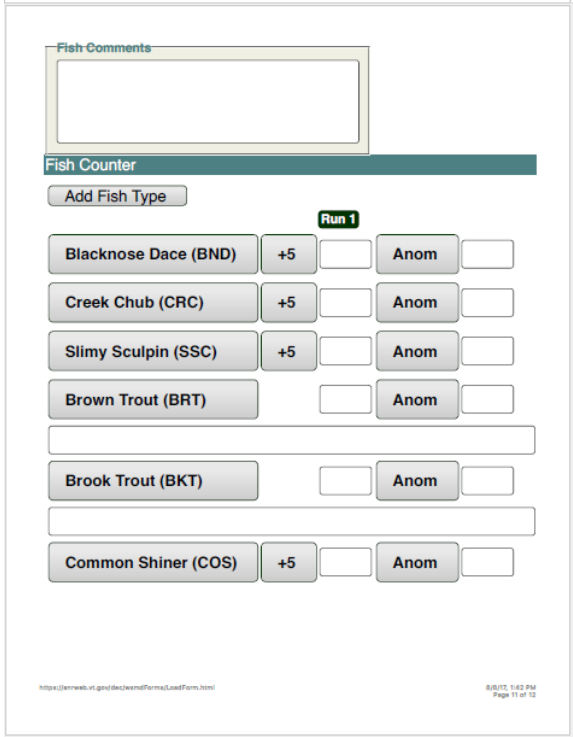
| | | | |
|---|---|---|---|
| Gravel | 4 1 to 5 mm | 4 >75% | 4 >75% |
| Sand | 5 5 to 20 mm | | |
| Silt | | | |
| Clay | | | |

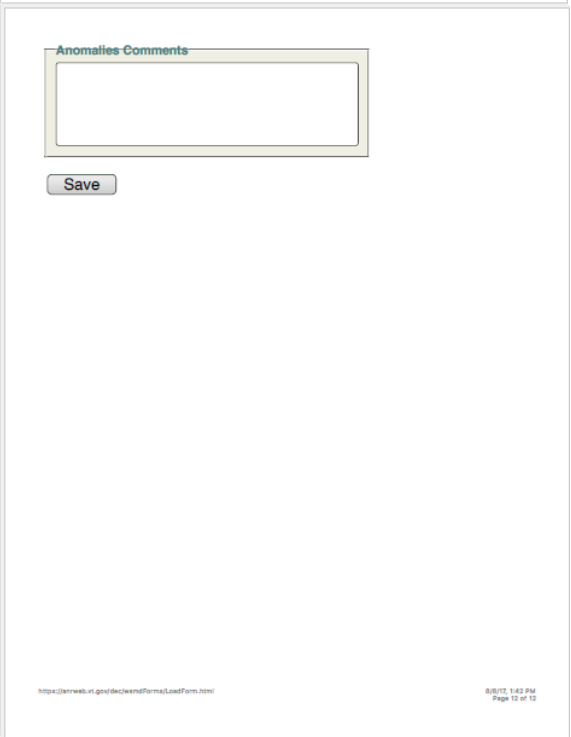
| | | | | | |
|---|---|---|---|---|---|
| Ledge: | Moss 0: | Macro Algae 0: | Micro Algae 0: | Didymo 0: | Iron 0: |
| Boulder: | Moss 1: | Macro Algae 1: | Micro Algae 1: | Didymo 1: | Iron 1: |
| Cobble: | Moss 2: | Macro Algae 2: | Micro Algae 2: | Didymo 2: | Iron 2: |
| Coarse Gravel: | Moss 3: | Macro Algae 3: | Micro Algae 3: | Didymo 3: | Iron 3: |
| Gravel: | | | Micro Algae 4: | Didymo 4: | Iron 4: |
| Sand: | | | Micro Algae 5: | | |
| Silt: | | | | | |
| Clay: | | | | | |
| Total: | | | | | |

## Bugs


Bugs
Sampler
Dup Sampler
Bug Gear
Kick Net/Sweep
Num Reps
Composites per Rep
Trophic Rating (0-5)
Bug Comments
Fish


Fish Event
Sampler 1
Sampler 2
Sampler 3
Fish Gear
Electroshock/Seine Net
Number of Runs
Quantitative
Section Length
Section Width
Shocker
Time Run 1
Time Run 2
Time Run 3
Anode #
Volts
PPS
Duty Cycle %


Fish Comments
Fish Counter
Add Fish Type
Run 1
Blacknose Dace (BND)
+5
Anom
Creek Chub (CRC)
+5
Anom
Slimy Sculpin (SSC)
+5
Anom
Brown Trout (BRT)
Anom
Brook Trout (BKT)
Anom
Common Shiner (COS)
+5
Anom


Anomalies Comments
Save

**Appendix 2: Benthos Laboratory Bench Sheet**

## **BENTHOS LAB SHEET** (updated 2016)

**River:_____ Station #:_____ Lab ID: _____**

| | A | B | C | D | E | F |
|---|---|---|---|---|---|---|
| Picked By / Date: | | | | | | |
| # of Squares Picked: | | | | | | |
| Checked By: | | | | | | |
| Sorted By / Date: | | | | | | |

**Taxa Sorted by Reps**:
Amphipoda_____;Isopoda_____;Chaoboridae;_____Coleoptera_____;Diptera_____;
Chironomidae_____; Ephemeroptera_____; Hemiptera_____; Hydrachnidea_____; Lepidoptera_____;
Megaloptera_____; Amphibia____; Plecoptera_____; Odonata_____; Trichoptera_____; Gastropoda_____;
Bivalvia_____; Oligochaeta_____; Tricladida_____; Decapoda_____;
Neorhabdocoela_____;Polychaeta_____; Nemertea_____; Anura_____; Conchostraca_____;
Neuroptera_____;Nematomorpha_____;Hirudinea_____;Anostraca_____; Caudata_____; Podocopa_____;

## Appendix 3: Benthos Excel Data Sheet

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Lab ID** | | | Instructions: Sorters are responsible for setting up and filling in site and picking data below. | | | | | | | | | | | | | |
| **Stream** | | | Indicate what orders were found in which reps and highlight. | | | | | | | | | | | | | |
| **Station** | | | Taxonomists should copy and paste the taxa from the library tabs and include their initials, confidence, and counts. | | | | | | | | | | | | | |
| | | | Please double check your work. Unhighlight the order once you've completed data entry. | | | | | | | | | | | | | |
| **Site ID** | | | **REPS:** | Rep 1 | Rep 2 | | | | | | | | | | | |
| **Date Collected** | | | **Picked By / Date** | | | | | | | | | | | | | |
| **# Reps Collected** | | | **# Squares picked** | | | | | | | | | | | | | |
| **# Rep Picked** | | | **Checked By** | | | | | | | | | | | | | |
| **Collection Method** | | | **Sorted By / Date** | | | | | | | | | | | | | |
| **TAXA:** | | | | | | | | | | | | | | | | |
| Amphipoda | | Megaloptera | | Decapoda | | Caudata | | | | | | | | | | |
| Isopoda | | Amphibia | | Tricladida | | Anura | | | | | | | | | | |
| Chaoboridae | | Plecoptera | | Neorhabdocoela | | Nemertea | | | | | | | | | | |
| Coleoptera | | Odonata | | Nematomorpha | | | | | | | | | | | | |
| Diptera | | Trichoptera | | Polychaeta | | | | | | | | | | | | |
| Chironomidae | | Gastropoda | | Hirudinea | | | | | | | | | | | | |
| Ephemeroptera | | Bivalvia | | Neuroptera | | | | | | | | | | | | |
| Hemiptera | | Oligochaeta | | Anostraca | | | | | | | | | | | | |
| Hydrachnidea | | | | Conchostraca | | | | | | | | | | | | |
| Lepidoptera | | | | Podocopa | | | | QA is confidence of ID. A=99%, B=90%,C=75%,D=50% | | | | | | | | |
| | | | | | | | | Count- only report a 0, in case of Rare taxa not found in subsample | | | | | | | | |
| | | | | | | | | | Rep1 | | | Rep2 | | | | |
| ExpandedKey | Order | Family | SubFamilyOrTribe | GenusGroup | Genus | SpeciesGroup | Species | ID | QA | Count | ID | QA | Count | NOTES | | |
| | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |