Biological Assessments of Running Waters in Vermont
Quality Assurance Project Plan

Vermont Department of Environmental Conservation

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A. Project Management

A1. Project Organization

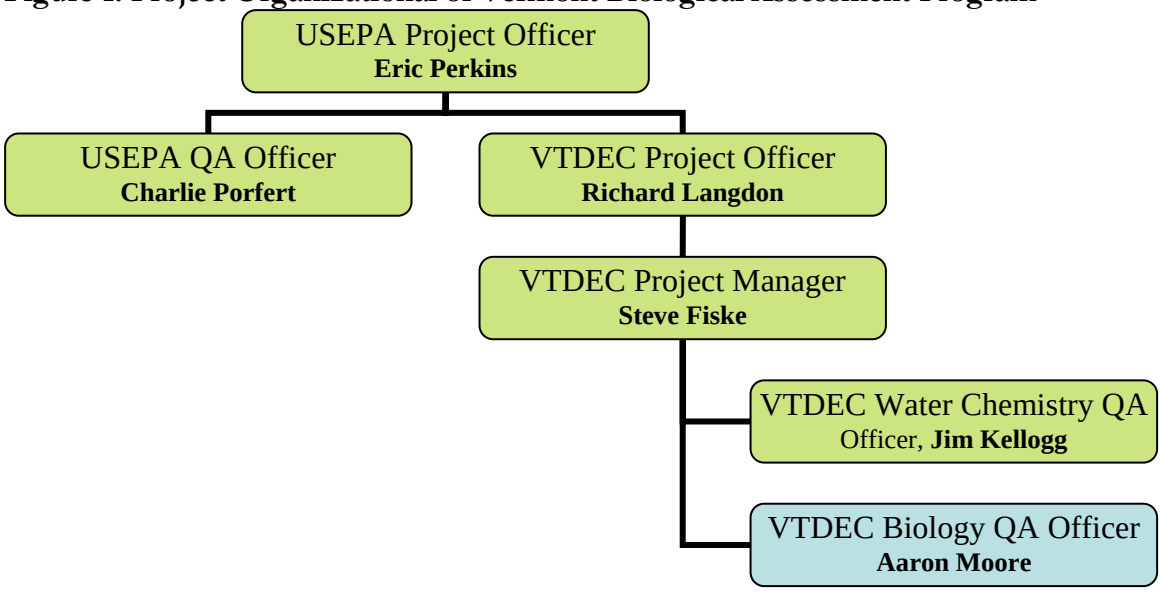
The present Quality Assurance Project Plan (QAPP) is written with an envisioned five-year lifespan. Minor revisions to protocols and procedures employed by the Biomonitoring and Aquatic Studies Section (BASS) during the five-year time period will be reflected in updated versions as necessary.

Figure 1 presents the organizational chart for staff involved in the Biological Assessment of running waters. The USEPA QA Officer is responsible for reviewing all QAPPs and serves as the primary contact with the USEPA and VTDEC Project Officers and Managers. The Vermont Department of Environmental Conservation (VTDEC), Water Quality Division (WQD), Monitoring Assessment and Planning Program (MAP), 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. Richard Langdon, BASS Section Chief, serves as the Project Officer and is responsible for general oversight and supervision and serves as the primary USEPA contact. Steve Fiske, 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 and coordinates activities with Christina Russo, QA Officer for the VTDEC Laboratory. Aaron Moore, Environmental Technician with BASS serves as the biological data and laboratory Quality Assurance Officer who has primary responsibility for overseeing biological quality assurance.

The VTDEC Laboratory 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. Gerry DiVincenzo, are responsible for internal QA/QC procedures and the initial data validation for samples analyzed by the VTDEC Laboratory. 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. VTDEC QAPPs are reviewed by the Laboratory QA/QC Officer, Christina Russo, to validate the information pertaining to the QA objectives and methods as described in the VTDEC Laboratory Quality Assurance Plan (VTDEC, 2010). The Laboratory QA/QC Officer is independent of the program. Section 4.2 of the VTDEC QAPP details the responsibilities of laboratory staff.

Occasionally, special projects require contracts with outside laboratories in order to process samples using methods the VTDEC Laboratory is not certified and 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.

Figure 1. Project Organizational of Vermont Biological Assessment Program



The principal data users include: VTDEC Water Quality Division 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 Division program managers and staff (NPDES, Indirect Discharge Regulations); VTDEC Waste Management Division program (CERCLA, RCRA, hazardous sites management); Vermont Agency of Natural Resources (VT ANR) 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

VTDEC has been conducting river and stream monitoring of macroinvertebrate and fish communities, water chemistry and physical habitat since the early 1970s in a manner that has retained a high level of methodological consistency throughout the years. With the addition of fish community assessments in 1982, the Ambient Biomonitoring Program was

established to: 1) monitor long-term trends in water quality as revealed by changes in ambient aquatic biological communities over time; 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, 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 main purpose of this program is to regularly provide or supplement data necessary to assess the biological quality and aquatic life designated use support 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 two Vermont-specific fish community Indexes of Biotic Integrity (IBI) and three macroinvertebrate stream type multimetric sets of biocriteria. Guidelines have been developed to determine water quality standards attainment using both the fish community IBI, and the macroinvertebrate community metrics (VTDEC 2004).

Fish assemblages are assessed at between 50-70 sites annually. Macroinvertebrate assemblages are assessed at approximately 100-140 sites per year. Physical and chemical habitat measures and observations are collected a minimum of once at the time of biological assessment. Chemical water quality measures include alkalinity, pH, conductivity, hardness, temperature, dissolved oxygen, chloride, turbidity, nutrients, anions, cations and metals. Physical habitat 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 on standardized field sheets, see **Appendix 1**.

Macroinvertebrate and/or fish populations of rivers and streams are assessed by comparing a series of biometrics measuring 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, i.e., 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.

A3. Project Description

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

Special projects are generally associated with a specific funding source such as a research grant or technical assistance grant that requires the development of, or operates under the aegis of 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: 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-needed basis in support of water and waste management regulatory programs. Recent examples include: assessment of impacts related to an illegal discharge of ammonia from an industrial facility.

Assessing the water management program is the largest activity for ambient biological assessments of running waters. For the routine ambient biological 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 VTDEC Ambient Water Quality Monitoring Strategy (VTDEC. 2005a, 2006).

There are 17 major drainage basins in Vermont. With the rotational approach, waterbodies in each watershed are targeted for assessment once every 5 years (**Figure 2**). During the year prior to monitoring within a rotational basin, a variety of input is solicited from other Monitoring and Assessment Program staff (program managers, basin planners), Waste Water Division 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 MAP staff with input from water program managers and staff. Generally, sites with regulatory implications NPDES, 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 allow. Stream reaches found to be biologically impaired during the initial rotational year are routinely followed up the next year with greater longitudinal coverage, and more stressor identification work.

Additionally to estimate the condition of all of Vermont's waters a probability based 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 probability estimate of river and stream biological condition. The most recent reporting of these data is found in the report entitled

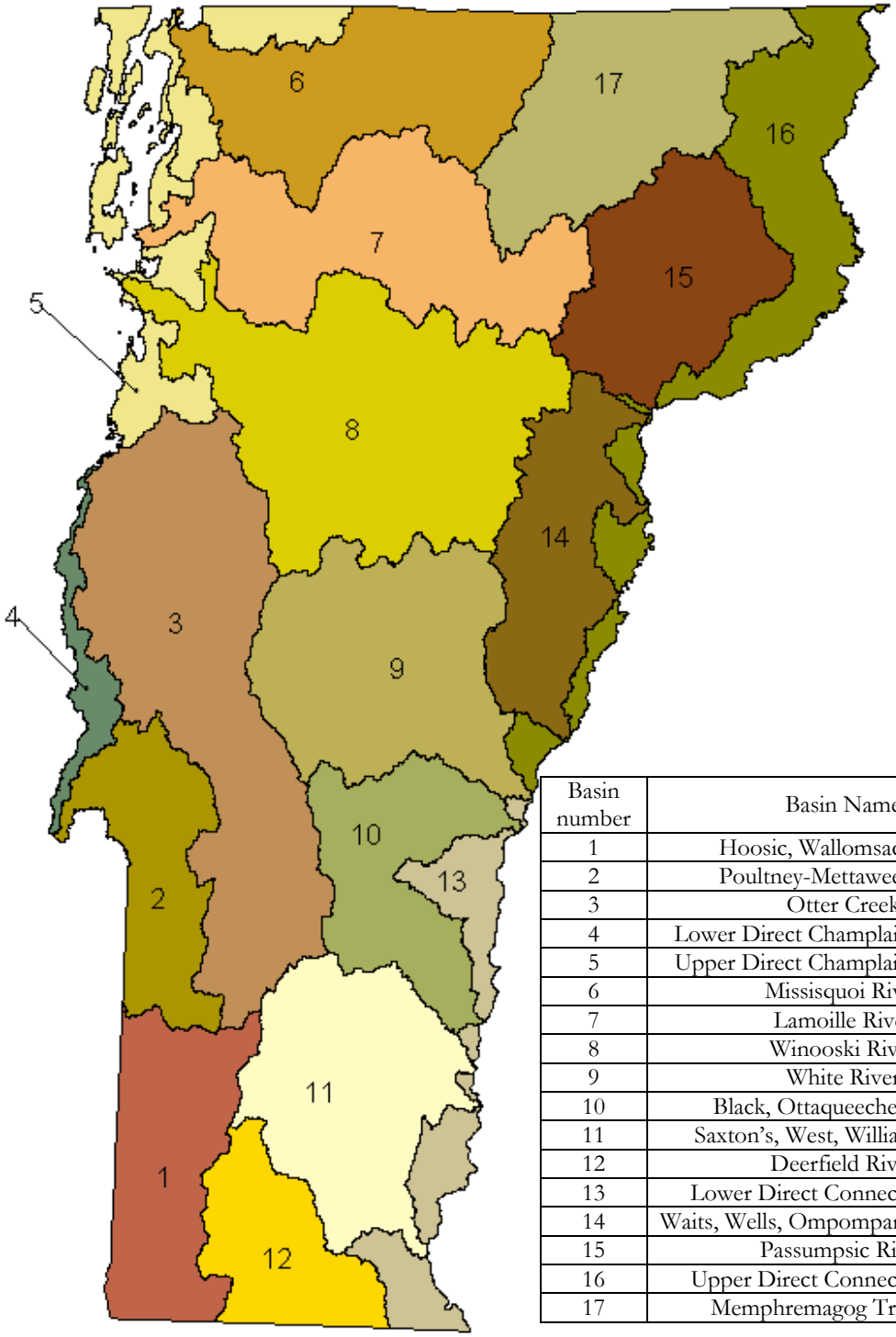
'A Probability-Based Comprehensive Statewide Assessment of Wadeable Stream Biological Condition Vermont 2002-2006' (VTDEC 2006).

Long term reference – sentinel site monitoring is done at approximately 12 reaches each year. These sites are assessed to allow for a periodic check on the biological expectation of reference sites in Vermont. Long term reference sites are sampled within the 5 year rotational schedule mentioned above. A subset of these reference sites have been selected as sentinel sites and will be sampled annually if possible to monitor the effects of climate change.

Biological site assessments generally involve a single visit during the late summer-fall index period (late August -October). Sampling within a certain time of year minimizes variability in population structure and density. The rationale for sampling during this particular 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.

All routine biological samples are collected, and completely processed and analyzed by BASS biologists and technicians. All routine chemistry samples are analyzed by the VTDEC Laboratory. All data management is conducted using VTDEC relational databases developed with Microsoft Access applications.

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



Basin number	Basin Name	Schedule year
1	Hoosic, Wallomsac Rivers	2008-2009
2	Poultney-Mettawee Rivers	2012-2013
3	Otter Creek	2011-2012
4	Lower Direct Champlain Drainages	2011-2012
5	Upper Direct Champlain Drainages	2009-2010
6	Missisquoi River	2009-2010
7	Lamoille River	2012-2013
8	Winooski River	2010-2011
9	White River	2011-2012
10	Black, Ottaqueechee Rivers	2012-2013
11	Saxton's, West, Williams Rivers	2008-2009
12	Deerfield River	2008-2009
13	Lower Direct Connecticut River	2008-2009
14	Waits, Wells, Ompompanoosuc Rivers	2012-2013
15	Passumpsic River	2010-2011
16	Upper Direct Connecticut River	2010-2011
17	Memphremagog Tributaries	2009-2010

A4. Quality Objectives and Criteria

The overall objective for VTDEC biomonitoring activities is to generate defensible chemical, physical and biological data necessary to support and direct implementation of VTDEC water management programs. Data generated will provide feedback to management activities that will support 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 VTDEC Laboratory's Quality Assurance Plan (VTDEC 2010). Precision is assessed based on 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 checked by a second biologist. Both the primary sample picker and the checker initial the Benthos Laboratory Sheet (**Appendix 1**). Ten percent of the samples are then checked by a third biologist to determine the PPE of a sample. Ten percent of the samples processed in the biology laboratory include at least one sample from each biologist-level sample checker. 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)

A sample found to have over 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 through the use of 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 kept to assure consistent identifications. Two biologists are responsible for each taxonomic group for in-house identification verifications as necessary. To keep current with taxonomic changes the BASS staff regularly consult the Integrated Taxonomic Identification System (ITIS), participate in regional NEAEB conference, participate in a regional taxonomic working group New England Aquatic Taxonomists (NEAT), and participate in the Freshwater Invertebrate Taxonomy list serv. 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 the Biomonitoring Laboratory in Waterbury.

Precision

Sample method precision is determined by processing duplicate samples collected under identical conditions in the field. At least 50% of sites sampled are sampled in duplicate. For these sites, two kick net samples are collected at each site. Ten percent of these are processed as duplicates in the Biomonitoring Laboratory. Descriptive statistics of density and richness are determined for each duplicate. Sites where relative differences between duplicates are greater than 40 percent in density and 20 percent in species richness fail to meet expected precision guidelines and can only be used with extreme caution for assessments.

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

Enumeration

Precision of counts is determined by calculating the % 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 lab/taxonomist and comparing the results between the taxonomist or laboratories by counting the number of agreements from which a % taxonomic agreement (PTA) is calculated:

$$PTA = [Comp_{pos} / N)] \times 100$$

$Comp_{pos}$ = 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 a large number of 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 really only hierarchical in taxonomic level and do not effect the biological assessment outcome. The corrective action is to establish what the critical taxonomic characteristics are that are necessary to determine the lowest practical taxonomic level. 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 2.25 feet. 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 (see VTDEC 2006, 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 2006). 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, harder to identify, individuals. 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 biologist 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 biologists that sample fish have been trained by the Project Officer

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 familiar with the methods and procedures used to conduct biologiocal collections. 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. mayfly taxonomy; fish identifications; algal identification. The Project Manager will bear responsibility 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 certification and VTDEC Laboratory safety training.

Staff are encouraged to participate in 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 is an impact to the project objectives. As this project conforms to the VTDEC Laboratory 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 data base 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 needed basis. All sample site locations are available to the public on the department web site.

BASS retains and archives all field sampling sheets and laboratory bench sheets. The Laboratory Information Management System (LIMS) number is provided by the VTDEC Laboratory 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 the makes the most efficient use of available resources to address water quality assessment priorities related to water management programs primarily under VTDEC jurisdiction. 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 indentified 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"; and probability sites.

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 2006).

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. If the mixed status is unknown, samples may be collected along a cross-sectional transect and either kept separate or composited as appropriate. For those parameters requiring filtration (i.e. total dissolved phosphorus and metals), filtration will be 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 in to the container. All containers (with the exception of total phosphorus and dissolved phosphorus) and filtering equipment are triple rinsed with ambient water prior to filling. Some parameters, such as pH, specific conductance 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 (FMM) (2006).

Macroinvertebrates: Sample Collection: For most wadeable streams, macroinvertebrate samples are collected using a 500u mesh kick net (KN) in riffle habitat following the method 6.4.1 described in the Water Quality FMM. Four KN net samples are collected in a designated riffle area (2 kicks in a high velocity area, 2 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 using in a sweeping fashion and samples are identified as sweep net (SW) samples WATER QUALITY FMM 6.4.2. 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,** and WATER QUALITY FMM 6.4.3 for physical habitat methods.

Macroinvertebrates: Sample Processing: Following methods described in WATER QUALITY FMM 6.6. 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 macroinvertebrates are then identified to genus/species except for the Oligochaeta which will be identified to family. All subsampling and taxonomic identifications are recorded on a bench sheet. See **Appendix 2**.

Fish: Fish populations are sampled as described in Water Quality FMM 6.5.1 by the use of 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 field sheets. Substrate composition and algal cover may be estimated either by observation or by semi-quantitative methods, such as a pebble count. All field sheets must be initialed by a designated QA individual verifying that the field sheet has been completely filled out and all fields are legible.

B3. Sample Handling and Custody

All samples are collected by BASS staff and remain in their custody until returning to the VTDEC Laboratory. The chemical samples 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 VTDEC Laboratory QAPP (VTDEC 2010) 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 VTDEC Laboratory 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 the latest VTDEC QAPP does not agree with the methods cited below, the latest VTDEC QAPP takes precedent. Any changes in the methodologies employed by the VTDEC Laboratory 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
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-Persullfate 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 cylindical	Filter* Cool, 4º C HNO_3 to pH ≤ 2	6 mo
Calcium	Grab-Thermo-Elemental X Series ICP-MS	P, 125 ml cylindical	Filter* Cool, 4º C HNO_3 to pH ≤ 2	6 mo
Magnesium	Grab-Thermo-Elemental X Series ICP-MS	P, 125 ml cylindical	Filter* Cool, 4º C HNO_3 to pH ≤ 2	6 mo
Potassium	Grab-Thermo-Elemental X Series ICP-MS	P, 125 ml cylindical	Filter* Cool, 4º C HNO_3 to pH ≤ 2	6 mo
Sodium	Grab-Thermo-Elemental X Series ICP-MS	P, 125 ml cylindical	Filter* Cool, 4º C HNO_3 to pH ≤ 2	6 mo
Iron	Grab-Thermo-Elemental X Series ICP-MS	P, 125 ml cylindical	Filter* Cool, 4º C HNO_3 to pH ≤ 2	6 mo
Manganese	Grab-Thermo-Elemental X Series ICP-MS	P, 125 ml cylindical	Filter* Cool, 4º C HNO_3 to pH ≤ 2	6 mo
Hardness	Calculated	NA	Cool, 4º C	NA
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
Apparent Color	Orbeco-Hellige Model 611-A Aqua Tester	P,50 ml	Cool 4º C	48 hours

Table 2. Laboratory analytical methods

Parameter	Method	References
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
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

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 VTDEC Laboratory QAPP (VTDEC 2010). It is included here rather than referenced only, 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.

Equipment Blanks are used to determine if contamination has been introduced through contact with sampling equipment or to verify effectiveness of equipment cleaning (VTDEC 2010, Section 11). 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, or every 20th sample. 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 with every 10th sample, or whenever contamination is suspected. Contamination detected in field blanks would need to be evaluated by both the Project QA Officer and Laboratory personnel Blank results are evaluated against practical quantitation limits provided in VTDEC (2010). Tables 5a and 5b, Section 11).

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

Field Replicates 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. Field replicates may be taken as deemed necessary by the Project QA Officer.

Split Samples are aliquots of samples taken from the same sample collection, after thoroughly mixing or compositing the sample. They are analyzed independently and are used to document intra- or interlaboratory precision. Split samples may also be used by program personnel to request matrix spike analysis for tests requiring two separate samples.

B6. Analytical Quality Control Samples, Solutions and Routines

See Section 11.2 of the VTDEC Laboratory QAPP for a detailed description of the sample analyses performed by the VTDEC Laboratory (VTDEC 2010). EPA certified laboratories with current EPA approved laboratory QAPPs are selected for any parameters that needs to be contracted outside of the VTDEC Laboratory 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 VTDEC Laboratory 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**.

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) 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%
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 VTDEC 2010 Quality Assurance Plan, except for field parameters, which are reported as operational ranges. It is possible that the specific conductance values may 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	<25 NTU
Barometric Pressure	500 to 850 mmHg		±10 mmHg	0.1 mmHg	n/a

B7. Instrument/Equipment Testing, Inspection and Maintenance

VTDEC Laboratory small instruments are tested and serviced by an outside contractor (Q.C. Services, Inc.) once a year. All other instruments are maintained according to Section 13.0 of the Laboratory QAPP (VTDEC 2010).

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

B8. Instrument/Equipment Calibration and Testing

The Hydrolab multiprobes are calibrated routinely by the Project Coordinator. 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 the Water Quality Division Field Methods Manual (2006).

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.

With the exception of the 4.75 pH 3rd point check sample, 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 Section 9.3 of the Laboratory QAPP (VTDEC 2010).

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 VTDEC Laboratory 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 6 months if properly preserved and stored, unless otherwise specified by the vendor.

B10. Data Management

Upon return to the VTDEC Laboratory 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. Section 7.0 of the VTDEC Laboratory QAPP presents the sample management procedures of the Laboratory (VTDEC 2010).

Data Management procedures for the VTDEC Laboratory are outlined in Section 10.0 of the Laboratory QAPP (VTDEC 2010). This section covers the data reduction, validation, reporting and storage.

Once the samples have been authorized by the VTDEC 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 VT Agency of Natural Resources (ANR) network. The VT ANR has a Microsoft Windows 2000 network consisting of Windows 2000 servers and Windows computers. An LTO tape is used to backup the files that comprise the LIMS system every Monday through Friday. Every fourth Friday, a monthly tape is stored in a fireproof cabinet in a locked room. See Section 10.4 of the VTDEC QAPP for a full description of data storage for the LIMS system(VTDEC 2010).

Fish sampling data are transferred manually from field sheets 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 book 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 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 manually entered into Microsoft Access data base.

C. Assessment and Oversight

C1. Assessments and Response Actions

The VTDEC 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.

The VTDEC Laboratory analyses all non-ambient chemistry samples collected by BASS. The VTDEC Laboratory 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 the VTDEC Laboratory. 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 Section 12.0 of the VTDEC Laboratory QAPP (VTDEC 2010).

Corrective actions are initiated as a result of problems identified through a systems audit, performance audit or interlaboratory comparison study. The steps are presented in Section 15.0 of the VTDEC Laboratory QAPP (VTDEC 2010). A review of all Internal Performance Evaluations are addressed in Section 12.2 of the VTDEC Laboratory 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 VTDEC Laboratory 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 Section 10.2 of the Laboratory QAPP (VTDEC 2010). **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. In the event that poor duplication or blanking is evident, the data for the corresponding run of samples is evaluated to ensure its quality. Poor replication or blanking may be cause for rejecting an entire run of samples, although this is not a necessity.

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 **Tables 3**. The practical quantitation limits shown in those tables form the basis for blank criteria.

Once the VTDEC Laboratory releases 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. 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. A Project QA Officer, in consultation with a Project Manager tags or deletes the outlier from the final database. A Project QA Officer works with the Laboratory 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. VTDEC Laboratory 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

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Appendix 1. Benthos Field Sheet

LOTIC BENTHOS FIELD SHEET
(2009 edition)

BioLab ID _____
Chem LabID _____

Site Name _____ **River Mile** _____
Site ID _____
Date _____ **Time** _____ **Crew** _____
Site Description _____

Town: _____ **Stream Order:** _____ **Drainage Area:** _____ Km^2 **Elevation:** _____ ft
D.D° Latitude: _____ **Longitude:** _____ **Lat/Long source (GPS – set to NAD83:)** _____
Weather: _____ **Flow/Weather Previous (2 weeks/2days):** _____
Surrounding Land Use: _____

SAMPLING INFORMATION
Sampler: _____ **Gear:** _____
Effort Time: ____ **min** **Mesh:** 500 **um**
Area: _____ m^2 **Quantitative: Y / N**
#Reps: _____ **Comp/rep:** ____

Qual. PERIPHYTON COVER for each type 0-100% (*See back for Periphyton Cover Form*)
Diatom _____% **Filamentous Green** _____% **and length** _____ **in**
Blue Green _____% **Moss** _____% **Green** _____% **Other** _____%

General Trophic Rating: _____ **(0=oligo, 5=Eutroph)**

EMBEDDEDNESS
(5) 0-5% Excel **(4) 5-25% V Good** **(3) 25-50% Good** **(2) 50-75% Fair** **(1) > 75%Poor** **Estimate** _____%
Silt Rating: _____ **(0=none, 5= chocolate)** **CPOM Rating (leaf packs):** _____ **(0= none,5=high)**
Lg Woody Debris (>4"dia) #: _____/100m (reach)

GENERAL WATER TYPE **Riffle, Winder, or Other** _____ **Warm, Cold, or Mixed** **Channelized: Y / N** **Upstream Dam: Y / N** ____ **mi**
B.F.Width: _____ **(m)** **Wetted Width:** _____ **(m)** **Riffle Depth:** _____ **(m)** **Pool Depth:** _____ **(m) and Obs:** _____
Bank Stability: EX VG G F **Velocity estimate (circle): (S) <0.4 ft/sec, (M) 0.4-2 ft/sec, (F) >2 ft/sec** **Measured:** _____ **ft/sec**

Riparian VEGETATION (both sides, does not need to add up to 100%) **Riparian Width (facing upstream) L** _____ **m, R** _____ **m**
Overstory: Softwood _____% **Hardwood** _____% **Understory: Shrub (brush)** _____% **Grass** _____% **Herbaceous** _____%
Canopy %: 100 90 80 70 60 50 40 30 20 10 0 **Overhead: Open, Partly Open, or Closed**

WATER QUALITY PARAMETERS **Sampler:** _____ **Meter (type, #)** _____
Baseflow or Freshet Flow **Present Flow: H - M – L** **Annotate? Y / N**

Temp Air _____ **°C,°F Temp Water** _____ **°C fpH** _____ **lab pH** _____ **fCond** _____ **D.O.%** _____ **D.Omg/l** _____ **Color** _____

Cond pH Alk TP DP Cl ICAnions Turb TN N02-3 Ca Mg Na K Hardness Metals, TNH3, TSS Other _____, _____,
_____, _____, _____, _____, _____, _____, _____

SITE SKETCH & GENERAL OBSERVATIONS (circle those that apply) **Overall Aesthetic Rating 0 (poor) – 5 (exc.)** _____

A – Pollution: Sludge | Sawdust | Paper Fiber | Sand | Silt | Sewage | Oily Sheen | Trash | Iron | Scum | None
B – Water Clarity: Clear | Slightly Turbid | Moderately Turbid | Very Turbid | Secci Tube_____mm
C – Water Color: Clear | Green Milky | Brown (Tannic) L M H | Gray | Metallic | Reddish
D – Odors: None | Musty | Fishy | Sewage | Manure | Sulfur(eggs) | Oily/gas
Aquatic Biota Observed: Mussels, Crayfish, Gastropods, Fish, Other

Field Sheet Complete: _____ **(initial)**
Photos: Y / N
Fish Survey Conducted: Y / N

River (Site) _____ Personnel _____ Date _____

Pebble Count Field Form

Complete % observed substrate if no pebble ct done

Particle	Millimeters	%Observed	Transect 1 (100 pebbles)	Tot #	Item %
Clay	<.004				
Silt	.004 -0.6				
Sand	0.06 – 2.0				
Gravel	2.0 -16				
Coarse Gravel	16 – 64				
Cobble	64 – 256				
Boulder	>256				
Bedrock					
			TOTALS		

Periphyton Cover Observations

	Moss Cover Index			
Category	0	1(<5%)	2(5-25%)	3(>25%)
Tally				

	Macro-Algae Cover Index			
Category	0	1(<5%)	2(5-25%)	3(>25%)
Tally				

	Micro-Algae Cover Index						
Category	0	1 (slimy)	2 (draw line)	3(.5-1mm)	4(1-5mm)	5(5-20mm)	6(>20mm)
Tally							

	*Other Macro or Micro*_____Cover Index					
Categoryy	0	1_____	2_____	3_____	4_____	5_____
Tally						

Appendix 2. Benthos Laboratory Sheet

BENTHOS LAB SHEET edited 2008

River/Lake_____ Sta. #_____ Lab ID _____

Date_____ Sample Type_____ # Reps._____ Subsampled Y/N

	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_____; Fish__

			1	2	3	4	5	6
NOTES	**TAXA** (Class / Order; Family / Genus; sp.)	ID/ Conf.	A	B	C	D	E	F

Page_____/_____