Vermont Department of Environmental Conservation

Water Quality Monitoring Program Strategy
2011-2020

May 2011
Interim Update – May 2015

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Updating Vermont's Surface Water Monitoring Strategy began in January of 2010 and the process was fortunate to have the involvement of many talented staff. Contributions were made by all programs

within the Watershed Management Division, and as a result, the Strategy represents a comprehensive approach to the Division's monitoring efforts. The staff listed below participated in development and vetting of this of this strategy and are gratefully acknowledged:

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Cathy Kashanski (Assessment)	Emily Schelley (Stormwater)
Leslie Matthews (Lakes and Ponds)	

Executive Summary

Purpose: The 2010 Vermont Water Quality Monitoring Strategy (WQMS) has two primary purposes: (1) to describe the who, what, where, when and why of monitoring Vermont's waters and (2) to work with our monitoring partners to provide additional information and communicate these results. Effective monitoring will allow us to better identify and prioritize waters in need of protection, restoration or management. It will allow regulatory programs to more fully assess the watershed condition and threats to receiving waters as it relates to individual permits and it will assess the effectiveness of our monitoring and management efforts.

The 2010 update was initiated to reflect the Watershed Management Division's new Monitoring Assessment and Planning program (MAPP), and the new statewide tactical basin planning approach as described in the Statewide Vermont Surface Water Management Strategy. These two strategies and the processes they represent have a symbiotic relationship, where monitoring drives planning, assessment and implementation of management actions. Effectiveness of these actions is judged by the results of more monitoring, creating an iterative an on-going process.

The 2015 update addressed select sections of the 2011 Monitoring Strategy. This was the first step in a mid-stream gap analysis planned for 2016. Only the following sections were updated to reflect the current priorities and resources need to accomplish our goals. Other sections will be updated in 2016.

Recommendations and Strategies sections of:

- *Monitoring Design Sections 3.D*
- *Data Management Section 6.C.*
- *Data Analysis and Assessment Section 7.C*
- *Reporting Section 8.E.*

Appendices: Appendix C: Mid-stream gap analysis and review of achievements from 2005 WQMS; and Appendix D: Recommendations timeline.

Staffing or Equipment Needs: Table: 10.B.iv. Monitoring Equipment Needs; and Section 10.B.v. Training and conference needs.

The Ten Elements: The WQMS is organized into 10 elements as recommended by the USEPA's "Elements of a State Water Monitoring and Assessment Program" and includes the categories to the right.

By addressing these elements, the strategy outlines the breadth and scope of the monitoring activities, and provides a description of the feedback loop which guides the monitoring and management activities. The monitoring program elements described in the remainder of this document will be achieved by reviewing this strategy every two years and documenting its progress.

This strategy presents specific monitoring goals and objectives, and provides recommendations on how to reach these targets. The goals for this strategy and the objectives used to reach them are outlined below. Recommendations on how to achieve these goals and objectives are presented in Section 3D.

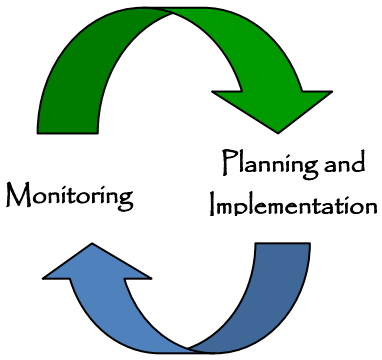
Ten Elements of the Surface Water Monitoring Strategy

Monitoring Strategy
Monitoring Goals and Objectives
Monitoring Project Design
Core and Supplemental Indicators
Quality Assurance
Data Management
Data Analysis and Assessment
Reporting
Programmatic Evaluation
General Support and Infrastructure

Goal 1: To monitor and assess the physical, chemical and biological condition of Vermont's surface waters to maintain, protect, enhance and restore their integrity and uses.

Objectives

A. Determine the status and trends in the condition of Vermont's waterbodies.
B. Determine if surface waters are meeting the Vermont Water Quality Standards.
C. Use probability assessments to provide an understanding of statewide surface water conditions.
D. Learn what stressors threaten the integrity and uses of Vermont waters.
E. Adapt monitoring efforts to identify and track pollutants in addition to emerging stressors.
F. Respond to public complaints and emergency situations regarding Vermont surface waters.
G. Evaluate effectiveness of management actions and mitigation activities in achieving water quality goals.
H. Integrate monitoring and assessment with management actions.
I. Integrate volunteer monitoring efforts with current departmental needs.



Goal 2: To interpret, analyze and communicate monitoring and assessment results within the Agency of Natural Resources and outside groups to support the development of good management decisions for Vermont surface waters.

Objectives

A. Expand accessibility and use of water quality assessments within the ANR, by other state and federal entities, and by the general public.
B. Provide information to support and evaluate Agency and Department planning, management and regulatory programs, including the development of environmental indicators.
C. Communicate, collaborate and coordinate on a regular basis with organizations, agencies, municipalities, and the general public to assure complementary monitoring programs.

The strategy provides a description and rationale of the monitoring designs used to assess Vermont waters. Vermont's monitoring designs include targeted fixed stations, probability based studies, and river geomorphic assessments. These approaches are broken into physical, chemical, biological, and volunteer-based categories.

Section 4 lists core and supplemental water quality indicators that are measured by individual monitoring projects. These indicators originate from the Vermont Water Quality Standards (VWQS), but also include parameters that relate to ecological and habitat quality. Section 5 describes approaches to quality assurance, provides a listing of active quality assurance project plans, and discusses briefly how quality assurance planning relates to quality management planning.

Section 6 of the strategy provides a listing of existing databases that house water quality information generated by the monitoring programs; discusses the current status of Vermont's water quality assessment databases; and relates information housed in those data archives to the Vermont Hydrography Dataset. Section 7 summarizes how VTDEC assesses water quality data to arrive at determinations of water quality standards attainment, fully described in the Vermont's Water Quality Assessment and Listing Methodology. Section 8 describes required Federal reporting that is supported in large part by the monitoring program and associated assessment and listing processes. Finally, Sections 9 and 10 describe monitoring program review and institutional needs.

Recommendations: Specific recommendations are provided according to the stated goals and objectives and for individual sections of this strategy. The highest priority and most pressing items requiring funding to fulfill this strategy include: (a) securing an Information Technology position to improve storage of, and access to monitoring data; (b) replacing three scientist positions for the biomonitoring (1), lakes (1), and wetlands (1) programs to initiate, continue to support or enhance biocriteria development; and (c) securing two environmental technician positions to (a) provide stable support of biomonitoring activities and (b) help with probabilistic studies on lakes, rivers and wetlands. The positions sought were previously lost to attrition. Other priority items regard developing a common language to communicate the physical, chemical and biological condition, increasing the accessibility to data and assessments, systematically identifying high quality waters and developing a strategy to identify and track emerging threats. For a full list of recommendations and the resources needed to meet them, refer to Section 3D, Recommendations and Strategies. **2015 update – the information technology position has been filled, as have several other positions. See Appendix D for further information regarding progress.**

1. Introduction

This surface water monitoring strategy provides a framework to describe existing monitoring and assessment efforts in Vermont, and describes elements of an ideal monitoring program to meet several objectives. The strategy presented has the following uses and purposes:

Provides specific monitoring goals and objectives;
Discusses monitoring designs used in Vermont;
Recommends core and supplemental water quality indicators;
Recommends strategies for meeting the goals and objectives;
Provides detail on quality assurance procedures;
Provides detail on data management approaches;
Gives data analysis and assessment procedures;
Describes required federal reporting;
Suggests periodic review of this monitoring program; and,
Provides estimates of necessary resources for full program implementation.

Throughout the strategy, the terms "waters" or "water resources" are intended to comprise rivers, streams, lakes, ponds, reservoirs, wetlands and even watersheds. Groundwater is not addressed by this strategy.

The term "monitoring" is intended to address measurement or estimation of ambient physical, chemical and biological water quality status and conditions. This includes the physical geomorphic river assessments.

The term "assessment" refers to the determination of physical, chemical or biological condition from monitoring data and information. It also refers to the determination of whether various surface water uses are supported by the condition. The assessment process is elaborated in the Vermont Surface Water Assessment and Listing Methodology.

Groundwater is not presently addressed in this strategy nor are monitoring activities related to permit compliance or in-facility monitoring, with the exception of biomonitoring conducted below wastewater treatment facilities.

This strategy is intended to be evolving, reflecting the ever-improving methods available for ambient water quality monitoring. It provides a range of activities that could be implemented based on availability of resources in any given year. This strategy is intended to have a finite lifespan of ten years, and provides for biennial and mid-stream changes to the monitoring program. Vermont's citizenry, federal and academic collaborators, and regulated entities are encouraged to view this strategy with an eye towards where and how they can participate in assessing, protecting, and improving Vermont's waters.

There are numerous reasons to monitor the quality of Vermont's water resources. Principally, the Clean Water Act requires states to characterize the baseline quality or status of waters; understand the trends or directions in which this baseline is moving; and determine what factors or stressors may be

influencing that movement. These are critical components to properly managing any waters. In Vermont, and indeed nationwide, significant emphasis is being placed on determining whether waters are in compliance with applicable water quality standards and criteria. Such decisions carry significant regulatory repercussions, hence the need for a robust and scientifically defensible framework that describes every step of the assessment, remediation, and protection processes.

The process of assessment begins with the three components listed above: status, trend, and causality. Estimating the status and trends of waters, with known and quantifiable precision, is the first step in assessing standards attainment. Should a waterbody be determined to not be attaining standards, then determining the extent of the water quality impact caused by any number of stressors, again with known and quantifiable precision, is the first step toward remediating a problem.

While the current water quality management climate forces scientists and managers to think about monitoring in the framework of use support, impaired waters listings and de-listings, and TMDL preparation, there are other, equally important goals that must be met by monitoring activities. Chief among these are the understanding of the current condition of a waterbody, and the understanding of how waterbodies respond to a variety of management actions. These two objectives provide for protection and efficient remediation of waters. An important corollary objective is to provide, via education and participation, avenues for Vermont's citizenry to contribute in a meaningful way to the protection and/or improvement of rivers, streams, lakes, ponds, and wetlands.

2. Monitoring Objectives

A. Regulatory Justification

The objectives of this Monitoring Strategy are intended to meet the goals and intent of Federal and State Law. Specifically, these objectives address several sections of the Federal Clean Water Act, including Sections 106(e), 303(d), 304, 305(b), and others. These objectives also support sections of Vermont Statutes Annotated (e.g., 10 V.S.A. Chapters 37 - 50, 10 Appendix V.S.A. Chapter 2). Goal statements and associated objectives are described in the following sections.

B. Goals and Objectives

This Monitoring Strategy has two broad goals, elaborated below:

Goal 1: To monitor and assess the physical, chemical and biological condition of Vermont's surface waters to maintain, protect, enhance and restore their integrity and uses.

Objectives

A. Determine the status and trends in the condition of Vermont's waterbodies.
B. Determine if surface waters are meeting the Vermont Water Quality Standards.
C. Use probability assessments to provide an understanding of statewide surface water conditions.
D. Learn what stressors threaten the integrity and uses of Vermont waters.
E. Adapt monitoring efforts to identify and track pollutants in addition to emerging stressors.
F. Respond to public complaints and emergency situations regarding Vermont surface waters.
G. Evaluate effectiveness of management actions and mitigation activities in achieving water quality goals.
H. Integrate monitoring and assessment with management actions.
I. Integrate volunteer monitoring efforts with current departmental needs

Goal 2: To interpret, analyze and communicate monitoring and assessment results within the Agency of Natural Resources and outside groups to maximize good management decisions for Vermont surface waters.

Objectives

A. Expand accessibility and use of water quality assessments within the ANR, by other state and federal entities, and by the general public.
B. Provide information to support and evaluate Agency and Department planning, management and regulatory programs, including the development of environmental indicators.
C. Communicate, collaborate and coordinate on a regular basis with organizations, agencies, municipalities, and the general public to assure complementary monitoring programs.

C. Existing and Designated Uses

Vermont's Water Quality Standards are promulgated under the legal jurisdiction of the Vermont Water Resources Panel (10 V.S.A. Chapter 47, §1252), consistent with the intent of the Federal Clean Water Act (40 C.F.R. 131.3). In keeping with C.F.R. 131.10(f), "Existing Uses" are those uses actually attained in a waterbody on or after November 27, 1975. Vermont's standards set narrative and numeric criteria to support the following designated and existing uses, as established in §1-03(B)(1) for those Standards. The text below is from the Vermont Water Quality Standards (WQS):

1. Aquatic biota and wildlife that utilize or are present in the waters;
2. Habitat that supports existing aquatic biota, wildlife, or plant life;
3. The use of waters for recreation and fishing;
4. The use of water for water supply, or commercial activity that depends directly on an existing high level of water quality; and,
5. With regard to the factors considered under paragraphs (a) and (b) above, evidence of the use's ecological significance in the functioning of the ecosystem or evidence of the use's rarity.

Thus, water uses protected under Vermont law are more colloquially described as aquatic life, habitat, aesthetics, fishing and swimming, and water supply. The present Monitoring Strategy describes Vermont's approach to assessing the level of support of these uses, in light of the standards and criteria established within the VT Water Quality Standards. A more thorough discussion of Vermont's standards is available in Section 4A, Recommended Core and Supplemental Indicators.

3. Monitoring Design

The monitoring design describes the what, why and how for the approaches chosen to best serve our monitoring objectives, as stated in Section 2B. In addition, how we monitor our waters should address the following objectives from the Clean Water Act:

1. What is the overall quality of waters in the State?
2. To what extent is water quality changing over time?
3. What are the problem areas and areas needing protection?
4. What level of protection is needed?
5. How effective are clean water projects and programs?

Three Approaches to Vermont's Monitoring Design:

1. Targeted fixed station sites
- **Rotational Basin approach**
- **Long Term Projects**
- **Special and TMDL Studies**

2. Probability based, randomly selected sites
3. River geomorphology assessments

A. Description

Vermont uses three approaches to meet its monitoring objectives: (1) targeted sites with fixed stations (2) randomly selected probability based stations and (3) river geomorphology assessments. Integrating the information gained from these three approaches is a major aim of this strategy and provides information about point sources, watershed processes, the overall condition of Vermont waters.

Targeted sites are chosen for a specific reason, such as a stream section with problematic erosion or a point discharge, or on a pond with increasing nutrients or a known nuisance or invasive species problem. Other targeted sites serve as reference sites for a class of streams, wetlands or ponds. Probability sites are randomly selected by the USEPA to give an unbiased assessment of water quality conditions statewide. This is useful in determining the overall status of waterbodies and identifying overall threats to those resources. Probability assessment can help management direct resources based on intensity and distribution of threats in a quantifiable manner. River geomorphic assessments identify physically unstable areas and river corridors in need of protection from a watershed perspective. Through these three approaches, Goal 1 and all its objectives are met.

i. Targeted Fixed Station Sites

Rotational Basin assessment approach

For the purposes of assessing and reporting water quality information, the state has been divided into seventeen major drainage basins that have from four to twenty-two river sub-basins or mainstem segments within them. The seventeen major basins drain into Lake Champlain, the Connecticut River, Lake Memphremagog or the Hudson River.

In order to more comprehensively and thoroughly assess the State's waters, the Vermont WQD has designed a rotational watershed assessment process such that lakes and rivers of all seventeen major basins in the state are evaluated once every five years. To the extent possible, wetland assessments will also follow this rotation schedule and geomorphology assessments will begin to in 2011. By focusing evaluations on selected watersheds each year, more systematic and intensive

efforts can be made to evaluate status and trends. A focus on a limited number of watersheds also provides the opportunity to determine the best characteristics of the river system to: use as indicators of improving water quality and aquatic habitat; potentially reveal water quality trends; involve the general public; and, provide interagency coordination. Assessment reporting and basin planning are summarized in Section 8 of this Strategy.

The boundaries and schedule for each basin assessment are shown in Figure 3.1.

Basin #	Basin Name	Monitoring Year	Assessment Year
1	Hoosic, Wallomsac Rivers	2013	2014
2	Poultney-Mettawee Rivers	2011	2012
3	Otter Creek	2015	2016
4	Lower Direct Champlain Drainages	2011	2012
5	Upper Direct Lake Champlain Drainages	2011	2012
6	Missisquoi River	2014	2015
7	Lamoille River	2013	2014
8	Winooski River	2015	2016
9	White River	2016	2011
10	Black, Ottaqueechee Rivers	2014	2015
11	Saxton's, West, Williams Rivers	2012	2013
12	Deerfield River	2016	2017
13	Lower Direct Connecticut River, Mill	2014	2015
14	Stevens, Waits, Wells, Ompompanoosuc Rivers	2012	2013
15	Passumpsic River	2015	2016
16	Upper Direct Connecticut River, Nulhegan, Willard, Paul Stream	2012	2013
17	Memphremagog Tributaries	2014	2015

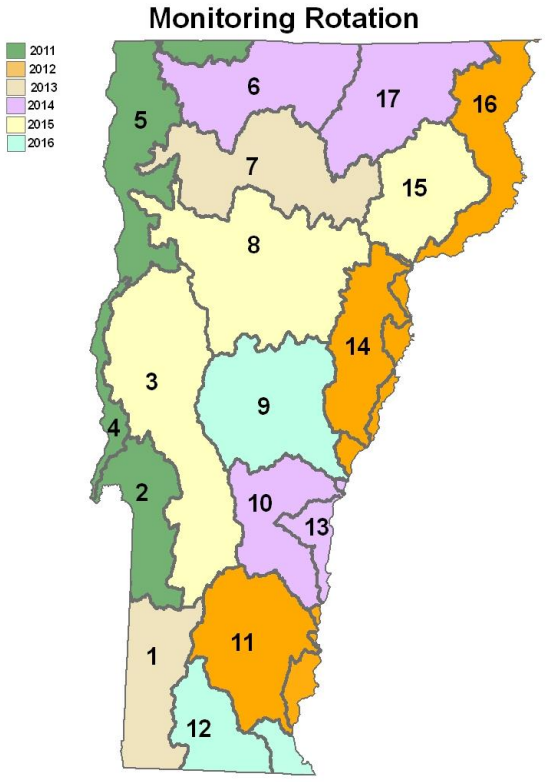


Figure 3.1. Vermont's 17 major river basin groupings with rotation monitoring schedule.

Long Term Projects

The Vermont DEC coordinates a large number of fixed-station monitoring projects, incorporating river, stream, and lake water quality projects. Fixed station, long-term, recurring projects are those that the Department has operated (or intends to operate) for several years. Some of these projects, such as the Ambient Biomonitoring Network and Lake Assessment Programs (both of which incorporate several individual monitoring projects and studies) achieve dense statewide spatial coverage. The total number of stream and lake stations established under these two programs alone exceeds 1,700 and 700, respectively. These monitoring networks are designed to assess status and detect trends, and therefore meet Objectives 1A, 1B, 1D, and 1G of this strategy. One of Vermont's major lake monitoring programs is a fixed-station, volunteer-based initiative, and meets Objective 1I of this Strategy. A listing of fixed station monitoring projects is provided in Appendix A. Stations are added as needed to achieve more comprehensive and complete coverage. In addition, the existing fixed stations can serve as pre-established monitoring locations for random-probability based projects allowing for hybridization of fixed and probability surveys, while maintaining consistency in monitoring location coverage. A map of existing monitoring stations is provided in Figure 3.2.

Special and TMDL studies

VTDEC undertakes special and TMDL studies as needed, in response to compelling data and information supplied under fixed-station and probability-based projects. Special and TMDL studies meet the Objectives 1 E and F. The number and nature of special studies is commonly dictated by the nature of issues and problems that are reported in Vermont's Priority Waters List, part C, Surface Waters in Need of Further Assessment (see Section 8.B). Such waters are typically those where additional information is necessary to make an informed impairment decision. These types of fixed station studies include detailed sampling to assess use support or standards violations, diagnostic-feasibility studies, watershed-based surveys and evaluations, and enhanced monitoring of stormwater-impaired watersheds. Section 303(d) of the Clean Water Act requires waters that do not meet state water quality standards have a Total Maximum Daily Load (TMDL) analysis prepared. TMDL studies are scheduled as needed consistent with the timeline established in Vermont's impaired waters-303(d) list, and depending on available resources. A list of current and historical studies is located in Appendix A.

ii. Probability based monitoring

Probability surveys are useful for determining the extent and intensity of statewide water quality conditions by waterbody type. Additionally, they can provide information on the extent and severity of new environmental or public health concerns. They provide statistically defensible estimates on stressors and use attainment state-wide or basin-wide and meet Objectives 1 A, C and D of this strategy. The USEPA works with Vermont to conduct the probability surveys through the National Aquatic Resource Surveys (NARS) studies.

Results from the NARS aid in the allocation of resources and can guide management activities on a larger basis. VTDEC strives to maximize the benefits of probability-based surveys, by actively supporting or designing projects in which a predictive system can be part of the outcome. VTDEC has undertaken probability-based projects in collaboration with USEPA Region 1 for rivers, lakes and wetlands. A schedule of upcoming surveys is presented in Table 3.A.ii with a description of the additional benefits to VTDEC. Vermont does not participate in the coastal assessments.

Table 3.A.ii. NARS monitoring schedule

Waterbody type	Monitoring year	VTDEC benefit
National Wetland Condition Assessment	2011	Develop wetland biocriteria
National Lake Assessment	2012	Implement lake biocriteria
National Rivers Assessment	2013	Provide methods for determining biological condition on large rivers
Wadeable Streams Assessment	2014	Identify and prioritize statewide stressors

NARS probabilistic surveys help to identify and prioritize the importance of statewide stressors due to an 'overdraw' of probability sites in Vermont. To achieve this, VTDEC monitoring staff have routinely worked with USEPA-ORD in Corvallis, OR and in Narragansett, RI, to build sample draws that provide such coverage. Sample 'overdraws' leverage the Environmental Monitoring and Assessment Program (EMAP) algorithms for site selection, are statistically robust and provide estimates of the target attainment condition with a 90+ % confidence level. Overdraws provide Vermont with enough sites to determine a statewide assessment in addition to the regional assessment determined by the USEPA. A description of Vermont's probability based projects is located in Appendix B.

iii. River or stream geomorphic assessments

Unlike targeted sites or probabilistic sampling, geomorphic assessments measure and assess the physical dynamics of an entire watershed or collection of river reaches. These assessments meet the Objectives 1D and H. These assessments are not strictly monitoring in the sense that sites are not re-measured on a regular basis. However, morphological assessments collect data and are an integral part of identifying and remediating watershed stressors and protecting Vermont rivers. Physical aspects of river dynamics are assessed using maps, existing data, and windshield surveys (Phase 1), using field observation and simple measurements (Phase 2) and/or using surveying techniques and quantitative analysis (Phase 3). Geomorphic assessments have been completed in

every major river basin in Vermont (Figure 3.2) and often provide the basis for restoration and protection efforts in riverine systems through the River Corridor Planning Guide.

B. Monitoring Support Facilities

LaRosa Environmental Laboratory

VTDEC maintains a full service environmental chemistry laboratory in Burlington, Vermont. The LaRosa laboratory provides a range of services to Vermont state agencies, as well as federal agencies and other users. The LaRosa laboratory is subject to strict USEPA quality assurance planning requirements, and participates in national-scale laboratory performance studies several times per year. The LaRosa facility is also accredited by the National Environmental Laboratory Accreditation Conference. The majority of environmental samples taken in conjunction with the monitoring projects discussed in Appendix A and B are processed at the LaRosa laboratory. The existing analytical equipment at the LaRosa facility is modern and up-to-date; however, new technologies will need to be acquired in the future.

Funding for the LaRosa Laboratory has changed since the 2005 WQMS. Previously, the cost to operate the laboratory was shared across all VTDEC Divisions, proportional to each Division's use, with the vast majority of services being allocated to the WQD. Due to a statewide budgetary crisis, the funding has returned to a fee-for-test model. This has resulted in a reduction of services provided to volunteer watershed groups. For FY2010, the WQD's assessment fee was $287K, which supported most core monitoring needs. Complete information regarding the analytical services provided by the VTDEC LaRosa laboratory is available online at www.anr.state.vt.us/dec/lab/index.htm.

C. Existing and Emerging Threats to Water Quality

There are numerous existing and potential threats to Vermont's waters. These threats range from the well understood and easily documented, such as infestations of Eurasian watermilfoil, to those that are newly emerging onto the environmental consciousness, such as estrogen mimicking compounds.

i) Stressors

The Statewide Surface Water Management Strategy, published online, addresses these individual threats or pollutants in a holistic manner by identifying ten umbrella stressors which yield single or multiple pollutants. Chapter 2 of the Management Strategy provides an extensive discussion of these stressors and they are summarized in Table 3.C.i. here. An ideal monitoring program would have a component to track each of these threats. Given fiscal realities, this roster of threats must instead be prioritized and monitoring efforts focused on the highest priority items. The WQD completed a prioritization effort in May of 2010 to rank the top stressors to our water resources. Forty individual stressors of water quality (or sources of stressors) were evaluated by 16 WQD staff representing all WQD programs, using a consistent scoring algorithm. The top ranked stressors according to the WQ Prioritization effort were: aquatic invasive species, encroachments, and channel alterations, although all stressors were deemed important.

Table 3.C.i. Summary of Stressor and their causes.

Stressor	Causes
Acidity	Long distant transport of atmospheric pollutants and mining activities.
Channel erosion	Alteration of hydrologic and sediment regimes, alteration of channel and floodplain morphology and alterations that increase streambank erodibility.
Flow alteration	Water withdrawals for water supply, snowmaking, industrial uses or agriculture; hydroelectric power; flood control; and manipulation of lake and reservoir water levels to support certain recreational uses or manage adjacent infrastructure.
Encroachment	Transportation infrastructure, structures, fills within rivers and streams, wetlands, and lakes, and removal of vegetation.
Invasive species	Overseas shipping and associated management of ballast-water, gardening or aquarium trades activities, and connectedness of waterways.
Land erosion	From developed lands, construction activities, agricultural activities and logging activities.
Nutrient loading	Under-treated domestic waste, poorly-managed animal wastes, overfertilization of residential lawns and cropland and improper spreading practices, legacy phosphorus loading from sediments, and loss of organic material (e.g., leaves and yard/garden waste) from urbanized areas.
Pathogens	Untreated/unmanaged Runoff from Developed Lands, agricultural activities, untreated or improperly treated wastewater, wastewater treatment facility loads and natural sources.
Thermal stress	Removal of vegetative buffers, alteration of the stream channel and floodplain, stormwater runoff, impounding rivers and streams, and water used for cooling, climate change.
Toxics	Atmospheric, organic and inorganic contaminants, pesticides, contaminants of emerging concern, and the product of biological processes.

ii) Pollutants

The 12 categories of pollutants are listed in Table 3.C.ii below for quick reference, however, Appendix B of the Management Strategy provides a full description and discussion of pollutants, in addition to identifying which of the 10 stressors are the result of that type of pollution.

Table 3.C.ii. Pollutant categories.

Pollutants	
•Nitrogen and Phosphorus	•Sediment
•E. coli bacteria	•Acid Deposition (a.k.a., Acid Rain)
•Metals (heavy metals, iron and manganese in groundwater, mercury)	•Contaminants of Emerging Concern, including Pharmaceuticals & Personal Care Products
•Organic contaminants (PCB's and PBDE's)	•Thermal Modification
•Invasive Species as Pollutants (e.g., Eurasian watermilfoil and water chestnut, fish pathogenic diseases).	•Cyanobacteria toxins
•Chlorides	•Pesticides

D. Recommendations and Strategies

These recommendations and strategies identify what steps need to be taken over the next 10 years in order to optimize monitoring and assessment program. Internal and external evaluations yielded this list including the 2010 Statewide Planning process, the 2010 Monitoring Strategy process, the 2005 WQMS process and USEPA's 2009 Critical Elements review for the biological monitoring program.

The following strategies and recommendations are organized in relation to the goals and objectives presented in Section 2B. **Appendix D summarizes the objectives and progress made as of early 2015. Brief updates are also provided below.**

Priorities identified in 2010 Strategy that have had no progress by 2015:

Objective 1A
3. Form workgroup between Lakes, MAPP, Wetlands and River Management to better integrate aquatic invasive species assessments and monitoring.
4. Use the rotational basin approach for 20-30% of geomorphic assessments performed or QC'ed by River Management Program.

Objective 1D and 1E
21. Conduct geomorphology assessments on biological sentinel sites

Objective 1H
27. Determine a process of communication whereby permitting staff identifies areas where new monitoring data is needed for permit renewals.

Objective 1A. Determine the status of, and/or trends in condition of each waterbody.

1. Form workgroup to systematically identify very high quality waters. Ensure that rotational basin sampling includes very high quality sites. **Progress 2015 – High quality waters and wetlands are now identified by the programs, and identified in tactical basin plans.**
2. Form workgroup between Biomonitoring and River Management in order to integrate the physical, chemical and biological stream assessments. Strengthen criteria for reference sites by conducting quantitative analysis of the relationships between physical-chemical characteristics of reference sites and resulting biological condition. **Progress 2015 – geomorphic assessments cannot be related to biological assessments due to issues of scale but it may be possible to use similar assessment protocols between geomorphic and river biological assessment.**
3. Form workgroup between the Lakes, MAPP, Wetlands and River Management Sections, to better integrate aquatic invasive species assessments and monitoring. **Progress 2015 – none.**
4. Use the rotational basin approach for 20-30% of geomorphic assessments performed or QC'ed by River Management Program. **Progress 2015 – none.**
5. Continue implementation of existing long term and core monitoring programs outlined in Appendix A. **Progress 2015 – On-going**
6. Continue support of the cooperative gauging network run by USGS, and collaborate with all affected state agencies and programs to meet their gauging needs. **Progress 2015 – VT ANR continues to work with USGS to support gauging stations.**

7. Work with the Waste Management Division to ensure that sediment contaminant screening is conducted downstream of hazardous waste sites. **Progress 2015 – sediment monitoring occurs on a case-by-case basis, as needed.**
8. Redirect volunteer monitoring of streams and rivers to assess waters identified by Division prioritization efforts. **Progress 2015 – staff now work with volunteer groups to direct efforts towards Division needs.**
9. Continue lake biocriteria development. **Progress 2015 – ongoing**
10. Continue wetlands biocriteria development. **Progress 2015 – ongoing, Water Quality Standards need to be updated to include wetlands for this to be fully implemented.**
11. Continue low gradient stream biocriteria development. **Progress 2015 – Analyses complete, draft criteria anticipated for Spring 2015.**
12. Finalize and implement lake assessment methodology to document the extensiveness of lake stressors. **Progress 2015 – ongoing.**

Objective 1B. Determine if surface waters are meeting the Vermont Water Quality Standards (VWQS).

13. Recommend updates to VWQS to reflect practical approaches to measuring use attainment. **Progress 2015 – ongoing.**
14. Develop numeric criteria in the Water Quality Standards for aquatic habitat in rivers and lakes. **Progress 2015 – Lakes criteria are moving forward, stream and river criteria are under discussion.**
15. Continue to monitor waters on List of Priority Surface waters part C (Surface Waters In Need Of Further Assessment) to determine compliance status. **Progress 2015 – ongoing.**

Objective 1C. Use probability assessments to provide a statewide understanding of surface water conditions.

16. Conduct biological, physical and chemical assessments at probabilistic sites. **Progress 2015 – WsMD continues to participate in national assessments efforts using an amplified approach to allow for statewide assessments. Lakes program piloted a probabilistic design at the basin level in 2014.**
17. Continue to participate in USEPA National Aquatic Resource Survey probabilistic assessments for lakes, wetlands, rivers and streams. **Progress 2015 – ongoing.**

Objective 1D. Learn what stressors threaten the integrity and uses of Vermont waters, and
Objective 1E. Adapt monitoring efforts to identify and track pollutants in addition to contaminants of emerging concern.

18. Work with partners to develop a plan and strategy to identify and track Existing and Emerging Threats outlined in Section 3C. **Progress 2015 – a draft strategy has been created.**
19. New monitoring initiatives or special studies related to water quality threats should address one or more of the threats outlined in Section 3C, Existing and Emerging Threats, to the extent practical. **Progress 2015 – ongoing.**
20. Support technical staff attendance at regional and national meetings and conferences which provide educational and professional development opportunities. **Progress 2015 – ongoing, driven by budgetary considerations.**
21. Conduct geomorphology assessments on biological sentinel sites (1-2 per year for next 10 years). **Progress 2015 – no progress.**
22. Develop list of potential monitoring projects for federal partners to conduct when they offer monitoring assistance (USGS, USFS and USEPA). **Progress 2015 – ongoing.**

Objective 1F. Respond to citizen complaints and emergency situations regarding Vermont's aquatic resources (as appropriate).

23. Develop a consistent and systematic triage approach to provide monitoring assistance to citizens and to emergency situations (e.g., fish kills, shoreline alteration, direct discharges, invasive species, wetland filling, and agricultural BMP violations). **Progress 2015 – ongoing, an emergency general permit was authorized in 2011 to provide for rapid response to new aquatic invasive species.**

Objective 1G. Evaluate the outcomes from management actions or mitigation activities.

24. Transform the ad hoc Water Quality Monitoring Strategy Team into a permanent steering committee for surface water monitoring. This steering committee would continue to exchange information and review the status of current efforts identified by the WQMS. **Progress 2015 – complete.**
25. Continue to report out assessment of monitoring downstream of BMPs, AMPs and AAPs implementation sites and National Pollutant Discharge Elimination System sites. **Progress 2015 – ongoing.**

Objective 1H. Integrate monitoring and assessment with management actions.

26. Incorporate existing monitoring data in stormwater permit review. **Progress 2015 – some progress.**
27. Determine a process of communication whereby permitting staff identifies areas where new monitoring data is needed for permit renewals. (For example, use stormwater information about density of development to guide monitoring efforts.) **Progress 2015 – no progress**

Objective 1I. Integrate volunteer monitoring efforts with current departmental needs.

28. Utilize LaRosa Partnerships Volunteer Monitoring to achieve WQMS goals. **Progress 2015 – some progress.**

- Convene an annual round table discussion within the WQD to identify what data gaps exist in order to inform proposals to LaRosa grants.
- Expand and refine criteria for accepting projects. (e.g., give preference to proposals that have an implementation plan or address a WQD-directed project.)
- Create workgroup to guide and prioritize volunteer monitoring efforts. (Focused on LaRosa partnerships.)
- Link Vermont volunteer groups with the EPA's regional volunteer monitoring equipment loan program.

Objective 2A. Expand accessibility and use of data and assessments both within and outside of DEC.

29. Integrate monitoring data and assessment information within the Division so all staff have access, and make this information available online to Vermont citizens in a user friendly fashion. **Progress 2015 – good progress, many online tools now available.**
30. Further evaluate opportunities to maximize use of relevant monitoring data in Act 250 permit review process as appropriate. **Progress 2015 – some progress.**
31. Further develop database capabilities to link the biomonitoring and water quality databases directly to geographic information systems to enhance spatial data analysis capabilities. **Progress 2015 – ongoing.**
32. Standardize process to upload data from WQX to STORET. **Progress 2015 – ongoing and mostly complete.**

Objective 2B. Provide information to support and evaluate Agency and Department planning, management and regulatory programs, including the development of environmental indicators.

33. Ensure adequate staff support for Division-wide management of monitoring data. **Progress 2015 – Now have a full time data manager.**
34. Continue monitoring initiatives in stormwater-impaired watersheds, including on-going chemical, biological, and geomorphic assessments. **Progress 2015 - ongoing**
35. Annually develop a list of newly identified very high quality waters and as appropriate surface waters with Outstanding Resource Water characteristics, based on monitoring and assessment data. **Progress 2015 – Programs have identified very high quality waters tactical basin plans, and are continuing to promote protection for these waters.**

Objective 2C. Communicate, collaborate and coordinate with organizations, agencies, municipalities and the general public to assure complementary monitoring programs.

36. Investigate the creation of a new Vermont Monitoring Council, facilitated with assistance from USGS, which will coordinate surface water monitoring efforts between academic, state and federal institutions. **Progress 2015 – The monitoring council was initiated in 2014.**
37. Continue to support and foster long-term partnership monitoring programs. **Progress 2015 – ongoing.**
38. Continue dialogue with colleges and universities to identify projects of need for WQD. **Progress 2015 – The Agency is strongly committed to this and supportive of Division efforts.**
39. Research more effective electronic communications for sharing monitoring results. (e.g. sharing 'Out of the Blue' via email and broadening its distribution, YouTube videos, creating a river scorecard, and brainstorming about other ways to reach staff and the public.) **Progress 2015 – WsMD initiated a blog in 2013 and developed a communication strategy in 2014.**
40. Host seasonal internal "brown bag" seminar series to share monitoring results with fellow staff. This could allow staff to be informed of upcoming projects, current unfinished projects looking for feedback, or completed projects. It would be an opportunity for staff to provide guidance to each other and learn about pertinent work in the division. **Progress 2015 – ongoing and dependent upon staff to coordinate.**

4. Recommended Core and Supplemental Indicators

A. Vermont Water Quality Standards

i) Overview

The Vermont Water Quality Standards (VWQS or Standards) are the foundation for Vermont's surface water pollution control and surface water quality management efforts. The VWQS are promulgated by the Water Resources Panel, under the Vermont Natural Resources Board and provide the specific criteria and policies for the management and protection of Vermont's surface waters. The classification of rivers, streams, lakes and ponds establishes the management goals to be attained, maintained and therein codified as "designated uses" for each class of water. The current Vermont WQS became effective January 1, 2008. Wetlands are managed under the Vermont Wetland Rules, effective August 1, 2010.

The Standards establish narrative and numeric criteria to support existing and designated uses. Existing uses of waters and the level of water quality necessary to protect those uses is to be maintained and protected regardless of the water's classification. A determination of what may constitute an existing water use on a particular waterbody is made during the basin planning process or by the Secretary of ANR during the consideration of an application, in conjunction with the Anti-degradation Procedure.

ii) Designated uses, surface water classification and water management types

All surface waters in Vermont are presently classified as Class A1, Class A2, or Class B. Waters designated as Class A (1) are Ecological Waters, managed to maintain an essentially natural condition. Surface waters designated as Class A (2) are Public Water Supplies. In this class, there may be a change from the reference condition of a natural waterbody due to the fluctuations in reservoir water level and in the reduction in streamflow that result from water withdrawals for water supply purposes. However, this shall not result in natural flows being diminished by more than a minimal amount provided that all uses are fully supported. Designated uses, as established in Sections 3-02(A), 3-03(A) and 3-04(A) of the Standards, mean any value or use, whether presently occurring or not, that is specified in the management objectives for each class of water. Table 4.A.ii.a excerpted from the Vermont WQS indicates applicable designated uses. Table 4.A.ii.b presents what type of monitoring is conducted to measure whether a waterbody is meeting the uses identified in the VWQS.

Table 4.A.i.a. Designated uses for water classifications.

Designated uses	Water management type Class A waters		Water management type Class B waters
	A(1) – ecological waters	A(2) – public water supplies	B(1), B(2), B(3)
Aquatic biota, wildlife & aquatic habitat	√	√	√
Aesthetics	√	√	√
Swimming & other primary contact recreation	√	√	√
Boating, fishing & other recreation uses	√	√	√
Public water supplies		√	√
Irrigation of crops & other agricultural uses			√

Table 4.A.ii.b. Types of assessments conducted on waterbodies to determine use attainability.

Designated uses	Type of Assessments conducted to measure attainment to VWQS		
	Lakes, ponds and reservoirs	Rivers and streams	Wetlands
Aquatic biota, wildlife & aquatic habitat	Biological -phytoplankton -aquatic plants* -macroinvertebrates -Invasive species* Chemical -Water clarity* -water chemistry* Physical -Littoral habitat assessment*	Biological -nongame fish* -macroinvertebrates* Chemical -water chemistry* Physical -Modified pebble count* -Semi-quantitative habitat assessment*	Biological -aquatic plants* -macroinvertebrates -Invasive species* Chemical -water chemistry* Physical -connectivity -soils -hydrology
Aesthetics	Physical -Observational evaluation	Physical -Semi-quantitative observational evaluation*	Physical -Observational evaluation
Swimming & other primary contact recreation	Bacteria (public beaches, as resources permit)	Bacteria (public beaches, as resources permit)	Not applicable

Designated uses	Type of Assessments conducted to measure attainment to VWQS		
	Lakes, ponds and reservoirs	**Rivers and streams**	**Wetlands**
Boating, fishing & other recreation uses	Biological -Invasive Species* Physical -Lake water level fluctuation	Biological -Invasive Species* -Fishery condition	Not applicable
Public water supplies	Chemical (as needed) -Water clarity -water chemistry	Chemical -water chemistry*	Not monitored by WQD
Irrigation of crops & other agricultural uses	Compliance with this use is presumed when compliance with other uses is achieved.		

*Core indicators

Class B waters comprise approximately 97% of all waters in the State. Class B waters are managed to achieve and maintain a level of quality that is compatible with designated uses. The Standards contain a requirement that all Class B waters shall eventually be designated as Water Management Type B1, Type B2 or Type B3. In designating a Water Quality Management Type, the Vermont Natural Resources Board must take into account attainable uses and the level of water quality already existing. Recommendations for Water Management Typing are developed during VTDEC's basin planning process. Once a basin plan is adopted by the Secretary of VTANR, a petition for classification and Water Management Typing is prepared by VTDEC and submitted to the Natural Resources Board for their consideration and adoption.

Due to numerous reasons, water management typing has proven to be challenging, and an explanation of the challenges is provided in the Water Management Typing Section of Chapter 4 of the Surface Water Management Strategy. Alternative approaches were provided to the Legislature in 2008 which suggested an expansion of existing authority under Vermont's Anti-Degradation Policy and the creation of new authority via statute and new classes of waters. To begin this process, the Department adopted an interim anti-degradation implementation procedure in October 2010 which will be used in 2011 to draft a final anti-degradation policy. Refer to the section entitled Other Approaches for Better Refining the Identification and Protection of Vermont's Surface Waters of Chapter 4 for a description of these proposed classes, including Tier 1 (Existing Uses), Tier 2 (High Quality Waters), Tier 2.5 (Very High Quality Waters) and Tier 3 (Outstanding Resource Waters).

iii) Water quality standards and criteria

The following provides a summary overview of the Standards, including a listing of parameters for which standards or criteria are promulgated (Table 4.A.iii). Guidelines for assessment of waters in light of the Standards and of the indicators below are provided in section 7B of this document. Copies of the Standards may be obtained from the Natural Resources Board or from the WQD. Persons may also access the Standards by visiting this web site http://www.nrb.state.vt.us/wrp/publications/wqs.pdf.

Table 4.A.iii. Roster of existing water quality standards and criteria

Water quality standards-section and parameter	Type of standard (numeric criterion or narrative)	Varies by water management type?	Water quality standards-section and indicator	Type of standard (numeric criterion or narrative)	Varies by water management type?
3-01 - B-1 Temperature	Numeric criterion (for point sources)	No[1]	3-01 - B-10 Toxic Substances	Narrative[2]	No
3-01 - B-2 Phosphorus	Narrative[3]	No	3-01 - B-11 Radioactivity[4]	Numeric criterion	No
3-01 - B-3 Nitrates	Numeric criterion	No[5]	3-01 - C Hydrology	Narrative	Yes
3-01 - B-4 Sludge and Refuse	Narrative	No	3-01 - D Biocriteria	Numeric criterion[5]	Yes
3-01 - B-5 Total Suspended Solids, Oil, and Grease	Narrative	No	3-02 - 3-04 Turbidity	Numeric criterion	Yes
3-01 - B-6 Taste and Odor	Narrative	No	3-02 - 3-04 Escherichia coli	Numeric criterion	Yes
3-01 - B-7 Color	Narrative	No	3-02 - 3-04 Habitat	Narrative	Yes
3-01 - B-8 Alkalinity	Narrative	No	3-02 - 3-04 Dissolved Oxygen	Numeric criteria	No
3-01 - B-9 pH	Numeric	No	3-02 - 3-04 Aesthetics	Narrative	Yes

1. Criterion varies with fish habitat designation and waterbody type.
2. Appendix C of the Standards provides numeric criteria for priority pollutants and organics.
3. Numeric criteria have been promulgated for 12 segments of Lake Champlain and two segments of Lake Memphremagog. Also in effect is a criterion limit of 10 ppb for waters above 2,500 feet of elevation. As of 2011, VTDEC is developing numeric criteria for other lakes and ponds.
4. Criteria are by reference to C.F.R. and to Vermont Health regulations.
5. Criteria vary by waterbody type.

B. Other Core and Supplemental Indicators

Table 4.B. provides a listing of core and supplemental indicators that are not expressly stated in the Standards.

Table 4.B. Core and Supplemental indicators of water quality.

Water quality indicator endpoint	Metric or parameter
Water clarity	Secchi transparency* Chlorophyll-a*
Water chemistry	Total nitrogen** Total silica Conductivity* Oxidation-reduction potential Salinity Base cations and anions* Iron, manganese, sulfides* Organic carbon, dissolved Mercury, total and methyl Pesticides, current use
Sediment quality	Acid volatile sulfides Metals, priority Organics, priority volatile and semi-volatile Pesticides, current use Loss on ignition
Recreational suitability	E. coli bacteria*
Biological integrity	Macrophyte cover* Fish tissue contaminants: mercury; PCBs; TCDD/TCDFs; PBDEs Fish kills and/or gamefish abnormalities Fish Index of Biological Integrity* Diatoms Phytoplankton Zooplankton Macroinvertebrate community* Fishery condition (from Fish and Wildlife Department)
Habitat integrity	Modified Pebble Count* Semi quantitative habitat condition assessment* Littoral habitat (in-lake)*
Physical integrity	Stream geomorphic condition Land use type and land use conversion Lake shoreline condition Lake level fluctuation Shoreline development density

*Core indicators

**Total nitrogen water quality criteria in development (2011).

C. Recommendations and Strategies

i) Nutrient criteria

Under authority of §304 of the Clean Water Act, USEPA has prepared ecoregional nutrient criteria for lakes and rivers for several regions of the United States. These criteria were introduced via 66 C.F.R.

1673 in 2001. That notice established a timeline of approximately four years for States to either adopt the proposed §304(a) criteria, or develop and implement a plan to derive similarly suitable criteria that are relevant to individual State conditions.

VTDEC submitted a technical document on Proposed Nutrient Criteria for Vermont's Lakes and Wadeable Streams to the Vermont Water Resources Panel in August 2009, along with proposed rule language to incorporate additional nutrient criteria into the Vermont Water Quality Standards. Consideration of these documents by the Panel was deferred pending resolution of concerns raised by USEPA Region 1 about nutrient criteria proposals in both Maine and Vermont regarding the issue of independent applicability. In order to resolve these concerns and to refine the analysis overall, the VTDEC WQD has decided to conduct a reanalysis of the supporting data. The reanalysis will take advantage of several more years of relevant water quality and biological data that are now available, and will explore the use of logistic regression as a potentially better statistical approach. Using logistic regression, it will be possible to directly quantify the risk of impairment associated with any proposed criterion value, and to predict the rates of false positive and false negative impairment determinations. Criteria values can then be selected in a way that minimizes the risk of use impairment and assessment errors.

A milestone schedule for adopting additional nutrient criteria in the Vermont Water Quality Standards for lakes and wadeable streams has been required of the WQD by our Performance Partnership Agreement, and is presented in Table 4.C.i. below. **Progress 2015 – nutrient criteria were added to the Water Quality Standards in 2014.**

Table 4.C.i. Schedule for adopting nutrient criteria

Task	Completion Date
Reanalyze the Vermont nutrient criteria dataset for lakes and wadeable streams incorporating new data collected since 2007 and using logistic regression methods for statistical analysis. Consult with Vermont DEC Biomonitoring Section, Lakes and Ponds Management, and Wastewater Management staff, and develop preliminary new draft criteria.	5/31/2011
Meet with USEPA Region 1 staff to present the proposed new criteria and explain the basis of derivation. Gain written concurrence from USEPA in support of the proposed criteria values.	7/31/2011
Submit revised technical document and proposed rule language to the Vermont Water Resources Panel for consideration in making revisions to the Vermont Water Quality Standards.	9/30/2011
Water Resources Panel adopts nutrient criteria in Vermont Water Quality Standards.	To be determined by the Water Resources Panel's rulemaking schedule

ii) Lake, wetland, and large river biological criteria

Lake Biocriteria: In early 2007, Vermont finalized its development of lake biological criteria for lakes and is available online at http://www.vtwaterquality.org/lakes/htm/lp_monitoring.htm. In 2009 and 2010, Vermont collected macroinvertebrates at sandy and rocky sites as part of the littoral habitat

assessment study. Data from this study will be used to determine if lakeshore development affects macroinvertebrates. Findings of this study will also be used to help interpret macroinvertebrate data collected during the 2007 National Lake Assessment surveys. In 2010, Vermont piloted the next generation of lake assessment methodology which tested the utility of using sediment diatom and macroinvertebrate sampling adapted from the USEPA National Lake Assessment survey methodology. **Progress 2015 – Evaluation of the new protocols is in progress.**

Wetland biocriteria: Since 1998, VTDEC has participated in the development of national and regional wetland biocriteria, in conjunction with the New England and National Wetlands Biological Assessment Workgroup. In 2010, the Wetland Section continued to refine methods and fill in gaps in geographic coverage, covering approximately 24 new sites. In 2011, the National Wetland Condition Assessment (NWCA) will be conducted in Vermont. Beginning in 2012, the wetland monitoring and assessment activities will become more fully synchronized with the Monitoring, Assessment and Planning Program activities with regard to the rotating basin assessment schedule. Future monitoring will be dependent on funding. For a full description of wetland biocriteria development, refer to Appendix A. **Progress 2015 – QAPP revision in progress to reflect the biocriteria, including critical element design.**

Large River biocriteria: To date VTDEC has not focused on these rivers because of the difficulty in collecting a representative fish sample as well as the requirement of specialized and expensive electrofishing gear. However, VTDEC is investigating an electrofishing method for larger wadeable streams which makes up a small portion of the database for fish assessments. VTDEC is developing a large-river database on macroinvertebrate communities, and is evaluating sampling methods including the National Non-wadeable Large River protocols used by the USEPA in the 2008-2009 National river Assessment. **Progress 2015 – Allowing EPA to take lead on large river biocriteria due to challenging sampling conditions and equipment needs. The current methodology does not accomplish goals on VT target reaches.**

iii) Pathogen criteria

In 2009, the VTDEC petitioned the Natural Resources Board to modify the existing water quality criteria for *Escherichia coli (E. coli)* in all waters to reflect a real-world approach that is consistent with current USEPA guidance. A decision from the NRB is expected in 2011. The rationale for updating the *E. coli* criteria is provided in the 2005 Ambient Water Quality Monitoring Program Strategy (VTDEC, 2005). Additional information regarding *E. coli* monitoring in Vermont is available in the Citizen's Guide to Bacteria Monitoring in Vermont Waters (VTDEC, 2003). **Progress 2015 – new E. coli criteria were added to the Water Quality Standards in 2014.**

5. Quality Assurance

A. Quality Management Plan

VTDEC maintains a Quality Management Plan (QMP) that establishes the flow of information used in environmental decision making. The QMP is updated regularly as required under VTDEC's partnership agreements with USEPA, and reflects the goals and priorities elaborated in current VTDEC Strategic Plan. The most recent QMP was approved by the USEPA in 2007 is available upon request.

B. LaRosa Laboratory Quality Assurance Plan

The LaRosa Laboratory is subject to quality assurance planning per USEPA requirements for laboratory certification. The LaRosa laboratory employs a full-time quality assurance officer, and the LaRosa Quality Assurance Plan is updated annually to reflect modifications to data handling procedures, as well as new analytical methods. The entire LaRosa laboratory Quality Assurance Plan is available online, at http://www.anr.state.vt.us/dec/lab/htm/QualityControl.htm.

C. Quality assurance plan preparation

All monitoring projects carried out in whole or part using USEPA funding are subject to quality assurance planning. VTDEC uses the most recent guidance for quality assurance project plan (QAPP) preparation, and typically consults with appropriate USEPA QA officers when beginning to develop a plan. VTDEC prepares comprehensive QAPPs that present collections of methodologies which are relevant to much of the routine field work described in this document. An example of this is the 2005 Lake Assessment Program QAPP, which provides field and analytical methods, and quality assurance procedures, for a wide variety of routine field tasks undertaken to assess lakes including chemical assessment, biological assessment, sediment analysis, and bacteriological monitoring. Where practical, these types of "umbrella" QAPPs can provide all of the necessary methodological detail needed by VTDEC to perform both routine sampling and also to perform sampling in response to emergency events, where there is no time to prepare a QAPP, or have it approved by USEPA.

D. Archive of QAPPs

The December 2010 QAPP list was provided to USEPA as a requirement of the Priorities and Commitments list for the Performance Partnership Agreement and provides the most current list of approved program QAPPs. A subset of this list, including the WQD QAPPs, is provided in Table 5.D.

E. Recommendations and Strategies

Quality assurance project planning is an essential part of any properly executed study. VTDEC recognizes that up to date QAPPs are a useful and sometimes critical tool for improving data collection and analysis. Accordingly, QAPPs are a means to an end, and not a final, free standing product of their own. Since QAPP preparation is time consuming, VTDEC recommends that QAPPs continue to cover multiple projects (e.g., the Lake Assessment Program QAPP), to introduce the maximum possible efficiency into the preparation and approval process. The use of umbrella QAPPs, prepared for a fixed time span of five years can greatly enhance efficiency in project planning by reallocation the resources necessary for project planning to project design and execution. Currently, VTDEC has in place "umbrella" QAPPs for the Lake Assessment Program, Ambient Biomonitoring Network, and Volunteer Lab Services Grants Program. **Progress 2015 – ongoing as noted above.**

Table 5.D. 2010 roster of quality assurance project plans.

Program	Project Manager	Year QAPP written/last updated	USEPA Approval in Place?	Scheduled Update?
Spring Phosphorus	Kellie Merrell	2005	Yes	2011
Lake Assessment Program	Kellie Merrell	2005	Yes	2011
Lake Champlain Long-term Monitoring & Zebra Mussel Monitoring	Eric Smeltzer Pete Stangel	2010	Yes	2011
Long-Term Monitoring (LTM) Acid Lakes Program	Jim Kellogg	2010	Yes	2015
Stream Geomorphic Assessment Program	Kari Dolan	2003	no USEPA funding	
Fish Contaminant Monitoring Program	Rich Langdon	2002	no USEPA funding	
Ambient Biomonitoring Network (ABN) Program	Steve Fiske Rich Langdon	2010	Yes	2016
Lake Bioassessment Project (within Lake Assessment)	Kellie Merrell	2005	Yes	2011
Aquatic Macrophyte Monitoring Program and Aquatic Nuisance Species Searches and Surveys	Ann Bove	1995	no USEPA funding	
Vermont Wetland Bioassessment Project	Alan Quackenbush	2009	Yes	2014
Northern Leopard Frog Surveys in the Lake Champlain Basin	Rick Levey	2001	no USEPA funding	
The Vermont Lay Monitoring Program	Amy Picotte	2007	Yes	2012
Volunteer Acid Precipitation Monitoring Program	Heather Pembrook	None in place	no USEPA funding	
LaRosa Laboratory Volunteer Monitoring Analytical Grants Project	Jim Kellogg	2009	Yes	2011

6. Data Management

A. Water Quality Data

i) Chemical data

Data collected in conjunction with VTDEC monitoring programs, as well as some volunteer-based data, are archived to VTDEC's dedicated water quality data archive. As of June 2010, this archive contains in excess of 720,000 individual data records, beginning prior to 1970. Data from all core chemical monitoring programs are archived on an annual basis, following quality assurance screening, in advance of the April STORET submission timeline (see below). In certain instances, project-specific data will be held outside of the data archive until a project is completed prior to submission. The Water Quality Data Repository is intended to be VTDEC's final storage area for water chemistry and associated data. It is structured to hold data in a 'quasi STORET-compatible' form, for incorporation into the national STORET data archive.

The Water Quality Data Repository is presently maintained in a Microsoft SQL© database on the main ANR Database Server. This database is backed up to an external tape daily and by the SQL server several times each day. Archive tapes are stored off-site.

ii) Biological data

VTDEC biomonitoring data are archived to a dedicated biomonitoring database, which is a component of the Water Quality Data Repository. As of June 2010, this database contains in excess of 168,000 individual macroinvertebrate occurrence records from 2,932 discrete sampling events. The database also holds 7,737 individual fish occurrence records representing 1,237 discrete sampling events. Lake Champlain zooplankton and phytoplankton data represent 799 and 621 discrete sampling events, since 2006. Aquatic plant data exists for 1,532 discrete sampling events from approximately 204 waterbodies, dating back to 1968. Data from all core biological monitoring programs are archived as data become available from the laboratory, following quality assurance screening. In certain instances, project-specific data will be held outside of the data archive until a project is completed prior to submission. The Water Quality Data Repository is intended to be VTDEC's final storage area for biomonitoring and associated data.

iii) Physical Data

Data collected through Phase 1 and Phase 2 Stream Geomorphic Assessments (SGA), River Reach Habitat Assessments, and Bridge and Culvert Surveys, are recorded in a web-based database called the Data Management System (DMS). SGA and habitat data are recorded at the scale of a river reach or segment (a smaller section of reach split off during Phase 2 SGA), and as of June 2010, the database contains 5,881 assessed reaches for Phase 1 SGA data, and 2,524 assessed reaches/segments for Phase 2 SGA and habitat data. Bridge and Culvert Survey data are recorded in a separate part of the DMS and are recorded at the scale of individual bridges and culverts, which as of June 2010 total 4,295 records. Data are entered into the database as geomorphic/habitat assessments and bridge and culvert surveys occur and undergo a thorough quality assurance review process, both automated and manual. SGA and habitat data are organized in the database by watershed. Typically, Phase 1 assessments comprise an entire watershed, while Phase 2 assessments are focused on a subset of high priority river reaches identified through a Phase 1 assessment. The data are available to the public for view and download via

the DMS website. The DMS is linked to the web-based mapping application called the Stream Geomorphic Assessment Data Viewer, which allows the user to view much of the SGA data in a spatial context, as well as link to the raw data of a specific reach.

iv) Field Data Collection

In 2009, VTDEC-WQD contracted to build field forms for hand held computers. The project was completed in the autumn of 2010. Beginning in the summer of 2011, biological and chemical field-generated data will be collected on these units. Back at the office, the data will be electronically downloaded, run through quality assurance steps, and uploaded into the appropriate databases.

v) STORET

VTDEC began implementing a local STORET archive in 2003. In response to USEPA requests, and with support from the National Environmental Information Exchange Network, VTDEC has been able to develop the largest STORET archive of all New England States, with nearly 612,000 records archived across numerous programs as of this writing. At present, the VTDEC STORET archive is limited to water chemistry information. The addition of all chemical data contained in the biomonitoring database is occurring in 2011. A permanent database manager would be responsible for annual uploads of all water quality data to STORET. Migrating long-term biomonitoring data to STORET is a major task, likely best accomplished by a suitable contractor. In order for biomonitoring data to be archived to STORET, taxonomic codes need to be translated by a taxonomic expert and a database technician. VTDEC annually uploads data contained in the local STORET archive to the national STORET data warehouse, typically in April.

vi) Standard Operating Procedures

Monitoring activities follow standard operating procedures for field collections as outlined in the WQD Field Methods Manual updated in April 2006. It is available on line at: http://www.anr.state.vt.us/dec/waterq/bass/docs/bs_fieldmethodsmanual.pdf. River Geomorphic Assessment Protocols can be found in a separate document located here: http://www.anr.state.vt.us/dec/waterq/rivers/htm/rv_geoassesspro.htm

B. Assessment Data

i) Lake inventory

VTDEC maintains a database containing physical and cultural characteristics, and water quality data summaries, for 824 inventoried Vermont lakes, including Lake Champlain. The so-named Lake Inventory is used to track information such as waterbody classification, known existing uses, lake physical attributes, counts of shoreline dwellings, and characteristics relevant to lake protection prioritization. Much of the data contained in the lake inventory database is available online through the VTDEC-WQD website. These data are updated on an annual basis, or as warranted based on new information.

ii) Assessment databases

VTDEC currently maintains two discrete databases that are used to track use support; one for lakes, and the other for streams. These databases are updated continually throughout the year, and each year, the database is archived prior to fulfilling USEPA-required assessment data submissions, in April. In this way, static archive copies of assessment databases for lakes and streams are maintained for each year.

No such assessment database is available for wetlands, but if IT resources become available, the dataset exists. Wetlands data is currently used to write the Integrated Report and the WQD will investigate the ADB to determine what fields would need to be included to incorporate wetlands data.

The lake assessment database is now one and the same with USEPA's Assessment Database known as ADB. The river assessment databases include one in-house Microsoft Access© database and then the USEPA river ADB. Although some of the information is redundant between the two databases, at this time, it is most efficient to maintain the in-house river and stream database with all the information needed for many purposes and use it as a way to populate the USEPA ADB every two years at least.

iii) TMDL database

Details regarding how waters are assessed and allocated into lists of impaired and priority waters are available in Section 7. VTDEC maintains a separate database of priority and impaired waters from the assessment databases. This database is presently maintained in Microsoft Access©, and is relationally linked to the assessment databases. Impaired and priority waters lists are provided to USEPA biennially in April of even-numbered years in conjunction with integrated reporting. As of the early 2011, VTDEC is working with USEPA contractors to merge the two ADBs and use this combined database for all listing purposes. The goal is to have the merged databases ready for the 2012 listing cycle, which begins in the fall of 2011.

C. Recommendations and Strategies

In general, database management is handled by a temporary technician and project-level staff with limited assistance from the Agency of Natural Resources Information Technology staff. Relying on a temporary technician for long term database management is a highly tenuous and vulnerable situation. One additional FTE in database management and assessment reporting would provide consistency in data archiving, provide greater accessibility to data internally and externally and permit program staff to focus on using monitoring data as opposed to simply archiving it. This additional staff time would enable the following:

Progress 2015 – the WsMD now has a full-time data manager, with responsibility to improve database management and facilitate access to data as outlined below.

i) Data access project

VTDEC has continued to expand the amount and variety of data accessible on-line. However, there is a pressing need to expand the available biological and chemical data and assessments internally and externally. There is a need to further develop database capabilities to link the biomonitoring, water quality and other databases directly to geographic information systems to enhance spatial data analysis capabilities. A vision for the future is to have on-line access to assessments of waterbodies, in a user friendly fashion, available for the staff and the public.

ii. Conversion of the Water Quality Data Archive

Implementation of STORET by VTDEC necessitated converting the structure of the water quality data archive from a ~70,000 record "transposed" database to a ~350,000 record standard database. This database was completely redesigned to accommodate data requirements of STORET. The size of the archive is now considerably larger. The water quality data archive was transferred to MS-SQL Server in 2008. Water chemistry data from the Biomonitoring database will be converted in 2010-2011. Biological data will be transferred when resources allow.

iii) STORET data submissions

Annually, VTDEC STORET data archive is uploaded using the USEPA network node architecture to transfer data to WQX and into the national STORET data warehouse on an annual basis. VTDEC moved approximately 220,000 records to the national STORET archive for its initial submission in December 2003. The next major initiative is to migrate existing water chemistry data from the biomonitoring database to STORET, then migrate existing biological (fish and macroinvertebrates) biomonitoring data to STORET, and build a routine data submission system. This will require resources of a biologist to consult on taxonomic code translations, a database technician to assist with data manipulations within VTDEC, and a qualified contractor to process the data into STORET. A permanent database manager would be responsible for the annual STORET data uploads, creating a more standard process and timeline for submissions.

7. Data Analysis and Assessment

A. Data Analysis

Specific procedures used to analyze project data are beyond the scope of this strategy. Project-specific data analysis approaches are commonly spelled out in QAPPs, although data analysis is often an adaptive task, where results of one analysis lead to subsequent analyses. For the purposes of use support assessment or enforcement, however, the following considerations regarding data quality and statistical analyses are relevant.

When used for assessment or enforcement, data employed must be of known quality and should be representative of the water's condition. All data generated in conjunction with any active and/or approved QAPP are considered reliable data, and are considered in determining use support. Data can be rejected from consideration in the event that it does not meet data quality objectives established by individual QAPPs. Guidance and assistance regarding quality assurance is also provided from the LaRosa Laboratory.

For data provided by organizations other than VTDEC and WQD, efforts are made to ascertain the quality of the data prior to considering it in the determination of use support. The number of samples, the length of the sampling period, the antecedent weather conditions, degree of compliance or violation, laboratory and field methods employed, quality assurance and control results are all considered when evaluating data from other organizations. Where data of unknown or unquantifiable quality are at odds with companion data of quantified quality, the higher quality data will be accorded greater weight in determining use support. Where data of unknown or suspect quality are the only information available, the waterbody is scheduled for additional monitoring prior to determining use support.

VTDEC has expertise in the use of non-parametric, parametric, and multivariate statistical methods. In most instances, it cannot be decided a-priori what type of statistical analysis may be used to assess use support, except for experimentally designed studies. For certain data types, long-term trend detection using linear, non-linear, or non-parametric regression approaches is appropriate. For designed studies aimed at determining the level of use support in an experimental framework (e.g., lakes that are likely to display elevated fish tissue mercury concentrations), parametric analyses of variance, covariance, and/or linear discriminant analysis are most appropriate. To classify waterbodies into meaningful biological groupings to compare biometrics to reference biological communities, linear discriminant analysis, principal components and factor analysis, canonical correspondence and non-metric multidimensional scaling analysis are appropriate. Simple T-tests and ANOVA tests are appropriate where data are being compared to a criterion value or to a set of reference waters. Consequently, these last two tests are more commonly or routinely performed during VTDEC assessment efforts. Where a statistically parametric method is used to evaluate hypotheses concerning standards attainment, consideration is accorded as to whether "attainment" is established as the null or alternative hypothesis.

VTDEC does not, on a unilateral basis, subscribe to the notion that a pre-determined proportion of samples exceeding a criterion value automatically equates to impairment, particularly where the total number of samples is low. The proportion of violations or frequency of exceedance in an array of data are treated and used by VTDEC on an individualized and case-specific basis to determine use support.

Refer to the 2006 Vermont Surface Water Assessment Methodology Including Vermont Listing Methodology (VTDEC, 2005) for a full description of data analysis procedures.

In general, waters must be proven to be impaired, and thus statistical hypothesis tests, when necessary, are most often structured in that fashion. Nonetheless, in the interest of maintaining solidly defensible and repeatable use support decisions, where the cost of erroneous decisions is high, a decision call of impairment will be accorded to the null or alternate, depending on which test provides the greatest statistical power while maintaining the type-I error rate to a pre-established level (typically 5% to 10%). In some cases, weight of evidence, including best professional judgment, is used to determine ecological condition, reducing the chances of a Type I statistical error.

B. Water Quality Assessment and Listing Methodology

Vermont's description of its assessment and listing methodology is maintained in Chapter 4 of the 2006 Vermont Surface Water Assessment Methodology Including Vermont Listing Methodology (VTDEC, 2005). This document is updated as needed to reflect current USEPA guidance, Vermont Water Quality Standards and understanding of how various stressors impact water quality. As such, it is referenced herein but maintained separately.

The assessment process involves identifying, compiling and evaluating all existing and readily available water quality data and information as well as point and nonpoint source pollution impacts on designated uses specific to the basins and waters being assessed in any given year. The data and other information are maintained in databases designed to be consistent with USEPA's current Assessment Database package. Vermont relies on the numerous sources of data and information when assessing designated use support, which are presented in detail in the Assessment and Listing Methodology.

Vermont presents assessment results along with a series of lists that are analogous, but not identical, to USEPA's reporting categories. The Vermont Part A list of 303(d) waters impaired by pollutants corresponds to USEPA 'Category 5' impaired waters. The Vermont Part B list of impaired waters not in need of a TMDL analysis corresponds to USEPA 'Category 4B'. The Vermont Part C list of 'waters in need of further assessment' partially corresponds to USEPA 'Category 3', and many are stressed per Vermont's methodology. The Vermont Part D list is a list of waters that have approved TMDLs, which is analogous to USEPA 'Category 4A'. In Vermont, so-called altered waters are those where water quality impairments exist due to non-pollutants. These occur on the Vermont Parts E, F, and G lists (exotic species, flow, and geomorphic alteration, respectively), and all are analogous to USEPA 'Category 4C'.

During the 2010 305(b) reporting period, VTDEC used USEPA's ADB application for both lake and stream water quality assessment information. For the lakes database, VTDEC staff continued to verify ADB entries, correcting minor problems that were noted from the 2008 assessment cycle. For the river and stream ADB database, staff used the available fields in a much more comprehensive manner than in prior reporting periods.

C. Recommendations and Strategies

The current use attainment process identifies the status of waterbodies as "uses supported; waterbody meets standards or "one or more uses not supported; Waterbody does not meet standards". If uses are supported, they are categorized into "full support" or "stressed". If uses are not supported, the waterbody is categorized into "altered" or "impaired". It is recommended that when a waterbody's

condition is communicated to the public, a less technical and more intuitive language be used, such as the biological condition approach of “excellent, good, fair, or poor”. The Lake Assessment Program has used this approach in developing the Lakes Scorecard, presenting 3 tiers of “good, fair, or reduced conditions” for four areas: water quality, atmospheric pollution, invasive species and shoreland and lake habitat.

Developing common language to communicate the physical, chemical and biological condition has become a priority. Biomonitoring and river geomorphology assessments have achieved a level of sophistication which make this recommendation well within reach. This will allow VTDEC to provide a common yardstick in the language describing the physical and biological condition of rivers and streams where methodology is well developed and tested. Using the biological condition gradient (BCG) is one method which will be employed to address this effort.

Progress 2015 – this remains an ongoing priority.

8. Reporting

A. The Basin Planning Process, Watershed Assessment Reports and Basin Plans

In late 2009, the VTDEC launched a new effort to better integrate water resource management. The result was the creation of the Monitoring, Assessment and Planning Program, the development of the Statewide Surface Water Management Strategy and the development of Tactical Basin Planning.

The Management Strategy will serve as an overall guide during the development of basin plans by focusing management, planning, regulatory and funding efforts on basin-specific stressors, thereby allowing for prioritization of efforts to maximize environmental gain. The Strategy will be used by basin planners, stakeholders and the public to identify and collectively prioritize the stressors impacting each basin and sub-basin.

The WQD has identified several primary challenges with the current framework of basin planning and has proposed a new approach called "Tactical Basin Planning", outlined in Chapter 4 of the Statewide Surface Water Management Strategy. Challenges to the current basin planning approach, such as Water Management typing and process development, in addition to a description of the new approach are provided there.

B. Integrated Assessment Reporting

As of 2010, the WQD has combined its assessment reporting and list of priority and impaired waters into a Water Quality Integrated Assessment Report. These reports present statewide water quality assessment reports and provides lists of priority and impaired waters on a biennial basis, in fulfillment of §305(b) of the Clean Water Act. VTDEC strives to produce reports that are concise, timely, and provide useful information for Vermont's citizenry. Assessment reports provide an opportunity to highlight Vermont's major surface water issues to USEPA and other federal agencies interested in water quality management. Vermont DEC also is continually modifying the outline and content of the "305(b)" report to reflect changing USEPA guidance. Vermont's integrated reports are submitted to USEPA every April of even-numbered years. Vermont's "305(b)" reports from 1998 to the present are available online at http://www.anr.state.vt.us/dec/waterq/cfm/ref/resources.cfm. Vermont DEC publishes the Vermont Priority Waters Listing and "303(d)" list online at www.vtwaterquality.org/mapp.htm. Also, in compliance with new USEPA guidance, Vermont DEC will submit to USEPA annual updates of Vermont's assessment database and STORET data archive every April. Vermont DEC has customarily provided USEPA copies of the other components of the Vermont Priority Waters List.

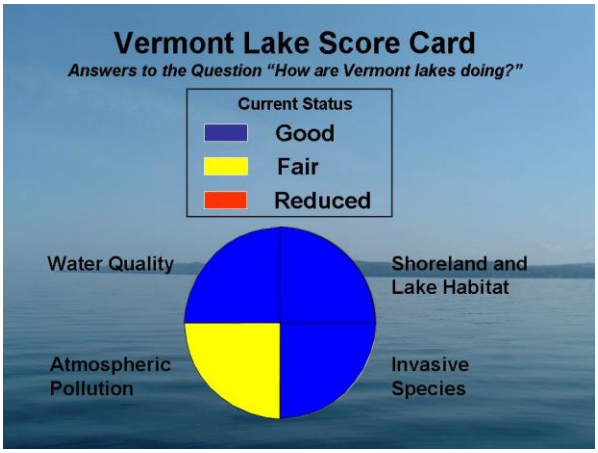
C. TMDLs

Section 303(d) of the Clean Water Act requires waters that do not meet state water quality standards have a Total Maximum Daily Load (TMDL) analysis prepared. A TMDL is a document that articulates the maximum permissible load of any given pollutant that can enter a waterbody while allowing that waterbody to attain the water quality standards for that pollutant. This maximum load, called the total

loading capacity, is divided into one allocation for the non-point source pollution load, and another for the point-source pollution load. The total loading capacity is also commonly reduced by a margin of safety, intended to ensure that implementation of the TMDL results in attainment of standards.

Part A of the Vermont Priority Waters List is also called the 303(d) list. It identifies those impaired waters in need of TMDL development, and provides a prioritization schedule. VTDEC strives to prepare all TMDLs within the scheduled time, however, changing resource availability and water quality priorities at times calls for a re-prioritization of the TMDL schedule. TMDL pollution control plans are prepared according to USEPA guidance that is in effect at the time the TMDL is drafted.

D. Other Reporting



In order to communicate with the public on water quality, various media formats are used by the Division so a range of user groups with different styles of learning are targeted. Amongst these include the Out of the Blue Newsletters, the newly launched Lakes Scorecard presented on Google Earth, the web mapping applications Atlas and the River Management Stream Geomorphic Assessment Viewer (RMSGAV), the Wetland Fact Sheets and the Lake Protection Series handouts among many others. The WQD regularly gives oral presentation to Watershed Associations and other interested groups. Technical reports, fact sheets, newsletter and brochures are provided on the WQD Resources web page.

E. Recommendations

Improve data access: VTDEC needs to continue adding specific assessment information to its ATLAS web mapping application or other readily accessible format. Specific stream reach information is available for physical assessments on the RMSGAV referenced above, and a similar approach could be taken for biological and chemical data and/or assessments. This work could be achieved with the additional database management position already recommended for the WQD. **Progress 2015 – ongoing priority.**

Implement Tactical Basin Plans: Future basin plans will be developed consistent with the new Statewide Surface Water Management Strategy. The Management Strategy recommends that the future of Basin Planning be redirected into the development of Tactical Basin Plans. Tactical Basin Planning is not a new program, but rather a way of coordinating existing programs and building new partnerships that will result in efficient and environmentally sound management of Vermont's surface water resources. Inherent in the design of the framework is the belief that many stakeholder groups and individuals must have ongoing opportunities to effectively participate in planning for the management of Vermont's watersheds. Chapter 4 of the Management Strategy describes the process for developing individual, basin-specific and geographically explicit plans, establishing priority monitoring and assessment approaches, and identifying planning, permitting, and project-level initiatives to protect or restore surface waters. **Progress 2015 - the WsMD continues to refine the use of tactical basin planning to achieve protection and restoration goals.**

9. Periodic Review of this Monitoring Program

A. Biennial Review

VTDEC will conduct biennial review of progress towards the goals contained in the present strategy. At that time, priorities for the coming year may be readjusted based on availability of resources and/or competing needs for monitoring information. In addition, the priorities identified for 2011—2013 in Appendix D will be reviewed and progress documented.

As part of ongoing Quality Management Planning, the quality assurance project plan (QAPP) archive is updated annually, and individual QAPPs are scheduled for revision at that time. The LaRosa Laboratory undergoes annual quality assurance assessment, biennial performance audits, and routine quality assessments consistent with its National Environmental Laboratory Accreditation Conference status as an accredited laboratory. Individual Standard Operating Procedures for monitoring will be updated annually as needed.

B. Mid-stream Gap Analysis

While this document was originally envisioned as a gap analysis of the 2005 Monitoring Strategy, due to fiscal and organizational changes, a full analysis was conducted to update the strategy, its goals and recommendations. Formation of the Monitoring Assessment and Planning Program (MAPP) in the WQD served as the major catalyst to this update. MAPP led the effort to create the Vermont Surface Water Management Strategy during 2010. The Management Strategy describes the management of pollutants and stressors that affect the uses and values of Vermont's surface waters. The Management Strategy presents the Division's goals, objectives and approaches for the protection and management of Vermont's surface waters, and will help to guide the Department's future decision-making to ensure efficient, predictable, consistent and coordinated management actions. The Monitoring Strategy is closely tied to the Management Strategy as results from management activities are assessed through monitoring and provide a feedback loop for further actions. All sections of the 2005 Monitoring Strategy have been updated in this document to reflect 2010 information.

Three high priority items were identified in the 2005 Strategy which required funding. These are presented in Table 9.B, with a summary of their 2010 status.

Table 9.B.

2005 Monitoring Strategy Priority Items Requiring Funding	2010 status
Securing long-term technician and summer staff support for the biomonitoring and lakes programs.	As of 2010, a total of four ¾ FTE technician positions have received consistent funding for the biomonitoring and lakes programs. No full time FTEs have been created.
Developing a coordinator position to support volunteer organizations participating in the highly successful LaRosa Laboratory Services Partnership Program.	As of 2010, a coordinator position has not been created, but coordination continues.

2005 Monitoring Strategy Priority Items Requiring Funding	2010 status
Increasing consistency in the archiving of water quality assessment findings, and expansion of the use of STORET (a national water quality data archive) to hold biomonitoring data.	As of 2010, the archiving to water chemistry data to STORET has progressed to include all of Lake Champlain, Spring Phosphorus, Lake Assessment, Acid Lakes and Lay Monitoring data. Archiving water chemistry data from Biomonitoring is scheduled to begin in 2011.
	Biological data from biomonitoring has not yet been archived.

All 2005 Monitoring Strategy recommendations and the progress made as of 2010 are presented in Appendix C. A summary of the major accomplishments achieved are provided below.

Major accomplishments towards the 2005 Strategy include the following:

- Developed Nutrient Criteria for lakes and wadeable streams and submitted to USEPA
- Revised the water quality criterion for E. coli and proposed to the Natural Resources Board
- Performed paleolimnological assessment on Shelburne Pond
- Completed lake biocriteria development
- Initiated wetland biocriteria development
- Increased support to volunteer-based monitoring groups
- Created umbrella QAPPs, such as the Water Quality Division Field Method Manual
- Converted the Water Quality Data Archive to a SQL server
- Developed pocket computer-based field data entry tool
- Completed mid stream gap analysis of the 2005 Monitoring Strategy

Major accomplishments towards the 2011 Strategy include the following:

- Hired a permanent database manager
- Hired a probabilistic survey coordinator
- Hired a permanent biomonitoring technician
- Hired permanent lakes scientist
- Updated Water Quality Standards with new chloride standards, nutrient criteria for lakes and wadeable streams and new criterion for E. coli.
- Completed report on Lake Champlain Agricultural BMP Monitoring
- Created the Vermont Monitoring Council in 2014
- Implemented new Tactical Basin Planning process in 2012
- Converted the Water Quality Data Archive to SQL server. All but wetlands have been converted

10. General Support and Infrastructure Planning

Implementing this monitoring strategy for Vermont waters is dependent on EPA's continued technical and financial support. To fully implement all aspects of this strategy, additional staff, training, laboratory resources and funding are necessary. Current resource levels are described below and projected needs follow which are needed to fully implement this monitoring program strategy.

A. Program Support

i) Field monitoring

The current field monitoring program elaborated in Section 3.B currently requires approximately 12.5 full time equivalents (FTE) of monitoring staff time plus another 1.75 FTEs for physical morphological assessments. This is a reduction from 2005 staff levels and the shortfall has reduced the State's ability to measure supplemental indicators and provide timely assessments for both rivers and lakes. This level of support does not allow core programs to be fully functional or address new threats which continue to arise. For example, development of large river biocriteria and a comprehensive monitoring of contaminants of emerging concern are presently beyond the scope of monitoring staff resources.

ii) Laboratory services

VTDEC Laboratory is transitioning from a fixed annual laboratory assessment to a fee-for-test service. Difficult state budgets have led to the change in the laboratory's funding mechanism and a reduction in the number of analytical laboratory staff. This change in funding necessitated a reduction in laboratory services provided from the lab to core and volunteer programs in the WQD. A long term plan for stable funding for the VTDEC laboratory is needed.

Loss of in-house analytical capabilities has hamstrung other state programs, resulting in loss of data, inconsistent analysis, loss of analysis for common parameters, reduction in the number of samples capable of being processed, and the need for a full time position to oversee the contracting and quality control process. Due to the negative experiences of other states which transitioned to private contractors, continuing long term funding for the in-house laboratory is extremely important. For a summary of how laboratory services in other northeastern states work, see Appendix E.

iii) Assessment, listing, and reporting

The current assessment and listing functions outlined in Section 7 are supported within VTDEC at approximately 1.5 FTEs. With the 2010 launch of the new Surface Water Management Strategy, and the melding of the 305(b) and 303(d) reports into the Integrated Assessment report, it is anticipated that some efficiencies will be realized, so no additional FTE resources are sought at this time.

iv) Information management

There is currently 0.25 temporary FTE allocated to database management associated with this strategy. Due to this low level of support, database maintenance and design activities have been pushed down to the project-level within the WQD and other Divisions of VTDEC. In terms of proper data management and metadata qualification, this is dangerous, as database skills vary widely among individuals at the project management level. Inconsistent management of data and limited oversight has resulted in bare bones support. While Vermont's information management system for monitoring and assessment data is currently functional, it lacks the long term support to move ahead with any new initiatives. The need

for rigorous data management approaches and tools continue to increase as the level of scrutiny over data used to make environmental management decisions increases. There is a pressing need to provide data access internally and externally, which cannot be achieved under current staffing levels. A dedicated full time FTE is necessary to accomplish the data access goals outlined in Objective 2A in addition to meeting the efficiencies provided by strategy.

v) Monitoring and assessment program planning and other functions

Planning for future years monitoring and assessment priorities occupies no more than 1.5 FTE, including in-house staffing for TMDL pollution planning. Quality assurance and water quality standards planning also requires significant staff-time, although an estimate of annual FTE's associated with these functions are not available.

B. Projected Needs

i) Staffing

In order to continue and build upon the core monitoring program, the staffing level needs to increase beyond the current bare bones level. Since the last monitoring strategy in 2005, positions that became vacant were left unfilled, yet programs and responsibilities have remained the same or have grown. The top priority identified in this strategy and in the Statewide Surface Water Management strategy is an IT data management position. This position will provide consistent database management, including annual STORET uploads of all applicable water quality data, and increase data access as identified in Recommendation 2A-C of this strategy and in the Surface Water Management Strategy. Most of the positions identified and requested are currently existing part time temporary positions that should be increased to full time to maintain core programs. This would not only secure highly trained and qualified personnel, but also allow a smooth transition as senior staff retire, resulting in the maintenance of high quality programs. Table 10.B.i outlines a summary of the minimum amount of positions required to fully implement this strategy.

Table 10.B.i. Staff positions required. **Bold** text indicates progress updates.

Description of Position required	**Need**	**Program**	**Cost and source of funding**
(1) permanent database manager (Increase ¼ to full time) **Progress 2015 – position filled**	Manage database and web site outreach	Serve all monitoring programs	$77,000K[A], partly from §106 funds
Permanent environmental technician (Increase ¾ technician to full time) **Progress 2015 – position filled**	Provide consistency for programs as senior staff retire and expertise in taxonomy, field work, and quality control for in-house taxonomy and the review of external compliance data.	Biomonitoring	$55,200[B], §106 funds

Description of Position required	Need	Program	Cost and source of funding
(1) permanent environmental scientist position. (Increase ¾ technician to full time) **Progress 2015, remains unfilled. Now temporary staff, reduced from ¾ to ½ time.**	Develop and implement biocriteria	Wetlands	$77,000K[A], §106 funds
(1) permanent environmental scientist position. Replace one vacant position. **Progress 2015 – position filled.**	Implement lake protection and assessment efforts.	Lakes and Ponds	$77,000K[A], §106 funds
(1) permanent environmental scientist position. Replace vacant position. **Progress 2015 – position filled.**	Support the core Biomonitoring program, integrate physical, biological and chemical assessments, and to develop and implement biocriteria for large rivers and low gradient streams	Biomonitoring.	$77,000K[A], §106 funds
(1) permanent environmental technician (Increase ¾ technician to full time) **Progress 2015 – position filled.**	probabilistic assessments	Shared: amongst Lakes, Wetlands and Biomonitoring	$55,200[B], §106 funds
Total Staffing needs	**6 full time positions, but only an additional 3.5 FTEs**		**$418,400**

[A] Calculated as an environmental scientist III (VT Pay Grade 22 $18.52), per FTE basis, plus fringe and indirect costs.

[B] Calculated as an environmental technician III (VT Pay Grade 20 $16.60), per FTE basis, plus fringe and indirect costs.

ii) Laboratory resources

Laboratory services currently meet the minimum needs of the present monitoring program strategy. A long-term commitment to implementation of this strategy will necessitate that laboratory equipment is upgraded as necessary, in keeping with advances in analytical chemistry. As stated in section 3.B, the LaRosa facility is well equipped. With the loss of laboratory and monitoring staff since 2005, additional equipment would provide efficiencies to both programs. Chief amongst these are: a radiometer to conduct automated Gran and regular alkalinities, as the test is now performed manually and automation could achieve great efficiencies; the 1998 Lachat for nutrient analysis; and a Reagent Free IC effluent generator to improve accuracy and reduce interference for anion analysis. Additional equipment purchases that would enhance the ability of VTDEC to implement this strategy include a mercury analyzer for fish and soils, a mercury analyzer cold vapor atomic fluorescence for low level mercury analysis, a LC/MS for PPCPs and an organic carbon analyzer for acid lakes and other lakes affected by global warming.

Table 10.B.ii presents all water quality monitoring equipment that will need to be replaced or acquired to provide continued support of monitoring efforts and to fully implement this strategy. Currently,

analytical equipment for the VTDEC laboratory is purchased by special approval of the Legislature, as there is no capital budget in place. While acquisition analytical equipment list is not the responsibility of the monitoring programs, it would help the programs achieve lower detection limits, improved accuracy and, in some cases, reduce the demands on monitoring staff time by providing equipment that is currently manually conducted by monitoring staff (radiometer). It is recommended that the VTDEC Laboratory move towards a capital planning approach to ensure adequate acquisition support of analytical equipment.

Table 10.B.ii. DEC Laboratory equipment needs from 2011-2020.

Item #	Instrument	Analysis Performed	Year Purchased	Projected Year of Purchase or Replacement	Cost to Purchase or Replace
1	Radiometer	Alkalinity (Gran and regular)	*	2012	$20,000
2	Lachat (AA1)	Nitrogen (TN, NH_3, NO_{x5}, TKN), Chloride and Silica	1998	2011	$70,000
3	Lachat (AA2)	Phosphorus (Total and Dissolved)	2008	2016	$70,000
4	Add Reagent Free IC effluent generator (RFIC)	Anions (SO_4, Cl, NO_3) to IC to improve accuracy and reduce interference	2000	2012	$15,000
5	ICP/MS	Metals in ambient water and air filters	2003	2013	$150,000
6	ICP	Earth metals in water, metals in soil.	2009	2018	$75,000
7	Millstone Mercury Analyzer	Mercury in fish and soil	*	2012	$35,000
8	Autoclave	Sterilization, digestion for phosphorus and total nitrogen	2001	2016	$30,000
9	GC/MS	Water / Soil	2005	2016	$70,000
10	Turner Fluorometer	Chlorophyll	2001	2013	$7,000
11	Dionex Ion Chromatograph	Anions	2000	2012	$60,000
12	Mercury Analyzer Cold Vapor Atomic Fluorescence	Mercury (Low Level)	*	2014	$40,000
13	LC/MS	Pharmaceutical and Personal Care Products	*	2015	$150,000
14	Sample Introduction Equipment and Purge/Trap Equipment	Volatile Organic Analysis	2003	2013	$35,000
15	Glassware Washer		1990	2015	$25,000
16	Gas Chromatograph	TPH by Method 8015	2003	2015	$50,000
17	Organic Carbon Analyzer	TOC, DOC	*	2015	$30,000

iii) Information technology resources

Information technology resources are presently inadequate to meet the needs of this strategy. Support for data archiving and assessment data maintenance, in addition to making data accessible internally and externally are a high priority. Accordingly, one permanent FTE of database management support will be needed by 2012 to continue support of this strategy. Also, site licenses for functional GIS software should be available to each staff member working on assessment of water quality data. **Progress 2015 – a database manager has been hired. GIS licenses are increasingly available in the Division.**

iv) Roster of monitoring equipment needs

Table 10.B.iv summarizes the monitoring equipment needs projected for the next ten years.

Table 10.B.iv. Monitoring Equipment needs.

Equipment	**Cost**
Trimble unit to share between Lakes, Biomonitoring, Stormwater **2015 – ongoing need**	$5,700
Surveyor unit to share between Lakes and Biomonitoring **2015 – ongoing need**	$2,500
Nets for electroshocking fish (6) **2015 – ongoing need**	$1,620
Microscope camera setup **2015 – ongoing need**	$600
Additional wet suit (1) for invasive species monitoring **2015 – ongoing need**	$500
Dry suit (1) for invasive species underwater monitoring in cold water conditions **2015 - purchased**	$5,000
Boat and equipment washing station at Montpelier National Life complex for decontamination **2015 – purchased**	$10,000
Updated taxonomic keys for algae, especially diatom identification **2015 – ongoing need**	$1,000
Dissecting microscope for aquatic plant identification **2015 – ongoing need**	$3,000
New 2015 – chains of temperature Hobo units for 13 sentinel climate change lakes (ideal set up would be $33,750)	$5,436
New 2015 – water level loggers for 13 sentinel climate change lakes and elevation surveying capability (stadia rod, autolevel and tripod)	$16,500
New 2015 – Ipads for field work in all programs, waterproof cases	$700 each
New 2015 – 10 HOBO units for conductivity/temperature monitoring in support of new chloride criteria	$7,500
New 2015 – high flow discharge measurement capability	$3,000 (for new)
New 2015 – lightweight canoe for remote lake monitoring	$3,000

v) Training and conference needs

The following provides a typical list training needs that may be distributed among staff during an average year.

1. Continue to develop taxonomic expertise of monitoring staff. This will become extremely important as expert taxonomists retire. This shall include fish, macroinvertebrates, algae and plants. Annual estimated cost is $1,000. **Progress 2015 - ongoing**

2. Secure taxonomic certification. This shall include securing North American Benthological Society certification for all macroinvertebrate taxonomic groups. Annual estimated cost is $300. **Progress 2015 – one MAPP taxonomist has gained this certification.**
3. Subscriptions to professional journals such as, but not limited to the Journal of North American Benthological Society ($75/year), the Journal of North American Lakes Management ($110/year), Transactions of the American Fisheries Society ($80/year) and the Northeast Naturalist ($45/year). **Progress 2015 – WsMD now has access to the UVM periodical library through a variety of avenues.**
4. Support to travel to and attend regional trainings and meetings such as, but not limited to the conferences hosted by the following professional organizations: the New England Association of Environmental Biologists (NEAEB), the National Water Quality Monitoring, the North American Benthological Association (NABS) and North American Lake Management Society (NALMS). **Progress 2015 – staff bring opportunities to the attention of management, attendance is funded as budget permits.**

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Appendix A: Existing Watershed Management Division Projects

The following description of the WQD's current ambient monitoring program, comprised of numerous discrete projects, is up-to-date as of December 2010. The WQD's monitoring efforts are classified here as physical, chemical, biological, volunteer, and other. Within each of these classes, monitoring projects are further described as core, or long-term projects; diagnostic studies, which identify the causes of particular water quality problems; and special studies, which provide information and data on specific water quality issues. Other projects coordinated by close partners of the WQD are also included in this listing.

I. Physical and chemical monitoring

A. Core Programs

The **Spring Phosphorus Program** collects nutrient, physical and chemical data during spring turn over on Vermont lakes and ponds that are 20 acres in size or larger. Parameters include total phosphorus, total nitrogen, alkalinity, calcium, magnesium, hardness, Secchi disk transparency, chloride and multi-probe profiles (temperature, dissolved oxygen, conductivity, chlorophyll-a and pH). Since 1977, 277 lakes have been monitored in conjunction with this program. Eighty-two lakes have 10 or more years of data, and 34 of these have 15 years or more. The Spring Phosphorus database contains over 14,779 records. Long-term nutrient enrichment trends from this program are used to calculate the water quality score for lakes found online as part of the Vermont Lake Score Card.

The **Lake Assessment Program** is designed to rapidly assess the extent to which lakes meet designated uses and to gather information to focus lake management and protection efforts. The sampling intensity for assessment lakes varies with the degree to which impairment is evident or must be documented. In general, lakes are circumnavigated and detailed assessment observations are made regarding in-lake and shoreline conditions with respect to designated uses and threats to water quality. Detailed notes are made regarding the extent and species composition of the macrophyte community. Sampling is performed for total phosphorus, alkalinity, Secchi disk transparency, and multi-probe profiling. Additional sampling may be performed as necessary to determine compliance with VT Water Quality Standards. From 1989 to 2009, 458 assessments have been performed. In 2010, VTDEC revamped and piloted the assessment methodologies to be more quantitative. The program has integrated methods employed by the 2007 National Lakes Assessment and Littoral Habitat Assessment into their assessment approach. Long-term nutrient enrichment trends from this program are used to calculate the water quality score for lakes found online as part of the Vermont Lake Score Card.

The **River Assessment Program** is designed to assess the extent to which rivers and streams support designated uses and to identify the causes and sources of any impacts to these waters. Rivers and streams in the basins of focus are visited to look for obvious sources of pollution from the land or indicators of problems or threats in the water such as sedimentation, heavy algae growth, or water with unnatural color or odor. The Ambient Biomonitoring Program (described below) provides most of the information used to determine aquatic life use support and compliance with Vermont Water Quality Standards. Temperature, nutrients, pH, conductivity, turbidity, earth metals, anions and alkalinity are parameters commonly measured with the biological sampling. Where such data are needed, loading

estimates for nutrients or other pollutants can assist in determining pollution sources and impacts. Water data from watershed organizations are often use to determine swimming use support.

The **Water Level Monitoring Program** monitors lake surface elevations to establish mean water levels for a variety of purposes, most notably to determine the jurisdictional boundary of the State's lakes and ponds under the shoreland encroachment permit program and Vermont's Public Trust Doctrine.

The **Lake Champlain Long-Term Monitoring Program**, initiated in 1991, surveys the quality of Lake Champlain waters on a biweekly basis, May to November, at 15 locations throughout the lake. Twenty-one major tributaries are sampled on an event basis as well. The program's large physico-chemical parameter list includes: species of phosphorus, nitrogen, chlorophyll-a; base cations; alkalinity; total suspended solids; dissolved oxygen; conductivity; and pH. As of January 2010, this program has assembled a database containing more than 115,000 records for lake and tributary parameters. Data is available on-line at Lake Champlain Long-term Monitoring Program website. Field staff from the Long-term Monitoring Program offer field support and a platform for research and monitoring projects coordinated by local universities (e.g. monitoring of toxic cyanobacteria on Lake Champlain, investigations of mercury movement through aquatic food webs, and sediment release of stored phosphorus.) Samples from selected lake and tributary stations are also collected for pesticides analysis performed by the Vermont Department of Agriculture.

The **Vermont Long-Term Monitoring of Acid Lakes Program (LTM)** collects chemical and biological data on lakes located in low alkalinity regions to determine the effects of acid deposition on Vermont's lakes. Initially, nearly 200 lakes statewide were surveyed during the winters of 1980 through 1982 to identify the acid sensitive areas of the state. Twelve lakes selected from these areas are now included in the LTM and are sampled at least eight times every year for 16 chemical parameters related to acidification. These data are used to classify lakes according to their acidification status, evaluate spatial and temporal variability in measured parameters, track changes in acidification status over time as related to reductions in atmospheric emissions of acid precursors (e.g., oxides of sulfur and nitrogen), and evaluate impacts of acidification on aquatic communities. As of June, 2010, the LTM data archive comprised 2,084 inlake and 768 lake outlet sampling records. Acid status for Vermont lakes is available online as part of the Vermont Lake Score Card. Trends from this project can be viewed on the USEPA's Clean Air Market's LTM web site.

The **Stream Geomorphic Assessment Program** collects geomorphic and habitat data on streams throughout the state to assess their condition relative to a dynamically stable equilibrium condition. Geomorphic assessments provide an understanding of current and historic river adjustment processes at the scale of a river reach and allow for an evaluation of the effects of various land and river management practices on geomorphic condition and physical habitat quality. An understanding of active river adjustment processes and stream sensitivities guide stream protection, management, and restoration projects and assist in the establishment of Vermont-specific physical criteria for water quality classification and use attainment determinations. Parameters measured include channel dimension (cross section), pattern (meander geometry), longitudinal profile, channel substrate conditions, structure and composition of riparian vegetation, and floodplain and valley morphology.

B. Diagnostic Studies

Diagnostic studies are typically aimed at identifying the cause of eutrophication on individual lakes in Vermont. Over the past 20 years, Vermont has performed numerous eutrophication studies, and the results have led to remediation steps. Lakes on which diagnostic studies have been performed include

Harveys Lake (Barnet), Lake Morey (Fairlee), Lake Iroquois (Hinesburg), Fairfield Pond (Fairfield), Lake Parker (Glover), Lake Carmi (Franklin), Ticklenaked Pond (Ryegate), Lake Rescue (Ludlow), Shelburne Pond (Shelburne) and Lake Champlain. Presently, VTDEC is performing a diagnostic study for Lake Memphremagog (Newport).

A wide variety of parameters are sampled in conjunction with diagnostic studies, and the actual tests performed are specific to the project. Standard eutrophication parameters (total phosphorus, Secchi disk transparency, and dissolved oxygen) are always measured. Other parameters from sediments and the water column are measured as needed.

C. Special Studies and TMDL Studies

Special studies are those performed to gain more information about a particular environmental issue of importance to the VTDEC, or to perform load and wasteload allocations for the purpose of TMDL development. TMDL studies recently completed include load and wasteload allocations for all of Lake Champlain, Lake Carmi and Ticklenaked Ponds.

Chloride Monitoring on Six Chittenden County Streams. A study conducted in 2005 by the Biomonitoring Section sampled six Chittenden County urban streams utilizing automated conductivity sensors. These sites were sampled weekly and found that elevated chloride levels occurred June through November. Centennial Brook, an unnamed tributary to Sunderland Brook, and an unnamed tributary to Muddy Brook all had mean daily calculated chloride exceeding the USEPA chronic criterion of 230 mg/L (USEPA 1988). For these three streams, 66-79% of daily mean chloride values exceeded the chronic criterion during the study period.

Monitoring, which occurred primarily during non-winter months, showed a clear relationship between precipitation events and stream chloride concentrations. Larger runoff events had lower chloride concentrations, suggesting that in-stream chloride levels were being diluted by precipitation runoff. Conversely, extended periods of dry weather resulted in higher chloride concentrations. The study concluded that, as discharge dropped during these periods, an increasing proportion of stream water was likely comprised of groundwater seepage, presumably containing high chloride levels that were not being diluted by surface inputs. The 2008 report entitled "Environmental Implications of Increasing Chloride Levels in Lake Champlain and Other Basin Waters" summarizes all information about chloride levels in Vermont waterbodies.

Monitoring streams in close proximity to landfills. In the fall 2006, the Biomonitoring section investigated a select group of stream sites on the 303(d) list. All but one site are in close proximity to solid waste disposal activities. Sites investigated in 2006 include Moon Brook (Rutland), Smith Brook (Randolph), Barney Brook and Hewitt Brook (Bennington), Rodman Brook (Morristown), and Inn Brook (Stowe). Inn Brook is not affected by a landfill but is affected by an orange precipitate. All sites are considered small high gradient stream types and managed as Class "B" waters. The purpose of this investigation was to determine the current biological condition and future course of action for these sites. Smith Brook was identified as a good candidate for remediation efforts due to the isolated nature of the problem. Hewitt brook was not biologically impacted by landfill activities and monitoring continues on the other sites to determine impairment.

The **Lake Champlain Agricultural Best Management Practices Monitoring Project** was a seven-year project (1994-2001). This comparative observational study used a three-way experimental design with

one control and two treatment watersheds. The goal was to evaluate the efficacy of both low- and high-intensity reach-specific BMP implementation strategies. Parameters measured included total phosphorus, total and Kjeldahl nitrogen, total suspended solids, and *E. coli*. Biological assessments were also performed on each of the three watersheds.

The **Best Management Practices Effectiveness Demonstration Project** is a stream monitoring effort designed to assess the efficacy of best management practices in controlling pollutants in nonpoint source runoff. This cooperative VTDEC-USGS project differs from the project described above in that it uses an upstream-downstream approach to pinpoint reductions in pollutant runoff attributable to specific installed BMPs. The project is being carried out on one agricultural and one urban stream in the Lake Champlain basin. The agricultural site was discontinued in 2005, but began again in 2010.

Ticklenaked Pond TMDL was based upon a comprehensive field program to support the development of a TMDL, with considerable support from USEPA. Automated instrumentation and intensive sampling was employed to generate a mass-balance for phosphorus to this nutrient-impaired lake. The purpose of the mass balance assessment was to identify influent phosphorus loads, internal loads, and to derive load allocations necessary to meet standards. The field program was carried out from May 26, 2005 through November 10, 2006. The TMDL was approved by USEPA in April of 2009.

Lake Carmi TMDL was approved by USEPA in 2009. It was based on Intensive water quality investigations carried out in Lake Carmi since 1994. From 1994 to 1996, the lake was intensively monitored on a bi-weekly basis to develop an understanding of the internal phosphorus dynamics in the lake. The goal of that sampling campaign was to determine the relative importance of watershed-based vs. internal sources of phosphorus to the lake. In 2007, volunteer monitors from the Franklin Watershed Committee collected samples on a weekly basis during the summer of 2007 in locations of the Marsh Brook watershed, as well as at the mouths of Tributaries 4, 5, 6, and the Alder Run.

In conjunction with the **Paleolimnology of Vermont Lakes Project**, the VTDEC collaborated with the University of Vermont to develop a set of indicators of present and historical trophic status based on the paleolimnology of carbon and nitrogen stable isotopes ($\delta^{13}C$ and $\delta^{15}N$). Using cores from the sediments of several lakes including segments of Lake Champlain, VTDEC and UVM identified the extent to which the present trophic condition in these lakes deviates from the historic background. Such information is instrumental in understanding the extent to which productivity (and thus phosphorus) has been elevated since the lake watersheds were first cleared in the early 1800s. This information was used in the development of TMDLs for two nutrient-impaired lakes (Lake Carmi and Ticklenaked Pond), and has verified the applicability of WQ criteria for segments of Lake Champlain. The project has also yielded important data on the historical condition of the nutrient-impaired Shelburne Pond.

Stormwater-impaired watershed monitoring was instituted in 2004. Vermont's 17 stormwater-impaired watersheds are being monitored using an integrated approach of precipitation and flow monitoring, biological monitoring, and geomorphic assessment. Additionally, best management practice (BMP) implementation and impervious surface creation will be monitored in these watersheds. Initial measurements of these data have been completed and will be updated on an annual basis for BMPs and every 3-5 years for impervious surfaces. These monitoring data will be used to assess improvements in individual watersheds given implementation of stormwater control initiatives.

Stormwater Mapping and Illicit Discharge Detection and Elimination Program

In 2000, the Vermont Legislature required the Department of Environmental Conservation to implement a statewide program to promote detection and elimination of improper or illegal connections and discharges. (Sec. 3. 10 V.S.A. § 1264 (b)(9)). The legislature's intent was to expand illicit discharge detection and elimination (IDDE) efforts from the communities—all in the greater Burlington area—required to perform IDDE in compliance with the Environmental Protection Agency's Phase II Stormwater Rule to encompass all developed areas of the Vermont. Following the legislature's mandate, VTDEC has assisted municipalities not subject to the Phase II Stormwater Rule by mapping drainage systems and performing IDDE. This work, funded through state Clean & Clear state water quality grants and Federal Section 319 and Lake Champlain Basin grants, has been completed for all major municipalities in the Missisquoi, Lamoille and Winooski River Basins (outside the greater Burlington area) and the three largest Connecticut River Basin towns; and is ongoing in the Otter Creek River Basin. About twenty-five communities have had GIS drainage maps completed. Stone Environmental, Inc. has conducted IDDE surveys in thirteen non-designated MS4 communities, ten of which overlap the state mapping effort. Stone identified 497 discharge points, 237 of which were flowing when inspected. A wastewater source was indicated at 28 discharge points. Other types of contamination included petroleum (11 locations), treated drinking water (13 locations), heated water, and road salt. By combining drainage mapping, environmental investigative work, and municipal cooperation, VTDEC and Stone eliminated seven wastewater discharges, decreasing phosphorus by an estimated 154 kg per year to Lake Champlain and reducing the risk of pathogen exposure.

In 2005, VTDEC initiated the **Littoral Habitat Assessment study**. This study was designed to determine what, if any, effect unbuffered lakeshore development has on littoral habitat. It compared littoral habitat conditions off of reference sites to sites where the natural vegetative buffer had been converted to lawn, patios, decks, driveways, and structures. To date, 40 lakes representing the five dominant lake classes in Vermont (large (>200 acres) mesotrophic, large oligotrophic, small (<200 acres) mesotrophic, small oligotrophic and small dystrophic) were sampled. The study found that littoral habitat is significantly altered from reference condition off of lakeshores removed of its natural vegetative buffer. In 2009 and 2010, VTDEC began measuring littoral habitat conditions off of developed lakeshores where a natural vegetative buffer has been maintained between the lake and any lawn, structure, patio, deck, or driveway. This data will be used in designing scientifically defensible guidelines on how a lakeshore property can be developed with minimal change to littoral habitat (i.e. in compliance with Vermont's Water Quality Standards). Results from this study are being incorporated in the Lake Assessment Program.

II. Biological monitoring

A. Core Programs

The **Ambient Biomonitoring Program** was established in 1982 to: 1) monitor long-term trends in biological integrity at fixed ecotype reference reaches now called sentinel site monitoring to facilitate the generation of and periodic reevaluation of Vermont-specific biological criteria for water body classification use attainment determinations; 2) evaluate potential impacts on aquatic biological communities from permitted direct NPDES discharges and state permitted indirect discharges, Act 250 (10 V.S.A. 151) development projects, nonpoint stormwater driven discharges from agricultural, urban and managed forests, and assist enforcement with spill evaluation; and 3) determine the overall biological condition of Vermont's streams and their primary stressors by sampling 65 randomly selected wadeable stream reaches over the course of the five year rotational watershed umbrella. Since 1985,

the VTDEC has used standardized methods for sampling and processing of fish and macroinvertebrate communities, recording physical habitat and sampling chemical water quality measures, 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 multi-metric indexes for three high gradient wadeable stream types in Vermont. Guidelines have been developed to determine the level of Aquatic Life Support for most wadeable streams in Vermont, that reflect the level of biological integrity along a biological condition gradient from excellent (Class A1) to poor (non-supporting), using both fish and macroinvertebrate community assessments. Approximately 125 sites per year are assessed using fish and/or macroinvertebrate assemblages. Additional physical and chemical measures are collected as part of a biological assessment to assist in interpretation of the community assessment and physical/chemical stressors. Chemical measures include alkalinity, pH, conductivity, nutrients, hardness, metals, sulfate, and chloride. Physical habitat measures and observations include temperature, substrate composition, embeddedness, silt rating, canopy cover, percent and type of periphyton cover, and dominate macro habitat sampled (high gradient riffle or low gradient reach). The majority of biological monitoring occurs in the late summer early fall index period from Sept 1st thru Oct 15th to standardize-seasonal sampling variation and collect organisms of optimal size for identification. From 1985 through 2009, over 2,800 macroinvertebrate and 1,000 fish stream assessments were completed from over 1,700 stream reaches. The program is in its third round of rotational watershed assessments, with the second complete probabilistic condition of the states wadeable streams report to be completed by 2011.

The **Aquatic Macrophyte Monitoring Program** collects baseline and ongoing information on aquatic plant communities in Vermont lakes and other waters by conducting descriptive surveys using a pre-established plant cover scale. The program was initiated in the late 1970s, and information is available from 1532 discrete surveys. The program remains active but is currently limited by lack of available staff resources. Macrophyte presence/absence data for Vermont lakes is available online as part of the Vermont Lake Score Card.

The WQD conducts numerous **Aquatic Invasive Species Searches** and Surveys each year to search for new populations and monitor existing populations of invasive aquatic species, including Eurasian and variable-leaved watermilfoil (*Myriophyllum spicatum* and *Myriophyllum heterophyllum,* respectively), water chestnut (*Trapa natans),* zebra mussels (*Dreissena polymorpha*), and to a limited extent, rusty crayfish (*Orconectes rusticus*), didymo (*Didymosphenia geminata*) and the wetland plant purple loosestrife (*Lythrum salicaria*).

The **Lake Champlain Zebra Mussel Monitoring Program** was initiated in 1993, when the first zebra mussels were confirmed in Lake Champlain. In-lake and shoreline stations were initially monitored in all basins for larvae and settled adults. Monitoring continues at selected stations for settled adults and larvae. Zebra mussel surveys were conducted at selected shoreline locations to document the progress of the infestation. Inland lakes and rivers with water quality conditions that could support zebra mussels are also surveyed annually for possible new introductions. Data collected by this program, one of the longest running projects of its kind in the US, can be found at www.anr.state.vt.us/dec/waterq/lakes/htm/lp_lczebramon.htm.

The **Lake Champlain Long-Term Monitoring Program**, described previously, also conducts sampling of phytoplankton, zooplankton, and mysid communities. With the introduction of zebra mussels in the mid-1990s and alewife in the mid-2000s, these data provide the opportunity to evaluate the effects of

invasive species on the food web of Lake Champlain. Data are available on-line at www.anr.state.vt.us/dec/waterq/lakes/htm/lp_longterm.htm.

B. Special Studies and TMDL studies

The stormwater-impaired watershed monitoring discussed above also carries a biological monitoring component. In addition to the physical/chemical monitoring, each watershed has been scheduled for macroinvertebrate and/or fish bioassessment at a minimum of one site per watershed. In concert with the physical/chemical parameters, these monitoring data will be used to assess improvements in individual watersheds given implementation of stormwater control initiatives.

The **Wastewater Treatment Facility Monitoring (WWTF) Project** measured water quality upstream and downstream of 20 target WWTFs during field season 2010, using existing or newly-established monitoring locations. Sampling was repeated on three occasions approximately tri-weekly, during periods near or below low-median monthly flow values for receiving waters. In addition to the water quality sampling efforts, the biological condition was evaluated based on macroinvertebrate or fish assessments at some or all of the downstream locations. These data will be used during the permit reauthorization process to assess the reasonable potential that each WWTF has to cause or contribute to a water quality impairment.

The **Biodiversity Monitoring Program** evaluates the status of selected biological species and communities in Vermont. Specific activities include: 1) distribution surveys of aquatic plant, fish and macroinvertebrate species listed by the Vermont Endangered Species Committee as rare, threatened, endangered, or of special concern; 2) distribution surveys of communities having species considered likely candidates for future listing (e.g., snails); and 3) monitoring of biological communities or community types, the diversity of which is threatened (e.g., Lake Champlain mussel and cobble/shale macroinvertebrate communities threatened by zebra mussels). Data are used to describe species distribution, identify species/communities at risk, and develop management plans for the protection of identified species/communities.

The **Lake Bioassessment Project** was initiated in 1995 to begin developing biological criteria for Vermont lakes. This monitoring effort was launched as a cooperative project with the State of New Hampshire. The goal of the project was to develop numeric measurements of the phytoplankton, macrophyte, and macroinvertebrate communities in reference lakes for use in assessing aquatic life use attainment in lakes. Consistent protocols were developed to measure these biological assemblages and 12 NH and 41 VT lakes have been included in the project. Statistically-validated multimetric indices have been developed for the phytoplankton and macroinvertebrate communities. To date, data describing macrophyte communities have proven insufficiently precise to develop macrophyte criteria. Results from the collection of macroinvertebrates during years 2009 and 2010 of the Littoral Habitat Assessment Study and the 2007 and 2012 National Lake Surveys will be used to direct the future of lake bioassessment. In 2010, Vermont outreached to New England Interstate Water Pollution Control to initiate a region-wide lake bioassessment development effort in an attempt to build a consistent regionwide approach. The New England Interstate Water Pollution Control Commission (NEIWPCC) is organizing a meeting at the spring 2011 New Association of Environmental Biologist Conference to discuss this with the states and begin planning a workshop in late 2012.

The **Littoral Habitat Study** began in 2009 and was designed to determine if macroinvertebrates are sensitive lakeshore development. DeSousa et al (2008) found that lakeshore development increased macroinvertebrate biomass in rocky littoral habitats and taxonomic composition changed with lake

development in sandy sediments. The Vermont study is collecting macroinvertebrates inhabiting the littoral zones of lakes at reference and unbuffered developed sites to determine if there is a change in macroinvertebrate communities and densities. Shoreland and lake habitat scores from this program are used to calculate the water quality score for lakes found online as part of the Vermont Lake Score Card.

The **Vermont Wetlands Bioassessment Project** began as a coordinated effort between the VTDEC and the VT Department of Fish and Wildlife's Nongame and Natural Heritage Program to document and understand the biological and physical characteristics associated with seasonal pools (vernal pools) and northern white cedar swamps in Vermont. From 1999-2000, the project collected biological, physical and chemical data from 28 seasonal pools throughout the state. In 2006, the wetlands bioassessment program incorporated these methods to sample water chemistry, macroinvertebrates, and vegetation to provide an accurate assessment of Vermont's wetlands. Eleven slow-winding stream-associated sites and six lake and pond-associated sites were sampled in 2006 for water chemistry, macroinvertebrates, and vegetation. Wetland quality, surrounding land use, and current wetland condition were also subjectively identified at all sites. In following years, no macroinvertebrates were collected due to lack of funding.

The 2007-2010 wetland monitoring and assessment program built on the findings of the USEPA-funded pilot wetland bioassessment projects. The specific objectives of the program are to: conduct assessments of wetlands across a condition gradient; record and gather chemical and physical data at each wetland site including water quality, hydrology and landscape characteristics; sample and describe the vegetation in assessed wetlands to develop vegetation-related metrics of wetland integrity; complete rapid assessments and evaluate the ability of the methods to reflect the overall wetland condition, and begin to expand the use of metrics in assessing the overall ecological health of Vermont's wetlands. In 2010, the Wetland Section continued to refine methods and fill in gaps in geographic coverage, covering approximately 20 new sites. Additionally, scoping work was conducted for the 2011 National Wetland Condition Assessment (NWCA). This included screening fourteen selected sites and twelve candidate reference sites. Beginning in 2012, the wetland monitoring and assessment activities will become more coordinated with other Division monitoring and assessment activities

Low gradient and Large River Biocriteria: As part of the long-term Ambient Biomonitoring Network, macroinvertebrate and fish community data are being collected from low gradient stream types in Vermont. A significant low gradient stream database has been jointly developed with our wetlands assessment program, and a sufficient number of stream reaches have been sampled to allow for a macroinvertebrate biological condition assessment index to be evaluated over the next five years. Fish community metric development for low gradient streams will continue with no set date for implementation.

The **Northern Leopard Frog Surveys** in the Lake Champlain Basin Project was initiated in response to reports of malformed frogs in the Lake Champlain basin in Vermont in the summer of 1996. Since the initial reports in 1996, VTDEC has gathered extensive information about the incidence and distribution of amphibian physical anomalies at numerous sites throughout the Lake Champlain Basin. VTDEC have examined over 10,000 *Rana pipiens* metamorphs from twenty-two sites throughout the basin, 6.0% of the metamorphs observed had some type of gross external abnormality.

The 2003 USEPA funded "Investigations into the Causes of Amphibian Malformations" report summarizes an intensive 5 year investigation that conducted a series of coordinated field and laboratory tasks designed to provide data that would help point the way to the cause of the abnormalities. Recent

studies conducted by Yale have confirmed VTDEC observations that parasitic flatworms were not the cause of the deformed frogs. The UV-B radiation theory has also been excluded based on the "symmetrical" morphological fingerprint of UV-B radiation.

Data characterizing the gross abnormalities and describing the frequency and occurrence of abnormalities within northern leopard frog populations continues to be gathered at 5 long term sites biannually within the Lake Champlain Basin.

(1) Other Biological Monitoring Projects either ongoing, conducted on a periodic or as needed basis include:

- Monitoring nontarget impacts to aquatic biota in lakes chemically treated with the aquatic herbicide Sonar® (fluoridone) to control Eurasian watermilfoil infestations;
- Monitoring the effects on both target and nontarget organisms of copper sulfate treatments to small recreational lakes and water supply reservoirs;
- Monitoring impacts to nontarget fish and macroinvertebrates in rivers treated with lampricide (TFM) to control sea lamprey (*Petromyzon marinus*) in Lake Champlain.
- Monitoring impacts to aquatic biota in lakes chemically treated with aluminum sulfate
- Managing the Fish Contaminant Monitoring Program in cooperation with the VT Department of Fish and Wildlife and the Vermont Department of Health. Edible tissue from game fish acquired throughout the state is analyzed for mercury and other contaminants. These data are then used to set and subsequently refine fish consumption advisories issued by the Vermont Department of Health.
- Collecting and identifying of odonate exuviae across 40 lakes along lakeshore sites categorized as unbuffered developed, buffered developed and reference.

III. Volunteer monitoring

Citizen groups are becoming increasingly involved in monitoring, education, protection, and restoration projects in Vermont. The VTDEC provides assistance and training to volunteers whenever possible. Watershed and lake associations are presently active on over 170 rivers and lakes state-wide. The VTANR has developed a directory listing various watershed associations and their activities available on line at http://www.anr.state.vt.us/cleanandclear/orgs/index.cfm.

A. Core programs

The **Vermont Lay Monitoring Program** equips and trains local lake users to measure the nutrient enrichment of lakes by collecting water quality data following a rigorously documented and quality assured methodology. This citizen monitoring program is based on trophic parameters and monitors approximately 55 lakes and 20 Lake Champlain stations per year. All Lake Champlain stations and many inland lakes in the program are sampled for chlorophyll-a, total phosphorus, and Secchi disk transparency. Other lakes are sampled only for Secchi disk transparency. All sampling occurs on a weekly basis during the summer. Since the development of the Lay Monitoring Program in 1979, data has been generated on 91 lakes and 40 Lake Champlain stations. Lay monitors have monitored 79 of the 158 lakes which are greater than 50 acres in size which is 50% of those lakes. In terms of long term monitoring, 30% of those lakes have less than 10 years of data, 42% have 10-20 years and 28% have over 20 years of data. In addition to their standard monitoring, Vermont's citizen lake monitors also assist in the Vermont Invasive Patrollers program (see below), and in collecting data for the Lake

Bioassessment Project. Long-term nutrient enrichment trends from this program are used to calculate the water quality score for lakes found online as part of the Vermont Lake Score Card.

The **Citizen Lake and Watershed Survey Program** provides survey sheets and technical training to volunteers, lake and watershed associations, and other interested groups to enable them to perform screening level assessments to identify potential nonpoint sources of pollution to lakes by conducting in-lake, lakeshore, and lake watershed surveys.

Vermont Invasive Patrollers (VIPs) trains citizen volunteers to monitor for the presence of invasive nonnative aquatic species. VIPs receive training in how to identify and distinguish between native and invasive aquatic plants and animals, and how to conduct systematic surveys for aquatic invaders like Eurasian watermilfoil and zebra mussels. Each summer, VIPs monitor their local waterbodies and report results to Vermont DEC. Newly detected invasive species can be responded to immediately, before the new invaders have a chance to become well established. The program is currently focusing on monitoring for Eurasian watermilfoil, water chestnut, and zebra mussels, as well as several other invasive species that are not yet known to occur in Vermont. More than 350 citizens have attended training VIP training workshops and there are approximately 50 certified VIP surveyors active at 20 lakes throughout Vermont.

The **Volunteer Acid Precipitation Monitoring Program** was initiated in 1980 to monitor changes in precipitation chemistry. Dedicated volunteers at five sites around Vermont (Morrisville, Mt. Mansfield, St. Albans, St. Johnsbury, and Underhill) collect precipitation samples on an event basis. The volume and pH of each storm event is recorded. Wind direction is also recorded at individual stations. The data are used to assess spatial and temporal variability in the pH of bulk precipitation and assess changes in the pH of bulk precipitation over time and as related to reductions in atmospheric emissions of acid precursors (e.g., oxides of sulfur and nitrogen).

B. Other volunteer initiatives

LaRosa Volunteer Water Quality Monitoring Analytical Services Partnerships. The VTDEC WQD collaborates with the LaRosa Laboratory on a novel program to assist citizen monitoring groups statewide. Beginning in 2003, the WQD and LaRosa Laboratory initiated analytical services partnerships with volunteer organizations, based on a competitive proposal process. The project has been extremely successful since its inception, when only eleven projects were supported. These projects ranged in scope from small, single-lake studies to large, multi-year and multi-parameter watershed assessment initiatives. This initiative grew until 2009 when budget cuts threatened to close the Laboratory facility. Each year, funded groups provide data and summary reports to VTDEC which are incorporated into the Water Quality Data Repository. For 2010, 15 projects are being supported, with coverage across most major Vermont watersheds. Since 2004, the LaRosa partnership project has analyzed 45,697 tests for volunteer groups at an approximate cost of $748,000. Due to severe state budget cuts, the future of this initiative remains uncertain.

In 2006, USEPA developed an **Equipment Loan Program for Volunteer Water Monitoring**. Applications are due each spring and guidelines about this program can be found on line at http://www.epa.gov/ne/lab/volmonequiploan.html.

C. Guidance for volunteer monitoring at the local level

VTDEC has two guidance documents intended to support volunteer monitoring statewide. These are the 2003 *Citizens Guide to Monitoring E. coli in Vermont Waters*, and the 2005 *Vermont Volunteer Surface Water Monitoring Guide*. VTDEC staff routinely interacts with individual citizens, lake, river and watershed associations to provide technical support and guidance.

IV. Types of Monitoring partnerships

Vermont works with many partner agencies to accomplish overlapping objectives. Federal, state, academic and local organizations fulfill important roles in monitoring the waters of the State.

A. Federal

US Environmental Protection Agency (USEPA). The USEPA coordinates national and regional water quality monitoring projects with VTDEC on a variety of waterbody types and topics, including those outlined below.

National Aquatic Resource Surveys (NARS). The USEPA and the State of Vermont partner on the NARS outlined in the Monitoring Design section on probability based monitoring, Section 3.A.ii. VTDEC has aided USEPA on the study design and conducted most of the field work, while USEPA has provided the training, coordination, equipment, and analysis. These surveys have become integral to the monitoring strategy of the VTDEC.

Regional projects which WQD has collaborated with USEPA on include: New England Lakes and Ponds Project (NELP) in 2007, New England Wadeable Streams (NEWS) from 2001-2003, and the National Study of Chemical Residues in Fish from 2000-2003. USEPA was also the principal sponsor of the REMAP Assessment of Mercury in Waters from 1998-2003, and the Sediments and Biota of Vermont and New Hampshire Lakes project from 1998-2000.

The **US Army Corps of Engineers (ACOE)** manages several flood control reservoirs in Vermont Waters. These are monitored routinely for flow and stage, and periodically for a variety of physico-chemical constituents. ACOE reservoirs with designated swimming beaches are also monitored for *E. coli* regularly during the swimming season. ACOE reports on its monitoring activities annually, and shares these reports with WQD. ACOE sampling results are used in conjunction with Integrated Assessment reporting.

The **US Fish and Wildlife Service (USFWS**) sponsors projects across New England dealing with toxic contamination of aquatic biota. WQD has collaborated with USFWS on several projects, and data are freely shared. In addition, USFWS co-sponsored the REMAP mercury project discussed above.

The **US Forest Servic***e* contracts annually with the ABN Program to conduct biological assessments of rivers in the Green Mountain National Forest. Samples are collected downstream of proposed logging jobs to assess the impact to the aquatic condition. Geomorphic assessments have also been conducted on Forest Service streams.

The **United States Geological Survey (USGS)** operates a network of gauging stations on Vermont waters, which are supported by a cooperative agreement with VTDEC (see map at right). This gauging network provides water flow data that are critical for numerous applications and programs, both within and outside of VTDEC. USGS also coordinates several water quality studies throughout Vermont and regionally in a variety of disciplines, and the results and data are commonly shared with VTDEC for numerous uses including permitting and integrated Assessment reporting. It is imperative that the gauging network remain in place, and to the extent practical, that new gauges can be emplaced with minimal difficulty. A gage network analysis that analyzes the current and past network to determine holes/duplication in the network should be carried out. This was done in NH using FEMA funds.

The USGS also operates two watershed study sites, and has developed (or is developing) useful models to predict nutrient losses and mercury bioavailability given watershed characteristics. The Sleepers River Watershed study, which is a long term monitoring program studying natural variations in the biogeochemistry of a small catchment. A similar study is being conducted at paired watersheds on Mount Mansfield. The SPARROW model is a geographically-based system that predicts nutrient export given watershed attributes, which has proven useful in several applications in Vermont since its publication in 2004.

The **Lake Champlain Basin Program** (LCBP) is a quasi-public agency, with core funding provided by USEPA. Additional funding is provided by USGS, the Great Lakes Fisheries Commission, National Park Service and NOAA appropriations. LCBP is dedicated to implementation of the pollution prevention and cleanup plan for Lake Champlain known as *Opportunities for Action.* LCBP supports numerous monitoring and research projects, which are overseen by a Technical Advisory Committee comprised of Federal, State, Academic, Non-profit, and public members. LCBP funds the Long-term Lake Champlain Monitoring Program nearly in entirety, and is a very important partner to VTDEC (and New York State DEC).

International Joint Commission. An internationally-coordinated monitoring effort in 2009 and 2010 was designed to allow a more thorough understanding of phosphorus sources in the lower Missisquoi River. As contracted by the International Joint Commission, the Lake Champlain Basin Program installed and maintained stations at 6 locations to measure flow and sample for various nutrients and pollutants. By design, these stations were intended to supplement on-going monitoring projects in the Missisquoi Bay watershed conducted by Québec Ministère du Développement durable, de l'Environment et des Parcs (MDDEP) and ANR. Though the project is to conclude in 2010, CCC may provide additional funding to continue monitoring.

The **National Atmospheric Deposition Program** (NADP) monitors precipitation chemistry nationwide. The program is a cooperative effort between many different groups, including federal, state, tribal and local governmental agencies, educational institutions, private companies, and non-governmental agencies. NADP consists of several monitoring networks including National Trends Network (NTN) which provides a long-term record of the acids, nutrients, and base cations in U.S. precipitation, the Mercury Deposition Network (MDN) which provides data on the geographic distributions and trends of

mercury in precipitation, and Atmospheric Integrated Research Monitoring Network (AIRMoN) which reports daily measurements of the acids, nutrients, and base cations in U.S. precipitation for studying and modeling atmospheric processes. Data from these networks in used to model critical loads for Vermont's acid lakes and mercury deposition.

B. State

The Ecosystem Restoration Program (ERP), formerly known as the **Center for Clean and Clear,** is a program in the WQD that has taken the lead on Lake Champlain Basin clean up efforts. ERP works closely with other programs in the WQD on monitoring, assessment, protection and restoration efforts in the basin. The program has launched several initiatives which are outlined below.

Green Streets 2010. Clean and Clear is currently conducting a monitoring project in the City of St. Albans designed to: (1) identify urban critical source areas of phosphorus and (2) determine the effectiveness of specific stormwater treatment systems. With the assistance of a contractor, CCC is monitoring the closed storm sewers on Ferris and Rugg Streets. Both flow and the analytes of TP and TSS are constantly monitored to characterize runoff volume and pollutant load. Once sufficient baseline data is collected and comparative hydrologic relationships are developed to describe the behavior of each sub-watershed, CCC is installing rain gardens on Rugg Street. Monitoring is to continue for two additional years to judge the efficacy of the rain gardens at reducing peak runoff volume and pollutant load.

Other monitoring is proposed to evaluate the condition of the terrain, the stream geomorphology, and hydrology of each stormwater impaired watershed. Specifically, DEC Clean and Clear partnered with the University of Vermont to establish baseline satellite images to inventory impervious cover for each watershed and then update the datasets at specified intervals. The Rivers Management Program has completed stream geomorphic assessments (both Phase I and II) for each of the 17 streams and will perform subsequent evaluations for specific metrics as implementation proceeds. Finally, the Storm Water Advisory Group is recommending continued collection of precipitation and stream flow data and DEC is aware that future analysis, including computer modeling, is necessary to validate the evaluation tools to determine attainment.

Air Monitoring Network. The VTDEC Air Pollution Control Division operates and maintains five permanent air monitoring stations as part of its Air Monitoring Network. Vermont established a monitoring network for criteria pollutants in the 1970s and a network for toxic air pollutants in 1985. Currently, the APCD monitors for 6 criteria pollutants and 94 toxic pollutants. Ambient air data is used by the WQD to assess and model mercury deposition to waterbodies.

The **Vermont Department of Forests, Parks, and Recreation** operates a comprehensive beach monitoring program for all of its public use beaches on State Park lands. Twenty-nine beaches are monitored on a weekly basis following established protocols. Swim advisories are posted based on results of the testing, when *E. coli* sample values exceed the Vermont standard for Class B waters of 77 *E. coli* /100ml. These data are openly shared with VTDEC. They are used for assessments as well as for identifying beaches subject to chronic, controllable bacterial contamination.

The **Vermont Department of Health (VTDOH)** operates a program whereby appointed Town Health Officers are trained to collect water quality samples at designated beaches. This program is suitable for small municipalities with informally-used swim beaches. Data reported back to Town Health Officers

from the VTDOH laboratory take the form “safe for swimming,” or “violates Vermont’s standard: unsafe for swimming.” These data are not reported or tracked as numeric results. Town Health Officers commonly use these data to post warnings at swim beaches. Owing to resource constraints, samples collected in conjunction with that program cannot follow the strict QA procedures required by VTDEC and the Department of Forests, Parks and Recreation in their *E. coli* monitoring projects. As such, this program provides useful and preliminary screening information to determine where swim beach water quality may need further assessment.

The **Vermont Monitoring Cooperative (VMC)** is a collaborative organization in which scientists collect and pool information and data for the purpose of improving our understanding, protection, and management of Vermont's forested ecosystems. Participating cooperators from government, academic and private sectors, conduct research projects on a variety of topics including forest health, air quality and meteorology, wildlife, aquatic systems and others. The VMC was initiated in 1990 as a state, university, and federal partnership, with a one-hundred year envisioned lifespan. The centerpiece of the VMC is the on line data library and card catalogue system that allow data to be shared, archived, and accessed. The data archive contains data and ancillary textual material from 233 projects, 66 of these projects have tabular data in the database, and the remainder have documents or outside links associated to them, which are all geographically referenced.

The data results and monitoring designs articulated above provide necessary information for use by other State permit and compliance programs. Examples of State programs that make use of monitoring data include the NPDES and Indirect Discharge Programs, the Source Water Protection Program, and the Stormwater Management Program.

The **Vermont Geological Survey**, also known as the Division of Geology and Mineral Resources in the Department of Environmental Conservation, conducts surveys and research relating to the geology, mineral resources and topography of the State. Their expertise provides guidance on river geomorphology, radionuclide monitoring in groundwater and other activities.

C. Academic

VTDEC maintains ties with several academic institutions interested in water quality monitoring. A partial list includes the following: Dartmouth College, Middlebury College, the University of Vermont (UVM), and member schools of the Vermont State College System. Collectively, these institutions carry out numerous projects, and their data are at times used by VTDEC for assessment purposes. UVM also carries out several larger-scale research and monitoring projects cooperatively with or of significant interest to VTDEC. Funded by the National Science Foundation, the Vermont Experimental Program to Stimulate Competitive Research (EPSCoR) Streams Project is managed by UVM with assistance from St. Michaels College. High school students and teachers work with professors and undergraduates to conduct and share results of water quality studies. Other UVM projects include: paired assessments of geomorphic and macroinvertebrate biometrics on streams, research into natural background levels and strategies to mitigate *E. coli* in Vermont waters, assessment of cyanotoxins in Lake Champlain and elsewhere, and impacts of non-native species on aquatic food webs.

D. Local

Vermont has a strong group of volunteer partners working to protect lakes, rivers and watersheds. Local groups are able to discover, monitor and resolve some issues more effectively within their communities than the State. Long term volunteer partners include:

- Addison County River Watch Collaborative
- Friends of the Mad River, including the Mid-Winooski Partnership and the Winooski Joint Conservation Commission
- Friends of the Winooski River
- Huntington River Conservation Partnership
- Lake Carmi Franklin Watershed Committee
- Munroe Brook-Laplatte River Watershed Partnership
- Memphremagog Watershed Association
- Missisquoi River Basin Association
- Ottauquechee River Group
- Poultney-Mettowee Watershed Partnership
- Thorp, Kimball and Holmes Watershed Group
- Upper Otter Creek Watershed Council
- West River Watershed Alliance
- White River Partnership
- Williston Conservation Commission

Appendix B: Probability Based Monitoring Projects

The seven probability surveys VTDEC has implemented or participated in are discussed in detail in Section 3.B, and include:

- A Regional Environmental Monitoring and Assessment Program (REMAP) assessment of mercury concentration in sediments, waters, and biota of Vermont and New Hampshire Lakes using a spatially randomized design (1998-2003).
- Characterization of use attainment for aquatic life using a spatially randomized draw of existing Ambient Biomonitoring Network data at varying site intensities (2001).
- A REMAP assessment of aquatic life use attainment in New England Wadeable Streams (2002-2006).
- Participation in the National Study of Chemical Residues in Fishes (2002-2005).
- Participation in the National Lakes Survey (2007-2008 and 2012-2013).
- Participation in the National Rivers Survey (2008-2010 and 2013-2014).
- Participation in the National Wetlands Survey (2011-2012 and 2016-2017).

Additional examples of probability-based surveys appropriate for determining statewide or basinwide use attainment, where predictability is an anticipated outcome of the project are as follows:

- Assessment of sediment-based toxics in large-order rivers and developed lakes.
- Development of a reproducible, indicator-based assessment of fish tissue contaminants (Hg and organic contaminants) across Vermont. With specific respect to mercury bioaccumulation, the sampling units selected for such an assessment should be stratified by trophic state, acidity, and degree of water level manipulation.

Appendix C: 2010 Mid-stream gap analysis and review of achievements from 2005 WQMS Recommendations

This section documents progress towards the stated goals presented in the 2005 Ambient Water Quality Monitoring Program Strategy. This is the mid-stream review of the original 2005 strategy and demonstrates those areas where progress has been made and those areas still needing attention. The table below summarizes all the recommendations made in the 2005 Strategy. Full time staff positions have not been secured due to state and federal budget crises culminating in the 2009 recession.

Priorities identified in 2005 Strategy which were not achieved by 2015:

2. Continue La Rosa annual assessment fee funding model
5. Perform biological monitoring associated with BMP Best Management Practices Effectiveness Demonstration Project
9. Add one wetlands staff person to develop an ambient monitoring program
11 and 12. Develop a synoptic fish tissue contaminant monitoring program
15. Acquire a dissecting scope to aid in accurate aquatic plant identification

2005 Ambient Water Quality Monitoring Program Strategy Recommendation	Achieved by 2010?	Achieved by 2015?
1. Continue implementation of existing core monitoring programs. Consistent base monitoring funding under the C.W.A. §106 mechanism, and supplemental funding in conjunction with on-going Performance Partnership agreements is critical to achieving these objectives.	Yes, core indicators continue to be monitored but monitoring for supplemental indicators has declined due to the reduction in monitoring staff since 2005.	**Yes** – Achieving all benchmarks for the core programs. River work now includes wastewater permitting review, in addition to extra monitoring efforts at specific sites, such as mines, Moon Brook in Rutland and ski area monitoring. Lakes consistently monitor a high number of sites.
2. Continue use of the LaRosa Laboratory annual assessment fee funding model to ensure availability of analytical capacity.	No. Assessment fee model ended in 2009 during State budget crisis. Now the fee for service model is used.	Fee for service model is still employed.
3. Continue operation of the cooperative gauging network run by USGS, and work with USGS to streamline procedures for instrumenting new sites. Implement a gage network analysis.	Yes, cooperative network continue, and systems for establishing new sites has been streamlined.	**Yes**, currently a cooperative approach to funding existing gauges. Funding constraints limit addition of new sites and have resulted in elimination of some existing sites.
4. Evaluate available biomonitoring data from the Lake Champlain Agricultural BMP Monitoring Project to determine the biological response to BMP implementation.	Yes. However, no report is yet available.	**Complete** - http://www.anr.state.vt.us/dec/waterq/planning/docs/pl_319report.pdf

2005 Ambient Water Quality Monitoring Program Strategy Recommendation	Achieved by 2010?	Achieved by 2015?
5. Perform biological monitoring associated with the new Best Management Practices Effectiveness Demonstration Project to relate changes in biological communities attributable to BMP implementation to changes in stream chemistry. Findings related to these efforts need to be publicized to generate confidence among the affected community that the practices they employ will make measurable improvements to the environment.	No, demonstration project was delayed due to landowner reluctance. A modified project was re-initiated in 2010.	Remains an on-going priority. Getting and retaining commitment to BMP installation and maintenance over the life of proposed studies has been difficult.
6. Perform paleolimnological assessments of lakes that are identified as not meeting or potentially not meeting water quality standards for nutrients to assist in the development of post-remediation target nutrient concentrations, and to provide a 'reality-check' on the applicability of the nutrient criteria proposed for promulgation by USEPA Region 1. (Note: 2005 TMDL funding will enable this analysis for the nutrient-impaired Shelburne Pond during 2005-2006).	Yes, performed on Shelburne Pond in 2006.	**Complete** - utilized on Lakes Carmi and Ticklenaked in preparation for TMDL plans. Now part of toolbox for future use.
7. Develop a program of sediment contaminant screening downstream of sites of concern (e.g., identified hazardous materials sites).	No. Identified as a high priority in the Statewide Management Plan in the toxics stressor chapter. This will involve collaboration between the VTDEC Hazardous Sites Section, the Solid Waste Section and the Watershed Coordinator.	**Yes**, a screening procedure has been developed. Sediment monitoring is implemented on a case-by-case basis as needed.

2005 Ambient Water Quality Monitoring Program Strategy Recommendation	Achieved by 2010?	Achieved by 2015?
8. In addition to professional staff, ensure funding for at least one FTE as a long-term technician in the lakes and biomonitoring programs. The cost for both technicians, in 2006 dollars, will be $109K.	No, see note above.	**Yes,** Both programs filled this need in 2013.
9. One additional wetlands staff would be necessary to develop an ambient wetlands monitoring program ($54.5K).	No, but a ¾ temporary technician has been maintained since 2007.	**No**, as of 2014, this position remains temporary and has been reduced to ½ FTE.
10. New monitoring initiatives or special studies related to water quality threats should address one or more of the threats outlined in the section on Existing and Emerging Threats to the extent practical.	Yes, Supplemental Environmental Project was used to conduct Pharmaceutical and Personal Care Products study on the Winooski in 2008.	**Ongoing** – the DEC now has a department level workgroup around this topic
11. The current approach to fish tissue contaminant monitoring should be changed to a synoptic recurring assessment aimed at assessing trends over time. Such an approach could be randomized or fixed-station, and would provide landscape-level monitoring data to measure changes in tissue contaminant burdens related to forthcoming national regulations on mercury emissions. One iteration of a recurring five-year initiative is estimated to cost $200K in 2006 dollars.	No, funding has not been available.	No regular fish tissue monitoring occurs. Typically, analyses of this kind are undertaken as special projects: - 2011 assessment completed for Lake Champlain (Basin program funded)
12. Fish tissue monitoring efforts must focus on emerging as well as known contaminants. Additional laboratory resources may be needed to provide analysis of low-level metals, and esoteric organic contaminants (e.g., PDBEs).	No, funding has not been available. Investigate if EPA has capacity to analyze samples.	See above.
13. There exists the need for a large, laboratory-grade freezer to store fish tissue samples, as the current capacity for tissue storage is too limited.	Yes	Freezer was purchased and subsequently lost in Tropical Storm Irene. Until fish tissue analysis funding is received, there is no need.

2005 Ambient Water Quality Monitoring Program Strategy Recommendation	Achieved by 2010?	Achieved by 2015?
14. There exists the need for a freeze drier to prepare fish tissue for organic contaminant analysis.	Yes.	Freeze drier was purchased and subsequently lost in Tropical Storm Irene. Until fish tissue analysis funding is received, there is no need.
15. There exists a need for a dissecting scope to aid in accurate aquatic plant identification.	No, funding has not been available.	**No**, Need still exists.
16. Monitoring for cyanotoxins and development of predictive systems to rapidly identify cyanotoxins-producing algal blooms should be supported to the extent practical. This is presently supported by the Lake Champlain Basin Program for waters within the Champlain Basin.	Yes. The Vermont Department of Health now has analytical capability for microcystin and anatoxin. The service is available for public water suppliers and town health officers at no charge, and to homeowners for a minimal charge. A draft guidance document for towns that wish to implement cyanobacterial monitoring has been developed. Currently, there is no state-supported monitoring outside of Lake Champlain.	**Yes,** the Basin Program continues to support the Champlain cyanobacteria monitoring through the Long-term Monitoring Project. VT Dept of Health continues to offer analytical capability for selected toxins.
17. Continue to employ Phase I, II, and III geomorphic assessments to assess stream geomorphic condition.	Yes.	**Ongoing**
18. Continue to foster monitoring of stream and river water chemistry by volunteer organizations to assess waters of specific interest.	Yes, however a change in the funding mechanism for the LaRosa lab has required a downscaling of laboratory analyses provided to individual projects.	**Ongoing**

2005 Ambient Water Quality Monitoring Program Strategy Recommendation	Achieved by 2010?	Achieved by 2015?
19. As needed and appropriate, continue to modify the monitoring-related indicators of program success published in the VTDEC Strategic Plan and the Performance Partnership Agreement with USEPA in accordance with the recommendations contained in Section 4.B.	Yes, VTDEC continues to report indicators as part of the Performance Partnership Agreement budget narratives.	**Yes**, VTDEC and WsMD continue to develop reporting indicators to follow program success
20. Continue implementation of monitoring initiatives in stormwater-impaired watersheds, including on-going physical/chemical, biological, and geomorphic assessments.	Yes.	**Yes**, additional flow monitoring now occurs through the MS4 permit process.
21. Prepare guidance for volunteer organizations to perform measurements of lake morphometry and thermal mixing to assist lake associations who need this information to design aquatic nuisance species control projects using aquatic herbicides.	No guidance has been prepared, however morphometry. However morphometry surveys have been completed for Lake Associations by VTDEC.	
22. Prioritize water quality standards and criteria that are not presently measured.	Yes, this is an on-going process.	**Ongoing process**. Chloride standards were added to the Standards in 2014.
23. Develop nutrient criteria for lakes that will satisfy Clean Water Act §304 criteria while being tailored specifically to Vermont.	Yes, currently revised in light of USEPA comments.	**Yes**, nutrient criteria for lakes and wadeable streams added to the Water Quality Standards in 2014.
24. Initiate process to revise the current water quality criterion for *E. coli.*	Yes, initiated in 2009, anticipate acceptance by Water Resource Panel and Natural Resource Board in 2011.	**Yes**, new criterion for E. coli went into effect November 2014.
25. Incorporate procedures presented at the 2003 National Symposium on Biological Assessment and Criteria for assessing the biological integrity of low gradient large rivers, and to the extent practical, wetlands.	No. VTDEC is evaluating methods including the National Non-wadeable Large River protocols being tested by the USEPA.	**Ongoing**
26. Complete lake biocriteria development.	Yes, completed in 2007.	

2005 Ambient Water Quality Monitoring Program Strategy Recommendation	Achieved by 2010?	Achieved by 2015?
27. Initiate wetland biocriteria development for lake-margin and stream-laved wetlands.	Initiated in 2007 and continues to include other wetland types.	**Ongoing**, QAPP revision in process to reflect biocriteria development, including critical element design
28. Through the basin planning process, ensure that watershed coordinators and monitoring staff are communicating regarding existing monitoring programs and outstanding monitoring needs in basins of interest, such that the Coordinators can bring this information to potential and existing volunteer organizations and to others involved in monitoring in the basins.	Yes. Communication will continue to improve under the new tactical basin planning process proposed in the Statewide Surface Management Strategy launched in late 2010.	**Yes**, new Tactical Basin Planning process implemented in 2012.
29. Open a dialogue with existing volunteer monitoring programs (such as those managed by RiverWatch Network, the University of Vermont, or St. Michaels College) to identify shared needs for volunteer-collected data and to determine where volunteer resources may exist to fill those needs.	No. A 2010 recommendation is to work with USGS to form a Vermont Monitoring Council, a state level branch of the National Water Quality Monitoring Council, which would coordinate such efforts.	**Yes**, the Vermont Monitoring Council was created in 2014 and will lead such efforts.
30. VTDEC has made great strides in enhance its ability to support volunteer-based monitoring groups through the LaRosa Partnership Program. In order to maximize our ability to properly manage data and quality control of individual projects findings, additional support of approximately ½ FTE of full-time staff, plus 0.3 FTE temporary technician support, is necessary. These personnel resources would supplement the ¾ FTE and 0.3 FTE temporary staffing already dedicated to volunteer monitoring in conjunction with the Lay Monitoring Program.	Partially. LMP has an additional 0.3 FTE temporary technician support, but not the 0.5 FTE full time staff. Coordination of the program continues with current staff.	**No**, no new staff have been hired. Existing staff were re-assigned to serve as coordinator for the Partnership program. LMP remains independent of LaRosa Partnership.

2005 Ambient Water Quality Monitoring Program Strategy Recommendation	Achieved by 2010?	Achieved by 2015?
31. Encourage USEPA's New England's monitoring equipment loan concept.	Yes.	-
32. Ensure wide distribution of the 2005 Volunteer Guide to Citizen Water Quality Monitoring in Vermont	No. Funds were received to print the guide but distribution has been limited. However, distribution continues and the guide is required reading for all recipients of LaRosa partnership grants	Approximately a dozen printed guides remain and are being distributed as they are requested.
33. Continue the LaRosa Laboratory Services Partnership Program	Yes.	-
34. Continue to support and foster long-term partnership monitoring programs.	Yes.	-
35. VTDEC recommends that QAPPs cover multiple projects (e.g., the Lake Assessment Program QAPP), to introduce the maximum possible efficiency into the preparation and approval process.	Yes, updated WQD Field Method Manual in 2006 which all WQD programs except for River Management refer to for monitoring methods.	Field Methods Manual is scheduled for review in 2015.
36. Waterbody segmentation and database integration	Yes.	-
37. Conversion of the Water Quality Data Archive to a more powerful database handling system	Yes, conversion began in 2008 and most WQ data in now in WQX, a SQL based server. Chemistry data from Biomonitoring database scheduled to begin in 2011.	**Yes**, the last remaining program, Wetlands, began adding data in 2014.
38. STORET data submissions	Yes.	-
39. Development of pocket computer-based field data entry tools.	Yes, completed in 2010 for Biomonitoring and Spring P.	**Ongoing** - Use of electronic field forms remains sporadic, used primarily for the large probabilistic studies such as NLA and NARS. Biomonitoring is piloting an iPad app in Spring 2015. .
40. Vermont's new assessment and listing methods will be standardized for a period of at least three listing cycles	Yes, in 2006.	-

2005 Ambient Water Quality Monitoring Program Strategy Recommendation	Achieved by 2010?	Achieved by 2015?
41. For consistency and predictability in the integrated reporting process, the process of 305(b) reporting and 303(d) listing should become part of the same process, due April of even-numbered years.	Yes, since 2010.	-
42. Mid-stream gap analysis. Since the present strategy has a ten-year lifespan, it will be beneficial to revisit recommendations at the midpoint of its implementation, approximately 2010.	Yes, begun in 2010 and completed in early 2011.	**Yes**, mid-stream gap analysis initiated in 2014 for anticipated completion in 2015. Full document revision scheduled for 2016.

Appendix D: Recommendations timeline

The following list of recommendations are organized by goals and objectives outlined in Section 3D. The list below outlines when completion of these tasks will be accomplished and provides a quick reference to track progress over time. These recommendations have been cross referenced to those presented in the Vermont Surface Water Management Strategy.

Priorities identified in 2010 Strategy with no progress by 2015:

2011-2015

3. Form workgroup between Lakes, MAPP, Wetlands and River Management to better integrate aquatic invasive species assessments and monitoring.
9. Use the rotational basin approach for 20-30% of geomorphic assessments performed or QC'ed by River Management Program.
15. Determine a process of communication whereby permitting staff identifies areas where new monitoring data is needed for permit renewals.
21. Investigate the USEPA Assessment Database to determine what fields would need to be included to incorporate wetlands data.

2011-2020

5. Conduct geomorphology assessments on biological sentinel sites
8. Incorporate existing monitoring data in stormwater permit review.

Goal – 2011 to 2015	Progress as of 2015
1. Form workgroup to systematically identify very high quality waters. Ensure that rotational basin sampling includes potentially very high quality sites. Annually develop a list of newly identified very high quality waters and potential Outstanding Resource Waters.	**Good** Lists now identify wetlands for Class I designation, lakes as "Best lakes" and rivers/streams as 'biologically excellent" or 'very good'. These are used during the basin planning process. Next steps: Finalize identification procedures for current lists, finalize Outstanding Resource Waters process, and identify the process that will increase protection for these waters.
2. Form workgroup between Biomonitoring and River Management in order to integrate the physical, chemical and biological stream assessments.	**Not a Priority.** The dynamics of geomorphic and biological processes in rivers operate on different spatial and temporal scales, complicating efforts to consistently predict the state of one from the state of the other, or to account for biological condition by assessing geomorphology. Rivers and Biomonitoring will collaborate to develop more consistency and overlap in physical measurements made during site visits.

Goal – 2011 to 2015	Progress as of 2015
3. Form workgroup between Lakes, MAPP, Wetlands and River Management to better integrate aquatic invasive species assessments and monitoring.	**No progress**
4. Ensure adequate staff support for Division-wide management of monitoring data by working to acquire a data manager.	**Complete** Data manager position created and filled in 2011
5. Integrate monitoring data and assessment information within the Division so all staff have electronic access, and make this information available online to Vermont citizens in a user- friendly fashion.	**Good** The Division, Department and Agency have made data available through tools such as the ANR Atlas, the Biofinder, the Lakes Score Card, and the Wetlands Inventory Map Viewer
6. Expand monitoring and assessment data availability on the web. Suggestions include expansion of the Atlas web page (formerly called Environmental Indicators) and/or Google Earth.	**Good** The Division continues to improve technology making data available to staff for assessment and planning. As example is the internal Water Quality Data portal which provides access to existing databases and offers an array of graphing tools.
7. Further develop database capabilities to link the biomonitoring and water quality databases directly to geographic information systems to enhance spatial data analysis capabilities.	**Good** The ANR Atlas currently provides water chemistry and macroinvertebrate data for rivers and streams. Next steps: Incorporate the Lakes ScoreCard into the Atlas.
8. Research more effective electronic communications for sharing monitoring results.	**Good** WsMD initiated a blog in 2013 and completed a communications strategy in 2014. Next steps: Implement the Communications Strategy recommendations and update the DEC webpages.
9. Use the rotational basin approach for 20-30% of geomorphic assessments performed or QC'ed by River Management Program.	**No progress**
10. Finalize and implement lake assessment methodology to document the extensiveness of impact to waters.	**Some Progress** The new assessment methodology has been implemented and a reporting format developed. Next step: Complete database development, which will facilitate the generation of lake 'report cards'.

Goal – 2011 to 2015	Progress as of 2015
11. Conduct biological, physical and chemical assessments at probabilistic sites in order to provide a statewide understanding of surface water conditions.	**Good** Participated in National Lakes Assessment in 2012, National Rivers/Streams Assessment in 2013 and 2014. To achieve statewide applicability, both assessments use an "amplified" approach that sampled more sites than the minimum requirement. The Lakes Program also piloted a probabilistic approach at the Basin level in 2014.
12. Develop and maintain list of potential monitoring projects for federal partners (such as USGS, USFS and USEPA) to conduct when they offer monitoring assistance.	**Some Progress** WsMD has successfully procured EPA assistance bathymetry surveys of large lakes and equipment loans. Next steps: Develop a list of successful projects for internal use in developing new partner projects with other entities. Utilize the newly created VT Monitoring Council to facilitate these partnerships.
13. Transform the ad hoc Water Quality Monitoring and Assessment Strategy Team into a permanent steering committee for surface water monitoring. This steering committee would continue to exchange information and review the status of current efforts identified by the WQMS. This team would be a natural liaison to the proposed Vermont Monitoring Council.	**Complete** The Water Quality Monitoring Strategy Team has been created and meets monthly during winter months to implement the recommendations and priorities summarized in this document.
14. Use stormwater permit information about density of development to guide location of monitoring sites to try and measure or assess cumulative impact.	**Progress** Planners provide a list of sites lacking biomonitoring data to BASS each year, in part based on storm water permits, among others, and the density of those permits. Next steps: continue to develop a process to identify monitoring sites for the assessment of impacts from changing development densities.
15. Determine a process of communication whereby permitting staff identifies areas where new monitoring data is needed for permit renewals.	**No progress**

Goal – 2011 to 2015	Progress as of 2015
16. Use Volunteer Monitoring via the LaRosa Partnerships to achieve WQMS goals. a. Convene an annual round table discussion within the WQD to identify what data gaps exist in order to inform proposals to LaRosa grants. This could be accomplished by the proposed Vermont Monitoring Council. b. Expand and refine criteria for accepting projects. (e.g., give preference to proposals that have an implementation plan or address a WQD-directed project.) c. Create workgroup to guide and prioritize volunteer monitoring efforts.	**Progress** As of 2012, Watershed Planners receive the LaRosa applications for initial review. Only approved projects get forwarded to the LaRosa Grant Coordinator and preference is given to proposals that have an implementation plan.
17. Further evaluate opportunities to maximize use of relevant monitoring data in Act 250 and other permit review processes as appropriate.	**Progress** The Rivers Program uses assessment data for permit review. MAPP review Act250 permits and apply monitoring data where appropriate.
18. Investigate the creation of a new Vermont Monitoring Council, facilitated with assistance from USGS, to coordinate surface water monitoring efforts between academic, state and federal institutions.	**Progress** The Vermont Monitoring Council was initiated in 2014 and will begin coordination role.
19. Host seasonal internal "brown bag" seminar series to share monitoring results with fellow staff. This could allow staff to be informed of upcoming projects, current unfinished projects looking for feedback, or completed projects. It would be an opportunity for staff to provide guidance to each other and learn about pertinent work in the division.	**Good** These occurred in 2011 and 2012. Interest remains high but implementation remains dependent upon availability of staff to coordinate the effort.
20. Link Vermont watershed groups with the EPA's regional volunteer monitoring equipment loan program.	**Good** This has been successful since 2011.
21. Investigate the USEPA Assessment Database to determine what fields would need to be included to incorporate wetlands data.	**No Progress**
22. Standardize process to upload data from WQData to STORET.	**Progress** Database conversion to SQL server began in 2011 and is nearing completion.

2011 - 2020

Goal	Progress as of 2015
1. Work with Waste Management Division to ensure that sediment contaminant screening is conducted downstream of hazardous waste sites.	**Progress** Sediment monitoring occurs on a case by case basis, as needed.
2. Recommend updates to VWQS to reflect practical approaches to measuring use attainment.	**Progress** Efforts are underway to update the VWQS to better align with current monitoring and assessment efforts. Anticipate a revised set of standards will be available for legislative review in 2016.
3. Develop numeric criteria in Vermont Water Quality Standards for aquatic habitat in rivers and lakes.	**Progress** Lakes criteria are moving forward, river/stream criteria are in development. See no. 2 above.
4. New monitoring initiatives or special studies related to water quality threats should address one or more of the threats outlined in Section 3.C, Existing and Emerging Threats, to the extent practical.	**Good** New initiatives include assessment of lead contamination at gun clubs and development of new monitoring methods for chloride in stream.
5. Conduct geomorphology assessments on biological sentinel sites (1-2 per year for next 10 years).	**No progress** Requires coordination between Rivers and MAPP to identify sites and standardize methods to obtain relevant data for both groups.
6. Develop a consistent and systematic triage approach to provide monitoring assistance to citizens and to emergency situations (e.g., Fish kills, shoreline alteration, direct discharges, invasive species, wetland filling, and agricultural BMP violations).	**Progress** An emergency general permit was authorized in 2011 to provide for rapid response to new aquatic invasive species.
7. Incorporate existing monitoring data in stormwater permit review.	**No progress**
8. Work with partners to develop a plan and strategy to continuously identify and track Existing and Emerging Threats outlined in Section 3C.	**Progress** A draft strategy has been developed to identify emerging contaminants of concern in VT. WsMD staff work with others in the DEC to raise awareness.

On-going goals

Goal	Progress as of 2015
1. Continue implementation of existing long term and core monitoring programs outlined in Appendix A.	**Remains a priority**
2. Continue operation of the cooperative gauging network run by USGS, and collaborate with all affected state agencies and programs to meet their gauging needs.	**Good** ANR continues to fund selected gauges within the USGS network.
3. Continue lake biocriteria development.	**On-going**
4. Continue wetlands biocriteria development.	**On-going** WQS need to include wetlands for this to be fully implemented
5. Continue low gradient stream biocriteria development.	**Good** Analyses completed, draft criteria will be released Spring 2015
6. Continue to monitor waters on the Stressed Waters List to determine compliance status.(305 b and c lists);	**On-going**
7. Continue to participate in USEPA National Aquatic Resource Survey probabilistic assessments for lakes, wetlands, and rivers/streams, adding the state level probabilistic surveys whenever possible	**On-going** Participated in all EPA surveys over this time span. Conducted statewide intensification for Lakes and Rivers/Streams, and used results to report on statewide condition
8. Support technical staff attendance at regional and national meetings and conferences which provide educational and professional development opportunities.	**On-going** Staff continue to bring these opportunities to the attention of management, with attendance dependent on budget and management approval
9. Continue to report out assessment of monitoring downstream of NPDES sites, BMPs, AMPs and AAPs.	**On-going**
10. Continue monitoring initiatives in stormwater-impaired watersheds, including on-going chemical, biological, and geomorphic assessments.	**On-going**
11. Continue to support and foster long-term partnership monitoring programs.	**On-going**
12. Continue dialogue with colleges and universities to identify projects of need for Watershed Management Division	**On-going** Division staff have participated in research, provide data for research use, provide internships and service learning projects

Appendix E. How Laboratory Services in Other New England States Work

State	Relevant experience	How adaptable is this system if you suspect a new environmental threat?	Data transfer smooth?	How are lab services funded?	Asked to describe ideal lab services
CT	Changed from state DOH state lab 5 yrs ago to UCONN & CBL (Maryland state lab)	Not very	Get electronically as Excel and put into Access. DOH had old hospital billing sys that took a lot of work to set up system with, but worked until lab personnel laid off	State and Federal money, mostly Federal (EPA)	Vermont is the model
ME	Consolidated Environmental & Health Labs in 1992	Adaptable, after 5 yr hiccup due to changing labs	Have not gotten to electronic data transfer yet.	State general fund for lake assessment	Described Vermont's set up, what they used to have until 1992
RI	Changed from University of RI contract to state DOH lab & contract out since DOH can't meet their detection limits	Adaptable, but constrained on biological side the DOH microbiological lab geared around disease and not zooplankton	Working toward it, behind VT.	Federal money (EPA)	Described Vermont's set up, 'always been envious of Vermont'
MA	State Environmental Lab	Adaptable	Yes, Get electronically	State and Federal money (EPA)	Described the Vermont set up. Having their state lab on site with more capacity.
NH	State Environmental Lab on site	Very, if the state chem lab can't do it, they can adapt their limnology lab to do method.	Yes, get electronically. LIMS system similar to Vermont's	State and Federal money, mostly Federal (EPA). Lake Assoc pay for Lay Monitoring Samples	What Vermont and NH have now
NY*	Lost access to DOH lab services in 1990s, use private contract labs now	Not very, any parameter w/ short holding time needs to be planned out far in advance.	Not asked	A contract line in the budget. Full-time Laboratory Coordinator in charge of bidding and payments	"I do know that we are envious of your (Vermont's) facility."

*Table 1. Summary of interviews with other New England States. Interviews were conduct in the spring of 2009. Contacts for each state's water quality monitoring programs were: CT DEP: Ernie Pizzuto 860-424-3715; ME DEP: Linda Bacon 207-287-7749; RI DEM: Sue Kiernan 401-222-4700 x7600; MA DEP: Bob Nuzzo 508-767-2809 and Rich Chase 508-767-2859; NH DES 603-271-3414. NY DEC: Fred Dunlap and Scott Quinn (*NY was not asked exact questions as other states so table uses most relevant response that addresses column question).*

Privatization of state lab services: Connecticut's Experience

Connecticut used to have their chemistry samples analyzed by their state Department of Health (DOH) laboratory. Five years ago the lab staff were cut and DEP had to put together an RFP for private labs. It was a 'nightmare', reviewing all the proposals, a lot of labs couldn't meet their low detection limits, or method needs. They have been contracting with UCONN ever since although couldn't do all the methods they needed. Since then have renewed contract with UCONN for 3 yr periods and have begun using Maryland's state lab, Chesapeake Biological Laboratory for samples UCONN couldn't do. Found out that can use POs with state and federal labs and do not have to go out to bid. USGS good quality analyses, but expensive. Five years after transition, things finally going smoothly, but took a lot of resources to iron out the kinks and problems (i.e. chain of custody protocols, data transfer, detection limits, methods, etc.). Really have to stay on top of QA though, which takes a lot of resources.

Consolidation: Maine's Experience

Maine went through consolidation of environmental lab with health lab. They had to throw out 1 yr of Chl a data as a result of the transition. It took them 5 yrs to work out all the kinks in the sample analyses for their long term monitoring programs. Consolidation caused environmental lab services to be moved offsite. No longer could they meet with lab personnel with 2 minutes notice to sort out a problem. They would like to have environmental lab back on site. In 1996, 4 yrs after state lab consolidation, went to using University of Maine at Orono for some analyses. Consistent and good collaborative relationship built with them, always easy to work out problems.

Conversion from private to state lab services: Rhode Island

Rhode Island's water monitoring lab services are provided by the state DOH lab. DEM transitioned to that when the private contract with the University of Rhode Island wasn't working out. They still have to contract out services, because the DOH lab doesn't have low enough detection limits or support the methods they need. They have a Master Price agreement that goes out to bid every 3 yrs for multiple state agency lab services. Need to make sure that labs that provide the methods and detection limits DEM needs are solicited, if not paying attention during negotiations then may end up out of luck for a contractor on approved list to get analyses done with. Worrisome for their long term monitoring programs, since changing labs every three years is a real possibility. Benefit of state lab's analyses is the dedicated QA

State Environmental Lab: Massachusetts

Like Vermont, Massachusetts has both an Environmental Lab and DOH lab in separate parts of state. Unlike Vermont, Massachusetts's lab is not located on site and DEP generates more samples than their lab can process so DEP has to contract out some samples for that reason. In past used to put out RFRs for specific tests, but this year doing Master Services Agreement RFR. Sent out to 120 labs in and out of state, and received proposals from 12. Plan to add to the existing list, for total of 18 labs with one as far away as British Columbia. Getting funding for contract lab work is a battle every year. They have had trouble with contract labs. They send them QC samples and while their state DEP lab does fine, the contract labs haven't always done as well. Have to be very careful with contract labs since there is a lot that isn't in the SOP that could be compromising the samples or data. Must make surprise audits of labs and must look through documentation very carefully. They spend time working with the lab if it fails its QC test. Like RI and CT they noted this is very time consuming and necessary for quality assurance.

State Environmental Lab on site: New Hampshire

New Hampshire is the most similar set up to ours. Their DEM Limnology lab is in the same building as their DEM chemistry laboratory (Similar to our biomonitoring and chem lab situation). They've been using this lab for 30 yrs. There really isn't anything that doesn't work. If they have a problem, they just pop into lab manager and chemist's office and work it out. Plenty of QC and consistency in long term monitoring data.

Privatization of state lab services: New York's Experience

New York State DEC lost access to lab services at the State DOH Lab in the 1990s and has used private contract labs for water quality analytical services since then. When they had access to DOH lab services, they enjoyed a much more robust ambient monitoring program than they do now. They had an aggressive wastewater monitoring program and an extensive stream surveillance network. Now they don't have either. Short holding time parameters are very difficult to do now. Any bacteria work they want to do has to be planned out well in advance as they generally have to have a sub-contract it with a local lab facility. It's difficult to respond to emergencies that may pop up from time to time. After some data quality problems early on with the change to private labs the low-concentration lake samples seem OK now. However, it is harder now to assess data quality because we don't do lab comparisons with split samples, etc. The large private labs don't run many of the typical lake parameters (e.g., phosphorus, chlorophyll-a) and tend to sub-contract these out to small research labs. Now there is additional planning, justification, and paperwork required to secure laboratory services and there is a full-time Laboratory Coordinator in charge of bidding and payments. There have been no savings in costs-per-sample compared with costs at the DOH lab. Because lab services are a contract line in the budget, these funds are vulnerable to cutting. All lab services funds were withdrawn in Nov 2008 due to the state budget crisis, and NY DEC has had to suspend all water sampling for an indefinite period. In summary, "We are used to it (contracting for laboratory services) but we don't like it."