State of Vermont
2010 Water Quality Integrated Assessment Report

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STATE OF VERMONT

2010 WATER QUALITY INTEGRATED ASSESSMENT REPORT

Clean Water Act Section 305B Report

Vermont Agency of Natural Resources
Department of Environmental Conservation
Water Quality Division
Waterbury, Vermont 05671-0408
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Executive Summary and Overview

Overall Description

Section 305(b) of the Federal Water Pollution Control Act (also known as the Clean Water Act or CWA) requires each state to submit a report about the quality of the state's surface and ground waters to the US Environmental Protection Agency (EPA) on a biennial basis. This 2010 Water Quality Integrated Assessment Report (the *305(b) Report*), prepared by Vermont's Department of Environmental Conservation (DEC) summarizes water quality conditions throughout Vermont with the known conditions updated with information and data from the 24-month reporting period of January 1, 2008 through December 31, 2009.

Vermont has approximately 7,100 miles of rivers and streams based on 1:100,000 scale maps. Vermont also has 300,000 acres of fresh water wetlands and 812 lakes and ponds (those at least 5 acres in size or those named on US Geological Survey maps) totaling about 230,900 acres. Surface waters (not including wetlands) are classified as Class A or Class B.

Vermont's water quality policy states that rivers, streams, lakes and ponds should be of high quality, and in most instances, DEC's water quality monitoring programs indicate this to be true. Detailed surface water assessment results are provided in Chapter 4, but aquatic life use support and swimming use support for Vermont's surface waters are summarized in the figure below. Aquatic life and swimming uses are supported on over 89% of assessed rivers and streams and on more than 62% of inland lake acres. In Lake Champlain, although phosphorus pollution impairs swimming uses in the majority of lake acres, aquatic life use is in fact supported on 88% of the lake.

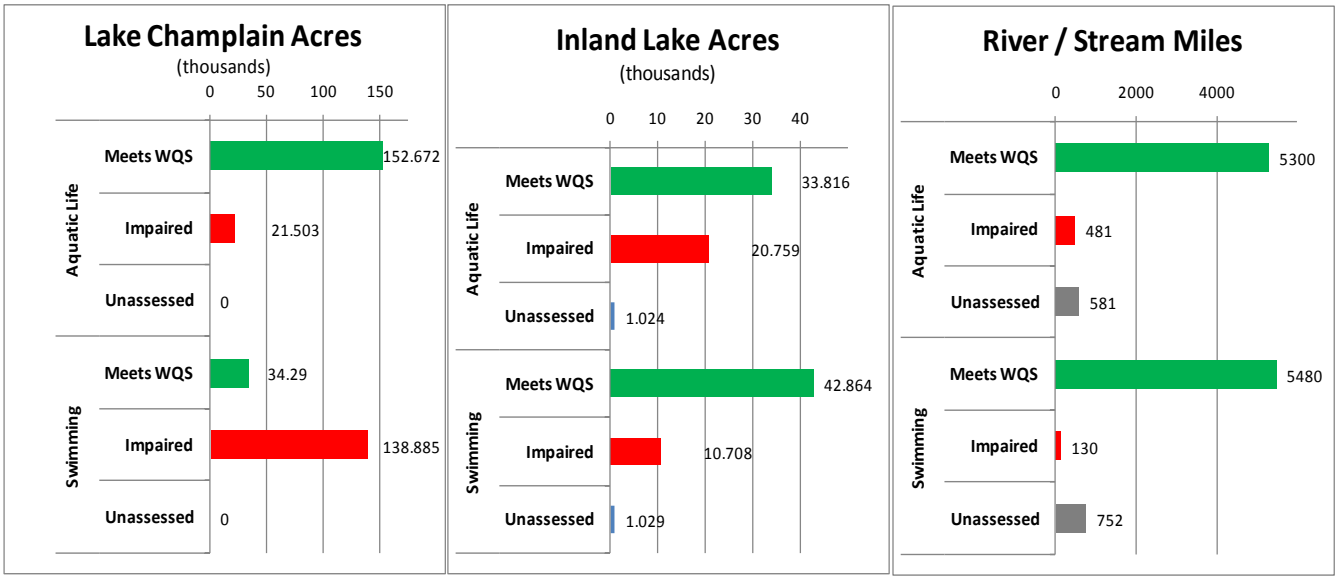


Figure 1. Assessment of Aquatic Life and Swimming Uses in Vermont Lakes and Rivers.

The US Environmental Protection Agency (EPA) has requested that Vermont also assess the attainment of fish consumption use in light of the advisory for mercury issued by the Vermont Department of Health in June 1995, and revised in 2000 and 2007. The advisory was issued as the result of fish tissue sampling that documented the occurrence of mercury in the tissue of all fish, particularly in walleye and lake trout, and also PCBs in lake trout in Lake Champlain. Taking the fish consumption advisory into consideration, the fish consumption use of all the state's waterbodies ranges from stressed to impaired. Deposition of mercury from the atmosphere is the overwhelming source of mercury in fish. The fish consumption advisory is in Appendix A.

The Wetlands Section of DEC's Water Quality Division (WQD) has assessed and monitored wetland condition in the state for over ten years. Since personnel and financial resources are limited, it has been incumbent upon the state to insure important wetland functions and values are protected from being lost or compromised to development or other destructive practices. The Vermont Wetland Rules are currently being amended through the formal rulemaking process. The new Rules contain a number of provisions that will enhance the protection of Vermont's wetlands.

No comprehensive studies have been completed on the quality of Vermont's groundwater. The quality of this vast resource is believed to meet drinking water standards for most of its consumers. During the 2010 305(b) reporting period, significant legislation passed relating to groundwater protection. On the state level, legislation passed that recognized the groundwater resources of the state are held in trust for the public. The legislation also created a Groundwater Withdrawal Permit Program in order to protect this finite public resource. On the federal level, the Groundwater Rule that requires sanitary surveys on a regular basis for public water systems became effective in 2009.

Assessment Methodology

As described in DEC's Assessment Methodology, miles of rivers and streams, and acres of lakes and ponds are placed into one of four categories by degree of support of designated uses - full support, stressed, altered or impaired. Fully supporting and stressed waters are those that meet the goals of the water quality standards. Impaired waters do not meet goals of the water quality standards because of one or more particular pollutants. Altered waters do not meet water quality standards because of non-pollutant effects (e.g., alteration of flow to generate electricity).

During the two years since the 2008 305(b) Report, the Basin 8 Winooski River Watershed Water Quality and Aquatic Habitat Assessment Report was completed and the Basin 16 Northern Connecticut River Watershed Assessment Report was started. Basin-specific assessment reports are available from DEC upon request and many are located on the DEC Water Quality Division website.

DEC continued to conduct its monitoring, assessment, and listing of waters consistent with the 2006 Assessment and Listing Methodology. Soon after this 2010 305(b)/303(d) integrated report is produced and impaired waters lists are finalized, there are plans to make some additions and revisions to the Assessment and Listing Methodology. In addition, a committee is reviewing and revising the September 2005 Vermont DEC Ambient Water Quality Monitoring Program Strategy with the idea of prioritizing the many monitoring efforts.

Rivers and Streams Assessment

The assessment of Vermont's river and stream surface water quality and aquatic habitat conditions has been updated from the 2008 305(b) assessment with water quality information and data from waters monitored and assessed during the 1/1/08 to 12/31/09 reporting period. Using the EPA estimate of 7,100 miles of perennial rivers and streams, approximately 5,781 miles or 81% were assessed for this 2010 305(b) report.

The major causes of impairment and stress to Vermont rivers and streams include sediments, flow alterations, physical habitat alterations, nutrients, metals, turbidity, pathogens, and temperature in that order. The river assessment process is in the process of attempting to distinguish the relative contributions of sediment due to overland sheet runoff from construction sites and other land use activities or streambank de-stabilization directly from the sediment impacts due to incising stream channels and the changes in channel and bank erosion and sediment deposition and transport that result from the stream system instability.

Lakes and Ponds Assessment

The assessment of Vermont's lake surface water quality and aquatic habitat conditions has also been updated from the 2008 305(b) assessment with water quality information and data from waters monitored and assessed during the 1/1/08 to 12/31/09 reporting period. All lakes and ponds within the borders of Vermont are considered as inland lakes or ponds except for the 11 segments of Lake Champlain. Moore Reservoir and Comerford Reservoir on the upper Connecticut River, Lake Memphremagog and Wallace Pond are transboundary waters that are reported as "inland lakes."

In Lake Champlain, none of its 174,175 acres found in Vermont fully support designated uses due to the combined effects of mercury and other contamination, nutrient accumulation, and non-native species. No acres in the Vermont portion of Lake Champlain support fish consumption use due to elevated levels of mercury or polychlorinated biphenyls (PCB) in fish tissue. Sedimentation is a stressor in Lake Champlain. In the 55,561 inland lake/pond acres that were assessed for the 2010 305(b) Report, the causes of impacts to those acres include mercury, phosphorus, pH (acidification), water level fluctuations, and invasive exotic species.

Wetlands

The Wetlands Section of the Water Quality Division has assessed and monitored wetland condition in the state for over ten years. Prior to 2010, bioassessment and monitoring strategies had been singularly linked with the lakes and rivers sections of the DEC's Water Quality Division. In many respects the connection between the Wetlands Section Bioassessment Program and the lakes and rivers water quality monitoring programs make sense since many of Vermont's wetlands occur adjacent to lakes and streams. Additionally, the assessment and monitoring programs measure a number of like water quality parameters. However, while bioassessment efforts were evolving, the opportunities to expand and include findings from the Vermont Natural Heritage Program's work related to wetland communities had not transpired.

The importance of biomonitoring being integrated with wetland community type is that once a specific wetland community type is identified, it will yield a well defined and expected set of ecological parameters. A specific wetland's biological condition and significance can then be measured against the predicted floral and faunal community members, soils, hydrology, bedrock influence, assessed functions, and water quality of the type. Thus, where possible the Vermont Natural Heritage Program wetland community types will be used in tandem with the Cowardin National wetland types, to assess like parameters specific to individual wetland communities.

As a practical approach to bioassessment and monitoring efforts, Vermont has developed a new Vermont Rapid Assessment Method (VRAM) that will be used and refined, along with existing level I, II, and III wetland bioassessment methods, thus including the identification of wetland stressors and impacts determining site specific wetland condition.

The recent completion of the National Wetland Inventory (2008) mapping effort increased Vermont's identified wetland acreage by approximately 10 percent statewide, and 34 town-funded wetland mapping initiatives increased those towns' wetland acreage even higher. Given the large increase in known wetland acreage, much of it forested, adjacent to existing wetlands, or newly identified small isolated wetlands, the benefits to assigning natural community types to wetlands becomes evident as the distinction between impaired, impacted but healthy, or reference conditions become clearer when linked to predicted natural community conditions. For 2010, the Wetlands Section will initiate its Vermont Wetland Bioassessment Program Monitoring Strategy working in tandem with the WQD Lakes and Rivers Sections and Vermont's Natural Heritage Program.

Groundwater

Groundwater is currently used for drinking water by approximately 70% of Vermont's population. About 46% of the population is self-supplied while about 24% is served by public water systems using groundwater. The results of the study on groundwater interference caused by the pumping of Public Community Water Supply (PCWS) sources indicate that, overall, groundwater interference is not a chronic problem in Vermont.

About 87% of the public community water systems in the State have their corresponding Source Protection Areas or aquifer recharge areas mapped on a hydro-geologic basis. The remaining public community water systems are using 3,000 foot radius circles as their Source Protection Areas.

During the 2010 305(b) reporting period, significant legislation passed relating to groundwater protection. On the state level, legislation passed that recognized the groundwater resources of the state are held in trust for the public. The legislation also created a Groundwater Withdrawal Permit Program in order to protect this finite public resource. On the federal level, the Groundwater Rule that requires sanitary surveys on a regular basis for public water systems became effective in 2009.

To date, nine areas in Vermont have had the groundwater re-classified due to contamination such that it can no longer be used for drinking water. One new area in Rockingham was re-classified this biennium while another area was investigated for re-classification and a third situation found an alternative means of addressing the contaminated groundwater without the reclassification.

Listings of Waters

Development of Vermont's 2010 303(d) List of Impaired Waters runs concurrently with the development of this 2010 Section 305(b) Integrated Report. Consequently, the final 2010 303(d) List of Impaired Waters has not been included directly in this 305(b) Report. The 303(d) List of Impaired Waters, which needs approval by EPA, will be finalized and made available separately. DEC will also make available separately Vermont's List of Priority Waters that includes waters not on the 303(d) List. This 305(b) report, in combination with Vermont's 303(d) List and List of Priority Waters are considered Vermont's complete Integrated Water Quality Report.

Vermont's 2008 303(d) List of Impaired Waters was approved by the New England regional office of EPA during the 2010 reporting period (approval on September 24, 2008). The 2008 303(d) listing identified a total of 113 waters as being impaired (98 river/stream segments and 15 lakes/ponds). The 2010 303(d) List potentially adds 10 segments, however, 13 segments are proposed for delisting resulting in a total of 110 segments as being impaired.

Vermont's 2008 listing of other priority waters outside the scope of 303(d) was also finalized in 2008. This consists of a number of listings and includes: impaired waters that do not need a TMDL; waters in need of further assessment; waters with completed and EPA-approved TMDLs; and, waters altered by exotic species, flow regulation and channel alteration.

During the 2010 Section 305(b) reporting period, the New England regional office of EPA approved nine TMDL determinations that had been completed by DEC. This brings to ninety-five the total number of TMDLs affecting Vermont waters that have been developed by DEC and approved by EPA since 2001. These TMDL waters are in various stages of TMDL implementation, but many remain impaired.

Major State Water Quality Issues

There are a number of statewide water quality issues which relate to the management and improvement of Vermont's water quality and water resources. Discussions and status have been prepared for the following topics and are fully presented in Chapter 3:
Stormwater TMDLs implementation
Climate change and water/wetland resources
Dams and hydro-electric facilities
Atmospheric deposition of pollutants
Lack of statewide vegetated buffer requirements
Floodplains and surface water protection
Lakeshore development and alteration of littoral habitat
Eutrophication of lakes
Large farms and potential pollution
Nutrient criteria
Invasive exotic plants and animals in surface waters and wetlands
Chlorides and water quality
Pharmaceuticals, personal care products, and other contaminants in waters
E .coli contamination and mircrobial source tracking

Chapter 1: Introduction

Section 305(b) of the Federal Water Pollution Control Act (also known as the Clean Water Act or CWA) requires each state to submit a report about the quality of the state's surface and ground waters to the US Environmental Protection Agency (EPA) on a biennial basis. The 2010 Water Quality Integrated Assessment Report (the *305(b) Report*) summarizes water quality conditions throughout Vermont with the known conditions updated with information and data from the 24-month reporting period of January 1, 2008 through December 31, 2009. Also included are water resources monitoring/assessment program information for rivers and streams, lakes and ponds, wetlands and groundwater. The report contains information on certain pollution control programs, costs and benefits, monitoring progress, swimming beach closures and statewide water issues.

Vermont has approximately 7,100 miles of rivers and streams based on 1:100,000 scale maps and about 24,500 miles based on 1:5000 scale maps. Vermont also has 300,000 acres of fresh water wetlands and 812 lakes and ponds (those at least 5 acres in size or those named on US Geological Survey maps) totaling about 230,900 acres. Surface waters (not including wetlands) are classified as Class A or Class B. Class A waters are managed for enjoyment of water in its natural condition, as public drinking water supplies (with disinfection when necessary) or as high quality waters which have significant ecological values. Class B waters, which are managed for high quality, may have minimal, minor or moderate change to aquatic biota or habitat according to the water's management type B1, B2 or B3. Certain Class B waters have an overlay Waste Management Zone for public protection below sanitary wastewater discharges. No waters have yet been typed as B1, B2, or B3.

There are approximately 1,192 miles of Class A rivers and streams and 3,383 acres of Class A lakes and ponds in Vermont (these figures do not include rivers/streams above 2,500 feet elevation which are also Class A). Approximately 908 stream miles are Class A(2) public water supplies and 284 miles are Class A(1) ecological waters. For lakes and ponds, there are about 2,990 acres of Class A(2) public water supplies and 393 acres Class A(1) ecological waters. Approximately 315 miles of the Class B rivers and about 15 acres of Class B lakes have a Waste Management Zone. The Waste Management Zone (WMZ), similar in effect to an overlay zone in land use regulation, is created on a site-specific basis to accommodate the direct discharge of treated sewage effluent to surface waters. The length of the zone must meet Class B standards but it recognizes an increased risk in the stretch of water for contact recreation.

The Vermont portion of the Batten Kill along with the West Branch of the Batten Kill (totaling about 33 miles), the Lower Poultney River (about 22 miles), a 3.8 mile segment of the Ompompanoosuc River and a 1.3 mile segment involving Pikes Falls on the North Branch of Ball Mountain Brook have each been designated as an Outstanding Resource Water (ORW). The 3.8 mile segment of the Ompompanoosuc was designated ORW in 1996. All other ORWs noted above were designated in 1991. No ORWs have been designated since 1996.

Wetlands within Vermont are classified as Class One, Class Two or Class Three. Class One wetlands are those wetlands that are exceptional or irreplaceable in their contribution to Vermont's natural heritage and that merit the highest level of protection. Class Two wetlands are those wetlands, other than Class I wetlands that, are so significant, either taken alone or in conjunction with other wetlands, that they merit protection. Class Three wetlands are those wetlands that have

not been determined to be so significant that they merit protection, either because they have not been evaluated or because when last evaluated were determined not to be sufficiently significant to merit protection. The majority of wetlands within Vermont are Class Two.

The 2010 Water Quality Assessment Report describes whether or not the state's surface water uses as defined by EPA and Vermont's Water Quality Standards fall into one of four use support categories. The four use support categories used by DEC are *full support, stressed, altered,* or *impaired.* The four use support categories are described below.

> ***Full Support*** - This assessment category includes waters of high quality that meet all use support standards for the water's classification and water management type.
>
> ***Stressed*** - These are waters that support the uses for the classification but the water quality and/or aquatic biota/ habitat have been disturbed to some degree by point or by nonpoint sources of human origin and the water may require some attention to maintain or restore its high quality; the water quality and/or aquatic habitat may be at risk of not supporting uses in the future; or the structure or integrity of the aquatic community has been changed but not to the degree that the standards are not met or uses not supported. Data or other information that is available confirms water quality or habitat disturbance but not to the degree that any designated or existing uses have become altered or impaired (i.e. not supported).
>
> ***Altered*** - These are waters where a lack of flow, water level or flow fluctuations, modified hydrology, physical channel alterations, documented channel degradation or stream type change is occurring <u>and</u> arises from some human activity, OR where the occurrence of exotic species has had negative impacts on designated uses. The aquatic communities are altered from the expected ecological state. This category includes those waters where there is a documentation of water quality standards violations for flow and aquatic habitat but EPA does not consider the problem(s) caused by a pollutant or where a pollutant results in water quality standards not being met due to historic or previous human-caused channel alterations that are presently no longer occurring.
>
> ***Impaired*** - These are surface waters where there are chemical, physical and/or biological data collected from quality assured and reliable monitoring efforts that reveal 1) an ongoing violation of one or more of the criteria in the Water Quality Standards and 2) a pollutant of human or human-induced origin is the most probable cause of the violation.

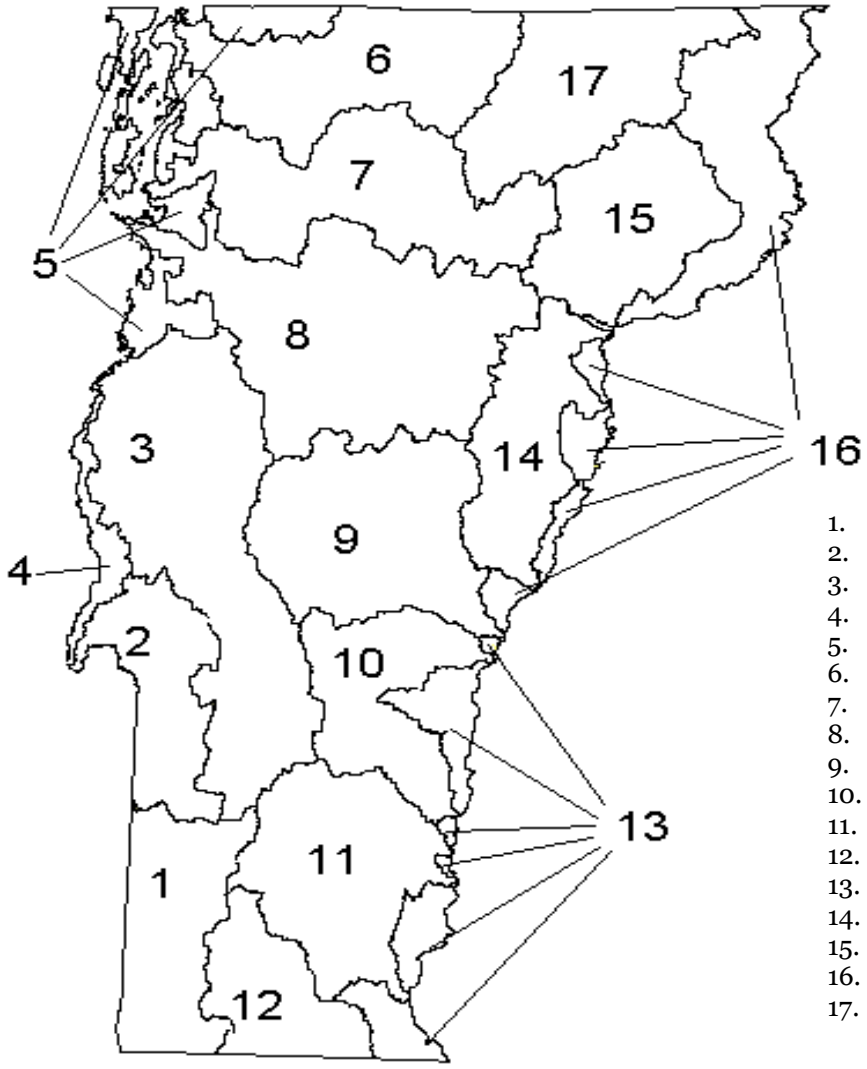
Water uses include, but are not limited to, aquatic biota/habitat, contact recreation (swimming and wading) and secondary contact recreation (fishing or boating), public water supply, aesthetics, fish consumption, and agricultural water supply. A determination of use support is made following the Vermont Surface Water Assessment Methodology (2006) and using information gathered and provided to DEC by water resources personnel, fish and wildlife biologists, aquatic biologists, lake and river organization members, and other qualified individuals or groups. The 2010 Water Quality Assessment Report identifies the distance in miles of rivers and streams and area in acres of lakes and ponds that were assessed.

For Section 305(b) reporting purposes, river or stream segments and lake and pond segments where one or more uses are not fully supported (i.e. either altered or impaired) are considered not to be meeting the Water Quality Standards, due to the violation of one or more Water Quality criteria. Violations of Water Quality criteria are substantiated by chemical, physical or biological water quality data collected through monitoring. In accordance with EPA 303(d) guidance, waters

reported for 303(d) purposes in the year 2010 list of waters are impaired waters that need or would benefit from a pollution budget determination more commonly known as a Total Maximum Daily Load (TMDL) determination. The 2010 303(d) list of waters is being developed concurrently to the 2010 305(b) Report. As the 2010 303(d) list needs EPA approval, that information is presented separately from the 2010 305(b) Report so as not to slow the schedule for releasing the 305(b) Report. The 305(b) Report, the 303(d) list, and the other lists of waters, when taken together, represent Vermont integrated reporting as the information is inextricably linked.

A rotating basin schedule is used when assessing the state's waters, covering roughly one-fifth of the state each year, from the 17 major river basins found in Vermont. The 2010 305(b) Report contains updated water quality information primarily for basins 1, 2, 7, 10, 11, 12, 13, 14, but also contains a summary of the entire state's water quality. For 2010 assessment reporting and listing purposes, DEC relied on its 2006 Assessment and Listing Methodology. This methodology can be found on DEC's Water Quality Division web site (www.vtwaterquality.org) or by referring to the 2006 305(b) Report. A map illustrating the 17 Vermont river basins is provided below. In addition, Vermont's 305(b) report provides information on any water quality sampling projects of statewide impact. In this report, findings from a statewide survey of lake water quality, undertaken in conjunction with USEPA's National Lakes Assessment, is presented (Chapter 4).

The 305(b) Report remains a highly visible mechanism for communicating to Congress, Vermont residents and the Vermont General Assembly about the state of the state's water quality and about the current major surface water quality issues. EPA's Index of Watershed Indicators relies heavily on 305(b) reports from each of the 50 states. Also, the 305(b) reporting process is an important tracking tool for the performance of water quality protection initiatives under the Core Performance Measures of the Performance Partnership Agreements and the Government Performance for Results Act. This report, as well as the last several biennial Vermont Section 305(b) Reports, can be found on the internet at http://www.anr.state.vt.us/dec/waterq/wqdhome.htm.



1. Battenkill,Walloomsac, Hoosic
2. Poultney-Mettowee
3. Otter Creek, Little Otter, Lewis
4. Lower Lake Champlain
5. Upper Lake Champlain
6. Missisquoi
7. Lamoille
8. Winooski
9. White
10. Ottauquechee, Black
11. West, Williams, Saxtons
12. Deerfield
13. Lower Connecticut
14. Wells, Waits, Ompompanoosuc
15. Passumpsic
16. Upper Connecticut
17. Lake Memphremagog

EPA's vision for State 305(b) Integrated Reports is the "...reports will characterize water quality and the attainment of water quality standards at various geographic scales." EPA's more detailed vision states that the 305(b) reports will:

- Comprehensively characterize the waters of the States, Tribes, Territories and the Nation, including surface water, ground water and wetlands.
- Use data of known quality from multiple sources to make assessments
- Indicate progress toward meeting water quality standards and goals.
- Describe causes of polluted waters and where and when waters need special protection.
- Support watershed and environmental policy decision-making and resource allocation to address these needs.
- Describe the effects of prevention and restoration programs as well as associated cost and benefits.
- In the long term, describe assessment trends and predict changes.

Chapter 2: Vermont's Waters and Water Programs

Summary Description of Vermont's Surface Water Quality

Vermont's water quality policy states that rivers, streams, lakes and ponds should be of high quality, and in most instances, DEC's water quality monitoring programs indicate this is the case. Support of designated uses in Vermont's water is high in most surface waters. The two exceptions to the high percent full support of uses are the fish consumption use in all waters because of mercury in fish tissue and the swimming use in Lake Champlain due to phosphorus.

As Vermont is only now developing a specific program of assessing and monitoring wetland water quality, the water quality of wetlands is not yet known. In addition to work it has already undertaken, Vermont is looking towards the EPA National Wetlands Assessment as one model for an operational wetlands assessment program. It has been incumbent upon the state's limited resources to insure important wetland functions and values are protected from being lost to development or other destructive practices.

No comprehensive studies have been completed on the quality of Vermont's groundwater. In most cases it is believed that groundwater quality meets or exceeds drinking water standards. A full evaluation of groundwater is needed, however, to provide a characterization of this important resource.

Atlas and Total Waters

The estimates of the number of miles of rivers and streams in Vermont varies depending on the source and the scale of the mapping on which that source draws. Vermont has approximately 7,100 miles of rivers and streams based on EPA's Total Waters Database, which uses 1:100,000 scale maps. However, Vermont has approximately 24,493 miles of river and stream calculated using the National Hydrography Dataset (Version NHD080221, local resolution, schema 1.06) derived by photo-interpretation of 1:5,000 scale aerial orthophotographs. Originally, Vermont DEC used Don Webster's 1962 list of miles compiled from the work of former Department of Water Resources engineers or the U.S. Army Corps of Engineers and the total was 4,936 miles for its assessment work. Vermont DEC currently uses the 7,100 number as the total on which to base assessed and unassessed miles. Discussion on how to use the large 1:5000 scale estimate of stream miles is underway.

Vermont has 230,900 acres of lakes, reservoirs and ponds and 300,000 acres of freshwater wetlands. The surface area of lakes, ponds and wetlands represent approximately 828 square miles of water or about 8.6% of the state's total 9,609 square mile area.

Vermont's border waters include the Connecticut River on the east (border with New Hampshire), Lake Memphremagog and Lake Champlain on the north (partial border with the Province of Quebec) and the Poultney River and Lake Champlain on the west (partial border with New York). The 17 major river basins of Vermont shown on the earlier map drain to one of four large regional drainages: Lake Champlain, the Connecticut River, Lake Memphremagog, or the Hudson River. Additional surface water resource information is contained in Table 1 below.

Table 1. Atlas

State population	621,254 (2007 estimate)
State population change (1990 - 2000)	8.2 % increase
State surface area	9,609 square miles
State population density	65 persons/sq mi
Number of water basins	17
Miles of perennial rivers & streams	7,099 (includes the Conn River)
Border miles of shared rivers/streams (subset)	262 (Conn R. 238, Poultney 24)
Longest river in the state (not including Conn R.)	100 miles (Otter Creek)
Largest river watershed in the state (not including Conn R.)	1080 sq miles (Winooski R watershed)
Number of lakes, reservoirs & ponds over 20 acres	280
Number of lakes, reservoirs & ponds from 10 to 20 acres	190
Number of lakes, reservoirs & ponds (at least 5 acres but less than 10 acres)	148
Number of significant lakes, reservoirs & ponds less than 5 acres(or size unmeasured)	206
Deepest in-land lake (Willoughby)	308 feet
Greatest depth of Lake Champlain (off Thompsons Point)	394 feet
Acres of lakes, reservoirs & ponds[1]	230,927
Acres of freshwater wetlands[2]	300,000

[1] Number includes the Vermont portion of Lake Champlain, some private waters and some waters less than 5 acres in size. This figure also accounts for two CT River impoundments, Moore and Comerford Reservoirs, which are 1,255 and 777 acres in size respectively. The figure also accounts for newly inventoried ponds that were not previously tracked in Vermont's Lake Inventory Database and for some minor lake size changes that were identified via GIS analyses.

2 Number does not include wetlands found on agricultural lands that are actively used for agricultural purposes

There are no coastal waters, estuaries or tidal wetlands in Vermont. However, due to the size of Lake Champlain (approximately 120 miles long and 12 miles wide at its widest), the lake is considered an inland sea by many residents of Vermont, New York and Quebec. The Atlantic Ocean and Inland Waterway are accessible to the south from Lake Champlain via the New York Barge Canal. The Richelieu River, St. Lawrence River and the Atlantic Ocean are accessible to the north through Canada.

For the 2010 Section 305(b) Report, DEC continues to use the EPA Total Waters estimate. Before the VHD-based estimate can be incorporated into its various water quality assessment efforts, DEC will need to revise the lengths of rivers and streams throughout the state on a systematic basis involving each waterbody.

Water Pollution Control Programs

DEC is designated as the lead water quality management agency for the State of Vermont. In that role, DEC administers a wide variety of programs that are intended to control, reduce or prevent pollution from point and nonpoint sources to the State's surface and ground water resources. For the purpose of describing program effectiveness, DEC's various water pollution control programs can be summarized into three categories: General, Point Sources and Nonpoint Sources.

General

Water Quality Standards

The Water Quality Standards are the foundation of the state's water pollution control and water quality management and protection efforts. The Water Quality Standards are promulgated by the Vermont Water Resources Panel and provide the specific criteria and policies for the protection and management of Vermont's surface waters. The classification of waters (rivers, streams, lakes and ponds) as Class A, Class B, or Class B with a Waste Management Zone are the management goals to be attained and maintained. The classification also specifies the designated water uses for each class. Class A waters are either A1 (ecological waters) or A2 (public water supplies). Class B waters could fall within one of three water management types (B1, B2 or B3) after consideration by the Water Resources Panel, however, as of the date of this report, no Class B water has been typed. The Standards used when preparing this report were last amended January 1, 2008 (www.nrb.state.vt.us/wrp/rules.htm).

The Standards establish narrative and numeric criteria to support designated and existing uses. 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 2 lists the designated uses.

Table 2. Designated Uses for Water Classifications.

Designated Uses	Class A(1) – Ecological Waters	Class A(2) – Public Water Supplies	Class B Waters
Aquatic Biota, Wildlife & Aquatic Habitat	✓	✓	✓
Aesthetics	✓	✓	✓
Swimming & Other Primary Contact Recreation	✓		✓
Boating, Fishing & Other Recreation Uses	✓		✓
Water Supplies		✓	✓
Agricultural Uses (Irrigation of Crops ...)			✓

Watershed Planning Process

Vermont has been implementing a watershed approach to surface water quality planning. The watershed planning process is an inclusive public process that takes into account current and past assessment, planning, and implementation activities at the state and local levels. Assessments are followed by basin plans that summarize current and prior water pollution or water quality management activities. This rotational planning process also identifies topics or areas of special importance in the basin, available management tools to address those topics, and specific recommendations on how to address key topics, including recommendations for continuing community-based planning or implementation action. River basin specific "watershed councils" provide input concerning strategies and recommendations. Each basin plan updates previous basin plans. Each basin is unique in its problems and opportunities. Assessment, planning and implementation are constantly occurring at many different levels from the activities of landowners to municipal, state and federal levels and evolving with public participation.

Watershed planning educates citizens about what they can do to reduce pollution, coordinates pollution reduction activities and invites the public to help establish priorities for management projects. In the 2008 305(b) reporting period, the watershed planning program had grown to eight watershed coordinator positions as part of the Clean and Clear program funding but program cuts have since reduced that number to five in the 2010 305(b) period. Watershed Coordinators, who work to develop consensus through Watershed Councils, have been the catalysts for dozens of projects and have interacted with thousands of people to promote water quality protection.

Table 3. Basin Planning Initiative - Status for All Basins (as of December 2009).

Components of the Basin Planning Process	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	17
Public forums held	I,O	C	C	I	C	C	C	I,O	C	C	C	O	O	C		C
Watershed Council formed	C	C	C	I	C	C	C	I,O	C	O	C	I		C		C
Local water quality concerns identified	I,O	C	C	I	C	O,C	C	I,O	C	O	C	O	I,O	C		C
Panel discussions on water quality issues held	C	C	C	O	C	I,O	C	I	C	O	C	I	I,O	C		I
Strategies for water quality issues formulated	I,O	C	C		C	I,O	C	I	C	I	C		I,O	C		I
Review of town plans & zoning regulations	I	C	C	C	C	I	C	I	C	I,O	C		I	C		I
Develop water management type classification proposal		C					C		C		C					
Meetings with towns on classification proposal		C					C		C		C					
Watershed plan draft	I	C	O		C	I	C		C	I	C			C		
Public hearings on draft plan		C	I		C		C		C		C			C		
Final basin plan		A			A*		A*		A		A			A		
Outreach to schools and local groups	I,O	O	O	O	O	O	O		O	O	O		I,O	O		O
Basin Assessment Report	C	C	C		C	C	C	C	C	C	C	C	C	C	C	C
Phase I SGA	I,O,C	O,C	O,C	C	I,C	O,C	O,C	O,C	C	O	O,C	O,C	O	O,C		I,C
Phase II SGA	I,O,C	O,C	O,C	C	I,C	O	O,C	O,C	O,C		O,C	O,C	O	O,C		I,C
Bridge & Culvert Inventory	I,O,C	O,C	O,C	C	O	O,C	C	C		O	O,C	O		O		
Dam Inventory		O	O	O	C		C	I,O	C		I					
Biological Monitoring	O,C	O	O	O	O,C	O	O,C	O,C	O,C	O	O	O		O		
Restoration Projects	O	O,C	I,O,C	O,C	I	O,C	O,C	O,C	O,C	I,O	I,O,C		I	O		O,C

Key to Table: I = initiated, O = ongoing, C= completed; SGA=stream geomorphic assessment; A= ANR adopted plan and A* = ANR approved plan but lacking mandated typing portion. The basins above are: Basin 1 - Batten Kill, Walloomsac, Hoosic; Basin 2 - Poultney-Mettowee Rivers; Basin 3 - Otter Creek; Basin 4 - Southern Lake Champlain; Basin 5 - Northern Lake Champlain; Basin 6 - Missisquoi River; Basin 7 - Lamoille River; Basin 8 - Winooski River; Basin 9 - White River; Basin 10 - Black and Ottauquechee Rivers; Basin 11 - West, Williams & Saxtons Rivers; Basin 12 - Deerfuield; Basin 14 – Stevens, Wells, Waits, Ompompanoosuc Rivers; Basin 15 - Passumpsic River; and Basin 17 - Lake Memphremagog.

At this time, there are six basin plans that have been completed and there are four others that are in progress. Many actions listed within each of these are in various stages of ongoing activity, initiation, and completion (see Table 3 above). A detailed description of the basin planning progress for 2010 is available in a report prepared for the Vermont Legislature and available from the Water Quality Division.

Strengthening the Watershed Planning Process

ANR's Water Quality Division is currently involved in an internal review of the basin planning process: identifying its strengths and weaknesses and opportunities for improvement. This effort is exploring the potential for a realignment of the process to more fully integrate it across ANR, DEC, and other State programs to leverage efficiencies where possible. The general goal is to enhance coordination of the numerous water-related planning processes within DEC and ANR, and develop a statewide plan that spotlights the highest-priority strategies needed to protect Vermont's waters in a time of competing resource needs. Examples where enhanced coordination is envisioned include the Lake Champlain TMDL Implementation Plan, the River Management Program's corridor planning and protection program, NPDES stormwater and wastewater permitting programs and ANR's State Lands Acquisition Process. The Water Quality Division's current vision is that the statewide strategic plan will feature such components as:

> *Identification of State Water Resource Goals and Objectives:* This component would lay out the vision for Vermont Waters, including descriptions of healthy, functioning, and supporting watersheds.
>
> *Water Quality Monitoring Program Strategy (WQMS):* This component would direct how monitoring resources are allocated, how monitoring data are vetted and archived, how information is assessed, and how it is delivered to the public.
>
> *Water Quality Education Chapters:* This would establish a statewide roster and description of stressors upon water quality and quantity that is typically a component of each individual basin plan. This would provide a statewide educational document on water quality issues.
>
> *Protection and Remediation Programs:* This section would be a compendium of rules, procedures, and best practices that outlines state technical assistance services available to assess and remediate various stressors. This section may update the current Continuous Planning Process, and can serve to focus implementation of the anti-degradation provisions of the Vermont Water Quality Standards and Clean Water Act, to maintain existing uses while identifying and supporting identification and protection of high and very high quality waters within each basin.
>
> *Gap Analysis:* This component would identify gaps between the most important stressors affecting water quality, and the regulatory, technical assistance, and cost-share funding programs currently in place.
>
> *Tactical Basin Implementation Plans:* This component would describe the process for developing individual, basin-specific and geographically explicit plans that document existing use where known, establish priority monitoring and assessment approaches, and list planning, permitting, or project-level initiatives to protect or restore uses.

ANR will initiate a public process for discussion of these issues after completion of internal review of its current basin planning process and the opportunities for enhanced planning and coordination.

Class A Re-Classifications
The 1986 "Pristine Streams Act" created the opportunity for any waterbody supporting habitat that is ecologically significant and has water quality that meets at least Class B standards to be re-classified to Class A. A re-classification is a rulemaking procedure before the Water Resources Panel where a public interest determination must be made pursuant to Vermont's Water Pollution Control Statute, Title 10 VSA Section1253. No streams have been re-classified to Class A since the 1998 305(b) Report.

Outstanding Resource Waters
An additional tool to manage and protect Vermont's waters is through the designation of Outstanding Resource Waters (ORWs). ORWs are waters of the State designated by the Vermont Water Resources Panel pursuant to 10 V.S.A. 1424a as having exceptional natural, recreational, cultural or scenic values. To gain an ORW designation, the petitioners must, in a contested case hearing before the Panel, provide evidence and testimony that the waters in question have exceptional natural, cultural, scenic, or recreational values. To date, the following waters have been designated as ORWs: the Batten Kill and its West Branch, Pikes Falls on the North Branch of Ball Mountain Brook, the lower Poultney River and Great Falls on the Ompompanoosuc River. No ORWs have been designated since 1996.

Point Source Control

Direct Discharge Program
Vermont administers a well-planned and comprehensive direct discharge water pollution control program consisting of planning loans and advances, construction grants and loans, permitting and compliance monitoring. In March 1974, Vermont received from EPA the delegation authority to administer discharge permits under the National Pollutant Discharge Elimination System. Within Vermont, there are 33 "major"wastewater treatment facilities and 139 "minor" facilities.

With the construction of the state's last originally identified municipal wastewater treatment facility (WWTF) and completion of the upgrades from primary to secondary, the program has continued to place emphasis on refurbishment of existing WWTFs, the completion of phosphorus reduction upgrades (see Appendix B, Table B.1), advanced waste treatment, correction of combined sewer overflows (CSO) (Appendix B, Table B.2), control of toxics, pollution prevention activities and facility enlargements.

Of the 35 facilities with planned phosphorus reduction projects in the Vermont portion of the Lake Champlain basin, 33 have been or are close to being completed. Of the 33 planned CSO correction projects, 25 have been completed, 1 is underway and 7 are pending.

During the 2008 - 2009 reporting period, approximately $54.6 million dollars were committed and construction commenced on wastewater treatment facility upgrades, combined sewer overflow corrections, sewer line extensions and rehabilitations and other wastewater treatment system improvements in 20 communities (see Table 4 below). This is compared to the 2006 – 2007 reporting period when about $3.2 million were committed in five communities (see 2008 305(b) report). This very large increase was a result of federal government stimulus money spending under the American Reinvestment and Recovery Act.

Dramatic progress has been made over the last several years in reducing the level of phosphorus in discharges from municipal wastewater facilities. Under the Clean and Clear Initiative described below, the reduction of 6.2 metric tons per year of permitted phosphorus discharge was funded in FY2005-FY2010 for the Richford, Hardwick and Proctor facilities, now completed. Funding of similar projects in Troy/Jay and Waterbury in FY2005-FY2010 will lead to reduction of another 4.1 metric tons of phosphorus per year (before Troy/Jay capacity expansion).

Table 4: Municipal Pollution Control Project Starts from January 1, 2008 to December 31, 2009

Community	Description	Estimated Project Cost
****** Lake Champlain Drainage ******		
Colchester	On-site septic systems	$ 150,000
Enosburg Falls	Aeration system rehabilitation	$ 115,000
Johnson	Sewer replacement	$ 95,000
Middlebury	Sewer force main	$ 1,043,000
Proctor	Combined sewer overflow abatement	$ 552,000
Proctor	Phosphorus treatment	$ 486,000
Saint Albans City	Biosolids management and trickling filter renovation	$ 2,682,000
Shelburne	Pump station rehabilitation	$ 224,000
Shelburne	Sewer extension	$ 120,000
Essex Junction	WWTF aeration blower replacement and sewer rehabilitation	$ 567,000
Essex Town	Stormwater facilities upgrade	$ 450,000
Hinesburg	Wastewater treatment facility upgrade	$ 1,618,000
Middlebury	Pump station upgrade	$ 1,800,000
Milton	Stormwater facilities upgrade	$ 483,000
Montpelier	WWTF solar panels, sewer rodder and vacuum truck	$ 1,182,000
Morrisville	Sewer rehabilitation	$ 400,000
Proctor	Sewer rehabilitation	$ 126,000
Rutland	Sewer and stormwater replacement lines	$ 925,000
Saint Albans City	RBC modifications	$ 2,008,000
Shelburne	Sewer rehabilitation	$ 318,000
South Burlington	Stormwater facilities upgrade	$ 74,000
South Burlington	Wastewater treatment facility upgrade and expansion	$25,832,000
South Burlington	Stormwater facilities upgrade	$ 213,000
South Burlington	Stormwater facilities upgrade	$ 198,000
South Burlington	Stormwater facilities upgrade	$ 90,000
South Burlington	Stormwater facilities upgrade	$ 104,000
Waterbury Village	Sewer replacement	$ 1,185,000

Community	Description	Estimated Project Cost
****** Hudson River Drainage ******		
	No new construction projects this reporting period	-
****** Lake Memphremagog Drainage ******		
	No new construction projects this reporting period	-
****** Connecticut River Drainage ******		
Brattleboro	Sewer replacement	$ 2,600,000
Springfield	Combined sewer overflow abatement	$ 2,545,000
Bellows Falls	WWTF headworks improvements	$ 2,963,000
Hartford	Pump station upgrades & sewer rehabilitation	$ 1,383,000
Springfield	Combined sewer overflow abatement	$ 2,107,000
TOTAL COST		**$54,638,000**

Stormwater Management
In 2003, the Stormwater Program commenced an effort to address a backlog of 1,757 expired permits. As of December 2009, there are fewer than 20 outstanding permits out of over 2,700 permitted facilities.

The Stormwater Management Program issued 193 individual or general permits for new development or redevelopment projects in 2009 of which 175 were operational general permits. In 2009, Stormwater Program staff conducted 147 operational site visits of which 57% were generally compliant.

As of November 2009, all twelve of the urban TMDLs for stormwater-impaired watersheds have been approved by EPA. To develop the basis for the implementation plans for these TMDLs, the DEC undertook a multi-year effort to fully characterize these watersheds, and to establish a process for developing the most cost-effective remediation strategies. This process resulted in the November 2009 *Final Report - A Framework for Remediation of Vermont's Stormwater-Impaired Waters*.

As outlined in the "Framework" remediation of the twelve urban stormwater-impaired waters will commence through a combination of permits issued pursuant to Vermont's federally delegated National Pollutant Discharge Elimination System (NPDES) permitting program. (A full description of the current status of the stormwater TMDL implementation is in Chapter 3 below).

Stormwater MS4 General Permit
On January 22, 2010, the Department issued a draft General Permit (3-9014) for Stormwater Discharges from Municipal Separate Storm Sewer Systems (MS4s). This draft permit contains detailed stormwater TMDL implementation requirements, including a requirement that each MS4 permittee, in consultation with the Agency, shall work cooperatively with other MS4 permittees that discharge into the same stormwater-impaired watershed to develop and submit a single, comprehensive Flow Restoration Plan (FRP) for the watershed within the first three years of the permit.

The FRP shall contain the following elements: 1) an identification of the suite of necessary stormwater BMPs that will be used to achieve the flow restoration targets; 2) a design and construction schedule for the stormwater BMPs that have been identified as necessary to achieve the flow restoration targets; 3) a financing plan that estimates the costs for implementing the FRP and describes a strategy for financing the FRP; 4) a regulatory analysis that identifies and describes what, if any, additional regulatory authorities, including but not limited to the authority to require low impact development BMPs, the permittee will need in order for the permittee to implement the FRP; and 5) an identification of regulatory assistance that the permittee will need from the Secretary in order to effectively implement the FRP. Within ten years of the effective date of the permit, the permittee shall implement the measures identified in the Flow Restoration Plan as necessary to meet the flow restoration target.

Stormwater Residual Designation Authority (RDA) General Permit

The Department has also issued a NPDES RDA permit with TMDL implementation requirements to over 450 individual dischargers to five of the 12 urban stormwater-impaired waters pursuant to the Vermont Environmental Court's August 28, 2008 Judgment Order which granted CLF's 2003 "Petition for Determination that Existing Discharges in Potash, Englesby, Morehouse, Centennial and Bartlett Brooks Contribute to Water Quality Standards Violations and Require NPDES Permits." The Department notified these dischargers of their obligation to apply for permit coverage by December 16, 2009. These identified stormwater discharges go directly to these impaired streams and do not enter or commingle with the stormwater discharges regulated under the MS4 permit. The TMDL implementation requirements in the RDA permit are geared for three categories of discharges, including: Designated Discharges from Property with Existing Impervious Surfaces that are Subject to a Previously Issued State Stormwater Permit; Designated Discharges from Property with Existing Impervious Surfaces Greater than One Acre that do not have a Previously Issued State Stormwater Permit; and Designated Discharges from Property with Existing Impervious Surfaces Less than One Acre that do not have a Previously Issued State Stormwater Permit. The Department has created a "Small Sites Guide for Stormwater Management" to assist small property owners in meeting these requirements.

Nonpoint Source (NPS) Control

Erosion Control at Construction Sites

The total acreage of planned disturbance permitted in 2009 under the Construction General Permit (2,059 acres) was substantial, despite a decrease in new housing starts. The Stormwater Management Program conducted a total of 60 construction site visits during 2009. Construction site visits declined in 2009 from previous years due to a decrease in available staff and a decline in total construction activity. In response to instances of significant non-compliance, the Stormwater Program participated in the issuance of approximately six Notices of Alleged Violation (NOAV) during 2009 and was involved in several formal enforcement actions.

319 Nonpoint Source Management Program

Vermont has been able to effectively target areas, design work plans, compete for and capture funding and implement NPS projects directed at restoring and protecting water uses and values. In the eighteen years of Clean Water Act Section 319 NPS implementation funding (1990-2009), Vermont has received a cumulative total of about $23.3 million to implement a variety of activities.

The goal of the NPS management program is to encourage the successful implementation of best management practices (also referred to as "BMPs") by diverse interests such as farmers, developers, municipalities, lakeshore residents, landowners and riparian landowners in order to prevent or reduce the runoff of NPS pollutants. Effective BMPs can be structural, vegetative or management-based as well as regulatory or advisory.

Some notable activities carried out with Section 319 funding during this 305(b) reporting period include watershed restoration efforts carried out in various drainages by the Vermont Youth Conservation Corps, cover cropping demonstrations in northwestern Vermont and in the Winooski River drainage, assistance to farm producers in priority watersheds with management intensive grazing for clean water, strategic riparian planting efforts on streambanks deemed as "stable," continuance of a portable logging skidder bridge pilot program and funding assistance for municipalities for reducing sediment runoff from unpaved backroads. Importantly, the Program was able to assist a variety of locally-led efforts to improve water quality and/or habitat conditions (e.g. NPS phosphorus and sediment control in the watershed of Lake Carmi, Bennington area impervious surfaces initiative).

Because of the diffuse but widespread nature of NPS source pollution, there are several other important programmatic aspects that are prominent features of Vermont's nonpoint program. Some management elements are part of DEC while other elements are conducted outside of DEC. Examples of the former include stream stability assessments and floodplain management, construction sediment and erosion control, hazardous and solid waste management, responding to spills and leaks and the control of stormwater from construction sites and developed areas. Examples of the latter include logging erosion control carried out by the Vermont Department of Forests, Parks and Recreation and agricultural runoff control by the Vermont Agency of Agriculture, Food and Markets. The US Department of Agriculture is an important NPS management partner in both forestry and agriculture arenas.

Specific details regarding the NPS program and project activities are available from DEC's Water Quality Division. DEC has maintained a listing of Section 319-assisted project titles by funding year. Vermont will continue to pursue and apply Clean Water Act Section 319 NPS funding in targeted areas that are likely to result in the successful implementation of BMPs and programs and in the improvement of water quality.

Clean & Clear Initiative

The Center for Clean and Clear was established in May 2007 to enhance Vermont's commitment to improve water quality in Lake Champlain by placing the resources dedicated to water quality in Lake Champlain under a single director. The Center established a multi-agency core group to ensure a coordinated, collaborative approach, calling on partners and reaching out to broad public and private constituencies. In addition to staff from the Agency of Agriculture, Food and Markets (AAFM) and all three of ANR's departments, the core work group involves representatives from the U.S. Natural Resources Conservation Service and the U.S. Fish and Wildlife Service.

The Center also operates an Ecosystem Restoration Grants Program that focuses on projects to improve stream function and stability, restore riparian wetlands for water quality and wildlife benefits, and control stormwater runoff from developed land. Since 2007, the Center has received

more than 200 proposals and awarded partial or full funding to over 100 ecosystem restoration projects. Ecosystem Restoration Grants are strategically distributed to complement §319 grants.

The Center recently completed a revised implementation plan for the Lake Champlain Phosphorus TMDL, which was sent to the General Assembly on January 15, 2010. This was a significant undertaking which involved technical staff from multiple departments and agencies, and public participation by over 300 Vermonters.

The Center also provided leadership in drafting revisions to the Lake Champlain Basin Program management plan *Opportunities for Action.* The Center Director worked to ensure a high degree of commonality between the priorities established in the revised TMDL implementation plan and the forthcoming version of *Opportunities for Action*, and encouraged partners in New York, Quebec, and federal agencies to develop similar commitments to phosphorus reduction.

Best Management Practices (BMP)/Alternative Manure Management (AMM) Program

The BMP program of the AAFM provides financial cost-share assistance for the implementation of practices that allow for more efficient use of manure nutrients and proper handling of agricultural wastes in order to improve water quality and help farmers comply with regulations. Typically these practices require a substantial capital investment and otherwise would not be affordable without the state's assistance. Common practices include manure storage facilities, silage leachate collection and treatment systems, and clean water diversions. For projects that have been deemed as a significant water quality improvement and completed in 2009, the project was eligible to receive up to 90% of the approved cost of installation. In an effort to increase the buying power of state capital funds, the state partners with other programs such as the USDA Natural Resources Conservation Service's Environmental Quality Incentives Program, which also helps reduce the costs to the farmer.

The BMP program worked directly with 37 farms to install engineered practices. Approximately $1,400,000 was awarded to these farms in fiscal year 2009 with an average grant award of $40,000 per farm. Twelve farms received 90% cost-share for projects that provided significant water quality improvements. Roughly half of the farm projects implemented silage leachate collection and treatment systems or diversion of clean water around silage bunkers.

Similar to the BMP program, the AMM program provides financial assistance to more efficiently use manure nutrients on farms and to help improve the handling of agricultural wastes to reduce the overall risks to water quality. However, AMM projects are demonstrations that help to develop new waste management technologies. Of the $1.4 million spent in the BMP program, approximately $165,000 was committed for alternative manure management. The majority of the AMM practices contracted are anaerobic digesters; however one manure separator was installed.

Nutrient Management Plan Incentive Grant (NMPIG) Program

Established in 2005, the NMPIG program also of the AAFM was developed to help farmers meet the demand for nutrient management created by the new MFO Rules and anticipated LFO Rule revision. NMPIG grants span four years and include a payment for the development of a Nutrient Management Plan (NMP) and an additional three years of plan updates.

From FY 2005 through 2009, 249 grants have been approved to receive cost-share funding for implementing NMPs on more than 134,000 acres statewide. So far 178 grants totaling roughly 102,311 acres have completed the process of developing a nutrient management plan and were reimbursed for the plan development costs. Of these, 110 grants have completed at least one annual update and received the first reimbursement payment from the Agency. In 2009, 11 grants were approved for cost-share funding pending the approval of the final nutrient management plan.

Farm Agronomic Practices (FAP) Program

The Agency of Agriculture's FAP program was first made available in 2006 to help farmers implement those practices typically required when implementing a NMP. These soil-based practices improve soil quality, increase crop production, and reduce erosion and agricultural runoff from cropland. Fiscal year 2009 exceeded 6,500 acres of cover cropping and nearly 260 acres of conservation crop rotation. Fiscal year 2010 is already proving to be another record year for the program. To date, enrollment has increased compared to fiscal year 2009 and for the first time all allocated program funds have been obligated for FAP Program practices.

Conservation Reserve Enhancement Program and Vermont Agricultural Buffer Program

By establishing perennially vegetated buffers between agricultural land and surface waters, sediment-bound phosphorus in runoff can be intercepted before it reaches water. The Conservation Reserve Enhancement Program (CREP), a partnership with the USDA and U.S. Fish and Wildlife Service, provides financial compensation in order to encourage farmers to install these buffers and maintain them for 15 or 30 years. The compensation attempts to cover the replacement costs of the lost agricultural production and is paid in the form of rental and incentive payments. Enrollment in 2009 (220.1 acres) was down compared to 2008 (338.7 acres), however, 2010 enrollment started out very strong with 264.5 acres to date, an indication that many of the 2009 contracts were completed in the next fiscal year. Total enrollment (2002 through the end of fiscal year 2009) has reached 2,313 acres statewide.

The Vermont Agricultural Buffer Program (VABP) is similar to CREP as it provides financial compensation for the installation and maintenance of vegetated buffers along surface waters. Unlike CREP, VABP allows farmers to harvest the buffer at certain times of the year. Because CREP offers higher incentive payments, it remains the dominant of the two programs. In 2010, the Agency of Agriculture hopes to expand the potential of the VABP program to make intermittent streams and ditches eligible for filter strips and to add water and sediment control basins as a practice that can be installed in ditch networks. These changes will help address erosion issues by improving ditch maintenance.

Agricultural Regulatory Programs to Protect Water Quality

Rules regarding Accepted Agricultural Practices (AAP), Medium Farm Operations (MFO) and Large Farm Operations (LFO) comprise the regulatory tiers of the Agricultural Water Quality Program and are designed to prevent discharges containing phosphorus and nitrogen. AAPs are a base level of management required of all farms regardless of size, type or location. Recent changes to the AAPs include a mandatory 10 foot buffer on all riparian cropland. Other changes include criteria for nutrient and pesticide storage, soil testing and riparian pasture management. MFOs are subject to an increased level of management because of the potential impact that greater numbers of animals can have being confined in a single area. Revisions to the LFO rules for nutrient management and waste storage structures became effective in 2007.

The AAFM conducted 120 initial facility evaluations between January and May of 2009 to check for compliance with the MFO general permit conditions. Starting in August, 24 follow-up inspections were performed on those operations. Twelve of the follow-up inspections were conducted in cooperation with the Department of Environmental Conservation to check for compliance with both the state MFO general permit and the Federal Confined Animal Feeding Operation (CAFO) program requirements. As a result of these follow-up inspections, the Agency issued corrective action letters to six medium farms.

In 2009, each of Vermont's 20 permitted large farm operations received at least one inspection to determine compliance with their individual LFO permit conditions, while 6 LFOs received additional inspections to confirm compliance with buffer requirements for a total of 26 compliance inspections. In addition, 4 inspections were conducted to confirm compliance with enforcement actions taken in 2008 and another 4 LFO inspections were conducted in response to complaints from the public. Agency staff also accompanied the U.S. Environmental Protection Agency on five inspections of Vermont large farms in order to assess compliance with the Federal CAFO permit requirements. As a result of compliance inspections conducted by Agency staff, six LFOs received enforcement actions: assurances of discontinuance (AODs) were issued to three farms, letters of warning (LOW) were issued to two farms, and one farm received an administrative penalty and an assurance of discontinuance.

River Management

Analysis of stream geomorphic assessment data collected during the first five years of the Clean and Clear Program is providing important information. Of the nearly 1,400 assessed river miles in Vermont, nearly three-quarters have become confined to deeper, straighter channels and no longer have access to historic floodplains. In response, DEC's River Management Program now emphasizes an avoidance strategy to pre-emptively address potential declines in river stability by promoting and investing in river corridor protection. Corridor protection in combination with the active removal of physical constraints (e.g., berms, floodplain fills, and undersized bridges/culverts) are the mainstays of the River Management Program restoration efforts.

The River Management Program, in collaboration with the state's regional planning commissions, leverages Clean and Clear funding annually to attract Federal Emergency Management Agency (FEMA) Pre-Disaster Mitigation Program planning grants that support corridor protection. A River Corridor Easement Program has been established in Vermont to conserve river reaches identified as high priority sediment and nutrient attenuation areas. To date, the program and land trusts have completed, or nearly completed, easements on 12.35 miles of river.

Better Backroads

The Better Backroads Program helps control phosphorus and sediment runoff by assisting towns with improved road maintenance and construction techniques and grants to implement them. Grants pay for bank and ditch stabilization and culvert upgrades, all of which stem erosion and decrease the transport of pollutants. A total of $397,000 in Better Backroads Program grant funds was awarded to Vermont towns and other organizations in 2009 for inventories, capital budget planning, and erosion correction projects, including the stabilization of ditches, culverts, and roadside banks. The Vermont Better Backroads Program continues to grow annually with 65 new towns participating with Clean and Clear funding between 2005 and 2009. Statewide 63% of Vermont towns have applied for and received a grant at some point.

Municipal Water Quality Protection Technical Assistance
The Vermont League of Cities and Towns (VLCT) Water Quality Coordinator, funded through the Clean and Clear Initiative, has continued to work with towns primarily in the Lake Champlain Basin providing technical assistance to support water quality enhancements to town zoning regulations and other municipal ordinances. In 2009, the Coordinator provided assistance to 45 towns within the Lake Champlain Basin and nine towns outside the basin. Currently 68 of the 136 Lake Champlain watershed towns have some to many water quality protection provisions in their local zoning regulations.

In 2009, the VLCT Water Quality Coordinator helped eight communities in Chittenden and Washington Counties exceed minimum NFIP standards through updating their flood hazard regulations. In addition to decreasing exposure to inundation and flood erosion hazards, these enhanced flood hazard regulations will better protect the floodplains in the Lake Champlain Basin. The VLCT position and the associated work has been cut from the Clean and Clear budget.

Forest Management
Department of Forests, Parks, and Recreation staff continued to work with the Vermont forest industry to support compliance with forestry Acceptable Management Practices (AMPs) for maintaining water quality. Technical assistance was provided to forest landowners and loggers during investigations of possible violations. Department staff also conducted and participated in AMP and Forest Water Quality workshops for 144 loggers or landowners during 2009.

The Portable Skidder Bridge Initiative provided opportunities for loggers to loan or rent bridges for temporary stream crossings on log jobs to protect water quality. During 2009, nearly 20 bridges were rented or loaned for use by loggers. Demand for bridges and logger participation in this program is expected to increase.

Wetland Protection and Restoration
To date, through the Clean and Clear program, Vermont has dedicated $1 million to wetland protection and restoration projects. In addition, changes enacted as part of the 2008 Farm Bill dramatically increased the amount of federal funding available for wetland protection and restoration through the Wetlands Reserve Program (WRP). The 2008 Farm Bill has made available more than $2 million annually for Vermont projects representing a five-fold increase in available federal funds. As a result of this increased funding and interest in WRP, Clean and Clear has shifted its focus to the active support of NRCS in seeking new sign-ups for WRP. Wetland Section staff have also been providing technical assistance on restoration projects to assist landowners and NRCS staff. The availability of WRP funds has greatly accelerated the rate at which wetland protection and restoration projects are being developed and completed. The program had approximately 315 acres of new sign-ups for wetland restoration projects during 2008, and an additional 940 acres were enrolled in 2009.

Wetland Management
In 2010, the Vermont Significant Wetland Inventory Maps were officially updated from revisions to the National Wetland Inventory. All town wetland mapping projects are also now available on-line. Due to changes in the Wetlands Statute, Act 31 gives the authority to the Agency of Natural Resources to update the maps on a continual basis, and gives ANR the authority to determine the classification of Class II and Class III wetlands.

Costs and Benefits of Water Pollution Control Programs

Point Sources

The total commitment and expenditure of state, federal and local funds for all municipal wastewater treatment facilities and appurtenances to date has been approximately $693.6 million. These facilities have improved the quality of 59 rivers and 3 lakes for such uses as swimming, fishing, boating and aquatic life. The $693.6 million figure includes the $54.6 million in improvements which started construction during the 2010 305(b) reporting period. Refer to Table 4 for the location and estimated cost of recent improvements.

The money spent on stormwater pollution clean-up has included geomorphic assessments, subwatershed mapping, flow and precipitation monitoring, and modeling work in impaired watersheds in order to develop the best management practices needed to understand the impairment and clean up the streams. To date, at least 1.39 million dollars have been spent on the stormwater impaired streams through grants and contracts for the work described above.

In addition, over 14 million dollars have been spent in private and/or public projects in about 16 towns retrofitting existing stormwater systems or enhancing stormwater treatment. Some of this work has provided stormwater offsets for new development by allowing the developers to purchase their offset credits rather than find an appropriate project themselves.

Nonpoint Sources

Unlike point sources, quantifying the financial resources spent on nonpoint source control of pollutants is not as easy to determine or link to specific river miles/lake acres of improvement. This is due to several factors: contributions of resources come from various state, federal and local agencies as well as from landowners, volunteer groups, foundations, businesses; NPS controls take many shapes and forms and can be applied as structural or non-structural measures; some NPS controls may be implemented one year and not applied the following year (e.g. cover crops); some NPS efforts are focused on education as a way to encourage adoption of recommended practices.

Funding for the two CWA programs under DEC administration from 1989 through 2009 has amounted to about $1.1 million (604b) and over $23 million (319). The 604b Program's 40% pass-through has helped the 11 Vermont regional planning commissions (RPC) conduct a wide variety of water quality planning related activities. In 2009, Section 604b funding was increased by $194,000 as a result of money arising out of the American Recovery and Reinvestment Act of 2009. Forty percent of that amount was distributed to the RPCs and linked to low impact development planning purposes. A portion of the 319 Program has, year to year, provided varying levels of funding to governmentand non-profit organizations to carry out a wide variety of NPS implementation efforts.

The notable state funded program (aside from Clean and Clear) is the Vermont Conservation License Plate Program. In the 11 years of its existence (1998-2009), the program has awarded close to $645,000 in state monies to many diverse groups for a wide variety of water quality or aquatic habitat projects. Many of the license plate funded projects provide water quality and/or aquatic habitat benefits that have some connection to NPS management.

Chapter 3. Major State Surface Water Quality Issues

This chapter summarizes a number of the significant state surface water quality and aquatic habitat issues in Vermont. The issues below are presented in an unranked and unprioritized manner.

Stormwater TMDLs Implementation

The Water Quality Division has been actively engaged in developing EPA-approved TMDLs for Vermont's twelve urban stormwater-impaired watersheds and preparing water quality remediation plans (WQRPs) for five mountain stormwater impaired watersheds. This effort is required by the federal Clean Water Act, which provides that a TMDL or equivalent water quality remediation plan must be prepared for each 303(d) listed impaired waterbody. The Department has now completed EPA-approved hydrologic TMDLs for the twelve urban watersheds and is continuing to work with responsible parties developing watershed-specific WQRPs for the five impaired mountain watersheds.

The Department was statutorily required to issue permits to implement the stormwater TMDLs and WQRPs by January 2010. It is crucial to recognize that there are no national models of TMDL implementation plans of the scale, nature and cost being requested of the Department. The number and scope of stormwater best management practices (BMPs) required to meet the TMDL flow reduction targets in these highly developed watersheds will be significant.

In order to increase the chance of successful implementation, the Department has taken a reasoned approach by exploring the issues and complexities of implementation, identifying the scientific uncertainties, developing a best management practice decision support system to identify different BMP options and associated costs, researching the necessary components and benefits of different implementation plans, and actively engaging stakeholders. In an effort to develop the most scientifically sound, cost-effective and administratively feasible implementation plans that will serve as the foundation for issuing permits, the Department has conducted extensive research on TMDL implementation approaches, including permitting options, from around the country. In April 2008, the Department also reconvened the Stormwater Advisory Group (SWAG) to discuss implementation issues, approaches, and strategies. Active SWAG participants included representatives of state agencies (including VTrans and Act 250), the U.S. Environmental Protection Agency, Conservation Law Foundation, Vermont Natural Resources Council, affected municipalities (including Burlington, Winooski, Essex, South Burlington, Colchester, Shelburne, Rutland, St. Albans), the business community, individual homeowners, consulting firms, UVM, Lake Champlain Committee, and regional planning associations.

In sum, the Department believes that without careful and thoughtful planning, implementation will fail. Moreover, without a strong and reliable funding mechanism, implementation will be very difficult. The Department's implementation framework set out below is supported by EPA guidance and by case studies of TMDL implementation efforts around the country.

The main elements of the Department's implementation framework include:

- Reissuance of the MS4 (municipal separate storm sewer system) permit by early 2010 with TMDL implementation requirements.

• Work with MS4 permittees to develop watershed-specific BMP plans that will identify the most cost-effective, feasible, and technically-sound stormwater treatment and control projects, and develop a priorities schedule for implementation.

• Work with MS4 permittees to identify "low-hanging" cost effective BMPs for implementation by the MS4 permittees while watershed-specific BMP plans are being developed.

• Creation of watershed-specific BMP plans that identify who will have responsibility for implementation of site specific BMPs. The MS4 permit will place initial responsibility on the MS4 permittees for controlling discharges from the MS4 system to the impaired streams to meet the TMDL targets. The permit will recognize that responsibility for site-specific BMP implementation may be shifted to either a local or regional utility or to individual dischargers into the MS4 system as necessary to ensure implementation. The Department may exercise additional residual designation authority as necessary to ensure that any private dischargers into the MS4 system that are identified as a necessary component of BMP implementation participate in implementation activities.

• Issuance of a final NPDES stormwater permit by the end of 2009 for designated dischargers notified by ANR on June 19, 2009 pursuant to the Environmental Court Judgement Order discussed below.

• Acknowledgment that the Department will use staged adaptive implementation and management in TMDL implementation.

• Continuing to pursue federal funding for implementation activities.

• Continuing to work with responsible parties in developing Water Quality Remediation Plans (WQRPs) for Vermont's five stormwater-impaired mountain watersheds.

In November 2009, the Department issued General Permit 3-9030 for Designated Discharges to the Bartlett, Centennial, Englesby, Morehouse and Potash Brook watersheds. This general permit was issued pursuant to the Department's federally-delegated NPDES program. Coverage under General Permit 3-9030 is required for designated discharges to these five watersheds if the discharge is not covered under the NPDES MS4, another NPDES permit covering stormwater discharges, or has been issued a state stormwater discharge permit resulting in no net contribution to the receiving water. The General Permit has different requirements for three specified categories of discharges including properties previously issued a state stormwater permit, properties with greater than one acre of impervious surfaces, and properties with less than one acre of impervious surface.

Climate change and water/wetland resources

The impact of climate change on water quality is an emerging issue for Vermont. There is general consensus among the scientific community that changing climatic conditions are the result of increased levels of greenhouse gas concentrations in the atmosphere over the last century – much of which are due to anthropogenic sources including industrial processes, combustion of fossil fuels, and land use changes.

It is also recognized that climate change can affect air and water temperatures and precipitation patterns, which will cause alterations to water quality, hydrology and water availability, resulting in impacts to ecological integrity and human infrastructure. Higher surface water temperatures reduce levels of dissolved oxygen, creating a condition of hypoxia, disrupting life cycle thermal cues, and directly affecting organism metabolic rates, all of which can be harmful to aquatic life.

Additionally, climate models for the northeast predict changes in hydrologic conditions, brought on by a greater frequency of extreme precipitation events, reduced snowpack, and drought conditions. The US Global Change Research Program's *The New England Regional Assessment of the Potential Consequences of Climate Variability and Change* published in 2006, reports that New England is expected to experience increases in periodic drought and flooding, with an increase in regional precipitation by as much as 30%. The heightened frequency of severe precipitation events could increase pollution and sedimentation from runoff and geomorphic instream channel adjustment. Greater runoff, coupled with expansion of impervious surfaces, could exacerbate flood risk and contamination from the overload of stormwater and wastewater systems.

Higher air temperatures and increases in the frequency of periodic drought will lead to greater demand for new and more reliable water supplies, which in turn, could cause further impacts to surface water quality, ecosystem functions of wetlands, riparian areas, and floodplains, and natural stability of the state's river systems. Climate change is also thought to foster shifts in native natural communities' makeup and range, greater influx of non-native invasive species, and a greater frequency of cyanobacterial blooms.

We could also expect significant and costly impacts to infrastructure, including dams, bridges, culverts and road ditches, roads, embankments, and stormwater systems, which could raise serious concerns for public safety. In fact, flooding associated with the failure of dams and undersized stream crossing structures are the most common cause of flood-related fatalities in Vermont.

One of the bigger challenges in confronting climate change impacts to such infrastructure concerns the issue of "non-stationarity" – that is, the understanding that the magnitude, timing, and pattern of rainfall, runoff, and streamflow will be different from what is shown in the historical record. Engineering methods and runoff assumptions rely on historical precipitation and hydrologic data, including design, sizing, and operating parameters for stormwater treatment, floodplain mapping, and bridges and culverts. Stationarity implies that the future is statistically insignificant from the past, and therefore, that the historical record is the best guide to expectations in the future. If the impacts of climate change on hydrologic variables mean that historical data are becoming less representative of future conditions, additional uncertainty will need to be incorporated into the design and operating parameters of stormwater and other infrastructure. In the short term, Vermont

will take steps to incorporate more recent hydrological and precipitation data into design calculations and runoff modeling, such as the Northeast Regional Climate Center's update to extreme rainfall intensity duration curves, expected to be made available in 2010.

Figure 2 summarizes the frequency of major flooding and associated damages in Vermont from 1955 through 2008. Note the dramatic increase in the number of damage-causing flood events in more recent years. Certainly, the increase in frequency of flood damage could be attributed to greater development in flood-prone areas, as well as chronic instability from historic and current channelization practices, such as channel straightening, dredging, bank armoring, and berming. A climatic shift in extreme precipitation events may also be having an effect. A closer evaluation of hydrologic and precipitation data will be necessary in order to more effectively isolate the impacts of climate change.

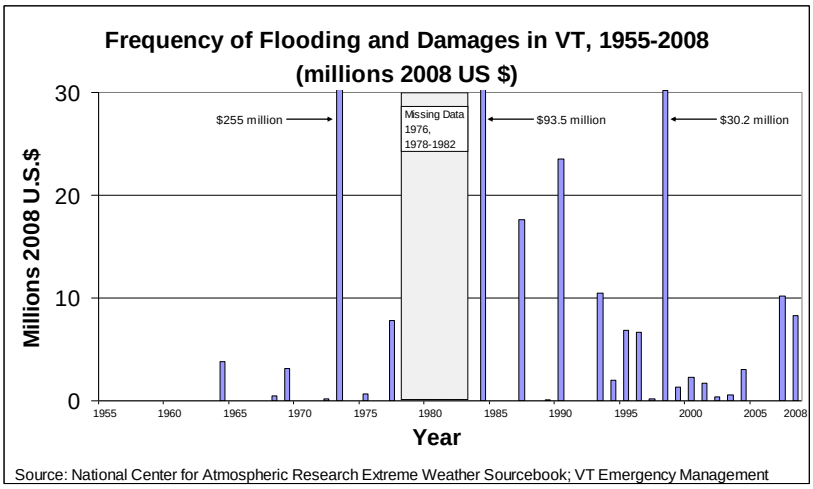


Figure 2: Frequency of Flooding and Magnitude of Damages in VT

The Vermont Water Quality Division is committed to undertaking the following initiatives to more effectively address water quality impacts associated climate change:

- Develop and implement a monitoring strategy to gather data on the impacts of climate change on the state's water resources and aquatic communities;
- Work with the Climate Change Collaborative – the partnership among state government, academic institutions, non-governmental organizations, and the private sector;
- Continue to manage Vermont streams toward achieving and maintaining geomorphic equilibrium (or naturally stable) conditions;
- Continue to promote policies and projects that protect key flood attenuation assets, such as floodplains and wetlands;
- Evaluate and amend plans, policies, and programs to more effectively manage conditions resulting from climate change;
- Foster public education and outreach initiatives to raise awareness and support for initiatives to mitigate impacts and promote sound adaptation planning;
- Provide technical assistance and incentives for municipalities to increase public understanding of climate change impacts and participation in strategies to: (a) plan for extreme precipitation events, (b) protect vulnerable water resources, (c) conserve the natural and beneficial functions of water resources, and (d) improve the local resilience to climate change impacts; and,
- Establish "adaptive management" mechanisms to monitor aquatic resources, stressors, and climate indicators and, where appropriate, modify strategies to continue to protect vulnerable water resources from the impacts of climate change.

Dams and Hydroelectric Facilities

There are over 1,200 inventoried dams on Vermont's rivers, streams and lakes. Recent stream assessments indicate that there are many more that are not included in the state dam inventory. While many of these dams continue to serve one or more useful purposes such as recreation, flood control, water supply and hydroelectric power generation, many more, literally hundreds, do not.

Most of the dams that are no longer serving a useful purpose were built many years ago, often to provide power for a mill that has long since ceased to operate and may no longer exist. The dams remain, and continue to have significant ecological impacts. Fundamentally, these dams change free-flowing streams to unnatural impoundments, having an impact on species that depend on river habitat for their survival. Specific impacts include:

- The larger surface area of the impoundment and generally shallower water often results in higher water temperatures in the impoundment and downstream, which can be detrimental or even fatal to species such as brook trout.
- The loss of turbulent flow may reduce the dissolved oxygen concentration. If the impoundment stratifies, the dissolved oxygen level may be further reduced.
- The movement of fish and other organisms both downstream and upstream can be limited or completely blocked.
- Natural sediment transport dynamics are interrupted and sediment accumulates in the impoundment.
- The natural flow regime can be altered.

In recent years, there has been increasing interest in removing dams to eliminate the ecological impacts of these structures. In addition to the ecological benefits, removal of old, unused dams resolves other issues including public safety (dams may exacerbate upstream flooding and many are poorly or not maintained) and economics (the cost of dam ownership to towns, the state, and private individuals can be significant).

Beginning in 2007, there has been increasing interest in developing hydroelectric power facilities at existing dams. This interest is part of a larger movement to develop new renewable energy sources in response to increased awareness of global warming and energy scarcity. The current situation is not dissimilar from that of the early 1980s, when public policy and economic incentives led to the development of 35-40 new hydroelectric projects in Vermont.

One major difference is that the sites that remain are less desirable from an economic perspective either because they have less head or are on smaller streams with less water or both. Most of the project proposals to date have been small, 100 kW or less. Incentives of various kinds (grants, preferential electric rates and tax incentives) will help the economics, but many of the sites that are being evaluated are likely to remain uneconomical even with incentives.

Another difference is that small-scale community energy projects seem to be very popular, especially among town energy committees that have been forming in the last few years. Consequently, many projects are being managed by citizens who are unfamiliar with the technical and regulatory issues associated with developing a hydropower project. They face the additional challenge of working with very tight financial constraints and they are often unable to engage

experienced engineering consultants to help them determine if their project is feasible and work through the design, permitting and construction process. Even if a project is not economically viable, there is often a belief that the economics will improve as the cost of energy increases over time.

Finally, there is a general lack of understanding about the impacts of dams and hydroelectric power development on rivers. Without understanding that the impacts of dams on river ecology make them one of the most significant alterations humans have wrought on river systems, the benefits of the renewable energy provided look environmentally sound. Depending on the design and operation of a hydroelectric facility, the original impacts of the dam itself can be multiplied by increased flow regulation and dewatering of reaches between the dam and powerhouse. A small facility does not necessarily mean there will be a small impact. However it does mean that the amount of energy produced will be relatively modest with the aquatic impacts from the hydroelectric facility remaining the same.

What does all this mean for Vermont's water resources? The laudable goal of doing something to reduce the production of greenhouse gases is creating a situation where the process of restoring rivers and streams that began with passage of the Clean Water Act could be undermined as dams that might otherwise have been removed are redeveloped or retained for future development. These dams will continue to fragment our rivers and streams at a time when restoring their continuity so they are more resilient and resistant to the effects of global warming is essential.

Atmospheric deposition of pollutants

Deposition of pollutants (mercury and low pH) to the Vermont landscape from the atmosphere is principally responsible for the impairment of fish consumption uses on 8,115 inland lake acres, all of Lake Champlain and 66 river and stream miles. Deposition of pollutants from the atmosphere impairs aquatic life uses on 4,420 lake acres. The two causes are linked, since in many instances, lakes that are vulnerable to acidification are also those which transfer atmospherically deposited mercury to the aquatic food web in the toxic methyl- form. However, many lakes that are not at risk of acidification exhibit elevated mercury levels in fish and wildlife.

Regional and long-range emissions of acid-forming precursors cause acidification of Vermont waterbodies. The atmospheric deposition of nitrous oxide (NO_x) and sulfate (SO_4) from midwestern sources (and NOx from regional and mid-Atlantic mobile sources) has resulted in acidification of 34 lakes and at least eight streams within Vermont. In Vermont, the potential for acidification is measured by direct measurement of pH as well as corollary measures such as acid neutralizing capacity, NO_x, SO_4 and others. Deposition of SO_4 and lake SO_4 concentrations are presently decreasing, although evidence of alkalinity increases and de-acidification is very limited in Vermont. All of the acid-impaired lakes are subject to an approved TMDL that address sources of the acid-forming precursors. Regionally, there is evidence of improvements in lake pH concentrations, although these changes have been slower to be manifested in Vermont. Vermont continues to monitor acid-impaired lakes to track these improvements.

Atmospheric deposition of mercury has resulted in the issuance of fish consumption advisories for many Vermont lakes and rivers, particularly those containing walleye. In 2007, the Vermont Department of Health issued a new fish consumption advisory incorporating results of fish tissue monitoring programs up to 2006. Important new contributing datasets included the U.S. EPA Connecticut River Fish Tissue Survey and ongoing monitoring by the Agency of Natural Resources. Some of the refinements to the advisory include new guidance on the consumption of the largest yellow perch, a minor relaxation in the suggested allowable meals-per-month of certain other locally-caught fish species, and minor modifications to specially-identified waters. Specific advisories are in place for Lake Champlain, the five Deerfield River waterbodies, for Moore and Comerford Reservoirs within the Fifteen Mile Falls Project on the Connecticut River, and for the Hoosic River. Guidance is provided for species where monitoring data were previously unavailable, such as the white sucker. The advisory is in Appendix A of this report.

The impacts of mercury deposition are not limited to loss of fish consumption uses. Reproductive and behavioral impacts to wildlife that feed on fish are common to a subset of New England lakes, including the reservoirs along the Deerfield River and Connecticut River (Fifteen Mile Falls). In Vermont, research published by the Hubbard Brook Research Foundation in 2007 identified the Fifteen Mile Falls project area as a documented mercury hotspot, and the Deerfield River area as an "area of concern." In these areas, mercury is known or highly likely to impact more than a single biological guild. Potential impacts to upper trophic level biota continue to be monitored by the Vermont Loon Recovery Project, in collaboration with the Biodiversity Research Institute.

The mercury that affects Vermont's watersheds is largely derived from mid-Atlantic or mid-western sources: principally coal-fired electric generating units; non-regulated waste combustors; and smelters. In 2007, the New England States and New York, in cooperation with NEIWPCC, issued a regional mercury TMDL addressing virtually all waters in the northeast. The TMDL articulates the need for a 98% reduction in anthropogenic mercury emissions from in and out-of-region sources, beginning with the base year 1998, in order to reduce mercury concentrations in smallmouth bass to EPA criteria levels. Since 1998, mercury emissions from within New England have declined by 71%, largely due to regulation of waste incinerators within New England. In addition, mercury in effluent and sludge is declining in light of programs to control losses of dental mercury to wastewater systems. These reductions significantly exceed the Phase I targets established in the TMDL implementation plan. Vermont and the Northeast States are presently implementing the TMDL through a variety of regulatory mechanisms.

DEC continues to participate in several regional mercury monitoring, research, and assessment projects including a mass-balance modeling effort for mercury in Lake Champlain and the regional "MERGANSER" mercury modeling project. With significant assistance and support from DEC, the Vermont Advisory Committee on Mercury Pollution continues to identify areas in Vermont where mercury use, emissions, and exposure can be reduced, and is active in advising the Vermont General Assembly on the efficacy of newly-passed mercury-related legislation for Vermont. Finally, DEC staff continue to interact with Vermont's congressional delegation to address this issue from a national perspective.

Despite these many efforts, there remains a significant need to properly assess inland Vermont waters for mercury contamination. During the prior reporting period, and in response to a

legislative directive, the Vermont Fish Contaminant Monitoring Committee had prepared a comprehensive fish mercury monitoring plan. This plan remains has yet to be implemented. Under the monitoring plan, Vermont would implement a six-year rotating tissue assessment program that would yield a stream of new fish tissue data on a biennial basis. In addition, Vermont would adopt a new, non-lethal approach of using biopsy-plugs for fish mercury testing. Department staff received valuable training from EPA during the reporting period on the use of this technique. In addition, the Department is appreciative of EPA's ongoing assistance to analyze mercury samples using the "direct mercury analyzer" that is now resident at the New England Regional Laboratory in Massachusetts. Department staff hope to continue to tap into this important resource to facilitate monitoring of mercury in multiple types of samples to meet management needs.

Lack of strategic statewide vegetated buffer requirements

Undisturbed vegetation along rivers and streams and lake shorelines is quite effective at reducing pollutants from reaching surface water. Areas of undisturbed vegetation along water also provide numerous other functions and values. Other than Act 250 development permit conditions, there are no statewide requirements that riparian landowners must maintain a minimum width of vegetation along bodies of water as there are in all other New England states. As a result, many miles and acres of Vermont's surface waters are negatively influenced by developed land runoff, sediment, increased temperature, fertilizers, manure, and other pollutants. Additionally, removal of shoreline vegetation negatively affects habitat conditions in the stream or lake and on the bank and shoreline. These effects can be reduced or eliminated by properly maintained vegetated buffers.

The Agency and DEC continue in the educational effort to inform the public and municipal planning commissions about the environmental benefits of riparian trees, shrubs, herbaceous vegetation, and duff. The Vermont League of Cities and Towns (VLCT), DEC and Regional Planning Commissions have been working with municipalities to strengthen their municipal plans and zoning regulations to maintain vegetated buffers on streams, lakes, ponds, and within protected river corridors. Model riparian buffer, lakeshore, and river corridor protection ordinances have been produced by DEC and VLCT, which hosts a Clean and Clear funded Water Quality Coordinator to focus on municipal zoning and water quality. Workshops for town officials and the general public have been conducted regarding strategies to encourage the maintenance of existing riparian vegetation as well as promoting the planting of riparian areas lacking vegetative buffers. The Agency of Natural Resources has a "Buffer Procedure," finalized in 2005, that is used in the Act 250 and Act 248 processes and that serves as guidance to riparian landowners, including public and quasi-public agencies.

DEC, the Vermont Youth Conservation Corps, the various Natural Resources Conservation Districts, watershed groups and other volunteer groups have worked on many stream and lakeside planting projects around the state. EPA 319 and Clean and Clear funding are being used to support the "Trees for Streams" program developed and coordinated through Natural Resource Conservation Districts. Trees for Streams targets those riparian buffer revegetation projects identified in river corridor plans where woody vegetation may be the most effective way to minimize bank erosion where streams are otherwise in equilibrium condition.

Floodplains and Surface Water Protection

Stream geomorphic assessment data from 2002 to 2009, quality assured by DEC, are now available in sufficient quantity to help explain the habitat alteration in many rivers in Vermont. Data, including the stage of stream channel evolution (Schumm 1984), demonstrate vertical and lateral channel adjustment processes that alter aquatic and riparian habitats. Stages II through IV (see Table 5) represent departures from equilibrium conditions and, therefore, where floodwaters lack access to a floodplain and the attenuation functions of the floodplain are reduced. Table 5 shows that 75% of the 1,090 river miles assessed at the "Phase 2 level" in Vermont lack access to a floodplain during the frequent or annual flood. In many of these river miles, channels are deeply incised, and even the large infrequent floods are confined within the channel.

Table 5. Miles of stream in different evolution stages

Stream Evolution Stage	**Stream Evolution Condition**	**Number of Miles**	**Percent Length**
I	Equilibrium	250.6	22.98
II	Incised & steepened	222.6	20.41
III	Incised & widening	424.9	38.96
IV	Incised & depositional	168.5	15.45
V	Equilibrium w/terraces	24.0	2.20
Total		**1,090.6**	**100**

In addition to erosion hazards, which dramatically increase when flood energy is unable to reach the floodplain, channelization and incision lead to a loss of sediment storage and an overall export of life-giving soil and nutrients from a watershed. Rivers that have downcut and lost access to their floodplains will erode their banks and transport anything that enters them until stream power is reduced through the floodplain formation process. The erosion and transport of bed and bank materials and woody debris stored within the channel represents a loss of aquatic and riparian habitat. Excess stream power may result in loss of stream bed undulations and the formation of a plane bed channel morphology. The loss of deposition and convergent flow patterns leads to a loss of pools and therefore a loss of riffles and rock steps. Many river miles in Vermont are in the stages that follow channel incision (Stage II) when plane bed channels widen then slowly begin to store the materials that serve as food and cover for aquatic organisms. Reference habitat is restored when channel slope, depth, and floodplain access return to the range associated with dynamic equilibrium, and flow and sediment regimes are in balance.

Without floodplains and river meanders, it is often the lakes and reservoirs that are the first quiet waters into which rivers deposit the eroded soil and nutrients. This lack of storage helps to explain the increasing eutrophication and algae along the shores and bays of Lake Champlain. The Agency's goal of a healthy Lake includes an objective to restore floodplain function, which is being pursued through landowner and municipal incentives to protect river corridors. Meanders and floodplains are essential to stable streams and sustainable water quality management.
Erosion and sedimentation have been listed as the number one cause of stress and impairment of aquatic life use support since Vermont began reporting the impacts of nonpoint source pollution. Sources have been reported to include entrainment of sediment in overland sheet runoff from cropland and construction sites; the erosion associated with concentrated stormwater; and

streambank erosion. While streambank erosion has been correctly associated with the loss of riparian woody vegetation, in most stream networks it is more complex with channel incision often at the heart of the problem (see continued discussion in Chapter 4).

The human activities that lead to channel disequilibrium and incision are many but may be categorized as those that:

1) decrease sediment supply (e.g., the creation of "hungry" water below dams, diversion, and undersized stream crossings);
2) increase peak flows (e.g., stormwater increases associated with impervious cover);
3) increase channel slope and/or depth (as a result of channelization practices like dredging, berming, straightening, and armoring of the stream channel); and
4) decrease channel roughness (e.g., dredging course bed sediments and removing woody debris and riparian vegetation).

Stream geomorphic data collected over the past five years provide an opportunity to add detail to Vermont's assessment of sedimentation sources and the BMPs required to remediate these stresses and impairments. Appendix C contains a description of the Agency's Lamoille Valley Rail Trail levee removal project which exemplifies the value of floodplain function and includes data on sediment and nutrient storage resulting from the project.

The Agency is pursuing river corridor protection as the primary BMP to restore and protect dynamic equilibrium in rivers. River corridors consist of lands adjacent to and including the present channel of the river. Delineations are based primarily on floodplain function, the lateral extent of stable meanders, i.e., the meander belt width, and a wooded riparian buffer to provide streambank stability. The meander belt width is governed by valley landforms, surficial geology, and the length and slope requirements of the river in its most probable stable form.

River corridor delineations are provided to landowners and town, state, and federal agencies as a science-based river and riparian land use planning and management tool to reducing current and future near-stream investment. River corridors are being protected in Vermont primarily through municipal adoption of fluvial erosion hazard (FEH) zoning and river corridor easements. Appendix D contains the Agency's progress to date with both the FEH and easement programs.

Lakeshore development and alteration of littoral habitat

The Vermont Water Quality Standards' Water Quality Criteria require no change from the reference condition that would prevent the full support of aquatic biota and aquatic habitat uses. The recent Littoral Habitat Assessment and Vermont Lakes Survey conducted by the Lakes and Ponds Section quantifies habitat parameters that can be used to evaluate whether these standards are being met in the ecologically important littoral zone of lakes. Unbuffered development has been identified as a common and widespread threat to Vermont lakes since the first lake assessments began in 1989. Vermont does not have statewide shoreland protection regulations and only 9% of towns have any sort of lakeshore buffer zoning regulations, therefore the majority of lakeshore development results in removal of the native vegetation along the shore.

The Littoral Habitat Assessment study was designed to determine what, if any, change in littoral biota and habitat was caused by unbuffered lakeshore development by comparing these sites to undeveloped shores (e.g. native woodland) and buffered developed sites. Forty lakes were studied. Eight lakes from each of five lake classes representing the majority of lake classes in the state were studied: small (<200 acres) oligotrophic, small mesotrophic, small dystrophic, large (>200 acres) oligotrophic, and large mesotrophic. The amount of unbuffered shoreline on each lake ranged from zero (reference lakes) to 74%. Unbuffered developed sites were paired with reference (naturally buffered) undeveloped sites with similar slopes, sediments and exposure. This design enabled DEC to quantify the biological and habitat features found off naturally buffered reference sites and then determine how much change unbuffered development causes to littoral habitat and biota. Figure 3 shows the statistically significant changes measured across all 40 study lakes. These findings show that, at least at the site level, aquatic habitat has changed significantly from the reference condition.

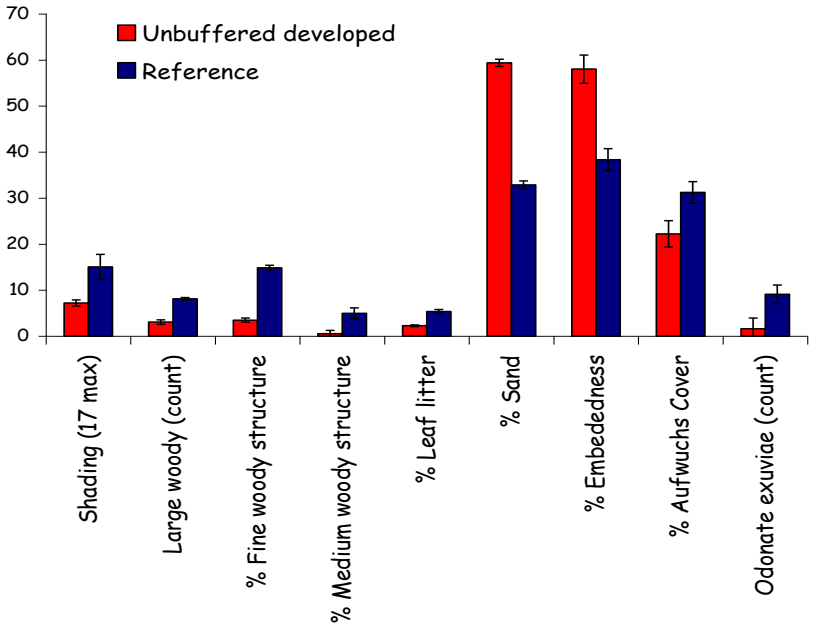


Figure 3. Mean and SE of littoral habitat and biota measured across all unbuffered developed sites (n=151) and all reference sites (n=234). All parameters show statistically significant difference when comparing developed vs. undeveloped sites.

In order to determine whether retaining a buffer on developed lakeshore mitigates the changes unbuffered development causes to littoral habitat and biota, 48 buffered developed sites were sampled on the eight large oligotrophic study lakes in 2009. Results are presented in Figure 4. With the exception of percent cover of fine and medium woody structure and aufwuchs, all the other littoral habitat and biotic measurements off buffered developed sites were not significantly different from the reference condition. These results indicate that a buffer conserves the majority of habitat indicators.

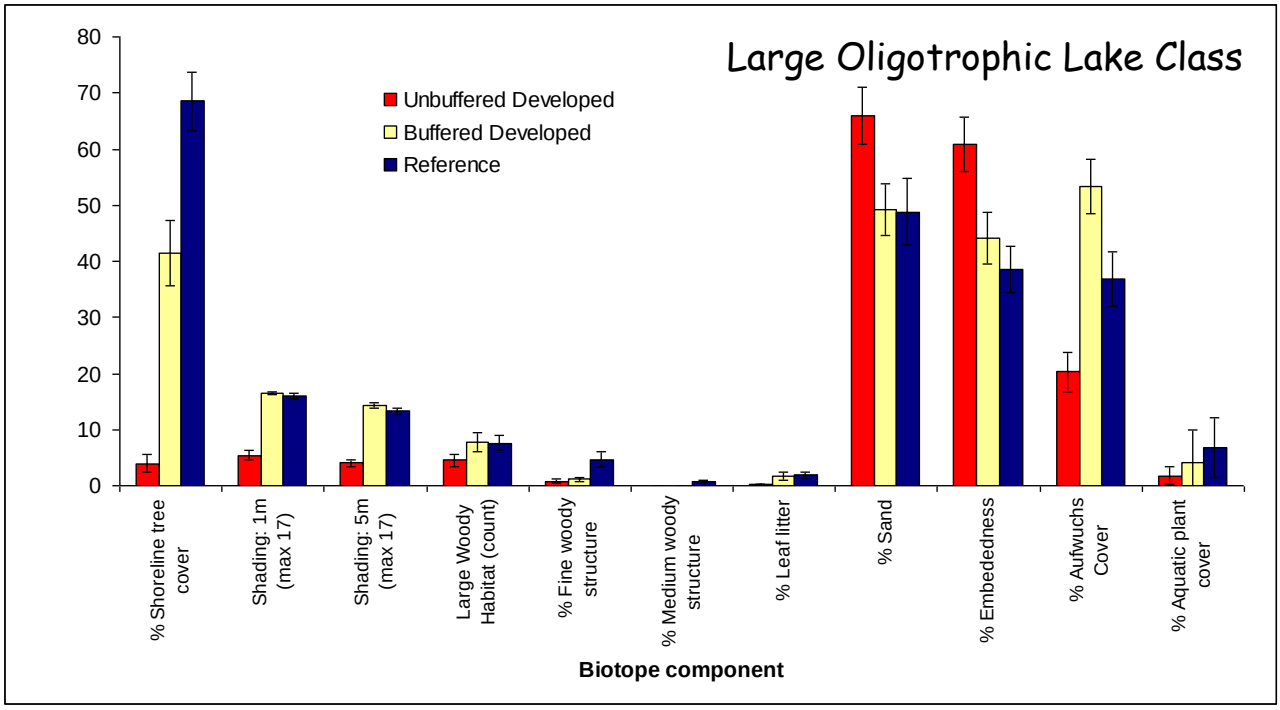


Figure 4. Mean and SE of littoral habitat and biota measured across all unbuffered developed sites (n=151), all buffered developed sites (n=48) and all reference sites (n=234) in the large oligotrophic lake class.

Overall, the findings indicate that changes to littoral habitat and biota caused by unbuffered development could be mitigated by retaining an intact natural treed buffer along the shore. Ongoing analyses will shed light on what setback distances and buffer characteristics will optimize the protection of littoral habitat and biota, while still allowing lakeshore residents to develop their properties, enjoy the view of the lake and establish access to it.

The Vermont Lake Survey quantified the current condition of the nearshore and littoral habitat. Because the VLS used a probabilistic design, the results showed the current condition of all Vermont lakes in aggregate. While the VLS measured the effect and extent of multiple stressors on Vermont lakes, unbuffered lakeshore development was a more widespread stressor than either eutrophication or acidification. So, while the Littoral Habitat Assessment established that unbuffered development at the site level is significantly altering aquatic habitat and biota, the VLS determined that, using thresholds developed by EPA in the 1990s EMAP survey of Northeastern Lakes, when greater than 49% of the shoreline on a lake is unbuffered a lake is considered to be in poor condition. When 25-49% of the shore is unbuffered, a lake is said to be in fair condition and when 25% or less of the shore is unbuffered a lake is said to be in good condition. Applying this analysis to Vermont lakes indicates that 20% of lakes are in poor condition, 30% are in fair condition and 50% are in good condition. The results of these two quantitative surveys show that the threat of unbuffered lakeshore development is indeed a widespread stressor to Vermont lakes. Further analysis will be conducted before use impairments are reported.

Eutrophication of lakes

Cultural eutrophication is the process of lake aging due to increases in nutrient inputs that are attributable to human activity on the landscape. On a national basis, 20% of lakes exhibit excessive levels of phosphorus or nitrogen, and the ensuing cultural eutrophication results in a twofold increase in impaired biology. Vermont has relatively unproductive lakes as compared to other parts of the country. A probability survey of lakes across Vermont indicates that the proportion of lakes in eutrophic or hypereutrophic condition is considerably lower than nationally or across the north-east (see Figure 5 below). Aside from Lake Champlain, only four lakes appear on Vermont's 303(d) list as impaired due to excessive eutrophic conditions as measured by phosphorus concentration (Lake Carmi, Shelburne Pond, Ticklenaked Pond and Lake Memphremagog). Nonetheless, DEC commits significant resources to the management of cultural eutrophication of Vermont lakes. During the reporting period, the Department completed TMDL analysis and approval for two impaired lakes, and has undertaken significant basin planning and watershed modeling for a third.

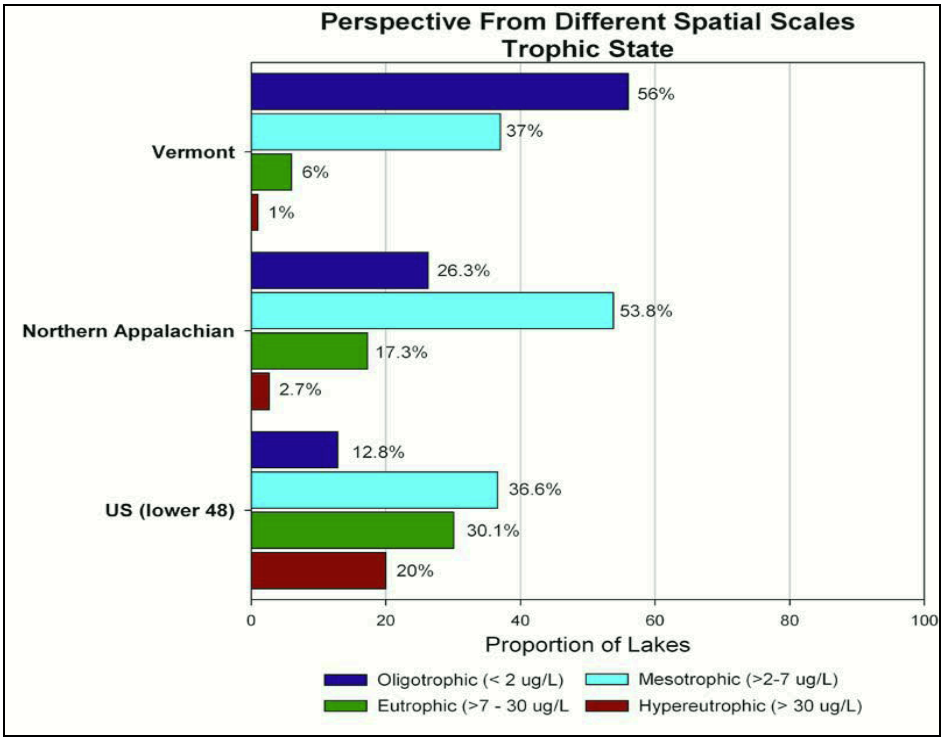


Figure 5. Percent of lakes in four categories of trophic state for VT, the Northern Appalachian Plateau, and the conterminous United States. Source: EPA National Lakes Assessment: A Collaborative Survey of the Nation's Lakes. Draft 2009.

The Lake Carmi and Ticklenaked Pond TMDLs were both approved by EPA during the reporting period. Implementation of phosphorus reduction plans is proceeding in both watersheds via a combination of basin planning and CWA §319 funding to initiate restoration actions. In Lake Carmi, restoration is taking place by rehabilitating geomorphically unstable tributaries, addressing agricultural runoff, and other watershed and shoreland nonpoint sources in conjunction with §319 funding. In Ticklenaked Pond, watershed sources are being addressed by a combination of NRCS

implementation and local actions, supported by discretionary §319 funding. The next step for Ticklenaked Pond involves conducting a feasibility analysis and impact study, and identifying funding sources for a sediment phosphorus treatment to reduce the magnitude of internal loading in that pond. The Department will approach EPA to explore opportunities for partnership in this project during the upcoming biennium. Due to resource constraints, the Department has not yet undertaken the load allocation or use attainability analyses envisioned for Shelburne Pond (see 2008 305(b) report), although these remain priorities for the coming biennium.

The Department continues its fruitful partnership with the Province of Quebec and several watershed partners in Vermont and Quebec on the management of Lake Memphremagog. During the reporting period, Vermont has taken a leadership role in the development of a modeling study to assess watershed contributions of phosphorus to the lake from the Vermont and Quebec portions of the watershed (one example of the model output is shown in Figure 6). During 2010, an in-lake model will be developed to complement the watershed model, which will permit the development of a TMDL that includes a geographically explicit implementation plan.

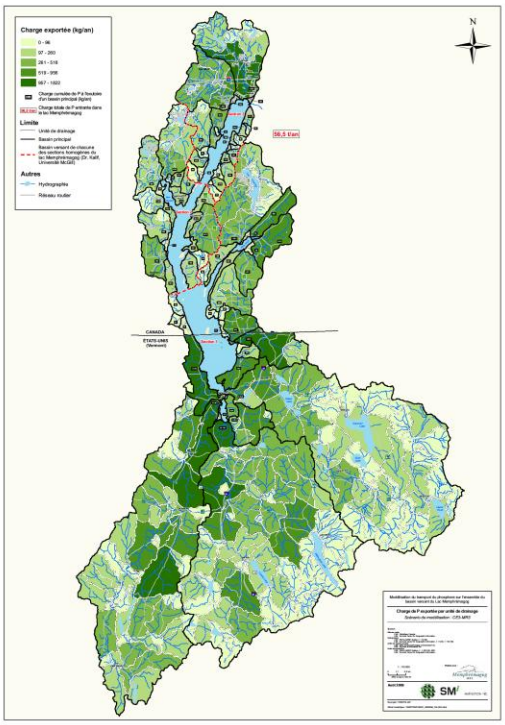


Figure 6. Map of modeled phosphorus export by subwatershed for the Lake Memphremagog Basin.

Implementing actions to reduce human impacts on lake trophic condition before impairments develop is more efficient and effective than waiting until restoration is needed. Toward this end, several lake protection initiatives have been carried out. One important example of this is Lake Seymour, a Northeast Kingdom oligotrophic lake. During the previous reporting period, monitoring data from this pond identified alarming increases in total phosphorus concentrations and associated decreases in Secchi transparency. The Department has worked extensively with the Seymour Lake Association on methods to remediate nutrient sources due to shoreline disturbances.

Other lakes not already mentioned in this section that are currently the subject of watershed remediation efforts to alleviate the threat of cultural eutrophication include Lake St Catherine, Lake Iroquois, Lake Rescue, Woodford Lake, Maidstone Lake and Lake Champlain. Such work is not without setback, however, as shoreland development continues at a rapid pace in lakes throughout Vermont (see companion section on littoral habitat).

Large farms and potential pollution

From a water quality perspective, concerns continue to exist regarding shifts in agricultural production from a large number of smaller farms to growing numbers of larger farms. The water pollution potential from such large farming operations is equivalent to the waste (and thus nutrients) generated by a small to medium sized city. It is essential that waste management and pollution prevention efforts are well coordinated between farm operators and state and federal agencies.

The Large Farm Operation rules (formally adopted November 2007) regulate about 20 farms in Vermont with greater than 700 mature dairy cows. The LFO Rules, administered by the Vermont Agency of Agriculture, Food and Markets (AAF&M), will help ensure animal wastes (plus odor, noise, traffic, pests) on these larger facilities are managed effectively. Other common LFOs include operations having greater than 1,000 beef cattle or cow/calf pairs, 1,000 youngstock or heifers, 500 horses, 55,000 turkeys, or 82,000 laying hens without a liquid manure handing system.

Changes at the federal level affect the Concentrated Animal Feeding Operation permit program, currently administered by DEC under the National Pollutant Discharge Elimination System (NPDES). Farms that have between 200 and 699 mature dairy animals, known as Medium-sized Farm Operations (MFO), now need a General Permit and need to demonstrate compliance with control of discharges from a farm's production area and land application of manure, compost and other wastes according to a nutrient management plan. There are about 200 dairy MFOs in Vermont. Other MFOs include beef operations (300 to 999 cattle or cow/calf pairs), young stock and heifer operations (300 to 999 young stock or heifers), horse operations (150 to 499 horses), turkey operations (16,500 to 54,999 birds), and egg facilities (25,000 to 81,999 laying hens without a liquid manure handling system). The MFO Rules, administered by AAF&M, became effective in February 2007.

Improvements to the Accepted Agricultural Practice (AAP) rules are recommended to keep pace with the changing nature of Vermont agriculture. Revisions to the AAPs have been promulgated by AAF&M (April 2006) and the revised rules provide an important set of requirements to which all farms throughout the state will adhere. The 2006 rules include the requirement for a 10-foot vegetated buffer along surface water, provisions on mortality burial and composting, and requirements for the management of livestock on pastures where access is given to surface water.

In order to achieve the greatest possible environmental protection benefit while supporting an important ingredient of Vermont's landscape and way of life, it is recommended these agricultural water quality rule and permit programs be developed or modified in a coordinated manner with various technical and financial assistance programs to address soil, waste and nutrient management.

Nutrient criteria

Vermont has been participating in the EPA's National Strategy for the Development of Regional Nutrient Criteria since this initiative began several years ago. Vermont DEC staff members have contributed to EPA technical guidance manuals, participated in the Regional Technical Advisory Group, and conducted extensive field sampling and data analyses for nutrient criteria development with EPA grant support. Vermont submitted a draft technical document on Developing Nutrient Criteria for Vermont's Lakes and Wadeable Streams to EPA for internal and external scientific review in April 2007. This review was completed by EPA in November 2007 and resulted in some important recommendations for additional analyses and considerations to strengthen the document.

Vermont DEC has submitted a revised nutrient criteria analysis that has gone through state and EPA agency review. Criteria have been proposed that are protective of Aquatic Life and Aesthetic uses, which are those considered to be the most sensitive uses for lakes/ponds, and rivers/streams. Criteria have been proposed for phosphorus, nitrogen, and for lakes, the response variables Secchi transparency and chlorophyll-a. DEC's proposal contains criteria that are hierarchically established, and which carry the rebuttable presumption that uses are met when the nutrient criteria values are met. The presumption may be rebutted by biological assessment data, or Secchi transparency and chlorophyll-a data that establish use attainment. Vermont DEC has established the proposed criteria in this way in order to minimize the likelihood of concluding use impairment due to a chemical stressor when there is no impairment based on the more sensitive response variables.

As of this writing, the Vermont Water Resources Panel is evaluating the proposed criteria within triennial Water Quality Standards review process. Vermont DEC's criteria recommendations range among Vermont's Water Management Types as follows:

	Phosphorus (ug/L)	Nitrogen (mg/L)	Secchi transparency (m)	Chlorophyll-a (µg/L)
Rivers and Streams	10 - 44	0.36 – 0.48	N/A	N/A
Lakes and Ponds	12 - 24	0.30 – 0.75	2.4 – 3.8	5 - 16

Invasive exotic plants and animals in surface waters

Non-native aquatic plants and animals are established in Vermont - at least 49 non-native aquatic species are known – and many of the state's waters, especially lakes, have a history of impacts related to these invasions. The number of new introductions of species already known into Vermont lakes continues to increase and one new aquatic invasive species (*Myriophyllum heterophyllum*) was identified in Vermont waters during the 2010 reporting period.
During the 2010 305(b) reporting period, Eurasian watermilfoil (*Myriophyllum spicatum*) was discovered in three waters: Fairfield Swamp Pond and two small private ponds, one in Hinesburg and the other in Orwell. Water chestnut (*Trapa natans*) was discovered in one water (a wetland in Benson) and two new Lake Champlain locations. No management actions by the State occurred in any of the new watermilfoil waters. All new water chestnut sites were targetted.

At the present time, zebra mussels are pervasive in Lake Champlain and Lake Bomoseen but have not emerged or become established elsewhere. If introduced to other waters, zebra mussels could threaten aquatic life and swimming uses in inland lakes that present conditions capable of supporting them.

Particularly alarming is the expansion of the invasive alewife (*Alosa pseudoharaengus*) fish population in Lake Champlain. First confirmed in 2005, alewives of all age classes have now been documented in the lake, and schooling alewives were observed for the first time during summer 2007 indicating a significant population increase. These fish have the potential to seriously alter trophic conditions and food chain dynamics as they have in the Great Lakes and Finger Lakes.

Finally, the alga *Didymosphenia geminata* ("didymo" or sometimes called "rock snot") was discovered in the Connecticut River, White River and Batten Kill during summer 2007. This was the first official report of this invasive diatom in the northeast and its presence has raised significant concerns about the potential impact on the ecology and aesthetic value of Vermont rivers. Although direct impact on fish populations has not been definitively documented in other parts of the world where didymo produces nuisance blooms, it is difficult to predict what the long term impact will be for Vermont waters. Preliminary evidence from macroinvertebrate biomonitoring in fall 2007 at several sites on the White River and one site on the Connecticut River revealed that abundant didymo significantly altered the composition of macroinvertebrate communities. The macroinvertebrate community response in these oligotrophic waters resembled that normally seen in waters with excessive nutrient enrichment, with proportionate increases in Chironomidae species and decreases in EPT (Ephemeroptera, Plecoptera and Trichoptera) taxa. The results suggest that didymo blooms could ultimately result in infested waters failing to meet Vermont's Class B aquatic life biocriteria. However, additional monitoring over the course of one or more seasons will be required to assess the longterm impact. The ability to monitor and investigate impacts in infested waters and to survey for new infestations is likely to be limited by insufficient staff and financial resources. Because there are no management or control options for didymo once it has been introduced, ANR's response has focused on public education and outreach to promote spread prevention practices among anglers and other recreationists.

The Department responded to the first occurrence of a Eurasian watermilfoil relative, the non-native, invasive variable-leaved watermilfoil (*Myriophyllum heterophyllum*), in a Vermont water body shortly after confirmation in Halls Lake in Newbury in the fall of 2008. Quick actions and a local partnership have drastically reduced the population of variable-leaved watermilfoil in the lake – 5 cubic feet of plant material removed by hand in 2009 versus 53 cubic feet in 2008. Continued success will depend upon consistent annual follow-up actions for a number of years. A second population of variable-leaved watermilfoil was confirmed in the fall of 2009 in Missisquoi Bay of Lake Champlain. No control actions are expected. Education and outreach initiatives will be ramped up to prevent spread outside of Lake Champlain.

A success story includes the sustained management efforts that appear to have eliminated the water chestnut populations in Root Pond (Benson), Lake Bomoseen (Castleton) and in over approximately 40 miles (representing both Vermont and New York shores) of Lake Champlain. This stretch of the lake previously managed by mechanical harvesting is now controlled by hand pulling. Continued surveillance efforts, however, are critical to ongoing success. Water chestnut management in

Vermont is the result of a successful partnership between DEC, The Nature Conservancy, US Fish and Wildlife Service and the Army Corps of Engineers. Funding from state, federal, the Lake Champlain Basin Program and private sources contribute to this partnership. Continued funding for water chestnut control at, or above, existing levels is critical in order to maintain the ground gained in the battle over the last 12 years against water chestnut in Lake Champlain and associated waters, and in inland waters.

During the 2010 reporting period, permittees/co-permittees for seven waters were engaged in long range management plans using chemicals (whole lake fluridone treatments, spot/partial lake treatments with triclopyr, or both) in conjunction with non-chemical means to control Eurasian watermilfoil. The lakes include the Lake St. Catherine, Little Pond and Lily Pond three-lake system in Wells and Poultney, Star Lake in Mt. Holly, the Burr Pond and Lake Hortonia system in Hubbardton and Sudbury, and Lake Morey in Fairlee. While control actions in all systems were deemed successful, Eurasian watermilfoil levels require continued management. DEC has concerns regarding the effectiveness and longevity of control from the chemical treatments, the effects of cyclical chemical treatments on the non-target environment and the ability of the lake associations to sustain the funding and staffing needs associated with this type of regime.

DEC continues to support the concept of biological control of Eurasian watermilfoil with the native weevil *Euhrychiopsis lecontei*. However, until more is understood about why naturally-occurring weevils can successfully manage watermilfoil populations in some lakes, yet have little impact in others, this method cannot be reliably used to manage Eurasian watermilfoil populations. Section 4005 of the Federal Water Resources Development Act (2007) requires the Army Corps of Engineers, under the authority of Section 104 of the River and Harbor Act (1958), to conduct a study in order to develop national protocols for the use of the *Euhrychiopsis lecontei* weevil for biological control of Eurasian watermilfoil in the lakes of Vermont and other northeastern states. Vermont DEC would like EPA to support this effort in every way possible.

Developing and implementing a Rapid Response Plan is crucial to prevent the introduction of new invasive species populations. In May 2009, the Lake Champlain Basin Aquatic Invasive Species Rapid Response Action Plan was approved by the Lake Champlain Basin Program Steering Committee. In essence, the plan is an administrative blueprint for appropriate state, federal and provincial agencies to work in partnership to facilitate rapid control or eradication of invasive species in Lake Champlain Basin waters. The next step is for each jurisdiction – Vermont, New York and Quebec - to appoint members to a new Rapid Response Task Force to help implement and oversee rapid response actions. The Plan will only be effective if each jurisdiction commits resources, funding and staff, to ensure effective implementation. The Department's response to the confirmation of variable-leaved watermilfoil in Halls Lake mirrored the steps outlined in this model. Efforts to develop such a plan for the rest of Vermont's waters are expected to follow sometime in the future.

Chlorides and water quality

Since completion of a Water Quality Division report on the environmental implications of increasing chloride concentrations in Lake Champlain Basin waters, the Division has continued to accumulate surface water data from around the state through several programs. After reviewing these data, the concentration indicative of background conditions was revised to <5 mg/L, which more accurately reflects aquatic habitats around Vermont, rather than the 10 mg/L suggested earlier. The original report on chloride in Vermont and a one page discussion of its findings can be found in the 2008 305(b) report as well as at www.anr.state.vt.us/dec/waterq/lakes/docs/lp_chloridereport.pdf.

Aquatic data are summarized here by program:

- Vermont's Spring Phosphorus Monitoring program sampled 219 lakes between 2006 and 2009. Of these, 67% had chloride concentrations <5mg/L (n=136). Three lakes had concentrations of 40–50 mg/L, the highest observed to date during spring turnover sampling.
- Though small fluctuations are detectable at some stations, concentrations of chloride in Lake Champlain have held steady in most locations since 2007 at <20 mg/L (graphs are available at www.anr.state.vt.us/dec/waterq/lakes/docs/lcmonitoring/lp_lc-chloride.pdf).
- The Wetlands program collected chloride samples from 42 wetlands during 2008 and 2009. Of these, 71% had concentrations below 5 mg/L (n=30). Two wetlands had chloride concentrations of 40 mg/L, two had concentrations near 70 mg/L and chloride reached 102 mg/L in one.
- The Ambient Biomonitoring program has been analyzing for chloride since 2003 in rivers and streams. Between 2003 and 2009, over 1340 chloride samples were collected at 724 sites (Figure 6). Concentrations were <5mg/L at 28% of the sites (n=202). Concentrations >230mg/L, the EPA criteria for chronic toxicity by chloride, were detected at 2 sites (2.7%). One additional site exceeded the EPA acute toxicity criterion of 860 mg/L. The majority of the streams tested (68%, n = 501) have chloride concentrations between background and the EPA criteria of concern.
- The Acid Rain program tracks chloride in 12 high elevation lakes. All of these lakes had chloride concentrations below 1 mg/L.

The final report on in-situ conductivity and inferred chloride measurements in six urban Chittenden county streams during 2005 has been completed. Using conductivity as a surrogate for chloride, the Biological and Aquatic Studies section determined that four of the streams were likely to have exceeded the EPA chronic criterion of 230mg/L more than 65% of the monitoring period, which ran from June through November. The three streams with the highest summer-fall chloride concentrations had impervious surfaces over more than 20% of their watersheds, however the stream with the highest percentage of impervious surfaces had relatively low chloride concentrations during summer and fall. While the data suggest a positive relationship with the percent impervious surface in the watershed and calculated chloride concentrations, there are other factors to be identified. In July 2009, water samples from these 6 urban Chittenden County streams were tested for toxicity. All six samples were found to be non-toxic using the 7-day *Ceriodaphnia* chronic toxicity assay. Chloride concentrations on the day of collection ranged from 230 – 350 mg/L in four of the streams, while two had ~95 mg/L.

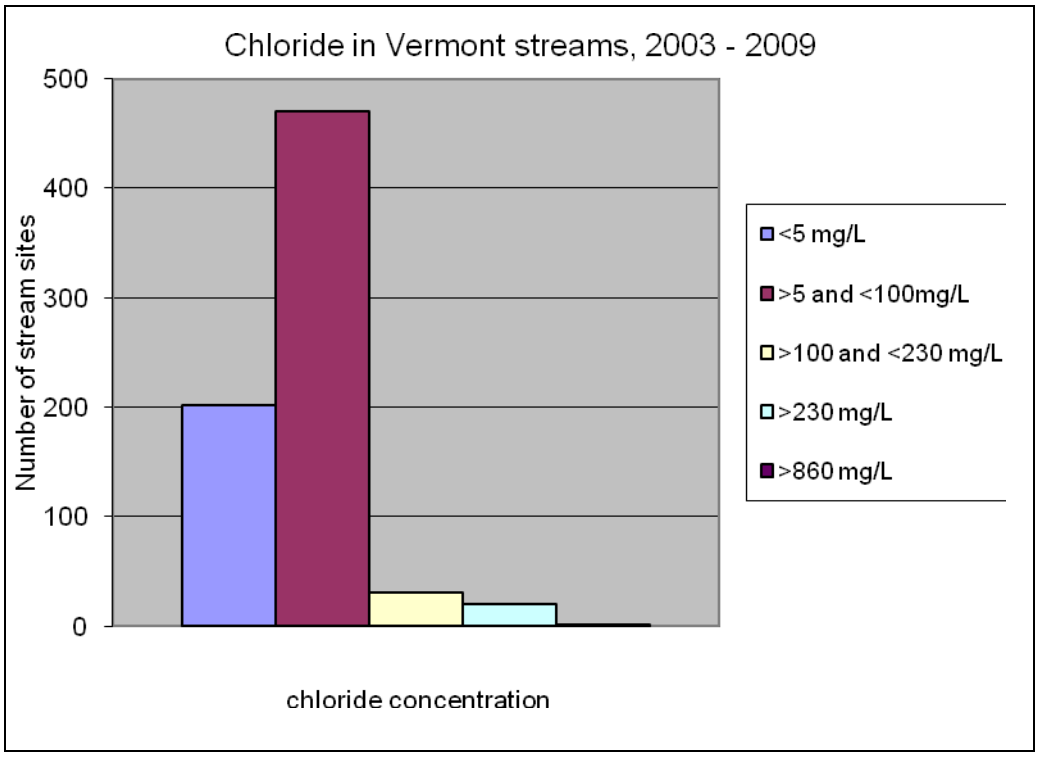


Figure 7. Chloride in Vermont streams, 2003 – 2009. Data from the Ambient Monitoring Program

The recent review of available data supports the conclusions from the earlier report. Currently, Vermont's lakes and ponds are not strongly affected by chloride. Observed concentrations (< 50 mg/L) are well below 200 mg/L, the concentration at which literature sources suggest biotic effects are likely to occur. Wetlands are also not strongly affected, although the data suggest that some wetlands near roads warrant closer monitoring. Highest observed concentrations of chloride in Vermont's surface waters occur in rivers and streams, with ~3% of sampled reaches exceeding the EPA chronic criterion for aquatic biota (230 mg/L). Most streams (93%) were below 100 mg/L.

Vermont has no water quality criteria for chloride and in 2008 proposed adopting the EPA recommendations of 230 mg/L and 860 mg/L, respectively, for chronic and acute levels. As Vermont moves to accept these criteria, there are important aspects to be considered:

- What is an acceptable level of chloride in lakes, wetlands, streams and rivers?
- Does a steadily increasing concentration of chloride warrant intervention even when it is well below the acceptable level?
- What are the sources of chloride in Vermont? Roadway deicing salts have high visibility, but are other sources also important?
- What effects do alternative deicers have on water quality? In particular, products made from sugar beet and corn processing wastes are gaining popularity but there is little information documenting how these products might affect stream nutrient concentrations or aquatic biota.
- Can we keep chloride in aquatic environments at acceptable levels while maintaining roadway safety and efficiency?

It will be important to draw all stakeholders into the discussion, in particular those in the transportation field at the state and local level.

Pharmaceuticals, personal care products, and other contaminants in waters

In the 2006 305(b) Report, DEC reported on initial efforts to investigate the occurrence of Contaminants of Emerging Concern (CECs) in Vermont waters. CECs include: pharmaceuticals and personal care products (PPCPs); persistent organic pollutants such as the polybrominated diphenyl ethers used in flame retardants, furniture foam, and plastics; endocrine-disrupting chemicals such as synthetic estrogens or organochlorine pesticides; and veterinary medicines. Pharmaceuticals and personal care products comprise a diverse group of chemicals including, but not to limited, prescription and over-the-counter human drugs and other consumer products.

This topic is becoming increasingly important as studies worldwide highlight the ubiquity of these substances in certain waterbody types. Potential risk to aquatic organisms due to exposure to PPCPs in the environment has been identified as a primary concern given that aquatic organisms may be continually exposed to these contaminants.

During the reporting period, USGS continued a number of PPCP studies in the Lake Champlain Basin. USGS has analyzed wastewater treatment facility effluent, combined sewer overflow effluent, urban streams, large rivers, an undeveloped control stream, and samples in Lake Champlain. An important finding of these studies was that combined sewer overflows were found to be enriched in CECs and this is the subject of continuing inquiry by USGS. In general, contaminant concentrations in Lake Champlain were low when evaluated either by total count of detectable contaminants or contaminant-specific concentrations. One exception to this was caffeine, which is poorly removed by wastewater treatment.

DEC partnered with International Business Machines (IBM) of Essex, Vermont as part of their EPA Performance Partnership to investigate the occurrence of PPCPs in wastewater effluents and in the surface water from the Winooski River. Eight municipal wastewater treatment facilities on the Winooski River, including the IBM wastewater facility, were monitored in 2008 for 85 analytes representing a diverse array of CECs and PPCPs. Funding for this analysis was provided by IBM. A report from DEC, *Occurrence of Pharmaceuticals and Personal Care Products in Wastewater Effluents and in the Surface Water from the Winooski River, Vermont*, is currently being prepared. Friends of the Winooski River and the Winooski Natural Resources Conversation District also participated in this project and will be working with communities on several restoration projects. Educational materials will be distributed to interested groups regarding the PPCP findings.

Contaminants of Emerging Concern are not limited to waters and wastewater effluent. DEC remains interested in developing the capability to analyze fish tissue for residues of CECs including the polybrominated diphenyl ethers and would be pleased to work with the EPA should these analyses become available at EPA's New England Regional Laboratory or another facility. It is DEC's understanding that analyses of CECs in fish tissue will be carried out in urban streams sampled by the National Flowing Waters Survey.

DEC is now routinely contacted by the public in regards to CEC/PPCPs, which reflects a growing concern about these compounds. DEC is assembling available informational materials for posting to the internet describing the studies being undertaken and current understanding regarding CEC/PPCPs.

E. coli contamination and microbial source tracking

E. coli contamination in Vermont's waters continues to be a problem across the state (see 2008 305(b) report). Over 20% of the waterbodies identified on the 2008 303(d) List of Impaired Waters have been listed because of elevated *E. coli* concentrations. This represents the largest single category of impairment cause on Vermont's 303(d) List. The Water Quality Division is currently investigating potential methodologies for TMDL development for these waters. While TMDL development, or identification of the total loading limits of *E. col*i for these impairments is a relatively simple exercise (flow x WQS), the main focus of the TMDL needs to be identification of *E. coli* sources and strategies for their elimination.

Source identification ranges from very basic to technically advanced techniques and multiple methods may be necessary to pinpoint sources. Vermont DEC has recently teamed with the USGS and undertaken a feasibility study to develop TMDLs using genetic markers. Two impaired reaches within the Huntington and Mettawee watersheds were selected for pilot investigations since each had several years of *E. coli* monitoring data and primary sources were believed to be different based on varying land uses. Samples were collected during storms and base flow conditions and analyzed for genetic markers to identify human, ruminant and dog as potential sources of fecal contamination. Results from the study are still pending but promising as this powerful method could be added to the arsenal of source identification techniques.

Chapter 4. Surface Water Monitoring & Assessment

Surface Water Quality Monitoring Program

Accomplishments of ANR's Ambient Water Quality Monitoring Program are described below, including reporting on program enhancements that are requested by USEPA as part of ANR's biennial reporting. The overall monitoring program is described in Vermont's Water Quality Monitoring Program Strategy document at http://www.vtwaterquality.org/lakes/docs/lp_monitoringstrat.pdf. The document was first approved by EPA in 2005. The top recommendations in the strategy involve addition of staff to the ANR biomonitoring laboratory and lakes programs, consistency of funding within the monitoring program, and resources to support information management services and wetlands strategy development. While the Program has not been successful at obtaining permanent staff, the allocation of EPA supplemental and Monitoring Initiative funds plus Clean Water Act Section 104b3 funds have provided a steady level of technician-level staff support in rivers biomonitoring, wetlands biocriteria development, and lakes monitoring program areas. The ongoing support provided by the supplemental funding has been critical to maintaining operations in the recent years of declining budgets.

In addition to staffing, ANR has made significant investments in information technology for the monitoring program. These investments include a rewrite of our water quality monitoring data archive to be compliant with the new WQX architecture, and the development of a project to automate data collection in the field using handheld personal digital assistants (PDAs) and tablet computers. Using a combination of EPA supplemental monitoring funds and National Environmental Information Exchange Network grants, ANR has purchased several field-ready devices, and is at the end of a contracted project to develop ArcPad-based software that transfers geo-referenced field data directly to the WQX-compliant archive. In addition, the biomonitoring data archive has been considerably augmented to include new metric calculations and assessment procedures, and to provide summary reports. ANR is presently discussing options for merging aspects of the Biomonitoring and WQX archives to increase the amount of data that can be shared.

ANR has made a firm commitment in regards to the National Aquatic Resource Surveys. The ANR's Monitoring Program views the value of each probability survey as high, even if a statewide augmentation is not undertaken. Over the reporting period, ANR staff completed field work and analysis of the Vermont Lakes Survey (part of the National Lakes Assessment), completed sampling for the National Rivers and Streams Assessment, and have participated in the National Wetlands Assessment design workgroups. ANR staff have participated actively in the New England Lakes and Ponds Project workgroup. In addition, one monitoring program staff member was assigned to a detail with US EPA as the lead technical author and analyst for the National Lakes Assessment. Finally, one staff member continues to serve as the New England representative to the National Water Quality Monitoring Council.

One other noteworthy accomplishment of the reporting period is the completion of Vermont's Nutrient Criteria Initiative, including submission of draft rule language to the Water Resources Panel. This effort included submittal of an initial draft report to EPA for independent scientific peer-review, comprehensive revisions to the initial analyses in light of the comments received, and drafting of technical rule language. The revisions undertaken included using several techniques

recommended by the newest EPA Nutrient Criteria Guidance, and the establishment of criteria recommendations for "predictor" and "response" measurements for lakes and wadeable streams. In addition, ANR is presently carrying out a comprehensive revision of the current Water Quality Monitoring Program Strategy. This is part and parcel of a larger initiative being undertaken to develop a statewide water plan and revised process for the issuance of Basin Plans.

Monitoring priorities and status for the 2010-2011 period include continuation of current monitoring approaches, execution of the supplemental monitoring tasks outlined below, and consideration for a restructured approach to monitoring that dovetails with revisions to the Water Quality Monitoring Program Strategy.

River Monitoring Program:

I) Complete the process of automating field-to-office data streams by constructing PDA-based electronic field data forms for the collection of routine ambient biomonitoring information. (Nearly complete)

II) Continue sampling in pursuit of a fifty-site probability survey of Vermont rivers using a randomized, rotating-basin probability design. (In progress)

Lake Monitoring Program:

I) Complete field testing of a newly redesigned lake assessment protocol that combines the methods developed under Vermont's Lake Habitat Assessment with methods of the National Lake Assessment. (Pilot sampling undertaken in 2009)

II) With contractor support from SEI, pursue development of PDA-based field-office dataflow automation forms for this new assessment method that adapts forms previously developed by EPA Region 1 for application to the NELP project. (Not undertaken)

III) In advance of the forthcoming 305(b) Integrated Report cycle, revise assessments of lake water quality segments. (Completed)

IV) Work with EPA-OW Contractors (RTI) and Vermont DEC technicians to create a properly segmented lakes assessment GIS datalayer that is compliant with current EPA guidance for geographic assessment data submission. (Completed)

V) Continue the process of developing a lake-specific IBI using results of contracted taxonomic analyses. The taxonomy portion of this project is supported using FY2008 §106 supplemental monitoring funds. Using FY2009 funds, we will conduct the IBI development analyses following protocols applied to the NLA by the joint EPA-OW/ORD team. (ANR is awaiting results of the macroinvertebrate analysis from the NLA to determine the applicability of this task)

Wetlands Monitoring Program:

I) Continue development of biological assessment procedures and biological criteria development for wetlands. (In progress)

II) Participate in pilot studies leading to the National Wetlands Assessment (NWA), and continue to participate in meetings and conference calls regarding the design of this survey. Pending additional dedicated funding, begin the process of carrying out a 50-site survey of Vermont wetlands in conjunction with the Survey. (Pilot sampling completed 2009. Application for augmented sampling was not supported by EPA in 2009)

Technician support, travel support, and services will be used to support these task areas. Activities include logistics and planning, field sampling, chemical analysis, contracting of taxonomic analysis (if practical), data analysis, and reporting.

Data Management:

ANR is continuing to improve and revise our data archives within Microsoft Sequel Server to develop WQX-compliant dataflows for nationally required reporting. We continue to investigate node technologies to seamlessly connect these data into the national exchange using a combination of §106 and "NEIEN" grant funding. We will continue to support these two concurrent initiatives by employing a part-time database manager whose sole function is the operation and maintenance of WQ monitoring data systems within VTDEC. (Completed)

Table 6 below lists the tasks in the workplan for FFY2007 and FFY2008 supplemental monitoring funds. These tasks were carried out over the course of the 2010 305(b) reporting period.

Table 6. Status of Supplemental Monitoring Program-Funded Workplan Items.

Task	Year established	Monitoring Program Strategy Priority Items	Status
Streamline biomonitoring sample throughput	2005	2,5, 13,16	Ongoing
Automated reporting of assessments	2005		Completed within biomonitoring data archive
Pilot ½ time coordinator of LaRosa Partnership Program	2005	3, 5, 10, 13, 16	Completed
Development of littoral habitat assessment program	2005		Program supported for 4 field seasons
Segment assessed lakes into ADB	2005		Complete
Automated reporting of lake assessments	2005		Ongoing
Increase number of assessed lakes	2005		Complete
Develop field→office data integration equipment and programming	2007/2008	15	Nearly complete
Implement National Lake Survey – core lakes	2006	5	Complete
Participate in New England Lakes and Ponds Project to carry out statewide lake survey	2006	5	Complete
Assess statewide trophic condition using statewide draw and existing data	2006	5	Complete
Support wetlands biocriteria development	2006	7, 12	Ongoing
Pilot project to implement waterbody typing	2006	n/a	Complete
Develop GIS Layer for Lake and Streams assessment Units	2008	16	Complete

Surface Water Assessment and Listing Methodology

The methods used to derive Vermont's statewide assessment of water quality conditions are found in the *Vermont Surface Water Assessment and Listing Methodology 2006*. This 2010 305(b) Water Quality Assessment Report describes whether or not the state's surface water uses as defined by EPA and the State Water Quality Standards fall into one of four use support categories. The four use support categories used by the Vermont Department of Environmental Conservation are *full support, stressed, altered,* or *impaired.* Definitions of these categories can be found on page 7 of this report.

Water uses include, but are not limited to, aquatic biota/habitat, contact recreation (swimming and wading) and secondary contact recreation (fishing or boating), aesthetics, fish consumption, and agricultural water supply. A determination of use support is made using information gathered and provided to the DEC by many sources including water resources personnel, fish and wildlife biologists, aquatic biologists, lake and river organization members, and other qualified individuals or groups – the sources of data and information are more fully described in the DEC document *Vermont Water Quality Monitoring Program Strategy 2005.*

As in prior years, Vermont is presenting assessment results along with a series of lists that are analogous, but not identical, to EPA's reporting categories. The Vermont Part A list of 303(d) waters impaired by pollutants corresponds to EPA "Category 5" impaired waters. The Vermont Part B list of impaired waters not in need of a TMDL analysis corresponds to EPA "Category 4B." The Vermont Part C list of waters in need of further assessment, partially corresponds to EPA "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 EPA "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 EPA "Category 4C." This report also provides a tabular assessment of waters by EPA reporting category.

During the 2010 305(b) reporting period, ANR used EPA's Assessment Database (ADB) application for both lake and stream water quality assessment information. For the lakes database, ANR 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.

Assessment Results for Rivers and Streams

Designated Use Support Status

Vermont has approximately 7,100 miles of perennial rivers and streams based on EPA's Total Waters estimate. Of the approximately 5,782 river and stream miles assessed for this report, overall about 89% of those miles are in compliance with the state's water quality standards and support designated uses, and 11% do not meet water quality standards or do not fully support the designated uses. Of the 89% meeting standards, approximately 16% are considered stressed by some pollutant or activity. These percentage results are the same as in the 2008 305(b) Report.

Table 7 is a summary of the number of miles of rivers and streams throughout Vermont that support or do not support the water quality standards or designated uses of the waters. For each river use or value that is assessed, the miles of river or stream fully supported, stressed, altered, or impaired are determined. For example, river miles that support aquatic biota have macroinvertebrate and fish communities in good to excellent health in the sampled reaches based on a number of metrics for each community. River miles that support swimming have a seasonal geometric mean of *E. coli* of 77 or less. River uses can be impaired by pollutants or altered by flow reductions or fluctuations and they can be stressed by a pollutant, condition, or direct instream activity.

Table 7. Summary of Use Support for Vermont Rivers & Streams (in miles)

Designated Use	Full support	Stressed	Altered	Impaired	Total Assessed	Total Measured
Overall - 2010 (2008 overall)	4320.7 (4208.0)	853.6 (838.3)	288.9 (300.2)	318.0 (329.4)	5781.2 (5675.9)	6361.9
Aquatic biota/habitat	4428.2	872.2	290.3	190.5	5781.2	6361.9
Contact recreation	5048.6	430.6	6.5	123.6	5609.3	6361.9
Secondary contact recreation	4897.2	617.6	101.3	47.4	5663.5	6361.9
Aesthetics	4808.5	676.9	166.5	108.8	5760.7	6361.9
Drinking water supply	127.9	3.2	0	13	144.1	6361.9
Fish consumption	0	6293.3	2.1	66.5	6361.9	6361.9

The number of miles in each support category are provided for six uses or values: aquatic biota and/or habitat, contact recreation (swimming, tubing), secondary contact recreation (boating, fishing), aesthetics, fish consumption, and drinking water supply. The use called "overall" reflects the miles for which one or more of the uses are fully supported, stressed, altered, or impaired. The fish consumption use is not factored into the "overall" category because all miles of river and stream are at least stressed for fish consumption due to a statewide fish consumption advisory. If taken into account in "overall", this status would mask the extent of other stresses.

Summary of Causes & Sources of Impairment, Alteration, and Stress for Rivers and Streams

A cause is a pollutant or condition that results in a water quality or aquatic habitat impairment, alteration or stress; a source is the origin of the cause and can be a facility, a land use, or an activity. Tables 8 and 9 below summarize the miles of rivers and streams affected by various causes and sources, respectively.

Because a stretch of river or stream may be affected by more than one cause or source, the same mileage may be tallied in several places in the tables. For this reason, the two columns on each table are not additive because the total would overestimate the total number of miles affected by all causes and sources in Vermont. The purpose of these summaries is to give natural resource managers and the public an idea of the relative size of the impact from different pollutants or conditions on Vermont's waters and from which land uses or activities they may originate.

Causes

Erosion and sedimentation have been listed as the number one cause of stress and impairment of aquatic life use support in rivers and streams since Vermont began reporting the impacts of nonpoint source pollution. Unnatural levels of sediment alter or destroy macroinvertebrate habitat and fish spawning areas and fill in swimming holes among other impacts.

Sources have been reported to include sediment in overland sheet runoff from cropland and construction sites; the erosion associated with concentrated stormwater; and streambank erosion. While streambank erosion has been correctly associated with the loss of riparian woody vegetation, in most stream networks it is more complex with channel incision often at the heart of the problem. The concept of channel incision (and thus loss of floodplain access), as a cause/source of erosion has now been verified in Vermont. Not only is the erosion of bed sediments a source in and of itself, the deepened channel accelerates bank erosion on otherwise stable vegetated banks when the exertion of stream power is well below the resistance associated with riparian root systems. The deepened channel also accelerates gully formation when tributaries and stormwater outfalls also deepen to match the new elevation of the receiving water. This later process, when it occurs on the glacial lacustrine land forms adjacent to Lake Champlain, results in gully erosion through fine sediment that is often dozens of feet deep.

Sedimentation occurs in a stream reach when the capacity to transport a sediment load is exceeded by the actual load. This process may occur when either the load is increased or the transport capacity is decreased. Fluvial geomorphic assessments in Vermont are making it increasingly clear that the full "sedimentation" story involves both actively eroding reaches whereby sediment loads are significantly increased and habitat is directly impacted as well as those streams physically altered into sediment transport reaches where capacity to move sediment out has been increased.

Erosion, transport, and deposition are components of natural sediment regimes. When streams are in dynamic equilibrium, the capacity and load are evenly distributed. Disequilibrium is a term increasingly used in Vermont to describe sediment regime alterations involving the uneven distribution of erosion and deposition. Sedimentation, involving the build up and/or embeddedness of stream sediments, is often the downstream end of a larger problem. In the future, ANR may report more stressed and altered miles as the full extent of sediment regime alteration and

disequilibrium are accounted for in Vermont waterbodies. This will promote a more comprehensive identification of sources of aquatic habitat and water quality problems.

Notwithstanding future assessments as predicted above, the number of miles currently reported as impaired by sediment is overall slightly less than in 2008 while the number of miles stressed is up – about 800 miles of stream are considered stressed by sedimentation.

The next three largest causes of alteration or impairment are flow alterations, physical habitat alterations (channelization, blow-outs of bridges and culverts that were not properly sized, gravel mining), and nutrients as was the case in 2006 and 2008.

Table 8. Summary of Causes of Impact to Vermont Rivers & Streams (in miles).

Cause of impairment, alteration or stress	Length impaired or altered by cause	Length stressed due to the cause	Total length on which causes have an impact
Sediments	211.1*	799.6	1010.7 (1032.0)
Flow alterations	209.7*	70.3	280.0 (302.9)
Physical habitat alterations	173.5	467.3	640.8 (651.6)
Nutrients	136.1	498.1	634.2 (617.5)
Metals	103.7	137.1	240.8 (233.2)
Turbidity	100.0	175.5	275.5 (261.6)
Pathogens	98.5	286.2	384.7 (399.1)
Temperature	75.9	479.4	555.3 (558.9)

(Note: values in parenthesis are from 2008 305(b) Report)

(*) These numbers do not include the 36.9 miles put into the newly created (for this database) cause of stormwater. The changes were made to better align the database with the impaired waters list pollutant names. Some miles of pathogens, temperature and other causes also went into the stormwater mix depending on the waterbody.

The other substantial causes identified include metals, turbidity, pathogens, and temperature in order of the number of miles impaired by these pollutants. Miles labelled as having impacts from metals are slowly increasing as more areas are identified where either old landfills exist or careless development disturbs certain soils or adds fill resulting in iron pollution. It should be noted that although temperature impaired fewer miles than the other causes above, thermal modification of streams stressed the thrid largest number of river or stream miles.

Past assessments have generally had similar results in terms of which pollutants or conditions have the most impact on water quality or aquatic habitat. The total miles on which each cause has an impact is quite similar between the 2008 and 2010 assessments.

Sources

The five sources of pollution identified as having the greatest impacts, or causing the greatest stresses, on miles of river and stream are flow alteration from hydroelectric facilities, snowmaking water withdrawals and other sources; streambank erosion/channel instability; agricultural land uses and activities; developed land runoff; removal of riparian vegetation; and atmospheric deposition. Additional significant sources of impacts include flood impacts resulting from poorly sited or designed human structures or activities, land development (active development as opposed to runoff

from existing roads and development), and upstream impoundments. See Table 9 below for sources affecting Vermont rivers and streams.

Table 9. Summary of Sources of Impact to Vermont Rivers & Streams (in miles).

Source of impairment, alteration or stress	Length impaired or altered due to source	Length stressed due to source	Total length on which sources have an impact
Flow modification (hydro, snowmaking withdrawals..)	216.3	68.1	284.4 (319.7)
Streambank erosion/ de-stabilization	176.3	608.9	785.2 (799.6)
Agriculture	135.2	558.8	694.0 (700.3)
Developed land runoff (includes roads)	100.0	327.3	427.3
Atmospheric deposition	114.1	39.9	154.0 (148.1)
Riparian vegetation removal	105.9	546.8	652.7 (675.6)
Channel instability/ Confined streams	74.1	175.8	249.9 (245.1)
Flooding (including infrastructure failures)	61.1	86.4	147.5
Land development	55.6	53.7	109.3 (114.4)
Upstream impoundment	53.3	72.5	125.8 (123.3)

(Note: values in parenthesis are from 2008 305(b) Report)

Streambank erosion is described above as a source in and of itself, but this 'source' results from other 'sources' such as riparian vegetation removal and channel instability. In addition, the interrelationship and overlap between several of these sources such as agricultural activities, riparian vegetation loss, streambank erosion, and channel instability makes the attribution of miles stressed, altered, or impaired to each of these sources an imprecise task. The relative contribution of each source should be the focus of the numbers in the table.

In the future, Vermont will use stream geomorphic data and other sources to identify stream erosion/sedimentation as a source of alteration or stress emanating from:

1. Channel instability – associated with disequilibrium (vertical instability), i.e., bed and bank erosion due an imbalance between sediment load and sediment transport capacity. In the above table this source is correctly listed in the channel instability row, but is also listed along with other sources in the streambank erosion/de-stabilization row.
2. Bank erosion – not associated with disequilibrium, i.e., bank erosion due to sources such as loss of woody vegetation, animal trampling, or gully formation. This source is currently reflected in the streambank erosion/de-stabilization row.

Relating erosion/sedimentation to the equilibrium condition of the stream will be very useful in prioritizing remediation efforts. Typically, BMPs targeted toward the direct treatment of bank erosion (not associated with disequilibrium) are successful at the local scale. On the other hand, remediation plans and treatments to deal with disequilibrium must typically be conceived and carried out over larger scales to deal with channel morphology, hydrology and sediment regimes.

Urban/developed land as a source includes runoff from any urban, suburban, village or other developed areas such as roads, bridges, and driveways. Developed land changes the amount and timing of runoff reaching rivers and streams and the runoff contains many pollutants including sediment, metals, nutrients and organic compounds. The impact from rapidly developing suburbia and residential sprawl as well as commercial development seems to outpace progress in erosion and runoff control, streamside vegetation re-establishment, and stream stabilization efforts.

Removal of riparian vegetation continues to be a growing problem in the state. Residential and commercial landowners, developers, farmers, town road crews, the Agency of Transportation, and utilities all encroach on the riparian zone with their activities and the result is the loss of the trees and shrubs protecting rivers and riverbanks. Flooding and channel instability also result in loss of riparian vegetation, but the loss of riparian vegetation also increases a stream's vulnerability to channel changes even in an otherwise stable system.

Atmospheric deposition is primarily responsible for mercury and acidified conditions in Vermont's surface waters. While these conditions are exacerbated in lake systems, stream biological communities do exhibit quantifiable impacts, particularly due to acidification.

The flood impacts are those that result from poorly sited or designed human structures (road, bridges, culverts), which blow out during a flood resulting in more damage to the river or stream habitat than would be otherwise. Channel instability can be a result of flood impacts, flood "repair" work, instream gravel mining, stormwater runoff, and watershed hydrology changes. A variety of human activities can cause channel instability but channel instability is a source of sedimentation and habitat alteration. As discussed above, this source of habitat impact and loss will be given more attention in the next 305(b) report cycle.

Assessment Results for Lakes and Ponds

Designated Use Support Status

In Table 10 below, use support is presented in relation to designated use and is consistent with the reporting the Department provided in the 2008 Integrated Report. Changes in use support from the 2008 report result from changes to altered acres due to Eurasian watermilfoil and other invasive species infestations, as well as minor adjustments or corrections made to individual waterbody assessments while updating the EPA Assessment Database (ADB). The reader should note that not all uses are assessed at all waters (e.g., swimming and boating uses are sometimes, but not always precluded at drinking water supply reservoirs). Therefore the total sum of acres by use will not necessarily tally to 55,561 acres for inland lakes or 174,175 acres for Lake Champlain.

Table 10. Summary of Use Support for Vermont Lakes & Ponds.

Use Support →		Fully Supporting acres	Stressed acres	Altered acres	Impaired acres	Unassessed acres
Waterbody Type ↓	Use ↓					
Inland Lakes	Aesthetic	32,742	10,269	3,612	7,974	1,002
	Aquatic Biota, Wildlife, and Aquatic Habitat	17,556	16,260	8,317	12,442	1,024
	Boating, Fishing, and Other Recreational Uses	31,503	9,194	4,925	7,974	1,018
	Fish Consumption	1,402	45,995	-	8,165	37
	Public Water Supply	1,196	-	-	-	5
	Swimming and Other Primary Contact Recreation	33,154	9,710	2,734	7,974	1,029
Lake Champlain	Aesthetic	35,290	-	6,832	132,053	-
	Aquatic Biota, Wildlife, and Aquatic Habitat	152,672	-	21,503	-	-
	Boating, Fishing, and Other Recreational Uses	156,980	-	17,195	-	-
	Fish Consumption	-	-		174,175	-
	Public Water Supply	148,691	-	15,673	-	-
	Swimming and Other Primary Contact Recreation	35,290	-	6,832	132,053	-

Size of Lakes & Ponds in EPA Assessment Categories

Table 11 below provides an EPA-required, ADB-based view of overall use attainment for Vermont lakes and ponds. By this view, the majority of lake acres are identified as impaired, falling in EPA Category 5, although this is the result of a relatively small number of large lake segments, where the size of Lake Champlain serves to overstate the severity of impaired waters in Vermont. It is important to note that where an impairment exists that is not yet subject to a TMDL, the acres associated with that impairment will be identified as Category 5, even if a TMDL has been completed for another pollutant on the same waters. For example, the existing impairments associated with PCBs cause all Lake Champlain acres to be assessed as impaired, even though TMDLs for phosphorus and mercury have been approved for those same lake segments. According to ADB, there are 53 lake segments that are altered which comprise 7,501 acres. There are 565 lake segments comprising 31,183 acres that support uses. A more detailed display of use support for lakes segregated by use and Champlain/non-Champlain waters is shown in Table 10 above.

Table 11. Size of Lakes & Ponds in EPA Assessment Categories (as per ADB).

Category	Description	Total size (acres)	Number of lake segments
1	All uses met	30,095	451
2	Some uses met, others indeterminate	1,088	114
3	Insufficient information to assess any use	-	-
4A	Impaired, TMDL approved	19,376	50
4B	Impaired, no TMDL needed	-	-
4C	Impaired, but not by pollutant	7,501	53
5	Impaired	171,714	36

Note: Segment is defined as a unique portion of a lake or stream. More than one segment may be present for an individually named stream or lake. Figures are provisional, pending outcome of 2010 303(d) list approval by EPA.

Summary of Causes & Sources of Impact (Impairment, Alteration, and Stress) - Lakes

Causes of impact to Lake Champlain and Vermont's inland lakes are shown in Table 12 and the related sources of impact are provided in Table 13. For Lake Champlain, the most widespread causes of impairment are mercury and PCB contamination in fish tissue, with atmospheric deposition of toxics and improper waste disposal being the respective sources. The third most widespread cause of impairment for Lake Champlain is phosphorus pollution. The sources of phosphorus vary by lake segment but arise from various categories of nonpoint source pollution, along with minor contributions from municipal wastewater effluents. Eurasian watermilfoil, water chestnut, and zebra mussel infestations are the causes of alterations to Lake Champlain, which result from transport of plant fragments and larval zebra mussels through recreational boating and fishing activities.

For the inland lakes of Vermont, mercury in fish tissue impairs the largest number of lake acres, resulting largely from atmospheric deposition. In the case of two reservoirs in the Connecticut River, mercury levels are also attributed to water level fluctuations. In the case of reservoirs within the Deerfield River drainage, mercury levels are also attributed to natural watershed susceptibility. The cause of the second largest number of impaired acres for inland lakes is phosphorus pollution. For all nutrient-impaired lakes, the sources of phosphorus are largely nonpoint sources, including agriculture, road maintenance, and sediment losses related to development. Acidity due to atmospheric deposition of acid-forming precursors and natural susceptibility also impairs a significant number of lake acres in Vermont. The principal causes of alterations to inland lakes arise from water-level management and Eurasian watermilfoil infestations that originate from the transport of plant fragments through recreational boating and fishing activities.

The observed effects that stress uses on Lake Champlain include Eurasian watermilfoil and other exotic species, sedimentation, native plants, and *E. coli* bacteria. The observed effects that stress uses on inland lakes are more diverse but principally include algae, Eurasian watermilfoil and other exotic species, acidity, flow alteration, phosphorus, and sedimentation.

Table 12. Summary of Causes of Impact to Vermont Lakes & Ponds (in acres).

Use →								
Waterbody Type ↓	Assessment of waterbody ↓	Cause of Impact ↓	Aesthetic	Aquatic Biota, Wildlife, and Aquatic Habitat	Boating, Fishing, and Other Recreational Uses	Fish Consumption	Public Water Supply	Swimming and Other Primary Contact Recreation
Inland Lakes	Impaired	Mercury in Fish Tissue				8,165		
		Organic Enrichment - DO		700				
		pH		4,468				
		Phosphorus	7,874	7,874	7,874			7,874
		Sedimentation/Siltation	100	100	100			100
	Altered	Eurasian Water Milfoil	2,122	2,122	2,122			2,122
		Exotic Species	118	118	118			118
		Flow Alteration	1,490	6,195	2,803			612
	Fully Supporting but Stressed	Escherichia coli						25
		Eurasian Water Milfoil	6,723	6,217	6,576			6,596
		Excess Algal Growth	27	27	27			
		Exotic Species	1,605	3,017	701			701
		Flow Alteration	193	4,385	193			3
		Mercury in Fish Tissue				45,788		
		Noxious Aquatic Plants - Algae	9,285	9,277	9,647			9,665
		Noxious Aquatic Plants - Native	886	889	1,346			1,346
		Nutrient/Eutrophication Biological Indicators		7				
		Nutrients	3,716	3,874	3,515			3,612
		Organic Enrichment - DO		1,419				
		pH		5,938				
		Phosphorus	3,716	3,874	3,515			3,612
		Salinity		9				
		Sedimentation/Siltation	3,191	3,535	3,004			3,041
		Zebra Mussel		829				829
Lake Champlain	Impaired	Mercury in Fish Tissue				174,175		
		PCB in Fish Tissue				163,678		
		Phosphorus	132,053					132,053
	Altered	Eurasian Water Milfoil	6,832	17,195	17,195			6,832
		Exotic Species		1,101	1,101			
		Zebra mussel		21,503			15,673	6,832
	Fully Supporting but Stressed	Escherichia coli						49
		Eurasian Water Milfoil	10,363					10,363
		Exotic Species	2,701	1,600	1,600			2,701
		Noxious Aquatic Plants - Native			500			500
		Sedimentation/Siltation	5,388	5,388				5,388
		Zebra mussel	5,281					6,162

Table 13. Summary of Sources of Impact to Vermont Lakes & Ponds (in acres).

Use →								
Waterbody Type ↓	Assessment of waterbody ↓	Source of Impact ↓	Aesthetic	Aquatic Biota, Wildlife, and Aquatic Habitat	Boating, Fishing, and Other Recreational Uses	Fish Consumption	Public Water Supply	Swimming and Other Primary Contact Recreation
Inland Lakes	Impaired	Agriculture	1,456	2,156	1,456			1,456
		Animal Feeding Operations (NPS)	1,456	2,156	1,456			1,456
		Atmospheric Depositon - Acidity		4,468				
		Atmospheric Depositon - Toxics				8,165		
		Flow Alterations from Water Diversions				2,012		
		Internal Nutrient Recycling	54	506	54			54
		Managed Pasture Grazing	1,854	2,554	1,854			1,854
		Natural Sources		4,468		3,692		
		Non-irrigated Crop Production	1,908	2,608	1,908			1,908
		Non-Point Source	7,422	7,422	7,422			7,422
		Post-development Erosion and Sedimentation	452	452	452			452
		Streambank Modifications/destablization	100	100	100			100
	Altered	Flow Alterations from Water Diversions	1,280	5,985	2,803			612
		Impacts from Hydrostructure Flow Regulation/modification	300	2,198	235			215
		Other Marina/Boating On-vessel Discharges	2,240	2,240	2,240			2,240
Lake Champlain	Impaired	Agriculture	31,859					30,259
		Atmospheric Depositon - Toxics				174,175		
		Combined Sewer Overflows	13,725					13,725
		Highway/Road/Bridge Runoff (Non-construction Related)	13,725					13,725
		Inappropriate Waste Disposal				163,678		
		Industrial Point Source Discharge	4,423					4,423
		Natural Sources	5,388			58,184		5,388
		Non-Point Source	132,053					130,453
		Post-development Erosion and Sedimentation	13,725					13,725
	Altered	Other Marina/Boating On-vessel Discharges	6,832	39,799	18,296		15,673	13,664
All Waters	Stressed	Sources are not attributed to stressed waters						

Note: Altered acres in 2008 associated with Other Shipping Releases (Wastes and Detritus) have been changed in 2010 to being associated with Other Marina/Boating On-Vessel Discharges, as this better represents the transport of exotic species through recreational boating and fishing activities. Also, the 2008 table for Lake Champlain mistakenly had impaired acres for Fish Consumption listed under Aquatic Life, altered acres for Public Water Supply listed under Fish Consumption, and altered acres for Primary Contact listed under Public Water Supply.

Probability-based Survey Results for Lakes

In the summers of 2007 and 2008, the DEC contributed to an initiative called the National Lake Assessment (NLA) set forth by the United States Environmental Protection Agency. The aim of the survey was to collect extensive data from lakes across the lower 48 states in order to assess the condition of the nation's lakes. The goals of the survey include:

1) Estimating the percentage of lakes that are in good, fair or poor condition, with respect to ecological integrity, water quality, and recreational suitability;
2) Examining the key stressors (e.g. nitrogen, phosphorus, acidification, aquatic invasive species) threatening lakes across the nation, establishing a baseline for future monitoring of lakes;
3) Assessing trends in lake status since the last national lake assessment (National Eutrophication Study of 1972); and
4) Helping state and other organizations better monitor and assess their lakes and promoting cooperation between jurisdictional boundaries.

Vermont's contribution to the national assessment included 11 lakes. However, to meet the goals laid out above specifically for Vermont, DEC augmented the sampling to visit 51 lakes statewide in total, permitting a statistically-valid assessment of lakes for Vermont. The *Survey of Vermont Lakes* report describes the condition of lakes in Vermont using several types of indicators and can be found at http://www.anr.state.vt.us/dec/waterq/lakes/docs/lp_VT_LakeSurvey_07-08.pdf.

The key trophic status indicators assessed for the survey were chlorophyll-*a*, Secchi disk transparency, total phosphorus, and total nitrogen. From the chlorophyll-*a* data, 56% of Vermont lakes are categorized as oligotrophic, 37% as mesotrophic, and 6% as eutrophic. Secchi depths categorized 38% of Vermont lakes as oligotrophic, 49% as mesotrophic, and 13% as eutrophic. Total phosphorus data categorized 37% of Vermont lakes as oligotrophic, 17% as mesotrophic, and 46% as eutrophic. Total nitrogen values from Vermont Survey Lakes ranged from 0.15 to 1.0 mg/l with a mean of 0.30 ± 0.15 mg/l. Lakes with total nitrogen in excess of 0.48 mg/l may exhibit diminished aesthetic value due to enhanced algal growth.

The chemical indicators assessed for the Survey of Vermont Lakes were dissolved oxygen and acidification potential assessed using alkalinity. According to the data for dissolved oxygen, 98% of Vermont lakes are in good condition and 2% are in fair condition. Alkalinity measurements ranged from 1 to 114 mg/l with a mean of 40 ± 29 mg/l, categorizing 61% of Vermont lakes as attaining standards, 36% as stressed, and 3% as impaired.

Ecological indicators assessed for the Survey of Vermont Lakes included littoral habitat, aquatic macrophytes and aquatic invasive species, and woody habitat. Data for percentage of lake shoreline development indicated that 52% of Vermont lakes have low stress to ecological integrity, 38% have moderate stress to ecological integrity, and 10% have high stress to ecological integrity. Data for percentage of total macrophyte cover indicated that 46% of Vermont lakes have high structural habitat, 40% have medium structural habitat, and 14% have low structural habitat. According to data for aquatic invasive species, 42% of Vermont lakes are affected but 58% are not. Data for percentage of woody debris cover indicated that 59% of Vermont lakes have low woody debris structural habitat, 40% have medium woody debris structural habitat, and 1% have high woody debris structural habitat.

The data collected from the Survey of Vermont Lakes will also be analyzed using the statistical criteria from the National Lakes Assessment to enable comparison across different spatial scales. This will allow lake managers and the general public to relate the conditions of lakes statewide to relevant ecoregional or national conditions. The current results from the Survey of Vermont Lakes have already facilitated the comparison of lakes by trophic state (based on chlorophyll-a) for Vermont, the Northern Appalachian Ecoregion, and the U.S., which cast trophic conditions in Vermont as considerably better than the surrounding region or the lower 48 states as a whole (Figure 4).

Trophic Status of Lakes

Trophic status can be defined as the level of "primary production," or algal growth that is supported by lakes. As an indicator of primary production, trophic state provides insight into how much overall biological productivity might be expressed in a given lake for all components of the food web. Lakes in higher trophic condition (e.g. eutrophic or hypereutrophic) have more biological productivity, and may exhibit undesirable conditions such as algal scums or the development of blue-green algae blooms. Oligotrophic and mesotrophic lakes are characterized by lower levels of productivity. Dystrophic lakes are those in which productivity is naturally controlled by deeply tannic-colored water, as commonly occurs in high-elevation, forested lakes.

During the reporting period, the Department re-evaluated trophic status for all lakes for which data are now available. Of the 558 lakes tracked in the assessment, trophic status has now been determined for 275 lakes, a considerable increase since the last time trophic state was reviewed for all assessed lakes statewide. This number of waterbodies comprises 219,019 acres of the total 229,788 acres assessed for trophic state. Trophic state is determined by evaluating data from a combination of programs: Spring Phosphorus, Lay Monitoring, Lake Champlain Monitoring, and Lake Assessment. Assessment thresholds for the determination of trophic state are used to classify lakes along a gradient of oligotrophic to dystrophic (Table 14). When assessing trophic state, summer monitoring data are prioritized over spring data when available.

Table 14. Trophic State of Assessed Vermont Lakes & Ponds (assessment thresholds also shown).

Trophic State	Secchi Average Summer (m)	Chlorophyll-a Average Summer concentration (ug/L)	TP Spring average concentration (ug/L)	TP Summer photic zone - LMP	Number of lakes in assessment	Acres
Undetermined	--	--	--	--	283	10,769
Hypereutrophic			>100		2	473
Eutrophic	0 - 3.0	> 7.0	> 15	> 15	52	27684
Mesotrophic	3.0 - 5.5	> 3.5 - 7.0	>7 - 15	>7 - 15	151	178,842
Oligotrophic	> 5.5	0 - 3.5	<7	<7	46	11,333
Dystrophic			<20 (and PtCo >50)		24	687

The increased number of assessed lakes, and the tracking of this information within the EPA ADB database system, permits a comparison of the change in trophic state from the 2008 Integrated Report to present (Figure 8). This comparison indicates that the proportion of lakes in the

oligotrophic and eutrophic categories has increased, while the proportion of lakes in the mesotrophic category has declined slightly. These changes can be explained in one of two ways. First, there are 42 additional lakes now assessed for trophic state that were not reported in the 2008 305(b) Integrated Report. Second, some lakes have changed from one trophic status class to another, with 18 lakes moving from a less to a more productive trophic state, and 13 lakes improving from a more productive to less productive trophic state. The movement of lakes from lower to higher trophic condition is cause for concern.

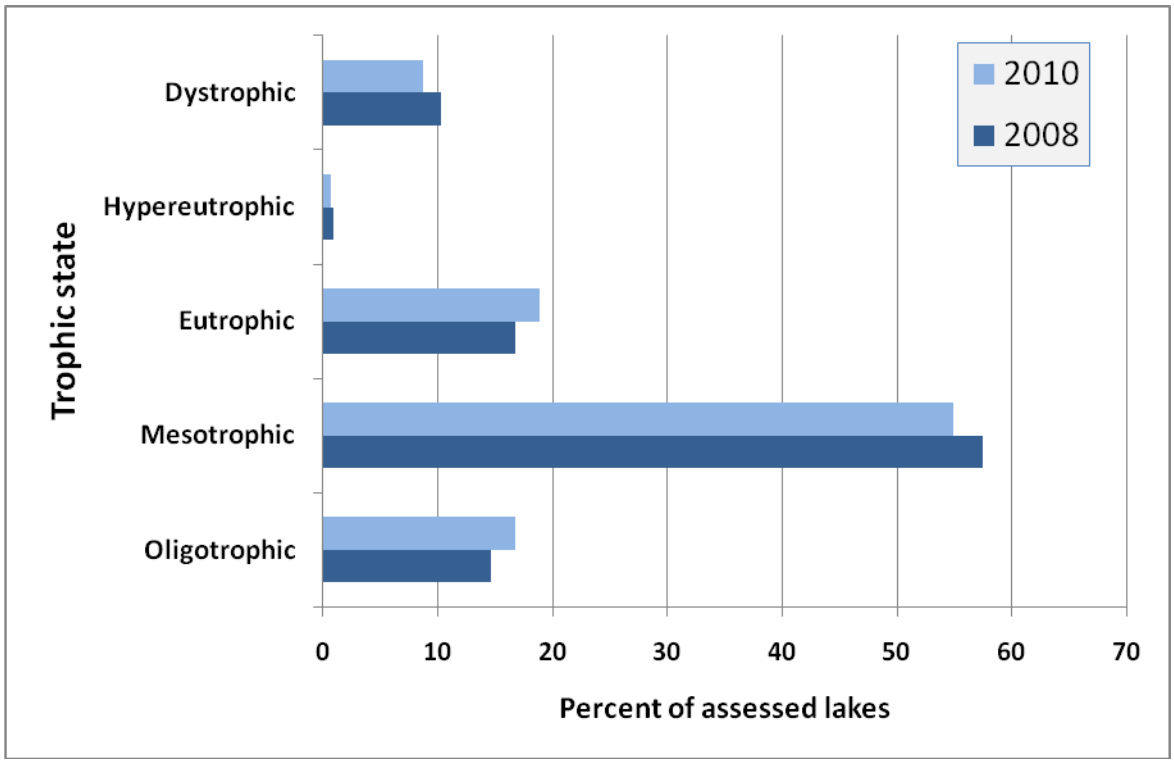


Figure 8. Comparison of the trophic state of Vermont lakes and ponds from 2008 to 2010, based on long-term monitoring data.

Impaired Waters of Vermont – Lakes and Rivers

Total Maximum Daily Load Program & Summary of Impaired Waters

Under Section 303(d) of the Clean Water Act, all states are required to develop lists of impaired surface waters. These impaired waters are lakes, ponds, rivers and streams that do not meet the water quality standards developed by each individual state. In Vermont, these waters are described on the state's Part A 303(d) List of Impaired Waters in Need of a TMDL; Part B List of Impaired Surface Waters - No TMDL Determination Required; and Part D Surface Waters with Completed and Approved TMDLs. The Clean Water Act requires that a Total Maximum Daily Load (TMDL) be developed for impaired waters on Part A of the list and the list provides a schedule as to when TMDLs will be completed.

A TMDL is the calculation of the maximum amount of a pollutant that a waterbody can receive and still meet the water quality standards. A TMDL serves as a plan that identifies the pollutant reductions a waterbody needs to meet Vermont's Water Quality Standards and are typically accompanied by an implementation plan that articulates the means to achieve those reductions. TMDL determinations are unique to each individual waterbody but the general process by which they are developed can be summarized in the following manner:

Problem Identification B the pollutant for which the TMDL is developed must first be identified. Examples might include sediment that impacts habitat for aquatic organisms, nutrients that cause excessive algal growth, or bacteria that creates an unsafe environment for swimming.

Identification of Target Values B this establishes water quality goals for the TMDL. These may be given directly in the Water Quality Standards or may need to be interpreted.

Source Assessment B all significant sources of the pollutant in question must be identified in the watershed. This often requires additional water quality monitoring.

Linkage Between Targets and Sources B this process establishes how much pollutant loading can occur while still meeting the water quality standards. This step can vary in complexity from simple calculations to development of complex watershed models.

Allocations B once the maximum pollutant loading is established, the needed reductions must be divided among the various sources. This is done for both point sources and nonpoint sources.

Public Participation B stakeholder involvement is critical for the successful outcome of TMDLs. Draft TMDLs are also released for public comment prior to their completion.

EPA Approval B EPA approval is needed for all TMDLs as required by the Clean Water Act.

Follow-up Monitoring B additional monitoring may be needed to ensure the TMDL is effective in restoring the waters.

Table 15 provides a summary of recently completed TMDL projects since the 2008 305(b) report and other upcoming TMDL related projects.

Table 15. Recently completed and future TMDL Projects.

Segment	Pollutant & Waterbody ID number	Project Status
Allen Brook	Stormwater VT08-02	TMDL approved August 2008
Sunderland Brook	Stormwater VT08-02	TMDL approved August 2008
Munroe Brook	Stormwater VT05-11	TMDL approved August 2008
Indian Brook	Stormwater VT05-09	TMDL approved August 2008
Moon Brook	Stormwater VT03-06	TMDL approved February 2009
Stevens Brook	Stormwater VT05-07	TMDL approved February 2009
Rugg Brook	Stormwater VT05-07	TMDL approved February 2009
Lake Carmi	Phosphorus VT05-02L01	TMDL approved April 2009
Ticklenaked Pond	Phosphorus VT14-07L01	TMDL approved November 2009
E. coli impaired segments	Approximately 27 segments throughout Vermont	Methodology for expressing E. coli TMDLs in development

Overview of the Vermont 2010 Priority Waters List including Section 303(d) List of Waters

Development of the 2010 Section 303(d) List of Impaired Waters is a process that is ongoing and concurrent to the development of the 2010 Section 305(b) Report. Consequently, the final 2010 303(d) listing has not been included in this report. The 2010 303(d) list will assume a content and format similar to the EPA-approved 2008 list. The 2010 303(d) list was developed consistent with DEC's Assessment and Listing Methodology (2006).

The 2008 303(d) List of Impaired Waters was approved during the 2010 305(b) reporting period (EPA approval on September 24, 2008). The 2008 303(d) List of Impaired Waters has been made available separately and can be inspected on the Water Quality Division's web site: www.vtwaterquality.org.

A brief summary of the Vermont Priority Waters List, which identifies and tracks both impaired and non-impaired waters, is given in Table 16. It should be noted that the Section 303(d) List of Impaired Waters is only a portion of the overall Vermont Priority Waters List (Part A) and much of the Priority Waters List process occurs outside the scope of Section 303(d). It is important to be aware of the overall listing process because it is indirectly involved with the 303(d) listing process.

Table 16. Overview of Vermont Priority Waters List.

Vermont Priority List Section	Description	Included as Part of 303(d) Listing?
Part A	**Impaired Waters in Need of a TMDL**	**Yes**
Interim List	Candidate Waters for Section 303(d) De-listing	Yes, until EPA approval. After approval these waters are removed from 303(d). EPA approved 303(d) list does not include de-listed waters.
Part B	Impaired Waters - No TMDL Required or Needed	No
Part C	Surface Waters in Need of Further Assessment	No
Part D	Waters with Completed & EPA Approved TMDL	No
Part E	Surface Waters Altered by Exotic Species	No
Part F	Surface Waters Altered by Flow Regulation	No
Part G	Surface Waters Altered by Physical Channel Changes/Adjustments	No

A summary of the number of waterbody segments listed as impaired on the 2010 DRAFT Lists is given in Table 17. Numbers in the table are tentative as the list is pending approval by EPA.

Table 17. Number of Impaired Segments (taken from DRAFT 2010 listings).

Impaired Segments	Lakes & Ponds	Streams & Rivers	Total
Listed in Part A – impaired waters needing a TMDL (newly listed waters in 2010 are given in parentheses)	15 (2)	95 (8)	110
Listed in Part B – impaired waters not needing a TMDL (no new waters were added in 2010)	1	8	9
Total number of impaired segments	16	103	119

Assessment Results for Wetlands

The 2008-2009 wetland monitoring and assessment program builds on the findings of the 2006-2007 wetland bioassessment program and an EPA-funded pilot wetland bioassessment project involving vernal pools and northern white cedar swamps. When applicable, sampling was coordinated with ongoing stream and lake bioassessment sampling, allowing the project to capitalize on the expertise of individuals currently engaged in similar water quality monitoring projects, while branching into an area of assessment that has received little biomonitoring attention.

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-based 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. (As a result of lack of funding, macroinvertebrate samples were not collected during the 2008 or 2009 seasons.) Over the longterm, it is expected that results from the wetlands bioassessment program may be used for improved permitting and planning decisions; providing significant information for mitigation and restoration projects; and identifying the effects of environmental and anthropogenic stressors on wetlands over time.

Site Selection

Overall

A total of fifty-one wetlands were sampled in 2008 and 2009 by Vermont DEC Wetlands Bioassessment Program staff (Table 18). Sampling was targeted in the Southern Green Mountains, Northern Green Mountains and Southern Vermont Piedmont biophysical regions to cover areas underrepresented in the past years.

Sites were selected in an effort to assess wetlands ranging in condition from reference (minimally disturbed) to highly disturbed based on landscape characteristics and historical data. Historical data was obtained from the Agency of Natural Resources' GIS database, orthophotos, and color infrared aerial photos. Sites were geographically analyzed to assess landscape characteristics such as watershed location, average buffer size, and intensity of surrounding land use. In most cases it was possible to identify the approximate wetland type (emergent marsh, scrub-shrub, or forested swamp) using aerial photographs. In addition to wetland type and perceived condition, factors influencing site selection included prior experiences with the wetland or watershed, site location and accessibility, land owner permission and sampling feasibility. Assessments included wetlands incurring a known change or impact in order to monitor the effects of the impact on wetland health and composition. Sites were also selected by considering the sampling histories of the VTDEC Lakes and Ponds Section and the Biomonitoring and Aquatic Studies Section in order to build on the data previously collected by these programs.

Reference Sites

Sites believed to be of a minimally disturbed condition were selected in order to create a baseline of disturbance level for all wetland sites. Reference sites were initially located within each biophysical region using color infrared aerial photos and orthophotos. Sites appearing to have a large, natural

buffer surrounding the wetland were considered to be of reference condition. Any site meeting the low disturbance level expected from a reference condition site was then assessed for the factors listed in the site selection section. Attempts were made to ensure that at least one-third of the sites sampled were reference sites during each sampling season in order to create a solid baseline of expectation for wetland quality.

Disturbed Site Selection

Disturbed sites were selected to inventory the response of wetlands to environmental and anthropogenic stressors including, but not limited to, encroachment, storm water runoff, point source pollution, filling, nutrient enrichment and farming as indicated from aerial and satellite photography. Non-reference condition sites were selected in an effort to encompass a range of disturbances from minimally disturbed to highly disturbed based on the amount and severity of the anthropogenic and environmental stressors. Site assessment areas also included wetlands undergoing restoration and were selected based upon best professional judgment.

Sampling and Assessment

Physical Habitat

Information about the physical environment in and surrounding each wetland site was recorded before, during, and after the site visit. At each site, wetland community size, maximum water depth, water source, water color and clarity, canopy cover, duration of inundation and saturation, and modifications or alterations to hydrologic regime, substrate and habitat were recorded onto the wetland bioassessment field data sheet.

Land use, wetland connectivity, dam presence, horizontal interspersion and invasive species cover were also recorded. Latitude and longitude were determined using a Garmin hand-held GPS unit with an accuracy ranging from 3 to 20 meters based on canopy cover and satellite coverage.

Vegetation Sampling

Vegetation was assessed between June and September at a total of fifty-one wetlands during the 2008 and 2009 field seasons. Vascular vegetation was sampled at each site using a transect-quadrat method. Plants were identified to the lowest taxonomic level possible and their presence was noted on the field data sheet. Vegetation outside of the transect was also noted and described to give a more complete picture of the wetland.

Table 18. Wetland bioassessment site locations, biophysical regions, and Cowardin wetland types.

Year	Site Name	Town	Region[1]	Wetland Type[2]
2009	Alder Branch Wetland	Granville	SGM	E/SS
2009	Barrows Brook Wetland	Stowe	NGM	F/SS
2009	Buel's Gore Wetland	Buel's Gore	NGM	E/UB
2009	Bettis Pond Wetland	Roxbury	NGM	E/SS
2009	Bingo Brook Wetland	Rochester	SGM	E/SS
2009	Burnt Meadow Brook Wetland	Peru	SGM	SS
2009	Cabot Annex Wetland	Waterbury	NGM	E/SS
2009	Elm Brook WMA Wetland	Fairfield	CV	SS
2009	Five Ponds Wetland	Braintree	NGM	F/SS

2009	Jay State Forest	Jay	NGM	E/SS
2009	John J Durand SF Wetland	Rockingham	SVP	E/SS
2009	Lamphear Road Wetland	Jamaica	SGM	E/SS
2009	Little Hollow Wetland	Rochester	NGM	E/ML
2009	Lowell Lake Wetland	Londonderry	SVP	E
2009	Lockwood Pond Wetland	Lowell	NGM	E/ML
2009	McAllister Pond Wetland	Lowell	NGM	E/SS
2009	Mollie Beattie SF Wetland	Grafton	SGM	E/F
2009	Mount Mansfield Beaver Wetland	Cambridge	NGM	E/SS
2009	Mount Tabor Wetland	Mount Tabor	SGM	E/ML
2009	Newport Town Forest Wetland	Newport Town	NGM	E/SS
2009	Newfane Town Forest	Newfane	SGM	SS
2009	Oak Lodge Wetland	Rochester	SGM	SS
2009	Pomainville	Pittsford	VV	E
2009	Potter Road Wetland	Wardsboro	SGM	E/SS
2009	Revoir Flat Wetland	Jay	NGM	E/SS
2009	Riley Bostwick WMA Wetland	Rochester	SGM	F/ML
2009	Roxbury SF Wetland	Roxbury	NGM	SS
2009	Tamarack Brook Wetland	Montgomery	NGM	F/SS
2009	Third Branch Wetland	Braintree	NGM	E
2009	Tunnel Brook Wetland	Hancock	SGM	SS
2009	West Hill Brook Wetland	Montgomery	NGM	E/ML
2008	Barney Brook	Bennington	VV	E/SS
2008	Berlin Reservoir	Berlin	NVP	E/SS
2008	Branch Pond	Sunderland	SGM	E/ML
2008	Brattleboro Retreat Meadows	Brattleboro	SVP	SS
2008	Coles Pond	Walden	NVP	E/SS
2008	Curtis Pond	Calais	NVP	E/SS
2008	Kent Pond	Killington	SGM	E/SS
2008	Knapp Brook	Cavendish	SGM	E/SS
2008	Lye Brook Wilderness	Sunderland	SGM	E/ML
2008	Mill Pond	Windsor	SVP	SS
2008	Mud Pond	Newbury	NVP	E/SS
2008	North Springfield Meadow	Weathersfield	SVP	SS
2008	Old Marsh Pond	Fair Haven	TM	E/SS
2008	Schofield Fen	Hyde Park	NGM	E/ML
2008	Seymour Cedar Swamp	Morgan	NVP	F
2008	South Stream	Bennington	VV	E/SS
2008	Thetford Marsh	Thetford	SVP	E
2008	North Shore Wetland	South Burlington	CV	E
2008	Woodford Site I	Woodford	SGM	E
2008	Woodford Site II	Woodford	SGM	F

[1] VT Biophysical Regions: NVP = Northern Vermont Peidmont, SVP = Southern Vermont Piedmont, NGM = Northern Green Mountains, SGM = Southern Green Mountains, CV = Champlain Valley, VV = Vermont Valley, TM = Taconic Mountains.

[2] Cowardin Wetland types: AB = Aquatic Bed, E = Emergent Wetland, F = Forested Wetland, ML = Moss-lichen Wetland, SS = Scrub-shrub Wetland, UB = Unconsolidated Bottom.

Water Chemistry
Water samples were collected at all sites assessed in 2008 and 2009. Samples were collected following the protocol outlined in the Vermont Wetlands Bioassessment Program Quality Assurance Project Plan.

Maximum, minimum and average water chemistry results were calculated from the combined data of the fifty wetland sites sampled. Aluminum, alkalinity, sulfate, iron, nitrate+nitrite-water, and total suspended solids had results that were measurable to a minimum level. The minimum level was interpreted as the final result when running the mathematical and statistical analysis. The Human Disturbance Rank (HDR) score was used to compare the water quality results of high and low disturbance wetlands. Sites with a score of 3 or lower were compared to sites with a score of 7 or higher. Sigma Stat© 3.1 software was used to run the statistical tests. Water chemistry results from Lye Brook Wilderness were not used due to improper collection techniques.

Human Disturbance Assessment
Wetlands were also assessed using both the Human Disturbance Ranking, which is mentioned above and is a ranking developed by DEC, and the Vermont Rapid Assessment Method (VRAM) adapted from the Ohio Rapid Assessment Method for Wetlands v. 5.0. The VRAM combined scores from six metrics assessing: (1) wetland area (size), (2) upland buffers and surrounding land use, (3) hydrology within the wetland, (4) wetland habitat alteration, (5) special wetlands, and (6) plant communities, interspersion, and microtopography.

Each wetland was given a score ranging between 0 and 100 based upon the VRAM metrics. A high score designates a site with little or no disruption; scores decrease with increased levels of human disturbances and lack of vegetation community diversity.

Site Reports
Fifty-one individual site reports for 2008-2009 will be included in the final report. The site report includes the physical setting, surrounding landscape condition, vegetation, and physical and chemical characteristics of each wetland site. A map illustrating the assessment location and surrounding landscape is also included with each report.

Results
Water Chemistry
The maximum, minimum, and average values for the 25 parameters sampled at each wetland are given in Table 19 below.

Table 19. Water chemistry results for 2008-2009 wetland sites.

Parameter	*Maximum*	*Site Name*	*Minimum*	*Site Name*	*Average*	*n=1*
Alkalinity (mg $CaCO_3$/l)	136	Berlin Reservoir	-1.25	Branch Pond Wetland	30.62	n=50
Aluminum (ug/L)	1140	Woodford Site I	< 10	Berlin Reservoir	89.13	n=43
Chloride (mg/L)	102	Cabot Annex Wetland	0.21	Old Marsh Pond	12.36	n=48
Conductivity (µmhos/cm)	528	Cabot Annex Wetland	16	Lamphear Road Wetland	108.44	n=50

Sulfate (mg/L)	14.5	Barrows Brook Wetland	0.5	Woodford Site I; Potter Road Wetland	3.15	n=50
Sodium (mg/L)	48.2	Third Branch Wetland	0.16	Little Hollow Wetland	6.71	n=47
Magnesium (mg/L)	11.9	Barney Brook Wetland	0.18	Branch Pond Wetland	1.76	n=47
Potassium (mg/L)	1.86	Kent Pond Wetland	0.05	Roxbury SF Wetland	0.58	n=47
Calcium (mg/L)	46	Berlin Reservoir	0.59	Branch Pond Wetland	10.75	n=47
Total Calculated Hardness (mg/L)	136	Berlin Reservoir	0.17	Cabot Annex Wetland; Bingo Brook Wetland; Lockwood Pond Wetland	31.85	n=50
Iron (ug/L)	24600	Woodford Site I	50	Seymour White Cedar Swamp	1220.73	n=47
Manganese (ug/L)	1115	Five Ponds Wetland	5	Elm Brook Wetland	175.76	n=47
Nitrate + Nitrite - Water (mg-N/L)	0.25	Elm Brook Wetland	< 0.05	33 Sites	0.07	n=50
Nitrogen, Total - Persulfate (mg-N/L)	2.27	Woodford Site I	0.1	Newfane Town Forest; Alder Branch Wetland	0.39	n=50
Phosphorus (ug P/L)	292	Berlin Reservoir	5.65	Mt. Mansfield Beaver Wetland	34.74	n=50
Filtered Phosphorus (ug P/L)	63	North Springfield Meadow	5	Mt. Mansfield Beaver Wetland	16.41	n=50
Solids, Total Suspended (mg/L)	120	Woodford Site I	< 1	9 Sites	8.37	n=50
Turbidity (NTU)	48.6	Cabot Annex Wetland	0.49	Barrows Brook Wetland	3.15	n=50
Temp (°C)	24.02	Oak Lodge Wetland	11.77	Mollie Beattie SF Wetland	18.13	n=31
SpCond (µs/m)[2]	497.1	Cabot Annex Wetland	12.5	Lamphear Road Wetland	81.33	n=31
pH	7.61	Coles Pond Wetland	4.7	Mount Tabor Wetland	6.52	n=46
Chlorophyll *a*[2]	13.41	Cabot Annex Wetland	0.83	Bingo Brook Wetland	4.09	n=19
DO (%)[2]	100	Oak Lodge Wetland	29.2	Cabot Annex Wetland	71.73	n=31
DO (mg/L)[2]	9.8	Pomainville Wetland	2.41	Cabot Annex Wetland	6.51	n=31
Color (HU)	500	Woodford Site I	7.5	Newfane Town Forest	79.72	n=47

[1] Lye Brook Wilderness water quality results were not included because the water sample was taken improperly.
[2] The results of these parameters include only the 2009 sites.

Human Disturbance

Four of the sites assessed in 2008-2009 received the lowest possible Human Disturbance Rank score (highest quality), while no sites received the highest HDR score (lowest quality). During the 2008-2009 sampling season, the lowest score any site received was 2 and the highest score received by any site was 9 . Sites receiving a score less than 3 were considered to be in reference condition; those receiving scores ranging from 3.5 to 6.5 were considered to be in moderate condition; and sites receiving scores of 7.0 or greater were considered to be in poor condition. Based upon this standard, a total of 15 sites in 2008-2009 were deemed to be in reference condition and 17 sites were identified as being in poor condition.

The six sites with the highest HDR score indicating a level of high disturbance were Mill Pond, Third Branch Wetland, Barrows Brook Wetland, Brattleboro Retreat Meadows, North Springfield Meadow, and Pomainville.

The four sites with the lowest HDR score, indicating a very low level of disturbance, are Woodford Site I, Lye Brook Wilderness, Lockwood Pond Wetland, and Branch Pond Wetland. The HDR score accurately reflects the high quality vegetation found at each site and lack of anthropogenic disturbance with the exception of acid deposition.

VRAM score results provided disturbance ranges from 32 to 94 out of a maximum of 100 points. Lower scores indicate a greater degree of disturbance. Sites with scores between 85 and 100 are considered to be of reference condition; of moderate condition between 64 and 84; and of disturbed condition between 0 and 65. Using this scoring regime, sixteen sites sampled in 2008-2009 were considered to be in poor condition. The sixteen sites that scored below 65 were also considered to be in poor condition according to the HDR except for Kent Pond and Berlin Reservoir. All sixteen sites were considered to be disturbed sites using the Level 1 assessment. Berlin Reservoir achieved a moderate condition rating using the VRAM in comparison to the HDR because of the extra weight on vegetation communities and hydrology. Kent Pond also received a higher condition rating based on vegetation, habitat, and hydrology. The VRAM scoring method determines that the more developed the wetland vegetation community, habitat and hydrology is in a site, the better the wetland is able to deal with stressors. As a result, the site has a higher condition rating.
Further data analysis has indicated that the VRAM method is generally more consistent in assessing the stressors impacting wetland condition. For instance, the VRAM metrics can be used to compare anthropogenic modifications to hydrology and water quality or vegetative communities, where the HDR cannot.

In many instances, vegetation and water chemistry data supported the conclusions describing wetland condition drawn by the both the VRAM and HDR method. The VRAM picks up where the HDR leaves off in condition analysis and has been helpful in identifying the shortfalls of the HDR. Conversely, the HDR method has been useful in revealing the tendency of the VRAM to judge a site based more upon its functions and values than its condition. As a result, both methods should be used in the future until they can be combined to create a more comprehensive and accurate measure of biological integrity and condition. Overall, the final score derived from each method is an indicator of site condition and biological integrity.

Biological
Vegetation, algae, macroinvertebrates and other aquatic biota measurements can provide insight into the overall health of a wetland, and indicate how a site is reacting to the stressors placed upon it. Metrics for these assemblages are still under development for wetlands. The New England Interstate Water Pollution Control Commission (NEIWPCC) has received a grant from EPA to develop a Floristic Quality Assessment Index for the New England states, and Vermont is participating on the technical workgroup. New metrics will also become available through the National Wetland Condition Assessment (NWCA) in 2011.

Future Wetland Monitoring and Assessment

In 2010, the Wetland Section will continue to refine its methods and fill in gaps in geographic coverage, covering about 20 new sites. DEC will also be doing scoping work for the 2011 NWCA. This will include screening selected sites and candidate reference sites. Beginning in 2012, the wetland monitoring and assessment activities will become more fully integrated into the Monitoring, Assessment and Planning Section.

Public Health Issues

Size of Water Affected by Toxicants

With the exception of fish consumption advisories described in Appendix A, there are no waterbodies in Vermont where toxicants are known to be impairing public health related uses. Nonetheless, water quality monitoring by NPDES permit holders and by suppliers of drinking water continues to provide data and other information related to environmental occurrences of toxicants in permitted municipal and industrial discharges and public water supplies.

Mercury and Fish Consumption

During the 2010 305(b) reporting period, and due to resource constraints, only 63 fishes from a handful of inland Vermont lakes were processed for the purpose of revising fish consumption advisories.

Every five years, the operators of the Fifteen Mile Falls reservoir system on the Connecticut River are required by their Federal operating license to sample fish mercury in project reservoirs. A total of 240 fishes were tested in 2008 by the Biodiversity Research Institute of Maine. Results indicate that there have been statistically significant declines in fish mercury levels of smaller prey-sized fish in the reservoirs. The researchers attribute these reductions to reduced water level fluctuations. Reductions were also observed in consumption-sized smallmouth bass, however, these were not statistically significant.

Cyanobacteria

Monitoring for cyanobacteria continues on Lake Champlain as a cooperative effort headed by the University of Vermont (UVM) and the Vermont Department of Health (VDH). The Vermont DEC, the Lake Champlain Committee and citizen volunteers are partners in this effort. UVM continues to conduct routine counting and evaluation following the established protocol. Anatoxin-a analyses are now undertaken by the VDH and, since 2008, the VDH lab has also offered cyanotoxin test kits to the general public, for a low fee, which include both microcystin-LR and anatoxin-a. Results of the monitoring program and any additional cyanobacteria sightings are reported on the VDH web page (http://healthvermont.gov/enviro/bg_algae/bgalgae.aspx) through a weekly status statement and a lake status map color-coded for alert levels. The weekly statement and lake map are routinely viewed by the public and by the members of the Champlain Coalition of Water Suppliers.

In 2008, cyanobacteria were detected in monitoring samples by July in most of Lake Champlain. Blooms with detectable microcystin concentrations were documented over the course of the summer in Missisquoi and St. Albans Bay, the Northeast Passage, in the vicinity of the Grand Isle Ferry crossing, and also in Burlington Bay. Visible cyanobacteria were reported from several lakes around the state (Memphremagog, Morey, Carmi, and Salem) but not all could be verified by DEC staff. No toxin analyses were submitted from these lakes.

In 2009, cyanobacteria were present in Champlain monitoring samples at most locations by early July, when patchy surface scums were first reported from Missisquoi Bay. The bloom reached alert

level by July 16th, with microcystin concentrations between 20 and 55µg/L. Most other locations were generally safe in 2009, although alert levels were reached in St. Albans, Dunham and Red Rocks bays. Samples were submitted for anatoxin analysis from several locations, but none was detected. Though scums were observed in St. Albans and Missisquoi in September, cyanobacteria densities were decreasing throughout the lake at that time and remained at levels below concern for the fall.

Few reports of cyanobacteria were received from other areas of the state in 2009. There was a dog death associated with a private pond in Newport. The dog died after swimming in, and possibly eating material from, the pond. A potentially toxic cyanobacterium was confirmed in a benthic sample, but no toxin samples were submitted for analysis. In May, researchers at the Dartmouth Hitchcock Medical Center released a study suggesting that cyanobacteria toxins might be linked to ALS (Lou Gehrigs Disease) clusters in Vermont and New Hampshire, resulting in a flurry of inquiries. A number of lake associations and lake shore residents were provided with materials to help them interpret the study results and identify cyanobacteria. Blooms were reported by the public or DEC staff on lakes Morey and St. Catherine.

Microcystin continues to be the toxin detected most frequently. Although samples are submitted for anatoxin analysis whenever potential producers are present, this toxin is rarely detected. In 2008, the VDH lab ran 81 samples for toxin analysis, primarily for Champlain samples containing potential anatoxin producers. One sample taken in September had detectable anatoxin below the reporting level. All others were negative. One Champlain water supplier documented a non-toxic bloom over their intake and a second reported microcystin (~2.1 ppb) in raw intake water. Two additional public suppliers experienced algal conditions that resulted in toxin testing (no toxins detected) and one private supplier reported possible problems with their water source on Lake Champlain. In 2009, more than 38 samples were analyzed for microcystin and anatoxin, about half of which were from a single Champlain water supplier. No toxins were detected.

To assist towns and lake shore residents respond to the presence of cyanobacteria in their waters, the VDH and the DEC developed a draft protocol that provided guidance in assessing recreational health risks associated with cyanobacteria, developing local monitoring networks, and facilitating communication between local residents and health officials. The protocol allows communities to create a network of monitoring and communication to fit their needs and finances. The Memphremagog area tested the draft protocol in 2009, establishing a local monitoring and communication network formed by members of the local lake association, local DEC and VDH staff, and municipal park and recreation employees.

Cyanobacteria remain an issue of concern to Vermonters, often as a result of the confusing and contradictory information that circulates each time blooms are reported. The confusion is exacerbated by the lack of consistency among states in the Northeast when responding to the presence of cyanobacteria. This occurs in part because the regulatory authority of the state is imprecise with respect to such local health issues, but also because there is little guidance at the national level. The New England Interstate Water Pollution Control Commission is beginning to address these issues by providing opportunities for regional representatives to discuss how best to respond to the presence of cyanobacteria in drinking water sources and recreational lakes. Legislation has been proposed in Congress that will facilitate this discussion at the national level.

Drinking water standards have not been established for cyanobacteria and their toxins in public water supplies. Cyanobacteria and their toxins are currently included in EPA's candidate list for contaminants that are known or anticipated to occur in public water systems, but there has not yet been a regulatory determination on this listing. Lake Champlain is a drinking water source for approximately 200,000 people, and the state would benefit from national guidance regarding these toxins.

Small Community Untreated Waste Discharges

Three village areas in the Town of Pownal began site preparations for a new wastewater treatment plant in 2003. In 2004, the first of eight sewer and pump station contracts began construction. The new wastewater treatment plant began treating sewage from two of the three village areas in 2006. In 2009 the last sewer contract was completed abating the last confirmed source of pollution.

DEC provides direct funding and technical assistance to small communities without sewers to help them evaluate and plan for their wastewater needs. It is anticipated there will be a steady demand by several small communities for wastewater evaluations and planning in the coming years. These communities have not been identified in the past as being the sources of surface water pollution, but residents are now realizing that they may have problems with their small lot and older on-site sewage systems. Another factor is the economic viability of small communities which cannot have commercial or residential growth due to limiting soil conditions for septic system leachfields. During the 2009 reporting period, the towns of Addison and Peacham began such studies for their village centers.

Sites of Known Sediment Contamination

During the reporting period, assessments for sediment contamination were conducted behind several low-head impoundments that are being considered for removal in order to restore stream connectivity. These include Dufresne Pond (Manchester), a small impoundment of the Walloomsac River in Bennington, a small impoundment of the Winooski River in Marshfield, a small tributary to Commissary Brook in Westminster, Hobbs Pond in Milton, and the "Combination Pond," an impoundment of the stormwater-impaired Moon Brook in Rutland.

Of these six impoundments sampled for priority metals or organic compounds, sediment contaminants slightly in excess of probable effects concentrations were noted at Dufresne Pond and the Winooski River location. Higher concentrations of metals were noted at Commissary Brook, although these metals are strongly complexed to the clay "varve" that is chararacteristic of the immediate Connecticut River vicinity, and therefore likely of low risk to human health or aquatic biota. The most acute sediment contamination was observed at Hobbs Pond. The Hobbs Pond investigation has also shown impacts to pond sediments with the highest concentrations of benzo(a)pyrene, cadmium, arsenic, chromium, lead and arochlor 1260.

There are contaminated sediments in Stevens Branch in Barre, Stevens Brook in St. Albans, and in a tributary to Muddy Brook in South Burlington.

Restrictions on Bathing Areas During the 2010 Reporting Period

The current Vermont criterion for *E. coli* in Class B swim waters is 77 organisms/100 ml of water for any single sample. This criterion was developed in the 1990s as an interpretation of then-current EPA guidance, which suggested that such a criterion would protect swimmers to somewhat less than 4 expected illnesses per 1000 swimmers. This criterion is significantly more stringent than the current EPA recommended recreational water quality standard for *E. coli* of 235 organisms/100 ml for any single water sample, which corresponds to approximately 8 gastrointestinal illnesses per 1000 swimmers. Other restrictions on bathing areas in Vermont have recently included beach closures due to cyanobacteria blooms and animal fecal waste (e.g. geese and gulls defecating along shoreline), which can be a source of *E. coli* contamination. The reader is cautioned that the occurrence of a beach closure should not be equated with the determination that the beach is impaired due to *E. coli* contamination.

Lake Champlain

The count of beach closures for Lake Champlain public beaches in 2008 and 2009 is shown in Table 20. The most notable results from this reporting period is that Burlington's Blanchard Beach only had two closures due to an *E. coli* violation since its reopening in 2007. This popular swimming beach had been closed since 1992 due to ongoing bacterial contamination from Englesby Brook. After significant stormwater remediation efforts in the watershed, the beach was reopened and water testing instituted beginning June 2007. As a result of this new data, the associated lake segment (VT05-10L01_03) has been upgraded from impaired status to stressed.

Table 20. Number of Beach Closures for Vermont Portion of Lake Champlain.

Segment & Beach	**Closures due to *E. coli***		**Other Closures**
NORTHEAST ARM	**2008**	**2009[1]**	**2008-2009**
North Hero State Park	0	No data	
St. Albans Town Beach	0	0	Jul 15-21 & Sep 3-11, 2009: animal fecal - geese & gulls defecating along shoreline
Kill Kare State Park	0	No data	
Burton Island State Park	0	No data	
Knight Point State Park	1	No data	
Grand Isle State Park	0	No data	
Sand Bar State Park	4	No data	
MALLETTS BAY	**2008**	**2009**	**2008-2009**
Bayside Beach	0	2	
Rossetti Nature Area	1	3	
MAIN LAKE	**2008**	**2009**	**2008-2009**
Leddy Beach	0	0	
North Beach	0	0	
Blanchard Beach	1	1	
Cove Beach (Oakledge Park)	0	0	
Red Rocks Park Beach	2	2	Jul 18-19, 2009: precautionary closing - cyanobacteria present, but no toxic levels

Shelburne Town Beach	1	2	
Charlotte Town Beach	0	0	Jun 23-24 & Aug 18-19, 2009: total coliform
Kingsland Bay State Park	2	1	
Alburg Dunes	1	No data	

1) *Due to budget constraints in 2009, the laboratory used to process these samples was changed, resulting in data not being available to DEC as of the publication of this Report.*

Inland Lakes

There were eight inland lakes with State Park beaches that were closed due to an *E. coli* violation during the 2010 305(b) reporting period (Table 21). In most cases, re-sampling taken the day that high results were received by the beaches revealed *E. coli* concentrations below the Vermont standard. It should be noted that Shaftsbury Lake has seen a substantial decline in the number of *E. coli* violations from twelve in 2007 to one in 2008 and zero in 2009, which may be attributable to goose control efforts reducing bacterial contamination from fecal waste.

Table 21. Number of State Park Beach Closures for Inland Lakes due to E. coli.

Waterbody	2008	2009[1]
Lake Bomoseen	2	0
Lake Carmi	6	No data
Lake Elmore	1	0
Ricker Pond	0	1
Shaftsbury Lake	1	0
Silver Lake (Barnard)	1	0
Spectacle Pond	0	1
Waterbury Reservoir	2	0

1) *Footnote Table 17.*

All five inland reservoirs with beaches operated and maintained by the US Army Corps of Engineers had beach closures due to one or more *E. coli* exceedances during this reporting period (Table 22).

Table 22. Number of Days US Army Corps of Engineers Beaches Closed due to E. coli.

Waterbody	2007	2008	2009
Ball Mountain Lake	12	15	0
North Hartland Lake	0	4	4
North Springfield Lake	0	2	4
Townshend Lake	8	15	18
Union Village Dam	9	38	20

Restrictions on Surface Drinking Water Supplies During the 2010 Reporting Period

One system was placed on a boil water restriction during the reporting period. The Montpelier Water System has a boil water notice for four homes that are not presently connected to the City drinking water distribution system.

Lampricide treatments of the Lamoille River in 2009 and the Winooski and Missisquoi Rivers in 2008 resulted in restrictions on surface drinking water supplies until 24 hours after the monitored levels of the lampricide TFM were below the value of 20 ppb TFM. Four active public water systems were in the water use advisory zone for the Lamoille treatment. Six public water systems were in the advisory zone for the Missisquoi and the Burlington water supply intake was in the Winooski River lampricide treatment advisory zone.

Chronic or Recurring Fish Kills

The Vermont Department of Fish and Wildlife (DF&W) maintains a fish pathology laboratory which responds to reports of fish kills and maintains records of the events. There was one recurring fish kill in Vermont during the 2010 305(b) reporting period, and two instances of commonly observed, natural mortality associated with post-spawning stress. Such natural fish mortality often occurs in Vermont on some lakes and ponds during late spring and early summer. These waters are as follows:

Recurring fishkill:
July 29/30, 2009 – Shelburne Pond - major fish kill of many species due to oxygen depletion.

Incidental fishkills:
June 18, 2008 – Round Pond, Newbury, VT - minor fish kill of bluegill, yellow perch and pickerel. Post spawning stress with warming water and Columnaris bacterium identified.

Jan. through April, 2008 – Lake Champlain– large alewife die-off. General immunosuppression due to cold water temperatures. Alewife die-off is common in many lakes and streams where this invasive species is found.

Chapter 5. Groundwater Monitoring and Assessment

Introduction

The Groundwater Coordinating Committee (GWCC) was active during the 2008 and 2009 biennial. The GWCC was established through legislation (Chapter 48: Groundwater Protection, 1985) with committee representation from the Department of Environmental Conservation, Department of Forests, Parks and Recreation, Agency of Agriculture, Food and Markets, Department of Health, along with representatives of other agencies and the private sector.

The purpose of the GWCC is to advise the Secretary of the Agency of Natural Resources (the Secretary) on the development and implementation of the groundwater management program. This program includes:

Developing a groundwater strategy and integrating the groundwater management strategy with other regulatory programs administered by the Secretary,
Cooperating with other government agencies in collecting data on the quantity and quality of groundwater and location of aquifers,
Investigating and mapping groundwater currently used as public water supply sources and groundwater determined by the Secretary as potential future public water supply sources,
Providing technical assistance to municipal officials, classifying the groundwater resources and adopting technical criteria and standards for the management of activities that may pose a risk to their beneficial uses,
Developing public information and education materials, and
Cooperating with federal agencies in the development of programs for protecting the quality and quantity of the groundwater resources.

Also, the Secretary shall adopt rules for the protection of public water source protection areas (Chapter 56: Public Water Supply). The administrative functions of the Committee are performed by the Water Supply Division (WSD) within the Department of Environmental Conservation.

In carrying out these duties the Secretary shall give due consideration to the recommendations of the GWCC. This relationship was most realized through the development of the strategy for the management and protection of groundwater along with the adoption of the Groundwater Protection Rule and Strategy (GWPR&S) Chapter 12 (adopted February 1988 and revised September 2005). The committee's interaction with the Secretary has most actively been involved with the reclassification of nine contaminated groundwater areas to Class IV Groundwater.

Groundwater Reclassification Issues

Unifirst Site

During the 2008-2009 biennium, the GWCC worked with a contaminated groundwater area at the UniFirst site located in Williamstown. The UniFirst facility is located on a 6.63-acre lot in the Rouleau Brook watershed. Rouleau Brook is a tributary to the Stevens Branch, which in turn is tributary to the Winooski River. The facility is bordered by a residential neighborhood to the east, by public schools to the north and south, and by residences and agricultural land to the west.

Interstate Uniform Services Company (now UniFirst) operated a laundry and dry cleaning business at the Herbert Road facility from 1973 through 1983. In 1973 and 1974, sludges containing PCE from a solvent recovery system were released onto the eastern portion of the property into a dry well. Between 1974 and 1981, water containing PCE was released from a manhole connection with a leaking seal located near the eastern side of the UniFirst building.

Groundwater and surface water were first tested for volatile organic chemicals by the Vermont Department of Health (VDH) in 1983. Perchloroethylene (PCE), trichloroethylene (TCE), and 1,2 dichloroethylene (1,2, DCE) were found in local drinking water wells. In response to the discovery of contamination, UniFirst worked in cooperation with the Town of Williamstown and the State of Vermont to expand the municipal water supply system, construct new water supply connections and replace private drinking water wells.

The effort by the Water Supply Division (WSD) and Waste Management Division (WMD) to reclassify this area to a Class IV Groundwater Area was met with opposition by the residents living nearby the site. The main argument of the residents was that the proposed Class IV Groundwater Area designation would lower their property value. After much discussion the Town of Williamstown and the WMD came to an agreement. The agreement relates to the Groundwater Reclassification of the Unifirst site which was proposed to be designated as Class IV Groundwater. To remedy this situation, the Town has passed a water supply ordinance that achieves many of the same goals as the Class IV Groundwater Reclassification. Based on this, the WMD withdrew the proposed Groundwater Reclassification for the Williamstown Unifirst site.

DSI Landfill

A second contaminated site the GWCC worked to reclassify is the DSI Landfill that is located on the west side of Route 5 just west of the Connecticut River in the northeastern portion of the Town of Rockingham, Windham County, Vermont. The landfill is bordered on the east by Route 5, on the west by Interstate 89, and on the northwest by Hogan Hill. The Connecticut River flows through a well defined valley southward just east of the DSI Landfill.

The DSI Landfill received construction materials in the 1960s and before. Afterwards, industrial wastes, including heavy metals, bases, pesticides and VOCs were deposited. The landfill was licensed as a municipal landfill in 1983 and stopped receiving waste in 1991.

Based on the topography, surface water runoff from the site generally flows southeast toward the Connecticut River. There is a small wetland area at the base of the steep slopes between the site and the Connecticut River. Groundwater in the overburden at the site flows toward the Connecticut River.

Contaminants found in the Connecticut River adjacent to the site have not been attributed to the landfill. Groundwater contamination data collected at the DSI landfill from the early 1990s to present show that the quality of groundwater has been impacted by both natural and man made influences. Naturally occurring levels of arsenic, iron, and manganese were found within the site and in wells not impacted by the waste disposal activities. These metals also exceeded the Vermont Groundwater Enforcements Standards (VGES) at the site and in one well chromium and nickel

exceeded the standard. Volatile Organic Chemicals (VOCs) reaching or exceeding the VGES at the site includes benzene, tetrachloroethene, and methylene chloride. Chemicals were mostly detected in bedrock, in the area between the landfill and the Connecticut River. There is a potential that cleanup goals within the 15 year period specified in the Record of Decision (ROD) will not be met. This concern has prompted the area to be reclassified to Class IV groundwater.

The reclassification area encompasses 52.7 acres. It includes a zone where 95% confidence-level statistics indicate that groundwater is contaminated above the Vermont Groundwater Enforcement Standards (VGES), and an approximately 200 feet wide buffer zone around the up-gradient and cross-gradient boundaries of the contamination zone.

Under the institutional control plan for the site, homes within the area have been connected to a water supply line located outside the Class IV Area. The ROD also required that the DSI Landfill be reclassified and this was a driving force behind the reclassification. The Environmental Protection Agency thought the reclassification should be put in place rather the changing the ROD which expired in 2009.

Hartford Landfill

The GWCC has also reviewed the Hartford Landfill during the biennium. However, it has yet to recommend groundwater reclassification for the site. This Landfill is located on approximately 30 acres situated on the east side of Route 5 in the southeastern portion of the Town of Hartford, Windsor County, Vermont, in vegetated, hilly terrain.

The landfill is bordered on the west by Route 5, on the east by Interstate 89, on the north by Neal Brook and on the south by an unnamed tributary. Both Neal Brook and its tributary flow eastward toward the Connecticut River.

The overburden at the site consists of glacio-fluvial and glacio-lacustrine materials. The waste units are situated on top of a thin sandy unit that has a perched water table. Directly beneath the waste units, the thin sandy zone is underlain by a much thicker silty layer that appears to have acted as a barrier to downward contaminant migration. Bedrock in the area is metamorphic, and includes the Waits River and Gile Mountain formations.

During a site inspection in 1984, the State detected contaminants in a stream bordering the landfill, in groundwater at the landfill, and in four private wells located less than a mile from the landfill. Subsequent investigations have shown that soil, soil gas, surface water and groundwater at the site are contaminated with a wide range of chemicals. As part of groundwater investigations, about 120 monitoring wells have been drilled and tested. The main contaminants of concern in the groundwater are trichloroethylene (TCE) and its daughter products.

The nine areas that have been designated as Class IV Groundwater are displayed on the Agency's Geographical Information System. This allows for public viewing and an increased awareness regarding groundwater contamination in the State.

Legislation

State Legislation

State legislature passed an act relating to a Groundwater Withdrawal Permit Program in 2008. The new law recognizes that the groundwater of Vermont is a precious, finite, and invaluable resource upon which there is an ever-increasing demand for present, new, and competing uses and that an adequate supply of groundwater for domestic, farming, dairy processing, and industrial uses is essential to the health, safety, and welfare of the people of Vermont. It also recognizes that the withdrawal of groundwater of the State should be regulated in a manner that: benefits the people of the State; is compatible with long-range water resource planning, proper management, and use of the water resources of Vermont; and is consistent with Vermont's policy of managing groundwater as a public resource for the benefit of all Vermonters.

The "Groundwater Withdrawal Reporting and Permitting Rules" spells out reporting requirements for groundwater withdrawals greater than 20,000 gallons per day. However, if the water is purchased from a public municipal water system, or uses surface water exclusively, no reporting is required. On or before September 1, 2009, any non-exempted entity that withdraws in aggregate more than 20,000 gallons of water per day, averaged over a calendar month, from groundwater sources at a single tract of land or place of business must file a report for the amounts withdrawn for the preceding calendar year. The law exempted from this requirement withdrawals for fire suppression and public emergencies, domestic residential use, farming, dairy processing and milk handling, public water systems, closed loop, standing column, or similar non-extractive geothermal heat pumps, and withdrawals reported to the Agency of Natural Resources under any program that requires the reporting of substantially similar data. This report is to be submitted yearly.

The new legislation also states that is the policy of the State that the groundwater resources of the State are held in trust for the public. The designation of the groundwater resources of the state as a public trust resource shall not be construed to allow a new right of legal action by an individual other than the State of Vermont, except to remedy injury to a particularized interest related to water quantity protected under this subchapter.

Federal Legislation

At the federal level, the Groundwater Rule became effective in 2009. This rule requires that sanitary surveys be conducted every three years for community water systems and every five years for the remaining systems. A focus of the rule is to increase State efforts to identify public water sources at risk of viral contamination. This requires source water microbial sampling for non-disinfecting systems, and if found vulnerable, to require the state to have public water systems either install disinfection treatment, remove the contaminant source, or develop a new water supply source that is not vulnerable.

To determine the microbial risk the Groundwater Rule requires that a source water sample (taken prior to treatment and storage) be taken within 24 hours from each groundwater source when a triggering event occurs. The triggering event is a positive fecal or total coliform detect. When a source water sample is required, it must be taken from a sample tap located prior to any water

treatment, as close to the water source(s) as practically reasonable. If there is not already a sample tap in a location that meets the above criteria, installation of such a sampling tap(s) is required.

Every groundwater water system using disinfection must determine that the disinfection process they are using meets a minimum 4-log virus inactivation requirement. A 4-log inactivation means that 99.99% of the viruses and bacteria present are made non-infectious. Treating the water going to the users with 4-log inactivation treatment will meet the Groundwater Rule requirements for correcting a positive fecal coliform detect deficiency in a source water sample.

Well Interference Project

The Vermont Rural Water Association has completed an assessment of groundwater interference caused by the pumping of Public Community Water Supply (PCWS) sources throughout Vermont. This study was completed under a contract with the Vermont Department of Environmental Conservation WSD. The majority of PCWS sources in Vermont are wells completed in fractured crystalline bedrock aquifers, with a more limited number completed in sand and gravel aquifers present in some valley locations. Due to the non-homogenous, anisotropic nature of these aquifers, interference with nearby private and public wells and springs is difficult to predict unless measured in the field. Existing source evaluation reports prepared since 1980 by the environmental consulting community were reviewed to develop a geodatabase with key information about the pumped wells and observation wells monitored during these tests. This information includes specific pumping test information, derived values such as aquifer transmissivity and storativity, the degree of interference noted at observation locations, and a determination of acceptable versus unacceptable interference. The geodatabase was developed in conjunction with Stone Environmental, Inc. of Montpelier, Vermont. Although the review was limited to currently active or permitted drilled PCWS sources, 203 PCWS sources and 1,082 observation points were evaluated across the state. The results of the study indicate that, overall, groundwater interference is not a chronic problem in Vermont. However, unacceptable interference – where a specific observation well source could no longer meet its design demand – was noted in several instances in areas of higher concentrations of PCWS sources.

Geothermal Wells

WSD staff is receiving numerous calls regarding geothermal wells, especially as they related to permitting. It is anticipated that there are more than several hundred geothermal wells in the State. Marketing these wells as a “green” energy source has probably increased both interest and appeal of this growing industry.

Types of geothermal wells include:

- Open loop wells that withdrawal groundwater, pass it through a heat exchanger and discharge it to septic, surface water, etc.
- Standing column wells withdraw groundwater from the bottom of the well pass it through the a heat exchanger and return it to the top of the water column,

- Closed loop wells circulate fluid within closed pipes and the well bore is grouted around the pipe and
- Direct exchange systems circulate refrigerant through closed looped copper pipe that is grouted from the bottom up.

In Vermont it is thought that 10% were closed loop and 90% were standing column.

Issues associated with these wells include heat pollution, groundwater contamination, and construction problems. It also appears that the industry is poorly regulated even though regulations regarding geothermal wells could involve a host of regulations including the Groundwater Rule and Strategy, Underground Injection Control Regulations, regulations regarding Groundwater Withdrawal, along with well construction standards and licensing. Given the complexity of this industry, it has been proposed that stand alone regulations for geothermal wells might be best.

Information & Public Education

Each of the source protection area (SPA) delineations includes a public notice. The town, residents or property owners in the SPA, and officials of the water system are contacted. An opportunity for a hearing regarding the SPA is also provided. This public process is also provided in the reclassification of groundwater. The outcome of both processes includes the identification of the groundwater resources along with the development of a rapport with concerned citizens at the town level. Groundwater planning at the local level can be better applied through such efforts. Such processes will go a long way towards educating the public and protecting the resource. SPAs and Class IV Groundwater Areas are also available on ANR's GIS website.

The WSD annually sponsors Drinking Water Day at the State House. The event provides a number of exhibits that explains the importance of drinking water and its protection. Attendance often includes students, the general public, interested parties, and members of the legislature. The ANR's Science on the Green is another annual event and has been an additional opportunity for the WSD to provide educational material to students and the public.

The VDH toll-free phone line and its website have assisted well owners in better understanding the quality of their water. Also, when there is a confirmed exceedance of a water quality standard, whether naturally occurring or due to nearby land activities, there is technical assistance outlining treatment options so as to minimize a family's risk of exposure. VDH has also been present at Home Shows and realtor meetings regarding water quality sampling and testing. Similarly, the WSD's well driller's database is available on ANR's GIS website providing geographic and geological information to the public.

Mapping

In 2008, the Vermont Geological Survey was asked to compile and assess existing datasets related to groundwater in Vermont. Digital datasets used in the study include: 1) the1961 Centennial

Geologic Map of Vermont (1:250,000 scale), 2) a digital compilation of the 1960-1970 surficial maps of Vermont at scales of 1:24,000 - 1:62,500, 3) an edited and amended Water Supply Division Well Driller database, and 4) other publically available data such as DEM, soils data, and locations of potential pollution sources. The preliminary maps will be posted on this web page as they become available. Planned maps include statewide maps at a scale of 1:250,000 and county maps at a scale of 1:100,000. Groundwater favorability maps for surficial materials aquifers are being produced. These maps are using located wells in valley bottoms. Detailed maps (1:24,000 scale) are available where in depth geological studies have been conducted. The water well data used in this study is a derivative set of the Vermont Department of Environmental Conservation Water Supply Division well driller database and includes data from 1961 and April 2008. The location of the data points is from 1) well driller maps and written descriptions, 2) E911 addresses (3100 wells), and 3) GPS measurements (7707 wells). The data includes 4116 wells identified as "gravel" wells and 92,315 other wells. Of the 92,315 wells, most are completed in bedrock, although many have no entry in the "well type" data field. Some corrections were made to the database where numerical errors were obvious and could be reconciled with a driller report.

Recommendation

Groundwater is fundamental to the ecosystem and as a drinking water resource. It recharges wetlands, streams, rivers, lakes, and ponds, which is critical to wildlife. It is a source of drinking water for most of the State's population. While groundwater is addressed through the Safe Drinking Water Act, this Act's prime focus has been on monitoring, treatment, operation, and infrastructure needs of public water systems. Additional regulations that address groundwater are often in reaction to contamination. Yet, the quantity and quality of groundwater which define its use remain largely unknown. Characterizing the groundwater resources is overdue relative to the continuing threats of contamination, the pressures and pace of economic development, and the importance of this resource.

Appendix A:Vermont Department of Health Fish Consumption Advisory

HEALTH ALERT

The Vermont Department of Health recommends that people limit eating some fish caught in Vermont waters.

These advisories are based on tests of fish caught in Vermont waters and scientific information about the harmful effects of mercury and, in the case of large lake trout in Lake Champlain and all fish in the Hoosic River, PCBs (polychlorinated biphenyls).

You can mix and match fish (you catch or buy) with the same limits, but once you meet the lowest limit eat no more fish that month. Do not eat the monthly limit within a single week.

Store bought fresh and canned fish—including tuna—have mercury levels that are about the same as many Vermont-caught fish. Add in store bought fish when you decide how many fish meals to eat each month.

One fish meal = 8 ounces uncooked fish

	Women of childbearing age and children age 6 and under	Everyone else
GENERAL ADVISORY:		
Brown Bullhead Pumpkinseed	No more than 5 meals/month	No Restrictions
Walleye	0 Meals	No more than 1 meal/month
Lake Trout Smallmouth Bass Chain Pickerel American Eel	No more than 1 meal/month	No more than 3 meals/month
Largemouth Bass Northern Pike Yellow Perch (larger than 10 inches)	No more than 2 meals/month	No more than 6 meals/month
Brook Trout Brown Trout Rainbow Trout Yellow Perch (smaller than 10 inches)	No more than 3-4 meals/month	No Restrictions
All Other Fish	No more than 2-3 meals/month	No more than 9 meals/month
SPECIAL ADVISORIES:		
Lake Carmi - Walleye	No more than 4 meals/month	No Restrictions
Lake Champlain - Lake Trout (larger than 25 inches)	0 meals (includes all children under 15)	No more than 1 meal/month
Hoosic River - All Fish	0 meals	0 meals
Deerfield Chain (Grout Pond, Somerset Reservoir, Harriman Reservoir, Sherman Reservoir, and Searsburg Reservoir)		
Brown Bullhead Brook Trout	No more than 5 meals/month	No Restrictions
Rainbow Trout Brown Trout (smaller than 14 inches) Rock Bass Rainbow Smelt Yellow Perch	No more than 1 meal/month	No more than 3 meals/month
Brown Trout (larger than 14 inches) All Other Fish	0 meals	No more than 1 meal/month
15 Mile Falls Chain (Comerford Reservoir and Moore Reservoir)		
White Sucker	No more than 1 meal/month	No more than 3 meals/month
All Fish	0 meals	No more than 2 meals/month
15 Mile Falls Chain (McIndoes Reservoir)		
Yellow Perch	No more than 2 meals/month	No more than 6 meals/month
All Other Fish	No more than 1 meal/month	No more than 3 meals/month

VERMONT DEPARTMENT OF HEALTH

For more information call 1-800-439-8550
healthvermont.gov

June 2007

Appendix B: Vermont Point Source Control Program Update

Table B.1. Status of Phosphorus Removal/Reduction Projects.

Municipality	Construction Status	Comments
***** Lake Champlain Drainage *****		
Barre City	completed	
Brandon	completed	
Burlington (North)	completed	
Burlington (Main)	completed	
Burlington (East)	completed	
Cabot	completed	
Castleton	completed	
Enosburg Falls (Phase 1 - chem)	completed	
Essex Junction	completed	
Fair Haven	completed	
Hardwick	completed	
Hinesburg	completed	
Johnson	completed	
Middlebury	completed	
Milton	completed	
Montpelier	completed	
Morrisville	completed	
Northfield	completed	
Proctor	completed	
Poultney	completed	
Richford	completed	
Richmond	completed	
Rutland City	completed	
South Burlington (Bartlett Bay)	completed	
South Burlington (Airport Parkway)	completed	
Shelburne (Plant #1)	completed	

Municipality	Construction Status	Comments
Shelburne (Plant #2)	completed	
St. Albans City & NW Correctional Facility	completed	
Stowe	completed	
Swanton	completed	
Troy/Jay	under design	construction will complete in 2012
Vergennes	completed	
West Rutland	completed	
Winooski	completed	
***** LAKE MEMPHREMAGOG DRAINAGE *****		
Barton Village	completed	
Newport City	completed	
Orleans	completed	

Table B.2. Construction Status - Combined Sewer Overflow (CSO) Projects.

Municipality	Construction Status	Comments
****** Lake Champlain Drainage ******		
Brandon	completed	
Burlington	completed	
Enosburg Falls	partially completed	
Hardwick	completed	
Middlebury	partially completed	
Montpelier (Phase 1)	completed	
Montpelier (Phase 2)	completed	
Northfield	completed	
Poultney	completed	
Richford	partially completed	monitoring 2 CSO's
Rutland City (Phase 1)	completed	
Rutland City (Phase 2A)	completed	
Rutland City (Phase 2B)	pending	monitoring Phase 2A
Swanton	completed	
Vergennes	completed	
****** Lake Memphremagog Drainage ******		
Barton	completed	
Newport City	partially complete	monitoring
Orleans	completed	
****** Connecticut River Drainage ******		
Bellows Falls	completed	
Hartford	partially completed	Order issued to abate remaining 2 overflows
Ludlow	completed	
Lunenburg	completed	
Lyndon	completed	
Randolph	completed	

Municipality	Construction Status	Comments
Springfield (Phase 1)	completed	
Springfield (Phase 2)	Contract 1 completed Contract 2 under construction	Contract 3 delayed to 2011 due to funding shortfall being requested by the Town
St. Johnsbury (Phase 1)	complete	
St. Johnsbury (Phase 2)	Phase 2A completed	Phase 2B pending
St. Johnsbury (Phase 3A)	scheduled for 2010	on holding pending study of system status
St. Johnsbury (Phase 3B)	scheduled for 2010	on holding pending study of system status
St. Johnsbury (Phase 4)	scheduled for 2010	on holding pending study of system status
Wilmington	completed	
Windsor	completed	

Appendix C: Black Creek and Lamoille River Floodplain Restoration Project

Black Creek and Lamoille River Floodplain Restoration Project

By Roy Schiff, Barry Cahoon, and Mike Kline

Introduction

A large floodplain restoration project was completed in 2008 in northern Vermont where approximately 6 miles of former rail embankment were removed to reconnect more than 200 acres of historic floodplain (Summarized in Schiff et al., 2008). The total project cost was $550,000 and resulted in excavation of 60,000 cubic yards of floodplain fill that led to the return of attenuation of fine sediment and associated nutrients on reconnected floodplains (Figure 1).

Vermont has conducted fluvial geomorphic assessments on nearly 1,500 miles of streams and rivers since 2003. A major finding from the statewide data set is the degree to which river channels are disconnected from their floodplains. Comparing the existing annual flood stage to the stage required for floodplain access, Vermont found that 75% of assessed miles are moderately to severely incised (Kline and Cahoon, 2008). Projects to restore floodplain function have become an important part of Vermont's River Management Program to reduce erosion hazards and restore water quality and river habitat.

FIGURE 1
Black Creek and Lamoille River Floodplain Restoration Project Summary

An agreement between the Vermont Agency of Natural Resources and the Vermont Agency of Transportation established a partnership in pursuing floodplain restoration along the former rail line following track removal and federal rail banking. The end of rail operations was largely the result of regular flood damage and a decrease in regional freight traffic (Pelletier, 2003). The rail line is leased by the Vermont Association of Snow Travelers that also supported the floodplain restoration effort. The Natural Resources Conservation Service funded a portion of the project along with the Vermont Agency of Natural Resources. The project was made possible by the willingness of landowners to naturalize flooding on their lands to achieve the project goals of capturing sediment and nutrients, reducing local flood and erosion hazards, improving water quality, and enhancing habitat. The diverse group of participating project stakeholders indicates floodplains reconnection can be compatible with a diverse set of land uses including agriculture and recreation.

Reconnected floodplains are now periodically inundated (Figure 2) and observable sediment deposition is taking place following flooding (Figure 3).

FIGURE 2
Floodplain Inundation along Black Creek

Inundated floodplain at the Fairfield_3 site. February 3, 2009, R. Schiff.

FIGURE 3
Floodplain Sediment Deposition along Black Creek

Evaluation

Evaluation monitoring was conducted at three floodplain restoration sites along Black Creek in Franklin County. The three monitored sites have an area of 21 acres of reconnected floodplain, thus representing approximately 10% of the total reconnected floodplain area for the project. The boundary of fine sediment deposited by the river on the reconnected floodplains was mapped with GPS, and sediment depth was recorded following floodplain access during spring snowmelt and storm floods (Figure 4). Composite sediment samples were collected for analysis of total phosphorus to provide an indication of potential nutrient capture.

Volume (cubic yards) of deposited sediment was calculated for each of the floods. Using a floodplain soil bulk density of 1.3 Mg/m^3 that was estimated during previous floodplain studies in the region, total phosphorus measurements (ppm) was converted to weight (metric tons).

Approximately 950 cubic yards of fine sediment with nearly 1.0 ton of associated total phosphorus was deposited on the three evaluated floodplains during the first spring flood following floodplain reconnection (Table 1). The level of sediment capture on the floodplains was lower in subsequent observations and is thought to be linked to smaller floods as the extent and duration of inundation appeared to be more limited prior to floodplain observations in summer 2008 and spring 2009.

FIGURE 4
Mapped Floodplain Sediment Deposition along Black Creek

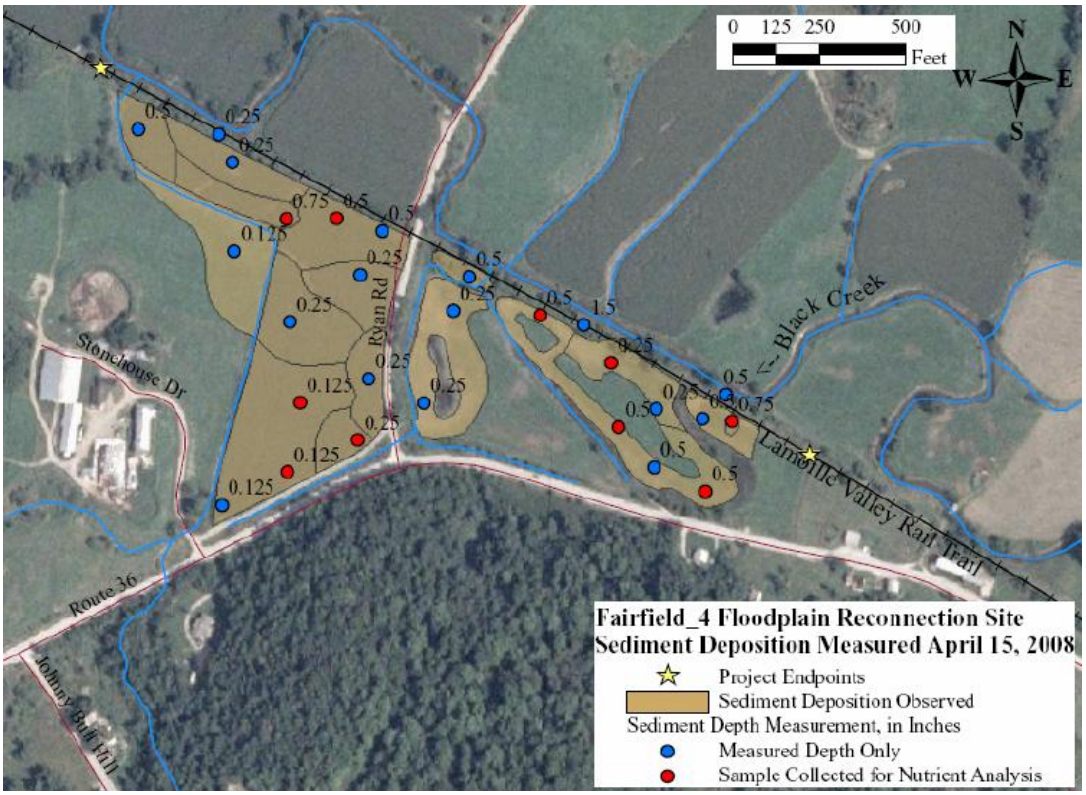


TABLE 1
Deposited Sediment Data

	Bakersfield_1		Fairfield_3		Fairfield_4 (Magnan)		Fairfield_4 (Ryan)		TOTAL	
Date	**Vol (cu yd)**	**P (ton)**	**Vol (cu yd)**	**P (ton)**	**Vol (cu yd)**	**P (ton)**	**Vol (cu yd)**	**P (ton)**	**Vol (cu yd)**	**P (ton)**
4/15/2008	261	0.2	34	0.0	400	0.5	252	0.2	**946**	**1.0**
7/29/2008	69	0.0	0	0.0	84	0.1	18	0.0	**171**	**0.1**
4/3/2009	85	0.1	14	0.0	8	0.0	93	0.1	**200**	**0.1**
6/2/2009	38	0.0	0	0.0	11	0.0	53	0.0	**102**	**0.1**
TOTALS	**453**	**0.4**	**49**	**0.0**	**502**	**0.6**	**416**	**0.3**	**1,419**	**1.3**

The mean concentration of total phosphorus in the deposited sediment (silt and fine sand) following the April 2008 flood was approximately 1,050 ± 230 mg/kg (Table 2). Mean total Phosphorus is lower in subsequent samples, and also could be linked to smaller floods.

TABLE 2
Total Phosphorus Data

	Bakersfield_1	Fairfield_3	Fairfield_4 (Magnan)	Fairfield_4 (Ryan)	TOTAL	
Date	**TP* (mg/kg)**	**TP (mg/kg)**	**TP (mg/kg)**	**TP (mg/kg)**	**Mean**	**SD**
4/15/2008	863	1260	1240	853	**1054**	**227**
7/29/2008	577	n/m	726	759	**687**	**97**
4/3/2009	909	n/m	670	644	**741**	**146**
6/2/2009	824	n/m	727	664	**738**	**81**
Mean	**793**	**1,260**	**841**	**730**	**805**	
SD	**148**	**n/a**	**267**	**96**	**168**	
*Total P was determined by microwave-assisted digestion in concentrated nitric acid (EPA Method 3051a).						
n/m = not measured						

The Bakersfield floodplain is a cutoff meander bend with native herbaceous vegetation that is hydrologically connected to a hay field across the valley. The Fairfield_3 floodplain is a mixed hay and corn field. The Fairfield_4 (Magnan) floodplain is a corn field and the Fairfield_4 (Ryan) is a hay field. Early spring samples were collected prior to commencement of manure spreading. Residual manure was observed during the June 2009 monitoring at Fairfield_3. The lack of a clear correlation between floodplain land use and total Phosphorus suggests that upstream watershed influences are likely dictating nutrient concentrations, and sediment deposition. Additional study is needed to establish a nutrient and sediment budget for the reconnected floodplains.

The removal of the former railroad embankment and reconnection of natural floodplain has led to observable sediment deposition and associated phosphorus storage. This brief evaluation study is not able to confirm the ultimate fate of the sediment and Phosphorus, yet it is believed that some or all of the sediment will reside on the floodplains over the long term, and some portion of the nutrients will be taken up during growth of wetland plants or crops. Floodplain restoration has achieved the primary project goal of reducing sediment and nutrient inputs to the Missisquoi River and Lake Champlain. Hydraulic modeling indicates that local flood and erosion risks have been reduced by floodplain reconnection.

"To put the 1.3 mt of total phosphorus deposited in those floodplains in perspective, it was more phosphorus than was discharged by 56 (out of 60) individual wastewater treatment plants in the Vermont part of the Lake Champlain Basin during 2008." (Smeltzer, November, 2009, personal communication)

It is likely that the benefits of this project are even greater than portrayed here as this evaluation only considers 3 of the 11 floodplain reconnection sites. Furthermore, larger floods and multiple floods each year are possible that could increase the potential for sediment and nutrient storage on the reconnected floodplains. This project will continue to effectively attenuate sediment and nutrient loads without additional investment for the foreseeable future and thus exemplifies a restoration approach that re-establishes natural processes.

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Appendix D:Vermont River Corridor Protection Programs

Vermont DEC Water Quality Division River Corridor Protection Programs

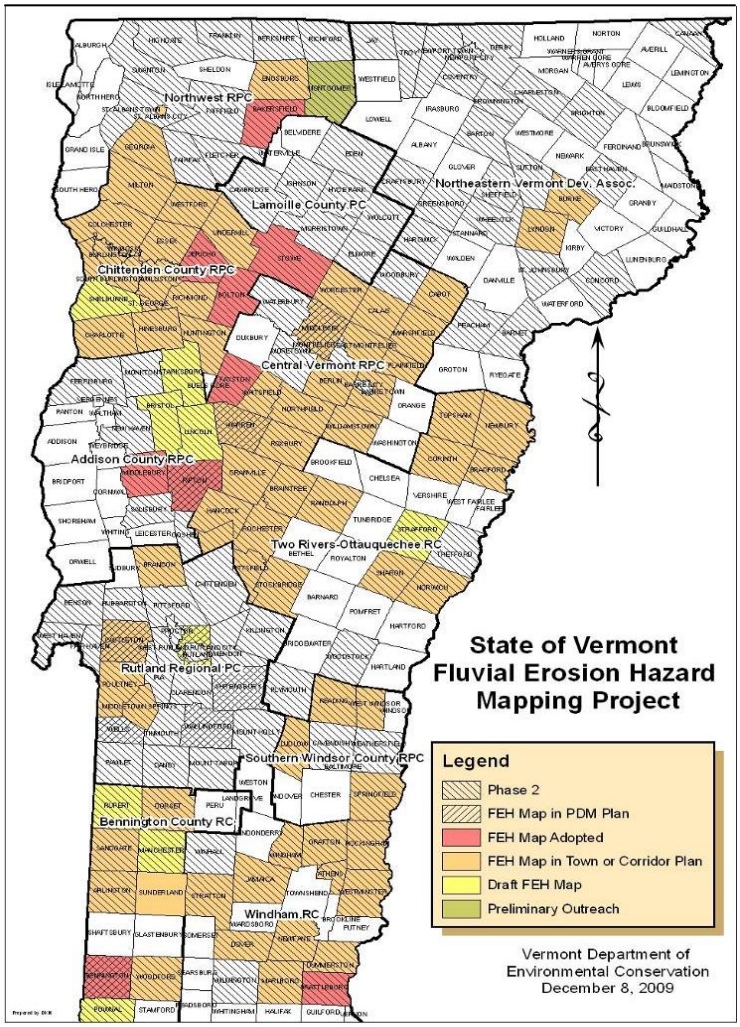
The Vermont Agency of Natural Resources (ANR) has adopted an avoidance strategy to restore and protect the natural stability of rivers. River corridor protection has become the a primary tool in the Agency's avoidance tool box. River Corridors consist of lands adjacent to and including the present channel of a river. Delineations are based primarily on floodplain function, the lateral extent of stable meanders, i.e., the meander belt width, and a wooded riparian buffer to provide streambank stability. The meander belt width is governed by valley landforms, surficial geology, and the length and slope requirements of the river in its most probable stable form.

A river is considered stable or in a state of "dynamic equilibrium," if it can adjust its channel geometry (width, depth, and slope) to efficiently discharge, transport, and store water, sediment, and debris without significant aggradation or degradation of its bed (i.e., changes in vertical channel bed position in relation to annually accessed floodplains) (Leopold, 1994, Rosgen, 1996). A river requires a sufficient corridor to accommodate equilibrium conditions and the channel adjustments that occur when stream geometry is changing vertically and laterally to achieve equilibrium (Brierley and Fryirs, 2005). Failure to provide a sufficient corridor will constrain the river from achieving the equilibrium condition. Thus, managing corridors to accommodate equilibrium and associated channel adjustment processes serves to reduce damages to existing structures and property, avoid new damages, protect public safety, achieve the general health of the river ecosystem, and avoid the high cost to install and maintain channelization practices (Piegay, 2005). Precluding the use of channelization practices, in turn, avoids the unintended consequences of transferring bank erosion and other damaging effects from concentrated flow and vertical channel adjustments to other locations along the river (Brookes, 1988; Huggett, 2003, Brierley and Fryirs, 2005).

The RMP is providing river corridor delineations as an important spatial context for restoring and maintaining the river processes and dynamic equilibrium associated with floodplain storage of nutrients and high quality aquatic habitats. River corridors are also intended to provide landowners and town, state, and federal agencies with a science-based river and riparian land use planning and management tool to avoid fluvial erosion hazards (FEH). Reducing current and future near-stream investment and achieving natural stream stability promotes a sustainable relationship with rivers over time, minimizing the costs associated with floods and maximizing the benefits of clean water and healthy ecosystems.

Restoration of floodplain function and stream equilibrium simply can not occur if river corridors are developed, especially those of formerly straightened rivers. It is critical that future land use development patterns recognize the dynamic nature of rivers and floodplains. Since most land use decisions occur on the local level, offering incentives is the most effective way of raising public awareness about river corridor and floodplain values and motivating landowners and municipalities to take proactive steps to reduce property loss, protect water quality, and build greater resilience to future flood damages. Protecting natural processes that maintain water quality and aquatic habitat enables the State to avoid the cost of developing and maintaining artificial structures to capture/retain sediments and nutrients. These actions would also represents an important step for the State to combat the ill effects of climate change, particularly in light of the hydrologic models that predict a greater frequency of flash flood events.

Financial incentives for municipalities includes qualifying criteria in grants, pass-through funds, technical assistance, and educational support that encourages municipalities to adopt and implement bylaws that conserve and restore river stability, floodplains, wetland and riparian buffer function. Three RMP regional scientists and the Fluvial Erosion Hazard Coordinator assist municipalities in developing maps depicting the river corridors, flood attenuation assets, and FEH zones. The ANR, in cooperation with a host of planning organizations and the Vermont League of Cities and Towns, conducts outreach and education and annually reports on the status and impact of river corridor easements and zoning, including development of FEH mapping.



The RMP, in collaboration with the state's regional planning commissions (RPCs), leverages State Clean and Clear funding to annually attract FEMA Pre-Disaster Mitigation Program planning grants to support corridor protection. The work involves developing Phase 2 stream geomorphic assessment data, generating FEH maps, working with communities to educate them about fluvial erosion hazards, and encouraging and supporting their adoption and implementation of fluvial erosion hazard zoning bylaws including provision of maps and model by-laws. Fluvial erosion hazard data are being incorporated into the Regional Hazard Mitigation Plans (RHMP). The RMP

has technically supported the work of the RPCs and their consultants and recently provided the RPCs with a suite of Enhanced Model Flood Hazard Area Regulations including fluvial erosion hazard area protection.

Communities involved in river corridor planning	**168**
Phase 1 geomorphic assessment underway or recently completed	**33**
Phase 2 geomorphic assessment underway or recently completed	**42**
FEH projects underway or completed as part of town and/or river corridor plans	**27**
Draft FEH maps completed	**69**
FEH maps adopted as an ordinance	**9**

A River Corridor Easement Program has been established in Vermont to conserve river reaches identified as high priority sediment and nutrient attenuation areas. The opportunity to purchase and sell river corridor easements was created to augment the state and municipal fluvial erosion hazard zoning which, if adopted, avoids future encroachment and flood damage, but does not restrict channelization practices. The societally-ingrained notion to stop all erosion, even where few investments are at risk, may limit the channel evolution process and slow the attainment of equilibrium conditions. The key provision of a river corridor easement is the purchase of channel management rights (Kline, 2008).

River Name	Stream Length (ft)	Easement acres
White River	1,360	16.3
Little River	1,460	8.4
LaPlatte River	15,100	160.0
North Branch Winooski	900	3.9
Ayers Brook	19,790	50.8
Browns River	2,800	20.3
Hungerford Brook	1,700	7.3
Middlebury River	1,340	11.7
Green River (Arlington)	2,300	11.4
Batten Kill	900	8.9
Mettowee River	3,700	7.5
Wanzer Brook	2,050	4.0
New Haven River	4,318	9.1
Lewis Creek	7,700	147.3
Totals	65,218	450.6

The Program works closely with state and federal farm service agencies, the Vermont Housing and Conservation Board, and land trust organizations to combine corridor easements with other land conservation programs. The purpose of the river corridor easement is to allow the river to re-

establish a natural slope, meander pattern, and access to floodplains in order to provide flood inundation and fluvial erosion hazard mitigation benefits; improve water quality through hydrologic, sediment and nutrient attenuation; and protect riparian habitats and the natural processes which form them. The easements gives the holder, or grantee, the right and opportunity within the corridor to establish a naturally vegetated, floating buffer measured from the river banks as they may move. The landowner may continue to conduct activities such as agriculture and timber harvesting within the river corridor, but is restricted from placing, repairing, modifying structural elements such as bank armor, levees, or earthen fills. Within the corridor, the easement ensures that watercourses and wetlands are not manipulated so as to alter the natural water level or flow, or intervene in the natural physical adjustment of the water bodies. To date the Program and land trusts have completed, or nearly completed, easements on 12.35 miles of river, which, when in equilibrium, will have access to over 450 acres of floodplain.

The promise of phosphorus storage through river corridor and floodplain protection was revealed through the study of a Clean and Clear funded floodplain restoration project (cost-shared with the USDA) where in just one year, 1.3 metric tonnes of phosphorus (Total) was captured in sediments deposited on 3 of the 7 restored floodplain sites, available to the Black Creek for first time in 150 years following the removal of a rail levee.

On another project, soils were excavated to create a belt width-sized floodplain along 2,000 feet of Wanzer Brook (Fairfield, VT), which had become deeply incised. The quantity of soils that would have, over time, been eroded to the Lake contained 5.9 metric tonnes of Total phosphorus.

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