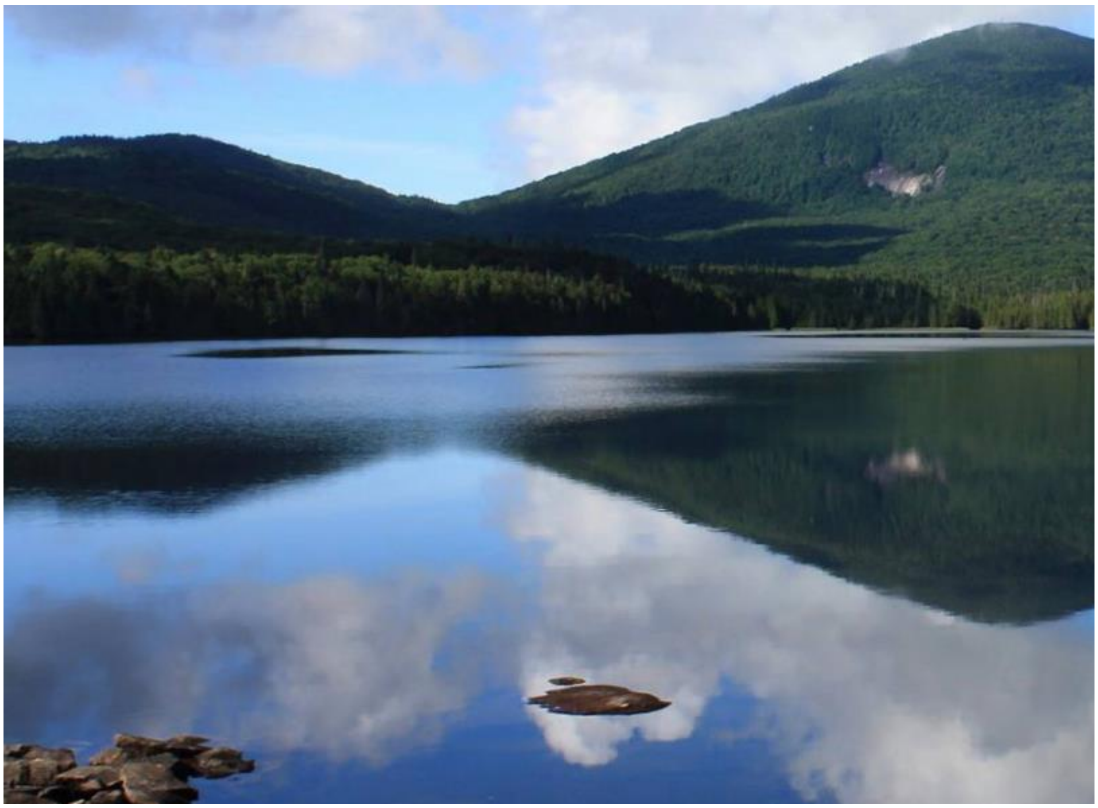
Vermont Department of Environmental Conservation

Watershed Management Division

Statewide Surface Water Management Strategy



Revised January, 2017

Chapter 1. Strategic Framework for Statewide Efforts to Guide Surface Water Management

Vermont Surface Water Management Strategy

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A. Introduction

Why a Watershed Management Division

A watershed is an area of land that drains downslope to its lowest point. Water moves through a watershed in a network of drainage pathways that generally converge in a stream or river system, perhaps leading to a lake or wetland. Watersheds can be large or small. Watershed boundaries follow the major ridge-line around the channels and meet at the bottom where the water flows out of the watershed. Rainfall and snowmelt run off the land surface, and water flows into and out of a watershed.

The interrelationship of land use impacts and the connectivity of watershed resources are the primary reason why surface water assessment, management, and restoration need to be conducted at a watershed scale. Since water moves downstream in a watershed, any activity that affects the water quality, quantity, or rate of movement at one location can change the characteristics of the watershed at locations downstream. All activities impacting watersheds must be managed simultaneously, with consideration of their cumulative impacts, to effectively manage the resource.

The best organizational design for a natural resources agency is one that closely parallels the resources it seeks to manage. Given the physical nature of watersheds, the consideration of land-based activities affecting watersheds, and the close alignment of the individual watershed elements (e.g., rivers, wetlands, and lakes), creating a corresponding management structure is the most predictable and comprehensive means of ensuring clear, efficient, and effective water resource management. The central goal driving the composition and design of the Division's organizational structure is to better leverage the concept of holistic watershed management.

1. The Vermont Surface Water Management Strategy

What is this Strategy?

The Watershed Management Division (Division) has prepared this Vermont Surface Water Management Strategy (Strategy) to describe the management of pollutants and stressors that affect the uses and values of Vermont's surface waters. The Strategy presents the Division's goals, objectives and approaches for the protection and management of Vermont's surface waters, and will help to guide the Department's future decision-making to ensure efficient, predictable, consistent and coordinated management actions. For the purposes of this Strategy, surface waters are defined as all rivers and streams, lakes, ponds and reservoirs, and wetlands. This Strategy fulfills provisions of 10 V.S.A. 1253d regarding preparation of a comprehensive statewide surface water management strategy, and effectively updates the "Continuous Planning Process" document of 2001, and the Clean Water Act §208 Areawide Plan of 1981, both required by the United States Environmental Protection Agency (USEPA).

Specifically, this Strategy:

1. Sets forth goals and objectives for managing Vermont's surface waters in light of the goals of the federal Clean Water Act, and Vermont's Clean Water Act and state surface water quality policy;

2. Describes pollutants and stressors that affect the uses and values of Vermont's surface waters, approaches to address stressors, and appendices describing regulations, funding and technical assistance programs.

3. Describes the Division's approach to protecting and improving surface waters by managing stressors rather than individual pollutants;

4. Presents the Division's Business Plan for implementing this Strategy.

5. Describes the Division's updated Ambient Surface Water Monitoring and Assessment Strategy that will work hand in hand with watershed management planning at the statewide and basin-specific level to identify and prioritize waters in need of protection, restoration and management; and

6. Implements a focused approach to tactical basin-level watershed management planning that provides the geographic specificity necessary to effectively implement this Strategy.

This Strategy draws upon over 35 years of watershed management planning experience, project implementation, and watershed restoration carried out by the Division and its partner agencies. The Strategy reflects experience gained and lessons learned by the Division in working with partner programs and watershed stakeholders. This Strategy will be widely accessible and continually updated on the Division's website.

What is different about this Strategy?

This Strategy does not focus on managing individual pollutants. Rather, the Strategy establishes an approach to managing the stressors that are responsible for the pollutants that affect water quality and uses of Vermont's surface waters. By moving the focus of this Strategy beyond individual pollutants, WSMD is emphasizing the importance of managing waters in a watershed context, by coordinating the management of stressors. As one example, a watershed-wide coordinated effort to reduce channel erosion, one of ten major stressors to surface water quality and uses, necessarily will mitigate the effects of phosphorus, nitrogen, sediment, and habitat alteration on surface waters in that basin.

What terminology is used in this Strategy?

The WSMD has established a set of ***goals and objectives*** for surface waters of Vermont. The goals define the Division's vision for surface waters of Vermont. The objectives, when met, will result in attainment of the goals. This Strategy discusses how 10 major ***stressors*** are managed by the Division's many surface water management programs, in support of the Strategy's objectives. A ***stressor*** is defined as a phenomenon with quantifiable deleterious effects on surface waters resulting from the delivery of ***pollutants*** (or the production of a pollutant within a waterbody) or an increased threat to public health and safety. Stressors result from certain activities on the landscape, although occasionally natural factors result in stressors being present. Managing stressors requires management of associated activities. When landscape activities are appropriately managed, stressors are reduced or eliminated, resulting in the objectives of this Strategy being achieved, and goals met.

This terminology can be demonstrated using a real-world example of a poor biological condition that is caused by unmanaged encroachment upon riparian areas of surface waters (see Figure 1 below). Improperly managed construction of homes, camps, and other infrastructure along riverbanks and lakeshores can result in riparian buffers being reduced or eliminated. As shrubs, trees, and other vegetation are lost, shallow nearshore areas of surface waters receive more sunlight, and water temperatures climb due to warming of the water and underlying lakeshore or streambed. Sediment and phosphorus is rapidly lost from the riparian zone during the construction phase, then more slowly thereafter due to increased imperviousness, and lack of vegetation to filter runoff. This pollutant cocktail (temperature, sediment, phosphorus) adversely affects biology. Put more simply, trout can't live in waters that are too warm, too silty, and overly phosphorus-enriched.

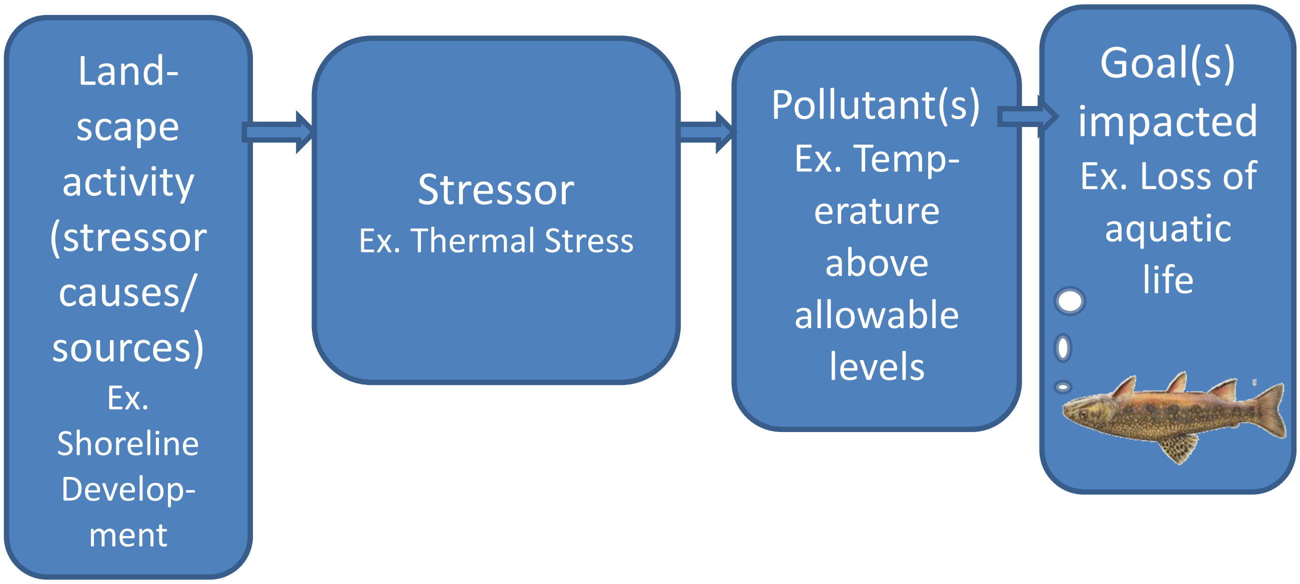


Figure 1. An example of the cascading effects of landscape-level activities that result in stressors, which produce pollutants.

How do I use this Strategy?

The user of this Strategy can access information pertaining to stressors, their causes and sources, and resultant pollutants, and readily observe the way these all interrelate. In addition, the Strategy, by means of several Appendices or standalone documents, provides a description of the monitoring and assessment, education and outreach, technical assistance, financial assistance, and regulatory programs carried out, supported by, or participated in by the Division. Using this Strategy as a starting point, the reader can access information and web-based resources for all of the Division's programs and actions in support of surface water protection and improvement. Section 11 of this Introduction presents a roadmap for each Chapter of the Strategy.

2. Surface Water Goals and Objectives

The federal Clean Water Act identifies biological, chemical, and physical integrity and recreational suitability as core goals of the Act, to be actively protected and restored by the U.S. Environmental Protection Agency, in partnership with States. These terms are commonly referred to by the colloquialism "fishable and swimmable." Vermont has incorporated these Federal Clean Water Act goals, along with the goals of the Vermont Clean Water Act (Act 64 of 2015) and other important state water quality policy (Acts 110 of 2012 and 138 of 2013) into this Strategy, In this Strategy, the Division has consolidated the Clean Water Act and state water quality policy goals into three broad goal statements pertaining to *integrity*, *use*, and *health and safety*. By supporting these goals and their associated objectives, the Division is implementing Federal and State law. Four specific objectives have been identified that, when met, should ensure the biological, chemical, and physical integrity, and public use and enjoyment of Vermont's water resources, and protect public health and safety.

The three primary goals of the Watershed Management Division are to manage Vermont's surface waters to:

- ***Protect, Maintain, Enhance and Restore the Biological, Chemical, and Physical Integrity of all Surface Waters***
- ***Support the Public Use and Enjoyment of Water Resources***
- ***Protect the Public Health and Safety***

Four objectives support these Goals:

Objective A. ***Minimize Anthropogenic Nutrient and Organic Pollution***

Objective B. ***Protect and Restore Aquatic and Riparian Habitat***

Objective C. ***Minimize Flood and Fluvial Erosion Hazards***

Objective D. ***Minimize Toxic and Pathogenic Pollution, and Chemicals of Emerging Concern***

3. About Biological, Physical, and Chemical Integrity

By managing stressors, the simultaneous goals of attaining biological, chemical, and physical integrity, public use and enjoyment, and public health and safety can be met. Goals pertaining to public use and enjoyment and health and safety are easy to understand. Consider these questions:

Can I swim and boat? Is the water aesthetically pleasing?
Can I eat the fish? During a flood, will my home be safe?

A "yes" answer to these questions implies attainment of public use and enjoyment, and public health and safety goals. The concept of ecological integrity captures the biological, chemical and physical integrity of a waterbody. The Division is required by Federal and State law to manage surface waters to support integrity, but what exactly is "integrity" in the context of surface waters?

Habitat for aquatic biota in and terrestrial biota adjacent to surface waters is directly a function of integrity. In essence, physical and chemical integrity inter-relate to support biological integrity. The inter-relationship of physical and chemical conditions defines the availability of habitat for biological communities. If physical and chemical integrity are compromised, biological integrity declines, because the habitat that supports biota is compromised. The following discussion is intended to provide a basin-wide understanding of physical, chemical, and biological integrity.

Biological Integrity

The condition (health) of the biological community is a reflection of the level of combined human-induced stresses acting upon it. Communities integrate the sum of stressors and associated pollutants, and exhibit, in a repeatable fashion, changing and measurable attributes with increasing stress. While it is possible to identify a particular stressor from such measurements, the specificity of the identified stressor is generally low. Aquatic communities that are most impaired suffer from an accumulation of multiple stressors.

The term "biological integrity" was introduced in the Federal Clean Water Act of 1972 as one part of a three-part objective of the Act: "to restore and maintain the chemical, physical and biological integrity of the nation's waters." The three forms of "integrity" were presented without being defined. The current operational definition of biological integrity offered by scientists is "the ability to support and maintain a balanced, integrated adaptive assemblage of organisms having species composition, diversity, and functional organization comparable to that of natural habitat of the region (Frey, 1977, per USEPA)." Section 1-01.B.10

of the Vermont Water Quality Standards defines biological integrity as the ability of an aquatic ecosystem to support and maintain, when consistent with reference conditions, a community of organisms that is not dominated by any particular species or functions (balanced), is fully functional (integrated), and is resilient to change or impact (adaptive), and which has the expected species composition, diversity, and functional organization.

Some would argue that implicit in the definition of biological integrity is the concept that the integrity exhibited by waters in the time of pre-European settlement is a standard by which waters may be evaluated. Under this interpretation, a waterbody with biota that closely resembles the pre-settlement condition is said to have the highest biological integrity. This approach does not fully accommodate society as a component of the natural world. Humans, like all other "social" animals, adapt their environment to benefit their own survival and reproduction. In so doing, the integrity of waters is affected. Vermont's water quality policy articulates the goal of managing towards a condition reflecting minimal changes from human alteration. Such waterbodies are in their current natural condition, and are known as reference waters[1]. Most commonly, then, evaluations of biological integrity use the reference of "nearly-natural" condition as a reasonable point from which to compare the current condition of any given waterbody. The farther the biological condition departs from the reference condition, the lower the biological integrity.

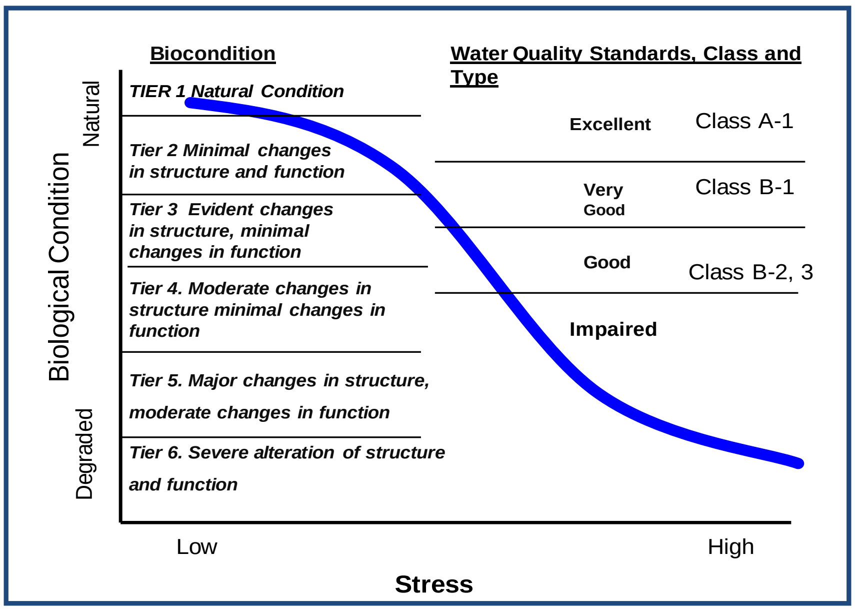


Figure 2. The Biocondition Gradient

Scientists have identified various levels of departure from the reference condition that exist along a gradient of increasing aquatic community change resulting from human influenced stressors. Aquatic communities respond in a predictable fashion to increasing levels of stress. The Biocondition Gradient (Figure 2) is a framework developed by the USEPA that describes in narrative fashion how

[1] The Water Quality Standards define reference condition as *"the range of chemical, physical, and biological characteristics of waters minimally affected by human influences. In the context of an evaluation of biological indices, or where necessary to perform other evaluations of water quality, the reference condition establishes attainable chemical, physical, and biological conditions for specific water body types against which the condition of waters of similar water body type is evaluated."*

biological attributes of the community change with increasing stress. There are six tiers of condition ranging from natural condition to highly degraded, each represented by a narrative description of the community. This framework embodies how biological integrity is defined by the Vermont Water Quality Standards, and provides a clear way of communicating aquatic community condition to the public.

Biological Integrity of Wetlands and Lakes

Wetland areas are known for being biological hotspots. Around 80% of bird species nationally rely on wetland habitat for some or all of their life stages. Over fifty percent of rare, threatened or endangered plant species in Vermont occur in wetlands. There are over 45 wetland natural community types identified in Vermont by the VT Fish and Wildlife's Natural Heritage Inventory. This includes forested wetlands, peatlands such as bogs and fens, shrub-scrub wetlands, marshes, and emergent aquatic beds. Each type of wetland and each species present has unique characteristics which in turn affect how the wetland influences chemical and physical characteristics of adjacent surface waters. For instance, wetlands with higher biodiversity are better able to absorb excess nutrients than monotypic stands which senesce in the fall and flush nutrients back into the waters. Native woody vegetation in floodplains hold and retain sediment while floodwaters enter the floodplain and dissipate much of the force of floods. Floodplains without healthy vegetation experience higher erosion, and floodplains with dense, shallow-rooted invasive species such as Japanese knotweed also experience erosion and are diminished in their flood storage capacity. The accumulation of peat mosses (*Sphagnum* spp.) in many bogs, fens, and acidic forested wetlands can act like a giant sponge, creating a raised water table which acidifies the waters but vastly increases the wetlands' water holding capacity. If these wetlands experience disturbance the peat may decompose, greatly reducing the ability of the wetland to carry out this function.

Lakes too support a large biological community, both within the lake itself and on the land adjacent to the water. Wetlands often merge into lakes, blending the habitats of terrestrial and aquatic life. Many species of birds, mammals, fish, amphibians, reptiles and insects depend on the lake littoral zone and nearby shore for food and shelter. Healthy native plant communities in the littoral zone and along the shoreline also serve to protect the physical and chemical integrity of lakes. These communities help dampen wave energy and slow erosion. Natural shorelines prevent ice damage in winter and absorb nutrients from runoff. The physical and chemical integrity of lakes is supported by a healthy biological community. In turn, the biological community thrives when physical and chemical integrity is maintained.

Physical Integrity:

The physical integrity of surface waters may be measured differently for rivers, streams, lakes, and wetlands, but in all instances, physical integrity is defined by the interactions between riparian areas, floodplains, and the surface water. The physical integrity of surface waters can be affected by actions on the landscape that are directly adjacent to the waterbody, or at the farthest-most up-gradient point in a watershed. Habitat in surface waters is a function of physical integrity.

Physical Integrity of Streams:

Physical integrity in streams is defined by the degree of "equilibrium" exhibited by the stream. Equilibrium is the condition in which a stream and floodplain morphology is sustained over the long-term by the dynamic interaction of water flow, sediment transport, and woody debris movement from the watershed. If dynamic equilibrium of a stream system is achieved at the watershed scale, the streams exhibit minimal erosion, minimal loss of sediment from watersheds to the stream channels, and high diversity in aquatic and riparian habitat.

Physical integrity is highest when there exists an optimum balance between the shape of a stream in terms of its sinuosity, depth, and access to floodplains, and the water flow, sediment, and woody debris supplied by the watershed. The type of equilibrium exhibited by a given stream is a function of the valley width and slope, bedrock and surficial geology, soils, and vegetation. Collectively, the forces associated with water, sediment, and debris runoff determine the shape or morphology of the river and floodplain. High physical integrity, as evidenced by persistent channel shape, depth, and floodplain access is developed and maintained over time by the annual high flow events and the sediment produced by the watershed. It is these high flow events that produce the greatest amount of "work" on the channel and floodplain and transports the greatest volume of sediment over time. Put simply, there is a balance between the shape of the river, and the amount of water, sediment, and debris the river can carry. When there are changes to any of these components, the dynamic fluvial equilibrium is affected, and physical integrity declines.

Figure 3 illustrates how water volume, sediment volume, sediment particle size, and the slope of a river channel are naturally balanced. If the balance is tipped the channel responds by either aggrading (building up sediment on the channel bed) or degrading (scouring down the channel bed). A change in any one of these factors will cause adjustments of the other variables until the river system comes back into equilibrium. For example, rapid urbanization of a watershed has been shown to increase peak runoff such that a river channel receives a greater volume of water more frequently. The diagram illustrates that an increase in the river's water volume would tip the scale downward on the right. The river will respond by degrading until either the volume and/or size of sediment (along the channel boundaries) increases enough to bring the scale (river channel) back into balance.

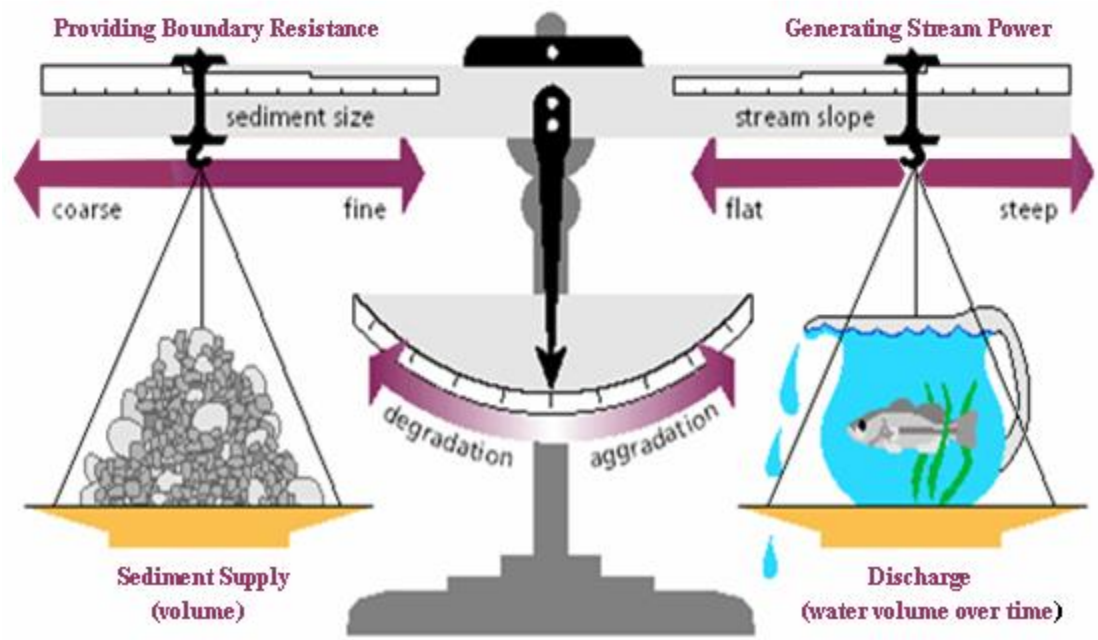


Figure 3. Balance of water supply and sediment supply (after Lane, 1955). Reproduced by permission of the American Society of Civil Engineers.

The actions people take on the landscape are constantly affecting physical integrity. Activities within or adjacent to riparian corridors that significantly alter the runoff patterns of water and/or sediment, will elicit a channel adjustment process. When these processes change the relationship of the river with its floodplain (by aggrading or degrading the channel bed), it becomes increasingly difficult to plan for, as well as expensive to maintain those land uses, and the risk of flooding damage increases considerably. Habitat quality is also degraded as a result of excessive scour of substrate cover, the fining or sedimentation of bed features (e.g., pools and riffles), and /or the vertical disconnection of aquatic with riparian habitats.

It must be recognized that streams that are in equilibrium still erode their banks, migrate over time across their valleys, and periodically experience small-scale lateral and/or vertical adjustments. Even with these changes, a stream will remain in equilibrium as long as the physical characteristics of the stream are consistent with the inputs of water, sediment, and organic debris at a given point in the watershed continuum (from highlands to lowlands). Climate change, geologic events, and major storms can change the shape of river channels. When this occurs, natural adjustments occur continually until dynamic equilibrium is reestablished. These adjustments, however, have been greatly altered during the past two centuries in Vermont by human-imposed changes to rivers from intensive watershed and riparian land uses. Nearly every Vermont watershed has streams that are "in adjustment" as a result of initial land clearing, the subsequent clearing of boulders, beavers, woody debris, and gravel from stream channels to move water and sluice logs from headwaters to village mill sites, and extensive ditching to drain wet soils to promote agriculture. The effects of these actions have been exacerbated by efforts to lock stream channels in place within floodplains to protect or expand infrastructure including transportation, agriculture, streamside homes, and impoundments. This is not to imply that high physical integrity of streams is exclusive of infrastructure. Rather, historical efforts to manage landscapes have resulted in many Vermont streams being in considerable disequilibrium. Act 110 (2010) substantiates the need to develop a balance between placement and management of infrastructure, and the

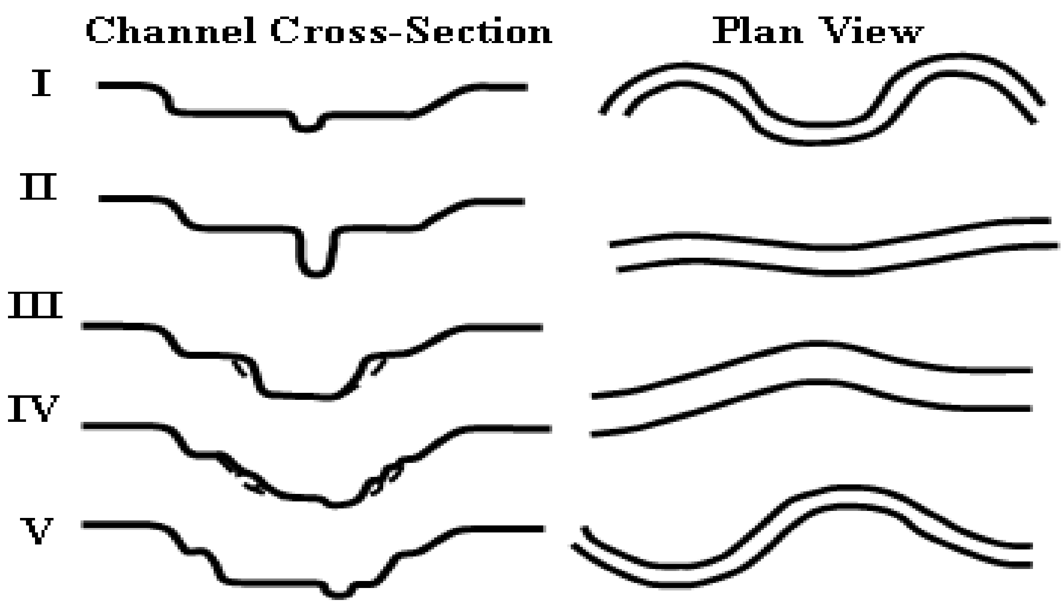


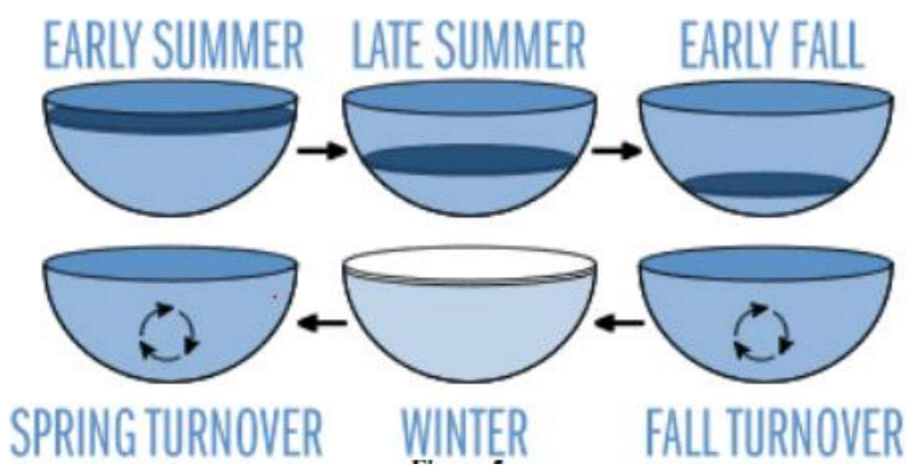
Figure 4. Channel Evolution Model showing a stable channel in Stage I, channel down-cutting or incision in Stage II, widening through Stages III and IV, and floodplain re-establishment at lower elevation in Stage V. Stages I and V represent equilibrium conditions. The Plan View shows the meander pattern of streams in the various stages of evolution.

physical integrity of streams. Stream access to floodplains may be the most important factor in maintaining equilibrium. Depending on the type of channel, the effects of disconnecting a channel from its floodplain vary. Channel evolution models help to explain a stream channel's response to losing its floodplain. Figure 4 shows how stream channels respond to deepening either due to excess water flow, or stream channel straightening. Channel evolution may also result in profound physical adjustments upstream and downstream from the site of alteration. To assess the physical integrity of streams, Vermont implements a three-phased approach to assessing stream geomorphic condition that permits scientists to assign streams to the stages of the channel evolution model, and to develop river corridor plans to manage streams towards equilibrium conditions.

The failure to understand, protect and preserve the access of rivers to their floodplains has directly resulted in conflicts between human investments and river system dynamics. Over the last century, many miles of Vermont's rivers have been subjected to channel management practices such as armoring, dredging, gravel mining and channelization, for the purpose of containing high flows in the channel and to protect human investments built in the historic floodplains. Following, and in support of the land drainage and damming practices started during the 19th century, structural controls and loss of floodplain access are largely responsible for loss of stream physical integrity in Vermont today.

Physical Integrity of Lakes and Wetlands

The natural physical integrity of lakes is highly variable. Lakes can be thought of as aquatic islands in a terrestrial landscape. Like islands, lakes are isolated but influenced by their surroundings. Lake shapes (morphology) vary, as do lake depths (bathymetry). Some lakes are fed primarily by groundwater, while others have enormous watersheds and are fed predominantly by runoff. Some lakes are located at high elevations that experience different weather than those at the same latitude located at sea level. As a result, lakes have different rates of water replenishment, different spatial and temporal patterns in temperature layering, and different ice cover durations. An integral part of the natural physical integrity of the open water of a lake is how it "mixes," or turns over. Monomictic lakes fully mix or 'turn over' once a year. Dimictic lakes turn over in spring and fall. Polymictic lakes, which are usually shallower, turn over multiple times a year. Meromictic lakes have stratified layers that do not fully mix (e.g. lakes with deep holes like Great Hosmer Pond). Most lakes in Vermont are either dimictic or polymictic. Managing lake



Graphic showing the progression of water temperature layering in lakes through the year. Image courtesy of USEPA. The cycle shown is for a "dimictic" lake.

water quality requires an understanding of these dynamics, which is obtained by water quality monitoring.

A key component protecting the natural physical integrity of the nearshore shallow area of a lake is the condition of the adjacent lakeshore. Natural lakeshores in Vermont are wetlands, forests, or forested wetlands. The physical characteristics of the littoral zone off a wetland are typified by soft or sandy sediments. The structure of wetland plants serves to dampen wave energy, allowing fine particles to settle out. Non-forested wetlands do not shade the littoral zone, so a diversity of submersed aquatic plants often thrive in the littoral zone adjacent to them. Plants provide physical structure and habitat and further dampen wave energy. Forested shores shade the littoral zone, and provide leaf litter as well as fine, medium and large woody structure. Many sediment types can be observed in the shallow water off a forested lakeshore in Vermont. Areas may have naturally fine sediments, but more commonly feature rocky or even boulder lake beds. This results in a three dimensional, physically complex, heterogeneous shallow water environment. Physical habitat heterogeneity increases species diversity because it provides a wide variety of niche environments. It is for this reason that the littoral zone is thought of as a lake’s nursery grounds. The structural complexity of the nearshore environment provides cover and food not found in either the open water environment of a lake or the terrestrial environment of the lakeshore.

Complex healthy habitat in the shallow-water area of a Vermont lake. The mix of boulders, sands and silts, and aquatic plants provide cover for fish and other aquatic animals.

The transformation of lakeshores and wetlands from natural vegetation to lawns and sandy beaches, accompanied by development (e.g. residential homes) can compromise physical integrity. As lakeshores are converted from forests to lawn, impervious surface, and sand, enhanced runoff results in increased littoral embeddedness, increased temperature (due to loss of shading) and in most cases more abundant aquatic plant growth in the shallows. Physical integrity of littoral habitat is further simplified by the direct removal of woody structure from the shallows, which is also considered wetland, and interruption in the resupply of this critical habitat component. In some cases, development is associated with introduction of fill material which completely removes the functions of low-lying lakeshores and their associated wetlands.

This alteration of the nearshore and littoral habitat affects a variety of both terrestrial and aquatic wildlife and has been well described by scientists. Green frog, dragonfly and damselfly populations decline. The nesting success and diversity of fish species also declines, with sensitive native species being replaced by more disturbance tolerant species. Turtles lose basking sites and corridors to inland nest sites, and bird composition shifts from insect-eating to seed-eating species. Even white-tailed deer are affected, with reduction in winter browse along shorelines reducing winter carrying capacity. The removal of conifers along shores can also reduce shoreline mink activity. Ultimately, the cumulative effects of lakeshore development impact considerably on physical integrity and habitat, affecting many types of aquatic and terrestrial wildlife.

The wetlands that offer benefits to surface water quality support a unique spectrum of ecosystem types that vary in hydrology, vegetation, and position on the landscape. The physical integrity of a wetland varies between these types. Wetlands that act as headwaters on sloping hillsides or high-elevation basins are an important transition between groundwater and surface waters, both through recharge of groundwater and discharge to surface water. Other types of wetlands comprise floodplains or backwaters along streams that feed into lakes and ponds. The wetlands that line the shores of lakes and ponds are the transitional zone between upland and deep water habitat, and are inherently sensitive to hydrological changes. Surface flow through many wetlands is largely undefined by channels, is seasonal in nature, and is critical in helping slow flood waters before entering more clearly defined river systems. Furthermore, unlike the lakes and ponds themselves, wetlands are sometimes completely lost in the face of extreme impacts. Fill, dredging, the alteration of hydrologic inputs and outputs, sedimentation, changes in water chemistry and the removal of vegetation from the wetlands can alter the physical integrity of a wetland or even lead to the complete loss of wetland functions and values. Such activities need not occur within the wetland to effect physical integrity and therefore activities within the adjacent upland need to be evaluated for change as well. For instance, diversion of streams that feed a wetland or installation of extensive impervious surfaces in the watershed of a wetland can cause severe impacts to the wetland.

Lakes and Eutrophication

Natural eutrophication of lakes refers to the aging of lakes in geological time, a gradual accumulation of sediment from a watershed that occurs over hundreds or thousands of years. As a lake ages and accumulates sediment naturally, biological and chemical characteristics also change (see Figure 5). Through this process, lakes naturally progress from the oligotrophic stage (deep clear water, few nutrients, few aquatic plants, high dissolved oxygen, sandy or rocky bottoms), through the eutrophic stage (high nutrients, extensive plant beds and algae, low dissolved oxygen, accumulated bottom sediments) to eventually become wetlands.

Human activities on the land have increased the movement of sediment and nutrients from the land to our lakes, a process known as 'cultural eutrophication'. As a result, lakes are aging much more rapidly and reaching the eutrophic stage much sooner (e.g. decades) than would occur in the absence of these activities. Lake management seeks to slow the cultural eutrophication process through the management of stressors while respecting the natural progress of lakes to wetlands.

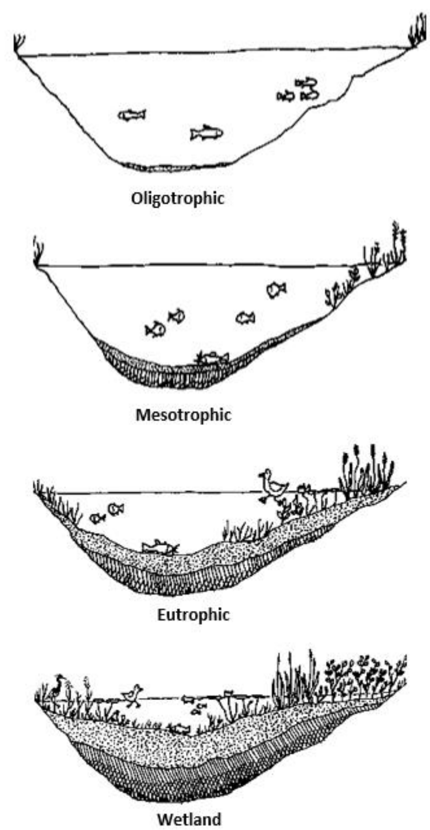


Figure 5. The stages of lake eutrophication.

Drawings by Susan Warren

Chemical Integrity

Compared to biological and physical integrity, chemical integrity is relatively simple to understand. The chemistry of water is an intrinsic component of habitat. When a chemical pollutant affects aquatic biota, it is because that chemical is affecting the organism's physiology owing to the contamination of the habitat. Thus, reducing pollutants in waters by managing stressors necessarily improves and restores habitat.

The chemical makeup of waters varies widely in Vermont. Some waterbodies are naturally enriched in phosphorus (e.g. Danby Pond, in Danby), or very low in phosphorus (Crystal Lake, Barton). Entire watersheds may be predisposed to acidification due to their geologic makeup (Lye Brook, Manchester), while other waters will never be at risk of acidification (Shelburne Pond or Lake Champlain). The chemical gradients that exist in natural waters are wide, and natural communities are adapted to these waters. However, when stressors affect the chemical integrity of waterbodies resulting in chemical levels outside of the expected natural range, biological integrity is likely to suffer.

The use of water management technologies (e.g. pesticides, alum, aeration) has successfully been used in Vermont and elsewhere to restore the chemical integrity of waterbodies. However, in some cases, these restoration approaches can also compromise the integrity of a waterbody. This depends on the capacity of the waterbody to sustain a balanced and resilient biological system with the full suite of ecological processes expected for the waterbody type. When these elements or processes are manipulated, the biological system of a waterbody can become unbalanced, which may result in a phenomenon called a "stable-state shift" (e.g. a lake with a plant-dominated stable state can shift to an algae-dominated stable state). These shifts can be difficult to reverse.

Wetland water chemistry is dependent on the water sources (surface or groundwater) and the bedrock and surficial deposits the source water flows through. Calcium is one of the more important minerals affecting plant composition in wetlands. Some of the most unique wetland types are on the opposite ends of the nutrient scale. Rich Fens are peatlands which are found where waters have surfaced from calcium-rich bedrock. They are high in minerals and pH, are typically very small, and are biological hot-spots. Conversely, true bogs such as Dwarf Shrub Bogs are peatlands which have a raised water table, primarily receive water from precipitation, are subsequently low in nutrients and high in water acidity, and have their own specialized plant community assemblages. A sudden change in nutrients due to alteration of the landscape of either of these wetland types would allow for invasive species intrusion, a loss in biodiversity and a loss in nutrient assimilation by native vegetation. In the case of bogs, increase in pH and nutrient level can also cause the peat layer in the wetland to quickly decompose, strongly compromising wetland function.

4. Protecting and Improving Surface Waters by Managing Stressors

In developing this Strategy, the Division engaged in an intensive evaluation process aimed at identifying areas of program duplication and program "gaps", as a way to ensure program efficiency in meeting the goals and objectives identified in the Strategy. A key element of this approach is the recognition that individual pollutants (often more than one) can be simultaneously mitigated by managing surface water stressors. These stressors are of interest not only to the Division, but also to Federal, State, and local agencies and organizations with in interest in surface water management. The Division has identified a list of 10 major stressors with unique causes and sources, and sometimes overlapping effects, which result in the surface water impacts documented in Vermont. By identifying stressors and approaches to their management, the Strategy sets the stage for the WSMD's approach to multi-agency planning and implementation that will meet the WSMD goals.

What are the 10 Major Stressors?

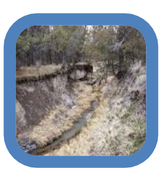
The ten major stressors are presented here in alphabetical order. The importance of each stressor has been evaluated in light of its extensiveness, intensity, duration, and urgency, and also in terms of the programs available to address the stressor. This information is described in detail in Chapter 2.

Acidity:

Acidification of Vermont's lakes and streams is a major problem caused primarily by the atmospheric deposition of acidic nitrogen and sulfur compounds (e.g., acid rain). Acidification can also result from runoff of active or abandoned mines. Acidification is widespread in the higher-elevations of Vermont, resulting in considerable impacts to lake and stream biology. Successful management of acidity meets Objectives A, B, and D of this Strategy.

The icon at left shows high-elevation forests that have been killed off due to acidification.

Channel Erosion:



Excessive channel erosion occurs throughout Vermont and is brought about by human activities that alter runoff patterns and channel morphology and lead to stream disequilibrium. Channels and floodplains that have the capacity to store sediment and associated nutrients are now transporting these materials. Excessive channel erosion adversely affects stream habitat, and higher loads of nutrients and sediments have become pollutants in downstream receiving waters such as inland lakes and Lake Champlain. Successful management of channel erosion achieves Objectives A, B, and C of this Strategy.

The icon at left shows a highly incised river channel and exemplifies channel erosion.

Flow Alteration:

Altering the natural flow regime of rivers and streams (i.e., impounding or dewatering) or the natural fluctuations of lake levels affects the extent and quality of aquatic, riparian and wetland habitats, water temperature, dissolved oxygen and other aspects of water chemistry, including concentrations of toxins in aquatic organisms. Flow alteration is an inevitable consequence of water withdrawals and hydroelectric power generation, so these activities must be properly managed to avoid impacting aquatic biota and recreational uses. Successful management of flows and water levels meets Objectives A, B, C, and D of this Strategy.

The icon at left shows an aerial view of the spillway at the Harriman Reservoir Dam, in Whitingham, Vermont.

Encroachment:

The placement of public or private infrastructure upon lakeshores, wetlands and river corridors results in the loss of riparian zone buffers, increasing sunlight penetration of shallows, and reducing habitat quantity and quality. Encroachments along river corridors can also create or perpetuate stream disequilibrium, both immediately adjacent to the structure, and in areas far upstream or downstream. Encroachments are pervasive along Vermont lakes and streams. In wetlands, fill, alteration of vegetation, and changes to hydrology result in a loss of the functions and values. Lakes with poor lakeshore habitat from overdevelopment can be three times more likely to have poor ecological integrity. Management of encroachments meets Objectives A, B, and C of this Strategy.

The icon at left shows an example of streambank and floodplain encroachment.

Invasive Species:

Invasive species such as Eurasian watermilfoil, Japanese knotweed, purple loosestrife, water chestnut, zebra mussels and spiny waterflea cause severe impacts to aquatic habitat. These species readily out-compete native plants, algae, and animals, ruin recreational opportunities, and alter entire ecosystem functions. Invasive species are at risk of spreading throughout Vermont surface waters, especially lakes, and are transported from one waterbody to the next by boats or following road ditches. Successful control of invasive species meets Objective B of this Strategy.

The icon at left shows a dense infestation of Eurasian watermilfoil.

Land Erosion:

Erosion of sediments off land surfaces delivers both sediment and nutrients to surface waters. These sediments can readily alter the dynamic equilibrium of naturally functioning stream channels, resulting in stream instability and delivery of sediments and nutrients to downstream waters. Land erosion occurs in all landscape types (urban areas, dirt roads, and improperly managed forest and farms). Successful control of land erosion meets Objectives A, B, and C of this Strategy.

The icon at left shows an example of rill erosion.

Nutrient Loading:

Direct discharge or runoff of nutrients also occurs independently of channel or land-based erosion. Wastewater treatment facilities, septic systems, and fertilizer usage in residential areas and agricultural settings deliver nutrients directly to waters. Nutrients like phosphorus and nitrogen are beneficial in naturally-occurring low levels, but excess nutrient loading results in eutrophication of lakes and streams, and increases the likelihood of toxic algae growth. Successful control of excessive nutrient loss meets Objectives A, B, and D of this Strategy.

The icon at left shows the chemical symbols for nitrogen and phosphorus.

Pathogens:

Pathogenic organisms may occasionally be present in Vermont's surface waters. When swimmers are exposed to pathogens in excessive levels, they may become ill, typically with gastrointestinal distress. Pathogenic organisms are the result of fecal contamination from several sources: poorly maintained septic systems, unmanaged agricultural runoff, pet waste, and natural sources. Vermont employs a readily-measured indicator organism called *E. coli* to assess the potential presence of pathogens from warm-blooded animals. Monitoring and controlling pathogens meets Objective A of this Strategy.

The icon at left shows coliform bacteria that are fluoresced under a microscope.

Toxic Substances:

Several categories of toxic contaminants may be present in Vermont's surface waters. Mercury contamination of lake fishes is widespread, reflecting that mercury is an atmospheric contaminant. Hazardous waste sites can result in localized contamination of PCB's, heavy metals, and other toxic compounds. Toxic cyanobacteria are becoming more frequently

observed in certain lakes and ponds. Of particular concern are "new generation" compounds such as endocrine-mimicking compounds, pharmaceutical degradates, and personal care products. These compounds come from the products society uses as part of daily living. They occur at very low concentrations, have poorly understood but consequential impacts to aquatic life, and are a direct manifestation of people as an integral part of Vermont's watersheds. Successful management of toxic substances meets Objectives A, B, and D of this Strategy.

The icon at left shows the chemical configuration of a poly-aromated hydrocarbon known as benzo-a-pyrene.

Thermal Stress:

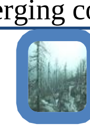
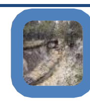
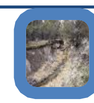
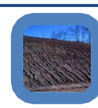
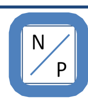
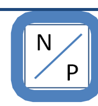
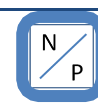
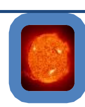
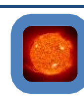
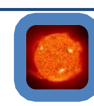
Excess warming occurs as a result of riparian buffer removal, the impoundment of water, loss of headwaters wetlands, cooling water discharge, and climate change. Excessive warming of surface waters impacts aquatic species that are intolerant of warm temperature. Further, excess warming can turn an otherwise cool babbling brook into bathwater; an undesirable effect on a hot day. Successful management of thermal stress meets Objectives A, B, and C of this Strategy.

The icon at left shows abnormally high sunspot activity.

Integrating Stressors, Objectives, and Goals

In the preceding sections, the basis for this Strategy was described in terms of a conceptual framework (Figure 1), goals that reflect federal and state law and Vermont's surface water quality policy, objectives that support those goals, and surface water stressors as a unifying theme for surface water management. The ways in which each stressor relates to the goals and objectives are shown graphically in Table 1 below. This table shows at a glance those stressors that must be managed to support the goals and objectives of this Strategy.

Table 1-1. Relationship of Goals, Objectives, and Stressors described by WSMD's Vermont Surface Water Management Strategy.

Strategy Goals	Biological, Chemical, Physical Integrity Public Use and Enjoyment Public Health and Safety	Biological, Chemical, Physical Integrity Public Use and Enjoyment --------	----------- Public Use and Enjoyment Public Health and Safety	Biological, Chemical, Physical Integrity Public Use and Enjoyment Public Health and Safety
<u>Objectives→</u> ***Stressors*** ↓	A. Minimize anthropogenic nutrient and organic pollution	B. Protect and restore aquatic and riparian habitat	C. Minimize and flood and alluvial erosion hazards	D. Minimize toxic, pathogenic pollution and chemicals of emerging concern
Acidity				
Channel Erosion				
Flow Alteration				
Encroachment				
Land Erosion				
Nutrient Loading				
Toxic Substances				
Thermal Stress				
Invasive Species				
Pathogens				

Using the Stressor Approach to Evaluate Program Effectiveness

In Chapter Two of this Strategy, ten stressor-specific summaries are provided that further describe the stressors, their associated pollutants, their unique causes and sources, and the State, Federal, Municipal, and non-profit programs in place to manage the stressors. Each stressor-specific subchapter describes the WSMD's programs and approaches for working with partner organizations to address the stressors through activities in five specific areas:

- ***Monitoring and Assessment*** activities to document locations of stressor impacts and identify areas to protect or remediate.
- ***Technical Support*** programs to assist individuals and organizations with the development of projects to address the stressor.
- ***Funding*** programs that provide cost-share assistance or complete funding for projects.
- ***Rules and Regulations*** that address the stressor, including permitting programs.
- ***Education and Outreach*** activities that confer understanding to the general public on the importance of the stressor.

The WSMD is has evaluated gaps in its ability to directly or indirectly protect and improve surface waters through the management of these stressors. By evaluating the extensiveness, intensity, urgency, and duration of 10 major stressors and their component causes, the WSMD evaluated stressor importance. The WSMD has also examined existing monitoring and assessment, education and outreach, technical assistance, financial assistance, and regulatory permitting programs pertinent to each stressor, to identifying gaps and areas of overlap in its ability to address the stressor areas. Chapter Three of this Strategy describes the results of this overall program evaluation and gap analysis, and identifies opportunities for greater program integration, enhanced internal and external coordination and other steps that would better promote the protection of Vermont's surface waters.

5. A Comprehensive Ambient Surface Water Monitoring and Assessment Program

Elements of the Surface Water Monitoring and Assessment Strategy

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

In parallel with the development of this Strategy, the WSMD has also recently completed a wholesale revision to its existing strategy for guiding surface water monitoring and assessment. This new 2015 Vermont Surface Water Monitoring Strategy has two primary purposes, to describe the who, what, where, when and why of monitoring Vermont's waters, and to coordinate with partners at all levels. Effective monitoring is integral to watershed management and planning at the statewide and basin-specific level, and to identify and prioritize waters in need of protection, restoration or management. Regulatory programs need monitoring data to more fully assess the impact of individual permit decisions, and monitoring results directly support the use of Vermont's Assessment and Listing Methodology to identify stressed, altered, and impaired waterbodies. The Monitoring Strategy is organized into 10 elements as recommended by the USEPA (see sidebar).

The Monitoring Strategy's goals and associated objectives are:

1) Predict and monitor the condition of Vermont's surface water resources to:

- identify emerging problems before they become widespread or irreversible;
- provide information essential to protecting, maintaining and/or restoring the integrity and use of these resources;
- achieve comprehensive monitoring coverage of all Vermont waters;
- identify water quality conditions, impairments, causes, and sources; and,
- evaluate the success of current policies and programs.

2) Communicate, collaborate and coordinate with organizations, agencies, and the general public to:

- increase public knowledge of and involvement in aquatic and wetland resource monitoring and assessment (and hence water resource management);
- promote efficient and effective monitoring and assessment programs; and
- collect useful data to supplement state monitoring and assessment programs.

On a biennial basis, the Division uses the data generated by the monitoring and assessment program to produce a statewide assessment of the conditions of Vermont's surface waters. This assessment, known as the Integrated Report on the Water Quality Integrated Assessment Report, is prepared in satisfaction of §305(b) of the Federal Clean Water Act.

For the purposes of identifying and tracking important water quality problems where the Vermont Water Quality Standards (VTWQS) are not met, VTDEC has developed the Vermont Priority Waters List. This list is composed of several parts, each identifying a group of waters with unique water quality concerns that are either impaired or altered: Impairment means that the surface water in question no longer supports one or more of the designated uses protected by the Water Quality Standards. Pursuant to the Federal Clean Water Act, impaired waters are those that are legally determined to be polluted, and that Act requires that most impaired surface waters be subject to a watershed specific pollution control plan known as a Total Maximum Daily Load (TMDL).

6. Total Maximum Daily Loads and other Pollution Control Plans

A TMDL is a legally binding document that identifies the surface water designated use that is impaired, the pollutant that causes the impairment, and the total maximum discharge of that pollutant that may be allowed to enter the waterbody in question and still maintain the designated use. TMDLs are unique to each waterbody. The general process by which they are developed can be summarized as follows:

- Problem Identification: the pollutant for which the TMDL is developed must 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: this element establishes water quality goals for the TMDL. Target values may be stated explicitly in the Water Quality Standards or they may need to be interpreted.
- Source Assessment: 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: this element of the 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: 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: stakeholder involvement is critical for the successful outcome of any TMDL. Draft TMDLs are released for public comment prior to their completion.
- EPA Approval: EPA approval is needed for all TMDLs as required by the Federal Clean Water Act. The New England regional office of EPA (Region 1), located in Boston, Massachusetts is responsible for TMDL approval.
- Follow-up Monitoring: additional monitoring may be needed to ensure the TMDL, once implemented, is effective in restoring the waters.

This surface water management strategy incorporates all TMDLs developed to date by the State of Vermont, and also the Lake Champlain Phosphorus TMDL that was promulgated by USEPA in 2016, following rescission of the 2002 Vermont Lake Champlain Phosphorus TMDL.

Lakes

- Lake Champlain Phosphorus TMDLs
  - (incorporated pursuant to USEPA's June 17 cover letter transmitting this TMDL to the State of Vermont)
- Lake Carmi TMDL - Franklin - phosphorus

- Ticklenaked Pond TMDL - Ryegate – phosphorus
- Lake Memphremagog Phosphorus TMDL – *forthcoming in 2017*.
- Moon Brook Thermal TMDL – *forthcoming in 2017*.

Rivers and Streams

- Winooski River - Cabot - pathogens
- Black River - Ludlow - phosphorus
- Tributary #1, Ball Mountain Brook - Stratton - sediment
- Styles Brook - Stratton - sediment
- Potash Brook - South Burlington - stormwater
- Bartlett Brook - South Burlington- stormwater
- Centennial Brook - South Burlington & Burlington - stormwater
- Englesby Brook - Burlington - stormwater
- Morehouse Brook - Winooski & Colchester - stormwater
- Allen Brook - Williston & Colchester - stormwater
- Indian Brook - Essex & Colchester - stormwater
- Munroe Brook - Shelburne - stormwater
- Sunderland Brook - Colchester – stormwater
- Moon Brook – Rutland - stormwater
- Rugg Brook – St. Albans – stormwater
- Stevens Brook – St. Albans – stormwater

TMDLs for Acidified waterbodies due to acid rain

- 2012 TMDL (2 acid impaired waterbodies)
- 2004 TMDL (7 acid impaired waterbodies)
- 2003 TMDL (30 acid impaired waterbodies)

Statewide/multiple waterbodies

- Statewide TMDL for Bacteria-Impaired Waters
- Vermont, 5 other New England states & New York state - mercury (note: concerns 31 Vermont waters)

In certain instances, TMDL's are not the most effective regulatory mechanism to address a water quality impairment. Pursuant to 40 C.F.R. §130.7(b), the State may use a Water Quality Remediation Plan (WQRP) in lieu of a TMDL for an impaired water when the State determines that the pollution control requirements of the WQRP are stringent enough to meet State Water Quality Standards within a reasonable period of time, and the regulatory authority exists to compel development *and* implementation of a WQRP. WQRP's are used most commonly in the case of impairments that result from the actions of a single landowner or business operator, and where that landowner or business operator controls all of the pollution sources in question. Several Vermont development areas are subject to WQRPs.

7. About the Vermont Clean Water Act (Act 64 of 2015)

The Vermont Clean Water Act (VCWA, or the Act) was signed into law by Governor Peter Shumlin on June 16, 2015. The Act represents a major step forward in Vermont's ability to reduce sediment and nutrient (phosphorus and nitrogen) pollution across the State. There are many areas in which the Act requires new or augmented efforts to control runoff. The roles and responsibilities of the State and the community in implementing these efforts is described in the following.

Agricultural Runoff

The State's Role:

- Promulgate new Required Agricultural Practices by the end of 2016.
- Train and certify businesses that apply manure to fields to minimize runoff in nearby waterways;
- Provide training for farmers and establish an annual certification for small farmers on how to comply with State standards by July, 2017;
- Increase farm inspections and technical assistance to ensure compliance with state agricultural water quality rules;
- Work with federal partners to increase support and funding to help farmers undertake water quality improvements on farms;
- Target support and funding to farms in the northern and southern segments of Lake Champlain Basin, where phosphorus pollution from agricultural sources are particularly significant;
- Evaluate and employ technical, regulatory and educational options for tile drain management. A report to the legislature on tile drains and recommendations for additional Required Agricultural Practices to address tile drainage is due Jan. 15, 2017.

The Farmers' Role:

- Provide a minimum of 25-foot buffers along streams and 10-foot buffers along field and road ditches;
- Eliminate gullies that are eroding valuable agricultural land;
- Develop nutrient management plans and implement actions to keep manure, fertilizer and topsoil from running into waterways;
- Install fences to keep livestock out of streams and rivers where needed.

Stormwater from Developed Lands

The State's Role:

- Update the standards contained in the Vermont Stormwater Manual during 2016;
- Provide municipalities support in identifying, prioritizing and initiating stormwater control needs;
- Help municipalities, developers and property owners reduce stormwater runoff from unregulated impervious surfaces by employing practical and cost-effective best practices including *green stormwater infrastructure* — actions that mimic or employ natural processes to capture, reuse or filter stormwater and minimize the cost of collecting, transporting and treating stormwater runoff.
- Release the general permit for existing development by 2018 and a schedule to require retrofits in the Champlain Basin no later than Oct. 2023, and in the rest of the State no later than Oct. 2028.

Municipalities' and Developers' Role:

- Control stormwater discharges at existing developments with 3 or more acres of impervious surface that were never permitted or not compliant with the 2002 Vermont Stormwater Manual − the rulebook for new development projects that require a state stormwater permit;
- Develop and go forward with more municipality-wide stormwater runoff control plans in communities that are discharging a significant amount of untreated stormwater into rivers and other waterways.

Stormwater from Roads

The State's Role:

- Develop and promulgate a Municipal Roads General Permit program by December, 2017
- Develop, in consultation with VTrans, and promulgate a General Permit to reduce erosion and stormwater discharges generated from state-managed highways and related infrastructure;
- Support municipalities in conducting road inventories that identify and prioritize critical areas in need of erosion and sediment control;

- Increase support and funding for municipalities in implementing practices that improve the resilience of local roads to flooding while minimizing erosion and stormwater runoff discharging into streams.

Municipalities' Role:

- Reduce erosion and stormwater discharges being generated from municipal roads;
- Apply for permit coverage by July 1, 2021.
- Implement necessary practices by 2026.

River Corridors and Floodplains

The State's Role:

- Provide support to cities and towns, including financial incentives, to aid adoption of enhanced floodplain and river corridor protection standards and enhance flooding resilience;
- Establish a "Flood Ready" website to promote municipal flood resiliency planning and actions;
- Provide education and training to municipalities on stream and river management practices as well as support prior to and during flood emergencies.

Municipalities' Role:

- Comply with the National Flood Insurance Program;
- Qualify for incentives to adopt floodplain and river corridor protection standards that enhance flood resilience and insure that actions of property owners do not heighten the risk of flood damages to other property owners;
- Increase floodplain and river corridor protection and restoration projects.

Wetlands Management

The State's Role:

- Expand support and financial assistance to landowners in wetland restoration and protection; Partner with federal and state agencies, local partners and landowners to identify and undertake wetland restoration projects;
- Increase inspections to achieve greater wetland permit compliance;
- Target critical wetlands for State Class I wetlands protection for flood resilience and phosphorus reduction.

- Collect data about wetlands to establish baselines of wetland condition throughout the state, monitor changes over time, and evaluate success of restoration and protection projects.

Lake and Pond Management

The State's Role:

- Provide support and technical assistance for the protection and restoration of lakes and ponds;
- Partner with federal, state, and local partners to identify and implement protection and restoration projects;
- Monitor waterbody and shoreland condition to inform protection, management and restoration activities;
- Identify high quality waters for increased protection through reclassification, shoreland best management practices and/or nutrient reduction

The role of Municipalities and Local Residents

- Learn about best management practices to promote shoreland health, reduce nutrients and protect water quality
- Control erosion and reduce storm water run-off utilizing best management practices and by creating increased opportunity for infiltration
- Identify high quality waters for increased protection

Forest Lands Management

The State's Role:

- Enhance measures to protect water quality during timber harvesting operations by July, 2016;
- Provide technical assistance to forest landowners participating in NRCS cost-share programs;
- Develop and promote "climate-smart" forest adaptation strategies through the Working Lands Enterprise Initiative to support environmentally sound logging technologies.

Loggers' and Landowners' Role:

- Be encouraged to use low-impact timber harvesting technologies, such as portable skidder bridges, to reduce polluted runoff risks on timber harvesting operations;
- Control erosion on logging roads and at stream crossings by participating in cost-share programs offered by the USDA Natural Resources Conservation Service;

- Improve watershed health by restoring river, floodplain and lake-side forested buffers, supporting forest conservation, expanding developed land forest cover and reducing invasive tree pests.

The Act also established a Clean Water Fund that will serve as a repository for Federal, State, and Private funds that are dedicated to support implementation of water quality improvement projects. While the fund is supported for the first three years using Vermont's property Transfer Tax, the Act compels the State Treasurer to complete a report on the total need and financing options to implement VCWA, the Lake Champlain TMDL, and other pollution control plans (see Section 7, below). That report will be provided to the Vermont General Assembly in January, 2017.

8. The Lake Champlain Phase I TMDL Implementation Plan

While all EPA-approved TMDLs are required to be accompanied by an implementation plan, the implementation plan of the Lake Champlain TMDL merits summary here as the provisions of the Plan largely apply state-wide, and are foundational to the Division's efforts to manage surface waters over the next two decades. The Lake Champlain Phase I Implementation Plan was developed by the Vermont Agency of Natural Resources (ANR) and the Vermont Agency of Agriculture, Food, and Markets (AAFM) from 2015 to 2016. These agencies worked diligently to develop the types of policy commitments requested by USEPA to provide, or reduce the need for, reasonable assurances in the then forthcoming new Lake Champlain Phosphorus TMDL. The final form of the VCWA as passed was in-fact informed by initial drafts of the Phase I Plan, itself informed by the draft Lake Champlain TMDLs. The final October 2016 final Phase 1 Plan reflects EPA's final Lake Champlain Phosphorus TMDLs. The policy commitments described in the Phase I plan address all major sources of phosphorus to the lake, including the following:

- Wastewater treatment facility discharges;
- Untreated/unmanaged runoff from existing developed lands;
- Discharges from farmsteads and agricultural production areas;
- Poorly managed cropland;
- Unmanaged or poorly managed pasture;
- River and stream channel modifications;
- Floodplain, river corridor and lakeshore encroachments;
- Stormwater runoff from developed lands and construction sites;
- Road construction and maintenance;
- Forests and forestry management practices;
- Wetland alteration and loss;
- Legacy effects of historic phosphorus loading; and
- Additional phosphorus contributions anticipated due to climate change.

The commitments presented in the Phase 1 Plan include new and enhanced regulation, funding and financial incentives, and technical assistance, and build on work already done by the State over the past 10 years to reduce phosphorus contributions to the lake. They will require new and increased efforts from nearly every sector of society, including state government, municipalities, farmers, developers, businesses and homeowners. The Division is employing a twenty-year implementation schedule to allow for communities to plan and stage the necessary improvements to roads, stormwater and wastewater infrastructure into long-term capital funding plans as a means of keeping costs and funding burdens down.

9. Tactical Basin Planning

The Federal Clean Water Act requires the development of a watershed planning approach, while VCWA requires the development of fifteen basin-specific watershed management plans[2]. Chapters Two and Three of this Strategy provide a statewide perspective on Vermont's approach and toolkit for watershed management, Chapter Four describes a tactical basin planning approach that maximizes geographic specificity and coordinates multi-program implementation to a common set of stressors. Tactical basin plans are the vehicle by which the WSMD will implement the actions laid out in the Strategy, by providing coordination of the many water quality protection and improvement programs in Vermont. In addition to the Agency of Agriculture, Food and Markets, Vermont's Regional Planning Commissions and Natural Resources Conservation Districts are statutory partners to the planning process. Sister agencies in State and Federal Government are also core partners. Since the initial implementation of the tactical basin planning process in 2010, tactical basin plans have been completed for all of Vermont's fifteen basins, and they have been re-issued every five years, as required by statute.

The tactical planning process is predicated on a monitoring and assessment cycle that provides refreshed data and information to guide prioritized implementation efforts. The Vermont Integrated Watershed Information System provides online access to all water quality and biological monitoring data compiled by the Division in a series of simple graphical reports. Monitoring and assessment data stored within this system provides the Starting point for geographic targeting strategies for protection or intervention. Through this system, the WSMD attributes individual surface water testing locations to categories of quality categories such as "High Quality Waters," and "Altered or Impaired Waters." Recent improvements to the tactical planning process include the technical capacity to conduct fine-scale phosphorus runoff modeling, and other geographically-based watershed targeting analyses, using tools such as the Keurig Green Mountain Coffee Roasters-supported Clean Water Roadmap.

In addition to water quality testing and modeling, there are five specific assessment processes that are integrated when producing a tactical basin plan. The priorities identified by each assessment are integrated into priorities for implementation. Each assessment process also yields critical on-the-ground information on the types of stressors at play. In sum, the assessment processes used in developing tactical basin plans include:

- Water Quality Monitoring;

[2] 40 CFR §130.6, 10 VSA §1253, and the VT Water Quality Standards

- Water Quality Modeling and the Clean Water Roadmap;
- Stream Geomorphic Assessment;
- Assessment and Monitoring of Wetlands;
- Stormwater Master Planning;
- Better Roads Capital and Road Erosion Inventories;
- Stormwater Mapping and Illicit Detection Discharge and Elimination (IDDE);
- Natural Resources Conservation Service high-resolution agricultural plans

The integration of these assessment processes in each tactical basin results in a five-chapter document. Chapter One presents a summary of the plan, including statements of the documented geographic areas and sector-specific areas for protection, practice installation, and restoration. Chapter Two presents a summary of all assessment information for that basin. Chapter Three presents detailed modeling results, and provides a breakdown of TMDL allocations where appropriate. Chapter Four presents opportunities for protection of very high-quality rivers, lakes, and wetlands using reclassification or other designation processes. Finally, Chapter Five of the tactical basin plan provides a summarized implementation table of actions necessary to protect, maintain, enhance, and restore surface waters in the basin.

10. Implementation Priorities and Tracking

As described above and by the Lake Champlain Phase I Implementation Plan, each tactical basin plan Implementation Table is housed within the Division-supported Watershed Projects database, This database includes a project grading system, addressing project readiness and prioritization factors, including estimates of environmental benefits, to assist Basin Planners and the Division's planning partners in prioritizing projects for implementation and funding. Implementation Tables will also address actions to be taken as a result of regulation, including compliance with RAPs, as well as various stormwater permit programs. As TMDL actions listed in Implementation Tables are implemented, the same DEC project database where Implementation Tables are housed will be used to track progress by the Division, on behalf of sister agencies and partner organizations.

The Division prioritizes management and remediation of pollution sources upstream of rivers, streams, lakes, ponds and wetlands prior to addressing in-water pollution. For example, it would be an unwise use of public resources to repair a failing streambank, when the cause of that failure is an upstream constriction in that stream. Addressing the constriction is a better use of resources. Full protection and restoration of surface waters can only be accomplished when upstream and upland stressors are reduced to levels which support biological, physical and chemical integrity in receiving waters. Under this policy, in-lake management approaches in most cases are utilized only when sufficient progress has been made on land immediately adjacent to the resource or deeper in the watershed. Ideally monitoring data should indicate that impacted waters are in the recovery phase. A good example of this practice was the implementation of an in-lake recovery treatment in Ticklenaked Pond, which was funded only after the watershed-level phosphorus sources were addressed.

11. Roadmap to this Surface Water Management Strategy

This strategy is comprised of four primary chapters, a standalone Monitoring and Assessment Program description, and several Appendices. Chapter One of the Surface Water Management Strategy is this document. Remaining chapters and appendices are as follows.

Chapter 2 - Managing Water Quality by Managing Stressors - Introduction

The 10 Major Stressors that result in pollution to surface waters are:

- Acidity
- Channel Erosion
- Flow Alteration
- Encroachment
- Invasive Species
- Land Erosion
- Nutrient Loading
- Pathogens
- Toxic Substances
- Thermal Stress

Chapter 3 - The Watershed Management Division Strategic Operations Plan for 2017-2019

Chapter 4 - Tactical Basin Planning: Managing Waters along a Gradient of Condition

Chapter 5 - Water Quality Monitoring Program

Appendix A: Vermont Regulations Pertaining To Surface Water management

Appendix B: Surface water pollutants that are found in Vermont surface waters

Appendix C: Landscape Activities that produce the stressors responsible for polluting our waters.

Appendix D: Programs that Protect and Restore Waters of Vermont

Vermont Department of Environmental Conservation

Watershed Management Division

Statewide Surface Water Management Strategy

Chapter 2. Stressors that affect Goals and Objectives for Surface Waters

Introduction

This introduction describes how the Division developed the list of ten major stressors, and how the importance of each stressor was initially evaluated as a preface to the subchapters presented below. In this introduction, a numeric evaluation of stressor importance is described, which the reader should understand as a starting point for further discussion, and not a complete statement as to the Division's view of the stressor priority. Detailed information about stressor impacts, management approaches, and gaps in the Division's ability to achieve complete management are provided in the subchapters below. In chapter 3, a more complete view of stressor priorities is provided, that relates the information presented throughout Chapter two to the Division's roles and priorities for the implementation of this Strategy.

How were stressors evaluated?

The ten stressors presented throughout this Strategy result from an internal planning process that included an initial brainstorming phase, followed by detailed technical and programmatic evaluations. In the brainstorming phase, a Division-wide exercise was conducted to collect and consider the widest possible array of potential impacts to surface waters that result from the variety of activities that occur on the Vermont landscape. From this long list of stressor sources, ten common categories, or major stressors were identified, many with several unique sources. The ten stressors, and their sources (e.g., the landscape activities that produce the stressors), are listed in Table 2-1.

Table 2-1. Activities that are sources of pollution to surface waters of Vermont, arranged within ten major stressor categories.

Major Stressor	Sources of the Stressor
	**Acidity** from: a) atmospheric deposition b) mine tailings runoff.
	**Altered hydrology** resulting in periodic dewatering or inundation of habitat (including extremely high velocities and rapidly changing flow) from: a) Non-natural variation in flows due to withdrawals, b) Decreased/altered flows from flood control and hydropower dams c) Lake or reservoir fluctuations d) Ditching of wetlands.
	**Aquatic Invasive Species** that cause loss of recreational opportunities and habitat/ecological integrity of aquatic or riparian habitats, due to: a) Human dispersion (aquaria release, ballast release, boat/trailer transfer, fish tournaments) b) natural spread (avian transfer)
	**Channel Erosion:** increased sediment & nutrient loading due to mass wasting and stream disequilibrium (erosion/transport/deposition) from: a) increased flow peaks (watershed ditching/draining, impervious cover runoff, dams, and climate change) b) sediment discontinuity (dams, diversions, and culverts) c) channelization practices (channel dredging, straightening, berming, and armoring) d) bed and bank disturbance.

	**Encroachments:** loss of habitat, equilibrium, and ecological process due to encroachments within or adjacent to floodplains, wetlands, lakes, streams, and rivers from: a) earthen fills b) roads c) buildings d) utilities e) stream crossings f) dams
	**Land Erosion:** increased fine sediment & nutrient (S&N) loading due to erosion of exposed soils and gully erosion from: a) ditching (conveyed surface flow) b) cropland c) forestland uses d) construction sites e) stormwater runoff.
	**Nutrient loading (non-erosion)** to surface waters from: a) over-fertilization (urban, agriculture) b) inadequately treated domestic waste c) animal and milk house wastes.
	**Pathogens** from anthropogenic waste attributable to: a) poorly-functioning septic systems b) domestic animals c) agricultural runoff d) nuisance wildlife.
	**Thermal Stress:** loss of habitat, equilibrium, and biological thermal reproductive cues due to: a) removal of woody and herbaceous riparian /shoreland vegetation b) impoundment c) climate change.
	**Toxic Substances** in surface water and groundwater from: a) atmospheric deposition b) inorganic and organic contaminant releases c) pesticides d) contaminants of emerging concern e) Biologically-derived toxins

In the second phase, the results of which are presented in the following stressor-specific documents, WSMD evaluated stressor importance, by evaluating four attributes using a gradient of importance. For each stressor, where available, empirical information from statewide monitoring, assessment or other scientific data were used. The four attributes of stressor importance are:

Extensiveness – how widespread is the problem

very few instances of affected areas
affected areas are discrete and effects localized
numerous occurrences, with regional (watershed or town-level) effects

widespread (basin-wide or statewide)

Intensity of Effect – what is the consequence of the problem
– none or positive
– perceived, but unquantified, effect on water resource goal(s)
– quantifiable, but limited, effect on water resource goal(s)
– substantial, quantifiable effect on water resource goal(s)

Duration of Impact – if the problem arises, then how long until the resource repairs itself?
< 5 years to heal
5 - 25 years to heal
25+ years to heal
the problem will never heal

Urgency of the Threat – what is the likelihood that the problem will arise
unlikely to occur
occurred, but not getting worse (damage has been done)
on-going
on-going and getting significantly worse over time

Thus described, the stressors were then evaluated in the context of the regulations, programs, and efforts in place within WSMD and partner organizations, within and outside of State government. Those regulations or programs, basically the "tools," were classified within five basic approaches:

- ***Monitoring and Assessment,*** which is used to document the occurrence of stressors. A robust monitoring and assessment program is necessary to document the condition of surface waters and relative importance of stressors to those specific waters.

- ***Technical Assistance,*** which may be used to provide assistance to on-the-ground practitioners in the development of specific projects or local regulations that are intended to restore or protect surface waters.

- ***Funding Programs,*** which may be used in conjunction with technical assistance efforts to directly pay for remediation or protection efforts, in whole or in part.

- ***Regulations,*** which may be in place or be established to address a particular stressor, and can take the form of permit programs or basic prohibitions.

- ***Education and Outreach*** activities which are an integral component of a comprehensive surface water management strategy. Education and outreach is differentiated from technical assistance by the intended audience. Education and outreach activities are aimed at the general public and are intended to confer a general understanding of how to protect surface waters.

Therefore, in the ten sub-chapters that follow, each of the stressors is described, using empirical evidence where available, with respect to extensiveness, intensity, urgency, and duration of impact, and in relation to the specific goals and objectives of this Plan that are met when the stressor is addressed (see Table 1-1). Existing programs that address the stressors are described within the five basic approaches, and gaps in the current program capability are identified, along with recommendations to close the gap. In chapter three, the collected recommendations are integrated to develop a roadmap of prioritized actions for the improvement of surface waters in Vermont.

What is Acidity?

Waterbodies exhibit a range of acidity, primarily reflected by the acidity level (or pH) of the water. Natural factors affecting a waterbody's pH include its landscape position, landscape slope, watershed size, bedrock and soil composition. Human activities can alter the acidity of a waterbody through long distant transport and deposition of atmospheric pollutants (commonly referred to as acid rain) and/or through mining activities. More detailed information concerning acidity can be found in Appendix B.

Long distant transport of atmospheric pollutants:
Acid rain occurs when sulfur dioxide (SO_2), and nitrogen oxides (NO_x) are emitted into the atmosphere from burning fossil fuels. These pollutants are known as acid-forming precursors, which combine with water and ozone to become sulfuric and nitric acid. Even though Vermont emits the lowest amount of acid-forming precursors in the nation, emissions from upwind states and provinces and blow eastward affecting the chemistry and biology of Vermont's lakes, streams, and forests.

The most obvious environmental effect of acid rain has been the loss of fish in acid sensitive lakes and streams. Acid sensitive lakes or streams have little or no buffering capacity, and because of the type of bedrock underlying these waterbodies, they cannot neutralize the acids. These lakes and streams are found in watersheds with granite bedrock which lack the buffering ions (like calcium) to neutralize the effects of acid rain. Many lakes in the Adirondack area of upper New York State are underlain with anorthsite (a type of granitic rock) and have suffered severe aquatic life loss because of acid rain; these lakes have been called "dead lakes." In reality, the lakes are not completely dead, but their biological communities have been so compromised that only the most tolerant fish, plants and insects can survive. In Vermont, we have also described some acid lakes as "dead" specifically in reference to their fish-less status. In poorly-buffered watersheds like these, scientists have documented significant incremental losses of buffering ions once present. In these areas, full recovery of surface waters may be difficult to achieve.

Fortunately, many lakes in Vermont have watersheds with calcium-rich bedrock (such as limestone), that protect surface waters by neutralizing the acidity of acid rain. Vermont surface waters that are most sensitive to acid rain are often smaller, at high elevation, and located in areas with low buffering bedrock. These acid-sensitive waters are mostly found in remote and undeveloped regions of the southern Green Mountains and in areas of the Northeast Kingdom.

Mining:
Vermont had three major copper mines operating from 1800-1958: Elizabeth, Ely and Pike Hill. All three mines are now closed, but the tailing piles left behind have caused acidification and the release of heavy metals in downstream waterbodies. Historically, sulfuric acid was used to extract copper from the ore, resulting in the release of acids and heavy metals from tailing piles. The leaching of acid mine drainage continues in some instances to the present day, even if the mines are no longer in operation. Four streams have been listed as acid-impaired due to the drainage from the former copper mines. The USEPA has designated Elizabeth and Ely Mines as Superfund sites. A comprehensive remediation effort at the Elizabeth Mine (Strafford and Thetford, VT) has resulted in recovery of several miles of the West Branch of the Ompompanoosuc River and Lord Brook. Additional remediation planned for 2017-2018 is intended to incrementally further restore the headwaters of Lord Brook. Acid mine leachate remediation activities are also planned for the Ely Mine (Thetford) to address acid mine drainage issues on Schoolhouse Brook. Also, water quality monitoring has determined that Pike Hill Brook and a portion of an unnamed tributary to Cookville Brook are impaired due to acid mine drainage from the defunct Pike Hill Mine (Corinth, VT).

How important is Acidity?

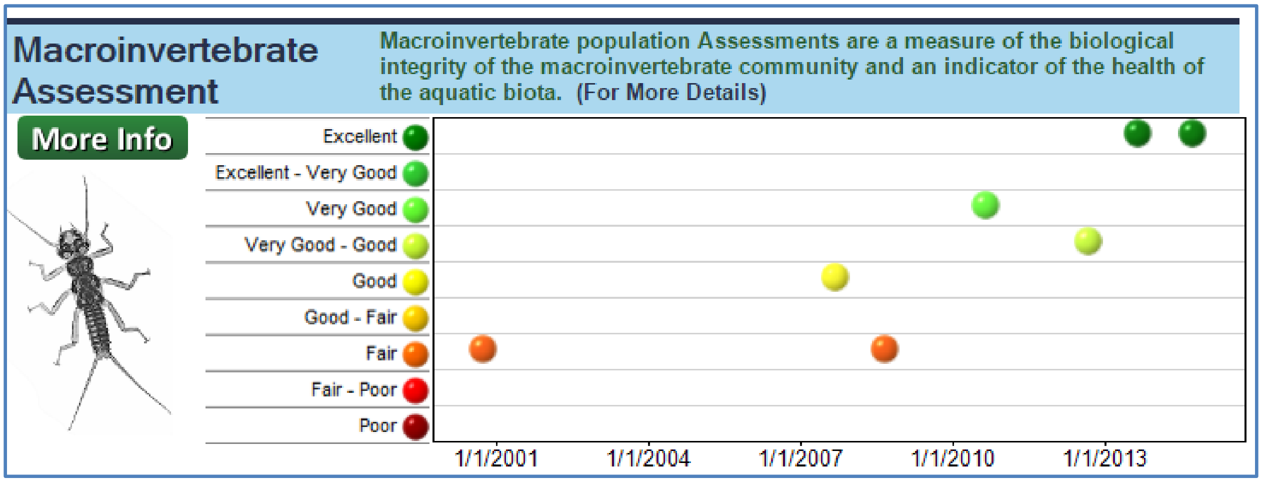


Figure 1. Recovery of biological integrity of Lord Brook, Thetford, VT, after partial remediation of the Elizabeth Mine's "South Cut."

Based on the Watershed Management Division's evaluation, acidity is a moderately ranked stressor, the effects of which are regional in scale, in that certain watersheds exhibit acid sensitivity. In other areas of the northeast, the effects of acidification are more pervasive. A 2010 NESCAUM project demonstrates the extensiveness and severity of acid-forming precursor deposition to northeastern States, concluding that ~30% of Vermont's forests receive excessive loads of acid-forming precursors. In these areas, acidity may be an intense stressor to surface waters with moderate to severe biological impacts. Based on a recent statistically-based survey, up to 16% of Vermont lakes may be stressed by acidity, while 3% of lakes are acid-impaired. The most recent statewide water quality assessment indicates that thirty eight ponds have been listed as acid impaired due to atmospheric pollutants, and ~160 miles of assessed streams are either stressed or impaired due to acidity. Two acid impaired lakes have improved enough to be taken of the TMDL list and moved to the acid strssed list. This is largely due to the federally mandated regulations associated ith the Clean Air Act and its amendments.

Long-term results from the volunteer Vermont Acid Precipitation Monitoring Program show trends of decreased acidity or improved pH as a result of the federal air pollution control regulations. With the passage of the 1990 Clean Air Act, sulfate levels in surface waters have been reduced, but there have been no significant trends observed for NO_x, which means it may be too early to detect decreased acidity levels in Vermont surface waters. However, these favorable trends may be too late for the most acidified lakes in Vermont. The reservoir of calcium and magnesium ions in watershed soils not only buffered the acidity of surface waters, but also provided for necessary essential minerals required by aquatic organisms. A decrease in calcium concentrations can be detrimental to the shell development of crustaceans and mollusks as well as to the ability of fish to respond to changes in water temperature and alkalinity. So for lakes like Branch Pond in Sunderland, the significant reduction in these beneficial minerals may prevent the full biological recovery once expected with the improving acidic conditions.

What objectives achieved by controlling Acidity?

Addressing and preventing acidity promotes several surface water goals and objectives, including:

Objective A. ***Minimize Anthropogenic Nutrient and Organic Pollution***
The acid-forming compounds of nitrogen oxides atmospherically deposited to Vermont's watersheds are themselves sources of nutrients. Atmospheric deposition of nitrogen oxides is responsible for a large proportion of the human-caused nitrogen load in undeveloped watersheds.

Objective D. ***Minimize Toxic and Pathogenic Pollution, and Chemicals of Emerging Concern***
Acidified waters often exhibit high levels of mercury in fish tissue. As such, reducing acidity also reduces the impact of fish mercury contamination.

What are the causes and sources of Acidity

The causes of acidity include atmospheric deposition, which is widespread throughout Vermont, and runoff of so-called "acid mine leachate," which is much more localized. The sources of atmospheric deposition include a wide variety of industrial and mobile sources that emit nitrogen oxides and sulfur dioxides. Industrial facilities such as coal-fired power plants, waste combustors, and utility boilers are all stationary sources of acidity to the atmosphere. Mobile sources such as cars and trucks account for over half of the nitrogen oxide emissions. Abandoned mining operations are the source of acidity from mine leachate. In Vermont, only a small number of surface waters fall into this category.

Monitoring and assessment activities to track Acidity

Most of the WSMD activities involved with acidity are associated with monitoring and assessment. This is due to the nature of the problem which is mostly created from long distance, out of state sources or from historical land uses. For acid lakes, VTDEC tracks responses to the Clean Air Act (See Vermont Long- Term Monitoring Project. This program has been critical to demonstrating the effectiveness of the Clean Air Act, determining TMDLs for acid lakes and in winning a major settlement with a mid-western coal powered utility, American Electric Power, to reduce emission of acid- forming pollutants. By providing long-term monitoring of water chemistry, the Division has demonstrated the benefits of the federal regulation and the need for further reductions to achieve biological recovery.

Other programs which assess the acidic conditions of Vermont waters or track precipitation chemistry include the following:

- Vermont Ambient Biomonitoring Program for acid streams (both from acid mines and acid deposition)
- Vermont Acid Precipitation Monitoring Program to track pH changes in precipitation
- National Atmospheric Deposition Program tracks changes in atmospheric chemistry nationwide

WSMD Scientist Jim Kellogg monitoring acid-impaired Levi Pond in Groton, VT. Jim has tracked acidification of Vermont surface waters since 1980.

- Vermont Air Monitoring Network tracks air pollution concentrations in Vermont

Technical assistance programs to address Acidity

Technical assistance for acidity is limited due to the nature of the stressor. For acid lakes, the WSMD has avoided actively treating lakes with lime or other alkaline substances to increase their pH. Research from experimental lakes in Europe and Canada showed that treating lakes would only temporarily increase the pH and buffering capacity. These lakes would require ongoing treatments and would provide a chemically unstable habitat, due to fluctuating pH, alkalinity and aluminum. Instead, Vermont acid lakes are monitored to assess the changes over time to the lakes and their watersheds from air pollutant emissions. For acid mine drainages, there are only a handful of former mining sites which have caused downstream impacts. These sites are coordinated by the VTDEC Hazardous Waste Management Program in cooperation with the US EPA Superfund program.

Regulatory programs to address Acidity

The Watershed Management Division does not regulate emissions from acid precursors. Instead, the Air Quality and Climate Division (AQCD) maintains up to date Air Pollution Control Regulations that comply with EPA's regulations issued under the Clean Air Act. These regulations confer to AQCD regulatory and permitting authority on several air emissions source types, both mobile and stationary, that have potential impacts to surface waters. AQCD maintains Air Quality Standards that are used similarly to Water Quality Standards to limit emissions of air contaminants to safe levels. Depending on the volume emitted, individual permits may be required. AQCD also issues a general permit for smaller emissions sources.

The VTDEC Waste Management and Prevention Division, Sites Management Program regulates the disclosure and cleanup of environmental contamination and spill sites.

Funding programs to address Acidity

Vermont has received funding from the US EPA, Office of Air and Radiation, Clean Air Markets Division, to monitor acid lakes for over 30 years. This funding has allowed consistent data collection and assessment of acid lakes in Vermont and the northeast. A grant for this program has been awarded to the VTDEC for 2015-2020.

The US EPA has provided funding through the Comprehensive Environmental Response, Compensation, and Liability Act (a.k.a. Superfund) since 2000 for acid mine drainage remediation in Vermont.

The Vermont Environmental Contingency Fund, Waste Management Division, Sites Management Section, has also provided significant funding for the treatment and clean-up of acid mine drainages.

There are specific no funding programs aimed at alleviating acidity in Vermont. The vast majority of acid-forming pollutants are emitted from out of state sources. As a result, the State of Vermont has lobbied the US Congress for strict pollution control emission regulations and successfully joined litigation with EPA, 8 states and 12 environmental organizations against a major coal powered utility. This settlement mandated the adoption of new pollution control methods which will significantly reduce the amount of nitrogen oxide and sulfur dioxide released to the air.

Information and education programs to address Acidity

VTDEC provides information and education about acid rain through the Vermont Long-Term Monitoring Project for acid-sensitive lakes and the Vermont Acid Precipitation Monitoring Program monitors the pH of precipitation on an event basis utilizing volunteer monitors.

The Waste Management and Prevention Division's Sites Management Program provides information and education to the public about acid mine drainages. They hold public meetings and inform the legislature about the current status and remediation efforts.

In addition, the Vermont Watershed Management Division's Tactical Basin Planning Program provides education through basin planning activities with the public.

What is Excessive Channel Erosion?

Channel erosion is a natural process that benefits stream and riparian ecosystems. Erosion in naturally stable streams (i.e., streams that are in equilibrium condition) is evenly distributed and therefore minimized along the stream channel. Erosion is also a dynamic process, where the movement, sorting, and distribution of sediment and organic material create a diversity of habitats. When streams are in disequilibrium, excessive erosion occurs in some channel locations, while excessive deposition occur at other locations up and down the length of the stream. Some habitats become scoured of beneficial woody debris and sediment, while others may become smothered. Where stream disequilibrium is prevalent in a watershed, nutrients (e.g. phosphorus) that are attached to eroded sediments are released in unnaturally large amounts.

When the slope or depth of flowing water increases, the power of the water to erode may increase beyond the resistance of the bed and bank materials, leading to excessive channel erosion. When excessive bed erosion is started (i.e., incision), the stream may go through a series of adjustments referred to as channel evolution, which causes systemic erosion over large temporal and spatial scales. From ANR field surveys, nearly three-quarters of Vermont streams (~2,100 assessed miles) have down-cut and lost some physical connection with their historic floodplains. Channel incision is pervasive, especially in the valley bottom streams. Deepened floods, contained in straighter, steeper channels, are resulting in a tremendous increase in stream power, channel adjustment and erosion (Kline and Cahoon, JAWRA, April 2010).

Stream Equilibrium Condition occurs when water flow, sediment and woody debris are transported in a watershed in such a manner that the stream maintains its dimension, pattern and profile without unnaturally aggrading or degrading at the river reach or valley segment scales. Benefits of managing streams toward equilibrium conditions include the reduction of flood damages, the naturalizing of hydrologic and sediment regimes, improved water quality through reduced sediment and nutrient loading and restoration of the structure and function of aquatic and riparian habitat.

Excess channel erosion can create critical gaps between habitats that are important in aquatic organism life cycles. Streambed, riparian and floodplain habitats become both vertically and laterally disconnected when streams down-cut and widen. Public property and private investments on floodplains and within river corridors are also threatened by flood and erosion hazards associated with rapid channel evolution and disequilibrium.

The ANR Stream Geomorphic and Reach Habitat Assessment Protocols (2009), the River Corridor Planning Guide (2010), Standard River Management Principles and Practices (2015), and the Vermont Stormwater Manual (2016) provide in depth discussions on channel erosion science, erosion-related stress to aquatic ecosystems, and fluvial erosion hazards. These Guides and the referenced literature explain channel erosion in terms of the human activities that modify hydrology, sediment regimes, natural streambank integrity, channel geometry, and floodplain function.

Pollutant: Fine sediment from eroded soils, when it accumulates on the bottom of a waterbody, results in sedimentation. The suspension of fine sediment in the water column causes turbidity which degrades habitat, e.g., reducing visibility for predators. Sedimentation smothers necessary rocky or riffle habitat for the invertebrates that provide an important source of food for fish. Some smaller species of fish also rely on the crevice space between rocks as a primary habitat. Sedimentation can cover spawning substrate and suffocate fish eggs by preventing water circulation and oxygenation. Additionally, the accumulation of sediment over spawning gravel may even deter fish from spawning at all. Fish species like walleye, trout and salmon rely on clean gravel for spawning.

How important is excessive channel erosion?

The effects of channel erosion are pervasive and consequential throughout the state. Where it occurs, unmitigated channel erosion causes long-term (>25 year recovery time) impacts that are very costly to repair. Numerous Vermont streams exhibit impaired biological communities due, in large part, to the erosion and subsequent habitat impacts caused by urbanization and altered hydrology. Stream geomorphic data show that two-thirds of assessed stream miles are in major vertical adjustment and experiencing excessive channel erosion due to disequilibrium. Cross-channel structures such as dams and culverts that contribute significantly to stream disequilibrium also impact habitat by obstructing aquatic organism passage. There are 1,200 dams and tens of thousands of undersized culverts in Vermont. Based on the Watershed Management Division's stressor evaluation, channel erosion is considered a highly-ranked stressor.

What objectives are achieved by controlling excessive channel erosion

Addressing excessive channel erosion promotes several surface water goals and objectives, including:

Objective A. ***Minimize Anthropogenic Nutrient and Organic Pollution*** **–** Nutrients and organic matter associated with eroded sediments are a major source of impairment to Lake Champlain, Lake Memphremagog, and other Vermont lakes. Published North American studies include results that a major proportion of the suspended sediment load may be attributable to excessive bank erosion. Vermont ANR and the LCBP have worked with the USDA Agricultural Research Station to conduct similar sediment loading calculations for the Missisquoi River watershed to better understand the contribution of channel erosion to the nutrient loading of Lake Champlain. Agency efforts to reduce excessive erosion, by promoting practices that mimic natural hydrology and by protecting and restoring channel and floodplain features that store sediments and nutrients, will help minimize anthropogenic nutrient and organic pollution.

Objective B. ***Protect and Restore Aquatic and Riparian Habitat*** – Cover, feeding, and reproductive habitats of aquatic organisms are dependent on flows, hydrologic cycles, and the quantity, size, sorting and distribution of sediments and woody debris. By managing streams and rivers toward equilibrium conditions, complex physical habitats, supporting a diverse assemblage of aquatic and riparian species, may be restored. Human-placed constraints on rivers and their corridors leads to the loss of flood-attenuating features such as floodplains and riparian wetlands. This, in combination with increased runoff from widespread ditching and impervious cover, is causing excessive scour and enlargement of Vermont stream and river channels. This erosion of aquatic and riparian habitat features, and the loss of both lateral and longitudinal habitat connectivity, may be reduced where the Agency works to remove constraints, protect attenuation assets, and manage stormwater.

Objective C. ***Minimize Flood and Fluvial Erosion Hazards*** **–** The Vermont geomorphic assessment data cited above, concerning loss of floodplain function and the extent of stream adjustment and channel evolution, confirm the conclusion of the 1999 Act 137 report to the General Assembly that fluvial erosion is the primary cause of flood hazards in the State. On average, the annual expenditures associated with flood recovery in Vermont are near $14 million (not including recovery costs from T.S. Irene in 2011). These costs may be reduced if the State is successful in working with towns and landowners to implement an avoidance approach that protects river corridors and floodplains in combination with hazard mitigation activities that restore equilibrium conditions.

What are the causes and sources of excessive channel erosion

The WSMD has identified four specific anthropogenic causes of channel erosion in Vermont's watersheds, and a suite of sources.

1. **Alteration of hydrologic regimes (flow characteristics).**
   The hydrologic regime may be defined as the timing, volume, frequency, and duration of flow events throughout the year and over time. Hydrologic regimes may be influenced by climate, soils, geology, groundwater, land cover, connectivity of the stream, riparian, and floodplain network, and valley and stream morphology. When flow characteristics have been significantly changed, stream channels will respond by undergoing a series of channel adjustments. Where hydrologic modifications are persistent, the impacted stream will adjust morphologically (e.g., enlarging when stormwater flows are consistently higher) and often result in significant changes in sediment loading and channel adjustments in downstream reaches. When land is drained more quickly and flood peaks are consistently higher, the depth, slope, and power to erode are higher. Activities that may be a source of hydrologic regime alteration when conducted without stormwater best management practices, include:
   a. Urban or Developed Lands (increased runoff)
      i. Stormwater runoff when farm and forest lands are developed
      ii. Transportation infrastructure
   b. Agricultural Lands
      i. Wetland Loss (dredge and fill)
      ii. Pastureland (incr. runoff & pollutants)
      iii. Cropland (incr. runoff & pollutants)
   c. Forest Land Management
   d. Climate Change

2. **Alteration of sediment regimes**

The sediment regime may be defined as the quantity, size, transport, sorting, and distribution of sediments. The sediment regime may be influenced by the proximity of sediment sources, the hydrologic regime, and valley, floodplain and stream morphology. There is an important distinction between "wash load" and "bed load" sediments. During high flows, when sediment transport typically takes place, small sediments become suspended in the water column. These are wash load materials which are easily transported and typically deposit under the lowest velocity conditions, e.g., on floodplains and the inside of meander bends at the recession of a flood. When these features are missing or disconnected from the active channel, wash load materials may stay in transport until the low velocity conditions are encountered, such as in a downstream lake. These alterations are significant to water quality and habitat, as the unequal distribution of fine sediment has a profound effect on aquatic plant and animal life. Fine-grained wash load materials typically have the highest concentrations of organic material and nutrients.

Bed load is comprised of larger sediments, which move and roll along the bed of the stream during floods. Coarser-grained materials stay resting on a streambed until flows of sufficient depth, slope, and velocity produce the power necessary to pick them up and move them. Bed load materials will continue to move (bounce) down the channel until they encounter conditions of lower stream power. The fact that it takes greater energy or stream power to move different sized sediment particles results in the differential sorting and transport of bed materials. This creates a beneficial sequence of bed features (e.g., pools and riffles). When these patterns are disrupted, there are direct impacts to aquatic habitat. The lack of sorting and equal distribution may result in vertical instability, channel evolution processes, and a host of undesirable erosion hazard and water quality impacts. Activities that may be a source of sediment regime alteration include:

a. Instream structures that impede sediment supply
   i. Dams and Diversions
   ii. Bridges and culverts
   iii. Stream bank armoring
b. Channel incision that leads to increases in sediment supply
   i. Erosion of legacy sediments
   ii. Mass wasting and landslides

3. Alteration of channel and floodplain morphology

Direct alteration of channels and floodplains can change stream hydraulic geometry, and thereby change stream processes that affect the way sediments are transported, sorted, and distributed. Vermont ANR Phase 1 and Phase 2 stream geomorphic assessments, the River Corridor Planning Guide (2010), and Standard River Management Principles and Practices (2015) are used to examine alteration stressors, their effect on sediment regimes, and subsequent stream processes. The table below sorts alteration stressor causes and sources into categories; those that affect stream power and those that affect resistance to stream power, as afforded by the channel boundary conditions. These categories are further subdivided into components of the hydraulic geometry, i.e., stream power into modifiers of slope and depth; and boundary resistance into those stressors affecting the streambed and stream banks. Finally, stressors are sorted as to whether they increase or decrease stream power and/or increase or decrease boundary conditions. By categorizing alteration activities, it becomes easier to see how they may lead to channel adjustment and the excessive erosion associated with disequilibrium. Activities that may alter channel and floodplain morphology include:

a. Floodplain and river corridor encroachment
b. Channel straightening, constriction, dredging, armoring, damming, or berming

4. Alterations that increase streambank erodibility

The resistance of the channel boundary materials to the shear stress and stream power exerted determines, in large part, whether streambanks will erode. Boundary resistance is a function of the type and density of riparian vegetation and the size and cohesion of inorganic bank materials (e.g., clay, sand, gravels, and cobbles). The root networks of woody vegetation bind stream bank soils and sediment adding to the bank's resistance to erosion. Herbaceous plants in lower gradient, meadow streams serve the same function. The table below categorizes those activities that increase or decrease the resistance of bed and bank materials. Decreasing resistance may lead directly to excessive erosion. Artificially increasing resistance works for a period of time (i.e., when other components of the system are in equilibrium), but will either fail or transfer stream power to the downstream reach. Activities that may increase streambank erodibility include:

a. Livestock trampling
b. Removal of riparian vegetation
c. Stream bank armoring (transferring erosive power downstream)

Recovery operations from major flood disasters as a predominate source of channel erosion

Tropical Storm Irene underlined a fact that had been previously borne out by nearly a decade of stream geomorphic assessments in Vermont, that major floods have resulted in major channel works that heretofore have led to increased channel erosion in the ensuing decades. Many of the major river systems that were dredged and straightened after the 1973 flood were the rivers that experienced the most severe damage during Irene. All four causes of excessive erosion described above have historically been accentuated during post-flood recovery operations.

		Sediment Transport Increases	Sediment Transport Decreases
	Stream power as a function of:	**Stressors that lead to an Increase in Power**	**Stressors that lead to an Decrease in Power**
Stream Power	**Slope**	• Channel straightening and armoring, • River corridor encroachments, • Localized reduction of sediment supply below grade controls or channel constrictions	• Upstream of dams, weirs, • Upstream of channel/floodplain constrictions, such as bridges and culverts
Stream Power	**Depth**	• Dredging and Berming, • Localized flow increases below stormwater and other outfalls, • Within, adjacent and downstream of channel constrictions	• Gravel mining, bar scalping, • Localized increases of sediment supply occurring at confluences and backwater areas
Boundary Conditions	**Resistance to power by the:**	**Stressors that lead to a Decrease in Resistance**	**Stressors that lead to an Increase in Resistance**
Boundary Conditions	**Channel Bed**	Snagging, dredging, and windrowing	Grade controls and bed armoring
Boundary Conditions	**Stream Bank and Riparian**	Removal of bank and riparian vegetation (influences sediment supply more directly than transport processes)	Bank armoring (influences sediment supply more directly than transport processes)

Monitoring and assessment activities addressing channel erosion

Monitoring and Assessment Activities

Existing monitoring and assessment activities that focus on the causes and effect of excessive channel erosion are listed below. Full descriptions of the programs that carry out these activities may be found in the State Monitoring and Assessment Strategy and in Appendix D. (the toolbox)

Stream Geomorphic Assessments
Bridge and Culvert Assessments
Dam Inventories
River Corridor Planning
Floodplain and River Corridor Mapping
Stormwater Modeling
Stormwater Mapping

Basin Assessment and TMDL Planning
Biological Monitoring
Wetland Inventories
Land Use Imagery
River & Stream Gauging
Climate Monitoring

Key Monitoring and Assessment Strategies to Address Excessive Channel Erosion

- Conduct stream geomorphic and reach habitat assessments and complete river corridor plans in stream and river watersheds and for small lake tributaries to support technical assistance, regulatory, and funding programs and track progress in achieving the State's surface water goals and objectives.

- Conduct integrated biological monitoring and physical assessment programs, with data and scale-appropriate interpretations, made accessible through tailored reporting from a web-based system. Achievement of this strategy will help:
    1. place streams on the physical/biological condition gradient;
    2. analyze the full suite of channel erosion causes and sources;
    3. identify and prioritize management activities;
    4. conduct alternatives analysis for designing and regulating management actions;
    5. evaluate the effectiveness of management actions; and
    6. conduct trend analyses for the development of channel erosion BMPs.

- Conduct monitoring and assessment programs to establish a robust (empirical) connection between the designated surface waters use (VWQS) and the maintenance of equilibrium conditions. This strategy will enable more uniform and consistent application of the antidegradation policy when regulating activities that may lead to excessive channel erosion.

- Conduct watershed hydrologic modeling to monitor the cumulative effects of impervious cover and other land use conversions. Include increases in runoff as predicted by regional climate change models.

- Maintain GIS-based data on the extent and condition of public lands and conservation easements along Vermont waterways as a part of Vermont's green infrastructure with the highest restoration potential in river corridors and shorelands.

Technical assistance activities addressing channel erosion

Technical Assistance Programs

Existing programs that provide technical assistance in various aspects of managing the causes and sources of excessive channel erosion are listed below. Full descriptions of these programs may be found in Appendix D. (the toolbox)

River Management Program
River Corridor and Floodplain Program
Basin Planning Program
Flow Protection Program
VTrans Environmental Services
Better Roads Program
FWD Fisheries Division
Natural Resource Conservation Districts
Natural Resource Conservation Service
UVM Extension
Partners for Fish &Wildlife (USFWS)
VT Dam Task Group
Green Infrastructure Program
Stormwater Program
Forest Watershed Program

Key Technical Assistance Strategies to Address Excessive Channel Erosion

- Develop and maintain the capacity to technically assist landowners, municipalities, land developers, agencies, and organizations in the:
    1. design and execution of data collection and analytical methods, necessary to understand channel erosion causes and sources at the appropriate temporal and spatial scales;
    2. analysis of alternatives consistent with Standard River Management Principles and Practices to design protection, management, and restoration projects, based on both a-priori and project-related river assessment and planning; and
    3. implementation of projects and management activities that avoid or resolve specific causes and sources of excessive channel erosion.

- Consistent with Act 110 (2010), further develop a River Corridor and Floodplain Protection Program and maintain the capacity to technically assist all municipalities and agencies, with land use authority and responsibility for public infrastructure, in the:
    1. development of plans, policies, procedures, and regulation that are consistent with the State surface water goals and objectives;
    2. implementation of strategies to avoid conflicts between human investments, wetland and floodplain function, and the dynamic equilibrium of streams; and
    3. implementation of stormwater regulations which require sustainable site planning and the use of Low Impact Development (LID) and Green Infrastructure (GI) techniques.

- Develop and maintain the capacity of conservation organizations to protect river corridors and shorelands and coordinate with the State's Conservation Reserve Enhancement Program (CREP).

- Assist VTrans and municipalities in the use of Standard River Management Principles and Practices (2015) in the design and implementation of non-emergency stream alterations, as well as emergency protective measures during post-flood recovery operations.

Regulatory activities addressing channel erosion

Regulatory Programs

Existing programs that regulate activities causing excessive channel erosion are listed below. Full descriptions of these programs may be found in Appendix D. (the toolbox)

Stream Alteration Permit
Section 404 Permits
Section 401 Water Quality Certifications
Wetland Permits
Act 250 / 248 Permits
Required Agricultural Practices
Accepted (Forest) Management Practices
Municipal Zoning
Flood Hazard Area and River Corridor Permits
Stormwater Operational Permit
Stormwater Construction Permits
Stormwater MS4 Program
Stormwater MSGP
Stormwater RDA
Stormwater Offset Program
Stormwater Impaired Waters Program
Road and Bridge Standards
Dam Orders

Key Regulatory Strategies to Address Excessive Channel Erosion

- Develop and maintain the regulatory and enforcement capacity to exercise the State's stream alteration jurisdiction on all perennial streams in both non-emergency and emergency situations. Careful management of small tributary streams is important to the Division's goal in reducing pollutant loads to Vermont lakes. Regulatory oversight of crossing structures and alterations in small stream is critical to sediment regimes and habitat connectivity in river systems and the mitigation of fluvial erosion hazards.

- Continue to implement the State's stormwater regulatory programs. The State's stormwater program is the primary mechanism for regulating discharges from developed land. Regulatory oversight of new development is necessary to ensure that stormwater discharges do not contribute to stream channel instability.

- Ensure that regulatory programs have full access to stormwater mapping/modeling and river corridor planning to enhance the rendering of decisions based on empirical data and interpretation of stream equilibrium at the reach and valley segment scales.

- Have in place a set of meaningful incentives for municipalities to adopt plans and bylaws which protect floodplains, river corridors, buffers and natural hydrology.

- Ensure that rules and regulations promulgated by other authorities are consistent with those of the Division to meet the goals and objectives of the State Surface Water Management Strategy. With respect to managing the four primary causes of excessive channel erosion, this means ensuring that other rules and regulations do not contain inconsistencies with stream equilibrium policy.

- Work with Agency of Agriculture to improve and enforce farm regulations with specific attention to preclusion of streambank stabilization or ditch and tile practices that may lead to disequilibrium.

- Develop and implement a set of water quality-based design standards and best management practices for road maintenance and drainage and link state transportation funding for municipalities to adherence to the standards.

- Work with VTrans to revise the town road and bridge standards to incorporate a suite of practical and cost-effective best management practices for the construction, maintenance, and repair of all existing and future state and town highways. These best management practices should address activities which have a potential for causing pollutants to enter waters of the state, including stormwater runoff and direct discharges to state waters.

- Develop robust design standards and best management practices for surface runoff management focused on infiltration, evaporation/transpiration, and capture and re-use.

- Work with VLCT, RPCs, VTrans Districts, and Emergency Management to assist municipalities in the reporting and implementation of post-flood Emergency Protective Measures in compliance with the standards established in the Stream Alteration Rule.

A key regulatory strategy for addressing the adverse effects of channel erosion was established in 2013 with adoption of the Stream Alteration Rule with the following **Performance Standards** for non-emergency activities:

> **Equilibrium Standard -** An activity shall not change the physical integrity of the stream in a manner that causes it to depart from, further depart from, or impedes the attainment of the channel width, depth, meander pattern, and slope associated with the stream processes and the equilibrium conditions of a given reach of stream.
>
> The equilibrium standard is met when it can be shown that, following the stream alteration, the water flow, sediment, and woody debris produced by the watershed will be transported by the stream channel in such a manner that the stream maintains its dimension, general pattern, and slope with no unnatural aggrading (raising) or degrading (lowering) of the channel bed elevation along the longitudinal stream bed profile.
>
> **Connectivity Standard-** An activity shall not change physical stream forms or alter local channel hydraulics, natural streambank stability, or floodplain connectivity in a manner such that changes in the erosion or deposition of instream materials results in localized, abrupt changes to or disconnects within the horizontal alignment of streambanks or vertical profile of the stream bed.
>
> A person shall not change the course, current, or cross-section of a watercourse so as to create a physical obstruction or velocity barrier to the movement of aquatic organisms or change the vertical stream bed profile in a manner that impedes the movement of aquatic organisms.
>
> A person shall not establish, construct, or maintain a berm in a flood hazard area or river corridor unless authorized as an emergency protective measure.

Implementation funding activities addressing channel erosion

Funding Programs

Existing funding programs that support projects to address the causes and sources of excessive channel erosion are listed below. Full descriptions of these programs may be found in Appendix D. (the toolbox)

CWA 319 Grants
Clean Water Initiative Program
Flood Hazard Mitigation
Lake Champlain Basin Program
Connecticut River Mitigation & Enhancement Funds
Conservation License Plate Grants
USDA Farm Bill Programs
CREP
Better Roads Program
Stormwater Utilities
Use Value Appraisal Program
Agricultural Buffer Program
SEP

Key Funding Strategies to Address Excessive Channel Erosion

- Seek to incorporate grant selection criteria in all relevant funding programs that projects be supported by stormwater and river corridor plans, such that funding decisions are based on empirical data and interpretation of stream equilibrium at the reach and valley segment scales.

- Consistent with Act 110, have in place a set of meaningful incentives in relevant State funding programs for municipalities to adopt plans and bylaws which protect floodplains, river corridors and buffers.

- Develop and maintain a stable and comprehensive funding program which the assessment, planning, and design phases necessary to identify projects consistent with the goals and objectives of the State Surface Water Management Plan.

- Develop and maintain a stable funding program to conserve floodplains, river corridors, shorelands, and wetlands. Limiting encroachment into riparian areas where critical attenuation processes are occurring is one on the primary tools for limiting a host of activities (sources) which lead to excessive channel erosion.

- Better align Federal and State funding programs and priorities. For example FEMA/COE funding programs need to be revised to better fit with size and objectives of VT programs.

In addition to these strategies, the Division has developed the following guidance to assist in the disbursement of discretionary funds in support of streambank stabilization projects:

Streambank stabilization projects proposed as emergency or next-flood protective measures that will not meet the Stream Equilibrium and Connectivity Performance Standards of the Stream Alteration Rule, may cause or contribute to erosion and aquatic habitat impacts. While such projects may be authorized to protect public safety and threats to improved property the State will hold the use of discretionary water quality and conservation grant funds to the higher performance standards set in the Rule . Consistent with the Guidance outlined below, publicly funded projects should align with the Division's surface water goals and objectives and should <u>not</u> alter or fix channel geometry in a manner that would cause a departure, further departure, or impede the attainment of equilibrium conditions.

Guidance

Prior to any Division determination that financial assistance will be made available to a landowner, municipality, or other entity for streambank stabilization, the Watershed Management Division and its staff, in concurrence with the Rivers Program, will review proposed projects and ensure consistency with the following guidance.

1. The Division will not promote or make available the use of discretionary public funds, granted for the purposes of water quality and natural resource conservation, for projects involving hard armoring or other structural treatments used to stabilize streambanks in a manner inconsistent with stream equilibrium conditions, except as provided for below. The Division's message to landowners and municipalities should be clear—water quality grants are not available for the sole purpose of property protection.

2. The Division may support the use of discretionary public funds for limited bank stabilization for the following types of projects:

    a. Hard armoring or the use of other structural treatments to stabilize streambanks, in a manner that is inconsistent with equilibrium conditions, but are part of a larger project, and:

        i. Where equilibrium is achievable in the overall stream reach; public assistance with bank stabilization serves as an incentive for a formal agreement to limit channel management and encroachment on the larger stream reach and other reaches with legal mechanisms that protect the stream or river corridor; or,

        ii. Where equilibrium is not achievable in the overall reach, due to the extent of existing encroachment, and public assistance with bank stabilization serves as an incentive for flood plain and wetland restoration, formal corridor protection in other reaches, and/or other project element(s) which result in net benefit to water quality, in a manner consistent with the goals and objectives of the Division's Surface Water Management Strategy.

    b. Hard armoring or the use of other structural treatments to stabilize eroding streambanks on vertically stable channels, which have the dimensions, pattern, and profile associated with its equilibrium condition. The Division and its staff may support stabilization of equilibrium streambanks, using discretionary water quality and conservation funds, with techniques including:

        i. Armoring only to the bankfull elevation, with the use of rock rip-rap or other structural treatments, but only where arresting the lateral erosion will provide other public riparian benefits[1], and only to the longitudinal extent necessary to protect developed property that would otherwise be threatened by the bank erosion in a next-flood; and/or,

        ii. Bioengineering and bank revegetation using native tree and shrub species where developed property is not threatened in a next-flood.

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[1] **Example**: In the case of a laterally unstable stream, in equilibrium condition, the limited use of rock rip rap may be used to arrest the lateral movement of the stream toward a road and thereby preserve a forested riparian buffer at least 50' wide. Where the eroding bank is already up against the road, rock armoring the bank should be the responsibility of the road owner and not be supported by the Division with discretionary water quality grants (unless as provided for above).

Information and education activities addressing channel erosion

Information and Education Programs

Existing programs that inform and educate the general public about the causes and effect of excessive channel erosion are listed below. Full descriptions of these programs may be found in Appendix D. (the toolbox)

River Management Program
River Coriodr and Floodplain Protection Program
Basin Planning Program
Rivers and Roads Program
Lake Champlain Basin Program
Chittenden County Regional Stormwater Education Program
Vermont League of Cities and Towns, Municipal Assistance Program
Natural Resource Conservation Districts
River and Lake Groups
Forestry AMP Program

Key Information and Education Strategies to Address Excessive Channel Erosion

- Create a multi-media educational program, including printed material, photo libraries, videos, power point presentations, field demonstrations, and river flumes, which may be readily applied by Division staff at public forums as opportunities arise.

- Enhance the use of river flumes and train regional staff inside and outside the Agency to make use of them. This has been a highly successful I&E effort to explain stream instability to the public.

- Develop and maintain information & education materials on the causes and effects of both natural and excessive channel erosion pertinent to both lay and technical audiences. Publish a lay-person Guide to Stream Processes to explain the causes and sources of excessive channel erosion and the TA, regulatory, and funding programs available to address this stressor.

- Increase the number of Tier 2 and Tier 3 Rivers and Roads workshops offered.

- Develop and maintain a set of outreach materials and reports that explain the Division programs addressing excessive channel erosion. Where possible, these materials should contain case studies that will make the Division's work more real to the lay public.

- Develop and maintain the State Surface Water Management Strategy as an interactive, web-based site where people can get information about how the State is dealing with stressors such as channel erosion, but also provide input on the policies and programs developed to address them.

- Develop and maintain an education program focused on local governing bodies and the importance of the local ordinance in achieving public surface water goals.

- Inform the general public about the impacts associated with impervious cover and the cumulative impacts of seemingly small hydrologic alterations.

- Promote the use of GI practices through trainings, workshops, social media, and the internet.

What is Flow Alteration?

Flow alteration is any change in the natural flow regime of a river or stream or water level of a lake or reservoir induced by human activities.

As illustrated below, five components of the natural flow regime are now recognized as requiring protection to maintain healthy river and lake ecosystems (Figure 1). They are:

- Magnitude – the amount of water flowing in the stream at any given time;
- Frequency – how often a given flow occurs over time;
- Duration – the length of time that a given flow occurs;
- Timing – how predictable or regular a given flow can be expected to occur;
- Rate of change – how quickly flows rise or fall.

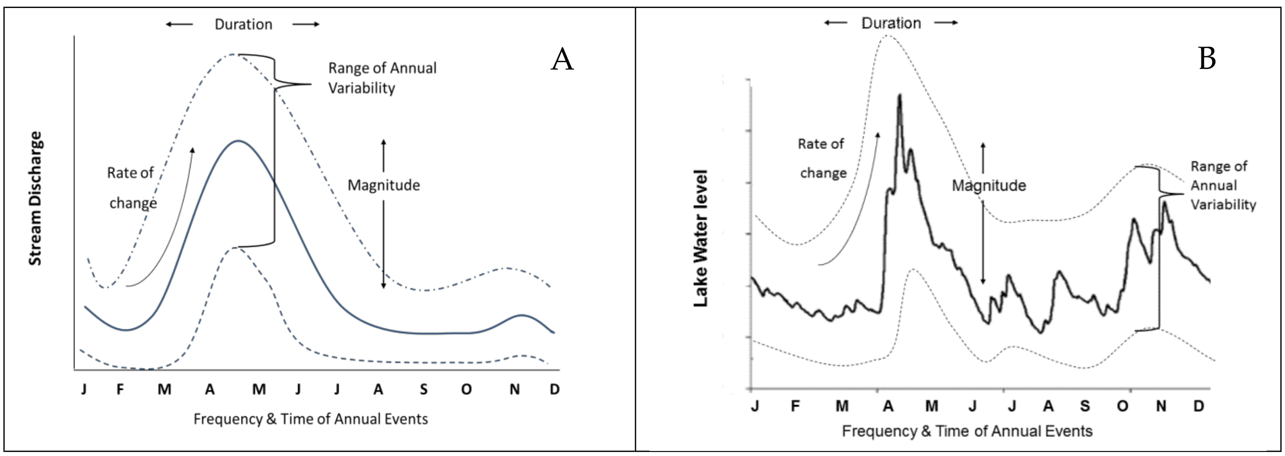


Figure 1: Hydrographs of a river (A) and lake (B) that illustrate the general seasonal pattern and the variability seen in Vermont rivers and lakes, with increased streamflow and water level in the spring followed by receding levels in the summer and an increase in streamflow and water level in the fall.

A natural flow regime refers to a range that each of these five components can be expected to fall within due to the variability of precipitation and other natural hydrologic processes. Significant flow alteration can push these components of flow outside the expected range, leading to environmental degradation. Climate change is another potential driver of shifting flow regimes, and must also be considered in a well-informed approach to addressing flow alteration. These same five components influence lake water level and changes from the natural condition in one or more of these components affect the health of lake ecosystems.

In rivers and streams, the flow regime is considered a 'master variable' that determines the stream form, habitat suitability and ecological function. The flow regime significantly affects the type and amount of habitat and the diversity and abundance of species that can utilize that habitat. This stressor chapter is focused on the habitat and water quality impacts associated with instream structures and practices that alter the natural flows or water levels (i.e., activities that obstruct, dewater, or artificially flood aquatic and riparian habitats). Altering flows can also have a negative impact on temperature and water chemistry (e.g., pH, dissolved oxygen, and toxicity), which may significantly lower habitat suitability for certain aquatic organisms. Flow regime alterations from increased runoff, such as stormwater, are addressed in the discussion on channel erosion, as are those dams that alter channel morphology and sediment regimes and create an obstruction to aquatic organism passage, but do not alter instream flows or create significant impoundments.

While rivers are much more dynamic than lakes, these systems also have annual cycles to which the plants and animals that inhabit them have adapted. Lake levels naturally fluctuate over the course of the year with higher levels in the spring and often gradually lowering water levels as the summer progresses. In lakes with natural outlets, rapid changes in water level are typically limited to small lakes during severe storms. In these cases, a rapid rise is usually followed by a more gradual decline back to a seasonally normal level. Rapid or frequent lowering of water levels is not normally found in natural systems. Some reservoirs are operated with substantial dewatered zones at various times of the year, depending on uses such as hydroelectric power or flood control.

Many Vermont lakes have a dam on the outlet which has raised the water level of a natural lake between 3 and 10 feet. In some cases, the water level may be drawn down, for varying reasons, in the fall and possibly through the winter. This creates an area of littoral zone exposed to freezing and results in change to the habitat and biota in that area. The consequences of unnatural water level fluctuations in lakes and reservoirs on the ecosystem can be significant. Most immediate is the exposure and stress or death of animals that lack the mobility to move down with the water: mussels, macroinvertebrates, small fish and fish eggs. Any species that have already hibernated may be unable to move. Aquatic plant communities in the dewatered zone can also be degraded, as can wetlands associated with the lake. When native plant communities are killed by drawdowns, often the first species to recolonize those areas are invasive ones. The end result can be a zone bordering the lake that lacks healthy littoral (shallow water), riparian and wetland communities. The extent of this zone depends on the magnitude of the drawdown and the relative slope of the lakeshore and littoral zone. These same dewatered littoral areas have been identified as zones in which atmospherically-deposited mercury may readily be converted to the more toxic methylmercury that is created in dewatered littoral zones and flushed into waters when water levels rebound, subsequently accumulating in fish tissue. This phenomenon has been documented by scientists in numerous research areas and helps explain why fish mercury contamination is more severe in managed reservoirs than in natural lakes. Mercury contamination in fish has consequence for wildlife that rely heavily on fish for their diet (loons, eagles, osprey, otters), and for people who regularly consume fish.

The importance of Flow Alteration as a stressor

Based on the Watershed Management Division's evaluation, flow alteration (including impoundment and dewatering) is a moderately ranked stressor. The effects are usually localized in scale (individual stream reaches, lakes, impoundments, or dewatered wetland areas), but in some cases, they may be evident for miles downstream. Further, flow alteration effects may be numerous on the landscape, so the cumulative impacts can be significant at a watershed level.

Where present, flow alteration is an intensive stressor that moderately to severely degrades aquatic habitat and biota. The most recent statewide water quality assessment indicates that biological condition does not meet water quality standards in over 6,000 acres (~11% of inland lake acres) of lake waters due to flow alteration, while a further 4,400 acres (~8% of inland lake acres) exhibit stress. While the number of lakes that are drawn down is relatively small, the practice tends to occur on larger lakes, increasing the area that is impacted. Further, drawdowns affect a significant amount of the ecologically important littoral zone in the state. This is because many of the largest impounded lakes may also have large stretches of intact riparian vegetation and habitat, but exhibit degraded littoral habitat due to drawdowns. For streams, the biological condition fails to meet water quality standards in over 206 miles (~4% of biologically assessed streams) due to flow alteration, while a further 70 miles exhibit stress.

What objectives are achieved by managing Flow Alteration?

Addressing and preventing flow alteration promotes several surface water goals and objectives, including:

Objective A. ***Minimize Anthropogenic Nutrient and Organic Pollution*** – Depending on the nature of the flow alteration, channel and shoreland stability and the integrity of adjacent floodplain function may be affected. Impoundments may become eutrophied from land runoff, accelerated shoreland erosion, and tributary loadings, and fluctuating waters levels can result in repeated re-suspension of bottom sediments. Sediment flows are disrupted in river impoundments; "starving" downstream reaches of sediment and leading to major channel incision and disequilibrium. Addressing channel erosion and curtailing new instream impoundments will help to reduce nutrient and organic loadings.

Objective B. ***Protect and Restore Aquatic, and Riparian Habitat*** – The magnitude, frequency, duration, and timing of flow are dominant factors in riverine ecosystems. The natural fluctuation of water levels in Vermont lake systems are typically small and happen gradually. Alteration of the natural flow and water level patterns may result in direct stress to aquatic organisms and may alter the chemical and physical aspects of aquatic and riparian ecosystems to the point where native species richness, abundance and distribution decline. Dams and water withdrawal structures create habitat discontinuity, restricting the movement of migratory and resident fish and other organisms. Riparian and littoral community integrity is compromised.
Further, in lakes and reservoirs, erosion of the dewatered sediments can occur. Water quality may be affected when intake structures draw water from the surface (elevating temperature) or the bottom of the impoundment (decreasing dissolved oxygen).

Objective C. ***Minimize Flood and Fluvial Erosion Hazards*** - Discontinuity in the sediment regime above and below an impoundment may lead to channel instability and erosion hazards in rivers and streams. The untimely release of water at dams to relieve upstream flooding during high flow events can exacerbate downstream flooding and erosion. Dams may significantly alter the floodway and inundation floodplain by changing the surface water profile during floods. The maintenance of natural water levels in lakes supports the maintenance of healthy aquatic plant beds that dampen the erosive energy of waves and unusual high water events.

Objective D. ***Minimize Toxic and Pathogenic Pollution, and Chemicals of Emerging Concern*** - Research shows that dewatered sediments in reservoirs result in elevated mercury levels in the water and biota. As such, flow alteration can exacerbate mercury contamination in managed waters.

What are the causes and sources of Flow Alteration?

In this stressor chapter, flow alteration, including water level manipulation, has five principal causes:

1. water withdrawals for water supply, snowmaking, industrial uses or agriculture;
2. hydroelectric power;
3. flood control;
4. manipulation of lake and reservoir water levels to support certain recreational uses or manage adjacent infrastructure; and
5. Anthropogenically driven climate change.

These causes stem from construction and operation of dams or other in- stream structures. Further information about the causes and resulting effects of flow alteration may be found in Appendix C.

Monitoring and assessment activities addressing Flow Alteration

Existing monitoring and assessment activities that focus on the causes and effect of flow alteration are listed below. Full descriptions of the programs that carry out these activities may be found in the State Monitoring and Assessment Strategy and in Appendix D. (the toolbox)

- Stream geomorphic assessments
- Vermont Dam Inventory
- River corridor planning
- Floodplain mapping
- Dam safety inspections
- Basin assessment and TMDL planning
- Biological monitoring
- Streamgaging (USGS)
- Fish and wildlife assessments

Key Monitoring and Assessment Strategies to Address Flow Alteration

- ➢ Develop a GIS-compatible water withdrawal inventory database that incorporates information on all water withdrawals throughout the state (including those that are *de minimis*) to support analysis of their cumulative impacts on a watershed.

- ➢ Develop analytical tools that use the water withdrawal inventory and existing Vermont Dam Inventory, water quality, biomonitoring, wetland, geomorphic and floodplain data in Agency GIS systems to enhance river corridor and basin planning capabilities for use by technical assistance, regulatory and funding programs of ANR and other agencies.

- ➢ Maintain and expand a lake level and streamflow gaging network to enable hydrologic monitoring and modeling at in-lake, river reach and watershed scales. The network should include both reference and treatment sites. This strategy is not only important to setting conservation flow and maximum drawdown requirements, but also in assessing the cumulative impacts of lake-level fluctuations and flow alterations within a sub-watershed and in characterizing hydrologic regimes of reference waters identified for monitoring the effects of climate change. Data collection at high elevation sites is essential for an improved understanding of upland hydrology and the Division’s ability to protect some of the most at-risk ecosystems in Vermont.

Finally, continued collaboration and support of stream gages maintained by the U.S. Geological Survey is necessary to monitor flows to impaired waters and adequately execute the TMDL process, as federally mandated by the Clean Water Act.

- ➢ Provide all relevant data on-line and develop web-based analytical and reporting tools (including maps) to help:
  1. place streams and lakes on the physical/biological condition gradient;
  2. analyze the full suite of flow alteration causes;
  3. analyze the cumulative impact of *de minimis* water withdrawals
  4. identify and prioritize flow protection activities;
  5. conduct alternatives analysis for regulating flow alterations;
  6. evaluate the effectiveness of management actions; and
  7. conduct trend analyses for the development of flow protection BMPs.

Technical assistance programs addressing flow alteration

Existing programs that provide technical assistance in various aspects of managing the causes and sources of flow alteration are listed below. Full descriptions of these programs may be found in Appendix D (the toolbox).

- Streamflow Protection Program
- Vermont Dept. of Fish and Wildlife – Fisheries Division
- Vermont Dam Task Force
- Dam Safety Program
- U.S. Fish &Wildlife Service
- River Corridor and Floodplain Management Program
- Lakes and Ponds Section
- Monitoring, Assessment and Planning Program

Key Technical Assistance Strategies to Address Flow Alteration

- ➢ Maintain technical expertise in hydrology to serve multiple programs within the Watershed Management Division.

- ➢ Develop and maintain technical expertise to address water level fluctuation and a strategy to stabilize lake water levels to mitigate those impacts.

- ➢ Develop and maintain the capacity to technically assist landowners, municipalities, technical consultants, agencies, and organizations in the:

  a. design and execution of data collection and analytical methods necessary to understand flow alteration causes at the appropriate temporal and spatial scales; and,

b. feasibility analysis of hydroelectric power and water withdrawal projects, based on both *a priori* and project-related river assessment and planning.

- Develop and maintain capacity in the private sector to provide hydrology and engineering expertise to proponents of flow alteration activities. This strategy involves training on the State's conservation flow and antidegradation requirements, which may create more efficiency during the regulatory process when proponents select alternatives consistent with the flow and water withdrawal procedures.

- Develop and maintain outreach materials about the impacts that anthropogenic water level fluctuations have on lake ecosystems.

- Develop and maintain the capacity to assist dam owners in the removal of structures that no longer serve a useful purpose.

- Work cooperatively with the Department of Public Service to analyze the potential for hydroelectric power development in Vermont to better inform statewide energy planning.

Regulatory programs addressing flow alteration

Existing programs that regulate flow alteration activities are listed below. Full descriptions of these programs may be found in Appendix D.

- Section 401 Water Quality Certifications
- Section 404 permits
- ANR streamflow procedure
- ANR's Environmental Protection Rules, Chapter 16, Snowmaking
- Act 250/248 permits
- WSMD water level rules for lakes
- 10 V.S.A. Chapter 41 §1003
- 10 V.S.A. Chapter 43
- Stream Alteration Permits
- Flood hazard area regulations

Key Regulatory Strategies to Address Flow Alteration

- Develop and maintain the regulatory and enforcement capacity, using adopted rules and procedures, to exercise the State's jurisdiction over flow alteration activities, including:
  - FERC jurisdictional and non-jurisdictional hydroelectric power projects
  - Water withdrawals including inter-basin transfers
  - Lake level management and the regulation of winter drawdowns

- Run an efficient regulatory program which maximizes the degree to which environmental impact and economic feasibility of flow alteration projects have been vetted before project proponents submit proposals for state technical assistance and regulatory review.

- Develop and maintain an integrated approach to flow management, stream alterations and lake and reservoir water level management. This strategy involves the inclusion of fluvial geomorphic science and objectives with respect to physical integrity and stream equilibrium into the regulation of water withdrawals and hydroelectric power projects. Science from biological and aquatic habitat assessments will also be used.

Funding programs addressing flow alteration

Funding programs that address flow alteration are listed below. Full descriptions of these programs may be found in Appendix D.

- USFWS habitat restoration funds
- Supplemental environmental projects funded through enforcement actions
- State unsafe dam fund
- Ecosystem Restoration Program (ERP)
- Connecticut River Mitigation and Enhancement Fund

Key Funding Strategies to Address Flow Alteration

- Develop and maintain a reliable source of funding to support high priority dam removal projects.

- Develop stable and sustainable sources of funding for the USGS streamgaging program.

Information and education programs addressing flow alteration

Existing programs that inform and educate the general public about the causes and effect of flow alteration are listed below. Full descriptions of these programs may be found in Appendix D.

- Streamflow Protection Program
- Monitoring, Assessment and Planning Program
- Lakes and Ponds Section
- Fish and Wildlife Department
- American Rivers
- Trout Unlimited
- River and lake groups

Key Information and Education Strategies to Address Flow Alteration

- Develop an information and education program that addresses the following topics:
    1. the importance of protecting streamflow and natural lake water levels to healthy river, lake and wetland systems and the provision of ecosystem services and other benefits that result;
    2. the impacts of dams, hydroelectric projects and water withdrawals on lake, river and wetland ecology and ecosystem services; and
    3. the true costs and benefits of hydroelectric power development in the context of a shift toward renewable energy sources, the characteristics of projects that would be considered low-impact.
- Partner with other government agencies (federal, state, local), non-governmental organizations and the private sector to enhance our educational efforts.
- Adopt a marketing approach to our information and education efforts that will engage the public and policy makers, enhancing our ability to deliver the facts in a compelling manner.
- Use social media and other 21st century communication approaches to reach multiple audiences, especially youth and young adults.
- Develop and maintain the State Surface Water Management Strategy as an interactive website where people can get information about how the State is dealing with stressors such as flow alteration, but also provide input on the policies and programs developed to address the stressor.

Encroachment

What is Encroachment?

Encroachment is a term used to describe the advancement of structures, roads, railroads, improved paths, utilities, and other development, into natural areas including floodplains, river corridors, wetlands, lakes and ponds, and the buffers around these areas. The term encroachment also encompasses the placement of fill, the removal of vegetation, or an alteration of topography into such natural areas. These encroachments cause impacts to the functions and values of those natural areas, such as a decline in water quality, loss of habitat (both aquatic and terrestrial), disruption of equilibrium (or naturally stable) conditions, loss of flood attenuation, or reduction of ecological processes.

Constructed encroachments within river corridors and floodplains are vulnerable to flood damages. Placing structures in flood prone areas results in a loss of flood storage in flood plains and wetlands and heightens risks to public safety. Moreover, protection of these encroachments often result in the use of river channelization practices -- including bank armoring, berming, dredging, floodwalls, and channel straightening -- to protect these investments. The removal of vegetation to improve viewscapes or access, and the removal of woody debris from rivers to facilitate human use can increase resource degradation and the property's susceptibility to flood damages, causing higher risks to public safety. As described in the channel erosion stressor chapter, such practices result in greater channel instability, excessive erosion, and nutrient loading by concentrating flows and increasing stream velocities and power.

Encroachment increases impervious cover adjacent to lakes, rivers and wetlands, thereby increasing the rate and volume of runoff, loading of sediment and other pollutants, and temperature of the receiving water. The cumulative loss of wetlands that provide water quality protection to adjacent surface waters can result in ongoing reduction in water quality. The extent of encroachment, the cumulative effects of impervious cover, and the degree to which natural infiltration has been compromised can also contribute to the instability of the stream channel.

Encroachment in lake shorelands usually is comprised of residential development and associated vegetation removal; it can also include roads, parks and beaches and urban areas. Recent development patterns on lakeshores have seen replacement of small "camps" with larger houses suitable for year-round use. This new development generally is accompanied by substantial lot clearing, lakeshore bank armoring (seawalls and rip-rap), and an overall increase in lawn coverage and impervious surface. Research in Vermont and nationally has shown this land conversion and development results in degraded shallow water habitat and increased phosphorus and sediment runoff. Encroachments into the lake itself include docks, retaining walls, bridges, fill and dredging. The table below documents the effects of encroachment upon surface waters.

Impacts from Encroachment	
Rivers and Floodplains	
Changes in Hydrology	**Changes in Geomorphology**
*increase in magnitude and frequency of severe floods	*stream disequilibrium: channel widening, downcutting
*increased frequency of erosive bankfull floods	*increased streambank erosion
*increase in annual volume of surface runoff	*elimination of pool\riffle structure
*more rapid stream velocities	*stream channelization
*decrease in dry weather baseflow on stream	*stream crossings form fish barriers
Changes in Water Quality	**Changes in Aquatic & Terrestrial Habitat**
*massive pulse of uncontrolled sediment during construction stage	*shift from external to internal stream energy production
*increased washoff of pollutants	*reduction in diversity of aquatic insects
*nutrient enrichment leads to benthic algal growth	*reduction in diversity of aquatic and terrestrial species
*bacterial contamination during dry and wet weather	*destruction of wetlands, buffers, and springs
*increased organic carbon loads	
*higher toxic levels, trace metals, and hydrocarbons	
*increased water temperatures	
Lakes and Ponds	
Changes in In-Lake Habitat	**Changes in Terrestrial Habitat**
*decreased submersed woody habitat	*decrease in natural woody vegetation along shore
*decreased rocky habitat/increased embeddedness	*decrease in habitat for species dependent on riparian areas
*decreased leafy debris	* loss of connectivity between aquatic and terrestrial habitat
*decreased shading/ insect fall	
*increased fine sediment (muck and sand)	
Changes in Water Quality	**Changes in Physical Function**
*increase in local nutrient availability	* increased adjacent erosion when one shoreline is armored or altered
*increase in attached algae growth	* increased risk of mass failure
*increase in temperature	
*increase in phosphorus loading to the lake	
*decrease in water clarity	
Wetlands	
Loss of the Functions and Values that Wetlands Provide:	
*Water Storage for Flood Water and Storm Runoff	*Rare, Threatened, and Endangered Species Habitat
*Surface and Ground Water Protection	*Education and Research in Natural Sciences
*Fish Habitat	*Recreational Value and Economic Benefits
*Wildlife Habitat	*Open Space and Aesthetics
*Exemplary Wetland Natural Communities	*Erosion Control through Binding and Stabilizing the Soil

Modified from: *Metropolitan Washington Council of Governments. Watershed Restoration Sourcebook. Washington D.C.: Anacostia Restoration Team, 1992.*

Encroachment

How important is Encroachment?

Based on the Watershed Management Division's evaluation, encroachment is a highly ranked stressor.

Empirical data from Vermont's Stream Geomorphic Assessment program indicate that 30 % of the assessed stream-miles have encroachment within their river corridor (active portion of the floodplain that allows for the re-establishment and maintenance of "equilibrium" or naturally stable slope and stream channel dimensions). Of those streams that have encroachments, roads and development (structures, parking lots, and fill) contribute 65% and 26% respectively to the overall extent of encroachment.

Perhaps of greatest concern along rivers are the traditional channelization practices that are used to protect existing encroachments. They can be expensive to maintain, do not address the underlying causes of channel instability, increase erosion hazards to adjacent properties, and cause impacts to aquatic and riparian habitat. More importantly, channelization practices are counter-productive in trying to restore and maintain a stream's access to its floodplain and its ability to achieve stream equilibrium over time. The State Hazard Mitigation Plan reports that, "channelization, in combination with widespread flood plain encroachment, has contributed significantly to the disconnection of as much as 75% of Vermont's streams from their flood plains."

Additionally, the National Flood Insurance Program (NFIP) had been seen as a way to control new encroachments from being located in floodplain areas. However, NFIP minimum requirements are designed to minimize the risk to new investments in flood hazard areas, but do very little to ensure that new investments do not increase the flood risk to existing investments. Another shortcoming of the NFIP is that only 20% of the river miles in Vermont have NFIP delineated floodplains. The remaining 80% of stream miles have virtually no floodplain protections, which facilitates new at-risk encroachments that further degrade the resource. In addition, Vermont experiences catastrophic flood damages to both public and private investments along rivers and streams that do not have an NFIP FHA designation.

Historical surveys indicate a loss of 35% (121,000 acres) of Vermont's wetlands through encroachment and conversion prior to the 1980s. Wetland encroachments continue at reduced rate and with minimized impacts through the regulation of wetlands based on their function and value. Wetland and buffer zone encroachment continues at a more accelerated pace in communities that have existing infrastructure located in or adjacent to wetlands. These encroachments affect not only the physical, chemical and biological integrety of the wetland resource but can also have determintal impacts on associated surface waters such as streams, rivers, lakes and ponds.

Based on a recent statistically-based survey, 71% of Vermont lakes (excluding Lake Champlain) exhibit moderate levels of lakeshore disturbance, and a further 11% exhibit high levels of shoreline disturbance (National Lakes Assessment ref.). More detailed information available from a subset of intensively studies lakes in Vermont suggests that shoreland development in Vermont results in a signficant loss of in-lake physical habitat features such as fallen trees and branches, leaf litter and cobble substrate. Encroachments upon buffers and waters by homes, driveways, lawns, walls and other infrastructure comprises the majority of this documented disturbance. Following the clearing and conversion of native vegetation to lawn, the ensuing increase in erosion frequently prompts the construction of retaining walls along lake shorelines. These structures present barriers to the natural movement of animal life to and from the lake, and are part of the overall impact of developed shores on in-lake habitat. Additionally, homes, retaining walls and other development can exacerbate flooding hazards and damages from floods when natural shoreline vegetation and in-lake physical habitat features are lost. Nationally, "poor shoreline condition" was found to be the most significant threat to lake biology (see EPA study here).

Encroachment

Global climate models predict an increase in temperature of 4°F in Vermont by the year 2100 and an increase in precipitation by as much as 30% during the winter months. Therefore, the degree of encroachment, the river channelization/lakeshore stabilization practices used to protect those encroachments, and subsequent loss of floodplain function in both rivers and lakes could make Vermont particularly vulnerable to climate change-related increases in flood frequency and magnitude.

What objectives are achieved by managing Encroachment?

The current extent of encroachment -- from transportation infrastructure, homes, businesses, utilities, and industries -- and the degree to which productive agricultural land is in close proximity to waterways are significant. Floodplains, river corridors, wetlands, lake shorelands, and buffer areas continue to experience development pressures. However, the economic viability of these businesses and the health and safety of our communities depend upon the quality of these resources and the long-term stability of our rivers and health of our lakes and wetlands. Working with communities and landowners to limit encroachment helps to meet several surface water goals and objectives, including:

Objective A. ***Minimize Anthropogenic Nutrient and Organic Pollution***

Wetlands can provide one of the best natural means of removing nutrients and organic matter from runoff prior to it reaching surface waters. This is achieved through the retention of flood waters, the uptake of nutrients by wetland vegetation, and settlement of particle-bound phosphorus in wetland pools. Limiting encroachment to protect wetlands is critical to minimizing the impacts from nutrient and sediment pollution.

Minimizing encroachment and allowing a river access to its floodplain, river corridor, wetlands, and buffer areas provides room for floodwater storage and conveyance. When floodwaters slow down and spread out, flood peaks are reduced, sediment, nutrients and other pollutants settle out, and ice jamming is reduced. These areas are also vital for ground water recharge and thus maintenance of base flow in streams. The natural vegetation in these areas helps to slow down and filter floodwaters, while also trapping and filtering out pollutants from overland flow coming from adjacent uplands.

Along lakeshores, a buffer of native vegetation is critical to filtering pollutants out of runoff from upland development. On many Vermont lakes, the shoreland is the most intensively developed part of the watershed, and is in effect "suburbanized." Such development often results in poor near-shore conditions relative to nutrient enrichment such as mucky bottom, attached algae and nuisance plant growth. Additionally, buffers on the small tributary streams that feed most Vermont lakes help alleviate nutrient and sediment inputs from the watershed as a whole.

Objective B. ***Protect and Restore Aquatic and Riparian Habitat***

River corridors, floodplains, wetlands, lake shorelands, and buffer areas provide important habitat for fish, wildlife, and some rare, threatened, and endangered species. These areas are also important for species migration, providing travel corridors between habitat features, and dispersal routes for fish, birds, and other wildlife. Minimizing encroachment reduces the likelihood of habitat fragmentation and loss of habitat function. The life histories of reptiles and amphibians necessitate regular movement between land and water. Fish that require shallow areas for spawning move into nearshore littoral areas during the spring season. Waterfowl, including ducks and loons, prefer to nest among vegetation on the shoreline, while still maintaining close proximity to water for feeding and predator avoidance. For these species,

maintaining healthy connectivity between different habitats is vital. Encroachments that pose a physical barrier between aquatic and riparian habitats (i.e. retaining walls) greatly impede access required by these species.

Minimizing encroachment also supports native plant growth and deters non-native invasive species. Maintaining native vegetative cover provides shade to moderate water temperatures, and supplies coarse woody habitat and other organic inputs for in-stream and in-lake habitat. Vegetation directly on the shoreline acts to intercept and filter out fine sediment before it reaches the stream or lake, helping to keep the stream bottom clean and preventing sedimentation of shallow lake waters. This in turn supports aquatic insects, a principle food source for fish and birds. On lakes, shoreland development resulting in removal of native vegetation is linked with a measurable degradation of shallow water habitat elements such as loss of woody habitat, overhanging vegetation and increasing fine sediments. Slowing phosphorus enrichment of lakes maintains a lake in its natural trophic state, which would be more ecologically stable. Overall, minimizing encroachment allows these areas to continue serving as important infiltration resources, supporting groundwater aquifer recharge and the maintenance of adequate base flow, crucial in supporting the biological integrity of streams during drier months.

Objective C. ***Minimize Flood and Fluvial Erosion Hazards***

A prudent and cost-effective public safety measure is to limit encroachment in floodprone areas. Keeping out of harm's way lessens the exposure to flooding, reduces damage to property and infrastructure, and minimizes the cost and misery associated with those damages. Most importantly, limiting encroachment reduces the need to subsequently channelize and armor stream channels to protect that development and infrastructure. This promotes reestablishment and maintenance of a physically stable condition over time. Providing for dynamic "equilibrium" attenuates the impacts of flooding, thereby reducing the risk of future damages to public and private investments.

Minimizing encroachments in lake shorelands, especially on the immediate shoreline, would reduce the perceived need by lakeshore property owners for winter drawdowns, which some dam owners conduct to protect shoreline structures from ice damage. Removing or avoiding construction of shoreline structures would allow a lake's water level to be managed with natural annual fluctuations. Additionally, as we find with riparian floodplain areas, a lakeshore floodplain with limited encroachment is essential for the protection of public safety, reduction in flood damages to property and infrastructure, and subsequently, the minimization of cost and hardship that comes with such damages. A functioning lakeshore floodplain provides many of the same functions that we see on river floodplains: storage of sediment, nutrients, and other pollutants, the reduction of damage from ice run-up and wave activity, and the reduction of flood peaks. These functions are minimized or reduced in lakes that have their natural riparian buffers fragmented by retaining walls, boathouses, and other such encroachments. Simply put, the disruption of natural lakeshore vegetation and buffer areas significantly reduces a lake's resilience to extreme flood and weather events.

What are the causes and sources of Encroachment?

The causes of encroachments are manifold, and include:

- Transportation infrastructure (roads, highways, railroads, bridges and culverts) within river corridors and floodplains, wetlands, buffers, and lake shorelines.

Encroachment

Locating transportation infrastructure, including the fill associated with roads and crossings, in riparian and shoreland areas has caused significant impacts. Many of Vermont's roads, highways, and railroads encroach on these resources due to Vermont's mountainous landscape, requiring rivers and transportation infrastructure to share narrow valleys. This is exemplified in the adjacent photograph of Long Pond, in Eden, Vermont. As a result of road encroachment, there are tens of thousands of stream crossings, particularly culverts, which are commonly undersized; their openings are not wide enough to span the channel. This practice leads to systemic habitat impacts and channel instability (see the Channel Erosion Stressor Chapter). The 1999 report to the Vermont General Assembly on flood control policies found that, "By far the largest single source of flood loss, both in terms of monetary loss and in terms of its effect on people, is loss to transportation infrastructure and utility services." At this time, ANR has begun working with VTrans to identify areas where infrastructure maintenance practices need to be changed to better accommodate both transportation infrastructure and river corridors. However, ANR will need to continue to work with VTrans and communities in systematically working to minimize impacts from existing and future encroachments and identifying more appropriate sizing for existing stream crossing structures.

- Structures, including camps, residential homes, commercial and industrial buildings, and utilities.

Land use decisions typically occur at the local level and are based on local standards. Proposed encroachments are routinely permitted, even in areas prone to flood damages and even if those developments exacerbate the vulnerability of flooding at adjacent properties. Encroachments into river corridors and riverine or lakeshore floodplains often result in landowners seeking to protect those properties using structural measures and other channelization or hardening practices. Structures located in wetlands often have ongoing drainage issues that result in landowners seeking to further alter the hydrology of an area. For wildlife dependent on wetlands, streams and lakes, ongoing impacts that are a result of these

encroachment-related practices are difficult to quantify.

Larger developments that are poorly planned, or designed without consideration of natural process or public safety, can have cumulative and ongoing impacts to lakes, floodplains, wetlands, and the functions they provide. High concentrations of small parcels crowd many of Vermont’s lakes in an effort to accommodate the demand for waterfront property. In Vermont, the density of residences within 100 feet of lake mean water level is roughly twice that of urban areas. Furthermore, camps that were once seasonal in nature, are more frequently being converted to year-round homes, resulting in increases in impervious surface and cleared area close to sensitive riparian areas. This overdevelopment of lakeshore areas compromises the physical, chemical, and biological integrity of lake systems. Wetlands that are crossed multiple times for access to single family lots become islands surrounded by development and lose their connection and function in the larger landscape. A Wisconsin study found that phosphorus loading to the studied lake increased by a factor of four and sediment loading increased by a factor of 20 during the period when a shoreland property is becoming “suburbanized.” The ANR works with developers and communities to protect these resources, not just from immediate impacts by reviewing individual projects, but also by working with towns to adopt plans and bylaws that protect these resources on an ongoing basis. Additionally, as part of Act 138, the ANR is required to adopt rules for Flood Hazard Areas in order to regulate activities exempt from municipal regulation. Currently, the ANR is in the process of developing, adopting and implementing statewide rules. The State Floodplain Rule will exceed the National Flood Insurance Program (NFIP) standards and incorporate the regulation of river corridors in order to address the vulnerability that new encroachments bring onto themselves, as well as identify and protect the floodplain functions that mitigate risks to existing developments and water resource values.

- Fills within rivers and streams, wetlands, and lakes.

While encroachment is not limited to fill, fill activities do represent the most permanent type of loss for rivers, streams, floodplains, wetlands and lakes. Once an area is filled, it no longer functions as an aquatic resource, but instead is an upland area. In addition to the immediate loss, fills can have ongoing impacts to water quality, habitat, and floodplain function depending on the quality of the fill material, and the extent and location of the activity. Fill that is poorly placed and is not stabilized represents an ongoing impact as an erosion hazard. In addition to eliminating habitat, fill can provide barriers to wildlife passage. The introduction of fill into an aquatic system has detrimental water quality effects that include iron-fixing bacteria blooms and the introduction of invasive species. Again, the ANR is currently in the process of developing, adopting and implementing as State Floodplain Rule, which would require a No Adverse Impact (NAI) analysis and certification for development for flood hazard areas outside of the FEMA designated floodway (an area FEMA terms the “flood fringe”). The NAI analysis would require a proposed development to demonstrate that there would be no increase in flood elevations and velocities or decrease in flood storage volume within the mapped Flood Hazard Area.. The State Floodplain Rule will apply an NAI approach to the river corridor by prohibiting new encroachments, including fill, that would exacerbate stream instability and erosion hazards.

- Removal of vegetation.

Part-and-parcel with encroachments to rivers, lakes, and wetlands, is the removal of riparian, shoreland, and buffer vegetation. Clearing the vegetation from lands adjacent surface waters

compromises many of the functions described above under Objectives A, B and C above. Areas lacking riparian or littoral vegetation lack the capability to filter sediment and nutrient pollutants, no longer provide shade cover, coarse woody debris and other organic material, and no longer have adequate root density and root strength to support the banks or shoreline, which can contribute to sedimentation problems in the surface water. Compared to a naturally vegetated area that has developed in concert with the natural fluctuations of mean water level over time, areas lacking littoral and riparian vegetation experience greater erosion, and subsequently greater property damage, during flood events.

This is particularly important in wetlands. Every function and value that wetlands provide depends in part or in whole on the vegetative component of the system. Persistent emergent or woody vegetation in wetlands along streams provide water quality protection, shading and refuge for fish, wildlife habitat, erosion prevention, and a means of slowing flood water. The removal of trees in a swamp can dramatically alter the hydrology of an area, destroy bird habitat, eliminate important shading for vernal pools, and reduce blow-overs that create micro-topography important for biological diversity. Some wetland natural community types, like bogs and fens, contain vegetative assemblages that are unique and important in the context of Vermont's natural heritage.

Monitoring and assessment activities addressing encroachment

Monitoring and Assessment Programs

Existing monitoring and assessment activities that focus on the causes and effect of encroachment are listed below. Full descriptions of the programs that carry out these activities may be found in the State Monitoring and Assessment Strategy and in Appendix D.

- Lake Aquatic Plant Surveys
- Lake Assessments
- Littoral Habitat Study
- Citizen Lake Watershed Surveys
- Lay Monitoring Program
- Stream Geomorphic Assessments
- Bridge and Culvert Assessments
- River Corridor Planning
- Floodplain Mapping
- Wetland Assessments
- VT Fish and Wildlife Department's Natural Heritage Information Project , including inventories of Natural Community Types
- Land Use imagery

Key Monitoring and Assessment Strategies to Address Encroachment

➢ Continue to conduct long term lake monitoring on a variety of stressors and update lake monitoring strategies as new stressors emerge.

Encroachment

- Implement the Lake Assessment methodology, which provides quantitative assessment of shoreland and related in-lake conditions and extent of encroachment. Lakes are assessed as part of Rotational Basin Assessments. Determine thresholds in aquatic habitat condition that result in violation of Water Quality Standards.

- Support continued local (town or lake association) use of Citizen Lake and Watershed Surveys to build local support for water quality projects.

- Integrate volunteer monitoring efforts with current departmental needs. Utilize Volunteer Monitoring via the LaRosa Partnerships to achieve WQMS goals. Expand and refine criteria for accepting projects. Create workgroup to guide and prioritize volunteer monitoring efforts. (Focused on LaRosa partnerships). Urge or give preference to proposals that have an implementation plan or address a WSMD-directed project.

- Conduct stream geomorphic and reach habitat assessments and complete river corridor plans in stream and river watersheds to document extent of encroachment, support technical assistance, regulatory, and funding programs, and track progress in mitigating surface water impacts due to encroachment.

- Conduct wetlands monitoring to establish baseline information on biological indicators and criteria.

- Document wetlands projects and associated encroachments to assess ongoing cumulative impacts to wetlands.

- Integrate monitoring and assessment programs, with data and scale-appropriate interpretations made accessible through program-tailored reporting from a web-based data management and map serve system. Make these map-based assessments available to town zoning boards, and Federal and State program staff who provide technical assistance, write permits, or implement remediation.

Technical assistance activities addressing Encroachment

Technical Assistance Programs

Existing programs that provide technical assistance in various aspects of managing encroachment are listed below. Full descriptions of these programs may be found in Appendix D. (the toolbox)

- Lake Shoreland Management Program
  - Website and publications
  - Workshops
  - Site-specific technical assistance
  - Citizen Lake and Watershed Surveys
  - Lake Seminar
- Act 250/248 comments
- Review of town plans and ordinances (VLCT and DEC)
- Shoreland Encroachment Program
- Stream Alteration Program
- River Corridor Management Program (Act 110)
  - Fluvial Erosion Hazards Programs
  - River Corridor Easement Program
- VTANR Roads and Rivers training program
- Floodplain Management Program
- Basin Planning Program
- Wetland Program
- Vermont Transportation Agency Environmental Services
- Better Backroads Program
- Natural Resource Conservation Districts
- Natural Resource Conservation Service
- Low Impact Development Program
- Regional Planning Commissions

Key Technical Assistance Strategies to Address Encroachment

- ➢ Develop and maintain the capacity to technically assist landowners, municipalities, land developers, agencies, and organizations to:
  - Conduct River Corridor and Floodplain Planning including development and implementation in order to promote avoidance of development within river corridors and floodplains;
  - Identify and protect wetlands, buffers and associated functions through remote sensing and field observations in order to prevent encroachment into wetlands and their buffers;

  - Identify and protect lake shoreland buffers and associated functions; and
  - Analyze alternatives to promote avoidance and minimization and the design of appropriate setbacks and buffers, based on both a-priori and project-related assessments and planning.
- ➢ Develop and maintain the capacity to technically assist municipalities in:

- Conducting River Corridor Planning including development and implementation;
- Developing and implementing Municipal Lake Shoreland Protection Plans

- Develop and maintain the capacity to technically assist all municipalities with regulations that protect river corridors, floodplains, wetlands, shorelines and associated buffers.

- Develop and maintain the capacity to technically assist agencies and programs with land use authority and responsibility for public infrastructure, in the:
  - Development of plans, policies, procedures, and regulation that are consistent with the State surface water goals and objectives; and
  - Implementation of strategies to avoid conflicts between human investments, the dynamic equilibrium of streams and important wetland, shoreland buffer, and floodplain functions.
- Increase education and training of municipalities and other State Agencies on the impacts associated with encroachment of transportation, bicycle, and pedestrian path infrastructure. This would include the continued ANR Rivers and Roads training program.

- Evaluate the effectiveness of Town Road and Bridge Standards implemented by the Vermont Agency of Transportation through funding to towns. Consider improvements needed during bi-annual updates.

- Develop lake shoreland restoration projects throughout the state as demonstrations of good management of existing development. Provide technical assistance on lakeshore stabilization and management projects that emphasize the use of native vegetation. Increase the capacity of the WSMD to provide technical assistance on shoreland management, restoration, retrofitting and stabilization.

- Develop a working model to improve the relevance and accuracy of the Vermont Significant Wetland Inventory maps by adding information from delineations, project review, and town wetland inventories.

- Provide more training on wetland identification to people outside of the agency

Regulatory Programs

Existing programs that regulate encroachment activities are listed below. Full descriptions of these programs may be found in Appendix D. (the toolbox)

- Lake Encroachment Program (Title 29, Chap 11)
- Shoreland Permit Program (Title 10, Chapter 49A).
- Section 401 Water Quality Certifications
- Wetland Permits
- Act 250 / 248 Permits *ANR Procedure on Floodway Determinations in Act 250 Proceedings*
- ANR Riparian Buffer Guidance
- Accepted Agricultural Practices
- Accepted (Forest) Management Practices
- Municipal Zoning

- Flood Hazard Area Regulation
- [ANR State Floodplain Rule for municipally exempt activities]

Key Regulatory Strategies to Address Encroachment

- Develop and effectively implement ANR River Corridor and Floodplain Procedures to limit encroachments and future conflicts with river systems, and achieve stream equilibrium conditions.

- Continue to evaluate and include options within stream alteration permits to require an analysis and/or waiver of alternatives that will accomplish protection and restoration of stream equilibrium, river corridors, floodplains, and buffers.

- Develop, adopt and implement State Floodplain Rule for activities that are exempt from municipal regulations. Such rules should address the vulnerability that new encroachments bring onto themselves, as well as identify and protect the floodplain functions that mitigate risks to existing developments and water resource values.

- Ensure that rules and regulations promulgated by other authorities are consistent with those of the Division to meet the goals and objectives of the State Surface Water Management Strategy. With respect to managing the four primary causes of encroachment, this means ensuring that other rules and regulations do not contain inconsistencies with stream equilibrium policy.

- Provide technical and scientific support to legislative efforts to promulgate statewide lakeshore buffer protection or regulation.

- Continue to integrate river corridor and buffer protection in storm water permitting and water quality remediation planning efforts.

- Ensure Act 250/Section 248 permits/CPGs avoid or minimize encroachment into river corridors, floodplains, wetlands and lake buffers.

- Implement the new Vermont Wetland Rules, which will protect more wetlands and their functions and values.

- Ensure Lake Encroachment permits make use of the least intrusive alternative, especially with respect to shoreline stabilization. Promote the use of vegetation and designs that mimic the natural shoreline.

- Assess the extent of violations of the Lake Encroachment statute (i.e. unpermitted fill and walls) and develop an approach to enforcement as needed.

- Ensure the standards for development under the Shoreland Protection Act are met to achieve the objectives for managing Encroachment.

Funding Programs to address Encroachment

Existing funding programs that support projects to address encroachment are listed below. Full descriptions of these programs may be found in Appendix D.

- Ecosystem Restoration Program
- Flood Hazard Mitigation Grants: PDM, FMA and HMGP grants
- Stronger Communities Grants Program
- ANR Watershed Grants (Conservation License Plate)
- State Land Acquisition Review Committee and process
- CWA Section 319 grants
- Lake Champlain Basin Program Local Implementation Grants
- Connecticut River Mitigation &Enhancement Funds
- Vermont Land Trust
- Vermont Housing and Conservation Board
- CREP
- Better Backroads
- Use Value Appraisal Program
- Agricultural Buffer Program

Key Funding Strategies to Address Encroachment

- ➢ Develop meaningful funding incentives for municipalities to adopt plans and bylaws which protect floodplains, river corridors, wetlands, lake and pond shorelands, and buffers. This would include seeking permanent funding to be provided to the Flood Resilient Communities Program. This program was created with the passage of Act 138 but no funding has been provided to date.

- ➢ Ensure that state and federal grant programs encourage activities that lead to equilibrium and discourage further encroachment into river corridors, floodplains, lake buffers, and wetlands.

- ➢ Explore all alternatives for providing funding from diverse resources to support core programs within the Division.

- ➢ Develop and maintain a stable and comprehensive funding program which supports not only the implementation of projects, but the assessment, planning, and design phases necessary to identify projects consistent with the goals and objectives of the State Surface Water Management Strategy.

- ➢ Develop and maintain a stable funding program to conserve floodplains, river corridors, lake shorelands, and wetlands.

- ➢ Develop a shoreland conservation program for lakes.

Information and education activities addressing encroachment

Existing programs that inform and educate the general public about the causes and effect of encroachment are listed below. Full descriptions of these programs may be found in Appendix D. (the toolbox)

- Lake Shoreland Management Program
  - Website and publications
  - Lake Score Card
  - Workshops
  - Citizen Lake and Watershed Surveys
  - Lake Seminar
  - Project WET
- River Corridor Management Program
- Flood Resilient Communities Program, including Flood Resilience Sharepoint site
- VT ANR/VTrans River and Road training Program
- Basin Planning Program
- Vermont League of Cities and Towns Municipal Assistance Program
- Natural Resource Conservation Districts
- River and Lake Groups
- Forestry AMP Program

Key Information and Education Strategies to Address Encroachment

➢ Educate the Division and Agency and other organizations about the impacts of encroachment and the importance of a river corridor and floodplain protection strategy that incorporates buffers. Policies that promote simple setbacks from streams do not accommodate the dynamic nature of fluvial processes. This would include the promulgation of the Flood Resilience Sharepoint site and the Flood Resilient Communities program.

➢ Create a multi-media educational program, including printed material, photo libraries, videos, power point presentations, field demonstrations, and river flumes, that discusses the impacts and mitigation strategies of encroachment, which may be readily used by Division staff at public forums as opportunities arise.

➢ Develop an effective outreach approach on the impacts to the lake environment from poor shoreland development practices. Use the Division’s scientific data on lake littoral zone impacts from the Littoral Habitat Study and involve lake associations, residents or towns in assessing lakeshore and in-lake conditions to foster greater understanding of the problems and commitment to the solutions. The approach should make use of social marketing techniques and focus on key understandable messages.

➢ Develop and maintain the State Surface Water Management Strategy as an interactive, web-based site where people can get information about how the State is dealing with stressors such as encroachment and other stressors, but also provide input on the policies and programs developed to address the stressor.

- Develop I&E tools that address land use in buffers, including the importance of naturally vegetated buffers, and the imperviousness of and water quality impacts from grassed lawns.

- Partner with regional planning commissions, municipalities, and other partners to conduct floodplain buildout analyses, overlaid with river corridors, floodplain maps, and buffers, to develop visuals on the potential impacts to the resource if the municipalities lack stronger zoning. The analysis will also determine the extent of channelization necessary to protect investments, the impacts of the buildout to base flood elevations, and the need for additional stream crossings. This information can be integrated into the Flood Resilient Communities Program or be developed as a result of the Program.

- Continue to work with VTrans on the development of the VTANR/VTrans Roads and River training efforts.

- Increase public awareness of wetlands, their functions and associated regulations that reflects the recently adopted Vermont Wetland Rules.

What are Invasive Species?

Invasive species are nonindigenous plants, animals, algae, fungi or pathogens – disease causing organisms like viruses and bacteria – that threaten the diversity and survival of native species or the ecological stability of infested ecosystems, or commercial, agricultural or recreational activities dependent on these natural resources. They are a form of biological pollution.

The defining characteristic of invasive species is that they possess traits that allow them to outcompete native species, negatively altering the structure and dynamics of ecosystems. In novel environments, invasive species often lack natural population controls, such as pathogens and predators, that keep most species in check in their native range. Invasive plants may be more efficient at extracting nutrients from sediments to assist their growth, or their inherent faster growth rate may allow them to rise above and shade out other native plants. Also, invasive species tend to be opportunists that can quickly adapt to a wide variety of conditions. Due to these advantages, they often outcompete native species.

At least 52 aquatic non-native species are present in Vermont. While many of these species have not become invasive, a significant number have, including Eurasian watermilfoil, zebra mussels, water chestnut, and purple loosestrife. A portion of the state's lakes and rivers have been impacted by invasions of these exotic pests, but many more are still free of aquatic invasives.

Preventing new aquatic invasive species from being introduced to and established in Vermont is critical, not only to limit the future cost of managing invasive species but also to protect the integrity of Vermont's ecosystems. Programs aimed at preventing the spread or introduction of invasive species into Vermont are the best and least costly means of protection available.

How important are invasive species?

Based on the Watershed Management Division's evaluation, invasive species of aquatic, wetland, and riparian habitats are a highly-ranked stressor, the effects of which can be found throughout the state and severe in many waters where infestations occur. Where infestations of invasive species achieve moderate or high densities and are left unmanaged, severe long-term impacts to recreation and ecosystem function can be expected. Roughly 21% of Vermont lakes over 20 acres in size are affected by invasive species, although not all lakes support high density populations. Few systematic surveys have been carried out of riparian invasive species. However, field observations suggest that species such as purple loosestrife and common reed (which preferentially invade wetlands), and Japanese knotweed (which colonizes streambanks with alarming efficiency) are increasingly dominating Vermont's riparian zones, wetlands and watersheds. Small-bodied invasive animals, such as zebra mussels, Asian clams, and spiny waterflea, are found in limited Vermont waters, and have prompted increased efforts to ensure that these species are not spread further.

Effective management or preclusion of invasive species infestations promotes several surface water goals and objectives, including:

Objective A. ***Minimize Anthropogenic Nutrient and Organic pollution***
Invasive plant species outcompete native plants or animals resulting in major changes to surface waters, and are considered a form of biological pollution. Invasive species populations can reduce or eliminate swimming, fishing and boating opportunities in waters where moderate or dense infestations are present. Zebra mussel infestations have necessitated significant infrastructure modifications of water systems and fish hatchery facilities.

Objective B. ***Protect and Restore Aquatic, and Riparian Habitat***
Invasive species cause significant habitat shifts by replacing biologically diverse populations with mono-cultures, generally considered of lower habitat value. In lakes, invasive plants such as Eurasian watermilfoil can degrade spawning habitat for fishes and reduce overall habitat complexity. Along streambanks, Japanese knotweed outcompetes desirable species that provide diversity. Water chestnut infestations form a dense mat on the water surface, which can raise temperatures and lower dissolved oxygen content in affected areas, thereby limiting use by fish and other animals.

Specific causes and sources of invasive species

From a global perspective, overseas shipping and associated management of ballast-water has for years been the primary mechanism by which aquatic invasive species arrive in North America. This has eased in recent years due to federal regulations concerning ballast water. Many species also arrived in this country by way of the gardening or aquarium trades. For those species that are already in U.S. waters, and that occur in or threaten Vermont, recreational activities are largely responsible for spreading invasive species. People spread invasive aquatic plants by moving plant fragments on boats, trailers and other equipment. Microscopic organisms or their larval stages, such as zebra mussel veligers, are moved when water or sediment in boats, bait buckets, or gear is carried from one waterbody to another. The connectedness of waterways also allows spread; in Vermont, Lake Champlain is connected to both the Hudson River through the Champlain Canal, and the Great Lakes through the Richelieu and St Lawrence rivers. Occasional natural spread of certain invasive species has been attributed to distribution by wildlife.

Riparian invasive species are spread by a different set of activities. In addition to recreational spread, transportation infrastructure (roadside ditches and mowing) can promote the spread of species like common reed or purple loosestrife. Also, the removal of streambank vegetation creates excellent opportunities for Japanese knotweed to gain a foothold on streambanks, which then allows flooding and bank erosion to distribute root pieces downstream. More information on spread prevention is available here (http://dec.vermont.gov/watershed/lakes-ponds/aquatic-invasives/).

Monitoring and assessment activities to track invasive species

Programs

- Surveys to monitor existing plant and animal infestations, or to detect new ones
- Aquatic plant surveys
- Vermont Invasive Patrollers (VIP) surveys
- Zebra mussel veliger and spiny waterflea monitoring (Lake Champlain and inland lakes)
- Crayfish monitoring (Biomonitoring and Aquatic Studies Program)
- Fish surveys (VT Dept. Fish and Wildlife and US Fish and Wildlife Service)
- Riparian species (US Forest Service (limited))
- Assessment of invasive species infestations as part of reporting to EPA and the public.

Key Strategies

- Expand the network of VIP programs.

- Discover new invasive species infestations early to maximize control options by monitoring for aquatic and riparian species of concern, including species not currently known in Vermont.
- Increase understanding of biological impacts of invasive species in riparian and wetland areas.

Technical assistance and implementation programs to address invasive species

Programs

- Aquatic Invasive Species Program to provide technical assistance and on-site visits to support the development and implementation of waterbody-specific, long-range control and spread prevention projects
- Water Chestnut Management Program (statewide) to reduce and prevent further spread of this species in Vermont
- Eurasian watermilfoil control efforts in high priority waters (e.g. Hinkum Pond)
- Implement the Rapid Response Action Plan for Invasive Aquatic Plants and Animals throughout Vermont (e.g., Halls Lake Variable-leaved watermilfoil, Lake Bomoseen Asian clam, Lakes Memphremagog and Derby starry stonewort)

Key Strategies

- Continue annual water chestnut program to ensure recently achieved milestones, especially in Lake Champlain, continue and are not lost.
- Maintain readiness to implement rapid response protocols when necessary.
- Maintain knowledge of current available control methods and regional issues through coordination with peers in New England and nationally. Support research to increase technical knowledge of spread prevention protocols.
- Emphasize spread prevention as the most cost-effective and successful strategy.
- Integrate invasive species spread prevention into all ANR field programs. Ensure that protocols are current, field staff are trained and field staff practice effective spread prevention techniques.
- Coordinate invasive species prevention and control plans within a region or basin for greatest effectiveness.
- Clarify environmental review process to ensure invasive "watch list" species are not utilized in projects undergoing state review.
- Develop best management practices for invasive species to ensure the highest level of control success and to minimize the use of pesticides.

Regulatory programs to address invasive species

Programs

- Aquatic Nuisance Control Permit Program (10 V.S.A. §1455): regulates the use of mechanical, biological, physical and chemical nuisance control activities in Vermont waters

- Aquatic Species Transport Law of aquatic plants and aquatic nuisance species (10 V.S.A. §1454) prohibits the transport of *all* aquatic plants or aquatic plant parts, zebra mussels *(Dreissena polymorpha*), quagga mussels *(Dreissena bugensis*), or other aquatic species identified by the Secretary by rule to or from any Vermont waters on the outside of a vehicle boat, personal watercraft, trailer or other equipment
- The Vermont Use of Public Water Rules, Section 4.1 authorizes the Secretary of the Agency of Natural Resources to identify areas of public waters as temporarily closed to all persons, vessels or both to prevent, control or contain the spread of aquatic nuisance infestations
- Noxious Weeds Quarantine Rule (AAFM #3) regulates the importation, movement, sale, procession, cultivation and/or distribution of certain plants known to adversely impact the economy, environment, or human or animal health. The rule provides penalties for violations.
- Rule regulating the introduction of any live fish to Vermont waters (10 V.S.A §4605)
- Baitfish Rule: Places restrictions on the purchase of baitfish and the movement of baitfish between waters of the State (10 V.S.A. §122)

Key Strategies

- Ensure prohibited aquatic nuisance species under 10 V.S.A. §1454 reflect current species of concern.
- Ensure invasive species spread prevention measures are integrated into Watershed Management Division permit programs.
- Implement the Aquatic Nuisance Control Permit program with consistency and accuracy to ensure quality projects and the meeting of statutory criteria.
- Work with enforcement staff from State Police Auxiliary, Fish and Wildlife Wardens and Border Patrol to ensure knowledgeable and effective enforcement of the Transport Law.
- Work with AAFM to implement Noxious Weeds Quarantine Rule #3.

Coordinate funding programs to address invasive species

Programs

- Aquatic Nuisance Control Grants-in-aid grants provides funding to municipalities for eligible spread prevention programs and nuisance (for native and non-native species) control activities
- Lake Champlain Basin Program grant program for certain aquatic invasive species projects
- US Army Corps of Engineers
- Local initiatives raise funds to support lake-specific control and spread prevention projects

Key Strategies

- Prioritize spread prevention programs, such as public access area greeter programs, based on risk of spread. Support programs at infested lakes.
- Evaluate funding options to meet statewide invasive species spread prevention and control project needs.

Information and education programs to address invasive species

Programs

- Vermont Invasive Patrollers (VIPs) monitor a local waterbody for new introductions of invasive species while also learning about native aquatic plants and animals and their habitats
- The Vermont Public Access Greeter Program and the Lake Champlain Basin Program's Lake Steward Program trains "greeters" to educate boaters, anglers and other recreationists about invasive species, encourage adoption of spread prevention methods, and offer courtesy boat and equipment inspections
- *Roving Aquatic Invasives Decontamination and Education Resource* (RAIDER) Program provides staffed, aquatic invasive species decontamination units at high-priority public access areas as educational and spread prevention tools
- Aquatic invasive species signs are posted and maintained at public boat access points to remind users to practice "Clean, Drain, Dry" spread prevention measures
- Aquatic Invasive Species website, educational materials, and distribution maps are available to provide up-to-date information on aquatic invasive species management, status and distribution
- Wise on Weeds, The Nature Conservancy (for riparian species)
- VT Better Backroads Program workshops

Key Strategies

- Maintain and grow a complete network of VIP programs.
- Establish a complete network of access area greeter programs regardless of local sponsorship.
- Evaluate funding options to support and expand the RAIDER initiative.
- Expand education and outreach coordination with Department of Fish and Wildlife to reach common audiences such as anglers, day users, and out-of-state users.
- Expand audiences that receive invasive species information.
- Expand existing programs to include all taxa, when appropriate.
- Encourage non-regulatory approaches to prevention such as voluntary codes of conduct for road crews and contractors.

What is Land Erosion?

Land erosion is the process by which material on the surface of the land is dislodged and moved. Land erosion becomes a water quality stressor when the transported materials reach surface waters. When this occurs, the sediment itself is a pollutant.. Land erosion is a natural process caused by both wind and precipitation; however, precipitation-driven erosion is the primary water-quality stressor in Vermont. Various human activities such as development of unmanaged impervious surfaces, or poorly managed agricultural or forestry activities can significnatly increase the natural rate of land erosion.

In the precipitation-driven erosion process, soil or other materials are first dislodged from the ground by either the impact of rain hitting the ground, or by being “swept up” by the flow of “sheet runoff water” across the ground surface. Land erosion increases rapidly when vegetation and the intact “duff” or organic outer layer of soil are removed. Erosion rates vary significantly depending on a site’s slope, the inherent erodibility or prior compaction of the soil, as well as the extent and condition of vegetation and antecedent moisture conditions. The pollutant load associated with land erosion is dependent on the amount of pollutants that exist on or in the eroding material. The extent to which eroded material is delivered to a receiving water depends on proximity and the existence of constructed or natural conveyances, such as swales, channels and ditches, pipes, or culverts. Barriers to sheet-flow based erosion, such as riparian buffers, filter strips, stone-lined roadside ditches, and other green infrastructure practices can significantly reduce or even preclude the impacts of land erosion.

How important is Land Erosion?

Available data indicate that the effects of land erosion are widespread throughout the state. The delivery of sediments and associated nutrients has multiple effects on receiving waters, with the intensity of the impacts dependent on the type of sediment involved, the nutrient content of the sediments, and the capacity of the receiving water.

Empirical data are not available to describe the quantity of sediments and nutrients delivered from land erosion separately from those delivered by channel erosion. However, the 2010 statewide water quality assessment suggests that for rivers and streams, 211 miles are impaired due to sediment, with an additional 800 miles stressed. For nutrients, there are 136 river miles impaired, and 498 miles stressed. Among Vermont’s lakes, 100 acres are impaired due to sediment, and an additional ~8,900 acres are stressed (~5,400 of which are in Lake Champlain). As for nutrients, there are 139,800 acres impaired (132,000 acres of which are in Lake Champlain), and ~3,900 acres stressed (hyperlink 305b report).

What objectives are achieved by managing Land Erosion?

Addressing and preventing land erosion promotes several surface water goals and objectives, including:

Objective A. ***Minimize Anthropogenic Nutrient and Organic Pollution***
Sediments from eroded lands contribute significantly to nutrient pollutant loading. Reducing land erosion can decrease the nutrient load delivered to receiving waters. Minimizing activities that contribute to erosion and implementing best management practices that prevent and control the rate of erosion are the focus of a substantive multi-agency effort to reduce this form of pollution.

Objective B. ***Protect and Restore Aquatic, and Riparian Habitat***
Excess sediment resulting from land erosion degrades aquatic and riparian habitat. Cover, feeding, and reproductive habitats of aquatic organisms are dependent upon the sorting, distribution and variety of

sediment types in lakes, wetlands, and streams. By minimizing land erosion, complex physical habitats that support a diverse assemblage of aquatic and riparian species are maintained. Excessive land erosion will yield uniform, sediment-embedded habitats of considerably lesser quality.

Objective D. ***Minimize Toxic and Pathogenic Pollution, and Chemicals of Emerging Concern***

Land erosion from excessively applied or poorly incorporated manure results in pathogen releases to surface waters, resulting in potential impacts to recreational uses. However, land erosion is not considered a major delivery mechanism for most toxic compounds, nor for Chemicals of Emerging Concern.

What are the causes and sources of Land Erosion?

The causes and sources of land erosion generally include activities that either eliminate the vegetation that protects soil from erosion, or result in increased runoff volume and velocity. The causes and sources of land erosion include runoff from developed lands; construction activities; agriculture; and forest management. Each of these categories is described in more detail below.

Land erosion from developed lands. Developed land generates more runoff than undeveloped land. Impervious surfaces, including roads (both paved and gravel), parking areas, and buildings prevent precipitation from infiltrating into the ground, and instead produce runoff of sufficient velocity to erode soil and other materials in the flow path. Additionally, developed land often includes a stormwater collection system, or storm sewer system, that effectively routes large areas of impervious system to single points, thus exacerbating the potential for erosion. Erosion is most pronounced where runoff is collected, or concentrated, such as in road ditches, or at outfalls of storm sewer systems. Land erosion due to stormwater runoff from developed land can be mitigated using traditional stormwater management practices, as well as Low Impact Development (LID) and Green Infrastructure (GI) practices. These include infiltration trenches, cisterns, rain gardens, porous pavements, and sustainable site design/redesign. These practices attempt to mimic natural hydrology by infiltrating, evapotranspiring, treating, and storing stormwater as close to the source as possible. Providing appropriate riparian buffers from surface waters can also mitigate the impacts of land erosion from developed land sources.

Land erosion from construction activities. Because construction activities typically result in the loss of vegetative cover, they can produce extremely high rates of soil loss. In addition, altering a site's topography can result in a concentration of runoff and stockpiling of erodible materials can cause significant erosion. Land erosion due to runoff from construction activities can be mitigated through: practices that reduce the amount of cleared land at a given time as well as reduce the period during which it is exposed or left without permanent cover or vegetation; practices that protect the soil during construction, such as mulching; and practices that slow runoff and filter or otherwise reduce the pollutants from the runoff. Providing appropriate riparian buffers from surface waters can also mitigate the impacts of land erosion from construction sources.

Land erosion from agricultural activities. Agricultural activities including: runoff from impervious surfaces in agricultural production areas, such as barn roofs and concrete barn yards; land disturbance associated with the planting and harvesting of annual crops, such as corn and soy; and unmanaged or poorly managed pasturing, allowing livestock direct access to surface water and wetlands and/or overgrazing and denuded vegetation, can all contribute to land erosion through alteration or removal of vegetation. This leaves soils exposed and alters natural drainage patterns, concentrating flows through ditching or tiling. Similar to runoff from developed lands, land erosion rates are highest where runoff is concentrated into a ditch or similar conveyance. Land erosion due to agricultural activities can be mitigated by following practices to reduce the potential for erosion, such as: expanding "clean water management" to include hydrologic considerations, planting only perennial crops in sensitive areas such as along rivers, ditches, lakeshores and steep slopes, using conservation tillage, planting cover crops, installing "WASCoB's (water and sediment control basins), excluding animals from surface waters, and implementing rotational grazing systems. Providing appropriate riparian buffers from surface waters also mitigates the impacts of land erosion from agricultural sources.

Land erosion from logging activities. The construction of logging roads, skidder trails, log landings, inadequate protection of stream and wetland crossings, and log transport activities that expose the soil to precipitation, as well as a lack of site maintenance and close-out, can result in land erosion similar to that of construction activities and runoff from developed lands. On a statewide basis, logging activities result in less land erosion than results from runoff from developed lands and construction activities, however, when erosion from logging operations is allowed unchecked, intense localized impacts occur. Land erosion due to logging activities can be mitigated by following practices that properly locate and construct logging roads, skidder trails, stream crossings, and log landings, as well as restrict the use of mechanized equipment to times when there are sufficiently dry or frozen conditions. Providing appropriate buffers from surface waters can also mitigate the impacts of land erosion from logging sources.

Monitoring and assessment activities to assess effects of Land Erosion

Existing monitoring and assessment activities that consider the causes and effects of excessive land erosion are listed below. Full descriptions of the programs that carry out these activities may be found in the State Monitoring and Assessment Strategy and in Appendix D.

VTDEC's Monitoring and Assessment Program carries out a comprehensive surface water monitoring strategy aimed at understanding the relative importance of sedimentation and nutrient pollution in Vermont surface waters.

VTDEC's Lake Assessment Program and Citizen Lake and Watershed Surveys particularly note erosion occurring along lakeshores.

VTDEC River Management Program
Stream Geomorphic Assessments
Bridge and Culvert Assessments

VTDEC Clean Water Initiative Program
Stormwater Infrastructure Mapping
Illicit Discharge Detection and Elimination Surveys

The LaRosa Partnership Program of VTDEC supports citizen scientists who are interested in monitoring the condition of waters in their watersheds.

The Natural Resources Conservation Service has developed a metric of soil loss called "T," or tolerable soil loss. This is tracked within NRCS databases, and is assessed on a farm-by-farm basis. As a pre-condition for enrolling in many of the cost-share programs offered by NRCS, agricultural producers are required to have a plan in place that reduces soil loss to T by applying best management practices. The T-factor was initially developed out of concern for preserving agricultural productivity, and represents the maximum annual soil loss expressed in tons per acre per year that can occur on a particular soil while sustaining long-term agricultural productivity. It is important to remember that T is based on agricultural productivity and does not directly consider water quality impacts that such soil loss would have on a receiving water.

Lake Champlain Basin Program – supports the Long-Term Water Quality and Biological Monitoring Program on Lake Champlain, which is operated jointly by the States of Vermont and New York. The program measures TSS, phosphorus, nitrogen and many other parameters in the lake and its tributary rivers. All chemical analyses are conducted by the Vermont DEC Laboratory. The tributary monitoring results are analyzed with data from the network of stream flow gauges in the basin operated by the U.S. Geological Survey. The monitoring results are updated annually on the Lake Champlain Long-Term Monitoring Program website where the data and graphical summaries are freely available. The Basin Program also supports individualized watershed-specific sampling efforts as needed.

Key Monitoring and Assessment Strategies to Address Excessive Land Erosion

- Conduct integrated analysis of biomonitoring and land use data to identify trends in and extent of land erosion.

- LiDAR, or "Light Detection and Ranging" is a method of very high-resolution elevation and contour mapping. Obtain statewide "LiDAR" data and use this to identify areas of localized erosion.

- Complete critical source area analysis, evaluating the relative erosion potential from different areas across the state.

- A major concept promoted through agricultural management programs is that soil loss should be maintained within a tolerable level, known by the farming community as "T." "T" is presently based on soil protection, and not water quality protection. Alternatives for a water quality-based "T" value would benefit both soil protection and surface water quality.

Technical assistance programs to address Land Erosion

Existing programs that provide technical assistance in various aspects of managing the causes and sources of excessive land erosion are listed below. Full descriptions of these programs may be found in Appendix D.

AAFM ARS Program
AOT Environmental Services
Better Roads Program
Local Roads Program
VTFPR Watershed Forestry and Urban and Community Forestry Programs
VTDEC Lake Shoreland Management Program
USDA NRCS Highly Erodible Land Conservation
USDA Conservation Technical Assistance
Vermont League of Cities and Towns (model ordinance development)

Key Technical Assistance Strategies to Address Land Erosion

- Develop and maintain the capacity to technically assist landowners, municipalities, land developers, engineers, agencies, and organizations in the implementation of sound land use practices, including shoreland management and green infrastructure.

- Continue to provide technical assistance to town road maintenance programs through the Better Back Roads Program to encourage proper ditch design and maintenance, and dirt road design specifications that minimize land erosion.

- Provide access to trainings on green infrastructure practices.

- The FPR Division of Forests staff provides technical assistance to forest landowners and loggers to help them comply with Vermont's Water Quality and the Heavy Cutting Laws.

- The Vermont Agency of Agriculture, Food and Markets - Division of Agricultural Resource Management and Environmental Stewardship offers a host of programs to protect water resources. These programs are both regulatory and voluntary in nature and are designed to be an efficient approach for Vermont farmers to protect their environment.

Regulatory programs to address Land Erosion

Existing programs that regulate activities causing land erosion are listed below. Full descriptions of these programs may be found in Appendix D.

AAFM Required Agricultural Practices RAPs
AAFM Large Farm and Medium Farm Operation Permitting Programs
AOT Access Management Permit Program
VTDEC Stormwater Management Program
- Construction General Permit and Individual Permits
- Stormwater Operational General Permit and Individual Permits
- Municipally-separated Storm Sewer System Permit
- State of Vermont Transportation-separated Storm Sewer System Permit
- Municipal Roads General Permit
- Three-acre Developed Lands Permit

VTFPR Accepted Management Practices for Logging AMPs

Key Regulatory Strategies to Address Land Erosion

- Continue to implement the State's stormwater regulatory programs. The 2009 Lake Champlain TMDL implementation plan also identified addressing stormwater runoff from developed lands as one of the top ten steps for reducing phosphorus pollution in Lake Champlain. The State's stormwater program is the primary mechanism for regulating discharges from impervious surfaces and construction sites. Regulatory oversight of new development is necessary to ensure that stormwater discharges do not contribute to excess land erosion.

- Conduct an analysis of existing jurisdictional thresholds (e.g. 1 acre of disturbed land) to determine if existing programs are sufficiently protective, particularly in sensitive areas such as within river corridors, or lakeshores.

- Further coordinate Agency of Agriculture, Food and Markets regarding implementation of Accepted Agricultural Practices (AAPs), which, are intended to reduce pollutants associated with common agricultural activities. The AAPs require, among other things, setbacks along surface waters. The AAPs are the State's primary regulatory for any agricultural operation that does not trigger the regulatory thresholds of the medium- or large-farm operation permitting program; the AAPs apply to all farm operations, regardless of type or size.

- Continue development of a Consolidated Animal Feeding Operation permit to supplement existing Medium (MFO) and Large Farm Operation (LFO) permitting programs as administered by the Agency of Agriculture.

- Coordinate with the Department of Forests and Parks to evaluate opportunities for enhanced surface water protection under the Accepted Management Practices (AMPs) for Maintaining Water Quality on Logging Jobs in Vermont. AMP's define allowable activities within river corridors and prescribe baseline practices to reduce land erosion.

Funding programs to address Land Erosion

Existing funding programs that support projects to address the causes and sources of land erosion are listed below. Full descriptions of these programs may be found in Appendix D.

AAFM Farm Agronomic Practices (FAP) and, Nutrient Management Plan Incentive Programs
Better Roads Grant Program
Clean Water State Revolving Fund
USDA-NRCS EQIP Program
USDA-NRCS/AAFM Conservation Reserve Enhancement Program
VTDEC Ecosystem Restoration / Clean Water Initiative Program Grants

Key Funding Strategies to Address Land Erosion

- The Clean Water Initiative Program (ERP) is the cornerstone of ANR's on-going efforts to reduce surface water pollution from phosphorus and sediment. ERP is specifically interested in proposals designed to improve water quality, including but not limited to projects that: improve stream stability, incorporate the science of fluvial geomorphology in river corridor management decisions, protect against flood hazards, and improve in-stream and riparian habitat; mitigate the effects of hydrologic modification (stormwater runoff) associated with urban development; protect and restore riparian wetlands; re-establish lake shoreline native vegetation and related shoreline erosion corrections; directly address in-lake (internal) phosphorus loading conditions; and enhance the environmental and economic sustainability of agricultural lands.

- The AAFM, Division of Agricultural Resource Management and Environmental Stewardship offers several funding programs to promote agricultural best practices that include very low cost-share requirements.

- The Vermont Better Back Roads Program provides direct funding to municipalities for road and culvert assessments and to promote improvements that are recommended by these assessments.

Information and Education programs to address Land Erosion

Existing programs that inform and educate the general public about the causes and effects of land erosion and BMP's to address them are listed below. Full descriptions of these programs may be found in Appendix D.

Chittenden County's Regional Stormwater Educational Program (RSEP)
Chittenden County Stream Team (CCST)
Ecosystem Restoration Program (ERP)
Lake Champlain Basin Program (LCBP)
Lake Champlain SeaGrant (LCSG)
Natural Resource Conservation Districts (NRCDs)
UVM Extension
VTDEC Lake Shoreland Management Program
VTFPR Watershed Forestry and Urban and Community Forestry Programs

Key Information and Education Strategies to Address Land Erosion

As described above there are a broad suite of technical and financial assistance programs, as well as regulatory measures that are designed to address land erosion. By in large these efforts target specific practices, activities or locations, and do not provide broad-based outreach to the general public about the causes and effects of land erosion. While it is unlikely that the typical Vermont homeowner will have substantial and uncontrolled erosion occurring in their backyard, each homestead contributes to the changes in hydrology and overland flow that can cause or contribute to land erosion.

In 2011, ANR completed a Green Infrastructure Strategic Plan that identified areas where green infrastructure efforts could be strengthened. Education and outreach was identified as a high priority for four target audiences: design professionals, municipalities, property owners, and agency staff. Working with local, regional, and state partners, ANR staff (specifically the Green Infrastructure Coordinator) will coordinate and assist in efforts aimed at increasing awareness and adoption of GI practices among these groups.

The Lake Shoreland Management Program works with lakeshore owners and municipalities to educate them about shoreland sources of erosion and to offer materials and technical assistance to correct and avoid problems.

Towns and other entities subject to MS4 stormwater permitting develop and distribute education about the source of stormwater and residential BMPs for protecting surface waters from stormwater and subsequent land erosion. To meet permit criteria, they provide information on websites, displays, commercials, and factsheets. The Smart Waterways program of the Regional Stormwater Education Program is one model for this collaborative educational approach.

In municipalities subject to mandatory stormwater pollution control efforts at the individual parcel level (e.g., where total maximum daily loads and residual designation authority has been imposed), considerable education and outreach effort is provided to residents on how to comply with the stormwater control requirements. Materials developed for that purpose are made available to residents and officials in other municipalities, coincident with a coordinated outreach effort through the Stormwater Management Program, via the Low Impact Development website (http://dec.vermont.gov/sites/dec/files/wsm/stormwater/docs/Resources/sw_LID%20Guide.pdf).

What is Non-Erosion Nutrient and Organics Loading?

Three stressors discussed in this Strategy comprise the vast majority of the nutrient load delivered to Vermont's surface waters: channel erosion; land erosion; and, the subject of this stressor evaluation, non-erosion nutrient and organics loading. Non-erosion based nutrient and organics loading results from direct application of nutrients to lands (e.g., fertilizer application on farm fields or gardens) that may be subsequently washed into surface waters without any attendant land erosion, leaching of nutrients embedded in soil or organic matter or from direct or indirect discharges (e.g., wastewater treatment facilities). Phosphorus and nitrogen are the two major nutrients of concern for Vermont's surface waters.

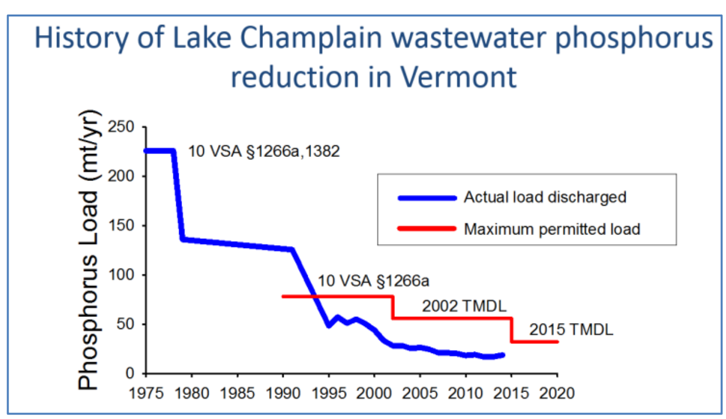
Eutrophication is a natural process of nutrient accumulation in surface waters over long time periods (hundreds to thousands of years). When human activities enhance phosphorus and nitrogen loading to surface waters, accelerated "cultural" eutrophication typically results. Signs of accelerated cultural eutrophication may include an increased incidence of algae, plants or cyanobacteria (formerly called blue-green algae) blooms and reduced water clarity, which can affect the biological communities in lakes, wetlands and rivers, and also significantly impact recreational uses. In most of Vermont's surface waters, as in most fresh water systems, phosphorus is considered the limiting nutrient; nitrogen tends to be the limiting nutrient in salt water or brackish systems.

Nutrients that are directly delivered to surface waters from non-erosional sources are typically in a chemical form that is more biologically available and therefore readily assimilated by algae and cyanobacteria. These nutrients are not bound to sediment particles at the time of discharge or application. Phosphates and ammonium, respectively, are examples of bioavailable phosphorus and nitrogen. Non-erosional nutrient loading tends to have more immediate and localized impacts when excess quantities of nutrients are discharged. For these reasons, direct discharges of phosphorus are regulated to low levels in most wastewater treatment plant and permitted indirect discharges. Limits are also imposed on nitrogen from permitted discharges to comply with current water quality criteria for nitrogen.

How important is Non-Erosion Nutrient and Organics Loading?

Since the passage of the federal Clean Water Act, considerable efforts have been made to control nutrient discharges from wastewater treatment facilities, and to impose regulations upon septic discharges. Villages that once discharged collected untreated septage directly to streams now treat this waste in well-functioning wastewater treatment facilities, the majority of which are subject to advanced phosphorus removal systems. Through the use of the Surface Water Revolving Fund and Vermont's implementation of National Pollution Discharge Elimination System and Indirect Discharge permits, the loads of nutrients to streams and lakes from direct discharges has been vastly reduced. Since passage of the Clean Water Act, $750M has been spent to construct, upgrade, and improve wastewater treatment infrastructure in Vermont, including $8M during the 2015-2016 funding cycle.

Vermont is presently involved in two major multi-State nutrient control planning efforts; the Lake Champlain Phosphorus TMDL and the Long Island Sound Nitrogen TMDL. Through implementation of the Lake Champlain TMDL, as well as through prior legislative efforts, current point source discharges of phosphorus from treated wastewater comprised only 3% of the phosphorus load to Lake Champlain, while in Lake Memphremagog, the total phosphorus load to the lake from Vermont wastewater treatment facilities has been estimated at 1.2%. A phosphorus load allocation study for Lake Carmi identified just over 1% of the total phosphorus load from septic and indirect discharge sources.



In rivers, nutrients resulting from municipal wastewater and associated combined sewer overflows affect under 2% of assessed river miles. Further, phosphorus loads to Lake Champlain are far below allowable levels based on the Lake Champlain total maximum daily load (see figure adjacent). Owing to the major success of point source controls in Vermont, non-erosion phosphorus is viewed as a lower-ranked stressor to Vermont waters. However, no empirical studies are available to assess the extensiveness of other non-erosion nutrient sources such as application of fertilizers or agricultural leachate in Vermont. There are only a few streams reaches, and no lakes, where impairments exist as a result of nitrogen loading.

What objectives are achieved by managing Non-Erosion Nutrient and Organics Loading?

Successful control of excessive nutrient loss meets Objectives A, B, D of this Strategy.

Objective A. ***Minimize Anthropogenic Nutrient and Organic Pollution***

Nutrient loads from any anthropogenic source can enhance the rate of eutrophication in surface waters.

Objective B. ***Protect and Restore Aquatic, and Riparian Habitat***

In some circumstances, nutrient loads and the associated decomposing organic debris can accumulate over the long-term in the deep waters of lakes. One result of this is the depletion of oxygen, and the development of so-called "hypoxic" deep water areas that are unsuitable as fish and invertebrate habitat.

Objective D. ***Minimize Toxic and Pathogenic Pollution, and Chemicals of Emerging Concern***

Excessive levels of phosphorus and imbalances in the ratio of nitrogen to phosphorus are known to promote blooms of cyanobacteria. These organisms can produce toxins that have significant health effects on humans and other animal species (see Chapter 2, Stressor Document on Toxic Substances for more information).

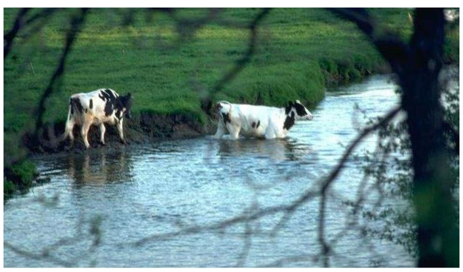
What are the causes and sources of Non-Erosion Nutrient and Organic Loading?

There are five principal causes of non-erosional nutrient and organic loading to Vermont's surface waters. They are:

Domestic and industrial wastewater

Direct discharges from industrial facilities and municipal wastewater treatment facilities are operated under NPDES and State permits which are crafted to limit the release of pollutants, including nutrients and organics. The limits are derived from existing TMDLs, the ability of the receiving waterbody to assimilate pollutants, available technology as well as some cost benefit calculations. In addition, releases of excess nutrients and organics can occur in these facilities due to seasonal factors or process upsets, combined sewer overflows during wet weather, and underperformance of infrastructure.

In addition, nutrients can be released due to poor maintenance of septic systems and underperforming indirect discharges.



Poorly-managed animal wastes and silage leachate

Inadequate farm production area management (including undersized manure storage or barnyard and feed storage area concerns) may in some circumstances result in direct runoff of manure or leachate to surface waters. Ongoing operation and maintenance of infrastructure to address these nutrient sources is critical to the practice success. Some infrastructure, such as silage leachate systems require ongoing maintenance to ensure containment of the runoff.

Over-application of fertilizer on residential lawns and croplands, and improper spreading practices

Overfertilization can lead to excess levels of soil phosphorus and elevated levels of nitrogen in surface and groundwater. The potential for overfertilization of Vermont lawns is high as local studies indicate that the soils already contain sufficient phosphorus for turf growth. Supporting studies include the Northeast Voluntary Turf Fertilizer Initiative, a St. Albans City study by Erica Gaddis, PhD, and a Lake Champlain Committee review of 2000-2002 UVM extension soil test of residential lawns throughout the state (pers. comm. Mike Winslow). Over fertilization does not promote better turf growth, but rather results in excess phosphorus runoff into surface water drainages, and ultimately into streams and lakes.

As of 2012, Vermont prohibits the application of phosphorus fertilizers to turf except in certain circumstances. Fertilizer with phosphorus may be applied to new lawns or if a soil test indicates a phosphorus deficiency.

Over-application of nutrients on agricultural croplands can also be a potential source of phosphorus and nitrogen to surface waters. Stormwater can carry leached nutrients to subsurface perforated pipes that are installed to drain fields. The discharge from the tile drains is often directed towards streams or other waterbodies. While the practice can reduce overland flow and therefore the erosion of soil, it can also lead to increased discharge of soluble phosphorus and nitrogen.

All farms in Vermont must conduct soil tests for phosphorus and adjust application rates accordingly as required by the state Required Agricultural Practice regulations. In addition, large, medium, and certified small farms are required to have a detailed nutrient management plans that is developed by a certified planner.

Legacy phosphorus loading from sediments

Internal phosphorus loading in lakes results from historic accumulation in deep lake sediments. Under the right environmental conditions, they may be released from the sediments to the overlying waters, resulting in algae and cyanobacteria blooms. This phenomenon is one factor contributing to the excessive phosphorus levels found in St. Albans and Missisquoi Bay of Lake Champlain. In Lake Morey (Fairlee, Vt.), an internal phosphorus loading problem was successfully controlled in the late 1980's, resulting in restoration of that lake that has been sustained to the present day. A second lake, Ticklenaked Pond in Ryegate, was treated in 2014. These two small lakes were selected for application of chemical treatments due to the likelihood of success and relatively low cost of treatment. However, the costs associated with similar treatments large embayments, coupled with uncertainty about the likelihood of treatment success, reduces the attractiveness of implementing this type of solution for St. Albans and Missisquoi Bay.

Leaching of nutrients from organic material (e.g., leaves and yard/garden waste) from urbanized areas and soil

Phosphorus is part of the matrix of molecules that make up organic material and is released to waterways through the decomposition process. In a natural system, the nutrients would be adsorbed to soil particles or taken up by plants; but where leaves collect at the edge of roads, stormwater can carry the leached nutrients to storm drains. Research from the Midwestern United States indicates that as much as 25% of the phosphorus in stormwater runoff is attributable to leaf debris and other yard wastes (Lehman et al, 2009). Where stormwater saturates soils, phosphorus can also be leached out as the stormwater percolates downslope through soils and eventually carried to storm drains.

Organic Pollution and Biochemical Oxygen Demand (BOD)

The presence of discharged organic materials, coupled with the organic matter from algae that proliferate as a result of nutrient discharges, contribute to accelerated bacterial growth in surface waters. These bacteria effectively decompose organic materials while consuming dissolved oxygen (DO), thus reducing the available DO for fish and other aquatic organisms. Biochemical Oxygen Demand (BOD) is a measure of the oxygen needed by microorganisms to decompose discharged organic matter and nutrients. The more organic waste present, the more bacteria are needed to decompose this waste. BOD is regulated in all Vermont direct waste discharges.

About the Long Island Sound Nitrogen TMDL

Low dissolved oxygen (DO), or hypoxia, has been identified as a major concern in Long Island Sound and is caused by excess nitrogen loading. To address the excess nitrogen, and resulting DO problems, US EPA – Region 1 developed a Total Maximum Daily Load for nitrogen.

With respect the Vermont's nitrogen contribution, modeling studies indicate:

- The estimated nitrogen contribution from Vermont is 7%. When inputs of nitrogen from direct precipitation on the Sound are accounted for, Vermont's contribution falls to about 4% of total loading to LIS.
- The estimated Vermont contribution from wastewater treatment facilities is 1% of the total point source load to the LIS.
- The estimated Vermont contribution from nonpoint sources is 18% of the total nonpoint source load to the LIS, but over half of this is due to nitrogen in precipitation which may or may not originate in Vermont.

Various nitrogen reduction scenarios have been analyzed to estimate the improvement in DO response in the Sound, and results indicate that if the entire load from Vermont was eliminated (all point and nonpoint), the average DO improvement would be 1%. Despite Vermont's small contribution to water quality problems in LIS, the Department of Environmental Conservation continues to work collaboratively with LIS states and US EPA to ensure Vermont's participation in the LIS TMDL.

During 2013, the Department worked with EPA to develop a plan to allocate an interim total wasteload of 1,727 lbs nitrogen per day across all municipal wastewater treatment facilities in Vermont's portion of the Connecticut River Basin. Reductions will be achieved through a mix of low-cost retrofits and operational adjustments, and in some instances, upgrades with wastewater treatment facilities.

Monitoring and assessment activities to assess effects of Non-Erosion Nutrient and Organics Loading

Monitoring and assessment of non-erosion nutrients and organics is coordinated by VTDEC and partner organizations under the following:

Department of Environmental Conservation
WSMD's Ambient Biomonitoring Network Program: The "ABN" monitors approximately 125 sites per year for water quality measurements and biological condition. The ABN ensures that nutrients are monitored in waters up and downstream of wastewater treatment facilities, for all facilities within the current-year monitoring rotation.

In concert with ABN, a study was conducted in 2012 within the Connecticut River Basin to develop facility-specific loading information for nitrogen. This supported development of a Vermont-specific nitrogen wasteload allocation for the Long Island Sound TMDL.

The Wastewater Management Program processes discharge monitoring reports submitted by permittees subject to NPDES and State discharge permits for wastewater facilities. As permits are re-issued, additional monitoring requirements are commonly inserted to assess the degree to which discharges will influence receiving water nutrient, dissolved oxygen, and other pollutant concentrations, and related biological integrity.

Lake Champlain Long-term Monitoring Program: This program tracks long-term trends in nutrients in Lake Champlain tributaries and also summarizes annual wastewater treatment facility phosphorus loads for facilities in the Lake Champlain Basin based upon the discharge monitoring reporting.

LaRosa Environmental Partnership Program: The LaRosa Program enables Vermonters to test water quality conditions in waters of mutual interest to VTDEC and watershed organizations.

Stormwater Multi-sector General Permit Monitoring Requirements: This permit program carries monitoring requirements that are carried out by regulated permittees that include hydrologic and chemical measurements.

Stormwater Mapping and Illicit Discharge Detection and Elimination (IDDE) Project: This VTDEC program maps stormwater infrastructure to identify potential cross connections to municipal sewer systems, and identify deficiencies for repair.

Lake Champlain Basin Program: The Lake Champlain Basin Program supports phosphorus and nitrogen cycling studies through its technical program, and funds the Long-term Monitoring Program. Numerous studies have been conducted relating to nutrient concentrations and effects in the Lake Champlain Basin.

Key Monitoring and Assessment Strategies to Address Non-Erosion Nutrients

The monitoring programs listed above should be continued. In addition, the following strategies have been identified.

Wastewater Discharges

As practical, the Department should provide annual estimates of nutrient loads from wastewater treatment facilities.

LaRosa Partnership participants should be encouraged to partner with municipalities to obtain relevant monitoring information at reduced expense to municipalities.

Agricultural and Developed Land Nutrient Sources

Current river-mouth monitoring may not fully capture non-erosional nutrients from agricultural and developed areas. Watershed-based monitoring designs that test both nitrogen and phosphorus at a range of flow conditions should be targeted in a rotational basis as part of the Tactical Planning Process, leveraging LaRosa Partnership resources as available. Resulting data can be used to support targeting of best management practices as necessary, and to support effectiveness monitoring.

The Monitoring, Assessment and Planning Program may assist AAFM where practical in conducting water quality monitoring as determined to be necessary as a result of farms inventories conducted under the Required Agricultural Practices rule.

The precise geographic locations of pipes discharging to surface waters from all sources should be integrated from the IDDE and geomorphic assessment programs.

Tile draining, the installation of subsurface drainage pipes, is an agricultural practice that can reduce land erosion and its related potential phosphorus contribution by increasing infiltration rates of soils to reduce surface flows. The practice is popular because it increases field productivity and decreases gully erosion in fields; however, the practice may enhance non-erosional nutrient loading to surface waters through the mobilization of soil nutrients to the tiles and increased channel erosion. The Lake Champlain Basin Program has funded a literature review in 2016 that provides a better understanding of both the advantages and disadvantages of the practice when used throughout the Lake Champlain Basin. The VAAFM will be providing a full report on tile drainage and water quality impacts to the Legislature in 2017.

Technical assistance programs to address Non-Erosion Nutrient and Organics Loading

Technical assistance to address non-erosion nutrients is coordinated by VTDEC and partner organizations under the following:

Department of Environmental Conservation
Watershed Management Division

- Stormwater Mapping and Illicit Discharge Detection and Elimination Project
- Concentrated Animal Feeding Operation Permit Program – staff support
- Wastewater Management Program – Operations and Management Section

Facilities Engineering Division

- Design, Construction, and Financial Management Sections

Drinking Water and Groundwater Protection Division
Innovative and Alternative Systems
Agency of Agriculture, Food and Markets
(although these are permit programs, staff support provide significant technical assistance):

- Required Agricultural Practice regulations
- Medium Farm Operations Permit Program
- Large Farm Operations Permit Program

Agency of Agriculture, Food and Markets/USDA Natural Resources Conservation Service – Vermont Association of Conservation Districts

- Conservation District Technical Assistance Program
- Required Agricultural Practices Assistance
- Farm*A*Syst
- Land Treatment Planners

New England Interstate Water Pollution Control Commission

- Wastewater Treatment Facility Nitrogen Removal Optimization Study – 2013

Vermont Rural Water Association

- Training programs for wastewater and source water protection

Key Technical Assistance Strategies to Address Non-Erosion Nutrients and Organics

The technical assistance programs listed above do a good job at supporting control of non-erosion nutrients and organics, but are not extensive enough to cover the number of farms in Vermont. As appropriate, WSMD staff should continue to cooperate with AAFM and VACD/NRCD programs to target education and technical assistance to areas where monitoring and assessment data suggest it is most highly needed (Critical Source Areas).

One full-time Technical Assistance position in the Wastewater Management Program – Operations and Management Section needs to be restored. This position provided invaluable assistance to wastewater treatment facilities on improving process control to maintain compliance with permit limits for nutrients and organics. This position was eliminated in 2009 and the program does not have the staff resources to provide technical assistance. With the implementation of the new Long Island Sound TMDL for nitrogen, 34 municipal wastewater treatment facilities are required to optimize their processes to achieve nitrogen removal. When the revised Lake Champlain TMDL for phosphorus is implemented, many wastewater treatment facilities may need to increase phosphorus removal. A full-time Technical Assistance person will provide critical support to these facilities in meeting the new regulatory requirements.

Additional technical assistance has been available to farms in the Lake Champlain Basin since 2011 due to short-term federal funds. These included four agronomists (through UVM Extension and the Poultney Mettowee Conservation District), engineering, grazing, and mapping specialists. These 12 positions have provided assistance in farm structural design, and field practice education and change, mostly focused on smaller farms that are not subject to the medium or large farm permit programs. Technical assistance and nutrient management implementation have been provided to hundreds of farms in the Basin and involved many thousands of acres of land. These positions are all scheduled to expire by the end of 2014. Funding for the continuation of the short-term agronomists and other technical service providers is critical to the ongoing agricultural management improvements in the Lake Champlain Basin and additional resources are needed outside the Basin for water quality improvement in other watersheds.

Stormwater mapping and IDDE efforts are coordinated as appropriate within the tactical planning process to further target municipalities where infrastructure mapping has not yet been carried out. Staff from this program work in collaboration with municipalities to design remediation steps that address the deficiencies identified, as well as pursue strategic stormwater treatment retrofits identified through the mapping effort. An analysis between traditional and Green Infrastructure (GI) approaches is typically completed as part of this process. Targeted municipalities are identified in the implementation tables of all new and forthcoming Tactical Basin Plans.

Regulatory programs to address Non-Erosion Nutrient and Organics Loading

Regulation of non-erosion nutrients and organics is coordinated by VTDEC and partner organizations under the following:

Department of Environmental Conservation

Watershed Management Division:

- National Pollutant Discharge Elimination System (NPDES), Pretreatment, and State wastewater permits
- NPDES Concentrated Animal Feeding Operation (CAFO) permit program
- Stormwater permits including Multi-Sector General Permit Program
- Reasonable Potential Analyses for wastewater permits
- Wastewater treatment facility inspections, permitting, compliance, and Wastewater Operator Certification Program

Drinking Water and Groundwater Protection Division:

- Indirect Discharge Permits, including Sewage General Permit for Septic Systems
- State's Universal Jurisdiction over onsite wastewater systems, less than 6,500 gallons per day
- Groundwater Protection Rule

Agency of Agriculture, Food and Markets

- Large Farm Operations Rule
- Medium Farm Operations Rule
- Required Agricultural Practices Rule
- Act 37 - Vermont Turf Fertilizer Law

Key Regulatory Strategies to Address Non-Erosion Nutrients and Organics

The VTDEC and AAFM regulatory programs listed above address the vast majority of directly and indirectly discharged non-erosion nutrients and organics from farms, however additional resources are needed to monitor and ensure compliance with these regulations. One new small farm operations inspector position has been added to VAAFM, but there are about 850 small dairy farms, and unknown hundreds of small non-dairy livestock farms in VT. Additional staff resources are needed to ensure compliance with the AAPs by all small livestock farms.

Revisions to the AAPs are currently being considered that would require a small farm certification program and changes in livestock exclusion, buffers and soil erosion tolerance on farms. A template for a small farm Nutrient Management Plan is also being developed.

In the past year, the Watershed Management Division has developed a revised approach to ensuring that where possible, NPDES permit limits do not have a reasonable potential to cause or contribute to impairment, by implementing a "Reasonable Potential Analysis" procedure. (This does not apply to the Concentrated Animal Feeding Operations (CAFO) permit as outlined in Clean Water Act requirements.)

In addition, the issuance schedule for NPDES direct discharge permits now follows the rotating monitoring, assessment, and tactical planning schedule described in Chapter 4 of this Strategy and the Lake Champlain TMDL. This ensures that reasonable potential analyses benefit from up-to-date monitoring information.

Funding programs to address Non-Erosion Nutrient and Organics Loading

Department of Environmental Conservation:
Clean Water State Revolving Fund, and the Intended Use Plans
Link to currently available funding including

- Vermont Watershed Grant Program
- Ecosystem Restoration Grant Program
- EPA 319 Funding Program (pass through funds are currently not available)

Agency of Agriculture, Food, and Markets:
Links to financial programs

Natural Resources Conservation Service:
Links to:
Environmental Quality Incentive Program (EQIP)
Conservation easement (Farm and Ranchland Protection Program)
Wetland Protection programs (WRP)
Cooperative agreements for technical assistance positions

Lake Champlain Basin Program
Links to:
Pollution Prevention Grants
Education and Outreach Grants
Watershed Environmental Assistance Program

Key Funding Strategies and Next Steps to Address Non-Erosion Nutrients and Organics

The Clean Water State Revolving Fund (CWSRF) is a major funding source for wastewater infrastructure. It is designed with a priority system to ensure that the most important remaining point-sources are addressed earliest, and the technical assistance provided by the Wastewater Management Division programs listed identify facilities in need of upgrading. The priority system established within the SRF may earmark up to 20% of funding for Green Infrastructure/Low Impact Development funding. In order to maximize the nutrient reductions achievable through the SRF, funding algorithms may need to be modified in order to give more weight to stormwater management projects, which currently tend not to score well when compared to wastewater projects. Incentives could be provided in the form of lower interest charges on loans to promote increased use of SRF for stormwater infrastructure improvement.

Funding for improved farm production area design, manure storage and nutrient management are critical. Primary sources of funding are the federal NRCS' EQIP program and the state VAAFM's Best Management Practice (BMP), Farm Agronomic Practice (FAP) and Capital Equipment Assistance (CEAP) programs. These programs offer cost-share assistance (generally 75-90%) to producers to support infrastructure construction as well as cost-share and technical assistance for changes in field based practices. Participation in these programs is voluntary, however all agricultural technical support staff work with farmers to direct them to these resources when water quality issues are found. To maximize the environmental gains through these programs, outreach and education is being focused on critical source areas (Identification of Critical Source Areas of Phosphorus Within the Vermont Sector of the Missisquoi Bay Basin. Technical Report # 63B) as determined by extensive mapping and assessment work. Additional LIDAR data that is being gathered currently will extend our ability to map these critical source areas throughout the Champlain Basin, with the hope of statewide mapping within the next two years. The Clean Water Roadmap presents the results of the Lake Champlain phosphorus model used to develop the phosphoprus TMDL for all areas of the Lake Champlain Basin.

An Agricultural Workgroup (AWG) of farmers and technical service providers was created to help DEC and VAAFM evaluate potential changes in regulatory programs as well as new incentive programs that will focus on additional improvements in agricultural water quality. Also, the agronomists and other field staff have been instrumental in educating about current and potential opportunities and providing valuable technical feedback to the agencies. DEC is using this input to address the needs of the upcoming TMDL as well as other future TMDLs and water quality needs statewide.

Information and education programs to address Non-Erosion Nutrient and Organics Loading

Department of Environmental Conservation

Watershed Management Division, Lakes and Ponds Section

Other

UVM Lake Champlain Sea Grant Programs

Lake Champlain Basin Program's "Lawn to Lake" group and associated "Don't P on your Lawn" campaign

Chittenden County's Regional Stormwater Educational Program (RSEP) and associated Stream Team project.

Various short term programs through NGOs and watershed groups

Key Education and Outreach Strategies to Address Non-Erosion Nutrients and Organics

The Agency of Natural Resources leaves much of the education of non-erosion nutrient and organics issues and interventions in the hands of other entities. The Vermont Association of Conservation Districts, in partnership AAFM and NRCS carry out the majority of educational efforts for agricultural lands.

In urban settings, the 2012 law restricting use of lawn fertilizer does require all retailers to post information about the law. Otherwise, education to help residential home owners reduce stormwater volume as well as fertilizer application is limited geographically and varies in effectiveness. A small-scale effort is provided by a loose partnership of non-governmental entities and DEC with limited funding from the Lake Champlain Basin Program, and educational efforts by watershed groups and others are funded through various grants. The “Lawn to Lake” effort is a collaboration of WSMD, AAFM, and LCBP to provide education about the new fertilizer restrictions on lawns. Additional support of the effort through all agency publications is needed. The Lawn to Lake organization distributes “Don’t P on the Lawn” brochure as well as signs for retailers that highlight the fertilizer ban on lawns for customers. The current approach would benefit from adequate resource support for developing and implementing a social marketing campaign to encourage adoption of residential BMPs; a current expertise of the Lake Champlain Sea Grant. Campaigns that are effective and far reaching require more funds then are available through current grant programs.

Towns and other entities subject to MS4 stormwater permitting develop and distribute education about the source of stormwater and residential BMPs for protecting surface waters from stormwater. To meet permit criteria, they provide information on websites, displays, commercials, and factsheets. Most recently towns have encouraged residents to reduce P fertilizer use by offering free soil test kits.

In municipalities subject to mandatory stormwater pollution control efforts at the individual parcel level (e.g., where total maximum daily loads and residual designation authority has been imposed), considerable education and outreach effort is provided to residents on how to comply with the stormwater control requirements. Materials developed for that purpose should be made available to residents and officials in other municipalities, coincident with a coordinated outreach effort.

Wastewater Treatment Facilities provide vital nutrient removal from the water environment. Many host tours to help communities understand the integral role the community wastewater facility provides in public health and environmental protection. The community supports these actions through user fees and capital improvements.

WSMD staff may assist DEC’s Environmental Assistance Program in encouraging businesses to implement water quality protection BMPs or meet municipal compliance in MS4 communities.

What are pathogens?

Waterborne human pathogens are disease-causing bacteria, viruses, and protozoa. The pathogens that are of concern in Vermont surface waters are those that come from fecal matter of humans and other warm-blooded animals. These pathogens may cause gastrointestinal problems and pose a more serious health risk to people who have weakened immune systems. Untreated surface waters containing fecal matter may pose a risk to human health when ingested through drinking water or inadvertently through contact recreation.

The primary indicator of fecal material in water used in most freshwater monitoring efforts is the enteric bacterium *Escherichia coli*. *E. coli* is a common component of the bacterial flora of humans and other warm-blooded animals. When detected in rivers, lakes, ponds, streams, or drinking water, *E. coli* may indicate that fecal material has made its way into the water. *E. coli* is therefore used as an indicator of potential fecal contamination of the water. *E. coli* are pathogenic in and of themselves, but the presence of *E. coli* is used in monitoring programs to indicate that other more common fecal pathogens may also be present, including pathogenic viruses, protozoa, or bacteria. While water contaminated with fecal material may contain pathogens, these pathogens may not survive outside the intestines for long periods of time and therefore may not stay alive in the water (Schaechter, 1992).

Based on epidemiological studies, the risk of contracting a gastrointestinal illness from swimming in water contaminated with a given concentration of indicator bacteria can be estimated. Vermont's water quality criterion for *E. coli* bacteria for Class B waters is 77 *E. coli*/100 ml in a single sample. This is the most stringent standard in the United States. This conservative standard of protection is readily exceeded due to natural *E. coli* sources, (*e.g.*, wildlife, run-off) that do not reflect the same risk level as those identified in the above mentioned epidemiological studies. In order to assess waters for support of contact recreation using *E. coli* monitoring data, DEC considers at least five reliable and quality assured sample results over a swimming season and gathered across a range of weather/flow conditions to be the minimum practical number of samples necessary.

Groups of Pathogens:

Bacteria: *The waterborne zoonotic bacteria are principally those shed in feces by warm-blooded animals (birds and mammals), including Escherichia coli or E. coli.*

Viruses: *Viruses are tiny infectious agents consisting of genetic material (DNA or RNA) encapsulated by a protein coat and incapable of multiplying outside the host, but often associated with larger particles in the water environment.*

Protozoa: *Protozoan pathogens, including microsporidia, amoebae, ciliates, flagellates, and apicomplexans, originating in human or animal feces, have been found in surface waters worldwide.*

Emerging or Re-emerging Infectious Disease: *A disease whose incidence has increased in recent years or is expected to increase in the near future. Primary amoebic meningoencephalitis (PAM) caused by Naegleria fowleri is an example of an emerging waterborne infectious disease in the United States*

How important are Pathogens?

Based on the Watershed Management Division's stressor evaluation, pathogenic bacteria is considered a lower-ranked stressor (in relation to the other 10 priority stressors), in that known affected areas are discrete and effects typically localized, and when addressed, impacts are rapidly mitigated. However, where pathogens are regularly monitored and found to be chronic in frequency and excessive in numbers, swimming and other contact recreation use is affected.

The extensiveness of pathogenic impacts varies depending on geographic location and also on precipitation. For example, *E. coli* may be widely detectable in surface waters following a significant rain event, particularly in agriculturally-dominated watersheds. Conversely, in forested watersheds during low flow, low concentrations of *E. coli* are noted. However, events in the absence of both land use and climatological influences can cause exceedences in *E. coli*, such as improper waste water treatment from facilities or septic systems.

The most recent statewide water quality assessment indicates that nearly 100 stream miles are identified as impaired due to pathogens indicated by *E. coli*, and contamination in Vermont's waters continues to be a problem across the state. Over 20% of the waterbodies identified on the 2008 303(d) List of Impaired Waters has been listed because of elevated *E. coli* concentrations. The incidence of excessive *E. coli* concentrations is most prevalent in rivers and streams. Available monitoring data indicate that very few lakes and ponds exhibit high *E. coli* concentrations. The Watershed Management Division is currently investigating potential methodologies to develop Total Maximum Daily Load pollution control plans for these waters. While TMDL development, or identification of the total loading limits of *E. coli* for these impairments is a relatively simple exercise, 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 Mettowee 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. The Division is also working with USEPA contractors to develop TMDL's based on a method developed in the state of New Hampshire.

The duration or fate of pathogens in the environment tends to be relatively short-lived. However, where sequestered in soils and sediments, *E. coli* bacteria can be mobilized during periods of land and streambank erosion and can enter surface waters. It is unclear whether other pathogens that may be indicated by *E. coli* can also survive in soils and sediments. Specifically, while *E. coli* can survive and reproduce with or without oxygen, *bacteroidales*, the bacteria that were used for the genetic marker testing, cannot survive in the presence of oxygen. This difference in survivability between these two species of bacteria complicates the understanding of the fate and transport of legacy bacteria.

Generally, the more sediment runoff, the more potential for transport of *E. coli* bacteria. Controlling sediment runoff on tributaries as well as mainstem streams can certainly go a long way towards decreasing concentrations of many pollutants, including nutrients, metals, and bacteria in streams. In addition, there could be some legacy amounts of these constituents stored in streambank or streambed sediments that can be cycled back into the water column, but these sources are difficult to parse out in conventional water quality monitoring of pathogens.

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 erroneous interpretation of now outdated 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 literature indicates corresponds to a risk of approximately 8 gastrointestinal illnesses per 1000 swimmers who frequent beaches adjacent to municipally-discharged wastes subject to minimal treatment. The current water quality criterion, when applied to guide beach closures, results in inaccurate public opinions about the suitability of surface waters for swimming, as is discussed fully in the Division's Citizens Guide to Bacteria Monitoring in Vermont. 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 polluted due to pathogens.

Objectives achieved by controlling excessive pathogenic bacteria

Addressing and preventing excessive pathogenic bacteria promotes several surface water goals and objectives, including:

Objective A. ***Minimize Anthropogenic Nutrient and Organic Pollution***

Managing activities (land uses) and discharges in ways that minimize or eliminate sources and exposure (via contact recreation) to pathogens also minimizes anthropogenic nutrient and organic pollution.

Objective D. ***Minimize Toxic and Pathogenic Pollution, and Chemicals of Emerging Concern***

Controlling the release of pathogens minimizes human exposure to pathogens.

What are the causes and sources of Pathogens?

Untreated/unmanaged Runoff from Developed Lands

Overland flow

Urban stormwater runoff occurs when precipitation collects and then runs off impervious surfaces, often directly into streams, rather than infiltrating into the soil. Stormwater in urban areas carries a significant load of pollutants to receiving water bodies. Concentrated activity in urban areas loads stormwater with fertilizers, road salt, animal feces, pesticides, oils, heavy metals, and decaying organic matter.

The bigger issue may be the changes in hydrology that occur in developed areas. Much of urban development involves the construction of buildings, roadways and parking – all of which create impervious surface, that both reduce infiltration and can speed the delivery of stormwater runoff to local receiving waters. These increases in stormwater runoff volume and rate (referred to collectively as "excess hydrology") can, in turn, increase rates of export of pollutants including sediment and sediment-bound phosphorus and other pollutants such as pathogens.

The end result of unmanaged stormwater can include the erosion of valuable property, degraded or destroyed aquatic life and wildlife habitats, algal blooms and pathogen contaminated beaches and water supplies.

Combined Sewer Overflows

In several of Vermont's larger communities served by Wastewater Treatment Facilities, combined sewer overflows (CSO's) represent an ongoing nonpoint source pollution problem. Strong state and federal standards are used in obtaining stormwater and or wastewater treatment permits. The standard used by Vermont for remediation for remediation of combined sewer overflows is to separate stormwater volumes from wastewater and to provide an acceptable level of treatment. Stormwater procedures encourage the use of overland flow and the attenuation of peak discharges and velocities.

Pet Wastes
In developed residential areas adjacent to surface waters, pet wastes can be a considerable source of *E. coli* bacteria and potential pathogens.

Agricultural activities

Agriculture has been identified as a contributor to surface water pollution in Vermont. While significant strides have been made to reduce agricultural nonpoint source pollution through the voluntary implementation of soil and manure management practices, agriculture remains one of the most significant potential sources of nonpoint source pollution. Inadequate animal waste and soil management results potential pathogen loading to surface waters and is the major source of agricultural nonpoint source pollution in the State. The following sources are described in Appendix C – Activities.

Farmsteads
Pastures
Cropland

Untreated or Improperly Treated Wastewater

On-site Septic Loads
Inadequate on-site septic systems can be a source of pathogens to surface waters. There are a number of historic villages in the state adjacent to rivers that do not have treatment facilities and where on-site septic systems are likely the source of elevated levels of E. *coli* in surface water. If a system is not working correctly and leachate is directly entering a lake, swimmers and other forms of contact recreation may expose users to high bacteria levels and potentially disease-causing organisms. (Note that such a system may not show any on-shore indications of malfunction.) This can happen under several conditions including when the soil below the leachfield is too shallow or too porous and leachate quickly joins the groundwater. Along a lakeshore groundwater is usually flowing toward the lake and entering the lake water through the lakebed.

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 2009, the towns of Addison and Peacham began such studies for their village centers.

Wastewater Treatment Facility Loads
Unlike nearly all of the other sources described in this chapter, wastewater discharges represent a regulated and readily measurable and controlled source of pathogens to waters in the state. There 91

municipal wastewater facilities statewide, and 81 industrial facilities all of which are subject to permit requirements requiring effluent limitations on *E. coli* at 77 *E. coli* /100ml.

Natural Sources

While forested watersheds generally have better bacterial water quality than that of other land uses (Kunkle and Meiman 1967, Kunkle 1970, Skinner et al. 1974, Doran and Linn 1979, Tiedmann et al. 1987, Niemi and Niemi 1991, Sargent 2001), these watersheds can nevertheless be important contributors to bacterial contamination downstream, due to wildlife sources. Several studies have documented the existence of indicator bacteria in "pristine" environments, even under non-storm conditions. Morrison and Fair (1966) reported coliform bacteria in "clean" streams in Colorado. Early studies by Kunkle and Meiman (1967) and Skinner et al. (1974) of natural areas essentially free of human impact consistently identified fecal coliforms, at low concentrations, although results were. much higher during non-storm events. A study of 3 small watersheds in Utah that had been protected from fire, domestic livestock, and timber cutting for 45 years yielded fecal coliform concentrations that ranged to maxima of 183 organisms/100 mL (Doty and Hookano, 1974). Ongerth et al. (1995) documented levels of fecal coliform higher than 100 organisms/100 mL in a pristine forested watershed, while Tiedmann et al. (1987) reported fecal coliforms in excess of 500 organisms/100 mL in forested areas of eastern Oregon that supported no domestic grazing. Recent local studies (Sergeant and Morrissey, 2000; Moir, 2003) tell us that under moderate rainfall, *E. coli* will be found in waters running off of completely undisturbed, forested watersheds at levels in excess of 77 E. coli /100ml, the current water quality criterion for Class B waters in Vermont.

Land use and pathogens:
Most studies quantifying the relationship between land use and water quality have been focused on sediment and nutrient loading, particularly phosphorus and nitrogen, and contamination by metals or toxic chemicals, but the spatial framework also applies to the study of bacterial water quality. Since watersheds integrate surface and subsurface flow of water above a sample point, they are appropriate spatial units for the study of nonpoint source stream pollutants like fecal bacteria (Omernik and Bailey, 1997). Cumulative impact studies have compared changes in water quality to changes in land use by locating sampling stations consecutively downstream. In the Appalachian Mountains of North Carolina, fecal coliform counts increased downstream as land use changed from forested to suburban (Bolstad and Swank, 1997). In a comparison of stream fecal coliform concentrations monitored above and below rural municipalities, the municipalities were found to contribute a significant amount of fecal bacteria to surface waters (Farrell-Poe et al., 1997). In contrast, Sargent (2001) found no difference between *E. coli* measurements above and below a Vermont village. However, she did find a significant negative relationship between watershed forest cover and *E. coli* concentrations in streams in the Mad River valley. Relating bacterial levels in streams to land use can be improved by aggregating and analyzing data within watersheds and drainage areas.

Streambed sediments as a reservoir of fecal bacteria:
Studies measuring the amount of bacteria found in streambed sediments and comparing it with levels in the overlying water column have documented that streambed sediments represent a significant reservoir of fecal bacteria. The phenomenon of deposition was demonstrated by a dye study conducted by Gannon et al. (1983), in which fecal coliform concentrations in bottom sediments were shown to increase in an upper area of the study lake while fecal coliforms in the water column were decreasing simultaneously. Gannon concluded that sedimentation of fecal coliforms attached to solid particles accounted for the high fecal coliform disappearance in that area of the lake. Van Donsel and Geldreich (1971) discovered approximately a 100-1000 fold increase in fecal coliforms in stream

sediments as compared to the overlying water. Stephenson and Rychert (1982) confirmed this finding with their own observations that E. coli concentrations in bottom sediment were 20-760 times that of the water. Both Crabill et al. (1999) and Buckley et al. (1998) observed fecal coliform sediment to water ratios of greater than 2000:1. There have also been several studies that did not directly sample the sediment, but instead used disturbance methods like raking to simulate the resuspension of the sediment and its associated bacteria such as would occur during recreational use or high stream flows. Sherer et al. (1988) found that manual disturbance of stream bottom sediments increased bacterial water concentrations an average of 17.5 times. Moir and Morrissey (in prep.) found that high storm flows are particularly effective in resuspending most of the fecal- bound sediments during a storm event. Thus recontamination of surface water can occur long after and at a considerable distance from the point of original fecal input to the stream.

Monitoring and Assessment Activities that Address Pathogens

Ambient Water Quality Monitoring Program Strategy

The Vermont ambient water quality monitoring program strategy provides a framework describing existing monitoring and assessment efforts in Vermont, and elaborates on elements of an ideal monitoring program to meet several objectives. The strategy has multiple uses and purposes, and is organized into USEPA's "Elements of a State Water Monitoring and Assessment Program" (March, 2003). This strategy presents a roster of specific monitoring goals and objectives, and a listing of existing and potential monitoring designs for Vermont waters. Recommendations for core and supplemental water quality indicators are provided (including pathogens). Detail is provided on quality control and assurance, data management approaches, a description of data analysis and assessment procedures, and the use of these procedures to support federally required reporting. The strategy also highlights approaches to developing nutrient criteria and modifying pathogen criteria.

Spotlight on Volunteer Monitoring

The Addison County Collaborative (ACC) is a volunteer-based consortium of local volunteer organizations that monitor waters in several watersheds in the vicinity of Addison County. Funding is typically allocated through the Addison County Regional Planning Commission and by member municipalities, with laboratory support from the LaRosa Partnership Program. ACC has monitored approximately 45 sites across several watersheds for *E. coli* and eutrophication-related parameters since 1992. ACC provides data and summary reports to VTDEC on an annual basis. These data are used to assist development and implementation of the Otter Creek and Lower Direct Champlain Basin Plans, and in Integrated Assessment reporting. ACC has provided valuable data in support of municipalities, and Division data needs. Several other LaRosa Partnership-supported groups support similar monitoring throughout Vermont.

LaRosa Laboratory Services Partnership Program

The VTDEC Watershed Management Division collaborates with the LaRosa Laboratory on a novel program to assist citizen monitoring groups statewide. Beginning in 2003, the Watershed Management Division and LaRosa Laboratory initiated analytical services partnerships with volunteer organizations, based on a competitive proposal process. The project has been extremely successful since its inception, when eleven projects were supported. These projects ranged in scope from small, single-lake studies to large, multi-year and multi-parameter watershed assessment initiatives that have included monitoring for pathogens.

Department of Forests, Parks and Recreation Monitoring

The Department of Forests, Parks and Recreation conducts weekly monitoring of E. coli indicator bacteria at all Vermont State Park beaches to post beaches when appropriate. The Division collects and stores these data annually to support individual surface water assessments.

Sanitary Surveys

A common perception in Vermont is that failing septic systems are a large source of fecal material, particularly to lakes. Determining the potential contribution of potentially failing septic systems is a tricky proposition, and is known as a 'sanitary survey.' Historically, testing of septic systems was accomplished using dye tablets, which were flushed down the toilet in a shoreline property with follow-up visual monitoring over the next several days to identify if and where dye may be leaching into the adjacent water. Additional information regarding sanitary surveys is also available in Chapter 4 of EPA's draft Ambient Water Quality Criteria for Bacteria (Appendix G, EPA, 2002).

Microbial Source Tracking

A relatively new monitoring technique, called Microbial Source Tracking (MST), analyzes the genetic fingerprint of the *E. coli* itself, to identify the organism that produced the fecal material containing the E. coli. Currently, there are different genetic techniques and approaches being developed for this purpose. This approach is still in the developmental stage, although it is likely to be a very valuable and powerful tool for identifying fecal contamination sources in the near future.

Basic concept The intestinal bacteria of animal groups (e.g. humans, livestock, and wildlife) are expected to be different and these differences can be detected by analyzing water samples in the laboratory. The relative difference between the different animal group intestinal bacteria in the water may provide evidence to determine from where the fecal contamination originated.

The research process

- → Characterize "reference material" (manure, scat, and sewage) from local sources. Scientifically, this step involves detection of specific DNA sequences (called "markers")
- → Test water for fecal contamination, i.e. *E. coli*.
- → Associate contamination with sources by matching markers in reference material with markers in water samples.

Stormwater Modeling/ Stormwater Mapping

Stormwater sometimes follows more of a hydro-illogical pattern, depending on the construction of roads rather than natural topography. To find out the path of stormwater and the pollutants it can carry, a GPS can be used to determine the coordinates of culverts, manhole covers, storm drain inlets, and outlets. Empirical information (such as water quality data) and observations on rainy days are utilized to clarify which direction stormwater travels through ditches and gutters that eventually drain into rivers and streams.

Once the series of storm drains and gutters is mapped out, this data was used to build a drainage network in a GIS or Geographic Information System. This digital drainage network provides a better understanding of how different urban areas in the state affect adjacent surface waters. Next, monitoring equipment can be placed where the surface water connects to the stream and water samples collected. Using the GIS, monitoring equipment and water quality collection in unison will help narrow down potential sources of water pollution that are being flushed into these surface waters.

Key Monitoring and Assessment Strategies to Address Pathogens

- ➢ Integrate existing stormwater mapping, water quality data, biomonitoring data, riparian corridor assessment (SGA-buffer gap analyses) and agricultural (NRCS) flow monitoring data in Agency GIS systems to enhance river corridor protection and basin planning capabilities. This strategy would engender the establishment of a map-based reporting program that could tailor outputs to assist the technical assistance, regulatory, and funding decisions of the ANR (e.g., within the Tactical Planning process) and other agencies.

- Identify public swimming beaches at lakes and ponds (either municipal swimming areas or state parks and other public lands). Work with communities, lake and pond associations, and others who are testing for indicators of pathogens and other health threats.
- Consider development of an electronic reporting system that can enumerate *E. coli* levels at public swimming holes that are monitored. This monitoring/ reporting program is intended to be used as a reporting tool at swimming areas to post episodic increases in bacteria levels. Results from such program could be used as public notification and information for decision-making for contact recreation activities. The use of VTDEC bacteria monitoring protocols will be imperative in this process.
-

Solution(s): 1) Increase pathogenic-bacteria monitoring at public swimming beaches at lakes and ponds by directing citizen groups supported through the LaRosa Partnership Program towards these areas. 2) Set up an electronic notification system for user groups and the general public to access *E. coli* monitoring results so that citizens engaged in contact recreation can make informed decisions for when and where to conduct that activity. 3) Continue to work with EPA to explore availability of federal funding mechanisms to support beach monitoring and reporting efforts.

- Through bracketed monitoring, investigate areas indicating high *E. coli* to determine the sources.

- Continue to address episodic overflows at wastewater treatment facilities where upgrades, expansion, and additional improvements are needed (such as under-sized pump stations).

Develop water quality bacteria monitoring data to better guide the assessment of pathogenic stressor impacts and the alternatives analysis for BMPs and projects to protect and restore existing uses such as swimming and other forms of contact recreation.

Technical assistance programs to address excessive Pathogens

Technical assistance to address pathogens is coordinated by VTDEC and partner organizations under the following:

Department of Environmental Conservation:
Facilities Engineering Division – Clean Water Revolving Fund
Wastewater Management Division - Design/Engineering Program
Wastewater Management Division – Operations and Management Program
Wastewater Management Division – Innovative and Alternative Systems
Watershed Management Division – Stormwater section assistance to municipalities (MS4, MSGP)
Watershed Management Division – Stormwater Mapping and Illicit Discharge Detection and Elimination Project

Agency of Agriculture, Food, and Markets

Farm Agronomic Practices (FAP)
Large Farm Operations (LFO) Program
Medium Farm Operations (MFO) Program
Conservation District Technical Assistance Program
Required Agricultural Practices Assistance
Farm*A*Syst
Land Treatment Planners
Farm Agronomic Practices Program (FAP)

New England Interstate Water Pollution Control Commission
Wastewater operator certification program

Vermont Rural Water Association
Training programs for wastewater and source water protection

Key Technical Assistance Strategies and Next Steps to Address Excessive Pathogens

- The technical assistance programs listed above do a good job at supporting control of excessive pathogens and should be continued. As appropriate, WSMD staff should cooperate with AAFM and NRCD programs to target technical assistance to areas where monitoring and assessment data suggest it is most highly needed.

- The addition of new agricultural extension agents in 2011 will enhance technical assistance capabilities of the conservation districts with assistance from the Lake Champlain Basin Program and UVM Extension to provide assistance and treatment designs in agricultural areas.

- Stormwater mapping and Illicit Detection and Discharge Elimination (IDDE) efforts should be continued, but coordinated as appropriate within the tactical planning process to further target municipalities where infrastructure mapping has not yet been carried out. Staff from this program work in collaboration with municipalities to design remediation steps that address the deficiencies identified.

- Encourage farmer participation in Nutrient Management Planning beyond the regulations governing Large and Medium Farm Operations.

- Buffer Outreach projects and federal cost-share programs should target sensitive riparian areas characterized by a lack of riparian vegetation that would benefit from the re-establishment of a vegetated riparian buffer. Encourage riparian landowners (and incentives, if possible) to maximize the width of buffer zones adjacent to the tributaries and the river itself.

- Assist farmers with manure storage and application practices. Help direct federal cost-share and other funding sources towards manure storage and handling improvement projects. Manure spreading close to tributaries and the river itself should be discouraged, especially in areas where the ground slopes into the water.

Regulatory programs to address Pathogens

Regulation of pathogens is coordinated by VTDEC and partner organizations under the following:

Department of Environmental Conservation:
Wastewater Management Division, National Point Source Discharge Elimination System Program
Wastewater Management Division, Vermont Indirect Discharge Permits
Wastewater Management Division, Residual Wastes Permits
Wastewater Management Division, Indirect Discharge of Sewage General Permit for Septic Systems
Wastewater Management Division, Concentrated Animal Feeding Operation Permits (pending)
Watershed Management Division, Stormwater Program Multi-Sector General Permit Program

Agency of Agriculture, Food and Markets:
Large Farm Operations
Medium Farm Operations
Required Agricultural Practices

Key Regulatory Strategies and Next Steps to Address Excessive Pathogens

The VTDEC and AAFM regulatory programs listed above address the vast majority of point-source pathogens, as such little additional regulation is needed. In order to assure more consistency in the standards for designing wastewater and water systems, the statute provided that all local ordinances and/or bylaws that regulated water and wastewater would be superseded (i.e. no longer in effect) as of July 1,2007. However, despite this Universal Jurisdiction, the following are key next steps.

- The Water Quality Criteria for *E. coli* in surface waters should be modified to reflect current EPA guidance.

- Consider evaluating AAP provisions to make clear manure management expectations for small farms, and possibly include additional management requirements for small farm operations.

- At present, a Concentrated Animal Feeding Operations general permit is in development, which confers regulatory oversight of certain on-farm pathogen-generating activities to the VTDEC. This general permit is being developed under EPA promulgation, in cooperation with AAFM.

Funding programs to address Excessive Pathogens

Department of Environmental Conservation:
Clean Water State Revolving Fund
Clean Water Act §319 Implementation Funding
Ecosystem Restoration Program Ecosystem Restoration Grants
Watershed Grants (jointly administered with Department of Fish and Wildlife)

Agency of Agriculture, Food, and Markets:
Best Management Practice (BMP) Program
Alternative Manure Management (AMM) Program
Nutrient Management Plan Incentive Grants (NMPIG) Program

Natural Resources Conservation Service:
Conservation Reserve Enhancement Program
Environmental Quality Incentives Program

Lake Champlain Basin Program:
Technical program grants
Local implementation grants

Key Funding Strategies and Next Steps to Address Pathogens

The Clean Water State Revolving Fund (CWSRF) is a major funding source for wastewater infrastructure. It is designed with a priority system to ensure that the most important remaining point-sources are addressed earliest, and the technical assistance provided by the Wastewater Management Division programs listed identify facilities in need of upgrading. As of 2009, the priority system established within the SRF may earmark up to 20% of funding for Green Infrastructure/Low Impact Development funding. In order to maximize the nutrient reductions achievable through the SRF, funding algorithms may need to be modified in order to give more weight to stormwater management projects, which currently tend not to score well when compared to wastewater projects. Incentives could be provided in the form of lower interest charges on loans to promote increased use of SRF for stormwater infrastructure improvement.

For agriculture sources, improved manure storage and management are critical. The two primary sources of funding for manure management systems are NRCS' EQIP program the AAFM's BMP program. Both programs offer cost-share assistance (generally 75-90%) to producers to support construction. Participation in both programs is voluntary. As a result, cost-share assistance tends to be biased towards producers who have pro-actively sought help from one or both funding agency(s), as opposed to the environmental risk/need associated with the operation. To maximize the environmental gains through these programs, it will be important to shift toward a model that involves more pro-active outreach to farmers. It is believed that the new extension agents will help in this regard, and AAFM has re-directed a portion of their Agricultural Resource Specialists time to identifying and prioritizing problem areas on small farms and connecting producers with implementation resources. ANR is also working with NRCS to establish a "showcase watershed" in Vermont, similar to a current effort in the Chesapeake Bay watershed; one component of such a program would be pro-active outreach to all producers within the basin.

Information and education programs to address Excessive Pathogens

Department of Environmental Conservation
Watershed Management Division, Lakes and Ponds Section – Lake Protection Series

Other
UVM Sea Grant Programs
Lawn to Lake group, "Don't P on your Lawn" campaign
Various short term programs through NGOs and watershed groups

Key Education and Outreach Strategies and Next Steps to Address Excessive Pathogens

Given the very stringent state standard for *E. coli* (77 colonies forming units per 100 milliliters), many public swimming area administrators are unsure of the proper protocol as to limit public access for water recreation when sample analysis exceeds the state standard. Inaccurate public opinions as to the suitability of swimming waters results. There exists a continuing need to improve public understanding of health issues related to water recreation and drinking water.

The Natural Resources Conservation Districts, in partnership AAFM and NRCS carry out the majority of educational efforts for agricultural lands.

In urbanized settings, education is limited geographically and varies in effectiveness. A small scale effort is provided by a loose partnership of non-governmental entities and DEC with limited funding from the Lake Champlain Basin Program, and educational efforts by watershed groups and others are funded through various grants. The current approach is piecemeal and would benefit from adequate resource support for developing and implementing a social marketing campaign to encourage adoption of residential BMPs (such as the "Poop the Scoop" campaign). Campaigns that are effective and far reaching require more funds then are available through current grant programs. Needless to say, additional sources of funds would be required to continually support these types of campaigns.

Towns and other entities subject to MS4 stormwater permitting develop and distribute education about the source of stormwater and residential BMPs for protecting surface waters from stormwater. To meet permit criteria, they provide information on websites, displays, commercials, and factsheets. In municipalities subject to mandatory stormwater pollution control efforts at the individual parcel level (e.g., where total maximum daily loads and residual designation authority has been imposed), considerable education and outreach effort is provided to residents on how to comply with the stormwater control requirements. Materials developed for that purpose should be made available to residents and officials in other municipalities, coincident with a coordinated outreach effort.

Further, WSMD staff could assist DEC's Environmental Assistance Program in encouraging businesses to implement water quality protection BMPs or meet municipal compliance in MS4 communities

What are Toxic Substances?

Toxic substances can be defined as broad group of chemicals capable of causing harm to plants and animals including humans. There are several classes of toxic substances that have the potential to affect surface waters in Vermont. While many Vermonters are aware that toxic mercury contaminates fish and fish-eating wildlife, there are many other types of toxic compounds that merit attention in this Strategy. For the purposes of this Strategy, toxic compounds have been grouped into five categories: atmospherically-deposited compounds; organic and inorganic contaminants that result from industrial, manufacturing or other point and non-point discharges from facilities; pesticides; contaminants of emerging concern (CECs); and biological contaminants. These groupings reflect the commonality of management options that are applied to address each contaminant group.

Mercury is the most well-known atmospherically-deposited contaminant. Mercury, a heavy metal, is emitted to the atmosphere by a wide variety of emissions sources, is readily bioaccumulated to hazardous levels in fish and fish-eating wildlife, and is a pollutant of global impact and concern. Mercury contamination has been widely studied in Vermont and New England. Other heavy metals (such as cadmium or vanadium) and certain "organic" contaminants (e.g., pesticides, dioxins) can also be atmospherically-deposited, although very few instances of this type of contamination have been documented in Vermont.

Organic and inorganic contaminants from municipal and industrial discharges, hazardous waste sites, landfills, storm water runoff comprise a wide variety of toxic constituents. Historically, compounds such as PCBs, or furans and dioxins were used in a variety of manufacturing applications. These compounds are now banned from use and only exist as "legacy" contaminants. Metals have also regularly been used in manufacturing (e.g., electroplating), and historically were commonly released to the environment. Facilities that store, distribute, or sell fuels may be sources of polycyclic aromatic hydrocarbons, which can contaminate groundwater and sediment. Mining is another source of metals that has localized effects in Vermont. Federal and State legislation and associated programs have addressed these sources in Vermont to a large degree, although legacy contamination persists. Road maintenance can result in discharges of toxic pollutants such as chloride and hydrocarbons to surface waters.

Groups of toxic substances:

Atmospheric: *contaminants that are emitted to the atmosphere and deposited upon Vermont's watersheds.*

Organic / Inorganic Contaminants *(PCBs, PAHs, Heavy Metals): that are directly or indirectly discharged from municipal and industrial wastewater treatment facilities, hazardous waste sites, landfills, stormwater runoff, and historic or ongoing discharges from manufacturing, fuel and roads.*

Pesticides: *insecticides, herbicides, fungicides, algicides, biocides used to control nuisances or pests that are applied to land or directly to waters.*

Contaminants of Emerging Concern (CECs): *mostly unmonitored and unregulated chemicals which have been recently "discovered" in wastewater discharges, ambient receiving waters, and drinking water supplies (e.g. pharmaceuticals, personal care products, industrial and household compounds, nano-technology products)*

Biological: *toxic compounds that are produced in nature (e.g. cyanotoxins)*

Pesticides are regularly used in Vermont, subject to regulation jointly by the Agency of Agriculture, and Department of Environmental Conservation, with assistance from the Department of Health. Cooling towers excepted, the largest usage of pesticides is in the agricultural sector, with lesser usage in smaller land uses, such as golf courses, urban grounds maintenance, railroad tracks, utility corridors, roadside guardrail maintenance, aquatic nuisance control, and forestry. The largest category of unregulated pesticide use is among private applicators and homeowners, who apply herbicides, insecticides, and fungicides to lawns, gardens and home. There is minimal to no reporting or tracking for private applicators and homeowner use and sales, even though this constitutes a significant portion of pesticides used in Vermont.

The use of traditional herbicides such as the corn herbicide Atrazine has declined somewhat in recent years, in favor of compounds that have much lower recommended application rates, more targeted toxicity, and faster environmental degradation times. This means that these compounds are not as readily released to surface waters, are thought to have lesser impacts, and may degrade faster. Limited research is available on the effects of these new pesticides on aquatic life.

Contaminants of Emerging Concern (CEC) are a group of mostly unmonitored and unregulated chemicals whose potential to impact the beneficial uses of water resources is largely unknown. CECs, which include pharmaceuticals and personal care products (PPCPs), polybrominated diphenyl ethers (PBDEs), veterinary drugs, and industrial and household compounds have been found at trace levels in wastewater discharges, ambient receiving waters, and drinking water supplies. They are pollutants not currently included in routine monitoring programs. PPCPs comprise a diverse group of chemicals including prescription and over-the-counter human drugs, fragrances, sunscreens, and antimicrobials. CECs from pharmaceuticals, antibacterial agents, detergents and cleaning products, personal care products such as soaps, shampoo, sunscreen, cosmetics, insect repellants and others, have been documented in Lake Champlain's tributaries, wastewater, and combined sewer overflows. Vermont's residents are both the source of, and solution to, this issue.

Quick-links

Topic	Appendix B of this Strategy	Other useful Websites
Contaminants of Emerging Concern	click here	NEIWPCC , EPA, USGS
Heavy metals	click here	EPA
Mercury	click here	HBRF
PCBs, dioxin, PAHs	click here	EPA
Pesticides	click here	Agency of Agric.
Cyanotoxins	click here	Dept. of Health

Although many of these compounds occur at very low levels, the potential risk to aquatic organisms due to exposure to CECs in the environment has been identified as a primary concern given that aquatic organisms may be continually exposed to chemicals, even over multiple generations. For humans, consumption of potable water which may contain trace concentrations of various CECs has been identified as one of the primary potential routes of exposure. To date much research has focused on the potential for development of pathogen resistance to antibiotics and endocrine disruption by natural and synthetic steroids. At this time, many unknowns remain regarding the potential for adverse effects on ecological receptors and humans from exposure to CECs in the environment. In some instances, it is combinations of low-level chemicals, as opposed to the occurrence of an individual compound that is of concern. There are 129 priority chemicals currently regulated by the USEPA under the Safe Drinking Water Act and Clean Water Act, but tens of thousands of CECs exist that may potentially require assessment to ensure that impacts to human and ecological health are minimal. The *Precautionary*

Principal, which has been adopted by the European Union as part of two major environmental directives, states that when there are suspected health or environmental concerns, preventative actions should be taken even when there is not a scientific certainty that harm will ensue.

A good example of an emerging class of contaminants with drinking water effects is called perfluorinated compounds (or PFCs). Some PFCs are ubiquitous at very low levels, but one PFC, called PFOA (or perfluorinated octanoic acid), was recently discovered in drinking and surface waters in southwestern Vermont, including North Bennington, Bennington, and Pownal, at levels of human health concern. PFOA is a manufactured PFC used to make household and commercial products that resist heat and chemical reactions, and repel oil, stains, grease and water. These chemicals are widely found in nonstick cookware, stain-resistant carpets and fabrics, water repellant clothing, paper and cardboard food packaging and fire-fighting foam. PFOA does not break down easily and therefore persists for a very long time in the environment, especially in water. Its toxicity and persistence in the environment means it is a potential danger to human health and the environment.

It is known that emerging contaminants undergo chemical reactions during wastewater treatment, and what is released to the environment is not always the same as what was sent into treatment. For example, recent scientific studies suggest that dioxin-like compounds found in sediments may result from chemical waste treatment reactions with triclosan instead of actual dioxins from industrial sources (triclosan is a very common antimicrobial agent contained in soaps and toothpaste). Many CECs are known to have endocrine-disrupting effects. For example, fluoxetine, the active ingredient of the antidepressant Prozac™ has been shown to alter the timing and effectiveness of reproduction in native freshwater mussels, while estrogenic contaminants from wastewater discharges have been linked to feminized male fish in several study areas. In 2009, the Vermont Advisory Committee on Mercury Pollution, under directive from the Vermont General Assembly, prepared a report regarding toxic substances management options for Vermont (http://www.mercvt.org/acmp/reports/2009ACT_report.pdf).

Some biologically-derived toxic compounds occur in Vermont waters. Cyanobacteria formerly known as blue-green algae) are naturally-occurring organisms found in nearly all aquatic and many terrestrial ecosystems. Cyanobacteria are favored by high-nutrient waters, where they may proliferate into thick accumulations known as blooms. In addition to being a nuisance, cyanobacteria may produce cyanotoxins which affect the nervous system or liver. These toxins have been implicated in the deaths of dogs on Lake Champlain and other parts of the country. The presence of dense blooms on Lake Champlain and some inland lakes is of concern because of the human health implications.

How important are Toxic Substances?

Based on the Watershed Management Division's evaluation, toxic substances comprise a moderately ranked stressor. The extensiveness of toxic substances impacts varies depending on the group of compound. For example, mercury contamination is widespread in Vermont. A statistical survey indicates that 25% of lakes in Vermont may exhibit mercury levels in standard-sized yellow perch in excess of EPA guidelines. The most recent statewide water quality assessment indicates that 8,115 lake acres and 68 stream miles are identified as impaired due to mercury. Known areas of PCB contamination of fish or sediment are limited to certain areas within Lake Champlain, and a short list of contaminated sites. Metals create known impairments in ~100 miles of stream, and stress an additional 137 miles, but have not been documented to impact lakes. Only a few studies have been carried out to investigate emerging contaminants in Vermont, most notably in the Lake Champlain Basin. However, a national USGS study of 139 streams from across the country found one or more of the 95 chemicals for which they sampled in

80 percent of the streams. Of the 95 chemicals, only 14 have drinking water standards or other human health or ecological health criteria. No specific research has been done to investigate the potential biological response to emerging contaminants in Vermont. The occurrence of cyanobacteria and associated cyanotoxins is well documented in areas of Lake Champlain, less so in Memphremagog. A few other lakes are also known to exhibit recurring cyanobacteria blooms.

The intensity of impact also varies by contaminant, and whether the toxic substance bioaccumulates or not. Exposure of biota to toxic compounds may be termed acute (where the toxicity impact is immediate and severe) or chronic (where low-level continual exposure elicits a milder and longer-term response). New science also suggests that although low levels of some contaminants may not have detectable toxic responses to biota, the synergistic effects of exposure to multiple low-level compounds simultaneously may have profound impacts.

The duration of effect also varies by contaminant. For some toxic contaminants, such as active metals releases or gasoline spills, the duration of toxic effects may be relatively short. This is because the effects are reduced or eliminated when a fuel spill is addressed, or a release of metals is stopped. Legacy effects can remain in sediments, however. By contrast, certain organic contaminants like dioxins or PCBs will immediately contaminate sediments, and create long-term toxicity to species that live in sediments, or that rely on sediment-dwelling species for their food source. Mercury is intermediate in the duration of effects. In areas where meaningful controls have been implemented, mercury levels in fish and wildlife of nearby ponds has declined in a few years. However, complete control of mercury is a long-term proposition, owing to the global distribution of mercury.

Management strategies are in place to address many of the toxic contaminants, and therefore, the urgency of threat posed by most toxic contaminants is lower than some of the other stressors addressed in the Strategy. However, emerging contaminants, due to the prevalence of sources and many unknowns associated with their distribution, toxicity, and synergistic effects have a high urgency relative to other toxic substances.

What objectives achieved by controlling Toxic Substances?

Managing and preventing toxic substances promotes one major surface water objective:

Objective D. ***Minimize Toxic and Pathogenic Pollution, and Chemicals of Emerging Concern***

Controlling the release of toxic substances also necessarily minimizes exposure to biota and to humans. The Precautionary Principal is a guideline that states that when there are suspected health or environmental concerns, preventative actions should be taken even when there is not a scientific certainly that harm will ensue.

What are the causes and sources of Toxic Substances?

Atmospheric

Atmospheric contaminants are the result of air emissions of toxic substances that occur as a result of a wide variety of energy or industrial applications. Major examples of atmospheric emissions sources include: coal-fired utilities, utility boilers, waste-to-energy incinerators, municipal waste incinerators, smelters, Portland cement facilities, and chlor-alkali facilities. Vermont has few such facilities in-state, although there are several utility boilers. Landfills are also known to emit smaller quantities of toxic contaminants directly into the atmosphere. Crematoria are becoming increasingly recognized as a small-scale but important source of mercury pollution. Atmospheric deposition of pesticides occurs globally through a variety of processes both during and after application. The relative importance of atmospheric inputs of pesticides to surface waters is dependent on the magnitude of the other sources of pesticides to that water body.

Organic / Inorganic Contaminants
A wide variety of industrial facilities, actively use toxic compounds in the process of manufacturing, and thus have the potential to discharge these compounds. Facility waste is often pre-treated, but then discharged to the local wastewater treatment facility. In many instances the use of toxic chemicals is part-and-parcel of the manufacturing process, and it should not be assumed that all facilities discharge chemicals simply because hazardous substances are used. Discharges from municipal and industrial wastewater treatment facilities may contain toxic contaminants that are controlled to permitted levels. Residual materials (sludges) from wastewater treatment may also contain certain contaminants, the concentrations of which are also regulated. Landfill leachate and hazardous waste sites are also sources of toxic substances. The full extent of the impacts from these sources are not yet well known. There are several Federal and state programs in place to control, reduce and/or eliminate toxic substance releases. The Vermont Toxic Discharge Control Strategy (TDCS) implemented by VTDEC, provides guidance for the implementation of narrative and numeric water quality standards and describes procedures for determining appropriate toxic pollutant criteria when necessary to protect aquatic biota and human health.

The overall goal of implementing the TDCS is to quantify all National Pollution Discharge Elimination System (NPDES) discharges in Vermont and to establish water quality criteria and discharge permit limits that can be used to regulate discharges in a manner that will assure that the state water quality standards and receiving water classification criteria are maintained. A progressively stringent three-tiered effluent characterization process is used for assessing the toxic nature of discharge effluents. The ultimate goal of this process is to determine whether or not a specific discharge has the reasonable potential to cause or contribute to violations of any applicable water quality standards.

Pesticides
Older records of commercial pesticide application from the Agency of Agriculture in Vermont indicate that 144,465 lbs of pesticides were applied in 2007, not including biocides (298,000 lbs) used in cooling towers. Corn herbicides comprised 55% of the pesticides applied followed by golf courses at 13% and electrical utilities at 5%. The corn herbicide atrazine which has declined in use in recent years still comprises 60% of all the corn herbicides applied in 2007. There are minimal to no records or tracking of private applicator or residential homeowner usage in Vermont, but pesticide use and sales surveys conducted in other parts of the country indicate that these users account for a significant portion of all pesticides applied (10-25%). Suburban lawns and gardens often receive heavier pesticide applications per acre than agricultural areas. According to the U.S. Geological Survey (USGS) National Water Quality Assessment (NAWQA) program, pesticides are widespread in streams and groundwater occurring at detectable concentrations more than 90% of the time in urban, agricultural and mixed areas. The USGS has reported that these pesticides are often found at higher concentrations in urban and suburban streams than in agricultural streams.

Contaminants of Emerging Concern
CECs are the most difficult to manage of all the compounds discussed in this Strategy. Many emerging contaminants are the result of necessary products or medications that are part of our everyday lives. Such compounds are used in and released from most Vermont households, hospitals, and businesses on a daily basis. These compounds are either delivered into septic systems, where they may be transferred to

groundwater, or to wastewater facilities, where they are discharged, directly or indirectly, into surface waters. The chemical reactions that occur within septic systems and especially wastewater treatment facilities can alter or transform benign compounds into compounds with known toxic effects.

Biological

Cyanobacteria are found in waterbodies around the world and are a common component of the biological community in Vermont waters. Not all cyanobacteria are capable of producing toxins, nor do they produce toxins at all times. Currently, there is no scientific consensus on what will trigger toxin production in cyanobacteria. Historically, cyanotoxin concentrations of concern in freshwater were primarily associated with dense, often persistent cyanobacterial blooms occurring in waterbodies with high nutrient concentrations, particularly phosphorus. More recently, cyanobacteria blooms have been observed on waterbodies that are not considered eutrophic. New precipitation patterns and increasing water temperatures linked to global climate change may be creating optimal growth conditions for cyanobacteria. Nutrient delivery to waterbodies may also increase as a result of climate change, and it is expected that the incidence of cyanobacteria blooms will increase in the future.

Monitoring and assessment activities to track Toxic Substances

Atmospheric:

The National Atmospheric Deposition Network (NADP) and associated Mercury Deposition Network, Atmospheric Integrated Research Monitoring Network, and Atmospheric Mercury Network are managed by NOAA jointly with other Federal agencies, and are designed to track acidity, nutrients, air contaminants (including heavy metals) and mercury. There are several NADP and related network sites occurring in or near Vermont.

The Ambient Air Monitoring Network is operated by the Department of Environmental Conservation, Air Pollution Control Division (APCD). The network measures lead, volatile organic compounds, and carbonyls among other pollutants outside the scope of toxic substances. There are monitoring stations in Underhill, Burlington, Rutland, and Bennington.

The APCD's Air Toxics Program inventories emissions of toxic atmospheric contaminants from Vermont's emissions sources

The Fish Contaminant Monitoring Committee (FCMC) – an ad-hoc group of scientific staff from DEC, Department of Fish and Wildlife and Department of health share joint responsibility for testing fish tissue for mercury contamination. The ability of this Committee to meaningfully and continuously assess fish mercury levels and track changes over time is limited by resource constraints in each Department. As such the monitoring coverage is spotty at best. In 2006, the Vermont Advisory Committee on Mercury Pollution issued a report, prepared jointly with the FCMC, recommending the optimal design of a fish contaminant monitoring program. The network design recommended in the report has yet to be implemented, resulting in a considerable information and risk assessment gap.

Organic / Inorganic

The Department of Environmental Conservation's Waste Management Division requires monitoring and assessment as part of permit requirements for normal, ongoing facilities operations. Actively operating landfills and solid waste management facilities are regulated as part of the Solid Waste Management Program. Hazardous Wastes are tracked as part of Hazardous Waste Management Program. Sites where legacy pollution may exist, or spills have occurred, including large scale industrial facilities as well as smaller-scale releases, are assessed under the Sites Management Program. Discharges from industrial and manufacturing facilities are subject to monitoring requirements set forth under the National Pollution Discharge Elimination System (NPDES), which in Vermont is administered by the Wastewater Management Division. EPA is involved in monitoring and assessment work on hazardous sites that become part of the Superfund program. The VTDEC Stormwater Multi-Sector General Permit carries monitoring requirements for facilities that operate under the permit.

Pesticides

The Agency of Agriculture and WSMD collaborate to carry out monitoring of certain waters in the Lake Champlain Basin and Lake Memphremagog for corn herbicides including atrazine and other pesticides used in Vermont. In 2001, a report entitled "Pesticides in the Surface Waters of Chittenden County described how some pesticides are found in Vermont streams. Samples were collected during rainfall events after known commercial pesticide applications and following periods of expected maximum homeowner activity. Turf herbicides in streams adjacent to residential complexes were detected following a commercial landscape application. Pesticides were found in 41 percent of the samples. Two chemicals were found at concentrations that exceeded acute water quality guidelines. The results indicate that pesticides commonly used for turf management are present in streams in developed areas of Chittenden County at certain times. The occurrence of some pesticides above water quality guidelines may pose some risk to aquatic communities in those waters.

Contaminants of Emerging Concern

There have been several efforts to document the occurrence of CECs in Vermont's surface waters, although no routine, on-going monitoring efforts are presently supported. In 2002, VTDEC and USEPA Region I collaborated to collect wastewater effluent samples from 12 municipal wastewater treatment facilities. The facilities were located throughout the state and represented a range of population served, a mix of industrial and domestic input as well as a variety of treatment technologies. Samples were analyzed for six selected CECs: triclocarban, an antifungal and antibacterial agent; 17b-Estradiol, 17a-Ethynylestradiol and Estrone, estrogenic hormones; Bisphenyl-A, used primarily in the production of polycarbonate plastics and epoxy resins; and 4-Nonylphenol, a breakdown product of a widely-used class of plasticizers and nonionic surfactants found in a wide range of products including liquid detergents and cleaning agents. These target compounds represent several classes of PPCP compounds.

The U.S. Geological Survey (USGS) is one of the leaders in PPCP research. In Vermont, USGS has conducted a number of PPCP studies in the Lake Champlain Basin. USGS has analyzed samples of wastewater effluent, combined sewer overflows, urban streams, large rivers, an undeveloped (control) stream, and samples in Lake Champlain in 2006.

An important finding of these studies was that wastewater effluent and combined sewer overflows (CSO) effluent were not the only sources of wastewater contaminants (including CECs). Urban streams contributed substantial amounts of wastewater contaminants to Lake Champlain during storms from untreated sewage sources. Two of the streams studied are underlain by old sewer pipes and combined sewer infrastructure; which may leak during storms, releasing sewage to the streams. These findings are 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. Nonetheless, caffeine, which is highly removed by wastewater treatment, and thus a good marker for the potential presence untreated wastewater (CECs), was found even in the lake. Researchers reported the lake to be “mildly caffeinated.” The 2009 report “*Wastewater Effluent, Combined Sewer Overflows, and Other Sources of Organic Compounds to Lake Champlain*” presents the most recent findings.

In 2008, DEC partnered with International Business Machines (IBM) of Essex 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. Funding for this analysis was provided by IBM.

In response to the identification of PFOA in this area of Vermont, the Department of Environmental Conservation, in partnership with other State and Federal agencies, has mounted a sampling and assessment effort aimed it identifying potential sources of PFOA, to identify if other drinking water sources may be contaminated.

Biological
The Watershed Management Division coordinates a collaborative cyanobacteria monitoring network for the waters of Lake Champlain and inland lakes. The program includes several partner organizations - the Department of Environmental Conservation’s Champlain Monitoring Project, the Vermont Department of Health, the Lake Champlain Basin Program, and the Lake Champlain Committee. Cyanobacteria status around the lake is updated weekly during the main recreational period of June to September and available to the public through the Department of Health’s webpage. The information is utilized by the Vermont State Parks beaches on Lake Champlain as well as the public water suppliers drawing from the lake.

Water quality monitoring by the DEC’s Lakes and Ponds Program assesses the nutrient status of Vermont waters. Because of the link between nuisance levels of cyanobacteria and phosphorus pollution, assessment of phosphorus concentrations around the state will assist in identifying lakes that a higher likelihood of potentially toxic cyanobacterial blooms. In addition, WSMD staff report suspected cyanobacteria blooms observed during their lake visits. Department of Health and Watershed Management Division staff respond to reports of cyanobacteria blooms on inland water bodies and provide assistance to affected towns and property owners.

Priority Next Steps for the Monitoring and Assessment Programs Addressing Toxic Substances

- Maintain a database of waterbodies with reported cyanobacteria blooms and/or cyanotoxins.
- Expand the cyanobacteria monitoring network to additional inland lakes.
- Consider implementation of Advisory Committee on Mercury Pollution recommendations regarding a fish-tissue monitoring program for Vermont.
- Develop a strategy for monitoring / surveying CECs and addressing those that reach a certain threshold of concern
- Evaluate mechanisms to monitor residential pesticide sales as proxy for use

- Develop a routine monitoring and assessment process for municipal and industrial wastewater effluents and receiving waters
- Work with USEPA, USGS, and other State agencies and partners to conduct further CEC monitoring.
- Involve a site manager representative from DEC Hazardous Materials Section, and DEC Solid Waste Section in the meetings as a tactical basin plan is started to address the need for potentially focusing on sediment monitoring, screening salvage yards and other monitoring needs with respect to sites and toxics in that basin. Include new information gained from this collaboration into the CEC strategy (see above under high priority.)
- Assist AAFM to enhance pesticide screening/monitoring
- Evaluate sediments behind dams slated for removal
- Ensure that macroinvertebrate and fish community sampling occurs below known contaminated sites
- Participate in DEC Waste Management Program Remediation of Contaminated Sites document development

Technical assistance programs to address Toxic Substances

Atmospheric
The Compliance Section of APCD, also called the "Field Services Section", ensures that industry, businesses, institutions, and individuals comply with air quality regulations and air pollution control permits issued by the Agency of Natural Resources. The most important activities of the Compliance Section are: Industrial and Commercial Air Pollution Source Inspections; Monitoring of Air Pollutant Source Emission Testing; Complaint Investigations; Issuing Open Burning Permits; and, Control of Vapors from Gasoline Marketing.

Organic / Inorganic
The Pollution Prevention Program is managed by the Compliance and Enforcement Division. The Environmental Assistance Office provides non-regulatory technical assistance for industry, municipalities, and other entities seeking to comply with Vermont's regulations concerning waste management.

Pesticides
The Agency of Agriculture offers technical assistance for licensed pesticide applicators.

CECs
There is limited technical assistance available to support improved efficiency of CEC capture from septic and wastewater. The New England Interstate Water Pollution Control Commission provides a comprehensive training program for wastewater treatment facility operators. As Vermont's wastewater treatment facilities are upgraded, or during the process of permit re-authorization, DEC and EPA should provide technical assistance to municipalities on low-cost means to increase treatment efficiency for release of CEC's.

Biological
The Watershed Management Division offers identification of potential cyanobacteria blooms and provides assistance to lake associations and residents wishing to develop local monitoring activities. The Department of Health provides technical assistance for public entities and private individuals regarding human health and recreational concerns, including testing for two cyanotoxins.

Regulatory programs to address Toxic Substances

Atmospheric
The APCD maintains up to date Air Pollution Control Regulations that comply with EPA's regulations issued under the Clean Air Act. These regulations confer to ACPD regulatory and permitting authority on several air emissions source types that have potential impacts to surface waters, including organic compounds and hazardous air contaminants. APCD maintains Air Quality Standards that are used similarly to Water Quality Standards to limit emissions of air contaminants to safe levels. Depending on the volume emitted, individual permits may be required. APCD also issues a general permits for smaller emissions sources.

Organic / Inorganic
Toxic contaminants from industrial and municipal discharges are regulated by the Wastewater Management Division, under the NPDES discharge permitting program, or the Indirect Discharge Program. Contaminants in wastewater residuals are managed by the Residuals Wastes Program, and regulated under the Solid Waste Management Rules.

Toxic and hazardous materials that are used within industrial and manufacturing facilities are regulated under the Hazardous Waste Management Program, which implements the federal Resource Conservation and Recovery Act for Vermont. Toxic contaminants that have the potential be discharged to surface waters from non-point sources within industrial, municipal, and manufacturing facilities are also regulated by the WSMD's Multi-sector General Permit for stormwater. Old hazardous waste sites stay under the purview of the Sites Management Section of the Hazardous Waste Program until they are officially closed and monitoring has ceased at the site.

Contaminants in landfill leachate are regulated by the Solid Waste Management Program.

Contaminants associated with fuel storage tanks and fuel dispensing facilities are regulated under the Underground Storage Tank Program.

Mercury that is derived from Vermont-specific sources is regulated by the Comprehensive Mercury Management Act (10 V.S.A. Chapter 164).

Contaminants that may be lost from facilities due to stormwater are regulated by the Stormwater Multi-Sector General Permit.

Pesticides
Pesticides are regulated by the Agency of Agriculture (see quick-link above), under 6 V.S.A. Chapter 87. The Agency of Agriculture also implements the Federal Insecticide, Fungicide, and Rodenticide Act. The DEC Watershed Management Division reviews applications and issues permits for pesticide use in lakes and rivers (e.g.lampricides, Sonar). The Vermont Pesticide Advisory Council is in place to promote better pesticide policy and regulatory development.

Contaminants of Emerging Concern
There are very few regulatory programs addressing emerging contaminants in surface waters. The Department of Environmental Conservation is in the process of updating the Groundwater Protection Rule to incorporate standards for PFOA.

Biological
There are no federal or state regulations addressing cyanobacterial toxins. The EPA has developed health advisories for two cyanotoxins in drinking water and has begun development of recreational advisories. Beach closure/reopening guidelines specific to cyanobacteria have been developed by the Vermont Department of Health. These guidelines are voluntary, and while strongly recommended by the Health Department, implementation is the responsibility of beach managers. The Lake Champlain Coalition of Municipal Water Suppliers has developed a voluntary process for responding to cyanobacteria in drinking water supplies and participate in a voluntary cyanotoxin monitoring program each summer.

Funding programs to address Toxic Substances

Atmospheric
There are few funding programs specifically directed towards controlling atmospheric emissions of toxic substances. Individual emitters are required to absorb the cost of emission controls necessary to meet permit requirements. National Oceanic and Atmospheric Administration and Lake Champlain Basin Program – Technical Program grants have been used to research mercury deposition.

Organic / Inorganic
The Waste Management Division offers the following funding options to address toxic substances:

- Municipal Pollution Control, Revolving Loan Fund
- Brownfields Site Assessment Grants
- Environmental Contingency Fund
- Hazardous Wastes Facility Grants
- Landfill Closure Grants
- Petroleum Clean-Up Fund
- Solid Waste Implementation Grants
- Solid Waste Assistance Grants
- Underground Storage Tank Removal
- Underground Storage Tank Replacement/Upgrade

Pesticides
Individual licensed pesticide applicators are required to absorb the cost of measures and controls necessary to meet Vermont and Federal regulatory requirements.

Contaminants of Emerging Concern
- Lake Champlain Basin Program Technical Program Grants
- Lake Champlain Basin Program – US Geological Survey Dedicated Research Funds

Biological
- Lake Champlain Basin Program Technical Program Grants

Information and education programs to address Toxic Substances

Atmospheric
Vermont's principal educational program for mercury is the Mercury Education and Reduction Campaign. ACPD's Air Toxics Program also provides educational materials for other classes of atmospheric contaminants.

Organic / Inorganic
The Environmental Assistance Office coordinates general pollution prevention education for municipalities and regulated facilities and manufacturers.

Pesticides
The Vermont Pesticide Advisory Council is charged with reviewing insect, plant disease, weed, nematode, rodent, noxious wildlife and other pest control programs within the state and to assess the effect of such programs on human health and comfort, natural resources, water, wildlife, and food and fiber production, and where necessary make recommendations for greater safety and efficiency.

Contaminants of Emerging Concern
The New England Interstate Water Pollution Control Commission (see quick-link above), through its regional working groups, coordinates education and outreach about emerging contaminants.

Biological
The DEC (Drinking Water and Groundwater Protection Division and Watershed Management Division) work with the Department of Health to provide training for water suppliers and beach managers focused on recognizing and responding to cyanobacteria. Champlain drinking water suppliers have the opportunity to participate at no cost in a voluntary 12 week cyanotoxin monitoring program each summer. Additionally, DEC and VDH work with water suppliers to develop source water protection plans and determine appropriate treatment processes to prevent cyanobacterial contamination of water processing facilities. The VDH issues annual reminders about cyanobacteria at the beginning of the summer recreational season and maintains an on-line tracking tool to keep the public informed about current conditions around the state. VDH and WSMD have developed a monitoring protocol for local towns and offer training workshops in cyanobacteria identification.

What is Thermal Stress?

Thermal stress is a term to describe a temperature change that is severe enough to cause unfavorable and even lethal conditions to aquatic organisms, their populations, community structure, or ecosystem. Aquatic organisms have evolved to function most efficiently within an optimal range of water temperature. Certain invertebrates, such as stoneflies and caddisflies, and cold-water adapted fish species, like the brook trout, Atlantic salmon, and slimy sculpins, require cold water to support all life stages. Water temperature in rivers and streams does vary by season, over the course of a day, and along the length of a river. However, certain land uses, activities, discharges, and the physical condition of the aquatic ecosystem can influence water temperatures beyond natural variation to cause thermal stress. Moreover, one of the anticipated impacts of climate change is an increase in ambient air temperatures that could, over time, influence water temperature to a point of exceeding incipient lethal limits for some cold-water dependent species. It is therefore extremely important to manage activities on the landscape and discharges to reduce their contribution to increased temperature stress.

The impacts of temperature on aquatic habitat are far-reaching, making changes in temperature one of the most influential stressors to aquatic habitat. Temperature can be a physical, biological, or chemical stressor. Physically, higher water temperatures reduce levels of dissolved oxygen, potentially creating a condition of hypoxia. Low oxygen levels can kill or affect species' life cycle functions, and can reduce species diversity and population sizes.

Biologically, higher temperatures directly affect the metabolic rates of aquatic biota, disrupt their life cycle thermal cues, and have an impact on their capacity to resist disease. Certain cold water aquatic macroinvertebrate species will be displaced. Higher water temperatures, coupled with sunlight and nutrients, create more favorable conditions for plant and algae growth. It can also result in blooms of microbial populations, such as cyanobacteria, which in some cases can be toxic to humans and animals. Higher temperatures can also cause E. coli populations to increase and remain viable for longer periods within a stream, causing and increased risk to recreational users. In extreme situations, extensive aquatic plant growth in lakes and ponds can result in critically low oxygen levels at night when photosynthesis stops, and respiration rates increase the biological demand for oxygen (BOD), that further depletes the water of oxygen.

Chemically, higher temperatures can alter concentrations of substances in water, which can have an impact on the ability of fish to withstand chemical exposure. Such impacts can also affect recreational uses and public enjoyment of rivers, lakes, and ponds. Climate change is resulting in shorter ice coverage seasons on many lakes and increased summer water temperatures. The full effects of these changes are not completely understood.

How important is Thermal Stress?

Based on the Watershed Management Division's evaluation, thermal stress is an important stressor. While excessively high temperatures impair a relatively small number of stream miles in Vermont, the impacts in those locations are significant. The potential for thermal stress in water bodies across the state is high, since over 60% of Vermont's streams are small, cold water habitats. Moreover, in many instances, thermal stress occurs in concert with other stresses to compound effects on aquatic organisms.

The 2010 statewide water quality assessment suggests that for rivers and streams, 76 miles are impaired due to excessively high temperature, and an additional 480 miles experience thermal stress (hyperlink 305b report).

What objectives achieved by managing Thermal Stress?

Addressing and preventing thermal stress promotes several surface water goals and objectives, including:

Objective A. ***Minimize Anthropogenic Nutrient and Organic Pollution***
A stable stream with adequate riparian woody vegetation and floodplain function will provide shade as well as the added benefits of filtering and storing sediment, nutrients, and organic pollution. Cooler water in shallow lake systems can mitigate the effects of nutrient pollution. Reducing impervious surfaces and encouraging infiltration can decrease temperatures of incoming waters while reducing flow and nutrient loading.

Objective B. ***Protect and Restore Aquatic, and Riparian Habitat***
Moderating and maintaining a suitable thermal regime for aquatic organisms avoids the physical, biological, or chemical impacts that higher temperatures can cause. It will also help to safeguard temperature-sensitive species from the impacts of climate change. Having healthy, vegetated river corridors, floodplains, wetlands, and lake shore lands is a key management tool for regulating water temperature to avoid exceeding incipient lethal limits, providing important sources of fine and coarse organic matter that benefits aquatic habitat, and filtering to minimize sedimentation from stream bank and shore land erosion. These areas will also provide important aquatic and terrestrial habitat connectivity within the watershed, including upland areas. Another important management tool is to preserve the natural or seasonal flow regimes, and in particular to ensure adequate flows during drier months. This can be achieved by promoting practices that mimic natural hydrology and function. These strategies will help to mitigate the impacts of climate change on aquatic habitat. Restoring and protecting these habitats will help to protect temperature-sensitive species and maintain public enjoyment of aquatic life and wildlife.

What are the causes and sources of Thermal Stress?

There are six principal causes of thermal stress to Vermont waters. Thermal stress becomes most apparent during periods of low flow or drought. The six causes are:

- The removal of vegetative buffers along lakeshores and riverbanks, allowing increased sunlight penetration into waters and warming of the water. Lack of riparian and lakeshore vegetation is widespread in Vermont;
- The direct alteration of the stream channel and floodplain, often to accommodate encroachment into a river corridor. This "channelized" condition inhibits the stream's capacity to achieve equilibrium. The "channelized" condition is often characterized by having a history of being dredged or straightened, excessive stream bank and bed erosion in some locations, and structural measures such as bank armoring and berming in other locations. A vegetated buffer on an altered, unstable stream will only marginally influence the stability of that stream. Additionally, buffers on unstable streams don't persist, since they are highly vulnerable to damages from fluvial erosion;
- Stormwater runoff. During the summer, rain falling on impervious surfaces such as roads and parking lots can quickly run off into nearby streams. These dark surfaces heat up and can cause a spike in stream temperatures by. as much as a 10ºC increase stressing the aquatic community. Over time, this can lead to the loss of high temperature intolerant fish and macroinvertebrates, leaving behind an altered community tolerant of warmer water.
- Impounding rivers and streams can create downstream reaches with warm, slow-moving and shallow water. Moreover, intake structures that draw water from the surface to feed hydropower turbines will discharge warmer water into receiving waters. There are numerous instances of on-stream ponds creating downstream warming in Vermont;
- Water used for cooling by some industries, wastewater treatment plants, and power generating facilities, that may be discharged at higher temperatures; and,
- Climate change, which implies that thermal stress will persist as water temperatures exceed the range of tolerance for vulnerable species. Although much of the thermal stress and associated water quality and ecological impacts observed today are due to causes and sources listed above, a warming climate will continue to contribute to increases in surface water temperatures if left unabated.

Monitoring and assessment activities addressing Thermal Stress

Key Monitoring and Assessment Strategies to Address Thermal Stress

- Conduct stream biological, geomorphic, and reach habitat assessments at sentinel sites to evaluate the condition of the biological community, the vegetation along streambanks and shorelands and within the river corridor or waterbody. These data will provide insight to the overall health of the riparian and aquatic ecosystems, including the degree of shade, changes over time, and the potential impacts from climate change.

- Pair monitoring with active restoration projects on longer time scales to evaluate the improvements in water temperature.

- Complete river corridor plans in stream and river watersheds to identify opportunities to restore vegetated conditions along the riparian areas, river corridors, and floodplains.

- Increase the number of temperature monitoring units in lakes and streams to provide state-wide coverage to better understand the extent of the problem, identify specific problem areas, and evaluate the cumulative impacts of thermal stress from all sources, including buffer loss, discharge from impoundments, and stormwater runoff.

- Monitor changes in land use and vegetation cover near lakeshores using on-site sampling or remote sensing.

- Develop and maintain a temperature gauge network in conjunction with a flow gauge network on rivers.

- Identify locations of potential thermal stress (i.e. parking lots within 50 feet of a river or stream, etc.)

- Assess thermal stress associated with the detention of stormwater for water quality treatment.

Technical assistance activities addressing thermal stress

Key Technical Assistance Strategies to Address Thermal Stress

- Develop and maintain the capacity to technically assist landowners, municipalities, land developers, agencies, and organizations in the:
  - Design and execution of data collection and analytical methods necessary to understand temperature impacts;
  - Identification of critical management areas outside a river corridor where excess surface runoff can be infiltrated, evapotranspired, or stored and reused;
  - Development and implementation of strategies to delineate, re-establish, and maintain vegetated buffers along river corridors, wetlands, and lake shorelands; and,
  - Alternatives analysis, project design, and implementation of appropriate river corridors, setbacks, and vegetated buffers, assessments and river corridor planning.

- Continue to support programs and other efforts to install vegetated buffers.

Regulatory activities addressing thermal stress

Key Regulatory Strategies to Address Thermal Stress

- Develop a set of meaningful incentives for municipalities to adopt plans and bylaws that protect floodplains, river corridors, lake shorelands, and buffers.

- Better utilize the water quality standards for temperature to minimize thermal stress from activities within shorelands, corridors, and floodplains by convening an internal workgroup to develop a proposal for modified temperature standards that address non-discharge related sources and propose these modifications during triennial standards review.

- Promote dam removal projects and develop regulatory tools to expand existing authorities to remove unsafe dams that no longer serve a useful purpose.

- Improve stormwater regulations and promote stormwater Best Management Practices to include temperature controls that promote infiltration over detention.

- Continue to uphold minimum flow standards in permitting of hydropower projects, impoundments, and other withdrawals, and manage releases from existing and new impoundments to mitigate thermal load.

  Promote the use of vegetation and biodegradable materials for shoreland stabilization projects to mimic the natural shoreland.

- Continue to uphold the Vegetation Protection Standards under the Shoreland Protection Act to protect and enhance shoreland vegetation on lakes and ponds

- Work with other agencies and ANR enforcement to ensure compliance with Act 250 permits that contain river corridor or buffer protection requirements.

- Increase technical assistance capacity within the Division to review proposals that encroach into buffers directly under State purview (Act 250).

Implementation funding activities addressing Thermal Stress

Key Funding Strategies to Address Thermal Stress

- Per Act 110, develop a set of meaningful incentives in relevant State funding programs for municipalities to adopt plans and bylaws that protect floodplains, river corridors and lakeshore buffers.

- Consider a stable funding program to conserve floodplains, river corridors, lakeshores, and wetlands, including vegetated buffers.

- Work with the Agency of Agriculture, Food, and Markets, NRCS, and FSA to evaluate buffer practices. As part of that effort, consider a more substantive buffer requirement for all landowners interested in cost-share programs that contain state funding.

- Continue to promote "trees for streams" programs to provide funding for landowners to plant vegetated buffers.
- Work with the Vermont Department of Fish and Wildlife to promote restoration and protection of buffers into the Statewide Wildlife Action Planning effort.
- Evaluate, as an incentive, tax policy that recognizes the societal value of permanent river corridor and buffer protection.

Information and education activities addressing thermal stress

Key Information and Education Strategies to Address Thermal Stress

- Develop Adopt-a-Stream program.
- Develop a marketing strategy to educate the public about the importance of river corridors, lake shorelands, buffers, and natural hydrology.
- Develop and maintain information & education materials on the causes and effects of thermal stress and the important strategies to address the causes and sources for both lay and technical audiences.
- Work with ANR Climate Team to develop and maintain web-based information & education materials on the thermal stresses associated with climate change for both lay and technical audiences.

VERMONT DEPARTMENT OF ENVIRONMENTAL CONSERVATION

WATERSHED MANAGEMENT DIVISION

STRATEGIC PLAN 2016-2018

Guiding the Division's collective work to meet our goal to
PROTECT, MAINTAIN, ENHANCE, and RESTORE
Vermont's surface waters

VERMONT DEPARTMENT OF ENVIRONMENTAL CONSERVATION
WATERSHED MANAGEMENT DIVISION

WATERSHED MANAGEMENT DIVISION --- OVERVIEW

The Watershed Management Division in the Vermont Department of Environmental Conservation is responsible for **protecting**, **maintaining**, **enhancing** and **restoring** the quality of Vermont's surface water resources. Inherent in this effort is the support of both healthy ecosystems and public uses in and on Vermont's 800 lakes and ponds, 23,000 miles of rivers and streams and 300,000 acres of wetlands. The Division has 113 full time employees located in its central Montpelier office and regional offices in St. Johnsbury, Rutland, Essex and Springfield. The Division's organizational chart is shown in **Attachment 1**.

The Division includes three media-specific programs, **Wetlands**, **Rivers** and **Lakes,** that provide for the comprehensive management of these resources through science based management and permitting programs and activities. The Division also administers federally delegated **Stormwater** and **Wastewater** permitting programs that regulate discharges to surface waters. The **Monitoring, Assessment and Planning** program serves to integrate the Division's program work through strategic monitoring and the development of tactical basin plans that identify priority implementation projects to both protect high quality waters and restore impaired waters. The newly reorganized and renamed **Vermont Clean Water Initiative** program (formerly the Ecosystem Restoration Program) is responsible for education, outreach, implementation and funding activities associated with Vermont's new Clean Water Act (Act 64) and Clean Water Fund, and cleanup plans for Lake Champlain, Lake Memphremagog, Long Island Sound, and other major ecosystems. The Division also recently consolidated its administrative, financial and compliance services into a new **Business Operational and Support Services** program to promote efficiency, enhance consistency, and better leverage technology.

INTEGRATED, HOLISTIC WATERSHED MANAGMENT

In the past five years, the Division has faced significant new challenges, including:

- An increase in the number and breadth of its regulatory programs, including the new shorelands management program, and river corridor permitting program, and a greatly expanded stormwater permitting program required under Act 64;
- A sharpened focus on river corridor protection and flood resiliency as a result of Tropical Storm Irene;
- The development of major ecosystem TMDLs and implementation frameworks, including those for Lake Champlain and Long Island Sound;
- The need to identify priority implementation projects based on sound science and up to date monitoring and assessment, and to link federal and state funds to priority projects to the greatest extent possible;
- Increased calls for the Division to carefully track its progress in a transparent and easily understood way.

As a result of self-initiated restructuring and a Division-wide embracement of integrated, holistic watershed management, we are meeting these challenges. The entire Division has pivoted to a fully collaborative, cooperative surface water management philosophy, with all eight programs actively engaged in strategizing and solving problems as a team. This "rowing together" was most recently seen in the team work necessary to complete the Phase 1 Implementation Plan for the Lake Champlain TMDL under tight timeframes imposed by EPA.

The Division has released the **Vermont Surface Water Management Strategy** (VSWMS) that provides a comprehensive framework for statewide surface water management. The VSWMS describes:

- The Division's goals and objectives for managing Vermont's surface waters to meet the federal Clean Water Act and Vermont's state surface water quality policy;
- Activities and stressors that affect surface waters, as well as individual pollutants;
- The tool kit (i.e. monitoring and assessment; regulatory/technical assistance; funding; education and outreach) used to protect, maintain, enhance and restore surface waters; and
- The monitoring, assessment and planning processes used by the Division for watershed management, including strategic tactical basin planning.

The VSWMS guides the Division's decision-making to ensure efficient, predictable, consistent and coordinated management actions. The resultant cross-pollination and collaboration among the Division's permitting and resource programs has significantly improved surface water management and protection in Vermont.

A central element expressed in the VSWMS is program integration, whereby all surface water-related resource programs, permitting, monitoring, and assessment and restoration activities and related funding, are housed and managed in a single Division. Over the past several years, the Division has realigned positions and programs to promote integrated surface water management, including:

- Assimilating the NPDES Direct Discharge Permit Program (that was formerly housed in the former Wastewater Management Division);
- Merging monitoring and planning functions into a single Monitoring, Assessment and Planning Program (MAPP) to better integrate monitoring, assessment and planning activities;
- Acquiring the water rulemaking authority of the Vermont Water Resources Panel was transferred to the Division, including authority over the Vermont Use of Public Waters Rule, the Vermont Water Quality Standards, Mean Water Level Rule, the Surface Water Level Rule, designations of Outstanding Resource Waters and Class 1 Wetlands;
- Creating a Program Coordinator position to coordinate the technical review necessary across programs to issue Section 401 water quality certifications for projects impacting Vermont's aquatic resources;
- Creating a hydrologist position to assist permit program decision-making;
- Assimilating the former Clean & Clear program to promote synergy between the technical aspects of project identification and funding;
- Forming a new Business and Operational Support Services (BOSS) Program to centralize administrative surfaces, financial operations and compliance services for all

Division programs to increase efficiency, especially in the administrative processing of permits; and

- As a result of Act 64, hiring 13 additional positions to foster implementation of the Lake Champlain TMDL and other requirements of Act 64, including new permitting program and planning staff, a modeler to assist in identifying the highest priority implementation projects for impaired waters restoration, and a position dedicated to tracking activities implementing the requirements of Act 64 and the Lake Champlain TMDL, and the funding of projects from the Clean Water Fund

STRATEGIC PLAN STRUCTURE

This Strategic Plan will guide the work of the Division and its eight programs over the next 3 years. The Plan is designed to ensure that federal and state requirements are met, that surface water resources are protected and impaired waters restored, and that the Division is responsive to citizen needs and concerns. Providing accountability, and accessible, measurable and comprehensive information on the Division's work is a central purpose of this Plan.

The Plan first sets forth the Division's **mission** and **vision**, and four central **Division goals** that will guide our collective work. Each Division goal will be met through the **objectives** and **strategies** described in program-specific strategic plans. Division and program progress will be tracked via **performance measures** as part of our annual Results Based Accountability report to the Legislature, which is discussed more below.

Finally, this Plan describes some of our recent successes under the Division's 2012-2015 Strategic Plan and Division-related elements in DEC's 2012-2015 Strategic Plan, and how we are poised to meet emerging challenges, such as increased regulatory requirements in Act 64, implementation of the Lake Champlain TMDL, identifying and funding strategic projects identified in tactical basin plans, and the need to streamline internal processes and fully leverage technology.

DIVISON MISSION, VISION AND GOALS

MISSION STATEMENT

To efficiently and effectively manage Vermont's surface water resources through a comprehensive, integrated, and holistic watershed based system.

VISION STATEMENT

To achieve full support of both healthy ecosystems and public uses in and on all of Vermont's water.

DIVISION GOALS

"PROTECT" --- DIVISION GOAL #1: Protect Vermont's pristine or "special waters by safeguarding these natural systems from deleterious change over the long term through the expanded use of proactive protection tools such as upward classification of waters, designation of outstanding resource waters, Class 1 wetlands, the identification and funding of projects focused on protection, and by working to better synchronize Vermont's statutes, regulations, and water quality standards to support this overall effort.

"MAINTAIN" --- DIVISION GOAL #2: Improve and expand the ongoing maintenance of Vermont's existing high quality waters through more protective and streamlined permitting and by updating rules and procedures to strengthen and clarify permitting standards, including Vermont's water quality standards and anti-degradation policy.

"ENHANCE" --- DIVISION GOAL #3: Increase opportunities for the enhancement of existing high quality waters to an improved condition through the development and use of programs, policies, outreach and education efforts and other tools that are designed to proactively identify and fund projects to enhance surface waters, and to promote the use of processes and measures by existing discharges to improve the existing condition.

"RESTORE" --- DIVISION GOAL #4: Aggressively pursue restoration of currently impaired waters through the development and timely implementation of comprehensive TMDLs, and implementation of remediation plans for Vermont's degraded waters using a combination of both regulatory and non-regulatory tools.

The Division's comprehensive planning strategy is illustrated in **Attachment 2** which shows how our mission, vision and four goals translate down through individual program strategic plans to individual staff workplans. **Attachment 3 outlines the full strategic plan and the link between the Division four goals and program-related objectives and strategies**. Each Division program has created its own program-specific strategic plan that describes the primary work of the program and its priorities, objectives and strategies for the next 3 years.

In addition to the work described in **Attachment 3**, over the next three years the Division will focus special attention on:

- Continued refinement of the tactical basin planning process to identify the highest value, prioritized projects for implementation based on the most recent data and assessments and modelling tools;
- Continued streamlining of the project-identification to project-funding continuum;
- Finalizing the Lake Champlain TMDL Phase 1 Implementation Plan after EPA's issuance of the final Lake Champlain TMDL, including a public comment period;
- Ensuring timely implementation of requirements under Act 64, and the Lake Champlain TMDL and Phase 1 Implementation Plan, including development of a database and systems to track these efforts;

- Promoting creation of electronic forms (nForms) to allow electronic submission of permit applications, monitoring and reporting forms;
- Development of clear and consistent “decision records” for permitting decisions in order to increase transparency;
- Pushing priority rulemaking efforts, including a second round of revisions to the Vermont Water Quality standards, and development of a Combined Sewer Overflow Rule; and
- Promoting proactive resource protection, through prioritizing upward surface water reclassifications, Class 1 wetland designations and Outstanding Resource Water designations.

MEASURING FUTURE SUCCESS – RESULTS BASED ACCOUNTABILITY

Success in implementing this Strategic Plan will be measured through a Results Based Accountability (RBA) framework. RBA is used to measure how well an agency, department, division or program is performing. The Division is actively engaged in RBA efforts has submitted its second annual RBA report.

The Division is working hard to develop comprehensive Division and program level performance measures and tracking systems to link the work we perform with State level indicators and population level outcomes. Division performance measures summarize work across numerous programs, whereas program level measures dig deeper to assess performance within programs.

MEASURING FUTURE SUCCESS - VERMONT CLEAN WATER ACT

As the Division’s responsibilities grow, so does its responsibility to transparently track its progress. In addition to annual RBA reporting, the Division is developing a comprehensive database to track our efforts in meeting Act 64 requirements, implementation of the Lake Champlain TMDL and Phase 1 Plan, and tactical basin plan implementation. Under Act 64, Vermont Clean Water initiative partner agencies will track and report on clean water restoration activities across all applicable programs and sectors (e.g. agriculture, forests, roads, wastewater, and developed lands). Through the *Vermont Clean Water Annual Investment and Performance Report*, we will report on the financial, social, performance, and environmental results of clean water efforts. The first annual report is due to the legislature in January 2017.

The Department is creating a project tracking system in order to meet these reporting requirements. The tracking system will contain information on each clean water project, including data on project performance, including pollutant load removed. The database will track the lifespan of projects from proposal to design to implementation and funding of projects, including Ecosystem Restoration Grants and Clean Water Fund monies. The system will also be designed for transparency so that the public can access project information through an on-line interactive map. We will also track and report on clean water-related outreach efforts through a recently developed on-line form that will be used by the Agency of Agriculture, Agency of Transportation and Agency of Natural Resources. Finally, the system will track priority projects that have been identified through tactical basin planning. This will allow the Department to identify high priority and cost effective projects to recommend for funding in the next fiscal year.

PAST SUCCESSES, NEW CHALLENGES, AND PRIORITIES

ACCOMPLISHMENTS UNDER DEC'S 2012-2015 STRATEGIC PLAN

The Division accomplished the outcomes/strategies for which it was responsible in DEC's 2012-2015 Strategic Plan, including:

> **"INCREASED LONG-TERM PROTECTION OF FLOODPLAINS AND RIVER CORRIDORS"**(DEC Goal 5, Outcome 1) through assisting municipalities in the development of river corridor plans, establishing a Flood Ready webpage, developing a floodplain protection permitting program for developments exempted from municipal regulations, developing a flood resilient community incentives program and providing outreach and training programs for municipal officials, and completing the development of river corridor maps for the entire state.
>
> **"SUPPORT IMPLEMENTATION OF GOVERNOR'S EXECUTIVE ORDER ON GREEN INFRASTRUCTURE AND REPORT BACK TO GOVERNOR"** (DEC Goal 6, Outcome 1, Strategy 3) through the Vermont Clean Water Initiative Program's representation on a Green Stormwater Council to implement Governor Executive Order 06-12, aimed at promoting green stormwater infrastructure. CWIP also helped to establish a Green Infrastructure Roundtable, a 90-member organization dedicated to supporting green infrastructure statewide and worked with the group to develop a Green Stormwater Infrastructure strategic plan, and sponsors training workshops, and develops educational materials.
>
> **"PROMOTE RESTORATION, PROTECTION AND MANAGEMENT OF WATER RESOURCES"** (DEC Goal 7, Outcome 1, Strategies 1-4) through the development in collaboration with EPA of TMDLs and implementation plans for the Lake Champlain TMDL and the Long Island Sound TMDL, exploration of the concepts of pollutant trading and offsets via a contractor-led process, recent efforts to explore the use of integrated planning and permitting with Vermont municipalities, developing an agricultural pollution control strategy in concert with AAFM, other federal and state agencies and an agricultural stakeholder group, and preparing to issue a revised general permit for municipal separate sewer system (MS4) stormwater discharges upon final issuance of the Lake Champlain TMDL.
>
> **"PROACTIVE RESOURCE PROTECTION AND MANAGEMENT"** (DEC Goal 7, Outcome 2) through the identification of waters for reclassification, waters for designation as Outstanding Resource Waters, and wetlands for Class 1 designations, and inclusion of these proposed reclassifications and designations in tactical basin plans; preparing to amend the Vermont Water Quality Standards to include these reclassifications.

ACCOMPLISHMENTS UNDER DIVISION'S 2012-2015 STRATEGIC PLAN

The Division met a significant number of its goals and objectives in its 2012-2015 Strategic Plan. Both cross-Division and program-specific accomplishments have significantly enhanced the overall management of Vermont's surface waters. Successful cross-Divisional efforts include:

- Cooperatively worked with EPA on development of Lake Champlain TMDL and Phase 1 Implementation Plan, and Long-Island Sound TMDL Implementation Plan;
- Undertook the first comprehensive triennial review of the Water Quality Standards in many years, including numeric nutrient criteria for better management of nutrient pollution;
- Participated in Department-level efforts to enhance enforcement and compliance efforts, and working to more effectively track Division compliance and enforcement work;
- Leveraged technology to enhance permitting program efforts and implemented Lean event(s) in each of the Division's programs to garner efficiencies, increase transparency;
- Tightening of the project identification process for tactical basin plan development.

Program-specific accomplishments during 2012-15 include:

BUSINESS AND OPERATIONAL SUPPORT SERVICES

- Completed a program reorganization, whereby all financial, administrative permitting and compliance functions from across the Division are now consolidated into one program;
- Involved in a number of Lean events to standardize permitting and financial processes handled by the program for the Division;
- Cross trained program staff so that absences and retirements no longer stop the flow of work, including public noticing and permit issuance;
- Developed an nForm for reporting and public posting of all combined sewer overflow events and unauthorized discharges of sewage;
- Utilized and leveraged technology to streamline and automate manual processes, such as permit issuance, permit renewal notifications and operating fee statements.

LAKES AND PONDS PROGRAM

- The Program worked tirelessly to promote passage of the Shoreland Management Act, and created a permitting program to implement the Act;
- In 2014, the Lake Encroachment and Shoreland Management permitting duties were regionalized across the state, to use staff time more efficiently, and to have "one stop shopping" for project proponents;
- The Aquatic Nuisance Control Permitting Section streamlined its processes and enhanced transparency through creation of an application review procedure and revised public notification procedure, a webpage developed for application status

and public notice, revised permit application forms, guidance created for the regulated community;

- The Program leveraged technology by developing new Shoreland permit and Encroachment permit databases for effectively managing the processing of applications and established the ANR.WSMDShoreland@vermont.gov email account to allow for efficient and timely responses to public inquiries;
- In 2015, the Program developed a curriculum for contractors and landscapers in Natural Shoreland Erosion Control to enhance the LakeWise program. Those certified through this six-hour training course are eligible for professional development credits.

MONITORING, ASSESSMENT AND PLANNING PROGRAM

- Realigned its planning functions, tightened the tactical basin plan issuance cycle, and increased its precision in identifying priority projects and has now completed a tactical plan rotation for the entire State;
- Conducted reasonable potential determinations for every wastewater permit issued since 2012 to ensure that permits are fully protective of water quality;
- Completed the first five-year survey of statewide water quality for Vermont' streams based on a scientifically sound survey method;
- Launched an on-line website that consolidates years of surface water monitoring data that is now available to the public;
- Continues to provide cross-Divisional coordination for large Act 250 and Section 248 projects, hydrologic reviews and analyses on flow protection issues and the identification of waters for reclassification and potential Outstanding Resource Water designation.

RIVERS PROGRAM

- Completed a river corridor map layer for the entire state that provides a delineated corridor for every stream over 2 square miles in drainage;
- Established a state floodplain rule that sets a standard of "no adverse impact" in floodplains and rivers corridors and addresses all developments exempt from municipal regulations, including state buildings and transportation facilities, utility projects, and agricultural structures;
- Developed Flood Hazard Area and River Corridor Protection Procedures to guide the regulation of Act 250 and Section 248 developments, and established River Corridor Best Management Practices;
- Established a stream alteration rule and general permit that set stream equilibrium and connectivity performance standards for both emergency (post-flood) and non-emergency actions in rivers and river corridors;
    - Developed Standard River Management Principles and Practices which is a growing compendium for selecting and designing geomorphic-based instream and floodplain restoration alternatives to support stream alteration permitting, clean water initiatives, hazard mitigation, and a River and Roads Training Program, which annually serves ~150 state and municipal roads worker trainees.

STORMWATER PROGRAM

- Implementing TMDLs in stormwater-impaired waters through the MS4 General Permit, which will be reissued shortly after completion of the Lake Champlain TMDL;
- As an outcome of a Lean event, recently launched an updated permit database that allows for automation of several functions, and has leveraged technology so that all project records are now available in electronic format;
- Worked cooperatively with the Agriculture Department to develop coordinated agricultural compliance and enforcement efforts, and participates on the Department's Municipal Assistance Task Force to assist municipalities in understanding and implementing Act 64 requirements;
- Nearing completion of a revised Stormwater Management Manual to enhance stormwater treatment and the use of green infrastructure to control stormwater runoff from roads and other impervious surfaces;
- Successfully implemented the Program's EPA-approved Compliance Monitoring Strategy.

VERMONT CLEAN WATER INITIATIVE PROGRAM

- The Program reorganized (was formerly the Ecosystem Restoration Program), and taken on new positions, including two agricultural specialists, a new position to track Act 64 and TMDL implementation, and a new communications AmeriCorp member to enhance outreach to partners and the public on clean water issues;
- The program is committed to improving grant management processes to better serve municipalities and other partners. The program participated in three LEAN events:
    - The first AID/WSMD LEAN event, completed in 2014, focused on the improving the grant approval process, grant administration, and invoicing.
    - The second MAPP/CWIP LEAN event, completed in 2015, focused on improving the Watershed Management Division's processes to use the Tactical Basin Planning process to identify and prioritize projects for funding.
    - The third LEAN event was a short, two-day evaluation of the technical grant management process. The outcome of this event defined grant management responsibilities and reaffirmed an intra-division commitment to finding programmatic efficiencies in grant and contract management;
- CWIP continues to partner with municipalities across the state to identify and map their stormwater drainage infrastructure and illegal untreated discharges. About 90 communities have had GIS drainage maps and infrastructure reports completed. We have or are currently conducting IDDE surveys in 65 non-designated MS4 communities;
- In 2015, DEC was the recipient (as a co-partner with AAFM) of a $16 million grant from USDA/NRCS to accelerate the implementation of agricultural best management practices on farms in prior areas of the Lake Champlain watershed over 5 years. This grant is managed by the CWIP and a new project coordinator was hired to assist;

- CWIP continues to elevate the importance of Green Infrastructure as an innovative and cost-effective approach to address water quality degradation associated with stormwater runoff. CWIP represents ANR on a Green Stormwater Council to implement Executive Order 06-12, aimed at promoting green stormwater infrastructure. CWIP helped to establish a Green Infrastructure Roundtable, a 90-member organization dedicated to supporting green infrastructure statewide;
- The Program established a St. Albans Bay Initiative to focus clean water implementation and outreach efforts in this impaired segment;
- The Program has been active in evaluating innovations for TMDL implementation, including trading and offset program.

WASTEWATER PROGRAM

- Has reduced permit backlog by reissuing NPDES permits for WWTFs on Connecticut River in accordance with Vermont's permitting plan for implementation of the Long Island Sound TMDL;
- Developed biosolids white paper to discuss options for managing biosolids in Vermont and working with advisory group to evaluate options for moving forward;
- In formal rulemaking for new Combined Sewer Overflow (CSO) Rule to replace Vermont's 1990 CSO policy, and developed electronic form (aka "nForm") for municipalities to use to post notice of CSO and other sewage releases directly onto Department public website;
- Conducted Lean event to evaluate current structure of program and currently working on restructuring effort;
- Actively working to transfer management of operator certification program to outside entity in order to free up staff resources and increase program efficiency.

WETLANDS PROGRAM

- Redistricted wetland ecologists to reduce travel times to sites and moving staff to district offices;
- As an outcome of a Lean event, implemented revisions to program website to allow public to find answers to their questions online;
- Created inquiry forms and checklists so users get the most out of staff site visits and applications when submitted;
- Created and implemented in-field data collection by phone and created a new database for tracking projects more efficiently;
- Developed allowed use guidance documents and standard operating procedures to provide transparency and clarity and streamline work.
- Developed criteria for use in identifying wetlands for Class 1 designation and developed list of potential wetlands for such designation after field verification.

USE OF LEAN TO GARNER EFFICIENCIES, PROMOTE CONSISTENCY

Faced with an ever increasing workload, expanding regulatory programs, the need for targeted project identification and funding, and rapid changes in technology and customer expectations, the Division has fully embraced the use of LEAN to garner efficiencies and improve transparency. Division management and staff have participated in a number of weeklong LEAN events, and used LEAN tools in several shorter events. Several of these events, like those focused on grant processes and priority project identification, were initiated to proactively prepare for Act 64 and the Lake Champlain TMDL. These events have already increased efficiency and productivity.

EXAMPLE PAST LEAN EVENTS INCLUDE:

- Division staff participated in a weeklong event to evaluate the public notice and comment process across all DEC permit programs to identify commonalities, enhance transparency and streamline these processes as much as possible;
- Business and Operational Support Services program staff participated in a weeklong event with a number of other DEC Divisions to evaluate how over $11 million in receipts is processed within DEC;
- The Business and Operational Support Services Program utilized a skills matrix tool to garnish efficiencies and evaluate training needs during its recent reorganization;
- The Vermont Clean Water Initiative Program held multiple multi-day events to create processes to more efficiently and effectively process grants and contracts;
- The Stormwater Program held a weeklong Lean event to improve its stormwater permitting business processes and enhance its database to more efficiently process applications, issue permits, collect fees and monitor compliance;
- The Wetlands Program held a weeklong event to explore how to shift staff time from inefficient processes to more protective actions for Vermont's wetlands, resulting in numerous database enhancements to increase customer satisfaction;
- The Rivers Program participated in a joint weeklong event with VTrans to streamline the Title 19 approval process for VTrans' projects;
- The MAPP Program and Clean Water Initiative Program held a joint event to more efficiently integrate the tactical basin planning priority project identification process with the CWIP funding process to ensure that priority projects are best identified and scoped, and to structure the grant issuance process so as to facilitate successful remediation projects;
- The Wastewater Program utilized Lean tools over several days to evaluate the federal and state requirements driving its workload and identify opportunities for streamlining processes and cross training staff; and
- The Lakes Program held a two-day Lean event to garner efficiencies in its newly regionalized shoreland and encroachment permitting programs.

UPCOMING LEAN EVENTS INCLUDE:

- The Lakes Program and MAPP will hold a multi-day Lean event to assess current monitoring conducted by the Division, to identify ways to garner efficiencies and streamline processes, and to ensure that monitoring is strategically targeted to support Division goals, protect Vermont's waters, and accurately assess performance;
- Division staff will use Lean tools to develop nForms for on-line reporting by NPDES permittees as the Division moves to meet requirements of the new federal e-reporting rule.

LEVERAGING TECHNOLOGY

The Division continues to leverage technology to increase its efficiency, streamline business and permitting processes, and better serve its customers, including an ever increasing number of permittees. As a result of two Lean events, the Stormwater and Wetlands programs have made significant database changes, including the establishment of on-line inquiry forms where the public can pose questions to staff and receive timely email responses. The Division is actively working to establish nForms that will allow electronic permit applications, fee payments and submission of reports and monitoring data from permittees.

The Monitoring and Assessment Program recently launched an on-line website that consolidates years of surface water monitoring data that is now available to the public. The Lakes program likewise has increased on-line availability of its monitoring data. The recently completed statewide river corridor maps are now available on-line courtesy of the Rivers Program. In addition, stormwater permits, wetland maps and other permit information are available on the Agency's "Natural Resource Atlas" website, thereby increasing transparency for the public and assisting project proponents in developing applications and siting projects.

Given the importance of outreach and education for the protection of our water resources and implementation of TMDLs, the Division is increasingly turning to technology to "spread our message." Division programs are using YouTube videos to highlight the importance of river corridor and floodplain protection and to educate local communities and the public about the science of river geomorphology. Other programs are using webinars as both an information sharing and training tool to increase participation and save travel time for staff and participants. Finally, the Division launched a blog, named "Flow", which regularly posts on the science of watershed protection, projects facilitated by Division programs, notices of grant opportunities and other topics related to protection of surface waters. Since September 2015, the Division has sponsored an AmeriCorp member in the Vermont Clean Water Initiative Program to foster communication around the Lake Champlain TMDL and other surface water issues. This AmeriCorp member has recently expanded the Division's on-line presence, through a new Facebook page.

ENHANCING PARTNERSHIPS

Federal, state and local partnerships have increased dramatically over the past five years, most notably in the development of the new Lake Champlain TMDL and the Phase 1 Implementation Plan. This collective "all in" approach will be critical in implementing the Plan and the requirements of Act 64, both of which require a heavy lift across multiple sectors – agriculture, municipal roadways, impervious surfaces, and forestry.

The Division holds alternating biweekly meetings with AAFM and VTrans to foster implementation. In addition, Agency Secretaries and senior staff meet bimonthly to monitor progress. Division staff have formed specialized work groups to focus on cross-Agency issues, such as development of a municipal roads permit, a TS4 permit for VTrans state highways, and an agriculture workgroup. Other cross-agency workgroups are closely collaborating on how best to target Vermont Clean Water Fund monies while ensuring transparency and public involvement, and establishing a tracking and database system that captures multi-agency work to meet EPA's accountability framework in the Lake TMDL and progress in implementing Act 64. Additionally, Division staff participate on the Department's Municipal Assistance Task Force in order to foster relationships with municipalities and help them better understand and meet increased obligations under Act 64 and the Lake Champlain TMDL.

Act 64 strengthened the Division's relationship with Regional Planning Commissions (RPCs) by defining specific roles and responsibilities for RPCs around the development of tactical basin plans, and education and outreach. Through this cooperative process, the Vermont Association of Planning and Development Agencies (VADPA) and the Division have set forth a series of activities that each RPC shall undertake in support of tactical planning for all watersheds in the State. This cooperative framework recognizes that significant municipal outreach is needed to develop an understanding of Act 64 requirements, develop tactical basin plans with targeted priority projects, foster implementation and track projects for purposes of accountability. The roles and responsibilities articulated in Act 64 for RPCs recognizes their strength in supporting municipal activities aimed at water quality protection and restoration.

The Division is also actively working to enhance our partnerships with local watershed organizations, including Watersheds United Vermont, to promote education and outreach efforts and identification of priority projects. Only through these close relationships will the Division be successful in meeting its four goals of surface water management – protect, maintain, enhance and restore.

STRATEGICALLY TARGETING PROJECTS AND FUNDING

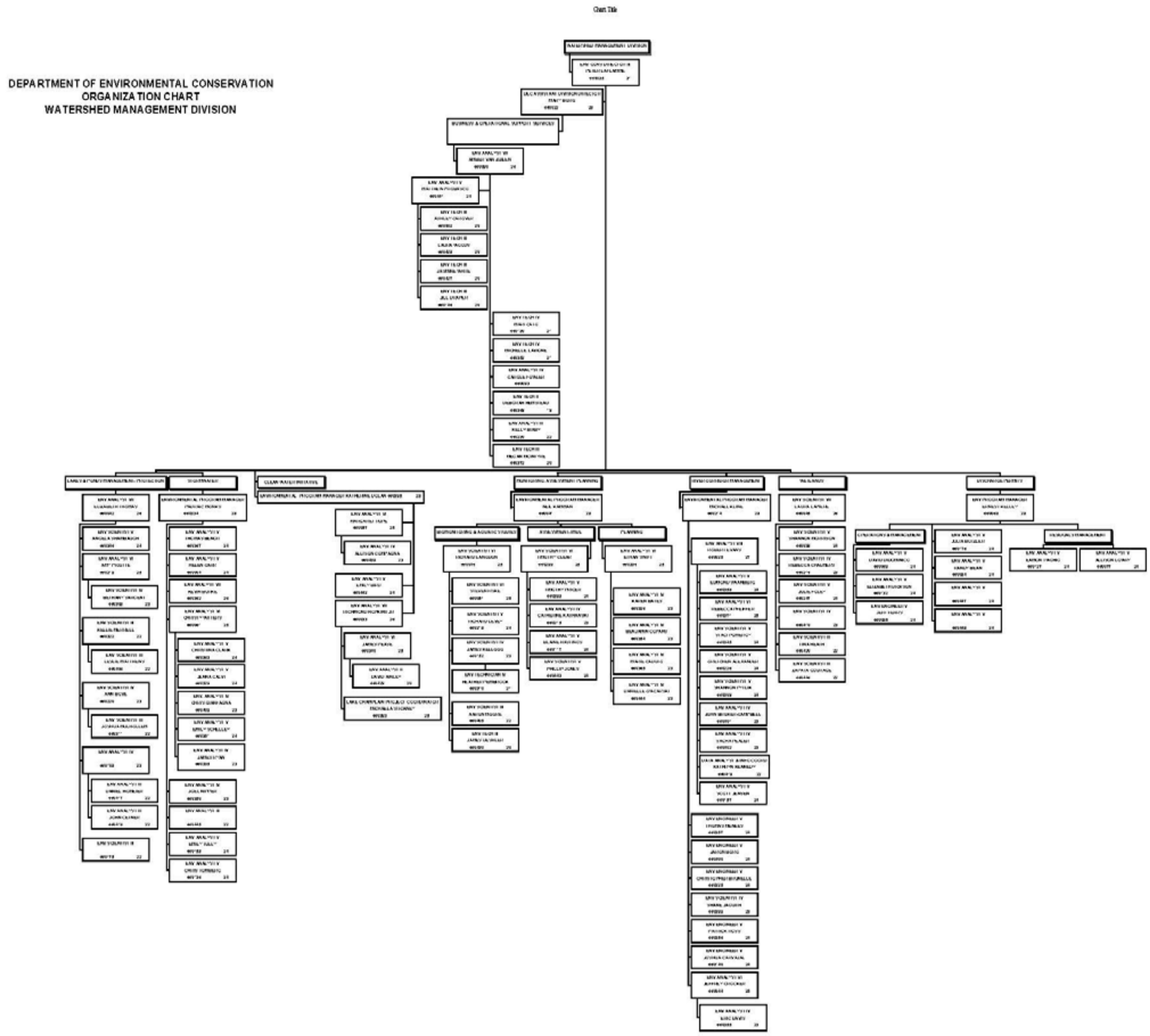
Given the huge lift – in terms of number and cost of projects – needed to successfully protect Vermont's waters, it is imperative that projects be strategically targeted and funded. Over the past few years, the Division re-envisioned the basin planning process and developed a strategic "tactical basin plan" approach. Tactical basin planning is a watershed management planning process in which water quality monitoring and pollution source assessment information is integrated with modeling or other land-based prioritization factors, to identify necessary actions to protect, maintain, enhance or restore surface waters. This planning process will integrate and deliver prioritized pollution control or mitigation actions for all Vermont surface waters. The benefits of these geographically explicit and data driven tactical basin plans include:

- More direct focus on the resource to be protected, tailored to basin-specific stressors and condition that are germane to that basin and sub-basins;
- Improved basis for management decisions as better coordination of monitoring is established and more information is gathered on a specific basin;
- Consistency and continuity is enhanced as an initial planning framework has been prepared and is applied to all basins and sub-basins in a systematic and rotational fashion;
- Increased opportunities for data sharing across agencies and organizations; and
- Encouragement of innovative solutions with input from various stakeholders and partner.

The draft Lake Champlain TMDL envisions that best management practices will need to be deployed on the landscape in such a manner to incrementally pursue required phosphorus load reductions. The Lake TMDL and associated Phase 1 Plan identify tactical basin planning as the vehicle by which "Phase 2" rosters of best management practices, identified projects and regulatory measures will be identified and phased in. Each tactical plan will be updated every five years, with a continually evolving implementation table that shows steady progress towards attaining priority actions. Most importantly, beginning in 2016, a significant amount of water quality modelling will inform each tactical basin plan. This will allow the Division to translate TMDL load reductions into very precise geographic prescriptions, in order to best target implementation projects. These new modelling approaches will further improve tactical basin plans and assist in targeting implementation of the new permit programs created in Act 64.

The Division has likewise been working hard to strengthen and tighten the project-identification to project-funding continuum to better link priority projects with federal and state funding. A recent outcome of a joint Lean event with the Monitoring Program and Clean Water Initiative Program was development of a project prioritization methodology, referred to as "Stage Gate," to direct funds towards priority projects (defined as those that will achieve important water quality improvements). For any given project phase or "Stage," there have been developed predictable criteria, or "Gates," that need to be satisfied to move a project forward to the next stage. This approach is designed so that incrementally higher-cost investments necessary to move a project forward are made on the most important projects first, and that projects that do not merit additional investment are identified early in the process.

ATTACHMENT 1 – WSMD ORGANIZATIONAL CHART



ATTACHMENT 2 – WSMD COMPREHENSIVE PLANNING STRATEGY

ATTACHMENT 3 – LINKAGE OF PROGRAM OBJECTIVES AND STRATEGIES WITH FOUR DIVISION GOALS (PROTECT, MAINTAIN, ENHANCE AND RESTORE)

LINKAGE OF PROGRAM WORK WITH WSMD'S FOUR GOALS

Each Program has outlined specific objectives and strategies for meeting each of the four Division goals. The Division goals are:

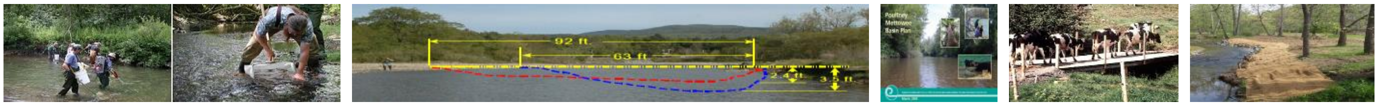
1. Protect Vermont's most pristine or special waters
2. Improve and expand the ongoing maintenance of Vermont's existing high quality waters
3. Increase opportunities for the enhancement of existing high quality waters to an improved condition
4. Aggressively pursue restoration of currently impaired waters through the development and timely implementation of comprehensive TMDLs, and implementation ore remediation plans for Vermont's degraded waters using a combination of regulatory and non-regulatory tools.

Specifics of each of the division's program objectives and strategies can be found here: http://dec.vermont.gov/sites/dec/files/wsm/boss/docs/WSMD-Strategic-Plan_2016-2018_Attachment-3.pdf

Vermont Department of Environmental Conservation

Watershed Management Division

Chapter 4. Tactical Basin Planning: Managing Waters along a Gradient of Condition using a Geographically Targeted Approach.



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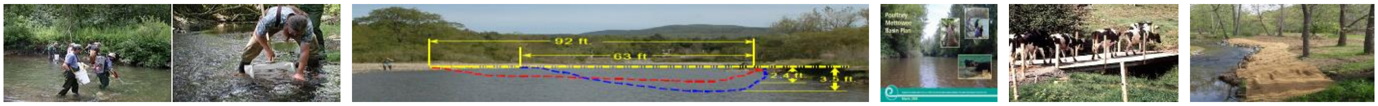


A. Introduction

The Vermont Agency of Natural Resources, Department of Environmental Conservation (DEC, or Department) and its federal, state, municipal, regional and local watershed partners engage in tactical basin planning process in all of Vermont's planning basins. The goal of the process is to develop tactical water quality watershed management plans for each of 15 planning basins that are built within a two-year timeframe, are revisited every five years, and for which implementation tables of priority actions are continually updated. Tactical basin planning is carried out for the Department by the Watershed Management Division (Division). The Monitoring, Assessment and Planning Program (MAPP) bears primary responsibility for implementing the basin planning process, and fostering effective partnerships, particularly with the Agency of Agriculture, the Natural Resource Conservation Service, Regional Planning Commissions, and the Conservation Districts of the Natural Resources Conservation Council.

The overall goal for each tactical basin water quality management plan is to establish and carry out strategies that will protect, maintain, enhance or restore the surface waters of the basin by directing regulatory, technical assistance, and funding to highest-priority sub-watershed areas

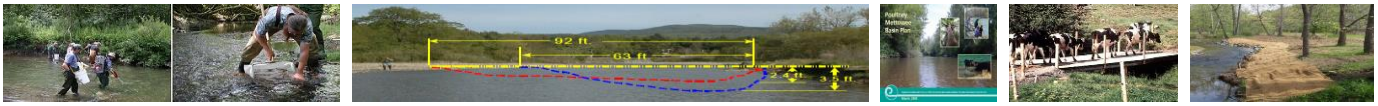
B. Federal and State Law Requirements for Basin Planning

Basin planning is required by both federal and state law. Sections 208 and 303(e) of the federal Clean Water Act (Public Law 92-500) require that states engage in water quality planning. Chapter 40 CFR 130, in part, directs state agencies to prepare basin plans, to focus on priority issues and geographic areas, to identify priority point and nonpoint water quality problems, consider alternatives and recommend control solutions and funding sources. At the state level, basin and watershed planning requirements are found in a number of statutory and regulatory provisions, including 10 V.S.A. §§ 1251, 1253 and 1258, 24 VSA Chapter 117, and the Vermont Water Quality Standards Rule (VWQS). Title 10 V.S.A. §1253(d) provides that basin plans must be developed on a five year rotational basis, while the VWQS requires that basin plans:

- Identify strategies, where necessary, by which to allocate levels of pollution between various sources as well as between individual discharges
- Contain specific recommendations by the Secretary that include the identification of all known existing uses
- Recommend changes in classification and designation of waters, including reclassifying waters' designated uses from Class B(2) to a higher classification level and designating waters as Outstanding Resource Waters,
- Contain schedules and funding recommendations for remediation, stormwater management, riparian zone management, and other measures or strategies pertaining to the enhancement and maintenance of the quality of waters within the basin.

Basics of Tactical Basin Planning

Tactical basin planning coordinates existing programs and builds partnerships to promote efficient and environmentally sound management of Vermont's surface water resources. Inherent in the process is the understanding that stakeholder groups and individuals have ongoing opportunities to effectively participate in planning for the management of Vermont's watersheds. The tactical



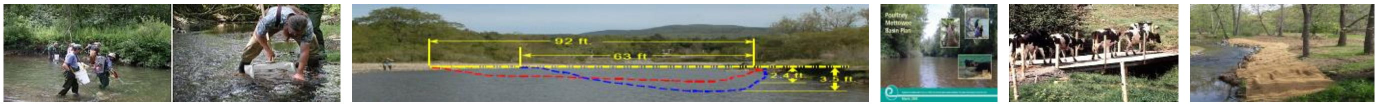
planning process is structured to identify and then consistently re-evaluate priorities for the project-level work funded by the Clean Water Initiative Program and other state and Federal water quality improvement funding programs. This chapter describes the process for developing individual, basin-specific and geographically explicit plans, establishing priority monitoring and assessment approaches, prioritized water quality improvement projects, and quantitative modeling information to support implementation of total maximum daily load pollution control plans (TMDLs).

C. Principles of Tactical Basin Planning

1. Tactical basin plans are developed to implement the goals and objectives of the Vermont Surface Water Management Strategy to protect, maintain and restore the biological, chemical, and physical integrity, and public use and enjoyment of Vermont's water resources, and to protect public health and safety.
2. Each tactical basin plan contains objectives, prioritized strategies, benchmarks and tasks in order to facilitate the implementation of the plans.
3. Each plan will spell out clear, attainable goals and targeted strategies to achieve those goals. The goals will be stated for the river basin and for individual sub-basins.
    - **a.** Document the highest priority water quality stressors across the basin.
    - **b.** Identify surface waters in very high quality condition (from biological, chemical, and physical assessment information).
    - **c.** Synthesize individual projects from available, existing assessments into an online database.
    - **d.** Provide understandable connections between the roles of participants and the environmental outcomes.
    - **e.** Track the outcomes and monitor the commitments of the participants.
4. Within tactical basin plans, priority for remediation is attributed to sub-watersheds where there are the most serious water quality problems. Priority for protection is ascribed to surface waters that exhibit higher quality conditions than Class B2 standards, where outstanding aquatic features are documented, or where wetlands exhibit unique exemplary functions and values.

There are fifteen major river basins that serve as hydrologic planning units within which tactical planning is focused. Within these major river basins, tactical basin plans are developed then updated on a five-year cycle as specified by § 10 VSA 1253. The tactical plans identify *priority sub-basins* for enhanced monitoring, assessment, project development, project implementation, or reclassification, within the lifecycle of each plan. The general idea is to focus resources and attention on a more concentrated area in a more coordinated fashion with the various stakeholders so that better utilization of resources (i.e., technical assistance and funding) can be achieved.

Each tactical plan is complemented by a continually-evolving implementation database that maintains information regarding specific monitoring, assessment, scoping, design, installation, or reclassification actions. This powerful database, called the Watershed Projects Database, is a



continually-updated resource with internal and external access points. In 2017 and beyond, the process of updating a tactical plan will boils down to taking stock of progress, elevating unfulfilled projects to higher priority where such is merited, identifying new monitoring and assessment priorities, and introducing new strategies or projects, while ensuring full stakeholder and public involvement in the update.

The Tactical Basin Planning Process provides the following benefits to interested stakeholders and Vermont's citizens:

- More cost-effective use of funds
- Better information to guide decision making for major river basins
- Increased ability (by ANR and partners) to resolve complex surface water resource problems
- Improved communication and coordination among governmental agencies
- More opportunities for stakeholders to get involved
- Increased ability to demonstrate results and benefits of environmental management
- Alignment of DEC regulatory and funding programs to surface waters most in need of improvement and protection.

D. Process for Developing Tactical Basin Plans

Step 1 - Scoping and information gathering to document conditions of surface waters

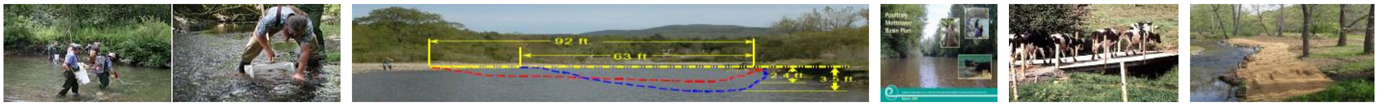
For targeted basins within the planning rotation (see Figure 1 for basin boundaries), DEC planners compile existing assessment data including:

- Water Quality Monitoring data (biomonitoring, chemical analyses, etc);
- Stream Geomorphic Assessment and attendant River Corridor Plans (RCP);
- Stormwater Master Planning (SWMP);
- Municipal Roads - Road Erosion Inventories and Capital Budget Planning;
- Agricultural-Farm Surveys and Assessments;
- Stormwater Mapping and Illicit Detection Discharge and Elimination (IDDE) Surveys
- MS4-derived Flow Restoration and Phosphorus Control Plans
- TS4-derived Phosphorus Control Plans

Step 2 - Prioritization and Targeting of Resources

In this phase of tactical plan development, DEC planners conduct structured meetings with four general groups, typically in the order indicated:

1) ANR Divisions, including Air Pollution Control, Drinking Water and Groundwater Protection, Waste Management and Prevention, Facilities Engineering, Fisheries, and Forestry.
2) Sister Agencies in State and Federal Government, including Agency of Agriculture, Food and Markets (AAFM), VTrans, US Environmental Protection Agency, Natural Resources Conservation Service (NRCS), Regional Planning Commissions (RPCs), and Natural Resources Conservation Districts.
3) Watershed organizations, municipal government, academia, consulting, other stakeholders.



4) Citizens.

The purpose of these meetings is to gather and review current and long term water quality monitoring data, discuss known issues in the basin, direct additional, near term monitoring, begin to identify both protection and restoration projects, and identify current levels of capacity for implementation. These core planning partners in groups one and two of the above-list coordinate shared priorities and develop a tactical approach to additional planning and project implementation for the basin in question. As current monitoring and assessment data is compiled and reviewed, DEC planners then initiate and coordinate external stakeholder meetings with other organizations (group 3).

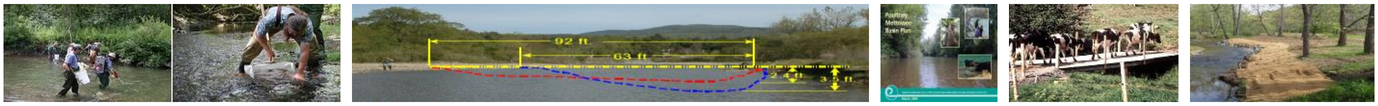
The Agency of Agriculture and Natural Resources Conservation Service provide specific information regarding the agricultural sector. The AAFM provides primary field assessments and leadership for farm water quality improvement projects, with substantial funding support by the NRCS. The NRCS also provides precision planning services for the highest-priority agricultural watersheds identified by the developing tactical basin plan.

Regional Planning Commissions and Conservation Districts play particularized roles in the tactical planning process, including:

1) Acting to increase municipal awareness and readiness to implement Act 64 by conducting municipal outreach and education, and cross-program integration and coordination and the municipal scale;
2) Promoting resilience and water quality protection and improvement by providing municipal planning assistance;
3) Developing better information for municipalities by providing coordination of water quality monitoring, and oversight of independently funded assessments;
4) Collecting municipal and regional input to assist in tactical basin plan development, including project prioritization;
5) Assisting in the protection of high quality resources and documentation of restoration efforts by promoting water quality reclassification or designation in their jurisdiction (see Section I of this Chapter).
6) Regional Planning Commissions are also charged with ensuring that Regional Plans are consistent with tactical basin plans.

Several RPCs have taken the additional step of forming Clean Water Advisory Committees to assist in the review and development of surface water priorities during each respective tactical basin planning process. These are official subcommittees of the RPC Commissioners/Board, and provide representation and expertise from the municipalities served by the RPC.

<u>Step 4 – Development of TMDL Phase II Implementation Actions.</u>
Each tactical basin plan within the Lake Champlain, Lake Memphremagog, or Connecticut River Basin will also contain information on how the State of Vermont will implement the TMDLs applicable to these watersheds. This content will include water quality modeling information that presents a consistent assessment of the total phosphorus reductions expected by implementation of the basin plan for Lakes Champlain and Memphremagog, and in future basin plan iterations,



the cumulative phosphorus reductions achieved over the planning cycle elapsed. The DEC is also developing similar capabilities for pollution that originates in the Connecticut River Basin, to support the Long Island Sound nitrogen TMDL. For a complete description of Phase II TMDL modeling and content, the reader is referred to the Lake Champlain TMDL Phase I Implementation Plan. As of this writing, completed phosphorus modeling is presented in the Lamoille and Missisquoi Tactical Basin Plans.

Step 5 – Public Outreach and Awareness of the Basin Planning Process

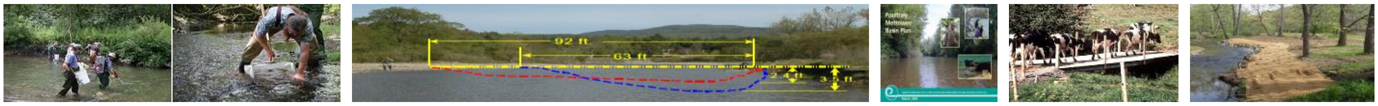
Following on the compilation of monitoring and assessment data to inform the draft tactical basin plan, public forums and targeted meetings are convened by DEC Planners, RPC's, and/or Conservation Districts to present the draft basin plan, and solicit public input to identify gaps and seek additional recommendations on priority surface waters for protection and restoration identified in Steps 1-3. Stakeholders and the public will have opportunities to inquire about the data and the proposed implementation actions, and can highlight gaps and areas of concern that may not be addressed at this stage in plan development. As these gaps are identified, subsequent monitoring and assessment actions can be highlighted in each plan to verify then address the new areas of concern.

Step 6 - Finalizing Tactical Basin Plans

During the final development of each Tactical Basin Plan, implementation tables are assembled. The printed implementation tables of the tactical basin plan summarize, at the strategic level, the hundreds of specific actions referenced in the dynamic online Watershed Projects Database. Implementation table elements include strategies for the protection of very high quality waters, actions to remediate impaired waters, project-specific recommendations for impaired and stressed waters, and present the regulatory actions required by the Vermont Clean Water Act at relevant geographic scales. The final plans and implementation tables will be presented at a final round of public meetings/ presentations. A web-based Watershed Projects Database has been created that provides for a continuously updated and accessible roster of projects that have been identified through monitoring data and assessment reports during the Tactical Basin Planning process.

Step 6 – Implementation of Tactical Basin Plans

As appropriate, agreements and MOUs may be developed between stakeholder groups to identify leads and project partners for funding and project implementation. Many projects identified in the Watershed Projects Database have funding source, potential partners, and an indication of the performance measures (as a function of environmental value and co-benefits) articulated in the project description. The Watershed Projects Database can be reviewed at queried from the Watershed Management Division website, at:
https://anrweb.vt.gov/DEC/IWIS/ARK/ProjectSearch.aspx



<u>Tactical Basin Planning Timeline for a Specific Basin</u>

Tactical Basin Planning Timeline	Month																							
Task	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
Scoping and information gathering (monitoring and basin assessment info compiled)	■	■	■	■	■	■																		
Prioritization and Targeting of Resources (internal) Identify and Secure Sources of Funding				■	■	■	■	■	■															
Prioritization and Targeting of Resources (external) Identify and Secure Sources of Funding				■	■	■	■	■	■	■	■	■												
Public Outreach and Awareness of the Basin Planning Process SW Plan and draft Tactical Plan presentation								■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Development of Tactical Basin Plans and Attendant Strategies										■	■	■	■	■	■	■	■	■						
Implementation of Tactical Basin Plans																■	■	■	■	■	■	■	■	■
Milestone(s)	Initial Assessment Report drafted						Final Assessment Report produced, Initial Tactical Plan drafted						Final Tactical Plan produced, Implementation Table, Report card drafted						Track implementation progress via report card, Sequence Rotational Basin Planning Process (ongoing)					

E. Stakeholder Process

The specific stakeholder outreach sequence associated with the steps outlined above is as follows:

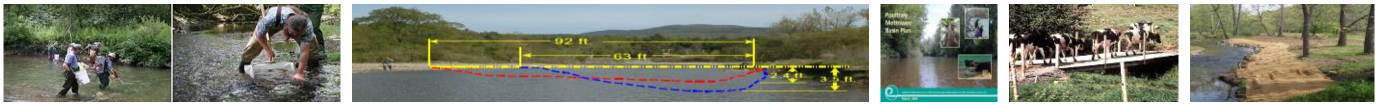
1. Invite technical ANR partners to consider their role for plan coordination and implementation and how this collaboration can be mutually beneficial. Develop a core group of internal staff responsible for construction of the Tactical Plan.

2. Outreach to determine which programs complement the effort to coordinate existing programs to protect or improve water quality. Solicit input on initial plan findings from State or Federal agency programs, Regional Planning Commissions, and Natural Resources Conservation Districts.

3. Solicit input from external partners and programs, including but not limited to watershed organizations, municipalities, lake associations, and other relevant groups. Simultaneously, Regional Planning Commissions and as appropriate Natural Resources Conservation Districts conduct municipal outreach.

4. Identify and reach out to additional advocacy organizations, major private sector entities as appropriate, and other relevant stakeholders.

5. Conduct media outreach at release of draft plan for public comment, and at final plan signature and release. Tactical basin plans are signed by the Secretary, ANR, and the Commissioner, DEC. A responsiveness summary is developed and issued concurrent with the approved plan.



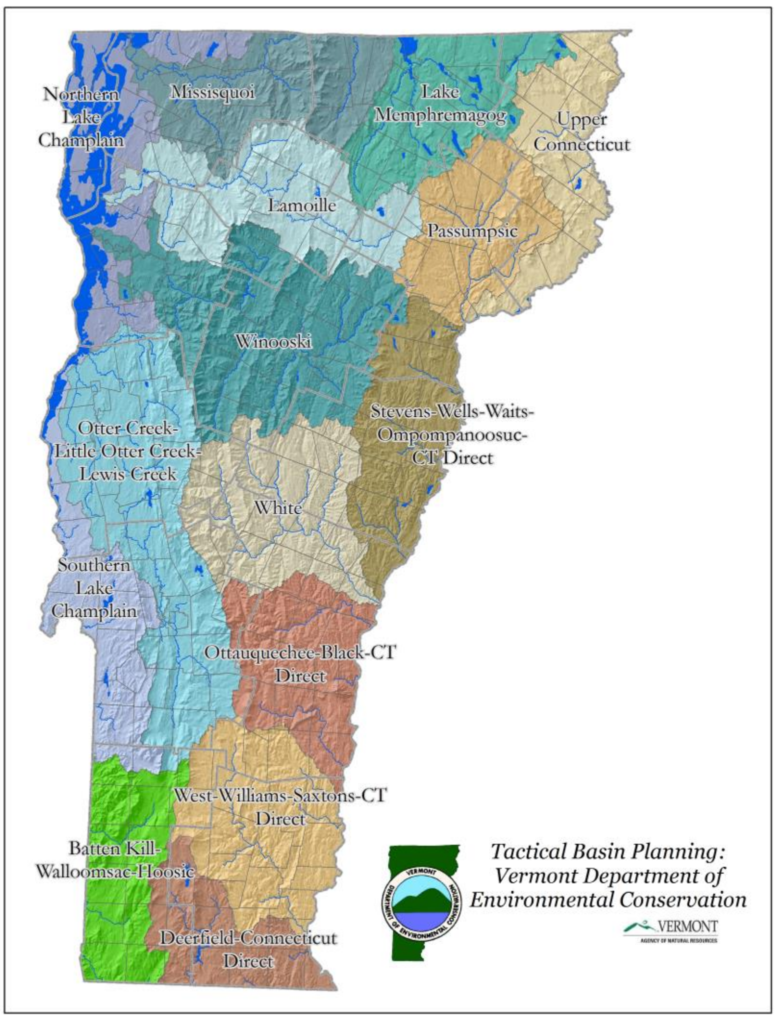
F. Tactical Planning Basins

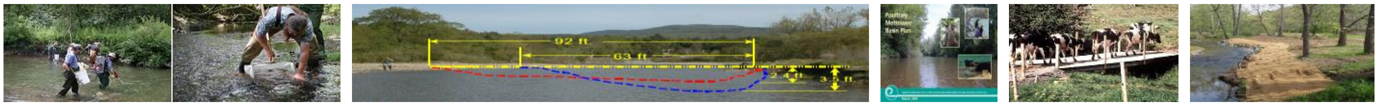
In Vermont, there are 15 planning basins, which occur within the Lake Champlain, Lake Memphremagog, Connecticut, or Hudson River drainages (See map of the 15 major river basins below).

Lake Champlain Planning Basins: Missisquoi, Lamoille, North Lake Champlain Direct Drainages, Winooski, Otter Creek, and South Lake Champlain Basins.

Connecticut River Planning Basins: Upper CT, Passumpsic, Stevens/Wells/Waits, Ompompanoosuc/Black, West/Williams/Saxtons, and Deerfield.

Hudson River Planning Basin: Battenkill/Hoosic/Walloomsac.





G. Tactical Plan Outline

The outline of a tactical basin plan is as follows:

Executive Summary

- Partners and Towns
- Executive Summary
- Top Objectives and Strategies
- Summary of Classification Opportunities

Chapter 1. Planning Process and Watershed Description

A. Tactical Basin Planning Process
B. Vermont Water Quality Standards
C. The Vermont Clean Water Act
D. River Basin description and Priority Sub-basins

Chapter 2. Water Resource Assessments & Recommendations

A. Overview of Water Resources and Stressors
B. Assessment and Management Methodology
C. Condition of Specific Water Resources
D. Water Quality Monitoring and Assessment
E. Additional Assessments
F. Status and Management of Water Resources by Land Use

Chapter 3. Regulatory Programs for Addressing Stressors and Pollutants

A. Approved TMDL Implementation Plans (e.g., Lake Champlain/ Long Island Sound, or others)

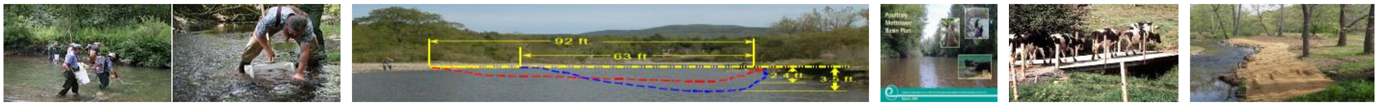
B. For Lake Champlain basins, a “Phase II” implementation plan that apportions the load and wasteload phosphorus allocations among the regulatory programs that will implement the TMDL, at relevant geographic scales. These apportioned allocations serve as planning level targets for the regulated sectors.

C. For the Memphremagog Basin, a phosphorus TMDL implementation plan that apportions the load and wasteload phosphorus allocations among the regulatory programs that will implement the TMDL, at relevant geographic scales. These apportioned allocations serve as planning level targets for the regulated sectors.

D. For Connecticut River and the Battenkill, Hoosic, Walloomsac Basins, a description of the regulatory processes in place to implement Act 64, and information that will assist municipalities in complying with the requirements.

Chapter 4. Management Objectives for Surface Waters in the Lamoille River Basin

A. Classification of Surface Waters Pursuant to the Vermont Water Quality Standards
B. Existing Uses
C. Outstanding Resource Waters
D. Class 1 Wetland Designations
E. Warm and Cold Water Fish Habitat Designations

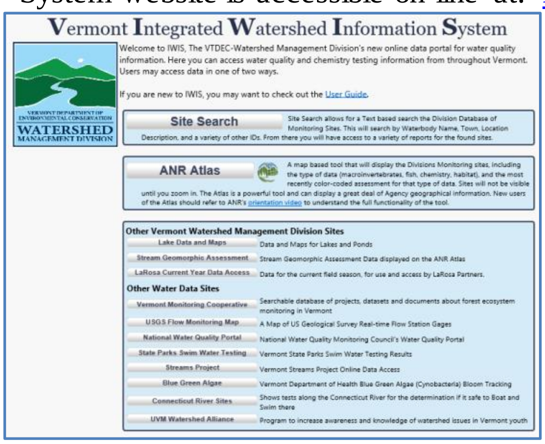


H. Resources to Support Tactical Basin Planning

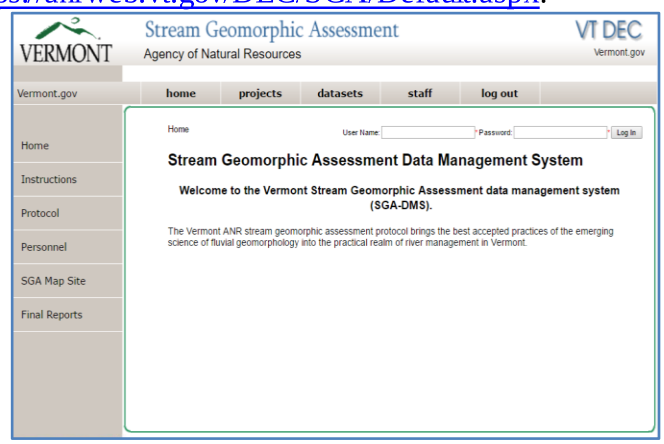
Vermont DEC, in partnership with other organizations, has developed several useful online resources that support and provide transparency to the basin planning process.

Water Quality Monitoring Data and Stream Geomorphic Assessments

A web-based portal for surface water data and information has been developed to provide information to citizens and stakeholders. The Integrated Watershed Information System presents water quality data housed by DEC, including water quality monitoring, and mapping that displays stream geomorphic assessments. The system also presents links to other useful sources of water monitoring data from Vermont. The system can be found on-line at: https://anrweb.vt.gov/DEC/IWIS/. The Stream Geomorphic Assessment Data Management System website is accessible on-line at: https://anrweb.vt.gov/DEC/SGA/Default.aspx.



Vermont Integrated Watershed Information System

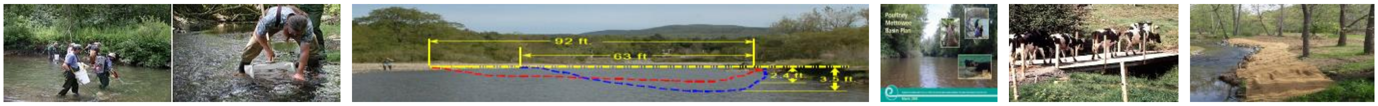


Stream Geomorphic Assessment Data Management System

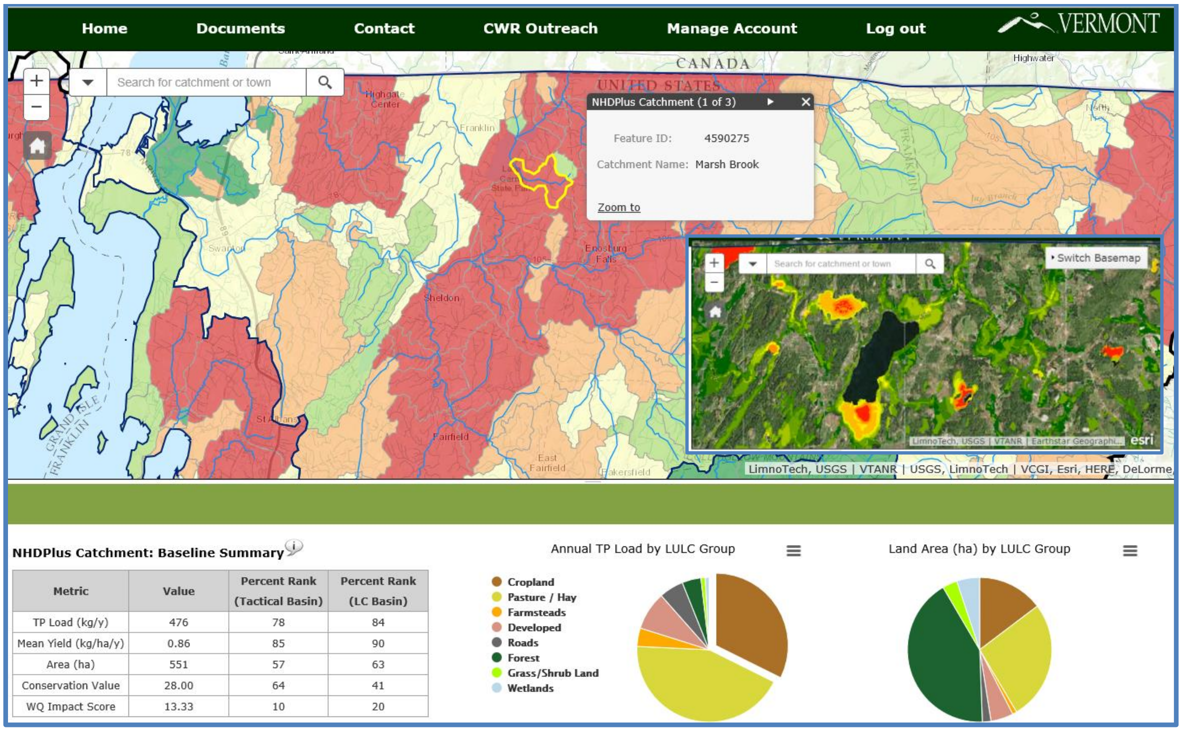
The Clean Water Roadmap

The Clean Water Roadmap Tool (CWR) is a partnership between DEC, Keurig-Green Mountain Coffee Roasters, the Nature Conservancy (TNC), and other stakeholders. The overall goal of the CWR is to 'map' the results of the Lake Champlain Soil Water Assessment Tool (SWAT) model and associated follow-on products, especially EPA's Best Management Practices (BMP) Scenario Tool, along with management actions contained in DEC's Tactical Basin Plan implementation tables and tracking systems. The CWR provides a description of *one way* the LC TMDL phosphorus reductions can be achieved, largely based on EPA's reasonable assurance scenario.

The CWR is a map-based application that allows users to click on a specified watershed and receive a summary report of relevant best management practices (BMPs) and ultimately, associated implementation table activities in the selected area. BMP suitability will be assessed using the landscape criteria in SWAT and EPA's Scenario Tool, while implementation table activity locations will be based on data in DEC's Watershed Projects Database. The Nature Conservancy's Conservation Blueprint for Water Quality shows locations that would be high priority for



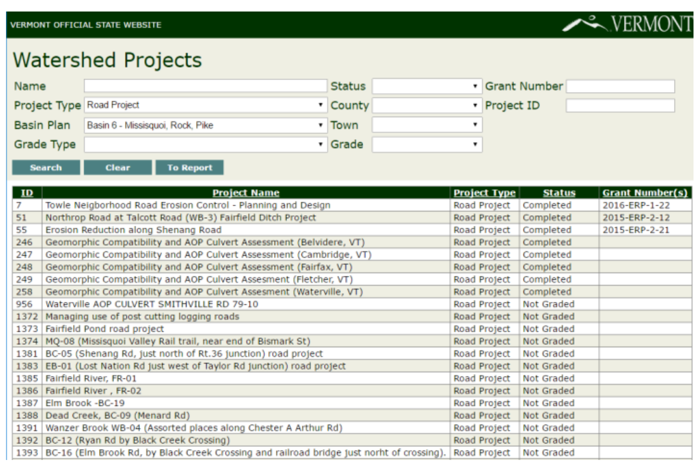
conservation. Additional relevant spatial information, such as township boundaries, partner data (TNC's), hydrologically connected backroads, etc., may also be included in the future. The CWR can be used by DEC staff, RPCs and Conservation Districts, and other organizations including the public, to identify priority areas and actions for Lake Champlain phosphorus reductions.



Screenshot of the Clean Water Roadmap, showing total phosphorus loading from the Marsh Brook sub-watershed of Lake Carmi, Franklin, VT. This is the scale at which total phosphorus loads have been estimated for every sub-watershed in the Lake Champlain basin. The inset shows high-priority conservation areas from The Nature Conservancy's Blueprint for Conservation.

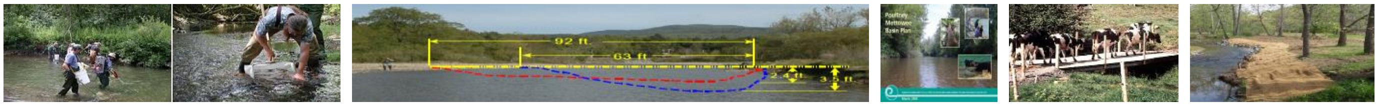
Implementation Tables and the Watershed Projects Database

The summary Implementation Table incorporated into each Tactical Basin Plan provides as an over-arching roster of priority implementation strategies identified for each Basin, which appears as a more detailed, prioritized, and "tactical" list of projects in the online Watershed Projects Database (as previously described in Step 6 of the planning process. Together, these resources include location information, project description, the source of the project if an assessment supports the project, and any partners that may have expressed interest in implementing the



ID	Project Name	Project Type	Status	Grant Number(s)
7	Towle Neigborhood Road Erosion Control - Planning and Design	Road Project	Completed	2016-ERP-1-22
51	Northrop Road at Talcott Road (WB-3) Fairfield Ditch Project	Road Project	Completed	2015-ERP-2-12
55	Erosion Reduction along Shenang Road	Road Project	Completed	2015-ERP-2-21
246	Geomorphic Compatibility and AOP Culvert Assessment (Belvidere, VT)	Road Project	Completed	
247	Geomorphic Compatibility and AOP Culvert Assessment (Cambridge, VT)	Road Project	Completed	
248	Geomorphic Compatibility and AOP Culvert Assessment (Fairfax, VT)	Road Project	Completed	
249	Geomorphic Compatibility and AOP Culvert Assesment (Fletcher, VT)	Road Project	Completed	
258	Geomorphic Compatibility and AOP Culvert Assesment (Waterville, VT)	Road Project	Completed	
956	Waterville AOP CULVERT SMITHVILLE RD 79-10	Road Project	Not Graded	
1372	Managing use of post cutting logging roads	Road Project	Not Graded	
1373	Fairfield Pond road project	Road Project	Not Graded	
1374	MQ-08 (Missisquoi Valley Rail trail, near end of Bismark St)	Road Project	Not Graded	
1381	BC-05 (Shenang Rd, just north of Rt.36 junction) road project	Road Project	Not Graded	
1383	EB-01 (Lost Nation Rd just west of Taylor Rd junction) road project	Road Project	Not Graded	
1385	Fairfield River, FR-01	Road Project	Not Graded	
1386	Fairfield River , FR-02	Road Project	Not Graded	
1387	Elm Brook -BC-19	Road Project	Not Graded	
1388	Dead Creek, BC-09 (Menard Rd)	Road Project	Not Graded	
1391	Wanzer Brook WB-04 (Assorted places along Chester A Arthur Rd)	Road Project	Not Graded	
1392	BC-12 (Ryan Rd by Black Creek Crossing)	Road Project	Not Graded	
1393	BC-16 (Elm Brook Rd, by Black Creek Crossing and railroad bridge just norht of crossing).	Road Project	Not Graded	

Watershed Projects Database showing certain road-related water quality projects in the Missisquoi Basin.



project. The database can be updated in real time to add new actions or update existing ones, as implementation proceeds.

As required by the Vermont Clean Water Act (2015 Act 64) and the Lake Champlain TMDL, the State has developed a companion tracking system that will be used to monitor progress meeting clean water restoration goals. The tracking system is being used to track the results of State investments in clean water through State funding programs, and is housed as a DEC internal access system in the Watershed Projects Database. The tracking system will also capture work implemented under State regulatory programs, and as actions listed in the implementation tables move through various stages toward completion, the environmental benefits of the projects will be tracked and quantified. Environmental benefits will include an estimate of annual nutrient load reductions achieved. Eventually environmental benefits will also capture metrics of additional benefits, such as flood resiliency, habitat function, and socioeconomic values. The Watershed Projects Database is online at: https://anrweb.vt.gov/DEC/IWIS/ARK/ProjectSearch.aspx.

Other resources

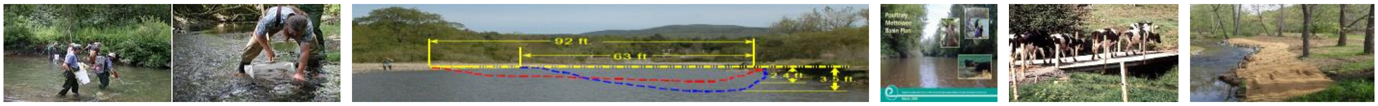
WSMD Staff Support
Watershed Management Division (WSMD) and internal and external partners play a role in natural resource monitoring and assessment. These partners provide monitoring and assessment, planning and technical assistance (Rivers, Wetlands, Stormwater, and Lakes and Ponds).

Watershed Coordinators/Basin Planners
Watershed coordinators serve as liaisons among the agencies, the basin stakeholders and local concerns. Their job is to specialize in their watershed, to know what resources might be available to address concerns and facilitate to the tactical basin planning process. DEC's basin planners also serve as the primary managers of the Watershed Projects Database. DEC's basin planner contact information is available online at: http://dec.vermont.gov/watershed/map/basin-planning.

Implementation Teams
Watershed "implementation teams" are the field-level, technical groups within the tactical planning process. These teams are composed of field staff from most State and Federal Natural Resource Agencies (e.g. USDA-NRCS), Regional Planning Commissions, Natural Resource Conservation Districts, Watershed Organizations, and citizen advocates. These teams help in development of monitoring strategies, education and outreach, prioritization of issues and watersheds within the basin, planning, and networking among technical staff and local leaders to apply agency resources to implement strategies identified in tactical basin plans.

I. Clean Water Funding

Projects that are explicitly identified in tactical basin plans, and are prioritized highly by DEC and Regional Planning Commissions/Conservation Districts become the priority projects to be funded using the Clean Water Initiative funding mechanisms. To this end, the process by which Clean Water Initiative funds are distributed has been re-engineered to align with the Tactical Planning Process. Throughout the process of Plan development, partner organizations are encouraged to



participate in a meaningful prioritization exercise that will identify the highest priority items for State support. Projects that are specifically identified in Tactical Plans and associated river corridor, stormwater, agricultural, capitol road inventory or other relevant Plans receive higher scoring in the allocation rubric.

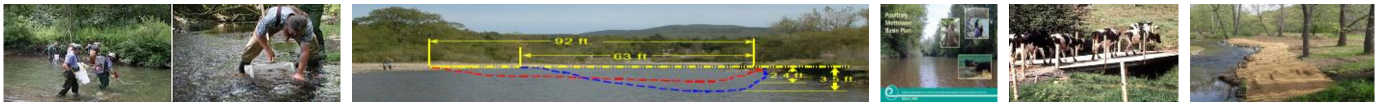
Through the Tactical Planning Process, Vermonters can be assured that:

- state dollars are invested in the most important water quality projects;
- state dollars are leveraged in every way possible to attract additional federal or private funds for appropriate and priority projects;
- there is accounting for successful pollution reductions; and,
- unique, widely applicable sets of priority funding recommendations are reflected in each basin in the tactical planning queue.

J. Schedule for Tactical Plan Development and Issuance

The Division has established a revised schedule for the issuance of Tactical Basin Plans that adheres to the five-year rotation established by VT Water Quality Standards. Table 3 provides a description of the status for each planning basin. An up to date accounting of the current status of planning for all Vermont Basins may be found in the annual legislative reports for tactical basin planning, at http://dec.vermont.gov/watershed/map/basin-planning.

Basin and Most Recent Plan Status	Major Watershed	Planner	Activity	2015	2016	2017	2018	2019	2020
Basin 15 – Passumpsic June 2014 – Tactical Plan	CT RIVER	Ben Copans	M+A	Mon	Assess				Mon
			Planning			Start	Finish		
Basin 16 – Northern Conn June 2014 – Tactical Plan			M+A			Mon	Assess		
			Planning					Start	Finish
Basin 17 - Memphremagog June 2012 – Tactical Plan			M+A	Assess				Mon	Assess
			Planning	Start	Finish				»
Basin 1 – Hoosic, Battenkill Jan., 2016 – Tactical Plan		Ethan Swift	M+A				Mon	Assess	
			Planning	Finish					
Basin 2 and 4 – Poultney, Mettawee, South Lake June 2014 – Tactical Plan	CHAMPLAIN		M+A	Mon	Assess				Mon
			Planning		Start	Finish			
Basin 3 – Otter, Lewis, Little Otter May 2012 – Traditional/Tactical Hybrid			M+A		Mon	Assess			
			Planning				Start	Finish	
Basin 7 – Lamoille February 2009 – Traditional Plan	CHAMPLAIN	Danielle Owczarski	M+A	»			Mon	Assess	
			Planning	Start	Finish				
Basin 9 – White July 2013 – Tactical Plan	CT RIVER		M+A	Assess				Mon	Assess
			Planning			Start	Finish		
Basin 14 – Stevens, Wells, Waits, Ompompanoosac			M+A			Mon	Assess		
			Planning	Finish				Start	Finish
Basin 5 – Northern L.C. Direct August, 2015 – Tactical Plan	CHAMPLAIN	Karen Bates	M+A		Mon	Assess			
			Planning	Finish			Start	Finish	
Basin 6 – Missisquoi, Rock & Pike March 2013 – Traditional Plan			M+A	»			Mon	Assess	
			Planning	Start	Finish				
Basin 8 - Winooski May 2012 – Traditional/Tactical Hybrid			M+A	Mon	Assess				
			Planning			Start	Finish		
Basin 10 (13) – Black, Ottauquechee May 2012– Traditional/Tactical Hybrid	CT RIVER	Marie Caduto	M+A	Assess				Mon	Assess
			Planning		Start	Finish			»
Basin 11 & 13 –West, Williams, Saxtons Jan., 2016 – Tactical Plan			M+A			Mon	Assess		
			Planning	Finish					Start
Basin 12 & 13 – Deerfield, Broad Brook March 2014– Tactical Plan			M+A		Mon	Assess			
			Planning				Start	Finish	



K. Protection of Vermont's Surface Waters

As noted above, tactical basin plans identify very high quality surface waters and identify appropriate legal mechanisms for their protection. This can take place either through water quality reclassification, wetland reclassification, or Outstanding Resource Water designation.

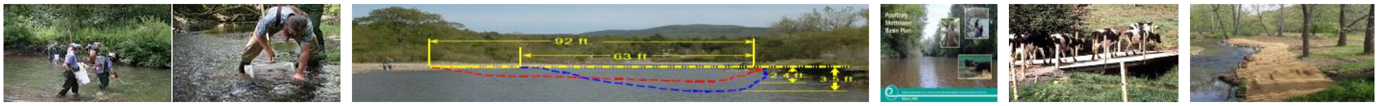
In Vermont, surface waters are classified by the governing water quality law that is implemented through rules of the State and guided by VTANR policy pursuant to the Water Pollution Control Act of 1972 (Clean Water Act, or Act). Pursuant to the Act, States are required to establish and implement water pollution control programs (see generally 40 CFR 131). Under these statutes, Vermont classifies surface waters, designates specific uses to each classification that those surface waters are managed to support, and adopts specific water quality criteria designed to protect the designated uses at the established classification level. Vermont's implementation of the Clean Water Act's framework of classification, use, and criteria is expressed in Statute in Title 10 V.S.A. Chapter 47 (see 10 V.S.A. §§ 1205-1253), most recently amended by Act 79 or 2016. Chapter 29a of Vermont's Environmental Protection Rules, also known as the Vermont Water Quality Standards (WQS) provides the designated uses and specific criteria for each classification. In determining whether water bodies meet water quality criteria and support designated uses, VTANR follows water quality policies and guidance documents which establish baseline expectations for surface waters.

Classification Structure under the Water Quality Standards.
The designated uses of Vermont's lakes and ponds, and rivers and streams may be classified in one of four Classes, as follows:

- Class A(1) waters are waters in a natural condition that have significant ecological value. By statute (10 V.S.A. § 1253), all surface waters above 2,500 feet of elevation in Vermont are Class A(1). Specific waters may have individual uses designated to Class A(1) through the process or amending the Vermont Water Quality Standards. Below the 2,500 ft. elevation threshold, there are numerous surface waters which have been documented to attain the biological criteria established for Class A(1), or to exhibit characteristics consistent with Class A(1). These waters are documented in the tactical plans, and where appropriate, proposed for reclassification.

- Class A(2) waters are waters of uniformly excellent character that, with filtration and disinfection, are suitable for a public water source. Where appropriate, tactical basin plans will recommend reclassification of Class A(2) public water source waterbodies when that waterbody is no longer used for the provision of drinking water.

- Class B(1) waters are waters of which one or more uses are of consistently and demonstrably higher quality than Class B(2) waters. Tactical basin plans catalogue all surface water that consistently and demonstrably attain a higher level of quality than Class B(2), and recommend reclassification for these surface water uses.



- Class B(2) waters are waters that are suitable for: swimming and other primary contact recreation; irrigation and agricultural uses; aquatic biota and habitat; good aesthetic value; boating, fishing, and other recreational uses; and, with filtration and disinfection, a public water source. Class B(2) is the base classification to which all surface waters, excepting those existing Class A(1) or A(2), are managed.

Class 1 Wetland Designation

There are now six Class 1 wetlands designated in Vermont to date, but there are others that qualify for this category, which enjoys additional statutory and regulatory protection. Currently, the wetlands designated as Class 1 include:

- Dorset Marsh in Dorset
- Tinmouth Channel in Tinmouth
- North Shore Wetland in Burlington
- Chickering Fen in Calais
- Dennis Pond in Brunswick
- Sandbar Wetlands in Milton and Colchester.

All Basin Plans approved since 2012 contain specific recommendations for wetland reclassification to Class 1. The latter three wetlands in the above list were reclassified as a result of identification in the respective tactical basin plans.

Outstanding Resource Waters (Tier 3 of Anti-Degradation)

An additional tool to manage and protect Vermont's waters is through the designation of Outstanding Resource Waters (ORWs) pursuant to Tier 3 of Vermont's Anti-Degradation Policy and 10 V.S.A. §1424. ORWs are waters of the State designated pursuant to 10 V.S.A. §1424a as having exceptional natural, recreational, cultural or scenic values. To gain an ORW designation, there must be evidence 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. All four Basin Plans approved since 2012 contain specific recommendations for ORW designation.

Existing Uses (Tier 1 of Anti-Degradation)

"Existing uses" are those uses of waters that have been designated by the Secretary and have actually occurred on or after November 28, 1975, in or on waters, whether or not the use is included in the classification of the water, and whether or not the use is actually occurring. Once an existing use is designated by the Secretary, the use cannot be eliminated. In addition, the level of water quality necessary to protect an existing use must be maintained and protected. All tactical basin plans catalogue existing uses as required by the VWQS.

Vermont Regulations Pertaining to Surface Water Management

Water Quality Planning

Water Quality Planning – A Brief History and Overview of Federal Requirements

During the early 1900's water management efforts focused closely on efficiency for irrigation, drinking water, navigation and similar purposes. The Rivers and Harbors Act of 1899, considered the oldest piece of environmental legislation in this country, served the sole purpose of preventing pollution from interfering with the navigable waters of the United States[1]. Legislation throughout the 1950's and 60's became increasingly focused on improvement of ambient water quality, and the Water Quality Act of 1965 introduced the first organized efforts to classify and inventory river basins, and develop basin plans for management. While this effort largely targeted interstate rivers, it was an important first step in states taking over individualized management strategies at the watershed level.

In 1972, the Federal Water Pollution Control Act Amendments established what we know today as the Clean Water Act (CWA or "the Act"). As the foundation of modern surface water quality protection in the United States, the CWA established a national goal "to restore and maintain the chemical, physical, and biological integrity of the Nation's waters[2]." The Act divided water pollution in the United States into two basic categories: point sources[3] and nonpoint sources. Point sources have traditionally been considered to be "end of pipe" discharges such as wastewater treatment plant and industrial discharges, whereas nonpoint sources are typically considered to be more diffuse, precipitation-driven discharges such as stormwater runoff from urban, agricultural and silvicultural sources.

Upon passage of the CWA, large point sources became the first major target of regulatory agencies. Section 303(e) of the Act required states to prepare basin plans to address point source issues[4]. These plans helped to inventory dischargers, as well as water quality throughout the country. Point source dischargers were also now subject to a requirement to obtain a permit under the National Pollutant Discharge Elimination System (NPDES). Under NPDES, dischargers are required to obtain permits for treatment of their discharges based on technology-based effluent limitations, and in cases where stricter limits are necessary, based on water quality based effluent limitations.

River Basin Water Quality Management Plans (CWA §§303(e) and 208 and PL 92-500)

Amendments to the CWA brought about a number of fundamental changes in pollution policy in the United States, several of which were dependent heavily on watershed management. Section

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[1] Ferrey, Steven. ENVIRONMENTAL LAW: EXAMPLES AND EXPLANATIONS, Fourth Edition. Page 244.
[2] 33 U.S.C. §1251(a)
[3] "Point source" is defined in 33 U.S.C. §1362(14) as "any discernible, confined and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged. This term does not include agricultural stormwater discharges and return flows from irrigated agriculture."
[4] United States Environmental Protection Agency. WATERSHED PROTECTION: A STATEWIDE APPROACH. 1995. Page 10.

303(e) of the Act required each state to prepare plans to achieve water quality standards for each watershed in the state, taking into account nonpoint sources of pollution from urban, agricultural, silvicultural, and mining activities as well as point sources of municipal and industrial pollution. Inclusion of nonpoint sources, widely distributed over the landscape and transported by stormwater runoff, increased the importance of watershed processes in pollution control strategies. Section 208 of the Act established area wide planning to embrace all municipal, industrial, and nonpoint sources of pollution in watersheds, particularly in metropolitan areas and other regions where point source controls alone were insufficient to satisfy water quality standards. Slow progress toward control of nonpoint sources led to inclusion of Section 319 in reauthorization of the Clean Water Act in 1987. That program established grants to states for reducing nonpoint source pollution on a watershed basis.

Comprehensive area-wide water quality management planning in Vermont was initiated with the promulgation of federal Public Law (PL) 92-500. These amendments to the Clean Water Act required that studies recommending specific solutions to water pollution problems be conducted before Federal monies are allocated for construction and management programs toward the improvement of water quality. These studies, known as the “303(e),” the “208 Areawide Plans”, and the “201 Plans,” consider federal, state and local objectives in the development of a comprehensive water quality management plan. The overall objective is to provide a planning, construction, and management process which will “restore and maintain” the quality of the nation’s waters.

Section 303(e) authorized the initial development of river basin plans that serve as a framework for subsequent plans that focus on more specific actions for known problems (e.g. the 208 Areawide Plans). The 208 Plan, as defined in Section 208 of PL 92-500, is required to propose implementable solutions to area-wide water quality and pollution problems, both from point and non-point sources.

Water Quality Management (WQM) Plans

The idea of managing water resources within watersheds is not a modern concept. According to EPA, the idea dates back as far as the late 19th century to the U.S. Inland Waterways Commission[5]. In 1908 the Commission, supported by President Roosevelt, reported to Congress that each river system from its headwaters to the coast is an integrated system, and must be managed accordingly[6]. There has been a considerable amount of legislation and regulation guiding watershed management since the Commission’s 1908 report.

The Water Quality Management (WQM) process described in the Clean Water Act provides the authority for a consistent national approach for maintaining, improving and protecting water quality while allowing States to implement the most effective individual programs. 40 C.F.R. §130.6 provides, in part:

> (a) *Water quality management (WQM) plans.* WQM plans consist of initial plans produced in accordance with sections 208 and 303(e) of the Act and certified and approved updates to those plans. Continuing water quality planning shall be based upon WQM plans and water quality problems identified in the latest 305(b) reports. State water

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[5] United States Environmental Protection Agency. WATERSHED PROTECTION: A STATEWIDE APPROACH. 1995. Page 10.
[6] *Id*.

> quality planning should focus annually on priority issues and geographic areas and on the development of water quality controls leading to implementation measures. Water quality planning directed at the removal of conditions placed on previously certified and approved WQM plans should focus on removal of conditions which will lead to control decisions.
>
> (b) *Use of WQM plans.* WQM plans are used to direct implementation. WQM plans draw upon the water quality assessments to identify priority point and nonpoint water quality problems, consider alternative solutions and recommend control measures, including the financial and institutional measures necessary for implementing recommended solutions. State annual work programs shall be based upon the priority issues identified in the State WQM plan.
>
> (c) *WQM plan elements.* Sections 205(j), 208 and 303 of the Act specify water quality planning requirements . . .

40 C.F.R. §130.6 contains a list of plan elements (e.g. TMDLs, controls for nonpoint pollution, etc.) that shall be included in the WQM plan or referenced as part of the WQM plan if contained in separate documents when they are needed to address water quality problems. In March 2008, the EPA issued the Handbook for "Developing Watershed Plans to Restore and Protect Our Waters." The handbook provides a comprehensive overview of how to develop and implement watershed plans at the state level. The handbook further explains the importance of management at the watershed level, and offers a framework for what EPA deems the most effective means of addressing water quality issues within these plans.

Nonpoint Source Pollution (CWA §§130 and 319)

Nonpoint sources were not comprehensively addressed in the CWA until it was amended in 1987. Now considered to be the most significant source of water pollution in the United States, nonpoint source pollution come from a variety of places. Some of the more common nonpoint sources of water pollution include agricultural and forestry runoff, storm water runoff, and atmospheric deposition of contaminants.

The basic planning and management aspects of the CWA were finalized in 1985. This CWA revision added §130, part of which called for the states to create and implement water quality management (WQM) plans. While other parts of the CWA required basin reports and water quality inventories, the purpose of §130 was to provide a more comprehensive planning strategy for states. In addition, the 1987 amendments added §319, under which states were required to identify navigable waters that would not meet water quality standards without control of nonpoint pollution[7]. Moreover, the states were required to identify the nonpoint sources, describe how they contribute to nonattainment of water quality standards, and design control programs to address the nonpoint sources contributing to nonattainment[8].

Water Quality Planning – A Brief Overview of State Law Requirements

Section 303(e) of the federal Clean Water Act (Public Law 92-500) sets out the basic requirements for state water quality planning. The Agency of Natural Resources, the Vermont Water Resources Panel, and the Agency of Agriculture, Food and Markets (which share the

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[7] 33 U.S.C. §1329(a)(1)(A)

[8] 33 U.S.C. §1329(a)(1)(B), (D)

administration of the federal Clean Water Act in Vermont) are empowered to carry out water quality planning and protection. The current federal rules implementing the 303(e) requirements are in 40 CFR 130. At the state law level, basin and watershed planning requirements are included in:

6 V.S.A. §4810 (which requires the Secretary of Agriculture, Food and Markets and the Secretary of Natural Resources to develop a memorandum of understanding describing how they will coordinate watershed planning activities to comply with Public Law 92-500 consistent with the Secretary's duties, established under the provisions of section 1258(b) of Title 10, to comply with Public Law 92-500);

6 V.S.A. §4813 (pertaining to the responsibility of the Secretary of Agriculture, Food and Markets to cooperate in preparing basin plans);

10 V.S.A. §1251 (which defines the term "basin plan");

10 V.S.A. §1253(d) (which requires the Secretary to prepare basin plans and provide progress reports);

10 V.S.A. §1258(b) (which requires the Secretary to adopt a continuing planning process approvable under section 303(e) of Public Law 92-500), essentially, this Strategy.

Basin and watershed planning are also addressed in the Vermont Water Quality Standards in Section 29A-103(e). Reference to basin planning requirements are also found in Section D 1 (e) of Chapter 13.12 of the Department's rules governing general permits for direct discharges and in Section 13.4 b. 1. (d) (iii) of the Department's wastewater permitting rules (which requires discharge permits to comply with waste load allocations included in plans prepared under 303(e) of the Clean Water Act.

The implementation of this Surface Water Management Strategy and associated Tactical Basin Plans accomplishes the aforementioned Federal and State planning requirements.

Water Quality Monitoring and Reporting – CWA § 305(b) Integrated Report and §303(d) List

Under these Sections, the Clean Water Act requires that every state develop and submit to EPA two surface water quality-related documents. The documents, to be prepared every two years, arise out of two sections of the Act. Section 305b of the Act requires submittal of a report that describes the quality of the State's surface waters and that contains an analysis of the extent to which its waters provide for the protection and propagation of a balanced population of fish, shellfish and wildlife. This analysis is also referred to as the extent to which Vermont's waters achieve the Act's "fishable and swimmable" goals. The biennial Vermont Water Quality Assessment Report is commonly known as the "305b Report."

The second document, developed in response to Section 303(d) of the Act, is a listing of surface waters that:

> 1) are impaired or threatened by one or more pollutants; and,
> 2) are not expected to meet Water Quality Standards within a reasonable time even after the application of best available technology standards for point sources of pollution or best management practices for nonpoint sources of pollution; and,

3) require development and implementation of a pollutant loading and reduction plan, called a Total Maximum Daily Load (TMDL), which is designed to achieve Water Quality Standards.

Vermont's Watershed Management Division – Management and Regulatory Programs for the Protection of Surface Waters

The primary mission of the Watershed Management Division is to protect, maintain, restore and enhance the overall quality of Vermont's surface-water resources. Inherent in this goal is the support of both healthy ecosystems as well as appropriate public uses in the 808 significant lakes and ponds, 7,100 miles of rivers and streams and over 300,000 acres of wetlands that exist within the State of Vermont. The Division's regulatory authorities are listed in the following.

Specifically, the Watershed Management Division:

* Conducts chemical, physical and biological environmental monitoring and publishes assessments of streams, rivers, lakes and wetlands.
* Provides guidance to citizen monitoring programs designed to evaluate the quality of the State's water resources and potential threats to that quality.
* Assures that permitted effluent discharges, and stream flows below dams, water withdrawals and hydropower reservoirs meet water quality standards.
* Issues grants and provides technical assistance to support local nonpoint source pollution management activities in lake and river watersheds.
* Devises plans designed to both protect high quality waters and to bring impaired waters back into compliance with water quality standards.
* Implements regulatory permitting programs for wetlands, floodplains, river corridors, stormwater runoff, erosion control, aquatic nuisance control, lakeshore encroachments, stream alterations, and the Vermont Water Quality Standards.
* Administers an aquatic nuisance management program, a flood hazard area and river corridor protection program, and sponsors Water Education for Teachers (Project WET).
* Prepares watershed plans for 17 major planning basins through a public-private collaboration that identifies water quality problems and develops and implements corrective strategies.

VT Water Quality Standards (2014, updated 2016)

The Vermont Water Quality Standards (VWQS) serve as a foundation for protecting Vermont's surface waters. The VWQS are regulations that establish uses (e.g. swimming and fishing) that must be protected, the classification to which the uses are managed (A1, A2, B1, or B2), and set minimum chemical, physical and biological criteria that must be met to support each use at its classification tier. The VWQS are promulgated by Watershed Management Division for the Agency of Natural Resources, and are used in planning, management and regulatory programs to protect Vermont's surface waters. The Water Quality Standards are required to be updated every three years pursuant to Federal requirements.

Aquatic Nuisance Species Control

Pursuant to 10 V.S.A. Chapter 50, the Watershed Management Division manages the Vermont Aquatic Nuisance Control Program. The goal of the Program is "to prevent or reduce the environmental and socio-economic impacts of nuisance (primarily non-native) aquatic plant and animal species." The Program administers permit and grant programs, and coordinates management activities associated with both aquatic invasive and nuisance species. Many species are included.

Transport of aquatic plants and aquatic nuisance species (10 V.S.A. §1454)
(a) No person shall transport an aquatic plant or aquatic plant part, zebra mussels (Dreissena polymorpha), quagga mussels (Dreissena bugensis), or other aquatic nuisance species identified by the secretary by rule to or from any Vermont waters on the outside of a vehicle, boat, personal watercraft, trailer, or other equipment. This section shall not restrict proper harvesting or other control activities undertaken for the purpose of eliminating or controlling the growth or propagation of aquatic plants, zebra mussels, quagga mussels, or other aquatic nuisance species.

(b) The secretary may grant exceptions to persons to allow the transport of aquatic plants, zebra mussels, quagga mussels, or other aquatic nuisance species for scientific or educational purposes. When granting exceptions, the secretary shall take into consideration both the value of the scientific or educational purpose and the risk to Vermont surface waters posed by the transport and ultimate use of the specimens. A letter from the secretary authorizing the transport must accompany the specimens during transport.

A person who violates a requirement under 10 V.S.A. § 1454 shall be subject to enforcement under 10 V.S.A. chapter 201, provided that the person shall be assessed a penalty of not more than $1,000.00 for each violation.

Aquatic Nuisance Control Permit (10 V.S.A. §1455)

An Aquatic Nuisance Control Permit is required to control nuisance aquatic plants, insects or other aquatic life (including lamprey) in Vermont waters. Some types of nuisance control activities are exempt. The use of chemical herbicides, benthic barrier materials or powered mechanical devices may also require a wetland permit. As required by 10 V.S.A., Chapter 47, Section 1263a(i), the Secretary of the Agency of Natural Resources has adopted the revised Public Review and Comment Procedures for Aquatic Nuisance Permit Applications and General Permits, effective January 30, 2003.

Aquatic Species Rapid Response General Permit (10 V.S.A. §1456)
The Secretary of the Agency of Natural Resources has new emergency permitting authority aimed at initiating a rapid response to a new invasive species invasion. An emergency rapid response general permit for both chemical and non-chemical methods with coverage is available to the commissioners of the Vermont Department of Environmental Conservation and the Vermont Department of Fish & Wildlife.

Multi-River, Multi-Treatment Aquatic Nuisance Control Permit
A new Aquatic Nuisance Control permit format was developed to address pesticide projects proposing multiple year treatments, multiple control methods and/or the treatment of more than one water body. Instead of individual permits, one permit decision could now cover multiple treatments, controls and water bodies.

Other Authorities to Control Aquatic Nuisance Species
Other entities also have authority to regulate aquatic nuisance species in Vermont. For example:

MINNOW NETS, TRAPS, TRANSPORTING and USE (10 V.S.A. § 122)

According to Vermont baitfish laws, anglers may harvest wild baitfish for personal use, provided they use them only on the same water where harvested and only species approved for use as baitfish. Anglers may NOT transport baitfish they harvest away from that waterbody, but may store them on that waterbody indefinitely.

When purchasing baitfish, anglers must purchase baitfish from a state-approved commercial bait dealer. At the time of purchase, a Baitfish Transportation Receipt will be issued, which is valid for 96 hours from time and date of sale. This means that when baitfish are purchased from a baitshop, anglers have 96 hours to transport and use said baitfish on the designated waterbody indicated on the receipt. These baitfish may NOT be transported to any waterbody other than the one indicated on your receipt.

The full law, as well as a list of approved species available for use as bait, is available here.

PEST SURVEY, DETECTION and MANAGEMENT (6 V.S.A. § 1030-1040)
The Vermont Department of Agriculture, through the Commissioner, has regulatory authority over plant pests pursuant to Title 6, Chapter 84, Pest Survey, Detection & Management. Within this statute, the commissioner may conduct surveys, establish quarantines and eradicate plant pests.

A plant pest is defined as any living stage of: insects, mites, nematodes, slugs, snails, protozoa or any other invertebrate animals; bacteria, fungi, mycoplasma or other parasitic plants, weeds or reproductive parts thereof; viruses or any organisms similar to or allied with any of the foregoing; and any genetically modified organisms or biological control agents that may directly or indirectly injure or cause disease or damage to any beneficial organisms, plants, parts of plants, or plant products.

NOXIOUS WEED QUARANTINE #3
(Vermont Department of Agriculture, Food & Markets)
In general, this rule prohibits the sale, movement, distribution, and in some cases, possession or cultivation of certain species of plants that have been recognized as invasive in Vermont or adjacent States. The impacts of these plant species on native ecosystems outweigh their value as ornamental plants in the nursery and landscaping trades to the extent that the Agency of Agriculture has banned their sale to prevent their introduction into yet uninfested areas, or slow their further spread across the state through commerce.

Click here for more information.

CONTROL of FISH, GAME; POWERS of COMMISSIONER (10 V.S.A. § 4138)
The Vermont Department of Fish and Wildlife, through the Commissioner, "may take, permit, or cause to be taken at any time from any waters, and in any manner, fish which hinder or prevent the propagation of game or food fish and may take, permit, or cause to be taken at any time wild animals which are doing damage. Such removal or taking and the possession and disposition of such fish or wild animals shall be under such regulations as the Commissioner may prescribe. The Commissioner may take necessary measures to control, in public waters, aquatic vegetation, insects, or aquatic life, for the purpose of improving such waters as a habitat."

PLACING FISH in WATERS (10 V.S.A. § 4605)
The Vermont Department of Fish and Wildlife, through the Commissioner, has the authority to regulate the introduction of all live fish or the live spawn thereof, into any of the inland or

outlying waters of the state. The Department also may dispose of unlawfully imported fish as it may judge best, and the state may collect damages from the violator for all expenses incurred. In this regard, no person is to bring into the state to introduce into any of the public waters any live fish or eggs unless a permit is first obtained from the Department of Fish and Wildlife.

IMPORTATION, STOCKING WILD ANIMALS (10 V.S.A. § 4709)
The Vermont Department of Fish and Wildlife, through the Commissioner, has the authority to regulate the introduction of any live wild bird or animal of any kind. The Department may dispose of unlawfully imported wildlife as it may judge best, and the state may collect damages from the violator for all expenses incurred.

Management of Encroachments in or around Vermont Lakes

Construction in or near Lakes and Ponds

Any project that encroaches beyond the normal summer water level of a lake or pond that is a public body of water may require a Lake Encroachment Permit. Encroachments include such projects as retaining walls or riprap to control shoreline erosion, commercial docks, large docks or docks involving concrete, dredging or filling, and repairs or replacements of existing encroachments. Some small projects may not require a permit, but it is best to check with the Watershed Management Division to be sure.

Effective July 1, 2014, the Vermont Legislature passed the Shoreland Protection Act (Chapter 49A of Title 10, §1441 et seq.), which regulates shoreland development within 250 feet of a lake's mean water level for all lakes greater than 10 acres in size. The intent of the Act is to prevent degradation of water quality in lakes, preserve habitat and natural stability of shorelines, and maintain the economic benefits of lakes and their shorelands. Any new development, redevelopment, or clearing of a property, may require a Shoreland Permit or Registration.

A permit from the U.S. Army Corps of Engineers may be required for projects or activities which encroach beyond the ordinary high water mark of Lake Champlain or Lake Memphremagog, including seasonal docks, moorings, jetties, beach replenishment or grading, shoreline stabilization, and water intakes. A Corps permit also may be required for projects on other lakes and ponds in the state, if the project involves the discharge of dredged or fill material or mechanized clearing beyond the ordinary high water mark. Projects that require a Corps of Engineers permit for the discharge of dredged or fill material or mechanized land clearing also require a Section 401 Water Quality Certification from the Watershed Management Division before the Corps permit is issued.

Finally, some projects in lakes or ponds or within the buffer zone along the shoreline may require an Act 250 Permit.

Docks.

Certain docks and other encroachments in Vermont Lakes must obtain a permit as provided in 29 V.S.A. §403.

§ 403. Encroachment prohibited

(a)(1) Except as provided in subsection (b) of this section, no person shall encroach on any of those waters and lands of lakes and ponds under the jurisdiction of the board without first obtaining a permit under this chapter.

(2) Except as provided in subsection (b) of this section, no person shall encroach on the following waters with a dock or pier without first obtaining a permit under this chapter:

(A) boatable tributaries of Lake Champlain and Lake Memphremagog upstream to the first barrier to navigation; and

(B) Connecticut River impoundments and boatable tributaries of such impoundments upstream to the first barrier to navigation.

(3) No permit shall be granted if the encroachment adversely affects the public good.

(b) A permit shall not be required for the following uses provided that navigation or boating is not unreasonably impeded:

(1) Wooden or metal docks for noncommercial use mounted on piles or floats provided that:

(A) the combined horizontal distance of the proposed encroachment and any existing encroachments located within 100 feet thereof which are owned or controlled by the applicant do not exceed 50 feet and their aggregate surface areas do not exceed 500 square feet; and

(B) concrete, masonry, earth or rock fill, sheet piling, bulkheading, cribwork, or similar construction does not form a part of the encroachment;

(2) A water intake pipe not exceeding two inches inside diameter;

(3) Temporary extensions of existing structures added for a period not to exceed six months, if required by low water;

(4) Ordinary repairs and maintenance to existing commercial and noncommercial structures;

(5) Duck blinds, floats, rafts, and buoys.

(c) Existing encroachments shall not be enlarged, extended, or added to without first obtaining a permit under this chapter, except as provided in subsection (b) of this section.

(d) This chapter shall not apply to encroachments subject to the provisions of chapter 43 of Title 10, concerning dams, or regulations adopted under the provisions of 10 V.S.A. § 1424 concerning public waters.

(e) This section shall not apply to the installation on lake bottoms of small filtering devices not exceeding nine square feet of disturbed area on the end of water intake pipes less than two inches in diameter for the purpose of zebra mussel control. (Added 1967, No. 308 (Adj. Sess.), § 3, eff. March 22, 1968; amended 1975, No. 162 (Adj. Sess.), § 3, eff. March 15, 1976; 1981, No. 222 (Adj. Sess.) § 41; 1993, No. 233 (Adj. Sess.), § 52, eff. June 21, 1994; 2009, No. 117 (Adj. Sess.), § 2.)

Drawdowns and Desilting Operations

Drawdowns of lakes or impoundments and sediment-removal operations can result in downstream discharges of sediment. The projects often do not require permits from any of the programs described above. The Agency of Natural Resources, however, has the authority to issue what is known as a Section 1272 Order (named for the statutory authority in 10 V.S.A. § 1272) for activities that may result in a discharge that is not otherwise regulated or may potentially violate the Vermont Water Quality Standards or the Vermont Wetland Rules.

Management of Wetlands

The Wetlands Program is responsible for the administration and implementation of the Vermont Wetland Rules, which require permitting for certain activities within wetlands or their buffer zone. Using the Vermont Wetland Rules as a guide, the program provides advisory recommendations on Act 250 projects with potential wetland impacts to the District Environmental Commissions; and review wetland projects that fall under federal jurisdiction (Section 404 of the Clean Water Act) to ensure that State Water Quality Standards are met. In 2012, Vermont Legislature passed Act 138, which transferred wetland rulemaking authority from the Natural Resources Board's Water Resources Panel to the Agency of Natural Resources' Department of Environmental Conservation. Now the Wetlands Program has the responsibility to administer the Vermont Wetland Rules ("the Rules") and receive petitions or internally initiate adoption, amendments, and repeal of the Rules. This includes the designation of wetlands to Class I status. The Vermont Wetland Rules, first enacted in 1990, had amendments adopted September 15, 2010.

The Vermont Wetland Rules identify and protect 10 functions and values of "significant" wetlands and establish a 3-tier wetland classification system to identify such wetlands. Class I wetlands are identified on the Vermont Significant Wetlands Inventory (VSWI) maps and are protected under the Vermont Wetland Rules. Class II wetlands are often mapped on the VSWI maps but not all. The new Rules allow the Vermont Wetlands Program to evaluate unmapped wetlands and designate as Class II. Wetlands which are unmapped but frequently found significant include: wetlands over a half and acre in size, vernal pools, peatlands, wetlands adjacent to lakes and streams, and headwater wetlands over 2,500 feet in elevation. In addition, the buffer zones associated with these wetlands (typically a 100-foot buffer zone for Class I wetlands, and 50-foot buffer zone for Class II wetlands) are also protected under the Vermont Wetland Rules. Any activity within a significant wetland or buffer zone, unless specifically called out as exempt or an allowed use, requires a Vermont Wetlands Permit which are issued by the Wetlands Program in the Watershed Management Division. A permit may only be issued when it is determined that the proposed activity will not have undue adverse effects on the protected functions of a significant wetland. We recommend that anyone contemplating work in or near wetlands contact a District Wetlands Ecologist or wetland consultant early in the planning stage.

Other Wetland Regulatory Programs

Class III wetlands have been found by the Wetlands Program to be insignificant for providing the wetland functions when last evaluated. These wetlands are not protected by the Vermont Wetland Rules and a wetlands permit is not required for projects in Class III wetlands. Class Three wetlands may, however, be protected by other federal or local laws and regulations, including those administered by the U.S. Army Corps of Engineers. Projects that require a federal permit will also require a Section 401 Water Quality Certification.

In 1986, the Vermont Legislature passed an act that allowed for state and local protection of wetlands in Vermont. The law enables Vermont towns and cities to protect wetlands at the local level. This can be accomplished through the Town's municipal plan, zoning and subdivision regulations, shoreland protection bylaws, health ordinances and flood hazard regulations.

Stormwater Management

10 V.S.A. §§1258, 1264 and 1264a

The Watershed Management Division implements a stormwater permitting program consisting of two major components: 1) the issuance of stormwater permits pursuant to state law for the post-construction management of stormwater runoff pursuant to 10 V.S.A. §§1264 and 1264a ; and 2) the issuance of permits pursuant to an EPA-delegated federal ”NPDES” program for construction site runoff, stormwater associated with industrial activities and stormwater discharges from municipal stormwater systems pursuant to 10 V.S.A. §§1258 and 1264. The Division may also issue NPDES stormwater permits for other point source stormwater discharges designated by the Secretary pursuant to 40 C.F.R. 122.26(a)(9)(i)(D) and stormwater discharges designated by the Secretary as requiring a NDPES permit pursuant to 40 C.F.R 122.26(a)(9)(i)(C) to implement a TMDL.

The Division uses a combination of individual and general permits to authorize stormwater discharges. There are currently five distinct Federal and State permits which regulate the runoff of stormwater. A permit could be required for construction of impervious surfaces (roads, buildings, parking lots, etc), for restoration of impaired waters in a few select watersheds, for stormwater runoff from certain industrial activities, for municipal management of stormwater in certain large municipalities, and for construction site runoff.

The Division has issued several stormwater rules governing the issuance of state stormwater permits for construction or operational stormwater runoff control from impervious surfaces. The specific rules and programs are listed as follows:

Operational Permits
Construction Permits
Industrial Permits
Municipal Permits
Transportation Permit

In addition to these permit programs, the Vermont Clean Water Act requires the development of a permit program to address stormwater discharges from impervious surfaces exceeding three-acres in size. In the Lake Champlain Watershed, the threshold may be smaller if necessary to comply with the wasteload allocations of the Lake Champlain TMDL. The so-called “Three-acre” developed lands permit will be issued by 12/31/2017.

River Management

Regulations, Permits, and Stream Crossing Approval

Most in-channel management activities and new projects like bridges, culverts or utility crossings require regulatory action by the River Management Program in the Watershed Management Division. State jurisdictional thresholds and guidance on permit application is provided within the documents below or by contacting the Stream Alteration Engineer in your area.

Construction in or near Rivers and Streams

Construction in a river or any perennial stream on or within the banks may require a Stream Alteration Permit if 10 or more cubic yards of material will be involved. There is an exemption for small-scale gravel removal by riparian landowners (up to 50 cubic yards), but any gravel removal above 10 cubic yards must be reported to the Agency prior to excavation and must be for personal use. The Stream Alteration Rule sets standards both non-emergency and emergency instream activities. Certain activities may be authorized under the Stream Alteration General Permit. Any activity not directly related to addressing an imminent or next-flood threat to public safety must meet the equilibrium and connectivity performance standards established by Rule. New berms within floodplains and river corridors are no longer a permitted activities unless necessary to protect a habitable structure.

An Act 250 Permit may be required for projects in rivers and streams or within a buffer zone along the bank. Projects in, under, or over any rivers and streams may require a permit from the U.S. Army Corps of Engineers and a Section 401 Water Quality Certification from the Watershed Management Division. We recommend that anyone contemplating work in or near rivers or streams contact a stream alteration engineer early in the planning stage.

Gravel Removal and Prospecting

Once a widespread commercial activity in Vermont's rivers, gravel removal is now restricted to maximum annual volumes for landowners use and for the maintenance or restoration of stream channel stability. As a commercial activity, gravel mining has proven to be extremely damaging to natural stable stream functions and has greatly increased flood and erosion damages in VT on stream systems that have experienced extensive mining in the past. Information on how to get assessment of potential stream sedimentation problems, approval for gravel removal projects and the effects of gravel removal on stream stability is provided in the documents below or by contacting the Stream Alteration Engineer in your area.

Mineral prospecting activities in Vermont streams are regulated under 10 V.S.A. 41, Section 1021(h)(1). Operation of suction dredges is prohibited. Operation of sluice boxes is allowed by permit. Hand panning is unregulated. Hand panning only is allowed on state owned lands. Written permission from property owners is required on private lands.

Streamflow Protection

Water Withdrawals

Water withdrawals in both streams and lakes usually require one or more permits. Act 250, Stream Alteration (in rivers), or Shoreland Encroachment (in lakes and reservoirs) permits may be needed, as well as a permit from the U.S. Army Corps of Engineers. As with other projects requiring a federal permit, a Section 401 Water Quality Certification from the Agency will be required before the permit is issued.

For most types of water withdrawals (except those for snowmaking), the Agency has adopted a procedure that defines the standards and process used by the Agency during its review of project proposals. The procedure defines how the Agency will determine the minimum streamflow that is necessary to meet Vermont Water Quality Standards.

For snowmaking water withdrawals, the Agency has developed rules (40 kb) as directed by 10 V.S.A. §§ 1031-1032. The rules serve the same purpose as the Agency procedure, but apply specifically to snowmaking projects.

Dams

Construction, reconstruction, alteration, modification, or removal of dams that can impound more than 500,000 cubic feet of water or other liquid require a Dam Order from the Department of Environmental Conservation. This program is managed by the Dam Safety Section of the Facilities Engineering Division. If the dam is associated with a hydroelectric project, it is regulated by the Public Service Board under the same statute (10 V.S.A. Chapter 43).

Some smaller dams may require a Stream Alteration Permit, if they would otherwise fall under the jurisdiction of that program. In addition, dams may require a Wetlands Permit, an Act 250 Permit, a permit from the U.S. Army Corps of Engineers and Section 401 Water Quality Certification, as well as local permits. Finally, any project that will obstruct the movement of fish requires authorization from the Commissioner of Fish and Wildlife.

Management of Lake Levels

Manipulation of water levels in lakes can have a direct impact on the physical and biological integrity of the littoral zone. Following the Hydrology Policy stated in the Vermont Water Quality Standards, the Watershed Management Division requires all lake dams to be set at one level. This allows lake levels and downstream flows to fluctuate naturally, protecting local natural communities and increasing their resiliency.

Flood Hazard Area and River Corridor Protection

Flood Hazard Areas and River Corridor Rules and Protection Procedures (10 VSA §§751, 752, 753, 6086 and 24 VSA § 4424)

Below is a summary of federal and state legislative actions, procedures, statutes, policies, and programs that form the basis for Watershed Management Division's flood and fluvial erosion hazard avoidance strategy and its Act 250 floodway determinations .

- Passage of Act 137. The 1998 legislative response to the magnitude of flood damages in the 1990s ($60 million in recovery costs) was the passage of Act 137 whose overarching objective was to promote long-term river stability to provide both protection from flood damage and a healthy riverine function. Sec. 2 10 V.S.A §905b(3).

- Woodford Packers Decision. In 2003, the ANR Secretary, through the ANR General Counsel's Office, successfully appealed the District 8 Environmental Commission's Woodford Packers decision to the State Environmental Board. The Attorney General's office successfully defended the Environmental Board's Ruling before the State Supreme Court. These rulings and case law confirm and support the Agency's authority to determine floodways using both inundation and erosion hazard standards under Criterion 1(D). re Woodford Packers, Inc. (2002-056); 175 Vt. 579; 830 A.2d 100 2003 Vt 60.

- Acts 110, 138, 16, and 107. A series of statutory changes were made between 2010 and 2014 which established public policy and directives to the Agency to map flood hazard areas and river corridors (the latter to include buffers and help define fluvial erosion hazards), promote their protection in municipalities planning and zoning, establish state protective procedures, and regulate activities exempt from municipal regulation. Act 138 allowed that state standards may be more restrictive than federal (NFIP) standards and Act 107 explicitly called for the protection of river corridors (i.e., river meander belt plus buffer) in state regulations.

- State Hazard Mitigation Plan. With respect to Disaster Assistance, 44 CFR Chapter 1, Subchapter D, Part 200, Section §201.4, p. 402 and Section § 201.6 p. 405 describe state mitigation plans and local mitigation planning, respectively. These plans must be in place in order for the state or local municipalities to receive funds as part of the FEMA mitigation grant programs (specifically the Hazard Mitigation Grant Program (HMGP), the Pre-Disaster Mitigation Program (PDM), and the Flood Mitigation Assistance (FMA) grant programs). The purpose of these funds is to reduce the loss of life and property from future natural hazard events. Every five years, the State Hazard Mitigation Committee (SHMC), which is chaired by the Deputy Secretary of Administration, is responsible for developing the State Hazard Mitigation Plan. Upon receipt of FEMA approval, the Secretary of Administration officially adopts the state mitigation plan. The current state plan, updated in 2013, states that there is consensus of the SHMC agencies that hazard avoidance "…should remain a primary focus of the state's overall mitigation efforts," describes the state's goal to reduce flooding and fluvial erosion hazards, and serves as a bridge between the public policies established in Act 138 and the state adoption of a No Adverse Impact Standard in its Flood Hazard Area and River Corridor Rules and Protection Proceduree s.

- ANR Flood Hazard Area and River Corridor Rule (FHARC). In October 24, 2014, the State adopted the Flood Hazard Area and River Corridor Rule . The Department also issued a General Permit pursuant to 10 V.S.A. §754. The purpose of the Rule and general permit is to ensure that all activities are regulated efficiently and effectively in accordance with the requirements of 10 V.S.A. Chapter 32, which requires the Department of Environmental Conservation's Watershed Management Division to regulate activities exempt from municipal regulation in flood hazard areas and river corridors. These activities include state-owned and operated institutions and facilities, accepted agricultural and silvicultural practices, and power generating and transmission facilities regulated under 30 V.S.A. §§ 248 and 248a.

- DEC Flood Hazard Area and River Corridor Protection Procedure. In December 5, 2014, the DEC adopted a Flood Hazard Area and River Corridor Protection Procedure that explains how the DEC will utilize the "no adverse impact" standard established in the FHARC Rule in providing technical assistance and regulatory recommendations to municipalities, Act 250, and other regulatory agencies. While NAI is the standard ANR has applied since 2004 in making Act 250 recommendations and under Criterion 1D for the NFIP floodway and the river corridor, it is a higher standard to be met in the flood hazard area outside of the NFIP floodway recommending measures of compensatory storage when necessary. The Procedures also explain how:
    a) Flood hazard areas, river corridor, and Act 250 floodways are delineated;
    b) Flood hazard area and river corridor maps are amended or revised by the Department and other parties;
    c) Waivers from the NAI standard are used to encourage land use planning for infill, redevelopment, and the shadowing of other structures; and
    d) Best practices may be used to promote stream and floodplain equilibrium conditions and the natural attenuation of flood sediments, heights, and velocities that influence flood inundation and fluvial erosion.

- State Land Use Planning Statute. Title 24 V.S.A. Chapter 117 section §4424 contains the authority for municipalities to adopt bylaws to address development in hazard areas. One of the purposes of this statute is to "minimize and prevent the loss of life and property, the disruption of commerce, the impairment of the tax base, and the extraordinary public expenditures and demands on public service that result from flooding, landslides, *erosion hazards* [emphasis added], earthquakes, and other natural or human-made hazards.

- Lake Champlain TMDL. 33 U.S.C.A. § 1313 (Federal Water Pollution Control Act FWPCA § 303(d) requires the establishment and U.S. Environmental Protection Agency (EPA) approval of a total maximum daily load (TMDLs) for impaired waters. The EPA had previously approved a TMDL for phosphorus loading into Lake Champlain and the associated implementation plan acknowledges the contribution of phosphorus loading from physically unstable river systems. These documents describe river corridor mapping and fluvial erosion hazard identification as an important strategy to identify the magnitude of river corridor necessary to maintain and restore stable riverine processes and the basis for local plans to address stream instability.

Watershed Management Division

- The Vermont League of Cities and Towns and Vermont Association of Planning and Development Agencies. The Vermont League and the Regional Planning Commiussions are important partners in educating municipalities throughout the state about pro-active steps that towns can take to reduce flood and fluvial erosion hazards and improve water quality.

Wastewater Management

The Wastewater Management Program provides regulatory oversight for and technical assistance to Vermont's wastewater treatment facilities in cooperation with State, regional and national organizations. Municipal wastewater, originating from a combination of domestic, commercial, and industrial activities, is conveyed to a centralized wastewater treatment facility and treated to established standards and discharged into a receiving water.

Vermont's 92 municipal wastewater treatment facilities process more than 15 billion gallons of wastewater per year. These facilities are re-authorized on a five-year recurring basis, and at that time, the re-authorized permits are subjected to "Reasonable Potential Determinations" to ensure that the permits will not allow a wastewater pollutant to cause or contribute to a receiving water impairment.

- National Pollutant Discharge Elimination System (NPDES) Permits
- Federal Pretreatment Permits
- General Permits for Discharges from Petroleum Related Remediation Activities
- Wastewater Regulations, Policies and Procedures

Vermont Required Agricultural Practices

In December, 2016, the Vermont Agency of Agriculture Food and Markets revised the Required Agricultural Practices (RAPs) to include many augmented or new practices. See http://agriculture.vermont.gov/water-quality/regulations for the RAP's, and related medium and large farm operation regulations.

Municipal Zoning

Municipal zoning bylaws may permit, prohibit, restrict, regulate, and determine land development, including the following:

(1) Specific uses of land and shoreland facilities;
(2) Dimensions, location, erection, construction, repair, maintenance, alteration, razing, removal, and use of structures;
(3) Areas and dimensions of land to be occupied by uses and structures, as well as areas, courts, yards, and other open spaces and distances to be left unoccupied by uses and structures;
(4) Timing or sequence of growth, density of population, and intensity of use;
(5) Uses within a river corridor and buffer, as those terms are (now) defined in 10 V.S.A. §§ 1422 and 1427. 3

Provisions of zoning bylaws must be uniform for each class of use or structure within each zoning district, except that additional classifications may be made within any district to regulate, restrict, or prohibit uses or structures at or near any of the following:
(A) Major thoroughfares, their intersections and interchanges, and transportation arteries.
(B) Natural or artificial bodies of water.
(C) Places of relatively steep slope or grade.
(D) Public buildings and public grounds.
(E) Aircraft and helicopter facilities.
(F) Places having unique patriotic, ecological, historical, archaeological, or community interest or value, or located within scenic or design control districts.
(G) Flood, fluvial erosion, or other hazard areas and other places having a special character or use affecting or affected by their surroundings.
(H) River corridors and buffers, as those terms are defined in 10 V.S.A. §§ 1422 and 1427.
A municipality may define different and separate zoning districts, and identify within these districts which land uses are permitted as of right, and which are conditional uses requiring review and approval. The list of districts now includes:

River Corridors and Buffers A municipality may adopt bylaws to protect river corridors and buffers, as those terms are (now) defined in 10 V.S.A. §§ 1422 and 1427, in order to:

- protect public safety; prevent and control water pollution;
- prevent and control stormwater runoff;
- preserve and protect wetlands and waterways;
- maintain and protect natural channel, streambank, and floodplain stability;
- minimize fluvial erosion and damage to property and transportation infrastructure;
- preserve and protect the habitat of terrestrial and aquatic wildlife;
- promote open space and aesthetics; and
- achieve other municipal, regional, or state conservation and development objectives for river corridors and buffers.

River corridor and buffer bylaws may:

- regulate the design and location of development;
- control the location of buildings;
- require the provision and maintenance or reestablishment of vegetation, including no net loss of vegetation;
- require screening of development or use from waters; and
- reserve existing public access to public waters.

Pollutants

Introduction

As noted in Chapter 1 of the Statewide Surface Water Management Plan, there are 10 major identified stressors, with associated causes and sources, which result in the delivery of pollutants to surface waters (see below). These pollutants in-turn affect the biological, chemical and physical integrity of Vermont's surface waters, as well as public uses. This Appendix provides brief descriptions of the major pollutants that impact Vermont's surface waters, and identifies the stressors that result in their presence. Links for detailed information about each pollutant are also provided. More detailed descriptions of each Stressor, as well as Vermont's programs to address them, are found in Chapter 2 of this Plan.


Aquatic Invasive Species


Channel Erosion


Encroachment


Thermal Stress


Land Erosion


Acidification


Toxic Substances


Flow Alteration

Nutrient Loading (non-erosion)


Pathogens

Nitrogen and Phosphorus

Stressors resulting in nitrogen and phosphorus pollution to surface waters:




Pollutant description:

The productivity of an aquatic ecosystem, reflected in plant and fish biomass, is closely tied to phosphorus and nitrogen levels. These nutrients are naturally limited in the environment and high levels cause aquatic plants, especially algae, and cyanobacteria (formerly known as blue-green algae) to grow in much greater densities than the aquatic ecosystem would naturally support. Phosphorus is the limiting nutrient in freshwater systems, while nitrogen is more typically the limiting nutrient in marine systems. The term “limiting” here means that the amount of nutrients available regulates productivity of the food web in waters. A limiting nutrient is akin to eggs in a cookie recipe – too few eggs means only a small batch of cookies can be baked regardless of how much flour or butter may be available.

In excessive amounts, algae and cyanobacteria can impair recreational uses, aesthetic enjoyment, the taste of drinking water, and the biological community. In some cases, cyanobacteria may produce toxins harmful to animals and people.

Excess plant growth can reduce the amount of space available to fish for habitat, and alter the fish species community balance. Excessive algal growth can cover lake bottom and vegetative habitat, and can result in reduced spawning success. Under certain conditions, when large amounts of aquatic vegetation die and decompose through the winter, extreme conditions of low dissolved oxygen (known as anoxia) may occur which could impact localized fish populations. In this instance, the die off of plant and algae material uses up available oxygen in the water for decomposition, leaving none behind for fishes.

The sources from agricultural runoff include fertilizers, animal manure, milkhouse wastewater and crop residues. Urban sources include fertilizer, pet waste, erosion, atmospheric deposition, sludge, and septic systems. The imperviousness of an urban area also increases the quantity of polluted runoff that would otherwise be absorbed into the ground before reaching a waterway. Because phosphorus adheres to soil particles, erosion from either urban or agricultural activities is another source of phosphorus if the eroded sediments wash into waterways. In addition, the erosion of rivers going through the channel evolution process can release a significant amount of phosphorus.

Phosphorus is relatively insoluble and moves slowly through the environment. Nonpoint source runoff from agricultural and developed landscapes provides the most significant source of phosphorus to waterbodies. Developed land contributes the highest levels of phosphorus compared to other land uses, as indicated by a study of land use in the entire Lake Champlain watershed. The study estimated that 53% of phosphorus entering the lake came from urban lands that cover just 8% of the watershed. Agricultural land use is second in line as a source of phosphorus to the lake at 39%. (Troy et al. 2007).

Point sources generally contribute a small percentage of phosphorus to waterbodies. In Lake Champlain, point sources, mainly from waste water treatment plants, are responsible for less than 10% of the phosphorus load (Lake Champlain Basin Program 2008).

Nitrogen in the environment comes from similar land-based sources as phosphorus, but a significant proportion also comes from atmospheric deposition. Direct discharges from treated wastewater and septic systems are also a source. Nitrogen takes several chemical forms such as ammonia or nitrate and nitrite, and it is highly soluble in water. It is easily washed from the soil by rain and carried to surface waters and groundwater. In northern fresh waters nitrogen is generally not a limiting nutrient but in high concentrations it can alter the make up of algal communities and can play a role in the development of cyanobacteria blooms. There is also a drinking water standard for nitrogen of 10 mg/l to protect against "blue baby syndrome;" a phenomenon where excessive nitrogen causes cyanosis in young children. Fortunately, blue baby syndrome is extremely rare in Vermont.

Links:

Clean Water Initiative Program

Lake Champlain Basin Program

Biochemical Oxygen Demand (BOD)/ Chemical Oxygen Demand (COD), as indicator of organic pollution

Stressors resulting in decreased dissolved oxygen in surface waters:


Pollutant description:

Natural organic detritus and organic waste from waste water treatment plants, failing septic systems, and agricultural and urban runoff, acts as a food source for water-borne bacteria. Bacteria decompose these organic materials using dissolved oxygen (DO), thus reducing the available DO for fish and other aquatic organisms.

Biochemical Oxygen Demand (BOD) is a measure of the oxygen used by microorganisms to decompose waste. The more organic waste present, the more bacteria there are decomposing this waste and using oxygen, so the BOD level will be high. The oxygen may diminish to levels that are lethal for fish and aquatic insects. As the river re-aerates due to atmospheric mixing and as algal photosynthesis adds oxygen to the water, the oxygen levels will slowly increase downstream. The drop and rise in DO levels downstream from a source of BOD is called the DO sag curve.

Nitrates and phosphates in a body of water can contribute to high BOD levels, by providing the nutrients for plants and algae to grow quickly. This contributes to organic waste in the water when the plants die, which are then decomposed by bacteria.

BOD is determined by measuring the loss of oxygen from the beginning to end of a 5 day test. The amount of oxygen consumed by these organisms in breaking down the waste is known as the biochemical oxygen demand or BOD.

Chemical Oxygen Demand (COD) measurements can be made in just a few hours instead of the 5 day BOD test to estimate BOD levels. COD does not differentiate between biologically available and inert organic matter, and it is a measure of the total quantity of oxygen required to oxidize all organic material into carbon dioxide and water. COD values are always higher than BOD values. Many wastewater treatment facilities use the faster COD test to estimate BOD levels. The USEPA requires wastewater treatment plants to bring BOD within limits before discharging treated wastewater, thus measuring BOD or COD in treated water is an important part of the monitoring process.

Links:

USEPA Biochemical Oxygen Demand

E. coli bacteria, as indicator of pathogens

Stressors resulting in bacterial pollution to surface waters:

Pollutant description:

Waterborne human pathogens are disease-causing organisms which include bacteria, viruses, and protozoa. The pathogens that are of concern in Vermont surface waters are those that come from fecal matter of humans and other warm-blooded animals. These pathogens may cause gastrointestinal problems and pose a more serious health risk to people who have weakened immune systems. Untreated surface waters containing fecal matter may pose a risk to human health when ingested through drinking water or inadvertently through contact recreation.

In surface waters, the most likely source of human fecal matter is sewage from a malfunctioning wastewater treatment plant or septic system. Sources of animal fecal matter are highest in urban and agricultural areas. Wildlife that resides in the water, such as beaver and waterfowl will also contribute pathogens.

It is very costly to measure and identify actual pathogens in waters. Therefore, managers rely on fecal indicator bacteria to suggest the potential presence of fecal matter. Two readily used indicators of fecal matter in freshwater are the enteric bacteria, *Escherichia coli* (*E. coli*), and *Enterococci spp*. These bacteria reside in the intestinal tract of warm-blooded animals and can survive for limited durations after they leave the host. Vermont relies on the *E. coli* indicator. Although most strains of *E. coli* are harmless to humans, epidemiological studies have identified a correlation between concentrations of E. coli in water and an increase in the risk of developing gastrointestinal. Vermont's water quality criterion for *E. coli* bacteria for all waters is 126 *E. coli*/100 ml as a geometric mean of several samples, and no more than 10% of individual samples in excess of 235 E. coli /100ml.

Links:

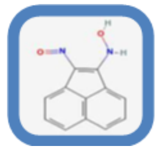
Vermont Volunteer Surface Water Monitoring Guide

Vermont Department of Health Swim Water Testing

Vermont State Parks Swimming

Metals

Stressors resulting in metals pollution to surface waters:



Pollutant description – heavy metals:

Heavy metals are a group of metallic elements with atomic weights greater than 40, and a specific gravity of greater than 4.0; they are a natural component of the Earth's crust.

In aquatic systems, the heavy metals of greatest concern are mercury, lead, arsenic, cadmium, selenium, copper, zinc, nickel, chromium, aluminum, antimony and silver. These metals are toxic to organisms above specific threshold concentrations but many of them, such as copper and zinc are also essential for metabolism at lower concentrations. Lead and cadmium are considered non-essential to biota and have no known biological function.

Toxic quantities of heavy metals can be present in industrial, municipal, and urban runoff, and by definition are harmful to humans and aquatic biota. Increased urbanization and industrialization have increased the levels of these trace elements especially in surface waters. Metal contamination in aquatic environments arises from industrial processes such as mining, smelting, finishing and plating of metals, paint and dye manufacturing and from pipes and tanks in domestic systems. Some metals may be discharged from malfunctioning treatment facilities, and others are also deposited atmospherically.

Aquatic organisms may be adversely affected by heavy metals in the environment. The toxicity of metals varies with aquatic species and environmental conditions; water quality (e.g. hardness, pH) greatly affects the chemical form in which the metals are measured. The toxicity is largely a function of the water chemistry and sediment composition in the surface water system. Metals may enter aquatic organisms through three main pathways: they can be absorbed through respiratory gills and diffuse into the blood stream; they can be adsorbed onto body surfaces and diffused into the blood stream; or, they can adhere to food and particulates and be ingested.

The ability of fish and invertebrates to accumulate metals is largely dependent on the physical and chemical characteristics of the metal. Heavy metals are dangerous because they tend to bioaccumulate. Mercury bioaccumulation poses the greatest concern to aquatic biota and humans.

Concentrations of heavy metals in the ambient environment have increased dramatically since the Industrial Revolution, although lead, copper, and even mercury has been in use since Roman times. Many heavy metals cause nervous-system damage, with resulting learning disorders in children. Exposure to metals such as lead and nickel can cause autoimmune reactions. Chromium occurs in a relatively harmless form and a much more dangerous, oxidized hexavalent form. Several studies have shown that chromium (VI) compounds can increase the risk of lung cancer and that ingesting large amounts of chromium (VI) can cause stomach upsets and ulcers, convulsions, kidney and liver damage, and even death, according to the Agency for Toxic Substances and Disease Registry. Many fish are very sensitive to heavy-metal pollution. For example, trout cannot live in waters that contain more than about five parts per billion of copper. Heavy-metal contamination is very widespread for certain compounds, especially lead and mercury.

Most heavy-metal contamination stems from high-temperature combustion sources, such as coal-fired power plants and solid-waste incinerators. Local metal sources may include metal-plating industries and other metal industries. The use of leaded gasoline has led to global lead pollution even in the most pristine environments, from arctic ice fields to alpine glaciers. The metal fluxes from point sources have been strictly regulated, and the introduction of unleaded gasoline has taken a major lead source away. Several sites with severe heavy-metal pollution have become Superfund sites, most of them still under study for decontamination. Site decontamination can be done with large-scale soil removal and metal stripping, or through more gradual methods, like phytoremediation. Nonetheless, even today metals are delivered from the atmosphere to the landscape. In the United States, drinking water is monitored for heavy metals to ensure that their concentration falls below the safe limit or maximum contaminant level (MCL) set by the Environmental Protection Agency. Many urban estuaries like Boston Harbor, San Francisco Bay, and Long Island Sound are severely contaminated with heavy metals. These sedimentary basins will remain polluted for decades, and a small percentage of the sediment-bound metals is released back into the water and occasionally transformed into more dangerous forms.

Pollutant description – iron and manganese in groundwater

Metals that are naturally occurring in soils can have a deleterious effect on surface waters and associated aquatic habitat when they are mobilized in groundwater and released to surface water. Effects most commonly observed are from iron and manganese as precipitates of these two minerals are deposited in streams and lakeshores.

The extent to which iron and manganese dissolve in groundwater depends on the amount of oxygen in the water and, to a lesser extent, upon its degree of acidity. Iron, for example, can occur in two forms: as ferrous iron (Fe^{2+}) and as ferric iron (Fe^{3+}). When levels of dissolved oxygen in groundwater are greater than 1- 2 mg/L, iron occurs as Fe^{3+}, while at lower dissolved oxygen levels, the iron occurs as Fe^{2+}. Although Fe^{2+} is very soluble, Fe^{3+} will not dissolve appreciably.

If the groundwater is oxygen poor, iron (and manganese) will dissolve more readily, particularly if the pH of the water is low. Dissolved oxygen content in groundwater is typically low and the iron dissolves as Fe^{2+}. Under these conditions, the dissolved iron is often accompanied by dissolved manganese. When this water breaks out to surface waters, the dissolved iron reacts with the oxygen in the water, changes to Fe^{3+} (i.e., is oxidized) and forms rust-colored iron minerals. Dissolved manganese may form blackish particulates in the water and cause similar colored stains on rocks.

The resulting water quality impacts represent themselves more as a loss of habitat for aquatic biota as opposed to toxic levels of metals. Precipitates can essentially coat the streambed and significantly impact macroinvertebrate habitat. In addition to the precipitates, iron bacteria can "feed" on the iron and grow into dense slimy mats further inhibiting macroinvertebrates.

Areas with disturbed soils or areas where iron rich soil used as fill is deposited at or below the groundwater table facilitate the exposure of groundwater to these minerals. In Vermont, many instances of water quality impairment exist adjacent to these disturbed areas represented by placement of fill for roads, structures, culverts or landfills.

Pollutant description - mercury

Mercury contamination is ubiquitous in Vermont's still waters. Mercury is a naturally occurring metal used in a wide variety of applications ranging from the production of household bleach to the mining of gold. Like other heavy metals, Mercury can be released into the environment directly to water via waste systems; however, unlike other heavy metals, it is more commonly emitted directly to the atmosphere. Over 90% of mercury contamination in Vermont is from out-of-State emission sources. The combustion of coal for energy production and incineration of municipal and medical wastes produces the majority of mercury deposited onto the watersheds of the northeastern US and eastern Canada. Once on the ground, mercury migrates through watersheds, arriving eventually into surface waters. Some mercury also enters the aquatic environment from direct wastewater discharges. Once in the environment, natural ecological processes will convert a small proportion of the mercury to the extremely toxic and readily bioaccumulated methyl-mercury.

Through the processes of biomagnification, the toxic methyl-form of mercury is passed up food chains, increasing to levels in fishes that pose a significant threat to those organisms at the top of the aquatic food web. Organisms that are at risk of methyl-mercury exposure include top-level carnivorous fish such as walleye, lake trout, and smallmouth bass, as well as fish eating birds such as eagles and loons. Top-level carnivorous fish are often the species most targeted by anglers. For example, a larger walleye (>25 inches) caught by anglers in Lake Champlain may be 10 to 15 years old. The long life span allows for many years of accumulation of mercury within the fish's body. As a result of this, humans who consume large quantities of top-level fish are also at risk.

The Vermont Department of Health has general advisories for women of childbearing age and children younger than six to limit consumption of fish. In addition, the department also identifies specific waterbodies where eating resident fish carries a greater level of risk because of elevated mercury concentrations in fish tissue. In Lake Champlain for example, children and women of childbearing age are advised not to eat any walleye or meals of lake trout 25 inches or greater. The primary health effect of methylmercury is impaired neurological development. Symptoms of methylmercury poisoning may include; impairment of the peripheral vision; disturbances in sensations; lack of coordination of movements; impairment of speech, hearing, walking; and muscle weakness.

Links:

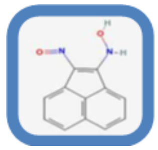
Vermont Department of Environmental Conservation – MERCVT

Hubbard Brook Research Foundation

USEPA

Organic contaminants (PCB’s and PBDE’s)

Stressors resulting in organic contaminant pollution to surface waters:



Pollutant description – PCBs

In the past, poly-chlorinated biphenyls or PCBs were used for a variety of chemical processes including the production of plastics like PVC piping. PCBs were also a component in the dielectric fluid used in transformers, capacitors and other heat transfer systems. The manufacture of PCBs was stopped in the US in 1977. Any remaining PCB transformers in Burlington were decommissioned by the late 1980s. Presently, stores of PCBs exist in landfills nationwide.

PCBs can escape into the environment either by waste incineration or via landfill leachate. Past manufacturing practices also dumped PCBs into waterways. PCBs do not readily breakdown in the environment and like mercury, PCBs also bioaccumulate, increasing in concentration with each step up the food chain. To date, fish tissue testing has uncovered PCB contamination only in the tissues of large lake trout from Lake Champlain and in smallmouth bass, white suckers and yellow perch in the Connecticut River. PCBs are known by USEPA to be carcinogenic to animals, and are considered likely human carcinogens as well. The Vermont Department of Health recommends that people limit their intake of lake trout based on PCB concentrations. Based on a considerable remediation initiative undertaken by the New York State Department of Environmental Conservation, PCB concentrations in Lake Champlain lake trout are expected to decline in the coming years.

Links:

USEPA

Pollutant description - PBDEs

Poly-brominated diphenyl-ethers (PBDEs) are a flame retardant used in a variety of household products including fabrics, furniture and electronics and are ubiquitously found in the environment and fish tissues. Significant public health concerns exist for PBDEs in other states and Europe, where studies have documented health impacts that are similar in nature to those attributed to PCBs. In Europe and elsewhere, studies have also shown that PBDEs bioaccumulate in fish, and have similar ecotoxicological effects to PCB’s. While the scientific literature indicates that these compounds are ubiquitous in the environment, the occurrence of PDBEs has to date been completely uncharacterized in Vermont. An assessment of the presence of PBDEs in specific lakes - perhaps Lake Champlain is a first step in characterizing their ubiquity in Vermont, and is warranted. Certain classes of PBDEs have been banned from use in the European Union, Maine and

Washington State, and a similar ban has been considered by the Vermont General Assembly.

Links:

USEPA

Pollutant description - PAHs and coal tar sealants.

PAHs (polycyclic aromatic hydrocarbons) are a group of compounds that can cause tumors, organ abnormalities, and disrupt immune and reproductive system function in fish and aquatic life. Seven PAH compounds are classified as probable human carcinogens. Coal tar sealants (coal by-products used to seal asphalt surfaces since the 1960s) are a major source of PAH pollution. PAH concentrations in coal tar sealants are about 1000 times higher than concentrations in asphalt-based sealant alternatives.

Over time, the sealants wear down and are carried into the environment by wind and rain, allowing PAHs to contaminate rivers, lakes, wetlands, and stormwater ponds. Little is known about PAH contamination from coal tar sealant in waterbodies in Vermont. Minnesota has calculated projected clean up costs for stormwater ponds contaminated with PAH runoff to approach $1 to $5 billion in the Twin Cities metropolitan area alone.

Links:

USGS

Invasive Species as Pollutants

Stressors resulting in invasive species pollution to surface waters:

Pollutant description –invasive species in Vermont

Invasive species are aquatic and terrestrial organisms introduced into new habitats that produce harmful impacts on natural resources. Aquatic invasive species can seriously hinder recreational use of a waterbody, out-compete native plants and animals, and otherwise alter the natural environment.

Aquatic invasive plants present in Vermont include Eurasian watermilfoil (*Myriophyllum spicatum* L.), water chestnut (*Trapa natans* L.), European frog-bit (*Hydrocharis morsus-ranae*), European water nymph (*Najas minor*), curly leaf pondweed (*Potamogeton crispus)*, purple loosestrife (*Lythrum salicaria*), and starry stonewort (*Nitellopsis obtusa*). Aquatic invasive animals include zebra and quagga mussels (*Dreissena spp.)*, rusty crayfish (*Orconectes rusticus*), white perch (*Morone americana*), spiny waterflea (*Bythotrephes longimanus*), Asian clam (*Corbicula fluminea*) and alewife (*Alosa pseudoharengus*). Riparian invasives include common reed (*Phragmites australis*), yellow flag iris (*Iris pseudacorus*), and Japanese knotweed (*Polygonum cuspidatum*). In addition, a number of other problematic exotic species are at the state’s doorstep. Aquatic plant species include hydrilla (*Hydrilla verticillata*), fanwort (*Cabomba caroliniana*), and parrot feather (*Myriophyllum aquaticum*), among others. Animals include silver and bighead carp (*Hypophthalmichthys nobilis* and *H. molitrix*), New Zealand mud snail (*Potamopyrgus antipodarum*), and Northern Snakehead (*Channa argus*).

The establishment of invasive species can result in a range of impacts. Alewives are known to impact native fish communities in a variety of ways. Alewives can out-compete other native fish species for food and cause shifts in zooplankton species composition and size structure, which can impact water quality. They are known to feed on the eggs and larvae of native fish species, they undergo massive fluctuations in abundance, and they have been identified as the cause of early mortality syndrome in salmon and trout fry.

Pollutant description – Eurasian watermilfoil and water chestnut

The presence of invbasive aquatic plants like Eurasian watermilfoil or water chestnut often bring a change in the natural lake environment. Over time, they may out-compete or eliminate the more beneficial native aquatic plants, severely reducing natural plant diversity within a lake. Since their growth is typically dense, these monotypic stands are poor spawning areas for fish and may lead to populations of stunted fish. Although many aquatic plants serve as valuable food sources for wildlife, waterfowl, fish, and insects, Eurasian watermilfoil and water chestnut are rarely used for food. Commonly found in shallow bays and in bands along the shoreline, dense surface mats of milfoil or water chestnut can also make fishing, boating and swimming virtually impossible.

Links:

Watershed Management Division's webpage on aquatic invasive species

Pollutant description – fish pathogenic diseases

In addition to the recognized invasive species, many fisheries biologists now consider newly introduced fish diseases as invasive species. These diseases are often viral and spread through similarly to other invasive species. For example, Viral Hemorrhagic Septicemia has been found in the Great Lakes and some inland waters of New York State. Viral hemorrhagic Septicemia (VHS) is a deadly fish virus that is considered to be one of the most serious diseases of trout and salmon in freshwater environments in Europe. The new strain of VHS now found in the Great Lakes region of North America has been found to infect over 30 species of freshwater fish. Outbreaks of the VHS virus can result in severe fish mortality events in commercial aquaculture practices as well as in wild populations, and can often have serious socio-economic consequences.

Links:

Department of Fish and Wildlife

Chlorides

Stressors resulting in chloride pollution to surface waters:

Pollutant description - chlorides

Chloride is a naturally occurring mineral used in a variety of materials and foods. Natural chloride deposits are not common in Vermont, and chloride concentrations above background are assumed to be associated with human activities. Chloride sources can include industrial effluents, landfill leachate, municipal wastewater, agricultural waste, and septic system effluents. Increasingly, winter road, parking lot and sidewalk maintenance practices are recognized as contributing large amounts of chloride to the environment each year.

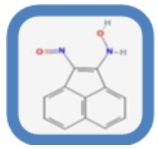
There is little concern about human health as a result of elevated chloride in the aquatic environment though the Vermont Department of Health does consider chloride above 250 mg/L to be a drinking water contaminant that impacts taste. In 2014, Vermont incorporated criteria for chloride into the Water Quality Standards. At concentrations exceeding 230 mg/L, "chronic" effects to aquatic biota (e.g. poor reproduction, poor health) are expected, with "acute" effects (severe illness or death) likely at concentrations exceeding 860 mg/L. Tolerance to elevated chloride varies widely among aquatic biota. Some organisms, including many fish, are not affected by chloride at concentrations exceeding 10,000 mg/L. Concentrations above 250 mg/L in lakes have been observed to impede natural mixing and stratification processes due to the formation of a strong density gradient. In time, poor mixing results affects water quality and oxygen availability within the waterbody.

Links:

Environmental Implications of Increasing Chloride Levels in Lake Champlain and Other Basin Waters

Contaminants of Emerging Concern, including Pharmaceuticals and Personal Care Products

Stressors resulting in organic contaminant pollution to surface waters:



Pollutant description

Contaminants of Emerging Concern can be defined as newly identified manmade compounds that result from human usage (e.g. pharmaceuticals, personal care products, homecare products, nano-technology products). Pharmaceuticals and Personal Care Products as Pollutants (PPCPs) refers, in general, to any product used by individuals for personal health or cosmetic reasons. PPCPs comprise a diverse collection of thousands of chemical substances, including prescription and over-the-counter therapeutic drugs, veterinary drugs, fragrances, lotions, and cosmetics. This topic is becoming increasingly important as studies worldwide highlight the ubiquity of these substances in certain waterbody types.

These compounds enter aquatic environments through a variety of sources, including, but not limited to, wastewater effluent, treated sewage sludge, landfill leachate, industrial effluent, combined sewer overflows, aquaculture, and animal feed lots. Pharmaceuticals and personal care product constituents are being detected in groundwater, streams, rivers, lakes, reservoirs, and drinking water supplies of the Northeast at very low concentrations, and have commonly been detected in combinations of chemicals. Currently there are no US EPA/state ambient water quality criteria, water quality standards, or drinking water standards for most of these individual chemicals.

The effects of PPCPs are different from conventional pollutants. Drugs are purposefully designed to interact with cellular receptors at low concentrations and to elicit specific biological effects. Unintended adverse effects can also occur from interaction with non-target receptors. Environmental toxicology focuses on acute effects of exposure rather than chronic effects. At this time, many unknowns remain regarding the potential for adverse effects on ecological receptors and humans from exposure to PPCPs in the environment. Research on human health effects should recognize the effects on sensitive populations such as children, pregnant women, and those with compromised immune systems.

Effects on aquatic life are a major concern. Exposure risks for aquatic organisms may be much larger than those for humans. Aquatic organisms have: continual exposures, embryonic exposures, multi-generational exposures, exposure to higher concentrations of PPCPs in untreated water and possible low dose effects. The presence of these chemicals in water bodies have been linked to impacts on aquatic species, including changes in fish sex ratios, development of female fish characteristics in male fish, changes in nesting behavior by fish, and adverse effects on invertebrates.

Links:

[New England Interstate Water Pollution Control Commission]

[USEPA]

[US Geological Survey]

Acid Deposition (a.k.a., Acid Rain)

Stressors resulting in acid rain pollution to surface waters:

Pollutant description – acid rain

Acid deposition is caused by the combustion of fossil fuels (coal, oil and gas). The primary pollutants of concern are sulfur and nitrogen oxides. The sulfur and nitrogen come from electrical power plants, industrial sources and automobiles. These pollutants get in the atmosphere and mix with rain, snow and fog to create "acid rain". Emissions from primarily eight mid-western states account for almost half of Vermont's sulfur pollution during the summer months, when air pollution is the worst. The pollution is visible as a smoggy frequently brownish layer in the atmosphere that can best be observed at high elevation when atop the Green Mountains.

Acid rain is formed when precipitation absorbs these pollutants from the atmosphere. The acidity of precipitation and waterbodies is measured by the **pH scale.** This scale ranges from 0-14 with 0 being the most acidic and 14 being the most alkaline. Normal rain and snow is slightly acidic and has a pH of 5.6. However, the rain and snow that falls on Vermont is much more acidic than what is attributable to natural causes. In Vermont, the average precipitation is now 4.3 – 4.5 with extremes ranging from 2.8 to 7.4. The pH scale is logarithmic which means that each numerical change in pH is a ten-fold change in acidity. So, rainfall with a pH of 4.6 is 10 times more acidic than normal rainfall of 5.6 and a pH of 3.6 is 100 times more acidic.

Vermont has been monitoring the chemical and biological effects of acid rain on lakes since 1980. We currently have 36 lakes listed as impaired by atmospheric deposition and monitor 12 acid lakes seasonally through the Vermont Long-Term Monitoring Project (VLTM). This project has revealed that many lakes have seen reductions in acid concentration as a result of the implementation of acid rain controls in the 1990 Clean Air Act. These controls have reduced sulfur deposition by greater than 50% and further reductions in both sulfur and nitrogen oxides are anticipated. However, these lakes have also seen reductions in their ability to buffer incoming acidic pollutants with declines in both calcium and magnesium. This means that even though our lakes are receiving less atmospheric pollutants, the loss of buffering has yielded little overall improvement in the lakes pH. As a result, we have seen no improvement in the biological condition of these lakes.

What are the consequences of acid rain to our lakes and sensitive streams?

Headwaters are susceptible to damaging pH decreases during spring runoff and periods of high flow. High elevation waterbodies are often naturally low in calcareous bedrock with limited ability to neutralize incoming acids.

Acid rain will dissolve and leach out aluminum and other metals that naturally occur in Vermont soils. These metals are then swept into lakes and rivers during precipitation events. If the waterbody has a pH lower than 5.6, the incoming aluminum can be toxic to fish and other aquatic life.

As acidification progresses, lake water clarity may improve for one of two reasons. Either, 1) the aquatic plankton that give water a typical green or aqua color are lost; or 2) naturally dark, tannic-colored lakes may, in time, become less stained as the strong mineral acids like sulfuric and nitric acid, replace the naturally occurring organic tannins. It is expected that as the acid levels improve because of the Clean Air Act, the color of acid lakes should be less transparent with the return of plankton and organic acids replacing the mineral acids.

Links:

Watershed Management Division

Sediment

Stressors resulting in sediment pollution to surface waters:

Pollutant description - sediment

Sediment is fine particulate matter originating from soils. The accumulation of sediment on the bottom of a waterbody results in sedimentation, while the suspension of sediment in the water column causes turbidity. Turbidity degrades habitat for aquatic biota, reducing visibility for predators as one example.

Sedimentation smothers necessary rocky or riffle habitat for the invertebrates that provide an important source of food for fish. Some smaller species of fish also rely on the crevice space between rocks as a primary habitat. Sedimentation can cover spawning substrate and suffocate fish eggs by preventing water circulation and oxygenation. Additionally, the accumulation of sediment over spawning gravel may even deter fish from spawning at all. Fish species like walleye, trout and salmon rely on clean gravel for spawning.

One source of sediment is runoff of bare soils from areas such as constructions sites, gravel roads and plowed fields. Runoff from storm events and snowmelt, especially where concentrated in urban areas, can easily pick up soil particles and wash it into waterbodies. Stream channel instability and the lack of vegetated riparian buffers result in stream channel erosion. Vegetative buffers help to stabilize stream banks and retain nonpoint runoff thereby reducing the amount of sediment input. Vegetated riparian buffers also benefit the aquatic biota by keeping water temperatures lower due to increased shading and, like lakes, provide food in the form of terrestrial insects. For the most part, erosion is a result of cumulative human disturbances, including flood plain encroachments, removal of riparian vegetation, channelization, wetland drainage, urbanization and in-stream gravel mining.

Links:

Watershed Management Division – River Management Program

Stressors resulting in thermal pollution to surface waters:

Pollutant description – temperature

Thermal modifications result in water temperatures that are too high or too low to fully support appropriate aquatic life. Thermal modification affects over 500 river miles in Vermont. High temperatures have a negative impact on coldwater fisheries. Removal of trees and shrubs and the cooling shade they provide along riverbanks and shorelands result in higher water temperatures. Dams and their resulting impoundments expose large surface areas of water to sunlight causing higher downstream water temperatures.

Temperature is a primary regulator of biological activities and an increase in the temperature regime of small streams may have an adverse impact on fish populations by increasing their rate of metabolism while, at the same time, reducing the amount of dissolved oxygen in the water. Elevated water temperatures may reduce the vigor of cold-water fish species and make them more susceptible to disease or parasites. Small headwater streams are most likely to be affected by the clearing of streamside vegetation.

Temperature is one of the most important factors in limiting trout abundance. Temperatures of 77 ºF can be lethal to trout. Directly related to temperature is dissolved oxygen. As temperature increases, dissolved oxygen levels decrease. Because trout require high oxygen levels, they require low temperatures. Once temperatures have reached the low 70s ºF, the amount of dissolved oxygen is low enough to drive trout out of marginal waters and into coldwater refuges, such as deep holes or groundwater seeps. They may stay in these protected enclaves as long as water temperatures remain high. Over prolonged periods of high temperatures, fish kills can occur (VFWD 1993).

Cyanobacteria toxins

Stressors resulting in cyanobacteria toxins in surface waters:

Pollutant description

Cyanobacteria (formerly known as blue-green algae) are a common and natural part of the aquatic community and are expected to be present in most Vermont waters. Under the right conditions, typically too much phosphorus, cyanobacteria can become very abundant, forming unsightly surface scums and discoloring the water. These nuisance conditions are reported from lakes around the state each year.

In some cases, cyanobacteria also produce toxins that affect humans, pets, livestock and wildlife. Some of these toxins have been documented routinely on Lake Champlain and dog deaths on the lake have been linked to them in the past. Anatoxin and microcystin are two cyanotoxins that are most commonly detected in areas of dense cyanobacteria blooms. Around the world, cyanobacteria toxins have been linked to human illness and, very rarely, death. People can be exposed to these toxins through recreational activities on affected lakes or through drinking water sources. In Vermont, there have been no known instances of human illness due to cyanobacteria toxins.

How does Vermont respond to cyanobacteria?

Excessive cyanobacteria are of concern because they lead to poor water quality and an increased risk of exposure to cyanobacteria toxins. Management practices that control nutrient inputs will also result in smaller populations of cyanobacteria. The Agency of Natural Resources and the Agency of Agriculture, Farm and Markets are focused on nutrient reduction from the landscape. The Agency of Natural Resources (Drinking Water and Groundwater Protection Division) and the Agency of Human Services (Department of Health) work with water suppliers, public beaches and towns around the state to monitor and respond to cyanobacteria in drinking water supplies and recreational settings. There are currently no federal or state regulations for cyanobacteria toxins. The EPA has established health advisories for drinking water supplies. The Drinking Water and Groundwater Protection Division has worked with suppliers to establish a practice for managing anatoxin, cylindrospermopsin and microcystin in drinking water systems.

Links:

Vermont Department of Health

Watershed Management Division

Pesticides

Stressors resulting in pesticide releases to surface waters:



Pollutant description

Pesticides are used in Vermont for a wide variety of pest control activities. The most widespread use of pesticides with the opportunity to widely affect surface waters is the agricultural use of herbicides in the growth of corn to feed dairy cattle. Other major uses of pesticides in Vermont include: golf course vegetation management; utility right of way vegetation control; forestry; aquatic nuisance vegetation control; and, lawncare activities.

Pesticide manufacturers have been gradually replacing older pesticides, such as the corn herbicide Atrazine, with pesticides which are designed to be more target specific and breakdown in the environment more easily. Ideally, pesticides are highly specific to the target pest, and then breakdown very quickly such that adverse side effects are minimized. In practice pesticides, do not kill just the target pest, do not stay solely where they are applied, and do not disappear as soon as they have done their intended job. Thus, the challenges are to minimize unnecessary pesticide use, migration of pesticides away from the point of use, and ultimately toxicity to non-target organisms.

The difficulty with management of pesticide impacts to surface waters, as compared with the other types of toxics and most "pollutants" is that these compounds are intentionally being added to the environment. All pesticide use in the US and Vermont is regulated to some degree, with those compounds applied most heavily, or those viewed as most hazardous being the ones most tightly regulated. Household pesticide use is one area where regulatory mechanisms are less stringent.

With the exception of pesticides used for aquatic nuisance control, the source of all pesticides in the aquatic environment is migration of pesticides away from the point of use and into the waters of Vermont. Many pesticides are at least moderately water soluble and therefore are capable of washing off target with rain water runoff, while other pesticides will bind with soil and other particulates, and be transported off-site when erosion occurs. Use of water soluble pesticides can cause more widespread contamination of Vermont's aquatic environment because they travel with the water, but these compounds tend to dilute relatively rapidly. Non-water soluble pesticides remain associated with sediment particles and can conceivably accumulate to high levels.

Links:

[Vermont Agency of Agriculture, Food, and Markets]

Human Activities as a Source of Pollutants and Water Quality Problems

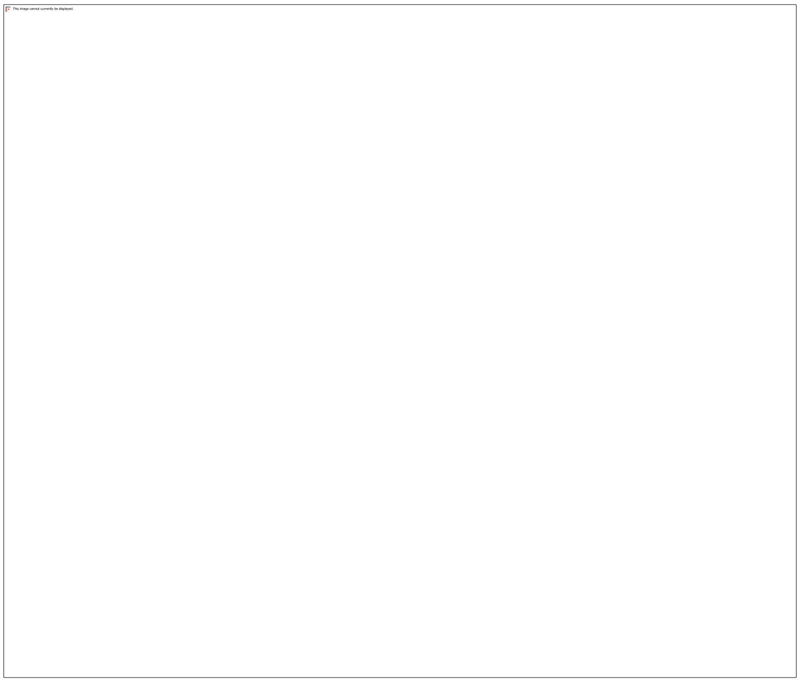
1. Land Conversion: loss of forest, wetland, and agricultural lands

The health of the rivers, lakes, and wetlands can be directly related to the type of landcover and associated land use in their watersheds. Pristine waters are associated with mainly undisturbed forested watersheds. The level of impact on water quality becomes higher as land uses intensify through the spectrum of agriculture, timber harvesting, housing, industry, and roads.

Land conversion of Vermont farms and forests from 1982 to 1997 reveals an increase of 74,800 acres of land developed for building sites (Bolduc, et al., 2008). Of these, an estimated 31%, or 23,450 acres, came from agricultural land, whereas an estimated 68%, or nearly 51,000 acres, came from forest land. Estimates from the Natural Resource Conservation Service's Natural Resource Inventory reveal that developed land in Vermont, not including land in rural transportation uses, increased from 158,900 acres in 1982 to about 254,200 acres by 2003, a significant increase of 60% over two decades." (2010 Vermont Forest Resources Plan, Division of Forests).

Conversion of forested lands

Forest is the dominant land cover in Vermont with approximately 76% (4.6 million acres) of the state in forest cover. Most of Vermont's forestland is privately owned (3.8 million acres). Forests protect water quality by slowing runoff, stabilizing soils and filtering pollutants, see Figure 1. Conversion of forest land to other uses interrupts these natural processes and increases the potential for water quality impairment.



1). Intercept rainfall, protect soils, provide shade.

2). Transpiration, nutrient storage, trap air pollutants.

3). Filter sediment and other chemicals.

4). Infiltrate, water and nutrient storage

5). Biological removal of nutrients and pollutants.

Figure 1. Forest Watershed Functions (adapted from DFPR 2009 http://www.vtfpr.org/watershed/waterfunction.cfm.)

Degradation of wetland and riparian function

Wetlands and naturally-vegetated riparian areas protect water quality by efficiently trapping, accumulating, and storing organic, nutrient-rich suspended sediment from land disturbance.

Since the time of European colonization the loss of wetland and riparian function in Vermont has been significant. For example, various estimates place current wetland acreage in Vermont between 220,000 (USFWS National Wetland Inventory) and 600,000 (NRCS National Resource Inventory) acres. The USFWS estimates that 35% of the state's original wetland acreage has been lost to agricultural development and other uses. This does not include other wetlands that have been degraded due to the loss of some functions such as sediment trapping or nutrient retention. While wetland losses have slowed in recent years, there is still significant incremental loss of wetlands and their functions throughout the state. Riparian areas are also subject to intense development or land use pressure including such activities as agricultural, transportation, and seasonal homes.

Conversion of agricultural to developed lands

A study completed by researchers at the University of Vermont identified developed lands as the predominant contributor of phosphorus loads in the Lake Champlain basin, despite the fact that it is not the predominant land-use in the basin as a whole.[1] On an acre for acre basis, load contributions from developed lands are consistently higher than agricultural lands. Specifically, the study estimated that on average, developed land generally contributes about four times as much phosphorus per acre as agricultural land.

The higher phosphorus export rate from developed land is significant because the same study also found an overall increase in the conversion of agricultural land to developed land in the Lake Champlain basin. A separate analysis of Natural Resource Inventory (NRI) data, by NRCS staff, strongly supports this trend in land use change. NRI data show that, statewide, developed land increased by about 31% from 1982-1997. Developed land increased by about 34% basin-wide in the Lake Champlain basin during that same time period. Based on preliminary analysis using unofficial 2003 data, it appears that developed land in Vermont increased by more than 40% from 1982-2003.[2]

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[1] "Updating the Lake Champlain Basin Land Use Data to Improve Prediction of Phosphorus Loading." Report to Lake Champlain Basin Program. (May 31, 2007). http://www.lcbp.org/publication_detail.aspx?id=211

[2] Personal Communication via email with Ray Godfrey (8/6/2007). Email was accompanied by data tables supporting this statement.

Summary of Agency's Key Strategies that Address Activity

The agency provides assistance to landowners to encourage them to maintain forested land, and protect wetlands and forested buffers including

- Technical assistance through the county foresters and a mix of programs for managing a productive forests for silviculture.
- Incentives to keep working forested lands in production and forested as well as riparian buffers and wetlands intact (Use Value Appraisal Program).
- Encourage restoration of wetlands through the NRCS Wetland Reserve Program
- Encourage landuse planning that reduces amount of land developed per unit of housing/commercial development
- Land acquisition
- Educate the public on the value of forestland, wetlands and buffers.

See also sections on Encroachment within wetland buffers, lake shorelines, and river corridors

For more in-depth information follow the links below:

- Toolbox section for activity
- Stressor factsheets including:




2. Runoff from Developed Lands

Stormwater runoff occurs when precipitation "runs off" impervious surfaces (rooftops, parking lots, drives ways, etc.,) rather than

infiltrating into the soil. As it travels along the land surface, the runoff increases in velocity and volume, picking up a wide variety of pollutants such as sediment, pathogens, and debris. These pollutants are delivered either directly or indirectly to Vermont's rivers, lakes and ponds.

In highly developed areas, such as urban centers, these pollutant loads can be relatively high. Lawn fertilizer, uncollected pet waste, road sand for winter safety, many detergents and lawn litter all contain phosphorus. In an undisturbed setting, much of this phosphorus is broken down by natural processes. In an urban setting, these processes may be disrupted or nonexistent. Instead of nutrient breakdown and uptake by plants or entrainment in soils, many pollutnats are simply carried away to surface waters. To put it simply, a leaf that falls onto a street is more likely to be carried away by swiftly moving stormwater flows in the gutter than a leaf that falls in the forest. Overall, studies have shown that lawns and streets contribute the most to total and dissolved phosphorous loads in residential areas. A USGS study, in cooperation with the City of Madison and the Wisconsin Department of Natural Resources, showed that lawns and streets combined contribute about 80 percent of the total and dissolved phosphorus in runoff from the residential areas studied, with lawns contributing more than streets.(3)

Changes in stream hydrology are also common due to development. Much of urban development involves the construction of buildings, roadways and parking – all of which create impervious surface, that both reduce infiltration and can speed the delivery and amount of stormwater runoff to local receiving waters. These increases in in volume and rate can, in turn, increase rates of erosion and decrease stream stability. As a result, most developed areas employ infrastructure that enhances drainage to protect roads and other structures from flooding, resulting in even higher discharge rates. The increased volume and discharge rates of stormwater runoff from developed land have been linked to channel enlargement processes and severe bank failures. For stream systems that may already be stressed by riparian encroachments and channelization –

the additional energy from stormwater runoff can contribute heavily to in-stream erosion. Studies suggest that Vermont streams channels will begin to erode and enlarge at watershed impervious cover values as low as 3%. Many Vermont streams are highly sensitive to hydrologic modification due to their geologic history and landscape setting.

High percentages of impervious can also reduce ground water levels due to a decrease in infiltration capacity. As a result, streams that depend on ground water to maintain a base flow during dry months can experience periods of extremely low or no flow. This can have devastating effects on aquatic habitat.

Construction sites

Developed lands contribute pollutants during both the construction and post construction phases. The construction phase increases loading via several mechanisms, including:

- The removal of vegetation during the construction phase, which increases the chance for erosion and mobilization of particulate-bound phosphorus during runoff events. Both runoff rates and volume have been shown to increase during the construction phase,(4) while the installation of drainage measures typical of developed areas provide quicker delivery rates. The availability of sediment to the erosive forces of stormwater runoff events and the increase of runoff itself result in the increased potential for loading of sediment-bound phosphorus to nearby surface waters. Because of the efficiency of the delivery system, 50% to 100% of the soil eroded from a construction site can be delivered to a stream. The reclamation phase of most construction projects involve amending the soil with fertilizers (sometimes without soil tests) to achieve grass growth for project closeout.

Industrial sites

Certain industries, by the virtue of their business (e.g., fertilizer manufacturers, paper manufacturers), import nutrients for use in production and therefore run the risk of discharging nutrients in excess of that which might be expected from undeveloped lands. Many industries also require large areas of impervious surface for warehouses, parking lots and access roads that contribute to excess hydrology and thus increased landside and in-channel sediment production.

Certain industries that involve the processing of sand/gravel may be particularly prone to exporting sediment and the associated sediment-bound phosphorus.

Residential sites

Residential areas can generate large amounts of water runoff relative to undisturbed areas. While each site itself may be a small contributor, the cumulative effect is quite large. A typical home with a roof of 1000 square feet can generate 623 gallons of run off in a 1" rainstorm. Multiply that by 100 homes and the result is 62,300 gallons. Add on driveways and outbuildings and the amount grows larger still. This amount of water entering an stream or storm drainage system already dealing with high storm flows can cause localized flooding, erosion, infrastructure damage and combined sewer overflows.

SUMMARY OF AGENCY'S KEY STRATEGIES:

- Implement stormwater BMPs through issuance of individual or general permits for construction and post-construction stormwater discharges, municipal stormwater discharges, and stormwater discharges from industrial facilities. Conducted operational site visits to determine compliance.
- Implement TMDL implementation plans for all twelve of the lowland (non-mountain) TMDLs for stormwater-impaired watersheds.
- Collaborate on illicit discharge and detection elimination studies.
- Promote and support green infrastructure practices that mimic natural hydrology in order to reduce the water volume and water quality impacts of the built environment.
- Implement the Agency of Natural Resources Green Infrastructure Plan collaboratively with other State agencies, local government, federal partners, and NGOs.

For more in-depth information follow the links below:

- Toolbox section for activity
- Stressor factsheets including:





3. Agricultural Activities

Inadequate animal waste, soil and nutrient management results in nutrient loading to surface waters and ground waters and is the major source of agricultural nonpoint source pollution in the State. Pesticide runoff can be another result of improper agricultural activities.

Farmsteads

Farm production areas represent the daily workspace where animals, feed, manure, and fertilizers are stored and therefore is also a location of concentrated nutrients. Over the last 50 years many small dairy operations have gone out of business, and at the same time remaining dairies have grown larger. Although there are fewer milk producers, those that remain produce more milk per animal and the total milk produced state-wide has remained relatively constant over the past 20 years. Much of the increase milk production is the result of genetic selection, as well as aggressive feeding strategies – including an increase in imported feed grains from the Midwest. Current estimates suggest that Vermont farms import over 100,000 tons of phosphorus-rich livestock meal annually. These production driven systems, however, have in many cases exceeded the ability of the farm to properly balance nutrient imports and exports and the excess phosphorus accumulates in farm soils and can be mobilized during wet weather events, as stormwater-related erosion carries both sediment-bound and soluble phosphorus into adjacent receiving waters. This has resulted in increased phosphorus losses from farms and transport to water bodies of concern including Lake Champlain. Although intense production systems were thought to be economically profitable, the external environmental costs associated with the increased phosphorus transported to Lake Champlain and other waters in the state were not considered.

There are a number of potential sources of pollutants, especially phosphorus and pathogens from production areas including barnyards, milk house waste, silage runoff, and improperly stored manure.

- ✓ Most animal production facilities have open outside areas where livestock are concentrated throughout the year. The runoff from these areas is often not collected or treated, and as such can contribute to increased phosphorus losses during periods of heavy rainfall.
- ✓ Dairy operations produce large quantities of wastewater from milk houses, which can include phosphorus from animal wastes and detergents. Most dairy farms either collect their milk house waste in their waste (manure) storage structure or use a septic system to treat the wastewater. In some cases milk house waste is not adequately collected and treated.
- ✓ The majority of Vermont farms have transitioned from tall upright silos to concrete walled bunker silos, which are more cost effective. Most farms cover their silage storages with plastic and tires, concentrated silage leachate and runoff from the bunker silos is typically not collected or stored.
- ✓ Manure is sometimes stacked in areas that are unsuitable and susceptible to runoff.
- ✓ Waste storage structures may be inadequately sized resulting in overflows of manure and/or the need to spread during winter months.

As farms began complying with the winter manure spreading ban that was part of the original Vermont Accepted Agricultural Practices (AAPs), the manure had to be stored for longer periods of time. Liquid manure storage structures or earthen pits were the most common systems employed on Vermont farms. The vast majority of the manure storage structures remain unprotected from precipitation which increases storage capacity requirements and results in the generation of greater volumes of wastes for land application. Due of the cost of hauling the heavier liquid wastes, farmers have been reluctant to haul it to more distant fields. As a result, soil phosphorus levels on many fields, especially those closest to the production area, eventually became elevated beyond optimum crop production levels. Because of soil phosphorus/phosphorus runoff relationships, elevated soil phosphorus levels result in proportionately higher concentrations of phosphorus in runoff, meaning more phosphorus transported to the lake, in areas with elevated soil phosphorus concentrations.

Pastures

In the early 1800's the majority of Vermont was cleared and used as pastureland for sheep, resulting in a great deal of erosion off very steep slopes. Major conservation efforts helped to reforest the hillsides when they were abandoned as the agricultural industry became more mechanized and the market for wool declined. Many farms transitioned from sheep to dairy operations. Early dairy farms were small pasture-based operations, which were eventually replaced by larger confinement operations. The non-milking animals typically still remain on pasture for the summer months, often with poor pasture management because these animals require less daily attention. These areas are often severely overgrazed with uncontrolled access to surface water. These areas are particularly susceptible to higher erosion and increased phosphorus runoff.

There is currently a movement in Vermont back to pasture-based farms. As farms transition to a pasture-based system, however, there is a need for improved pasture management. It is important to balance forage requirements with the land base using a planned grazing strategy to avoid the potential for erosion from over-grazing. Additionally, offsite watering facilities and controlled animal access to streams are necessary to maintain streambank stability and prevent streambank erosion, direct deposition of animal wastes, and loss of riparian buffer capacity. If managed properly, pasture-based agriculture will be good for water quality because it means less soil tilled annually that is subsequently at risk for erosion.

Cropland

Farms in Vermont typically participate in federal government programs which in turn require compliance with 1985 Food Security Act highly erodible land requirements. This means they must follow an approved conservation plan that manages soil erosion on crop land to two times the tolerable soil loss (2T) or less. The “tolerable” soil loss rate is equal to the assumed soil formation rate. Therefore, tolerable soil loss from erosion is not expected to negatively affect soil productivity. The AAPs also require erosion to be controlled to 2T or less. The NRCS nutrient management standard, which is used for voluntary programs and has also been adopted by the State of Vermont under the MFO rule, requires that erosion be controlled to T or less. Sediment bound and soluble phosphorus losses due to erosion can be a major source of phosphorus delivered to surface waters, especially when erosion rates are above T. On many hillside fields there are additional sources of erosion and phosphorus from ephemeral and/or classic gully erosion. Most floodplain fields are depositional areas for the sediment carried downstream thereby keeping it from entering Lake Champlain. Floodplain fields can also be an additional source of sediment and phosphorus. During flood flow events many floodplain fields, because they lack sufficient vegetative cover, experience scour erosion in recurring areas that contribute to phosphorus loads.

Erosion controls deal with sediment losses which help reduce sediment-attached phosphorus losses from fields; however phosphorus can also leave a field in a soluble form during runoff events. With the historic clearing and draining of land in Vermont to create a more suitable agricultural landscape, and the abundance of water in the State, nearly every farm has some stream or water resource within its land boundaries. This makes controlling phosphorus losses especially difficult. Many Vermont farm fields have been tiled and ditched for many decades, leading to the same hydrologic impacts and channel enlargement described above under runoff from developed lands section Plastic drain tile is now used extensively in some parts of the northern lake watershed to lower water tables on crop fields. This can be an effective practice that allows for increased access to fields during wet periods of the year. In some cases the drainage of fields can allow nutrient applications to occur with decreased surface runoff of water and nutrients. However, research in many parts of the country, and in Quebec, has documented increased concentrations of nutrients in tile and ditch discharge.

Summary of Agency's Key Strategies that Address Activity:

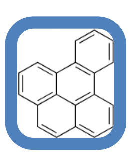
The agency supports the Agency of Agriculture, Food and Markets work:

- works with farm operators to ensure compliance with Appropriate Agricultural Practices (AAPs)
- regulates medium and large sized farms, requiring nutrient management plans (NMP) and encourage smaller farms to develop NMP
- Encourages agricultural operations to deal with non-point source pollution from production areas and farm fields. Encourage enrollment in federal and State cost share programs and provide additional engineering assistance.
- Help implement controls to deal with soluble losses from ditching and tiling of farm fields through surface and subsurface connections to natural surface waters.

For more in-depth information follow the links below:

- Toolbox section for activity
- Stressor factsheets including:







4. Forestry Management Practices

Timber harvesting has the potential to alter streamflow, sediment, nutrients and water temperature. Sediment is the principal pollutant associated with forest management activities (Pardo 1980; Golden et al. 1984). Sediment originating from the construction and use of logging roads and skid trails generally exceeds that from all other forestry activities (Meghan 1972; Patric 1976). Observations of logging operations in Vermont suggest that gully formation on logging roads and/or skid trails occur on sensitive soils and/or when best management practices (BMPs) are not used. These gullies then become efficient pathways for transporting runoff, sediment and nutrients to receiving waters. Stream crossings are the dominant feature where roads make the major contribution of sediment to water bodies.

Summary of Agency's Key Strategies that Address Activity

- Work with Vermont forest industry to promote use of Acceptable Management Practices (AMPs) in an effort to eliminate discharges resulting from logging operations. AMP Technical Advisory Teams directly assist any logger or landowner when there is a potential discharge, complaint or request for assistance.

- Continue to promote better stream crossing practices on timber harvesting operations through the use of portable skidder bridges.

For more in-depth information follow the links below:

- Toolbox for activity
- Stressor factsheets, including:

5. Hydrologic Modification: changes to river flows or water levels

Dams and hydropower generation

All dams – whether serving useful purposes or not – cause ecological impacts, as illustrated and described in Figure 2. While all of these impacts are important considerations, flow and water level manipulation and sediment regime alteration merit further elaboration.

Instream flow, or the flow of water in a stream or river, is an essential and defining component of a riverine ecosystem. Today it is widely accepted that maintaining the natural flow regime and hydrologic characteristics are important to conserve the physical and biological components of a river. Artificial flow manipulation is usually the major environmental issue at hydroelectric projects regardless of size. Typically, hydroelectric projects alter flows by creating an impoundment above the dam, reducing the amount of flow in the bypass reach between the dam and powerhouse, and modifying g flow downstream of project.

With respect to downstream flow, most hydroelectric projects, especially small projects, are operated as "run-of-river." That is, the volume of water released below the dam and powerhouse is equal to the volume of water flowing in the stream or river above the dam on a continuous, real-time basis. Put another way, water is not stored in the impoundment to be released at a later time. For these projects, flows in the bypass reach are usually the only flow-related concern, as downstream flow manipulation is not an issue as long as the project is properly maintained and operated.

In addition to run-of-river projects, there are projects that operate in “peaking” mode, where water is stored in the impoundment and released to generate power when the demand for electricity is high. These projects alter downstream flows, potentially resulting in impacts to aquatic organisms and their habitat, by modifying the physical and chemical conditions (i.e. dissolved oxygen and water temperature). In addition, the impoundment elevations at peaking projects tend to fluctuate, resulting in upstream impacts to aquatic habitat and wetlands. The third issue with peaking projects is again the amount of flow that remains in the bypass.

Dams and diversion structures that change the depth and slope of a stream significantly alter the size and quantity of bed sediments and how they are moved, sorted, and distributed along both the cross-section and profile of the channel.[3] In a natural system, a river’s bed sediments (substrate) and eroded riverbank materials are transported downstream during high-flow periods. Due to stream equilibrium process, however, the material that is lost from a reach of river is normally replaced, as flows recede, through deposition of material transported from upstream reaches. When the transport of sediments, e.g., gravels and cobbles, is interrupted in an impoundment, the channel may become vertically unstable. The instability takes two forms. The impoundment becomes a sediment “sink” as the sediments from upstream hit the flattened river reach and are deposited, resulting in *aggradation*, or raising of the natural riverbed. The downstream instability is essentially the opposite effect. The river channel becomes *incised*, or downcuts, as the materials naturally eroded from the streambed during a flood event below a dam are no longer being replaced by an equivalent amount of sediment from upstream. This mode of

[3]MacBroom, James G. The River Book. Hartford, CT: Connecticut Department of Environmental Protection; 1998.

sediment regime alteration (i.e., sediment discontinuity) has been observed above and below dams, diversions, and undersized culverts throughout Vermont and has a profound effect on stream stability and aquatic habitat.

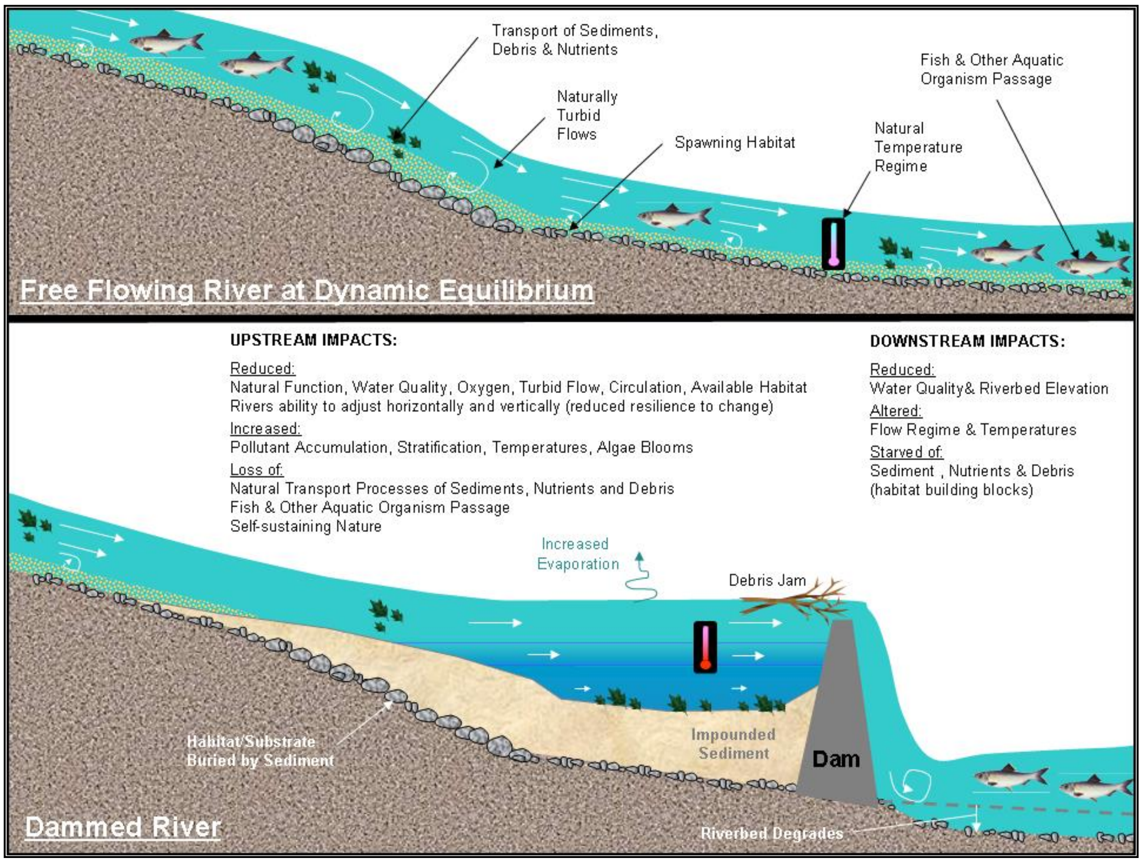


Figure 2 Effects of a dam on a free-flowing river (Graphic courtesy of American Rivers)

Materials aggraded in the slower and deeper water behind the dam alter habitat structure, typically by finer sediments covering or embedding the larger substrates that provide cover for aquatic organisms. In watersheds with high sediment loads, the aggradation process behind a dam during storm events may lead to significant changes in flood stage, bed and bank erosion, and in some cases an avulsion, or change in course of the stream. When channel incision occurs due to sediment starvation downstream of a dam, the streambed may drop in elevation until annual flood flows no longer access the floodplain. The erosion/deposition processes that ensue during channel evolution as new floodplains are created often lead to significant habitat and water quality impacts and fluvial erosion hazards over a period of decades.

During discussions and debates of small hydropower, the terms “small” and “low-impact” are sometimes used interchangeably. They are not the same. Small hydroelectric facilities that are added to existing dams and properly operated can certainly provide societal benefits with limited additional impacts on fish, aquatic habitat, water quality and geomorphic processes. However, this is not true of all facilities, and whether a facility is low-impact must be determined on a case-by-case basis.

Because of their small size, the cumulative impact of developing multiple facilities in a watershed might not be obvious, but the interruption of geomorphic processes within a watershed will have cumulative impacts on aquatic habitat and water quality. Even facilities that would be considered low-impact are not impact free. If they are located at existing dams, the impacts resulting from dams described earlier are present. Bypassed reaches are impacted when water is diverted – the conservation flow does protect habitat, but the quality and quantity of the habitat is degraded relative to natural flow conditions.

There are many dams in Vermont that are not currently serving a useful purpose and, for both economic and ecological reasons, are unlikely to be developed for hydroelectric power. However, these dams will continue to fragment habitat, degrade water quality and cause other impacts on rivers and streams. In terms of developing resiliency to the long-term prediction of an increase in flooding events, droughts and water temperature as a result of climate change, restoring watershed continuity by removing dams and other obstructions will become increasingly important.

Water withdrawals

In addition to dams, Vermont's rivers and streams are affected by water withdrawals that serve a variety of purposes: drinking water supply, irrigation, snowmaking and industrial uses. Many of these withdrawals do not involve dams, but an in-stream intake structure that diverts water to a pump house. Most of these withdrawals are consumptive, that is, the water is used for some purpose and not returned to its source. In some cases, such as when the water is used for heating or cooling, it is returned to the river or lake.

The impacts of water withdrawals on streamflow are similar to those described for hydroelectric projects. Multiple characteristics of the natural flow regime may be affected by water withdrawal activities including, magnitude, frequency, duration, timing and rate of change. However, state regulation of water withdrawals focuses on maintenance of seasonal conservation flows, i.e., the flow downstream of the withdrawal that is necessary to support fish and other aquatic life. In other words, regulated withdrawals are not allowed to operate when the natural streamflow is less than the conservation flow value.

Most of the larger water withdrawals in the state are regulated by the State and operate under permits that require adequate conservation flows. Some are operating under old permits that have lower conservation flow requirements, and there are likely other water withdrawals that are unpermitted.

Water withdrawals from lakes are typically not a problem since streamflow is not an issue. However, large volume withdrawals from lakes in small watersheds can be problematic during dry periods if the flow in the outlet stream is reduced.

Water level manipulation in lakes

Many of Vermont's lakes have dams at their outlets that have varying capabilities to manipulate the water level. The management and regulatory oversight of these is also variable – the Vermont Agency of Natural Resources (ANR) does not have jurisdiction over all situations. Some Vermont lakes are lowered in the fall for the winter period by local residents for the purpose of protection of shoreline structures. Depending on the timing and extent of a winter drawdown, there can be negative impacts on aquatic habitat and biota.

Summary of Agency's Key Strategies that Address Activity

- Issuance of Section 401 Water Quality Certifications for hydroelectric projects and water withdrawals
- Participation in the federal hydroelectric project relicensing process
- Vermont Dam Task Force created to identify opportunities for dam removals where dam owners are willing and funding is available.
- Seek to reduce or eliminate artificial lake level fluctuation and winter drawdowns

For more in-depth information follow the links below:

- Toolbox for activity
- Stressor factsheets, including:

6. Encroachment: wetland buffers, lake shorelands, and river corridors

Fills within rivers and streams, wetlands, and lakes.

While encroachment is not limited to fill, fill activities do represent the most permanent loss for river, stream, wetland and lake habitat. Once an area is filled, it no longer functions as an aquatic resource. In addition to the immediate habitat loss, fills can have ongoing impacts to water quality and floodplain function depending on the quality of the fill material, and the extent and location of the activity. Fill in a river corridor: floodplain, wetland or channel, eliminates sediment and nutrient storage from both channel and land-based sources. In addition, reduction in water and sediment storage also reduces the stability of a river, causing erosion or sediment deposition down stream.

Floodplain fills are common in Vermont. Lands are filled to elevate structures or make land less susceptible to inundation during flood events. These fills eliminate flood flow storage and the attenuation of flood energy, and often cause flood elevations to rise upstream and downstream of the filled area. The loss of flood attenuation tends to concentrate flood energy within the channel causing incision (downcutting). Ironically, fills placed to avoid inundation hazards may ultimately lead to erosion hazards.
Fill that is poorly placed and is not stabilized also represents an ongoing impact as an erosion hazard. In addition to eliminating habitat, fill can provide barriers to wildlife passage. The introduction of fill into an aquatic system has detrimental water quality effects that include iron-fixing bacteria blooms and the introduction of invasive species.

Removal of vegetation.

Part-and-parcel with encroachments to rivers, lakes, and wetlands is the removal of riparian, shoreland, and buffer vegetation. The areas lacking buffer vegetation no longer filter sediment and nutrient pollutants, do not provide for shade cover, coarse woody debris and other organic material, and no longer have the root density and root strength to support the banks, which can contribute to sedimentation problems in the surface water of the lake, river or wetland. On lakes, the removal of shoreland vegetation and replacement with lawn and other development has a substantial impact on the lake, both in terms of an increase in sediment and nutrient pollution, and by resulting in a significant alteration of the shallow water habitat features. (See Lakeshore Development and Alteration of Shallow Water Habitat section below.)

River corridor development

The Vermont Agency of Natural Resources (ANR) uses the river corridor as a primary tool in its avoidance strategy to restore and protect the natural values of rivers and minimize flood damage. River corridor delineations are based primarily on the lateral extent of stable meanders, the meander belt width (Figure 3), and a wooded riparian buffer to provide streambank stability. The meander belt width is governed by the shape of the valley, surficial geology, and the length and slope requirements of the river in its most probable stable form.

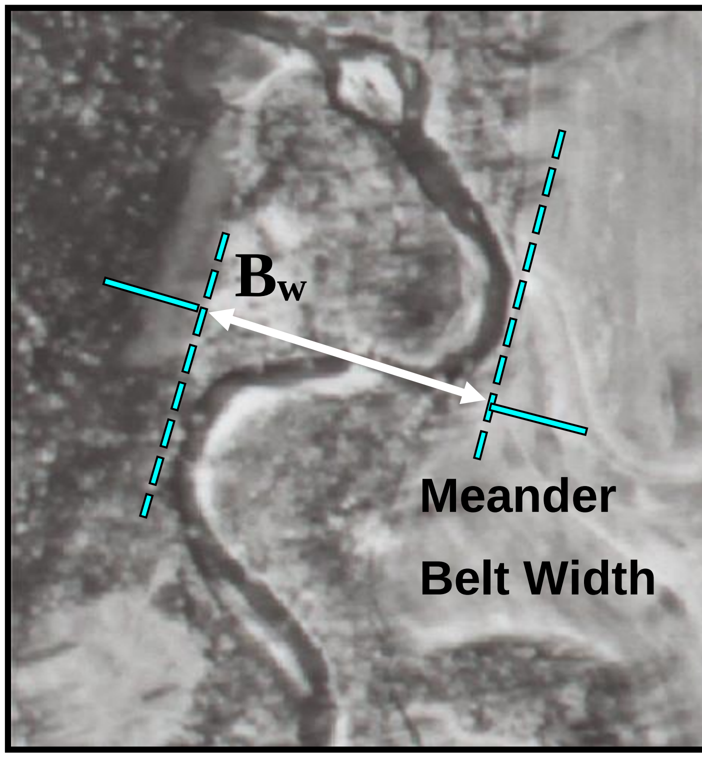


Figure 3. Meander Belt Width (**B_w**) defined by the lateral extent of meanders when the channel slope is in equilibrium with the sediment transport requirements of the river.

River corridors provide an important spatial context for restoring and maintaining the river processes and dynamic equilibrium associated 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).

Vermont ANR stream geomorphic assessments in have documented extensive, historic channel straightening and subsequent encroachment within the river corridors needed for meander redevelopment and equilibrium conditions to reestablish. These activities have resulted in over-steepened, erosive streams throughout Vermont that have become incised and disconnected from floodplains. Reducing current and future near-stream investment and achieving natural stream stability will promotes a sustainable relationship with rivers over time, minimizing the costs associated with floods and maximizing the benefits of clean water and healthy ecosystems.

Vermont ANR has considered that establishing socially acceptable buffers, as development setback areas, without considering river corridor functions, may make it very difficult if not impossible to establish the corridor setbacks necessary to sustainably achieve the State's water quality and hazard avoidance objectives. Once people build within the corridor, corridor functions are compromised. Buffers as a setback zone, which do not provide for the functions of a corridor, will most likely be eroded away.

A river corridor is designed with a meander belt to accommodate the geometry of the river in its least erosive, equilibrium condition, and extended laterally to include a buffer zone, equal in width to the bankfull channel. Any down valley movement of the channel along the perimeter of the meander belt would, therefore, include sufficient, adjacent open area for the maintenance of perennial, woody vegetation and naturally stable stream

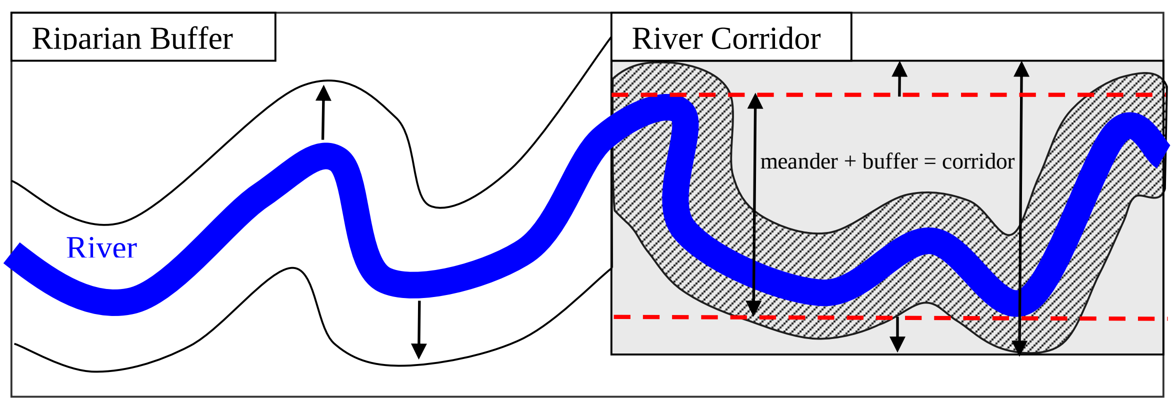


Figure 4. Comparing a buffer setback to a river corridor. Source: Adapted from Ohio DNR, Rainwater and Land Development Manual, 2006 Ed., Ch 2. Post Construction Stormwater Management Practices, p. 21

banks (Figure 4). The vegetated buffer area within the corridor may vary in width depending on the desired functions.

Lakeshore development and alteration of shallow water habitat

The transformation of lakeshores from natural forested and wetland cover to lawns and sandy beaches, accompanied by development (and redevelopment) of residential homes is a major stressor to lakes.

A Wisconsin study found that phosphorus loading to a lake increased by a factor of four and sediment loading increased by a factor of 20 when a shoreland property becomes "suburbanized" through the removal of the natural shoreland vegetation and the replacement with lawns, driveways and buildings.

In a survey of 345 lakes in the Northeast during the early 1990s, the US Environmental Protection Agency and US Fish and Wildlife Service determined that the stress from shoreline alteration was a more widespread problem than even eutrophication and acidification[4]. Since 2005, the VTDEC has documented the effects of shoreline development on nearshore and littoral habitat quality in lakes throughout Vermont, with striking results.

Conversion of treed shorelines to lawn radically changes the chemical, physical, and biological components of lake habitat in the shallow water zone: shading decreases in the littoral zone, the amount of large woody structure is reduced as well as the percent cover of leaf litter while the amount of fine sediments and filling of space between rocks increases. The natural community of aquatic and terrestrial organisms that has evolved to grow, reproduce, and survive in the lake/shore interface will change or disappear as the habitat undergoes physical, chemical, and biological transformation to something with substantially diminished habitat quality.

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[4] (Whiter et al, 2002)

The state lacks a shoreland protection act and only 10% of towns have adequate lakeshore buffer zoning regulations. The Vermont Littoral Habitat Assessment (LHA) project was undertaken on 40 Vermont lakes to quantify the current condition of the nearshore and littoral habitat[5]. It concluded that the lack of a buffer is a significant stressor to Vermont lakes. Overall, findings indicate the changes to shallow water habitat and biota caused by unbuffered development could be mitigated by retaining an intact natural treed buffer along the shore. Preliminary analyses suggest that to protect the shallow water habitat, buildings need to be set back 112 ft or more and at least 51% or more of the immediate shoreline needs to remain in mature trees (>5m tall). A 100-foot plus wide buffer with mature forest, understory, and an uneven spongy duff layer is also optimal for intercepting runoff and dampening the energy of rain.

The Vermont Lake Study also determined the percentage of Vermont lakes that are stressed at the whole lake level due to the extent of unbuffered developed shore using thresholds developed by EPA in the 1990s EMAP survey of Northeastern Lakes. The study estimates that 11% of Vermont lakes are in poor condition, 71% are in fair condition and 18% are in good condition. While the VLS measured the effect and extent of multiple stressors on Vermont lakes, unbuffered lakeshore development was more widespread a stressor than either eutrophication or acidification (Figure 5).

[5] (DEC, 2009)

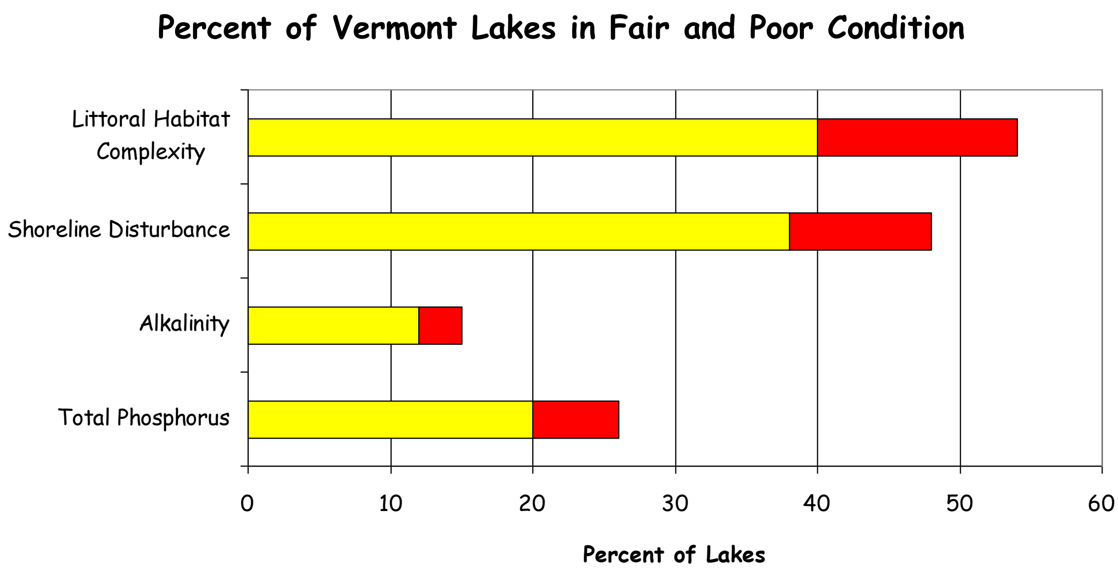

Figure 5. Results of the Vermont Lake Survey, showing the percent of lakes in fair and poor condition due to four different stressors. Yellow and red represent percent of lakes in fair and poor condition respectively.

Summary of Agency's Key Strategies that Address Activity

- Protect significant wetland functions under the Vermont Wetland Rules. Continue to educate community about Rules and assist landowners in complying with rules.

- Provide technical assistance and encourage towns to increase floodplain protection under the auspices of the FEMA's National Flood Insurance Program. Provide maps, technical assistance and incentives to towns in applying land use regulations to protect areas within the river corridor. In addition identify reaches through geomorphic assessments that are particularly valuable sediment and nutrient attenuation assets. Identify as a high priorities those areas in need of permanent protection and conserve irreplaceable functions with the purchase of easements.

- Provide technical assistance and incentives to towns to adopt shoreline protection. Support passage of a statewide buffer bill, similar to those existing in New Hampshire and Maine.

- Provide documentation of floodways, FEH areas, buffers, and lakeshores to Act 250 district commissions.

For more in-depth information follow the links below:

- Toolbox for activity
- Stressor factsheets, including:

   

7. Flood and Erosion Hazard Mitigation

Human investments within river corridors, on floodplains, and adjacent to lake shores has resulted in conflicts between those investments and dynamic movement of streams or lake shorelines. These conflicts lead to great desire and effort to keep streams from moving in the landscape or shorelands from eroding.

Stream channelization to address flood damage

The history of channelization to protect riparian land use investments, and the erosion and flood damage that follow, are among the most significant threats to water quality, aquatic habitat, and public safety in Vermont.

Since the 1950s, an estimated $14 million a year is spent remediating flood damage. A vicious cycle has played out in Vermont where encroachments occur; those encroachments are threatened from flood-related erosion; and then channel works are completed to put the stream back or relocate the stream away from the investments. Years pass, a perception grows that the stream is actually stable, further encroachment occurs, a flood happens, and the cycle repeats itself.

The exact number is not known, but ANR stream geomorphic assessments indicate that somewhere between a third and half the stream miles in Vermont were historically straightened. Most of these same miles were bermed, dredged, windrowed, and/or armored with stone. The physical manipulation of stream depth, width, meander pattern, and slope has resulted in pervasive stream channel incision, widening, and aggradation throughout Vermont. A recently published article in the Journal of American Water Resources Association[6] provided data showing that 75% of the 1,345 miles of stream miles assessed by the ANR were incised and evolving to form new floodplain.

The loss of flow and sediment attenuation due to incision may be contributing to erosion processes and a significant percentage of the nutrient loading to Lake Champlain and other lakes in Vermont. The channelization that occurs after floods also has a large impact on aquatic habitat, primarily due to the loss of instream and riparian cover. Steepened and deepened streams result in higher velocities which scour of the sediments and woody debris that give shelter to aquatic organisms. Straightened channels also lack the riffle-pool sequences and provide shelter and feeding habitats. Habitat in downstream channels and lake littoral zones that receive all the eroded material become smothered and unusable by fish and macroinvertebrates.

For decades state and federal agencies were as convinced as property owners that stabilizing streambanks was always good for water quality. Now, after 10 years of fluvial geomorphic assessment, stream resource managers have the data to understand why the

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[6] Kline, M. and B. Cahoon, 2010. Protecting River Corridors in Vermont. Journal of the American Water Resources Association (JAWRA) 46(2):227-236.

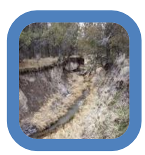
bed and banks of a stream are eroding, and what alternatives people may or may not have to manage stream channel adjustments. In built-up or developed areas, there is often little choice but to keep up with expensive channel works. For this reason, the Vermont River Management Program works with landowners to avoid making large investments next to streams that will rely on channelization to maintain.

Summary of Agency's Key Strategies that Address Activity

- Conduct stream geomorphic assessments and develop river corridor plans to identify and prioritize the actions that will help manage a channel back to equilibrium conditions, and protect the river corridor necessary to accommodate the equilibrium channel.
- Protect technical assistance and regulatory oversight of stream alterations.
- Participate in the Army Corps 404 "dredge and fill" permit process.
- Provide regulatory oversight of shoreland stabilization projects.

For more in-depth information follow the links below:

- Toolbox for activity
- Stressor factsheets, including:




8. Treated and Untreated Wastewater

On-site septic

The list of pollutants in domestic waste water includes nutrients, chlorides and pathogens. A lesser amount of pharmaceuticals and personal care products are also present in waste water but because of a lack of understanding of their fate in soil-based treatment systems, will not be discussed in this section as they are discussed in the section on municipal waste water treatment (see below).

The standard practice for on-site waste water treatment is the separation of solids and liquids followed by the discharge of liquids to soil. When adequate separation from the ground water table is provided, pollutants are filtered out or treated by the soil and its microbial community. As a result, most pathogens expire and nutrients and chlorides are incorporated into the soil. However, on-site treatment does not permanently remove nitrogen and chloride. Eventually both will move readily through soils to reach ground water and often further to surface waters. Nitrogen may under go denitrification, becoming a gas, but chloride remains in the watershed.

Phosphorus is more apt to stay attached to soil particles than nitrogen or chlorides, becoming more available for plant uptake. On-site septic is considered the best treatment for phosphorus removal over wastewater treatment plants. Several studies and analyses of shoreline on-site septic systems conclude that on-site septic are likely not a large contributor to the phosphorus loading problem in Vermont lakes[7]. A non-point source assessment for the Lake Champlain basin as a whole concluded that even under worst-case assumptions, septic systems were not likely to represent more than 5% of the total phosphorus load to Lake Champlain.[8]

Moreover, an evaluation of the benefits of sewering lakeshore camps efforts to reduce phosphorus loads provides evidence that on-site septic ultimately provides more treatment than a wastewater treatment facility. While collection of wastewater for centralized treatment may be necessary in some situations to eliminate discharge of pathogens and protect public health, it is not necessarily a beneficial practice from the standpoint of phosphorus reduction. Phosphorus concentrations discharged from an on-

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[7] a 1991 study done for the Towns of Georgia and St Albans by TWM Northeast, Inc. evaluated the potential for phosphorus loading to the bay from septic systems, based on phosphorus removal rates in soil column tests and on sanitary survey information. Septic systems were estimated to contribute less than 2% of the total phosphorus load to St Albans Bay. This estimate was based on the assumption (not directly verified and likely worst-case) that 20% of the shoreline septic systems provided no phosphorus removal treatment before discharge to the bay.

[8] http://www.lcbp.org/publication_detail.aspx?id=42

site septic system following soil contact would typically be in the range of 0.1 mg/l. Phosphorus concentrations discharged from even the most advanced municipal wastewater facilities are rarely as low as 0.1 mg/l. For example, the discharge permit for the St Albans City Wastewater Treatment Facility limits the phosphorus concentration in this discharge to 0.5 mg/l, which is the strictest phosphorus concentration limit applied to any municipal facility in the state. Treating wastewater on-site though soil contact is nearly always preferable from a phosphorus removal standpoint over collection in sewers, centralized treatment, and discharge back to the lake. In addition, a sewer system will enable more intensive development, which would have the secondary effect of increase runoff to the lake with likely greater impact on the lake than the replaced septic systems.

An adequate separation between point of discharge and ground water level removes the greatest amount of pollutants; however, the majority of on-site septic systems in Vermont were installed without benefit of regulatory oversight. Regulations to separate domestic waste from the ground water table and surface waters when treated on-site were first enacted for subdivisions of single family lots under 10 acres in 1969. It was only in 2002 that all new lots came under state jurisdiction. There are a number of historic villages in the state adjacent to rivers that do not have treatment facilities and where on-site septic systems are likely the source of elevated levels of E. *coli,* an indicator of pathogens, in surface waters.

Municipal wastewater treatment facility

Phosphorus and Nitrogen

Unlike nearly all of the other sources described in this chapter, wastewater discharges represent a regulated and readily measurable source of pollutants, including phosphorus and nitrogen and *E. coli* to waters in the state. There are 91 wastewater treatment facilities (WWTF) that discharge to surface waters in Vermont.

Phosphorus loadings to Lake Champlain from Vermont WWTF have declined by 79% since 1991 and the total discharge of phosphorus from Vermont is now well below the aggregate wasteload allocation contained in the Lake Champlain Phosphorus TMDL. Only a few facilities remain to be upgraded in order to achieve their individual phosphorus wasteload allocations, and all these remaining projects are currently in the design or construction process.

Nitrogen loads from Vermont wastewater treatment plants and other point sources are significantly less than the loads from nonpoint sources. Half of the nonpoint sources are estimated to be atmospherically deprived[9]

Pharmaceuticals and personal care products

During the 2008 reporting period, the US Geological Service (USGS) continued a number of pharmaceuticals and personal care products (PPCP) studies in the Lake Champlain Basin. USGS has analyzed samples of wastewater plant (WWTP) 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 wastewater effluent and CSO effluent were not the only sources of wastewater contaminants**.** Urban streams contributed substantial amounts of wastewater contaminants to Lake Champlain during storms from untreated sewage sources. Two of the streams studied are underlain by old sewer pipes and combined sewer infrastructure; which may leak during storms, releasing sewage to the streams. These findings are the subject of continuing inquiry by USGS.

Industrial wastewater

There are 81 industrial discharges in Vermont, ranging from fish hatcheries to manufacturing facilities. Since industrial discharges are issued NPDES permits (see below) and thus regulated in a manner that will assure that state water quality standards are maintained, water quality problems from industrial discharges are not anticipated. On

[9] http://www.neiwpcc.org/neiwpcc_docs/USGS%20CT%20River%20Monitoring%20Report.pdf

occasion a noncompliance issue may occur, but these are addressed and corrected in a timely manner.

Summary of Agency's Key Strategies that Address Activity

- Regulate or encourage towns to regulate septic system installation
- Implement the Vermont Toxic Discharge Control Strategy (TDCS) to quantify all NPDES discharges in Vermont and to establish water quality criteria and discharge permit limits that can be used to regulate discharges in a manner that will assure that the state water quality standards and receiving water classification criteria are maintained.
- Administer the National Discharge Pollutant Elimination System (NPDES) permit program under federal delegation for discharges from individual, municipal and industrial wastewater treatment facilities to state surface waters.
- Assist towns in obtaining loans to upgrade municipal wastewater systems to reduce pollutant loads.
- Work with industry to reduce waste that would otherwise have to be sent to a wastewater treatment plant.

For more in-depth information follow the links below:

- Toolbox for activity
- Stressor factsheets, including:

9. Transportation Infrastructure

Transportation infrastructure is essential to the Vermont economy and way of life. . Transportation infrastructure includes elements such as roadways, embankments, drainage systems, railroads, driveways, parking lots, recreation paths, sidewalks, airport runways, culverts and bridges.

Vermont has an extensive network of over 15,000 miles of paved and gravel roads (over 90% of which are maintained by local municipalities) 600 miles of operating rail lines (305 state owned), over 70 miles of bicycle/ pedestrian facilities, and many acres of associated private driveways and parking lots.

Transportation infrastructure can be a significant source of nonpoint source (NPS) pollution to rivers and streams if infrastructure is not properly sited, constructed and maintained. Railroads and roadways have historically followed rivers and streams. This close proximity contributes to runoff of pollutants, sediment, and stormwater into waterways.

Undersized bridges and culverts, and floodplain fill for transportation infrastructure constrain the natural movement of waterways, thus exacerbating flooding, erosion, sediment transport and other problems. Road-related fill that causes the river to lose access to its flood plain concentrates more energy within the channel, and will cause erosion and increased flooding in the watershed. Undersized culverts are also an ecological challenge. They can be a barrier to fish and wildlife and prohibit movement through the landscape, thus cutting off and eliminating essential habitat.

Transportation infrastructure leads to NPS pollution in a number of ways, but many of these have to do with the amount and rate of water flowing over the surface of un-stabilized soils. An obvious example is the erosion of the road surface itself when it is not built or maintained with proper drainage.

Other sources of sediment include: erosion from ditches that are not vegetated or lined with stone, bank failures near the road, bridges and culverts that wash out, erosion during road construction and maintenance, and traction sand runoff from winter maintenance of both paved and gravel roads. Correcting these sources of sediment can involve significant under-budgeted costs and transportation disruptions..

The demand for wider, safer roadway facilities is another concern. Bicycle and local pedestrian traffic must be accomodated Widening existing roads, and adding new sidewalks with curbing often without adequate stormwater infrastructure or treatment, increase and often concentrate stormwater runoff, thus resulting in increased NPS pollution.

Transportation facilities are linked to growth and development patterns. Transportation access is a key factor in the location of development within the watershed. In addition, development patterns spread across the landscape, such as car-oriented commercial strip development on the edges of towns and villages, requires far more impervious surface than compact development patterns. The amount of impervious surface within the watershed and the existence and adequacy of the treatment of storm water discharges from those surfaces greatly affect the quality of the receiving waters

Spreading of salt and sand

Salt and sand are spread during the winter to provide safe driving surfaces. Road salt has been used as a deicing mechanism since the 1940s. Roughly 16 million tons of rock salt were mined in the United States in 2004, and used primarily for road deicing[10]. Use of sodium chloride and calcium chloride, in conjunction with plowing, is recognized as the most efficient way to keep roadways clear in winter[11]. Sodium chloride is also currently the least expensive deicing option available. While road salt is not the only source of chloride in the environment, there is evidence that application at current rates is resulting in increased chloride concentrations and conductivity levels in surface and ground waters in the northern United States.

There is sufficient evidence that chloride and its affect on the aquatic environment warrant closer scrutiny in Vermont:

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[10] (Salt Institute 2006)

[11] (USGS 2006)

- Chloride levels have been steadily increasing in Lake Champlain since 1992. At this time, concentrations in the open waters of the lake (6.8– 25.3 mg/L) are not of biological concern.
- Major lake tributaries are now carrying higher loads of chloride than they have historically.
- Urban streams in the greater Burlington area have the highest chloride concentrations observed to date in Vermont and are experiencing levels considered harmful to biota. Mean chloride concentrations in three of six urban Burlington streams studied in 2005 ranged from 250 – 275 mg/L, exceeding ambient water quality criteria.
- High chloride levels are occurring during summer and winter low flow periods in these small urban streams, strongly suggesting that groundwater contamination may exist. There appear to be no current groundwater data on chloride in these areas.
- Road salt application was linked to increasing chloride concentrations in the West Branch of the Waterbury River in Stowe and Forester Pond in Jamaica[12].

Summary of Agency's Key Strategies that Address Activity

- Support the Better Backroads Program (BBR) financially and with some technical assistance. The program hires technical staff to assist towns in identifying road erosion problems and applying for grant funds. The grant funds are used for inventories, capital budget planning, and erosion correction projects, including the stabilization of ditches, culverts, and roadside banks.
- Support Local Road Programs workshops to promote road BMPs to town road crews, including winter maintenance.
- VTrans provides the Agency with road salt application data on state roads. The agency supports VTrans efforts to identify methods for reducing chloride use.
- Monitor chloride levels in surface waters

[12] DEC

- Continue the outreach and educational efforts of the River Management section and other Agency of Natural Resources programs.
- River management engineers and floodplain managers provide technical assistance and regulate new transportation infrastructure when placed within floodplains and stream channels.
- Continue collaborative research and regulatory efforts with VTrans and other partners.

For more in-depth information follow the links below:

- Toolbox for activity
- Stressor factsheet including:




10. Spreading Aquatic Invasive Species

Acres of beds of nonnative species are now found within our water bodies. These aquatic invasive species (AIS) have reached beyond their historic range and threaten the diversity or abundance of native species or the ecological stability of infested waters. In addition, the spread of AIS threatens commercial, agricultural, aquacultural or recreational activities dependent on such waters.

The potential pathways of introduction for AIS into the state are numerous. The movement of boats and other aquatic equipment is the most visible and readily recognized pathway, but aquarium dumping, improper disposal of live bait, accidental releases from cultivation, and intentional introductions all play a role.

Natural and artificial waterways also serve as conduits for AIS into the Lake Champlain Basin and the state. The Champlain Barge Canal connects the southern end of Lake Champlain to the Hudson-Mohawk watershed, which is, in turn, connected to the Great Lakes drainage basin by the Erie Canal System. The Champlain Barge Canal likely provided access for numerous AIS into the Basin, including zebra mussels, blueback herring, water chestnut, flowering rush, purple loosestrife, white perch, and mud bythnia. The Richelieu River, which flows out of the northern end of Lake Champlain and ultimately into the St. Lawrence River, has a similar potential to move nonindigenous species into and out of the Lake Champlain Basin. For example, tench likely entered Lake Champlain via this waterway. Some preliminary work has been done to identify potential management options for the Champlain Barge Canal, but a great deal more work and funding will be required to eliminate the threat of AIS introductions from the Canal.

Summary of Agency's Key Strategies that Address Activity

- Enforce state legislation that limits spread of AIS to new areas, and regulates the use of mechanical, biological, physical and chemical nuisance control activities in Vermont waters.
- Assist shoreline owners and other community members with the management of AIS by providing technical assistance and financial assistance through the Aquatic Nuisance Control grant-in-aid program.
- Support continued annual state funding for water chestnut to ensure successful control and maintain recently achieved milestones
- Coordinate with Lake Champlain Basin Program on invasive species management in Lake Champlain and its basin
- Maintain readiness to implement Rapid Response protocols when necessary.

For a more in-depth discussion, see the following links:

- Toolbox for activity
- Aquatic Invasive Species stressor factsheet:

11. Air Emissions

Power plants, industrial manufacturing, and motor vehicles are all sources of air emissions that can adversely impact water quality. The compounds in these air emissions fall to the earth in either dry form (such as gas and particles) or wet form (such as rain, snow, and fog). Prevailing winds transport the compounds, sometimes hundreds of miles, across state and national borders.

Pollutants from air emissions result in acid deposition that acidity our lakes and are the predominant source of mercury in our waterbodies. These pollutants become part of the air masses circulating in the upper atmosphere, which flow predominately into the Northeast. With regard to sources that lead to acid deposition, the industrial Midwest is responsible for about half the sulfur dioxide emissions east of the Mississippi. The state of Ohio produces two times more tons of sulfur dioxide than all of New England, New York, and New Jersey put together. It is pollutants from these distant sources that contribute to damages in the Northeast environment.

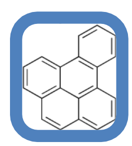
Nitrogen is another component of air emissions. In Vermont, the air emissions provide a significant source of nitrogen.

Summary of Agency's Key Strategies that Address Activity

- The majority of the sources of air emissions are out of state. Continue monitoring and assessing surface waters to develop TMDLs, demonstrate benefits of the federal regulation and the need for further reductions to achieve biological recovery.

For more in-depth information follow the links below:

- Toolbox for activity
- Stressor factsheet, including:



12. Legacy Effects

Legacy sediments

The widespread deforestation of Vermont's landscape through most of the 19th century into the early 20th century resulted in tremendous erosion of upland soils and accumulation of alluvial sediments in the river valleys. Streambank stratigraphy assessments[13] document the aggradation of valley floodplains up to 20 feet in the post-settlement period. Deep deposits of highly organic alluvium are commonly visible in eroding riverbanks throughout the Champlain Valley. In a sample of 245 streambank stratigraphy investigations in the Lake Champlain Basin, Skinas found 150, or 63%, of sites to consist of recently deposited post-settlement alluvial sediments. Depth of alluvium ranged from one foot to 20 feet with an average depth of five feet.

Reforestation during the 20th century dramatically reduced the watershed sediment supply. In the latter half of the century rivers began downcutting through the alluvial sediments. At least 70% of Vermont's rivers have become incised and thereby disconnected from their historic floodplains. These rivers have begun, very efficiently, mobilizing and transporting not only the current-day sediments washing off the land, but more importantly the deforestation-related legacy sediments and nutrients.

Internal Phosphorus Loading

Internal phosphorus loading refers to the process in which phosphorus is supplied to the water of a lake from sources within the lake, usually the lake sediments, as opposed to external loading from streams and land-side sources. Phosphorus entering a lake from watershed sources is taken up by algae and other organisms and then a portion of this phosphorus sinks to the bottom of the lake in the form of dead cells, waste products, and other particulate matter. Depending on the chemical conditions in the sediments and overlying water, this previously deposited phosphorus can be recycled back into the

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[13] (Field, Skinas)

water column where it can stimulate algal growth again. A diagram of the phosphorus cycle in St Albans Bay showing the internal loading process is shown in Figure 6.

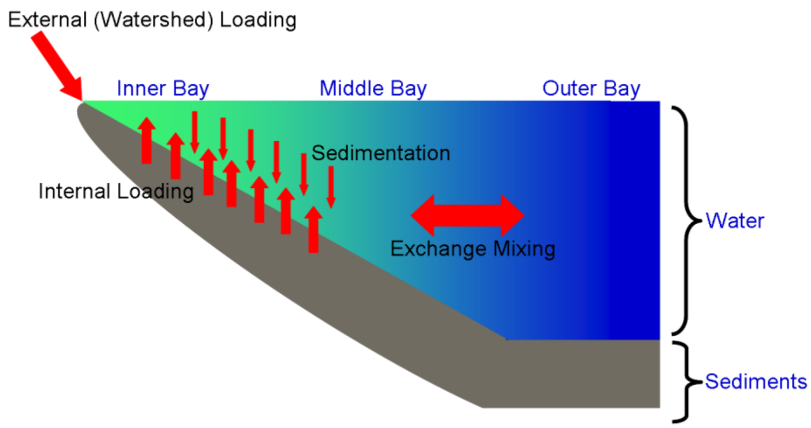

Figure 6 The Phosphorus Cycle in St Albans Bay - showing internal loading.

When external phosphorus loading to a lake has been excessive over a long period of time, large quantities of phosphorus become stored in the sediments. Internal loading from this historic residue of sediment phosphorus can continue long after external loads have been reduced through wastewater treatment improvements and non-point source control. In this situation, internal loading can delay the recovery significantly.

This is the situation that exists in St Albans Bay, as documented by a large body of research on the bay.[14,15] A wastewater treatment plant upgrade and watershed-wide implementation of certain agricultural best management practices (BMPs) in the 1980s did not result in measurable phosphorus reductions in the bay's water. Internal loading is causing phosphorus levels to remain high, especially during the summer months when algae blooms peak. The same situation is likely to exist in Missisquoi Bay, based on research and modeling done for the Lake Champlain Basin Program.[16,17]

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[14] http://www.anr.state.vt.us/dec/waterq/lakes/docs/lp_stalbansphosphorus.pdf

[15] http://www.anr.state.vt.us/cleanandclear/StAlbansBaySedimentPstudy.pdf

[16] http://www.lcbp.org/publication_detail.aspx?id=77

[17] http://www.lcbp.org/publication_detail.aspx?id=78

Landfills and hazardous waste sites

Agency assessments conducted in the early 1990s found that unlined landfills throughout Vermont had caused degradation of ground water and surface water quality. Post-closure maintenance and monitoring is needed to minimize the risks to public health and the environment, and to ensure that necessary corrective actions are taken to protect public health and the environment. Of the 68 municipal solid waste and special waste landfills which have closed and capped since 1989, 16 are not covered by a regulatory document specifying post-closure maintenance and monitoring requirements. About 14 of these landfills do not currently perform post-closure maintenance and monitoring. Additionally, landfills that closed before 1989 were not subject to detailed closure regulations and may require additional attention to ensure that they are not causing environmental degradation.[18] Pollutants generally include iron, manganese and heavy metals. The leaching of iron and manganese from the disturbed nature of the landfill and groundwater interaction impacts habitat more that actual "toxicity" through both precipitation of iron and the smothering effects of iron bacteria. Currently about a dozen stream waterbodies are known to have impacts from these old landfills.

In addition, hazardous waste disposal was not regulated until federal legislation was released in 1980 (The Comprehensive Environmental Response, Compensation, and Liability Act). Sites like the Barge Canal in Burlington and the Elizabeth Mine in Strafford have contaminated both soil and surface water with hazardous waste constituents. Site management by the agency and EPA has begun on these two sites, but many others exist. The number and complexity of sites and variety of potential receptors (surface water, groundwater, soils, and sediments) make reducing the environmental impacts of these sites, especially older sites, challenging. There are 100 active high priority hazardous sites and 500 active medium priority sites in the State. The universe of Vermont hazardous sites (active, inactive, closed) is over 3000. Most monitoring that

[18] State Of Vermont Revised Solid Waste Management Plan, Agency of Natural Resources DEC, adopted 8/31/2001

occurs is groundwater or soil monitoring so it is difficult to assess river or stream impacts but currently 13 river or stream segments are assessed as having impacts from hazardous waste sites.

Summary of Agency's Key Strategies that Address Activity

Legacy effects

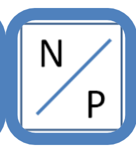
- Support studies that identify appropriate methods for sealing phosphorus into lake bottom sediments. Implement appropriate methods when new loads to the waterbody are sufficiently reduced to maintain appropriate trophic level for waterbody.

Landfills and hazardous waste sites

- Maintain database on hazardous waste sites

For more in-depth information follow the links below:

- Toolbox for activity
- Stressor factsheets, including:

13. Climate Change and Surface Waters

The impacts of climate change on water quality are an emerging issue for Vermont to address. 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 landuse 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 acerbate 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, 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 7 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.

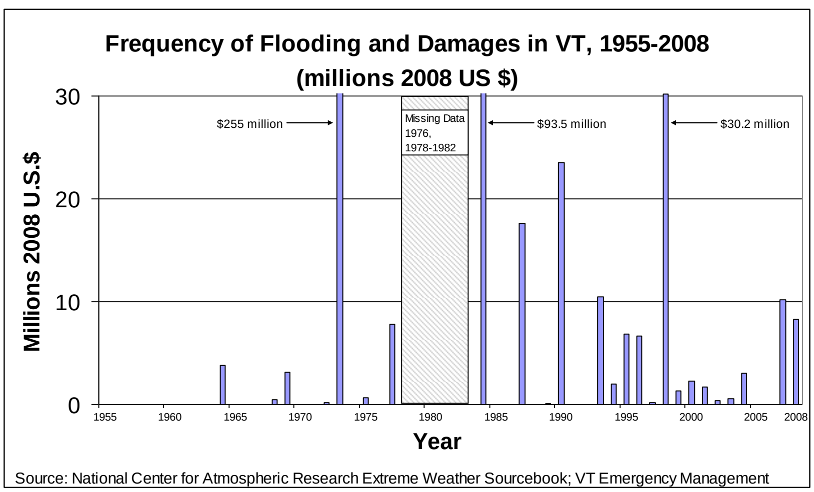


Figure7: Frequency of Flooding and Magnitude of Damages in VT

Summary of Agency's Key Strategies that Address Activity

- Monitor to collect data on water resources: Maintain and expand river gauging network to monitor trends in streamflow
- Develop and implement a statewide climate change plan.

For more in-depth information follow the links below:

- Toolbox for activity
- Stressor factsheets, including:



Programs that Protect and Restore Waters of Vermont

This appendix contains brief program summaries for numerous monitoring and assessment, regulatory/technical assistance, funding, and education and outreach programs. In addition to these summaries, the Watershed Management Division Website contains detailed information pertaining to all Division programs.

WATERSHED MANAGEMENT DIVISION – QUICKLINKS TO PROGRAM WEBPAGES

The most comprehensive accounting of Watershed Management Division Programs may be found by perusing the Division's program specific webpages:

Business Support Services
Clean Water Initiative Program
Lakes and Ponds Management and Protection
Monitoring, Assessment and Planning
Rivers and Floodplains
Stormwater
Wastewater
Wetlands

MONITORING AND ASSESSMENT PROGRAMS

Vermont Agency of Natural Resources, Department of Environmental Conservation (DEC)

DEC Watershed Management Division

Surface Water Monitoring & Assessment

The overall goal of the environmental monitoring and assessment program is to ensure that good science is used to develop an understanding of the attributes of, and the forces which affect, the physical, chemical, and biological characteristics of Vermont's aquatic ecosystems, and ensure that this information is available to be used as the basis for making, and evaluating the consequences of, environmental management decisions made or influenced by DEC. The specific objectives of this program include the following:

- Determine the present and future health of aquatic ecosystems in Vermont;
- Establish empirical limits of natural variation in aquatic ecosystems in Vermont;
- Diagnose abnormal conditions to identify issues in time to develop effective mitigation;
- Identify potential agents of abnormal change;
- Assess ecological changes resulting from the implementation of environmental management activities; and
- Identify risks to human health associated with the use of aquatic resources.

In order to accomplish these objectives, this program conducts activities to monitor and assess the chemical, physical, and biological components of aquatic ecosystems. Findings relate to both ecological and human health. Activities are conducted both in response to identified issues, activities, and potential problems; and in the framework of long-term environmental status and trends monitoring.

DEC's surface water monitoring and assessment program is guided by a standalone Water Quality Monitoring Strategy.

Fluvial Geomorphic Assessments

Fluvial geomorphic (FG) assessment data provide the basis for stream alteration regulatory decisions, technical assistance for fluvial conflict resolution, stream corridor protection and restoration, flood hazard mitigation and water quality protection. The assessment data is critical to prioritization of riparian and fluvial process-related water quality restoration and protection projects, project design alternatives analyses, and project design criteria. FG assessment data provides insight into the social, economic and ecological interrelationships between people and fluvial systems and as such, it is also a valuable educational tool. Assessment data is compiled in the fluvial geomorphic assessment database, and the database is used to ensure that projects are implemented in a manner consistent with and complementary to equilibrium conditions.

Vermont Invasive Patrollers

A volunteer "watch" program created by the Department of Environmental Conservation in 1987 to utilize volunteers to search for populations of Eurasian watermilfoil. This program has since grown to include other invasive aquatic plants and aquatic animals under the auspices of the "Volunteer Invasive Patroller" Program or VIPs. VIPs monitor a local waterbody for new introductions of invasive species while also learning about aquatic plants and animals, and their habitats.

Ambient Biomonitoring Network

The Ambient Biomonitoring Network (ABN) is the flagship monitoring program of the collection, processing and analysis of biological samples; the assessment of physical habitat features; the collection of chemical water quality samples; the assessment of monitoring data results to ensure that data are of the highest possible quality and that the assessment results are appropriately integrated into a wide variety of DEC management programs.

Lake Assessment Program

The program consists of a variety of monitoring projects that range from simple one-day site visits to long-term diagnostic studies. The results of these monitoring projects help the DEC characterize current water quality conditions, detect trends, and determine which lakes are supporting their designated uses. Ongoing special projects of basin-wide significance include a project to determine lakes most likely to exhibit mercury contamination in fish, and an effort designed to characterize expected biological communities in lakes of differing types, under varying degrees of human disturbance.

Vermont Long-Term Monitoring (VLTM) of Acid Sensitive Lakes

DEC has been monitoring the chemistry of low ionic strength lakes in Vermont since the winter of 1980. In 1983, the US EPA Long-Term Monitoring Project was initiated within the National Acid Precipitation Assessment Program (NAPAP). Since 1983, the VLTM project has been conducted in cooperation with the US EPA. This cooperative project consists of six federal/state agencies and universities in different regions of the U.S. and is managed by the US EPA's Environmental Research Laboratory in Corvallis, OR. (ERL-C). Currently, Vermont monitors the chemistry of 11 lakes. Each lake has been monitored under the current VLTM project from 16 to

20 years, making it one of the oldest lake monitoring programs designed specifically to assess acidification.

Vermont Acid Precipitation Monitoring Program (VAPMP)

The VAPMP was initiated in 1980 to monitor the pH of bulk precipitation on an event basis through volunteer monitors located throughout Vermont.

Lay Monitoring Program

Volunteers are equipped and trained to monitor lake water quality on a weekly basis during the summer months. The program enables the DEC to obtain detailed water quality information on a larger number of lakes than would otherwise be possible, while educating volunteers about lake ecology and lake protection. Participation ensures the DEC has long-term seasonal data on lakes in the Basin, and accordingly, emerging water quality problems can be caught more quickly.

LaRosa Partnership Program

Since 2003 this partnership has helped watershed associations and monitoring groups across the state of Vermont implement new and/or ongoing surface water monitoring projects for waters in need of water quality assessment by helping to alleviate the financial burden of laboratory analysis costs. This testing allows citizens to get out and see their streams and rivers firsthand, learn about water quality issues, and use water testing to identify where impacts are present.

REGULATORY AND TECHNICAL ASSISTANCE PROGRAMS

DEC Watershed Management Division

Rivers Program

General

The goal of the Rivers Program is to resolve conflicts between human investments and the dynamics of rivers in an environmentally and economically sustainable manner. The Rivers Program supports and implements channel assessment and management practices that recognize the functions and value of floodplains, conservation flows, and stream in their equilibrium condition. The Program provides regulatory review and technical assistance for protection, management, and restoration projects that affect the flow and physical nature of streams, rivers, and floodplains. The objective is to guide and encourage projects that provide increased property and infrastructure protection and maintain or restore the ecological functions and economic values of the river and floodplain systems.

River Management Program

The River Management Program provides regulatory review and technical assistance to landowners, municipalities, non-governmental organizations and other agencies to help determine the appropriate stream channel management practices necessary to resolve and avoid conflicts with river systems. The practices selected are designed to recognize and accommodate, to the extent feasible, the stream's natural stable tendencies (connectivity and equilibrium conditions). The conflicts are resolved with the recognition of a stream's long-term physical response to past and proposed management practices. The resulting work is intended to provide increased property and infrastructure protection and maintain or enhance the ecological functions and economic values of the river system. Regulation is conducted pursuant to 10 V.S.A., Chapters 41 and 32, the Stream Alteration Rule, and Section 401 of the Clean Water Act.

River Management Engineers are experienced in river dynamics, conflict resolution, and the environmental damage and human suffering that occur when projects fail during floods. It is their day-to-day field exposure to Vermont river systems and the people and communities that live along them that has created accountability back and forth between the service provider and the communities they serve and toward sustainable relationships at larger natural and economic scales. The number of stream alteration permits issued in a year is a small fraction of the field visits and face to face technical assistance provided to help project proponents understand the eventual river response and the risks they create to the environment, themselves, and their neighbors. On average, Vermont has experienced a flood disaster every year for the past twenty-five years, and it is the River Management Engineer who works with local officials for days, weeks, and often months putting things back together in a way that is better than before. The expert professional work in the field helping people and communities reduce both costs and risks is a basic tenet of the River Management Program.

River Corridor and Floodplain Protection Program

The River Corridor and Floodplain Management Protection Program provides regulatory review of any development exempt from municipal land use regulation (Primarily state facilities, agricultural structures, and utility projects) in accordance with 10 V.S.A. Chapter 32. The Program provides technical support to Act 250 and National Flood Insurance Program (NFIP) enrolled communities. In addition to providing general technical assistance, education, and outreach, staff provides floodplain development reviews in accordance 24 VSA Chap.117, Section 4424. Technical assistance is available to communities wishing to better protect river corridors from potential encroachments that will cause conflicts with stable channel functions and potentially increase future flood and erosion damages. In addition, the RCFPP provides support to the VT Division of Emergency Management, communities, watershed associations, Regional Planning Commissions and individuals to help plan for, design and implement flood and fluvial erosion hazard avoidance, reduction, mitigation and recovery planning and projects. River management engineers, floodplain managers and river scientists provide technical assistance and state funding, and use FEMA flood hazard and pre-disaster mitigation grants to assist non-government entities and municipalities with the planning and implementation of flood and erosion hazard mitigation projects. Mitigation projects and the program's assistance are increasingly used as leverage to get landowners and communities involved in greater river corridor and floodplain protection. FEMA pre-disaster mitigation planning funds in Vermont are also be used to help communities develop strategic hazard mitigation plans to restore, remove, or retrofit infrastructure likely to become damaged during or after floods. Recent Stafford Act amendments (44 CFR Part 201.6) required local governments to adopt Hazard Mitigation Plans in order to retain eligibility for certain FEMA (Federal Emergency Management Agency) grant programs. The State Hazard Mitigation Plan and 12 Regional (multi-jurisdictional) Hazard Mitigation Plans all set high priority on mitigation and avoidance of fluvial erosion hazards through river corridor protection. In this way, hazard mitigation planning is complementary to water quality objectives and can be a powerful local planning tool.

Regional river scientists and floodplain managers assist Act 250 and municipalities in developing river assessments and maps depicting river corridors and key flood and sediment attenuation assets. The RCFPP Program, 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 River corridor mapping. The Program leverages state and federal funding to develop Phase 2 stream geomorphic assessment data and river corridor plans that identify river corridor and restoration projects consistent with the achievement of equilibrium conditions. The regional scientists, working with DEC Watershed Coordinators, educate communities about stream instability and fluvial erosion hazards, and provide incentives for their adoption and implementation of river corridor plans and bylaws. The RCFMPP Program has provided the RPCs and municipalities with a suite of Enhanced Model Flood Hazard Area and River Corridor Regulations. These Program activities are conducted pursuant to 10 V.S.A. Chapter 49 and 24 V.S.A Chapter 117 as amended by Acts 110, 138, and 16 (passed by the General Assembly in 2010, 2012, and 2013, respectively).

A River Corridor Easement Program has been established by the RCFPP Program 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 river corridor zoning which, if adopted, avoids future encroachment and flood damage, but does not re-strict channelization practices. The key provision of a river corridor easement is the purchase of channel management rights. 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 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.

Streamflow Protection Program

The goal of the RMP Streamflow Protection Program is to maintain flows necessary to protect aquatic habitat and stream ecology. In addition to minimum flows, the Program addresses the timing, frequency, duration and magnitude of both high and low flow events and their influence on the physical and biological attributes of a stream or river.

The Program works with Vermont ski areas to protect streamflow at snowmaking water withdrawals. These projects usually include withdrawals designed to maintain conservation flows and construction of storage reservoirs so that water can be withdrawn during periods of high streamflow and used at other times when needed to make snow. The Agency of Natural Resources works closely with ski resorts to design systems that address the resorts' need for water while protecting the aquatic environment.

The Program is charged with ensuring that hydroelectric projects are operated so that the state's rivers and lakes continue to meet Vermont's water quality standards. In addition, the U.S. Army Corps of Engineers operates five flood control projects in Vermont on tributaries of the Connecticut River. The Program works closely with the Fish and Wildlife Department and federal resource agencies to ensure that water quality and aquatic habitat are protected at and below hydroelectric and Corps projects while they still serve their primary purpose of providing power generation or flood hazard mitigation.

Water withdrawals in both streams and lakes usually require a permit from the U.S. Army Corps of Engineers under Section 404 of the CWA. As with other projects requiring a federal permit, a Section 401 Water Quality Certification from the Agency is required before the permit is issued. For most types of water withdrawals (except those for snowmaking), the Agency has adopted a procedure that defines the standards and process used by the Agency during its review of project proposals. The procedure defines how the Agency will determine the minimum streamflow that is necessary to meet Vermont Water Quality Standards. For snowmaking water withdrawals, the Agency has developed rules as directed by 10 V.S.A. §§ 1031-1032. The rules serve the same purpose as the Agency procedure, but apply specifically to snowmaking projects.

Dam removal has in recent years been used as a tool to restore rivers while addressing the on-going problems of aging, and deteriorating, infrastructure. Of the 1,200 known dams in Vermont, many no longer serve a useful purpose and impose legal and financial burdens on their owners. The Program works with many partners to remove dams where it makes sense for economic, public safety, ecological or social reasons. In 2000, the Agency and other groups and individuals interested in restoring our rivers formed the Vermont Dam Task Force. Task force members are working with dam owners and local watershed groups to identify dams that are good candidates for removal or modification.

Lakes and Ponds Management and Protection Program

General

The Lakes and Ponds Management and Protection Program monitors the water quality, aquatic biota, and aquatic habitat of Vermont lakes; seeks to prevent water quality problems or habitat degradation; determines the causes of problems that arise; and in collaboration with others, develops management or restoration plans to address problems. Technical and financial assistance is provided to municipalities, lake associations, and individuals to help them implement lake management and protection activities. The Program also administers permits for aquatic nuisance control activities, shoreland clearing or construction, and encroachments into lakes, and assists other state programs with lake-related issues such as water level management, Act 250 review, point source discharge permitting, Use of Public Waters rulemaking by the Water Resources Board, and near-shore waterski course regulation by the Vermont State Police. Public information and education is an important part of the Lakes and Ponds Management and Protection Program, and educational materials for all ages on a wide variety of lake and watershed-related topics are available from the Program.

Aquatic Invasive Species Program

The Aquatic Invasive Species Program seeks to prevent or reduce the environmental and socio-economic impacts of nuisance (primarily non-native and invasive) aquatic plant and animal species. The Program is concerned with species currently found in Vermont (e.g. Eurasian watermilfoil, variable-leaf watermilfoil, water chestnut, zebra mussels, and spiny waterflea) and species from nearby states or Quebec with the potential to spread into Vermont. The Program's components include monitoring, control and technical assistance, spread prevention, a permit program, a grant program for municipalities, and public information and education initiatives.

Public information and education is an essential part of the this program. Users of all Vermont water bodies should understand the serious impacts that aquatic invasive species can have on the state's aquatic resources and on people's use of those resources, and be aware of what can be done to prevent the spread invasive species to uninfested waterbodies. In the case of invasive aquatic species, an ounce of prevention is truly worth a pound of cure.

Public Access Area Greeter Programs

These programs are one of the most effective methods for preventing the spread of invasive aquatic species to recreational waters. Public Access Greeters educate boaters, anglers and other recreationists about invasive species, offer courtesy watercraft inspections and STOP invasions. The Department of Environmental Conservation provides annual training workshops and support materials (e.g., training manuals, "Greeter on Duty" welcoming boards, "Access Greeter" t-shirts) to support Vermont greeter programs. Greeter program "saves" are documented annually. In 2015, greeters intercepted and removed 469 instances of aquatic invasive species, roughly 64% of recorded intercepts.

The Lake Wise Program

The LakeWise Program provides technical assistance to local governments, volunteer groups, and lakeshore residents for a wide variety of lake protection activities. Groups are provided information and guidance on shoreland best management practices to reduce the impact of shoreland land uses on the lake.

Shoreland Permit Program

Effective July 1, 2014, the Vermont Legislature passed the Shoreland Protection Act (Chapter 49A of Title 10, §1441 et seq), which regulates shoreland development within 250 feet of a lake's mean water level for all lakes greater than 10 acres in size. The intent of the Act is to prevent degradation of water quality in lakes, preserve habitat and natural stability of shorelines, and maintain the economic benefits of lakes and their shorelands. The Act seeks to balance good shoreland management and shoreland development. Comprehensive information regarding the Shoreland Permit Program may be found at: http://dec.vermont.gov/watershed/lakes-ponds/permit

Stormwater Program

The Stormwater Management Program provides regulatory oversight and technical assistance to ensure proper design and construction of stormwater treatment and control practices as well as construction-related erosion prevention and sediment control practices, necessary to minimize the adverse impacts of stormwater runoff to surface waters throughout Vermont.

The management of stormwater runoff is at once a simple concept and a complex problem. Precipitation runs off impervious surfaces rather than infiltrating into the soil. The cumulative impact resulting from the increased frequency, volume, and flow rate of stormwater runoff can lead to destabilization of downstream channels and can also result in increased pollutant loading to waterways.

The following links provide permit-specific information:
Operational Permits
Construction Permits
Industrial Permits
Municipal Permits
Transportation Permit

Stormwater Permit Fees
Stormwater Forms

Wastewater Program

The Wastewater Management Program provides regulatory oversight for and technical assistance to Vermont's wastewater treatment facilities in cooperation with State, regional and national organizations. Municipal wastewater, originating from a combination of domestic, commercial, and industrial activities, is conveyed to a centralized wastewater treatment facility and treated to established standards and discharged into a receiving water.
Vermont's 92 municipal wastewater treatment facilities process more than 15 billion gallons of wastewater per year.

Direct Discharge Permits
All municipal, industrial and commercial facilities that discharge wastewater directly from a point source (such as a pipe, ditch or channel) into a receiving waterbody (lake, river, or ocean) are issued an NPDES permit. Facilities that discharge to a wastewater treatment facility, which in turn discharges into the receiving waterbody, are not subject to NPDES permits; rather they are controlled by the national pretreatment program. The state of Vermont has assumed the NPDES program from the federal government and issues permits through the Wastewater Management Program.

Pretreatment Permits
The Wastewater Management Program issues permits under the Federal Pretreatment Permit program for certain industrial and commercial discharges to municipal wastewater treatment facilities which may interfere with the operation of municipal treatment facilities.

Wetlands Program

The Vermont Wetlands Program is responsible for identifying and protecting wetlands and the functions and values they provide by the implementation of the Vermont Wetland Rules. Activities to achieve these goals include education, project review, and enforcement.

The State of Vermont protects wetlands which provide significant functions and values and also protects a buffer zone directly adjacent to significant wetlands. Wetlands in Vermont are classified as Class I, II, or III based on the significance of the functions and values they provide. Class I and Class II wetlands provide significant functions and values and are protected by the Vermont Wetland Rules. Any activity within a Class I or II wetland or buffer zone which is not exempt or considered an "allowed use" under the Vermont Wetland Rules requires a permit.

DEC Vermont Geologic Survey

The Vermont Geological Survey, also known as the Division of Geology and Mineral Resources in the Department of Environmental Conservation, conducts research and mapping relating to the geology, resources and topography of the State. Accessible geoscience data, maps and publications provide a foundation for understanding and stewardship of natural resources. The Survey also provides information to the public, government, industry, and other organizations who request assistance; reviews projects as they relate to Criteria 9D and 9E of Act 250; and maintains and publishes Vermont geological information.

DEC Drinking Water and Groundwater Protection Division

Indirect Discharge Permits

A. Land-based sewage treatment and disposal systems greater than 6,499 gallons per day, including septic tanks and leachfields and also treatment plants and spray disposal systems, all of which use soil as part of the waste treatment process. Following primary and/or secondary treatment, the soil provides final effluent renovation and polishing before it reaches groundwater and, eventually, surface water. This is in contrast to direct discharge systems, which may discharge through a pipe directly to surface waters.

B. Regional Office Permits -This section issues water supply and subsurface wastewater disposal permits required for all buildings other than single family homes and all permits for subdivisions, sewer line extensions, mobile home parks and campgrounds which have flows less than 6,500 gallons per day. If the subdivision involves 10 or more lots, Act 250 may take jurisdiction. Engineers in five regional offices examine applications and approve permits including:

- Discharge of Sewage General Permit for Septic Systems

- Innovative and Alternative Systems

  Innovative/Alternative systems and products may be authorized by the Secretary for General Use (§ 1-1001), Pilot Projects (§ 1-1002) or Experimental Designs (§ 1-1003) under the Wastewater System and Potable Water Supply Rules, Effective September 29, 2007 (Rules). The application process for approval of Innovative/Alternative systems and products is described in § 1-1004 of the Rules.

Underground Injection Control (UIC)

This program within DEC regulates all non-sanitary sewage discharges to the groundwater. It is a federally delegated program. If the discharge receives a permit from another DEC program, the UIC permit is not required.

Groundwater Protection

The Groundwater Protection Rule and Strategy is the groundwater management and protection strategy for the State of Vermont. The Rule outlines the principles, directives and goals relating to groundwater protection. The Rule also contains groundwater quality enforcement standards and outlines the four classes of groundwater. The Groundwater Coordinating Committee, an interagency committee, oversees the groundwater reclassification efforts and provides a forum for interagency coordination on groundwater issues. The DEC Water Supply Division provides administrative and technical support to the Committee. The program reviews weekly Act 250 applications for potential water supply and groundwater impacts. The Water Supply Division also serves as a clearinghouse on groundwater protection information. Through their regulatory and outreach programs, other divisions also protect groundwater and provide information on groundwater protection issues.

Public Water Supply

The DEC Water Supply Division is responsible for the regulation of all public water systems in the state of Vermont. A public water system has fifteen connections or serves an average of twenty-five people at least sixty days a year. Examples of public water systems include municipalities, mobile home parks, schools, restaurants, motels. The major program functions involve permitting construction and operation, approving new sources of drinking water, review of monitoring data, technical and financial assistance, enforcement, source water protection, operator certification, enforcement, and inspections.

DEC Waste Management and Prevention Division

Residual Wastes Program

Permits are required for treatment, storage, disposal of septage and wastewater sludge and for the operation or construction of such facilities.

There are several regulatory requirements for the land application of sludge (biosolids) and septage that assist in protecting surface waters and groundwater, such as required set backs and separation distances, maximum allowed slope of site, nutrient management for site, among others. In 1998, the Solid Waste Management Rules were revised to include, along with other items, the prohibition of land application of solid waste in the area of the 100-year floodway as another measure to assist in protecting surface water quality.

Sites Management Program

The Sites Management Section (SMS) provides State oversight for the investigation and cleanup of properties where a release of a hazardous material has contaminated the environment, including soils, groundwater, surface water, and indoor air.

DEC Facilities Engineering Division

The Facilities Engineering Division administers state and federal pollution control and drinking water funding programs, assists municipalities through the planning and construction of pollution control and drinking water projects, provides fund administration for other Department of Environmental Conservation grant and loan programs, and provides project engineering and implementation services to the Agency for a variety of projects, including construction and maintenance of state park facilities, fish culture stations, access areas, and dams. The division also includes the Dam Safety Section, which is responsible for programs related to the safety of dams.

Dam Safety Program

The Dam Safety Section administers the State Dam Safety program, and periodically inspects the 85 state-owned dams found throughout Vermont for their repair/improvement needs. The section operates a permit program for construction and alteration of non-hydroelectric dams (the Public Service Board regulates hydroelectric dams) to serve the public good and provide adequately for the public safety. A permit is required to alter any dam, pond or impoundment not related to generation of electric energy for public use or part of a public utility system which is or will be capable of impounding more than 500,000 cubic feet of water or other liquid, as measured to the top of the dam. Submittal of a completed application form, fee, plans and specifications and design data is required. A public information meeting may be required. The section inspects privately owned dams on a resources-available basis, maintains an inventory of dams, and provides technical assistance to dam owners.

DEC Environmental Assistance Division

Pollution Prevention Program

The focus of this program is to help businesses research and identify opportunities to reduce the amount of waste generated and the amount and toxicity of chemicals used in their operations. Technical assistance may be provided on-site at the facility's request. The program is also responsible for administering Vermont's Pollution Prevention Planning Requirement affecting over 100 businesses that generate hazardous waste and/or use certain listed toxic chemicals. The Program is located in the Environmental Assistance Division and shares a toll-free number with the Small Business Compliance Assistance Program that businesses and others can use to get answers to their environmental questions.

Agricultural Runoff Control Programs

Vermont Agency of Agriculture, Food & Markets

Accepted Agricultural Practices (AAP)

Base level of management required for all farms in Vermont. Easy to implement, low-cost solutions for addressing water resource concerns. The AAPs were designed to reduce non-point pollutant discharges through implementation of improved farming techniques rather than investments in structures and equipment. State law requires that these practices must be technically feasible as well as cost effective for farmers to implement without governmental financial assistance.
www.vermontagriculture.com/ARMES/awq/AAP.html

Alternative Manure Management Program (AMM)

Provides funding to farmers interested in implementing new technologies dedicated to enhancing water quality and improving waste management. Projects funded through this program have included solid separation, nutrient removal, and waste treatment systems. Maximum cost share is limited to $100,000 through the AMM program. Total VAAFM payment is limited to 35% if the project is coupled with federal cost share.
www.vermontagriculture.com/documents/BMPApplication.pdf

Best Management Practices Program (BMP)

Provides cost share payments for installation of conservation practices to address water resource concerns. While farmers may realize an economic benefit from BMPs, it is unlikely that they will be affordable without governmental cost sharing. Commonly funded production area practices include waste storage facilities, silage leachate systems, milkhouse waste systems, and barnyard runoff collection. Production area practices are eligible for up to 80% cost share. Field practices, such as animal trails and walkways, are eligible for 50% cost share. If coupled with federal cost share, Agency cost share is limited to 35%. The yearly maximum payment for a single practice is $50,000 and $75,000 for two or more practices.
www.vermontagriculture.com/documents/BMPApplication.pdf

Conservation Reserve Enhancement Program (CREP)

In partnership with the USDA, encourages the installation of conservation buffers along waterways by providing land owners with a yearly rental payment and by covering the cost of planting the buffer. Additionally, CREP covers the cost of installing fencing and livestock watering systems where animals on pasture are excluded from waterways. Contracts are either 15 or 30 years in length and payment is dependent upon past land use and whether the buffer is comprised of either trees and/or grasses. Minimum buffer widths are 25 feet for grass and 35 feet for tree buffers. Buffers cannot be harvested under this program. Payments can cover up to 100% of practice costs (for fencing, watering systems and plantings) and include a signup incentive of $2,005/acre and annual rental payments of $266/acre/year.
www.vermontagriculture.com/ARMES/CREPwebsite/Home/Home.htm

Farm Agronomic Practices Program (FAP)

Provides farms with state financial assistance for implementation of soil-based practices that improve soil quality, increase crop production, and reduce erosion and agricultural waste discharges at up to $5,000 per farm. FAPP will provide funding incentive for NMP update, implementation, and maintenance with the aim of improving outreach education on agricultural water quality impacts and regulations. Eligible practices are: Cover Cropping ($30/acre); Nurse Crops ($25/acre); Strip Cropping ($25/acre); Conservation Crop Rotation ($25/acre); Alternative Manure Incorporation ($25/acre); Cross-Slope Tillage ($10/acre); Conservation Tillage ($12/acre); and Educational and Instructional Activities (up to $1,000).
www.vermontagriculture.com/ARMES/awq/FAP.html

Large Farm Operations Program (LFO)

An individual permitting process for farms with more than 700 mature dairy cows, 1,000 beef cattle or cow/calf pairs, 1,000 youngstock or heifers, 500 horses, 55,000 turkeys, or 82,000 laying hens. Like the MFO program, the goal of this program is to provide large farms with a Vermont-based alternative to federal permitting while assisting those farms with maintaining economic

viability. A LFO permit prohibits the discharge of wastes from a farm's production area to waters of the state and requires the farm to land apply manure, compost, and other wastes according to a nutrient management plan. Unlike the MFO Program, LFO permits are individual to each farm and also regulate odor, noise, traffic, insects, flies, and other pests.
www.vermontagriculture.com/ARMES/awq/LFO.html

Medium Farm Operations (MFO)

All dairies with 200-699 mature animals, whether milking or dry, qualify as a MFO. Other common MFOs include beef operations (300-999 cattle or cow/calf pairs), horse operations (150-499 horses), turkey operations (16,500-54,999 turkeys), and egg facilities (25,000-81,999 laying hens without liquid manure handling system). The MFO program provides a cost-effective alternative to a potentially burdensome federal permitting program by allowing medium sized farms to seek coverage under a single Vermont state General Permit. The General Permit prohibits discharges of wastes from a farm's production area to waters of the state and requires manure, compost, and other wastes to be land applied according to a nutrient management plan.
www.vermontagriculture.com/ARMES/awq/MFO.html

Nutrient Management Incentive Grant Program (NMPIG)

Provides for development of a nutrient management plan (NMP) and three additional years of updates. The initial payment to develop NMP is $9 per acre, $15 per soil test, and $35 per waste storage facility test. Up to $5,000 is available for plan updates for following three years (not to exceed $14,000 total for NMPIG). Plans must meet state requirements for nutrient management, as explained in the General Permit for Medium Farm Operations, before receiving payment. Farms with NMP's that have completed the NMPIG or farms that developed their plans through alternate means can apply for annual update payments of $3 per acre (up to $1000). Funding is also available for Pre-sidedress Nitrate Tests ($8 per test).
www.vermontagriculture.com/ARMES/awq/NMPIG.html

Vermont Agricultural Buffer Program (VABP)

The program offers a 5-year maximum rental contract for the installation of conservation grassed buffers on cropland. Unlike the CREP program, VABP consists of planting harvestable grassed buffers. Areas in crop fields that are prone to erosion caused by flood events, which can be classified as flood chutes, are also eligible under this program to be planted into grass and harvested. Additional program details include that, No manure can be spread in the buffer area; Fertilizer can be used with soil test and nutrient recommendation; Payment of $123/ac to cover the establishment costs of new filter strips in addition to the annual incentive payments of $90 to $150 per acre per year; Forage in buffer can be harvested between June 1st and September 1st only; and Most buffers are 25 feet wide unless a water quality concern deems the need for a larger buffer
www.vermontagriculture.com/documents/VABP.pdf

Local Government Programs

Agricultural Resource Specialist Program (ARS)

Offered by the Vermont Association of Conservation Districts and supported by funding from the VAFFM. Three main services are offered to farmers: AAPA, AEM and FWWT:

> *Accepted Agricultural Practices Assistance (AAPA)* offers farmers free technical assistance and information to help them meet the requirements of VAAFM's AAP regulations. The ARS works with farmers on developing strategies specific to the farm, accommodating seasonal changes and soil characteristics. If strategies involve implementation costs, the ARS provides information and referrals for State and Federal cost-share programs.
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> *Agricultural Environmental Management (AEM)* is a statewide, voluntary program that assists farmers in environmental stewardship, protecting the quality of the farm natural resources as the foundation of the farmer's long-term economic viability. Assessments cover farmstead water supplies, nutrient management, pesticide use, and many other farm practices. Suggested actions are linked with technical resources for design and implementation and financial resources for cost-share opportunities.
>
> *Farm Well Water Testing (FWWT)* is a free drinking water protection service for farms. Water testing for farm wells provides information on bacteria, nitrates and common pesticide levels. If a water quality problem is found, ARS staff will assist the landowner in trying to determine the cause of the contamination and to find the best solution.

Land Treatment Planners (LTP)

Assist farmers in developing land treatment plans, which provide detailed information on farm soil and water resources, recommendations for continued stewardship and compliance with state and federal regulations. Land treatment planning is the foundation of a nutrient management plan (NMP). Although LTP is not itself required for Vermont farms, it provides the core data needed to develop a NMP. A NMP, however, is required for all Medium and Large Farm Operations and is encouraged for Small Farm Operations (SFOs). This free program is provided to farmers through a partnership between the USDA NRCS, Conservation Districts, and VAAFM.
www.vermontagriculture.com/ARMES/awq/LTP.html

Federal Programs

Agricultural Management Assistance (AMA) program

Assists agricultural producers to manage risk and voluntarily address issues such as water management, water quality, and erosion control by incorporating conservation practices into their farming operations. Producers may construct or improve water management or irrigation structures; plant trees for windbreaks or to improve water quality; and mitigate risk through production diversification or resource conservation practices, including soil erosion control, integrated pest management, or transition to organic farming. An AMA plan of operations, developed with NRCS, is required. Participants are expected to maintain cost-shared practices for the life of the practice. Contracts are for 1-10 years. Applicants must own or control the land and comply with adjusted gross income limitation provisions. Eligible land includes cropland, rangeland, grassland, pastureland, non-industrial forestland, and other private land that produces crops or livestock where risk may be mitigated through operation diversification or change in resource conservation practices. Total payments shall not exceed $50,000 per year.
www.nrcs.usda.gov/programs/ama

Conservation Reserve Program (CRP)

A voluntary program for agricultural landowners. Through CRP, you can receive annual rental payments and cost-share assistance to establish long-term, resource conserving covers on eligible farmland. Participants enroll in CRP contracts for 10 to 15 years. CRP protects millions of acres of American topsoil from erosion and is designed to safeguard the Nation's natural resources. By reducing water runoff and sedimentation, CRP protects groundwater and helps improve the condition of lakes, rivers, ponds, and streams. Acreage enrolled in the CRP is planted to resource-conserving vegetative covers, making the program a major contributor to increased wildlife populations in many parts of the country. Eligible producers must have owned or operated the land for at least 12 months prior. Eligible land must be either cropland that is planted to an agricultural commodity 4 of the previous 6 crop years or pastureland that is suitable for use as a riparian buffer or for similar water quality purposes. Payments include; Annual Rental Payments for establishing long-term, resource-conserving covers; Maintenance Incentive Payments for certain practices; and Cost-share Assistance at up to 50% of the participants' costs in establishing approved practices.
www.fsa.usda.gov/FSA/webapp?area=home&subject=copr&topic=crp

Conservation Stewardship Program (CSP)

A voluntary program that encourages agricultural and forestry producers to address resource concerns by (1) undertaking additional conservation activities and (2) improving and maintaining existing conservation systems. CSP provides financial and technical assistance to help land stewards conserve and enhance soil, water, air, and related natural resources on their land. CSP is available to all producers, regardless of operation size or crops produced. Eligible lands include cropland, grassland, prairie land, improved pastureland, rangeland, nonindustrial private forest land, and agricultural land under the jurisdiction of an Indian tribe. CSP pays participants for conservation performance—the higher the performance, the higher the payment. An annual payment is available for installing new conservation activities and maintaining existing practices. A supplemental payment is available to participants who also adopt a resource conserving crop rotation. NRCS makes payments for activities installed and maintained in the previous year. Contracts may not exceed $40,000 in any year or $200,000 in any five-years.
www.nrcs.usda.gov/programs/new_csp/csp.html

Environmental Quality Incentives Program (EQIP)

A voluntary conservation program that provides financial and technical assistance to farmers and ranchers who face threats to soil, water, air, and related natural resources on their land. NRCS develops contracts with agricultural producers to implement conservation practices to address environmental natural resource problems. Payments are made to producers once conservation practices are completed according to NRCS requirements. Persons engaged in livestock or agricultural production and owners of non-industrial private forestland are eligible for the program. Eligible land includes cropland, rangeland, pastureland, private non-industrial forestland, and other farm or ranch lands. An EQIP plan of operations, developed with NRCS, is required. NRCS provides conservation practice payments to landowners under these contracts that can be up to 10 years in duration. Program payments are limited to a person or entity to $300,000 during any 6-year period.
www.nrcs.usda.gov/programs/eqip/

Farm and Ranch Lands Protection Program (FRPP)

A voluntary program that helps farmers and ranchers keep their land in agriculture. The program provides matching funds to State, Tribal, or local governments and non-governmental organizations with existing farm and ranch land protection programs to purchase conservation easements. From 1996 through 2007, FRPP has enrolled over 533,000 acres in cooperation with more than 400 entities in 49 States. The program allows for long term agreements with cooperating entities. Such agreements may be 3-5 years in duration. The share of the easement cost must not exceed 50% of the appraised fair market value of the conservation easement. As part of its share of the cost of purchasing a conservation easement, a state, tribal, or local government or nongovernmental organization may include a charitable donation by the landowner of up to 25% of the appraised fair market value of the conservation easement. As a minimum, a cooperating entity must provide, in cash, 25% of the appraised fair market value or 50% of the purchase price of the conservation easement.
www.nrcs.usda.gov/programs/frpp/

Grassland Reserve Program (GRP)

A voluntary program for landowners and operators to protect grazing uses and related conservation values by conserving grassland, including rangeland, pastureland, shrubland, and certain other lands. The program emphasizes support for working grazing operations; enhancement of plant and animal biodiversity; and protection of grassland and land containing shrubs and forbs under threat of conversion. Eligible land includes privately owned or Tribal grasslands; land that contains forbs for which grazing is the predominant use; or land that is located in an area that historically has been dominated by grassland, forbs, or shrubland that has the potential to serve as wildlife habitat of significant ecological value. GRP rental contracts and easements prohibit crop production other than hay. A grazing management plan is required. GRP enrollment options include: Rental Contracts of 10-20 years, Permanent Easements or Restoration Agreements. USDA can also enter into cooperative agreements with entities to enable them to acquire easements.
www.nrcs.usda.gov/programs/GRP/

Partners for Fish and Wildlife Habitat Restoration Program (PFW)

Established in 1987 for on-the-ground wetland restoration projects on private lands. At the heart of the Service's mission are the conservation and management of the Federal Trust Species: migratory birds; threatened and endangered species; inter-jurisdictional fish; certain marine mammals; and species of international concern. The Partners Program provides technical and financial assistance to private landowners and Tribes who are willing to work with us and other partners on a voluntary basis to help meet the habitat needs of our Federal Trust Species. The Partners Program can assist with projects in all habitat types which conserve or restore native vegetation, hydrology, and soils associated with imperiled ecosystems such as longleaf pine, bottomland hardwoods, tropical forests, native prairies, marshes, rivers and streams, or otherwise provide an important habitat requisite for a rare, declining or protected species. Locally-based field biologists work one-on-one with private landowners and other partners to plan, implement, and monitor their projects. Partners Program field staff help landowners find other sources of funding and help them through the permitting process, as necessary.
www.fws.gov/partners/

Regional Conservation Partnership Program

The Regional Conservation Partnership Program (RCPP) promotes coordination between NRCS and its partners to deliver conservation assistance to producers and landowners. NRCS provides assistance to producers through partnership agreements and through program contracts or easement agreements.

RCPP combines the authorities of four former conservation programs – the Agricultural Water Enhancement Program, the Chesapeake Bay Watershed Program, the Cooperative Conservation Partnership Initiative and the Great Lakes Basin Program. Assistance is delivered in accordance with the rules of EQIP, CSP, ACEP and HFRP; and in certain areas the Watershed Operations and Flood Prevention Program. There are three active RCPP efforts in Vermont, assisting landowners in the Lake Champlain, Memphremagog, and Connecticut River Watersheds. https://www.nrcs.usda.gov/wps/portal/nrcs/main/vt/programs/farmbill/rcpp/

Rural Energy for America Program (REAP) Grants and Loan Guarantee funding

Available from USDA Rural Development's REAP to assist agricultural producers and rural small businesses with costs for the purchase and installation of renewable energy systems and energy efficiency improvements. Solar, wind, biomass, geothermal, and efficiency projects are eligible. The grants are awarded on a competitive basis and can be up to 25% of total eligible project costs. Grants are limited to $500,000 for renewable energy systems and $250,000 for energy efficiency improvements. Grant requests as low as $2,500 for renewable energy systems and $1,500 for energy efficiency improvements will be considered. https://www.rd.usda.gov/programs-services/rural-energy-america-program-renewable-energy-systems-energy-efficiency

Additional Programs

Farmland Access Program (FAP)

Provides farmers with opportunities to purchase or lease affordable farmland so that they can start up or expand agricultural businesses. Supporting local communities, local food production, and the long-term productive use of farmland are all objectives of this program. Gaining access to high quality, affordable farmland is one of the most difficult obstacles for beginning farmers and expanding agricultural operations. The challenge is especially acute for enterprises that depend on being near Vermont's economic growth centers—areas where land values remain strong even in the current economic climate.

Minimum qualifications require candidates to have 3 years of commercial farming experience, strong agricultural references, plans to develop an agricultural enterprise that would gross $100,000 per year within 5 years of start up, and sufficient financial resources (or ability to be financed) for start-up expenses. Our focus is on farms producing food and fiber that would use at least 25 acres of land.

www.vlt.org/initiatives

Farmland Preservation Program (FPP)

Focused on retaining the state's quality agricultural land base in strong farming regions of the state. The purchase of conservation easements on farmland preserves Vermont's working

landscape--the open farm fields, woodlands and farmsteads that comprise the third largest sector in the state's economy and draw visitors that make tourism the largest sector. Because of VHCB's investment in conservation easements, some of Vermont's most productive farmland will remain undeveloped and the best soils will remain available for farming in the future. Selling conservation easements enables a landowner to keep land in agricultural use and be compensated for potential development value of the land, recognizing the asset value of the land. The landowner retains title and agrees to terms of a conservation easement limiting future ability to subdivide and develop the land.
www.vhcb.org/conservation.html

Technical Assistance Programs (TAP) through Northeast Organic Farming Association

Free to farmers - made possible by grants from the VHCB's VFP and VAAFM. Vegetable and Fruit Technical Assistance provides technical assistance to organic farmers in Vermont seeking production and financial assistance on small fruit and vegetable operations. Dairy and Livestock Technical Assistance provides Information, Services and Support for Vermont's Organic Dairy & Livestock Community.
www.nofavt.org/programs

Pesticide Management Programs

The Agency of Agriculture, Food and Markets Pesticide Management Section administers Vermont's pesticide regulations, manages pesticide permits, provides and approves training courses in the proper handling, storage and use of pesticides. The section also tests and certifies pesticide applicators, enforces state and federal laws on the sale and use of pesticides, investigates pesticide spills, incidents and consumer complaints.
http://agriculture.vermont.gov/pesticide_regulation

Silvicultural (logging) runoff control program

Agency of Natural Resources, Department of Forests, Parks and Recreation

Vermont Acceptable Management Practices (AMP)

Acceptable Management Practices (AMPs) for Maintaining Water Quality on Logging Jobs in Vermont were developed and adopted as rules for Vermont's water quality statutes and became effective in 1987 and were subsequently revised effective October 22, 2016. AMPs are intended and designed to prevent sediment, petroleum products, and woody debris (logging slash) from entering Vermont's waters.

Vermont Heavy Cutting Law (Act 15)

The Vermont Legislature passed the so-called heavy cutting law in 1998. The purpose of the law is to monitor and regulate the amount and approach to heavy cutting being done in Vermont. Heavy cutting is defined as cutting below the "C" line in excess of forty acres or 80 acres in a two-mile radius. The "C" line is a silvicultural stocking level provided for in US Forest Service guidelines for managing various forest types. This level establishes the minimum stocking for

stands of trees that would allow stands to return to a fully stocked condition. The AMPs (see above) are among the requirements of this law.
http://fpr.vermont.gov/forest/vermonts_forests/heavycut

Portable Skidder Bridge Initiative

The goals of this initiative are three-fold.
(1) Inform loggers, landowners and foresters about the benefits of using portable skidder bridges through workshops and presentations, field demonstrations, informational brochures, static displays, video and web production, and news articles.

(2) Provide portable skidder bridges to loggers for purchase, loan and rental using a variety of means and partners.

(3) Provide assistance and support for existing and start-up businesses that would fabricate and sell portable skidder bridges.

Complete information about this expanding program is available at:
http://fpr.vermont.gov/forest/your_woods/harvesting_your_woodlots/skidder_bridge

Federal Programs

Federal Wetlands Protection

A U.S. Army Corps of Engineers permit is required for all work beyond ordinary highwater in or above navigable waters of the United States under Section 10 of the Rivers and Harbors Act of 1899 (33 U.S.C. 403). In New England, for the purpose of Section 10, navigable waters of the United States are those subject to the ebb and flow of the tide and a few major waterways used to transport interstate or foreign commerce. Permits are required under Section 404 of the Clean Water Act for those activities involving the discharge of dredged or fill material in all waters of the United States, including not only navigable waters of the United States but also inland rivers, lakes, streams and wetlands. In inland waters, Corps jurisdiction extends landward to the ordinary high water mark or the landward limit of any wetlands. The term "discharge" in this context may include the re-depositing of wetlands soils such as occurs during mechanized land clearing activities, including grubbing, grading and excavation.

The term "wetlands," used above, is defined by Federal regulations to mean "...those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions..." (33 C.F.R. Part 328.3 (b), as published in the November 13, 1986 Federal Register). Wetlands generally include swamps, marshes, bogs and similar areas. The term "fill material," used above, is defined by Federal regulations to mean "...any material used for the primary purpose of replacing an aquatic area with dry land or of changing the bottom elevation of a waterbody. The term does not include any pollutant discharged into the water primarily to dispose of waste..." (33 C.F.R. Part 323.2 (b), as published in the November 13, 1986 Federal Register).

Land Use Programs

Agency of Natural Resources

Act 250

Act 250 provides a public, quasi-judicial process for reviewing and managing the environmental, social and fiscal consequences of major subdivisions and development in Vermont through the issuance of land use permits. Activities include review of land use permit applications for conformance with the Act's ten environmental criteria, issuance of opinions concerning the applicability of Act 250 to developments and subdivisions, monitoring for compliance with the Act and with land use permit conditions, and public education.

In an Act 250 application, applicants need to supply sufficient information for the District Commission to make findings on the ten environmental criteria. In so doing, certifications and/or approvals from other agencies and departments, utilities, regional planning commissions and local government may be necessary.

With regard to water pollution, Criterion 1 states that the project will not result in undue water or air pollution. This criterion deals with water and air pollution potential generally and such specific matters relating to water pollution as: (A) Headwaters; (B) Waste disposal; (C) Water Conservation; (D) Floodways; (E) Streams; (F) Shorelines; and (G) Wetlands.

Towns
with assistance from Regional Planning Commissions
and the Vermont League of Cities and Towns

Municipal Plans

Municipal plans adopted under 24 VSA Chapter 117 provide the legal basis for local land use regulation for water quality protection or other purposes. Municipal plans vary widely in level and scope of commitment to water quality protection and sustainability, and may not describe the means to attain water quality objectives.

Local Zoning

Through local zoning, municipalities can limit the impact of land development on water quality by concentrating development into designated areas. For example, local governments have clear legal authority under 24 VSA Chapter 117 to regulate riparian buffers. The Vermont League of Cities and Towns (VLCT) has produced a model riparian buffer ordinance for towns.

Other model ordinances are under development or available to municipal governments to support water quality protection and restoration including National Flood Insurance Program (NFIP) and Enhanced NFIP ordinances, Fluvial Erosion Hazard Overlay District Ordinance, Stormwater ordinance and Conservation subdivision ordinances.

The VLCT Water Quality Specialist, in conjunction with Vermont DEC, has reviewed the most current town zoning or other applicable regulations. VLCT is available to help towns navigate the process of including ordinances/bylaws related to stormwater management, riparian corridor protection and other local water quality protection measures.

Flood Hazard Area Regulations

The majority of municipalities are enrolled in the National Flood Insurance Program (NFIP) and have adopted regulations restricting development in mapped floodplains. However, local flood hazard area regulations are designed to prevent the loss of property and life in the event of a flood. In this regard, local flood hazard area regulations contribute little to the protection and restoration of water quality.

Fluvial Erosion Hazard mapping

Fluvial erosion hazard mapping consists of a data layer generated from fluvial geomorphic assessments and provides an overlay district that defines a corridor within which a stream can recover or maintain its equilibrium condition thus minimizing the production of sediment and nutrients and maximizing sediment and nutrient attenuation.

Stormwater Utilities

Communities across the nation are increasingly examining the option of stormwater utilities to fund stormwater management. A stormwater utility charges fees to property owners who use the local stormwater management system. The revenue can be used to maintain and upgrade existing storm drain systems, develop drainage plans, construct flood control measures, and cover administrative costs. Stormwater utilities are seen as a fair way of collecting funds for stormwater management. The properties that contribute stormwater runoff and pollutant loads and, therefore, create the need for stormwater management, pay for the program. Stormwater utilities provide a predictable and dependable amount of revenue that is dedicated to the implementation of stormwater management. Over 400 communities in the United States have created stormwater utilities.

Act 109 (Vermont Legislature, spring 2002) gave Vermont municipalities the authority to create stormwater utilities. So far, only the City of South Burlington has created a stormwater utility. Each single family home pays an additional $4.50 a month which goes to providing funds for the identification and management of stormwater problems, projects and infrastructure upgrades. Additionally, subdivisions with stormwater permits can apply to have their permit and systems taken over by the City of South Burlington. Overall, it is more efficient to have one entity managing the upkeep and maintenance of the stormwater management systems; rather than multiple groups having to contract out for the maintenance of their systems, the City can provide those services with its own equipment and technical resources. The City of Winooski reports on its website that it, too, is considering the formation of such a utility.

Conservation Plans

Local conservation plans tend to address water quality objectives in a general sense, recommending vegetated riparian buffers and wildlife corridors.

The Community Wildlife Program supported by the Department of Fish and Wildlife provides assistance and resources for professional and lay planners in Vermont. We help regional and municipal planning commissions and non-governmental organizations in their efforts to protect wildlife habitat and significant natural communities by providing them with the most up-to-date information on conservation science and help them with the implementation of their conservation projects.

We help towns identify their important wildlife habitat by providing data for GIS review as well as instruction in how to do field work and how to use these information sources. We help towns translate conservation goals that the community has agreed on into language suitable for the Town Plan and further assist with turning that language into appropriate zoning and subdivision regulations that bring these conservation goals into action. We help towns and organizations connect with other assistance organizations and finding funding in moving their goals forward

Road Maintenance Programs

Vermont Agency of Transportation (VTRANS)

Handbook for Local Officials

This guide is produced by VTrans and is designed to assist local officials in the State of Vermont. Much of this handbook contains practical, day-to-day information concerning the contents of Title 19. Orange Book Local Officials Handbook

Better Roads Program

The Vermont Better Roads Program provides technical support and grant funding to municipalities to promote the use of erosion control and maintenance techniques that save money while protecting and enhancing water quality around the State.

Stormwater Compliance

The Stormwater Compliance Management Program includes regulatory oversight and technical assistance associated with stormwater permitting and management on VTrans facilities, striving to ensure proper design, construction, operation, maintenance, and regulatory compliance with Federal and State Water Quality Standards and Stormwater Management Rules, Regulations and Laws.

FUNDING OPPORTUNITIES

Funding sources are continually changing. The table in this section represents a compilation of known funding sources as of December, 2016. Please notify the Watershed Management Division of other relevant surface water improvement funding sources.

Category (State, Fed., Foundation)	Grant Name	Funding Type	Contact
WSMD	319 Nonpoint Source Grant	Restore water quality in waters threatened by non-point sources	emily.bird@vermont.gov
WSMD	Ecosystem Restoration Program Grant	Environmental remediation, protection and runoff mitigations, P loading, Ag land enhancement, nonpoint source	emily.bird@vermont.gov
F+W	VT Watershed /License Plate	Enhance/restore water resources, restore or protect fish and wildlife habitat, education, cultural resources, reducing P loading	emily.bird@vermont.gov
WSMD	Aquatic Nuisance Control Grant-in-aid control	Available for municipalities; first priority to new infestations, second to controlling infestations or prevention, third to ongoing maintenance. (Ann Bove)	Ann.bove@vermont.gov
FED	The Vermont Planning Advance Program	For planning community water resources; sewage, drinking water, feasibility studies for the aforementioned works. *Funds currently available.*	Bryan.Redmond@vermont.gov
FED	CWSRF	For WWTF construction, sewer works, stormwater mgmt. facilities. Available to municipalities Currently, funds available for planning and final design applications are accepted on a rolling basis. Funds will be available for construction projects later this year but all new projects will need to go through planning and design prior to approval. Currently there are some subsidy opportunities of up to 50% on planning and final design activities. There is also a call out for the next month for asset management grants.	terisa.thomas@vermont.gov 802-828-1550

Category (State, Fed., Foundation)	Grant Name	Funding Type	Contact
FED	Unsafe Dam State Revolving Fund	Available for dam removal, either 100% loan or 75% loan and 25% grant funding (if breaching or removing—maintenance or reconstruction are eligible for loan only). Generally $50,000 cap, may be expanded.	Stephen.Bushman@vermont.gov
FED	DWSRF	Public and private drinking water utilities are eligible for this funding. Can be used for easements that help with drinking water quality.	Ashley.Lucht@vermont.gov
WSMD	Regional Conservation Partnership Program (NRCS)	Projects related to soil and water quality, flood prevention, water resource conservation, reducing runoff and irrigation improvement. Available to state, farmers' cooperatives, municipal water orgs, orgs with a history of working with farms, and higher education organizations. Pre-proposals already submitted for this calendar year.	RCPP@wdc.usda.gov
F+W	Clean Vessel Act Grant	Grants for public or private marinas or a state, county/municipal org for installing or upgrading pumpout stations or dump stations, or projects related to boating septic waste. Due August 15, grant covers up to 75 percent of the project.	(802) 828-1000 Mike Wichrowski
AAFM	BMP financial assistance	Financial assistance for up to 90 percent cost share on NRCS approved practices on production areas, up to 50 percent on non-production areas. Can be coupled with federal NRCS funds. Available to growers in the state of Vermont/livestock producers or private land holders	Jeff Cook Jeff.Cook@vermont.gov 802-828-3474
AAFM	CREP Grants	Available to landowners for land in ag use, that is adjascent to a perennial stream or waterway. Cost share may cover 90-100 percent of funding needed for swales, vegetated buffersfil;ter strip, livestock fencing etc	
AAFM	Various Farm Agronomic Practices	Funds forractices that restore soil quality and enhance water quality by reducing runoff. Includes grants for educational activities and cover cropping (paid by acre). Usually due one month prior to implementation, available to growers and livestock owners.	Jeff Cook Jeff.Cook@vermont.gov 802-828-3474

Category (State, Fed., Foundation)	Grant Name	Funding Type	Contact
NRCS	EQIP	Provides assistance in the form of reimbursement up to $ 300,000 for projects that conserve agricultural or forested land, or other wildlife habitat. Project can only be started AFTER contract with NRCS signed for funding. Priority given to historically underserved customers and projects which address significant resource concerns	http://www.nrcs.usda.gov/getstarted Contact local NRCS field office
ACCD	Municipal planning grants	Municipalities eligible, priority given to those in historic settlement pattern—villages and town centers. Joint applications may be accepted. Funding provided for meetings, hearings, workshops, conservation work, legal fees, easements, administrative materials, research, inventories and mapping, and payment for support staff.	Annina Seiler 802-828-1948 annina.seiler@vermont.gov
WSMD	Flood Mitigation Assistance Grant Program	State government applies for FEMA funding, which local governments may then access by working as "subapplicants". Project must support the flood hazard portion of State, tribal, or local mitigation plans to meet the requirements outlined in 44 CFR Part 201 Mitigation Planning. Funds are only available to support communities participating in the National Flood Insurance Program (NFIP).	Ned SwanBerg ned.swanberg@vermont.gov 802.490.6160.
DEM	Hazard mitigation Grants	Provides funding for land acquisition, infrastructure projects, flood planning. State, local government and non-profits eligible. Communities must have a FEMA approved and adopted local mitigation plan to be eligible. Funds not currently available but possibly in future.	Lauren Oates (802) 241-5363 lauren.oates@vermont.gov
LCBP	Local Implementation Grants	Grants for Lake Champlain basin bioremediation and pollution control/ environmental improvement. State, interstate, and regional water pollution control agencies, and public or nonprofit agencies, institutions, and organizations are eligible to receive grants from EPA through this program.	Jeanne Voorhees voorhees.jeanne@epa.gov

Category (State, Fed., Foundation)	Grant Name	Funding Type	Contact
AAFM	Water Quality Grant	For Water Quality projects initiated by VAAFM. Can be applied for through a RFP opportunity.	AGR.waterquality@vermont.gov
Foundation	Vermont Community Foundation	"Small and Inspiring" grants: connect people to each other through volunteer work or community-building efforts connect people to the environment around them in new ways	Kim Haigis, khaigis@vermontcf.org
Foundation	Vermont Community Foundation	"Lamoille County and Beyond: Green Mountain Fund" serving children, elderly and family services, education, environment, sustainability, and the arts in Lamoille County and other parts of the Northeast Kingdom.	Kim Haigis, khaigis@vermontcf.org
Foundation	Vermont Community Foundation	"Upper CT River Mitigation and Enhancement Fund" river restoration work in the upper Connecticut River Watershed; wetland restoration, protection, and enhancement; and shoreline protection. Region: Connecticut River watershed upstream of the confluence of the White River and the Connecticut River at White River Junction, Vt. and West Lebanon, N.H.	Kim Haigis, khaigis@vermontcf.org
Foundation	Vermont Community Foundation	Lake Champlain Tributaries and Restoration Fund: protection, restoration, and enhancement of Lake Champlain's ecosystem.	Kim Haigis, khaigis@vermontcf.org
Foundation	Vermont Community Foundation	Special and Urgent Needs- helps Vermont nonprofits with unexpected expenses that impact their ability to meet their mission. A SUN grant can help an organization manage an unbudgeted, unforeseen, and time-sensitive emergency or take advantage of an unanticipated opportunity that will enhance its work.	Kim Haigis, khaigis@vermontcf.org
Foundation	Vermont Community Foundation	"Kelsey Trust" Lake Champlain and Tributaries protection. We are particularly interested in programs aimed at protecting Lake Champlain and its tributaries, the Green Mountains, and the Adirondacks. LOI needed	Kim Haigis, khaigis@vermontcf.org

Category (State, Fed., Foundation)	Grant Name	Funding Type	Contact
VTRANS	Transportation Alternatives	F. Any environmental mitigation activity, including pollution prevention and pollution abatement activities and mitigation to-- (i) address stormwater management, control, and water pollution prevention or abatement related to highway construction or due to highway runoff, including activities described in sections 133(b)(11), 328(a), and 329; or (ii) reduce vehicle-caused wildlife mortality or to restore and maintain connectivity among terrestrial or aquatic habitats. (iii) Construction of salt sheds is eligible under the environmental mitigation category. Eligibility for salt sheds will be considered on a case by case basis based on proximity of the existing storage location to a major water body (generally within 50 ft.). We recommend reviewing eligibility with VTrans prior to application submittal.	Scott Robertson, P.E. Telephone: (802) 828-5799 Fax: (802) 828-5712 E-mail address: scott.robertson@vermont.gov
VTRANS	Better Back Roads	funding to support municipal road projects that improve water quality and result in maintenance cost savings. The grant funds are provided by VTrans and the Vermont Agency of Natural Resources. The Vermont Better Roads Program's goal is to promote the use of erosion control and maintenance techniques that save money while protecting and enhancing Vermont's lakes and streams. Funds, subject to availability, will be distributed as grants to municipalities to address town erosion problems.	Alan.may@vermont.gov

Category (State, Fed., Foundation)	Grant Name	Funding Type	Contact
VTRANS	Category (A) planning grants	Road Inventory and Capital Budget Planning (Maximum Grant Amount $8,000) Road erosion reduction requires planning and budgeting to implement road improvements that also result in cost savings. Eligible projects under this category must include: (1) Inventory of roads and/or culverts and identification of road related erosion and/or stormwater problems affecting water quality in a particular watershed or the whole town. (2) Sites identified must then be prioritized by problem area for future repair. (3) The final step is the development of a capital budget plan to correct these problems over a specific period of time.	Alan.may@vermont.gov
VTRANS	Category (D) culvert upgrade grants	Structures or culverts that carry streams or rivers must have accompanying documentation showing consultation with an ANR River Management Engineer and/or Army Corps Engineer indicating use or nonuse of river management standards prior to submittal of application.	Alan.may@vermont.gov
VTRANS	Category B – Road Erosion	Correction of a Road Related Erosion Problem and/or Stormwater Mitigation/Retrofit for both gravel and paved roads	Alan.may@vermont.gov
VTRANS	The Category (C) bank stabilization	Stream and river/road conflicts must have accompanying documentation showing consultation with an ANR River Management Engineer and/or Army Corps Engineer indicating use or non-use of river management standards prior to submittal of applicatio	Alan.may@vermont.gov
Foundation	Joe W. & Dorothy Dorsett Brown Foundatio	Environmental research; housing for the homeless; support for organizations that care for the sick, hungry or helpless; religious and educational institutions; as well as organizations and groups concerned with improving our local communities. Within these areas, the focus is primarily on alleviating human suffering. Secondary consideration includes cultural, spiritual, educational, or scientific initiatives.	bethbuscher@thebrownfoundation.org, 504-834-3433

Category (State, Fed., Foundation)	Grant Name	Funding Type	Contact
Foundation	Weyerhaeuser Giving Fund	The fund helps cultivate growing minds and bodies, promote sustainable communities, and nourish the quality of life in these Weyerhaeuser communities. The Foundation's main funding areas are: affordable housing and shelter, education and youth development, environmental stewardship, human services, civic, and cultural growth.	253-924-3658 anne.leyva@weyerhaeuser.com
Foundation	The Dale & Edna Walsh Foundation	DEW contributes to medical, relief, welfare, education, community service, ministries and environmental programs, and arts organizations. All organizations must submit a letter of inquiry (LOI) to be considered for funding.	775-200-3446 info@dewfoundation.org
Foundation	Toolbox for Education Grants	Lowe's Charitable and Educational Foundation . Giving on a national basis in areas of company operations; giving on a national basis for the Outdoor Classroom Grant Program and Lowe's Toolbox for Education to support parks and playgrounds and organizations involved with K-12 education, environmental beautification, environmental education, home safety, and community development. No support for schools established less than two years ago for Lowe's Toolbox for Education. Pre-schools are not eligible.	1-800-644-3561 ext. 7 info@toolboxforeducation.com
Foundation	Captain Planet Foundation	The foundation supports projects that: 1) Promote understanding of environmental issues; 2) Focus on hands-on involvement; 3) Involve children and young adults 6-18 (elementary through high school); 4) Promote interaction and cooperation within the group; 5) Help young people develop planning and problem solving skills; 6) Include adult supervision; 7) Commit to follow-up communication with the foundation.	404-522-4270 grants@captainplanetfdn.org

Category (State, Fed., Foundation)	Grant Name	Funding Type	Contact
Foundation	G. Unger Vetlesen Foundation	Giving on a national basis. Foundation established a biennial international science award for discoveries in the earth sciences; grants for biological, geophysical, and environmental research, including scholarships, and cultural organizations, including those emphasizing Norwegian-American relations and maritime interests. Support also for public policy research and libraries. No grants to individuals. A Letter of Inquiry must be submitted before a full proposal will be considered.	212-586-0700 contact@vetlesenfoundation.org
Foundation	Max and Victoria Dreyfus Foundation, Inc.	Giving on a national basis to support museums, cultural, and performing arts programs; schools, hospitals, educational and skills training programs, programs for youth, seniors, and the handicapped; environmental and wildlife protection activities; and other community-based organizations and their programs. Organizations seeking support from the Foundation may submit a letter of request, not exceeding three pages in length, which includes a brief description of the purpose of the organization, and a brief outline of the program or project for which funding is sought.	202-337-3300 info@mvdreyfusfoundation.org
Foundation	American Honda Foundation	The American Honda Foundation engages in grant making that reflects the basic tenets, beliefs and philosophies of Honda companies, which are characterized by the following qualities: imaginative, creative, youthful, forward-thinking, scientific, humanistic and innovative. We support youth education with a specific focus on the STEM (science, technology, engineering and mathematics) subjects in addition to the environment.	310-781-4091 ahf@ahm.honda.com
Foundation	Dr. Scholl Foundation	In general the Foundation guidelines are broad to give them flexibility in providing grants. Applications for grants are considered in the following areas: Education, Social Service, Healthcare, Civic and Cultural, and Environmental.	1033 Skokie Blvd., Suite 230, Northbrook, IL 60062 847-559-7430

Category (State, Fed., Foundation)	Grant Name	Funding Type	Contact
Foundation	The Andrew W. Mellon Foundation	Giving nationally on a selective basis for higher education and scholarship, scholarly communications and information technology, art history, conservation, and museums, performing arts, conservation and the environment.	212-838-8400 inquiries@mellon.org
Foundation	The Xerox Foundation	The foundation supports: Education/Workforce Preparedness, Science/Technology, Employee/Community Affairs, and Environmental Affairs. Grants are made only to organizations that have been granted exemption from Federal Income Tax under Section 501 (c)(3) and ruled to be publicly supported under Section 509(a) of the Internal Revenue Code.	203-849-2453
Foundation	Lintilhac Foundation	Giving primarily in north central VT, including Chittenden, Lamoille, and Washington counties supporting medical education programs, health services, community development, civic projects, and educational institutions. Support also for local scientific, environmental, and educational issues. Grants given for building/renovation, curriculum development, equipment, general/operating support and seed money. No support for religious organizations. No grants to individuals.	886 North Gate Road, Shelburne, VT United States 05482-7211 (802) 985-4106 lint@together.net
Foundation	Perkins Charitable Foundation Educational Grants	Giving nationally, primarily in CA, CT, FL, MA, MT, OH, RI, VA, and VT for education, the arts, environmental conservation, animals, wildlife, health and medical care, and children, youth and social services. No grants to individuals.	1030 Hanna Bldg. , 1422 Euclid Ave., Cleveland, OH United States 44115-2001 (216) 621-0465

Category (State, Fed., Foundation)	Grant Name	Funding Type	Contact
Foundation	Fields Pond Foundation, Inc.	The Fields Pond Foundation awards grants to projects and programs primarily in Connecticut, Maine, Massachusetts, New Hampshire, New York, Rhode Island, and Vermont. The primary mission of Fields Pond Foundation is to provide financial assistance to nature and land conservation organizations that are community-based and that serve to increase environmental awareness by involving local residents in conservation issues.	781-899-9990 info@fieldspond.org
DOI	Rivers, Trails and Conservation Assistance Program	Applications for Rivers, Trails and Conservation Assistance program are competitively evaluated based on how well the applications meet the following criteria: 1. The project has specific goals and results for conservation and recreation expected in the near future. 2. Roles and contributions of project partners are substantive and well-defined. 3. There is evidence of broad community support for the project.	Jennifer Waite jennifer_waite@nps.gov (802) 457-3368, ext 221
Foundation	Waterwheel Foundation Grants	The WaterWheel Foundation was created by Phish in 1997 to oversee the band's various charitable activities. The primary effort then and now is our Touring Division, though in keeping with our "Local" mission we also support Vermont-based non-profits and others in need.	ww@phish.com or write to WaterWheel, PO Box 4400, Burlington VT 05406-4400.

Master List of Acronyms

319	Federal Clean Water Act, Section 319
604(b)	Federal Clean Water Act, Section 604b
AAFM	Agency of Agriculture, Food and Markets
AAP	Accepted Agricultural Practice
AMA	Agricultural Management Assistance Program
AMP	Acceptable Management Practice
ANS	Aquatic Nuisance Species
AOP	Aquatic Organism Passage
AR	American Rivers
ARRA	American Reinvestment & Recovery Act
ARS	Agricultural Resource Specialist
B1	Class B Water Management Type 1
B2	Class B Water Management Type 2
B3	Class B Water Management Type 3
BBR	Better Backroads Program
BMP	Best Management Practice
C&C	Clean & Clear Program
CAFO	Concentrated Animal Feeding Operation
CCP	Corridor Conservation Plan
CISMA	Cooperative Invasive Species Management Area
CREP	Conservation Reserve Enhancement Program
CRP	Conservation Reserve Program
CRREL	Cold Regions Research and Engineering Laboratory / US Army Corps of Engineers
CVPS	Central Vermont Public Service Co.
CWA	Federal Clean Water Act
CWSRF	Clean Water State Revolving Fund
DPW	Department of Public Works
DWSRF	Drinking Water State Revolving Fund
EQIP	Environmental Quality Incentive Program
EU	Existing Use
FAP	Farm Agronomic Practices
FEH	Fluvial Erosion Hazard
FEMA	Federal Emergency Management Agency
FERC	Federal Energy Regulatory Commission
FSA	Farm Service Agency (USDA)
GIS	Geographic Information System
GMNF	Green Mountain National Forest
GMP	Green Mountain Power
LFO	Large Farm Operation
LID	Low Impact Development
LIP	Landowner Incentive Program
LTP	Land Treatment Planner

LWD	Large Woody Debris
MAPP	Monitoring, Assessment and Planning Program
MFO	Medium Farm Operation
NASS	National Agricultural Statistics Service
NEAS	New England Agricultural Statistics
NEGEF	New England Grassroots Environmental Fund
NFIP	National Flood Insurance Program
NFWF	National Fish and Wildlife Foundation
NOAA	National Oceanic and Atmospheric Administration
NOFA	Northeast Organic Farming Association of Vermont
NPDES	National Pollution Discharge Elimination System
NPS	Non-point source pollution
NRCD	Natural Resource Conservation District
NRCS	Natural Resources Conservation Service
ORW	Outstanding Resource Water
PDM	Pre-Disaster Mitigation
PFW	Partners for Fish and Wildlife
R, T&E	Rare, Threatened and Endangered Species
RC&D	Resource Conservation and Development Council of USDA
RCP	River Corridor Plan
RMP	River Management Program
RPC	Regional Planning Commission
SCA	Student Conservation Association
SEP	Supplemental Environmental Program
SFO	Small Farm Operation
SGA	Stream Geomorphic Assessment
SPA	Source Protection Area
SVNMP	Southern Vermont Nutrient Management Program
SWG	State Wildlife Grant
T4S	Trees For Streams
TMDL	Total Maximum Daily Load
TNC	The Nature Conservancy
TU	Trout Unlimited
USACE	United States Army Corp of Engineers
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
UVA	Use Value Appraisal program, or Current Use Program
UVM	University of Vermont
VAAFM	Vermont Agency of Agriculture, Food and Markets
VABP	Vermont Agricultural Buffer Program
VANR	Vermont Agency of Natural Resources
VANR	Vermont Agency of Natural Resources
VDEC	Vermont Department of Environmental Conservation

VDFPR	Vermont Department of Forests, Parks and Recreation
VDHP	Vermont Department of Historic Preservation
VDOH	Vermont Department of Health
VEM	Vermont Emergency Management
VFB	Vermont Farm Bureau
VFWD	Vermont Fish and Wildlife Department
VGS	Vermont Geological Survey
VHCB	Vermont Housing and Conservation Board
VINS	Vermont Institute of Natural Science
VIP	Vermont Invasive Patrollers
VLCT	Vermont League of Cities and Towns
VLRP	Vermont Local Roads Program
VLT	Vermont Land Trust
VNNHP	Vermont Nongame and Natural Heritage Program
VNRC	Vermont Natural Resources Council
VRC	Vermont River Conservancy
VSA	Vermont Statutes Annotated
VTrans	Vermont Agency of Transportation
VYCC	Vermont Youth Conservation Corp
WHIP	Wildlife Habitat Incentive Program
WMA	Wildlife Management Area
WMT1	Class B Water Management Type 1
WMT2	Class B Water Management Type 2
WMT3	Class B Water Management Type 3
WQRP	Water Quality Remediation Plan
WQS	Water Quality Standards
WRP	Water Resources Panel
WWTF	Wastewater Treatment Facility

Glossary

Acceptable Management Practices (AMP) - methods of silvicultural activity generally approved by regulatory authorities and practitioners as acceptable and common to that type of operation. AMPs may not be the best methods, but are acceptable.

Accepted Agricultural Practices (AAP) - land management practices adopted by the Secretary of Agriculture, Food and Markets in accordance with applicable State law.

Aggradation – a progressive buildup or raising of the channel bed and floodplain due to sediment deposition. The geologic process by which streambeds are raised in elevation and floodplains are formed. Aggradation indicates that stream discharge and/or bed-load characteristics are changing. Opposite of degradation.****

Alkalization – to make or cause a pH value to increase to greater than 7.

Anadromous – a fish species that feeds and grows to maturity in the ocean, then migrates into freshwater rivers and lakes to spawn.

Aquatic biota - all organisms that, as part of their natural life cycle, live in or on waters.

Atmospheric deposition – the transfer of airborne pollutants onto the land and into surface waters, usually by being carried down in precipitation.

Basin - one of seventeen planning units in Vermont. Some basins include only one major watershed after which it is named such as the White River Basin. Other Basins include two or more major watersheds such as Basin 10 including the Ottauquechee and Black Rivers.

Best Management Practices (BMP) - a practice or combination of practices that may be necessary, in addition to any applicable Accepted Agricultural or Silvicultural Practices, to prevent or reduce pollution from nonpoint source pollution to a level consistent with State regulations and statutes. Regulatory authorities and practitioners generally establish these methods as the best manner of operation. BMPs may not be established for all industries or in agency regulations, but are often listed by professional associations and regulatory agencies as the best manner of operation for a particular industry practice.

Bioassessment - surveys of the macroinvertebrate and fish communities of lakes, wetlands, rivers, and streams in order to evaluate the biological health, or biological integrity, of the resource surveyed. This type of survey is called biomonitoring or biosurveying.

Biological Integrity – See Chapter 1.

Causes – the pollutants or conditions that stress, impair or otherwise have an impact on the aquatic biota, the aquatic habitat, swimming, fishing, the fishery, boating, drinking water supply, fish consumption or other uses of the river or stream.

Channelization – the process of changing (usually straightening) the natural path of a waterway.

Classification - a method of designating the waters of the State into categories with more or less stringent standards above a minimum standard as described in the Vermont Water Quality Standards.

Conductivity – a measure of the water's ability to conduct an electrical current, directly related to the total dissolved ions in the water. *

Contact recreation (Primary) – this water classification protects people from illness due to activities involving the potential for ingestion of, or immersion in, water. Primary contact recreation usually includes swimming, water-skiing, skin-diving, surfing, and other activities likely to result in immersion. (EPA Water Quality Standards Handbook, 1994)

Designated use - any value or use, whether presently occurring or not, that is specified in the management objectives for each class of water as set forth in §§ 3-02 (A), 3-03(A), and 3-04(A) of the Vermont Water Quality Standards.

Direct Discharge – the introduction of pollutants to waters of the US from any point source through a defined conveyance or system such as, outlet pipes, sewers and ditches; a point source.

Dissolved Oxygen – the concentration of free molecular oxygen dissolved in water.*

Dystrophic - a lake or pond having brownish acidic waters, a high concentration of humic matter, and a small plant population.***

Easement – a restriction placed on a piece of property to protect its ecological and open-space values. It is a voluntary, legally binding agreement that limits certain types of uses or prevents development from taking place now and in the future. In a conservation easement, a landowner voluntarily agrees to donate or sell certain rights associated with his or her property, such as the right to subdivide, and a private organization or public agency agrees to hold the landowner's promise not to exercise those rights.*****

Eutrophic - A high level of nutrient availability and biological productivity in

Existing use - a use that has actually occurred on or after November 28, 1975, in or on waters, whether or not the use is included in the standard for classification of the waters, and whether or not the use is presently occurring

Fluvial erosion hazard - refers to the endangerment of human investments and public safety resulting from land use choices and expectations that conflict with the dynamic and oftentimes catastrophic physical adjustments of stream channel and flood plain dimensions, elevations, locations and longitudinal slope, in response to rainfall/runoff events and sometimes ice jams.

Fluvial geomorphic equilibrium - the condition in which the physically dynamic nature of fluvial systems is freely expressed over time in response to the range of watershed inputs and climatologic conditions, and as influenced by topographic, geologic, and existing human imposed boundary conditions.

Fluvial geomorphology - a science that seeks to explain the physical interrelationships of flowing water and sediment in varying land forms.

Hypolimnetic - the layer of water in a thermally stratified lake that lies below the thermocline, is noncirculating, and remains perpetually cold.***

Impaired water / impairment - a water that has documentation and data to show: a violation of one or more criteria in the Vermont Water Quality Standards, or conditions that cause lack of full support for any given designated use for the water's class or management type.

Impervious – a surface that does not allow water or other liquids to penetrate through

Improved Barnyards - a series of practices to manage and protect the area around the barn, which is frequently and intensively used by people, animals, or vehicles, by controlling runoff to prevent erosion and maintain or improve water quality. Practices may include: heavy use area protection, access roads, animal trails and walkways, roof runoff management, and others.

Index of Biotic Integrity (IBI) – a synthesis of diverse biological information that numerically depicts associations between human influence and biological attributes. It is composed of several biological attributes or "metrics" that are sensitive to changes in biological integrity caused by human activities.*

Indirect Discharge – land-based sewage treatment and disposal, including septic systems, leachfields, treatment facilities and spray disposal systems that use soil as part of the waste treatment process to provide final effluent renovation and polishing before it reaches groundwater and, eventually, surface water.

Isolation Zone - horizontal distances between drinking water sources and potential sources of contamination.

Littoral – the shoreline zone of a lake where sunlight penetrates to the bottom and is sufficient to support rooted plant growth.**

Lotic - pertaining to or living in flowing water.***

Low Impact Development - a set of innovative stormwater management techniques that infiltrate, filter, store, evaporate, and detain runoff close to its source through small, cost-effective landscape features located at the lot level. These include practices such as raingardens, bioretention facilities, dry wells, filter/buffer strips, grassed swales, and rain barrels.

Macroinvertebrate –animals without backbones and large enough to see with the naked eye.*

Macrophyte – a rooted aquatic plant that grows in or on the water.*

Mesotrophic An intermediate level of nutrient availability and biological productivity in an aquatic ecosystem.

Natural condition - the condition representing chemical, physical, and biological characteristics that occur naturally with only minimal effects from human influences.

Natural flow - the flow past a specified point on a natural stream that is unaffected by stream diversion, storage, import, export, return flow, or change in use caused by modifications in land use. ****

Nonpoint source pollution - waste that reaches waters in a diffuse manner from any source other than a point source including, but not limited to, overland runoff from construction sites, or as a result of agricultural or silvicultural activities.

Oligotrophic A low level of nutrient availability and biological productivity in an

pH - a measure of the hydrogen ion concentration in water on an inverse logarithmic scale ranging from 0 to 14. A pH under 7 indicates more hydrogen ions and therefore more acidic solutions. A pH greater than 7 indicates a more alkaline solution. A pH of 7.0 is considered neutral, neither acidic nor alkaline.

Point source - any discernable, confined and discrete conveyance including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, landfill leachate collection system, vessel or other floating craft from which either a pollutant or waste is or may be discharged.

Private Drinking Water Source – include dug, driven, and drilled wells and springs.

Public Water Supply - any water supply system with fifteen or more connections or that serves at least 25 individuals daily at least 60 days per year.

Reference condition - the range of chemical, physical, and biological characteristics of waters minimally affected by human influences. In the context of an evaluation of biological indices, or where necessary to perform other evaluations of water quality, the reference condition establishes attainable chemical, physical, and biological conditions for specific water body types against which the condition of waters of similar water body type is evaluated.

Riparian – located on the banks of a stream or other body of water.

Riparian Buffer Zone - the width of land adjacent to lakes or streams between the top of the bank or top of slope or mean water level and the edge of other land uses. Riparian buffer zones are typically undisturbed areas, consisting of trees, shrubs, groundcover plants, duff layer, and a naturally vegetated uneven ground surface, that protect the waterbody and the adjacent riparian corridor ecosystem from the impact of these land uses.

Runoff - water that flows over the ground and reaches a stream as a result of rainfall or snowmelt. ****

Secondary contact recreation – this water classification is protective when immersion is unlikely. Examples are boating, wading, and rowing. These two broad uses can be logically subdivided into an almost infinite number of subcategories (e.g., wading, fishing, sailing, powerboating, rafting.). Often fishing is considered in the recreational use categories. (EPA Water Quality Standards Handbook, 1994)

Sediment / Sedimentation - soil, sand, silt, algae, and other particles either suspended in the water column or their deposition on the bottom of rivers, streams, lakes, ponds, or wetlands.

Source Protection Area (SPA) - the area delineated around a ground or surface water supply in which contaminants are reasonably likely to move.

Sources – the land uses, human activities, or occurrence of conditions that are the origin of the causes of impairments, impacts or stresses on river and stream in the basin.

Terrigenous - derived from the land, especially by erosive action. Used primarily of sediments.***

Thermal modification - the change in water temperature.

Total maximum daily load (TMDL) - the calculation of the maximum amount of a pollutant that a waterbody can receive on a daily basis and still meet Vermont Water Quality Standards.

Total phosphorus – the total amount of phosphorus dissolved in solution (reactive) and in particulate form.*

Total suspended solids – the total amount of particulate matter that is suspended in the water column.*

Transparency – a depth measurement taken by lowering a white and black, 8-inch diameter, Secchi disk into the water to the point just before it cannot be seen.

Trophic – a relative level of productivity.*

Turbidity - the capacity of materials suspended in water to scatter light usually measured in Nephelometric Turbidity Units (NTU). Highly turbid waters appear dark and “muddy.”

Type / Typing - a category of water management requirements based on both the existing water quality and reasonably attainable and desired water quality management goals. Through the basin plan all Class B waters must be allocated into one or more Water Management Types pursuant to § 3-06 of the Vermont Water Quality Standards.

Waste Management System -a planned system in which all necessary components are installed for managing liquid and solid waste, including runoff from concentrated waste areas and silage leachate, in a manner that does not degrade air, soil, or water resources. The purpose of the system is to manage waste in rural areas in a manner that prevents or minimizes degradation of air, soil, and water resources and protects public health and safety. Such systems are planned to preclude discharge of pollutants to surface or ground water and to recycle waste through soil and plants to the fullest extent practicable.

Water quality parameter – the physical, chemical or biological attribute measured to determine water quality.

Water Quality Standards - the minimum or maximum limits specified for certain water quality parameters at specific locations for the purpose of managing waters to support their designated uses. In Vermont, Water Quality Standards include both Water Classification Orders and the Regulations Governing Water Classification and Control of Quality.

Waters - all rivers, streams, creeks, brooks, reservoirs, ponds, lakes, springs, wetlands and all bodies of surface waters, artificial or natural, which are contained within, flow through or border upon the State or any portion of it.

Watershed - all the land within which water drains to a common waterbody (river, stream, lake, pond or wetland).