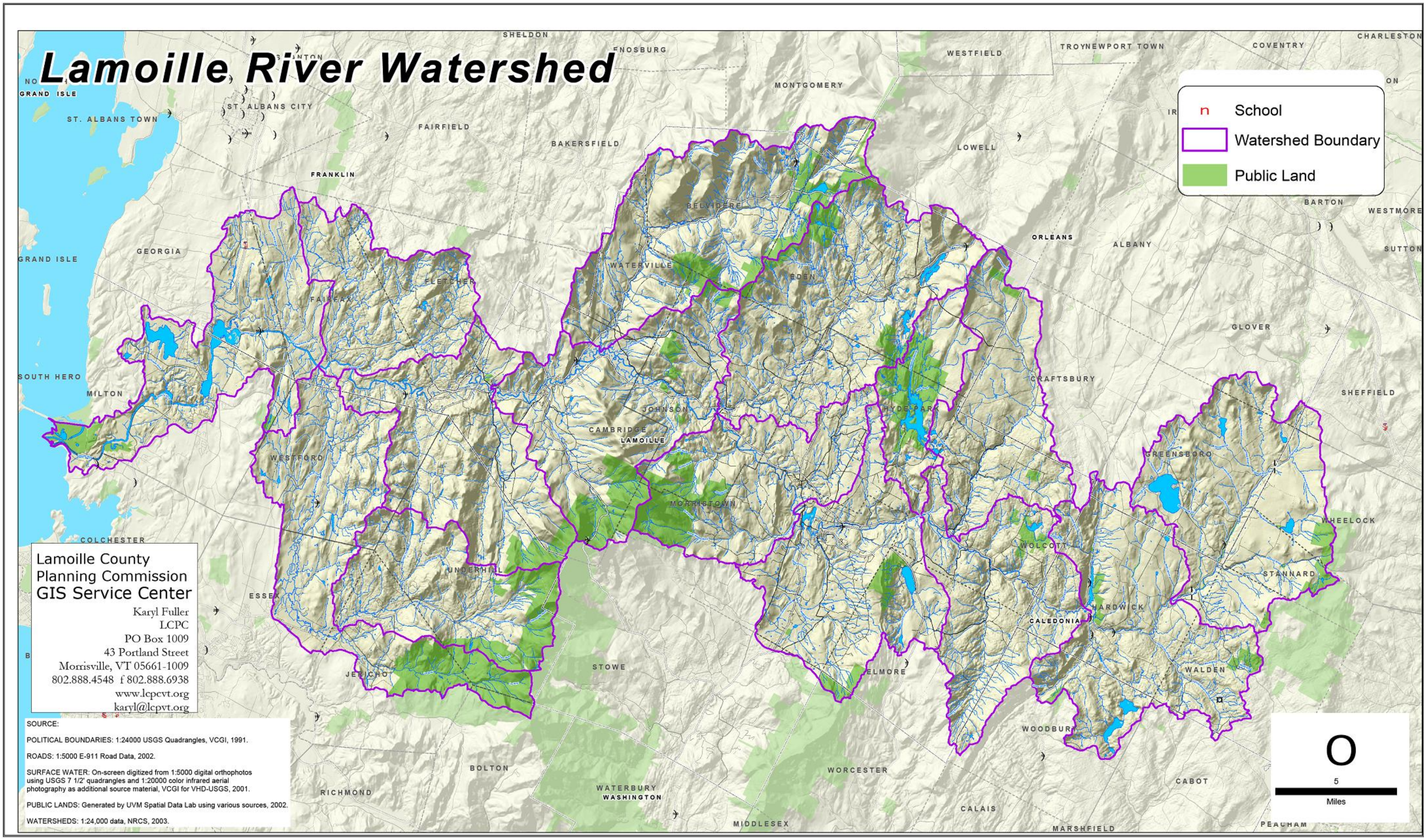
Lamoille River Watershed

Agriculture & River Resource Guide


Lamoille River Watershed
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Watershed Boundary
Public Land
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Miles
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SOURCE:
POLITICAL BOUNDARIES: 1:24000 USGS Quadrangles, VCGI, 1991.
ROADS: 1:5000 E-911 Road Data, 2002.
SURFACE WATER: On-screen digitized from 1:5000 digital orthophotos using USGS 7 1/2' quadrangles and 1:20000 color infrared aerial photography as additional source material, VCGI for VHD-USGS, 2001.
PUBLIC LANDS: Generated by UVM Spatial Data Lab using various sources, 2002.
WATERSHEDS: 1:24,000 data, NRCS, 2003.
SHELDON
ENOSBURG
WESTFIELD
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ST. ALBANS CITY
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BAKERSFIELD
MONTGOMERY
LOWELL
FRANKLIN
BELVIDERE
BARTON
WESTMORE
ORLEANS
ALBANY
SUTTON
GEORGIA
GRAND ISLE
WATERVILLE
EDEN
FAIRFAX
FLETCHER
GLOVER
SOUTH HERO
MILTON
CRAFTSBURY
SHEFFIELD
JOHNSON
HYDE PARK
CAMBRIDGE
LAMOILLE
WESTFORD
GREENSBORO
MORRISTOWN
COLCHESTER
WOLCOTT
WHEELOCK
UNDERHILL
STANNARD
ESSEX
HARDWICK
CALEDONIA
STOWE
WALDEN
JERICHO
ELMORE
WOODBURY
BOLTON
WORCESTER
RICHMOND
WATERBURY
WASHINGTON
CABOT
CALAIS
MIDDLESEX
MARSHFIELD
PEACHAM

Vermont Association of Conservation Districts

The *Lamoille River Watershed Agricultural & River Resource Guide* was produced by the Lamoille County Natural Resources Conservation District & Nature Center (LCNRCD) with organizational support from the Vermont Association of Conservation Districts (VACD). Vermont communities can turn to a number of agencies, including their local Conservation District, for information on implementing the information within this resource guide. Conservation Districts were initially established to serve as a liaison between the federal government United States Department of Agriculture (USDA) and local farmers to address soil and water concerns. The 14 Districts of Vermont often work together on statewide issues, such as Accepted Agricultural Practices (AAP), via the Vermont Association of Conservation Districts. Throughout the years the role of Conservation Districts has expanded to involve numerous partners and natural resource concerns in addition to those connected with farming practices. One of the key roles of Districts is to create partnerships with other state and federal organizations which include the USDA, Natural Resources Conservation Council (NRCC), Vermont Agency of Natural Resources, US Fish and Wildlife Service, etc. to facilitate programs to protect natural resources in local communities.

There are 14 Natural Resources Conservation Districts in the State of Vermont; some of which are organized by county and some by watershed (see back page for listing). They are autonomous groups that sometimes share resources but are each run by their own local Board of Supervisors made up of members from the local community. Each Conservation District decides its' own goals and work plans based on community needs and interests. VACD operates strictly as a non-profit organization and is supported via dues and grant income. Individual Conservation Districts receive small stipends from the Vermont Agency of Agriculture, Food & Markets; this allocation is supplemented by a variety of sources such as memberships, grants, and specific fundraising efforts.

The Lamoille County Natural Resources Conservation District & Nature Center (LCNRCD) was established in 1945 in response to the degradation of natural resources vital to the agricultural livelihood of residents in Lamoille County. LCNRCD works in partnership with the USDA's Natural Resources Conservation Service (NRCS):

- To maintain and improve our natural resources;
- To aid and educate our fellow citizens to appreciate and adjust to the changes taking place in our natural resource system;
- To be a local voice for conservation, preservation and stewardship of all natural resources and work in conjunction with other agencies (private and public) at the grassroots level.

Current LCNRCD projects are focused in three general areas: water quality, protection of the working landscape (both agriculture and forestry), and education and outreach. To help support their efforts and educate the community, the *Lamoille River Watershed Agriculture & River Resource Guide* was created for landowners, conservation groups, teachers, etc. The guide contains information on and the correlation between these topics - the Vermont Accepted Agricultural Practices (AAPs), the role of Phosphorus in Water Quality, and the Benefits of Riparian Buffers. The guide is supported by Power Point presentations on the same topics. In addition, a resource compendium of existing tools and educational resources that includes brochures, informational pages, study materials, lesson plans, etc. is available to facilitate a general understanding of how agricultural practices specifically protect water quality, how to monitor for water quality, and how to restore riparian buffers, areas of land critical to watershed health. Within the compendium, LCNRCD highlights resources that are already available to the public and provides contact information for trusted and proven organizations so that interested parties might investigate further into these programs or program resources.

LCNRCD would like to thank the Vermont Agency of Agriculture, Food and Markets and the Morrisville Rotary Club as generous contributors to this publication. Compiled and edited by Kimberly Jensen Komer with help from Susan Alexander, Christina Goodwin and Zach Thomas. Information on study kits, classroom presentations, and copies to download are available on-line at the LCNRCD website.

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THE RIVER

**The world is proud of its rivers,
The mighty, grand and free
And their praise is a theme forever-
I bring my praise to thee.**

**Thou art not named in story,
A stranger art to fame,
No deeds of war or glory
We mingle with thy name;**

**But of all the mighty rivers,
That haste to meet the sea
Not one to me shall ever
Be beautiful like thee.**

**But sweet and beauteous daughters,
And hardy sons of toil
Have a home beside thy waters,
O, beautiful Lamoille.**

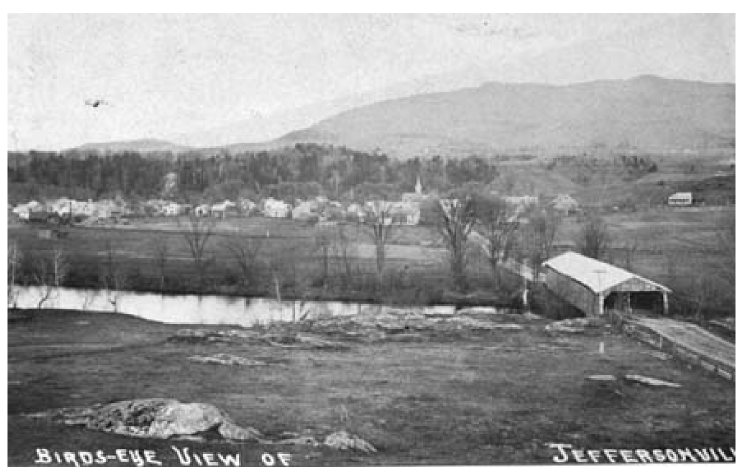
**I would dwell beside thee ever,
And by the crystal wave
Of my dear Green Mountain River,
Let them make my peaceful grave.**

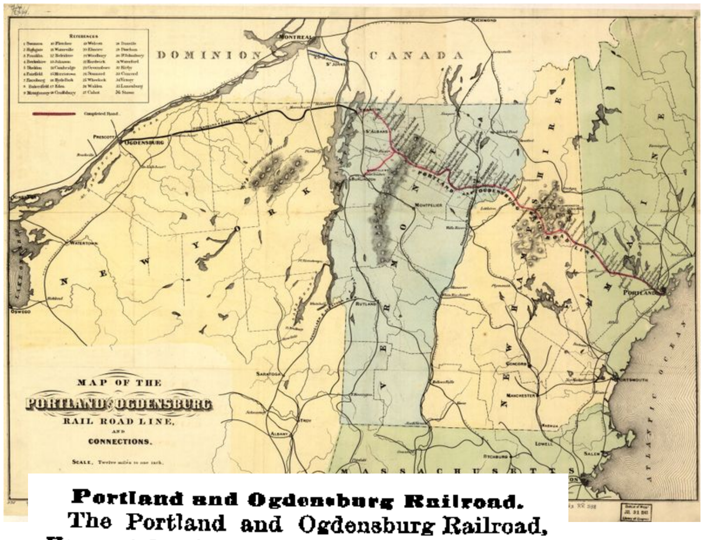
**Lamoille – by Ms. Lavina L. Fletcher
Who later became the wife of State Legislator Frank Plumley
-Circa 1865-**

HISTORY OF THE LAMOILLE RIVER

The Lamoille shares a cultural history of time like other Vermont rivers. Evidence from artifacts and burial sites discovered along the river reveals that Native American tribes camped, fished and found the river to be of great importance. Perhaps it was the incredible diversity of fish; Atlantic salmon, Lake sturgeon, walleye, Brook trout, shad, that attracted them to the sandy shores. These fish may have caused a stir when spawning up river that caused gulls to fly about the mouth of the river when Samuel de Champlain first spotted the river in 1609 and stated "La Mouette" in French or "the gull". One such theory for how Lamoille received its name is that "La Mouette" was misspelled when a clerk forgot to cross the "T's" and in 1744, "La Riviere a la Mouelle" appears on the Charlevoix map . Later explorations and writings describe the river "Alamoille" which is now modestly known as Lamoille.

The arrival of colonists who settled the land began a series of landscape changes that shape the management issues that are realized and present today. Land was cleared to fuel the needs of the colonists, from the immense White pine trees prized for English ship masts, to hardwoods for home construction, furniture, paper and fuel. It was estimated that thirty to forty cords of wood were consumed to construct and warm a home. Later, entire sections of land were cleared of wood to fuel kilns to process pig iron. As the forests were cleared, mills sprung up on waterfalls, gorges and cascades. Whether privately owned or owned by the town, mills were used to saw timbers, grind grains, process wool or grind apples, all of which contributed to a new agrarian way of life.



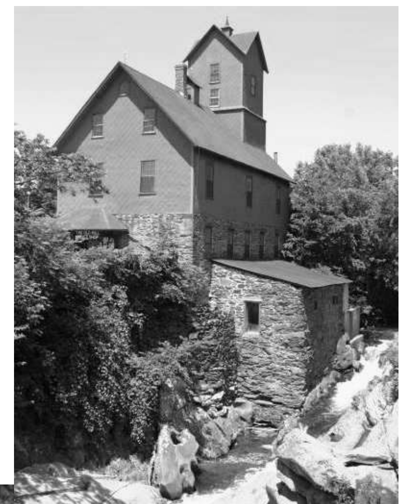


Portland and Ogdensburg Railroad.

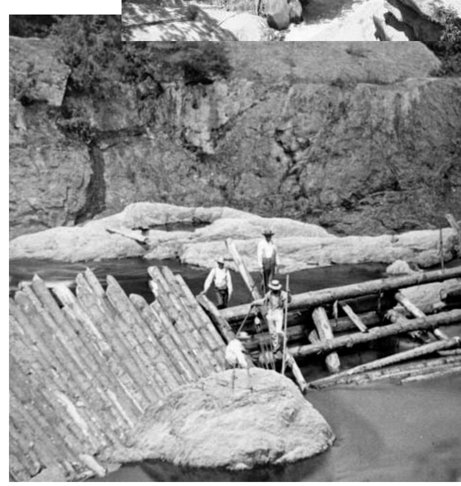
The Portland and Ogdensburg Railroad, Vermont division, is one of the marvels of the age. It is being built for $700 a mile less than the estimate, making a saving of $42,000 on the whole sixty miles, and, for a wonder, there seems to be no "bottom ring" to pocket the money thus saved, and the road will get the benefit of it. The line will be open to Whitefield, N. H., the coming season, giving direct communication with Boston via the Boston, Concord and Montreal Road, and when the whole line is completed through New-Hampshire, and one or two railroads in Canada, now building, are done, the Portland and Ogdensburg will have eighty miles the advantage of the Grand Trunk in carrying the lumber, grain, and other products of Canada and our own North-west to Boston. This advantage will give it the business.—*Springfield Union.*

The New York Times
Published: May 7, 1873

Farming comprised a large part of the people's livelihood in the mid 1800's until the rise of industry shifted the agricultural community to a commercial one. Merino sheep proved profitable as they were well suited to graze in poor, rocky, newly deforested land. However, dairy farming replaced the "Merino Mania" that eventually became unprofitable due to the competition from farmers out West. Eventually, dairy farms decreased as people were attracted to the easier life that emerging cities and new industries could provide. Railroads also played a part in opening new economic opportunities and providing exciting new prospects for "greener pastures" in Michigan, Minnesota and Wisconsin and in cities such as Boston and Concord. The St. Johnsbury and Lake Champlain Railroad (also called the Lamoille Valley Railroad) was a 96-mile east-west connection from St. Johnsbury to Swanton completed in 1877. This line connected with the Vermont Division of the Portland & Ogdensburg railroad, called the Burlington and Lamoille Railroad (the B&L) and traveled from Burlington to Cambridge where it transported resources, goods, and people.



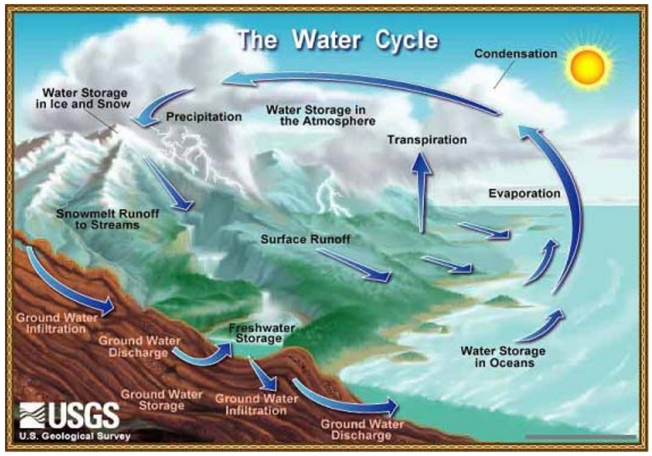
Farms were increasingly abandoned, especially after two flooding events in 1927 and another in 1936 washed out mills so important for the wealth of a farmer's lot but too expensive to rebuild. However, harnessing a river's energy proved to be successful and economically feasible and many of the mill sites were transformed into dams to provide hydroelectric power.



Settlement, industry, and transportation not only changed the landscape of the forests and fields but also changed the ***hydrology*** of the waterways. Deforestation, mills, dams, railroads and subsequent sedimentation, invariably affected the ebb and flow of the rivers ***hydrogeology*** and ***ecology***. As deforestation occurred, sediments from the lack of ground cover washed and filled in headwaters and creeks. Mills created barriers to spawning fish interrupting access to spawning grounds, and consequently were often a site where barrels of fish were taken out of the river. Sediments filled in the waterways from mill waste, such as sawdust, grain chaff, etc. that was dumped directly in the water. Sediments filled in mill ponds that were used to store and release water when needed. Dams caused the same effects of sedimentation and blocked access to spawning fish. Even railroads, whose lines were constructed along the path of rivers along the flat, valley bottom terrain, tamed the meandering main stem. In some sections either from railroads or for the ease of roads, the river was straightened to accommodate.

THE LAMOILLE RIVER WATERSHED

The Lamoille River winds its way along an eighty-five mile path through farms, forests, along roads, and through small and big towns. From the forested source of the river northwest of Wheelock at the outlet of Horse Pond the river travels through six counties before flowing into Lake Champlain. Collectively, the river's ***headwaters*** and ***tributaries*** replenish the waters from thirty towns. Within the ***watershed***, the water that flows from the highest elevations to the lowest elevations drains a land area of 706 square miles. Snow melts into headwaters from mountain tops such as Elmore Mountain, Belvidere, and Arrowhead Mountain. These waters lead to tributaries such as Elmore Branch, Gihon River, and the Browns River that eventually flow to the ***main stem***, the Lamoille River. The Lamoille's headwaters, tributaries, and main stem along with water from ponds and lakes of the watershed such as Caspian Lake, Green River Reservoir and Arrowhead Mountain Lake, eventually makes its way into Mallet's Bay of Lake Champlain. The waters continue their voyage north to the Richelieu River to the St. Lawrence River then finally into the Atlantic Ocean.

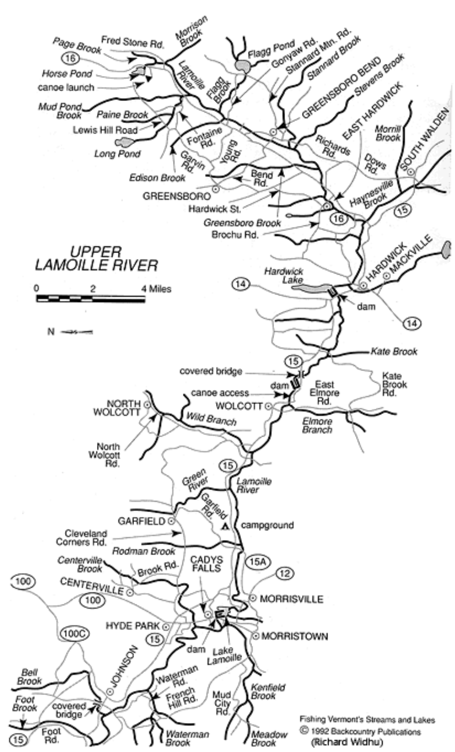


The land and water play an integral role in a watershed and its hydrology. The hydrologic cycle, or the water cycle, is controlled by the flow of water throughout the land, and other factors such as the atmosphere and the sun. Change or alter one factor and results are apparent. For example, as forests were cleared the lack of shade trees intensified the sun and increased the evaporation of surface water. With additional sediments filling in waterways, the two fold result caused waterways to dry up.

During seasonal flooding events, sediments that built up in mill ponds or behind dams were washed away in flash floods and deposited downstream. These additional sediments scoured out and widened banks, were then deposited within the river bed, which ultimately made waterways wider and flatter. Waterways that were in a natural state of balance between sediments and water changed physically, chemically and biologically.

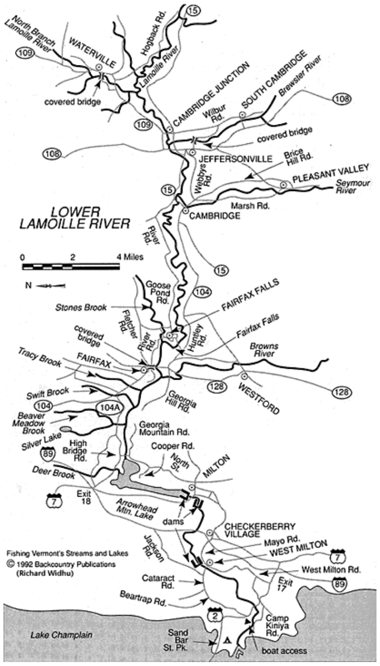
Rivers are forever in a dynamic state of balance between sediments and water. Study of how water and earth physically change over time in a river, is called ***fluvial geomorphology***. Scientists who study rivers use this science by observing the present state of a river to read a river's history and can also help make recommendations to restore rivers to a natural state of balance.

While not all rivers are alike, they do share fundamental physical features – channel, banks, floodplain, and sinuosity. These physical features are shaped by the regions climate, geology, and vegetation. In one watershed one would expect to find these aspects all together quite similar. However, In the Green Mountains elevation shapes the physical features as well as the environmental aspects. Within the Lamoille River Watershed mountains form the upper-reaches of the watershed basin. Within these high elevation reaches, fast flowing, oxygen rich ***headwater*** streams cascade over bedrock and large boulders forming small waterfalls that lead to small pools. These headwaters lead to ***tributaries*** found in the mid-reaches. In these tributaries, the force of the water deposits boulders, scours cobbles, and creates gravel which forms mini dams, or steps, to slow the water down. Finally, these tributaries flow to the lowlands that contain the ***main stem*** of the river. The main stem of the river contains small cobbles, gravel, and sand. In the main stem of a river the water slows down and typically meanders back and forth.



A main stem of a river consists of a primary channel that contains the water and sediments within the river. River banks give form to the channel and retain the river's structure. Vegetation along banks provides a buffer to the scouring action of water (see page 17 for additional information regarding Riparian Buffers). When a river floods beyond its banks, floodplains act as a sponge to absorb excess waters. Floodplains are found in low valleys near to rivers and the water they are inundated with is absorbed into the ground-water which is then released slowly back into the river. Sinuosity is the amount the river channel meanders, or bends and relates to the stream length versus the valley length. Generally, meanders are created as the water flows through the channel and scours sediment on the outside of the meander forming pools. The sediment is then deposited opposite onto point bars, towards the inside of a meander forming riffles. Watersheds formed by glacial lakes like the Lamoille River form a predictable and repetitive pattern called the *Riffle-Run-Pool Sequence*.

In the upper watershed, the source of the main stem of the Lamoille River is at the outlet of Horse Pond in Wheelock. The river gathers steam from small



brooks that flow from the hills, mountains and ponds throughout the watershed. In the upper reaches, the Lamoille is characterized mostly by a riffle-pool channel with short sections of steeper cobble-dominated rapids and ledges. Once in Hardwick downstream of the pedestrian bridge, the channel is ***armored***, ***channelized*** and dammed (Hardwick Dam is the first of nine dams on the Lamoille River). West of Hardwick and through Wolcott, the river meanders and portions are ***armored*** and constrained within a small portion of its floodplain to accommodate the now defunct Lamoille Valley Railroad (now being developed into the Lamoille Valley Rail Trail along Route 15).

From Wolcott, the first influx of water from Elmore Branch and Wild Branch feed cold oxygen rich waters into the Lamoille where the river meanders again throughout its floodplain. In Morrisville, Cady's Falls Dam is the next major upstream impoundment on the river. After this slow down, the river is re-nourished again by the cold waters of the North Branch and Brewster River and returns to a high gradient riffle-pool channel. However, changes are substantial when the river reaches Cambridge as the river slows and becomes a low gradient, widely meandering channel.

Further along the lower watershed, the Lamoille River changes from a characteristic meandering river to one that is dammed, added to by tributaries and set to meander, then dammed again. After Fairfax Falls, the river increases in size with water from the Browns River. The river is again dammed to form Arrowhead Mountain Lake. From there, the river enters two dams. The Lamoille's confluence with Lake Champlain includes the vast Lamoille River Delta Sandbar Wildlife Management Area.

RESTORING THE LAMOILLE RIVER

Hardly the coursing river that Champlain encountered in 1807, the Lamoille's physical, chemical and biologic makeup has in some cases been impaired over time. Of the 611 total river miles, approximately 68% has been assessed and studied by scientists to evaluate the river's water quality. Their studies revealed that "… water reaches that are listed as impaired and, therefore, do not meet current Vermont Water Quality Standards." Most of the impaired waters are located in the lower watershed, and are due to drawdown from hydroelectric plants, agricultural and stormwater runoff and atmospheric deposition from mid-western power plants. However, these impairments from various land uses are present throughout the watershed.

The historical use of the river has brought about a dramatic imbalance of the sediments and water within the channel. The effects of this dramatic imbalance are still present within many tributaries along and within the Lamoille River. For example, in addition to the dams that altered the course and flow of the waters, the Lamoille River was ***channnelized***, or straightened via bulldozers. Whether for mining gravel, to accommodate a road, or to protect infrastructure, these channelized sections lose their effectiveness. Over time these channelized sections are ***armored,*** where ***rip-rap*** and large stones are brought in to maintain the unnaturally straightened channel.

When the river is mined for gravel, armored, channelized, or dammed, the water has lost the ability to deposit sediments in a natural manner such as in a Riffle-Pool Sequence. As a result, the river erodes and deposits sediment haphazardly. For example, the river may erode a farmer's field, and then deposit the sediment down river to form a dam that in turn creates flooding on the field. Or the river erodes its bank one year and drops out sediment in the middle of the river, and the following year does the same further down the river. The result in a stretch of river that is wide and shallow. These examples are a common sight on the Lamoille River.

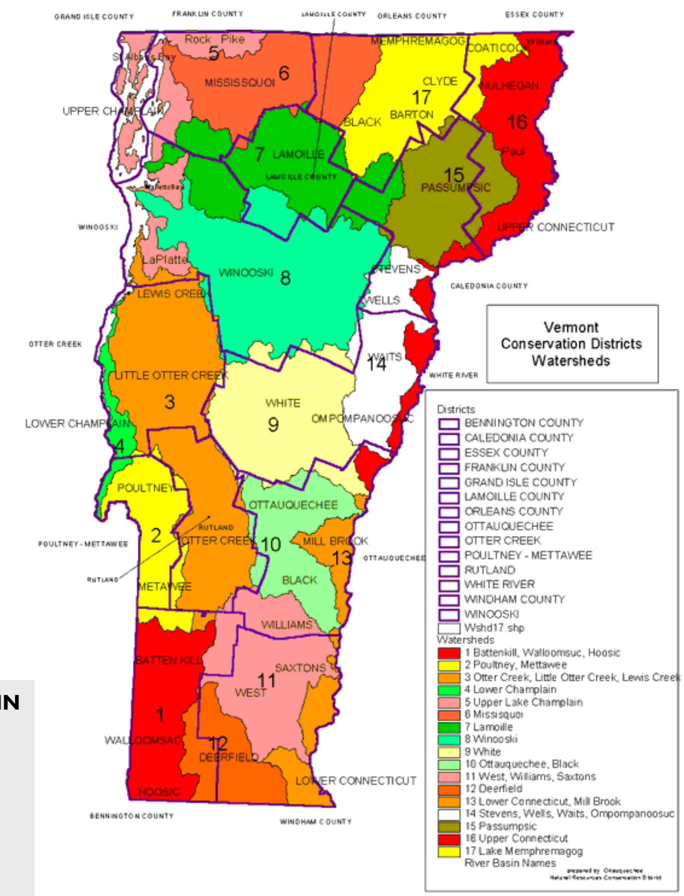
Chemical and biological changes result from erosion and deposition of sediments whether from the soil and/or gravel themselves or by pollutants that enter the water. In addition, the depth and current of the water can contribute to a change in the chemical make-up**.** When sediments are added and suspended in the water, the water becomes murky or turbid. Turbidity, along with the effects of a slow and broad river, increases the temperature and decreases oxygen levels. On a biological level, the organisms that are adapted to live within a cold, well oxygenated, and deep, fast running river will not survive. This is true for the macroinvertebrates that live in the riverine habitat as well as certain types of fish, such as Brook trout. Additional chemical inputs (phosphorus, nitrogen, pesticides, fertilizers, heavy metals, oil, and gas) to the water cause additional problems both on a biological level and a health level.

A Snapshot of Human Imposed Changes to Vermont Rivers

Deforestation *– led to dramatic increases in the water volume and sediment runoff;*
Snagging & ditching *– clearing boulders and woody debris for logging and flood control, and ditching poorly drained land for agricultural improvements increased the rate of water and sediment runoff;*
Villages, roads, and railroads *– early settlements led to the first attempts to straighten rivers and streams resulting in increases in channel slope, stream bed degradation, and floodplain encroachments;*
Mills, dams, and diversions – *led to alterations in the amount and rate of water and sediment runoff. While dozens of dams are in place in each Vermont watershed today, historically there were hundreds;*
Floods and flood works *– each major flood event brought enormous loads of sediment into channels that were already aggrading or degrading, causing damage to human infrastructure which in turn led to new efforts to straighten and deepen the rivers;*
Gravel removal *– advocated as a way to maintain straighter, deeper channels; large-scale commercial gravel mining resulted in bed degradation, head cutting, channel over-widening, and severe bank erosion;*
Encroachment *– investments on lands previously occupied by river meanders or inundated during floods created unrealistic and unsustainable human expectations in the absence of continuous or periodic channel management activities; and*
Stormwater and urbanization *– increases in impervious surface and ditching to support economic development and land use conversion increased the rate and volume of water and sediment runoff entering stream systems. (Cahoon & Kline, 2003)*

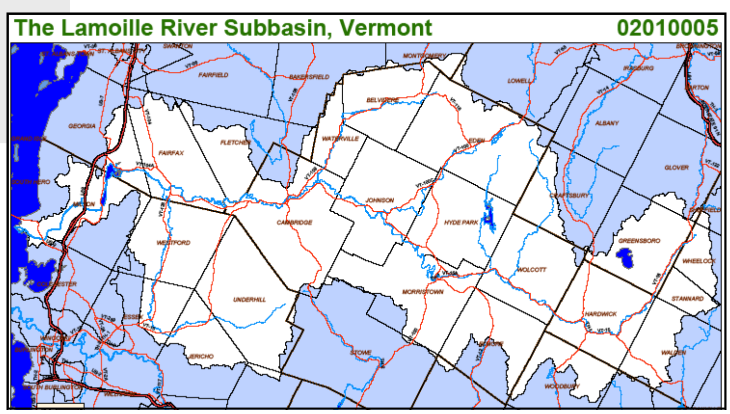
The State of Vermont Water Quality Policy is to "protect and enhance the quality, character and usefulness of its surface waters and to assure the public health, maintain the purity of drinking water," and to "assure the maintenance of water quality necessary to sustain existing aquatic communities". Throughout Vermont an analysis of all the watersheds were made by the Vermont Department of Environmental Conservation to evaluate the water quality within each of the 17 watersheds in Vermont. Public participation was strongly solicited and information and recommendations from concerned citizens were included in the completed Watershed Basin Plans.

Scientific results and analysis, public recommendations, and the guidelines and regulations set by the Water Quality Policy are included in these Watershed Basin Plans to ensure that the water quality standards are met. The Lamoille River Basin Plan set guidelines for the activities that occur within the watershed and how to maintain or restore the water quality in the watershed. From the plan, the issues that affect the water quality in the watershed are stated below.



Top water quality issues for the Lamoille River Basin

- Stream instability and flooding
- Stormwater runoff (from pervious and impervious surfaces)
- Agriculture and water quality
- Transportation infrastructure problems embankments, & driveway accesses)
- Dams and water quality (water level fluctuation, stream instability & fish passage)
- Loss of working lands (farms and forestland to sprawl)



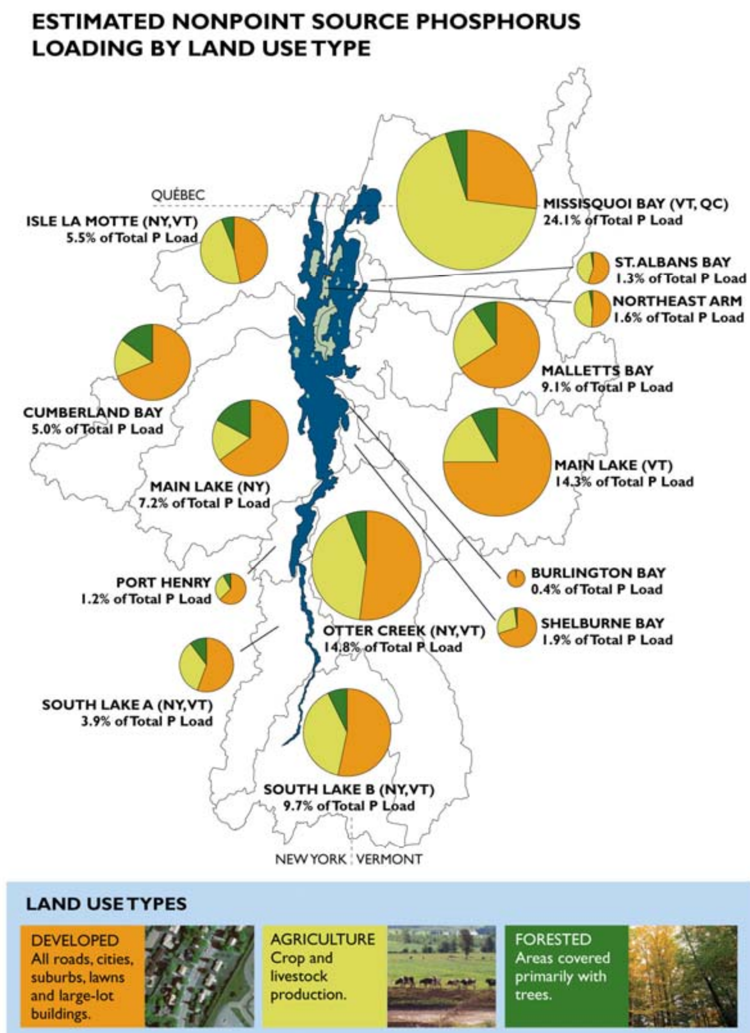
The next sections will address some of these issues effecting water quality in the Lamoille River Watershed, and offer tools to help restore the Lamoille River to a healthy and dynamic river.

Non Point Pollution

Efforts were made in the last few decades to control water pollution from sources have been well documented. Waste products from sources that were traced back to a specific point and the origin identified, are called ***point source pollution***. The contributors of point source pollution such as waste water treatments plants and industrial facilities were asked to comply with local, state, and federal regulation to control or stop altogether wastes from entering waterways. While the results were promising, regulation and policies are still in place to strengthen the initial efforts to further reduce point source pollution.

Presently, the most concerning contributor to poor water quality is ***non point source pollution***. Non point source (NPS) pollution is waste that reaches surface water or groundwater indirectly or in a diffuse manner. NPS pollution occurs when rainfall, snowmelt, or irrigation runs over land or through the ground, picks up pollutants, and deposits them into rivers, lakes, and coastal waters or introduces them into ground water.

The most common NPS pollutants are nutrients and sediments. These wash into water bodies from developed areas, agricultural land, small and medium-sized animal feeding operations, construction sites, and other areas of disturbance. Other common NPS pollutants include pesticides, pathogens, salts, oil and grease, toxic chemicals, and heavy metals. Many environmental and human health problems result from NPS pollutants. In Vermont, phosphorus is a significant non point pollutant (see Phosphorus section on page 12).



NOTE: The land use data is from 2001 satellite imagery— the most recent comprehensive and complete data for this region.
DATA SOURCE: Updating the Lake Champlain Basin Land Use Data to Improve Prediction of Phosphorus Loading. LCBP Technical Report #54. May 2007. Page 45, Table 2-11.
GRAPHIC FROM: State of the Lake and Ecosystem Indicators Report - 2008. Lake Champlain Basin Program, June 2008.

Originally, point sources such as factories and waster water treatment plants were credited to be the leading contributor of phosphorus. After strict management actions were taken, phosphorus loads were decreased considerably from these point sources. Most recent studies from the Lake Champlain Basin Program's *State of the Lake Report 2008* estimates that the current phosphorus load is derived from less than 10% by point sources and 90% by non point sources; developed land appears to be the leading cause of non point pollution (see graphic to right). Non point sources of phosphorus can be attributed to three different land use types: Developed, Agriculture and Forested. Developed land contributions of phosphorus can be from septic systems, runoff from driveways, rooftops, parking lots, and construction sites. Uninformed everyday citizens also contribute phosphorus from lawn fertilizers, detergents, and pet waste. Agricultural sources from crop and livestock production can also create runoff that leads directly to waterways. While agricultural sources are mostly secondary to developed areas, it is important to address each contributor and provide long term solutions for the health of Vermont's waters.

ACCEPTED AGRICULTURAL PRACTICES

In Vermont, and especially in the Lamoille Basin, agriculture is part of the cultural heritage that communities identify as a rich tradition as well as a economic benefit that supports jobs and income. One hundred years ago the landscape was 80% open and there were more sheep than people in Vermont. Today the land is 80% forested and there are only about 1,200 dairy farms remaining in Vermont. While Vermont farms are struggling to survive amidst global markets, they are gaining attention for their cottage items such as cheese, maple products, and other locally made specialties. Farms contribute to the local economy through purchases of feed, machinery, supplies, and direct employment. The Vermont landscape is famous for its farms, cows, and rolling green fields and billions of dollars are spent by tourists to enjoy this landscape. Most importantly, farms provide our food.

ACCEPTED AGRICULTURAL PRACTICES:

Reduce non-point source pollution
Protect soil resources
Improve animal and plant health

THROUGH

Erosion and sediment control
Animal Waste Management
Fertilizer Management
Pesticide Management

So we need to be able to find a balance between the benefits farms provide Vermonters and the concerns associated with farm operations to ensure the continuance of the working landscape while maintaining water quality. The Accepted Agriculture Practices or AAPs were developed by the Vermont Agency of Agriculture to provide guidance to farmers as to what management practices will help strike that balance between farming and water quality. The Vermont Association of Conservation Districts oversees the Agricultural Resource Specialist Program which offers farmers free technical assistance and information to help them meet the requirements of the Vermont's AAPs regulations (see page 37).

SUMMARY OF AAPS

- Discharges
- Nutrient and Pesticide Storage
- Nutrient and Pesticide Application
- Soil Cultivation
- Agricultural Waste Management
- Buffer Zones
- Construction of Farm Structures
- Ground Water Quality
- Stream Bank Stabilization

The AAPs are a statewide set of rules designed to reduce non point discharges through implementation of improved farming techniques versus investment in expensive structures and equipment. These practices will maintain the health and long-term productivity of the soils, water, and related plant and animal resources and reduce the potential for water pollution. Farmers who participate in these practices benefit in that they are able to maintain, and possibly increase, their investments of land, soil applications and the health and vigor of their crops.

Farms that must follow the AAPs are animal farms (dairy, horse, livestock), food producers (vegetable, orchards, maple syrup) and greenhouses, crop farms (hay, corn, pasture) and Christmas tree farms. While the AAPs apply to all farms it is important to note that there are certain circumstances under which an exception can be made. Permission for any exception when warranted is granted by the Vermont Agency of Agriculture prior to the activity.

1. Discharges

Discharges that flow directly into the river can occur through different sources, whether directly from a pipe or culvert, or indirectly from erosion. Both forms of discharge can have an immediate and withstanding effect on water quality. Direct discharges can introduce concentrated and lethal amounts of toxins to macroinvertebrates, fish, and other river species especially at the point of discharge. Indirect discharges in most cases are caused by the effects of water erosion and therefore are diluted. However, these discharges can have dramatic effects as they have the potential to cover a greater area, and once they enter a waterway, build up over time. The main rule for discharges directly into a waterway is quite simple: there can be none. This means no wastes may enter a pipe or ditch and conveyed to surface water. Agricultural practices to control runoff from barnyards, manure storage areas, and pastures are more defined and are discussed further.

Eliminating discharges on farms also includes ensuring that the manure produced by agricultural operations does not run off site to surface water, groundwater or across property lines. Some farms have installed concrete barnyard areas that slope to a grass waterway or are scrapped into a manure pit to keep the manure from entering surface water. In addition, insuring that barnyards or manure storage areas are safely located or "setback" from the waterways is another practice. Further on, we'll discuss this same practice and the recommended distances that pesticides and manure can be applied.

Another method to reduce erosion is to leave stream banks in their natural state and reduce the impacts from agricultural operations. Maintaining or planting native trees, shrubs and other perennial vegetation is a significant approach in protecting stream banks from erosion, equipment damage, or livestock trampling.

While it is not illegal for livestock to have access to streams it is a best to limit their access and their possible impacts on the native vegetation and stream banks. The AAP guidelines suggest using fencing and watering tubs, and to create designated stream crossings to minimize the effects of trampling. These guidelines are also beneficial in that it helps prevent leg and hoof injuries from excessive time spent standing in deep muddy areas or walking down steep and rocky inclines to get to the water.

2. Nutrient and Pesticide Storage

The second section of the AAPs has to do with nutrient and pesticide storage and application. The term "nutrients" include manure as well as commercial fertilizers which contain essential elements for a plants growth and longevity (such as nitrogen, phosphorus and potassium - NPK) and other inert materials. "Pesticides" is a generic term for herbicides, insecticides, fungicides and other agricultural chemicals.

There are three storage rules that must be followed on the farm:

- Store nutrients and pesticides where they are not subject to inundation and overland flow
- Manage manure storage to prevent discharge or structural failure
- Adhere to minimum storage separation distances

Minimum Storage Distances	
Distance from manure stacking, nutrient and fertilizer storage to private well	100 feet
Distance from manure storage to property line	100 feet
Distance from manure stacking to surface water	100 feet

These setback distances are recommendations to follow. Minimum distances will not ensure 100% that there will be no impact from nutrient and pesticide storage, but they do provide a significant level of protection under most conditions. When possible these distances should be maximized as space allows.

3. Nutrient and Pesticide Application

Just as there are guidelines that cover the rules governing the *storage* of nutrients and pesticides, there are also rules regarding the *application* of these materials in the field. First and foremost, soil tests should be taken every five years to determine the amount of nutrients to be applied in any given season. This ensures that nutrients applied to any given field are taken up by the crop and not available for runoff to surface water or leaching to groundwater where they are problematic. Leaf and manure analysis may help improve recommendations for nutrient application but they are not required.

- Soil tests taken every 5 years
- Use soil test recommendations to determine application rates
- Soil test recommendations may be amended by results of manure and leaf analysis

Minimum Application Distances	
Distance from manure application to surface water	10 feet
Distance from manure application to *point of runoff*	25 feet
Distance from manure application to private well	50 feet
Distance from livestock pasture to private well	50 feet

Applications of nutrients must be consistent with a nutrient management plan if the farm is required to have one. Small farms are generally not required to have a plan unless they have specific contracts with the USDA. All medium and large farms which will be discussed later must have a nutrient management plan and follow it.

Farmers using manure as a cost saving fertilizer are subject to the same guidelines for nutrient application. If land applied with manure is subject to overland flow, the manure must be incorporated within 48 hours (except for no till or cover crops). Manure cannot be applied between December 15 and April 1. This rule prevents the release of large quantities of manure which can flow over the top of frozen ground and then be released directly into surface water when a fast thaw occurs.

There are circumstances under which exemptions are granted. For example, if the ground has not yet frozen by December 15 the Vermont Agency of Agriculture may extend this deadline; or if a farmers pit has filled up in late March and in jeopardy of overflowing, an alternative stacking site may be allowed. As with all exceptions this must first be approved by the agency. It is interesting to note that while Quebec shares this same requirement, New York does not and we share our largest lake, Lake Champlain, with them.

As with nutrient and pesticide storage, the setback distances for nutrient applications are minimums and where common sense and specific scenarios dictate they should be increased. The first three distances are for mechanically spread nutrients and the fourth is animal application. For pesticides, follow the label as each pesticide has specific distance requirements and always obtain proper certification from the State when necessary. If a pesticide does not specifically list a setback than these distances would apply.

4. Soil Cultivation

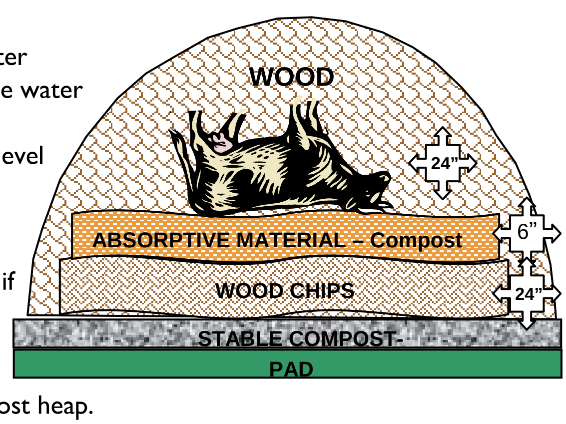
Different soils and different cultivation practices result in different amounts of soil loss potential. For example, plowing against the contour on a steep slope in a field with light fluffy (silty) soils will result in higher soil loss potential than using a cover crop on a flat clay soil in the valley. The amount of soil that can be lost each year and still maintain its productivity is referred to as soil loss tolerance or commonly referred to as "T". For all farms, maintaining less than 2T or 2 times the soils loss tolerance for that specific field under specific soil cultivation practices is required. This calculation can be obtained from the USDA or the Agency of Agriculture. For more information on soil cultivation, contact the local NRCD.

5. Agricultural Waste Management

There is some interpretation required for some of the AAPs. What is deemed appropriate for storage, handling and disposal of one waste may not be appropriate for another. If the waste product has a label, what is appropriate should be clearly marked. The Solid Waste District, Department of Environmental Conservation, Conservation District, or the Agency of Agriculture are excellent resources for providing guidance when there is no label.

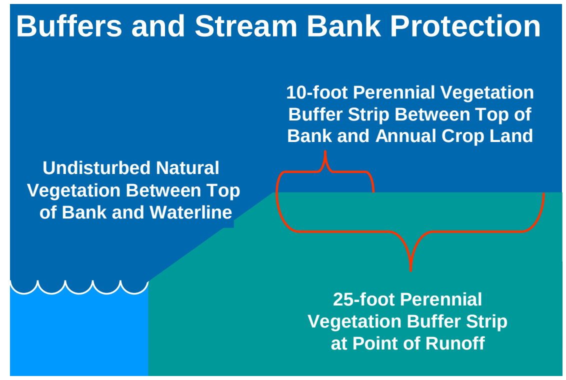
Animal mortalities in need of disposal are considered an agricultural waste. Composting or burial of dead animals are both acceptable practices but they need to be done properly. The AAPs prescribe guidelines for burial of animal mortalities. These are:

- ♦ Maintain 100 feet separation from property lines, wells, and surface water
- ♦ Do not compost on land subject to overland flow from adjoining surface water
- ♦ Establish composting site at least 300 feet from neighboring domiciles
- ♦ The bottom of the grave should be 3 feet ABOVE seasonal high water level
- ♦ Cover carcass with at least 24 inches of soil



An instructional video produced by the Vermont Association of Conservation Districts shows step by step process for composting animal mortalities which if done properly is a tidy, odor free, and nutrient preserving method. A composting pile, when constructed properly, follows the guidelines as stated below to protect water quality. They also help to maintain peace in the neighborhood and prevent domestic animals from interfering with your compost heap.

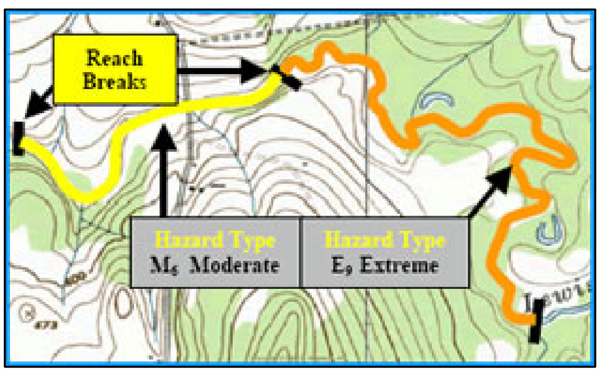
6. Buffer Zones



AAPs outline a demonstrative technique called a buffer zone, to filter out sediments, nutrients and agricultural chemicals, and to protect the surface water from erosion of streambanks due to excessive tillage. Simply defined, a buffer zone is an area of perennial vegetation maintained between the crop land and the top of the bank of the adjoining surface water. There are many definitions and types of agricultural buffer zones. A whole section is dedicated to the explanation of the different types and the methods used to create buffers . (See Vegetated Buffer Strips, page 17)

AAPs require that buffers are at least 10 feet wide between the annual crop land (i.e., corn which is planted and harvested each year) or the edge of a field, and the top of the bank of surface water. The top of the bank is the point at which the ground slopes towards the water. In circumstances where the water runs off a field and gathers to form a concentrated channel in a low spot (point of runoff), then the vegetated buffer needs to be at least 25 feet from the edge of the field to the top of the bank. The buffer must consist of perennial vegetation such as grass or forestland. Farmers can opt to plant hay and in these cases, opt to make the buffer wider to allow for their equipment to cut the buffer crop along the edge of a corn field. This use of the buffer helps balance the need for protecting the water with the need for the farmer to produce enough feed for his animals.

To establish and maintain a buffer, commercial fertilizers may be applied and plowing may occur. However, manure cannot be applied within 10 feet of surface water which means the 10 foot minimum buffer width may not receive *any* manure applications.



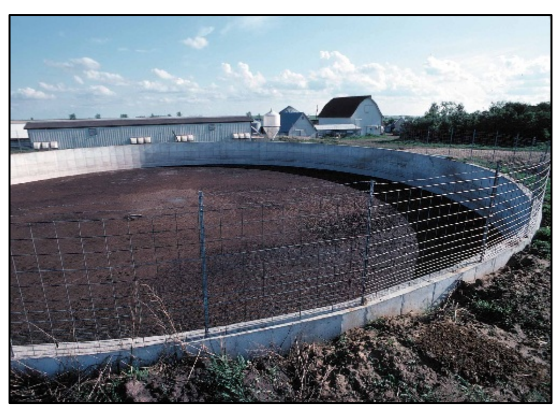
7. Construction of Farm Structures

Any new farm structure needs to be protected from the potential loss or inundation due to flooding. Fluvial Erosion Hazard (FEH) zones are areas adjacent to streams that are at a high to extreme risk of loss due to erosion. Different from a floodplain, the FEH zones, on either side of a stream, are determined by the Vermont Department of Environmental Conservation through a geomorphic assessment of the stream or river. Geomorphic assessment is the process of "understanding the natural tendencies of a stream, its current condition, and what changes may be anticipated in the future." Towns need to adopt these zones through municipal plans and zoning. The FEH zone is not the same as the floodplain.

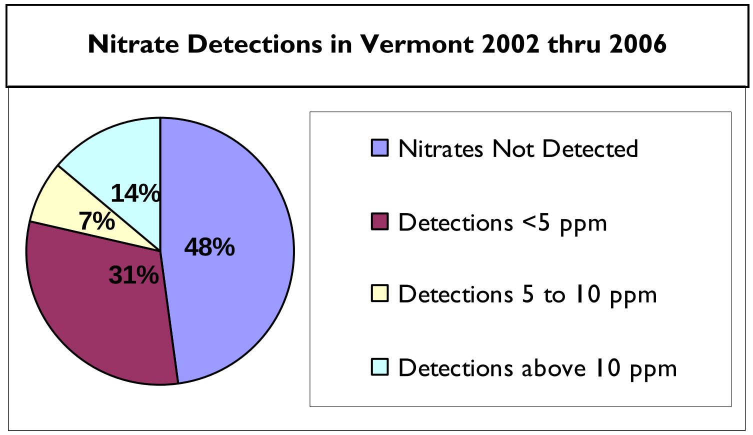
Statewide regulations on construction do not relieve a farmer from local regulations. Prior to construction, the proper town zoning must be in place and/or a town clerk must be notified by farmers. Local set back distances must be maintained for any type of construction, whether it be a storage area or a manure pit, even if they exceed the States minimum standards.

If a farmer wants to build a manure pit, it must be up to the minimum design and construction standards developed by the Natural Resources Conservation Service to ensure protection of water quality. These projects are sometimes eligible for technical and financial assistance from the Natural Resource Conservation Service or the Vermont Agency of Agriculture who recognize the benefit of clean water to all Vermonters.

8. Groundwater Quality



Groundwater resources may also be threatened by farm management practices. Maintaining groundwater quality is equally important as maintaining surface water quality, as many Vermont homes obtain their drinking water from groundwater wells. Therefore, farm operations shall be conducted such that the groundwater resources are protected. The Vermont Agency of Agriculture has operated a groundwater monitoring program for many years and routinely analyzes drinking for nitrates and a commonly used corn herbicide, atrazine. The drinking water standard for nitrates is 10 parts per million (ppm) and atrazine is 3 parts per billion (ppb). Farm operations shall be conducted such that wastes in groundwater do not reach or exceed the standards. From 2002 thru 2006, a total of 625 samples were collected from wells and analyzed for nitrates, of these 48 percent had no detections and 14% were above the drinking water standard.



Of the 14% that did not meet the minimum drinking water standard, those farm operations are required to change their practices and conduct future operations in order to reduce the levels to meet the Preventative Action Limits (PALs). The PALs limits are lower than the drinking water standard; nitrates = 5 ppm and Atrazine = 1.5 ppb. Ways to decrease the amount of nitrates reaching groundwater might include installation of infrastructures, such as a lined manure pit, or better management of manure and commercial fertilizers through the development of a nutrient management plan.

9. Stream Bank Stabilization

Streams have a natural pattern of development. However, changes in land use and alteration of streams for residential and commercial purposes have caused streams in Vermont to abort their natural pattern of development. The result is accelerated erosion and stream channel migration. In some cases, it is determined that the best course to protect land and buildings is to stabilize a section of stream bank using a variety of techniques such as stone ***rip rap***, ***rock or tree veins***, or ***tree revetments***. These practices must be done in accordance with the USDA NRCS or State of Vermont standards.

Enforcement of Accepted Agricultural Practices

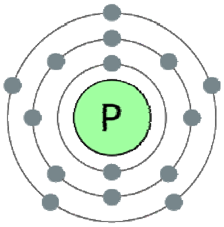
These AAPs are intended to be protective while not being overly burdensome on the farm operator. Outreach and education of agricultural land users is the best tool for bringing about these practices on all farms. However, there are situations which may arise that require a stronger incentive for compliance. The Vermont Agency of Agriculture has 5 Field Agents who follows up on complaints and investigate claims of AAP violations. They will work with a landowner to rectify the situation but when voluntary efforts cannot be obtained the Secretary of the Agency can levy stiff fines and penalties for violators.

Farm Size: Medium Farm Operators and Large Farm Operators

When it comes to water quality protection rules on farms, size matters. As was discussed, all farms must comply with the AAPs just reviewed. However, larger farms create unique situations for larger areas of trampling, more manure in a concentrated area, and greater surface areas of barn footprints. Therefore, the State of Vermont has established additional requirements for larger farm operations. These include Medium Farm Operations (MFOs) and Large Farm Operations (LFOs).

Medium Farms Operations *(MFO)*
It is estimated that there are approximately 150 MFOs in Vermont. The MFO program is new to Vermont as of 2007. An MFO is a farm with 200 or more mature cows (different number criteria exist for beef, pigs, chickens, etc.). These farms are required to have a general permit which includes a Nutrient Management Plan (NMP).

Large Farm Operations *(LFO)*
The LFO program in Vermont has been established since 1997. These farms are defined as having 600 or more mature cows (different criteria for beef, pigs, chickens, etc.). As of January 2008 there are just 18 in Vermont; 16 of these are dairy operations, one is a poultry operation and one is a beef operation. LFOs are required to have individual farm permits from the Vermont Agency of Agriculture.



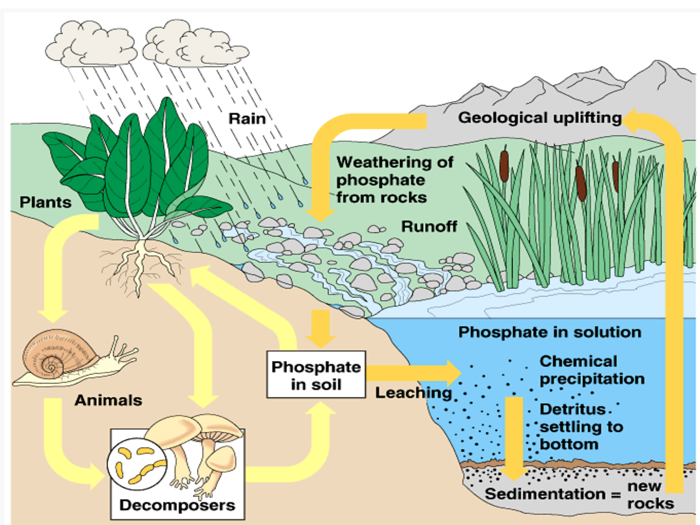
PHOSPHORUS

The basis for the Accepted Agricultural Practices (AAPs) were founded on the evidence that a non point pollutant, phosphorus, is a major contributor to nutrient enriched waters which have caused an increase of undesirable algae, fish kills, and human illness. On a national level, "The state reports indicate that agriculture impacts 48% of impaired river miles and 41% of impaired lake acres." (EPA, 2002) On a state level, a 2001 study "determined that 38% of the NPS phosphorus load to Lake Champlain is derived from agricultural activities." Because agriculture has a significant historical presence here in Vermont, it is of no surprise that state water quality assessments have identified agriculture as a significant contributor to NPS pollution. This isn't to say that all waters are impaired or that agriculture is the only contributor to NPS pollution but it does require us to apply the best management systems possible on the working landscape.

Although the act of agriculture can contribute to phosphorus pollution, agricultural and forest lands also have the ability to absorb and process potential pollutants; urban and commercial development often does not have this capacity. Forest lands and agricultural lands are permeable in that water is absorbed, filtered and slowly released. Impermeable surfaces, such as parking lots, roofs, and roads do not absorb water and instead pick up pollutants and allow water to wash away into a nearby stream or indirectly via storm drain systems. Once the agricultural or forested landscape is lost to development, we also lose its storage capacity. For this reason it is important to protect the working landscape AND follow AAPs.

Over the last century, the use of phosphorus-based fertilizer increased dramatically to enhance the soil fertility and achieve maximum possible yields of crops. Originally, phosphorus was thought to be immobile in soil and could not be applied in excess for a crop's requirements. However, studies found that an excess of phosphorus accumulations in the soil can be lost by leaching from subsurface waters or eroded by surface waters. These losses do minimal harm agronomically but can have a very large impact on water quality.

What is phosphorus? Phosphorus is a naturally occurring element and the letter P represents the 15th element on the Periodic Table. This element originates in bedrock and is released into the environment as the bedrock weathers and breaks down. Without P we would not be here; it is essential for all forms of plant and animal life. Without a minimum amount of P a plant cannot grow and develop regardless of how much other nutrients, such as nitrogen, are applied. While both nitrogen and phosphorus are applied on Vermont's agricultural lands and have the potential to degrade water quality, in Vermont phosphorus is a larger concern.



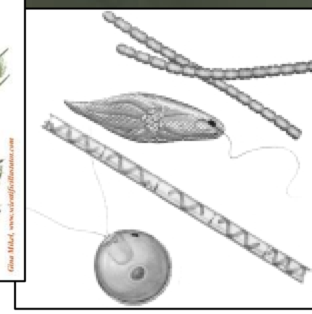
The Phosphorus Cycle

The P cycle is perhaps the slowest in nature. It begins with the weathering of bedrock releasing phosphate which becomes part of the soil. Plants take up the phosphorus and use it for growth and development. Animals eat the plants and part of the P becomes body tissue and part is excreted back into the environment. When animals and plants die, the P in their tissue is then released back into the soil. Some of that soil, along with the P molecules attached to the soil particles, erodes and runs off into the water where they become sediment. As these sediments thicken over glacial periods of time they are transformed back into bedrock. Then the cycle starts all over again with weathering of the sedimentary rocks. This is how the P cycle works when in balance.

Though phosphorus is naturally occurring and essential for life, elevated levels of P can lead to an exponential increase in plant growth, such as algae. Algae are single or multicellular green plants that have no roots or leaves and are a necessary part of the ecology of a healthy lake. They photosynthesize just like their terrestrial counterparts and are an imperative part of the food chain. Algae is a primary producer, the base of a food web, and without algae there are no crayfish or bass in a lake. When excess amounts of phosphorus are present the existing algae population begins to grow rapidly which leads to degraded water quality with detrimental side effects. What was once a healthy population of algae necessary for the food chain becomes an over population of algae forming dense floating mats or slimy filaments.

As exploding populations of algae die, decomposing bacteria increases dramatically. These bacteria then begin to use up all of the Dissolved Oxygen (DO) in the water which fish and other water organisms need for survival. As the DO levels drop so do the fish populations. Decreases in light from the dense growth of algae make it harder for organisms to find prey. The temperature, pH, and turbidity of the water also increase forming an ecological imbalance.

When this ecological imbalance continues at such an accelerated rate, it upsets the entire aquatic community which includes humans. Excess P levels that lead to concentrated amounts of algae and decomposing bacteria can lead to more severe results. Some algae contain neurotoxins which in normal amounts are not harmful but become a significant health hazard in concentrated populations (algal blooms). Red tide is a manifestation of algal blooms that can become toxic. Increases in algae, and algae blooms especially when toxic, creates problems with recreational uses of the lake such as swimming, fishing, and boating. An increase in algae can also lead to more permanent changes by accelerating lake eutrophication.



Eutrophication is the process by which a body of water becomes nutrient rich resulting in increased levels of algae and vegetation that exceed their critical value eventually causing the water body to fill in with aquatic plants. As the growth of algae and vegetation increases, the amount of detritus that is deposited on the bottom of the lake also increases. Some of this plant material is recycled back into the water column but the remainder builds up on the bottom of the lake. This allows favorable growing conditions for more plant growth. As that build up occurs the water becomes shallower and warmer, and deceases the oxygen content that fish and other organisms depend on for survival. Over time, the water quality decreases significantly and fails to support aquatic organisms. The process of eutrophication occurs naturally and gradually in natural environments. Eutrophication can be rapidly accelerated by human activities with the addition of phosphorus (and nitrogen).

Cultural Phosphorus Sources

There are many nonpoint sources that contribute P to cause eutrophication, agriculture being only one. It is important to understand what types of human activities contribute to eutrophication and learn how to minimize phosphorus loading from homes, places of work and within towns. Consumers use phosphorus based fertilizers to produce lush grass lawns, it's found in dishwashing soap and laundry, and P is also found in human sewage treated at municipal plants and on-site septic systems and in pet waste.

Roads and construction projects are other activities that have a potential to significantly add to the nonpoint source of phosphorus. The average Vermont town has 46 miles of dirt roads that can be a significant source of phosphorus depending on how the roads are maintained and upgraded. Vermont's roads and ditches effectively become part of the stream network during a rainstorm or spring snow melt. It is not unusual for these ditches to discharge directly into streams, lakes and wetlands and carry eroded soil with P attached.

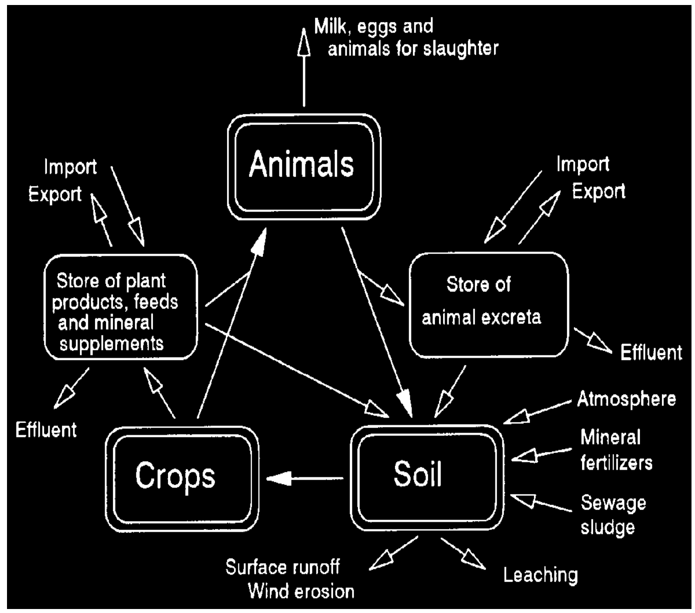
Relatively large areas of soil are exposed to the erosive effects of wind and rain due to the earthwork on construction sites. This eroded sediment is transported by storm water runoff to streams, lakes, ponds and wetlands. It has been estimated that the erosion rate on construction sites can be 500 times greater than that of the same land under a natural vegetative cover of forest or pastureland.

Agricultural Phosphorus Sources

Imbalances caused by excessive amounts of agricultural phosphorus are the result of more feed and fertilizer entering the farm or generated on the farm than is leaving the farm in crops, livestock or other products. Phosphorus is added to commercial fertilizers and feed to ensure adequate nutrient to both plants and animals. Commercial fertilizer is mined from bedrock (what we call rock phosphate) and manufactured in many forms. Manure is another form of fertilizer generated by livestock and it contains large quantities of P.

This schematic diagram shows the pathways that phosphorus travels in a livestock or dairy operation. Beginning with the soil and moving clockwise you can see how P is transferred around the farm but also where it might be exported or imported onto the farm. Phosphorus is added to the soil as a nutrient in the form of manure, sewage sludge from waste water treatment plants, commercial fertilizers and atmospheric deposition. A fraction of the P in soil is taken up by the plant, some remains in the soil, and the remainder is lost to erosion.

The P taken up by plants, such as corn, is fed to the animals. A P loss occurs when animals and animal products are exported off the farm. Crops are often stored in bunker silos, which is another opportunity for P loss; as the crops ferment and moisture leaches out of the bunkers, effluent runoff can occur. Some crops are exported to supply farms where feed production is below demand or to farms with an inadequate land base or growing conditions for a specific feed.



After the animal ingests the crops a large quantity of P is transferred as manure. Sometimes manure is exported off a farm or imported depending on the amount of nutrients needed for crop production and the amount of land a farm has available for spreading manure. Especially for confined feeding operations, it has been generally recognized that more phosphorus is imported onto a farm through feed than leaves the farm through meat and dairy products, run off and/or manure export.

Transport of Phosphorus

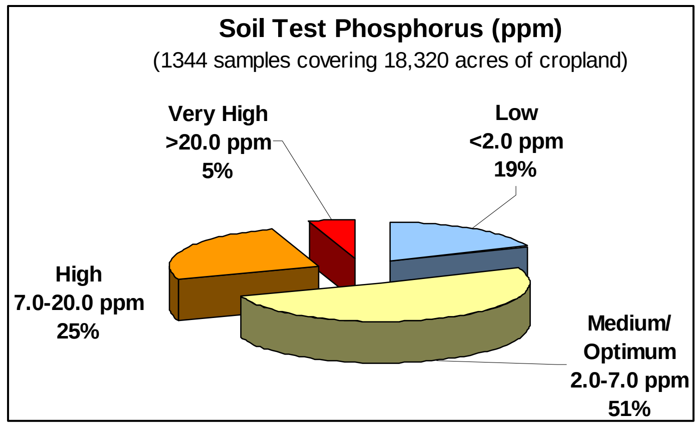
Because P is only mildly soluble and most of the P spread on the land attaches itself to soil particles, surface runoff is "typically the dominant pathway of P loss from agricultural land," occurring through sheet or rill erosion. (EPA, 2002) Sheet erosion (left photo) occurs when rain water picks up sediments and carries sediment gradually. Rill erosion (middle photo) is caused by more intense velocity and accelerated erosion to form small concentrated channels. These types of erosion were found to carry a higher proportion of pollutants. Gully erosion (right photo) is another method of P transportation. Gully erosion is formed when sheet and rill erosion become more severe and unchecked. The largest and more substantial impact from gully erosion is the loss of viable productive land for the farmer.

Another type of erosion is stream bank erosion. The course of a river changes naturally through erosion and deposition over long periods of time. However, erosion can be accelerated unnaturally by the installation of dams and rip rap, channelization, and the removal of natural vegetation along river banks. When the river can no longer flow out of its banks during a flooding event the energy of the water scours the river bed deeper. This scouring or incising exposes large areas of river banks that are easily undercut and eroded by fast moving water associated with floods and spring runoff. As the river bank sloughs off, more P laden sediment enters the water and the landowner loses part of their property forever.

One way that farmers already limit phosphorus inputs is to apply manure in drier weather periods after April, and before the risk of frozen ground in December, to maximize the amount of phosphorus that can be taken up immediately by the soil. Applications of manure on frozen ground during the winter season leads to a substantial increase in sediment (manure) loss from fields during winter thaw and spring melts.

Reducing Phosphorus Soil Tests & Application

To reduce their P sources, farms are required to have soil tests at regular intervals and to manage their fields according to the results and recommendations of the soil test. It is equally important that home owners do the same for their lawns and gardens. Understanding soil fertility is the first step in reducing P. The diagram to the right shows a great example of why soil testing is so important. In 2007, a total of 1344 soil samples were analyzed in Vermont and the results are shown here. The optimum range for P in soil is 2-7 ppm. Only 19% of all samples had P levels in the low range. Fifty-one percent were in the optimum range and 30% of all of these samples were already above the optimum range for plant growth and development. Therefore, only 19% of the total number of samples required additional P fertilizer.



Soil test kits are available by contacting a local Conservation District, a local UVM Extension Office, or the UVM Agricultural and Environmental Testing Lab. The University of Vermont maintains a soil fertility program that includes recommendations that are Vermont specific. The kits include instructions for collecting a representative sample of soil as well as a questionnaire that helps guide the recommendations based on the types of crops grown, previous manure applications, and other agronomic practices. Many farms now have Nutrient Management Plans (NMPs) that consider all the nutrient inputs on a farm, including P, while simultaneously considering soil characteristics. NMPs are another tool used by farmers to protect water quality.

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AgTesting@uvm.edu
www.uvm.edu/pss/ag_testing/

If completed soil tests recommend fertilizer applications, it is important to select the proper type of fertilizer and apply it correctly. Reading and understanding the label is important in choosing the best one that matches the soil test's recommendations and the best method for application. Most common fertilizers contain three major nutrients N-P-K and they *always* occur in this order on a container of fertilizer. These letters stand for Nitrogen, Phosphorus, and Potassium. The designation for the amounts of each of these nutrients is written as a series of three numbers separated by dashes. Each of the numbers represents the percent of each nutrient in that specific container.

As an example, a 10 pound bag of 5-10-10 contains 5% N or 0.5 pounds of N, 10% or 1 pound of P, and 10% or 1 pound of K. The other 7.5 pounds are often referred to as "fillers" or "carriers" and generally considered "inert" or inactive. Since P never occurs in nature as a pure element the 1 lb of P really refers to 1 pound of phosphate P_2O_5.

When to Test Soils?

Requirements of the AAPs:
Small Farms every 5 years
Medium and Large Farms every 3 years

Best for Lawns and Gardens also

There are many ways to apply fertilizers and the correct equipment depends on the size of the application (backyard or corn field), the formulation (liquid versus granular), and the method of application (band versus side dress versus broadcast). The only way to ensure proper rate of application is to make certain that the equipment has been calibrated for this criteria: rate, method, formulation. Excess fertilizer use is expensive, can damage the target plant and poses a threat to water quality both by runoff and leaching.

Weather conditions play a significant role in the absorption and effectiveness of the applied fertilizer. A gentle rain following an application may help move the fertilizer to the root zone more quickly but a torrential downpour will wash it away before it has a chance to be effective.

Precautions must be taken to avoid spreading fertilizer in sensitive areas. These include the edge of fields where drainage ditches could potentially capture and transport excess fertilizer. As discussed previously under the AAPs section, setback distance guidelines must be followed. In lawn applications, avoid spreading near storm drains that often discharge directly into a stream or lake. Many of our large cities' storm water and sewer lines once flowed into a waste water treatment facility but now are separated and have a direct line to surface water.

Manure is a common form of fertilizer applied to farm fields and vegetable gardens. All manure is not created equal. Animals that are fed grains produce different potency manure than all-grass fed livestock. Also, liquid manure and solid or semi solid manure have different characteristics, which is why a manure test, like a soil test, is an important step in reducing the amount of P. The UVM Lab, USDA, NRCS, and Conservation Districts can supply kits for manure analysis.

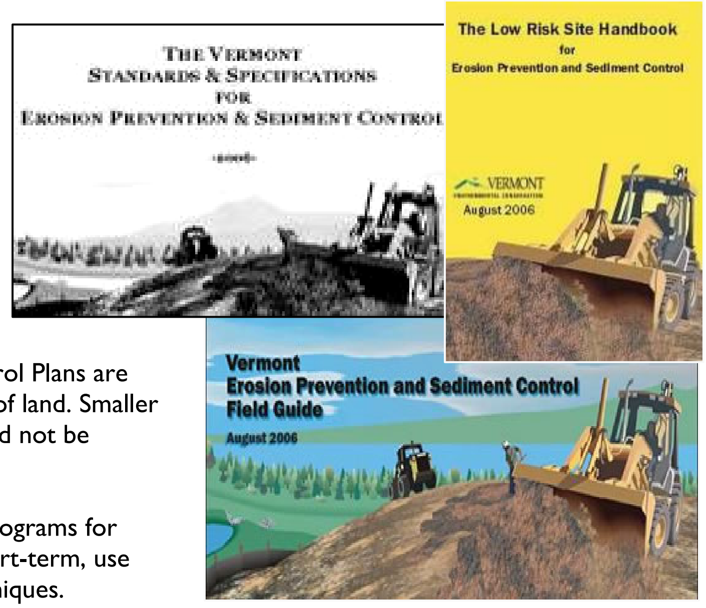
Many farms have developed Nutrient Management Plans which help a farmer plan for fertilizer and manure applications on a field by field basis. Following these plans and making necessary adjustments will save money on fertilizers and reduce the potential for excessive P applications. For the most part manure has equal parts of P and N requirements; however, because plants take up 2 to 5 times more N than P it is easy to apply too much fertilizer if the application is based on the N need of the crop. To correct for this, farmers are turning to P-based manure applications using the Nitrogen Leaching Index and the Phosphorus Index.

Erosion Prevention

There are many opportunities for landowners to reduce or prevent erosion on their property. The USDA, the Vermont Agency of Agriculture and local Conservation Districts offer financial incentives for landowners to apply these management practices in an effort to improve water quality. Farmers can use different cropping methods such as no till corn, cover cropping, and contour cropping. Other tools used by farmers include fencing animals out of the streams and designating stream crossings where trampling by livestock and equipment wears down the protective vegetation. These tools prevent muddied feet and stuck equipment while reducing the amount of P entering the water and preserving the natural fertility and productivity of the soil.

Farmers and non-agricultural landowners, who are just as important in reducing erosion on their land, can also create buffers to prevent soil from moving off fields. There are a variety of local, state and federal partnerships that offer incentive programs which provide technical and financial assistance for landowners of all types who are willing to create vegetated buffer strips adjacent to the water resources.

Although reducing erosion away from surface water bodies is important, it is critical to also manage culverts, drainage ditches and construction sites which are all at risk for erosion and can significantly contribute to the transportation of



phosphorus into larger water bodies, ultimately ending up in Lake Champlain. Maintaining stone-lined or vegetated ditches are two ways to minimize erosion from drainage ditches. For more thorough examples of how these contributors are being addressed, the Vermont Department of Environmental Conservation (DEC) has recently developed technical and educational materials (See Manuals in Bibliography) to assist consultants, land owners, and contractors limit erosion on construction sites. Storm water discharge permits and Erosion Prevention and Sediment Control Plans are now required for projects that will disturb one acre or more of land. Smaller projects can still contribute to our erosion problem and should not be neglected by equipment operators and landowners.

The River Management Program of the DEC has developed programs for stream restoration which, although more expensive in the short-term, use balanced and stable science-based natural channel design techniques. Stabilization of stream banks can tremendously reduce the amount of erosion that occurs in Vermont. Funding for these types of improvements are available through USDA, Vermont Agency of Agriculture and the DEC.

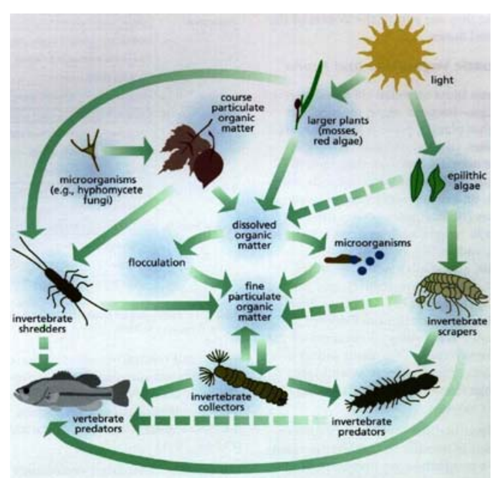
In addition to "fixing" unstable sections of stream banks, the protection of river corridors from encroachments that would lead to channel adjustment is a relatively cost-effective phosphorus control measure. The Vermont River Management Program has developed a mapping methodology to describe local fluvial hazards. The information provided is useful and important to any type of community planning process. Fluvial Erosion Hazard zones are being considered in an increasing number of Vermont communities as a way to provide long term and financially feasible water quality protection.

VEGETATED BUFFER STRIPS

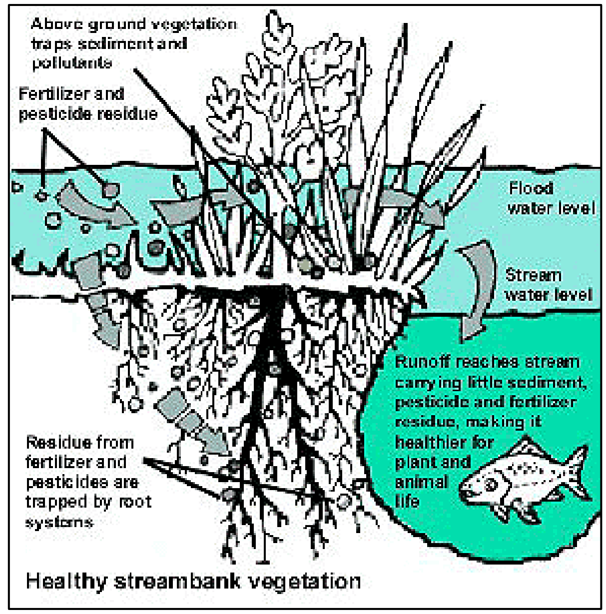
Outlined in the AAPs, Vegetative Buffer Strips (or Buffer Zone) are required to be "maintained between cropland and adjoining surface waters." They are defined as an area of perennial vegetation between the edge of annual cropland and the top of the bank of the adjoining surface water. There are a number of terms used to describe this vegetated area, or buffer, and in some cases it depends on the use. There are buffers for backyards, forestland, habitat, and urban areas. There are also buffers for lakes and ponds and different requirements for each. Scientists have found that in the absence of vegetation, waterways become eroded, polluted with sediments and chemicals, are void of animal and aquatic life, degrade the water quality downstream and negatively affect the cycle of life in the river. Here are two definitions that describe their function:

Filter Strip is an area of grass or other permanent vegetation used to reduce sediment, organics, nutrients, pesticides, and other contaminants from runoff. (USDA)

Buffer Strip refers to a barrier of permanent vegetation between waterways and land uses such as agriculture or urban development. (VT DEC)



Buffers are an effective tool to maintain water quality but they also serve other valuable functions. Most notably, buffers reduce the amount of topsoil lost from erosion. The loss of topsoil reduces the effectiveness of the soil for plant growth and in turn costs are increased to maintain healthy productive soils. Fertilizers and pesticides are often used to replete the soil's potential. Improperly applied amendments in combination with erosion can result in non-point source pollution. In effective buffers, 50%-80% of dissolved nutrient and pesticide runoff filters into the soil where it is broken down by microbes and then recycled back into the vegetation. This is especially true with nitrogen which is highly soluble and can be filtered and recycled easily in the right conditions. Seventy-five to ninety percent of phosphorus, which is tightly bound to soil particles and has an increased chance of erosion, can be trapped *before* sediments enter the stream with the proper buffer type.



Buffers also help maintain stream bank and stream bed stability during normal seasonal flooding events by absorbing surface water runoff and slowing water velocity. Vegetation, especially trees and shrubs in buffers, deflects the cutting action or scouring of waves, snow melt and ice on the river banks. Buffers prevent erosion from overland stream flow when a river flows out of its banks and runs across the landscape and prevents soil from the landscape from flowing back into the river as the flood waters recede. They also help maintain the stability of the river channel both in depth and in width and decreases the scouring of the river bed and sides.

For more information on the ecology of buffers, go to the Floodplain Forest Section from:

Wetland, Woodland, Wildland: A Guide to the Natural Communities of Vermont. *by E.H. Thompson and E.R. Sorenson.*

An electronic version can be found in the VT Fish and Wildlife library on the internet.

Ecologically, buffers serve a variety of purposes that benefit species that are adapted to live in these environments as well as people, who use buffers in more ways than one. Mature trees and some taller shrubs provide shade over the water which maintains temperatures, leading to higher oxygen levels that are conducive to wild fish populations and other aquatic life. Natural vegetation within a buffer is often unique in that it is adapted to grow near water. Some of these adaptations include a hardiness to overcome flooding and an ability to withstand wet roots. Species such as dogwood, willows, and red maples share these qualities. In turn, particular wildlife species are also adapted to these types of conditions. Animals such as the water shrew, mink, and barred owls are residents of river edges. In the river itself, macroinvertebrates feed off leaf, bark and twig litter from the buffer and the fish feed on them—on shore and in the water, buffers add to the diverse flora and fauna of a stream system. Not just a home for permanent residents, buffers are an important migratory corridor, used by temporary residents for feeding and drinking. Insects, birds, and mammals use buffers as a travel corridor, linking habitats across the landscape. Buffers are also a site used by fishermen, boaters, and often a favorite swimming hole is accessed by a shaded buffer.

There are a few attributes one must consider when creating or maintaining an effective buffer for its particular function. There are several different guidelines which suggest or in some cases dictate the appropriate width of a buffer for specific purposes such as an agricultural buffer. It is important to recognize that the required minimum buffers may not always provide adequate protection of the water resource and should be evaluated on a case by case basis. The type of land use adjacent to the buffer and the characteristics of the topography, hydrology, and soils can decide the width and the vegetation best suited for the buffer. Depending on the function of the buffer it is best to consider these attributes and how each interrelates with the other:

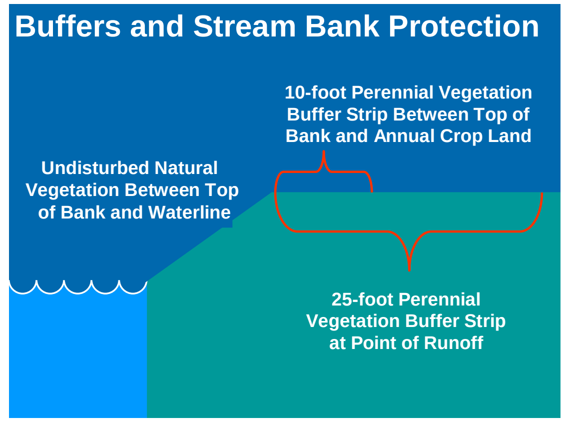
- Current geomorphology stage
- Buffer objective and associated width
- Vegetation type
- Adjacent land use and buffer connectivity
- Topography
- Hydrology and Soils

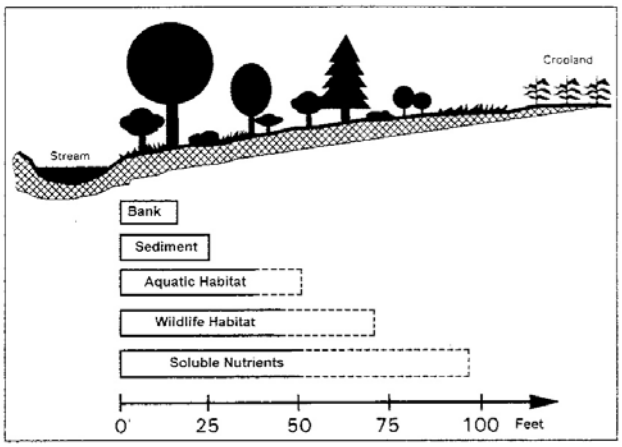
Current Geomorphology Stage

It is important to determine at what stage of channel evolution the river is to ensure that investing (plants and labor) in a buffer is the most appropriate tool for the specific site in question. Assessing the present stream condition, how sensitive it is to disturbance, and how the stream might adjust to a disturbance is necessary before approaching a management process. For unstable reaches of a river, the chances of losing the buffer to erosion are significant and would result in a complete loss of the project or may require planning for some erosion and thus planting the buffer with a setback. For unstable reaches, another option such as bioengineering or a corridor easement may be a more appropriate tactic. Using up to date fluvial geomorphic studies to target, select, and prioritize buffer programs informs and guides landowners in the decision making process.

Buffer Width

The Acceptable Agricultural Practices (AAPs) require a 10 foot wide vegetated buffer between the top of the bank and annual crop land (e.g. corn fields or vegetable and fruit plots). If there is a point within the field and buffer where the runoff flow is concentrated and the point of runoff is obvious, then an additional 15 feet of vegetated buffer is required. Medium Farm Operations and Large Farm Operations must maintain a wider buffer than what is required under the AAPs. For these a standard of 25 feet and 50 feet at point of runoff is required.





Although there are generally no requirements for buffers on residential land unless dictated by local zoning or ordinance, buffer widths and their associated benefits are illustrated in the diagram to the left. The wider the buffer, the greater the benefits for preventing erosion, creating aquatic and wildlife habitat, and for absorbing soluble nutrients. For buffers on residential or commercial parcels, landowners may also want to consider aesthetics and access.

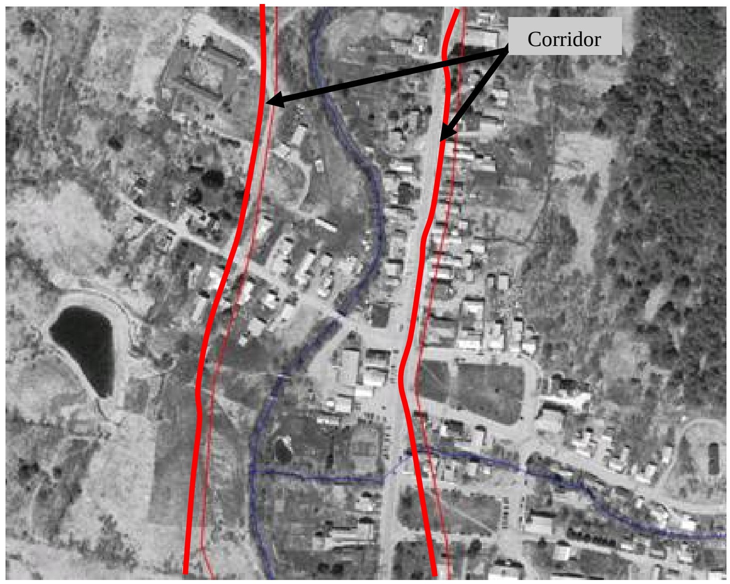
Vegetation Type

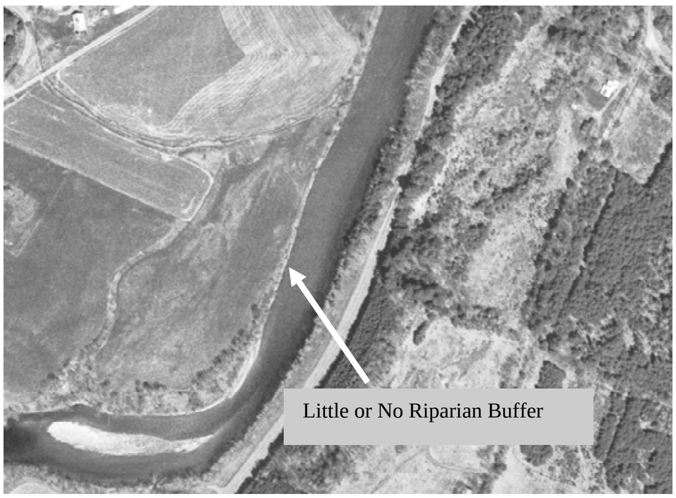
Basically there are two types of vegetated buffers, those with perennial grasses and those planted or naturally forested with shrubs and trees. ***Perennial Grass Buffers*** are often associated with agricultural land and can be harvested annually. A majority of buffers are referred to as ***Riparian Buffers***. Any buffer along a stream is technically a riparian buffer since riparian means "relating to or living or located on the bank of a natural water course". A riparian buffer is commonly used to describe a wooded buffer as opposed to a grass buffer.

The type and height of the vegetation effects how much and how well it can trap and slow runoff, grass versus shrubs versus trees. Some studies have shown that increasing the height of the vegetation as it approaches the stream bank delays the initiation of runoff into the stream allowing more time to infiltrate and also reduces the amount of nutrients reaching the stream. Grass has a dense sod which is effective at holding soil in place and trapping sediment as it moves from the land towards the water but it lacks the deep root systems of trees. Slow growing trees, with their deep root systems, can help stabilize stream banks against the erosive energy of fast flowing water during rain events or spring runoff while providing critical shade to keep water cooler and provide fallen branches that create favorable aquatic habitat conditions. Shrubs may not develop as sturdy or extensive a root system but they often grow fast and tend to form clumps which amplify their effectiveness. In all cases it is widely encouraged to use native riparian plants in a buffer as they are best adapted to these unique sites and provide the greatest benefit to native wildlife.

Adjacent Land Use & Buffer Connectivity

To receive the best benefits from a buffer, consider the type of adjacent land use. Whether the land is forested, a farm field, road, or residential will influence the permeability of the surface, or how well the water soaks into and over the ground. More permeable surfaces such as forests and grasslands intercept and slow the velocity of water, hence preventing the sediments and nutrients from entering rivers. If the adjacent land contains a high percentage of impermeable surfaces (pavements and roof tops) then the amount of water carried towards the stream and the velocity at which it travels will be higher. Impervious surfaces, especially those in found in business and residential areas, often carry chemical toxins such as fluids and emissions from automobiles and thus create different water quality problems.

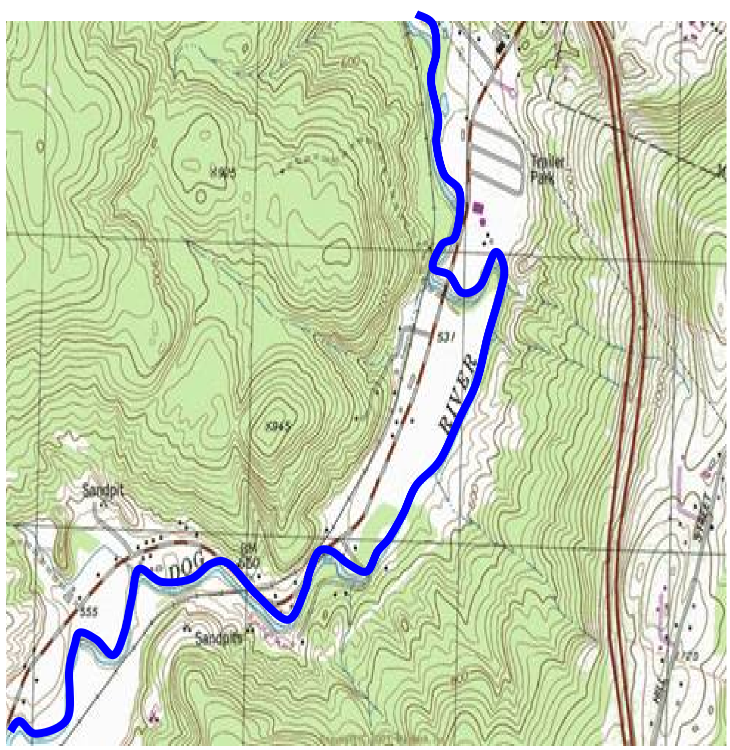




A contiguous buffer that increases the overall connectivity of the riparian habitat along a river is more effective and a highly regarded objective. A gap within a mostly vegetated bank is a weak point in the buffer that disrupts the ecological connectivity within the riparian corridor. Within this gap, the existing buffer can be undermined leading to concentrated amounts of runoff that has a potential to create rill or gully erosion. Gaps also disrupt the dispersal and colonization of native plants and animals. If left unchecked these areas are prone to the establishment of invasive plants. Reestablishing the gaps within the buffer accelerates the potential for native plants to establish within this protective habitat, and in turn, create a more manageable and beneficial river corridor.

Topography

Knowing the ***topography***, the surface features and their relative positions and elevations, gives a frame of reference for the river itself and thus the objective properties of a buffer. Features such as slope and the size of the watershed area contributing runoff to the buffer are aspects to consider when maintaining or creating a buffer. For instance, slow shallow streams may be acceptable with grass buffers, while steep flashy streams with high energy flows during rain events would benefit from the strong root systems of mature trees in a buffer. Observing the regional aspects such as valley slopes is important also; a steep walled valley, for example, will transmit water to a stream faster than a wide flat valley. Smaller aspects such as small hummocks and undulations in the land near the stream are also significant. If the land adjacent to the stream is flat and dips towards the stream, there will be more stress on the buffers effectiveness than a rough hummocky landscape which slows and dissipates high energy water flows.



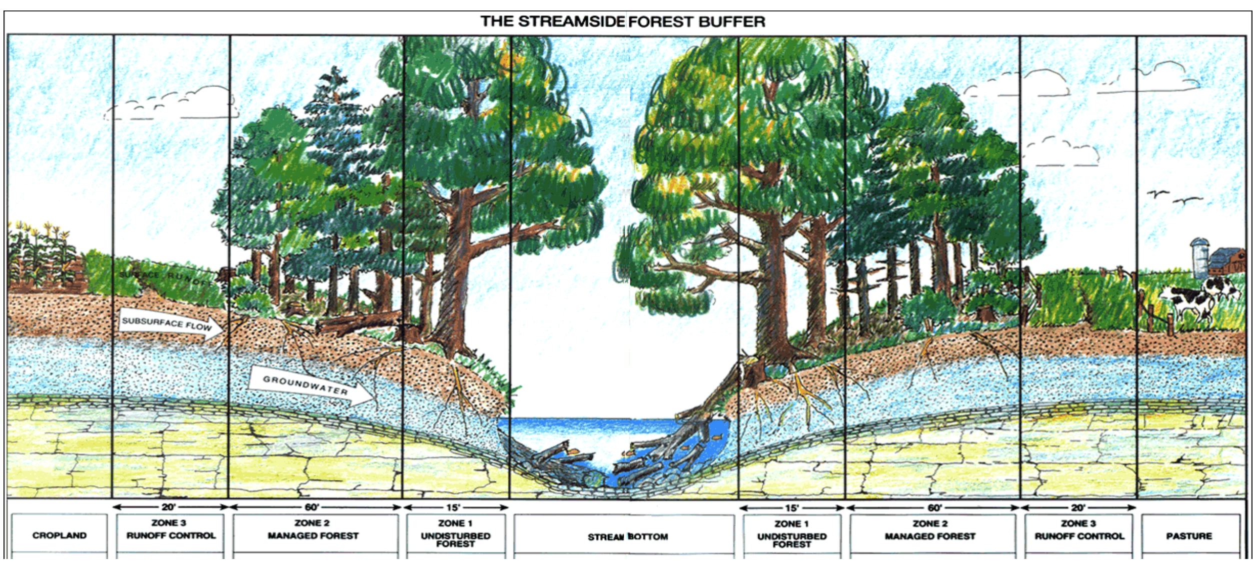
Hydrology and Soils

The ***hydrology*** or the movement of water throughout the watershed will determine how effective a buffer will be in protecting for water quality. Climate, geology and soils, and vegetation interact with, intercept, and transpire the water within the buffer locale. Investigate the moisture holding capacity of the soil, if the soils in a buffer are fairly wet with a high percentage of clay then their ability to absorb moisture is diminished and therefore a wider width or higher density of plants for the buffer can be a solution. Well drained sandy soils will have faster infiltration rates than heavy clay soils so a narrower, grass and shrub buffer might suffice. Climate is another important aspect. The rate at which rainfall occurs is highly correlated with the amount of runoff. Therefore, a high intensity rainfall will produce more runoff and reduce the effectiveness of the buffer than a low intensity rainfall because the rain is falling faster than can be absorbed by the soils.

Buffer Zones

Ideal buffer zones are easily found in areas that have not been manipulated by human development or encroachment but it is becoming more common to see these natural communities replicated in buffer restoration projects. Construction of buffer restoration projects can include minor grading of an area either to slow flow through irregular micro topography, or to shape the stream bank to allow for seasonal inundation where scouring and undercutting is a serious undertaking that requires the technical expertise of river scientists and environmental engineers. An ideal buffer would incorporate all these different parameters and have three distinct zones of vegetation.

- Zone 1: Contains mature trees and shrubs that provide shade and have robust root systems to maintain bank stability and support a healthy wildlife ecosystem.
- Zone 2: Consist of trees and shrubs that pull nutrients up through their root systems sequestering P and N. Some management of vegetation could occur in this zone so long as the functions of the zone are not compromised.
- Zone 3: Strips of tall grass that traps sediments and dissipates the energy of the flow of runoff slowing it down enough to allow for some infiltration.



River Bank Bioengineering

After understanding the types and functions of a buffer, ***soil bioengineering*** is a type of method used to create or improve buffers that is economically feasible and relatively easy to accomplish with the right tools and manpower. Soil bioengineering refers to a technique using live vegetation to stabilize, control or minimize erosion problems. In most cases, using native species that are adapted to the riparian area, the local climatic conditions and easily located from local sources is best. Planting native species also encourages and benefits native wildlife species. In many cases, when soil bioengineering is used, active erosion is taking place and banks may be severely angled. Because of the cost consideration and the threat of active erosion occurring until plants are established, the vegetation used and planted is opposite from a best or constructed scenario. Therefore, Zone 1 consists of grasses, Zone 2 consists of shrubs, and Zone 3 consists of trees. This allows time for the vegetation in the buffer to establish roots, and a hold on the river bank.

The techniques used for soil bioenginnering are varied and can be complicated depending on the achievable goals and the characteristics of the buffer. A successful soil bioengineering project is a fairly complex design and labor-intensive. Generally, there are three types of methods used live staking, live fascines or wattles, and trenchpacking. The live staking method uses dormant, woody cuttings of riparian species adapted to root quickly. Willows are typical, although shrubby dogwoods and alder can also be used. These species are used for most for the methods discussed here. Eighteen inch long cut stakes are driven into the ground in stream banks of moderate slope and moist soil. Live fascines or wattles are bundles of live dormant branches about six feet long. They are used in banks that are frequented by wash outs and seeps. Working up the slope, bundles are placed in dug out trenches, held in place by live stakes, and then covered over loosely to allow plant growth. Trench packing (or branch packing and brushlayering) and brushrolls again use bundles of live branches except these are placed in small trenches perpendicular to the bank then backfilled with soil. Finally, there is the relatively easy method of planting rooted cutting or live tree and shrub seedlings (bare root, or container grown) on shaped stream banks and in the buffer zone. Seeding grasses or forbs is also an option for areas that are completely denuded of any vegetation.

This is an example of a major river bank restoration project in Vermont. This deeply incised stream was eroding the exposed stream bank contributing extensive quantities of phosphorus laden sediments to the water. Using scientific principles and engineering the land adjacent to the water was shaped such that the stream can over top the banks during high flows rather than continue to scour away the vertical walls that had developed. At present, perennial vegetation has established a solid root system to withstand over bank flooding. When the river has access to its natural floodplain inundation still occurs but the loss of sediment is minimized. Because there are no buildings or roads adjacent to this stretch of river the land can withstand seasonal inundation. One concern for this approach is the financial cost which is prohibitive for all stretches of the river that are severely degraded. However, we can use the simpler management tools of the past and the consideration of well tested geomorphic assessment as a compromised approach to guide future projects and planning.

Vermont Buffer Programs

There are many resources and programs available to landowners adjacent to a stream or river to create and improve buffers. There are currently three cost share programs that are meant to assist landowners to transition the land adjacent surface water into valuable filters and habitats. Representatives are available to help guide and discuss options available for landowners to choose the program that best suits their particular needs. Each program provides initial funding and requires a contract, which the landowner must commit to.

Land enrolled in the federal Conservation Reserve Enhancement Program (CREP) is contracted for either 15 or 30 years and is typically planted into a filter strip and/or a riparian buffer. It is a combined cost share effort between the USDA and the Vermont Agency of Agriculture which leverages adequate funds to compensate a landowner for removing land from agricultural production and committing it to a buffer. There is an upfront and an annual lease payment for contracts of 15 or 30 years. Recognizing that livestock need to have access to water and be able to cross from one pasture to the next, this program also provides 50-100% of the funding for fencing, stream crossings, walkways and watering tubs. The minimum widths for buffers in this program are 25 feet for a grass buffer and 35 feet for a riparian buffer. In the CREP Program, the buffer may not be harvested.

The Vermont Agricultural Buffer Program (VABP) is similar to CREP, in that the Vermont Agency of Agriculture provides financial incentives to landowners for a buffer. Within this program, the contract period is shorter, only 5 years, and the required width is 25 feet. This buffer can be planted or maintained with grass, and harvested for livestock feed. It is possible for landowners to transition from a VABP contract to a CREP contract should they desire.

Trees for Streams (TFS) is another buffer incentive program that is more flexible with regards to buffer size and is an attractive offer for landowners, since it's not limited to agricultural producers. TFS is coordinated among the five Conservation Districts in the Lamoille Watershed and works with landowners willing to enter a perpetual contract in return for an installed buffer. Landowners pay 20% of material cost and the planting itself is accomplished with volunteer labor. Harvesting within the buffer is not allowed.

As with river buffers, lake shoreline buffers are also important for protecting water quality. Both Trees for Streams and the Vermont DEC Lake and Ponds Section works with lake associations and individuals to design and implement shoreline protections. Pesticides and fertilizers from lawn care products and other pollutants coming off roads and driveways have an immediate impact on water quality. Especially true on lakes and ponds, water quality has a direct impact on swim-ability and recreation, aesthetics and property value. Similar to river buffers, shoreline buffers have a 15 foot required width for bank stability. The VT Lakes and Ponds Section recommend buffer widths that are dependent upon the objective of the buffer. There are other required widths of 25 feet for in-lake habitat maintenance, 100 feet for treatment of runoff, and up to 600 feet for on-shore wildlife habitat.

To illustrate the extent of buffers in Lamoille County and the cost of implementing woody buffers along a major river, a 2002 study completed by the Lamoille County Planning Commission reported that there are 43 miles of the main stem of the Lamoille River in Lamoille County. Of these, 57% have some type of woody buffer, 42% has the recommended 50 foot wide woody buffer and 39% has 100 foot wide woody buffer. The cost of planting a woody buffer along the remaining miles includes $24,000 in annual lease payments to the landowners and another $220,000 to purchase and plant the trees. Fortunately, the buffer programs mentioned above have been a great success in educating people about the importance of riparian buffers and each year, more ground is covered with trees and shrubs to protect the future of the Lamoille River.

Glossary

Accepted Agricultural Practices *or* **AAPs** – guidelines established and designated by the Vermont State Legislature to reduce non-point source pollution from farm operations.
Armored (river bank) – an erosion control device in place, such as rip rap used to maintain a river channel.
Channelization – the process of changing (usually straightening) the natural path of a waterway.
Headwaters – the source of a stream or river.
Ecology – the study of the interrelationships of living organisms to one another and to their surroundings.
Eutrophication – the process of enrichment of water bodies by nutrients that leads to excessive plant growth and decay.
Fluvial Geomorphology – the scientific study of how water and earth interact and physically change over time.
Hydrogeology – a branch of hydrology which relates to groundwater, subsurface or subterranean water. Hydrogeology involves the study of the distribution and movement of water below the Earth's surface, especially the distribution of aquifers, groundwater flow and groundwater quality.
Hydrology – the scientific study of the water of the earth, its occurrence, circulation and distribution, its chemical and physical properties, and its interaction with its environment, including its relationship with living things.
Main Stem – the principal channel of a drainage system into which smaller streams or rivers flow.
Nonpoint Source Pollution - pollution which cannot be traced back to a single origin or source such as storm water runoff, water runoff from urban areas and failed septic systems.
Perennial Grass Buffer – is thick sod that holds top soil in place often associated with agriculture and can be harvested annually.
Point Source Pollution –pollution that can be traced back to a single origin or source such as a sewage treatment plant discharge.
Riparian Buffers – the width of naturally vegetated land adjacent to the stream between the top of the bank (or top of slope, depending on site characteristics) and the edge of other land uses. A buffer is largely undisturbed and consists of trees, shrubs, groundcover plants, duff layer, and naturally uneven ground surface.
Rip-Rap – rock or other material with a specific mixture of sizes referred to as "gradation," used to stabilize stream banks or riverbanks from erosion or to create habitat features in a stream.
Rock or Tree Veins – similar to rip-rap but are designed to direct the energy of the river back to the center of the channel by narrowing it and armoring it for a section, reducing scouring.
Soil Bioengineering – uses live plant materials to provide erosion control, slope and stream bank stabilization, landscape restoration, and wildlife habitat.
Tree Revetments – freshly cut coniferous trees secured to the soil at the toe of a river bank with the intention of deflecting currents, reducing erosion, and collecting sediment to eventually support plant growth.
Tributaries – streams that flow into another stream, river, or lake.
Watershed – an area of land whose total surface drainage flows to a single point in a stream.

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