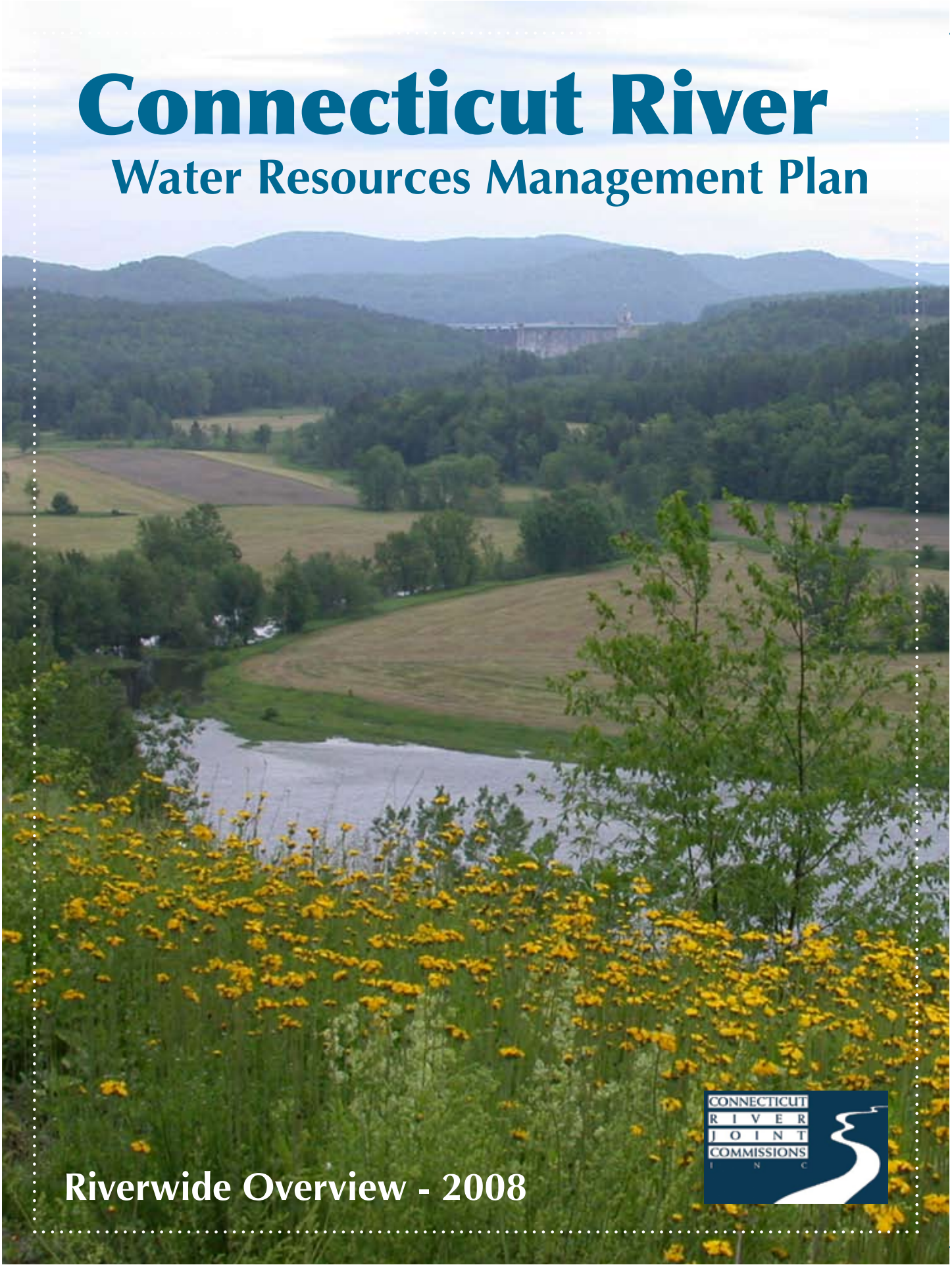
Connecticut River

Water Resources Management Plan



Riverwide Overview - 2008

CONNECTICUT RIVER JOINT COMMISSIONS INC

The Connecticut River, looking upstream from Lyme, N.H and Thetford, Vt.

Adopted CRJC January 28, 2008

Produced with support from the New Hampshire Department of Environmental Services, the National Oceanographic and Atmospheric Administration, and TransCanada Hydro Northeast.

Commissioners thank the many people who attended meetings and commented on drafts of this Plan. We also thank the Staff: Sharon Francis, Executive Director, Rebecca Brown, Communications Director, Barbara Harris, Office Manager, and special thanks goes to Adair Mulligan, Conservation Director, for her work in compiling the Plan.

Appreciation also goes to MajaDesign, Inc for design of this publication, and to XXX for printing.

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Cover image: The Riverbend region in Barnet, Vt.

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I. Executive Summary

The Connecticut River, largest in New England, drains a third of New Hampshire and two-fifths of Vermont, uniting the two states for 271 miles of its 410 mile flow to Long Island Sound. This new Water Resources Riverwide Overview builds upon the 1997 *Connecticut River Corridor Management Plan* and upon the findings of CRJC's five local river advisory subcommittees. It focuses on topics of riverwide importance in the context of climate change and other broad influences upon the Connecticut River watershed.

This plan explores new and continuing challenges to water resources in the watershed. It encourages economic development that is compatible with the well being of the river, and aims to stimulate stewardship and build partnerships across town lines, across the river, and across the array of interests of those who live and work on each side. Many recommendations contained in this plan touch on issues created by competing human interests and environmental needs around the river and its tributaries.

The most fertile soils, most valuable fish and wildlife habitat, and some of the most desirable real estate in the Connecticut River watershed are found along rivers and streams. Shoreland protection is unevenly applied: while New Hampshire has had limited statewide protection in place since 1994, Vermont remains the only state in New England that does not have a shoreland protection law. Development of all kinds, from industry and commerce that seek expanses of flat, open land for building, to house lots marketed for river views, competes increasingly with agriculture for room on riverfront lands, often on floodplains that offer natural flood storage. A town that permits building in its floodplain may be unwittingly creating a public nuisance by contributing to flooding of another community across the river or downstream. Protecting floodplains from development would benefit public safety, agriculture, recreation, wildlife, and scenic values.

Riparian buffers are the river's best hedge against pollution, erosion, and flooding, and its best protection for wildlife. Landowners along rivers and streams should retain and enhance buffers of native vegetation. Towns should apply shoreland and buffer guidelines. The public should support the work of land trusts in protecting riparian lands in cooperation with interested landowners.

Riverbank erosion remains one of the most prevalent and misunderstood problems in the watershed. People cannot completely stop erosion - they can only speed it up or slow it down. Often, their attempts to treat localized erosion moves the problem elsewhere. The best solution is avoidance – choosing a river corridor protection strategy that gives the stream the room it needs to re-establish a healthy equilibrium. Activities in this sensitive area should be limited to agriculture, recreation, forestry, and wildlife conservation.

Stormwater runoff is the most common culprit in contamination of surface water. Anticipating impacts resulting from climate change, town planning boards and commissions should encourage new stormwater engineering practices such as "low impact development" designs,

to reduce runoff and promote stormwater infiltration. New Hampshire towns should survey culverts and bridges to identify those that are undersized and poorly placed for fish passage.

While the federal Clean Water Act and local investments have brought the Connecticut River back from its days as an open sewer, some issues remain and new ones have arisen. Aging treatment plants require expensive maintenance while federal cost-sharing has disappeared. Today's facilities are not designed to remove pharmaceuticals and personal care products from the wastewater stream. Combined sewer overflows in St. Johnsbury and Lebanon mean dangerous pollution after storms and require costly remediation.

Every once in a while it becomes very obvious why it is best to keep polluting uses, like this gas station, out of the floodplain.

Groundwater, one of the region's hidden but most valuable resources, is closely linked both to public health and the health of surface water. Without a policy on groundwater withdrawal, and without adequate aquifer mapping, Vermont remains a target for commercial profit from a public resource. Further effort is needed to protect aquifers from contamination. States should ensure adequate water quality monitoring and continue to work with town conservation commissions and watershed groups to encourage and coordinate volunteer monitoring.

Water withdrawals for irrigation or industrial use can cumulatively affect the flow of streams. While a Protected Instream Flow for the Connecticut River is not imminent, it would be useful to have a means of identifying and controlling water withdrawals during extreme droughts.

There is room to expand river ecosystem and recreation benefits at existing dams and to carefully evaluate the public benefits of new hydropower proposals. There is currently no prescribed ramping rate for releases from Vernon, Bellows Falls, or Wilder dams, and water levels can change abruptly above and below the dams when gates are opened. Ramping rates should be part of their future license, with provisions to allow a "black start" if energy conditions require it. The U.S. Army Corps of Engineers should institute a minimum flow at its flood control dam facilities and create or improve opportunities for fish passage.

The entire Connecticut River valley harbors rich agricultural soils of national significance that stand ready to provide healthy locally grown and distributed food – as long as these lands are not developed. With transportation costs increasing and the possibility of disruption of transportation networks, a sustainable local food supply is a matter of homeland security. Management practices to protect surface waters from pollution are still unevenly applied in the region, despite their clear benefits for the waters that drain farms and forests. Vermont has made great strides in assisting farmers with their efforts to protect water resources, including its Conservation Reserve Enhancement Program. New Hampshire's oversight of water quality impacts from farms is more limited, and Best Management Practices are not treated as requirements. There have been complaints from Vermont farmers witnessing poor practices across the river in New Hampshire, such as winter spreading of manure that was then washed downstream by spring high water.

Invasive plants are spreading rapidly in the region's rivers and streams, although the zebra mussel, despite the proximity of infested Lake Champlain, has not yet arrived. Eurasian milfoil now infests the river from Fairlee south, and a half-dozen other aquatic invasive species have also appeared in the river, especially near Massachusetts. Japanese knotweed, purple loosestrife, and exotic honeysuckle have aggressively colonized streambanks, and knotweed has formed pure stands along many streams. The invasive diatom Didymo or "rock snot" was discovered in the river in 2007.

Acid mine drainage continues to damage Vermont's Ompompanoosuc and Waits River watersheds. Three abandoned mines, all listed on the National Priorities List ("Superfund"), are pernicious sources of pollution that have severely affected aquatic life in these tributaries. The Vermont Congressional delegation should make copper mine remediation a priority, and seek adequate funding for EPA to permit capping and proper stabilization of the tailing piles.

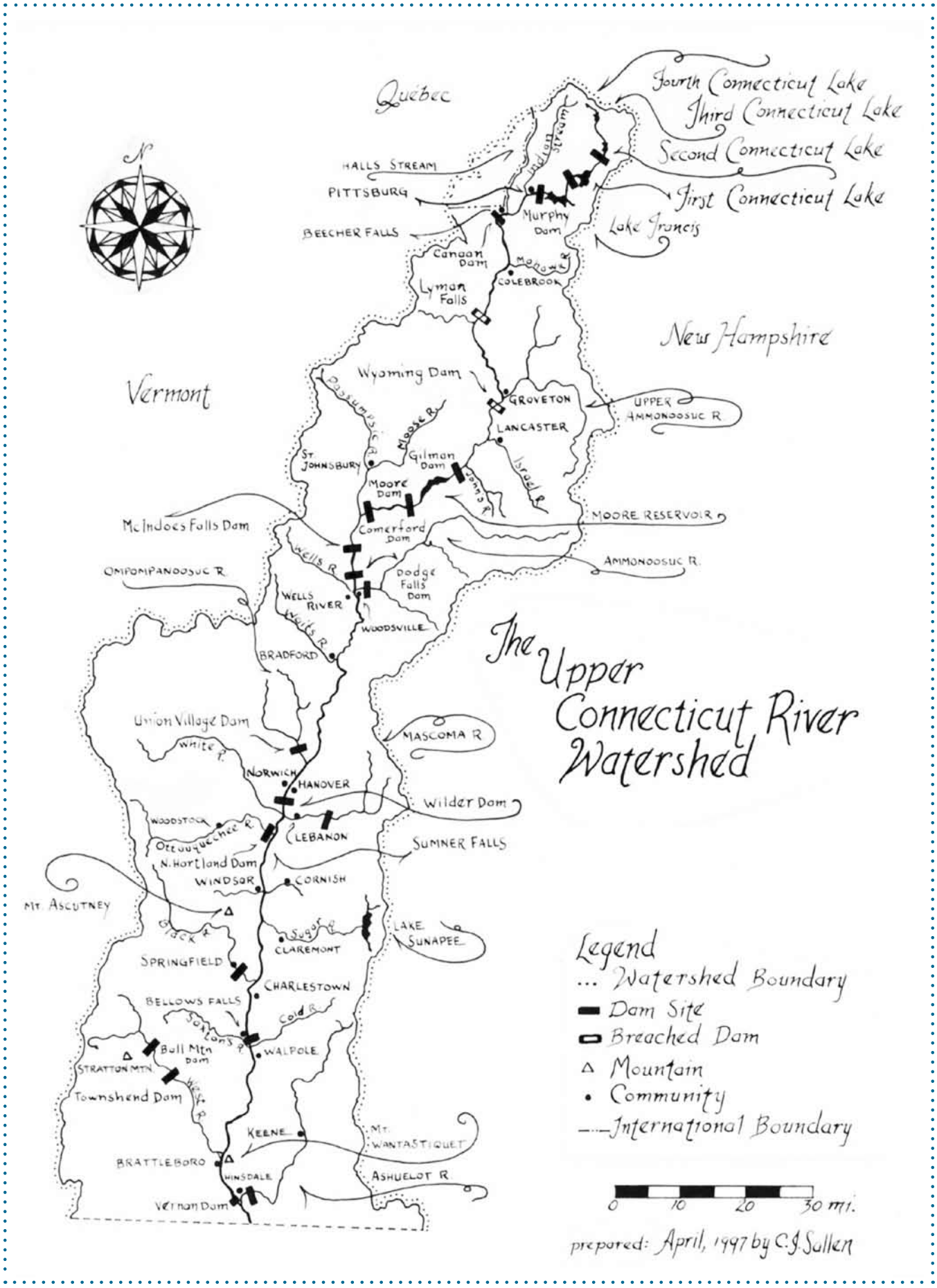
The neurotoxin mercury gravely threatens public and environmental health and the region's tourism economy. Studies confirm that mercury is a dangerous presence in the tissues of Connecticut River fish, particularly from Canaan Dam to Moore Dam. More than 70 percent of the mercury affecting New England comes from pollution in upwind states. Vermont and New Hampshire will not be able to solve this problem without better federal regulations.

Climate change may affect river dynamics, water quality, aquatic habitat, erosion, and much more. Most scientists agree that climate change is already underway, and that the Northeast can expect higher temperatures and shifting seasons, reduced snow cover, and more extreme weather. More flooding could lead to greater erosion and increases in sediment, fertilizers, and other pollutants in stormwater runoff. The region has experienced some very severe storms in recent years, including a 500-plus year event in the Cold River watershed that took four lives. Climate change effects in the watershed may also include droughts, especially if emissions are not soon controlled.

The river slips beneath the 1911 Mt.Orne covered bridge at Lancaster N.H. and Lunenburg, Vt.

Studies in the Ashuelot River watershed suggest that current specifications for culvert sizing are inadequate to handle the higher frequency of greater intensity storms. The micro-watersheds of many culverts have less storage for runoff now than they did 30 to 40 years ago when these culverts may have been installed, because wetlands have been drained, land has been cleared, and more impervious surface has been added.

Protecting riparian buffers and the shallow soils of ridgelines, hillsides, and steep slopes from development can avoid contributing to sudden runoff that leads to flooding. Sustainable stormwater management in this new context is more important than ever, as is assuring open floodplains, effective riparian buffers, and property safe from sudden high water.


The Upper Connecticut River Watershed
Québec
Vermont
New Hampshire
Fourth Connecticut Lake
Third Connecticut Lake
Second Connecticut Lake
First Connecticut Lake
Lake Francis
Halls Stream
Pittsburg
Beecher Falls
Murphy Dam
Canaan Dam
Colebrook
Lyman Falls
Wyoming Dam
Groveton
Lancaster
Upper Ammonoosuc R.
St. Johnsbury
Gilman Dam
Moore Dam
Moore Reservoir
Comerford Dam
Ammonoosuc R.
McIndoes Falls Dam
Ompompanoosuc R.
Wells River
Dodge Falls Dam
Woodsville
Bradford
Union Village Dam
Mascoma R.
Norwich
Hanover
Wilder Dam
Woodstock
Ottauquechee R.
Lebanon
Sumner Falls
N. Hartland Dam
Windsor
Cornish
Mt. Ascutney
Lake Sunapee
Claremont
Springfield
Charlestown
Bellows Falls
Walpole
Bull Mtn Dam
Stratton Mtn.
Townshend Dam
Keene
Mt. Wantastiquet
Brattleboro
Hinsdale
Ashuelot R.
Vernon Dam
Legend
... Watershed Boundary
Dam Site
Breached Dam
Mountain
Community
International Boundary
0 10 20 30 mi.
prepared: April, 1997 by C.J. Sullen

II. Introduction

The Connecticut River, the one that the Abenaki called *Kwinitekw*, is New England's largest and most powerful river, flowing 410 miles from its source in tiny Fourth Connecticut Lake near the Canadian border to its meeting with the sea at Long Island Sound. The Connecticut gathers the flow of thousands of streams spilling from the White and Green mountains and the highlands running the length of both states.

In its first 271 miles, the Connecticut River forms New Hampshire's sinuous west coast and its border with Vermont. While royal decree gave the river to colonial New Hampshire in the eighteenth century, well over half of its 4.5 million acre upper watershed lies within Vermont. The watershed encompasses a full third (33 percent, 93 towns) of New Hampshire's land mass, and even more (41 percent, 114 towns) of Vermont. Fifty-three communities in these states claim the Connecticut River as a boundary. Long a migration corridor for commerce, waterfowl, and culture, the river remains a living thread that binds together the people of both these states in one valley.

Twenty-four major tributaries and countless smaller ones drain a third of New Hampshire and two-fifths of Vermont, through the bed of a former glacial lake whose mark remains on the landscape to this day. Creating a plan for a river on this scale is a daunting challenge. This Water Resources Plan for the Connecticut River is inevitably focused on its mainstem, but there is much of value in this plan for the tributaries.

Citizens of the Connecticut River valley are well aware of the asset they now enjoy. The Connecticut commands respect when it releases its ice in the spring, when it floods after a storm, and when it turns turbines day after day to produce electricity for millions of people. With a floodplain fertilized over thousands of years, the river's valley is home to some of the richest agricultural soils on the continent. Its waters, woods, and wetlands provide nationally recognized fish and wildlife habitat. It draws people to fish and canoe, and to explore the historic heritage of its nearby villages.

Water, the essence of life in nature, must be the essential target of protection. By most yardsticks, protecting the quality of the water also ultimately means protecting the economic value of the water and the health and security of those who depend upon it. This plan encourages continued economic development that is compatible with the well-being of the river. Stewardship of both the quality and the quantity of water flowing in the river is the responsibility of us all. Much has been learned and accomplished since CRJC first published the *Connecticut River Corridor Management Plan* in 1997. Many critical needs lie ahead.

This plan is not an attempt to dictate to citizens and towns what they can and cannot do on the banks of the Connecticut River. Instead, it aims to stimulate stewardship and build partnerships across town lines, across the river, and across the array of interests of those who live and work on each side, aided by state and federal agencies with an interest in safeguarding the river's resources.

The Connecticut River Management Plan ~ A New Water Resources Chapter

Seeking a local avenue for river decision-making, the Connecticut River Joint Commissions (CRJC) mobilized hundreds of valley residents and local officials to nominate the Connecticut River into the New Hampshire Rivers Management and Protection Program in 1991-1992. Working with local citizen members of their five local river subcommittees, CRJC published the *Connecticut River Corridor Management Plan* in 1997.

At the request of CRJC, the New Hampshire Department of Environmental Services (NH DES) conducted a new assessment of water quality in the Connecticut River mainstem in 2004 with the support of the U.S. Environmental Protection Agency (EPA). CRJC's local river subcommittees began work on updating, revising, and expanding the 1997 Water Quality chapter, building upon the findings of this assessment in addition to new EPA studies of Connecticut River sediment quality and fish tissue toxins, geomorphic assessments sponsored by CRJC on the northern river, and erosion inventories conducted by the county conservation districts for the entire river in New Hampshire and Vermont. The subcommittees also explored new topics such as flow, flooding, drought, and groundwater, in an attempt to portray and address the full range of water resources in the region. The Commissions then examined their findings and selected topics of riverwide importance to explore and highlight in this Overview, in the context of climate change and other broad influences upon the Connecticut River watershed.

The Connecticut River has many faces, but is always a pleasure to paddle. The photographer's wood and canvas canoe explores the Connecticut River's designated "natural" segment in Stratford and a "rural" segment in Monroe, N.H.

The Connecticut River Joint Commissions

Since 1989, when the Vermont Connecticut River Watershed Advisory Commission and the New Hampshire Connecticut River Valley Resource Commission first met together, we have been listening to people in the valley. From the many discussions that the Commissions have fostered across the river among communities and between local citizens and federal and state agencies, the Connecticut River Joint Commissions realize that aspirations for the river and its watershed are high and are widely shared.

The New Hampshire Legislature created the Connecticut River Valley Resource Commission in 1987 to preserve and protect the resources of the valley, to guide growth and development here, and to cooperate with Vermont for the benefit of the valley. The Vermont legislature established the Connecticut River Watershed Advisory Commission in the following year. The two commissions banded together as the Connecticut River Joint Commissions in 1989, and also achieved the status of a non-profit organization. The legislatures assigned the

commissions to work throughout the watershed in the two states, comprising approximately one third of the land area of New Hampshire and two-fifths of Vermont. The Connecticut River Joint Commissions are advisory and have no regulatory powers, preferring instead to advocate and ensure public involvement in decisions that affect the river and its valley. The CRJC's broad goal is to assure responsible economic development and economically sound environmental protection.

The 30 volunteer river commissioners, 15 appointed by each state, are citizens who live and work in the valley and are committed to its future. The CRJC believe that the most effective action takes place when all the players come to the same table to achieve consensus. Members represent the interests of business, agriculture, forestry, conservation, hydro power, recreation, and regional planning agencies on both sides of the river. The Commissions hold joint meetings throughout the year, and are supported by four staff: the executive director, conservation director, communications director, and office manager. The Commissions are headquartered in Charlestown, N.H.

III. Shoreland Protection

Issue: Statewide Protection is Uneven.

The most fertile soils, most valuable fish and wildlife habitat, and some of the most expensive real estate in the Connecticut River watershed are found along rivers and streams. Given the power of flooding waterways to destroy private property, sensible policy is required. What happens on the shore of a river has a profound influence on its water quality, riverbank stability, aquatic habitat value, recreational use, and scenic value.

New Hampshire enacted limited protection for lake, river, and coastal shores in 1994 through the Comprehensive Shoreland Protection Act, RSA 483-B, and in 2007 made improvements in the law based on findings of a legislative study committee representing diverse interests. The law applies to fourth order streams and larger, but leaves it to local communities to decide whether to protect the waters that flow into them. Since larger rivers are the sum of smaller ones that feed them, it makes sense that if shoreland protection extends to their tributaries, especially to headwater streams where the highest quality habitat may often be found, it will also benefit the larger rivers.

Vermont remains the only state in New England that does not have a shoreland protection law, although it permits towns to regulate land use activities near surface waters through a shoreland overlay. Indeed, more Vermont towns have enacted such protection than have their New Hampshire neighbors.

The land area covered by New Hampshire's law extends 250 feet from the ordinary high water mark, a distance less than the length of a football field and narrower than the width of the Connecticut River through most of its path between Vermont and New Hampshire. New Hampshire's law sets minimum standards for building setbacks, cutting of riparian buffers, building density and impervious surfaces, and use of fertilizer close to the water. It also prohibits establishment or expansion of salt storage yards, auto junk yards, solid waste, and hazardous waste facilities in this area.

"Would you really advise your neighbor to build his building 51 feet from that river, the way it moves?"

Riverfront Landowner Orford

New Hampshire's setback for buildings is only 50 feet from the water, a distance which may make sense on a relatively stable shoreline such as that of a rocky-bottomed lake, but which is of questionable value for a major river such as the Connecticut, which may claim 5-10 feet of territory each year where it is actively eroding.

The Silvio O. Conte National Fish and Wildlife Refuge, the only true watershed-wide refuge of the nation's 550 refuges, could be a significant player in water resource protection. Much of the important work in shoreland protection has been done, however, not by state or federal agencies but by local and regional conservation organizations. The Connecticut River valley is home to some of the most competent land trusts in the United States. The Upper Valley Land Trust, for example, has protected more than 30 miles of river frontage in its region.

Opportunities & Recommendations: Provide shoreland protection to both shores.

Both sides of the Connecticut River deserve at least the minimum level of protection from the states, with an invitation to local communities to add their own. This Water Resources Plan goes far beyond current laws, such as the Shoreland Protection Act, in recommending a diversity of tools for protecting the river, including regulatory and non-regulatory measures.

1. The Vermont Legislature should adopt similar if not greater measures than those in RSA 483-B to protect the shoreland of both the Connecticut River and its tributaries. Citizens should alert their legislators about the importance of shoreland protection and call upon the legislature to take action.

2. The New Hampshire Legislature should consider adding shoreland protection for third order streams, the smaller but still substantial tributaries that feed the larger streams already protected under the law. Citizens should alert their legislators about the importance of protecting these smaller streams and call upon the legislature to take action.

3. N.H. Department of Environmental Services should educate town officials, real estate agents, developers, and landowners about the Comprehensive Shoreland Protection Act, including the agency's responsibility for enforcement. DES should provide GIS layers and

mapping of the protected shoreland for local zoning officers. All the tools currently exist to use recent aerial photography, snap a 250-foot offset from the centerline of all rivers of interest, and digitize existing vegetative buffers. This would be very low cost and could be given to each town, and could also be available on the GRANIT site for download. Towns that had digitized parcels could overlay that layer for the protected shoreland. Slope can be added relatively easily, as can floodplain elevations and varves, to be sure these aspects are considered as planning boards and commissions review proposals for development. Vermont should provide similar services as soon as possible after the legislature enacts statewide shoreland protection.

4. Town planning boards/commissions should adopt ordinances to ensure that structures, including roads, are set a safe distance back from the river to reduce the risk of property loss in erosion-prone areas. Vermont needs enabling legislation to allow this. Town planners should consult their regional planning commissions to help bring life to the river protection recommended in this Overview and their local subcommittee's plan, by incorporating meaningful standards for shoreland development in their town's master plan and zoning ordinance. Tailor these shoreland ordinances to reflect local shoreland conditions. CRJC believes that a setback of 50 feet for buildings and 75 feet for septic system leach fields (as set forth in New Hampshire law) is entirely inadequate in situations where the riverbank could become unstable, and urges communities to establish more conservative setbacks to prevent property loss and water contamination. Soil conditions and slope are important to consider because they will determine how septic leachate and runoff will move to the river.

5. Town planning and conservation commissions, and (in Vermont) development review boards should provide information to every new riverfront landowner to explain the special challenges of owning and managing riverfront land, including the benefits of riparian buffers and the requirements of state shoreland protection laws. CRJC and state agencies should assist in preparing this information.

6. Federal, state, regional, and local agencies and organizations should pursue conservation of key riverfront land in cooperation with willing landowners, to protect water quality, flood storage, prime agricultural soils, wildlife habitat, and scenic views.

IV. Flood Storage

Issue: Natural floodplain storage is being lost.

The Connecticut River watershed contains 11,250 square miles in New Hampshire, Vermont, Massachusetts, and Connecticut. Wetlands and floodplains are where the river naturally stores flood water and relieves the water's energy. The Connecticut River's broad floodplain, famous for its fine agricultural soils, has become key waterfront property now that the river is clean and attractive once again.

Development of all kinds, from industry and commerce seeking large expanses of flat, open land, to house lots marketed for their river views, competes increasingly with agriculture for room on riverfront lands. Yet few people remember those times when the worst possible combination of weather and river conditions produced catastrophic floods. In 1936, many riverfront towns were ten or twenty feet underwater. Flooding in Vermont on July 11, 2007 caused millions of dollars in damage. We do not know when such floods could come, but they could well come within our lifetimes, as they did on the Cold River in Alstead, N.H. in October of 2005.

The river's broad floodplain here in Piermont, N.H. and Bradford, Vt., is an essential piece of "green infrastructure," naturally storing floodwater as well as any multi-million dollar dam.

During the mid 1900s, the U.S. Army Corps of Engineers built seven flood control dams on tributaries of the Connecticut in an attempt to reduce hazard to downstream communities that had grown too close to the riverbanks. Yet, these massive structures are able to control less than 15 percent of the 6,266 square miles of the Connecticut River's watershed that drains through Vernon Dam near the Massachusetts line, and provide substantially less flood protection for the 250 miles above the West and Ashuelot rivers where four of these seven dams sit.

The large investment of taxpayer dollars and the heavy fiscal and environmental cost of these dams eventually redirected attention to the idea of non-structural or natural flood storage, which meant keeping floodplains open and relatively undeveloped. The Corps' 1994 Connecticut River Basin Natural Valley Storage Reconnaissance Study identified two major flood storage areas in the upper basin. These are the reach from West Stewartstown to Lancaster (12,000 acres of floodplain) and Woodsville to Bradford (4,000 acres). The study strongly advised discouraging development in these flood storage areas, although application of the Corp's standard cost/benefit formula led to the conclusion that federal purchase or easement acquisition would be economically unfeasible. Fortunately, the Upper Valley Land Trust has stepped in, working with willing farm landowners to protect much of the prime farmland in the lower reach, but 14 years after the Corps report, the rest remains vulnerable or is in the process of being developed.

"A flood is never a disaster until people get in the way."

Barry Cahoon, River Management Engineer, VT Agency of Natural Resources

The Federal Emergency Management Agency's (FEMA) Flood Insurance Program prohibits development in the floodway (the area near the stream channel where water moves the fastest during a flood event), but permits it in the rest of the 100-year floodplain if the developments are "flood proofed." This program does not consider environmental, social, aesthetic, or other relevant values. Most communities considered this to be adequate to protect their citizens from flood damage. Yet simply building a mound for a house site or calling for flood proof design does not solve the problem–it just moves it somewhere else. A town which permits

building in its floodplain may be unwittingly creating a public nuisance by contributing to flooding of another town across the river or downstream. Only four of the 53 towns along the Connecticut River in New Hampshire and Vermont now specifically exclude construction in their floodplains.

Floodplain maps provided to the towns by FEMA show only calculated probabilities of flood frequency, rather than lines the river should not be expected to cross. Flood damage to structures built within the floodplain costs taxpayers billions of dollars in disaster relief nationwide. The maps are frequently inaccurate and do not reflect changes in hydrology due to development. Because the maps are based on inundation hazard, they also do not show areas that might be vulnerable to fluvial erosion hazards, which is a frequent form of flood damage in this region due to topography and river alteration. Most maps were done in the 1970s, when many of the rivers depicted were well out of equilibrium condition. Floods have the greatest impact in terms of cost and loss of life on transportation infrastructure, principally due to catastrophic erosion affecting roads, road drainage systems, bridges, and culverts. Stream channels are enlarging due to the demand of carrying a larger volume of stormwater runoff from pavement and other development and more intense storms linked to climate change, making the public more exposed to floods.

"You best not be building in those floodplains. Mother Nature doesn't like it. Now, money talks more than common sense."

Riverbend Subcommittee member and riverfront farmer from Guildhall

The public may have a sense of false security that the large hydro dams on the Connecticut River mainstem will prevent damage from a major storm, yet at times during the preparation of both this plan and its 1997 predecessor, the river has carried enough water to cause significant flooding in spite of the best efforts of dam managers. Even when Moore Reservoir is lowered the full 40 feet allowed by its license, it can only capture one inch of rainfall in its 1,600-square mile watershed without spilling it into the river below. Following heavy rains in October 2005, flood water exceeded storage capacity at both Moore and Comerford dams at Fifteen Mile Falls, and flooding occurred for miles below them.

Opportunities & Recommendations: Protect floodplains from development & retain natural valley flood storage.

People cannot control flooding, but can manage it so that the water, when it inevitably arrives, can go where it can do the least damage to human investments. FEMA regulations encourage adoption of higher standards than the FEMA minimums. Towns that adopt No Adverse Impact floodplain regulations may be rewarded by FEMA's community rating system. Since Hurricane Katrina, recognizing that it makes more sense and is less expensive to prevent disasters than to repeatedly repair damage after a disaster has struck, FEMA has provided funding to towns with a pre-disaster mitigation plan to address hazards such as floods before they happen.

Towns are often faced with difficult choices about where to permit development and where to prevent it. The first choice should be to avoid new development anywhere in the floodplain, as some towns have already voted to do. However, while adding to existing development in

a heavily settled area of the floodplain, such as a historic village, still invites flood damage, it may be a better use of the land to continue to develop there than to allow new development in undeveloped agricultural floodplains. In the first setting, additional development can be flood-proofed with mitigation from new compensatory storage. In the latter setting, towns should strive to prohibit new floodplain development, both to prevent a public nuisance and to protect the integrity of this land use in addition to its vital flood storage function. Towns should carefully consider whether to continue to offer agricultural exemptions for such aspects of zoning, since structures such as greenhouses invite flood damage as readily as structures with other uses. To participate in flood insurance, towns should update their flood regulations to bring them into compliance with the minimum federal requirements.

New Hampshire has initiated a wetlands mitigation program to compensate for unavoidable losses of wetlands, and intends to use the funds to address wetland functions and values lost through land conversion. The program seeks to protect other wetlands within the same watershed as those that were lost. Towns can take advantage of this program if they are prepared with a natural resource inventory and knowledge of their valuable local wetlands needing protection. The Nature Conservancy has recently completed a GIS-based floodplain analysis of the Connecticut River watershed. This analysis could be useful to regional and local planning agencies in selecting areas for floodplain restoration.

1. Towns should not permit new building in the 100-year floodplain, or the special flood hazard area, to protect their citizens and businesses from damage, to avoid adding to flooding of their downstream neighbors, and to reduce the public cost of disaster relief. Review preliminary Flood Insurance Rate Maps and meet with FEMA and the state to comment on the maps. Consider the flood implications of access roads to development sites in the floodplain, and ensure that they will not act as berms during high water. Vermont towns should avail themselves of the Municipal Education Grant Program to bring training to their communities as they consider adopting new river protections such as this.

2. FEMA should create a system for evaluating the costs and benefits of avoiding floodplain development, not just retrofitting development. The agency should also provide accurate floodplain maps for all river towns. Maps should include accurate river gradient drop as well as elevation for floodplain determination. Data sources could include the many USGS geodetic discs in the area, dam elevations, LIDAR type flights and the vertical GPS points collected.

3. Public agencies, conservation organizations, and private landowners should work together to retain natural flood storage in floodplains and wetlands. New Hampshire town conservation commissions should develop a list of candidate sites for protection through the state's wetlands mitigation program. The Nature Conservancy should make local planning boards and conservation commissions aware of its floodplain analysis.

4. State emergency management offices should include local watershed groups in emergency planning for river-related issues. Watershed groups should be at the table for river management and disaster planning long before a disaster occurs.

5. Land conservation organizations and other appropriate agencies should purchase development rights from willing owners of land in the natural valley flood storage area to help prevent flooding downstream. The U.S. Fish and Wildlife Service's Conte Refuge can also help accomplish flood storage protection by focusing on protecting riparian habitat.

6. The U.S. Army Corps of Engineers should revisit its cost-benefit analysis of protecting natural valley storage areas in the Connecticut River valley. The 2007 authorization in the Water Resources Development Act provides an opportunity to pursue creative non-structural means of flood control. Include consideration of economic studies by the N.H. Lakes Association, costs of community services studies, and insurance pay-outs for flood damage.

V. Riparian Buffers

Issue: Riparian buffers have been destroyed or rendered ineffective.

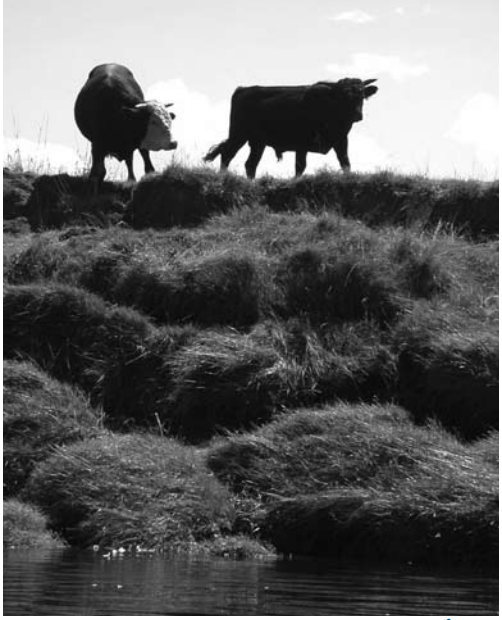
Riparian buffers are the river's best hedge against pollution, erosion, and flooding, and its best protection for wildlife habitat. These strips of native grass, shrubs, and especially trees along the banks of rivers and streams filter sediment and other contaminants from runoff and provide a transition zone between water and human land use. Riparian buffers capture pollutants from both water running off the land surface and, when thickly forested, from subsurface water moving toward the stream. They also provide biological services, protecting aquatic habitat by shading water and capturing pollutants, adding leaves and woody debris to the river ecosystem, and providing rich wildlife habitat and travel corridors. This essential "green infrastructure" is a real bargain compared to a multi-million dollar piece of built infrastructure to accomplish or provide similar services.

Riparian buffers are a river's right-of-way.

Erosion inventories show that Connecticut River banks tend to exhibit more erosion when riparian buffers are absent. CRJC's 2004 geomorphic assessment of the northernmost 85 miles of the Connecticut River, conducted by John Field, Ph.D., found a lack of riparian buffer along a full 20 percent of the riverbank, and concluded that bank stability generally increases as buffer width increases, as long as a buffer is at least 25 feet wide. Dr. Field observed a 67 percent greater chance of finding erosion where there is no riparian buffer (1). While a stream-side buffer can't promise to stop erosion – nothing can – it's the river's original stabilizer and provides other benefits, too.

A 100-foot buffer will generally remove 60 percent or more of pollutants, depending on local conditions. It will also provide food, cover and breeding habitat for many kinds of wildlife.

For slopes gentler than 15 percent, most sediment settling occurs within a 35-foot-wide buffer of grass. Greater width is needed on steeper slopes, for shrubs and trees, or where sediment loads are particularly high. Because a century of channel straightening has forced many stream channels out of equilibrium and they are now becoming incised, cutting down through their beds, the river is below the root zone of many buffer plants, but the buffer can still create roughness that slows the water and captures sediment.



Cattle have eliminated the riverbank vegetation that would otherwise have helped protect this Maidstone, Vt., shoreline from erosion.

Vermont and New Hampshire have differing policies regarding riparian buffers, although river experts in both states agree that buffers are very important for protecting water quality and reducing erosion. Septic systems must be set back 75 feet from rivers and streams in both states. New Hampshire's Comprehensive Shoreland Protection Act requires that the area within 50 feet of a fourth order stream (and larger) must remain undisturbed, and also protects the natural woodland buffer within 150 feet of such waters.

Vermont has no statewide buffer protection, although the Agency of Natural Resources has adopted a Buffer Procedure (3 V.S.A. § 835) that may be used as guidance in conditioning Act 250 permits. This guidance can also be used by towns wanting to protect their local waters. Vermont requires a very minimal buffer of 10 feet on farms, and only between land used for growing annual crops (such as corn) and surface water. The state has appropriated funds for the Conservation Reserve Enhancement Program to assist farmers and other landowners who want to improve water quality by setting aside and even replanting riparian buffers. New Hampshire has no such requirement for farms, and no comparable state assistance, although it recommends use of buffers as a best management practice. Fortunately, silver maple floodplain forests, a well-documented and valuable plant community that provides an excellent riparian buffer, are returning in many places in the North Country, due to changes in farm practices.

While forestry is exempt from NH RSA 483-B, the Basal Area Law (RSA 227-J:9) requires that within 150 feet of fourth order streams and great ponds, 50 percent of the pre-harvest basal area must be maintained, and that 50 percent of the pre-harvest basal area must be maintained within 50 feet of all perennial streams, rivers, and brooks. Vermont's Acceptable Management Practices for forestry specify that except for stream crossings, a protective strip shall be left along streams in which only light thinning or selection harvesting can occur.

Opportunities & Recommendations: Put nature's own water treatment systems to work.

Riparian buffers are a time-tested way of working with the land, not against it. The rewards of riparian buffers are many. *They provide economic services:* protecting citizens against

property loss through flood damage and erosion; recharging aquifers and protecting the quality of public drinking water supplies; supporting the recreation and tourism industry; supporting sustainable yields of timber; and shielding farm fields from flood-borne debris. *They provide social services:* protecting clean surface water for public recreation; protecting prime agricultural soils from erosion; providing natural fences, visual screens, and noise control; providing outdoor laboratories for teaching and research; offering places for camping, nature study, bird watching, hiking, hunting and fishing; improving air quality; recycling nutrients; trapping heavy metals and toxins; storing excess sediments; and trapping carbon dioxide. *They also provide biological services:* protecting aquatic habitat by shading water and capturing pollutants and providing rich wildlife habitat and travel corridors. Conservation easements are a useful tool for establishing and maintaining riparian buffers.

1. Landowners should encourage riverfront forests. Landowners along rivers and streams should retain and enhance buffers of native vegetation and remove invasive plants that try to gain a foothold there. Farmers will especially appreciate the capture of flood debris by large woody buffers during high water. Landowners can protect their privacy, enhance the appearance of their property, and protect water quality by leaving the natural buffer undisturbed. They should take advantage of state and federal cost-sharing programs and of the advice offered by county conservation districts and CRJC's printed guidance, *Riparian Buffers for the Connecticut River Watershed*.

2. Towns should encourage riverfront buffers. Stating the town's support of riparian buffers in the master plan is only window dressing if the zoning ordinance does not back it up. Apply shoreland and buffer guidelines on small streams as well as on larger rivers. Small streams are most vulnerable because they respond most dramatically to changes in adjacent land uses, tend to be located on the steepest sloping and erosion-prone lands, are subject to flash flooding, and often have the highest quality remaining habitat.

3. State and local transportation departments should treat riparian buffers as natural allies in preventing pollution by retaining buffers as a natural curb to road-related runoff. Encourage road agents to avoid mowing vegetation in riparian buffers where roads are close to streams. The often-too-small strip of grass, ferns, and other volunteer plants has a big job to do to keep trash, road pollutants, and sand out of the water. Include riparian buffer restoration, using native plants, as an integral part of road projects near rivers and streams. Too often, road project designs near waterways concern only the road surface itself, and ignore the biological portion of the project.

4. The states of New Hampshire and Vermont and the U.S. Fish and Wildlife Service's Conte Refuge should invest in riparian habitat conservation and restoration in cooperation with interested landowners.

5. County conservation districts should work with riparian landowners, including residential homeowners, to provide buffer plant material, planting plans, and buffer plant packages for various settings.

6. The states should support buffer restoration through tax incentives and cost-sharing. Vermont should continue to fund its Conservation Reserve Enhancement Program, and New Hampshire should consider creating a similar program to make buffer restoration more affordable for riparian landowners.

7. Vermont should ensure that its current use program is not at odds with conservation goals and allow riparian buffer protection on enrolled lands. Foresters designing management plans for property enrolled in the program should incorporate best forestry management practices to protect and enhance forested buffers.

8. The public should support the work of land trusts and other conservation organizations in protecting riparian lands. Trusts should make aquatic and riparian habitat quality a priority in cooperation with interested landowners. An easement should include both the streambank and a buffer around it that includes the belt width of the river meander, or the lateral distance the stream is likely to migrate. This varies depending upon topography and the size of the stream, but usually averages six times the width of the channel. Encourage local conservation commissions to educate townspeople about the value of buffers and the ways in which personal choices can have lasting effects, both good and bad, on the region's water resources.

VI. Streambank Erosion

Issue: Riverbank erosion is one of the most prevalent and misunderstood problems on the Connecticut River and its tributaries.

While it is the nature of rivers and streams to move sediment through the landscape, human activities are having an increasing impact on river behavior. Rivers are constantly adjusting to many changes, from dam building or breaching to increases in stormwater runoff, deforestation, reforestation, road and railroad building, and even deglaciation. For example, a full third of the 85 miles from Murphy Dam in Pittsburg to Gilman Dam in Lunenburg was straightened in the late 1800s, probably for log drives. The river has been attempting ever since to restore a natural path by seeking a stable slope and depth to handle its sediment load. Erosion delivers not only sediment to a stream, thus increasing turbidity, but nutrients and other pollutants attached to the sediment.

Since publication of the *1997 Connecticut River Corridor Management Plan,* research sponsored by CRJC and others has contributed greatly to our understanding of the reasons for erosion. Erosion inventories of the mainstem in both states have provided a snapshot in time

of their condition. A new tool is fluvial geomorphology, a science that attempts to understand how river channels adjust their shape and planform through erosion and deposition to reach an equilibrium with natural conditions and human land use in the watershed. Since channels in equilibrium do not change their shape and planform over time, urging a stream toward equilibrium can greatly reduce erosion and deposition and minimize impacts on humans and aquatic habitat. Vermont's Agency of Natural Resources (VT ANR) estimates that up to 70 percent of the state's stream miles have been channelized and straightened over the years, to accommodate roads, the railroad, agriculture, and development, meaning that people will end up fighting those rivers at a cost of millions of dollars.

"Topsoil – it's New Hampshire's number one export."

Headwaters Subcommittee representative and select board member from Stewartstown

People cannot completely stop erosion - they can only speed it up or slow it down. Often, attempts to treat localized erosion move the problem elsewhere downstream. The best solution is avoidance – choosing a river corridor protection strategy that gives the stream the room it needs to re-establish healthy equilibrium conditions. Another important deterrent is allowing the banks to naturally fortify themselves with a protective buffer of vegetation, although not even a buffer will reduce bank erosion in an area where the river is out of equilibrium.

CRJC's geomorphic assessment of 85 miles of the river above Gilman Dam identified three causes of erosion and channel instability: human channel building and straightening; sediment inputs from tributary watersheds; and sediment inputs from high eroding banks of glacial outwash deposits (2). CRJC has provided maps of erosion and riverbank condition to the northernmost 16 towns along the river based on a geomorphic assessment. Farther downstream, erosion occurs where water levels fluctuate with the operation of dams, and where boat wakes strike soft riverbank soils. The Connecticut River can and does erode valuable agricultural soils and threatens roads and buildings. However, some ill-informed attempts to stop erosion can have unintended effects, and can actually start erosion somewhere else, on someone else's property. All projects on riverbanks require permits from the state.

Several areas of particularly severe erosion stand out on the mainstem. At the Northumberland Cemetery, a steep, high bank is eroding into the river, threatening a number of burials at the top of the bank. Studies sponsored by CRJC indicate that bank instability at the cemetery is related to the breaching of the Wyoming Dam three miles downstream, the breaching of Nash Stream Bog Dam in the Upper Ammonoosuc watershed, and the resulting sand bar development on the Connecticut River at the confluence with the Upper Ammonoosuc River. The erosion situation is complex and as yet unresolved.

Such high sandy banks are often associated with eskers, reminders of glacial activity that are frequently close neighbors to rivers. Disturbance of these high sandy banks very close to the river, including sand and gravel removal, threatens to deliver large amounts of sediment to the river below that could smother aquatic habitat and even cause the river to shift its course.

Another significant problem area is a delta of gravel, silt, and clay deposited by Commissary Brook in Rockingham, Vt. six miles upstream from the Bellows Falls Dam. Fishermen and divers report that the Connecticut River is now only six inches deep in places where it was once 30 feet deep. The brook is sending a plume of turbidity into the river that violates the New Hampshire surface water quality standard, and in the five years since the turbidity was measured, this plume has moved hundreds of yards downstream. The sediment is coming from a small tributary to Commissary Brook, where clay extraction penetrated to the depth of shallow groundwater. Changes in hydrology caused from removing trees adjacent to the clay pit created the instability and failure of downstream embankments. A head cut is developing that could affect nearby homes. Officials believe that the plume will persist until the site is stabilized.

Boat wakes are among the leading causes of human-induced riverbank erosion, especially in the Connecticut River's impoundments.

The presence of varved soils associated with glacial Lake Hitchcock appear to be a major contributing factor to the release of tons of sediment that have washed down the steep tributary into Commissary Brook and the Connecticut River. VT ANR and the state's Act 250 Environmental Board both granted permit approval to the clay extraction in the early 1990s, and did not foresee the subsequent severe erosion and sedimentation that later occurred. The location of varves remains little known in much of the river valley, although mapping technology exists that could provide this valuable information to local planning boards and commissions. Soils maps can help predict the presence of varved soils.

A feature not identified in earlier erosion inventories is hidden riverbank undercuts. Observed in the Wilder impoundment, the extent of their presence is unknown. In these undercuts, cavities extend back some four to six feet. In such places, the root structures of the trees are currently holding up the bank, but the trees may eventually fall, bringing a large root ball with them and destabilizing the bank. It is not currently known whether this kind of erosion occurs only on impoundments with fluctuating water levels or throughout the Connecticut River system.

"We have to stop chasing our rivers with riprap – it's not a sustainable policy."

River Management Engineer, Vt. Agency of Natural Resources

People place their homes and businesses in danger if they build them too close to the river on erosion prone ground. The federal government spends millions of taxpayer dollars nationwide each year in disaster relief for damage to structures which may have been unwisely built within a river's eventual path. Vermont's River Management Program has developed a fluvial erosion hazard mapping method to better identify areas near streams

that are highly prone to flood damages due to erosion. The maps can be used to delineate river corridors that should be protected from encroachments to preserve channel stability and avoid flood hazards.

Opportunities & Recommendations: People living, farming, and doing business near the river should understand how a river works.

It is the nature of rivers and streams to change course, especially to re-establish a lost equilibrium of flow within their watershed. Avoid setting up an erosion-prone situation in the first place.

1. New Hampshire should consider offering fluvial erosion hazard mapping similar to Vermont. Towns should work with regional planning commissions to identify their fluvial erosion hazard areas and develop pre-disaster mitigation plans.

2. State agencies and local boards issuing permits for sand, gravel, or clay extraction close to the river should fully consider the potential for bank failure in such excavations, require significant setbacks, and have a plan for mitigation and stabilization or restoration.

3. Towns should contribute to controlling both erosion and property damage by discouraging development too close to the river or within the floodplain, and adopt meaningful building setbacks. Activities in this sensitive area should be limited to agriculture, recreation, forestry, and wildlife conservation. Enforce developers' use of erosion and sedimentation control practices, and ensure that riverside activities do not impact riverbanks and riparian buffers.

"A wise public must give the river room to be a river."

Sharon Francis, CRJC Executive Director

4. Towns should work with state geologists to map varves in their towns, to be sure major construction does not take place on unsafe soils. These varve maps could also be a source of more accurate elevation data and include indication of the 100-year floodplain. Towns should consult existing soils maps and work with their county office of the USDA Natural Resources Conservation Service to identify where these unstable soil formations may occur within their boundaries.

5. The U.S. Army Corps of Engineers should work with state environmental agencies to examine and address severe erosion sites such as at Commissary Brook in Rockingham, Vt. and at the cemetery in Northumberland, N.H.

6. Riverbank restoration projects should include riparian buffer restoration that is monitored for a number of years to ensure success, and include protection against rodent predation and a means of eliminating competing vegetation and invasive species, so that plantings can become established.

7. Land conservation organizations and others acquiring conservation easements on riverfront land should ensure, wherever possible, that the easement includes the belt-width of

the river meander in that area, to accommodate future movement of the channel without harm to structures. Organizations that provide funds for easements should consider the same belt-width requirement for funding conservation, where adequate undeveloped space remains.

8. The USDA county conservation districts should survey riverbanks for the presence of hidden riverbank undercuts, with the assistance of local conservation commissions, and identify and test a means of restoring these cavities. These locations should be GPS located and attribute data added (tree species, depth and size), and the data base made public so that others may add to this documentation over time using proper methods and forms. It might also be of use to note any invasive or rare or endangered species encountered. Landowners should check their own property for these erosion features.

9. The New Hampshire Legislature must provide sufficient funds to allow the Department of Safety's Marine Patrol to adequately enforce existing boating laws on the river. N.H. Marine Patrol should ensure a regular presence on the Connecticut River to help reduce boat wake-induced erosion. The legislature should also update the definition of personal watercraft to ensure that these wake-producing craft are limited to the widest areas of the river. Boaters should obey existing speed laws and watch their wakes to be sure that they do not strike the bank with erosive force.

10. Landowners faced with an erosion problem should contact professionals such as the Natural Resources Conservation Service for help in evaluating which solution, if any, is the best for the site, since each site is different and requires a practiced hand. Anyone contemplating work on a riverbank must obtain the proper permits before starting the project.

VII. Stormwater

Issue: Stormwater management is inadequate in the face of climate change.

Stormwater runoff is the most common culprit in contamination of surface water. Runoff from roofs, roads, driveways, and sidewalks carries automotive pollutants, sediment, pet waste, and litter down drains and into streams. Runoff from barnyards and feedlots brings mud and manure, while runoff from logging jobs brings silt and slash. With the specter of more frequent heavy storms as a symptom of climate change, the problem becomes even more urgent. If intercepted by a berm, buffer, bog, or other basin, the stormwater can drop its load and reduce velocity before reaching the stream. Water that can seep back into the soil won't reach the stream so fast, and the stream is less likely to flood or erode. The Wildlife Action Plans recently completed by New Hampshire and Vermont identified the impact of roads, pollution/sedimentation, and climate change as three of the top five threats to wildlife and wildlife habitat. Stormwater is involved in all three.

"Terrain drains!"

Upper Valley River Subcommittee member from Thetford, Vt.

In the past, streets and sewers were designed simply to shed the water as quickly as possible. Newer designs seek to remove any hitchhiking contaminants before they reach a stream, and to capture runoff to recharge underground reservoirs. The EPA, which regulates stormwater under the Clean Water Act, has phased in efforts to control this source of pollution. Beginning in 1992, permits have been required for manufacturing facilities, hazardous/solid waste processing, junkyards, sand and gravel mining, timber processing, power plants, vehicle maintenance, sewage treatment plants, and construction that disturbs more than five acres. More recently, permits have been required for construction sites from one to five acres and for town-owned activities such as sand pits, recycling centers, school bus maintenance, and treatment works.

Every time it rains, thousands of storm drains, such as this one in the village of Wells River, Vt., deliver to nearby rivers and streams whatever pollution is picked up by stormwater as it runs over lawns and pavement.

New Hampshire does not issue its own stormwater permits, but reviews and certifies EPA's permits. The state does limit impervious surfaces within 250 feet of lakes, ponds, and fourth order and larger streams, and considers stormwater through its alteration of terrain permitting program. Otherwise, the state is involved only to provide technical assistance and public education. If DES receives a water quality related stormwater complaint, the state will go out to be sure there is a federal stormwater permit and a stormwater pollution prevention plan. Otherwise, controls on stormwater are through local regulation, if it exists.

In Vermont, the Department of Environmental Conservation Stormwater Program issues separate permits for runoff from impervious surfaces, construction sites and industrial facilities. VT ANR is delegated by EPA to issue these latter permits. Vermont has also provided funding to regional planning commissions to assist towns in identifying culverts and bridges that are undersized.

Culverts came under the microscope in 2005, when an oversized storm met an undersized culvert in the Cold River watershed, with devastating and deadly results in Alstead, N.H. A report to the city of Keene that same year, from Michael Simpson of Antioch New England Graduate School, concluded that current engineering design specifications for culvert sizing in the nearby Ashuelot River watershed is inadequate to handle the higher frequency of more intense storms that can be expected with climate change. Geomorphic assessments are indicating that culverts should be sized to handle the bankfull flow of a waterway. Dams and under-size stream crossings (bridges and culverts) affect sediment transport, part of the reason why stream channels are incised and have lost floodplain access downstream.

Opportunities & Recommendations: Recognize the polluting power of stormwater, and make stormwater an asset, not a liability.

Towns and developers have promising new tools for managing stormwater, collectively called "low impact design." Rather than channeling runoff into drainage ditches, LID calls for spreading runoff around in small vegetated catch areas and swales where it can slow down and soak into the ground to recharge groundwater rather than run off the land. At the University of New Hampshire's Stormwater Center, research has shown that bio-retention areas ("rain gardens," gravel wetlands, pre-treated subsurface units, and porous asphalt) all provide significantly better stormwater treatment than conventional ways of dealing with runoff. Fortunately, most of these techniques are cheaper than conventional ones.

Towns have both a public safety and an ecological opportunity in examining culverts. Studies of culverts in the watersheds of several major tributaries (the West, White, and Ashuelot rivers) by volunteers organized by The Nature Conservancy, the White River Partnership, and others, have discovered situations where culverts are not only dangerously undersized but also disrupt aquatic habitat, creating impassable drops that fish and other aquatic life cannot overcome. These assessments can be used by states and towns to prioritize culverts for replacement by combining safety features with ecological benefits.

1. Federal, state, and local agencies should adopt new stormwater engineering practices, anticipating impacts resulting from climate change. NH DES should seek funding to support regional planning commissions in assisting New Hampshire towns to survey culverts and bridges to identify those that are undersized and poorly placed for fish passage, and seek funding for replacement where necessary. Simple mapping of each drainage area would serve as a useful reference as development occurs or is proposed.

2. State agencies should inform local planning boards and commissions, developers and landowners about changes in the stormwater permitting process.

3. Town planning boards and commissions should plan for stormwater control and look at ways to include "low impact development" ideas as they review projects, and at how to change existing development to reduce runoff and promote stormwater infiltration. Where possible, towns should discourage addition of impervious cover because of its effects on storm water runoff and harm to aquatic systems, and work with commercial and industrial developers to assist them in finding ways to retain all stormwater on site. Consider rewarding or crediting developers who provide vegetative buffers and maintain hydrologic connectivity of wetlands within projects.

Erosion of poorly graded dirt and gravel roads such as this one in Barnet, Vt., can deliver sediment to streams after heavy rain.

4. Developers, farmers, and forest workers should use best management practices for stormwater, such as low impact development design techniques, redirecting barn roof runoff away from high cattle use areas, and smoothing and seeding skidder ruts after timber harvest so that these places do not become channels for erosion.

VIII. Wastewater Discharges

"I've been working on this river for 34 years, and I never thought in 1970 that I'd see how clean this water has gotten. I didn't see too much swimming in 1970; it depended on what color the water was running that day."

Ken Alton
TransCanada Hydro Northeast

Issue: Wastewater discharge problems remain.

The federal Clean Water Act and local public and private investments have largely brought the Connecticut River back from its days as an open sewer. A half century ago, the federal Public Health Service rated 219 of 269 miles of the upper Connecticut River as "Damaged. Unsuitable for recreational uses except boating, unsuitable for use in some industrial processes without treatment, and unsuitable for irrigation of crops consumed without cooking." Six miles were described as "unsuitable for most legitimate water uses. Suitable only for the transportation of sewage and industrial wastes, power development, and limited industrial uses."

Among the culprits were untreated wastewater discharges from pulp and paper mills, milk processing plants and other industries, and domestic sewage from 21,650 people in 17 municipalities on the mainstem alone. Twenty-four tributaries delivered their own pollution, bringing sewage and discharge from textile mills, machine tool factories, slaughterhouses, and more (3).

Passage of the federal Clean Water Act and construction of multi-million dollar facilities to treat sewage and industrial wastewater utterly changed the river's character, allowing it to flush itself of most of these pollutants. Some issues remain, however, and new ones have arisen. Modern wastewater treatment facilities are not designed, for instance, to remove the complex organic molecules and sometimes tiny particles of pharmaceuticals and personal care products, and these drugs, artificial hormones, (whether consumed first or put directly in the wastewater stream) and perfumes pass virtually unaltered, or mixed to form new compounds, into the river with unknown results. Until 2007, the only guidelines that existed for disposal of pharmaceuticals was to flush them and send them to this fate, rather than recycle or landfill them.

Many years have passed since most communities built their wastewater treatment facilities. These plants are now serving larger populations and accepting wastewater from an increasing number of industries and leachate from landfills. Costs of maintaining, replacing, and upgrading these expensive public works projects have gone up, but except for revolving loan funds, assistance from the state and federal government has disappeared. A renewed and ongoing federal and state commitment is needed to help local communities with the costs of a new generation of upgrades, expansions, and replacements.

Phosphorus, a nutrient essential for plant growth and a common ingredient in soaps and detergents, also can move through most wastewater treatment systems to be discharged to the river, where it causes unsightly algal blooms and reduces habitat quality for aquatic life. While Vermont's phosphorus reduction efforts have been focused almost exclusively on Lake Champlain, an exception was made in the Connecticut River watershed. One of the most important achievements of the last decade was the investment by the state of Vermont and the town of Springfield in phosphorus removal at the town's wastewater treatment facility. As a result, massive mats of algae that had formed on the Black River at one of the river's busiest boat ramps are now a thing of the past. However, phosphorus continues to travel through other treatment plants from households throughout the valley, especially in Keene's discharge to the Ashuelot River.

Paper processing was once a much more prevalent source of pollution in the Connecticut River and its tributaries. This discharge is in the mainstem at Putney, Vt.

Nitrogen from the Connecticut River and its impact on Long Island Sound are also of concern, and are being evaluated by EPA and the states of Connecticut and New York. Should the New Hampshire and Vermont portion of the watershed be found to contribute substantial nitrogen loading that affects Long Island Sound, some nitrogen control may be needed in the future.

One wastewater discharge that could not have been imagined a century ago is the thermal discharge of cooling water from the Vermont Yankee nuclear power plant in Vernon, which began operating in 1973. The plant pumps heated water into the river's impoundment behind Vernon Dam, raising the water temperature while lowering its oxygen content and ability to assimilate other wastes in this heavily populated region. Distinctly warmer water is deleterious to the coldwater fish species that use the river for spawning and migration. The plant's owners have proposed to increase the temperature of this discharge and to relicense the plant. Despite the clear impact to the quality of Connecticut River waters, which are owned by New Hampshire, Vermont chose to apply a $20 million mitigation payment to water quality improvements in the Lake Champlain watershed. During the summer of 2007, a malfunction and collapse of part of a cooling tower renewed concerns about the nuclear power plant's safety and its implications for the Connecticut River and nearby communities.

For four upper watershed communities, combined sewer overflows (CSO) are expensive leftovers of earlier efforts to manage stormwater. When municipal wastewater treatment systems were built, they were connected to collection systems for stormwater as well as for sewage. In some cases, the systems allow street runoff to overwhelm the wastewater treatment plant during a heavy storm, causing it to discharge untreated sewage to the river. Separating such an engineering tangle is a very expensive project. State aid grants and revolving loans are available but may not be sufficient. White River Junction and Springfield, Vt. have eliminated nearly all of their CSOs (and may have done so by the time this goes to print), but St. Johnsbury (with 25 CSOs draining into the Passumpsic River system) and Lebanon (with five remaining CSOs discharging to the Connecticut) still face costly repairs. The states consider portions of the receiving rivers to be impaired as a result. The threat to human health is one we cannot afford to ignore, especially now that the river has once again become popular for swimming and boating.

Opportunities & Recommendations: Take steps toward the next generation of wastewater discharge cleanup.

Vermont decided to tackle the phosphorus problem at the source, and passed legislation that prohibits phosphorus above trace quantities in most household cleansing products sold and used in the state. Legislation is pending that would also affect dishwashing soap. EPA has just announced new guidelines for disposal of unused medicines, although the public remains largely unaware of them.

1. Federal and state agencies should focus on phosphorus, and educate federal and state legislators about the cost of phosphorus pollution to the environment, and the cost to local communities of removing phosphorus from discharges. Congress should appropriate funds and provide legislative support to allow EPA to assist towns in adding capacity to remove phosphorus from wastewater. New Hampshire should follow Vermont's example on management of phosphorus entering wastewater, and limit the amount of phosphorus in cleaning products sold and used in the state.

2. Federal and state agencies should assist local communities with the high costs of upgrades, expansions, and replacements of aging wastewater treatment facilities.

3. Federal and state agencies should work with local partners in guiding disposal of pharmaceuticals and educate federal and state legislators about the need for action. Congress should appropriate funds to allow the U.S. Fish and Wildlife Service, EPA and the Food and Drug Administration to work with state agencies to develop better rules and well-distributed guidance for health care professionals and the public regarding the disposal of unused medicines, so that these pollutants do not end up in wastewater that can eventually reach the river. EPA should assist Hospitals for a Healthy Environment, a non-profit organization headquartered in the Upper Valley, in working with medical providers to encourage responsible disposal of pharmaceuticals. Hospital associations should encourage return of unused pharmaceuticals at consumer friendly locations.

4. The states and affected communities should seek federal assistance through the Congressional delegations to remedy combined sewer overflows on behalf of St. Johnsbury and Lebanon as quickly as possible.

5. Federal and state agencies should cooperate to ensure the safety of Vermont Yankee and limit the temperature of its discharge to New Hampshire waters. The Nuclear Regulatory Commission should reconsider its findings relative to Vermont Yankee and conduct a thorough safety inspection, inviting closely neighboring states to participate. Vermont should reconsider the propriety of applying mitigation funds outside the affected watershed, and should invite advice and comment from New Hampshire in recognition of New Hampshire's responsibilities for the Connecticut River and the shared responsibility of the two states for communities within the impact zone of Vermont Yankee.

IX. Groundwater

Issue: Groundwater supplies are not always well known or protected.

Groundwater, one of New England's hidden but most valuable resources, is closely linked to the quality and quantity of surface water and to public health. Groundwater feeds the river's flow, and the water beneath the river feeds groundwater. Pollution in groundwater can therefore pollute a nearby stream, and vice versa. A drop in underground water supplies could affect base streamflow, with domino effects on aquatic habitat and waste assimilation, let alone boating and recreation. The erratic precipitation patterns promised by models of climate change suggest that droughts could lower groundwater levels and affect the drinking water supply of the many thousands of rural residents who depend on shallow wells.

"You protect the land, you protect the water."

Kurt Gotthardt, Chair, Mascoma Watershed Conservation Council

As severe and prolonged droughts threaten the southeastern and western United States, New England is learning not to take its abundant groundwater for granted. New Hampshire has made more progress than Vermont at this writing. DES has regulated new groundwater withdrawals for public community water systems since 1991, to ensure that these wells have a sustainable yield and are sited in appropriate places, and, since 1998, has regulated all groundwater withdrawals larger than 57,600 gallons per day. Stratified drift aquifers have been mapped for New Hampshire, and more detailed mapping is underway in some Connecticut River valley communities.

Vermont's aquifers have not been mapped as comprehensively, although Source Protection Area maps are available for community water systems. A few towns along the river are studying and mapping aquifer recharge areas. Vermont requires that new public community

water systems delineate the areas from which the groundwater is drawn, with potential sources of contamination identified. Fortunately, Vermont's new statewide policy on groundwater withdrawal removes the state as a target for commercial water bottling companies looking for private profit from a resource that belongs to the public.

The list of threats to groundwater is long. Oil spills and snow dumps join a litany of historical contaminants from unlined landfills, long-banned chemicals, junkyards, and old industrial sites, too often located on the banks of rivers. MtBE, a gasoline additive and suspected carcinogen now banned in the two states because of its ability to rapidly contaminate groundwater supplies, is an example of how groundwater can be threatened. Casual disposal of the many hazardous materials present in today's households can threaten both surface and groundwater when they are not removed from landfill leachate. A New Hampshire study in 2000 showed that only 11 percent of lands through which water flows to sources of public drinking water are protected by ownership or conservation easement, and 39 percent of community water systems do not even own the sanitary protective radius of between 75 and 400 feet around their wells (3).

At this writing, only one third of the towns along the river, including Norwich, Vt., have adopted any sort of protection for their drinking water.

Opportunities & Recommendations: Evaluate and protect groundwater supplies.

Consistently thorough maps of groundwater resources are needed to ensure that groundwater extraction is well controlled by the states and protected from contamination. Brownfields and other contaminated sites should be investigated and threats to groundwater removed, enabling the sites to be restored and returned to active use.

1. Vermont should complete mapping of its aquifers to complement its new law regarding commercial groundwater withdrawal. Expand upon the groundwater mapping program begun in 2007 and provide aquifer mapping information to local planning commissions. Establish and amplify programs that offer grants to protect critical aquifer recharge areas.

2. New Hampshire and Vermont should establish rules to protect key aquifers from contamination. The states should not permit landfills, hazardous waste disposal facilities, auto salvage yards, junkyards, wastewater or septage lagoons, and outdoor salt storage or other de-icing chemical storage to be located on aquifers.

3. Towns should evaluate water supplies for short and long term growth, and seek protection of water sources. Avoid placing snow dumps and permitting other potentially contaminating

activities on aquifers. Map the "cone of influence" for public wells, and develop regulations, such a ban on underground petroleum tanks, to apply in that cone of influence.

4. Regional planning commissions should continue and increase their work on brownfields. Seek federal funds to assist communities in evaluating and addressing brownfields sites, and encourage owners of potential brownfields properties to participate. Assist towns in providing more frequent and convenient opportunities for household hazardous waste collection, and put more effort into educating the public about the reasons.

X. River/Watershed Inventory and Management

Issue: Connecticut River tributaries remain unevenly understood and managed.

New Hampshire initiated river resource inventories in 1990 through the Rivers Management and Protection Act, relying on citizen volunteers within each river's watershed to nominate their river and then develop a corridor management plan. The Connecticut River entered this program in 1992. Vermont took a different approach in 2002, borrowing the useful concept of citizen participation and applying it to a state-directed inventory and planning process for entire basins.

Each approach has increased the knowledge and understanding of issues affecting individual rivers, and enhanced cooperation between volunteer and professional river watchers. However, New Hampshire's approach has left many important Connecticut River tributaries unstudied and without stewardship, waiting until energetic citizens decide to step forward. Only the Ammonoosuc, Cold, and Ashuelot rivers are designated protected rivers in New Hampshire's Connecticut River watershed. Israel's River and the Mascoma and Sugar rivers quickly come to mind as large multi-community tributaries with much to gain by inclusion in the state program. Seeking to avoid this problem, Vermont set a goal of completing basin plans for all 17 major watersheds in the state by 2006. It has missed its deadline, largely because a major question regarding water classification typing has not been resolved. Little is yet known about any Vermont tributaries north of the Passumpsic River, with the possible exception of the Nulhegan.

Among the first steps in gathering information about the state of a river is to monitor the quality of its water. Fortunately, both states have developed an ability to train and support citizen volunteers to make progress in this direction, and Vermont actively leads monitoring on those rivers for which basin planning is underway. However, most rivers in the watershed, including the Connecticut River itself, are not visited by volunteers bearing probes, test tubes, or monitoring apparatus. Volunteers are sometimes discouraged by the logistics of getting samples back to distant state labs for analysis, when local wastewater plants are capable of doing the tests.

"If you get in there and try to put the river where you think it ought to go, it may not necessarily agree with you."

Ben Copans, Vt. Agency of Natural Resources watershed coordinator, speaking of the value of geomorphic assessments

NH DES and EPA responded to a call from CRJC in 2004 to undertake an intensive, one season effort to establish water quality information for the river (5). In some cases these results raised more questions than they answered, especially in the North Country, where bacteria apparently contaminate 50 miles of waters popular for canoeing, kayaking, and swimming, including the designated "natural" segment of the river. A brief effort the following year in Colebrook found no problems, but further study is needed. DES does not have the staff to ensure a thorough follow-up effort, and an adequate corps of volunteers has not assembled to cover this gap.

In order to galvanize public action for river protection, the public needs ready access to information. Much remains to be done to improve public access to data such as from the 2000 sediment study, which examined sediment quality at many locations on 100 miles of the river from Fourth Lake to the mouth of the Ottauquechee River (6).

Opportunities & Recommendations: Support water quality monitoring and river management.

Citizens have many avenues for attracting the assistance of the states in monitoring and improving the rivers that are important to them. Citizen groups may apply to Vermont for funding for water quality testing. In New Hampshire, the Volunteer River Assessment Program offers training and other support for water quality work and nominating rivers. The National Park Service's Rivers and Trails Conservation Assistance Program offers technical assistance.

1. States should ensure adequate and regular water quality monitoring and continue to work with town conservation commissions and watershed groups such as the Connecticut River Watershed Council to encourage, expand, and coordinate volunteer water quality monitoring on the tributaries and on the mainstem. State agencies should make water quality monitoring data easily accessible to the public, including those who do not use computers, so the public understands the present condition of their waters. Assist local wastewater treatment plants with the cost of processing bacteria samples from river monitoring.

2. EPA and state agencies should post sediment quality data from their sediment study on the Web.

3. Vermont should resolve questions associated with water classification typing to complete basin planning as quickly as possible, including water quality monitoring of the Connecticut River tributaries in question.

4. New Hampshire citizens in tributary towns should consider nominating their rivers into the state program.

XI. Instream Flow

Issue: Incomplete information exists for future river management planning.

The threat of irregular precipitation linked with climate change, put together with New Hampshire's requirement to create instream flow rules for each river in the Rivers Program, points to a need to know where the water is coming from and how it affects the mainstem's flow. Many sources of information can guide river managers, including streamflow gage data, reports from hydro power producers, and water withdrawal data. However, other than the dam reports required by federal regulators, other information about flow can be sparse or missing altogether.

"People think the Connecticut River doesn't need any help because it flows all by itself."

Hank Swan, Connecticut River Commissioner

Some gages, such as in North Stratford, Dalton, and West Lebanon, are critical for management of hydro dams, telling dam managers what flow to expect from upstream. Generally, the cost ($12,500/year/gage) of maintaining gages is shared by the U.S. Geological Survey with the states, and efforts to cut state budgets have threatened gage funding, especially in New Hampshire. While Vermont generally adds one to two gages a year, and has added 10 gages between 2000 and 2005, New Hampshire has been losing stream gages since 1969, and in 2007 its stream gage network was at its lowest numbers since 1939. Fourteen stream gages were abandoned in 2004-2005 alone, including a number in the Connecticut River system. Fortunately, the New Hampshire Legislature approved new funding for gages in 2007, and at least four gages will be reinstated in the watershed.

Water withdrawals from the tributaries and mainstem, for irrigation, industrial use, or even to support fish hatcheries, can cumulatively affect the flow of the river. New Hampshire does not assess a fee for use of this water. That state has a registration program in place for withdrawals over 20,000 gallons/day, but there is no corresponding program and no record of how much water is withdrawn from the Vermont side of the river. While Vermont has an agency procedure for determining minimum instream flow and standards for water withdrawals that are applied in any permitting situation, including snow-making, the state does not have a withdrawal registration program. In a drought year, this information could be very valuable.

RSA 483 directs NH DES to establish flow rules for the Connecticut River and other rivers designated in the Rivers Management and Protection Program. Progress has been made on the Lamprey and Souhegan rivers, and a Protected Instream Flow will soon be adopted for the Souhegan. At this time, there is no schedule for creating flow rules for the Connecticut River, whose flow is already fairly tightly controlled by federal operating licenses and sidebar agreements for the dams at Fifteen Mile Falls, Wilder, Bellows Falls, and Vernon. While the relicensing of these last three dams in 2018 offers an opportunity to consider flow and possibly adjust minimum releases from these dams, it is unlikely that New Hampshire will ever have broad discretion to set flow rules that differ substantially from what is already inscribed in federal dam licenses for the Connecticut.

Opportunities & Recommendations: Lay the groundwork for an instream flow policy.

While a Protected Instream Flow for the Connecticut River is not imminent, it would be useful to articulate the valuable uses, characteristics, and resources of the river that are affected by instream flows, and to have a means of identifying and controlling water withdrawals during extreme droughts.

1. Vermont should institute a water withdrawal registration system.

2. CRJC should identify Instream Protected Uses, Outstanding Characteristics and Resources listed in RSA 483 – for the Connecticut River, based on consultations with organizations, agencies, and communities, as well as discussions in the local river subcommittees.

3. USGS and the states should adopt and implement an effective system of stream flow gages. New Hampshire should reinstate and place gages using a science-based approach to river management.

XII. Dams

Issue: There is room to expand river ecosystem and recreation benefits at existing dams and to carefully evaluate the public benefits of new hydropower proposals.

When the hydro dams on the Connecticut River were first built, the river was so degraded that energy production was one of the few values it offered, other than waste assimilation. Since the Clean Water Act stimulated water quality improvements beginning in 1972, the river once again offers a rich resource for the public, who expect assurance that the river will be well managed by the private companies that hold licenses to use the public's resource to generate

power. The Clean Water Act (section 401) gives the states review over dam operations, alterations, and the terms of dam licenses.

The 2001 license for Fifteen Mile Falls is a model of creative configuring of provisions that benefit the public and the river while assuring that this renewable power resource will continue to produce electricity. This license, devised in consultation with a wide range of stakeholders including CRJC, serves as an excellent example for TransCanada Hydro Northeast's three dams at Wilder, Bellows Falls, and Vernon, whose licenses expire in 2018.

The federal license for Bellows Falls Dam, between Walpole, N.H. and Bellows Falls, Vt., is scheduled for renewal along with that of Wilder and Vernon Dams in 2013.

Two issues at these dams are of particular interest. There is currently no prescribed ramping or "acceleration" rate for releases from these dams, and water levels can change abruptly above and below the dams when gates are opened. Sensitive habitat exists below Wilder Dam, at Sumner Falls for example, where an assemblage of rare, threatened, and federally endangered species inhabits the river. Just below Sumner Falls, is an active sand and gravel operation very close to the river on a steep, high bank. Erosion from the river's scouring action at the base of the bank has destabilized it, and, in combination with the mining activity at the top, threatens to add a heavy sediment load to a key piece of aquatic habitat. A hydrogeologist's report suggests that modifying the nature of the release from Wilder Dam could reduce this threat. Controlling the rate of release at the dams could also improve safety for recreational users below them and create more natural conditions for fish and other aquatic life.

The ability of hydro dams to provide a "black start" during an energy blackout is one of the great assets of this kind of power generation. Hydro dams can come on-line almost instantly to provide power when all other sources of electricity are down. However, a black start can create a sudden change in water levels and speed of current. A new operating license for Wilder, Bellows Falls, and Vernon dams should provide for black starts when power conditions require them, and for ramping rates under normal operating conditions.

The U.S. Army Corps of Engineers identified water level fluctuations behind the dams as a key cause of riverbank erosion in the Vernon to Wilder segment of the river, as pressure imbalances on the bank face lead to piping when gates are opened. Slower ramping rates could help ease this condition. Other erosion conditions have appeared that may or may not have a relationship with dam operations, and should be investigated. These include hidden undercuts and cavities within forested banks in the Wilder impoundment.

The U.S. Army Corps of Engineers owns and operates seven flood control dams in the Connecticut River watershed, on the Ompompanoosuc, Ottauquechee, Black, West, and Ashuelot rivers. These dams are operated according to protocols that reflect flood management needs but not habitat. Yet these rivers offer important aquatic habitat themselves, and operations of these dams affect habitat in the mainstem. Atlantic salmon have returned to spawn on the West River, and may eventually use the rest these tributaries. The dams block fish passage and have no minimum required flow.

Pressures to make the most of alternative energy sources are redirecting attention to rivers and streams as renewable sources of power. Interest is growing in small hydroelectric development for this purpose, and agencies will probably see new applications in the watershed, either for retrofit of existing but unused dams, or for construction of new facilities, especially on smaller streams. While there are important benefits from local production of power, this raises questions of habitat and sediment transport disruption, altered flow, and future maintenance for projects that will likely operate on a small profit margin. Vermont is pursuing a way to help developers of small hydro projects to understand the natural resource issues involved as they begin planning their projects.

McIndoe Falls Dam at Monroe, N.H. and Barnet, Vt., smallest of the three dams at Fifteen Mile Falls.

Of the approximately 1,000 dams in the watershed, some have outlived their usefulness, and have become a liability to their owners and in some cases a hazard to those living downstream. An unusual situation is dams or other structures built, mostly in the 1960s, to control ice, which have had unwanted effects upon the rivers. Both states now have river restoration programs that assist in the assessment and removal of such structures.

Opportunities & Recommendations: Continue and enhance good river stewardship by dam owners.

The Upper Connecticut River Mitigation and Enhancement Fund, established as part of the new license for the three dams at Fifteen Mile Falls, has provided very substantial permanent improvements in the watershed north of the White River confluence, from conservation of important natural flood storage areas to river-related research and habitat improvements. TransCanada Hydro Northeast, which acquired the Connecticut River dams from U.S. Gen New England, also plans to conserve company-owned lands around Fifteen Mile Falls and also at an ecologically sensitive area at Sumner Falls in Hartland, Vt. Much of this conservation work is complete. U.S. Gen set a fine example for other riverfront landowners by planting extensive riparian buffers on its land in Charlestown, N.H.

Opportunities exist in many parts of the watershed for responsible, sustainable new development of power generation, carefully considered in light of river science so that non-hydro benefits are fully addressed. Such a hydro project should not create new barriers or interfere with ongoing watershed restoration, should maintain water quality, aquatic habitat, fisheries, and recreational values, and should also be economically sound. Should mitigation be necessary, it could include removal of other existing non-functional dams or dams that cannot be redeveloped for hydropower.

1. The Federal Energy Regulatory Commission should include moderated ramping rates in the 2018 license for Wilder, Bellows Falls, and Vernon dams, with provisions to allow a "black start" if energy conditions require it. When laying out the terms for the new license, TransCanada (or its successor) and river stakeholders should consider extending the Upper Connecticut River Mitigation and Enhancement Fund to the entire Connecticut River watershed in Vermont and New Hampshire. Dam owners should thoroughly evaluate impacts of impoundment cycling on riverbank erosion as part of relicensing studies, and undertake mitigation as appropriate.

2. TransCanada should complete and implement its conservation plans in the Fifteen Mile Falls and Connecticut Lakes regions and at Sumner Falls, and should consider conserving the rich agricultural lands it owns in the Bellows Falls pool.

3. The U.S. Army Corps of Engineers should institute a minimum flow at its flood control dam facilities and create or improve opportunities for fish passage. When dams are not being operated for flood control, the discharge from flood control dams should mimic run-of-river levels, or inflow equals outflow, to protect aquatic life downstream. The Corps should institute larger water releases from the dams every few years to maintain a more natural channel shape in the rivers below them. It should take advantage of the expertise offered by The Nature Conservancy to "re-operate" these dams to alter flood control operations to allow for higher peak flows to restore riparian and floodplain habitats. The Corps should work in concert with NH DES to resolve issues of dam ownership; if a dam in Connecticut River tributary that is non-functional or in a state of serious disrepair is found to be owned by the Army Corps of Engineers, the Corps should act expeditiously with NH DES to remove it.

4. The states should investigate issues surrounding development of micro hydropower generation facilities, and develop policies and guidance for design that ensure that water quality, aquatic habitat, sediment transport, fisheries, recreation, and historic resources are not affected by new small hydro development. States should consider requiring off-site mitigation for projects that cannot be designed to avoid impacts and ensure that permittees set aside adequate funds to address facility maintenance and removal. Consulting potential stakeholders such as CRJC, the Connecticut River Watershed Council, and other appropriate watershed organizations would be helpful in identifying potential issues and concerns on this scale, as has already proved useful for relicensing of larger projects.

5. Other riparian landowners should follow U.S. Gen's example of riparian buffer planting on riverfront lands.

XIII. Agriculture and Forestry

Issues: Agricultural land is inadequately protected from development. Best management practices are inconsistently applied and used.

The entire Connecticut River valley, from Pittsburg on down the river, harbors rich agricultural soils of national significance that, if not paved or otherwise developed, stand ready to provide healthy locally grown and distributed food. Yet, in all but two of the 26 New Hampshire river towns and 10 of the 27 Vermont towns, there is no local protection in place to restrain development of these valuable soils, and they are falling prey to badly-conceived development. In most towns, the only deterrent is the current use taxation program, which permits a reduced property tax on such land.

Agriculture must have as firm a future in the Connecticut River Valley as it has a past.

Lyme historian

Much of the food sold in the Connecticut River valley is produced many miles away, requiring wasteful combustion of fossil fuel for transportation and unsustainable use of water for irrigation. Water supplies in the western states – a source of much East Coast food - are increasingly undependable as the region is gripped by a long-term drought that could be exacerbated by climate change. Snowpack to feed western water supplies is diminishing, and Lake Mead, the largest reservoir in the United States, has fallen to 49 percent of its capacity, showing a foreboding bathtub ring. Food supplies that depend upon irrigation from such sources could be disrupted. A water-rich area such as New England should not be putting pressure on a water-poor area to grow food for its people. With transportation costs increasing with the price of gasoline, and the possibility of disruption of transportation networks, the ability to produce a sustainable local food supply looks more and more like a matter of homeland security.

Vermont has made great strides in assisting farmers with their efforts to protect water resources, especially through its Conservation Reserve Enhancement Program. CREP adds state dollars to the federal Conservation Reserve Program to make water quality-related improvements such as buffers, fencing, and alternative livestock water sources more affordable for cash-strapped farm operations. New Hampshire offers no such program, although the need and benefits are just as great.

Management practices to protect surface waters from pollution are still unevenly applied in the region, despite their clear benefits for the waters that drain farms and forests. Vermont's

Acceptable Agricultural Practices, the base level of management required for all farms in the state, are designed to be easy to implement, low-cost solutions for addressing water resource concerns. They include a ban on spreading manure on frozen ground, a 10-foot vegetated buffer between annual crops and surface water, and provisions for managing livestock on pastures where access is given to surface water, among other practices, and they are enforced.

Vermont instituted farm permit programs for medium-sized farms in 2007 and updated its 1995 program for large farm operations. These protect water quality by providing a cost-effective alternative to a potentially burdensome federal permitting program. Farms with more than 700 dairy cows (or other livestock measures) must have a Large Farm Operation permit and adequate waste storage, and must land apply manure and other wastes according to a nutrient management plan. Odor, noise, traffic, insects, and other pests are also considered. The Medium Farm Operations Program applies to dairies with 200-699 mature animals (or other measures of livestock), and, under a single state general permit, prohibits discharges of wastes from a farm's production area to waters of the state and requires manure and other wastes to be land applied according to a nutrient management plan. Vermont offers financial assistance for crop practices and creating these plans, which ensure that fertilizer is captured by crops before it can enter streams. Vermont's Alternative Manure Management program helps bring income back to the farm or at least reduce the energy consumption from the grid by producing it with farm wastes.

Indian Stream Farm in Pittsburg, N.H., the northernmost farm in the state, has been conserved for many years. The family has converted to an organic operation.

New Hampshire's oversight of water quality impacts from farms is more limited, although the state offers grants to farmers for creating nutrient management plans and for implementing nutrient Best Management Practices (BMPs) where there is a water quality benefit. While New Hampshire distributes a manual on BMPs for agriculture, these practices are requirements. State law requires the agriculture department to respond to complaints involving the mismanagement of manure, agricultural compost, and chemical fertilizer. There have been complaints from Vermont farmers witnessing poor practices across the river in New Hampshire, such as winter spreading of manure that was then washed downstream by spring high water.

Opportunities & Recommendations: Preserve the vitality of agriculture throughout the valley and ensure use of best practices to protect water resources.

Thriving local agriculture and productive agricultural soils are assets of national significance. Vital Communities, a non-profit organization headquartered in the Upper Valley, has

piloted an immensely successful and innovative self-marketing program for promoting local agriculture that currently covers the region from Newbury/Haverhill to Vernon/Hinsdale.

Basic best management practices for agriculture should be consistently applied and employed by farm operations in the valley. Good forestry practices are equally important for protecting rivers and streams. *Acceptable Management Practices for Maintaining Water Quality on Logging Jobs in Vermont, Best Management Practices for Erosion Control on Timber Harvesting Operations in New Hampshire, and Good Forestry in the Granite State* provide essential guidance.

The effect of timber harvesting on water quality is legendary. Now, forest landowners and foresters must recognize and respect the increased frequency of episodic weather events upon the forest, its soils, and timber management infrastructure. Forest roads, culverts, and bridges are at increased risk and should be constructed to accommodate excessive storm water drainage and minimize extreme snow melt damage. Additionally, the financial impact of insect, disease, wind and ice storms can be reduced if access to the forest is managed and maintained to facilitate possible salvage harvesting.

1. The public should continue to support and encourage local agriculture. Buy local and enjoy the festive and refreshing atmosphere at a local farmers' market. Chambers of commerce can assist by publicizing these events.

2. Vermont should continue its Conservation Reserve Enhancement Program, and New Hampshire should investigate ways to institute such a program.

3. Both states should continue their current use taxation programs, that reduce development pressures on valuable agricultural and forest land and allow them to remain available for production.

4. Towns should consider adopting agricultural soil protection ordinances to keep valuable soils available for farming and to keep development from interfering with flood storage.

5. Vital Communities should continue to expand its Valley Food and Farm program to encompass the entire northern Connecticut River Valley. State agriculture departments should support this successful and innovative program.

6. New Hampshire should enforce best management practices, including a ban on winter spreading of manure. States and county conservation districts should encourage farmers to use best management practices to control erosion and protect and enhance riparian buffers.

7. Farmers should prepare a total nutrient management plan for their farm if they have not already done so, with help from county conservation districts and the Cooperative Extension Service, to make best use of available nutrients, reduce potential for water quality impacts, and save money in purchasing fertilizer. Funding is available from both the federal and state levels to help with the cost.

8. Forest landowners should follow guidelines such as *Good Forestry in the Granite State* and minimize the water quality impacts of harvesting. Follow forest management plans created for land in current use. Take advantage of cost-share programs. Construct forest roads, culverts, and bridges to accommodate excessive storm water drainage and minimize extreme snow melt damage. Manage and maintain access to the forest to facilitate possible salvage harvesting of timber damaged by insect, disease, wind and ice storms.

XIV. Invasive Aquatic Species

Issue: Invasive plants are spreading rapidly in the region's rivers and streams.

The 1997 edition of the *Connecticut River Corridor Management Plan* warned about the threat of invasive exotic species, noting that Eurasian milfoil had been discovered two years before at Hoyt's Landing in Springfield, Vt. by one of CRJC's local river subcommittee members. The 1997 *Plan* focused largely on the zebra mussel. Fortunately, despite the proximity of Lake Champlain, which is now heavily infested with the mussel, the Connecticut River apparently remains free of them at this writing.

"Didymo is going to make purple loosestrife look minor. At least that's pretty."

Mt. Ascutney River Subcommittee representative from Plainfield

The river did not fare so well with respect to invasive plants. Eurasian milfoil now infests the river from the outlet of Lake Morey in Fairlee to Hinsdale, appearing in sporadic populations above Hoyt's Landing, but more consistently in the river below. It has become particularly dense in Retreat Meadows at the mouth of the West River in Brattleboro. Inventories sponsored by CRJC and the county conservation districts have discovered that a half-dozen other submerged and floating aquatic invasive species have also since appeared in the river, especially in the reach closest to Massachusetts. Such plants reduce wildlife habitat value and interfere with recreation.

Perhaps the most visible biological shift has occurred within riparian buffers, where Japanese knotweed, purple loosestrife, and exotic honeysuckle have aggressively colonized streambanks. Within the last five years, Japanese knotweed has formed pure stands along many rivers and streams, notably the Black and Saxtons rivers. Such stands are even present in the far north, along portions of the Connecticut River in Maidstone, Canaan, and West Stewartstown, and along Israel's River in Lancaster. While knotweed spreads energetically on its own, it is possible that this and other invaders are getting a lift from highway crews as they

work on roads near infested riverbanks and are careless with the spoils. Ironically, Japanese knotweed was imported from Asia as a means of stabilizing streambanks, yet because it dies back each season and inhibits native plant growth structure, leaving riverbanks bare and vulnerable to erosion, it is poorly designed for the job. While introduced *Galerucella* beetles are showing promise in helping to control purple loosestrife in the valley, no biological control for knotweed or honeysuckle has yet appeared.

Eurasian Milfoil, discovered on the upper Connecticut River at Springfield, Vt., in the 1990s, has now spread to many sites from Fairlee, Vt. south. Shown here near Wilder Dam.

Perhaps the most disturbing news relative to invasive aquatic species was the discovery in June, 2007 of the invasive diatom *Didymosphenia*, also known as Didymo or "rock snot." This organism, confirmed in the northernmost reaches of the Connecticut River mainstem and in the White River near Bethel, can form extensive colonies on the bottoms of rocky river beds, smothering aquatic life such as macroinvertebrates (aquatic insects). Its appearance is also very unattractive, making the water less appealing for recreation. Biologists believe that Didymo was introduced to this region on contaminated fishing gear, especially felt-soled waders, and that it could be spread by any other recreational equipment. There is currently no way to control or eliminate Didymo, and the agencies have concluded that the best approach is to attempt to prevent further spread by humans, especially to tributaries.

Opportunities & Recommendations: Pursue wide education on preventing dispersal of invasive species.

Good information and support are needed for the full range of those whose activities affect the dispersal of invasive plants.

1. The U.S. Fish and Wildlife Service's Conte Refuge should continue its coordinating work on invasive species in the watershed.

2. The U.S. Department of Agriculture should sponsor studies of potential bio-controls for Japanese knotweed and honeysuckle similar to those for purple loosestrife, and inform the public about the results.

3. Transportation agencies and road crews should make efforts not to transport fragments of invasive plants during road construction projects, and consult agriculture departments about best practices for dealing with invasive species, including ways to sanitize spoils before disposal. New Hampshire's Roads Scholar Program and Vermont's Better Back Roads Program can offer special training for road crews on this issue.

4. Vermont and New Hampshire conservation officers and wardens should educate about invasive species when issuing fishing and boating licenses, perhaps with an attention-getting enclosure in the application or license. Replace signs at boat landings urging boat inspection

and cleaning with more informative and effective signs. Maine's program and signage provide a good example.

5. State environmental and fisheries agencies, TransCanada, sporting groups, and recreational users should continue to cooperate to better understand and address the Didymo infestation. Publicize practical prevention measures that the public is likely to use. TransCanada, which sponsors the largest number of boat launches of any landowner on the Connecticut, should consider providing boat cleaning stations at its access sites, as should state agencies managing public access sites on the river. Local outfitters and guides should educate their customers about Didymo and other invasives. Fishermen and other river users must carefully clean their gear after visiting the Connecticut River and report sightings of invasive aquatic species to state agencies. Do not release unused bait into the water.

6. Boaters or divers traveling from waters infested with zebra mussel and other invasives must wash and dry all equipment before reuse, hose off the boat, diving gear or trailer, and drain and flush the engine cooling system and live wells of the boat, bait buckets and buoyancy control devices on diving equipment.

7. Town conservation commissions should conduct an education and control campaign against Japanese knotweed and other invasive species in their towns. Consult with the White River Partnership, New England Wildflower Society, Conte Refuge, and the Invasive Plant Atlas of New England for assistance and methods for dealing with invasive species.

XV. Copper Mines

Issue: Acid mine drainage continues to damage Vermont rivers in the Upper Valley.

Vermont's Ompompanoosuc and Waits river watersheds have a long history of copper mining that supported industrial growth for several centuries. The now-abandoned Elizabeth Mine, Pike Hill Mine and Ely Mine are now pernicious sources of pollution, sending acidic water drainage from both the mines and tailing piles that has severely affected aquatic life by increasing acidity, depleting oxygen, and releasing heavy metals. EPA included the Elizabeth Mine on the National Priorities List ("Superfund") in 2001, adding the Ely Mine in 2002 and the Pike Hill Copper Mine in 2004.

The Elizabeth Mine produced copperas (iron sulfate or green vitriol) from 1809 to 1882, and copper from 1832-1958. Between 1943 and 1958, approximately 90 million pounds of copper were produced at this mine, which employed up to 220 people from 16 surrounding towns. At its peak in about 1880, the Ely Mine employed 850 people.

The *Connecticut River Management Plan* raised concerns about acid mine drainage in 1997, when CRJC declared the Elizabeth Mine one of the top water pollution "hot spots" in the Connecticut River watershed. Media coverage of that meeting captured the attention of Thetford residents who then organized the Elizabeth Mine Study Group. CRJC awarded grants to the study group through the Partnership Program in 1998, 1999, 2001 and 2002, to support efforts to organize a cooperative, community-based environmental remediation and historic documentation project at the mine. This work, and that of Vermont's Department of Environmental Conservation, led eventually to designation as a Superfund site.

One of the tailing piles at the Elizabeth Mine in Strafford and Thetford, Vt., a half century after copper mining operations ceased. (photo by Dr. Robert Christie)

A total of 16.1 miles of the Ompompanoosuc River and its tributaries, and 3.0 miles of Pike Hill Brook in the Waits River watershed have been placed on Vermont's impaired waters list because of their contamination by metals and acid from abandoned mine drainage. Copper emerged as a sediment pollutant in the two sediment studies conducted by EPA on the upper Connecticut River, appearing at levels high enough to have ecological effects in the Waits River at Bradford and in both Ompompanoosuc River samples, in concentrations five to ten times higher than in most other samples. Copper also appeared in the sediments of the Connecticut River mainstem below the confluences of these tributaries.

After extensive planning with local governments and interested citizens, EPA began work in 2005, intending to stabilize, grade, and cap the tailing piles, divert surface and groundwater around the piles, and treat runoff. In 2007, however, residents noted an increase in the orange coloration of sediments in the river. Because EPA was not given the funds to clean up the most difficult tailing pile, but only to stabilize it, some additional iron loading has occurred, and in combination with very low summer water levels, this has resulted in higher concentrations of iron in the river. The Ompompanoosuc River also contributes a noticeable sediment load to the Connecticut River after a heavy rain, and the plume of sediment can be seen running down the west side of the Connecticut mainstem for well over a mile, contrasting with clearer water delivered from upstream. This sediment has come from tailing piles and other exposed soils that are still not yet stabilized.

Opportunities & Recommendations: Move forward with remediation and put the mines back into the history books.

Copper mining in the Vermont hills ravaged the landscape for 150 years, creating a leviathan of a contamination problem that is not likely to be solved easily, inexpensively, or quickly. The effects of the mines appear not only in the tributaries draining these mines, but also in the Connecticut River mainstem for miles downstream. While it is unlikely that all stakeholders

will always agree how best to eliminate the problem, it is important to proceed. EPA estimates that if the project were adequately funded, the clean-up could be completed in three years. However, with the severe under-funding of the Superfund program, the project is apt to drag on for many years, resulting in inflated project costs, aggravation to the affected communities, and perpetuation of degraded rivers.

1. The Vermont Congressional delegation should make copper mine remediation a priority, and seek adequate funding for EPA to permit capping and proper stabilization using the cleanup plans at the Elizabeth Mine that have been accepted by both the state and the local community. Proceed with remediation at the Pike and Ely mines.

XVI. Mercury

Issue: The neurotoxin mercury threatens public and environmental health and the region's tourism economy.

Results of the 2000 *Connecticut River Fish Tissue Contaminant Study: Ecological and Human Health Screening,* released in 2006, are cause for deep concern, but are no surprise to anyone who has followed the mercury contamination issue. In response to the 1997 Connecticut River Corridor Management Plan. EPA worked with the four Connecticut River states to conduct a comprehensive look at toxins in Connecticut River fish. This landmark study, which may be the first river-wide study of fish tissue in the nation, represents significant cooperation among the four states, each of which contributed substantial funding and staff (7).

"The magic starts to leave the North Woods when you can't eat the fish. Where is the federal leadership? That's the problem."

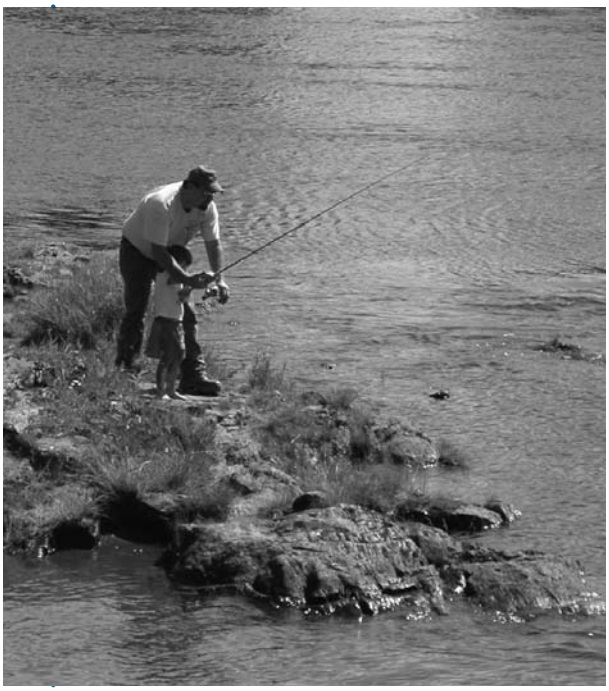
Hank Swan, Connecticut River Commissioner

Results confirm that mercury is a dangerous presence in the tissues of Connecticut River fish, particularly in the reach from Canaan Dam to Moore Dam. Total mercury concentrations in all three species of fish studied were significantly higher upstream than downstream, although the design of the study did not permit results to be tied to specific geographic locations on the river. As part of the 401 certification of Fifteen Mile Falls, the operators will carry out fish tissue mercury testing at five-year intervals.

Mercury levels prompted the states to issue fish consumption guidelines, including much stricter cautions for the Fifteen Mile Falls region of the Upper Connecticut River. Other recent studies have associated water level manipulations in reservoirs and reservoir creation with increases in fish mercury concentrations, and identified the Fifteen Mile Falls region and similarly

managed parts of the upper Androscoggin and Kennebec river watersheds as mercury hot spots.

Reacting responsibly to the issue, New Hampshire and Vermont joined a larger regional mercury reduction effort in 1998, setting an aggressive goal of reducing mercury emissions by 75 percent by 2010. In 2007, the New England states and New York jointly submitted to EPA a cleanup plan, called the "Northeast Regional Mercury Total Maximum Daily Load," (TMDL) which calls on EPA to require other states to take similar steps to reduce mercury emissions. New Hampshire, along with several other states, has brought suit against EPA to enforce their requirements regarding mercury.



Mercury is building up in Connecticut River fish. (Fishing Dodge Falls: Family fishing below Dodge Falls in Monroe, N.H.) (KidFishing: Photo by Bob Linck)

New Hampshire has already reduced emissions from waste-to-energy plants and medical waste incinerators by 95 percent, has banned certain mercury-containing products, passed a comprehensive law to control emissions from the state's coal-fired power plants, and banned disposal of mercury-containing materials in landfills. Since 1998, overall mercury emissions in New Hampshire have been reduced by more than 60 percent. While Vermont has not had the mercury-emitting industries of its sister state, it too has passed legislation to control the sale and disposal of mercury-added products and set up a Mercury Education and Reduction Campaign.

Mercury is not just an environmental issue – it is an economic issue for those on the receiving end of the emissions that deliver this heavy metal. In a 2007 study of the economic impact of the potential decline in New Hampshire water quality, more than two-thirds (69 percent) of respondents to a survey indicated that they would decrease the number of visits they make to a river, stream, lake, or pond if they perceived a change in water clarity and purity. For the purpose of this study, "water clarity and purity" include mercury, milfoil or other invasives, and algae. Perceived declines in water clarity and purity would result in about $51 million of lost sales, $18 million in lost income and more than 800 lost jobs statewide (8).

Opportunities & Recommendations: Address mercury poisoning of the environment – and the tourism economy – on a national scale.

More than 70 percent of the mercury affecting New England comes from pollution in upwind states. Downwind states such as Vermont and New Hampshire will not be able to solve this problem without better federal regulations.

1. Congress must act to reduce the total amount of mercury entering the environment from man-made sources such as coal-burning power plants, and not simply allow one polluter to shift the ability to release mercury to another with no net reduction.

2. State authorities should continue to legislate reductions in mercury contamination. New Hampshire has recently followed Vermont's example in regulating outdoor furnaces, which could be sources of mercury. States should enforce their ban on barrel burning of trash.

3. EPA and the states of Vermont and New Hampshire should plan to cooperate on a follow-up study of mercury and other fish tissue toxins in the next decade, to track progress in achieving mercury reductions. CRJC should participate in design of future studies. The next effort should include a focus on coldwater species in the northernmost reach of the river.

XVII. Climate Change

Issue: Climate change may affect river dynamics, water quality, aquatic habitat, erosion, and much more.

Most scientists agree that climate change is already underway, and that the Northeast can expect higher temperatures and shifting seasons, reduced snow cover, and more extreme weather (9). During the 20th century, the average temperature in Hanover increased 2°F (10). Climate change has potential for wide-spread economic effects, ranging from collapse of the states' current reliance upon snow-dependent tourism such as skiing and snowmobiling to loss of the iconic maple sugar industry, but there are implications for the river system as well.

"The rain that fell on October 8 and 9 completely rewrote our river."

Deb Hinman, Cold River Local Advisory Committee

Effects of climate change are predicted to include more precipitation in short, intense bursts (more than two inches of rain in a day), which could lead to more flooding. Measurable increases in the number of heavy rain storms have already occurred across the Northeast in recent decades, including two micro-bursts in Westmoreland in 2003 affecting Mill Brook; severe storms in Canaan affecting Leach and Bolter Creeks and in Hanover in 2004; floods on Indian Stream and the Sugar River in 2005; and two severe storms in the Mohawk River watershed in 2006. All of these storms resulted in heavy erosion and turbidity in the Connecticut River, in some instances causing a shift of the huge mainstem's current in response to sediment deposited there by a relatively tiny tributary.

None of these storms, however, matched the unraveling of the Cold River in 2005, when a 500-plus year storm brought 11 inches of rain in 24 hours, reaching a total of 17 inches during the ensuing week. Flooding caused over $4 million in damage in New Hampshire and seven deaths, four of them in the Cold River watershed. At the same time, floodwater exceeded storage capacity at the large hydro dams at Fifteen Mile Falls, and flooding occurred below them.

Heavy sustained rainfall led to the October, 2005 flood on the Cold River that severely affected roads, homes, and lives.

More flooding could lead to greater erosion and increases in sediment, fertilizers, and other pollutants in stormwater runoff. The Soil and Water Conservation Society predicts that a relatively small increase in rain intensity of 10 percent will result in a 24 percent average increase in soil erosion (11).

Climate change effects in the watershed may also include droughts, especially if emissions are not soon controlled. Such droughts could lower groundwater levels and affect the drinking water supply of rural residents who depend on shallow wells. Farmers finding reduced soil moisture in their fields due to drought and increased evaporation may turn toward irrigation to satisfy water needs of crops at a time when river flow is already down, setting up a possible conflict with flows needed to support fisheries. During the drought of 2002, the hydropower company supplied water from Lake Francis and the Connecticut Lakes to Comerford Reservoir to meet a new minimum flow requirement, dropping water levels upstream in the Lakes and stranding docks and boats.

A warmer climate could lead to earlier spring snowmelt and result in higher streamflows in winter and spring and lower streamflows in summer and fall. Warmer water temperatures also reduce dissolved oxygen, adversely affecting fish habitat, and lower summer streamflows could reduce the ability of rivers to assimilate waste. This is a subject of special concern in some parts of the valley where multiple wastewater treatment plants discharge into the Connecticut River mainstem within a short distance, or into impounded reaches such as at Vernon that are also warmed by a thermal discharge from the Vermont Yankee nuclear power plant.

Solutions for reducing greenhouse gas emissions often refocus attention on alternative energy sources such as hydro power. However, studies show that reservoirs behind hydro dams contribute methane, a potent greenhouse gas, through anaerobic decay of organic matter, and can remove some of the carbon sink provided by vegetation by removing trees and flooding the area (12). While use of the dams avoids the effects of conventional fossil fuel-burning plants, these effects should be taken into account.

A 2005 study by Michael Simpson at Antioch New England Graduate School in Keene projects a 30 percent increase in the occurrence of 25-year storms (13). This study concluded that current engineering design specifications for culvert sizing is inadequate to handle the

higher frequency of storms of greater intensity that can be expected with climate change. The micro-watersheds of many culverts have less storage for runoff now than they did 30-40 years ago when these culverts may have been installed, because wetlands have been drained, land has been cleared, and more impervious surface has been added.

Engineering guidelines for culvert sizing, created in 1960, have not been updated to reflect increasingly heavy storms, or even to compensate for increased imperviousness. The Antioch study found that steep slopes are closely associated with flashy runoff in headwater streams, because soils are thin and cannot absorb much runoff. In the Black Brook micro-watershed in the Ashuelot River basin, the study predicted a 104 percent increase in runoff over baseline conditions, in a two year storm over 24 hours when steeply sloped areas were built out according to current zoning. Removing steep slopes from the build out analysis reduced runoff nearly to the baseline level. The Antioch study also found that by instituting riparian buffers of at least 75 feet in width, runoff increase under a build-out scenario was limited to seven percent.

Opportunities & Recommendations: Think globally, act locally.

There never was a more appropriate context for this popular adage. Actions taken in the Connecticut River watershed can join those across the country and elsewhere in the world to mitigate the effects of climate change both here and abroad. The states are developing a climate change policy, and need the support and encouragement of citizens. Policymakers have begun to recognize the role of the states' forests in storing carbon and mitigating climate change. Recently, a researcher at the University of Vermont suggested that increasing that carbon storage could have a value of some $1 billion (14).

Sustainable stormwater management in this new context is more important than ever, as is assuring open floodplains, effective riparian buffers, and property safe from sudden high water. Protecting riparian buffers and the shallow soils of ridgelines, hillsides, and steep slopes from development can avoid contributing to sudden runoff that leads to flooding. Low Impact Development measures for stormwater capture, such as porous pavement, can also be a key to reducing runoff. Identifying undersized culverts in a hazard mitigation plan can help a town qualify for funding for their replacement.

"Climate change is reshuffling the deck and changing all the rules."

Barry Cahoon, River Management Engineer, Vt. Agency of Natural Resources

1. States should articulate a clear policy with regard to climate change, and provide guidance to towns and citizens regarding actions they can take to maximize energy efficiency, cope with the impacts of climate change, and reduce their carbon footprint.

2. State transportation agencies should revise design guidelines for culverts and stream crossings to reflect new storm frequencies and runoff volumes.

Winter's grasp on the Connecticut River Valley may shift with climate change. Here, Grant Brook meets the Connecticut River in Lyme, N.H.

3. Public agencies and private landowners should work together to retain existing natural flood storage, such as in wetlands and floodplains. Promote riparian buffers to shade and help control water temperatures and protect riverbanks against erosion. Promote effective, dispersed stormwater management to help control stormwater runoff.

4. Towns should evaluate whether culverts and bridges are sized properly in order to carry the water that might come their way during larger storms. Towns should adopt ordinances prohibiting filling and building in the 100-year floodplain and on flowage rights of way. Discourage development on steep slopes in order to minimize the burden on culverts and bridges to carry runoff during heavy storms. Require riparian buffers of at least 75 feet along all rivers and streams to promote stormwater absorption and help guard against erosion. Require developers to use Low Impact Development measures for capturing stormwater and reducing runoff. Weigh the costs and benefits of identifying and replacing inadequately sized culverts, and go to a phased, risk-based program of culvert upgrades to reduce exposure to damaging floods.

XVIII. Local River Subcommittee Executive Summaries

Headwaters Region

Introduction

This Water Resources Plan is an updated and expanded edition of the Water Quality chapter originally published by the Connecticut River Joint Commissions as part of the *1997 Connecticut River Corridor Management Plan, volume II,* for the Headwaters Region. This plan is a requirement of the New Hampshire Rivers Management and Protection Act. It was prepared by CRJC's Headwaters Subcommittee in 2005-2007 by volunteer representatives of the riverfront towns from Pittsburg to Northumberland, N.H. and Canaan to Maidstone, Vt., assisted by CRJC's conservation director. Planning boards and commissions can review its recommendations and integrate them into their local master plan, and select appropriate recommendations to bring to townspeople for adoption into their zoning ordinances.

The Headwaters Region - The 80-mile Headwaters segment begins at the river's source at Fourth Connecticut Lake at the Canadian border. The river falls over 1,800 feet from Fourth Lake to the breached Wyoming Dam. Offering some of the finest trout water in the Northeast, the river passes through boreal forest and fertile farmlands. For the better part of a century, starting in the mid-1800s, the river's headwaters were scoured, straightened, dammed, and flooded to move timber downstream to waiting mills during the legendary Connecticut River log drives. While the quality of the river deteriorated less here than in downstream reaches, it too has improved with the investment in modern septic systems, wastewater treatment plants, manure storage facilities, and use of best management practices.

Economic Value of Clean Water - Good water quality is important economically for the Headwaters region. Studies in New Hampshire have found that its rivers and lakes annually contribute an estimated $1.5 billion in total sales and $247 million in property taxes to its economy (2002 dollars). Statewide, fishing, boating, and swimming have the same economic impact as snowmobiling, ice-fishing, downhill skiing, and cross-country skiing combined. Overall, water-based recreation in New Hampshire's Great North Woods region generates over 400 jobs, over $9 million in personal income, and more than $26 million in business sales, totaling about seven percent of the recreational revenue generated by anglers, boaters and swimmers in New Hampshire. A perceived decline in water clarity and purity in the Great North Woods could lead to a loss of some 30 jobs, a loss of about $650,000 in personal income and a loss of nearly $2 million in business sales.

Condition of the Connecticut River Today

Water Quality - Very good water quality, adequate dissolved oxygen, and an aquatic food web that is for the most part in excellent condition distinguish the Headwaters segment of the river. Still, the river carries bacteria, nutrients, sediments, and other forms of pollution, and faces new challenges from riverside development and the invasive diatom Didymo. Much of the region suffers from low pH, partly because of the chemistry of its rocks and thin soils and partly because of acid rain. High water temperatures can occur in summer, due partly to lack of shading where riverside trees have been removed or to low flows. Turbidity and sedimentation can be a serious water quality problem in the Headwaters region. More care is needed to keep sediment from land development and logging from getting into the river and its tributaries.

There is currently no regular, ongoing water quality monitoring program on the Connecticut River. When the N.H. Department of Environmental Services (NH DES) assessed the river in 2004, bacteria levels violated state water quality standards for 50 miles from Stewartstown to the Guildhall/Northumberland bridge, although limited sampling in 2005 did not find such high levels. Bacteria may come from wildlife rather than from farming or other human activities, although high counts may also reflect poor septic systems. There are also bacteria problems in several tributaries. The 2004 findings for bacteria are disturbing, given the popularity of these waters for swimming, canoeing, and kayaking.

Sediment Quality - Recent studies of river sediments by EPA help paint a picture of what is in the silts and sands of the river bottom. There are low levels of pesticides, oils and other engine pollutants, and some metals, but most contaminants are not concentrated enough to threaten aquatic life. Just below Pittsburg village, however, more pollutants appeared than anywhere on the northernmost 200 miles of the river except for a flooded industrial site near White River Junction. "Paris Green," an arsenic compound, was once used on Pittsburg farms later inundated by Lake Francis. The highest concentration of manganese was found in the Mohawk River near Nash Equipment. Fourth Connecticut Lake also carries pesticides and dioxins, and enough arsenic, cadmium, lead, and mercury to have an effect upon aquatic life.

Toxins in Fish Tissue - In 2000, EPA and the four Connecticut River states conducted the first river-wide study of fish tissue in the nation. While few fish were studied in the Headwaters region, the results are still sobering. The study found that mercury concentrations were significantly higher upstream than downstream. Mercury poses a risk to people who eat the fish and to fish-eating wildlife. Much of the mercury appearing in Connecticut River fish is believed to come from Midwest power plants and urbanized eastern seaboard emissions. DDT, PCBs, and dioxins were also found in small amounts. Dioxins can be produced through burning trash in backyard barrels, now illegal.

Invasive species - While most of the invasive plants that plague the river below the Headwaters have not yet arrived here, the region was shocked in June, 2007 by the discovery of Didymo, a highly invasive diatom, in the designated natural segment at Bloomfield. Didymo can form extensive colonies on the bottoms of rocky river beds, smothering aquatic life such as macroinvertebrates. Biologists believe that Didymo was introduced on contaminated fishing gear, especially felt-soled waders, and that it could also be spread by

any other recreational equipment. It has been identified in the area between the mouth of Perry Stream in Pittsburg to Bloomfield.

Key recommendations for river quality

- New Hampshire should sponsor a regular water quality monitoring program that includes bacteria, pH, and turbidity, and the acidity of rain storms. Arrange with local wastewater plants to process bacteria samples to encourage local volunteer monitoring, and reimburse local plants for this service. State agencies should make water quality monitoring data easily accessible to the public, including those who do not use computers, so the public understands the present condition of the river and its tributaries.

- Congress and the states should continue to reduce sources of mercury contamination and acid precipitation.

- Fishermen and other recreational users must clean their gear after visiting the river to avoid spreading Didymo.

River Flow

Instream Flow - Gages at Indian Stream and North Stratford provide real-time data for flow, precipitation, air temperature, and water temperature on a daily basis via the Internet. Three of the region's five gages were abandoned due to budget cuts by New Hampshire, but the legislature has set aside new funding.

When there is a drought, the Connecticut Lakes retreat naturally, since they are located at the head of the watershed. The lakes are sometimes affected by operations at the Fifteen Mile Falls hydro development 75 miles downstream. If there is not enough natural flow in the river to meet the dams' required minimum release, the lakes may be lowered to provide water for the rest of the river. River flow is also influenced by releases from Murphy Dam. Below Lake Francis, the river valley is a large floodplain of varying width bounded by steep sides. Heavy rain creates flooding on a regular basis, especially when enough water is received in the Lakes to force gates to open at Murphy Dam. Tributaries also have a strong influence on the river, and isolated storms can be restricted to one tributary watershed.

Flooding and Flood Control - The Headwaters region of the Connecticut River, occupying the steepest and highest part of the watershed, has more experience with flooding than any other. Floodplains and wetlands provide natural flood control by storing water, absorbing it quickly and releasing it slowly. The valley from West Stewartstown south into Lancaster and Lunenburg is one of the four most important natural valley flood control areas on the entire 410-mile long river. Here, the river can spread out on 12,000 acres of floodplain and reduce its energy.

Lake Francis is the only dam in the Headwaters Region that was built for flood control, and the dams at First and Second Lakes hold water when possible to reduce spring flooding downstream. Ice has a powerful role in flow and flooding in the area. Unexpected releases from Murphy Dam combined with high water from storms can catch riverfront farmers

unaware, stranding equipment and livestock in lower fields as far down river as Guildhall. An effective warning system is urgently needed for public safety and to allow farmers to move equipment and livestock to higher ground.

The Headwaters region is experiencing more frequent extreme storms in recent years, creating local flooding and threatening riverbank stability as well as local roads, bridges, and buildings. Sudden, severe storms have been described as symptoms of climate change. By the end of the century, the Headwaters region may be the only part of the Connecticut River Valley that retains snow cover for at least 30 days during the winter. Reduced snowpack could affect the flow of much if not most of the river.

Key recommendations for flow and flood control

- The N.H. Dam Bureau, along with emergency management officials from towns below Murphy Dam in New Hampshire, Vermont, and Quebec, and TransCanada should work together to develop a effective and reliable system for warning town officials about water releases that could result in flooding below the dam. Essex and Coös County Conservation District managers can assist with contacts for riverfront landowners.

- Land conservation organizations and the U.S. Army Corps of Engineers should purchase development rights from willing owners of land in the natural valley flood storage area to help prevent flooding downstream.

Working River

Headwaters Region Dams - There are five dams on the mainstem of the Connecticut River in the Headwaters. Moose Falls Dam and Murphy Dam at Lake Francis are owned by the state of New Hampshire, and TransCanada Hydro Northeast owns the dams at First and Second Lakes. Murphy Dam and First and Second Lakes are operated for recreation, water storage, and flood control. They provide flow for TransCanada's downstream hydroelectric facilities and do not generate electricity themselves. Canaan Dam, between Canaan and West Stewartstown, is owned by Public Service Company of New Hampshire, and is preparing for relicensing in 2009. The state rates Murphy Dam as having high hazard potential to life should it fail, although officials report that the dam is extremely safe and well maintained. Should the dam fail suddenly and massively, the Connecticut River would rise 30 feet from Pittsburg to Stratford, and also into Quebec. Flooding would stop 85 miles downstream at Moore Reservoir. There is no early warning system to alert these towns.

Key recommendation for dams

- The N.H. Bureau of Emergency Management and DES Dam Bureau should enlist the help of the federal Homeland Security Agency to install an early warning system that will reach all communities in New Hampshire, Vermont, and Quebec that could be affected by a failure of Murphy Dam. Radio may be the easiest way to communicate with downstream towns.

Using the Waters

Water withdrawals - As a designated river in New Hampshire's Rivers Management and Protection Program, the Connecticut River's water is protected from being diverted outside of the watershed. The state requires registration of water withdrawals over a certain size, which helps identify future problems of well interference, declining water tables and/or diminished streamflows, but does not limit withdrawals. Vermont has no system for tracking withdrawals and the amount of water that would otherwise have flowed in the river from Vermont is unknown.

Groundwater and drinking water supplies - Clean drinking water may be our most valuable but under-appreciated commodity. New Hampshire has mapped stratified drift aquifers and regulates new groundwater withdrawals for public community water systems and large withdrawals to prevent harm to existing water users and nearby streams and rivers. Vermont has not mapped aquifers as comprehensively and does not regulate groundwater withdrawals. Groundwater can be contaminated by pollutants which are difficult if not impossible to remove, including salt. Some homes in the region are located on lots too small to keep wells and leach fields properly separated. Colebrook withdraws from an aquifer connected to the Mohawk River, and has purchased land to protect drinking water.

Key recommendations for water use

- Towns should take advantage of source water protection grant and loan programs. Discourage development that puts both wells and septic systems close together on very small lots.

Land Use and Water Resources

Wastewater discharges - Most towns now have wastewater treatment plants that discharge to the Connecticut River, and have made improvements to them in recent years. However, at Stratford Hollow, several homes are on lots too small for individual septic systems, and there were straight pipe discharges to Bog Brook. The town won grants to help many homeowners install better treatment. Bog Brook flows into a part of the Connecticut River that is popular for paddling and swimming but is contaminated with bacteria. Several industries discharge wastewater to the river and its tributaries, including Ethan Allen in Beecher Falls and Columbia Sand and Gravel's washing water in settling ponds very close to the river. Before the plant closed, Wausau treated paper mill effluent before returning it to the Upper Ammonoosuc River. Of concern is how medicines that can pass through a wastewater treatment plant could affect fish and other river life.

Key recommendations for wastewater discharges

- Town conservation commissions and regional planning commissions should teach people to wrap and discard their unused and out-dated medicines in regular household trash rather than flushing. EPA and the states should establish updated rules for disposal or return of unused medicines.

Landfills, Junkyards, & Transfer Stations - Most public dumps have been identified and capped. Canaan is currently searching for a safe location for a transfer station. The unlined Colebrook landfill was sending a plume of contaminated groundwater toward Lime Pond in Columbia, until the town and NH DES reached an innovative agreement for capping and closing the landfill and dealing with the groundwater. At a long-established junkyard near the Mohawk River, scientists found high levels of manganese and other pollutants. Because of these findings, it might be wise to see if there has been an effect on surface and groundwater. Riverbank littering remains a problem at some fishing access points and at some riverfront properties. Illegal dumping of tires and appliances rose after towns started charging to take them.

Key recommendation for landfills, junkyards, and transfer stations

- NH DES should work with the owner of the equipment salvage yard in Colebrook to test surface and groundwater above and below this site, which may be a good candidate for a brownfields study.

Shoreline and Floodplain Development - The value of shorefront property throughout the Connecticut River valley has risen sharply, and development along the Connecticut River and the Lakes has suddenly increased. There is presently no means to guide shoreline development in most Headwaters towns, other than New Hampshire's Shoreland Protection Act. Vermont is the only state in New England that does not have a statewide shoreland protection law. Because building in floodplains takes over valuable farmland, transfers flooding problems downstream, and costs taxpayers money when flooding occurs, Northumberland has passed an ordinance banning construction within the 100-year floodplain. This region's Flood Insurance Rate Maps are often grossly inaccurate. Glacial lakes left behind layers of ancient lake-bottom sediments, called varves, that can create unstable drainage. Siting landfills, bridges, large buildings, and other important structures on varved deposits is risky although their location is not well known.

Key recommendations for shoreland and floodplain development

- FEMA should provide accurate floodplain maps for Headwaters region towns. Towns should not permit building in the 100-year floodplain, to protect their citizens and businesses from damage, to avoid adding to flooding of their downstream neighbors, and to reduce the public cost of disaster relief.

Roads, gravel pits, and railroads - In the Headwaters region, roads and railroads must often follow streams closely to move through their often steep-sided valleys. Better riparian buffers help hold streambanks in place and capture road-related pollutants. Faulty construction or lack of maintenance of woods roads is a problem. An under-sized culvert or bridge can block with debris in a sudden storm and cause a stream to cut through a road, affecting the Connecticut River. A blocked culvert on Route 3 in West Stewartstown led to severe riverbank slumps above Canaan Dam. Improper road salt storage and loading procedures can lead to trouble, since salt dissolves so easily in water. There are several gravel mining operations close to the river, and downstream farmers report that fine particles of rock powder reach the river which spreads them on their fields nearly every year. The railroad follows the mainstem on the

New Hampshire side. Rusting rail cars, stored on tracks near the river, are less often the visual blight they once were.

Key recommendations for roads, railroads, and gravel pits

- Gravel mining operators should process gravel at a safe distance from the river, to avoid contaminating the water with fine rock powder particles, and take steps to keep such fine material from blowing around. State environmental agencies should monitor and enforce permit conditions for gravel pit construction.

Storm Water Runoff - Cleared, compacted, or paved land sends water downhill faster than when it is captured by thick vegetation and transpired by trees. Stormwater may be washing pet waste into the river and contributing to the higher bacteria levels found here. Good decisions now can keep development from increasing water temperature and adding pollution, ruining the fine fishing for which the region is so well known.

Key recommendations for stormwater management

- State agencies should inform developers and landowners about recent changes in stormwater permitting. Developers should include infiltration methods such as small swales and runoff basins to capture runoff.

- Loggers should use best forestry management practices when working near intermittent and year-round streams.

Home Landscapes - Residential development has increased noticeably in the last decade, especially as second-home buyers come to the area. Unlike U.S. farmers, who are professionally trained and certified to apply fertilizers and pesticides in the proper amount and at the proper time in the growing season, homeowners have no such training and are likely to use much more of these potential pollutants than is necessary or advised.

Key recommendations for home landscapes

- States should educate owners of shoreland about the best ways to manage their property. Homeowners living near waterways should retain buffers of native woody vegetation along the banks.

Farms - Prime agricultural soils distinguish much of the floodplain in the Headwaters region. Much of the quality of life on the river has been affected by agriculture, and mostly in a positive way. It is more desirable to see riverbottom land used for farming than developed into house lots. This land offers prime soils of national significance, and, from a homeland security point of view, is essential to supply a local source of food.

Unregulated use of manure and farm chemicals on the Canadian side of Hall Stream is a concern for the river. Some farmers grow corn on river bottom lands more continuously than is good for either the soil or for water quality, since corn land is highly exposed to erosion

during flooding. Vermont's Conservation Reserve Enhancement Program has helped at least one Headwaters dairy farm to install a substantial riparian buffer along the river.

Key recommendations for farming

- Farmers should voluntarily adopt best agricultural management practices; learn how conservation easements help keep the farm in the family and the land working; keep good records of yields, fertilizing, and soil/plant tissue analysis; decide on their own to establish/retain filter strips between fields and water courses; and rotate corn frequently with other crops, particularly on flood-prone land. Vermont farmers should make use of the Conservation Reserve Enhancement Program to plant riparian buffers or provide livestock water sources.

- NH DES should investigate contamination in Hall Stream, and if necessary, speak with Quebec authorities.

Forests and rivers - The Northern Forest is likely the single most important factor in the water quality, fisheries, wildlife, recreational, scenic, and economic values of the river in the Headwaters Region. Forest landowners who are aware of the many values of streamside forests use forested riparian buffers to control flooding and erosion, trap pollutants, shelter coldwater fisheries, and provide an attractive streambank and recreational opportunities. Current and potential problems include siltation from improperly built stream crossings or skidder trails, harvesting when soils are prone to erosion, and faulty construction or lack of regular maintenance of woods roads. Flash flooding and siltation can result from increased surface runoff when large areas of forest cover are removed.

Key recommendations for forests

- Forest landowners should adopt the principles of sustainable forest management; develop management plans for their forests and conduct logging with the help of professional foresters; follow guidelines in *Good Forestry in the Granite State;* minimize the visual and water quality impacts of clear-cutting, especially near the river; promote and use integrated pest management to lessen the reliance on chemicals; protect and maintain a forested riparian buffer along waterways; dispose of slash away from streams; consider conservation easements on their property to allow it to continue in active forest management and to contribute to the economic, scenic, and timber resource base of the region, but also allow it to remain unfragmented by development.

Riverbank Erosion

Causes of Erosion - Sedimentation and turbidity may be the most important problem threatening water quality in the Headwaters region. The river can run light brown after storms. Erosion is a natural process, but human actions also cause unnatural erosion through poorly designed stream crossings, livestock trampling riverbanks, sudden water releases below dams, boat wakes, and especially removal of the riverside vegetation that naturally holds the bank together.

In 2004, the Connecticut River Joint Commissions sponsored an intensive study of 85 miles of the river from Murphy Dam to Gilman. Results show that one third of the river had been artificially straightened before 1925, probably to remove obstructions for log drives. The resulting long, straight stretches of river are not natural, and the river is now reshaping the resulting sharp corners back into smoother, more natural curves. Straightening the channel has also caused the river to cut down within its bed. The river is now trying to widen and slow as it recovers from these dramatic changes. Therefore it is dangerous to build berms close to the river, because they will not stand up to the river forces at work. A better approach would be to keep development far enough from the river to allow it to continue readjusting without threatening homes or businesses. CRJC provided Headwaters towns with maps showing local erosion sites, bank composition, and riparian buffer condition, along with guidance about how to approach riverbank projects.

Tributaries are also changing the mainstem. Sediment deposited by the Mohawk River in the Connecticut is causing erosion at the Colebrook Business Park. In Stark, sediment deposited by Mill Brook in the Upper Ammonoosuc River watershed is causing erosion near a road close to the river's edge. Heavy land clearing in a tributary watershed may cause too much sediment to wash away. High eroding banks of glacial outwash have a major role in erosion. Sand and gravel sliding down these bare slopes, such as at Brunswick Springs, fall into the river and are deposited in bars that deflect the river current onto nearby riverbanks. Erosion of the 40-foot high bank at the Northumberland Cemetery threatens burials above. CRJC's 2005 study of this site found that the 1980s breaching of the Wyoming Dam has caused the river to drop at least three feet, resulting in higher stream velocity and slumping along the high banks upstream to the cemetery.

Riparian Buffers - Riparian buffers are the single most effective protection for rivers and streams. These strips of shrubs and trees along the banks filter polluted runoff, capture sediment and nutrients, and provide a transition zone between water and human land use. Vegetated buffers are relatively inexpensive and have the added advantage of providing habitat for both land based and aquatic animal species and privacy for landowners. Shading streams with vegetation helps to optimize light and temperature conditions critical to the survival of certain species, such as trout.

The 2004 study found a 67 percent greater chance of finding erosion where there is no riparian buffer. The study found a lack of riparian buffer along a full 20 percent of the riverbank, and concluded that bank stability generally increases as buffer width increases, as long as a buffer is at least 25 feet wide.

Key recommendations for erosion and riparian buffers

- Landowners along rivers and streams should retain and enhance buffers of native vegetation on their banks to help hold soil together.

- Towns and landowners should consider conservation easements to prevent development in places where the river is actively eroding, to give the river room to move.

- Boaters should abide by state boating laws, which require travel at headway speed only throughout the Headwaters region of the Connecticut River (except for the lakes), and avoid creating wakes that cause erosion.

Riverbend Region

This Water Resources Chapter is an updated and expanded edition of the Water Quality chapter originally published by the Connecticut River Joint Commissions as part of the *1997 Connecticut River Corridor Management Plan, Volume III, Riverbend Region*. This plan is a requirement of the New Hampshire Rivers Management and Protection Act. It was prepared by CRJC's Riverbend Subcommittee in 2005-7 by volunteer representatives of the riverfront towns from Lancaster to Haverhill, N.H. and Guildhall to Newbury, Vt., assisted by CRJC's conservation director. Planning boards and commissions can review its recommendations and integrate them into their local master plan, and select recommendations to bring to townspeople for adoption into their zoning ordinances.

The Riverbend Region - The Connecticut River assumes many different personalities in its flow through the Riverbend Region, traveling 70 miles through fertile farmlands and forests. From Guildhall to Lunenburg, the river flows freely until it reaches Gilman Dam. The river's dramatic drop at Fifteen Mile Falls, once a spectacular series of cascades, has been exchanged for the expanse of Moore and Comerford Reservoirs and hydropower production. Operations at these, the largest hydro dams in New England, influence the flow of the river through the rest of its path. Below Dodge Falls, the river is free-flowing and meets two major tributaries at "The Narrows" at Woodsville and Wells River before slowing as it reaches the Wilder impoundment.

Clean Water Has Clear Economic Value - Good water quality is important economically for the Riverbend region. Studies in New Hampshire have found that its rivers and lakes annually contribute an estimated $1.5 billion in total sales and $247 million in property taxes to its economy (2002 dollars). Statewide, fishing, boating, and swimming have the same economic impact as snowmobiling, ice-fishing, downhill skiing, and cross-country skiing combined. Overall, water-based recreation in New Hampshire's White Mountains Region, of which the Riverbend area is a part, generates over 1,000 jobs, over $24 million in personal income and over $67 million in business sales, totaling about 18 percent of the recreational revenue generated by anglers, boaters and swimmers in New Hampshire. A perceived decline in water clarity and purity would cause a loss of nearly 200 jobs, a loss of about $4 million in personal income and approximately $12 million in lost business sales (2006 dollars).

Condition of the Connecticut River Today

Connecticut River Water Quality - On the Connecticut River mainstem, most of the river is safe for swimming except for 5.72 miles in Lancaster that are above state standards for the bacteria E. coli. There are sporadic problems elsewhere with pH and aluminum. Bacteria are also above state standards on several brooks in Lancaster and Oliverian and Clark brooks in Haverhill. Combined sewer overflows in St. Johnsbury deliver bacteria to the Passumpsic River. Several ponds and the John's River in Dalton have problems with low pH and high aluminum. There is currently no regular, on-going water quality monitoring program on the

Connecticut River in the Riverbend region. However, recently organized citizen groups are now conducting monitoring on the Ammonoosuc, Israel's, Wells, and Stevens rivers.

Sediment Quality - Studies indicate that at the majority of sampling sites, no contaminants were found in sediments above levels at which one would expect a risk to aquatic life, although traces of many appeared. However, road runoff has probably had an effect upon the river as heavy metals and polyaromatic hydrocarbons associated with automobiles appear in the sediments. A large variety of pesticides showed up, although in very low concentrations that do not present much risk to aquatic life. At Guildhall, just above the breached Wyoming Dam, EPA found very low concentrations of endrin and the breakdown products of DDT, a pesticide that is now banned and has not been used for years, but persists in the environment. Eight kinds of dioxins and furans appeared in low levels in Moore Reservoir.

Toxins in Fish Tissue - In 2000, EPA and the four Connecticut River states conducted the first river-wide study of fish tissue in the nation. For the Riverbend region in particular, the results are sobering. The study found that total mercury concentrations in all three species of fish were significantly higher upstream than downstream, and particularly in this region. Mercury poses a risk to people who eat the fish and to fish-eating wildlife. Much of the mercury appearing in Connecticut River fish is believed to come from Midwest power plants and urbanized eastern seaboard emissions. The states have set stricter fish consumption guidelines for Moore, Comerford, and McIndoe Falls reservoirs than elsewhere, due to the presence of mercury in the sediments of these fluctuating impoundments, which moves up through the food chain in its dangerous methylated form. DDT breakdown products are a threat to subsistence fishermen and fish-eating birds in the region, but not to fish-eating mammals. Risk from PCBs was generally lower in upstream areas than downstream. Dioxins and furans pose a threat to subsistence fishermen but not to other fish consumers. Dioxins can be produced through burning trash in backyard barrels, now illegal.

Key recommendations for river quality

- States should ensure adequate and regular water quality monitoring; continue to work with town conservation commissions and watershed groups to encourage, expand, and coordinate volunteer water quality monitoring.

- State and federal authorities should continue to legislate reductions in mercury contamination of the region. EPA should work with the states every 10 years to conduct a more detailed, comprehensive long-range study of sediment and fish contamination to better understand the distribution and types of contaminants, and their trends.

River Flow

Instream Flow - There are two gaging stations on the mainstem at Dalton and at Wells River and three remaining gages on area tributaries. Since more extreme weather patterns seem to be emerging, it is important that gages remain funded so that the data will continue to be available. Gaging on high elevation and flashy streams could offer protection to areas under development pressure.

The Connecticut River in this region typically flows heavily with spring ice-out and snowmelt and also after heavy rains in the river's upper watershed, but the strongest influence on the river year-round is from the dams at Fifteen Mile Falls. Water from the Connecticut Lakes is the lower river's insurance in August and September, when rainfall is typically less than at other times of the year. The 2002 license for Fifteen Mile Falls set a new minimum flow from Comerford Dam.

Flood Control - Major natural valley flood storage in the Riverbend region is focused on the river's floodplain in Dalton, Lancaster, Lunenburg, and Guildhall, and Haverhill, Newbury, Bradford, and Piermont. There are no flood control dams in this region; the mainstem hydro dams were built for power generation, not flood control, although when possible, they are operated to help ease flooding.

Key recommendations for flow and flood control

- Land conservation organizations and the U.S. Army Corps of Engineers should purchase development rights from willing owners of land in the natural valley flood storage area to help prevent flooding downstream.

Working River

Riverbend Region Dams - The Connecticut River is more heavily developed for hydropower generation here than anywhere else on its four state path. Five dams power riverside industry or send electricity throughout the region, including the two largest hydro dams in New England. A sixth dam is now breached. The river now flows free for 85 miles from Murphy Dam at Lake Francis in Pittsburg before encountering the Gilman Dam in Lunenburg, Vt. and Dalton, N.H., a run-of-river dam now owned by Dalton Hydro, and then enters a 30-mile run that is almost entirely managed for peaking hydro generation before once again passing through a run-of-river dam between Monroe, N.H. and Ryegate, Vt.

The three dams at Fifteen Mile Falls are daily peaking generation plants, controlled remotely through connections to Wilder Dam in Wilder, Vermont. Their federal operating license was renewed in 2002 and expires in 2042.

Key recommendations for dams

- Citizens and local citizen groups should encourage continued communication between TransCanada and its successors, with local communities and landowners. Town emergency management plans should call for better coordination with dam managers.

Using the Water

Water withdrawals - As a designated river in New Hampshire's Rivers Management and Protection Program, the Connecticut River's water is protected from being diverted outside of the watershed. The state requires registration of water withdrawals over a certain size, which helps identify future problems of well interference, declining water tables and/or diminished streamflows, but does not limit withdrawals. Vermont has no system for tracking withdrawals

and the amount of water that would otherwise have flowed in the river from Vermont is unknown.

Groundwater and drinking water supplies - While no individual actually owns groundwater, clean drinking water may be our most valuable but under-appreciated commodity. New Hampshire has mapped stratified drift aquifers and regulates new groundwater withdrawals for public community water systems and large withdrawals to prevent harm to existing water users and nearby streams and rivers. Vermont has not mapped aquifers as comprehensively, although it recently passed regulations governing groundwater withdrawals. The gasoline additive MtBE, which was intended to reduce air pollution, has polluted groundwater in Barnet.

In the Riverbend region, only Bath, Haverhill, and Newbury have groundwater protection regulations and regulate the use of land on top of underground water supplies, and Bath and Newbury have also identified public well supply areas. Littleton and Barnet have taken steps in this direction. The subcommittee believes it is more cost-effective to protect the source of drinking water before it can be contaminated.

Key recommendations for water use

- Town planning boards and commissions should evaluate water supplies for short and long term growth. Towns should not permit landfills, hazardous waste disposal facilities, auto salvage yards, junkyards, snow dumps, wastewater or septage lagoons, and outdoor salt storage or other de-icing chemical storage to be located on aquifers.

Land Use & Water Resources

Wastewater discharges - Eleven municipal wastewater treatment facilities discharge to the mainstem and tributaries in the Riverbend region. Approximately 25 combined sewer overflow discharges within the St. Johnsbury collection system affect the Passumpsic and Sleeper's rivers and thus the Connecticut River. The Subcommittee is concerned at the delay in addressing CSOs in St. Johnsbury. While NH DES has not identified CSOs in area New Hampshire towns, it is possible that they exist, particularly in Lancaster and Littleton. Several industrial wastewater treatment facilities are permitted to discharge directly to the mainstem, including heated water from the Ryegate chip plant and a discharge from Dalton Hydro at Gilman. Straight pipe discharges and failed septic systems in the Passumpsic River watershed, reported in the 1997 Plan, have since been cleaned up.

Key recommendations for wastewater discharges

- VT DEC and EPA should assist in eliminating combined sewer overflows in St. Johnsbury. NH DES should check New Hampshire towns for CSOs.

Landfills, Junkyards, & Transfer Stations - The major regional landfill on the New Hampshire side of the Riverbend region is located on an aquifer near the Ammonoosuc River in Bethlehem. The Boltonville landfill, capped but unlined, may be leaching into the Wells River. More frequent and convenient household hazardous waste collections would help keep

hazardous materials out of landfills and eliminate the temptation to burn them or toss them on roadsides or streambanks. A volunteer group on the Israel's River has energized local citizens for a series of highly successful cleanups on this beautiful tributary.

Key recommendations for landfills, junkyards, and transfer stations

- The state of New Hampshire should assist North Country Council in holding more frequent and more convenient household hazardous waste collections. Towns should strongly encourage citizens to make use of regular household hazardous waste collections and should organize carpooling or "waste pooling" to distant collection sites.

Shoreline & Floodplain Development - Riverfront land has growing appeal for riverfront homes, especially since lakefront and oceanfront land has now largely been developed, and memories of the river as a "nuisance" or a health hazard have begun to fade. Flat floodplains attract the attention of large commercial developers in a region that is known more for its steep and difficult terrain. The Subcommittee believes that there should be more shoreland protection for smaller streams. Vermont is the only state in New England that does not have a statewide shoreland protection law.

All of the towns along the Connecticut River in this region, except for Bath and Lunenburg, currently permit building in the 100-year floodplain. Floodplain maps are inaccurate. These floodplains also hold some of New England's most valuable agricultural soils, still useful for growing crops to feed the valley's own population. The Upper Valley Land Trust has worked successfully with the owners of much of the rich floodplain farmland in Haverhill and Newbury, and together they have protected many acres from development, keeping these soils open both for farm production and for flood storage.

Key recommendations for shoreland and floodplain development

- Town zoning ordinances should prohibit development in the 100-year floodplain. FEMA should ensure that floodplain maps are accurate. Towns should consider adopting agricultural soil protection ordinances to keep valuable soils available for farming and to keep development from interfering with flood storage.

Roads and railroads - An active rail line runs on the Vermont side of the river. Woodsville was once a key railroad hub, but no longer sees rail traffic. There is concern about whether the railroad manages brush near the river with herbicides rather than cutting. Spraying of herbicides in power and railroad line rights-of-way near waterways may be a threat to water quality. Winter road salt threatens water quality in the many streams followed too closely by roads. An uncovered sand/salt pile located very close to Cushman Brook in Dalton, managed by the N.H. Department of Transportation, may be allowing salt to reach this tributary of the Connecticut River. Many culverts may be too small, keeping both water and sediment from moving through, and present a barrier to fish passage that is as effective as any dam.

Key recommendations for roads and railroads

• Town highway departments, working with conservation commissions, should ensure that culverts are properly sized and placed for fish passage when replacing them during road work; use a natural bottom where possible and appropriate. New Hampshire towns should ask for help from regional planning commissions to survey culverts and bridges to identify those that are undersized; also note if they block fish passage and seek grants for replacing them where necessary, such as the recent improvement in the Route 135 culvert at Rix Brook in Dalton.

Storm Water runoff - Heavy clearing, whether for forestry or for development, can change stormwater runoff, how a tributary flows, and ultimately the Connecticut River itself and even property in another state. Runoff contaminated by bacteria from pet waste could cause a swimming hazard during and just after storms, as in downstream reaches of the river. Developers can mimic natural runoff by slowing it down and soaking it up when a property is developed, with "low impact development" techniques.

Key recommendations for stormwater runoff

• Town planning boards and commissions should plan for stormwater control and look at ways to include "low impact development" ideas as they review projects, and at how to change existing development to reduce runoff and promote stormwater infiltration. These include keeping riparian buffers to filter the runoff and other innovative, yet cost-free natural treatments.

Home Landscapes - Second-home development has added in recent years to residential development in the Riverbend region. Many people building on a waterfront parcel are tempted to cut down the vegetation along the stream in order to get a water view, not realizing that they are removing the protective barrier that keeps runoff from their lawns and gardens from reaching the water, or keeps the riverbank from eroding.

Key recommendations for home landscapes

• Homeowners living near waterways should retain buffers of native woody vegetation along streambanks, and consider planting some of the many ornamental native plants listed in CRJC's riparian buffer guidance. States should offer an information packet to owners of shoreland to educate them about the best ways to manage their property.

Farms and rivers - Prime agricultural soils distinguish much of the remaining floodplain in the Riverbend region. Working farms on these productive soils are a better use of these floodplains and shorelands than residential or commercial development. Dairying, which for well over a century has been the primary form of farming in the Riverbend region, has recently diversified to include organic dairy farming, which offers many water quality benefits. Most farmers working near the river understand how to manage manure and other fertilizers well so that they serve the farm and are not lost to the river, where they could cause algal growth downstream. However, at least one farm on the New Hampshire side still spreads manure on the snow.

Key recommendations for farming

- Agencies should enforce best/acceptable management practices, including a ban on winter spreading of manure, and look more closely at the effect of nutrient enrichment on river life, including fish. States and county conservation districts should encourage farmers to use best management practices to control erosion and protect and enhance riparian buffers.

Forests and Rivers

A forest is well known as the best guardian of the quality of water for drinking and for trout. Those who manage forests also indirectly manage the water quality of the Connecticut River and its tributaries. Forest landowners can use forested riparian buffers to control flooding and erosion, trap pollutants, shelter coldwater fisheries, and provide an attractive streambank and recreational opportunities.

Key recommendations for forests

- Landowners should follow best/acceptable management practices for timber harvesting, and minimize the water quality and visual impacts of clear-cutting and other timber harvesting operations, particularly near surface water. Skidder ruts should be smoothed and seeded as soon as possible once a timber harvest is done.

Riverbank Erosion

Erosion - Bank erosion and loss of river bottom land is a significant problem, particularly in Haverhill and Newbury. Eroded sediments are accumulating in the reservoirs and to a slight extent in the six miles of free-flowing river below Dodge Falls Dam. On the New Hampshire side alone, there is bank erosion on half of the 49 miles from Moore Reservoir to Haverhill. Three erosion studies showed that most of the moderate and severe erosion sites occurred on agricultural land, and areas with no vegetative buffer at all tended to have a higher rate of erosion, especially in combination with lack of vegetation due to livestock grazing.

Steep, high banks of glacial outwash, such as at the Groveton Cemetery opposite Guildhall, create deposits of bars that deflect the river current onto nearby riverbanks. In 2005, CRJC investigated the role of dams in causing erosion in this part of the river, and assessed three miles of the Connecticut River from the mouth of the Upper Ammonoosuc River to the breached Wyoming Dam. They found that the breaching of the dam resulted in a drop in the riverbed here, which has likely led to increased erosion at the Groveton Cemetery.

Riparian Buffers - Vegetation along streams and rivers is probably the simplest, least expensive, and most effective way to slow erosion and capture nutrients and sediments washing off the land and keep these waters from overheating. All studies conducted here concluded that human activity appears to be affecting erosion rates in some reaches where riparian vegetation has been removed from the bank, and that landowners need to be aware of the potential erosion that removing riparian buffers could cause.

Key recommendations for erosion and riparian buffers

- Landowners should establish or retain riparian buffers on their waterfront property to help filter out sediment and nutrients washing off the land, to allow trees and vegetation to help stabilize the banks and keep waters cooler, and to provide privacy. County conservation districts should be sure landowners know about sources of assistance such as Vermont's Conservation Reserve Enhancement Program and where they can find nurseries for buffer plant material.

Upper Valley Region

Introduction

This Water Resources Chapter is an updated and expanded edition of the Water Quality chapter originally published by the Connecticut River Joint Commissions as part of the 1997 Connecticut River Corridor Management Plan, Volume IV, for the Upper Valley region. This plan is a requirement of the New Hampshire Rivers Management and Protection Act. It was prepared by CRJC's Upper Valley Region River Subcommittee in 2005-2007 by volunteer representatives of the riverfront towns from Piermont to Lebanon, N.H. and Bradford to Hartford, Vt., assisted by CRJC's conservation director. Planning boards and commissions can review its recommendations and integrate them into their local master plan, and select appropriate recommendations to bring to townspeople for adoption into their zoning ordinances.

The Upper Valley Region - This segment of the river embraces 39 miles of the Connecticut River. Where it is impounded above Wilder Dam, the river functions ecologically more as a lake than a river. Riverbanks are affected by water level fluctuations at the dam and by boat wakes, as well as by natural processes including wind-driven waves, ice movement, and flooding. Below Wilder Dam, the Connecticut River functions more like a free-flowing river although it remains subject to flows that vary in volume and velocity due to operations at the dam. Major tributaries to this section of the Connecticut are the Waits, Ompompanoosuc, and White rivers and Blood Brook in Vermont, and the Mascoma River and Eastman, Jacobs, Clay, Grant, Hewes, Mink, and Great brooks in New Hampshire.

Economic Value of Clean Water - Good water quality is important economically for the Upper Valley region. Studies in New Hampshire have found that its rivers and lakes annually contribute an estimated $1.5 billion in total sales and $247 million in property taxes to its economy (2002 dollars). Statewide, fishing, boating, and swimming have the same economic impact as snowmobiling, ice-fishing, downhill skiing, and cross-country skiing combined. Overall, surface water recreation generates over 100 jobs in the Dartmouth-Sunapee tourism region of New Hampshire, which includes the Upper Valley. These jobs equate to $2.6 million in personal income and almost $7.5 million in business sales, totaling about 3.5 percent of the recreational revenue generated by anglers, boaters and swimmers in New Hampshire. A perceived decline in water clarity and purity would cause a loss of 14 jobs, about $309,000 in personal income and almost $1 million in business sales (2006 dollars).

River Quality

Connecticut River Water Quality - Water quality monitoring in 2004 indicated that the mainstem river meets state standards. However, because combined sewer overflows (CSOs) still exist in [Lebanon, the state of New Hampshire continues to classify the river from its confluence with the White River to Cornish as not supporting swimming. Because bacterial contamination results when storm water overwhelms the capacity of wastewater treatment facilities, which occurs only during heavy storms, the river is probably safe for swimming on most days in this area. Among Vermont tributaries, 16 miles of the Ompompanoosuc River system and three miles of Pike Hill Brook in the Waits River watershed are contaminated by metals and acid from abandoned mine drainage. Several sections are contaminated by the bacteria E. coli, barnyard runoff, and milk-house effluent. Some New Hampshire tributaries show problems with pH, dissolved oxygen, aluminum, and *E. coli*.

Monitoring efforts are presently insufficient to determine whether or not water quality in some areas of river popular with recreational users is actually good enough to support that recreation. As of this writing, no on-going efforts to monitor the Connecticut River are underway, despite the growth in the region's population and its dependence upon the river. In Vermont, volunteer monitoring occurs on Blood Brook and on the White, Waits and Ompompanoosuc rivers.

Connecticut River Sediment Quality - Results of two EPA studies show that road runoff has probably affected the river as heavy metals and polyaromatic hydrocarbons (PAHs) associated with automobiles appear in the sediments. PAHs below the confluences of the White and Mascoma rivers are in levels high enough to have an effect upon aquatic life. Sediments also show striking signs of copper contamination from abandoned mines in this part of the watershed at levels that threaten aquatic life. Other heavy metals, including zinc, lead, chromium, and nickel, appear near the I-89 bridge in Lebanon in concentrations that could have these effects. Arsenic appeared above the screening level at four sites. Traces of pesticides linger in the sediments near Dartmouth's Ledyard Boathouse swimming area just downstream from the Hanover golf course. The longest list of pollutants (37) found anywhere on a 200-mile study came from Wilder Dam Recreation Area in Hartford, where a number of contaminants were present well above levels where ecological effects can be expected. This site has a long history of industrial papermaking and was partially inundated by the construction of Wilder Dam.

Connecticut River Fish Tissue Toxins - In 2000, EPA and the four Connecticut River states conducted the first riverwide study of fish tissue in the nation. In the reach that included the Upper Valley region, total mercury concentrations in fish were significantly higher upstream than downstream, and are a threat in this region to subsistence fishers and also to mammals and birds that eat the fish. Risk from PCBs was generally lower in upstream areas than in downstream areas, although this varied by fish species and was different for the humans, mammals, birds or fish that eat them. DDT breakdown products pose a risk to subsistence anglers and to fish-eating birds such as kingfishers, but not to recreational fishermen or to fish-eating mammals such as otter.

Key recommendations for river quality

- States and the federal government should provide financial assistance to Lebanon to complete the elimination of CSOs. Lebanon should pursue elimination of remaining CSOs.

- Congress and the states should take immediate action to reduce mercury contamination of the region.

- Landowners and town road crews should restore and retain riparian buffers to capture road pollutants.

River Flow

Instream Flow - Except in very high water conditions, operations at Wilder Dam almost completely control instream flow of the Connecticut River in the Upper Valley region. The large watershed of the free-flowing White River, which enters just below the dam, adds natural variation to the closely managed mainstem flow. One gage on the mainstem and six on tributaries provide real-time data for flow, precipitation, and air temperature via the Internet.

Flooding and Flood Control - The Connecticut River in this region typically experiences large flows with spring ice-out and snowmelt, and also after heavy rains at other times of year in the river's watershed upstream. The dams on the mainstem of the Connecticut River were built for hydropower generation, not for flood control, although they are operated when possible to help ease flooding. Flooding in Norwich and Hanover and south is now reduced to a minor extent by the Union Village Dam on the Ompompanoosuc River, but this dam controls only 130 of the nearly 4,000 square miles of the Connecticut River watershed that lies above it.

The pace of development in the Upper Valley is likely to have an increasing effect upon river flow as forests and other precipitation-absorbing land cover become roads, parking lots, roofs, and lawns. In the spring, the White River delivers rubble ice to the mainstem's sheet ice below Wilder Dam, and that rubble ice may jam and back up water in the river, especially at a large ledge just below the I-89 bridge. When this happens, ice jams may endanger the shopping plazas built in the floodplain at West Lebanon by deflecting the current toward the riverbank.

The U.S. Army Corps of Engineers identified the floodplains in Bradford and Piermont as an important natural valley flood control area where the river can spread out and dissipate its energy. Additional loss of the region's "green infrastructure" to development could transfer flooding downstream, increasing flood damage in the Upper Valley and beyond.

Key recommendations for flow and flood control

- Public agencies and private landowners should work together to retain current natural flood storage, such as in wetlands and floodplains, which is effective and valuable.

Working River

Wilder Dam - Wilder Dam, the major hydropower dam influencing the Upper Valley segment of the Connecticut River mainstem, is a "daily peaking" generation plant, raising and lowering water in the 45-mile Wilder impoundment as it stores and releases water during the day. Since 2000, Wilder Dam has been the control center for hydropower operations along the entire Connecticut River in New Hampshire and Vermont. Hydropower plays a crucial role in the New England power grid, since dams can provide a "cold" or "black start" when other sources are not available. Wilder and other dams on the Connecticut did just this during the historic widespread blackout of the Northeast in 1965. However, rapidly changing water levels associated with the sudden opening of dam gates may have less desirable effects. The U.S. Army Corps of Engineers has identified water level fluctuations from operations at Wilder Dam as a key factor in riverbank erosion in this region, along with natural scouring action of the river ice and moving water. Rapidly changing water levels can cause pressure imbalances at the water-saturated bank face, causing water to seep out of the bank, carrying small particles of soil with it. For this dam, the federal operating license does not currently spell out a "ramping rate," or how quickly the gates may be opened and the impoundment can be raised or lowered.

Key recommendations for dams

- The Federal Energy Regulatory Commission should institute a ramping rate at Wilder Dam in the next license, to reduce soil piping in the riverbanks of the impoundment and to minimize negative effects on aquatic and riparian habitat; include a provision for emergency gate operation, such as in the context of a black start when a sudden release from the dam is needed to provide immediate power in case of a blackout.

Using the Water

Water withdrawals - As a designated river in New Hampshire's Rivers Management and Protection Program, the Connecticut River's water is protected from being diverted outside of the watershed. The state requires registration of water withdrawals over a certain size, which helps identify future problems of well interference, declining water tables and/or diminished streamflows, but does not limit withdrawals. Vermont has no system for tracking withdrawals and the amount of water that would otherwise have flowed in the river from Vermont is unknown.

Groundwater and drinking water supplies - It is important to know where aquifers are located before development is proposed. New Hampshire has mapped stratified drift aquifers and regulates new groundwater withdrawals for community water systems and large withdrawals to prevent harm to existing water users and nearby streams. Vermont has not mapped aquifers as comprehensively, although it has recently passed legislation to regulate groundwater withdrawals. Most groundwater contamination in the Upper Valley area is from leaking underground storage tanks. Several towns have groundwater protection regulations. Increases in population and demand have also put pressure on groundwater supplies. Changing the surface of the soil, such as through paving and development, prevents water from soaking into

the soil to restore groundwater. Low impact development techniques can encourage water to soak in and recharge groundwater as it might have naturally.

Key recommendations for groundwater

- Vermont should identify and map groundwater supplies in cooperation with the towns. Towns should understand their capacity for providing drinking water, evaluate water supplies for short and long-term growth, and establish a baseline for use.

Land Use & Water Resources

Wastewater discharges - This segment of the river receives treated wastewater discharges from three municipal plants within a fairly short distance of each other (Hanover, Hartford, and Lebanon), and river water quality is noticeably poorer during times of low flow. There have been rare releases of untreated sewerage from the wastewater treatment plants in Hanover and also to the White River from a treatment plant in Bethel, Vt. The development capacity of the region may be partially limited by the capacity of the Connecticut River to assimilate the wastewater such development creates. At the same time, the cleaner river is partly responsible for the appeal of the region to new residents and businesses. Pathogens from combined sewer overflows in Lebanon and Hartford affect the river for nearly 13 miles. The most significant CSO problem in the region is in Lebanon, where the combined sewerage system dates from the 1930s. Hartford eliminated the last of its six CSOs in late 2007.

Key recommendations for wastewater discharges

- Upper Valley towns should study their capacity for providing wastewater treatment and the river's ability to assimilate it in this region. EPA and the states should work together to establish updated rules for disposal or return of unused medicines. EPA should provide support to Hospitals for a Healthy Environment, a non-profit organization headquartered in the Upper Valley, to work with medical providers to encourage responsible disposal of pharmaceuticals.

Landfills, Junkyards, & Transfer Stations - Most of the region's older landfills, such as at Post Mills, are not lined, and their contents can still seep into groundwater and may pose a threat to drinking water supplies. Informal dumps remain untreated on several tributaries. Major landfill work has recently occurred close to the Connecticut River in Lebanon, where the city's older landfill has been capped and a new area opened. At the same time, a recycling facility has been moved and improved.

Key recommendations for landfills, junkyards, and transfer stations

- Area solid waste districts should assist towns in holding more frequent household hazardous waste collections and sites and in exploring options to create greater recycling markets and reducing solid waste.

Shoreline & Floodplain Development - The increased demand for level land, easily developed soils, and picturesque house sites could suburbanize the river corridor, threatening water

quality and eliminating wildlife habitat and flood storage. Such development also changes the overall visual quality of the riverfront and, by fragmenting or removing what are often prime agricultural soils from potential production, threatens agriculture as a viable enterprise in the area.

Vermont is the only state in New England that does not have a statewide shoreland protection law. However, Bradford, Fairlee, Norwich, and Hartford have adopted their own shoreland protection for the Connecticut River and other streams. These ordinances are comparable to or more effective than New Hampshire's shoreland protection law. The Subcommittee believes that buildings should be set a safe distance back from the river even when outside of the floodplain, to protect water quality and to reduce the risk of property loss in erodible areas.

Because building in floodplains takes away valuable farmland, transfers flooding problems downstream, and costs taxpayers money when flooding occurs, several but not all towns have passed ordinances banning construction here. Others continue to permit construction in the floodplain if buildings are built according to certain restrictions, a policy that has led to heavy big box store development in Lebanon. Building a mound to raise a building above the 100-year floodplain may reduce the chance of flood damage to that particular building, but it does nothing to prevent pollution and eliminates flood storage space, forcing floodwater somewhere else.

Glacial Lake Hitchcock left behind layers of varves, ancient lake-bottom sediment layers that have differing physical properties that can slip and collapse. Siting landfills, bridges, large buildings, and other important structures on varved deposits is risky, yet most towns do not have information about the location of varves.

Key recommendations for shoreland and floodplain development

- New Hampshire DES should educate town officials, real estate agents, developers, and landowners about the Comprehensive Shoreland Protection Act. The New Hampshire Legislature should consider shoreland protection for tributaries not currently covered by the Act.

- Vermont should consider adopting measures to protect the shoreland of both the Connecticut River and its tributaries.

- Towns should adopt ordinances prohibiting filling and building in the 100-year floodplain and ensure that buildings are set a safe distance back from the river even when outside of the floodplain. They should encourage developers and landowners to establish and/or maintain buffers of native vegetation along rivers and streams for privacy, pollution control, and habitat.

Roads and railroads - The construction, repair, and maintenance of roads built close to a river or stream can result in loss of the riparian buffer and cause sediment to be washed into these waters. Sand from roadways and bridges can affect habitat quality of the riverbed. A sudden heavy storm can cause problems with blocked culverts and send sediment from such a blockage into a stream. Winter road salt threatens water quality in the many streams followed too closely by roads. For nearly a decade, the City of Lebanon, just upstream from one of

the most biologically interesting areas of the Connecticut River, considered building a road on the edge of the riverbank to relieve traffic problems in West Lebanon. The Subcommittee strongly advises against adding more pollutants from a roadway so close to the river. Salt is a contamination problem for both surface and groundwater, brought into sharp focus in the Upper Valley when the railroad built a salt storage shed on the Fairlee/Thetford line in Ely. Shortly after the salt shed went into operation, a nearby residential well was contaminated.

Culverts and bridges can have a critical role in preventing flooding and property damage, and also in ensuring good fish passage along the streams they traverse. Because the capacity of culverts and bridges is so important for public safety, they should be checked in all towns.

Key recommendations for roads and railroads

- New Hampshire should consider working with the regional planning commissions to conduct a bridge and culvert survey program similar to Vermont's to identify culverts that are undersized or block fish passage, and should seek grants for replacing them where necessary. Towns should ensure that culverts are properly engineered and installed when replacing them during road work.

- Railroads should employ best management practices in siting structures such as salt sheds in order to protect water quality and expand testing of groundwater near the Ely salt shed. Towns and the railroad should locate all salt storage at least 250 feet from rivers.

Storm Water runoff - Stormwater runoff may be the simplest but least understood means of water pollution, and possibly the easiest source of pollution to control. Rising demands for impervious surfaces (roofs, roads, driveways, parking areas) cause tremendous increases in runoff and in sources of pollution. The quantity of pollutants in runoff in an urban area is directly related to the imperviousness found in its watershed. Stormwater is washing pet waste into the river in some Upper Valley towns and contributing to bacteria levels found here.

Key recommendations for stormwater runoff

- Developers should include infiltration methods such as networks of many small swales to capture runoff for groundwater recharge. Towns should encourage "low impact development" design and consider how to retrofit existing development to reduce runoff and promote stormwater infiltration.

Home landscapes - Residential development pressure is significant in the Upper Valley, and much of the riverfront, features homes built to take advantage of river views, especially in Norwich, Hanover, and Lyme. A number of them have lawns extending to the river's edge. This shift from farmland to residential use often means a change for the river. Uncontrolled and often uninformed use of fertilizers, pesticides, and other toxic materials by homeowners can lead to unintended addition of these pollutants to streams.

Key recommendations for home landscapes

- Towns should educate landowners to establish, maintain and enhance the native riparian

buffer vegetation on their property. Consider a cost of community services study to investigate how conservation easements can help keep town service and school costs down if the land is not developed into house lots or into second homes that later become year-round residences.

Farms and cultivated landscapes - Prime agricultural soils, some of the highest quality soils in the nation, distinguish much of the floodplain in the Upper Valley region. This valuable land provides healthy, locally grown foods as well as beautiful views. The Upper Valley River Subcommittee believes that food production is a good use of riverfront land, and that it is well worth the cost and effort to conserve this land to prevent its conversion to development. Agriculture is diversifying in the Upper Valley, and a region once known for its dairy farms now also features vegetable and fruit farms, horticultural operations, and a number of horse farms, both large and small.

Key recommendations for farming

- The Cooperative Extension Services in each state should educate the general public about the many water quality protection measures used by and/or required of farmers, including regulations surrounding septage spreading. Outreach should also go to horse owners about ways to manage their land and animals to protect water quality.

Brownfields - The Westboro Rail Yard in West Lebanon is a site with recreation, tourism, and economic development potential that has been waiting for federal funds to assist the City in cleaning up contamination left over from this once-busy transportation hub. Others under investigation are the former Tip Top Tire site in downtown White River Junction and three other sites in Hartford, and the Thetford town garage.

Acid Mine Drainage

Vermont's Upper Valley has a long and rich history of mining that supported industrial growth for several centuries. These mines, located in the Ompompanoosuc and Waits river watersheds, include the now abandoned Elizabeth Mine, Pike Hill Mine and Ely Mine, now designated as Superfund sites. Their legacies include severe effects upon water quality from acidic water draining out of above ground or underground mines and tailing piles. Mine drainage affects stream and river ecosystems by increasing acidity, depleting oxygen, and releasing heavy metals. Work has begun at the Elizabeth Mine to stabilize, regrade, and cap the tailing piles, divert stormwater, and treat runoff.

Key recommendations for brownfields and acid mine drainage

- Upper Valley Lake Sunapee Regional Planning Commission should seek a grant to conduct a brownfields inventory of its member towns and prioritize cleanup. Lebanon should continue seeking funds to clean up the Westboro Rail Yard.

- EPA should continue with cleanup at the Elizabeth Mine and other mines.

Riverbank Erosion

Erosion is a significant cause of concern for landowners on this segment of the Connecticut River. While it is a natural process, and is caused primarily by shear stress of water forced against the bank, abrasion by ice, and also wind-driven waves, erosion is made worse by human actions, particularly in the Upper Valley reach. Factors include water level fluctuations from operations at Wilder Dam, boat wakes, and removal of the riverside vegetation that naturally holds the bank together. Area landowners report that losing as much as 5-10 feet of their land along the river in a year to erosion.

Some riverbanks formerly thought to be forested and stable are actually riddled with hidden undercuts and six-foot deep holes. In such places, the root structures of the trees are currently holding up the bank, but they may eventually fall, bringing a large root ball with them. Pressure imbalance at the bank face, when there is a rapid drawdown of the water level at Wilder Dam, occurs when pressure builds up behind the bank face and seepage occurs, forcing soil particles to loosen.

Riparian Buffers - Riparian buffers filter out sediment and debris from surface runoff, trap pollutants that could otherwise wash into surface waters and groundwater, stabilize streambanks and reduce erosion, and absorb surface water runoff and slow water velocity. Vegetated buffers are inexpensive, easy to install and grow, and have the added advantage of providing habitat for both land-based and aquatic animal species. Studies of the Upper Valley riverbanks show that human activity appears to be affecting erosion rates in some reaches where riparian vegetation has been removed from the bank, and that landowners need to be more aware of the potential erosion problems that removing riparian buffers could cause. Buffers of 50 feet or more in width do appear to slow the rate of erosion in most places.

Key recommendations for erosion and riparian buffers

- The USDA county conservation districts should survey the Upper Valley reach of the river for the presence of hidden riverbank undercuts, and identify and test a means of restoring these cavities. The federal government should conduct a study of the effects of dam-related water level fluctuations on bank erosion as well as upon fish habitat and populations of endangered species. The USDA Natural Resources Conservation Service should continue research into appropriate methods of bank stabilization including the funding of test areas, expand education of riparian landowners concerning methods of stabilization, expand programs that offer professional and financial assistance to riparian landowners for appropriate methods of bank stabilization, and investigate ways to simplify the permitting process.

Mount Ascutney Region

Introduction

This Water Resources Plan is an updated and expanded edition of the Water Quality chapter originally published by the Connecticut River Joint Commissions as part of the *1997*

Connecticut River Corridor Management Plan, Volume V, for the Mount Ascutney Region. This plan is a requirement of the New Hampshire Rivers Management and Protection Act. It was prepared by CRJC's Mount Ascutney Region River Subcommittee in 2005 - 2007 by volunteer representatives of the riverfront towns from Plainfield to Charlestown, N.H. and Hartland to Rockingham, Vt., assisted by CRJC's conservation director. Planning boards and commissions can review its recommendations and integrate them into their local master plan, and select appropriate recommendations to bring to townspeople for adoption into their zoning ordinances.

The Mount Ascutney Region - The 39-mile Mount Ascutney segment runs from the northern boundaries of Plainfield and Hartland south to the Bellows Falls Dam. The character of the river is distinctly different in the northern and southern parts. In the upper 10 miles, water moves with a perceptible current and there is an opportunity for flushing of nutrients and sediment. Rapids at Sumner Falls return oxygen to waters that may have acquired pollutants from upstream sources. The remaining 29 miles are captured by the Bellows Falls impoundment. Wilder Dam, just upstream, also influences the flow. Major tributaries to this section of the Connecticut are the Ottauquechee, Black, and Williams rivers and Mill Brook in Vermont, and the Sugar and Little Sugar rivers in New Hampshire.

Economic Value of Clean Water - Good water quality is important economically for the Headwaters region. Studies in New Hampshire have found that its rivers and lakes annually contribute an estimated $1.5 billion in total sales and $247 million in property taxes to its economy (2002 dollars). Statewide, fishing, boating, and swimming have the same economic impact as snowmobiling, ice fishing, downhill skiing, and cross-country skiing combined. Overall, surface water recreation generates over 100 jobs in the Dartmouth-Sunapee Region of New Hampshire, which includes the Mount Ascutney Region. These jobs equate to $2.6 million in personal income and almost $7.5 million in business sales (2006 dollars), totaling about 3.5 percent of the recreational revenue generated by anglers, boaters and swimmers in New Hampshire. A perceived decline in water clarity and purity by recreational users would cause a loss of 14 jobs, about $309,000 in personal income and almost $1 million in business sales.

Condition of the Connecticut River Byway Today

Water Quality - For 29 miles from Cornish/Windsor downstream to the Bellows Falls Dam, the river's quality fully supports swimming and other contact recreation. However, just north of this section, the 13.8 miles from the confluence of the White River to Blow-Me-Down Brook in Cornish, is deemed by the state of New Hampshire as unsafe for swimming because of combined sewer overflows (CSOs) in the wastewater collection systems serving Hartford and Lebanon and discharging to the Connecticut and Mascoma Rivers (Hartford's remaining CSO was disconnected in 2007). CSOs occur when runoff from a heavy storm mixes with untreated sewage and flow into rivers and streams. CRJC is sponsoring water quality monitoring by volunteers in this section during 2008 and 2009, under a cooperative agreement with EPA, to learn more. CSOs can also contribute bacteria to the lowest 2.5 miles of the Black River. Parts of the Sugar River do not meet standards for pH, dissolved oxygen, aluminum, copper, and E. coli bacteria due to the effects of municipal discharges. Invasive aquatic plants are present, particularly near the Cheshire Bridge. With the exception of the Sugar River, there is currently

no regular, on-going water quality monitoring program on the Connecticut River or its New Hampshire tributaries.

Sediment Quality - A study by EPA indicated significant amounts of polyaromatic hydrocarbons in sediments below the confluence of the Sugar River. These chemicals can get into streams and rivers from leaks and drips from automobiles, snowmobiles, or other vehicles on nearby roads, and from leaking underground storage tanks.

Toxins in Fish Tissue - In 2000, EPA and the four Connecticut River states conducted the first river-wide study of fish tissue in the nation. In the reach that included the Mount Ascutney region, mercury in fish is a threat to subsistence anglers and to fish-eating birds and mammals, but not to recreational fishers. Dioxin-like PCBs pose a risk to recreational and subsistence fishers and to fish-eating mammals and fish-eating birds. DDT and related breakdown products pose a risk to human subsistence fishers and to fish-eating birds, but not to recreational anglers or fish-eating mammals. The study found that total mercury concentrations in all three species of fish were significantly higher upstream than downstream. Risk from PCBs was generally lower in upstream areas than in downstream areas.

Invasive species - The first recorded invasive aquatic plant in the Connecticut River, Eurasian milfoil, was reported at Hoyt's Landing in Springfield in 1995 by a member of the Mount Ascutney Subcommittee. This plant has since spread downstream. A 2006 survey added curly leaf pondweed, purple loosestrife, and Japanese knotweed at this site. Knotweed is particularly prevalent on banks of the Black River.

Key recommendations for river quality

- Town conservation commissions, tributary watershed groups, school groups, and other interested citizens should work with their state's water quality agency to ensure more regular and sustained monitoring of the Connecticut River and its tributaries. The states should continue to act to reduce sources of mercury contamination that affects Connecticut River fish and other wildlife. Congress should join this effort.

River Flow

Instream Flow - Two gages on the mainstem and six on tributaries provide real-time data for flow, precipitation, and air temperature via the Internet. Except in very high water conditions, instream flow of this part of the Connecticut River is controlled almost completely by operations at Wilder and Bellows Falls dams. A factor adding natural variation to the closely managed mainstem flow is the large watershed of the free-flowing White River.
Flooding and Flood Control - The Connecticut River in the Mount Ascutney region typically experiences heavy flows with spring ice-out and snowmelt. Flooding is now dampened by flood control dams on the Ottauquechee and Black rivers and also upstream on the Ompompanoosuc River, but these dams control less than 10 percent of the flow from the 5,400 square mile watershed that drains through Bellows Falls. Ice movement and management are very important on the Connecticut River here, due in part to the White River, which enters the mainstem just above the Mount Ascutney section. The region has

recently experienced some sudden, severe rainstorms, although none as strong as on the Cold River in 2005.

Key recommendations for flow and flood control

- The Cold River flood experience suggests that towns should ask regional planning commissions for help with culvert and bridge surveys to identify those that are undersized. State agencies should assist towns with engineering costs for sizing culverts and bridges. State and local highway departments should ensure that culverts are properly sized when replacing them during road work, and that culverts for perennial streams do not impede fish movement.

Working River

Mount Ascutney Region Dams - Two major hydro power dams influence this part of the Connecticut River mainstem: Wilder Dam, located just above the segment in Lebanon/Hartford, and Bellows Falls Dam at the foot of the segment in Rockingham/Walpole. Their current federal operating licenses expire in 2018 with that of Vernon Dam. Both are daily peaking generation plants, raising and lowering water in the Bellows Falls impoundment as they store and release water during the day. There are currently no required "ramping rates," or controls on the suddenness with which water is stored and released at these dams. Sending large amounts of impounded water into the tailrace can also abruptly change water flow and temperatures there, which can affect spawning and other fish movements.

Key recommendations for dams

- The Federal Energy Regulatory Commission should include best management practices such as moderated ramping rates in the 2018 license for Wilder and Bellows Falls Dams. Owners of other dams should consider removing those that no longer serve a purpose and cost more to fix than the benefits they offer or those that pose a threat to areas downstream. Springfield should seek state assistance for removing the Springfield Reservoir Dam.

Using the Water

Water withdrawals - As a designated river in New Hampshire's Rivers Management and Protection Program, the Connecticut River's water is protected from being diverted outside of the watershed. The state requires registration of water withdrawals over a certain size, which helps identify future problems of well interference, declining water tables and/or diminished streamflows, but does not limit withdrawals. Vermont has no system for tracking withdrawals and the amount of water that would otherwise have flowed in the river from Vermont is unknown.

Groundwater and drinking water supplies - Clean drinking water may be our most valuable but under-appreciated commodity. New Hampshire has mapped stratified drift aquifers and regulates new groundwater withdrawals for public community water systems and large withdrawals to prevent harm to existing water users and nearby streams and rivers. Surficial geology mapping has been completed for south Claremont and Charlestown. Vermont recently adopted groundwater withdrawal regulations, but has not mapped aquifers

comprehensively. Rockingham is undertaking an aquifer recharge area study and mapping project. Groundwater, which many residents pump into their homes for drinking, can be contaminated by a long list of pollutants which are difficult if not impossible to remove.

Key recommendations for water use

- Vermont should adopt water withdrawal registration rules for the Connecticut River mainstem similar to New Hampshire's. Towns should take advantage of source water protection grant and loan programs.

Land Use & Water Resources

Wastewater discharges - Just upstream of this section the river receives wastewater from Hanover, Lebanon, and White River Junction. A major issue is combined sewer overflows. Three communities have had CSOs that have affected the Mount Ascutney region. Lebanon is making progress and has eliminated four of its six CSOs. In late 2007, the last of the six CSOs in White River Junction was eliminated. Springfield, Vt. has recently completed a major upgrade of its wastewater treatment facility, vastly improving the quality of its discharge. It has worked aggressively to eliminate its 26 CSOs, and the town expects that all will be gone by mid-2008. Other concerns include pharmaceuticals and personal care products in wastewater. A better way to dispose of these materials is needed.

Key recommendations for wastewater discharges

- Communities with combined sewer overflows, including those upstream of the Mount Ascutney region, should continue their efforts to eliminate them as quickly as possible. EPA should provide funding to assist with these expensive projects.

Landfills, Junkyards, and Transfer Stations - Landfills must be carefully sited, based upon good surficial geologic mapping. When a new solid waste landfill was proposed in Rockingham in 2004, a partial knowledge of the location of unstable varved soils – a type of soil left by ancient glacial lakes - was important in the decision not to locate the landfill close to the Connecticut River. Communities are working to reduce the tonnage of solid waste they bring to landfills, by recycling, although rates vary greatly. WinCycle in Windsor recycles old computer equipment, thus removing an important source of hazardous material from the waste stream. At the unlined Browning-Ferris landfill site in Rockingham, monitoring wells down-gradient from the landfill near the river showed pollutants at levels higher than the clean-up criteria. A landfill has been proposed by Upper Valley Solid Waste District for land in Hartland but not yet built. From time to time, people still illegally dump tires in the Connecticut River, and roadside dumping is also still a problem. The Black River Action Team has recruited local citizens for successful cleanups. A new carbon injection system at the Claremont incinerator has reduced mercury emissions and other pollutants by 98 percent.

Shoreline and Floodplain Development - The Subcommittee is concerned about development of lands along the river which could threaten water quality through changes in stormwater movement, erosion during construction, and new septic systems. Vermont is the only state in New England that does not have a statewide shoreland protection law. The subcommittee

believes that there should also be more protection for the Connecticut River and for smaller streams. With the exception of Cornish, all of the towns along the Connecticut River in the Mount Ascutney region currently permit building in both the flood hazard area and in the 100-year floodplain.

Key recommendations for shoreland and floodplain development

- Towns should adopt ordinances prohibiting building in the 100-year floodplain and ensure that buildings are set a safe distance back from the river even when outside of the floodplain, to reduce the risk of property loss in erosion-prone areas. Vermont should adopt statewide shoreland protection. New Hampshire towns and NH DES should inform landowners about the Shoreland Protection Act, and should not issue permits for projects that violate state law. Towns should work with state geologists to map varves in their towns, to be sure major construction does not take place on unsafe soils.

Roads and railroads - When flooding or erosion damages riverfront roads, people have responded by widening, straightening, and armoring the roads, but rarely by moving them a safer distance from the river. While the railroad has contributed much to the river valley over its history, the proximity of the rail line to the river has new and chronic implications for river health, especially in the potential for contamination by salt. There are also several places in the Mount Ascutney Region in Vermont where salt is stored near water by town and state highway departments. Long-time snow dumping sites may also show signs of lead accumulation in the soil from the days of leaded gasoline. Because culvert and bridge size is so important for public safety, these structures should be checked in all towns.

Key recommendations for roads and railroads

- Rail managers should manage the rail system to protect nearby surface waters, by ensuring protection from salt and waste contamination. Federal agencies should partner with the railroad to identify ways to help its management become more aware of ways to avoid pollution of surface waters.

- **Storm Water runoff** - Cleared, compacted, or paved land sends water downhill faster than when it is captured by thick vegetation and transpired by trees. There are a number of common sense ways to mimic the natural pattern of runoff when a property is developed, with "low impact development" techniques that runoff down and soak it up.

Key recommendations for stormwater management

- Towns should look at ways to include "low impact development" ideas as they review projects, and at how to change existing development to reduce runoff and promote stormwater infiltration.

Home landscapes - Residential development in the Mount Ascutney region sometimes occurs very close to the river. Many people building on a waterfront parcel are tempted to cut down the vegetation along the stream in order to get a view. Homeowners living near water have a responsibility to be sure they are good caretakers of those waters.

Key recommendations for home landscapes

- Landowners should encourage native plants on their riverbanks, resist the temptation to cut and mow to the water's edge, and remove invasive plants. Towns should educate landowners to establish, maintain and enhance the native riparian buffer vegetation on their property.

Farms and rivers - Prime agricultural soils distinguish much of the floodplain in the Mount Ascutney region. Land on both riverbanks has a long farming tradition. Development pressures focus easily upon the remaining available farmland, which is often flat and easy to build upon. Few functioning farms remain, and those that do should be encouraged by spirited local markets for their produce and, for those who are willing, with assistance in conserving their land.

Key recommendations for farming

- Farmers should employ best management practices and work with conservation districts and the Cooperative Extension Service to prepare a total nutrient management plan for their farm, to make best use of available nutrients, reduce potential for water quality impacts, and save money in purchasing fertilizer.

Brownfields - Historical industrial towns and cities along the Connecticut River, including Bellows Falls, Springfield, Claremont, and Windsor, have properties where contamination may linger in the soil and prevent the property from contributing once again to the tax rolls and economic vitality of the community.

Key recommendation for brownfields

- State environmental agencies should make up to date information on brownfields assessment discoveries readily available, especially for nearby residents who may be affected.

Riverbank Erosion

Causes of Erosion - Riverbank erosion is a significant cause of concern for landowners. While it is a natural process, and is caused primarily by shear stress of water forced against the bank, wind-driven waves, and abrasion by ice, erosion is made worse by human actions, including fluctuating water levels at the dams, boat wakes, and removal of the riverside vegetation that naturally holds the bank together.

Commissary Brook - Varved soils associated with glacial Lake Hitchcock appear to be a major factor to the release of tons of sediment that have washed down into Commissary Brook and the Connecticut River. Fishermen and divers report that in places where the Connecticut River was once 30 feet deep, it is now six inches deep, due to sediment delivered by this brook. It is also sending a plume of turbidity into the river that violates the New Hampshire surface water quality standard. Sediment comes from exposed, sloughed banks of a gully draining a reclaimed clay extraction pit. As of this writing, the sediment from Commissary Brook has continued to spread into the Connecticut River and a visible plume has moved hundreds of yards down river to Roundy's Cove. A head cut is developing that could affect nearby homes.

Riparian Buffers - Riparian buffers are the single most effective protection for water resources in Vermont and New Hampshire. These strips of grass, shrubs, and/or trees along the banks of rivers and streams filter polluted runoff, capture sediment and nutrients, and provide a transition zone between water and human land use. Natural riparian buffers have been lost in many places over the years. US Gen New England sponsored the largest buffer planting projects in New Hampshire, on floodplain farmland owned by the company in Charlestown.

Key recommendations for erosion and riparian buffers

- State and federal agencies should examine the severe erosion involving varves at Commissary Brook, identify its causes, and fund a means to halt the surge of sediment into the Connecticut River mainstem.

- Towns should require developers and landowners to establish and/or maintain buffers of native vegetation along rivers and streams for privacy and pollution control. Landowners should encourage native plants on their riverbanks and remove those that are invasive.

Wantastiquet Region

This Water Resources Chapter is an updated and expanded edition of the Water Quality chapter originally published by the Connecticut River Joint Commissions as part of the *1997 Connecticut River Corridor Management Plan, Volume VI, Wantastiquet Region*. This plan is a requirement of the New Hampshire Rivers Management and Protection Act. It was prepared by CRJC's Wantastiquet Subcommittee in 2005 - 2007 by volunteer representatives of the riverfront towns from Walpole to Hinsdale, N.H. and Westminster to Brattleboro, Vt., assisted by CRJC's conservation director. Planning boards and commissions can review its recommendations and integrate them into their local master plan, and select recommendations to bring to townspeople for adoption into their zoning ordinances.

The Wantastiquet Region - The Wantastiquet Region River Subcommittee's segment covers 40 miles of the Connecticut River as it runs from the Bellows Falls Dam and the northern boundaries of Walpole and Westminster, south to the Massachusetts border in Hinsdale and Vernon. Within the river corridor is the busy town of Brattleboro and nearby clusters of residential, commercial, and industrial development. In the upper 10 miles of this segment, water moves with a perceptible current that helps to flush nutrients and sediment. A short set of rapids below the Bellows Falls Dam and other quickwater sections return oxygen to waters that may have acquired pollutants from upstream sources. The Vernon Dam, just downstream from the Vermont Yankee Nuclear Power plant, creates a 26-mile long impoundment on the mainstem. Major tributaries to this section of the Connecticut are the Saxtons and West rivers and Sackett's Brook in Vermont, and the Cold and Ashuelot rivers and Mill and Partridge brooks in New Hampshire.

Clean Water Has Clear Economic Value - Good water quality is important economically for the Wantastiquet region. Studies in New Hampshire have found that its rivers and lakes annually contribute an estimated $1.5 billion in total sales and $247 million in property taxes to its economy (2002 dollars). Statewide, fishing, boating, and swimming have the same

economic impact as snowmobiling, ice fishing, downhill skiing, and cross-country skiing combined. Overall, water-based recreation in New Hampshire's Monadnock Region, of which the Wantastiquet area is a part, generates over 120 jobs and almost $3 million in personal income and almost $8 million in business sales, totaling about 4 percent of the recreational revenue generated state-wide by anglers, boaters and swimmers. A perceived decline in water clarity and purity would cause a loss of approximately one-half million dollars in business sales (2006 dollars).

Condition of the Connecticut River Today

Water Quality - Results from testing in 2004 indicated that the river's quality fully supports swimming and other forms of recreation, although it found elevated aluminum and copper levels create poor aquatic habitat below Vernon Dam. Ten miles of the West River have elevated temperatures and degraded aquatic habitat from sediment releases from flood control dams. A number of tributaries in both states have low pH or bacteria problems. Sackett's Brook suffers from fish habitat degradation from undefined pollutants. Some New Hampshire segments have problems with dissolved oxygen or aluminum. At a mill site in Hinsdale, there is contamination by organic chemicals as well as aluminum and copper. Volunteer water quality monitoring is occurring on the Cold and Ashuelot rivers and on parts of the West and Saxtons rivers. Vermont Yankee has a long record of water quality data since 1967 for 26 miles of the Connecticut River from the West River to Northfield, Mass. Otherwise, there is currently no regular, on-going water quality monitoring program on the Connecticut River mainstem or lesser tributaries in the region.

Sediment Quality - Studies of sediment by EPA showed that in general, sediments looked relatively clean, although results indicate that road runoff probably has an effect upon aquatic life. An exception is chrysene near Sackett's Brook, which exceeded the level at which ecological effects might occur. Copper and nickel exceeded this level here and below the West River. Breakdown products of the pesticide DDT were detected in low concentrations downstream of Sackett's Brook.

Toxins in Fish Tissue - In 2000, EPA and the four Connecticut River states conducted the first river-wide study of fish tissue in the nation. Wantastiquet region fish were sampled as part of Reach 5 from Wilder Dam to Vernon Dam. In this reach, mercury in fish is a threat to fish-eating birds and mammals, but not to recreational or subsistence anglers. Dioxin-like PCBs pose a risk to recreational and subsistence fishers and to fish-eating mammals and fish-eating birds, but not to fish-eating fish. DDT and related breakdown products pose a risk to subsistence fishers and to fish-eating birds, but not to recreational anglers or fish-eating mammals. The study found that total mercury concentrations in all three species of fish were significantly higher upstream than downstream. Risk from PCBs was generally lower in upstream areas than in downstream areas, although this varied by fish species and was different for the humans, mammals, birds or fish that eat them. Dioxins and furans are a threat to subsistence fishermen, and a slight threat to fish-eating mammals, but not to recreational fishermen.

Key recommendations for river quality.

- State water quality agencies should sponsor increased water quality monitoring activities in the region and make use of data collected by Vermont Yankee. Train and equip a team of roving volunteer monitors to track down sources of pollutants for which monitoring data suggest problems, such as elevated levels of phosphorus or copper.

- Congress and the states should continue to reduce sources of mercury contamination and carbon dioxide emissions. States should consider regulations for outdoor furnaces. Citizens should obey the ban on barrel burning of trash. All should pursue increased energy efficiency to reduce pollutants, including carbon dioxide that contributes to climate change.

River Flow

Instream Flow - Except in very high water conditions, the flow of the Connecticut River is controlled almost completely by operations at Bellows Falls and Vernon Dams, and is also affected by Northeast Utilities' dam at Turners Falls and pump storage at Northfield Mountain. The Connecticut River here typically exhibits heavy flows with spring ice-out and snowmelt. Flooding is now controlled to some extent by four U.S. Army Corps dams on the West and Ashuelot rivers, and on the Ottauquechee, Black, and Ompompanoosuc rivers upstream. Together, these dams control less than 15 percent of the flow from the 6,266-square mile watershed that drains through Vernon Dam. Sudden releases from Ball Mountain and Townsend dams for whitewater recreation contribute to sedimentation in the West River, affecting fish habitat downstream. A more natural flow increase has recently been instituted to help minimize these problems.

In the Wantastiquet Region, the effect of flow upon temperature is especially important for fish habitat and migration and also for waste assimilation. The river must accept and disperse heated water from Vermont Yankee and warmed runoff from pavement. There is one gaging station on the Connecticut River in the Wantastiquet region and eight on area tributaries. The Drewsville gage on the Cold River, inactive at the time of the October, 2005 flood, is currently recommended for reinstatement.

Extreme storms and Floods - The Wantastiquet Region has suffered from a number of sudden, severe rainstorms in recent years. Two isolated heavy rainstorms in the Westmoreland area in 2003 caused severe erosion in Mill Brook, sending enough debris into the Connecticut River to alter the river's flow and erode the opposite Vermont bank. Brattleboro's Whetstone and Crosby brooks tend toward flash flooding with their steep, high watersheds and high levels of stormwater runoff from concentrated development.

In October, 2005, the Cold River watershed experienced a 500-plus year storm and received 11 inches of rain in 24 hours, reaching a total of 17 inches during the ensuing week. Flooding caused over $4 million in damage in New Hampshire and seven deaths, four of them in the Cold River watershed. A confluence of conditions on the ground, including an undersized culvert that caused a road washout resulting in a devastating loss of lives and homes, led to declaration of a federal disaster area. In addition to buildings, a number of septic systems were washed away during the Cold River flood, probably contaminating the Cold and

Connecticut rivers for miles. During this same month, flows in the nearby Ashuelot River exceeded the largest flow since construction of the Surry Mountain and Otter Brook flood control dams.

Road and streambank repair work after such a flood must be consistent with good river science. Work in and around rivers and streams (including the extent of debris removal, need for clear-cutting banks, placement of rip-rap, backfilling of flood channels, earth-moving to protect homes, and the placement of heavy equipment) requires clear oversight by the state and can benefit from the involvement of the local river watershed group and conservation commission.

Key recommendations for flow and flood control

- Ensure a coordinated, inclusive, and efficient response to floods and other river-related disasters that is based in good river science. NH DES and VT ANR should each develop a coordinated approach to such disasters, and assign an agency staff person to ensure communication between the state environmental and transportation agencies, town officials, conservation commissions, and local river advisory committees or watershed groups. Town officials should meet regularly to discuss emergency planning, and include local watershed groups for river-related issues.

Working River

Hydro Dams - Two major hydropower dams influence the Wantastiquet segment of the Connecticut River mainstem: Bellows Falls and Vernon stations. Their federal operating licenses expire in 2018. Both are daily peaking generation plants, storing and releasing water during periods of the day. They are controlled remotely by an operator at Wilder Dam upriver. TransCanada has installed four new units at Vernon Dam, replacing four that were so unreliable and difficult to run that they were not being used. Because Bellows Falls and Vernon are operated in a peaking mode, where water is alternately stored and released, they can affect the stability of riverbanks and impoundment shorelines, creating erosion. There are currently no required "ramping rates," or controls on the suddenness with which water is stored and released. Questions remain about possible further inundation of the shoreline since hydraulic flash boards were installed at Vernon Dam in 1991. Since that time, four culverts built in the 1800s in Hinsdale are inundated and now have to be regularly cleared of silt.

Key recommendations for dams

- The Federal Energy Regulatory Commission should include best management practices such as a slower, more natural raising and lowering for the ramping rate in the 2018 license for Bellows Falls and Vernon dams. Include a provision for emergency gate operation, such as in the context of a "black start" when the dam is needed to provide immediate power in case of a blackout. Local citizen groups should participate in the relicensing process.

Using the Water

Water withdrawals - As a designated river in New Hampshire's Rivers Management and

Protection Program, the Connecticut River's water is protected from diversion outside of the watershed. The state requires registration of water withdrawals over a certain size, which helps identify future problems of well interference, declining water tables and/or diminished streamflows, but does not limit withdrawals. Vermont has no system for tracking withdrawals and the amount of water that would otherwise have flowed in the river from Vermont is unknown.

Groundwater and drinking water supplies - New Hampshire has mapped stratified drift aquifers and regulates new groundwater withdrawals for public community water systems and large withdrawals to prevent harm to existing water users and nearby streams and rivers. Vermont recently started regulating groundwater withdrawals but has not mapped aquifers as comprehensively. Groundwater, which many residents pump into their homes for drinking, can be contaminated by a long list of pollutants that are difficult if not impossible to remove. Leaking underground fuel storage tanks remain a problem in many villages in the Wantastiquet region. Salt above a certain level in groundwater makes the water unhealthy for drinking, since it can lead to high blood pressure and other diseases. MtBE contamination has been discovered in the town of Putney and may be present elsewhere.

Key recommendations for water use

- Towns should protect groundwater recharge areas and consider a wellhead protection program such as Hinsdale's to save money in sampling costs; provide information on wellhead protection to new property owners.

Land Use & Water Resources

Wastewater discharges - Careful management of wastewater discharges is important for public safety and for the health of the streams that receive these discharges. Phosphorus readings in the Ashuelot River increase downstream of Keene. Keene has funds to improve its phosphorus removal but is awaiting an updated discharge permit from EPA which will dictate the level of phosphorus to be discharged, and the wastewater treatment facility is prepared to upgrade to meet the limit. The Wantastiquet region is fortunate that Brattleboro and Keene have always had separate stormwater drainage and sewerage systems, and have not subjected area waters to pollution by combined sewer overflows.

Vermont Yankee Nuclear Power Station - This nuclear power plant, producing electricity since 1972, is situated on the banks of the Connecticut River 3/4 mile upstream of Vernon Dam. The plant was constructed with cooling towers. Shortly after it went on line, plant managers received a permit to discharge heated water to the Connecticut River to avoid the costs of using the cooling towers for this purpose. Warmer water is discharged when there is enough flow to mix it. There is an upstream ambient river monitoring station and another located one half mile below Vernon Dam.

Since Entergy's application to increase production by 20 percent beyond that for which it was originally designed, cooling tower motors have been increased in size to handle the upgrade. An agreement reached with Vermont includes a $20 million payment to Vermont that the state intends to apply not to the Connecticut River, where the discharge takes place, but to

benefit the Lake Champlain watershed on the opposite side of the state. Entergy has also applied to increase the temperature of its discharge by 2 degrees F to the Connecticut River. Legal challenges to the Vermont decision to issue a permit for this thermal discharge have not yet been resolved. Temperatures sometimes reach high levels even without discharge from Vermont Yankee and at times, there is not sufficient flow in the river to dilute the warm water discharge. The Subcommittee is concerned about the biological effects on migrating salmon, shad, and other aquatic life if thermal criteria are relaxed. The Vernon pool has limited ability to accept more wastewater, since warmer water holds less oxygen.

Key recommendations for wastewater discharges

- Ensure that wastewater discharges are as clean as possible. The EPA should decide upon standards for phosphorus in wastewater treatment plant effluent so that Keene can plan effective phosphorus removal. EPA should update standards for disposing of unused and out-dated medicines, and assist area solid waste districts in educating consumers about proper disposal to reduce the pharmaceuticals that enter wastewater.

Stormwater runoff - Runoff from impervious or deforested surfaces has altered the effects of stormwater in many parts of the Wantastiquet region. Towns may become concerned how such clearing can affect the roads and culverts they are responsible for maintaining. Experience in Hinsdale shows that there is more runoff after clearing of land. Stormwater may be washing pet waste into the river and contributing to the higher bacteria levels found here.

Key recommendations for stormwater management

- Towns should minimize addition of impervious cover because of its effects on storm water runoff and harm to aquatic systems. Look at ways to include "low impact design" ideas for development to reduce runoff and promote stormwater infiltration for groundwater recharge. Towns should require additional treatment to remove oil for new discharges to surface waters and dry wells, and treatment to remove toxic metals for redevelopment projects.

Solid Waste - The Wantastiquet Subcommittee is concerned about soil and water contamination from old junkyards and capped but unlined landfills within the floodplain, including Putney Paper Company discharge from unlined lagoons. Leachate from the Brattleboro landfill is entering groundwater, with potential water quality impacts from metals, organics and inorganics, although nearby groundwater was reclassified so it would not require remediation. The Hinsdale landfill at the end of River Road, located on a steep bank next to the water, could be a continuing source of pollution although it was capped in the 1970s. The fast growth of "ReNew Salvage" in Brattleboro reflects demand for its service of de-constructing buildings and reselling the materials.

Vermont Yankee plans to store radioactive waste from its operations in dry casks on its Connecticut River front site, since the federal government, which is responsible for solving the problem of nuclear waste, has not provided a better solution.

Key recommendations for solid waste

- NH DES should investigate whether the Hinsdale Landfill at the end of River Road was adequately capped and whether it is leaching into the river. The federal Nuclear Regulatory Commission should address the storage problem of spent fuel and nuclear waste, to prevent the necessity of storing Vermont Yankee's radioactive waste near the Connecticut River.

Shoreline & Floodplain Development - The Connecticut River shoreline in the Wantastiquet Region is under heavy development pressure for riverfront homes. While New Hampshire has a state shoreland protection law, until 2008 it has been largely unable to enforce it and violations have occurred. Vermont has no such law, although the towns on the Vermont side of the river, except for Vernon, have their own shoreland protection for the Connecticut River and other streams that is comparable to or more protective than the New Hampshire law. The Subcommittee is concerned about development of lands along the river that could threaten water quality through changes in storm water movement, erosion during construction, and new septic systems. Homeowners may apply too much fertilizer or pesticide, or underestimate the importance of riparian buffers in protecting their property against erosion and capturing sediment and other pollutants. Septic systems within the floodplain have also proved to be a source of contamination.

Knowledge of varves - layered glacial clay deposits - is important for land use planning, as varves tend to be unstable. Siting landfills, bridges, large buildings, and other important structures on varved deposits is risky.

This part of the upper Connecticut River has the most marina development north of Massachusetts. The Subcommittee suggests that sufficient marina service now exists, and discourages development of further marinas elsewhere in the segment that could threaten pollution and create more boat traffic congestion leading to boating conflicts and bank erosion.

Key recommendations for shoreland and floodplain development

- Towns should evaluate their rules regarding shoreland protection and floodplain development, and consider if there are areas that need more protection. The New Hampshire Legislature should apply the Comprehensive Shoreland Protection Act to smaller streams. Vermont should adopt statewide shoreland protection.

Roads and railroads - An active rail line follows the Connecticut River on the Vermont side. In many places, the railroad has removed riparian buffer vegetation, a source of protection for the bank and for water quality. The integrity of the rail bed is vulnerable to uneven drainage patterns, such as those created by varved soils. The resulting instability has led to at least one disaster: a train derailment in 2001 spilled a locomotive and six cars carrying materials toxic to river life into a thaw-swollen Connecticut River.

There are problems with inadequately sized or located road culverts, inadequate drainage ditch construction, and disruption of fish habitat by perched culverts. Good information about the adequacy and safety of culverts and bridge crossings is missing in the New Hampshire

towns of the region, except for the Ashuelot River watershed, where The Nature Conservancy has enlisted volunteers to survey 1400 crossings to see if they are interrupting fish movement.

Key recommendations for roads and railroads

- Town road agents should ensure that culverts are regularly cleared of debris to prevent blocking during storms. Ensure that culverts are properly sized when replacing them during road work. New Hampshire should aggressively promote bridge and culvert surveys, by providing funds to the regional planning commissions to identify those that are undersized. Note if they block fish passage and seek grants for replacing them where necessary.

Home landscapes - Residential development pressure is significant in the Wantastiquet Region, and much of the riverfront, especially in Chesterfield, Brattleboro, Dummerston, and Westmoreland, features homes that have lawns extending to the river's edge. Development has taken place over many years, and sometimes, in the case of New Hampshire, in violation of state shoreland protection laws. Some of this change has occurred on prime agricultural soils after farm landowners decided not to keep the land in production, and sold it for subdivision and development.

Key recommendations for home landscapes

- Expand education for landowners and real estate agents about best management practices for waterfront land and applicable shoreland regulations. Town conservation commissions should provide information to every new riverfront landowner to explain the special challenges of owning and managing riverfront land, including the benefits of riparian buffers and the requirements of state shoreland protection laws. State agencies should provide similar information to real estate agents

Cultivated lands and rivers - Prime agricultural soils distinguish much of the floodplain in the Wantastiquet region. Land use along both sides of the river still speaks of a lively agricultural economy and way of life in the river valley. Farms, golf courses, and home landscapes can all be sources of unwanted nutrients that can reach streams and rivers in the region. Choosing good sites for winter field stockpiling of manure has been a struggle with the weather changes in the last several years. The U.S. Department of Agriculture offers cost-sharing programs for farm projects that improve water quality, but some farmers consider the requirements too complicated and the cost-share too expensive for structures they consider over-built. In the past, some designs have brought their own water quality problems, such as runoff from earth storage manure pits and pits that collect too much water.

Brownfields - Historic industrial areas such as Keene and Brattleboro have properties where contamination may linger in the soil and prevent it from contributing once again to the tax rolls and economic vitality of the community. The regional planning commissions have assessed brownfields in the region, and can assist property owners and prospective purchasers of brownfields with environmental site assessments, grants and loans for cleanup.

Riverbank Erosion

Streambank erosion and removal of riparian vegetation are difficult problems in the Wantastiquet region, not only on the mainstem but particularly on the West and Saxtons rivers in Vermont, and on tributaries affected by recent sudden heavy storms. Towns sometimes place rock riprap along streambanks without consulting the state or local conservation commissions.

Causes of Erosion - Causes of erosion are many and complex on the Connecticut River. The U.S. Army Corps of Engineers concluded that the primary cause on the Connecticut River is shear stress of high-velocity flows, especially on banks composed of non-cohesive material. The Corps also identified pool fluctuations behind dams, boat wakes, gravity, seepage, natural flow variations, wind-driven waves, ice, flood variations, and freeze-thaw effects on the banks as causes of erosion, in that order of importance. Later studies by the county conservation districts found that most of the reaches with moderate or severe erosion had moderate to high banks and slopes greater than 60 percent. Low banks with gentle slopes were generally stable. Recreation-related foot and motorboat traffic have also led to erosion.

Riparian Buffers - Vegetation along streams and rivers is probably the simplest, least expensive, and most effective way to slow erosion and protect these waters from pollution and overheating. The conservation districts concluded that human activity appears to be affecting erosion rates in some reaches where riparian vegetation has been removed from the bank, and that landowners need to be more aware of the potential erosion problems that removing riparian buffers could cause. Several farm parcels on both sides of the river lack riparian buffers and crops are planted less than 10 feet from the top of the bank, a significant problem in the lower third of Walpole and in Westmoreland. In many of these reaches, undercutting is occurring at a slow but persistent rate.

Key recommendations for erosion and riparian buffers

- Ensure that development does not contribute to erosion on the river. Towns should require developers to follow best management practices for erosion and sedimentation control, and ensure that riverside construction activities do not impact riverbanks and riparian buffers.

- Encourage wide understanding of the value of riparian buffers. State water quality agencies should take an active role in encouraging waterfront homeowners to plant and maintain buffers of natural vegetation along the riverbank, and encourage the use of vegetative bank stabilization techniques, in combination with riprap only where necessary, to control erosion. County conservation districts should supply landowners with information about sources of assistance including nurseries offering buffer plant material.

XIX. Footnotes

Riparian Buffers

(1) Field Geology Services, *Fluvial Geomorphology Assessment of the Northern Connecticut River, Vermont and New Hampshire,* prepared for the Connecticut River Joint Commissions, October 2004.

Streambank Erosion

(2) Field Geology Services, *op.cit.*

Wastewater Discharges

(3) Federal Security Agency, Public Health Service, *Connecticut River Drainage Basin: A Cooperative State-Federal Report on Water Pollution,* 1951.

Groundwater

(4) Research funded by NH DES and performed by the Society for Protection of New Hampshire Forests.

River/Watershed Inventory and Management

(5) *2004 Connecticut River Water Quality Assessment, Preliminary Assessment Status,* N.H. Department of Environmental Services.

(6) Upper Connecticut River Valley Project, New Hampshire and Vermont. U.S. Environmental Protection Agency, Region 1, prepared by Roy F. Weston, Inc., 2001.

Mercury

(7) *Connecticut River Fish Tissue Contaminant Study: Ecological and Human Health Screening (2000)*. Prepared for the Connecticut River Fish Tissue Working Group by Greg Hellyer, Ecosystem Assessment Unity, USEPA - New England Regional Laboratory, N. Chelmsford, Mass., May 2006.

(8) *The Economic Impact of Potential Decline in New Hampshire Water Quality: The Link Between Visitor Perceptions, Usage and Spending*. Prepared by Anne Nordstrom for the New Hampshire Lakes, Rivers, Streams and Ponds Partnership, May 2007.

Climate Change

(9) *Climate Change 2007: the Physical Science Basis; Summary for Policy Makers*. Intergovernmental Panel on Climate Change, Paris, February 2007.

(10) *Climate Change and New Hampshire*. U.S. Environmental Protection Agency, Office of Policy (EPA fact sheet 230-F-97-008cc), September 1997.

(11) *Conservation Implications of Climate Change: Soil Erosion and Runoff from Cropland,* Soil and Water Conservation Society, 2003.

(12) Gaffin, Stuart R., "Comparing CH4 Emissions from Hydropower to CO2 from Fossil Fuel Plants," Submission to World Commission on Dams, Thematic Review of Dams and Global Change.

(13) Stack, L.J., M.H. Simpson, T.W. Crosslin, W.S. Spearing, and E.P.M. Hague, 2007. "A point process model of drainage system capacity under climate change." *In publ.*

(14) William Keeton, cited in "Researcher sets value on Vermont's forests in mitigating climate change," in Burlington Free Press, October 30, 2007.

XX. Appendices

Appendix A: Recommendations, Arranged by Responsible Party

Federal

1. Environmental Protection Agency:

a. Focus on phosphorus, and educate federal legislators about the cost of phosphorus pollution to the environment, and the cost to local communities of removing phosphorus from discharges.

b. Assist local communities with the high costs of upgrades, expansions, and replacements of aging wastewater treatment facilities.

c. Work with local partners in guiding disposal of pharmaceuticals and educate federal legislators about the need for action. Assist Hospitals for a Healthy Environment in working with medical providers to encourage responsible disposal of pharmaceuticals.

d. Post sediment quality data from their sediment study on the Web.

2. Congress:

a. Appropriate funds and provide legislative support to allow EPA to assist towns in adding capacity to remove phosphorus from wastewater.

b. Appropriate funds to allow the U.S. Fish and Wildlife Service, EPA and the Food and Drug Administration to work with state agencies to develop better rules and well-distributed guidance for health care professionals and the public regarding the disposal of unused medicines.

3. Silvio E. Conte National Fish and Wildlife Refuge:

a. Continue its coordinating work on invasive species in the watershed.

b. Pursue conservation of key riverfront land in cooperation with willing landowners, to protect water quality, prime agricultural soils, wildlife habitat, and scenic views.

c. Help accomplish flood storage protection by focusing on protecting riparian habitat.

4. U.S. Army Corps of Engineers:

a. Revisit its cost-benefit analysis of protecting natural valley storage areas in the Connecticut River Valley. The 2007 authorization in the Water Resources Development Act provides an opportunity to pursue creative non-structural means of flood control. Include consideration of economic studies by the N.H. Lakes Association, costs of community services studies, and insurance pay-outs for flood damage.

b. Work with state environmental agencies to examine and address severe erosion sites such as at Commissary Brook in Rockingham, Vermont and at the cemetery in Northumberland, New Hampshire.

c. Institute a minimum flow at its flood control dam facilities and create or improve opportunities for fish passage. When dams are not being operated for flood control, the discharge from flood control dams should mimic run-of-river levels, or inflow equals outflow, to protect aquatic life downstream.

d. Institute larger water releases from the dams every few years to maintain a more natural channel shape in the rivers below them.

e. Take advantage of the expertise offered by The Nature Conservancy to "re-operate" these dams to alter flood control operations to allow for higher peak flows to restore riparian and floodplain habitats.

f. Work in concert with NH DES to resolve issues of dam ownership; if a dam in Connecticut River tributary that is non-functional or in a state of serious disrepair is found to be owned by the Army Corps of Engineers, the Corps should act expeditiously with NH DES to effect removal of such a dam.

5. Department of Agriculture:

a. Sponsor studies of potential bio-controls for Japanese knotweed and honeysuckle similar to those for purple loosestrife, and inform the public about the results.

b. Encourage farmers to use best management practices to control erosion and protect and enhance riparian buffers.

c. Work with riparian landowners, including residential homeowners, to provide buffer plant material, planting plans, and buffer plant packages for various settings.

d. Survey riverbanks for the presence of hidden riverbank undercuts, with the assistance of local conservation commissions, and identify and test a means of restoring these cavities..

6. U.S. Geological Survey: Adopt and implement an effective system of stream flow gages.

7. Federal Emergency Management Agency:

a. Create a system for evaluating the costs and benefits of avoiding floodplain development, not just retrofitting development.

b. Provide accurate floodplain maps for all river towns. Maps should include accurate river gradient drop as well as elevation for floodplain determination. Data sources could include the many USGS geodetic discs in the area, dam elevations, LIDAR type flights and the vertical GPS points collected.

8. Federal Energy Regulatory Commission:

a. Include moderated ramping rates in the 2018 license for Wilder, Bellows Falls, and Vernon Dams, with provisions to allow a "black start" if energy conditions require it.

b. Extend the Upper Connecticut River Mitigation and Enhancement Fund to the entire upper watershed.

9. Nuclear Regulatory Commission:

Reconsider its findings relative to the temperature of the discharge at Vermont Yankee and conduct a thorough safety inspection, inviting closely neighboring states to participate.

State

10. Vermont

a. Legislature:

i. Adopt similar if not greater measures than those in NH RSA 483-B to protect the shoreland of both the Connecticut River and its tributaries.

ii. Continue to legislate reductions in mercury contamination.

b. Department of Agriculture:

i. Continue its Conservation Reserve Enhancement Program.

ii. Support Vital Communities' Valley Food and Farm program in the Connecticut River Valley.

iii. Encourage farmers to protect and enhance riparian buffers.

c. Agency of Transportation:

i. Treat riparian buffers as natural allies in preventing pollution by retaining buffers as a natural curb to road-related runoff. Avoid mowing vegetation in riparian buffers where roads are close to streams.

ii. Make efforts not to transport fragments of invasive plants during road construction projects, and consult agriculture departments about best practices for dealing with invasive species, including ways to sanitize spoils before disposal. Vermont's Better Back Roads Program can offer special training for road crews on this issue.

iii. Adopt new stormwater engineering practices, anticipating impacts resulting from climate change. Revise design guidelines for culverts and stream crossings to reflect new storm frequencies and runoff volumes.

d. Department of Fish & Wildlife:

i. Conservation officers and wardens should educate about invasive species when issuing fishing and boating licenses, perhaps with an attention-getting enclosure in the application or license. Replace signs at boat landings urging boat inspection and cleaning with more informative and effective signs. Consider providing

boat cleaning stations at its public access sites on the river

ii. Continue to cooperate with sporting groups and sister agencies to better understand and address the Didymo infestation. Publicize practical prevention measures that the public is likely to use.

e. Department of Environmental Conservation:

i. Focus on phosphorus in the CT River and educate state legislators about the cost of phosphorus pollution to the environment, and the cost to local communities of removing phosphorus from discharges.

ii. Assist local communities with the high costs of upgrades, expansions, and replacements of aging wastewater treatment facilities.

iii. Work with local partners in guiding disposal of pharmaceuticals and educate state legislators about the need for action

iv. Seek federal assistance through the Congressional delegations to remedy combined sewer overflows on behalf of St. Johnsbury as quickly as possible.

v. Reconsider the propriety of applying Vermont Yankee mitigation funds outside the affected watershed, and invite advice and comment from New Hampshire in recognition of New Hampshire's responsibilities for the Connecticut River and the shared responsibility of the two states for communities within the impact zone of Vermont Yankee.

vi. Provide aquifer mapping information to local planning commissions. Establish and amplify programs that offer grants to protect critical aquifer recharge areas.

vii. Establish rules to protect key aquifers from contamination, and not permit landfills, hazardous waste disposal facilities, auto salvage yards, junkyards, wastewater or septage lagoons, and outdoor salt storage or other de-icing chemical storage to be located on aquifers.

viii. Ensure adequate and regular water quality monitoring and continue to work with town conservation commissions and watershed groups such as the Connecticut River Watershed Council to encourage, expand, and coordinate volunteer water quality monitoring on the tributaries and on the mainstem. Make water quality monitoring data easily accessible to the public, including those who do not use computers, so the public understands the present condition of their waters. Assist local wastewater treatment plants with the cost of processing bacteria samples from river monitoring.

ix. Inform local planning commissions, developers and landowners about changes in the stormwater permitting process.

x. Resolve questions associated with water classification typing to complete basin planning as quickly as possible, including water quality monitoring of the Connecticut River tributaries in question.

xi. Institute a water withdrawal registration system.

xii. Investigate issues surrounding development of micro hydro power generation facilities, and develop policies and guidance for design that ensure that water quality, aquatic habitat, sediment transport, fisheries, recreation, and historic resources are not affected by new small hydro development. Consider requiring off-site mitigation for projects that cannot be designed to avoid impacts and ensure that permittees set aside adequate funds to address facility maintenance and removal. Consulting potential stakeholders such as CRJC, the Connecticut River Watershed Council, and other appropriate watershed organizations would be helpful in identifying potential issues and concerns on this scale, as has already proved useful for relicensing of larger projects.

xiii. Enforce the ban on barrel burning of trash.

xiv. Invest in riparian habitat conservation and restoration in cooperation with interested landowners. Support buffer restoration through tax incentives and cost-sharing.

xv. Fully consider the potential for riverbank failure when issuing permits for sand, gravel, or clay extraction close to the river; require significant setbacks, and have a plan for mitigation and stabilization or restoration.

f. State emergency management office: Include local watershed groups in emergency planning for river-related issues.

g. Department of Forests, Parks & Recreation:

i. Pursue conservation of key riverfront land in cooperation with willing landowners, to protect water quality, flood storage, prime agricultural soils, wildlife habitat, and scenic views.

ii. Ensure that its current use program is not at odds with conservation goals and allow riparian buffer protection on enrolled lands. Foresters designing management plans for property enrolled in the program should incorporate best forestry management practices to protect and enhance forested buffers.

11. New Hampshire

a. Legislature:

i. Consider adding shoreland protection for third order streams, the smaller but still substantial tributaries that feed the larger streams already protected under the law.

ii. Continue to legislate reductions in mercury contamination.

iii. Provide sufficient funds to allow the Department of Safety's Marine Patrol to adequately enforce existing boating laws on the river.

iv. Update the definition of personal watercraft to ensure that these wake-producing craft are limited to the widest areas of the river.

b. Department of Safety, Marine Patrol: Ensure a regular presence on the Connecticut River to help reduce boat wake-induced erosion.

c. Department of Agriculture:

i. Enforce best management practices, including a ban on winter spreading of manure.

ii. Support Vital Communities' Valley Food and Farm program in the Connecticut River Valley.

iii. Encourage farmers to protect and enhance riparian buffers.

iv. investigate ways to institute a Conservation Reserve Enhancement Program.

d. Department of Transportation:

i. Treat riparian buffers as natural allies in preventing pollution by retaining buffers as a natural curb to road-related runoff. Avoid mowing vegetation in riparian buffers where roads are close to streams.

ii. Make efforts not to transport fragments of invasive plants during road construction projects, and consult agriculture departments about best practices for dealing with invasive species, including ways to sanitize spoils before disposal. New Hampshire's Roads Scholar Program can offer special training for road crews on this issue.

iii. Adopt new stormwater engineering practices, anticipating impacts resulting from climate change. Revise design guidelines for culverts and stream crossings to reflect new storm frequencies and runoff volumes.

e. Fish and Game Department:

i. Conservation officers and wardens should educate about invasive species when issuing fishing and boating licenses, perhaps with an attention-getting enclosure in the application or license. Replace signs at boat landings urging boat inspection and cleaning with more informative and effective signs. Consider providing boat cleaning stations at its public access sites on the river

ii. Continue to cooperate with sporting groups and sister agencies to better understand and address the Didymo infestation. Publicize practical prevention measures that the public is likely to use.

iii. Pursue conservation of key riverfront land in cooperation with willing landowners, to protect water quality, flood storage, prime agricultural soils, wildlife habitat, and scenic views.

f. Department of Environmental Services:

i. Educate town officials, real estate agents, developers, and landowners about the Comprehensive Shoreland Protection Act, including the agency's responsibility for enforcement. Provide GIS layers and mapping of the protected shoreland for local zoning officers.

ii. Inform local planning boards, developers and landowners about changes in the stormwater permitting process.

iii. Seek funding to support regional planning commissions in assisting New Hampshire towns to survey culverts and bridges to identify those that are undersized and poorly placed for fish passage, and seek funding for replacement where necessary.
iv. Focus on phosphorus in the Connecticut River and educate state legislators about the cost of phosphorus pollution to the environment, and the cost to local communities of removing phosphorus from discharges.. Follow Vermont's example on management of phosphorus entering wastewater, and limit the amount of phosphorus in cleaning products sold and used in the state.
v. Assist local communities with the high costs of upgrades, expansions, and replacements of aging wastewater treatment facilities.
vi. Work with local partners in guiding disposal of pharmaceuticals and educate state legislators about the need for action.
vii. Seek federal assistance through the Congressional delegations to remedy combined sewer overflows on behalf of Lebanon as quickly as possible.
viii. Establish rules to protect key aquifers from contamination; do not permit landfills, hazardous waste disposal facilities, auto salvage yards, junkyards, wastewater or septage lagoons, and outdoor salt storage or other de-icing chemical storage to be located on aquifers.
ix. Ensure adequate and regular water quality monitoring and continue to work with town conservation commissions and watershed groups such as the Connecticut River Watershed Council to encourage, expand, and coordinate volunteer water quality monitoring on the tributaries and on the mainstem. Make water quality monitoring data easily accessible to the public, including those who do not use computers, so the public understands the present condition of their waters. Assist local wastewater treatment plants with the cost of processing bacteria samples from river monitoring.
x. Post sediment quality data from their sediment study on the Web.
xi. reinstate and place stream flow gages using a science-based approach to river management.
xii. Investigate issues surrounding development of micro hydro power generation facilities, and develop policies and guidance for design that ensure that water quality, aquatic habitat, sediment transport, fisheries, recreation, and historic resources are not affected by new small hydro development. Consider requiring off-site mitigation for projects that cannot be designed to avoid impacts and ensure that permittees set aside adequate funds to address facility maintenance and removal. Consulting potential stakeholders such as CRJC, the Connecticut River Watershed Council, and other appropriate watershed organizations would be helpful in identifying potential issues and concerns on this scale, as has already proved useful for relicensing of larger projects.
xiii. Consider offering fluvial erosion hazard mapping similar to Vermont.
xiv. Fully consider the potential for riverbank failure when issuing permits for sand, gravel, or clay extraction close to the river; require significant setbacks, and have a plan for mitigation and stabilization or restoration.
xv. Enforce the ban on barrel burning of trash.
xvi. Invest in riparian habitat conservation and restoration in cooperation with interested landowners. Support buffer restoration through tax incentives and cost-sharing

g. State emergency management office: Include local watershed groups in emergency planning for river-related issues.

Regional

12. Regional Planning Commissions:

continue and increase their work on brownfields. Seek federal funds to assist communities in evaluating and addressing brownfields sites, and encourage owners of potential brownfields properties to participate. Assist towns in providing more frequent and convenient opportunities for household hazardous waste collection, and put more effort into educating the public about the reasons.

13. Connecticut River Joint Commissions:
Identify Instream Protected Uses, Outstanding Characteristics and Resources listed in RSA 483 for the Connecticut River, based on consultations with organizations, agencies, and communities, as well as discussions in the local river subcommittees.

14. Vital Communities:
Continue to expand its Valley Food and Farm program to encompass the entire northern Connecticut River Valley.

15. Land conservation organizations:
a. Pursue conservation of key riverfront land in cooperation with willing landowners, to protect water quality, flood storage, prime agricultural soils, wildlife habitat, and scenic views.
b. Ensure, wherever possible, that the easement includes the belt-width of the river meander in that area, to accommodate future movement of the channel without harm to structures. Organizations that provide funds for easements should consider the same belt-width requirement for funding conservation, where adequate undeveloped space remains.
c. The Nature Conservancy should make local planning boards and conservation commissions aware of its floodplain analysis.

Local

16. Towns

a. Planning boards and commissions:
i. Adopt ordinances discouraging new building in the 100-year floodplain, or the special flood hazard area. Review preliminary Flood Insurance Rate Maps and meet with FEMA and the state to comment on the maps. Consider the flood implications of access roads to development sites in the floodplain, and ensure that they will not act as berms during high water. Vermont towns should avail themselves of the Municipal Education Grant Program to bring training to their communities as they consider adopting new river protections such as this.
ii. Encourage riverfront buffers. Apply shoreland and buffer guidelines on small streams as well as on larger rivers.
iii. Adopt ordinances to ensure that structures, including roads, are set a safe distance back from the river to reduce the risk of property loss in erodible areas. Vermont needs enabling legislation to allow this.
Town planners should consult their regional planning commissions to help bring life to the river protection recommended in this Overview and their local subcommittee's plan, by incorporating meaningful standards for shoreland development in their town's master plan and zoning ordinance. Tailor these shoreland ordinances to reflect local shoreland conditions.
iv. Discourage development on steep slopes in order to minimize the burden on culverts and bridges to carry runoff during heavy storms. Require riparian buffers of at least 75 feet along all rivers and streams.
v. Plan for stormwater control and look at ways to include "low impact design" ideas as they review projects, and at how to change existing development to reduce runoff and promote stormwater infiltration.
vi. Evaluate water supplies for short and long term growth, and seek protection of water sources. Avoid placing snow dumps and permitting other potentially contaminating activities on aquifers. Map the "cone of influence" for public wells, and develop regulations, such a ban on underground petroleum tanks, to apply in that cone of influence.
vii. Consider adopting agricultural soil protection ordinances to keep valuable soils available for farming and to keep development from interfering with flood storage.
viii. Provide information to every new riverfront landowner to explain the special challenges of owning and managing riverfront land, including the benefits of riparian buffers and the requirements of state shoreland protection laws.

ix. Work with regional planning commissions to identify their fluvial erosion hazard areas and develop pre-disaster mitigation plans.
x. Fully consider the potential for riverbank failure when issuing permits for sand, gravel, or clay extraction close to the river; require significant setbacks, and have a plan for mitigation and stabilization or restoration.
xi. Enforce developers' use of erosion and sedimentation control practices, and ensure that riverside activities do not impact riverbanks and riparian buffers. Limit activities close to the river or within the floodplain to agriculture, recreation, forestry, and wildlife conservation.
xii. Work with state geologists to map varves in their towns, to be sure major construction does not take place on unsafe soils. Consult existing soils maps and work with their county office of the USDA Natural Resources Conservation Service to identify where these unstable soil formations may occur within their boundaries.

b. Highway departments and road crews:

i. Treat riparian buffers as natural allies in preventing pollution by retaining buffers as a natural curb to road-related runoff. Avoid mowing vegetation in riparian buffers where roads are close to streams.
ii. Make efforts not to transport fragments of invasive plants during road construction projects, and consult agriculture departments about best practices for dealing with invasive species, including ways to sanitize spoils before disposal.
iii. Adopt new stormwater engineering practices, anticipating impacts resulting from climate change. Evaluate whether culverts and bridges are sized properly in order to carry the water that might come their way during larger storms. Use a phased, risk-based program of culvert upgrades.
c. Conservation commissions:
i. Conduct an education and control campaign against Japanese knotweed and other invasive species in their towns. Consult with the White River Partnership, New England Wildflower Society, Conte Refuge, and the Invasive Plant Atlas of New England for assistance and methods for dealing with invasive species.
ii. Pursue conservation of key riverfront land in cooperation with willing landowners, to protect water quality, flood storage, prime agricultural soils, wildlife habitat, and scenic views.
iii. Educate townspeople about the value of buffers and the ways in which personal choices can have lasting effects, both good and bad, on the region's water resources.
iv. In New Hampshire. develop a list of candidate sites for protection through the state's wetlands mitigation program.
d. St. Johnsbury and Lebanon: Seek federal assistance through the Congressional delegations to remedy combined sewer overflows as quickly as possible.

Private

17. TransCanada Hydro Northeast:

a. Consider providing boat cleaning stations at its access sites, as should state agencies managing public access sites on the river.
b. Complete its conservation plans in the Fifteen Mile Falls and Connecticut Lakes regions and at Sumner Falls, and should consider conserving the rich agricultural lands it owns in the Bellows Falls pool.

18. New Hampshire citizens in tributary towns should consider nominating their rivers into the state program

19. Landowners:

a. Encourage riverfront forests where they remain. Landowners along rivers and streams should retain and enhance buffers of native vegetation and remove invasive plants that try to gain a foothold there. Farmers will especially appreciate the capture of flood debris by large woody buffers during high water. Landowners can protect their privacy, enhance the appearance of their property, and protect water quality by leaving the natural buffer undisturbed. They should take advantage of state and federal cost-sharing programs and of the advice

offered by county conservation districts and CRJC's printed guidance, Riparian Buffers for the Connecticut River Watershed.
b. Contact professionals such as the Natural Resources Conservation Service for help in evaluating erosion problems. Anyone contemplating work on a riverbank must obtain the proper permits before going ahead.
c. Check riverbanks for the presence of hidden riverbank undercuts and invasive plants with the assistance of local conservation commissions.
d. Farmers:
i. Prepare a total nutrient management plan for their farm if they have not already done so, with help from county conservation districts and the Cooperative Extension Service, to make best use of available nutrients, reduce potential for water quality impacts, and save money in purchasing fertilizer.
ii. Use best management practices for stormwater, such as redirecting barn roof runoff away from high cattle use areas.
e. Forest landowners:
i. Follow guidelines such as Good Forestry in the Granite State and minimize the water quality impacts of harvesting. Follow forest management plans created for land in current use. Take advantage of cost-share programs. Construct forest roads, culverts, and bridges to accommodate excessive storm water drainage and minimize extreme snow melt damage. Manage and maintain access to the forest to facilitate possible salvage harvesting of timber damaged by insect, disease, wind and ice storms.
ii. Use best management practices for stormwater, such smoothing and seeding skidder ruts after timber harvest so that these places do not become channels for erosion.

20. Hospital associations: Encourage return of unused pharmaceuticals at consumer friendly locations.

21. Recreational users:

a. Boaters or divers traveling from waters infested with zebra mussel and other invasives must wash and dry all equipment before reuse, hose off the boat, diving gear or trailer, and drain and flush the engine cooling system and live wells of the boat, bait buckets and buoyancy control devices on diving equipment.
b. Boaters should obey existing speed laws and watch their wakes to be sure that they do not strike the bank with erosive force.
c. Sporting groups should continue to cooperate to better understand and address the Didymo infestation. Publicize practical prevention measures that the public is likely to use.
d. Fishermen and other recreational user must carefully clean their gear after visiting the Connecticut River and report sightings of invasive aquatic species to state agencies. Do not release unused bait into the water.
e. Local outfitters and guides should educate their customers about Didymo and other invasives.

22. General public:

a. Continue to support and encourage local agriculture.
b. Alert their Vermont legislators about the importance of shoreland protection and call upon the legislature to take action.
c. Support the work of land trusts and other conservation organizations in protecting riparian lands. Encourage them to make aquatic and riparian habitat quality a priority in cooperation with interested landowners.

Appendix B. Acknowledgments

We have been fortunate to be able to call upon the expertise of state agencies, regional planning commissions, and local watershed group leaders to advise in the preparation of this plan. We would like to express our gratitude to those who lent their time to this effort:

- Steve Couture, Rivers Coordinator, NH Department of Environmental Services Rivers Coordinator

- Rick Hopkins, Vermont Department of Environmental Conservation, Water Quality Planning Division
- Laura Weit, NH DES Watershed planner
- Ben Copans, VT DEC Watershed Coordinator
- Marie Caduto, VT DEC Watershed Coordinator
- John Field, Field Geology Services
- North Country Council, N.H.
- Northeastern Vermont Development Association, Vt.
- Upper Valley Lake Sunapee Regional Planning Commission, N.H.
- Two Rivers Ottauquechee Regional Commission, Vt.
- Southern Windsor County Regional Planning Commission, Vt.
- Southwest Region Planning Commission, N.H.
- Windham Regional Commission, Vt.

Technical assistance - Mapping and other technical assistance were provided by

- Upper Valley Lake Sunapee Regional Planning Commission through a grant from USGen New England.
- N.H. Department of Environmental Services
- U.S. Geological Survey

Funding to support the work of the Connecticut River Joint Commissions in preparing this plan came from:

- N.H. Department of Environmental Services
- National Oceanographic and Atmospheric Administration
- US Gen New England
- Upper Connecticut River Mitigation & Enhancement Fund

TransCanada Hydro Northeast

Appendix C. Members of the Connecticut River Joint Commissions

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Connecticut River Watershed Advisory Commission

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Mary Sloat, Lancaster
Henry Swan, Lyme
John Tucker, New London
George Watkins, Walpole

Appendix D. Glossary of Terms

24. Basin - watershed, the land area drained by a body of water.
25. Black start - the process of restoring a power station to operation after a wide-area power outage has occurred.
26. GIS - geographic information system, a system for capturing, storing, analyzing and managing data and associated attributes which are spatially referenced to the Earth. GIS is a tool that allows users to create interactive queries, analyze the spatial information and create maps.
27. Head-cut erosion - a fluvial process of erosion that lengthens a stream, a valley or a gully at its head and also enlarges its drainage basin. The stream erodes away at the rock and soil at its headwaters in the opposite direction that it flows. Once a stream has begun to cut back, the erosion is sped up by the steep gradient the water is flowing down. As water erodes a path from its headwaters to its mouth at a standing body of water, it tries to cut an ever-shallower path. This leads to increased erosion at the steepest parts, which is head-cut or headward erosion.
28. LIDAR - Light Detection and Ranging, an optical remote sensing technology that measures properties of scattered light to find range and/or other information of a distant target, usually with laser pulses. LIDAR technology can be used to discern subtle landscape features, such as the shadows of old river flood chutes.
29. Meander belt width - the breadth of the landscape through which a river or stream channel may migrate over time. The larger the belt width, the more erosion hazard posed by the stream. Averages six times the width of the channel.
30. River ramping rate - the change in water release rate at a dam.
31. Soil piping - a particular form of soil erosion that occurs below the soil surface. It is associated with water level fluctuations behind dams as well as sink hole formation. Water pressure imbalance at the riverbank face can cause water to leave the soil at the bank face, carrying soil particles with it. Eventually, such weeping of soil and water can cause bank slumping.

32. Stream order - a means of roughly describing the size of a stream based on a hierarchy of its tributaries. Streams range from the smallest at the headwaters (a first order stream) to the most powerful (the Amazon River is a "12.")When two first-order perennial streams (streams that flow all year round) come together, they form a second-order stream. When two second-order streams come together, they form a third-order stream, and so on. Streams of lower order joining a higher order stream do not change the order of the higher stream. Thus, if a first-order stream joins a second-order stream, it remains a second-order stream.

33. Varve - an annual layer of sediment. Varves form in marine and lake depositional environments from seasonal variation. The classic varve is a light / dark colored couplet of layers deposited in a glacial lake. The light layer is usually silt and fine sand deposited when meltwater deposits a sediment load into the lake water. During winter months, when meltwater and associated suspended sediment input is reduced, and often when the lake surface freezes and stills the water, fine clay-size sediment is deposited forming a dark colored layer. Varves are common in the Connecticut River valley in areas that were once submerged under glacial Lake Hitchcock and other ancient glacial lakes. They are important because the layers behave differently with water; the clay layers can slip against the sand/silt layers or convey water laterally.

Appendix E. List of Acronyms

AAP	Accepted Agricultural Practice
AMP	Acceptable Management Practice
ANR	(Vermont) Agency of Natural Resources
BMP	Best Management Practice
CRJC	Connecticut River Joint Commissions
CREP	Conservation Reserve Enhancement Program
CRWC	Connecticut River Watershed Council
DES	(New Hampshire) Department of Environmental Services
EPA	(United States) Environmental Protection Agency
FEMA	Federal Energy Regulatory Commission
GIS	Geographic Information System
LID	Low Impact Development (a stormwater management system)
NOAA	National Oceanographic and Atmospheric Administration
TMDL	Total Maximum Daily Load

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