# OPTIONS FOR STATE FLOOD CONTROL POLICIES

# AND A FLOOD CONTROL PROGRAM

*West Hill Brook, Montgomery*

**Prepared for the Vermont General Assembly**
**Pursuant to Act 137 Section 2 (1998)**

**Prepared by the**
**Vermont Agency of Natural Resources**
**Department of Environmental Conservation**
**Water Quality Division**
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# Overview

Floods are awesome. Floods can be terrifying. Floods cause millions of dollars in property damage, and can result in loss of human lives. Anyone who has experienced a major flood will tell you of the incredible power of water running down hill and the helplessness of those in its path.

Floods are inevitable. Floods have ravaged the land periodically throughout history, and we may be subjected to even more frequent flooding in the future because of global climate change. We certainly cannot expect to be immune from serious flooding, a luxury that was enjoyed by Vermonters for over three decades, between 1938 and 1973. Serious flooding has occurred much more frequently in the last twenty-five years in Vermont, and there is no reason to believe that it will not continue to be a problem. We need to be prepared.

Because we know that floods will continue to occur in Vermont, it is important that we be prepared to react to the dangers of floods as they are happening and to protect the public health and safety during these emergencies. Other reports to the General Assembly under the provisions of Act 137 will deal with these emergency issues.

We also need to be proactive in managing our river systems, now, to reduce the potential for flooding in the future and to design our recovery efforts following flood events to both accommodate the needs of Vermonters affected by the flood **and** to reduce the potential for the recurrence of similar damage in the future. This report will focus, primarily, on how we prepare for floods, how we prevent flood damage, and how we clean up after the flooding is over. How well we fare in the next flood will depend a lot on how well we prepare for it now.

## The Science

The science of stream hydrology is complex and even the experts have made mistakes about how to best manage our rivers and streams to protect property and natural resource values. Although unruly flood waters may appear to be unconstrained, they are in fact governed by the laws of nature and physics. Rivers and streams are, by their very nature, changeable...dynamic; but changes occur in a generally predictable way. For example: rivers generally stay the same length. If a river straightens in one reach, it will, over time, develop a curve in another to re-establish its length. Another example: rivers must carry a certain amount of sediment (often gravel, in Vermont) along with the water. If there is too much sediment, the channel will become unstable. If there is not enough sediment, the river will erode its banks or bed. As we consider ways to manage river systems to protect property or natural resource values, we need to be sure that our actions in one spot do not result in unintended consequences in another. Key to achieving this goal is to look comprehensively at longer river reaches rather than trying to address one particular problem, or symptom of a larger problem, at a time.

Although there continue to be disagreements among specialists over some of the issues related to river hydrology, and the treatment of any particular river reach will always require the application of professional judgement, expert opinion is converging around one central theme: **establishing long-term river stability will provide both protection from flood damage and a healthy riverine environment.** This means that, with a comprehensive approach to river and stream management, we will seldom have to choose between protection of human investments and protection of our state's natural resources. The right answer in most situations will work for both, and the wrong answer will work for neither.

## Dredging

There has been considerable debate over dredging (gravel removal) as a method of protecting property from flood damage. Dredging is a legitimate strategy for protecting property when the dredging will help to restore or maintain river stability. DEC is expanding its policy on gravel removal to make it clear that dredging that protects property and contributes to increased stream stability will be allowed. Even under existing DEC policy, the department has approved more than 100 stream dredging proposals in the past two years associated with flood recovery and other property protection projects. However, dredging can also destabilize river systems and lead to greater flood damage in the future. This is not a fish vs. people issue. The fish are not any better off with an unstable stream system than we are. Dredging operations that restore stream stability will also support a healthy fishery. The key here is to insure that the work we do in our rivers is designed to promote stability, which benefits both the natural systems, our rivers, and the people who live and work near them.

## A More Comprehensive Policy and Program

The flooding that has occurred in the last few years has caused the DEC to seriously evaluate its programs and policies related to river and stream management, including restrictions on dredging. An independent study of present policy found that Vermont is in the "middle of the pack" when compared to dredging restrictions in other states. DEC has also looked at its river management program and found that more resources are required there in order to effectively implement a river restoration and flood protection program where dredging is used appropriately as one of the tools for restoring stability. We have begun to enhance this program by re-directing existing resources and are proposing additional support in this year's budget, taking advantage of new federal funding.

## Flood Damage

Vermont has experienced loss of life, substantial human suffering, degraded natural resources, and nearly 50 million dollars in damage in floods over the last few years. By far the largest single source of flood loss, both in terms of monetary loss and in terms of its effect on people, is loss to transportation infrastructure and utility services. With respect to transportation infrastructure, the state system withstands flooding quite well. Although there are a few notable exceptions, most of the state system is designed and maintained to standards that accommodate high flood flows. Municipal transportation infrastructure does not fare so well and, in some cases can actually be the cause of flood damage. This is the result of a number of factors. Pavement helps resist flood damage and a high percentage of town roads are unpaved. Many town roads are built in relatively difficult terrain when compared to the state system. Also, most towns do not have the financial resources or the expertise to build roads to the standards used for the state system. This report explores options for improving municipal transportation infrastructure and providing additional support to towns to help them prepare better for future flood events.

## Flood Damage Prevention

There are other actions we can take, besides improving our municipal transportation infrastructure, to prevent future flood damage. We can limit unwise investments in areas that are prone to flooding. The federal flood insurance program serves as a good model here. Very little flood damage has occurred to structures built under this program. The shortcomings of this program are that it is not in effect in all Vermont towns and, where it is in effect, it does not cover all flood prone areas. The program does well with mapping flood prone areas adjacent to our larger rivers and streams, but it does not account well for flooding in smaller tributaries and flooding that results in the formation of ice jams or debris jams. We need to explore ways to improve the way this program works in Vermont.

Another way to prevent future flood damage is to avoid rebuilding flood-damaged structures with structures that will be damaged or cause damage in the future. There have been a few buy outs of buildings that were damaged in recent Vermont floods because they could not be rebuilt in a way that would protect them against future flood damage. We should explore the benefits of expanding this program.

This report also suggests a more aggressive application of the Federal Emergency Management Agency's (FEMA) 1995 mitigation policy which provides federal funding for building more expensive, but properly designed, replacements for inadequate structures (undersized culverts, etc.) lost or damaged during floods.

Prior to 1995, FEMA would only allow replacements "in kind", even when it was clear that the replacement would likely fail again in the next flood. Their change in policy is encouraging, but implementation has been slower than expected.

### Agricultural Losses

Farmers own and manage a substantial percentage of Vermont's riparian land and they typically suffer significant losses during floods. Federal programs to assist farmers with routine streambank maintenance have been cut back substantially in recent years. Emergency, flood recovery funds are available; but these funds, by their very nature, are seldom used for comprehensive riparian corridor management designed to restore stability to the river system as a whole. However, the new federal Conservation Reserve Enhancement Program (CREP) does provide financial incentives to help farmers improve riparian corridor management. This report recommends consideration of enhanced support of this and other programs to assist Vermont's agricultural community with streambank problems.

### Other Program Changes

This report discusses a number of other potential program changes in addition to those discussed above. DEC is initiating a watershed planning process, partly in response to federal initiatives unrelated to flooding, and comprehensive riparian corridor management for flood protection should be an integral part of the watershed planning process, which will be designed to maximize public involvement in decisions about the future of water resources management in their watersheds. There are also recommendations on the management of structural hazards and debris and for structural flood control and hazard mitigation. The report discusses ways to improve coordination between the alphabet soup of government agencies involved in flood control and recovery and suggests ways to help municipalities deal with the various state and federal programs. A system of incentives to accomplish meaningful and effective levels of flood preparation, prevention, response, recovery and mitigation is reviewed.

### State and Local Financial Resources

This report discusses a number of instances where state or local resources have not been fully adequate to address flood-related issues, particularly for those issues associated with investments to prevent future flood damage. This is not a criticism of existing programs, which have actually operated quite well, based on available knowledge and resources. What this report does suggest is a review of past practices in the light of recent experiences with flooding in Vermont and advances in the science of river management. It appears that even modest, increased expenditures now may substantially reduce costs to both our investments and our natural resources in future floods.

### Summary

Flooding has been a very serious problem in Vermont in the last two decades, particularly when compared to the previous three. We know that flood events will recur in the future, and we need to be prepared.

A comprehensive program of river system management, one that focuses on maintaining or restoring the river system as a whole, should be a key component in our efforts to reduce damage from future floods, as should support to towns for the maintenance and design of municipal infrastructure.

We need to consider investments in preventive projects and policies now in order to avoid much higher costs in the future. There is little doubt that wise investments of time and money now will be cost effective in the long run. The nature and extent of those investments needs further discussion. It is the purpose of this report to provide a reasonable and helpful basis for those discussions.

## Summary of Issues, Policy Considerations and Program Options

### Issue 1: Excessive damages to state, municipal and utility service infrastructure

- Policy Consideration: Consider increased levels of state assistance to communities for the purpose of reducing flood related municipal service infrastructure damage.

- Program Options: Provide state agencies with additional resources to provide public assistance to guide and support disaster resistant municipal infrastructure investment and management.

### Issue 2: Compatibility of human investment with risk of loss from flooding

- Policy Consideration: Continued high risk private investments in flood prone areas should be discouraged and avoided.

  Consider providing municipalities with incentives, technical guidance and the methodology to be able to map and identify high risk areas for development.

- Program Options: Fund state agencies, ANR and C&CD, to develop the technical methodology and staffing to assist communities in implementation.

### Issue 3: Management of River Morphology (i.e., river form and structure)

- Policy Consideration: The Vermont Agency of Natural Resources plans to implement a comprehensive, river management program that focuses on improving river stability which will balance the need to protect public and private property and the need protect the environment.

- Program Options: Establish a River Management Section within DEC using existing resources and new opportunities for federal funding. Consider additional state funding to leverage available federal monies and other sources to perform river restoration projects.

  DEC plans to implement a comprehensive, coordinated river restoration approach to river and stream management, designed to produce the following outcomes:

  1. Reduction in the magnitude of property and infrastructure damage resulting from future flooding
  2. Reduction in the cost of flood prevention, repair and recovery operations
  3. Improved river system and watershed stability
  4. Protection of both human investments and our state's natural resources Fortunately, both goals are usually served by maintaining or restoring a stable river system.

### Issue 4: Management of Structural Hazards and Debris

- Policy Consideration: Improve statewide management of in-stream structural hazards and debris.

- Program Options: Examine the contribution of beaver dam failures to flood damages; to commence immediately following the next appropriate disaster event to take advantage of federal funding.

  Improve our state dam safety program, incorporating nationally recognized standards.

**Issue 5: Opportunities for Structural Flood Control and Flood Damage Mitigation**

- Policy Consideration: Expand state support for flood damage mitigation and reduction at the state and local levels through support of structure acquisition and/or relocation and other cost-effective applications.

- Program Options: Greater emphasis and support for statewide and local hazard mitigation opportunities by and within VEM.

  Provide increased state resources to support and assist municipalities in the formulation, design and implementation of the most cost-effective hazard mitigation opportunities possible.

  Provide additional state resources to identify and take advantage of statewide hazard mitigation opportunities.

  Provide additional support of the Vermont Local Roads Program to provide technical and financial assistance to communities for construction and capital investment formulation grants for hazard mitigation projects.

**Issue 6: Changes in Watershed Hydrology and Runoff Conveyance**

- Policy Consideration: DEC should continue efforts to identify the watershed management issues that influence susceptibility to and protection from floods. Results from on-going and future studies should be made available to support comprehensive basin planning efforts and meaningful flood hazard mitigation.

- Program Options: Support of on-going DEC efforts to quantify and implement the flood hazard mitigation opportunities available through watershed management and basin planning.

  Continued support of the USGS stream gaging program.

**Issue 7: Agricultural Practices**

- Policy Consideration: Federal and state farm policies should take into account the potential effect on flood hazards and flood loss. The state, in cooperation with federal agencies, should develop the guidelines necessary to assure that implementation of farm policies and programs protect against soil and crop loss from flooding.

- Program Options: Support state participation in the new USDA Conservation Reserve Enhancement Program (CREP).

**Issue 8: Public Understanding of Watershed Processes and River Dynamics**

- Policy Consideration: It is beneficial to the State of Vermont to have an informed public that supports erosion and storm water management programs that minimize flood hazards by restoring and maintaining natural stable stream morphology.

- Program Options: Enhance public education component of the DEC Rivers Program.

**Issue 9: Incentives**

- Policy Consideration: State disaster aid to municipalities should be disbursed in a way that creates incentives that will encourage better disaster preparedness, reduce total flood losses, improve emergency response, facilitate disaster recovery and support mitigation efforts.

- Program Options: Enhance staffing within DHCA to assist municipalities in implementation of the flood disaster aid eligibility requirements.

  The state should review all flood disaster aid policies and programs and attach appropriate pre-requisites to each in a manner that encourages reduction of future flood loss. A 3-5 year phase-in period should be allowed for implementation of the eligibility requirements by municipalities. Implementation of the eligibility requirements should be accompanied by adequate state assistance and guidance necessary to provide appropriate financial, technical and administrative support.

  State participation in FEMA IA grants program and FEMA HM structure acquisitions should be structured in a manner that encourages enrollment in the NFIP.

  State aid to municipalities should, where appropriate, encourage the alleviation of flood hazards associated with deficient infrastructure.

  Increase in the Town Highway Bridge & Culvert Program annual appropriation to reduce or eliminate flood hazards.

**Issue 10: Coordination of Flood Response , Recovery and Mitigation**

- Policy Consideration: Make adequate resources available to support and assure a well coordinated disaster response effort.

  Eligible uses of the state disaster emergency fund should be better defined.

- Program Options: Consider increased base funding of the state disaster emergency fund.

  Consider providing coordination support through a disaster response ombudsman in VEM and to municipalities by helping fund contracted professional flood coordinators.

# Introduction

Since 1973, Vermont has suffered thirteen major statewide and regional floods (see figure 1). This constitutes a frequency of one destructive flood nearly every other year. Each event received a presidentially declared federal disaster designation with one exception. In just the last four years, Vermont has experienced five devastating regional flood events (see appendix 1). The magnitude of human economic loss from these last five flood disasters alone is estimated by the Vermont Department of Environmental Conservation (DEC) to exceed $50 million (see appendix 2). Hazardous conditions of public safety and human misery add to the toll.

The 97-98 Vermont General Assembly rightly considered that much can and should be done to avoid or reduce our exposure to flood damage and to better respond to flooding in a way that provides more immediate and greater long term public benefit. The frequency of flooding and the monetary cost of flood recovery demonstrate the need to assure that money spent to avoid, mitigate, prepare for, respond to and recover from floods is applied in the most cost effective manner. Act 137 mandates that DEC "develop flood control policies and a flood control program (which).......shall direct appropriate remedial measures following significant flooding events and shall define appropriate flood hazard mitigation measures" (see appendix 3).

An economic loss that is difficult to quantify is the damage Vermont's surface waters, themselves. Natural resource degradation is a consequence of both the extreme flood flows and, sometimes, the recovery operations. Our investments within and along stream corridors can constrain the river system until the system is energized by enough rainfall to burst through those constraints and wreak havoc with anything or anyone in the way.

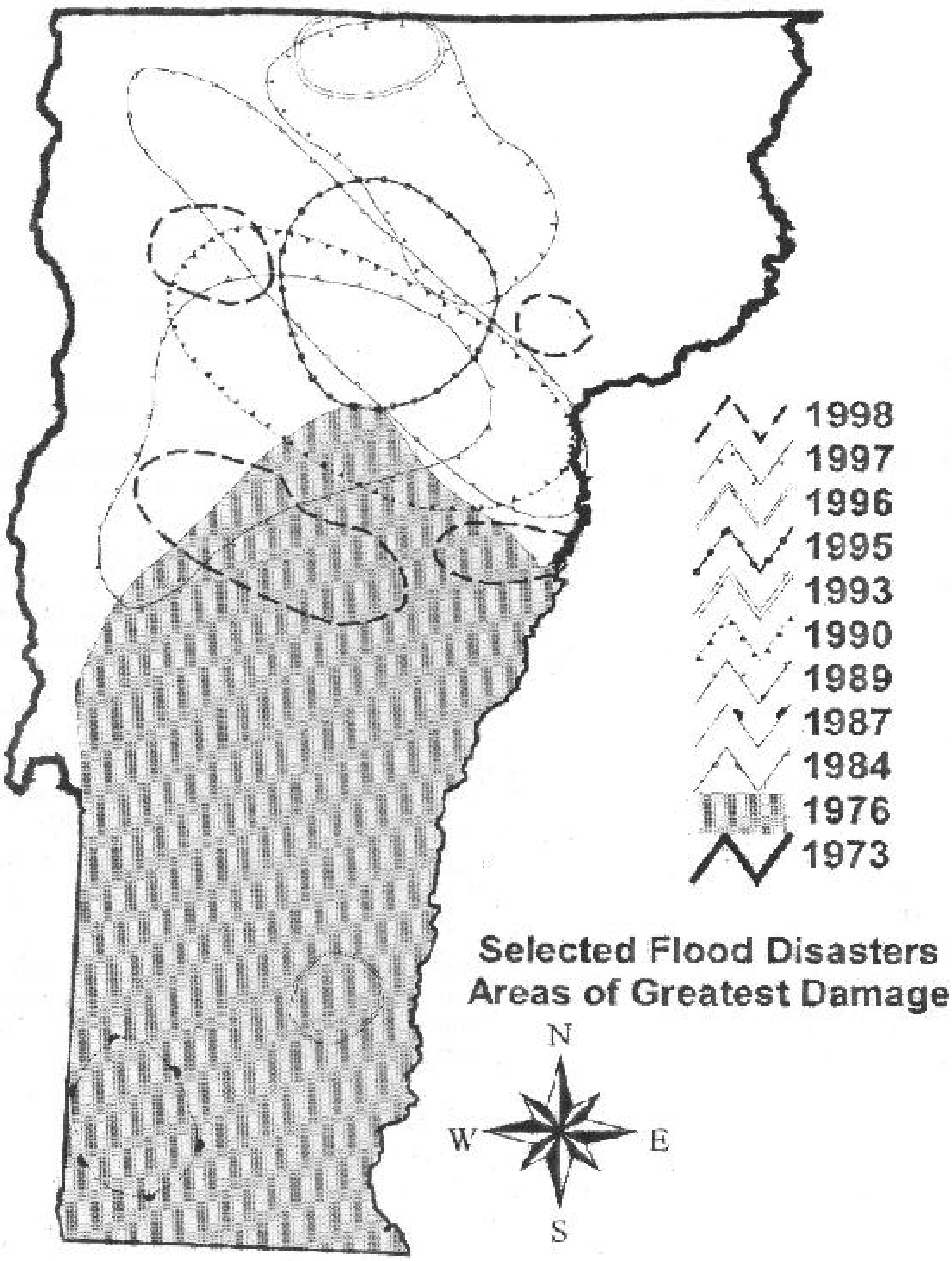
Land development in areas at risk to flooding and erosion eventually demand protection. Both the increased investments and the physical constraints result in greater conflict between human expectations and values and the adverse reaction of the natural system during a flood event. This is a key issue identified and emphasized by the General Assembly through Act 137; that the flood control policies and programs "balance the need to protect the environment with the need to protect public and private property."

This report supports an approach to flood disaster recovery that will achieve the goals of long term property protection, flood loss reduction, as well as protection and restoration of natural resource values, by focusing on policies and programs that will enhance the stability of Vermont's river systems. The report provides policy considerations, discusses program approaches and offers suggestions for substantive measures which will promote long term property protection *and* sustain natural resource values.

DEC believes it is a realistic goal that statewide flood losses can be reduced by up to 50% within 20 years. If achieved, this could represent one of the most cost effective expenditures of state funding ever. We should not miss this opportunity.

This report was developed in consultation with the Vermont Division for Emergency Management; the Vermont Department of Agriculture, Food & Markets; the Vermont Department of Housing and Community Affairs; the Vermont Agency of Transportation; the Vermont Department of Social Welfare; the Vermont Local Roads Program; and the Lamoille County Regional Planning Commission..

*Areas of greatest flood damage; 1973-1998*



# Considerations for Flood Control Policies, Program and Budget

## Issue 1: Excessive Damages to State, Municipal and Utility Service Infrastructure.

By far the largest single source of flood loss, on both a monetary basis and in terms of directly affecting the greatest number of people, is damage to transportation infrastructure and utility services. Infrastructure damage also represents the greatest public safety hazard. All of the three flood related fatalities since 1995 were associated with washed out culverts on town highways; although a number of near fatalities have been experienced with residential flooding. Public health and safety is also compromised when access to homes and businesses is unavailable or essential services such as power, telecommunications, fire and rescue, water supply and wastewater collection and treatment are interrupted.

In a study of public damages suffered in 6 rural Vermont communities (Wolcott, Elmore, Hardwick, Middlesex, Underhill and Worcester) during the 1995 flood, DEC and an independent consultant collaborated to determine how much of the damage was avoidable. After examination of all FEMA Damage Survey Reports (DSR) for the studied towns, field inspections and interviews with local officials, the consultant report indicates that an average of 50% of the total flood damage to public infrastructure could have been avoided (Final Report for Watershed Hydrology and Flood Mitigation: Phase I; Stone Environmental, Inc.).

- **Roads:**

By and large, the state highway system withstands flood events with relatively minimal interruptions of service compared with the municipal system. There are, of course, notable exceptions; such as VT 100 in Granville Gulf and VT 116 and 17 in Bristol during the 1998 flood. Road damages on the state system typically consist of shoulder wash outs and embankment failures.

Town roads, however, commonly experience major destruction during flash floods. There are multiple reasons for this difference:

1. Pavement oftentimes will hold a road together. The vast majority of town highways are not paved.

2. State highways are commonly constructed to higher standards for storm water drainage and roadway embankment stability.

3. Town highways are often built in steeper terrain, in more unforgiving topography, in close proximity to natural drainage ways and on less stable soils.

*Kate Brook, Hardwick*

4. Many towns have had to substantially widen their roads to accommodate the increasing demands of rural growth patterns. In many cases, this has resulted in significant encroachments into stream channels or flood flowage areas. Oftentimes, the flood loss is a function of the stream restoring its historic channel during the flood.

5. Municipal roadway improvements or expansions have often been and continue to be poorly or inadequately funded. This results in cut and fill slopes being constructed too steep, with improper or ineffective permanent erosion or stabilization controls and with inadequate drainage systems (bridges, culverts, ditching, etc.).

The flood damage resistant quality of town roads can be substantially improved through better training of municipal employees, enhanced funding and implementation (through incentives), at the local level, of construction and maintenance guidelines or standards.

- **Bridges and Culverts**:

Much the same contrast can be seen between the level of damage experienced by bridges and culverts on the state system as opposed to municipal structures. This is almost entirely due to the deficient hydraulic standards that have been and, in many cases, continue to be applied by the towns (generally in the absence of state AOT participation) in the replacement of stream crossing structures. A historical perspective provides some insight.

The 1927 flood continues to be the most extreme statewide flood of record; although several regional floods have exceeded the 1927 event in local or regional magnitude and damage level. Although not quantified, a large percentage of all stream crossing structures were lost in the devastating storm of '27.

From the time of the 1938 hurricane until 1973, the state experienced no statewide and only a few regional floods of any significance. This period of time represents nearly two generations of Vermonters who grew up experiencing virtually no extreme flood events.

During the 60's and 70's, literally hundreds of the old 1927 flood replacement structures reached the limit of either their functional or structural lifetimes. During this period, the state exercised no oversight of the majority of these structure replacements or upgrades. Although significant assistance ($ millions annually) has been provided over the years by AOT to fund bridge and culvert replacements, it has not been adequate to keep up with the demand. Towns have largely been unwilling to raise the local revenues necessary to assure that appropriately designed and constructed capital investments were made in all cases.

The combination of experiencing nearly 4 decades of no major floods, the availability of cheap, easy to install bridge replacements in the form of old water power penstocks, underground fuel storage tanks, railroad tankers (even missile silos), and the shortfall of state funding assistance resulted in the proliferation of hydraulically and structurally inadequate stream crossings.

These cheap culvert crossings were often undersized or did not match the stream morphology well; causing undesirable headwater depths, inlet stream channel deposition and instability, high outlet velocity, bed scour and erosion and would experience frequent washouts and maintenance requirements.

Where single pipes wouldn't or didn't work, multiple tubes were installed. These caused even greater incompatibility with the channel morphology, increased debris blockage problems, and provided little or no hydraulic improvement or reduction in frequency of damage.

In some cases, replacement bridges were constructed with inadequate scour protection resulting in substantial and frequent investment by the towns to protect against undermining of the abutments, piers and wingwalls. Culvert headwalls suffer from the same problem.

Vermont AOT has expended considerable effort and funding to assess and document over 400 “scour critical” bridges over 20 feet in length. Most of these have been municipally owned bridges. Those bridges that are most scour susceptible have been identified. Towns have been notified and provided recommendations for scour protection or monitoring. Present AOT standards for new structure designs on both the state and town systems appear to adequately protect against failure due to scour and undermining.

*Twin pipes, Gihon River, Eden*

*Undermined abutments, Jay Branch, Jay*

Beginning in 1973 through 1994, many, if not most bridges and culverts on the municipal highway systems damaged during federally declared disaster events were funded by the federal relief agencies only to a level which allowed replacement with the same structure that existed prior to the loss. This has simply perpetuated the problem. The record of Federal Emergency Management Agency (FEMA) Damage Survey Reports (DSR) is littered with structure repairs in which the same site is revisited again and again.

In 1995 FEMA began promoting a policy of mitigation in which it claimed that no more would federal dollars be poorly spent by paying to replace deficient structures in kind. However, in practice, the opportunity to factor mitigation into the federal disaster relief has often been missed, ignored or refused. Hundreds of thousands, if not millions of dollars have been spent in Vermont, since 1995, reconstructing deficient stream crossings, because of FEMA’s contention that it was “not cost effective to upgrade.” It is not cost effective to rebuild in a manner that virtually guarantees future loss, and FEMA needs to be more consistent in applying its new mitigation policy.

During the most recent flooding, there have been numerous sites where AOT has funded the difference between the structure funded by FEMA and the actual cost of a replacement structure deemed necessary from the hydraulic requirement. AOT has stated that the first priority of the funds within the Town Highway Bridge Program is to assist in emergency situations. In the event of emergency needs exceeding the funding available, AOT will look to the legislature to replace unbudgeted expenditures.

Municipalities should be encouraged to have their deficient structures identified as part of an infrastructure assessment. AOT assistance should include hydraulic analyses of all identified deficient structures. This will not only help towns prioritize their needs but will also facilitate disaster recovery. Occasionally, but still too frequently, structure replacements after a flood result in the installation of a new deficient or inappropriate structure or are delayed due to the lack of a hydraulic analysis.

Adequate and appropriate investments in stream crossing structures will provide future benefits through decreased maintenance costs, enhanced public safety, improved capacity to withstand flood events as well as contribute to river and stream stability. There is no reason that municipal bridges and culverts should not perform as well as structures on the state system if they are built to the same standards.

*Culvert failure, Lowell*

*Settlement Brook, Cambridge*

■ **Drainage Facilities:**

For many of the same reasons as mentioned under “Roads” above, the vast majority of damage to roadway drainage facilities is experienced on the municipal system in comparison with state highways.

*English Settlement Road, Underhill*

Only in 1998 has meaningful progress been made by FEMA to consider funding, as mitigation, the construction of stone lined roadside ditches, addition of cross culverts and installation of headwalls and outlet erosion control. Many opportunities to make such improvements and avoid future losses continue to be neglected.

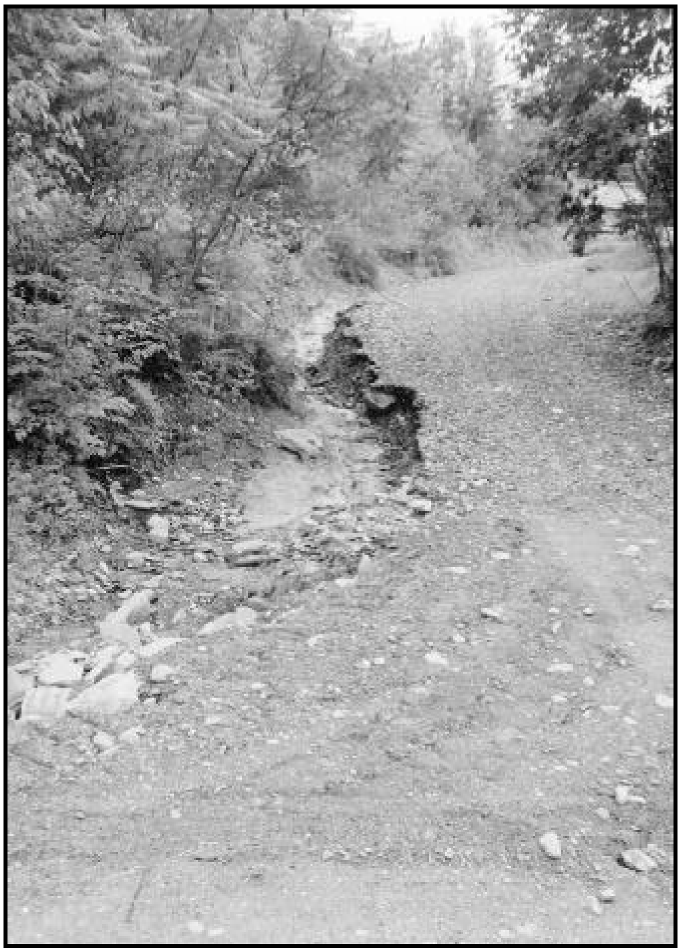
Towns without adequate levels of organization and communication to deal with disasters or with inexperienced people in decision making positions contribute to the problem. Small rural towns with major damages may miss important opportunities to gain relief and often do not make cost effective decisions due to inexperienced management.

On the state and federal level, there is inadequate commitment to taking advantage of every opportunity for mitigation that occurs. Occasionally decisions at the federal level to disallow mitigation are made for seemingly unjustifiable reasons.

■ **Private Driveway Access:**

DEC has observed that, with each subsequent flood disaster event, damage to municipal roadways is increasing in direct proportion to the magnitude and density of rural development. Much of this damage is directly associated with improperly sited and constructed driveway access. Typically, driveways constructed directly upslope or across the contours above a town road collect and channel water into the roadway, eroding the roadway surface and often overwhelming the capacity of ditches and cross culverts.

Despite the adoption of curb cut or driveway access control ordinances in many towns, few towns are able to do an adequate job of implementing and enforcing these ordinances. It is common to observe the new construction of driveways even in towns with the most comprehensive driveway access ordinances and see existing or future problems developing.



*Typical private drive, Machia Hill Road, Westford*

Tens, if not hundreds of thousands of dollars of damage to roadway infrastructure and private property after every flood can be associated with inadequate control of driveway access. In fast growing towns, particularly in Chittenden, Franklin and Washington Counties, the existing and potential problem is ballooning.

In the town of Elmore in the 1995 flood, an inadequately sized private drive culvert diverted stream flow onto the town road and completely destroyed a 1300 foot long section of road leaving a gaping hole 6-8 feet deep and 25 feet wide for the entire length of the washout isolating several families for several days from their homes. The repair cost was over $10,000. (see appendix 4)

In the town of Westford in 1998, the Machia Hill road was severely damaged at a cost of $68,556 (Source: Town of Westford). The damage was primarily due to poor driveway access control.

The Vermont Local Roads Program has developed a model driveway access ordinance for reference to municipalities. Towns must be provided with the incentives and the training to deal with this major problem.

■ **Utilities:**

Flood damage to utilities such as wastewater treatment plants, hydroelectric facilities, pump stations and sewer, water, natural gas, telecommunications, and electrical distribution systems frequently represent substantial economic loss and threats to public safety and health. Urban and suburban growth patterns have contributed to significant expansion of utility grids and the proliferation of both overhead and underground stream crossings. Any such investment in either public or private utility infrastructure is at risk of loss during flooding.

Most wastewater treatment and water supply system components are constructed for protection up to a 100 year flood level. However, several recent flood events have exceeded this standard resulting in enormous public expenditures for repair and reconstruction. The Johnson Village wastewater treatment facility is an example.

100 year flood stage protection addresses only the inundation aspect of flooding. Much utility damage is associated with streambank erosion and lateral migration of stream channels over time.

Many older underground utility crossings were sited in extremely unstable locations and with inadequate scour and erosion protection. These sites are frequently damaged and the systems threatened with loss of service.

Poles supporting overhead utility lines often experience scour and erosion due to stream dynamics. These tend to be less problematic as there is greater flexibility in siting poles to minimize conflicts with stream systems.

*Mad River, Warren*

**Issue 1 Policy Consideration:**

- Consider increased levels of assistance to communities for the purpose of reducing flood related municipal service infrastructure damage.

**Program Options to Implement the Suggested Policy:**

- State agencies would be provided with resources to guide and support disaster resistant municipal infrastructure investment and management.

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# Issue 2: Compatibility of Human Investment with Risk of Loss From Flooding.

*Settlement Brook, Cambridge*

*Mad River, Warren*

Ever since the beginning of contemporary settlement of the northern New England landscape, we have relied on development of lands and resources along rivers and streams. Periodic loss of human investments (homes, businesses, private bridges, culverts and roads) to floods in Vermont have been a fact of life now for over two centuries. But only within the last couple decades has the primary responsibility for paying for flood relief and reconstruction shifted to the public sector.

This fact alone is justification enough to support sufficient and legitimate public interest in the development of land uses and financing of infrastructure investments that may contribute to an elevated risk of flood hazard.

- **National Flood Insurance Program**

It is this concern regarding the public cost of inappropriate development that resulted in the implementation, at the federal level, of flood plain management through the National Flood Insurance Program (NFIP). This management consists of mapping and designating flood plains and floodways, providing flood insurance to the public and empowering municipalities to regulate land uses in the designated flood areas.

Within the scope of its authorization, the NFIP has worked reasonably well with an acceptable compliance record by municipalities within the program. The NFIP has successfully prevented the construction of hundreds of buildings in flood prone areas. All but a handful of the approximately 200 structures built in flood plains in Vermont over the last 20 years have been constructed to the NFIP standards (properly elevated and floodproofed).

However, many Vermont municipalities (55 of 272 eligible) do not participate in the program. Within municipalities that are in the program there is an extremely low rate of policy coverage.

Public officials often hear, from homeowners who have suffered flood damage, that they were told or understood that they could not buy flood insurance because they were not located in the flood plain. Two public education needs arise from this fact.

First is that people should know that anyone living in a town which is in the NFIP is eligible to buy flood insurance, even if they live on top of a mountain. Second is that just because a residence or business is not located in a designated flood plain, doesn't mean that the property is not susceptible to flooding.

High premiums, limited coverage and lack of incentive to obtain coverage all contribute to the low percentage of homeowners who enjoy the insurance protection. Flood insurance has proven not to be a cost-effective investment for most policy holders in Vermont. Over the past 20 years, $14 million in premiums have been paid compared to only $4,132,000 in claims.

The NFIP Community Rating System (CRS) provides municipalities the opportunity to institute a number of initiatives that, if implemented, can reduce premium rates within the community. However, only towns with a large number of covered properties and full time paid administrators can generally justify the effort to implement CRS alternatives. The process does not treat small, rural communities well. Additional technical and administrative support is necessary, perhaps from sources such as Regional Planning Commissions (RPCs).

If the implementation and success of the NFIP policy coverage through reimbursement of flood loss matched the benefits provided by the mapping program in avoiding flood loss, Vermonters would be enjoying very positive results indeed.

## ■ Need for Additional Protection

Nonetheless, there do exist significant deficiencies in the scope of the NFIP mapping program with regard to the mode of flooding damages most commonly experienced in this state. NFIP flood plain maps typically cover major rivers and streams. Even in communities that participate in the NFIP, most streams are not mapped; i.e. there are no designated flood plains or floodways. These are mostly upland streams draining small watersheds. However, flash floods along small streams cause a large proportion of disaster damage to roads, driveways, residences and private property in Vermont.

Provisions of the NFIP essentially address only the problem of inundation related damages because the mapping is primarily elevation dependent and does not recognize variability in channel morphology or how the river system changes over time. The NFIP mapping does not recognize the contribution of ice and debris jams. The NFIP mapping scale does not provide the detail necessary to designate high risk areas for flooding and erosion especially on small steams.

Although the department is unaware of any quantitative assessment addressing this question, observation and anecdotal evidence indicates that a significantly greater proportion of flood damage is associated with erosion, debris dams and other dynamic responses of watercourses to intense storm events than is caused by inundation. In this respect, the federal flood plain management program is not adequate as an indicator of the high risk areas for development.

Municipal growth planners have no quantitative tools other than the NFIP maps upon which to base growth management decisions to avoid future flood damage. Options such as requiring a minimum setback from the streambank or restricting development within the meander width do not realistically address the problem .

FEMA has begun to recognize its obligations to identify erosion prone areas and has begun a pilot project (in other states) to develop appropriate methodology (see appendix 5). This may be years away and may or may not be feasiblely implemented in Vermont. However, DEC believes a mapping methodology can be developed that would pay tremendous benefits in avoiding the continued proliferation of at-risk investments in riparian corridors not presently protected under NFIP.

The success of the NFIP program over the last two decades, in the avoidance of at-risk development in mapped flood plains, provides a high degree of confidence that similar benefits can be generated through application of flood hazard protection methodology to other Vermont streams not presently addressed under NFIP.

For additional information, refer to Community Planning for Flood Hazards; VT Department of Housing and Community Affairs, August , 1998.

- **Private Bridges and Culverts**

Additional guidance is also necessary to provide towns the ability to address the problem of inappropriately designed and hydraulically inadequate private bridges and culverts. After each major flood there are typically dozens of families unable to access or egress their homes due to the loss of stream crossing structures.

*Private bridge, Miller Brook, Stowe*

*Private culvert, Worcester*

The role of Regional Planning Commissions (RPCs) in the support of communities to become better able to withstand flood disaster events has been greatly strengthened through FEMA's Project Impact. The Lamoille County RPC is presently coordinating flood mitigation projects, forming partnerships, and leveraging funds to support implementation of a myriad of flood hazard mitigation applications by municipalities throughout Lamoille County for the purpose of "building disaster resistant communities". The Two Rivers-Ottauquechee RPC has just received a Project Impact grant and is beginning the process it its region.

The success of regional based flood hazard mitigation initiatives such as the LCRPC Project Impact, to a great extent, depend on the level of technical support and input from state agencies, particularly ANR and C&CD. Such resources are in very short supply.

**Issue 2 Policy Consideration:**

- Continued high risk private investments in flood prone areas should be discouraged and avoided.

- Consider providing municipalities with incentives, technical guidance and the methodology to be able to map and identify high risk areas for development, to plan for and implement other flood loss reduction initiatives and to seek grants and other funding for disaster preparedness, response and mitigation.

**Program Options to Implement the Suggested Policy:**

- State agencies including ANR and C&CD and RPCs would require funding and staffing to provide the technical assistance to communities to help them to become more disaster resistant.

# Issue 3: Management of River Morphology

*VT 12, Worcester*

*West Hill Brook, Montgomery*

## ■ The Issue

Many Vermont landowners and municipalities have experienced extreme, and in some cases multiple, flood events and have suffered an enormous magnitude of damage to property and public infrastructure particularly over the last four years. Increasingly strident calls to legislators and state government have demanded that more extensive stream channel dredging be allowed as flood damage prevention.

Criticism has also been directed at all involved federal and state relief agencies regarding lack of coordination and the site specific nature of flood repair as opposed to assessing or restoring a larger stream segment (reach) or identifying broad based problems being experienced or manifested by the river system.

In the latter case, some criticism is valid. Flood recovery operations have historically and frequently addressed only the symptoms of a greater problem rather than focusing on identification of the cause and determining how to facilitate improved system stability. This is somewhat a funding driven shortcoming but a problem of institutional focus as well. The fragmented nature of disaster response and the alphabet soup of agencies (FEMA, VEM, FHWA, VAOT, VANR, NRCS, FSA, COE, SBA, etc.) with sometimes conflicting and/or overlapping responsibilities contribute to the problem.

## ■ River Dynamics

Flood response and recovery decisions related to management of river morphology (stabilization, dredging, realignment, reshaping, relocation, debris removal) too often do not include an adequate assessment of historical context and a determination of what, besides the flood event itself, contributed to the damaged condition. An important question that far too frequently goes unanswered is how can the river system or a specific stream reach be restored to a stable condition in which the same damage scenario will not be repeated in future floods?

The aspect of historical context is critical and can hinder timely, objective and accurate evaluations. River systems are highly dynamic, readily responding to all system stresses such as watershed land use and hydrologic regime, past stream alteration practices, flood plain encroachments, structural constraints and changes in boundary conditions (such as loss of streambank vegetation). The system response may take place over years, or even decades thereby masking the physical cause-effect relationships.

A stable river can be likened to a finely tuned musical instrument that can easily be knocked out of adjustment by a myriad of external forces. In the past, we worked without complete understanding on a string here or a string there. Not surprisingly, the repair has not always been satisfactory. We need, instead, a trained ear, mindful of all the adjustments needed to restore the system to its properly functioning condition.

Some aspects of the complex physical relationships (sediment transport, hydraulic efficiency, velocity distribution, channel formation and stability) exhibited by dynamic river systems can be counter-intuitive and, until recently, relatively poorly understood even by leading professionals in the field. The effect of stream channel dredging on flooding is a pertinent example.

- **Dredging/Gravel Mining**

The effect of historical gravel excavation practices is an important consideration in the evaluation of the present physical condition of many stream systems, but is hindered by often inaccurate public perception of the actual effect of the practice on stream stability, property damage and flood protection.

Experience from the 1970's and early 80's in Vermont has demonstrated unequivocally the destabilization of river systems and excessive damages to private property and municipal roads and bridges resulting from gravel mining (see appendix 6). Damage occurs from stream channel dredging where such practice is not accompanied by restoration of channel dimensions, (width and depth), pattern (curvature or sinuosity) and profile (channel slope along the valley) appropriate to the geographic location and other physical attributes of the stream and its valley setting.

Damage is also associated with removal volumes exceeding the rate of gravel replenishment being transported from upstream. In a recent assessment of the Third Branch in Braintree, Randolph and Bethel, NRCS Geomorphologist Lyle Steffen described in detail the physical processes and relationships of excessive gravel removal and increased stream instability. “the change in channel dimension and pattern due to gravel mining typically results in accelerated erosion and deposition processes” (Steffen, 1998).

However, stream dredging to protect property and to restore river channels can be an appropriate component of comprehensive river restoration and stabilization. Gravel removal is allowed by existing statute and is frequently implemented under DEC operating procedures wherever such practices accomplish property protection and contribute to greater system stability. Well over 100 stream channel dredging projects involving up to 120,000 cubic yards (10,000 ten-wheeler loads) of gravel excavation have been approved by DEC in the last two years (see appendix 7).

In studies done by an independent consultant and by FEMA, Vermont’s approach to gravel excavation has been characterized as middle-of-the-pack in comparison with many other states. Several states are much more restrictive, others significantly more liberal. Vermont’s existing regulatory policy may be more flexible than any other state’s (Summary of Stream Alteration Laws and Regulations of New England and Other Selected States, Czaplinski, 1998 and Memorandum Concerning Stream Gravel Deposits, FEMA, 1998). The DEC technical approach to river management is supported by independent professional geomorphologists and state-of-the-science information from leading sources in the field throughout North America.

In 1995, the US Department of Transportation issued a notice to state transportation agencies indicating that federal funds will no longer be available to repair bridges damaged by (river responses to) gravel mining (typically undermined abutments and piers) (Kondolf, 1997).

In recognition of all of the above and the need to protect private property and public infrastructure, DEC is expanding and redefining its gravel removal policy to allow excavation, for flood protection purposes, where channel hydraulic capacity is reduced below the Q1.5 discharge (that flow which is exceeded on an average of once every 1.5 years) and wherever excavation will be used to restore the river channel to stable conditions.

The 1.5 year return frequency discharge is strongly associated with the normal hydraulic conveyance capacity of natural stable river channels. Where a higher level of property protection is required, DEC may approve maintenance of channel capacity, for instance, to a Q5 or Q10 level, to accommodate the larger, less frequent discharge. However, maintenance to this level must be evaluated on a case-by-case basis against the risk of increased, long term channel instability, and the effect on adjoining stream reaches and all riparian ownership interests.

It is important to recognize that ANR decisions on stream gravel removal must be made within the context of maintaining river reach and system stability. Through administration of its gravel removal policy, ANR recognizes that protection of existing development will occasionally require compromises between providing an adequate level of property protection and maintenance of the integrity of the river system. It is important to plan well for new development or land use investments to insure that such developments do not create the need for similar compromises in the future.

Any state policy on gravel removal from streams should not be seen as an encroachment on the rights of individuals or municipalities to perform emergency protective measures (including stream channel dredging) necessary to preserve life or prevent severe imminent damage to public or private property as provided under 10 VSA, Section 1021(b). The statute further provides that the emergency measures be limited to the minimum amount necessary to remove imminent threats to life or property, requires approval of a member of the selectboard and must be reported to ANR within 72 hours. Following every disaster event, DEC field staff will liberally apply the emergency interpretation to projects to speed and facilitate recovery operations.

- **Implementation of Comprehensive River Management**

Existing DEC resources are not adequate to implement a comprehensive, coordinated strategy for the management of river morphology that would result in a significant reduction in future flood loss. Presently, the DEC employs two full time employees to accomplish all physical river management responsibilities. This includes flood disaster preparation, avoidance, response, recovery and mitigation as it relates to physically addressing or reducing conflicts between river system dynamics and human investments.

These limited resources have not been adequate to allow DEC to implement a comprehensive river management program nor to provide the public assistance necessary to protect property from future flood loss by restoring river system stability. Program changes to address these needs are already underway in DEC, and additional resources may be needed in the future.

DEC is presently developing, with the assistance of a FEMA Hazard Mitigation Grant, EPA 319 funding and partnerships with the USGS, NRCS and USF&WS, the technical infrastructure necessary to support a river restoration approach to morphological management. Funding to construct two demonstration projects to repair two heavily flood damaged river reaches on the Trout River in Montgomery and the Huntington River in Huntington has been obtained and design work is in progress.

At the national level, federal agencies are pushing states to establish and attain ambitious goals for reduction of non-point source pollution (NPSP). Far above all other sources, streambank erosion and channel instability are the greatest and most pervasive sources of NPSP. With legislative support, DEC hopes to be able to expand its Stream Alteration Section into a River Management Section and begin implementation of a comprehensive river restoration approach to reduction of flood damages, property protection, reduction of NPSP and enhancement of system stability.

The benefits of this approach will also include substantial funding from the federal Clean Water Action Plan Fund which can be applied directly to river restoration and property protection projects. This source of funding can also be applied to watershed basin planning as it applies to flood prevention.

The river restoration approach to stream alterations management and flood hazard prevention, response and recovery includes several other desirable attributes:

a. Structural applications, such as rock vanes, can provide significant cost savings over traditional bank armoring practices.
b. Projects will generally be reach specific rather than site specific thereby providing much longer term benefit.
c. The approach seeks to recognize, accommodate and restore, to the extent possible, the natural tendencies of the river. This helps avoid adverse system reaction and reduces the likelihood of suffering increased damage elsewhere in the system.
d. Practices of channel dredging, realignment and reshaping may be more frequently applied in order to recreate or restore the most stable river form (dimensions, pattern and profile).
e. The restoration approach will result in a convergence of the goals of flood loss reduction, repair and restoration and the preservation of the natural resource values of river systems.

DEC has already redirected some existing resources to increase support of the river management program and additional resources may be necessary to implement a comprehensive statewide river restoration approach that is adequately coordinated among all involved agencies. We believe that the public benefit from reduction of property damage from floods will pay back this investment many times over. In addition, federal funds are available to pay for most of the program improvements. Every state dollar invested in river restoration projects can be multiplied substantially by other funding sources.

**Issue 3 Policy Consideration:**

- The Vermont Agency of Natural Resources plans to implement a comprehensive, river management program that focuses on improving river stability which will balance the need to protect public and private property and the need protect the environment.

**Program Options to Implement the Suggested Policy:**

- DEC will establish a River Management Section using existing resources and new opportunities for federal funding. In addition, we should consider using additional state funding to expand and improve program staffing and operations and to leverage available funding from federal and other sources. This will provide for enhanced public assistance and facilitate and perform river restoration projects in the future.

- DEC plans to implement a comprehensive, coordinated river restoration and flood protection approach to river and stream management, designed to produce the following outcomes:

1. Reduction in the magnitude of property and infrastructure damage resulting from future flooding
2. Reduction in the cost of flood prevention, repair and recovery operations
3. Improved river system and watershed stability
4. Protection of both human investments and our state’s natural resources; fortunately, both goals are usually served by maintaining or restoring a stable river system.

This new program will enable:

1. Better project management and improved public assistance and education.
2. Improved ability to help plan and support cost effective municipal infrastructure investment decisions and other flood loss avoidance, reduction or response projects.

3. Improved ability to help guide private investment decisions in stream crossings, riparian zone encroachments and agricultural practices with the goal of reducing future flood loss.
4. Improved ability to provide guidance and the tools to municipal growth planners to avoid greater conflicts with river systems.
5. A more active role at the state, regional and local level in the identification and implementation of cost effective flood hazard mitigation investment opportunities

- Implementation of a river restoration approach to management of stream morphology should be accompanied by a public process in which communities and individuals are given opportunity to express their needs, desires and values, inform themselves with regard to the scientific aspects of the policy and to provide feedback on how they feel this new initiative will affect their lives and property. DEC plans to make river restoration an integral part of the basin planning effort, where the public in each watershed is encouraged to get involved in decisions involving all aspects of water resources management in the area.

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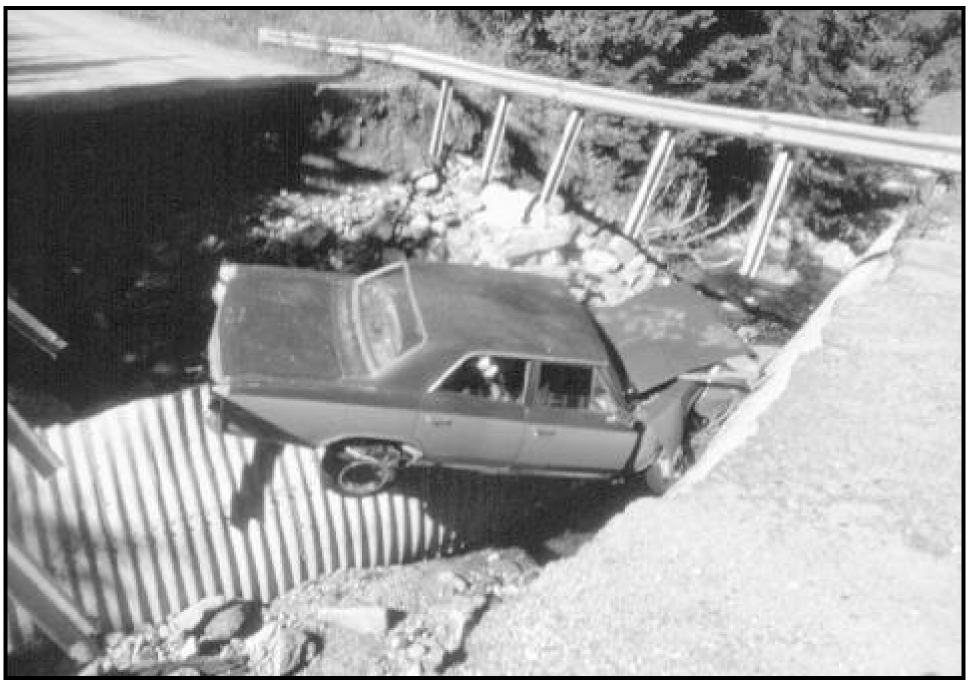
## Issue 4: Management of Structural Hazards and Debris



*Tamarack Brook, Wolcott*

- **Road Crossings**

By far the most common and dangerous type of structural hazard is the roadway culvert; public or private. Particularly hazardous to public safety are those culverts buried in a deep fill and conveying a stream which drains a steep, forested watershed. These structures may simply be undersized to handle severe flash flooding or can be blocked with debris generated from bank erosion and storm generated channel enlargement that undermines trees along the banks.

The debris blocked or undersized structure and the associated roadway fill then function as a dam across the valley and a temporary impoundment will form upstream of the crossing. Ultimately, if the storm is of long enough duration or great enough magnitude, the water level will overtop the road and, because the roadway embankment is not built like a dam spillway, will frequently result in a catastrophic failure. In higher fills, failure can result from saturation of the embankment fill without ever overtopping.

Not only are motor vehicle occupants endangered in this situation, but the resultant flood surge of the temporarily impounded water creates a substantial hazard to any other facilities or people across or along the watercourse downstream.

*Failed culvert and road fill; Roaring Brook, Underhill*

*Flooded property downstream, Underhill Flats*

Several options exist that help avoid or reduce the public safety hazard:

1. Proper site evaluation to determine the likelihood of debris blockage, the level of hazard created based on the depth of fill, potential impoundment volume and the at-risk developments downstream.
2. Design and install structures less prone to debris blockage than round culverts.
3. Reduce fill height by adjusting roadway grade or location of crossing.
4. Design a stable overflow section similar to a dam spillway.
5. Install debris rack upstream of the crossing (should be considered as the least desirable alternative and installed only with professional guidance; requires strict maintenance).

Professional assistance is usually necessary to evaluate the desirability, feasibility and cost effectiveness of any of the above options.

Hundreds, if not thousands, of culverts statewide contribute to stream instability and create flood hazards due to their inability to efficiently transport the water flows *and sediment* produced by the watershed (See Issue 8: Watershed Processes and River Dynamics). This includes many new culverts sized and designed according to both the current VT State Standards for highway design and the national AASHTO standards.

The typical standard for a town highway specifies that the culvert, or other structure, convey a Q25 storm discharge (that volume of water or rate of flow expected to occur on a frequency of once every 25 years) while creating a headwater depth no greater than the height of the top of the inlet of the structure. This is referred to as a headwater/depth (HW/D) ratio of 1.0.

The deficiency of this design standard influences the stream's ability to transport its sediment load through the structure particularly where streams characteristically move large volumes of bed load (boulders, cobble and gravel rolling along the bed).

Significant energy or head losses occur at the inlet to stream crossing structures. The magnitude of this energy loss varies by type of structure, by its hydraulic capacity and other inlet conditions such as alignment with the channel, stream gradient and the physical characteristics of the structure opening.

As these energy losses occur, the stream flow slows down and builds up head, or a higher water surface elevation, ahead of the inlet to the structure. As the velocity drops, the stream loses its ability to transport its sediment load past the culvert or bridge. The result is excess deposition and build-up (aggradation) of the bed elevation upstream of the inlet to the structure. After a few years, streambank erosion associated with the unstable bed elevation typically results in the stream attempting to outflank the structure and setting the stage for a flood induced failure.

*Sediment filled channel, Alder Brook, Richford*

*River outflanking inappropriate structure, East Branch Missisquoi River, Lowell*

Downstream of the structure there also occur undesirable morphological changes to the channel due to the interruption of sediment transport. As the coarse sediment is trapped upstream, the stream is still exercising its energy and ability to mobilize sediment downstream. The bed and banks continue to be scoured away but little or no coarse material is brought down from above to provide the balance required to maintain stability. In a natural situation, there would always be an equal volume of material being transported from above to replace whatever is being eroded away. This is the way a stream naturally maintains its stability over time and how this process is being adversely affected by an inadequate state and federal design standard for stream crossing structures.

In the absence of any known technical analysis, it may be appropriate to apply a lesser maximum HW/D value for stream crossing designs on high bed load streams. This problem should be examined and addressed in cooperation and consultation by AOT and ANR. Revising the state standards to address this issue will have the added benefit of greatly strengthening the state's position with FEMA to influence the expenditure of the funding necessary to upgrade hundreds of deficient structures damaged during floods.

- **In-stream Impoundments**

Less common than the culvert crossing hazards but of equal potential endangerment to public safety are the unregulated (usually privately owned) dams and in-stream impoundments. Hundreds of in-stream impoundments exist throughout the state that have been constructed to no specific engineering or flood hazard protection standard.

The failure scenario is similar to that described above for the roadway culvert crossings.  Most private impoundments consist of earth fill dams; many with inadequate primary drainage conveyance capacity and an unstable or non-existent spillway.  Failure may be catastrophic,  resulting in a large, rapid flood surge released downstream.

Pursuant to 10 VSA Chapter 43, only dams impounding more than 500,000 cubic feet (11.5 acre-feet) require state approval to construct, reconstruct, alter or remove regardless of the size of the watershed.  Dams on small streams can be particularly prone to flash flooding.  The larger the impoundment and the higher the dam, the greater the potential flood damage experienced downstream in the event of a dam failure.  A large proportion of the excessive damages suffered in Wolcott village and the complete devastation of the Jones Road in 1995 was associated with a private dam failure.  It is extremely fortunate that no one was killed in this catastrophic flood surge.

*Failed private dam; Wolcott Pond Brook, Wolcott*

*Downstream of failed private dam; Jones Road, Wolcott*

Dam construction can also be regulated under 10 VSA Chapter 41, Alteration of Streams; 10 VSA Chapter 11 Obstructing Streams; and by municipalities under 24 VSA, Chapter 117.  However, construction of many in-stream impoundments continue to be unregulated in Vermont.

About 450 of the larger dams (in excess of 11.5 acre-feet) and 1000-1500 smaller dams exist in Vermont.

In many of the regional floods of the last 25 years, there are numerous examples of incremental downstream damages that resulted from the failure of privately owned in-stream impoundment such as the example in Wolcott mentioned above.

The risk of failure of new dams can be greatly reduced by proper design and construction supervision by a registered professional engineer experienced with the design and investigation of dams; and, proper operation, maintenance, inspection and emergency action planning by the dam owner.  The risk of failure of existing dams can likewise be reduced by construction of properly engineered and supervised structural and hydraulic improvements and subsequent proper operation, maintenance, inspection and emergency action planning.

Municipalities are enabled through 24 V.S.A. Chapter 117 to regulate the construction of private ponds.  Communities should require through their zoning by-laws that every in-stream impoundment be designed and inspected by a professional engineer.  Better yet, it is usually better not to build them in the first place.  Municipalities should generally discourage the construction of in-stream impoundments.  A regular safety inspection of existing in-stream impoundments should be made a component of every town's disaster preparedness plan.  Municipalities should inventory all existing dams to determine what general exposure to flood hazards exist downstream.

The DEC Dams Safety Section is not staffed to inspect all dams. DEC does not propose to take on this responsibility, even with increased funding and staffing levels.

A strong state dam safety program incorporating nationally recognized standard, e.g. the 1998 Model State Dam Safety Program, can be a significant flood mitigation activity by improving inspection, rehabilitation and emergency action planning. A state dam safety program meeting national standards could also qualify municipalities in the NFIP for lower rates under FEMA's Community Rating System (CRS).

- **Beaver Dams**

Beaver dam failure during storm events is often blamed for contributing to flash flood damages. The wash out of a large beaver impoundment in Fairfield in January, 1996 is associated with two fatalities. An undersized culvert was also a contributing factor. The August, 1995 flood related fatality in Wolcott occurred at a culvert wash out downstream of a large beaver flowage; but it has never been confirmed that beaver dam failure contributed to the loss (a private pond upstream failed as well). In a non-declared disaster event, a fatal Amtrak derailment in Williston in 1984 was associated with beaver activity blocking a drainage structure.

As far as the DEC can determine, only one aerial survey immediately following a flood has been performed to determine the frequency of beaver pond failure within a storm damage area (Underhill, June 1998). This survey by DEC and VT Emergency Management, with the assistance of the Civil Air Patrol, showed a very low frequency of failure; less than 4% out of approximately 50 beaver impoundments observed. The location and size of the failures did not appear to contribute significantly to damages experienced.

With the proliferation of beaver colonies primarily due to depressed fur prices and experiences of beaver dam failures contributing to downstream damage, there has been some advocacy expressed at the local level for a policy to remove beaver dams as a flood control measure. There may be some justification to identify high hazard locations and for communities, in partnership with landowners, to trap, kill and remove beavers from these sites and to remove enough of the dam so that it will not impound water during a flood.

However, in the absence of more information, existing beaver dams may, in the balance, actually contribute to reduced flood damage by increasing the storm water storage capacity of the watershed. A broad policy to drain beaver impoundments may be counter productive to the purpose of flood hazard reduction. However, beaver dams that obstruct spillways, gates or other parts of man made dams should be removed immediately as part of routine dam maintenance.

Societal perception of beavers as a valuable renewable resource and beaver fur as a desirable and ecologically responsible type of winter outerwear would create an economic incentive to harvest beaver populations and reduce the likelihood of the creation of high hazard dams. There need be consideration made for greater public education in this area to convert both the public perception and the reality of beavers from that of a public nuisance to a valuable natural resource.

Further study may be appropriate to determine the advisability of beaver dam removal as a flood prevention measure.

*Failed beaver dam, Glover*

## ■ Debris Control

In addition to debris impacted structures as described above, flood borne woody debris is often a major concern for agricultural landowners and other riparian property owners. Large debris jams frequently accumulate in the channel or floodplain and represent an impediment to flow, increase bank erosion, contribute to formation of new channels or divert flow to old historic flow paths. Debris deposited on agricultural land or other developed property degrades use values and creates substantial clean-up expense.

The primary source of flood debris is upland forested streambanks. In a major storm event, a previously stable channel may enlarge itself or experience substantial lateral movement through erosion in order to accommodate the immense flood discharge. Undermined trees, brush and logging debris become a component of the watershed outflow and are typically deposited in the flood plain or stream channel lower down within the system.

While some landowners and a few towns employ the practice of removing undercut trees and flood debris from streams as a preventive measure, it is unlikely such practices significantly reduce the debris associated damage caused by major storm events.

Clear cutting streambanks over extensive stream reaches might reduce debris volume but likely at the expense of increased bank instability and significant natural resource impacts. Large debris flows are typically caused by storms of relatively low expected frequency (once every 25 years or more). The relatively low contribution of debris to overall flood loss makes such an intrusive treatment unjustifiable.

Four federal flood relief programs can address flood debris. FEMA Public Assistance grants will help pay for removal of debris in association with the repair of public infrastructure. FEMA Individual Assistance will pay for debris clean up in association with the restoration of an individual's essential services. The NRCS Emergency Watershed Protection Program (EWP) has provided the greatest amount of resources to debris removal on a large scale. However, the program does not lend itself well to debris clean up in numerous, small, isolated and poorly accessible locations such as backyards of village lots or isolated rural residences. The Farm Service Administration assists agricultural landowners with debris removal under the Emergency Conservation Practices (ECP) program.

DEC has observed that large woody debris deposition on agricultural lands and residential lots is more common where vegetated streambank buffers have been lost or removed. A continuous buffer of trees as little as 25 feet wide along the river bank typically will keep the majority of flood debris contained in the channel and off the improved property thereby saving significant clean-up costs.

A statewide commitment by all agencies of state and federal government and communities to the retention, enhancement and establishment of vegetated streambank buffers would represent a relatively low cost, high benefit approach to reducing flood hazards of many types besides just debris. This is another area where significant natural resource benefits can be accrued through application of a flood hazard reduction practice.

Studies done in other states seem to indicate that in some systems, the presence of large woody debris jams actually contribute to system stability through their velocity attenuation and dissipation of energy. No quantitative analysis of this relationship has been done in Vermont. River managers and flood relief and prevention programs should recognize, however, that it may not be necessary to remove all debris from all channels everywhere.

*Debris jam, Trout River, Montgomery*

*Debris on culvert inlet; Truland Brook, Lowell*

**Issue 4 Policy Consideration:**

- Provide for better statewide management of in-stream structural hazards and debris.

**Program Options to Implement the Suggested Policy:**

- Study the contribution of beaver dam failures to flood damages; to commence immediately following the next appropriate disaster event to take advantage of federal funding.
- Improve the state dam safety program, incorporating nationally recognized standards.
- Support the USDA CREP program as recommended under Issue 7 below.

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# Issue 5: Opportunities for Structural Flood Control and Flood Damage Mitigation

## ■ Flood Control Dams

The USDA Soil Conservation Service (now NRCS) built four significant flood control dams and one stream diversion project on tributaries to the Black River in the Town of Ludlow between 1969 and 1972. These dams helped reduce flooding in Ludlow during the 1973 and 1976 floods. Another diversion project was built in the City of St. Albans about the same time period.

The Winooski River flood control dams,- Waterbury, Wrightsville and East Barre-and the Connecticut River watershed dams built by the Corps of Engineers have provided significant flood reduction downstream of the dams for 25 years. Can new flood control projects of either type play a role in reducing future flood damages in Vermont?

The larger projects were constructed relatively low in the watersheds, primarily on second order tributaries (first order is the furthest downstream, second order drains into a first order stream and so on). These impoundments provide protection only for communities located on or along the main stem of the river downstream. They are designed to alleviate flooding associated with very low frequency, long duration storms or flash floods over extensive geographic areas; such as the 1927, 1938 and 1973 floods. They do nothing to protect the widely dispersed areas along upland tributaries where the majority of flash flood damage occurs.

The small watershed projects built by USDA may have provided some benefit in the watersheds protected. However, while there has been no quantitative analysis, DEC observation indicates at least some are poorly maintained, possibly even non-functional. The cost of designing and constructing such small watershed projects is vastly greater than it was in the mid-70's. The cost effectiveness of other flood hazard mitigation or prevention alternatives may be much more desirable.

DEC believes, while isolated opportunities may exist, the feasibility of significantly achieving a cost-effective reduction in flood damages along upland streams in Vermont through the construction of in-stream flood control impoundments is quite low.

### ■ Structure Acquisition, Relocation and Floodproofing

Beginning in 1997, FEMA began emphasizing the alternative of acquisition and removal or relocation of structures in high hazard areas. The state supported this alternative where it was determined that the cost of providing continued protection for these properties was greater than they were worth. Only willing sellers with support of the municipality were considered for eligibility. Assessed value was used as the purchase price. Future redevelopment of the purchased property is prohibited.

The program, however, is relatively expensive and has resolved only the most high priority and problematic sites. A total of 23 buy-outs were exercised in 1997 and 1998. More are in the works.

DEC continues to support the acquisition option where:

1. the cost effectiveness standard noted above is met;
2. the building is located within the 100 year flood limits;
3 the structure has been substantially damaged or flooded two or more times within the last 20 years; and
4. buy-out offers are equal to the pre-flood fair market value minus available flood insurance coverage

Floodprooofing existing structures may be a viable option in some limited number of cases. However, trying to keep water out of existing buildings can cause more damage from hydrostatic pressure than simply letting the building flood. In most cases, it may be more cost-effective to simply move fuel tanks and other susceptible utilities and property out of the cellar and above the 100 year flood level.

*FEMA acquisition property, Montgomery*

- **Hazard Mitigation**

15% of all FEMA funds expended for any declared disaster is dedicated to hazard mitigation (HM) (Section 404). This may be the most cost effective portion of FEMA funding as it usually enables the upgrade of existing, deficient facilities that presently require frequent repair and represent a safety hazard. Occasionally, public agencies are able to fund statewide initiatives which, once implemented, can provide extensive benefits in flood loss reduction.

Unfortunately, the potential benefit of this valuable program may be significantly reduced due to the lack of technical assistance and administrative guidance available, particularly for small communities in the planning and preparation of grant applications. Many important HM opportunities are lost simply because of the inability of local government to envision alternative solutions, define the scope of the project, assess costs and benefits of the alternatives and submit a complete application.

In order to wring the greatest possible benefit out of the FEMA HM program, DEC and other agencies specializing in community assistance, such as Regional Planning Commissions or the Vermont Local Roads Program should be enabled to provide a greater level of technical and administrative assistance to local government.

**Issue 5 Policy Consideration:**

- Expand state support for flood damage mitigation and reduction at the state and local levels through support of structure acquisition and/or relocation and other cost-effective applications.

**Program Options to Implement the Suggested Policy:**

- Greater emphasis and support for statewide and local hazard mitigation opportunities within VEM.

- Provide increased state resources to support and assist municipalities in the formulation, design and implementation of the most cost-effective hazard mitigation opportunities possible.

- Provide additional state resources to identify and take advantage of statewide hazard mitigation opportunities.

- Provide additional support of the Vermont Local Roads Program to provide technical and financial assistance to communities for construction and capital investment formulation grants for hazard mitigation projects.

- The state should expand its support for flood damage mitigation and reduction at the state and local levels through support of structure acquisition and/or relocation and other cost-effective applications.

# Issue 6: Changes in Watershed Hydrology and Runoff Conveyance

Three physical parameters are the primary influences on the characteristics of a storm water runoff event: (1) the total volume and intensity of the rainfall; (2) the physical characteristics of the watershed including topography and land cover; and (3) the physical condition of the stream channels which drain the watershed.

## ■ Concept of Watershed Hydrology

The volume, intensity and duration of a rainstorm (or snowmelt or combination) greatly influences the potential for flash flooding. A 2-3 day storm with six inches of rain may produce little flooding, whereas, a three inch rain falling in a short 2-4 hours may result in severe localized flooding. But three inches of rain over 4 hours may result in nothing more than high water if the groundwater table is down, soil moisture conditions are dry and the streams are low. But reverse all those conditions and the same rainfall at the same intensity can be disastrous.

Land cover conversion toward greater degrees of impermeability and toward reduced storm water retention eventually will substantially affect the watershed runoff characteristics during rainfall events. When land cover conversion causes impermeability of approximately 15% of the land surface, profound changes in stream channel morphology including increased erosion and sediment production begin to be observed as the natural channels enlarge to accommodate the increased peak storm water discharge and total volume (C. McCrae, Aquafor-Beech and R. Claytor, Center of Watershed Protection in a presentation to VT DEC, 1998). Capacity of stream crossing structures can be rendered inadequate and a number of other serious disaster related outcomes are affected by the watershed hydrology.

An intense runoff event, with unrestricted flow through natural channels and flood plains, may cause little erosion and no property damage. Major amounts of erosion and property damage may occur, however, during runoff events where channel alterations and flood plain encroachments have constrained the system boundaries, increased energy and velocity by eliminating the river's access to flood plains or simply been straightened and deepened by channelizing and dredging.

The level of encroachment to some Vermont rivers is reaching a critical point at which it may become very difficult and expensive or impossible to re-establish the natural dissipation of flood flows. The condition of stream channels and flood plains, which constitute the natural drainage system of the land, is critical to the ability of the watershed to withstand or suffer the effects of a flash flood.

## ■ Case History

The history of the West Branch of the Little River in Stowe provides an educational case history that illustrates the relationships above.

Back in the 1940's and 50's the West Branch valley was primarily agricultural with forested uplands. At this time, examination of aerial photos and other historical evidence indicate that the river morphology allowed for access of flood flows to the flood plain on a frequency of approximately once every 1.5 years. This is a common characteristic of natural, stable alluvial stream systems. (McCrae and Rosgen)

Large scale conversion of land use through economic development occurred along the river, its tributaries and the uplands from the 60's until the present. Flood plain encroachment and channel alteration through dredging and bank armoring accompanied the development to protect it from the frequent overbank flooding. It is unknown at this time what percentage of land cover in the watershed is impervious.

This resulted in almost complete isolation of flood flows from access to the previous flood plain. Consequently, all the energy of a flood is concentrated in the channel. Without access to the flood plain, floods cause tremendous rates of erosion and generate immense volumes of sediment load as the river attempts, through increased bank erosion, to reform a new flood plain within the boundaries of the altered channel.

Literally hundreds of thousands of dollars of both public and private funds have been expended to protect the investments along the river from a condition that is directly resultant from past watershed and river channel mismanagement.

*West Branch, Stowe, 1987*

*West Branch, Stowe, 1987*

- **Technical Evaluation/USGS Stream Gauges**

The evolution of silvicultural management into intensive, large scale operations which are now commonly seen being implemented over thousands of acres in individual watersheds are being questioned with regard to their contribution of flood hazards. Very little technical information exists upon which the state might base some flood hazard mitigation recommendation relative to silvicultural practices, their impact on watershed hydrology and flood hazards. More research is necessary.

A DEC contracted and FEMA funded study by an independent consultant is on-going to determine if examples of stream channel enlargement due to alteration of watershed hydrology exist in Vermont. The study also includes a component which will evaluate the effect of past gravel mining and dredging on the condition of selected rivers. The study is scheduled to be complete in the spring of 1999.

AOT has an on-going $300,000- 4 year contract with USGS to upgrade the existing flood flow frequency models used to determine the appropriate hydraulic capacity of structures and channels.

The importance of the USGS stream gaging program cannot be overemphasized. DEC and AOT rely on this data for many hydrologic and hydraulic investigations and analyses relating to dam safety, structure designs, operation of flood control facilities and disaster alerts. Past state and federal funding cutbacks in this program are very shortsighted. The money is *well spent*. Funding should be enhanced rather than suffer further reduction.

### Issue 6 Policy Consideration:

- DEC should continue efforts to quantify and characterize the watershed management issues that influence susceptibility to and protection from floods. Results from on-going and future studies should be made available to support comprehensive basin planning efforts and meaningful flood hazard mitigation.

**Program Options to Support the Recommended Policy:**

- Support of on-going DEC efforts to quantify and implement the flood hazard mitigation opportunities available through watershed management and basin planning.
- Continued support of the USGS stream gaging program.

# Issue 7:  Agricultural Practices

## ■ Streambank Management Assistance, Cost

The 1996 Farm Bill significantly changed the way federal dollars are used to pay for agricultural best management practices.  It is now much more difficult to get USDA program assistance for traditional streambank management practices.  Both state and federal cost share programs largely, if not completely, focus on structural best management practices such as manure pits and barn yards.  This is not to say that nutrient reduction should not continue to receive high priority.  The pie just hasn't gotten any bigger and the slice going to streambank management has just gotten smaller.

The burden of streambank management cannot be placed completely on the shoulders of the individual landowner as long as Vermont's streams remain unstable from decades of watershed development and the lack of any comprehensive river system management program.  Many past government supported practices such as removal of trees on streambanks and wetland draining and ditching have contributed to the problem.

Miles of streambank management projects, primarily consisting of dredging, filling, and rock rip-rap stabilization, are completed following floods. A growing percentage of these fall into the category of projects where the flood was an indirect or even minor factor in the cause of the damage.  Landowners, many of whom are farmers, line up quickly for USDA EWP and ECP funds after a flood to receive public assistance for a longstanding streambank or crop land erosion problem for which little or no assistance was available before the flood.  Streambank management completed in an emergency scenario rarely addresses the real problems behind the instability.

## ■ Compatibility With Risk of Soil/Crop Loss in Flood Plains

One of the most significant changes made in agricultural Best Management Practices policy at the national level is the identification of highly erodible soils and the establishment of incentives to move tillage off such lands.  The problem in Vermont is that it has removed much upland, well drained but sloped and shallow to ledge lands from tillage.  Farmers have been more or less forced by national farm policy to replace this lost land through more intensive utilization of flood plains.  Farm expansions and other economic pressures are contributing to this trend.

The problem with the federal classification of highly erodible soils is that it does not recognize deep, well drained loams on flat flood plain land as highly erodible.  But farmers are experiencing tremendous soil and crop loss in their flood plain tillage during this cycle of extreme storm events.
In some cases they are tilling flood plain land much more susceptible to massive soil loss during floods than if they had continued cropping their upland sites.

Farm conservation plans prepared with the assistance of USDA must help landowners identify those flood plain areas that do not just store water during floods but actually convey flow at erodible velocities over plowed ground any more often than once every 10-25 years.  These flood chutes can be relatively easily mapped and should be treated with grass cover only.  USDA managers at the state level and in the field should recognize what is truly erodible and not be hamstrung by a deficient and potentially counterproductive national standard, definition or policy.

*Streambank erosion; Trout River, Berkshire*

*Crop land flood plain erosion; North Branch, Worcester*

Attempts to identify conflicting practices and farm land conservation policies which may actually be contributing to increased susceptibility to flood damage were commenced in early 1998 by DEC, VDA,F&M., FSA and NRCS but there has been no outcome of this effort produced at this time. This work must continue but is handicapped by the absence of clear directives from federal agencies to be able to comprehensively address this issue at the state level.

- **Riparian Buffers**

The USDA Conservation Reserve Program (CRP) provides payments to landowners to take land out of production and convert to vegetated buffer zones. But the payment schedule is so low and acreage involved so small that there is minimal landowner interest in this potentially valuable practice. A new Conservation Reserve Enhancement Program (CREP) has been proposed which should enhance the attractiveness of this alternative to landowners. The state should consider contributing to encourage greater participation in this practice. Other potential financial incentives should be considered.

**Issue 7 Policy Consideration:**

- Federal and state farm policies should take into account the potential effect on flood hazards and flood loss. The state, in cooperation with federal agencies should develop the guidelines necessary to assure that implementation of farm policies and programs protect against soil and crop loss from flooding.

**Program Options to Implement the Suggested Policy:**

- Support VDA,F&M incentives to landowners to participate in the Conservation Reserve Program (CRP) and the Conservation Reserve Enhancement Program (CREP).

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# Issue 8: Public Understanding of Watershed Processes and River Dynamics

One of the most important tasks for any successful river management program is creating an informed public with respect to watershed processes, river dynamics, and the methods to minimize flood related losses. After many decades of exposure in the media and other educational programs, people understand the watershed processes at work when a toxic or disease causing pollutant is discharged in one place potentially affecting the environment and public health miles away downstream.

The same level of general public awareness must be pursued in the areas of river channel dynamics, river sediments, riparian and floodplain function, and watershed hydrology. When landowners and public officials understand, for instance, that building a road laterally across a mountain-slope without the appropriate drainage and flow attenuation structures may create the same level of environmental and public safety concern as other "pollution", then watershed management and long-term flood loss avoidance are possible.

Public education will be difficult given that it is often the cumulative effect of many seemingly innocuous landscape and stream channel alterations throughout a watershed, over the course of many years, that causes the avoidable environmental impacts and flood-related hazards.

- **Watershed Perspectives of Time, Space and River Dynamics**

It is a constant refrain heard by state river managers in their discussions with the public about conflicts with river dynamics; "It never did that before." and; "It always used to be over there."

Landowners and local officials tend to exercise a perspective of time that extends back as far as they can remember. River managers or fluvial geomorphologists tend to embrace a time perspective that goes back at least as long as there has been Euro-American influence on the watershed landscape and up to as much as 10,000 years ago to cover the entire post-glacial period.

Reconciling this differing perspective through communication and education is a vitally important task that river managers must constantly exercise in order to develop working partnerships with individuals and communities in the resolution of conflicts with river dynamics.

River managers recognize that even the most severe floods have, in fact, occurred before; that dynamic change in channel location over time is exactly the way the river has been acting for thousands of years; and that over the millennia, the river has shaped the valley, formed its soils and supported and nurtured the plants and animals that live here including human beings.

Of paramount interest to landowners and municipal officials is a desire to protect the investments that support human livelihood from the sometimes damaging and always threatening forces of river dynamics.

But, "When the works of man run contrary to the natural, stable tendencies of the river, the river eventually dominates."-- Rosgen, Applied Fluvial Geomorphology. Too often, our historic and even contemporary attempts to manage the river system and to develop and protect our property have resulted in even greater levels of conflict with the system. Eventually the system will be energized by an intense rainfall event and the subsequent storm water discharge from the watershed. It is at this time that the river resolves all existing conflicts; and on its terms.

The greatest challenge in managing river morphology comes down to striking that balance between accommodating, to the greatest extent possible, the river's natural tendencies, while at the same time applying an adequate level of physical constraint to the system as necessary to provide protection of property and infrastructure.

## ■ Realistic Expectations of Channel Stability

Stable streams experience minimal erosion and effectively transport the flow and sediment load produced in their watershed. Stream stability may be defined as:

> "The ability of a stream, over time and in the present climate, to transport the flow and sediment of its watershed in such a manner that it maintains its dimension, pattern, and profile without aggrading or degrading." Rosgen, D., 1996, Applied River Morphology.

Channel down cutting (degradation) or, conversely, the build up of channel sediment (aggradation), that culminate from large and small watershed changes in flow and sediment erosion rates, are not generally understood by the public. Landowners are demanding site specific channel armoring and dredging to alleviate what may be delayed symptoms of a larger river reach problem. For instance, the build up of a mid-channel gravel bar that is causing bank erosion, may be the result of stream bank failures a mile upstream that were initiated by channel down cutting and ultimately caused by a channel straightening operation conducted ten years earlier in response to a major flood event.

The stream channel factors associated with width, depth, meander, slope, and sediment are interrelated. A significant change in one will result in the adjustment of others. A destabilizing change in one stream reach, from one or more causative factors, may propogate a ripple of channel adjustments for miles upstream and downstream over the course of many years. The evolution of the channel back to a stable form is a predictable process.

Vermont is at a critical juncture in watershed management. Natural channel stability may be orders of magnitude more cost effective than engineered channel stability. The growing rate of stream encroachment and channelization puts us on an untenable and costly track to armor channels to withstand the greater slopes and higher velocities that result from these practices. The state will lose the natural, social, and economic benefits of natural channel stability if it does not address the lack of adequate public educational tools to explain river dynamics, channel evolution, and the watershed management practices to achieve and maintain natural channel stability.

## ■ River Morphology and Sediment Transport

Intuitively, people understand that a larger river channel is needed to convey flows during high runoff periods. It is counter-intuitive, however, that a smaller, deeper channel is more effective at moving the sediment volume generated in its watershed during higher flows and averts sediment, flow-diverting plugs from forming.

When gravel extraction was conducted for commercial purposes, the annual dredging of sediment from river channels contributed to the erroneous assumption that removal was an adequate treatment for streambed scour and bank erosion. Even though channels were down-cutting severely causing property damage and loss of natural resource values, people saw extraction practices as a benefit to channel function because more-frequent high flows were contained.

But “The river channel and its flood plain are dynamic features that constitute a single hydrologic and geomorphic unit characterized by frequent transfers of water and sediment between the two components. The failure to appreciate the integral connection between flood plain and channel underlies many environmental problems in river management today.” (Kondolf, 1997)

Every river has a certain capacity to transport gravel. Volume of flow and channel slope are proportional to sediment size and sediment yield (Lane, 1955). Hence, along the gradient of a stream, an equilibrium exists between the production of sediment and the ability of the stream to keep it moving. It is essential that landowners and natural resource managers at the state and local level understand that certain land uses and river alterations can increase or decrease sediment yields that alter river morphology and hydraulic capacity to the point of destabilizing an entire river reach.

The frustration and heated, post-flood debates that have occurred recently over sediment buildup in river channels, points to a crucial need for educational tools and a greater Department presence to explain sediment transport at the watershed level. The Department needs to build both capacity and credibility, using scientifically-based analysis of Vermont streams, to explain the costs and benefits associated with different channel/floodplain management approaches including natural versus engineered stream morphology strategies, repetitive dredging programs, land use and channel encroachment limitations, and storm water/erosion control.

DEC, in conjunction with the FEMA and USGS is conducting a comprehensive study of the long term changes in channel bed elevation and flood profile on three stream reaches which have been substantially impacted by flooding in 1995 and 1997. These streams include the Trout River in Montgomery, the Wild Branch in Wolcott and the Lamoille River in Cambridge. USGS is performing a detailed survey, flood stage analysis and sediment transport modeling for all three stream reaches as a tool to check the effect of the state's gravel removal policy on flooding and channel stability. Results of this analysis will be available in the spring of 1999.

## ■ Implications of Climatological, Meteorological Trends

Many landowners, residential and agricultural, rightfully complain that they are experiencing more frequent flooding, more severe erosion and greater crop, soil and other property damage than they have ever experienced. Oftentimes the opinion is expressed that greater flooding is being induced by lesser rainfall and that changes in channel morphology (usually sediment deposits) are to blame for the increased flooding and erosion.

DEC in conjunction with USGS and NWS conducted a brief and informal analysis of USGS stream gauge information, NWS rainfall projections and in-the-field high water marks for several recent floods. No significant anomalies have been found. Flood elevations are generally consistent with those projected on FEMA flood profiles for the discharge frequency recorded at USGS gauges. Headwater depths were also observed at stream crossings where design hydraulic analyses information exists.

Correlation of stream discharge and rainfall volume and intensity exhibits somewhat greater variability for two apparent reasons. First, there is not a good distribution of reliable, on-the-ground rain gauges for reference and there is not a high degree of precision in the NWS Doppler radar rainfall estimates. Second, precedent soil moisture conditions, groundwater levels and river stages can influence greatly the effect of any given subsequent storm. Several of the most severe flash floods over the last 4 years were preceded by torrential rains within the 24 hour period prior to the disaster (see appendix 8).

Neither USGS nor NWS is ready, at least as expressed in 1997, to concede that anything is happening out of the ordinary with respect to the recent frequency and magnitude of storms and flooding disasters. Clusters of severe events have occurred before. This cycle has not extended long enough nor included storms severe enough for these agencies to state that any significant climatological or meteorological trend is taking place.

It is however, important to note that scientific projections of the impact of global warming on climate change indicate that presently temperate, humid regions of the world (includes Vermont) will become warmer and wetter. "in a warmer world, the amount of precipitation in a given event would change more than the frequency of precipitation."--T.R. Karl, A Briefing on Global Warming; "it seems probable that regional changes towards more severe weather and climate extremes will accompany the warming. Scientific models predict an increase in precipitation intensity, suggesting a possibility for more extreme rainfall events." -- Intergovernmental Panel on Climate Change, Summary for Policy Makers: The Science of Climate Change; as reported in Community Planning for Flood Hazards by the VT Department of Housing and Community Affairs, September, 1998.

It's hard not to see what is predicted by climatologists being manifested in the pattern of storms we are experiencing today. It may be quite cost beneficial and socially responsible to be conservative in our approach to building disaster resistant communities and managing river systems.

**Issue 8 Policy Consideration:**

- It is beneficial to the State of Vermont to have an informed public who understand river dynamics and support erosion and storm water management programs that seek to minimize flood hazards by restoring and maintaining stability in our rivers and streams.

**Program Options to Implement the Suggested Policy:**

- An enhanced public education component of the DEC Rivers Management Program designed to increase public awareness of:

    1. the interrelationships of land use, the hydrologic response of watersheds and the physical or morphological reactions of river systems
    2. how to reduce, avoid or minimize conflicts between river systems, public infrastructure, and individual land use and development investments
    3. a long term perspective of time, space and river dynamics
    4. potential flood related effects on human land use due to climatological and meteorological trends

- Support a multimedia educational program delivered by the DEC in cooperation with other state and federal agencies, regional planning commissions, conservation districts, municipalities, and watershed associations that explains river dynamics during floods and the natural, social, and economic values associated with natural stable stream morphology.

- Slide show, video, and printed materials are needed to demonstrate, through the use of Vermont watershed and stream reach information, the costs and benefits associated with different channel/floodplain management approaches including natural versus engineered stream morphology strategies, repetitive dredging programs, land use and channel encroachment limitations, and storm water/erosion control.

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# Issue 9: Incentives

## ■ Eligibility for State Aid

The most direct, meaningful and substantial reduction in future flood damage can be accomplished through financial incentives to communities and individuals to implement policies at the local level designed to avoid flood loss.

It has been the policy of the state administration for many years now to cover one-half of the town's 25% match for FEMA grants. The state has historically provided the entire 25% match for towns and individuals for the Emergency Watershed Protection projects. Additional state funding assistance for flood relief and mitigation has been provided through disbursement of CDBG grants, agricultural crop loss aid and other avenues. The mechanism to provide financial incentives already exists.

The existing system, in reality, results in a disincentive to communities to implement decision making processes that can reduce flooding damages.

For example, a town which cuts corners and installs deficient stream crossing structures, builds inadequate roadway drainage and erosion control facilities, exercises no local control over the growth pattern in town, is not in the flood insurance program, has no emergency response plan, no driveway access policy or takes no other proactive stance to avoid flood loss is just as eligible for state and federal aid as a community which does take all these steps to protect itself and its citizens from the ravages of flash floods. Under this scenario, there is no incentive to change the way we do things and there can be no realistic expectation that future flood loss can ever be reduced.

DEC recommends that the level of state aid to communities and individuals within those communities be tied to the level of implementation of policies and programs which will reduce the communities' future susceptibility to flood loss. The following policies and programs should be considered for inclusion in a matrix of eligibility standards:

1. Adopt a comprehensive emergency response plan.
2. Adopt and implement a policy that municipal infrastructure maintenance and capital investments meet minimum standards to withstand a certain level of flood event such as Q25.
3. Adopt an infrastructure capital investment plan which includes an assessment that considers flood susceptibility and flood hazard in its priority for investment.
4. Adopt and implement a municipal plan pursuant to 24VSA117 that takes into account physical limitations on infrastructure expansion without increasing flood hazards and defines those areas outside designated floodways within which public or private investment may be at risk to flood loss. Appropriate guidance must be exercised to assure that development within high risk areas is compatible with the level of risk.
5. Is enrolled in the flood insurance program.
6. Adopt, implement and enforce an effective driveway access construction ordinance.
7. Active participation with the state in the effort to educate the public on the dangers of flooding and opportunities to reduce damages.
8. Control construction of new in-stream impoundments by requiring engineered design and supervised construction. Provide for the periodic inspection of existing impoundments by a qualified professional engineer in the municipal disaster preparedness plan.

Implementation of these incentives to the towns should be accompanied by adequate state guidance and assistance to provide the appropriate technical, financial and administrative support. A phase in period should be provided, such as 5 years. A sliding scale for the state contribution to disaster aid could then be tied to the level of the communities' implementation of the above programs. A number of state agencies and other programs would need to participate including ANR, AOT, C&CD, RPC's, the Vermont Local Roads Program, R,C&D Districts and others.

- **Infrastructure Capital Investment Funding**

The magnitude and pace of the rural development and growth in many communities is outstripping the ability of towns to make adequate and appropriate capital investments in roads and bridges to serve the development. This problem contributes directly to increased susceptibility to flood damage.

The administration and legislature should consider basing eligibility for infrastructure capital investment and community development assistance on the degree of implementation of the policies and programs listed in the preceding subsection.

The legislature should consider increased funding of the Town Highway Bridge & Culvert Program to help communities; (1) reduce the susceptibility of critical and deficient stream crossing structures to flood loss and; (2) enhance the towns' ability to adequately fund necessary capital improvements to bridge and culvert crossings.

- **Flood Insurance**

In the event of a federal disaster declaration that includes Individual Assistance (IA)**,** any property owner who qualifies for a grant to restore essential services suffers no penalty if he or she did not have flood insurance coverage. This results in a disincentive to purchase flood insurance because the homeowner who has been paying the premiums has his or her grant amount reduced by the value of the insurance settlement. Any IA grant to non-covered households should be reduced by the amount of coverage provided by flood insurance had coverage been in place.

In the same respect, any residence being considered for acquisition should be enrolled in the flood insurance program or have the purchase price reduced by the value of any damage coverage provided by flood insurance had the coverage been in place.

**Issue 9 Policy Consideration:**

- State disaster aid to municipalities should be disbursed in such a manner as to create incentives that will encourage better disaster preparedness, reduce total flood losses, improve emergency response, facilitate disaster recovery and support mitigation efforts.

**Program Options to Implement the Recommended Policy:**

- The state should review all flood disaster aid policies and programs and attach appropriate pre-requisites to each in such a manner that encourages reduction of future flood loss. A 3-5 year phase-in period should be allowed for implementation of the eligibility requirements. Implementation of these eligibility requirements should be accompanied by adequate state guidance and assistance to provide the appropriate technical and administrative support.
- Enhanced staffing within C&CD could assist municipalities in the implementation of the flood disaster aid eligibility requirements.
- Some additional program resources within DEC and AOT could assist communities in the implementation of the eligibility pre-requisites and help to assure compliance.
- Strengthen and support the ability of RPC's to assist communities in the implementation of eligibility for state disaster aid requirements.
- State participation in FEMA IA grants program and FEMA HM buy-outs could be structured in such a manner as to encourage enrollment in the NFIP.
- Increase in the Town Highway Bridge & Culvert Program annual appropriation to reduce or eliminate flood hazards associated with deficient infrastructure.

## Issue 10: Coordination of Flood Response, Recovery and Mitigation

There are several factors which make difficult a coordinated approach to river related disaster response, recovery and mitigation. Following is a list of identified problems with suggestions for solution or alleviation.

1. Large number of involved agencies with specific, oftentimes too narrow, yet sometimes overlapping or even conflicting interests. Unnecessary contacts are, in some cases, mandated.

*Suggestion*: This results primarily from the myriad federal agencies that don't seem to communicate well and often demonstrate little flexibility in the interpretation and administration of their authority. The federal Small Business Administration (SBA), in particular, has been singled out for complaint by several individuals seeking assistance. To that extent, there is little action on the state's part that can be done to improve the situation. However, establishment of a program coordinator or ombudsman position within VEM and an adequate number of knowledgeable state personnel in the field working for either ANR, AOT or VEM can help provide the direction, communication and coordination to keep things moving.

A coordinated effort should be made by all state agencies involved in disaster preparation, response, recovery and mitigation to identify what is not working with the federal disaster relief programs and to communicate these issues to FEMA and the congressional delegation; so that which is within federal purview can be evaluated and corrected by federal action.

2. Disaster relief funding restrictions and other bureaucratic impediments that make difficult or even disallow comprehensive, coordinated or partnered approaches to solving river management problems.

*Suggestion*: As above, since the primary funding sources are federal, there is little the state can do. However, a project coordination or ombudsman position in VEM would be able to make critical connections enabling significantly more efficient, comprehensive and cost-effective improvements in disaster recovery.

3. Chronic shortage of adequate, skilled and experienced state personnel resources to provide the public assistance necessary for efficient and appropriate response and recovery.

*Suggestion*: The present FEMA sliding scale fund is insufficient to adequately cover state administrative, technical support and public assistance costs during disaster response and recovery. State programs are not generally budgeted for disaster related costs. The state disaster emergency fund could be made available or other funding sources identified for state agencies to hire the contracted or temporary help, cover overtime costs or otherwise provide critical services associated with disaster response and recovery.

4. Unskilled, inexperienced and overwhelmed disaster coordination and direction at the local level.

*Suggestion*: Many towns with any substantial amount of damage would be much better served by hiring a full or part time professional flood coordinator. Much less confusion, better communication and coordination and more cost-effective damage assessments would result. But, as in (3) above, neither FEMA nor the state presently provides adequate public assistance to fund the costs of contracted local flood coordinators. Other funding sources, such as the disaster emergency fund, must be identified to better support local disaster response coordination.

5. Poor communication between damage survey teams, relief agencies and resource agencies.

*Suggestion*: See suggestions (1) and (5).

6. Inadequate state support of the FEMA 404 Hazard Mitigation program.

There should be a state Hazard Mitigation Officer within VEM. State agencies have historically provided the public assistance for towns to adequately assess the feasibility and cost effectiveness of hazard mitigation (HM) projects. This is typically an unbudgeted expense. State agencies need additional resources to be able to prepare the grant applications and to develop and implement their own HM projects. Since agency HM projects can provide statewide benefits, investment in these projects have the potential to produce a much greater return on the investment.

7. Unclear regulatory framework.

Aside from the continuing public discussion over the role of gravel excavation and stream channel dredging, DEC has encountered or is aware of very little public displeasure or criticism of its regulatory activities during the disaster response and recovery phases. The greatest amount of conflict has been between FEMA and DEC.

10 V.S.A. Chapter 41 contains an emergency provision that allows for "the minimum amount of work necessary (in the stream) to alleviate the (emergency) condition" without requiring a permit. In the event of a declared disaster, DEC has liberally interpreted this statutory provision to cover all work for which a federal agency DSR or IA grant is written even if it is weeks or months after the flood. All DEC has asked in the process is for good communications between local, state and federal entities and a cooperative effort to include DEC input into the assessment of the repairs.

Federal jurisdiction under Section 404 of the Clean Water Act is not suspended. The state 404 General Permit (GP) issued by the US Army Corps of Engineers authorizes replacement of structures in-kind without significant expansion or extension and that meet good engineering standards. These projects require no further regulatory action.

However, where an engineering analysis shows that the replacement structure is hydraulically deficient and does not meet the appropriate standard, the project must be reported to the Corps and requires issuance of a state Section 401 Water Quality Certification.

This is an extremely important regulatory imperative that benefits, primarily, municipalities. It provides the vehicle that allows FEMA to fully fund bridge and culvert upgrades to a minimum hydraulic and geomorphic standard. In the absence of this requirement by DEC under the Clean Water Act, many deficient structures will be replaced with new deficient structures paid for with public funds and are guaranteed to wash out again sometime in the future.

This regulatory approach has worked reasonably well, particularly with the towns and state agencies. Where it doesn't work, it is usually associated with a communications breakdown.

However, FEMA has not fully accepted DEC's regulatory authority under the Clean Water Act. Despite this disagreement, DEC has used its environmental regulatory authority to convince FEMA to appropriate the money needed, for the benefit of municipalities, to adequately repair and upgrade many deficient facilities.

DEC feels that its regulatory actions on behalf of VT municipalities have resulted in hundreds of thousands of dollars in increased disaster relief aid and should therefore continue. The disagreement over regulatory authority between FEMA and DEC needs to be resolved.

Some confusion at the local level has occurred with respect to federal Section 10 waterways (navigable waters) under the Rivers and Harbors Act. Any problems with this, however, are isolated and few in number.

**Issue 10 Policy Consideration:**

- Provide additional resources to support and assure a better coordinated disaster response effort.
- Eligible uses of the state disaster emergency fund should be better defined.

**Program Options to Implement this Policy:**

- Increase the base funding of the state disaster emergency fund.
- Provide coordination support to VEM through funding a disaster response ombudsman and to municipalities by helping fund contracted professional flood response coordinators.

## Summary of Staffing and Budget to Address Short Term Program Options

## Redirection of Existing Resources and Proposed FY 2000 Budget

| Issue | Program Options | Staffing (FTE) | Budget |
|---|---|---|---|
| 3 | 100% Federally funded field service position (DEC) | 1 | $50,000 |
| 7 | CREP participation (VA, F&M) | 0.5 | $25,000 |
| | Total new staffing and annual expenditures | 1.5 | $75,000 |
| 3,6 | Reallocation of Existing Position (DEC) | 1 | $50,000 |

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# Appendices

# Appendix 1

## Vermont Flooding Dates and Watersheds Suffering the Greatest Damage

June 30-July 1, 1973: Statewide

August, 1976: Southern half of Vermont

June, 1984: Missisquoi, Lamoille, Winooski and Waits River watersheds

May, 1987: Walloomsac and Batten Kill watersheds (not a federally declared disaster)

August, 1989: Winooski, Otter Creek watersheds

August, 1990: Winooski, Lamoille, Wells and Waits River watersheds

March, 1992: Montpelier City, Winooski River ice jam

August, 1993: Missisquoi watershed

August 5-6, 1995: Lamoille, Winooski River watersheds

January, 1996: Nearly statewide.

August 16, 1996: West and Saxtons River watersheds

July 5, 1997: Lamoille, Missisquoi, Black and Passumpsic River watersheds

June 18, June 28-29, August 16, 1998: Lamoille, Winooski, Waits, Otter Creek and Passumpsic River watersheds

# Appendix 2

| Total Public and Private Losses During the Floods of 1995, 1996, 1997, and 1998 | |
|---|---|
| Total disaster expenditures by FEMA (primarily municipal infrastructure damages) Source: Angela McGara, VEM | $27,464,065 |
| Total federal flood insurance claims Source: FEMA | $1,249,000 |
| Total cost of projects that received 75% Emergency Watershed Protection (EWP) funds Source: Rob Allen, NRCS | $5,828,359 |
| Total cost of emergency livestock feed at farms experiencing at least a 20% loss and covered on a 25% basis with State appropriated funds (1997 & 98) Source: Louise Calderwood, VDA,F&M | $2,800,000 |
| Total cost of projects that received 64% Emergency Conservation Program (ECP) funds (1996, 97 & 98) Source: Linda Cronin, FSA | $647,711 |
| Total cost of Individual Assistance (IA) grants Source: Martha Lang, VDSW | $908,115 |
| Total cost of damages to state highway infrastructure Source: AOT Maintenance Division | $8,500,000 (projected) |
| Uncovered or unknown private and public losses (Estimated as 20% of all other documented losses) Source: DEC and VEM | $9,480,000 |
| Total Losses | $56,877,250 |

*VT 17 and 116, New Haven River, Bristol*

# Appendix 3

## NO. 137. AN ACT RELATING TO DEVELOPMENT OF A DISASTER RELIEF, RECOVERY AND MITIGATION PLAN.

(H.621)

Sec. 2. 10 V.S.A. § 905b(3) is amended to read:

The department shall protect and manage the water resources of the state in accordance with the provisions of this subchapter and shall:

(3) have supervision over and act as the state's agency in all matters affecting flood control, channel clearing and river bank protection. To discharge this responsibility, the department shall

(A) develop flood control policies and a flood control program that balances the need to protect the environment with the need to protect public and private property. The policy and program shall direct appropriate remedial measures following significant flooding events and shall define appropriate flood hazard mitigation measures. These measures may include:

(i) flood debris removal and streambed and stream bank maintenance and restoration practices;

(ii) identification of disaster-prone areas;

(iii) land use planning assistance to minimize future damage from flooding;

(iv) flood proofing measures for existing vulnerable private or public structures;

(v) acquisition and relocation of structures away from hazard-prone areas;

(vi) development of state standards to protect public infrastructure from disaster damage;

(vii) structural hazard control, such as debris basins or floodwalls to protect critical facilities;

(viii) educating the public regarding the availability of flood insurance and the advisability of obtaining flood insurance;

(B) develop and implement steps to incorporate into other programs administered by the department measures that decrease the likelihood and impact of future flooding incidents;

Sec. 3. REPORT

By no later than January 15, 1999, the secretary of natural resources, in coordination with other state agencies, shall present to the general assembly a report which contains a proposed flood control policy, program and budget, as necessary to carry out the provisions of this act. This report shall include any necessary proposals for statutory change.

Sec. 5. EFFECTIVE DATE

This section and Secs. 1, 3 and 4 of this act shall take effect upon passage. Sec. 2 of this act shall take effect on July 1, 1999.

Approved: April 21, 1998

# Appendix 4

DATE: 09/05/95 FEDERAL EMERGENCY MANAGEMENT AGENCY DSR NO: 24720
TIME: 03:17PM DAMAGE SURVEY REPORT SUPP TO DSR:

## PART I - PROJECT DESCRIPTION

COUNTY - LAMOILLE

APPLICANT NAME - ELMORE (TOWN OF)

INSPECTION DATE: 8/26/95

PROJECT TITLE - ROAD AND CULVERT WASHOUT
DAMAGED FACILITY - T 4 & 41 BEDELL BROOK ROAD

DISASTER NO: 1063

P.A.ID 015-23725

LOCATION - 0.15 MILES FROM T4 #3

CATEGORY C

PROJECT NO: 305

% COMPLETE 99

WORK ACCOM BY: FORCE ACCT

DAMAGE DESCRIPTION AND SCOPE OF ELIGIBLE WORK:

FLOOD DAMAGE TO ROAD SURFACE, CULVERT AND DITCHES. REPLACE LOST AGGREGATE SURFACE MATERIAL, INSTALL NEW CULVERT AND REGRADE SURFACE AND DITCHES. THE CULVERT UNIT PRICE INCLUDES EXCAVATION AND BACKFILL EXCEPT WHERE THE ROAD WASHOUT IS EXTENSIVE. FLOODWATERS DAMAGED A CULVERT AND 1300 LF OF ROADWAY. RESTORE TO PRE-DISASTER CONDITION.

| RECOMMENDATION BY INSPECTOR | INSP NO. | AGENCY | ELIGIBLE | F.O |
|---|---|---|---|---|
| FEDERAL - JOHN PHALE | 1111 | FEMA | Y | |
| STATE - PETE PELKY | 1506 | MTRLS | | |
| LOCAL - MARK WHIPPLE | | | | |

## PART II - ESTIMATED COST OF PROPOSED WORK

| ITEM | CODE | MATERIAL AND/OR DESCRIPTION | UNIT | QTY | UNIT PRICE | COST |
|---|---|---|---|---|---|---|
| 1 | 9007 | LABOR | LS | 1.00 | $ 246.91 | $ 247 |
| 2 | 9008 | EQUIPMENT | LS | 1.00 | $ 347.00 | $ 347 |
| 3 | 9009 | MATERIAL | LS | 1.00 | $4,165.20 | $4,165 |
| 4 | 9021 | CONTRACT LABOR | HR | 1.00 | $ 108.00 | $ 108 |
| 5 | 9026 | CONTRACT EQUIPMENT | LS | 1.00 | $5,430.00 | $5,430 |
| 6 | | WORK TO BE DONE | | | | |
| 7 | 3070 | DITCH CLEANING AND SHAPING | LF | 1300.00 | $ .20 | $ 260 |

TOTAL: $10,557
AMOUNT ELIGIBLE: $10,557
75 % FEDERAL SHARE: $ 7,918

## PART III - FLOOD PLAIN MANAGEMENT/HAZARD MITIGATION REVIEW

| IN OR AFFECTS FLOOD-PLAIN OR WETLAND: N | FLOODPLAIN LOCATION: | % DAMAGE | DISASTER HISTORY: | LAND USE U - D | FPM RECOMMEN-DATION: |
|---|---|---|---|---|---|

## PART IV - FOR FEMA USE ONLY

| AMOUNT | ELIGIBLE | SPECIAL CONSIDERATIONS | FLOOD PLAIN REV. NO. | WORKSITE |
|---|---|---|---|---|
| $10,557 | Y | M1S1 | | |

SUPP# DATE ?

DSR NO: 24720

## APPENDIX 4 (continued)

Sheet ___ of ___

### DAMAGE SURVEY CONTINUATION SHEET

| Applicant | Date | | DSR No. |
|---|---|---|---|
| ELMORE | 8/31/95 | 24720 | |

| Declaration No. | P.A. No. | | Work Category |
|---|---|---|---|
| FEMA | 1063VT | 015-23725 | A B C D E F G |

Sketches and/or Narrative

A 48" culvert plugged with debris and floodwaters eroded 1300 lf of roadway. With the exception of some ditching, work had been completed by the time of inspection.

### WORK COMPLETED

| 9007 | 9008 | 9009 | 9021 | 9026 |
|---|---|---|---|---|
| Labor | Equipment | Materials | Contract Labor | Contract Equipment |
| $2,46.91 | $347.00 | $4,165.20 | $108.00 | $5,430.00 |

### WORK TO BE DONE

| | | |
|---|---|---|
| 3070 | ditching | 650 LF X 2 sides = 1300 LF |

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# Appendix 5

## EVALUATION OF EROSION HAZARDS

Section 577 of the National Flood Insurance Reform Act of 1994 requires that FEMA conduct an "Evaluation of Erosion Hazards" study that evaluates the economic impact of erosion and erosion mapping on communities, and on the National Flood Insurance Program (NFIP). The legislation defines "Erosion Hazard Area" as "an area where erosion or avulsion is likely to result in damage to or loss of buildings and infrastructure within a 60-year period." This definition includes coastal as well as riverine erosion, however, the legislation recognizes potential technical difficulties in mapping riverine erosion, and therefore mandates a feasibility study of this category of erosion.

### Coastal Erosion Hazard Areas

FEMA is conducting the coastal portion of the study in two phases. The first phase is to map erosion hazard areas in 27 coastal counties (distributed among 18 states). The second phase is to inventory structures located within the mapped erosion hazard areas. These data will be used to conduct an economic impact analysis of erosion on coastal communities and on the NFIP, and to conduct an analysis to determine whether it is cost-beneficial to map erosion hazard areas through the NFIP.

FEMA began work on the coastal portion of the study in the Fall of 1995, when two preliminary tasks were initiated. The first task was to determine a statistically valid and representative sample of coastal counties with erosion hazards. This task was contracted to the Department of Environmental Sciences at the University of Virginia. The second task was to conduct a pilot economic impact analysis of erosion on Sussex County, Delaware. This task was contracted to the Laboratory for Coastal Research at the University of Maryland. The results of these preliminary tasks assisted in the development of methodologies used in the two phases of the national study.

Following completion of these preliminary efforts, the first full phase of the study was initiated in February, 1996. FEMA contracted with 18 State Coastal Zone Management Programs or their designees to conduct erosion mapping for 27 coastal and Great Lakes counties. The studies were completed in December of 1997. The second and final phase of the study was initiated in September of 1997, and is being conducted by the H. John Heinz III Center for Science, Economics, and the Environment. This phase consists of an inventory of structures within and near the mapped erosion hazard areas, as well as the economic impact analysis. The inventory of structures will be completed by November 1998, and the economic impact analysis will be completed by December, 1999.

### Riverine Erosion Hazard Areas

In response to the NFIRA mandate, FEMA is conducting a study to determine the technological feasibility of mapping Riverine Erosion Hazard Areas (REHAs). "Technologically feasible" means that methodologies exist that are scientifically sound and can be implemented. "Scientifically sound" means the methodologies are based on established physical principles and are supported by the scientific community. "Implementable" means that the approaches can be applied by FEMA as part of a nationwide program under the NFIP for an acceptable cost.

The objectives of the study are to:

- define riverine erosion processes,
- discuss geomorphic and engineering methods that could be used to map REHAs,
- evaluate the methods of predicting and modeling REHAs that have been applied in selected case studies within the U.S.,
- evaluate the cost to study and map REHAs,
- discuss programmatic elements associated with mapping and regulating REHAs.

The study team is conducting an in-depth search of existing methodologies used to predict riverine erosion, with emphasis on case studies. The study team began in October 1997 and will complete its report in Fiscal Year 1999.

### Final Report

The final report for the coastal study will be delivered to FEMA by January, 2000. Following internal and external review it, along with the riverine study, will be submitted to Congress in early 2000. The conclusions of the reports will help provide closure to a long-standing debate and Congressional concern as to whether FEMA should map erosion hazard areas and use these data in determining insurance premium rates through the NFIP.

Mike Grimm (michael. grimm@fema.gov) is leading

FEMA’s Riverine Erosion Study.

Mark Crowell (mark.crowell@fema.gov) is leading

FEMA’s Coastal Erosion Study.

# Appendix 6

## Examples of Property Damage Resulting from Gravel Mining and Channel Dredging in VT

### Example 1: Mad River

As part of the recovery efforts following devastating floods in 1973 and 1976, USDA funded several miles of streambank armoring with rock rip rap to protect agricultural lands. The design and construction standard called for the rock armor blanket to be keyed into the streambed two feet below streambed grade. All the work was supervised by a federal inspector.

The Soil Conservation Service (now NRCS) at that time provided maintenance guidance to the landowners that included a recommendation to periodically remove gravel bars along the river to help protect the long term viability of the armor blanket.

During the post-flood 70's and 1980's, rapid economic development in the Mad River Valley was occurring. Demand for gravel for construction was high. Upland sources in the valley were largely exhausted. The value of river gravel reached $2.00 per cubic yard sitting in the river. Many landowners were selling 1000-5000 cubic yards annually, a few up to 10,000 cubic yards periodically.

By 1985, DEC was observing indicators of extreme streambed degradation, or a lowering of the streambed elevation. The most important indicator was that much of the bank armoring that had been installed 2 feet below streambed was now totally exposed and the streambed in several locations was as much as 1.5 feet below the bottom of the blanket; a change of up to 3.5 feet in less than 15 years!

Much of the rip rap was failing as a result. The excessive gravel excavation was threatening to destroy much of the hundreds of thousands of dollars in investment in bank stabilization done just a few years before.

*Gravel mining, 1986; Mad River, Waitsfield*

*Undermined rip rap, 1987; Mad River, Waitsfield*

The physical process that was occurring can be described this way:

As the river approaches bank full stage, it develops enough energy to start mobilizing its boundary materials; the gravel, stone or sand which make up its bed and banks.

In a stable river reach, there is always an equal amount of material being brought in from above to replace that which is being scoured away below.

But if we remove a large proportion of the sediment available for the stream to move, an insufficient volume of material is available to replace the sediment being naturally scoured away from the next reach downstream.

The result is either increased bank erosion, or, in the case of the Mad River where the banks were extensively armored, increased bed scour (degradation) which ultimately undermines the banks and erodes them too.

The gravel mining had deprived the river system of sediment available and necessary to maintain its stability.

**Example 2: White River**

The reach of the White River through the village of Granville has been periodically dredged and channelized in response to flooding in 1927, 1938, the mid 50's and in 1973. Local residents and town officials observed and were experiencing extensive bank erosion downstream of the channelized reach and began excavating gravel on an annual basis.

The 1998 flood resulted in major erosion and sedimentation within the channelized reach and channel instability is extreme downstream.

In response to local concerns about the condition of the river, federal repair proposals and actions by landowners, DEC engaged an independent geomorphologist to evaluate the condition of the river, the reasons for it and to recommend a recovery plan.

The preliminary report of the consultant confirmed DEC's evaluation that the primary cause of the system instability is the periodic and extensive channelization of the river which included removal of all sediment deposits and building up the streambanks to protect adjacent developed lands from flooding.

*Streambank elevation of pre-channelized White River, Granville, 1998*

*White River, Granville, 1998*

Again the physical processes at work can be described as follows:

Most stable, natural, alluvial streams in Vermont can be expected to flood over their banks into the flood plains on a frequency of approximately once every 1.5 years. The reason this characteristic contributes to system stability is that much of the excess energy developed by these frequent floods is dissipated in the flood plains or overbank areas.

But development of  the flood plains, as in the case in Granville, rendered a flooding frequency of once every 1.5 years unacceptable.  So the solution was to dig the channel deeper and wider and build the banks up higher.

As each iteration of this practice took place in Granville, the capacity of the channel to contain flood events grew ever larger. Presently, the channelized reach can contain up to a 100 year flood event.

But the problem is, the channel cannot withstand the concentration of energy associated with even a 25 year storm, to say nothing about a 100 year event, without suffering extreme erosion and sedimentation.

The result is an enormous volume of sediment is produced in the channelized reach which far exceeds the capacity of the river to move it efficiently.  When the flood flow eventually leaves the channelized section and is able to access the flood plain, there is an abrupt drop in stream power.  Not only do downstream landowners suffer increased flooding downstream of the channelized reach, the increased deposition of the excessive sediment load contributes to a vicious cycle of more bank instability, more erosion and more sedimentation.

The condition of instability then propagates over time down the valley as the river attempts to reform a new flood plain and develop a stable condition.

Typically, the public reaction to the condition is to dredge the river.  While dredging and reshaping a new river channel may be a component of restoration of a stable condition, it must be recognized that dredging is what caused the condition in the first place and, in the case of Granville, has contributed to far more damage than it ever prevented.  Extension of indiscriminate dredging downstream will cause the problem to grow to unmanageable proportions.

**Example 3: Trout River**

In response to two major floods in the early 80's the Towns of Montgomery and Enosburg began excavating tremendous volumes of gravel from the Trout River to repair and maintain town roads.  DEC observed possibly the highest rates of lateral movement (streambank erosion) of any river channel in Vermont during this time period.  This is associated with the same physical aspects of sediment transport and river dynamics described in Example 1 above.

A slow recovery toward stability was observed following the ban on commercial excavation in 1987.  But major floods in the '90's have set the process of recovery back substantially.

Extensive dredging was performed after the flood in 1997.

A river restoration project is funded and scheduled to be implemented in the summer of 1999.

*Trout River, Montgomery, 1982*

*Trout River, Montgomery, 1998*

**Example 4: Browns River**

The Browns River in the towns of Underhill and Jericho was mined heavily in the ‘70's and ‘80's primarily to obtain gravel for commercial use. The physical reaction of the river was observed to be just as described in the examples above.

Two private bridges suffered undermining; one failed and one near failure.

Landowners have had to invest tens of thousands of dollars in streambank armoring in reaction to the increased instability; much more than the value of the gravel sold.

Virtually all the mature streambank vegetation was undermined and lost. The high quality natural resource values of this reach of the Browns River suffered severe degradation as a result of the gravel removal practices.

*Browns River, Underhill, 1985*

*Browns River, Underhill, 1983*

**Example 5: West Branch:** (See the discussion of the West Branch in Stowe under Issue 6, pg. 31.)

*Black Falls Brook, Montgomery, 1997*

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# Appendix 7

## Gravel Removal Sites Approved by DEC in 1997 and 1998.

| # of sites | Stream | Town | estimated gravel volume (cubic yards) |
|---|---|---|---|
| 7 | Wild Branch | Wolcott | 4,000 |
| 4 | Black Falls Brook | Montgomery | 5,000 |
| 2 | Seaver Brook | Craftsbury | 1,500 |
| 2 | Seaver Brook | Albany | 800 |
| 7 | Trout River | Montgomery | 20,000 |
| 1 | Lockwood Brook | Lowell | 1,000 |
| 1 | Taft Brook | Westfield | 800 |
| 1 | West Hill Brook | Montgomery | 2,500 |
| 2 | Beaver Meadow Brook | Enosburg | 700 |
| 4 | Tributaries to Elmore Branch | Elmore | 600 |
| 2 | Wild Branch | Eden | 1,000 |
| 1 | Lamoille River | Cambridge | 1,000 |
| 1 | Wild Branch | Craftsbury | 2,000 |
| 3 | South Branch Trout River | Montgomery | 1,500 |
| 1 | Gihon River | Eden | 400 |
| 1 | Bedell Brook | Morristown | 200 |
| 2 | Minister Brook | Worcester | 600 |
| 2 | McLeary Brook | Albany | 500 |
| 2 | Jay Brook | Montgomery | 1,500 |
| 2 | Tyler Branch | Enosburg | 3,000 |
| 1 | Missisquoi River | Troy | 200 |
| 1 | Shatney Brook | Albany | 500 |
| 1 | Tributary to Trout River | Enosburg | 400 |
| 10 | Mad River | Warren, Waitsfield | 18,000 |
| 1 | Stetson Hollow Brook | Warren | 200 |
| 2 | Clay Brook | Warren | 500 |
| 2 | New Haven River | Lincoln, Bristol | 3,000 |
| 4 | Roaring Brook | Underhill | 1,000 |
| 1 | Tributary to Browns River | Westford | 500 |
| 1 | Tributary to Connecticut R. | Bradford | 1,000 |
| 1 | White River | Hancock | 1,000 |
| 1 | Sleepers River | Danville | 500 |
| 1 | Whiteman Brook | Danville | 300 |
| 2 | Roy Brook | Danville | 500 |
| 1 | Water Andric | Danville | 200 |

## Appendix 7: (continued)

| # of sites | Stream | Town | estimated gravel volume (cubic yards) |
|---|---|---|---|
| 1 | Dog River | Northfield | 100 |
| 1 | Jay Branch | Jay | 200 |
| 1 | Barton River | Glover | 200 |
| 1 | Missisquoi River | Lowell | 100 |
| 1 | Settlement Brook | Cambridge | 300 |
| 1 | Hancock Branch | Hancock | 1,000 |
| 2 | White River | Granville | 6,000 |
| 1 | White River | Hancock | 500 |
| 1 | Otter Creek | Weybridge | 1,000 |
| 1 | Green River | Guilford | 1,500 |
| 1 | Hollow Brook | Poultney | 200 |
| 1 | East Creek | Rutland | 100 |
| 1 | Connecticut River | Brattleboro | 2,000 |
| 1 | Third Branch | Granville | 500 |
| 5 | Third Branch and tribs | Randolph | 50 |
| 2 | New Haven River | Bristol | 6,000 |

**Totals:**
113 sites — 124,600 cubic yards

*Miller Brook, Stowe*

*New Haven River, Bristol*

# Appendix 8

## Flooding Dates, Magnitude and Duration. Associated Storm and Discharge Frequencies.

**August 5-6, 1995:**

Approximately 6 inches of rain fell in the hardest hit areas over less than a 12 hour period. Soil and groundwater conditions are characterized as normal at the onset of the storm. Rivers were low. In excess of a 100 year flood discharge was recorded at the Johnson USGS gauge on the Lamoille River. Flood stages in excess of the 500 year flood level were observed in tributaries of the Lamoille such as the Wild Branch. The National Weather Service (NWS) 12 hour rainfall projection for a 100 year expected return frequency for Vermont is 4.8 inches. (data for a 500 year return frequency rainfall projection is unavailable).

**January, 1996:**

This was primarily a snow melt induced event caused by unseasonably warm weather followed by a moderate rainfall. DEC has not found any information relating to the amount of rainfall equivalent snow melt produced during this event. Flood stages ranged statewide from 10-25 year return frequency.

**July, 1996:**

2-4 inches of rain were reported to have fallen in intense thunderstorms one evening. This resulted in local washouts. The following evening another band of intense thunderstorms hit the same area dumping 4-6 inches in less than six hours. The ground was saturated and streams high from the previous night's deluge. Stream discharges were observed to be in the range of a 100 year discharge although no stream gauge information is available. The NWS 6 hour rainfall projection for a 100 year expected return frequency for VT is 3.9 inches.

**July 5, 1997:**

The most heavily impacted areas received 6 inches or more of rainfall in less than six hours. Up to 2 inches of rain had fallen the night before. The ground was saturated, ground water table low to moderate, it being an overall dry season and streams were at a low to moderate stage at the beginning of the storm. The North Troy and East Berkshire USGS gauges on the Missisquoi River recorded 500 and 100 year flood flows respectively. High water marks on the main stem and tributaries fell within that range as projected by the FEMA flood profiles. The NWS predicted six hour rainfall for a 100 year expected return frequency is 3.9 inches and for 24 hours is 5.0 inches.

**June 18, 1998:**

4-6 inches of rain fell in a deluge lasting approximately 3 hours. Water surface profiles determined by high water marks appear to be in excess of a 100 year expected return frequency discharge. The soil was saturated and groundwater table high due to the excessively wet season. Stream stages were low at the onset of the storm. The NWS 3 hour rainfall projection for a 100 year storm for this area of Vermont is 3.2 inches.

**June 28-29, 1998:**

The most heavily damaged areas received up to 6 inches of rain over approximately six hours. The night before, 1-2 inches had fallen on already saturated ground. The groundwater table was high from the excessively wet summer and stream stages moderate. Observed high water elevations ranged up to the 500 year flood level. The NWS six hour rainfall projection for a 100 year storm is 3.9 inches. The Moretown USGS gauge on the Mad River recorded only a 25 year discharge. However, the gauge is located well downstream of the area of most rainfall and downstream of the confluence of several unaffected tributaries.

**August 16, 1998:**

At a gauged site, 2.3 inches were recorded the previous night and 4.7 the night of the 16th. Flood stage elevations observed were in the 500 year range. Soil was saturated, groundwater table high and streams high at the onset of the second storm. The 7.0 inch rainfall over just over 24 hours is well in excess of the 5.0 inch NWS projected 100 year return frequency storm.

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# Appendix 9

## List of Acronyms Used in this Report

| | |
|---|---|
| AASHTO | American Association of State Highway and Transportation Officials |
| ANR | Vermont Agency of Natural Resources |
| AOT | Vermont Agency of Transportation |
| C&CD | Vermont Agency of Commerce and Community Development |
| CDBG | Community Development Block Grant |
| COE | US Army Corps of Engineers |
| CRP | Conservation Reserve Program |
| CRS | Community Rating System |
| DEC | Vermont Department of Environmental Conservation |
| DHCA | Vermont Department of Housing and Community Affairs |
| DSR | Damage Survey Report |
| DSW | Vermont Department of Social Welfare |
| ECP | Emergency Conservation Practices program |
| EPA | Environmental Protection Agency |
| EWP | Emergency Watershed Protection program |
| FDAA | Federal Disaster Assistance Administration |
| FEMA | Federal Emergency Management Agency |
| FHWA | Federal Highway Administration |
| FSA | USDA Farm Service Agency |
| FTE | Full time employee |
| HM | Hazard mitigation |
| HW/D | Headwater/depth ratio |
| IA | Individual Assistance grant program |
| NFIP | National Flood Insurance Program |
| NRCS | Natural Resource Conservation Service |
| NWS | National Weather Service |
| PA | Public Assistance grant program |

| | |
|---|---|
| Q25, Q50... | Floodwater discharge volume (Q) or flood stage elevation associated with that discharge and the statistically projected return frequency in years |
| R,C&D | Resource Conservation and Development District |
| RPC | Regional Planning Commission |
| SBA | Small Business Administration |
| THB&C | Town Highway Bridge & Culvert program |
| USDA | United States Department of Agriculture |
| USF&WS | United States Fish & Wildlife Service |
| USGS | United States Geological Survey |
| VDA,F&M | Vermont Department of Agriculture, Food and Markets |
| VEM | Vermont Emergency Management |
| VLRP | Vermont Local Roads Program |
| VSA | Vermont Statutes Annotated |
| VT | Vermont |

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