Impacts to Stream Habitat and Wild Trout Populations in Vermont Following Tropical Storm Irene

Vermont Fish and Wildlife Department Annual Report

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Summary:
Damage suffered from Tropical Storm Irene required immediate and in some cases extensive stream channel alteration to protect life and property and rebuild critical transportation infrastructure. However, a significant amount of instream activity was also conducted without proper consultation and oversight or for reasons beyond necessary flood recovery. These activities continued for several months after the flood event and covered a wide area of the central and southern portion of the state.

Post-flood activities which were detrimental to aquatic habitat quality and diversity included large scale removal of streambed material and natural wood, berming of streambed materials to raise streambank elevations and the straightening of stream channels. These activities resulted in homogeneous, overwidened stream channels comprised of small substrates and lacking the diversity of habitats, flows and depths necessary to support robust aquatic populations.

As fish population recovery and fisheries management options will be dependant on aquatic habitat quality and complexity, the Vermont Department of Fish and Wildlife conducted an assessment of post-flood aquatic habitats in selected watersheds. This partial assessment estimated a total of 77 miles of stream with major degradation of aquatic habitat resulting from post-flood stream channel alteration activities.

Long-term monitoring studies in Vermont indicate that, in the absence of post-flood channel alterations, wild trout populations generally recover within 2-4 years. Where aquatic habitat has been severely altered through streambed and natural wood mining, channel widening and straightening, complex habitat features will need to re-establish before improvements in fish and aquatic populations can be expected. While relatively short reaches of impacted streams may recover in a matter of years, the recovery of longer reaches may take decades and will depend upon the availability and mobility of upstream sources of coarse streambed material and natural wood, as well as the magnitude and frequency of future flood events.

Improvements in post-flood response regulations, policies and procedures as well as effective use of internal staff and outside expertise will be necessary to minimize unnecessary degradation of stream channels and aquatic habitats following major flood events. More importantly will be the need to minimize future conflicts between the built and stream environments by ensuring that future development is compatible with the hydraulic, geomorphic and ecological processes of Vermont’s streams and rivers.

Introduction:

On August 27-28, 2011 Tropical Storm Irene deposited over six inches of rain on several watersheds in the central and south-eastern portion of Vermont. The US Geological Survey reported record discharges for eight stream gauges in Vermont including the Saxtons River (Rockingham), Little River (Waterbury), Ayers Brook (Randolph), Williams River (Rockingham), Walloomsac River (North Bennington), Otter Creek (Middlebury), Dog River (Berlin) and Mad River (Moretown). In addition to extensive damage to private and commercial property, Vermont's transportation infrastructure was severely impacted in many areas. The *Irene Recovery Report* indicated that the state transportation system incurred damage to over 200 road segments and 200 bridges, while towns reported over 2,000 road segments, 300 bridges and more than 1,000 culverts were damaged or destroyed (Lunderville 2011).

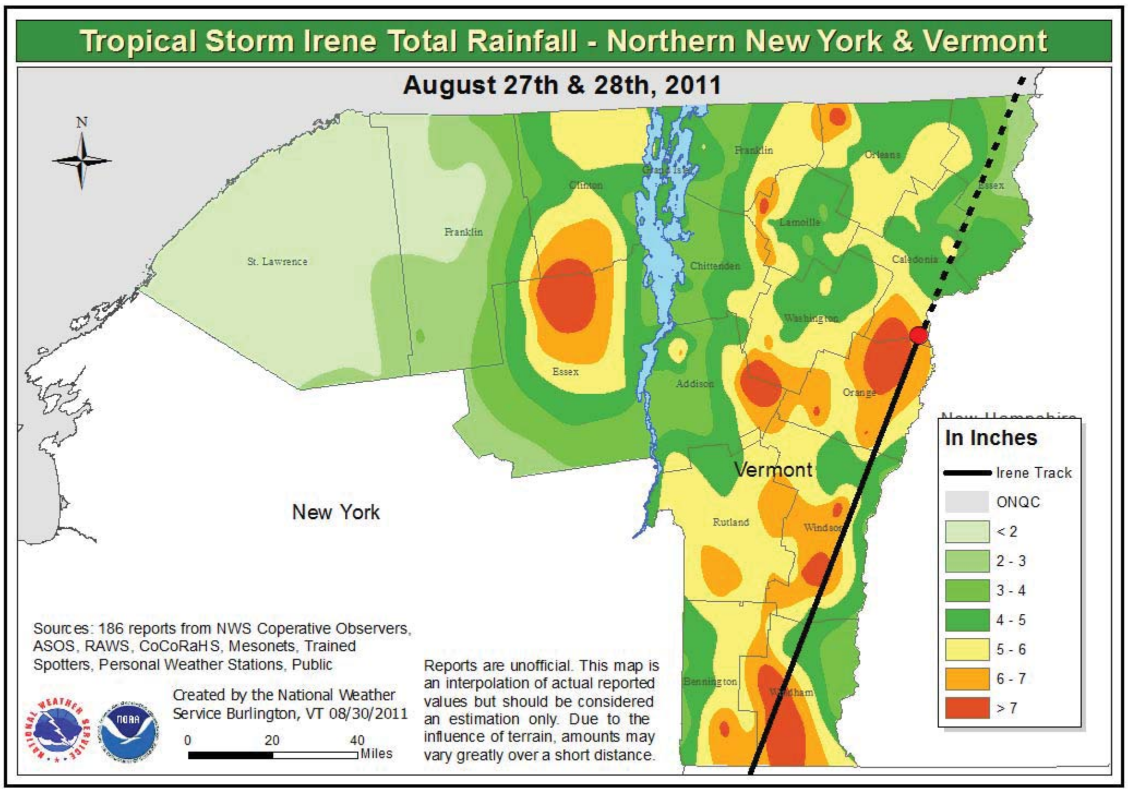


Figure 1. National Weather Service estimates of total rainfall from Tropical Storm Irene in Vermont and northern New York.

Long Term Impacts of Floods to Wild Trout Populations:

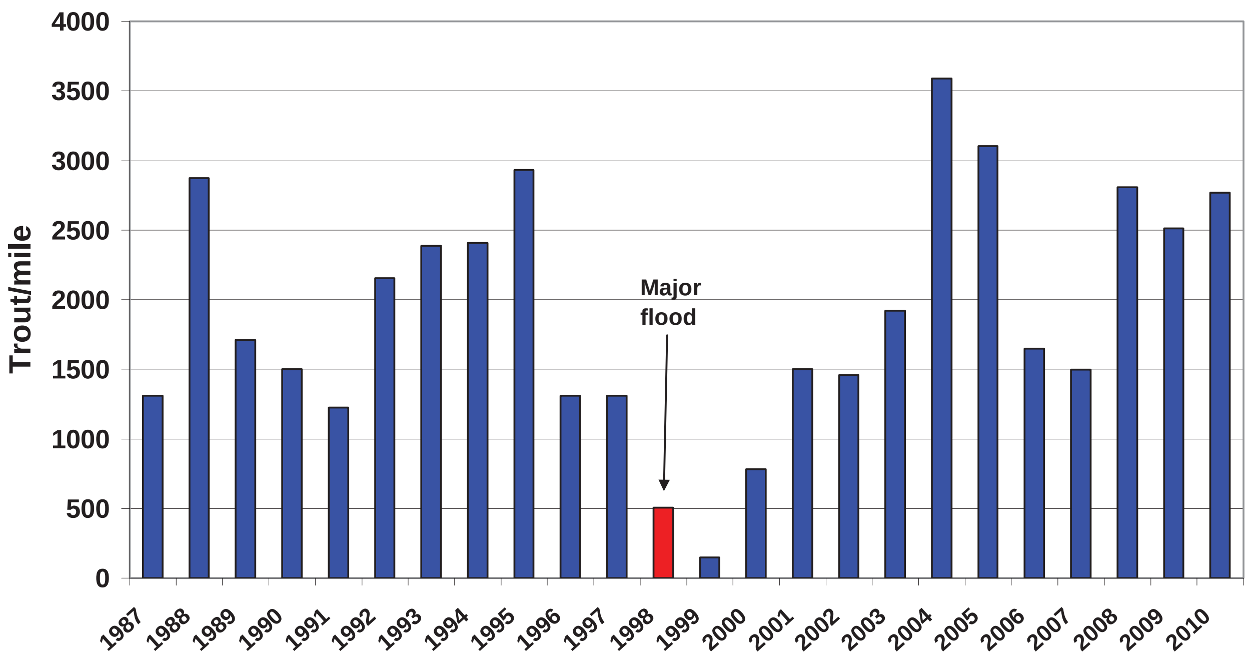
Catastrophic flood events can also have profound effects on wild trout and other aquatic populations. Waters (1999) reported floods and sedimentation as the main environmental causes for the variation of wild brook trout populations in a long-term study of a Minnesota stream. Numerous studies have linked the abundance of age-0 trout to the timing and magnitude of flood events (Warren et. al. 2009, Carline and McCullough 2003, Seegrist and Gard 1972). While young fish are often more susceptible to loss during flood events, high mortality of adult trout have been documented as well (Young et. al 2010, Carline and McCullough 2003).

The decline and subsequent recovery of fish populations following flood events are directly related to aquatic habitat quality and complexity. Pearsons et. al (1992) reported that following flooding, hydraulically complex reaches lost fewer fish and had higher species diversity than reaches with low complexity. Large floods will often result in large scale movement of stream substrates and may recruit large quantities of natural wood to stream channels resulting in changes in the size and depth of habitat features. Studies by Carline and McCullough (2003) and Dolloff et. al.(1994) indicate that while individual habitat units may have changed, overall habitat composition and complexity did not suffer and in some cases improved.

Long-term monitoring of wild trout populations in Vermont provides direct evidence of population decline and recovery following large flood events. In the examples presented below, catastrophic flood events resulted in widespread damage to private and public infrastructure and caused large scale movement of stream substrate and large wood. However, significant post-flood channel alterations was not conducted and habitat quality remained intact.

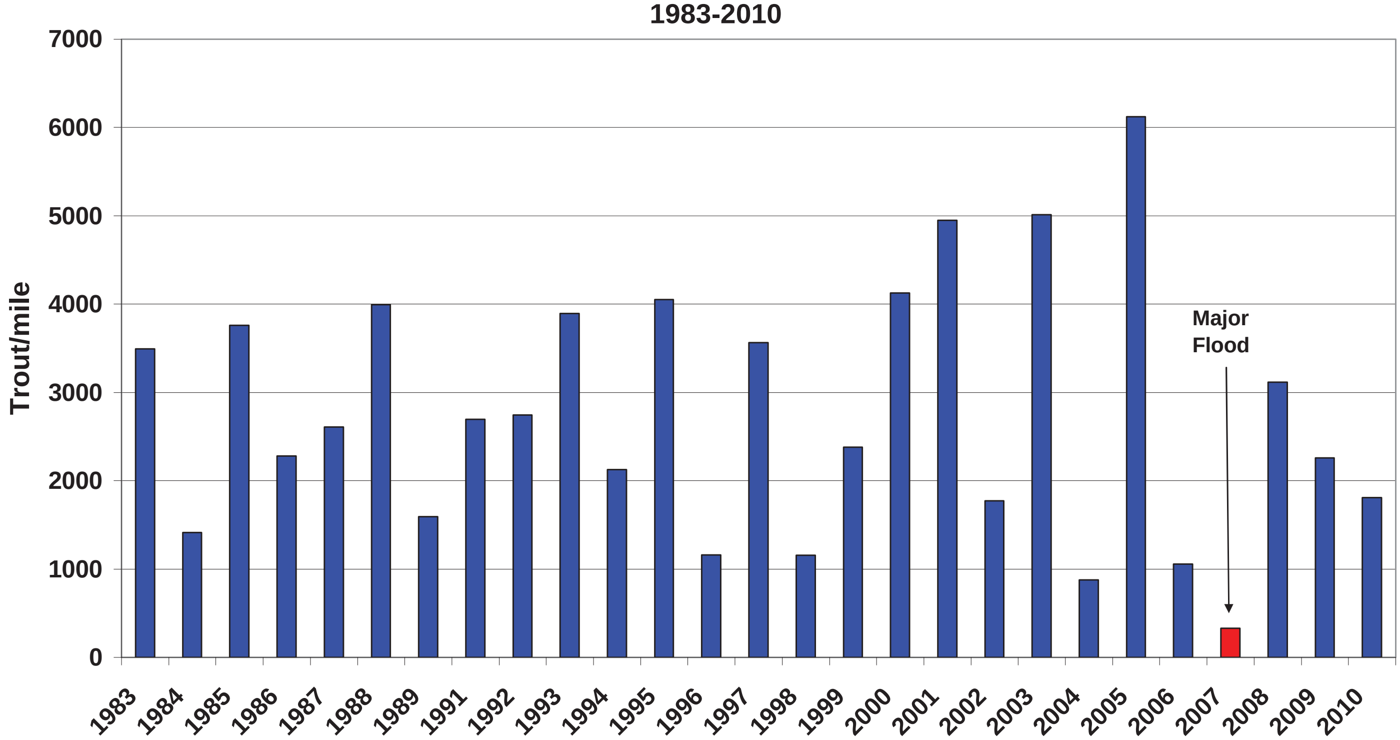
Clay Brook is a tributary of the Mad River and supports a fish population consisting exclusively of wild brook trout. Following the June 1998 flood event, brook trout populations dropped to their lowest levels in 11 years, totaling only 41% of the previous low recorded (Figure 2). A further decline in 1999 was recorded before recovery was apparent in 2000 while in subsequent years population levels were sustained at pre-flood levels.

Figure 2. Clay Brook Wild Brook Trout Population Estimates
Vermont Department of Fish and Wildlife Surveys
1987-2010



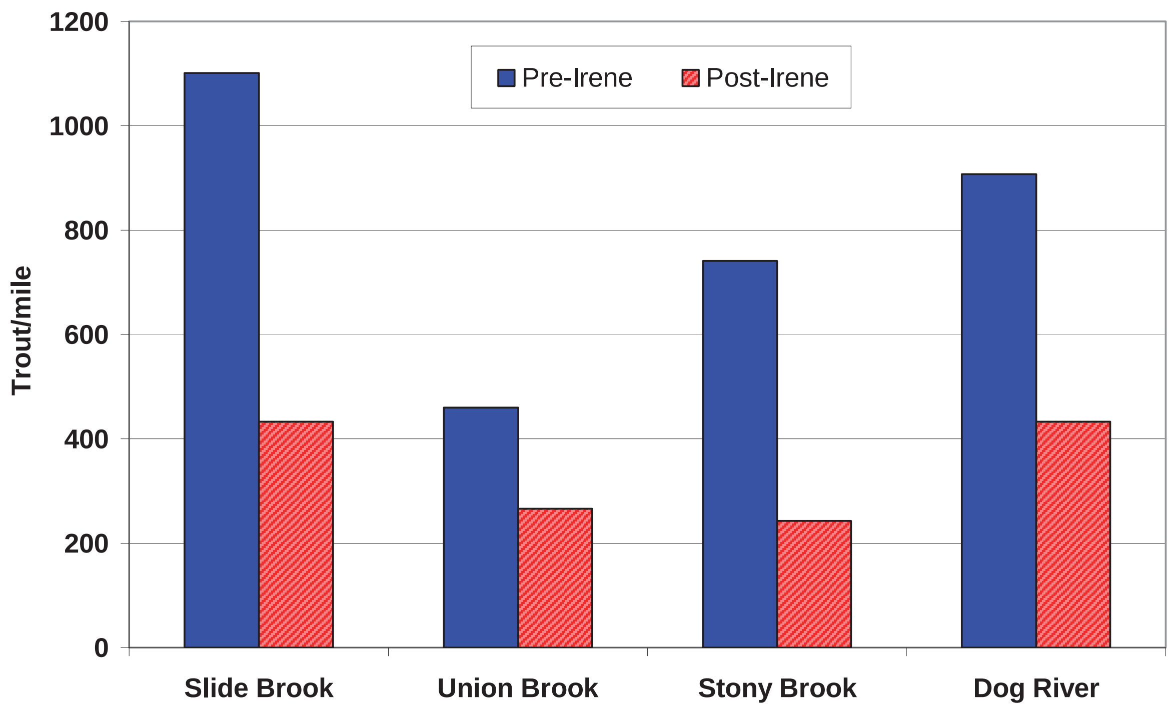
Lilliesville Brook is a tributary of the White River and serves as a spawning and nursery stream for wild rainbow trout, consisting largely of two age classes of trout. Wild brook trout are also present in relatively low numbers. A major flood event in July 2007 reduced wild trout populations to their lowest level in 24 years (Figure 3). However, successful spawning of wild rainbow in 2008 resulted in the rapid recovery of this population.

Figure 3. Lilliesville Brook Wild Trout Populations
Vermont Department of Fish and Wildlife Surveys
1983-2010



Impacts of Tropical Storm Irene to Wild Trout Populations:
Several trout population surveys conducted in the Mad River and Dog River watersheds in 2011 prior to Tropical Storm Irene were repeated following the flood. Slide Brook is a tributary of the Mad River and supports wild brook trout. The upper Dog River supports wild brook trout as does its tributary, Union Brook. Stony Brook is also a tributary of the Dog River and supports both wild brook trout and rainbow trout. A comparison of pre- and post-flood population levels provides insight into the impact of flooding on wild trout resources in Vermont. As in previous extreme flood events, wild trout populations declined substantially. In the four streams surveyed, wild total trout population levels were reduced to 33-58% of pre-flood levels (Figure 4). Young fish were particularly affected (0-37% of pre-flood levels) while older trout fared better (41-64% of pre-flood levels). As in the previous examples, only limited post-flood channel alterations were conducted and despite significant movement of streambed material, these stream reaches maintained diverse and complex habitat conditions following the flood.

Figure 4. Wild Trout Populations - Before and After Irene
Vermont Department of Fish and Wildlife Surveys



Post-flood Channel Alteration Impacts to Aquatic Habitat:
Damage suffered from Tropical Storm Irene required immediate and in some cases extensive stream channel alteration to protect life and property and rebuild critical transportation infrastructure (Lunderville 2011). However, a significant amount of instream activity was also conducted without proper consultation and oversight and for reasons beyond necessary flood recovery. These activities continued for several months after the flood event and covered a wide area of the central and southern portion of the state.

Post-flood activities which were detrimental to aquatic habitat quality and diversity included large scale removal of streambed material and natural wood, berming of streambed materials to raise streambank elevations and the straightening of stream channels. These activities resulted in homogeneous, overwidened stream channels comprised of small substrates and lacking the diversity of habitats, flows and depths necessary to support robust aquatic populations.

The photo below depicts a Vermont stream characterized by a variety of habitat types sustained by forested streambank vegetation, a variety of streambed substrates including natural wood, and a diversity of depths and velocities. In contrast, the lower photo shows the result of post-flood channel alteration activities where streambed material and natural wood has been removed and the channel is left over-widened and devoid of habitat complexity and diversity.

Figure 5. A Vermont stream depicting complex and diverse habitat conditions.

Figure 6. Gilead Brook (Bethel) following extensive streambed and natural wood mining, berming and straightening after Tropical Storm Irene.

As previously discussed, the quality and diversity of aquatic habitats is directly linked to the ability of fish populations to withstand and recover from flood events. Documenting the scope and magnitude of instream habitat degradation in Vermont streams will therefore be critical to our understanding of future fish population dynamics and for developing appropriate fisheries management strategies. This report provides a partial estimate of instream habitat degradation from post-flood channel alterations in selected watersheds within Vermont.

Methods:
Vermont Department of Fish and Wildlife staff conducted roadside assessment of instream habitat degradation throughout the central and southern portion of Vermont. In some instances, assessments were obtained from Agency of Natural Resources and watershed organization staff intimately familiar with specific stream reaches. Field maps were used to demarcate reaches of stream with minor or major instream habitat degradation as described below:

1. **Minor –** Channel activities limited to providing channel dimension and/or capacity or are confined to a localized area directly associated with restoring transportation infrastructure (bridge, road) or protecting buildings, water supply, wastewater system, etc. from imminent loss. Diversity of streambed materials and sizes and other habitat structural features (e.g. large wood, woody riparian vegetation) are little changed. Examples:
    a. Streambank stabilization (e.g. riprap) largely done from top of bank.
    b. Berming using only alluvium deposited in floodway and not from within channel.
    c. Limited removal of large wood or streambed deposits that obstruct channel(s) and/or pose direct threat to transportation infrastructure.

2. **Major –** Channel has been significantly altered resulting in bed largely devoid of habitat features. Includes the removal of coarse materials and/or large natural wood. Channel is substantially homogenized.
    Examples:
    a. Extensive channel straightening and widening.
    b. Streambed substrate and large natural wood extraction.
    c. Channel berming involving streambed materials.

The distance of individual stream reaches identified on field maps or with GPS waypoints was estimated using ArcGIS or other topographic mapping software.

Results:
A total estimate of approximately 406,000 feet, or nearly 77 miles, of stream were identified with major degradation of instream habitat from post-flood stream channel alteration activities (Table 1). An additional 45,000 feet (8.6 miles) of stream channel were estimated with minor impacts (Table 1). Individual length of impacted stream reaches ranged from less than 100 feet to several miles long. The White River (27.1 miles), West River (13.0) miles, Ottauquechee (9.2 miles), Saxtons River (8.1) and Hoosic River (4.8) were the watersheds where the most significant impacts were observed.

It should be noted that estimates of instream habitat impacts should be considered conservative for the following reasons:

- Only stream reaches accessible/visible by public roads were assessed.
- Not all watersheds were assessed.
- Not all streams within watersheds were assessed.
- Once an assessment was completed, additional activity may have occurred which would not be captured.

Where major impacts were recorded, stream channels were largely devoid of coarse streambed material and natural wood, and berming of streambanks or channel straightening may have also occurred. Figures 7 through11 show examples of stream channel conditions during and after post-flood channel activities.

Figure 8. The West Branch of the White River (Rochester) following streambed mining activities.

Table 1. Estimated length (feet) of instream habitat impacts from post-flood channel alterations identified in a partial assessment of Vermont watersheds.

Watershed	Subwatershed	Major impact (feet)	Minor impact (feet)
Batten Kill	Roaring Branch	4708	0
	White Creek	500	455
	watershed total	**5208**	**455**
Black River	Mainstem	5064	0
	North Branch	7381	2547
	watershed total	**12445**	**2547**
Hoosic River	Walloomsac River	**25425**	**300**
Mettawee River	Mainstem	750	0
	Indian River	520	50
	watershed total	**1270**	**50**
Mill Brook	Mainstem	859	0
	Bailey Brook	2218	0
	watershed total	**3077**	**0**
Ottauquechee River	Maintstem	1300	850
	Barnard Brook	1030	2620
	Broad Brook	28361	690
	Curtis Hollow Brook	1405	0
	North Branch	11663	0
	Reservoir Brook	3750	0
	Roaring Brook	1000	0
	watershed total	**48509**	**4160**
Otter Creek	Mainstem	300	0
	Clarendon River	350	200
	Cold River	7350	150
	Homer Stone Brook	1350	0
	Sucker Brook	585	0
	Mendon Brook	7750	100
	Middlebury River	4200	0
	Mill Brook	1900	0
	Mill River	1250	4450
	Neshobe River	6150	150
	New Haven River	700	0
	watershed total	**31885**	**5050**

Table 1. Continued.

Watershed	Subwatershed	Major impact (feet)	Minor impact (feet)
Poultney River	Castleton River	**2150**	**0**
Saxtons River	Mainstem	**42767**	**0**
West River	Mainstem	2165	1903
	Ball Mountain Brook	21877	1641
	Flood Brook	150	0
	Greendale Brook	225	2000
	Rock River	14000	0
	Turkey Mountain Brook	0	390
	Utley Brook	75	0
	Wardsboro Brook	24332	370
	Winhall River	5795	711
	watershed total	**68619**	**7015**
White River	Mainstem	12550	0
	Alder Meadow Brook	4000	10650
	Broad Brook	1340	0
	First Branch	200	0
	Hancock Branch	12800	0
	Lilliesville Brook	5000	1600
	Locust Creek	10000	0
	Stony Brook	11300	0
	Third Branch	54110	2020
	Tweed River	15050	0
	West Branch	11300	0
	Marshs Brook	1500	0
	Nason Brook	1700	0
	Clark Brook	500	0
	unnamed tributary	1700	
	watershed total	**143050**	**14270**
Williams River	Middle Branch	**6125**	**0**
Winooski River	Mad River	9100	9250
	Dog River	6325	2235
	watershed total	**15425**	**11485**
All Watersheds	***Grand Total (feet)***	***405955***	***45332***
	Grand Total (miles)	***76.9***	***8.6***

Figure 8. The Middlebury River (Middlebury) showing excavators in the process of removing coarse material from the streambed and creating berms along the streambank.

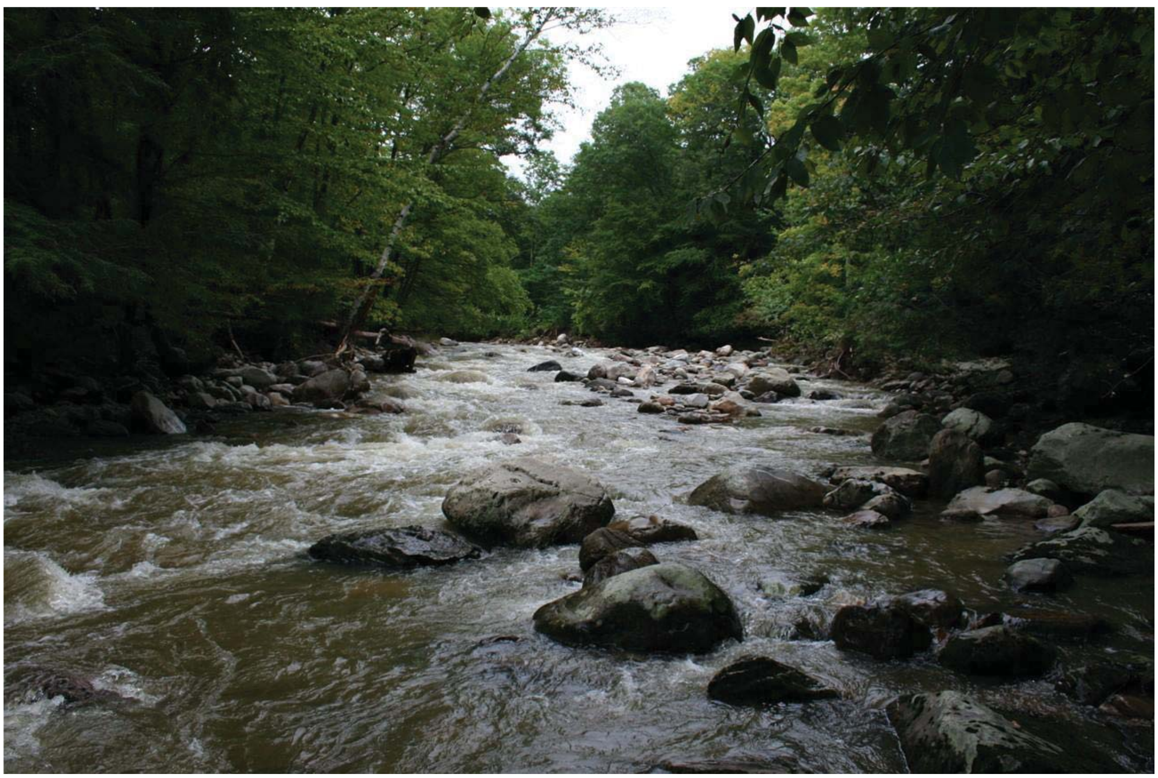


Figure 9. The Middlebury River just upstream of the previous picture. Note the variety of stream substrates and diversity of habitat features which were still in tact after the flood.

Figure 10. Wardsboro Branch (Wardsboro) during a natural wood harvesting operation.

Figure 11. An engineered stream channel of the Roaring Branch (Bennington) provides proper channel and flood plain dimensions, but is devoid of complex aquatic habitat features.

In a few cases, stream channel restoration was required as mitigation for excessive stream channel alteration. However, due to limited time, funding and available materials (coarse streambed substrate, natural wood); these efforts largely fell short of restoring aquatic habitat complexity (Figure 12).

Figure 12. Camp Brook (Bethel) following instream channel restoration. Stream channel dimensions were improved but limited availability of materials precluded the restoration of aquatic habitat diversity and complexity.

Discussion:
This partial assessment of central and south-eastern Vermont watersheds estimated 77 stream miles with major aquatic habitat degradation from post-flood channel alterations. Large scale removal of coarse streambed substrate and natural wood, channel widening, berming and straightening have left overwidened stream channels devoid of aquatic habitat features. The loss of habitat diversity and complexity has been well studied and is directly linked to decreased diversity and abundance of macroinvertebrate and fish populations (Lau et. al 2006, Carline and Klosiewski 1985, Edwards, et. al 1984, Chapman and Knudsen 1980, Groen and Schmulbach 1978). In addition, these altered channels maintain higher and more uniform velocities, and this increased stream power leads to greater streambank erosion, channel incision and risk of catastrophic failure during future flood events (Orth and White 1999, CWP 1999).

Long-term monitoring studies in Vermont indicate that, ***in the absence of post-flood channel alterations***, wild trout populations generally recover within 2-4 years. Where aquatic habitat has been severely altered through streambed and natural wood mining, channel widening and straightening, complex habitat features will need to re-establish before improvements in fish and aquatic populations can be expected. While relatively short reaches of impacted streams may recover in a matter of years, the recovery of longer reaches may take decades (Orth and White 1999, Waters 1995) and will depend upon the availability and mobility of upstream sources of coarse streambed material and natural wood, as well as the magnitude and frequency of future flood events.

In addition to the ecological costs of post-flood channel alterations, the economic impact to sportfishing should also be considered in the cost of flood recovery. The 2006 National Survey of Fishing, Hunting and Wildlife Associated recreation estimated that over 63 million dollars were spent by resident and nonresident anglers in Vermont (USFWS 2008). Of the variety of sport fisheries available in Vermont, stream trout fishing has always been one of the most popular. A statewide survey of Vermont anglers confirms this and estimated over 875,000 trout fishing trips in streams and rivers by resident and non resident anglers in 2009 (Connelly and Knuth 2010). Degradation of aquatic habitats will likely impact the quality of stream fisheries in several Vermont watersheds.

Post-flood channel alteration will continue to be a necessary response in situations where life and property are at risk and where critical transportation infrastructure is jeopardized. Following Tropical Storm Irene, channel alteration activities were widespread but in many instances occurred without review, oversight or were unrelated to necessary flood recovery. A report to the Vermont legislature identified several constraints which limited post-flood river management effectiveness following Tropical Storm Irene (Kline 2011) and included:

- unclear or conflicting authority under emergency operations
- perceptions of imminent threats to public safety
- limited staff and resources to effectively cover a large scale disaster
- social pressures in the face of a natural disaster

As described by Kline (2011), improvements in post-flood response regulations, policies and procedures, as well as effective use of internal staff and outside expertise will be necessary to minimize unnecessary degradation of stream channels and aquatic habitats following major flood events. More importantly will be the need to minimize future conflicts between the built and stream environments by ensuring that future development is compatible with the hydraulic, geomorphic and ecological processes of Vermont's streams and rivers.

Recommendations:

- Continue to advocate for regulations, policies and procedures which minimize conflicts between built and stream environments.
- Advocate for clarification and improvements of regulatory authority for instream activities conducted under emergency and non-emergency conditions.
- Advocate for effective use of internal staff for review of instream activities conducted under emergency and non-emergency conditions.
- Advocate for regulations, policies and procedures which adequately address aquatic habitat protection during instream activities.
- Continue to advocate for stream crossings which accommodate hydraulic, geomorphic and ecological processes.
- Continue instream habitat impact assessments in watersheds with known damage from Tropical Storm Irene.
- Evaluate the long-term effect of stream channel alteration activities on fish populations within impacted watersheds.

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