Town of Duxbury, VT
Local Hazard Mitigation Plan Update
March 26, 2018
Adopted March 26, 2018
Prepared by the Town of Duxbury

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1. Introduction

The impact of expected, but unpredictable natural and human-caused events can be reduced through community planning. The goal of this Plan is to provide an all-hazards local mitigation strategy that makes the community of Duxbury more disaster resistant.

Hazard mitigation is any sustained action that reduces or eliminates long-term risk to people and property from natural and human-caused hazards and their effects. Based on the results of previous Project Impact efforts, FEMA and State agencies have come to recognize that it is less expensive to prevent disasters than to repeatedly repair damage after a disaster has struck. This Plan recognizes that communities have opportunities to identify mitigation strategies and measures during all of the other phases of emergency management – preparedness, response, and recovery. Hazards cannot be eliminated, but it is possible to determine what the hazards are, where the hazards are most severe and identify local actions that can be taken to reduce the severity of the hazard.

Hazard mitigation strategies and measures alter the hazard by eliminating or reducing the frequency of occurrence, avert the hazard by redirecting the impact by means of a structure or land treatment, adapt to the hazard by modifying structures or standards, or avoid the hazard by preventing or limiting development.

2. Purpose

The purpose of this Local Hazard Mitigation Plan is to assist the Town of Duxbury in recognizing hazards facing the region and their community and identify strategies to begin reducing risks from acknowledged hazards.

Duxbury strives to be in accordance with the strategies, goals and objectives of the State Hazard Mitigation Plan, including an emphasis on proactive pre-disaster flood mitigation for public infrastructure, good floodplain and river management practices, and fluvial erosion risk assessment initiatives.

The 2018 Duxbury Local Hazard Mitigation Plan is an update of the 2011 plan. Updates to the plan include:

- Plan Update Process
- Plan Maintenance
- Update of Flood and Severe Storm Hazards
- Updates of Local Areas of Concern Map
- Status of 2011 mitigation strategies
- Identification of new mitigation strategies

3. Community Profile

The Town of Duxbury is located on the western edge of Washington County and is bounded by the towns of Moretown to the east, Fayston to the south, Huntington to the west, and Waterbury and Bolton to the north. Duxbury's northern border is set by the Winooski River, while its western edge is marked by the principal ridge of the Green Mountains. These elements give Duxbury one of the most rugged physical reliefs in Vermont; with an elevation change from about 360 feet above sea level along the Winooski River to 4,083 feet at the summit of Camels Hump only four and a half miles away. These elevations are the lowest and highest, respectively, in Central Vermont (Town Plan).

Principal rivers and streams include Ridley Brook, which drains the northwestern portion of the Town into the Winooski, Crossett and Dowsville Brooks draining the eastern section of Town, and Shepard Brook, which provides drainage to a small area in the southwestern portion of Town.

According to the 2010 US Census, Duxbury has a total population of 1,337 people living in 639 housing units. Duxbury has seen its population increase by 3% from the 2000 Census, while its number of housing units has increased by 28%. Approximately 90% of Duxbury's workforce is employed outside of the community, while the remaining 10% are employed within the Town.

Much of the development within the Town is concentrated along Route 100, the single paved highway that transects the town in a north-south direction along its eastern boundary. There is concentrated residential development in the "village" of Duxbury Corner, but for several years much of the new residential development has been taking plan in the more remote, higher elevation areas of town, which are reached by Ward Hill Road, Dowsville Road, Crossett Hill Road, and Camels Hump Road. Despite this trend, the Town Plan limits land uses and densities in outlying areas and high elevations and instead encourages appropriate clustered or concentrated patterns of development.

The Washington Electric Cooperative provides electricity to approximately 411 members in the southern portion of the Town. Green Mountain Power serves the remaining north sections of Duxbury.

Natural springs and drilled wells provide water to most sections of Town; however, residences in Duxbury Corner, students at Crossett Brook Middle School, and the Town Offices are served by the Waterbury municipal system. Wastewater treatment within the town is treated by individual subsurface disposal facilities. These facilities are regulated by the State's wastewater regulations.

The Waterbury Fire Department provides fire coverage in the northern section of Duxbury, while the Moretown Fire Department provides protection for residents in the southern section. Both Waterbury and Moretown Fire Departments are members of the Capital Fire Mutual Aid System, which is composed of approximately 45 departments in Washington, Orange and Caledonia Counties. The Departments responded to a combined 32 calls in 2004, which includes grass fires, propane leaks, automobile accidents and structural fires. There were 21 responses

to fire calls in 2016. Waterbury Ambulance Service responds to emergencies throughout the Town, with back up support provided by The Mad River Valley Ambulance Service. The Ambulance departments report they responded to a total of 67 calls in 2016.

Police services are provided by the Vermont State Police stationed at the Middlesex Barracks. Thatcher Brook Primary School serves as the Town's Primary Emergency Shelter. The Town has a warming shelter in the Town Garage and other buildings that could provide shelter are Crossett Brook Middle School, and Harwood Union High School and Green Mountain Community Alliance Church. Backup generators are located at Thatcher Brook Primary School and the Town Garage.

The Town Plan was adopted in 2014 and includes goals, policies, and tasks in regards to natural resources, future land use, flood resiliency, wastewater treatment, transportation, and public services. The 2011 Zoning Ordinance greatly limits development within the Ecological Reserve Lands District, any land above 2,500 feet. Only low-impact uses are permitted within this District and special consideration must be made in regards to erosion control. In addition, the Ordinance prescribes a Flood Hazard Overlay District that limits the construction of structures within the National Flood Insurance Program's 100-year floodplain. The Town is in the process of updating its zoning regulations, including those that relate to flood hazards.

4. Planning Process and Maintenance

4.1 Planning Process

The Duxbury Emergency Management Team assisted by the Planning Commission coordinated the Duxbury Local Hazard Mitigation Plan process. Emergency Management and Planning Commission members updated the 2011 LHMP with the intention of submitting the update for review to the Selectboard at the December meeting. The purpose of the December review will be to identify future hazard mitigation programs, projects and activities based off of an assessment of past projects and a predictive analysis of future weather events.

The 2018 update indicates that the Town continues to be most vulnerable to flash flood/flood/fluvial erosion, hurricanes/severe storms/tropical storms, and wildfire/forest fire. Previously identified hazards include flooding, power shortage/failure, and forest fires. The Town will focus on flooding hazards as these events are the most common.

Changes identified at the December Selectboard meeting will be made and a notice for public review and comments on the draft will be posted. Additional opportunities for the public to weigh in on the planning process have been made available at Emergency Management meetings, Selectboard meetings and via opportunities through the zone reporting system. After public comments are considered and the draft plan is updated it will be made available during Town Meeting Day and local meetings with State and local officials to allow for more public comment and review. After Approval Pending Adoption, the plan will go before the

Select Board for adoption with and anticipated adoption date of 26 March 2018. Public comments submitted in the future will be reviewed by the Select Board (and CVRPC Staff dependent on funding) and attached as an appendix.

Also during the Town Meeting a LHMP Committee will be identified and a Chairperson appointed. The LHMP will update the plan annually and provide updates at all future Town Meeting Days.

4.2 Plan Update Process

The 2018 LHMP update will be submitted as a single jurisdiction local mitigation plan.

The current plan is not a drastic departure from the 2011 plan, however, significant analysis was done to best determine where the Town should put resources in the future.

General Updates

- Update of all data and statistics using available information (Section 3)
- Revaluation, identification and analysis of all significant hazards (Section 5)
- Acknowledgment of implemented mitigation strategies since 2011 – see matrix below (section 4.2)
- Identification of on-going mitigation projects and strategies – see Existing Mitigation Programs, Projects and Activities section (section 4.2)

Hazard Analysis Updates (Sections 5 and 6)

- New hazards added – severe storms, winter storms, dam failures
- Added location/vulnerability/extent/impact/likelihood table for each hazard to summarize hazard description (Section 5.1-5.3 – after each hazard)
- Review of Vermont Hazard Mitigation Plan (Section 5 – hazard analysis table)

Maps

- Review of 2017 Areas of Concern map – updated flood prone areas, added forest layer
- Review of 2016 Culvert and Bridge Survey

Updates to the 2018 LHMP included a review of all of Duxbury's planning documents.

The following chart provides an overview of Duxbury's proposed 2011 local hazard mitigation actions along with their current status. Additionally since the 2011 plan, the Town is in the process of updating their flood regulations post TS Irene to maintain NFIP compliance.

2011 Mitigation Action	2018 Status
Update homebound persons phone tree	Work in progress. Use the CARE form from Vermont 211 to gather information and update. Perform a sensitive populations survey.

Provide backup power to town shelters	The town garage has backup power and can be used as a warming shelter as required.
Upgrade bridge on Pitts/Camels Hump Rd	3-5 Years. Must prioritize and budget
Upgrade bridge on Camels Hump Rd	3-5 Years. Must prioritize and budget
Upgrade box culvert on Camels Hump Rd	3-5 Years. Must prioritize and budget
Work with State to develop wildfire suppression methods for the State Forest	3-5 Years
Work with appropriate officials to ensure continues NFIP compliance	2-3 Years
Participate in a Stream Geomorphic assessment	Still interested in – no funding

Existing Mitigation, Maintenance, and Preparedness Programs, Projects & Activities

The ongoing or recently completed programs, projects and activities are listed by strategy and have occurred since the development of the previous plan.

Community Preparedness Activities

- VTAlert was adopted by the Town in 2016 as the official Emergency Management notification system
- Capital Equipment Plan
- Water Supply Contamination Plan
- Homebound Persons Phone Tree
- The list of equipment that residents have to assist in emergency management systems was updated.
- Development of a Red Cross Shelter in Duxbury is being explored.

Hazard Control & Protective Works

- Maintenance Programs (Culvert Survey & Replacement) – CVRPC Survey 2016
- Informal Winooski River dam release agreement with Green Mountain Power?
- Adoption of new VTrans bridge and culvert standards –2016?

Insurance Programs

- Participation in NFIP

Land use Planning/Management

- Ecological Reserve Lands District

    - Section 1 – Above 2,500 feet, all structures prohibited except Conditional Uses for structures associated with low intensity non-commercial recreation.
      Development in this area must make special consideration for impact on wildlife habitat and natural vegetative cover, along with erosion control
- Timber Management & Wildlife District
    - Section 2 – Between 1,500 feet and 2,500 feet only low impact, nonstructural development is a Permitted Use and minimum lot sizes are 25 acres. Low impact structures are a Conditional Use.
- Flood Hazard Overlay District
    - Section 7 – Limits construction of structures in floodplain areas designated within the Flood Insurance Rate Map for Duxbury.
- Zoning Ordinances are being updated

Protection/Retrofit of Infrastructure and Critical Facilities

- Dry hydrants – 2
- Spare batteries for the repeaters were purchased so that repeater coverage will be available during power outages.
- Radio equipment was purchased so that each zone captain has a portable radio with an automobile antenna. In addition, reflective vests and highway cones were purchased for each zone.

Public Awareness, Training & Education

- VTAlert exercise messages have been sent to Town Residents and all Residents are encouraged to sign up to receive alerts.
- Semi Annual radio checks and an annual table top exercises are being scheduled.
- A mailing will be sent to residents to reinforce the town zone system.

4.3 Plan Maintenance Process

The Duxbury Local Hazard Mitigation Plan will be updated and evaluated annually by a LHMP Committee to be created at the 2018 Town Meeting. At Future February Selectboard meetings the LHMP Committee will present recommend updates to the board. A review of the Basic Emergency Operations Plan will also occur at this meeting. Updates and evaluation by the Select Board will also occur within three months after every federal disaster declaration and as updates to town plan/zoning and river corridor plans come into effect. The plan will be reviewed by the Select Board, Planning Commission and public at the abovementioned February Select Board meeting. CVRPC will help with updates or if no funding is available, the Select Board Chair will update the plan.

The process of evaluating and updating the plan will include continued public participation through public notices posted on the municipal website, notice in the municipal building, Valley Reporter, Front Porch Forum, Duxbury Store, Crossett School, bottom of Camel's Hump Rd., and CVRPC newsletter and blog inviting the public to the scheduled Select Board (or specially scheduled) meeting. Additional stakeholders invited to the meeting will be the School. Also invited in the future will be the VT Agency of Natural Resources (VT ANR), as they are able to provide assistance with NFIP outreach activities, models for stricter floodplain zoning regulations, delineation of fluvial erosion hazard areas, and other applicable initiatives. These efforts will be coordinated by the Select Board.

Monitoring of plan progress, implementation, and the 5 year update process will be undertaken by the Select Board Chair and the LHMP Committee. Monitoring updates may include changes in community mitigation strategies; new town bylaws, zoning and planning strategies; progress of implementation of initiatives and projects; effectiveness of implemented projects or initiatives; and evaluation of challenges and opportunities. If new actions are identified in the five year interim period, the plan can be amended without formal re-adoption during regularly scheduled Select Board meetings. After a five year period, the plan will be submitted for re-adoption following the process outlined the schematic found in the Attachments section.

Duxbury shall also consider incorporation of mitigation planning into their long term land use and development planning documents. It is recommended the Town review and incorporate elements of the Local Hazard Mitigation Plan when updating the municipal plan, zoning regulations, and flood hazard/FEH bylaws. The incorporation of the Local Hazard Mitigation Plan into the municipal plan, zoning regulations and flood hazard/FEH bylaws will also be considered after declared or local disasters. The Town shall also consider reviewing future Winooski River planning documents for ideas on future mitigation projects and hazard areas.

5. Risk Assessment

5.1 Hazard Identification and Analysis

The following natural disasters were discussed and the worst threat hazards were identified based upon the likelihood of the event and the community's vulnerability to the event. Hazards not identified as a "worst threat" may still occur. Greater explanations and mitigation strategies of moderate hazards can be found in the State of Vermont's Hazard Mitigation Plan.

Hazard	Likelihood [1]	Community Vulnerability[2]	Worst Threat
Avalanche/ Landslide	Low	No	

[1] High likelihood of happening: Near 100% probability in the next year.
Medium likelihood of happening: 10% to 100% probability in the next year or at least once in the next 10 years.
Low likelihood of happening: 1% to 10% probability in the next year or at least once in the next 100 years.

[2] Does the hazard present the threat of disaster (Yes)? Or is it just a routine emergency (No)?

Dam Failures (beaver)	Med	No	
Drought	Low	No	
Earthquake	Low	No	
Extreme Cold/Winter Storm/Ice Storm/Power Failure	High	No	
Flash Flood/Flood/Fluvial Erosion	Med	Yes	X
High Wind	Low	No	
Hurricane/Tropical Storm/Severe Storms	Med	Yes	X
Structure Fire	Low	No	
Tornado	Low	No	
Water Supply Contamination	Low	No	
Wildfire/Forest Fire	Med	Yes	X

The following hazards were found to be most significant in the Town of Duxbury:

- Flash Flood/Flood/Fluvial Erosion
- Hurricane/Severe Storms/Tropical Storms
- Wildfire/Forest Fire

Due to the frequent and severe nature of flooding events, Duxbury feels flooding is the worst natural hazard within the Town and will focus on mitigation efforts to reduce the impacts from flooding events.

Non worst threat hazards include
- Dam Failures (Bolton Falls No. 1, Duxbury Mill, Ice Pond, beaver dams)
    - Duxbury is in the flood inundation zone for both Waterbury and Wrightsville Dams
- Extreme Cold/Winter Storm/Ice Storm/Power Failure

A discussion of each significant hazard is included in the proceeding subsections and a map identifying the location of each hazard is attached (See map titled *Areas of Local Concern.*) Each subsection includes a list of past occurrences based upon County-wide FEMA Disaster Declarations (DR-#) plus information from local records, a narrative description of the hazard and a hazard matrix containing the following overview information:

Hazard	Location	Vulnerability	Extent	Impact	Probability
Type of hazard	General areas within municipality which	Types of structures impacted	Magnitude of hazard: Scale dependent on	Dollar value or percentage	Likelihood of hazard occurring based upon past events:

	are vulnerable to the Identified hazard.		hazard	of damages	HIGH = 10% to 100% probability within the next year or at least once in the next 10 years. MED = less than 10% to 100% probability within the next year or less than once in the next 10 years.

5.2 Worst Threat Hazards

Flash Flood/Flood/Fluvial Erosion

History of Occurrences: Local and County Wide Data – nearest flood gauges are Winooski Gauge, Waterbury and Mad River Gauge, Moretown (from NCDC website and FEMA DR List)

Date	Event	Location	Extent
8/28/2011	Flood/Tropical Storm	Statewide, Duxbury	Winooski Flood gauge knocked out – above 423.3 feet (flood stage is 419 feet) – DR 4022
5/27/2011	Flood	Duxbury	Winooski flood gauge at 423.3 feet DR 4001
4/11/2011	Flood	Duxbury	Winooski flood gauge at 421.0 feet
10/01/2010	Flood	Duxbury	Winooski flood gauge at 421.8 feet
1/19/2006	Flood, Ice jam	Duxbury	Winooski flood gauge at 421.9 feet
12/17/2000	Flood	County Wide	3” of rain, $1 M in damages
6/27/1998	Flash Flood	County Wide	3-6” of rain over 2 day period – Mad River flood gauge at 14.13 feet (flood stage is 9 feet) DR 1228
1/19/1996	Flood; ice jam	County Wide	3-5” of rain, not historical crest
8/4/1995	Flood	County wide	$1.5 M damages; Mad River gauge at 8.12 ft
8/10/1976	Flood	County Wide	Mad River flood gauge at 13.47 feet DR 518
9/22/1938	Flood	County Wide	Mad River flood gauge at 16.34 feet
11/03/1927	Flood	County Wide	Mad River flood gauge at 19.40 feet

Flooding/flash flooding/fluvial erosion is Duxbury’s most commonly recurring hazard. Flooding is the overflowing of rivers, streams, drains and lakes due to excessive rain, rapid snow melt or ice. Flash flooding is a rapidly occurring flood event usually from excessive rain. Fluvial erosion is the process of natural stream channel adjustments. Fluvial erosion causes erosion of

sediment in some areas, while causing aggradation of sediment in other. Fluvial erosion processes occur more quickly and severely during flood events.

The major water bodies within the Town of Duxbury are: Ridley Brook, which drains the northwestern portion of the Town into the Winooski; Crossett and Dowsville Brooks draining the eastern section of Town; and Shepard Brook, which provides drainage to a small area in the southwestern portion of Town. The Winooski River, which serves as the Town's northern border, drains into Lake Champlain. These waterways drain the Green Mountain's principle eastern ridge, resulting in a vertical drop of over 3,700 feet within the Town. As a result, there exists great variability in the streams' water levels, which makes them prone to flooding and erosion during snowmelt and after heavy rains.

The majority of the Town's National Flood Insurance Program (NFIP) designated 100-year floodplain is located along the Winooski and out of reach of most of the Town's built environment. However, based on the results of overlaying the FIRM flood maps with the location of the E911 points, there exist 37 buildings and 70 properties in the Town that are vulnerable to potential flooding. The estimated loss for a severe flooding event for all properties located within the Town's 100-year floodplain is approximately $32,468,400. There are no repetitive loss structures in Duxbury.

As previous events have made clear, even areas beyond the NFIP designated 100-year floodplain may be vulnerable to flood related hazards. Channel adjustments with devastating consequences have frequently been documented wherein such adjustments are linked to historical channel management activities, floodplain encroachments, adjacent land use practices and/or changes in watershed hydrology associated with conversion of land cover and drainage activities, within and beyond the NFIP floodplain. The attached Local Areas of Concern Map identifies the Crossett Brook Middle School and Town Offices, as well as other buildings, as outside the designated floodplain, but nearest major waterways.

In order to maintain NFIP compliance, Duxbury adopted a flood hazard overlay district to limit new development in flood prone areas. The Development Review Board is charged with reviewing development applications in the overlay areas. The Zoning Administrator is charged with enforcement of the regulations. The overlay is based on the NFIP 100 year floodplain data. Duxbury's current FIRM date is 3/19/2013. New digital flood maps for Washington County are in the preliminary approval stages as of writing this plan. The Town has three policies in force for a total coverage of $2,358,800. The Town has not reported any flood hazard regulation compliance issues.

The worst anticipated flooding varies throughout the Duxbury due to the terrain. Most flooding in the highlands is experienced as flash flooding. The worst flooding event in Duxbury's recorded history occurred in 1927, followed closely the 2011 events in April, May and August. Data from the Winooski flood gauge for the 1927 is not available. The Mad River gauge was 10 feet above flood stage. During Irene, the Winooski flood gauge was damaged and the Mad River flood gauge was 10 feet above flood stage. Lesser but more regular flooding occurs in

Duxbury, with generally 1 -2 feet of flooding in low lying areas every two or three years. In the future, Duxbury can better gather data for flooding extent by having individuals call in local flood levels in areas around Duxbury.

In 2011, storms in April, May and August caused severe damage to Duxbury public and private infrastructure. Duxbury estimates that it cost close to $2 million to repair public infrastructure damages from the storms. Damage to road and culverts from the April storm occurred on:

- Camels Hump Rd – slide on lower road, bridge abutment severely damaged
- Dowsville Rd
- Scrabble Hill Rd
- Mountain View Rd
- Legal trails – Wescott Rd
- Ward Hill Rd
- Crossett Hill Rd – bridge and road damage
- River Rd
- Pollander Rd

On August 28, 2011, 4-5" of rain fell during Tropical Storm Irene. Damages from Irene cost the Town approximately $750,000. Tropical Irene storm damaged occurred in the following areas:

- Stevens Brook Rd – culvert
- Dowsville Rd – 6 ft culvert
- Camel's Hump Rd – lower portion again, bridge 41 at Marshall Rd
- Crossett Hill Rd
- River Rd

Camels Hump Road is partially closed for the winter and only open to local traffic due to damages to the bridge and road.

In addition to public infrastructure, there was extensive damage to private driveways on steep hills, and riverside properties in low lying areas, especially mobile home parks. Mobile home parks that were damaged were Crossett Hill and Duxbury Corner mobile home parks.

Hazard	Location	Vulnerability	Extent	Impact	Probability
Flood/Flash Flood/Fluvial Erosion	Camel's Hump Rd, Dowsville Rd, Scrabble Hill Rd, Mountain View Rd, Wescott Rd, Ward Rd, Crossett Hill Rd, flood plain	Roads, bridges, culverts, mobile home parks, properties in floodplain	Winooski River gauge highest recorded historical crest at 423' on 5/28/11; gauge damaged during TS Irene event, but water was	Over $2 million	medium

			higher		

Vermont's Act 64 is our legislature's response to the effects of flooding and runoff from roads connected to its major streams, rivers, ponds and lakes. Full implementation begins in 2018. It provides guidelines and goals to communities throughout Vermont for improving the resilience of roads during severe weather thereby enabling them to be more effective in diverting pollutants and sediment from entering these water resources. It provides grant opportunities to aid municipalities in funding the remediation of erosion or flood-prone areas. Many towns are already engaged in implementing the Act's directives. 2038 is the target year for the successful completion of road improvements required for all municipalities via an incremental yearly approach.

Damage to roads and the cost of their rehabilitation is a continuing challenge for communities around the state. Although no storms approaching Tropical Storm Irene's magnitude have occurred since 2011, heavy rainfall at rapid rates of accumulation continue to effect road infrastructure. Events are often localized but cumulatively have sometimes triggered federal and state disaster status allowing grant money to be accessed by affected communities. The following table shows the cost of some major events that have occurred in Duxbury since 2014.

Year	Weather Event	Location	Work needed	Cost
April 15–18 2014	Heavy rain, flooding	River Rd–four culverts, Scrabble Hill Rd–	6 culverts; road washout repair	Federal/state cost ~$200.000
June 19 2015	Heavy rain, flooding	Mountainview Rd, Camels Hump Rd Scrabble Hill Rd–	ditching w/ stone-lining, culvert installation and replacement, road surface repair	~$70,000
August, ●●● 2016	Heavy rain, flooding	Welch Rd, Turner Hill, Stevens Brook Rd, Crossett Hill Culvert replacement, road restoration	Culvert replacement, road restoration	~$70,000

Year	Weather Event	Location	Work needed	Cost
■■■■■	Heavy rain	Dowsville Rd	Professional engineering Large Culvert Replacement Temporary remediation	

Hurricanes/Tropical Storms/Severe Storms

History of Occurrence (from NCDC website and FEMA DR List):

Date	Event	Location	Extent
8/28/2011	TS Irene	Statewide	~6” rain , Mad River flood gauge at 19.07 feet; 9 ft is flood stage (Winooski gauge damaged) DR 4022
5/27/2011	Severe Storm, flash flooding	Waterbury Center	1” hail, 3-5” of rain, 52 knot winds DR 4001
7/21/2008	Severe storms, flooding	County Wide	3-5” of rain
8/25/2007	Severe Storms	Waterbury Center	65 mph wind gusts, 1” hail
7/9/2007	Severe Storms, hail, flooding	Duxbury, Waterbury, Middlesex	1”-2.75” hail. $20k property damages, DR 1715
6/19/2006	Severe storms	Waterbury	55 knot winds, downed trees and power lines
8/1/2005	Severe Storm	Waterbury Center	1” hail
9/16/1999	Tropical Storm Floyd	Statewide	Tropical Storm, DR 1307, Mad River gauge 8.23 feet
6/17/1998	Severe Storms	County Wide	DR 1228, Mad River gauge 14.13 feet
5/29/1998	Severe Storms	Duxbury, Waterbury, Middlesex	50 knot winds, heavy rains, downed trees and power lines
7/15/1997	Severe Storms	County Wide	Data gap - gauge data not available
8/4-6/1995	Severe storms, flooding	County Wide	DR 1063 – 3-6” of rain – Mad River gauge at 8.12 ft

7/23/1990	Severe Storms, flash flooding	County Wide	DR 875 – not a historical crest
8/4/1989	Severe Storms, Flooding	County Wide	DR 840 – Mad River gauge at 10.23 feet
6/7/1982	Severe Storms	New England	14" of rain, $276 M damages
8/5/1976	Hurricane Belle	Statewide	Gale force winds, 2 deaths, DR 518 - gauge data not available
7/3/1964	Hail	County Wide	1.5" hail
9/22/1938	Hurricane	Statewide	Category 1 force winds - gauge data not available

Hurricanes and tropical storms are violent rain storms with strong winds that have large amounts of rainfall and can reach speeds up to 200 mph. Hurricane season is between the months of June and November. These types of storms originate in the warm waters of the Caribbean and move up the Eastern seaboard where they lose speed in the cooler waters of the North Atlantic. A severe thunderstorm is a thunderstorm that contains any one or more of the following three weather conditions: hail that is 3/4 of an inch or greater in diameter , winds 58 miles per hour or greater, and/or tornadoes. Severe storm events can occur in late spring and early summer as temperatures increase in the summer season. The frequency and intensity of hurricanes, tropical storms, and severe storms is expected to increase with climate change.

The impacts associated with hurricanes and severe storms are mainly associated with flooding impacts. Damage locations from April, TS Irene, and the May 28, 2011 storm events are outlined in the Flood/Flash Flood/Fluvial Erosion hazard section. There were no high wind impacts associated with these events.

Similar to flooding, the extent of severe storms is not well documented in the Town of Duxbury. The impact of storms is usually flood related. See flood extent description in flood section above. Wind extent from storms is not well documented as there is no monitoring station in Duxbury. Estimates for wind are gathered from county wide data off the NCDC website. To date, the worst wind extent in Duxbury were hurricane force winds from Hurricane Belle. In the future, Duxbury could consider installing a monitoring station on major brooks and training staff as spotters to better gather data for wind and flood events. The scales used by spotters to measure the extent of the severe storm events are:

Beaufort Scale

Beaufort number	Wind Speed (mph)	Seaman's term		Effects on Land
0	Under 1	Calm		Calm; smoke rises vertically.
1	1-3	Light Air		Smoke drift indicates wind direction; vanes do not move.
2	4-7	Light Breeze		Wind felt on face; leaves rustle; vanes begin to move.
3	8-12	Gentle Breeze		Leaves, small twigs in constant motion; light flags extended.
4	13-18	Moderate Breeze		Dust, leaves and loose paper raised up; small branches move.
5	19-24	Fresh Breeze		Small trees begin to sway.
6	25-31	Strong Breeze		Large branches of trees in motion; whistling heard in wires.
7	32-38	Moderate Gale		Whole trees in motion; resistance felt in walking against the wind.
8	39-46	Fresh Gale		Twigs and small branches broken off trees.
9	47-54	Strong Gale		Slight structural damage occurs; slate blown from roofs.
10	55-63	Whole Gale		Seldom experienced on land; trees broken; structural damage occurs.
11	64-72	Storm		Very rarely experienced on land; usually with widespread damage.
12	73 or higher	Hurricane Force		Violence and destruction.

Saffir-Simpson Scale for Hurricane Classification				
Strength	**Wind Speed (Kts)**	**Wind Speed (MPH)**	**Pressure (Millibars)**	**Pressure**
Category 1	64- 82 kts	74- 95 mph	>980 mb	28.94 "Hg
Category 2	83- 95 kts	96-110 mph	965-979 mb	28.50-28.91 "Hg
Category 3	96-113 kts	111-130 mph	945-964 mb	27.91-28.47 "Hg
Category 4	114-135 kts	131-155 mph	920-944 mb	27.17-27.88 "Hg
Category 5	>135 kts	>155 mph	919 mb	27.16 "Hg
Tropical Cyclone Classification				
Tropical Depression	20-34kts			
Tropical Storm	35-63kts			
Hurricane	64+kts or 74+mph			

Combined NOAA/TORRO Hailstorm Intensity Scales

Size Code	Intensity Category	Typical Hail Diameter (inches)	Approximate Size	Typical Damage Impacts
H0	Hard Hail	up to 0.33	Pea	No damage
H1	Potentially Damaging	0.33-0.60	Marble or Mothball	Slight damage to plants, crops
H2	Potentially Damaging	0.60-0.80	Dime or grape	Significant damage to fruit, crops, vegetation
H3	Severe	0.80-1.20	Nickel to Quarter	Severe damage to fruit and crops, damage to glass and plastic structures, paint and wood scored
H4	Severe	1.2-1.6	Half Dollar to Ping Pong Ball	Widespread glass damage, vehicle bodywork damage
H5	Destructive	1.6-2.0	Silver dollar to Golf Ball	Wholesale destruction of glass, damage to tiled roofs, significant risk of injuries
H6	Destructive	2.0-2.4	Lime or Egg	Aircraft bodywork dented, brick walls pitted
H7	Very destructive	2.4-3.0	Tennis ball	Severe roof damage, risk of serious injuries
H8	Very destructive	3.0-3.5	Baseball to Orange	Severe damage to aircraft bodywork
H9	Super Hailstorms	3.5-4.0	Grapefruit	Extensive structural damage. Risk of severe or even fatal injuries to persons caught in the open
H10	Super Hailstorms	4+	Softball and up	Extensive structural damage. Risk of severe or even fatal injuries to persons caught in the open

Hazard	Location	Vulnerability	Extent	Impact	Probability
Hurricane/ Severe Storms/Tropical Storms	Camel's Hump Rd, Dowsville Rd, Scrabble Hill Rd, Mountain View Rd,	Roads, bridges, culverts, mobile home parks, properties	Winooski River historical crest at 423' on 5/28/11; gauge damaged during TS Irene	Over $2 million	medium

	Wescott Rd, Ward Rd, Crossett Hill Rd, flood plain	in floodplain	event		

Wild Fire/Forest Fires

FEMA indicates there are three classes of wild land fires – surface fires, ground fires and crown fires, with the most common type indicated as a surface fire. Surface fires burn slowly along the forest floor, killing and damaging trees. Ground fires burn on or below the forest floor and are usually caused by lightning. Crown fires move quickly by jumping along the tops of trees. Crown fires can spread quickly during windy conditions.

Approximately 90 percent, or 27,000 acres, of Duxbury is wooded. Despite the absence of recent forest fires of significant size, the volume of the Town's forested landscape in conjunction with dry and windy weather has the potential to rapidly spread fire and create a hazardous situation. Much of Duxbury is unreachable by road and an extensive dry hydrant system does not exist, limiting firefighting ability. Properties within the Town's interior are at greatest risk to forest fires; especially in the case where access is limited to a single road, such has Devlin Road, Richardson Road, and the properties off of Camels Hump Road. Approximately 122 residences are located within these three areas. Using Duxbury's average grand list property value, the approximate total value of properties with the greatest risk to forest fire is approximately $34 million.

Hazard	Location	Vulnerability	Extent	Impact	Probability
Wildfire/Forest Fire	Camel's Hump State Forest, Town Wide, Devlin Rd, Richardson Rd, Camels Hump Rd	Properties on urban/forest interface, private homes, road infrastructure	To date - 0 acres, total forested area - 27,000 acres	$34 million, plus firefighting costs	Medium

5.3 Moderate Threat Hazards

Dam Failures (beaver)

The dams of concern in Duxbury are beaver dams. The exact number and location of all the beaver dams is unknown; however, the majority of them are located in Camel's Hump State Park and the heavily wooded areas of Duxbury. Known locations of beaver dams include:

- Vigilante Rd
- VAST Trail in Camel's Hump State Park

- Dowsville Rd
- Atwood Rd

There have been several occurrences of beaver dams washing out and flooding downstream property. The most recent breech occurred in April 2011. The previous winter had been especially snowy, followed by a period of heavy rain. The dam on Dowsville Rd was washed out. The additional water from the dam in conjunction with the heavy rains and snowmelt damaged a 6 foot culvert downstream of the dam.

Hazard	Location	Vulnerability	Extent	Impact	Probability
Dam Failure (beaver)	Camel's Hump State Park, Vigilante Rd, VAST Trails, Dowsville Rd, Atwood Rd	Roads, culverts	Data gap – depends on severity of event	Depends on severity rain/ snowmelt events	Medium

Winter Storm/Ice Storm/Extreme Cold/Power Outage

History of Occurrence (from NCDC website and FEMA DR List.) Due to the area-wide nature of winter storms, snowfall depths vary in and around the Town of Duxbury:

Date	Event	Location	Extent
3/6/2011	Winter storm	Washington County, Duxbury	15-25" of snow, 10,000 customers lost power statewide
2/23/2010	Winter Storm	Washington County, Duxbury	20" of snow and 50,000 customers lost power statewide
2/22/2009	Winter Storm	Washington County, Duxbury	10-18" of snow, 30 mph wind gusts
2/1/2008	Winter storm	Washington County, Duxbury	3-7" of snow and ice ¼-1/2"thick, 50 mph wind gusts
2/14/2007	Winter storm	Washington County, Duxbury	18-22" of snow
1/4/2003	Winter storm	Washington County, Duxbury	12-20" of snow
3/5/2001	Winter storm	Washington County, Duxbury	15-30" of snow
12/31/2000	Winter storm	Washington County, Duxbury	15" of snow
12/29/1997	Winter storm	Washington County, Duxbury	8-21" of snow
12/7/1996	Winter Storm	Washington County, Duxbury	12" of snow

3/21/1994	Winter storm	Washington County, Duxbury	5-11” of snow
11/1/1993	Winter storm	Washington County, Duxbury	10-20” of snow
1/3/1993	Freezing Rain	Statewide	

A winter storm is defined as a storm that generates sufficient quantities of snow, ice or sleet to result in hazardous conditions and/or property damage. Ice storms are sometimes incorrectly referred to as sleet storms. Sleet is similar to hail only smaller and can be easily identified as frozen rain drops (ice pellets) that bounce when hitting the ground or other objects. Sleet does not stick to wires or trees, but in sufficient depth, can cause hazardous driving conditions. Ice storms are the result of cold rain that freezes on contact with the surfaces coating the ground, tress, buildings, overhead wires and other exposed objects with ice, sometimes causing extensive damage. Periods of extreme cold tend to occur with these events.

Although winter storms and periods of cold temperatures are a frequent occurrence, the extent of winter storms within Duxbury is difficult to estimate as it is dependent on the size and path of the storm.

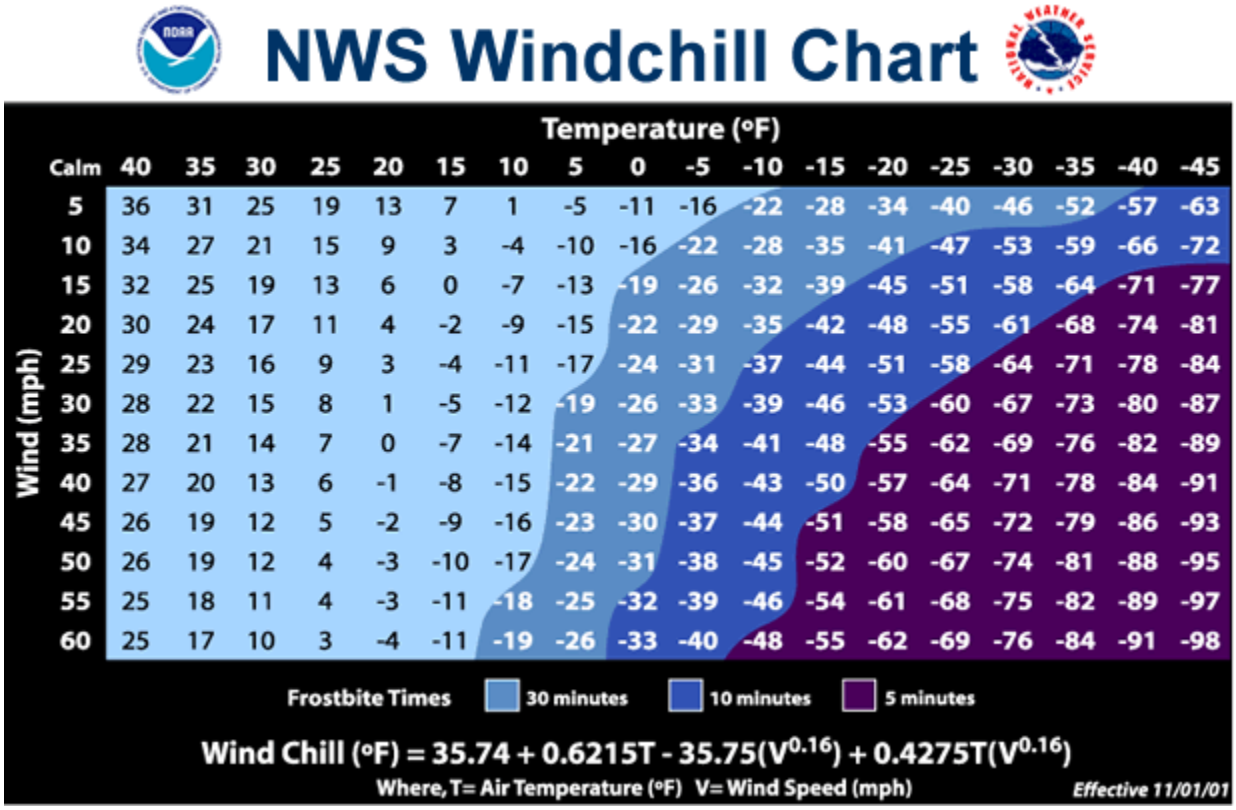
For the next plan update, Duxbury will more closely monitor winter storms and collect data to determine the worst extent possible on the Town. Based on past occurrences, the worst anticipated winter weather Duxbury could experience would be 2-3’ of snow with more at higher elevations and several days of power outages. The worst recent storm was in March 2011, and after that the Blizzard of 1888. Extent data can be based on volumes of snow, winter weather alerts issued, or wind chill factor. See tables below for descriptions and scales.

Extent Scale - Winter Weather Alerts

Winter Weather advisory	This alert may be issued for a variety of severe conditions. Weather advisories may be announced for snow, blowing or drifting snow, freezing drizzle, freezing rain, or a combination of weather events.
Winter storm watch	Severe winter weather conditions may affect your area (freezing rain, sleet or Heavy snow may occur separately or in combination).
Winter Storm Warning	Severe winter weather conditions are imminent.
Freezing rain or freezing drizzle	Rain or drizzle is likely to freeze upon impact, resulting in a coating of ice Glaze on roads and all other exposed objects.
Sleet	Small particles of ice usually mixed with rain. If enough sleet accumulates on the ground, it makes travel hazardous.
Blizzard Warning	Sustained wind speeds of at least 35 mph are accompanied by considerable falling or blowing snow. This alert is the most perilous winter storm with visibility dangerously restricted.
Frost/freeze	Below freezing temperatures are expected and may cause significant damage

warning	to plants, crops and fruit trees.
Wind Chill	A strong wind combined with a temperature slightly below freezing can have the same chilling effect as a temperature nearly 50 degrees lower in a calm atmosphere. The combined cooling power of the wind and temperature on exposed flesh is called the wind-chill factor.

Wind Chill Extent Scale



One of the major problems associated with ice storms is the loss of electrical power. Major electric utility companies have active, ongoing programs to improve system reliability and protect facilities from damage by ice, severe winds and other hazards. Typically, these programs focus on trimming trees to prevent encroachment of overhead lines, strengthening vulnerable system components, protecting equipment from lightning strikes and placing new distribution lines underground.

Electric service in Duxbury is provided by Green Mountain Power(GMP) and Washington Electric Cooperative Inc. (WEC) Each utility has a specific area they are allowed to serve under the State of Vermont rules governing a utilities service territory. WEC serves 395 residential homes and commercial businesses via 28.533 miles of high voltage distribution lines located in the town of Duxbury. In general WEC serves those homes and businesses located in the more remote areas of Duxbury served by dirt roads and located in the higher elevations of the Town.

WEC serves the Duxbury area from a substation several miles away located on the Moretown Common Road. Because the lines serve much of the remote and higher elevation areas in Duxbury they are more prone to damage from falling trees especially during heavy wet snows, ice storms and violent electrical storms. As a result, homes located in these areas may experience a higher frequency and duration of outages than homes located in the low lying areas and valleys such as those along the Route 100 corridor. GMP serves homes and businesses located generally along the Route 100, Route 100B and Route 2 corridors along the Winooski River and Mad River. These areas are not as prone to significant weather events and therefore experience a reduced frequency of outages. When outages do occur, access to make repairs is via a paved road and therefore can be done more quickly than in the more remote areas.

Both GMP and WEC have online real time outage tracking tools. In addition WEC and the Duxbury Emergency Team have redundant means of communication in place in the event of a sever outage in WEC territory.

Vulnerable populations, such as the elderly and handicapped are of greatest risk to this hazard. If this type of multiple hazard event takes place for an extended period of time, back-up power would be necessary for critical facilities such as the Crossett Brook Middle School, Thatcher Brook Primary School building, Harwood Union High School, Town Offices, and Town Highway Garage.

Duxbury does have a Homebound Persons Phone Tree that lists vulnerable residents. This list is disseminated to members of the community with All-Terrain Vehicles or Snowmobiles who volunteer to rescue their homebound neighbors in the case of a hazard.

By observing winter storm watches and warnings, adequate preparations can usually be made to lessen the impact of snow, ice and sleet, and below freezing temperature conditions on the Town of Duxbury. Providing for the mass care and sheltering of residents left without heat or electricity for an extended time and mobilizing sufficient resources to clear broken tree limbs from roads, are the primary challenges facing community officials. Shelter locations include: Crossett Brook School, Harwood Union High School and Thatcher Brook Elementary (Waterbury). The Town encourages residents who are in remote locations to be equipped with generators and backup fuel supplies in the event of prolonged power outages and travel restrictions.

Other major problems include closed roads and restricted transportation.

Hazard	Location	Vulnerability	Extent	Impact	Probability
Extreme Cold/Winter or Ice Storm in	Town Wide	Elderly & handicapped populations, remote	Minimal to Moderate depending on severity; 18+"	Depends on severity – additional sheltering/	High

conjunction with power failure		structures, old/under insulated structures, utilities, trees	in March 2011 event	plowing/ emergency services costs for town	

6. Mitigation

6.1 Town Plan (December 2014) Goals and Objectives that Support Local Hazard Mitigation

- The quality of the town's forest, water, air, wildlife and soil resources is protected and enhanced. (Natural Resources)
    - Make public and private new and existing infrastructure (e.g., culverts, roads, housing, etc.) more compatible with natural resources so that the impact on natural resource are minimized.
- Water resources and the built environment are not in conflict. (Flood Resiliency)
    - Avoid new development in identified flood hazard, fluvial erosion, and river corridor protection areas. If new development is to be built in such areas, it does not exacerbate flooding and fluvial erosion.
    - Encourage the protection and restoration of floodplains and upland forested areas that attenuate and moderate flooding and fluvial erosion.
    - Engage in flood emergency preparedness and response planning.
- Land development protects natural resources and maintains Duxbury's rural character by concentrating smaller scale commercial use and residential development in areas near services, reducing strain on infrastructure and providing access to open space for recreation. (Land Use)
    - Regulate land development in a manner that protects important natural resources while encouraging a range of land uses in appropriate locations.
    - Maintain existing forest resources while promoting sustainable forest product enterprises.
    - Concentrate residential development in areas that does not increase strain on town infrastructure or impact natural resources.
- Facilities, services, and utilities are safe, practical, efficient, reliable, affordable and available. (Community Utilities, Facilities and Services)
    - Provide emergency services to Duxbury residents at a level adequate to protect public health and safety.
    - Assure public health is protected through adequate waste disposal programs and systems.

6.2 Proposed Hazard Mitigation Programs, Projects & Activities

Hazard mitigation programs, projects and activities that were identified for implementation at the Duxbury Local Hazard Mitigation meeting:

Hazards Mitigated	Mitigation Action	Local Leadership	Prioritization	Funding Resources	Time Frame
Flooding, Severe storms	Upgrade sections of Crossett Hill Road to meet new State requirements	SB, Road Foreman	High	HMGP, town funds	1-2 years
Flooding, Severe Storms	Upgrade sections of Camels Hump Road to meet new State Requirements	SB, Road Foreman	High	HMGP, town funds	1-2 years
Flooding, Severe Storms	Upgrade and expand culvert on Atwood Rd	SB, Road Foreman	High	HMGP, town funds	years
Flooding, Severe Storms	Repair/Upgrade Head Wall on Scrabble Hill Road	ANR,SB,Road Foreman	High	HMGP, town funds	2-3 years
Flooding, Severe Storms	Upgrade and expand 6 foot culvert on Stevens Brook Rd	SB, Road Foreman	Medium	HMGP, town funds	2-3 years

VEM also emphasizes a collaborative approach to achieving mitigation on the local level, by partnering with ANR, VTrans, ACCD, Regional Planning Commissions, FEMA Region 1 and other agencies, all working together to provide assistance and resources to towns interested in pursuing mitigation projects and planning initiatives.

The mitigation activities are listed in regards to local leadership, possible resources, implementation tools, and prioritization. Prioritization was based upon the economic impact of the action, the Community's need to address the issue, the action's cost, and the availability of potential funding. The action's cost was evaluated in relation to its benefit as outlined in the STAPLEE guidelines.

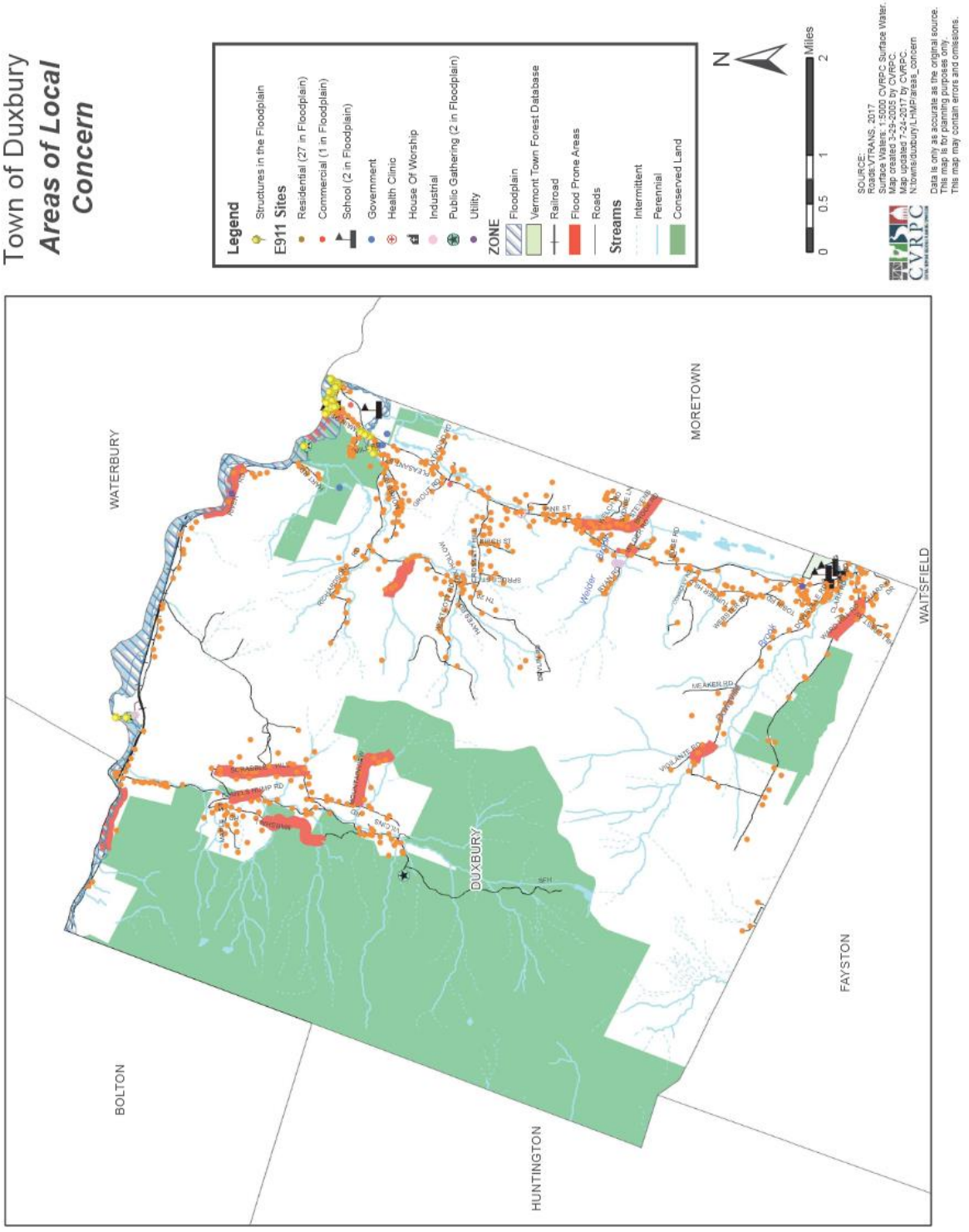
Duxbury understands that in order to apply for FEMA funding for mitigation projects that a project must meet FEMA benefit cost criteria. The Town must also have a FEMA approved Hazard Mitigation Plan as well.

A High prioritization denotes that the action is either critical or potential funding is readily available and should have a timeframe of implementation of less than two years. A Medium prioritization is warranted where the action is less critical or the potential funding is not readily available and has a timeframe for implementation of more than two years but less than four. A Low prioritization indicates that the timeframe for implementation of the action, given the action's cost, availability of funding, and the community's need to address the issue, is more than four years.

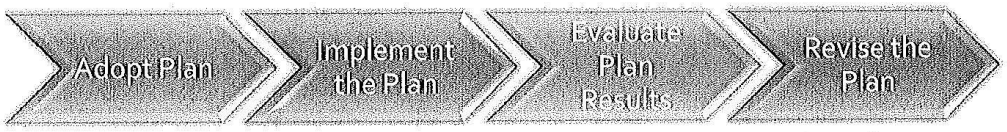
Attachments

- Areas of Local Concern Map
- 5 year plan maintenance and review process
- Town Resolution Adopting the Plan

2017 Local Area of Concerns Map



5-Year Plan Review/Maintenance



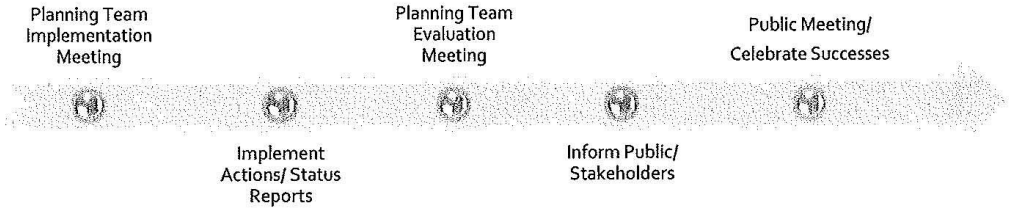
- Brief local leadership on plan approval
- Formally adopt plan
- Publicize plan approval and adoption
- Celebrate success

- Confirm/clarify responsibilities
- Integrate mitigaction actions
- Monitor and document implentation of projects and actions
- Establish indicators of effectiveness or success

- Effectiveness of planning process
- Effectiveness of actions
- Document success & challenges of actions
- Update and involve community
- Celebrate successes

- Review factors affecting community's context
- Analyze findings; determine whether to revise process or strategy
- Incorporate findings into the plan

After Plan Adoption-Annually
Implement and Evaluate



Fifth Year, and After Major Disaster
Evaluate and Revise