Discovery Report

Merrimack Watershed, 01070006
Essex, Middlesex, and Worcester Counties, Massachusetts; Belknap, Hillsborough, Merrimack, Rockingham, and Strafford Counties, New Hampshire
Communities listed inside cover
Report Number 02

06/30/2016

FEMA

Project Area Community List

Community Name
Essex County, MA
City of Amesbury
Town of Andover
Town of Boxford
Town of Georgetown
Town of Groveland
City of Haverhill
City of Lawrence
Town of Merrimac
City of Methuen
Town of Newbury
City of Newburyport
Town of North Andover
Town of Salisbury
Town of West Newbury
Middlesex County, MA
Town of Ashby
Town of Ayer
Town of Bedford
Town of Billerica
Town of Boxborough
Town of Burlington
Town of Chelmsford
Town of Concord
Town of Dracut
Town of Dunstable
Town of Groton
Town of Lexington
Town of Lincoln

Community Name
Middlesex County, MA, continued
Town of Littleton
City of Lowell
Town of North Reading
Town of Tewksbury
Town of Tyngsborough
Town of Westford
Town of Wilmington
City of Woburn
Worcester County, MA
Town of Ashburnham
Town of Harvard
Belknap County, NH
Town of Alton
Town of Barnstead
Town of Belmont
Town of Gilford
Town of Gilmanton
Hillsborough County, NH
Town of Amherst
Town of Bedford
Town of Bennington
Town of Brookline
Town of Deering
Town of Francestown
Town of Goffstown
Town of Greenfield

Project Area Community List, *continued*

Community Name
Hillsborough County, NH, continued
Town of Greenville
Town of Hollis
Town of Hudson
Town of Litchfield
Town of Lyndeborough
City of Manchester
Town of Mason
Town of Merrimack
Town of Milford
Town of Mont Vernon
City of Nashua
Town of New Boston
Town of New Ipswich
Town of Pelham
Town of Peterborough
Town of Sharon
Town of Temple
Town of Weare
Town of Wilton
Merrimack County, NH
Town of Allenstown
Town of Andover
Town of Boscawen
Town of Bow
Town of Canterbury
Town of Chichester

Community Name
Merrimack County, NH, continued
City of Concord
Town of Dunbarton
Town of Epsom
City of Franklin
Town of Henniker
Town of Hooksett
Town of Hopkinton
Town of Loudon
Town of Northfield
Town of Pembroke
Town of Pittsfield
Town of Salisbury
Rockingham County, NH
Town of Atkinson
Town of Auburn
Town of Candia
Town of Chester
Town of Danville
Town of Deerfield
Town of Derry
Town of East Kingston
Town of Hampstead
Town of Kensington
Town of Kingston
Town of Londonderry
Town of Newton

Project Area Community List, *continued*

Community Name	Community Name
Rockingham County, NH, continued	
Town of Northwood	
Town of Plaistow	
Town of Salem	
Town of Sandown	
Town of Seabrook	
Town of South Hampton	
Town of Windham	
Strafford County, NH	
Town of Farmington	
Town of New Durham	
Town of Strafford	

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I. General Information

The Merrimack HUC8 Watershed drains a large part of New Hampshire and northeastern Massachusetts through the Merrimack River and most of its tributaries. (Some of its largest tributaries drain their own HUC8 watersheds and are not included in this study: Concord River, Contoocook River, Nashua River, Pemigewasset River, and Winnipesaukee River.) The southern half of the watershed covers a heavily populated area of northern Massachusetts and southern New Hampshire, but northern parts of the watershed cover less developed areas with vegetation and higher elevations. The watershed is mostly inland and stretches into the foothills of the White Mountains, with a mean elevation of 450 feet NAVD88 and a maximum elevation of 2,357 feet NAVD88, and is relatively steep, with a mean slope of 10.62% (all determined from LiDAR). The Merrimack Watershed drains 1,801 square miles through 3,732 catalogued river miles. The major rivers draining the watershed include Merrimack River, Soucook River, Suncook River, Little Suncook River, Piscataquog River, Souhegan River, Spicket River, Shawsheen River, Little River, and Powwow River.

Because of the high risk to life and property associated with densely populated areas, many communities and flooding sources in the southern half of Merrimack Watershed have been prioritized in the past for detailed flood studies. Most large rivers and even many small rivers are currently mapped as Zones AE with high levels of detail in available flooding information (660 total miles, according to CNMS [FEMA, 2015a]). However, there are still many Zones A indicating areas of approximate study (782 total miles).

The Merrimack Watershed is a largely inland area with a centroid latitude of 43.0 degrees. The typical climate (NOAA's New Hampshire Climate Division 2) is an average January temperature of 19.2 °F, an average July temperature of 67.9 °F, and an average annual precipitation total of 44.41 inches (NOAA, 2016).

There are 110 communities in eight counties and two states that touch the Merrimack Watershed. (See the cover and the Project Area Community List.) According to the 2010 census (U.S. Census, 2010), the 110 communities have a total population of 1,557,681. Many of the peripheral communities have some area outside the watershed, so the total population inside the watershed is a marginally smaller number. The Merrimack Watershed is the one of the most heavily populated HUC8 watersheds in FEMA Region I (New England).

FEMA's Discovery effort in the Merrimack Watershed involves data collection, cursory analysis, and community outreach for the purpose of prioritizing work for new engineering analysis (surveying, hydrology, and hydraulics) and floodplain mapping within a limited financial budget.

II. Watershed Stakeholder Coordination

Watershed stakeholders include the communities in or touching the Merrimack Watershed, non-governmental organizations (NGOs) such as watershed associations and regional planning commissions, and state and Federal agencies. The Federal agencies involved in Discovery for the Merrimack Watershed are FEMA, the agency initiating the study, and the U.S. Geological Survey (USGS), the cooperating technical partner performing the study. In the Commonwealth of Massachusetts, the Department of Conservation and Recreation (MADCR) manages the National Flood Insurance Program (NFIP) and is directly involved with Discovery. In the State of New Hampshire, the Office of Energy and Planning (NHOEP) manages the NFIP and is directly involved with Discovery. The 110 communities and 13 various NGOs in Massachusetts and New Hampshire that touch the Merrimack Watershed were contacted in early June 2015 through an invitation letter to the Discovery Meeting. The full list of stakeholders contacted is included in this report as Appendix 1.

Community and NGO stakeholders were invited to submit data collection questionnaires and supporting technical data throughout the Discovery timeline. Data collection questionnaires were available as an online webform, a hardcopy paper form, and a digital Excel spreadsheet available online after the Discovery Meeting. Of the 123 stakeholder organizations identified, plus one unexpected Federal contributor, 14 responded by at least one of these means, and 10 others responded by other means (mail, email, or in person). To date, 24 organizations have furnished data applicable to Discovery. The remaining 100 organizations provided no response. One individual filed a response that he could not fill out the questionnaire because of time demands or insufficient knowledge. Overall, stakeholder engagement was minimally effective, positive, and informative.

In addition to data furnished for the purposes of shaping the scope of an engineering project, stakeholders provided information about their needs in understanding, assessing, and communicating flood risk in their communities. Communities that requested help from FEMA in various topics relating to flood risk are listed in Appendix 2, with the nature of the assistance needed.

III. Data Analysis

Data collected for or during Discovery are described below and discussed in two different categories – data that can be used directly for Flood Risk Projects, and other data. Other data include data that provide information that assists in the selection during Discovery of high-priority reaches for study in a potential Flood Risk Project, but that are likely not useful to the analysis in any other way.

i. Data that can be used for Flood Risk Projects

This section describes the availability and analysis of data that could potentially be used in the development of regulatory and (or) non-regulatory products in a Flood Risk Project (RiskMAP program).

Topographic Data

Light Detection and Ranging (LiDAR) elevation data are available for the entire Merrimack Watershed and were used in First Order Approximation (see below). LiDAR data for the western two-thirds of the watershed are from September 2012 (FEMA, 2012a); data for the remaining portions of the watershed in Massachusetts are from April 2011 (USGS, 2011a); and data for the remaining portions of the watershed in New Hampshire are from May 2011 (USGS, 2011b). A mosaicked LiDAR dataset for the entire watershed was created and will be available for floodplain mapping and analysis in a Flood Risk Project.

Basemap Data

Transportation, hydrography, and political boundary features shown on the Discovery and Community Information Maps were obtained from the online state GIS depots for Massachusetts (http://www.mass.gov/anf/research-and-tech/it-serv-and-support/application-serv/office-of-geographic-information-massgis) and New Hampshire (http://www.granit.unh.edu) in 2012. The hydrography features are sourced from the U.S. Geological Survey's National Hydrography Dataset (NHD). All basemap features will be useful in the FIRM database for a potential flood risk project.

First Order Approximation Data

First Order Approximation (FOA) is a relatively new FEMA initiative, to take place during Discovery, that involves performing an approximate engineering analysis, updated floodplain mapping, and CNMS validation for all Zones A in the watershed (FEMA, 2014). In the Merrimack Watershed, FOA was performed in part for all Zones A (FEMA, 2015b). Updated floodplain mapping was not performed for these zones. The results of the analysis and mapping could be very useful in a potential flood risk project. Current results include water surfaces for the 10%, 4%, 2%, 1%, and 0.2% annual exceedance probability (AEP) floods for all analyzed reaches. Once generated from the surfaces, the floodplains can be used directly in updated regulatory mapping (i.e., FIRM panels), and the water surfaces and depth grids can be used directly in non-regulatory products, such as the Flood Risk Report and the Hazus loss analysis that accompanies it. Water surfaces can also be used in the validation of Letters of Map Change

(LOMCs) that FEMA receives regarding properties that are mapped in Zones A. Currently, it is difficult to determine if a property or structure is above or below the flood level, because no numerical value for water surface elevation is available. With the creation of these new water surfaces, a numerical value for the base flood elevation is now available for comparison with the property and structure elevations to determine the validity of a LOMC.

Effective FIS/FIRM Data

Except parts of Worcester County, Massachusetts, and all of Belknap County, New Hampshire, all of the counties touching the Merrimack Watershed had a countywide FIS and digital FIRM (with database) released during the Map Modernization program. Worcester County's digital database does not include the northwestern half of the county, which is unfortunately part of the area touched by the Merrimack Watershed. Of the 110 communities touching the watershed, 6 do not have a countywide FIS or digital FIRMs or database.

Portions of the effective FIS reports in digital format can be copied directly into revisions of those reports for a potential flood risk project. Likewise, much of the content of the effective FIRM database and panels can be copied directly into revisions of the database and panels, with minor or no editing necessary. These include tables such as the FIRM panel index, the political areas, and the areas of coastal flooding, which would not be updated, since the flood risk project following this Discovery would focus on riverine flooding sources only.

ii. Other Data and Information

This section describes the availability and analysis of data that could not potentially be used directly in the development of regulatory and (or) non-regulatory products, but instead could be very useful in directing the scope, focus, and outreach of a flood risk project.

Community Data

Large volumes of aggregate community data related to the NFIP were downloaded from the Community Information System (CIS), an online FEMA database with restricted access. There are many available CIS reports, some of which report the same information. Among CIS reports that contained the same information, there were some small discrepancies in values for some communities. In cases of discrepancies, the value from the first report consulted was kept. Many of the data obtained from CIS were used to fill out the Community Information Sheets distributed to the community stakeholders before the Discovery Meeting.

Community populations were obtained from the 2010 national census (U.S. Census, 2010). This information was also included on the Community Information Sheets. The Community Information Sheets and corresponding maps are included as Appendices 3 and 4, respectively, to this report.

CNMS Data

The most recent Coordinated Needs Management Strategy (CNMS) validation of effective Zones AE in FEMA Region I (New England) was recently completed in March 2015. CNMS is a

FEMA spatial database that tracks the viability of effective studies and alerts FEMA when an effective study is considered obsolete based on updates in available topography, hydrology, or human development (FEMA, 2015a). Re-assessment of all reaches in CNMS is required by law every five years.

According to the 2015 CNMS assessment, Zone AE reaches listed below in Table 1 are "Unverified," indicating that at least one critical (C) element and/or at least four secondary (S) elements have failed for the reach (FEMA, 2015a). Reaches are ranked from most to least critical elements failing and then most to least secondary elements failing.

Table 1: Prioritization of Restudy Reaches Based on CNMS Assessment

Number of Critical Elements Failing	Number of Secondary Elements Failing	Reach	Elements Failing
2	5	Beaver Brook	C1, C2, S1, S2, S4, S6, S10
2	3	Hidden Valley Brook	C1, C2, S1, S6, S10
2	3	Little River No. 3	C1, C2, S1, S6, S10
2	3	Soucook River	C1, C2, S4, S9, S10
2	3	Tributary C to Beaver Brook	C4, C5, S1, S6, S10
2	2	Spicket River	C1, C2, S2, S6
2	1	Arlington Mill Reservoir	C1, C2, S6
1	4	Gumpas Pond Brook	C6, S1, S4, S6, S10
1	4	Kelly Brook	C1, S1, S4, S6, S10
1	4	Tributary O to Beaver Brook	C5, S1, S4, S6, S10
1	3	Hussey Brook	C6, S1, S6, S10
1	3	Hussey Brook Tributary	C6, S1, S6, S10
1	3	Black Brook (Lowell)	C6, S1, S2, S10

Number of Critical Elements Failing	Number of Secondary Elements Failing	Reach	Elements Failing
1	3	Beaver Brook No. 1	C2, S1, S2, S10
1	3	Hill Brook	C5, S1, S6, S10
1	3	Black Brook (Londonderry)	C5, S1, S6, S10
1	3	Bryant Brook	C1, S1, S6, S10
1	2	Bowman Brook	C6, S1, S10
1	2	South Branch Piscataquog River	C1, S9, S10
1	2	New Meadow Brook	C1, S1, S10
1	2	Piscataquog River	C1, S2, S9
1	2	Little Cohas Brook	C5, S1, S10
1	2	Suncook River	C1, S2, S9
1	2	Merrimack River	C1, S2, S6
1	2	Pennichuck Brook	C5, S6, S10
1	2	Little Suncook River	C5, S4, S6
1	1	West Channel Suncook River	C1, S6
1	1	Shawsheen River	C1, S6
0	5	Dalton Brook	S1, S2, S4, S6, S10
0	5	Tributary J to Black Brook	S1, S2, S4, S6, S10
0	5	Tributary E to Little Cohas Brook	S1, S3, S4, S6, S10

Number of Critical Elements Failing	Number of Secondary Elements Failing	Reach	Elements Failing
0	5	Cochichewick Brook	S1, S4, S5, S6, S10
0	5	Fish Brook – Town of Andover	S1, S2, S4, S6, S10
0	4	Bare Meadow Brook	S1, S4, S6, S10
0	4	Riverside Airport Brook	S1, S4, S6, S10
0	4	Elm Brook	S1, S4, S6, S10
0	4	Content Brook	S1, S2, S6, S10
0	4	Vine Brook	S1, S2, S6, S10
0	4	Cohas Brook	S1, S4, S6, S10
0	4	Flatrock Brook	S1, S4, S6, S10
0	4	Hog Hill Brook	S1, S4, S6, S10
0	4	Bartlett Brook	S1, S2, S6, S10
0	4	Harris Brook	S1, S4, S6, S10
0	4	Hawkes Brook	S1, S2, S6, S10
0	4	Peat Meadow Brook	S1, S4, S6, S10
0	4	Tributary to Neal Pond	S1, S4, S6, S10
0	4	Beaver Brook 3	S1, S2, S6, S10
0	4	Heath Brook	S2, S4, S6, S10
0	4	Mud Pond Brook	S1, S4, S6, S10

Number of Critical Elements Failing	Number of Secondary Elements Failing	Reach	Elements Failing
0	4	Lawrence Brook	S1, S4, S6, S10
0	4	Martins Pond Brook	S1, S4, S6, S10
0	4	Sutton Brook	S1, S4, S6, S10
0	4	Peppermint Brook	S1, S4, S6, S10
0	4	Tributary to Beaver Brook 3	S1, S4, S6, S10
0	4	Trull Brook	S1, S4, S6, S10
0	4	Bennetts Brook	S1, S4, S6, S10
0	4	Beaver Brook 4	S1, S4, S6, S10
0	4	Tioga River	S1, S4, S6, S10
0	4	Limit Brook	S1, S4, S6, S10
0	4	Naticook Brook	S2, S4, S6, S10
0	4	Pointer Club Brook	S1, S3, S6, S10
0	4	Tributary H to Nesenkeag Brook	S1, S4, S6, S10
0	4	Sheilds Brook	S1, S4, S6, S10
0	4	Upper Beaver Brook	S1, S4, S6, S10
0	4	Nesenkeag Brook	S1, S4, S6, S10
0	4	Tributary G to Beaver Brook	S1, S4, S6, S10
0	4	Tributary E to Beaver Lake	S1, S4, S6, S10

Number of Critical Elements Failing	Number of Secondary Elements Failing	Reach	Elements Failing
0	4	Messer Brook	S1, S4, S6, S10

Effective FIS/FIRM Data

Floodplain Mapping

An inventory of Letters of Map Change (LOMCs) for each of the 110 communities touching the Merrimack Watershed was obtained from FEMA, with a grand total of 3,712 LOMCs. Of those 3,712, 2,671 are currently valid. Coordinates listed in the inventory are precise only to the hundredth of a degree and therefore are not very useful in a hotspot or cluster analysis, but the inventory also lists the flooding source for most valid LOMCs. The flooding sources with the most associated valid LOMCs are ranked in Table 2. "Local flooding" (usually designating unnamed Zones A) and coastal flooding sources are left out of this table, since this is a riverine project. A high number of LOMCs indicates faulty or imprecise mapping that should be considered a high priority for restudy or redelineation.

Table 2: Prioritization of Redelineation Reaches Based on Number of LOMCs

Flooding Source	Community(ies)	Number of valid LOMCs
Merrimack River	Andover MA, Methuen, Lawrence, North Andover, Haverhill, Groveland, West Newbury, Merrimac, Amesbury, Salisbury, Newburyport	107
Merrimack River	Manchester, Hooksett, Concord NH, Bow, Pembroke, Allenstown	51
Shawsheen River	Tewksbury, Billerica, Wilmington, Bedford MA	45
Merrimack River	Dracut, Tewksbury, Lowell, Chelmsford, Tyngsborough	40
Baboosic Brook	Merrimack, Amherst, Bedford NH	33
Canobie Lake	Salem NH, Windham	30

Flooding Source	Community(ies)	Number of valid LOMCs
Spicket River	Salem	27
Great Cohas Brook	Manchester	26
Trull Brook Tributary	Lowell, Tewksbury	26
Northwood Lake	Northwood, Deerfield, Epsom	23
Souhegan River	Merrimack, Amherst, Milford, Wilton	23
Suncook River	Allenstown, Pembroke, Epsom, Chichester, Pittsfield	22
Island Pond	Hampstead, Derry, Atkinson	19
Mascuppic Lake	Tyngsborough	18
Pine Island Brook	Loudon	18
Piscataquog River	Manchester, Goffstown, New Boston	18
Salmon Brook	Nashua	18
Beaver Lake	Derry	17
McQuade Brook	Bedford NH, Merrimack	16
Hassells Brook	Nashua	15
Nabnasset Pond	Westford	15
Soucook River	Loudon	15
Wash Pond	Hampstead	15
Arlington Mill Reservoir	Salem	14

Flooding Source	Community(ies)	Number of valid LOMCs
Content Brook	Tewksbury, Billerica	14
Lost Lake	Groton	14
Black Brook	Lowell	13
Great Pond	Kingston	13
Lake Attitash	Merrimac, Amesbury	13
Hussey Brook	Andover MA	12
Pointer Club Brook	Bedford NH, Merrimack	12
Shawsheen River	Lawrence, North Andover, Andover MA	12
Elm Brook	Bedford MA	11
Long Pond	Dracut, Tyngsborough, Pelham	11
Vine Brook	Burlington, Lexington, Bedford MA	11
Beaver Brook	Pelahm, Windham, Hudson, Londonderry, Derry	10
Beaver Brook No. 1	Pelham, Hudson, Windham	10
Merrimack River	Merrimack, Litchfield, Nashua, Hudson	10
Pleasant Lake	Deerfield, Northwood	10
Policy Brook	Salem	10

Hydrology

The "Summary of Discharges" table from each county's effective FIS report was analyzed for accuracy against nearby U.S. Geological Survey streamgages, where available. Streamgages with applicable statistics were available for ten reaches in the Merrimack Watershed. Of these ten, two were found to compare very poorly to streamgage statistics.

The “Summary of Discharges” tables were also analyzed for discontinuities in discharge, such as a lower discharge at a point further downstream in a reach, due to very different analyses performed in different communities and counties touching a single reach. Problems in either hydrologic analysis were used to choose reaches that may be in need of updated analysis. Seven reaches were selected by this analysis.

Hydraulics

Independent high-water mark (HWM) analysis was previously performed in New Hampshire, including the Merrimack Watershed (FEMA, 2008). There were no additional high-water marks available in the Massachusetts portion of the watershed. The USGS surveyed 32 HWMs in the Merrimack Watershed after the May 2006 and April 2007 flooding events in New Hampshire. These HWMs were located on Zone AE reaches with flood profiles in the effective FIS reports and had verified elevations. The elevations of these HWMs were plotted on the flood profiles, and the recurrence intervals on which they fell were recorded. These recurrence intervals were then compared to the published recurrence intervals on their respective gaged reaches from the flooding events. The results of the comparison for these 32 HWMs are shown below in Table 3, ranked from worst to best percentage of disagreeing recurrence intervals.

Table 3: Prioritization of Reaches Based on Comparison of HWM Recurrence Intervals

Reach	Total HWMs	Rank
Souhegan River	10	1
South Branch Piscataquog River	7	2
Suncook River	11	3
Piscataquog River	4	4

First Order Approximation Results

In the Merrimack Watershed, FOA was performed in part for all Zones A needing CNMS validation (see section on “First Order Approximation Data” on page 4). In addition to the potential applications of FOA results to Flood Risk projects, FOA results were also used in the prioritization of reaches for detailed study in potential future Flood Risk projects in this watershed. The particular result that is useful in evaluating each reach is a pass/fail metric based on a numerical evaluation of the effective floodplain against two of the new water-surface elevations generated in FOA. The two water surfaces are the “1%+” and “1%-” – the surfaces calculated from the 1%-annual-chance flows plus the positive standard error from regression equations and minus the negative standard error, respectively. Along the boundary of the effective floodplain, a point is created every 100 feet. Within a 37.5-foot radius around each point, the ground surface elevation from the LiDAR DEM is compared against the water-surface elevations – plus a vertical tolerance buffer – of the 1%+ and 1%- profiles at the point. (The value of the vertical tolerance is one half of the contour interval used to map the effective Zone A.) If the ground surface elevation is between the buffered 1%+ and 1%- water-surface elevations, then the point passes; otherwise, it fails. For each reach, all passing and failing points are counted, and a reach passes if 95% or more of the points pass and fails otherwise. For a more thorough discussion of the FOA process and the Zone A evaluation metrics, see the FOA report (FEMA, 2015b) and its appendices for more details.

A summary of FOA pass/fail results is in Table 4. A second pass/fail value has been added, this time not buffering the 1%+ and 1%- values with the vertical tolerance. The vertical tolerance is required by FEMA, but it effectively results in an evaluation of the effective zone against the topography on which it was originally mapped, ignoring how well the effective zone may perform against new, more precise topography. The second pass/fail value, then, indicates how well the zone is mapped against the best currently available topography. Although there were many Zones A that scored poorly in the FOA validation, only Soucook River and Suncook River were selected for detailed study.

Table 4: Pass/Fail Results of FOA Zone A Validation

Vertical Tolerance	Total Zones	Passing Zones	Failing Zones
With	496	233	263
Without	496	9	487

State NFIP Coordinator Priorities

The NFIP Coordinator's offices for the States of Massachusetts and New Hampshire publish annual reports for FEMA outlining a business plan for each year. These plans discuss mapping progress and current mapping needs based on known issues and data gaps. The most recent business plans were written in December 2014 for Massachusetts and February 2015 for New Hampshire.

The Massachusetts business plan highlights two major concerns. First, it points out that there are many mismatches in floodplains and water-surface elevations along community boundaries, where they are supposed to match but often don't because of the community-centered analysis and mapping practices of the past. This needs to be addressed by performing new detailed studies across community boundaries that tie into or completely replace effective studies. Second, it points out an unfortunate consequence of FEMA's preference for mapping an entire county at one time: counties with large unpopulated areas don't get mapped at all, leaving their communities and residents with antiquated hardcopy maps and no access to the enhanced digital tools of the modern programs. The business plan recommends that this be addressed by making exceptions to the countywide rule so that populated areas in largely unpopulated counties can still be mapped.

However, given that funds for study and mapping are limited, the Massachusetts State NFIP Coordinator still gave higher priority to updating existing maps in densely populated areas than to creating new digital maps in currently unmapped areas.

The New Hampshire business plan highlights another major concern: the very high percentage of approximate studies in the State that are categorized as not valid in CNMS. The New Hampshire State NFIP Coordinator identifies the validation and, potentially, restudy of these reaches as a mapping need. Finally, the New Hampshire coordinator recommends the Floodplain Boundary Standard (FBS) on effective reaches as a potential method for evaluating effective floodplain maps. This recommendation has not been incorporated into this Discovery process due to funding constraints.

The two states' coordinator's list of ranked priorities is copied below from the business plans as Table 5. Note that the Merrimack River Watershed (MA priority 3) and the Spicket River Watershed (MA 6) are both included in the Merrimack HUC8 Watershed. Also note that the Suncook River (NH 3) is also included in the Merrimack HUC8 Watershed and could potentially be addressed in a RiskMAP project for this watershed.

Table 5: State NFIP Coordinator's Top Mapping Priorities

State	Rank	Description	Cited Reason
MA	**1**	Physical Map Revisions to incorporate data submitted by communities for areas too extensive to be handled by LOMR	
MA	**2**	Ipswich River Watershed	Discrepancy between peak streamflow data from effective FIS and from USGS streamgages; new regional regression equations
MA	**3**	Merrimack River Watershed	Discrepancy between peak streamflow data from effective FIS and from USGS streamgages; new regional regression equations
MA	**4**	Parker River Watershed	Discrepancy between peak streamflow data from effective FIS and from USGS streamgages; new regional regression equations

State	Rank	Description	Cited Reason
MA	**5**	Saugus River Watershed	Discrepancy between peak streamflow data from effective FIS and from USGS streamgages; new regional regression equations
MA	**6**	Spicket River Watershed	Discrepancy between peak streamflow data from effective FIS and from USGS streamgages; new regional regression equations
MA	**7**	Community mismatches due to new studies (e.g., South Hadley Connecticut River)	WSE mismatches violate FEMA program requirement and make risk analysis and management difficult
MA	**8**	Berkshire County full countywide digital conversion, incorporating USGS Hoosic River and Deerfield River studies	No DFIRM; FIRMs very inadequate, imprecise, and outdated; new engineering available
MA	**9**	Hampshire County full countywide digital conversion, including Connecticut River restudy	No DFIRM; FIRMs very inadequate, imprecise, and outdated; new engineering available
MA	**10**	Franklin County full countywide digital conversion, incorporating USGS Deerfield River study and including Connecticut River restudy	No DFIRM; FIRMs very inadequate, imprecise, and outdated; new engineering available
MA	**11**	Charles River Watershed	Discrepancy between peak streamflow data from effective FIS and from USGS streamgages; new regional regression equations; high-water marks (HWMs) from spring 2010 flood
MA	**12**	Northern Worcester County digital conversion and Nashua River restudy	No DFIRM; FIRMs very inadequate, imprecise, and outdated

State	Rank	Description	Cited Reason
NH	**1**	Digital conversion of Belknap County	No DFIRM; FIRMs very inadequate, imprecise, and outdated
NH	**2**	Lower Connecticut River Watershed	Best watershed with LiDAR availability, high flood risk, and highest-priority CNMS mapping needs
NH	**3**	PMR to incorporate Suncook River study (too extensive to be handled by LOMR)	

NFIP Claims Data

FEMA furnished a dataset of all claims made against the National Flood Insurance Program (NFIP) since its inception in the 1970s until September 30, 2014. In the 110 communities touching the Merrimack Watershed, the data pull returned 4,155 NFIP claims in that period, totaling $70,544,590.01. Of these, about 2.0% were discarded from analysis because of ambiguity in geographic location, and a further 1.0% were discarded because it was found that they were classified under the wrong community and were actually located outside the project area. There were 4,028 claims remaining for analysis, totaling $70,377,490.99. Of the 4,028 claims, 3,150 (or 78.2%) were successful (i.e., were reimbursed a non-zero dollar amount).

Note that, almost all the time, a successful NFIP claim occurs when a property is flooded that, according to the effective FIRM, is at risk of flooding during the base flood. (The exceptions are claims against "discount" policies for properties that are located outside the SFHA. The percentage of claims in this category could not be ascertained with the data provided but is assumed to be small.) Therefore, NFIP claims data cannot be used to draw any conclusions for Discovery about reaches that may be high priorities for restudy because of outdated hydrology, hydraulics, topography, or structure inventories. However, high concentrations of NFIP claims (especially expensive ones) may draw attention to hotspots where population, structure inventories, and flood hazard are all unusually high, highlighting the highest-priority opportunities for mitigation.

NFIP claims were analyzed for hotspots by a point density analysis calculating the cumulative dollar value of claims within a one-kilometer radius. According to this spatial analysis, areas of highest priority for mitigation are ranked in Table 6. Note that this analysis does not take the timing of claims into account, so mitigation efforts may have already been undertaken on some or all of these reaches in response to flood events early in the history of the NFIP.

Table 6: Priority Areas of Mitigation Based on NFIP Claims

Rank	Flooding Source	Communities
1	Merrimack River (Essex)	Lawrence
1	Shawsheen River (Essex)	Andover (MA)
3	Atlantic Ocean	Newbury, Salisbury (MA)
3	Beaver Brook 3	Dracut, Lowell
3	Shawsheen River (Middlesex)	Billerica
3	Merrimack River (Middlesex)	Lowell, Tyngsborough
3	Piscataquog River	Goffstown
3	Suncook River	Allenstown, Pembroke

Community Interviews

The communities in the watershed were solicited for information about their flood risk and mitigation capabilities. Communities were asked for the following types of information:

- Desired study areas
- Existing data studies
- Funding
- Levees
- Mitigation planning
- Mitigation projects
- Areas of Mitigation Interest (AOMIs)
- Environmentally sensitive areas
- GIS data
- Communication and outreach
- Compliance and training

Responses in the category of desired study areas can be used to prioritize reaches for a potential flood risk project. Mapping needs identified by communities are summarized in Table 7 below.

Table 7: Community Mapping Needs

Community	Description
City of Concord	Ash Brook, Hackett Brook, Hayward Brook, Merrimack River, Mill Brook, Turkey River
City of Lowell	Beaver Brook, Merrimack River, Northern Canal, Pawtucket Canal
City of Nashua	Harris Brook, Hassells Brook
Town of Allenstown	Suncook River
Town of Bedford, NH	McQuade Brook
Town of Bow	Bela Brook, Bow Bog Brook, Merrimack River
Town of Chichester	Suncook River
Town of Dracut	Peppermint Brook
Town of Groveland	Johnsons Pond, Merrimack River
Town of Hooksett	Dalton Brook, Dubes Pond
Town of Hudson	Second Brook
Town of Lexington	North Lexington Brook, Vine Brook
Town of Salem	Policy Brook, Spicket River

Reach Selection

By synthesizing the results of all analyses presented above, as well as study age, map age, and risk (how many structures and people are in the effective floodplain), a final list of reaches was selected for updated engineering and mapping. The selection is presented in Table 8 below. The list of all reaches considered is included as Appendix 5.

Table 8: Final Reach Selection List

Flooding Source	Study Length (mi)	Study Type	Study Limits
Beaver Brook	26.5	Detailed	From the confluence with Merrimack River, Lowell, MA, to the headwaters at Beaver Lake, Derry, NH
Dalton Brook	1.4	Detailed	From the confluence with Merrimack River, Hooksett, NH, to the effective upstream limit of flooding at Londonderry Turnpike, Hooksett, NH
Hassells Brook	0.5	Detailed	From the confluence with Salmon Brook, Nashua, NH, to the effective upstream limit of flooding below Everett Turnpike, Nashua, NH
Peppermint Brook	2.9	Detailed	From the confluence with Beaver Brook, Dracut, MA, to the effective upstream limit of Zone A flooding above Bridge Street, Dracut, MA
Soucook River	10.7	Detailed	From the corporate limits of Loudon, NH, to the headwaters at the confluence of Bumfagon Brook and Gues Meadow Brook, Loudon, NH
Spicket River	14.0	Detailed	From the confluence with Merrimack River, Methuen, MA, to the headwaters at Arlington Mill Reservoir, Salem, NH
Suncook River	15.1	Detailed	From the USGS streamgage number 01089500 in Chichester, NH, to the headwaters at Lower Suncook Lake, Barnstead, NH
Suncook River	16.7	Mapping only	From the confluence with Merrimack River, Pembroke, NH, to the USGS streamgage number 01089500 in Chichester, NH
Vine Brook	6.8	Detailed	From the confluence with Shawsheen River, Bedford, MA, to the effective upstream limit of flooding below Hayes Lane, Lexington, MA

IV. Discovery Meeting

Three Discovery Meetings were hosted by FEMA and the USGS in the Merrimack Watershed. The meetings are summarized below in Table 9. The agenda for all three meetings was the same, and all organizations (Federal, State, community, and non-governmental stakeholders) were invited to any of the three. Lists of attendees at and minutes from each of the three meetings are also included as Appendices 6 and 7, respectively. At each meeting, an opening presentation (Appendix 8) was made, followed by breakout sessions in which stakeholders were given the opportunity to consult with project team members on flood risk issues particular to their communities or watersheds. Community input on mapping and other needs was received during these breakout sessions and during the four weeks following the meetings. After the four weeks, all information received from the stakeholders was aggregated and used with other data sources to prioritize mapping needs for the Merrimack Watershed.

Table 9: Discovery Meetings

Date	Time	Location
Tuesday, July 7, 2015	10:00 AM	Manchester City Library Auditorium 405 Pine Street Manchester, NH 03104
Tuesday, July 7, 2015	2:00 PM	Department of Environmental Services Auditorium 29 Hazen Drive Concord, NH 03301
Wednesday, July 8, 2015	10:00 AM	Haverhill City Hall, Room 301 4 Summer Street Haverhill, MA 01830

V. Sources Cited

Sources cited are listed in Table 10 below.

Table 10: Sources Cited

Citation	Reference
FEMA, 2008	*Independent Evaluation of Recent Flooding in New Hampshire*. Washington, D.C.: Federal Emergency Management Agency, 2008. Print.
FEMA, 2012a	*TERRAIN, Merrimack HUC 8 Watershed, Massachusetts and New Hampshire*. Washington, D.C.: Federal Emergency Management Agency, 14 Sep 2012. Web. <http://hazards.fema.gov>
FEMA, 2014	"First Order Approximation." *Guidance for Flood Risk Analysis and Mapping*. Washington, D.C.: Federal Emergency Management Agency, November 2014. Print.
FEMA, 2015a	"CNMS Technical Reference." *Guidelines and Standards for Flood Risk Analysis and Mapping*. Washington, D.C.: Federal Emergency Management Agency, May 2015. Print.
FEMA, 2015b	*FOA Report, Merrimack Watershed, 01070006*. Washington, D.C.: Federal Emergency Management Agency, 29 Feb 2016. Print.
NOAA, 2016	"Climate at a Glance | National Centers for Environmental Information (NCEI)." *National Centers for Environmental Information (NCEI) formerly known as National Climatic Data Center (NCDC) | NCEI offers access to the most significant archives of oceanic, atmospheric, geophysical and coastal data*. National Oceanic and Atmospheric Administration, 2 Feb 2016. Web. 2 Feb 2016. <http://www.ncdc.noaa.gov/cag/>.
U.S. Census, 2010	"2010 Census." *Census.gov*. U.S. Census Bureau, 21 Dec 2010. Web. 1 Apr 2015. <http://www.census.gov/2010census/>.
USGS, 2011a	*State of Massachusetts (Raster DEM): LIDAR for the North East – ARRA and LiDAR for the North East Part II*. Unpublished, 22 Apr 2011.
USGS, 2011b	*State of New Hampshire (Raster DEM): LIDAR for the North East – ARRA and LiDAR for the North East Part II*. Unpublished, 30 May 2011.

Citation	Reference
USGS, 2014	"U.S. Geological Survey - National Hydrography Dataset." *U.S. Geological Survey - National Hydrography Dataset*. U.S. Geological Survey, 13 Jan 2014. Web. Jan 2015. <http://nhd.usgs.gov/index.html>.

VI. Appendix and Tables

Table 11: Appendices

No.	Description	File Name	File Size (MB)
1	List of stakeholders contacted during Discovery	stakeholder_list.xlsx	0.1
2	List of communities requesting assistance from FEMA	watershed_communities _requesting_assistance.xlsx	0.1
3	Community Information Sheets	CIS.zip	0.2
4	Community Information Maps	CIM.zip	89.4
5	Complete list of reaches considered in prioritization for restudy	priority_ranking.xlsx	0.1
6	Discovery Meeting attendees	Attendance.zip	2.9
7	Discovery Meeting minutes	Minutes.zip	0.1
8	Discovery Meeting presentation	Presentation.zip	6.9