

2015 WETLAND PROGRAM DEVELOPMENT GRANT – TRACK 2 FINAL REPORT

Building Climate Change Resiliency in New Hampshire by
Prioritizing Wetland and Stream Mitigation Opportunities



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Project Summary and Goals

The New Hampshire Department of Environmental Services (NHDES), working with partners, completed activities outlined in the New Hampshire Wetland Program Plan (NHWPP) that built on recent work and improvements to the Aquatic Resource Mitigation (ARM) program. The main objectives of this grant included:

- 1) Provide updated environmental and infrastructure information to aid in land protection, mitigation and flood resiliency in the Merrimack and Salmon Falls watersheds, which have been identified as “at risk urban watersheds.” Incorporate enhanced technical resources (i.e. enhanced National Wetland Inventory (NWI+) maps, conservation parcels data, and updated New Hampshire Fish & Game Department (NHFG), Wildlife Action Plan (WAP) information) to protect water quality, restore aquatic connectivity and build flood resiliency in the two urban watersheds. The New Hampshire Geographically Referenced Analysis and Information Transfer System (GRANIT) and their online mapping tools will be enhanced through this updated information. Updated information includes:
 - Enhanced National Wetland Inventory (NWI+) maps.
 - The location and type of conserved lands in New Hampshire.
 - Stream crossing assessment data layer and prioritization mapping tool.
- 2) Collect data and develop the tools necessary for prioritizing stream crossing replacements to address issues with aquatic organism passage (AOP), geomorphic compatibility and hydraulic capacity through re-establishment of a New Hampshire Stream Crossing Initiative Steering Team (Steering Team), formerly the state stream crossing technical advisory committee. The Wetlands Bureau partnered with the NH Geological Survey (NHGS) and the NH Coastal Program to conduct stream crossings surveys stream crossings in the Merrimack and Salmon Falls-Piscataqua River watersheds (HUC-08). NHDES will provide the AOP and geomorphic scoring information to GRANIT for public display and create a prioritization tool for use in local and regional planning purposes.
- 2) Assist municipalities in identifying stream crossing replacements that will increase flood resiliency, restore stream connectivity and habitat, and improve aquatic ecosystem function through educational workshop and materials. Conduct outreach and develop guidance materials to inform stakeholders on identify potential funding opportunities. The final outcome will be the tools municipalities need to develop a compensatory mitigation inventory list that includes high priority land conservation sites, wetland/stream restoration sites, and stream passage improvements.

This grant was approved by the EPA on 8/5/2015 and awarded on 9/22/2015. The necessary approvals were made by the Fiscal Committee and Governor & Council on 2/10/2016, and NHDES was able to advertise, interview and hire a qualified individual (Cheryl Bondi, Ph.D.) to fill the part-time position funded by this grant to assist with the stream crossing work on May 13, 2016.

Task 1: Update of NWI Mapping

NHDES contracted with Virginia Tech (VT) to update and provide enhanced National Wetlands Inventory (NWI+) maps for the Merrimack and Salmon Falls watersheds. Mapping updates were initiated in the first quarter of 2016 and the summer of 2016; Vermont conducted field verification in different areas of the watersheds. The mapping effort and final deliverables were completed in 2017. Updates to the map include:

- Wetlands and deepwater habitat classified according to the Cowardin wetland classification system with the most recent hi-resolution photography and complies with the U.S. Fish and Wildlife Service (FWS) data collection guidelines for inclusion in the NWI master geodatabase.
- Mapping completed at a minimum scale of 1:8,000 and a target mapping unit (TMU) of 0.25 acres.
- Application of the NWI+ Wetland Classification system developed by FWS (Tiner, 2011) to provide a landscape-level assessment of the wetland which includes landscape position, landform, water-flow path and water-body type descriptors (LLWW), followed by the assignment of wetland function.



The data is available as a data layer download and map service on NH GRANIT – New Hampshire’s statewide GIS clearinghouse hosted by the University of New Hampshire. The data layer is also displayed on the NH Coastal Viewer and GRANIT View, online mapping tools that offer users access to spatial data describing New Hampshire’s coastal resources and coastal hazards. It was developed and is managed by NH GRANIT in partnership with the NHDES Coastal Program and provides access to a suite of GRANIT data layers as well as data sets and map services published by project partners and other state, regional and federal organizations.

NH GRANIT
NEW HAMPSHIRE'S STATEWIDE GIS CLEARINGHOUSE

News	Projects	Resource Library	
Download Free Data	Order Data	Online Maps & Services	Map Library

GRANIT Data Discovery Tool

Data Download Compression & Storage Type

Zip Tar Compressed Tar (gzip)

1 records match your search criteria

Dataset	Metadata	Sample Image	Format	Download Mark / Download
National Wetlands Inventory Plus (NWIPlus) - Southern and Southeastern New Hampshire	"Lite" Record Full Record		<input checked="" type="radio"/> shp	<input type="button" value="Download Now"/> <input type="checkbox"/> Mark as part of set

Task 2: Re-establish statewide stream crossing technical advisory committee (GRANIT & UNHSC, NHFG, TNC, NHDES, NHDOT, and others) related to stream crossings.

The New Hampshire Stream Crossing Initiative is a program involving five state entities, and several partners, with the mission to inventory stream crossings throughout the state to inform data-driven decisions on culvert replacement and stream restoration. The initiative is led by the multi-agency Stream Crossing Steering Team (Steering Team) – established in 2016 as part of this grant – and is tasked with decisions regarding program management and facilitating communication across partner agencies. The Steering Team is comprised of members from the NHDES Wetlands Bureau and New Hampshire Geological Survey (NHGS), the NH Departments of Transportation (NHDOT) and Fish and Game (NHFG), the Division of Homeland Security and Emergency Management (HSEM), and the Technology Transfer Center at UNH (UNH T²). This team is chaired by Shane Csiki of NHGS. The Steering Team consults and collaborates with partners including Trout Unlimited, consulting firms and regional planning commissions as necessary. The Steering Team meets regularly to discuss issues regarding the New Hampshire Stream Crossing Initiative, collaborate on outreach, and ensure consistent data collection and management. The objectives of the Steering Team are:

- To produce a single, stream-lined protocol to collect data on transportation and environmental concerns for stream crossings and manage the data in an online geodatabase that is shared among the members of the New Hampshire Stream Crossing Initiative partner entities.
- To establish and clarify individual member responsibilities on specific program objectives and assign tasks to individuals based upon their expertise.
- To coordinate field assessments to minimize duplication of effort and promote surveys in areas that have the highest mitigation and stream restoration potential.
- To provide guidance on training methods and materials used by NHGS in their annual stream crossing training workshops to ensure data consistency.
- To provide consistent messaging to the public on program objectives, stream crossing scores, and their interpretation, and develop methods to prioritize culvert replacements to meet mitigation and restoration goals.

Steering Team meetings were conducted monthly from January to May 2016 to prepare for the summer field season, and quarterly starting September 2016. The Steering Team meetings focused on increasing the coordination between state entities regarding multiple stream crossing assessment initiatives.

Development of Stream Crossing Subcommittees

As the New Hampshire Stream Crossing Initiative expanded and more project partners became engaged in data collection, management and distribution, there was an increased workload and need for resources to coordinate field assessments, maintain a consistent protocol with evolving knowledge, and to advance the database to support program needs. In addition, with the large amount of surveys completed and culvert scores produced there was an increased demand to conduct public outreach and

distribute information consistently to stakeholders. To address workload demands in an efficient manner, subcommittees were created to meet in focused work groups and report decisions and make recommendations to the Steering Team. These subcommittees include:

1. Protocol Development Subcommittee: A general consensus of the Steering Team, data collectors, and those working with data management, was that the current Stream Crossing Assessment Protocol was too long. The Protocol Development Subcommittee was formed in 2017 and consists of members from NHDES, NHFG, HSEM, NHDOT, UNH T² and was chaired by Cheryl Bondi of NHDES. The first goal of the Protocol Development Subcommittee was to screen all of the variables collected in the field and stored in the online geodatabase (125 parameters total) to determine those that are essential for stream crossing rankings and to identify those that can be omitted. The objective was to narrow the variables collected to those most critical for each agency's decision making and ranking scheme, and ensuring all agencies' needs are represented in a single, streamlined protocol. The subcommittee held three meetings on March 23, April 3 and April 20, 2017. During these meetings, the subcommittee successfully reduced the number of parameters collected to 93 essential variables, increasing survey efficiency and the number of stream crossings a field team can assess, without compromising the data needed to run the scoring algorithms. The second task of the Protocol Development Subcommittee was to revise the field guide to provide clear definitions, diagrams and photographs, for clarity and quality control of survey methods and data collection. The first draft of the field manual was completed and distributed to partner agencies, and posted on the NHDES webpage in May 2017. Following the 2017 field season, the subcommittee met on September 1, 2017, and March 2 and April 9, 2018 to discuss the effectiveness of the updated stream crossing protocol and use feedback from data collectors to improve the field manual. Several updates were made to the field manual to improve data collection and quality and were distributed to data collectors and posted on the NHDES webpage for the 2018 field season. The "New Hampshire Stream Crossing Initiative Field Manual" is posted on the NHDES Wetlands Bureau webpage: <https://www.des.nh.gov/organization/divisions/water/wetlands/documents/culvert-assessment-protocol.pdf>.

2. Database and Data Management Subcommittee: This subcommittee was led by Tom Taggart at NHGS during the grant period, with members from NHDOT, UNH T² and NHFG. The goal of this subcommittee is to address technical concerns regarding program data management, work processes, and the online geodatabase – Statewide Assets Database Exchange System (SADES) – hosted by UNH T². After the 2016 field season, numerous database issues were identified by NHGS during the Quality Control process, and this subcommittee reorganized database structure, renamed attributes, and set domains to accommodate changes to the field protocol and improve data consistency. The subcommittee first met in April 2017 and had a modified version of the database online in time for the summer 2017 field season.

3. Outreach Subcommittee: The chair of this subcommittee was Cheryl Bondi from NHDES and includes members from the NHDES Wetlands Bureau, NHFG, HSEM and NHDOT. Because of the variety of stakeholders (town officials and safety personnel, road agents, conservation groups and state agencies) that have interest in the stream crossing data and ranking scores, the State Stream Crossing Steering Team recognized the importance of consistent communication of the results and program initiative. This subcommittee was developed to create program messaging to be delivered and communicated to the various groups. The subcommittee completed a brochure and several fact sheets that have been distributed to stakeholders and posted on the NHDES webpage. In addition, it was extremely important that the results of stream crossing rankings (i.e. geomorphic compatibility, aquatic organism passage, and hydraulic capacity scores) be communicated consistently, so this subcommittee

developed a cartographic standard (symbolology and map overlays) for presentation at public information meetings.

Each subcommittee presents their results of the workgroup sessions to the larger Stream Crossing Steering Team at their quarterly meetings to ensure all agency team members are involved in final decisions. At the April 21, 2017 meeting of the *Steering Team* each subcommittee presented to the larger group with the general consensus being that the formation of the subcommittees is a significant improvement to the program and greatly increased the efficiency of the five entities working together. In May, 2018 it was decided that the **Protocol Development** and **Database and Data Management Subcommittees** would be combined to increase communication and reduce duplicity of efforts.

Statewide Asset Database Exchange System (SADES)

All survey teams upload assessment data to the Statewide Asset Data Exchange System (SADES), a cloud-based platform coordinated by NHDOT and UNH T². This database platform reduces duplication of efforts because data is shared among partners. Data are collected using a mobile device and cloud technology, and no paper forms and data transfer are required – this ensures consistent data collection because all data collectors are entering data using the same form. By using a cloud-based data exchange, NHGS can conduct QA/QC nearly real-time as the data is collected and prompt feedback can be provided to data collectors in the field. This information can then be used to correct potential sampling errors or inconsistencies throughout the field season; rather than once all the data has been collected and submitted, typically at the end of a field season.

Training Guidance

Stream crossing assessment protocol trainings were conducted by NHGS and UNH T² for all people conducting assessments during the 2016 and 2017 field seasons. The training is essential to provide consistent, quality data and ensure that similar measurement methods are used. The training consists of a field visit to a local box culvert and the participants are guided step-by-step through the “New Hampshire Stream Crossing Initiative Field Manual.” As part of this grant, in 2016 and 2017 several wetlands staff members also attended this training to better understand what data is collected, and how this data may be used during application review and wetlands permitting. In 2017, with consultation from the Steering Team, the stream crossing training was expanded to include a three-hour classroom session to better describe methods and concepts regarding the protocol.

Stream Crossing Initiative Support and Program Development

From support provided by this EPA grant, Cheryl Bondi, Ph.D., was hired as an Environmentalist III with NHGS in May 2016. Dr. Bondi has a strong background in ecosystem ecology and aquatic biology that she applied directly to several tasks in this grant, particularly in developing more robust criteria for prioritizing aquatic organism passage projects and in refining the Aquatic Resource Mitigation (ARM) Fund Program selection criteria for funding stream restoration projects. Upon her hire in May 2016, Dr. Bondi immediately began assisting with the stream crossing initiative through Quality Control and Assurance of collected stream crossing data and co-managed and provided leadership to the eight interns who collected stream crossing data in 2016 and 2017. Dr. Bondi worked closely with NHFG to develop a statewide fisheries habitat data layer, to incorporate fish survey data in an online mapper of the stream crossing data. This GIS layer will be useful in prioritizing stream crossing improvement

efforts. Dr. Bondi serves as the co-chair of the **Protocol Development/Data Management** and the **Outreach Subcommittees** and organizes and leads the regular meetings.

Task 3: Collection of field data in Merrimack & Piscataqua watersheds (up to 7 subwatersheds).

Stream crossing data collection began in June 2016 after two interns were hired (wetlands program match for this grant) to complete stream crossing assessments in the Merrimack River watershed. Additional assessments were done by two interns in the Piscataqua-Salmon Falls watershed with support from the NHDES Coastal Program. This work was done in partnership with the Merrimack assessment team and all of the data was used to develop prioritization criteria. Surveying stream crossings across a broader geographical area was critical in developing criteria that is applicable to all watersheds, and ultimately to towns that have different issues and characteristics. A second field season was required to get adequate survey coverage in these two developed watersheds, so four interns were hired in 2017 and funded by the NHDES Wetlands Bureau as a match for this grant. Because the number of stream crossings within a watershed (or town) exceeds the number that can actually be surveyed in a field season, a selection method was developed to direct field efforts to those stream crossings that are most likely to be candidates for stream restoration and support mitigation. An intersection analysis was done using a Geographic Information System (GIS) of the most recent road (NH DOT) and stream (NHD Flowline) networks to identify all of the potential stream crossings in New Hampshire. A GIS model was developed Dr. Cheryl Bondi to conduct an overlay analysis to identify those crossings that met the following criteria:

- Were within a town that is expected to have large stream impacts within the next 10 years based on transportation development projections.
- Provided critical linkages between conservation parcels.
- On a waterbody that has been designated as important fishery habitat by NHFGfishery biologists.
- Within an area that has been identified by a town's Hazard Mitigation Plan as a high risk for road flooding and safety concern.
- Excluded those intersecting large interstate highways that are unsurveyable.

Using a targeted survey approach has allowed NHDES to maximize the limited time and resources available during our summer field season and visit those sites that will yield the most usable data. In addition to the surveys done by the NHDES interns in 2016 and 2017, 256 stream crossing assessments were done in the focus watersheds by a contractor (Trout Unlimited) as part of this grant.

A request for qualifications (RFQ) was posted by NHDES to the department web page, and in the *Union-Leader* newspaper on May 22, 2017. A total of nine proposals were received in response to the RFQ. From that group, six contractors were selected to interview, and four were selected to be retained, for eligibility to be invited to bid on assessment opportunities. The retained contractors were invited to bid on the stream crossing assessment on July 7, 2017. Trout Unlimited was the lowest bid and was chosen to complete the work and began surveys in November 2017; however, assessments were suspended due to unsuitable weather conditions. A grant extension was requested by NHDES and granted by EPA on December 18, 2017, so this work was completed in the spring and summer of 2018.

Summary of stream crossing assessments in focus watersheds

A total of 1,163 site visits were done by NHDES interns in 2016 and 2017 (Tables 1 and 2; Figure 1). An additional 250 assessments were done by Trout Unlimited, contracted to do surveys under this EPA grant, in 2017-2018. During the 2016 summer field season, 584 potential stream crossings were assessed by the NHDES interns between June 1 and August 17, 2016. The majority of surveys (560) were done in the Merrimack and Salmon Falls-Piscataqua Rivers watershed, with another 24 surveys in the Lower Connecticut that were of interest to the mitigation program due to flood risks. Some of the potential sites visited were not associated with waterbodies, but were drainages (33) where a shortened version of the protocol is used because many of the stream crossing parameters do not apply. While these structures are important to document for understanding runoff contributions into local waterbodies, they are not assessed for stream restoration potential. Some of the potential sites were not surveyed due to unsafe conditions or landowner restrictions, and marked accordingly as “Not Surveyable.” Five-hundred-and-fifty (550) crossings were associated with a perennial or intermittent waterbody (stream, wetland or surface water), and assessed for stream and wetland restoration potential (Table 1 and Figure 1).

In 2017, the NHDES interns visited 579 potential stream crossing sites between May 31 and August 24, 2017 (Table 1). There were 348 and 114 surveyed in the Merrimack and Salmon Falls-Piscataqua watersheds, respectively, and another 117 in the Connecticut River, to support NHDES’ mitigation program. Of these, 32 were identified as being disconnected from a perennial or intermittent stream, or other permanent waterbody, and classified as storm water drainage. An additional 137 sites were unsurveyable due to land owner restrictions (private property) and other site access issues – by documenting these sites in the geodatabase, future visits and duplication of efforts were avoided. Four-hundred-and-ten (414) crossings surveyed were on a perennial or intermittent waterbody (stream, wetland or surface water), and assessed for stream and wetland restoration potential.

Table 1. Crossing types surveyed by NHDES interns in 2016 and 2017 by watershed.

	Crossing Type	Merrimack	Piscataqua-Salmon Falls	Other watersheds	Total
2016	Drainage	12	21	0	33
	Not Surveyable	1	0	0	1
	Stream	188	175	22	385
	Surface	12	18	0	30
	Wetland	73	60	2	135
Total		286	274	24	584
2017	Drainage	17	11	4	32
	Not Surveyable	91	30	16	137
	Stream	172	36	88	296
	Surface	13	8	3	24
	Wetland	55	29	6	90
Total		348	114	117	579
Total Surveys		634	388	141	1163

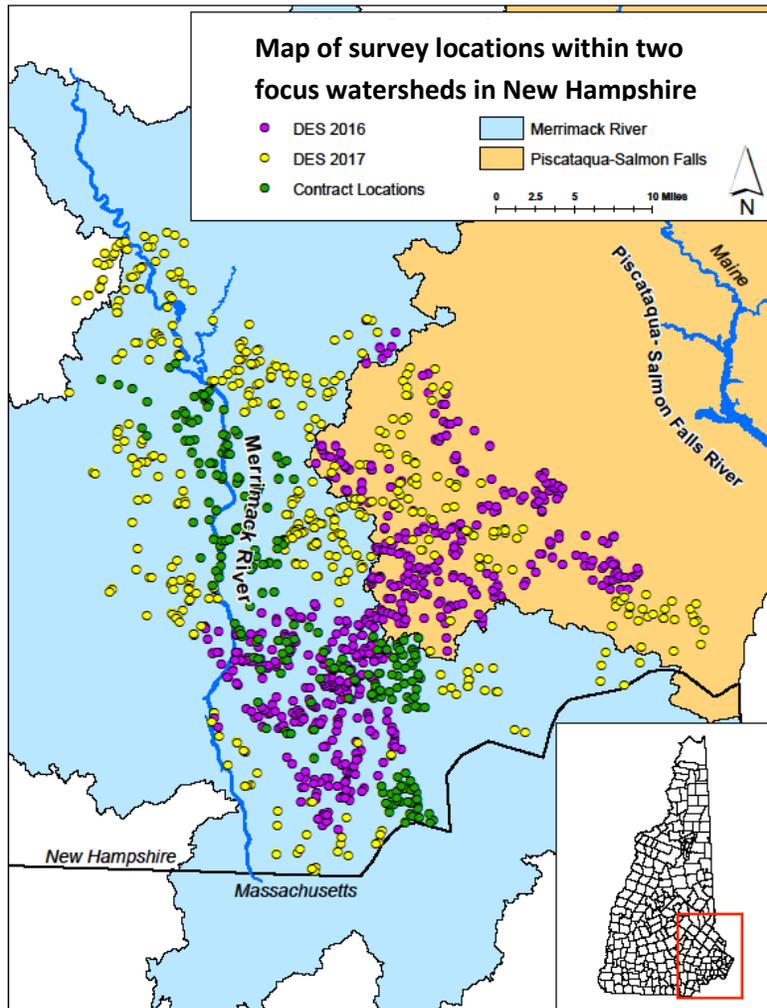


Figure 1. Map of survey locations by NHDES interns and Trout Unlimited in the two focus watersheds.

In fall 2017 and summer 2018 an additional 250 crossings were surveyed by Trout Unlimited LLC under contract with NHDES from funds from this EPA grant. These 250 stream crossings were targeted to only the Merrimack watershed due to mitigation potential from large transportation projects occurring in this watershed. Trout Unlimited visited all 250 crossings and were able to perform a full assessment at 210 crossings on stream, surface or wetland waterbodies.

Table 2. Crossing types surveyed by Trout Unlimited in 2017-2018 in the Merrimack watershed.

Crossing Type	Surveyed
Drainage	34
Not Surveyable	34
Stream	117
Surface	8
Wetland	42
Total	258

There are an estimated 4,584 road crossings that intersect a waterbody (surface, stream or wetland) in the Merrimack River watershed. During the two field seasons funded under this grant, NHDES visited 634 (7%) sites, contributing to the overall 2,532 (55%) that have been surveyed in this watershed to date. In the Piscataqua-Salmon Falls watershed, there are a predicted 2,423 stream crossings – the NHDES team visited 388 in the two field seasons, contributing to the overall 1,524 (63%) surveyed in this watershed.

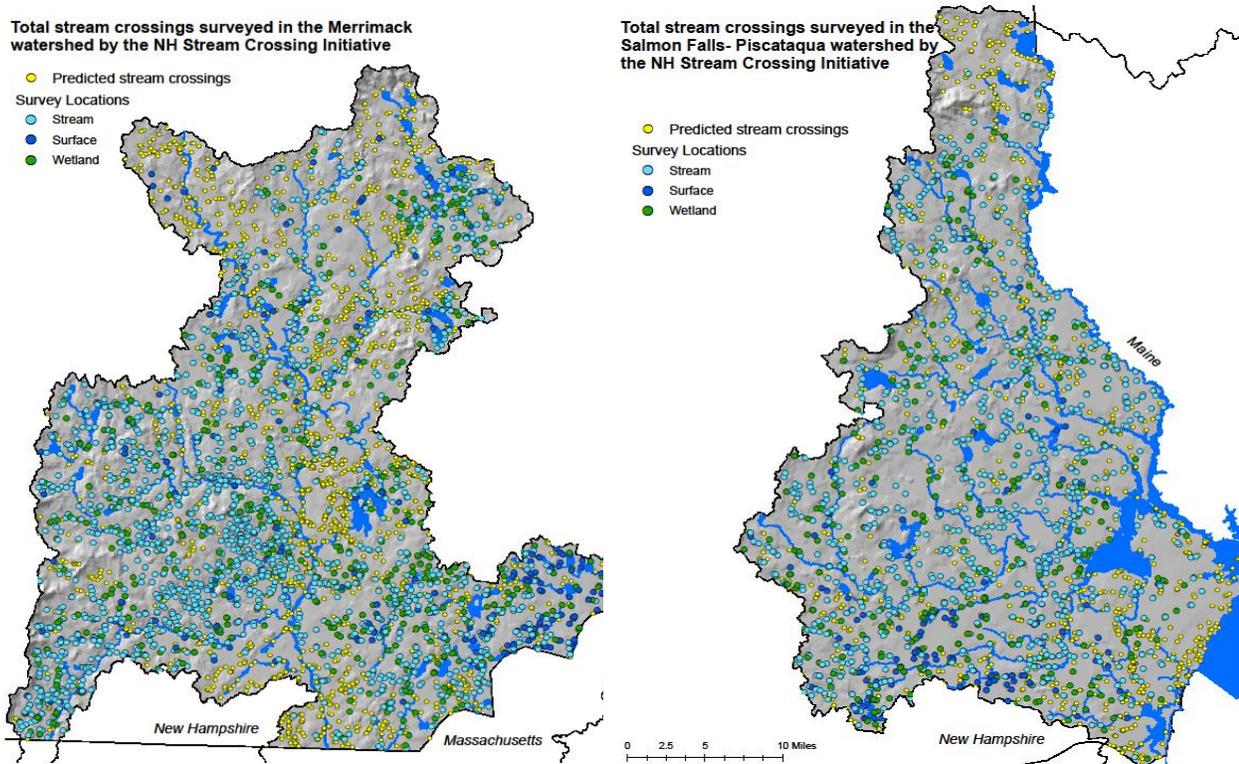


Figure 2. Map of the total number of stream crossing surveys done in the Merrimack watershed (left) and the Salmon Falls-Piscataqua watershed (right) to date under the New Hampshire Stream Crossing Initiative program.

Task 4: Evaluate surveyed stream crossings for aquatic organism passage and geomorphology parameters

All sampling teams that conducted assessments uploaded data to the cloud-based database (SADES hosted by University of New Hampshire Technology Transfer Center (UNH T²). By using an online data exchange system, NHGS was able to conduct QA/QC nearly real-time as the data was collected and prompt feedback was provided to data collectors. The prompt feedback and turnaround that NHGS has been able to achieve in its QA/QC process was due to the work process and database modifications undertaken in 2016 and 2017.

A total of 1,421 stream crossing survey records were run through the ranking algorithms for Aquatic Organism Passage (AOP) and Geomorphic Compatibility (Appendix A). Due to limiting conditions such as private property access issues, unsurveyable field conditions and stormwater drainage structures, there were 1,116 data records that received a score (Figure 3). A significant number of crossings were on non-flowing bodies of water and cannot be scored for geomorphic compatibility – a model that is based on channel flow processes – and categorized as wetland and lake/pond crossings. Only 6% of the stream crossings scored fully compatible, with the majority of crossings ranked as mostly compatible (26%). The majority of crossings scored reduced AOP (54%), indicating that they have some characteristics that prohibit most organisms (moderate-weak swimmers) from passing. Only 18% of the crossings surveyed are open to all aquatic organisms.

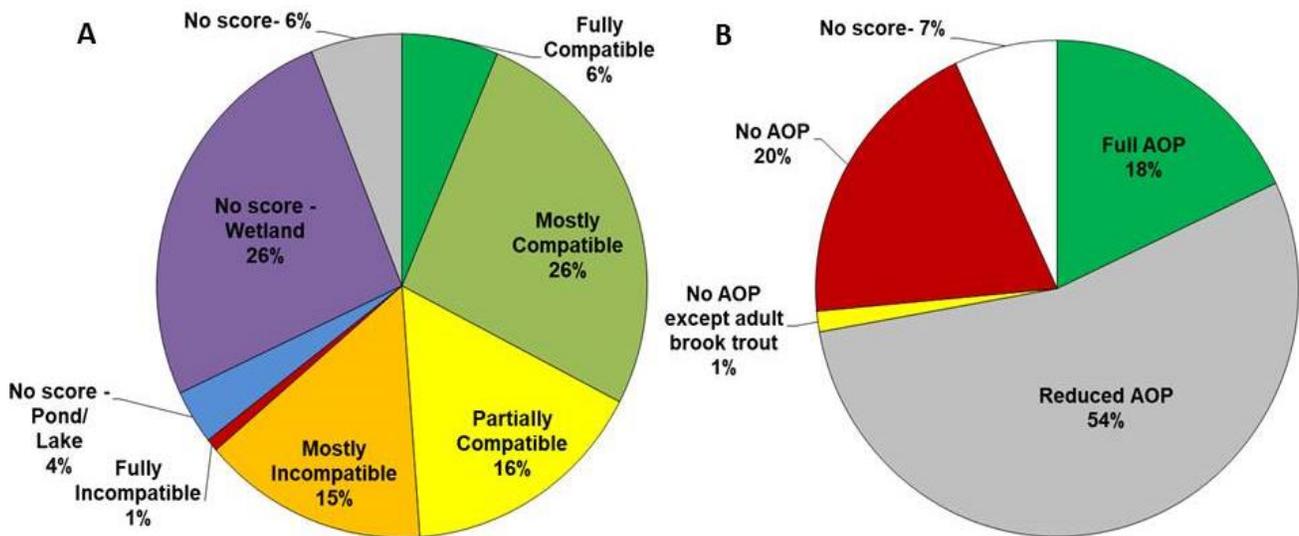


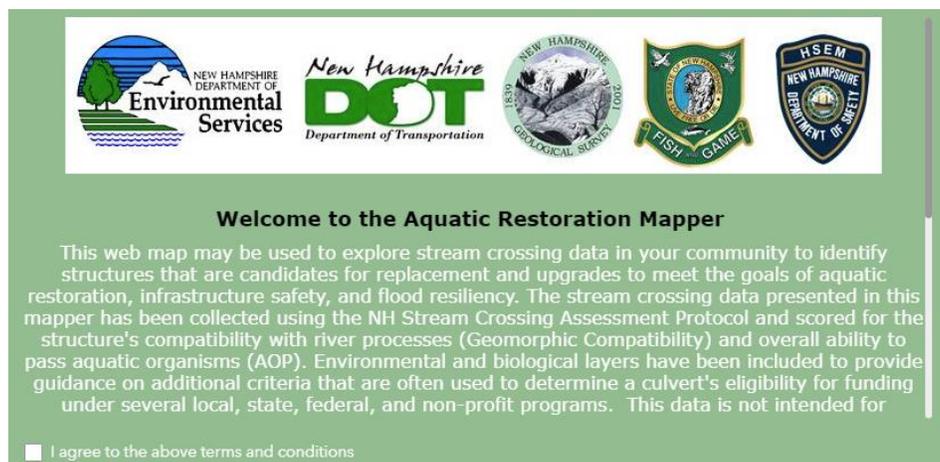
Figure 3. Geomorphic (A) and Aquatic Organism Passage (B) compatibility scores for 1,116 stream crossings surveyed between May 2016 and September 2018 by NHDES and Trout Unlimited contract.

Task 5: Culvert prioritization model

As part of a separate program, the Southern New Hampshire Planning Commission (SNHPC), with assistance from NHDOT, contracted with the firm Milone & MacBroom (MMI) to develop a screening tool to aid communities in the Piscataquog River Watershed to identify priority culvert replacements. NHGS and NHDES (among others including Trout Unlimited and UNH) were invited to be part of the technical advisory committee (TAC). There were many aspects of the model developed by MMI and piloted in the Piscataquog watershed that aligned with the criteria proposed in this EPA grant, so participation of NHDES staff on the TAC was very timely and informative. The Piscataquog Watershed project built on previous studies and data collected in the watershed including culvert inventories, geomorphic compatibility screening, approximate hydraulic capacity analysis modeling and AOP screening. The MMI model prioritizes culverts for replacement to improve flood resiliency and improve infrastructure identified as critical to the local transportation network.

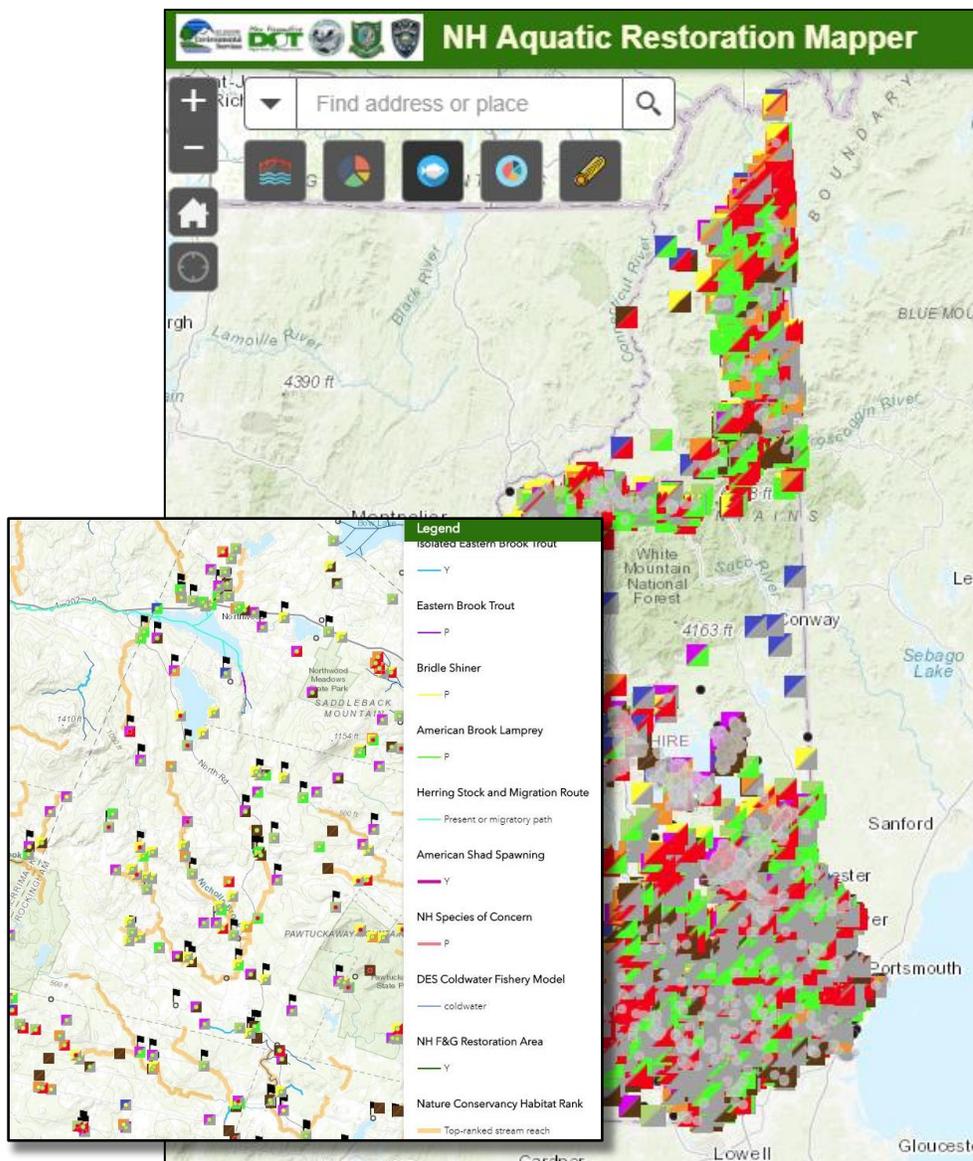
Based on feedback from communities and the New Hampshire Regional Planning Commissions during several meetings, it was determined that culvert replacement decisions vary from town to town, region to region, and depend on the funding source targeted to replace the structure. The State Stream Crossing Steering Team decided to explore the use of web-based mapping tools as a public interface for the stream crossing data. The Steering Team members agreed that a flexible tool that allows users to query and display the stream crossing data in their community, based upon their own priorities and funding ability, would best support municipalities and stakeholders involved in stream crossing replacements. In 2017, the NHDES Wetlands Bureau and Geological Survey partnered to develop the [New Hampshire Aquatic Restoration Mapper](#), an interactive viewer to explore stream crossing and aquatic habitat data to identify and prioritize stream crossings for replacement to meet restoration, aquatic connectivity and flood resiliency goals. The Aquatic Restoration Mapper is a decision support tool to help target restoration efforts and identify mitigation opportunities to improve stream connectivity, restore important fish habitats and increase flood resiliency.

To support individuals using this tool, a series of guidance documents were created and several outreach events conducted (see Task 7). The New Hampshire Aquatic Restoration Mapper is easily accessible to the public and is hosted on the NHDES Wetland mitigation program website. A simple, instruction manual was developed and posted online to guide users in the various tools and function of the mapper (Appendix B).



The web map includes several tools that allow the user to:

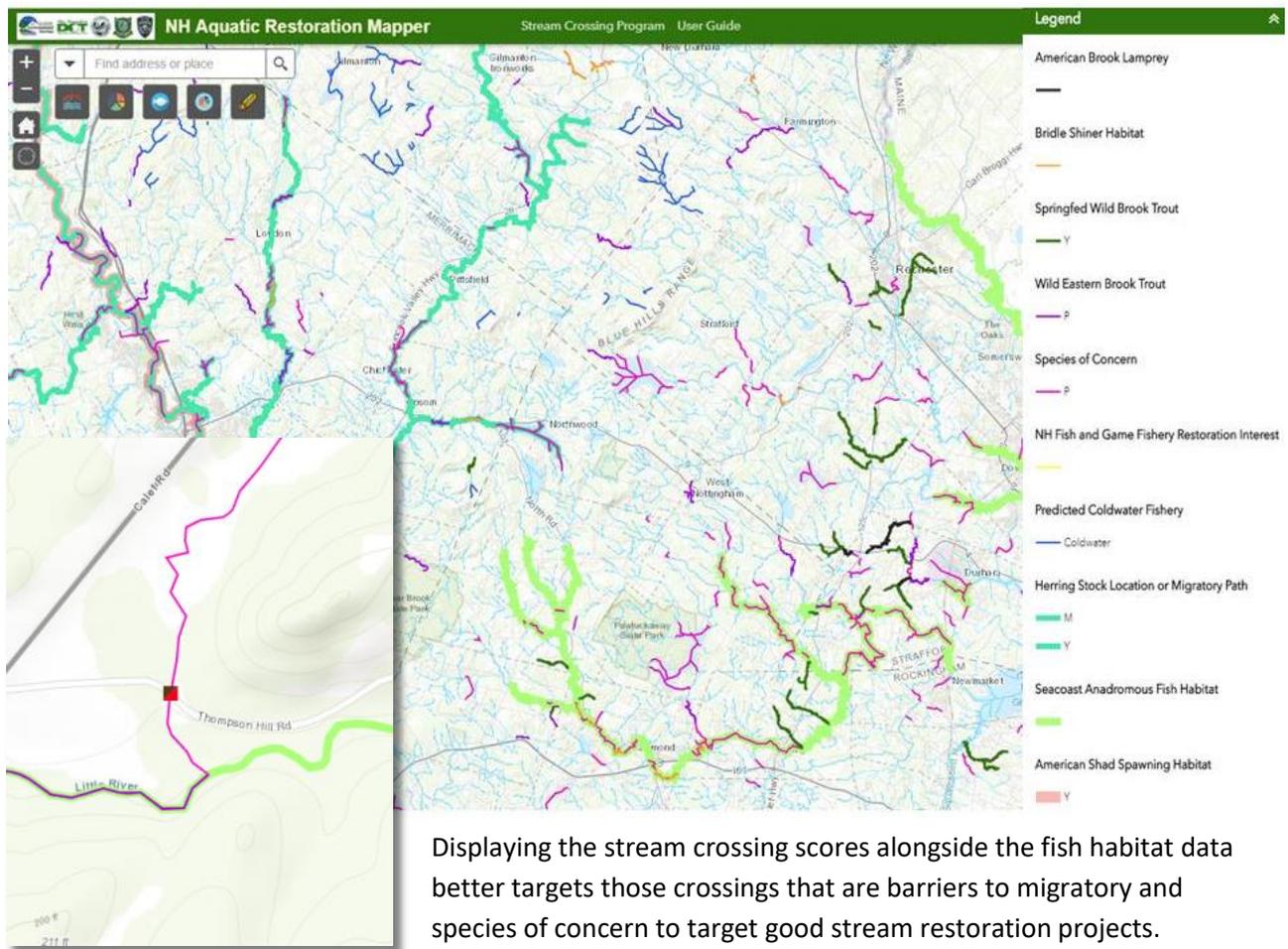
- View stream crossing survey data by town, watershed or specify their own area of interest.
- Query and explore stream crossing data, including photographs from the field.
- Filter by AOP and geomorphic compatibility scores to identify deficient crossings.
- View the flood history of each culvert from town Hazard Mitigation Plans.
- Display summary statistics of scores in charts and graphs for presentations and reports.
- Easy to use pop-up windows that display additional information and provide links to NHFG aquatic species information.
- View stream habitat, fishery and riparian data to understand the ecological importance and habitat connections of a restoration area.
- Export selected data as a text file to view and analyze in other software.
- Print maps of your project area to include in grant applications and presentations.
- Links to program information and user guides.



Task 6: Update conservation layers -post 2006

NHDES developed a GIS layer of all ARM-funded projects in collaboration with New Hampshire Fish and Game (NHFG). During development of the data layer all sites were reviewed with the New Hampshire Conservation/Public Lands data layer (CONSNH) provided by NH GRANIT. A comparison of these two layers identified 4 of 60 projects funded through 2015 that were not in the CONSNH layer. NHDES coordinated with the grantees on these projects to ensure they are included in future updates to the CONSNH data.

In 2016, the NHDES Wetlands Bureau and Geological Survey worked with the Department of Inland Fisheries at NHFG to incorporate fish habitat data collected by the department into the Aquatic Restoration Mapper. NHFG has been conducting freshwater surveys for fish for several decades across the state and has compiled data from about 4,000 surveys into a geodatabase. The survey data is derived from various methods including electrofishing, dipnet counts, and seine and gillnetting. The single location survey points were spatially joined to the National Hydrography Dataset flowline using a GIS overlay analysis and survey data was extrapolated to the stream reach level based on predictive models and expert knowledge. The fish data is now displayed on the Aquatic Restoration Mapper to highlight species of concern, potential coldwater fishery streams, diadromous migration routes, and areas of restoration interest held by NHFG. By displaying the stream crossing data in the context of instream habitat quality, stakeholders can identify those crossing replacement projects that will provide meaningful stream restoration and funding eligibility.



Displaying the stream crossing scores alongside the fish habitat data better targets those crossings that are barriers to migratory and species of concern to target good stream restoration projects.

Task 7: Conduct outreach of updated information

A final outcome of this EPA grant was to develop and provide guidance documents, educational experiences, and the tools for municipalities to develop a compensatory mitigation inventory list that includes high priority land conservation sites, wetland and stream restoration sites, and stream crossing replacement projects (Table 3). Providing workshops and educational handouts will better prepare local conservation commissions in their ability to identify valuable mitigation projects for consideration under permittee-responsible mitigation and that may be candidates for grants from the Aquatic Resource Mitigation (ARM) Fund. The NHDES Wetlands Bureau and Geological Survey staff organized and conducted several outreach events for audiences that included regional planning commission directors, non-profit conservation groups, conservation commission members, town engineers and planners, and partner programs in other states. The goal of these events was to convey information about the *NH Stream Crossing Initiative* and its role in mitigation and ARM Fund grant process. Announcements for the outreach events were posted on the NHDES Wetlands Bureau webpage and flyers were distributed electronically to local stakeholders involved in stream crossing replacements, mitigation, and conservation (Appendix C).

To support these numerous outreach events and ensure that the *Stream Crossing Initiative* is delivering a clear, consistent message, the NHDES Geological Survey and Wetlands Bureau partnered to create a series of handouts and guidance documents. The Stream Crossing Outreach Subcommittee developed an informational brochure outlining the role of stream crossings in public safety, infrastructure resilience, and aquatic habitat restoration (Appendix D). The NH Department of Transportation printed several hundred copies of the pamphlet that were available at the outreach sessions and given to project partners to distribute across the state— the brochure is also available for [download](#).

In September 2018, several NHDES staff attended the Northeast Transportation & Wildlife Conference hosted by the MA Departments of Transportation and MA Department of Fish and Game at UMass, Amherst (Table 3). NHDES has excellent representation with Lori Sommer and Cheryl Bondi presenting a panel entitled “**Integrating stream habitat, fish passage, and flood vulnerability data to prioritize culvert replacements for restoration and mitigation in New Hampshire**”, in partnership with NHFG. Thomas Taggart, a partner in the *NH Stream Crossing Initiative* from NHGS hosted a panel discussion on “**Analyzing the hydraulic capacity and flood resiliency of culverts across the Northeast**”. Participation in this widely attended conference, allowed key members of NH’s stream crossing effort, the opportunity to build partnerships in the region.

Table 3. List of outreach events participated in by NHDES Wetlands Bureau and Geological Survey staff. All events were located New Hampshire unless otherwise indicated.

Date	Event	Location
01/27/2017	NH Association of Natural Resources Scientists Annual Conference	Concord
04/18/2017	NH Timber Harvesting Law Workshop	Hillsborough
3/08/2017	Trout Unlimited / U.S. Forest Service / U.S. Fish & Wildlife Service Stream Restoration and Flood Resiliency Workshop	Hadley, MA
3/23/2017	Land Trust Coalition Meeting/Workshop	Concord
3/24/2017	Water-Watershed Conference	Plymouth
4/8/2017	Saving Special Places Annual Meeting	Alton
4/13/2017	Regional Planning Commissions – Directors Meeting	Concord
5/8/2017	NEIWPC Buffer Meeting	Chelmsford, MA
5/31/2017	Trout Unlimited Androscoggin Watershed Meeting	Littleton
6/27/2017	Southern Region Planning Commission Meeting	Keene
5/28/2017	TU and NHFG Warner River Watershed Meeting	Warner
10/26/2017	Rockingham Regional Planning Commission	Exeter
1/18/2018	NHDES & NHDOT Aquatic Resource Mitigation Workshop	Concord
1/24/2018	NHDES & NHDOT Aquatic Resource Mitigation Workshop	Londonderry
2/5/2018	Conservation Roundtable – Association of Conservation Commissions	Concord
2/6/2018	NHDES & NHDOT Aquatic Resource Mitigation Workshop	Rochester
3/14/2018	Belknap County Conservation District Workshop	Meredith
3/23/2018	NH Water & Watershed Conference	Plymouth
3/28/2018	MS4 Seacoast Stormwater Coalition Workshop	Dover
5/21/2018	NRSC Web Soil Survey and NHDES Aquatic Resource Mapper workshop	Laconia
5/24/2018	NH Association of Natural Resources Scientists Quarterly Meeting	Concord
9/10/2018	Northeastern Wildlife and Transportation Conference	Amherst, MA

Task 8: Cross training permitting staff

During the summer of 2016 three NHDES Wetlands Bureau staff, and in 2017 four Wetlands Bureau/Shoreland staff, were trained on the NH Stream Crossing Protocol by NHGS to better understand what data is collected, and how this data may be used during application review and wetlands permitting. This experience allowed staff to receive field training on parameters they often review during permit or compliance review.

As a commitment under this grant, during the spring of 2017 the Wetlands Bureau provided training on stream crossings to all Land Resources Management (LRM) technical permitting staff and alteration of terrain staff (Table 4). NHDES wetland permitting and mitigation staff provided training on “Stream Crossings – Level 1,” which included an overview of terms, basic stream functions, goals of a proper crossing, data collection, rules and putting it all together. Dr. Shane Csiki, a fluvial geomorphologist with NHGS, provided training on “Geomorphic Compatibility and NHGS Stream Crossing Assessments.” The NHFG fish habitat biologist, John Magee, provided a presentation on “Fish Passage at Stream Crossings.” Additionally, Dr. Tom Ballestero, a hydraulic engineer and UNH professor, presented an Advanced Training on Stream Crossings. The training events fostered excellent discussion among LRM staff and the presenters and follow-up competency quizzes of the attendees ensured consistent understanding of the material provided. NHDES supervisors and managers noted increased confidence and consistent interpretation of terms and rules following the training.

Table 4. Summary of the trainings offered to the Land Resources Management staff.

Date	Topic	Presenters
02/23/2017	Stream Crossings – Level 1	Karl Benedict, Mindy Bubier, Stefanie Giallongo
03/16/2017	Geomorphology and Aquatic Organism Passage	Dr. Shane Csiki (NHGS), John Magee (NH Fish & Game)
3/20/2017	LRM Mitigation Training	Lori Sommer & Mindy Bubier
3/20/2017	Advanced – Sizing of Crossings	Dr. Tom Ballestero (UNH)

Conclusion

With the funds provided by this 2015 Wetland Program Development Grant— Track 2, the NHDES Wetland Bureau was able to accomplish several of the goals outlined in the NH Program Plan (NHWPP). Significant advancements in the *NH Stream Crossing Initiative* were made as a result of this grant and major accomplishments include, re-establishing the *Steering Team* to facilitate coordination among partner agencies; conducting 1,160 stream crossing surveys in the focal watersheds; developing an online mapping prioritization tool; and program outreach and educational materials. In addition, major updates were made to New Hampshire’s spatial data (NWI+ analysis and conservation parcel layer) and made publicly available for project and conservation planning. The *NH Stream Crossing Initiative* has gained significant momentum as a result of this grant and is now better able to support the NHDES Wetlands Bureau mitigation program. Future grants that support continued stream crossing assessments in targeted locations will help identify optimal mitigation opportunities to offset stream impacts.

APPENDIX A: Geomorphic Compatibility and Aquatic Organism Passage ranking systems based upon The Vermont Culvert Assessment Method, March 2009.

Score	% Bankfull Width	Sediment Continuity	Slope	Approach Angle	Erosion and Armoring
5	%BFW ≥ 120	No upstream deposition or downstream bed scour	Structure slope equal to channel slope, and no break in valley slope	Naturally straight	No erosion or armoring
4	100 ≤ %BFW < 120	Either upstream deposition or downstream bed scour, without upstream deposits taller than 0.5 bankfull height or high downstream banks	n/a	n/a	No erosion and intact armoring, or low upstream or downstream erosion without armoring
3	75 ≤ %BFW < 100	Either upstream deposition or downstream bed scour, with either upstream deposits taller than 0.5 bankfull height or high downstream banks	Structure slope equal channel slope, with local break in valley slope	Mild bend	Low upstream or downstream erosion with armoring
2	50 ≤ %BFW < 75	Both upstream deposition and downstream bed scour, without upstream deposits taller than 0.5 bankfull height or high downstream banks	Structure slope higher or lower than channel slope, and no break in valley slope	Channelized straight	Low upstream and downstream erosion
1	30 ≤ %BFW < 50	Both upstream deposition and downstream bed scour, with upstream deposits taller than 0.5 bankfull height or high downstream banks	n/a	n/a	Severe upstream or downstream erosion
0	%BFW < 30	Both upstream deposition and downstream bed scour, with upstream deposits taller than 0.5 bankfull height and high downstream banks	Structure slope higher or lower than channel slope, with local break in valley slope	Sharp bend	Severe upstream and downstream erosion, or failing armoring upstream or downstream

VT Aquatic Organism Passage Coarse Screen	Full AOP	Reduced AOP	No AOP	
Updated 2/25/2008	for all aquatic organisms	for all aquatic organisms	for all aquatic organisms except adult salmonids	for all aquatic organisms including adult salmonids
AOP Function Variables / Values	Green (if all are true)	Gray (if any are true)	Orange	Red
Culvert outlet invert type	at grade OR backwatered	cascade	free fall AND	free fall AND
Outlet drop (ft)	= 0		> 0 , < 1 ft OR	≥ 1 ft OR
Downstream pool present			= yes (= yes AND	= no OR (= yes AND
Downstream pool entrance depth / outlet drop			n/m (≥ 1)	n/a (< 1) OR
Water depth in culvert at outlet (ft)				< 0.3 ft
Number of culverts at crossing	1	> 1		
Structure opening partially obstructed	= none	≠ none		
Sediment throughout structure	yes	no		

APPENDIX B: User manual for the Aquatic Restoration Mapper – a stream crossing prioritization tool.

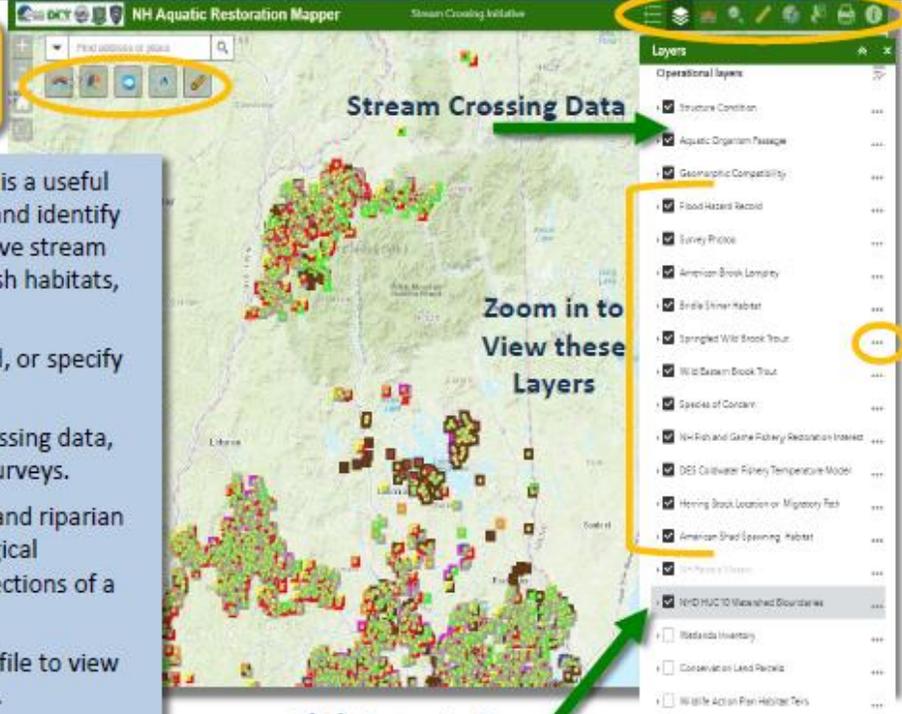
New Hampshire Aquatic Restoration Mapper

An interactive viewer to explore stream crossing and aquatic habitat data to identify restoration opportunities in your community

www.des.nh.gov/organization/divisions/water/wetlands/wmp

The *Aquatic Restoration Mapper* is a useful tool to target restoration efforts and identify mitigation opportunities to improve stream connectivity, restore important fish habitats, and increase flood resiliency.

- View data by town, watershed, or specify your own area of interest.
- Query and explore stream crossing data, including photographs from surveys.
- View stream habitat, fishery, and riparian data to understand the ecological importance and habitat connections of a restoration area.
- Export selected data as a text file to view and analyze in other software.
- Print maps of your project area to include in grant applications and presentations!



Get Familiar with the Layout of the Mapper

- Zoom in and out, pan around the map, and enter a search address to explore an area.
- Click on the **info** button to get definitions for the stream crossing scores, stream and riparian habitat, and flood hazards data.
- Click on the **legend** icon to expand the symbology of each layer.
- Expand the **layers** tab to view what information are available, try turning layers on/off, and opening the data table.



Click on any point, line, or polygon feature in the map to view a pop-up window that displays attribute information for every record!

The New Hampshire Stream Crossing Initiative is a multi-agency program aimed at improving infrastructure, flood resiliency, and stream connectivity across the state.

New Hampshire Aquatic Restoration Mapper

A decision support tool to prioritize culvert replacement and stream restoration projects

Data Layers of the Mapper

Find out about barriers to stream connectivity, important fish habitats, and flood hazards in an area by exploring the layers together.

- Stream Crossing Data and Photos
- Important Fish Habitats
- Presence of NH Species of Concern
- Predicted Coldwater Fish Streams
- Highest Ranked Wildlife Habitat
- Land Parcels
- National Wetlands Inventory
- Conservation Parcels
- HUC 10 Watershed Boundaries
- Flood Hazards Data



How to Explore Stream Crossing and Habitat Data

➤ **Narrow in on Your Area of Interest** — You can select stream crossing data by Town using the filter tool or select records in a defined area manually (hold down shift to select multiple areas).

- To select records within a watershed, turn on the HUC 10 boundaries layer and use the manual tool to select the data within the polygon.

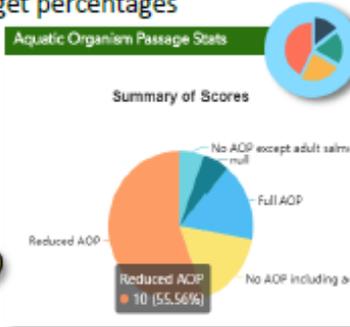


➤ **Get a Summary of the Stream Crossing Data** — Click on the Data Summary icon to get a list of stream crossings in your search area categorized by scores and flood vulnerability.

➤ **View Statistics** — Click on the Summary Stats icons to get percentages on stream crossing scores for the area of interest

- Right-click on the graph to save a graphic file of the chart to use in reports and presentations!

➤ **Filter Data** — Put a filter on the stream crossing data to view records that have certain scores.



Data Summary	
Acquatic Organism Passage	46
Full AOP	5
No AOP except adult salmonids	1
Culvert (R/S/S)	
No AOP including adult salmonids	8
undefined	1
Reduced AOP	31
Geomorphic Compatibility	46
Local Flood Report	33
Structure Condition	46

➤ **Measure Distances** — Use the ruler tool to get estimates of stream length and distance between features.

- By measuring along the flowline you can get an idea of how much upstream habitat can be gained if a given culvert was removed/replaced.



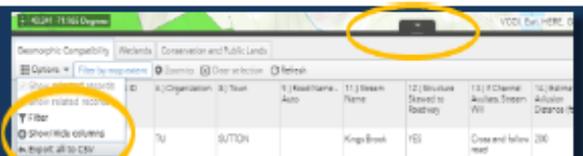
Export Data, Create Maps and Share Your Results!

➤ **View the Data Table** by clicking on the grey arrow at the bottom of the map and export selected records as a text file.

- Latitude and longitude coordinates of each record are included

➤ **Mark up the map** by using text and drawing tools to communicate key results.

➤ **Export your map** to a PDF file to include in reports, grant applications, and presentations!



APPENDIX C: Flyers posted on the NHDES website and distributed electronically for outreach events.

Aquatic Resource Mitigation Workshops

The NHDES Aquatic Resources Mitigation (ARM) Fund, in partnership with the New Hampshire Department of Transportation, is hosting three informational sessions relative to improving stream resources.

Topics covered include:

- Available ARM funding in the 2018 grant cycle;
- Updated tools to submit applications, and
- The State Stream Crossing Initiative.

Workshops are designed to provide stakeholders with information to move projects from conceptual ideas to candidate projects for mitigation funding.

We hope your participation enables your community to discover meaningful restoration projects that will be competitive for ARM funds and meet your town's needs in terms of flood resiliency and infrastructure updates!

Please attend one of our regional workshops in your community!

Central Merrimack January 18th 2018
 Department of Environmental Services
 Conference Room 208C
 29 Hazen Drive, Concord

Lower Merrimack January 24th 2018
 Londonderry Town Hall
 Moose Hill Council Chambers
 268B Mammoth Rd, Londonderry

Salmon Falls February 6th 2018
 Rochester Community Center
 150 Wakefield Street, Rochester

Potential ARM Fund grant applicants from all service areas including: municipalities (conservation commissions, road agents, and town engineers), regional planning commissions, non-profit groups, land trusts, and consultants are encouraged to attend!

4:00-4:15 Registration: participants sign in, collect information packets, and grab a snack.

4:15-4:30 Welcome and Introductions
Lori Sommer, NHDES, Wetlands Bureau

4:30-5:00 Aquatic Resource Mitigation Program
Melinda Bubier, NHDES, Wetlands Bureau will give an overview of the ARM program including available funds, project eligibility, and updated application materials to provide guidance for potential applicants.

5:00-5:30 State Stream Crossing Initiative and Interactive Web Mapper
Cheryl Bondi, NHDES, Geological Survey will introduce a multiagency program tasked with assessing stream crossings across the state. Topics covered will include infrastructure vulnerability, geomorphic compatibility, and aquatic organism passage, and how this information can be used to prioritize culvert replacement projects.

5:30-5:45 Stream Passage Improvement Program (SPIP)
Kevin Nyhan, NHDOT, will introduce a developing program that will help towns update outdated culverts to fulfill mitigation obligations.

5:45-6:00 Questions & Answers
 Participants will have the opportunity to engage with presenters and other attendees to develop ideas on potential projects in their community that may be eligible for ARM or SPIP.

Refreshments will be served!

For more information and to RSVP please visit the workshop web page at www.arm-workshop-concord.eventbrite.com or email Lori Sommer, Mitigation Program Coordinator at lori.sommer@des.nh.gov

Stream Restoration and Flood Resiliency Workshop

Programs and resources available to improve streams and reduce flooding in your community

The NH Department of Environmental Services, Department of Transportation, NH Association of Conservation Commissions, and Belknap County Conservation District invite you to a free information program funded in part by the New England Forest and Rivers Fund. Speakers will cover topics including:

- How streams and roads interact with transportation and ecosystem services.
- Aquatic Resources Mitigation (ARM) Fund and other resources available & how to use them.
- State Stream Crossing Initiative stream assessments and culvert replacement.
- Examples of successful flood resiliency and stream restoration projects.

**Meredith Community
Center**
March 14, 2018
4:30 – 6:30
One Circle Drive
Meredith, NH

Who Should Attend: Conservation Commissions, road agents, town engineers, Regional Planning Commissions, non-profit groups, land trusts, lake and homeowner associations, interested public and elected officials, and consultants interested in stream restoration, flood resiliency & infrastructure improvements.

- 4:30-4:45** **Registration:** Participants sign in, collect information packets, and grab a snack.
- 4:45-5:00** **Welcome and Overview**
Lisa Morin, Belknap County Conservation District
Colin Lawson, Trout Unlimited New England Culvert Manager
- 5:00-5:20** **New Hampshire Aquatic Resource Mitigation Program**
Melinda Bubier, NHDES, Wetlands Bureau – Overview of ARM program, funds available, project eligibility and guidance on application materials.
- 5:20-5:40** **State Stream Crossing Initiative and Web Tool**
Cheryl Bondi, NHDES, Geological Survey – Stream crossing assessments across the state with focus on prioritizing culvert replacement projects for flood resiliency and stream restoration.
- 5:40-6:15** **Panel on Stream Restoration and Flood Resiliency Resources**
Speakers will discuss Chapter 319 Watershed Assistance Grants, Homeland Security and Emergency Management Hazard Mitigation Assistance Grants, and NRCS and State Programs
- 6:15-6:30** **Stream Restoration through Partnerships**
Colin Lawson, Trout Unlimited – Using culvert replacement and large wood to restore stream condition and flood resiliency – recent project examples.
- 6:30-6:45** **Opportunity to Speak with Presenters** – Speakers available for questions.

Free event
with light
refreshments
provided!

For more information and to RSVP please visit the workshop web page at
<https://www.eventbrite.com/e/stream-restoration-and-flood-resiliency-workshop-tickets-42363874489>
or email Lisa Morin at lisa.morin@nhacdnet.net or 527-5880

APPENDIX D: Program brochure and guidance documents.

PUBLIC HAZARD



Road washout in Jackson, NH

Stream crossings – where the river meets the road

- Any location where a road intersects a waterway requires a stream crossing to convey the water under the road.
- There are approximately 20,000 stream crossings in New Hampshire.
- Many are old, damaged and undersized, and need to be assessed and replaced.

Undersized culverts present a public safety hazard

- Undersized culverts can't handle large stream flows and will cause flooding during heavy rain events or sudden snow melts. They are also prone to becoming blocked, further increasing likelihood of flooding.
- When water overtops a culvert, it can quickly erode road fill material, leading to washouts. This leads to stranded homes, expensive road repairs and impaired rivers and streams due to sediment being deposited into the water.

More information

Stream Crossings: https://www.des.nh.gov/organization/divisions/water/wetlands/streams_crossings.htm
 ARM Program: <https://www.des.nh.gov/organization/divisions/water/wetlands/wmp/>
 HSEM Hazard Mitigation Planning: https://apps.nh.gov/blogs/hsem/?page_id=839



**NEW HAMPSHIRE
STREAM CROSSING
INITIATIVE**

CONTACTS

New Hampshire Department of Environmental Services
 Flood Hazards Administrator: Shane.Csiki@des.nh.gov
 Mitigation Program Specialist: Cheryl.Bondi@des.nh.gov
 Wetlands Mitigation Coordinator: Lori.Sommer@des.nh.gov

New Hampshire Department of Transportation
info@dot.state.nh.us

New Hampshire Fish and Game Department
 Fish Habitat Biologist: John.Magee@wildlife.nh.gov

Homeland Security and Emergency Management
HazardMitigationPlanning@dos.nh.gov



Produced by NHDES and distributed by the Interagency Outreach Committee

WILDLIFE AND SAFETY – A ROAD TO SUCCESS

BEFORE



Improperly designed culverts create barriers to fish and other wildlife

- Under-sized culverts can increase water velocity and prevent a natural streambed from forming inside the structure. Fast-moving water and lack of natural eddies and protected areas can prevent passage for smaller aquatic animals.
- Elevated or perched culverts can prevent any animal passage – many local aquatic species need to move freely in a stream to complete their life cycles.



New Hampshire Stream Crossing Initiative

Project partners are working to address flood risks and make our infrastructure more resilient through a proactive approach by identifying and replacing problem culverts **before** they can fail and cause damage. Identifying crossings for replacement that will maximize ecological benefits while addressing infrastructure safety can save money and help to restore aquatic habitat in the long run.

The goal is to assess and prioritize which crossings are the best candidates for replacement to improve public safety, infrastructure resilience and aquatic habitat restoration.



Replacing culverts for watershed restoration

- Removing crossings that are barriers to fish and wildlife contributes to watershed restoration goals. Waterways will be reconnected and both water quality and stream habitat will be improved.
- A suitable crossing will span the stream banks and have similar water flow, depth and substrate to the natural stream.
- A properly designed stream crossing can accommodate fish and wildlife passage and stream channel adjustments, while reducing flood hazards and expensive damage by allowing for flood flows.

Success Story – Falls Brook, Swanzey, NH

A six-foot corrugated metal culvert originally served as the crossing structure for Hale Road. It was identified as a priority replacement due to the amount of quality cold-water habitat within the stream reach and because it posed a potential hazard to the community during extreme storm events.

The goals of the project were:

- Improving aquatic organism passage.
- Improving geomorphic compatibility with the stream.
- Improving flood resiliency.

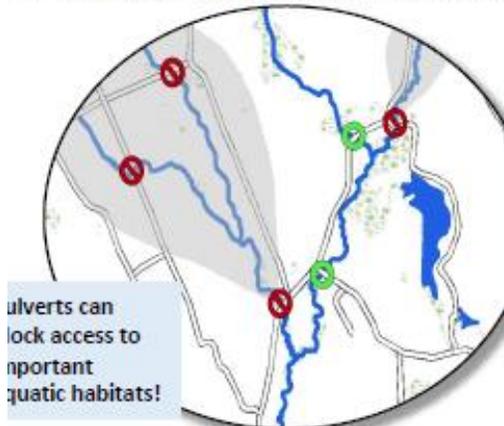
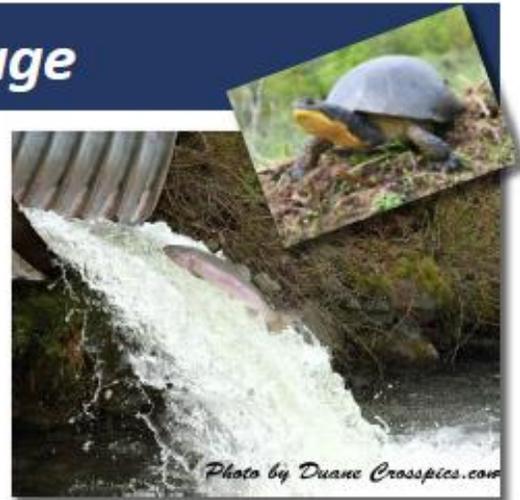
In 2016, the culvert was replaced with a 24-foot aluminum arch culvert, consistent with bankfull measurements. The streambed was restored and the downstream banks were planted with trees and vegetation to ensure stability.

The Falls Brook project was partially funded through a NHDES Aquatic Resources Mitigation (ARM) grant to the Cheshire County Conservation District, in partnership with Trout Unlimited, NH Fish and Game and others.

Aquatic Organism Passage

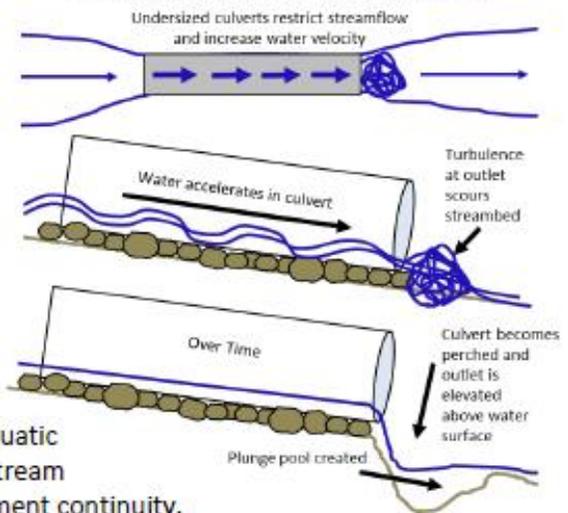
What is Aquatic Organism Passage (AOP)? This identifies whether aquatic animals such as fish, turtles or amphibians can pass through a stream crossing without restrictions such as:

- A large vertical drop between the crossing and the stream (known as a perched culvert).
- Water in the crossing that is either too shallow or too fast.
- Physical barriers that block the crossing inlet or outlet.
- A lack of natural substrate in the crossing.



Just like we need roads to get us places, aquatic animals require a connected stream network to get around!

How a culvert becomes perched



How do we know if a culvert is a barrier to animals?

Information is collected on the culvert and river channel in the field and the data is used to assign a score.

Full AOP – The crossing functions like the natural stream for all aquatic organisms, maintaining a connection between the up- and downstream environment without changes in slope, a drop in height, and sediment continuity.

Reduced AOP – The crossing can have any of the following conditions: (1) the stream cascades over steep rocks on the downstream side; (2) consists of multiple culverts; (3) an obstruction at the entrance; or (4) the structure lacks natural sediment. These conditions limit AOP for some species or life stages, but may allow strong and moderate swimming fish to pass.

No AOP except adult salmonids – The crossing is perched with a vertical drop of ≤ 1 foot to the water surface and there is a >1 foot deep plunge pool immediately downstream. Only strong swimming and leaping fish such as Eastern Brook Trout and other salmonids can pass these crossings.

No AOP including adult salmonids – The crossing is perched with a >1 foot drop to the water surface, or the drop is <1 foot and no downstream pool is present or the depth of water in the culvert is <0.3 feet.



Fish-friendly culvert



For more information on the Stream Crossing Initiative contact the Flood and Geologic Hazards Program at NHDES:
 Cheryl Bondi: Cheryl.Bondi@des.nh.gov, (603) 271-0587
 Tom Taggart: Thomas.Taggart@des.nh.gov, (603) 271-5762



Geomorphic Compatibility

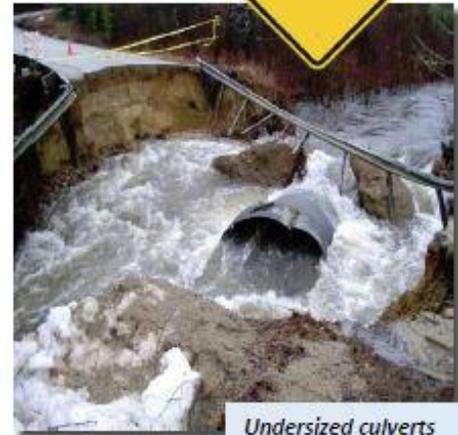


What is Geomorphic Compatibility (GC)? This describes the long-term compatibility of a stream crossing with river channel form and sediment transport.

Channel form is the shape of a stream within its floodplain and is determined by local topography and streamflow patterns. To evaluate if a stream crossing is compatible with channel form we ask:

- Is the culvert aligned with the channel or is it set at an angle?
- Does the culvert span the stream banks or is it too narrow?
- Is the slope of the structure similar to that of the stream channel?

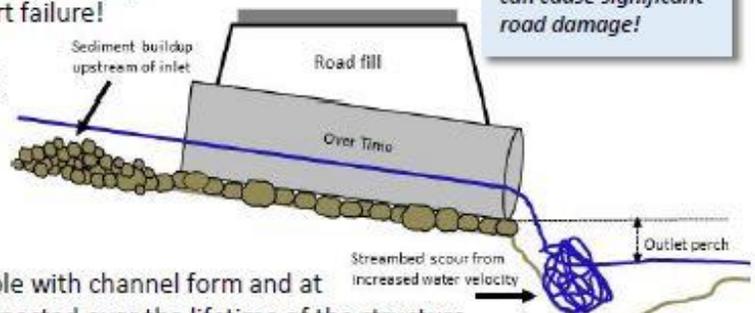
Sediment transport refers to how water moves rocks and sand along the stream bed. Undersized or improperly-angled stream crossings increase the potential for sediments to deposit upstream of a culvert. Sediment that accumulates in front of the culvert reduces the amount of water that can pass through the pipe and increases velocity – during a storm this can lead to catastrophic culvert failure!



Undersized culverts can cause significant road damage!

How do we evaluate Geomorphic Compatibility?

Information is collected on the culvert and river in the field and used to assign a score. The score acts as a guide for which culverts are more likely to fail and need to be replaced or upsized.



Fully Compatible – The structure is fully compatible with channel form and at a low risk of failure. Culvert replacement is not expected over the lifetime of the structure.

Mostly Compatible – The crossing is mostly compatible with channel form and has a low risk of failure. Culvert replacement is not expected over the lifetime of the structure, but if a replacement does occur, minor design adjustments are recommended to make the culvert fully compatible.

Partially Compatible – The crossing is either compatible with channel form or sediment transport, but not both. Compatibility is likely only in the short term. Culvert replacement may be needed, given the moderate risk of failure during its design lifetime.

Mostly Incompatible – The crossing is undersized, poorly aligned, and not compatible with channel form or sediment transport. As a result, these structures are at a moderate to high risk of failure.

Fully Incompatible – The structure is severely undersized, impeding sediment transport, and causing streambed scour and bank erosion. Crossings in this category are not compatible with channel form or sediment transport process and are at a high risk of failure.



An undersized culvert ranked as “fully incompatible” that has significant downstream bed scour and bank erosion.



For more information on the Stream Crossing Initiative contact the Flood and Geologic Hazards Program at NHDES:
 Cheryl Bondi: Cheryl.Bondi@des.nh.gov, (603) 271-0587
 Tom Taggart: Thomas.Taggart@des.nh.gov, (603) 271-5762



Hydraulic Vulnerability and Flood Resiliency

What is Hydraulic Vulnerability? This describes how well a stream crossing transports flows during storm events and can be evaluated based on predictions of hydraulic capacity or flood event records.

How is Hydraulic Capacity predicted?

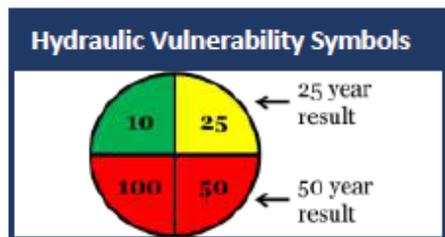
A hydraulic capacity analysis estimates the amount of water that a culvert can transport based on hydraulic equations and streamflow predictions. It also estimates the water that will accumulate upstream of a culvert. The results help predict a culvert's potential to sustain damage or overtop during a specific storm event.

Data used in the hydraulic capacity analysis include:

- **Field-based data** on culvert inlet shape, structure material, dimensions, slope and elevation relative to road surface.
- **Watershed Characteristics** based on a geospatial analysis, including drainage area, landcover, soil type, precipitation, etc. Streamflow predictions are based on the [USDA Technical Release 55 curve](#) number method for smaller drainages and the [USGS NH Streamflow Regression Equations](#) for larger watersheds.



Undersized culvert that has failed



How are Hydraulic Capacity results interpreted?

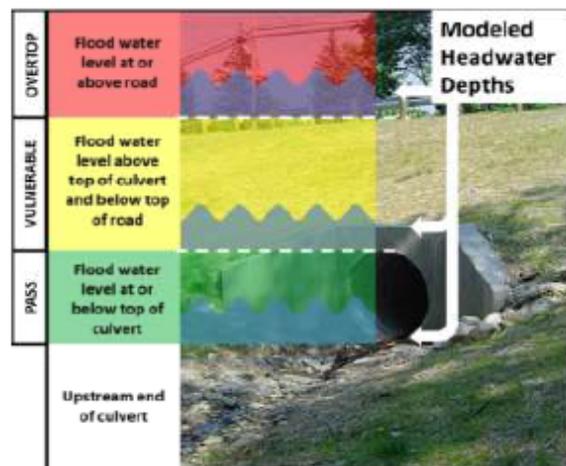
The results are translated into the following scores:

Overtop – Flows are predicted to reach the top of the road fill and possibly flood the road.

Vulnerable – Water levels are predicted to reach above the top of the culvert, but remain below the top of the road, so erosion of road fill is possible, but road flooding unlikely.

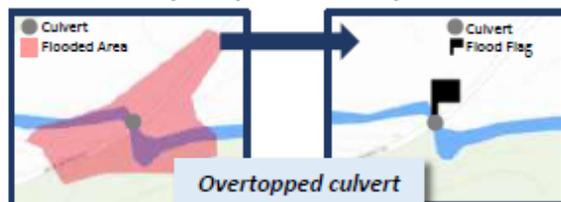
Pass – Water is predicted to remain below the top of the culvert, so the structure may transport that streamflow.

These predictions are useful for identifying potentially vulnerable culverts and are not intended to replace in-depth engineering analyses for design and permitting.



Recorded Historical Flood Events

Local hazard reports provide descriptions of flood concern within a community and identify problem culverts.



Overtopped culvert

- Emergency planners and road agents document past and potential flooding as part of their Hazard Mitigation Plan process.
- Information on flooding related to stream crossings is available for viewing and flagged in the NHDES' [Aquatic Restoration Mapper](#).



For more information on the NH Stream Crossing Initiative contact

NH Geological Survey at NHDES:

Cheryl Bondi- Cheryl.Bondi@des.nh.gov (603) 271-0587

Tom Taggart- Thomas.Taggart@des.nh.gov (603) 271-5762



Stream Habitat and Aquatic Connectivity

Aquatic Barrier Prioritization to Improve Aquatic Connectivity

Stream crossing removal and upgrades projects should focus on areas that will connect important aquatic habitats, while improving infrastructure and increasing flood resiliency.

- Restore instream habitat for sensitive aquatic species.
- Reconnect critical spawning habitat for coldwater fisheries and migratory corridors for anadromous fish.
- Establish connections between important conservation land and high quality wildlife habitat to support landscape connectivity.

Replacing this flood-prone culvert will connect Brook Trout and critical wildlife habitat, and conservation land.



New Hampshire Fish and Game Wildlife Action Plan- Fishery Priorities

This data layer highlights important aquatic habitat at the stream-reach level identified by the F&G Inland Fisheries Division based on over 4,000 field surveys, predictive models, and expert knowledge.

Stream Reach Label	Symbol	Description of Fish Habitat
American Brook Lamprey	Black line	American Brook Lamprey occupied stream based on survey data.
Bridle Shiner Habitat	Yellow line	Stream reach is has confirmed Bridle Shiner from survey data.
Springfed Wild Brook Trout	Green line	Presence of a springfed Brook Trout population that is vulnerable due to its geographic isolation and local coldwater conditions.
Wild Eastern Brook Trout	Purple line	Wild Brook Trout is present in the stream based on field surveys.
Fishery Restoration Interest	Yellow line	Rivers with past, ongoing, or planned restoration and conservation work that is supported by the NH Department of Fish and Game.
Coldwater Fishery Temperature Model	Blue line	Displays stream reaches predicted to be suitable for coldwater fish communities based up the NH Department of Environmental Services' coldwater fishery model.
Herring Stock Location or Migratory Path	Light green line	Stream where river herring is stocked by F&G or there is a migratory path downstream to the Merrimack River.
Seacoast Anadromous Fish Habitat	Bright green line	Anadromous fish habitat accessible to river herring and sea lamprey for spawning on the seacoast.
American Shad Spawning Habitat	Pink line	An area that has potential American shad spawning or juvenile rearing habitat.
Species of Concern	Magenta line	Confirmed presence of a fish or mussel species of conservation concern that is included in the NH Wildlife Action Plan.

Wildlife Action Plan (WAP)- Abbreviations of species present in streams from F&G field surveys.

AE- American Eel	AS- American Shad	AW- Alewife	BDS- Banded Sunfish	BRB- Burbot
BF- Brook Floater	BS- Bridle Shiner	EBT- Brook Trout	LT- Lake Trout	FD- Finescale Dace
LW- Lake Whitefish	SL - Sea Lamprey	RFP- Redfin Pickerel	SD- Swamp Darter	NRD- Northern Redbelly Dace
RS- Rainbow Smelt	DWM- Dwarf Wedge Mussel		ABL- American Brook Lamprey	



For more information on the Stream Crossing Initiative

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