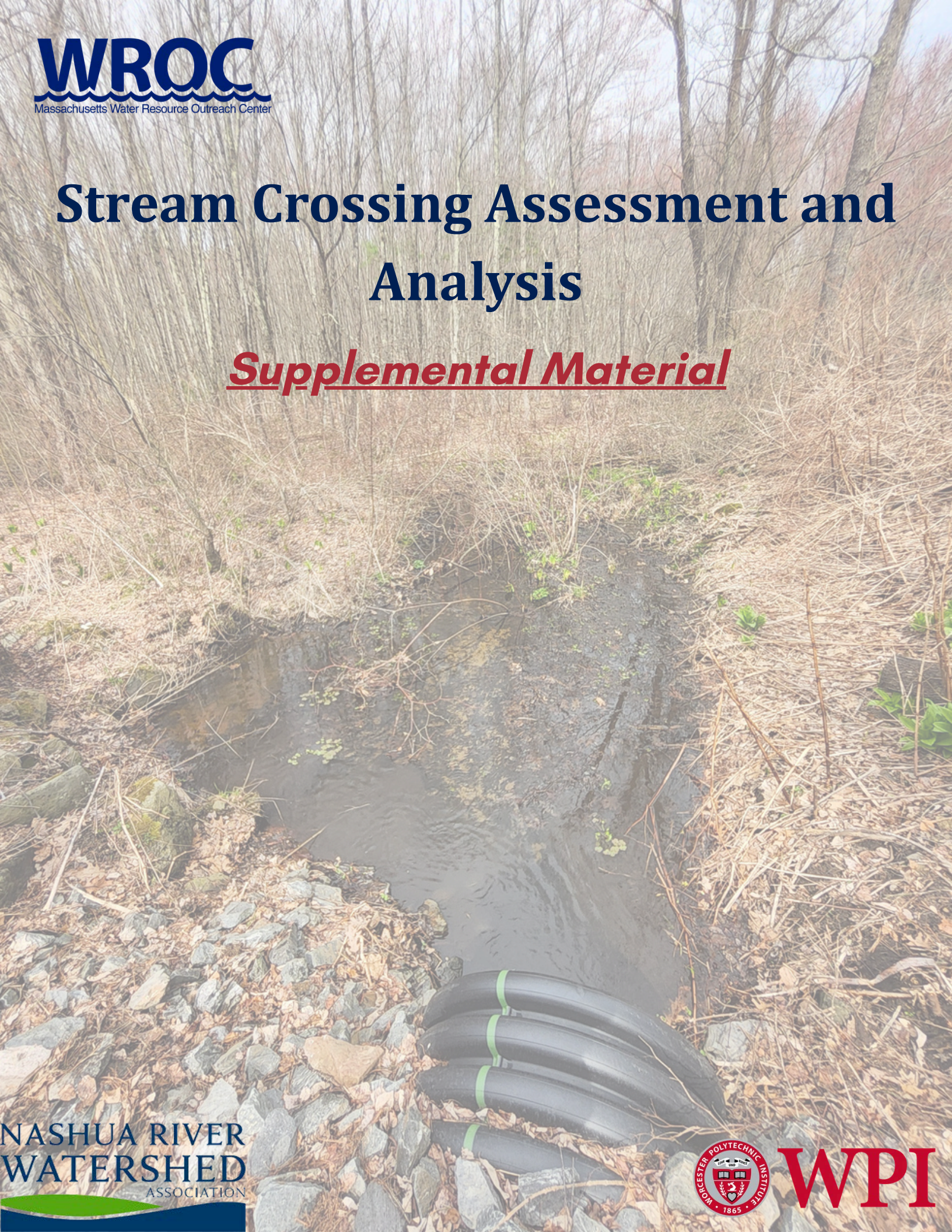
WROC
Massachusetts Water Resource Outreach Center

Stream Crossing Assessment and Analysis

Supplemental Material



NASHUA RIVER WATERSHED ASSOCIATION

WPI

An Interactive Qualifying Project Report Submitted to the Faculty of
WORCESTER POLYTECHNIC INSTITUTE
In Partial Fulfillment of the Requirements of the Degree of Bachelor of Science.

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Water Resource Outreach Center

Report Submitted to:
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This report represents work of WPI undergraduate students submitted to the faculty as evidence of a degree requirement. WPI routinely publishes these reports on its web site without editorial or peer review. For more information about the projects program at WPI, see https://www.wpi.edu/project-based-learning/global-project-program

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Abstract

Massachusetts has approximately 25,000 culverts, of which.only 9,000 (36%) have been mapped, and 6,600 (26%) have been assessed, and on average only 200 (3%) are repaired annually. Our goal was to explore whether socioeconomic factors impact the quality and condition of culverts. We worked with the Nashua River Watershed Association and researched eight towns in the watershed. From nine interviews, analyzing fiscal records, and participant observation we found that residents are unaware of the importance of culverts, towns have limited budgets, and state funding options are hard to get and time consuming. In order to increase public understanding of how important culverts are, we developed a 4-minute educational video for widespread distribution.

Table of Contents

Table of Contents i
List of Tables and Figures ii
Authorship Page iii
Appendix A: Informed Consent Preamble v
Appendix B: General Interview Questions vii
Appendix C: Specific Interview Matrix viii
Appendix D: Data Collection Instruments ix
Appendix E: Raw Data ix
E-1: Culvert Material and Cost Table x
E-2: Town Funding xi
E-3: Culvert Assessment xii
E-4: Town Tax Bracket and Percentage xiii
E-5: Town department of revenue and Chapter 90 xiv
Appendix F: Linked to Sites xv
Appendix G: Video Script xvii
Appendix H: Storyboard xx

List of Tables and Figures

List of Tables

- Table 1 - pg.10: Culvert Material and Cost Table
- Table 2 - pg.11: Town Funding
- Table 3 - pg.12: Culvert Assessed
- Table 4 - pg.13: Town Tax Bracket and Percentage
- Table 5 - pg.14: Town department of revenue and Chapter 90

Authorship Page

Chapter Sections, Authors, Editors		
Chapter/Section	**Primary Author**	**Primary Editors**
TOC	Drafted by All	Edited by All
Literature Review	Drafted by All	Edited by All
Background Chapter	(Drafted by Section)	----------
Introduction	Adam	Edited by All
I. Climate Change in New England	Adam	Edited by All
Use of AI for Topic 1: ChatGPT was used to give recommendations for spacing settings. AI was not used to generate any text or information that appears here.		
II. Impacts of Climate Change in New England	Dakota and Kenerson	Edited by All
Use of AI for Topic 2: Artificial intelligence was used in an extremely limited capacity. AI was only used to help with formatting due to issues with Google Docs. Besides that, nothing else was made by AI. All text was hand typed.		
III. Mitigating Impacts of Climate Change	Kenerson and Dakota	Edited by All
Use of AI for Topic 3: Artificial intelligence was used sparingly throughout this section. Like the others, it was only used to help format the Google Doc and for nothing else. Everything written was hand typed.		

Authorship Page

IV. Organizations involved in stream crossing protection	Evan and Dakota	Edited by All
Methodology	(Drafted by Section)	----------
Introduction	Adam	Edited by All
Objective 1: Gain Understanding of Culverts and the Assessment Process	Kenerson	Edited by All
Objective 2: Determine Factors and Sources	Kenerson	Edited by All
Objective 3: Explore Best Practices in Culvert Repair	Adam	Edited by All
Objective 4: Draw Conclusions and Come Up With Recommendations	Evan & Dakota	Edited by All
Bibliography	Drafted by All	Edited by All
Appendices	Evan & Kenerson	Evan & Kenerson

Authorship Page

Finding 1	Evan	Kenerson and Evan
Finding 2	Kenerson	Kenerson and Evan
Finding 3	Kenerson	Kenerson and Evan
Finding 4	Evan	Kenerson and Evan
Recommendations	Kenerson	Kenerson and Evan
Conclusion	Evan	Kenerson and Evan
Video	Adam	Adam
Booklet Organization and Structuring	Dakota	Dakota

Appendix A: Informed Consent Preamble

Description: Below is the template of the email we sent to people we wanted to interview

Interview Request - Culvert Replacement Prioritization Research | WPI

Hello,

We are a group of four students from Worcester Polytechnic Institute who are doing research. We previously emailed about setting up an interview but were just reaching back out in case the first one got buried. Regardless, we will follow up in a few days with a phone call to figure out if there is a best time to meet. We know it is a very busy time of year with impending grant application deadlines and heavy snowfall, so we understand if you are unable. Our group is working with the Nashua River Watershed Association to do research on culvert assessment, replacement prioritization, and grant applications. Questions will be about culvert conditions in <INSERT TOWN>, grant applications, costs associated, and replacement / repair prioritization. Let us know if you feel there is a better candidate for the interview to reach out to. The interview should take around 30 minutes to complete.

Your participation in our interview is completely voluntary, and you may choose to end it at any time. Your answers will be associated with your name and credentials unless you choose to remain anonymous. We would like to disclose your name if possible to ensure credibility, but if at any time you would not like us to use your name, we can remove your name and any identifying factors from our research. Please feel free to contact us at any time with any questions or concerns. We are available Tuesday, Wednesday, and Friday from 9AM to 5PM. We can be reached at gr-d26.streamcrossing@wpi.edu and our faculty advisor can be reached at cdehner@wpi.edu. If you would like to be informed on our findings of this research, we can send you our final report on May 1st. Alternatively, our findings will be publicly available at https://digital.wpi.edu/collections/iqp. Thank you for your time and consideration. We appreciate it.

Sincerely,

Kenerson Cronin: Robotics Engineering
Adam Dean: Mechanical Engineering
Evan Goodman: Computer Science
Dakota Wellerbrady: Computer Science

Worcester Polytechnic Institute
Faculty Advisor: Corey Dehner, cdehner@wpi.edu
Team Email: gr-d26.streamcrossing@wpi.edu

Appendix B: General Interview Questions

Description: This appendix contains interview questions we asked conservation commission agents and town Department of Public Works employees.

1) Did your town submit an expression of interest (EOI) and what feedback did you get?
2) Who applies for grants, how much work?
3) Cost to repair vs. cost to replace?
4) Opinions on Mass. Ready Bill?
5) Any ongoing projects?
6) Did you apply for the EcoOneStop grant? If so, how difficult was it? (time, resources required, etc.)
7) What percent of your budget goes into culvert maintenance?
8) Did you have to put up a cash match for any grants you applied for?
9) Did you get plans approved by engineers and do you feel that that requirement is fair?
10) How does your prioritization process work for stream crossing replacement?
11) How long does planning for replacement take and how many different companies do you typically consult with?
12) How much planning goes into every stream crossing, what factors are considered?
13) How do you decide lifespan and material usage for stream crossings? How is it?
14) What are the largest issues you face when doing culvert repairs or replacements?
15) Do you find that residents are aware of how important culverts are to protecting their towns infrastructure?

Appendix C: Specific Interview Matrix

Description: Below is a matrix we made to keep track of specific questions we had for certain interviewees

Subject	Questions
Department of Public Works (DPW)	• How much work are you able to put into applying for grants? • How does your prioritization process work for stream crossing replacement? • How long does planning for replacement take and how many different companies do you typically consult with? • How much planning goes into every stream crossing, what factors are considered? • How do you decide lifespan and material usage for stream crossings? How funding dependant is it? • Do you test the water quality to decide the material of the culvert • What are the largest issues you face when doing culvert repairs or replacements? • What percentage of your budget is allocated to replacements/how much of the funding comes from grants?
Leominster Department of Works (DPW)	• What have you learned from the aftermath of the flooding in 2023? • Do you think there was a lack of future sighted design for the culverts? • What considerations were made for the replacements for Pleasant Street, Lancaster Street, and Commuter Rail track washouts?
Nashua River Watershed Association (NRWA)	• Are there certain towns that receive less funding compared to others, even though they applied for grants? • How does the grant application process work, and how often do you get the requested funds?
Massachusetts Division of Ecological Restoration (MASSDER)	• When evaluating ecosystems near culverts: Do you find any common factors that show up together when evaluating poorer wildlife conditions? • Are there forms of pollution that are more common after flooding?

Appendix D: Data Collection Instruments

Description: This table contains the methods and sources of data for our research

Data Collection Instruments	
Instrument	**Data**
Content Analysis	NAACC database Role Culverts Play In Stream Crossings Department of Public Works (DPW) Massachusetts Division of Ecological Restoration (MassDER) Interactive Qualifying Projects (IQP) at Worcester Polytechnic Institute Town Fiscal Records ArcGIS QGIS Artificial Intelligence (Like ChatGPT, Google Gemini, Claude) Google Scholar MongoDB
Interviews	Utkir Adkhamov - Senior Water Quality and Restoration Associate MassDER Employee Kerry Reed - Hopkinton DPW Superintendent Sam Belanger - Lancaster Conservation Agent Jesse Averka - Leominster Conservation Agent Michael Fleming - Shirely Conservation Agent Mark Piermarini - Leominster DPW Assistant Director Wendy Wiiks - Leominster Grant Administrator Lydia Olsen - Massachusetts Rivers Alliance Research Manager
Participant Observation	Culvert Assessments Shadowing NAACC Training

Appendix E-1: Raw Data

Description: Below is a matrix of different types of culvert data ranging from price, structural strength, design, material, and more seen below. Used to show both the benefits and downsides of a variety of types of culverts

Material	Structural Strength	Lifespan	Best used case	Cost Per Ft
Concrete	Strongest	75 - 100 years	Everything	100$ - 250$
Metal	High	25 - 50 years	Roads moderate loads	72$ - 150$
Plastic	High	50+ years	Quick and cheap to install	50$ - 100$

Table 1: Culvert Material and Cost Table

Material	Typical Design Type	Structural Strength	Durability / Lifespan	Best Use Case	Relative Cost (Material)	Typical Cost Range
Reinforced Concrete (RCP / Box)	Rigid (pipe or box culvert)	Very high (handles heavy loads, highways)	50–100+ years	Highways, large drainage, high load areas	$$$ (most expensive)	~$40–$110 per ft (material only)
Corrugated Steel (CMP)	Flexible pipe (corrugated)	High (but less than concrete)	25–50 years (corrosion dependent)	Roads, moderate loads, rural crossings	$$	~$200–$500 per section
HDPE / Plastic	Flexible pipe	Moderate (depends on soil support)	50+ years (no corrosion)	Residential drainage, low–moderate loads	$ (cheapest)	~$150–$400 per section
Aluminum (Corrugated)	Flexible pipe	Moderate–high	30–50 years (corrosion resistant)	Coastal or corrosive environments	$$–$$$	Similar to steel but slightly higher
Structural Plate Steel / Arch	Flexible (large-span arch)	High (for large spans)	50+ years with coating	Large crossings, fish passage	$$$	Highly variable ($10k–$100k+)
Concrete Box Culvert	Rigid frame	Extremely high	75–100+ years	Bridges, large water flow	$$$$ (highest)	$7,000–$25,000+ installed

Appendix E-2: Raw Data

Description: Below is a matrix of each town we were focusing on and the amount of self culvert funding, i.e. the amount of funds the town itself used (in the millions), the amount of funding they got from Municipal Vulnerability Preparedness (MVP) grants, and the amount of funding they got from Mass Department of Transportation (DOT) grants (in the millions).

Self Culvert Funding is the amount of money a municipality pays out of pocket (no Grants nor funding) to fix culvert.

Town	Self Culvert Funding (Million)	MVP	Mass DOT (million)
Fitchburg	6.51	0	0
Groton	0	0	0
Lancaster	0	0	0
Leominster	0	487483	5.28
Rutland	0	0	0
Shirley	0	0	0.04
Sterling	0	0	0
Townsend	0	154500	0

Table 2: Town Funding.

Appendix E-3: Raw Data

Description: Below is a matrix of each town we were focusing on and the amount of culverts each one had along with the number of assessed and unassessed culverts in each town along with an overall average at the bottom of it

Town	#Culverts	Assesed	Not Assesed
Fitchburg	154	134	20
Groton	88	79	9
Lancaster	93	93	0
Leominster	129	128	1
Rutland	96	96	0
Shirley	48	47	1
Sterling	109	100	9
Townsend	152	147	5
AVERAGE	**869**	**103**	**5.625**

Table 3: Culvert Assessment.

Appendix E-4: Raw Data

Description: Below is a matrix of each of the eight towns we were focusing on and a variety of important statistics about them from property tax to number of households (the rest can be seen below). The matrix also includes an average at the bottom of it for each column as well

Town	Property Tax (Residential)	Homeowner %	Renters %	# Households	Median Gross Rent	Prorperty Tax Income (million)
Fitchburg	1.28%	54.10%	45.90%	16659	1222	31.94
Groton	1.48%	88.80%	11.20%	3705	1458	38.05
Lancaster	1.62%	85.10%	14.90%	2960	2338	16.5
Leominster	1.37%	62.30%	37.70%	18483	1354	88.45
Rutland	1.39%	89.40%	10.60%	3185	1078	18.2
Shirley	1.24%	77.40%	22.60%	2277	1481	12.4
Sterling	1.26%	86.30%	13.70%	3283	1699	22.8
Townsend	1.38%	82%	18.00%	3339	1469	12.68
AVERAGE	**0.0137425**	**78.18%**	**21.83%**	**6736.38**	**1512.38**	**30.1275**

Table 4: Town Tax Bracket and Percentage

Appendix E-5: Raw Data

Desciption: This table shows the eight town budgets and chapter 90 funding they received for fiscal year 2027

Town	Department Of Revenue Income	chapter 90 FY27
Fitchburg	1,061,558,000	1,703,505.51
Groton	1,049,259,000	851,840.80
Lancaster	398,121,000	535,889.70
Leominster	1,538,724,000	1,665,763.63
Rutland	437,683,000	649,553.18
Shirley	267,090,000	390,195.96
Sterling	514,857,000	750,287.76
Townsend	379,939,000	690,410.08

Table 5: Town department of revenue and Chapter 90

Appendix F: Link to Sites

Description: Below are links that were used when researching demographic and financial information. Town specific links are kept together.

DLS (Population, DOR Income)
https://dls-gw.dor.state.ma.us/reports/rdPage.aspx?rdReport=DOR_Income_EQV_Per_Capita

Mass cities by population
https://www.massachusetts-demographics.com/cities_by_population

US Census Bureau (Homeowner%, Households): https://www.census.gov/quickfacts/fact/table/fitchburgcitymassachusetts/HSD410224

Mass Dot Grant Archive: https://hwy.massdot.state.ma.us/projectinfo/projectinfo.asp

MVP Grant 2026: https://experience.arcgis.com/experience/fd26505b82bc49b1bac525dc95a2a50a/page/MVP-Grant-Programs?views=All-MVP-Filters-View%2CAll-MVP-Grants-View

MVP Grant 2024: https://www.mass.gov/news/healey-driscoll-administration-awards-52-million-in-climate-resiliency-funding-to-communities

Culvert Type and price table: https://latestcost.com/culvert-cost-price-budget-typical-ranges/

Chapter 90 funding FY27: https://www.mass.gov/info-details/chapter-90-apportionment

Fitchburg
Population, Land Area, Median household income, https://censusreporter.org/profiles/16000US2523875-fitchburg-ma/#:~:text=Here's%20some%20demographic%20information%20about%20Fitchburg:%20*,**Families**%2016%2C659%20households%2C%202.4%20people%20per%20household

Fiscal Year 26: https://www.fitchburgma.gov/Archive.aspx?AMID=58

Groton
Town Site: https://datausa.io/profile/geo/groton-ma

Fiscal Year 26: https://www.grotonma.gov/wp-content/uploads/2025/06/June-23-2025-Special-Town-Meeting-Budget-Presentation.pdf

Appendix F: Link to Sites

Other Fiscal Year Files: https://www.grotonma.gov/government/budget/

Lancaster
Fiscal Year 26: https://www.ci.lancaster.ma.us/426/Budget-Documents

Leominster
Census Reporter:
https://censusreporter.org/profiles/06000US2502735075-leominster-city-worcester-county-ma/#:~:text=Here's%20some%20information%20about%20census%20reporters%20for,native%2C%201%25%20Asian%2C%205%25%20other%2C%2017%25%20two+

Fiscal Year 26: https://www.leominster-ma.gov/Archive.aspx?AMID=40

MassDOT Culvert Grant: https://hwy.massdot.state.ma.us/ProjectInfo/Main.asp?ACTION=ViewProject&PROJECT_NO=616375

Rutland
About US: https://www.rutlandma.gov/312/About-Our-Community

Fiscal Year 26: https://www.rutlandma.gov/Search?searchPhrase=Rutland%20Tax%20Brochure%20Fiscal%20Year%20&pageNumber=1&perPage=10&departmentId=-1

Shirley
About US: https://www.shirley-ma.gov/487/About-Shirley

Fiscal Year 26: https://www.shirley-ma.gov/Archive.aspx?AMID=38

Sterling
Fiscal Year 26: https://www.sterling-ma.gov/332/Approved-Budgets

Townsend
Income: https://www.townsendma.gov/departments/assessing/community_preservation_act.php

Fiscal Year 26: https://www.townsendma.gov/departments/town_administrator/budgets/index.php#outer-621

Appendix G: Video Script

Description: Below is a script outlining our video that we created for educational outreach. The purpose of the video was to help residents understand the importance of culverts.

Hook:

<Shot of flooding>

As climate change gets worse, how do we prevent flooding? How do we keep roads intact and ecosystems connected even after we develop the land around them?

<Shot of road washout>

When we block the flow of a river, mother nature will hit back and erode her way through whatever structure interrupted her. As time goes on, rain and severe weather only get more powerful due to climate change, increasing this side effect.

<Shots of good culverts>

To confront this problem, we use culverts, but what is a culvert?

Intro:

<Animation>

A culvert is a passageway that is designed to eliminate the conflict of nature and infrastructure. If you design a road to cross a waterway without accounting for erosion, it will quickly get eaten away. To fix this, we install culverts. They allow safe passage for human resources, natural waterways, and our natural wildlife.

Aquatic Connectivity:

<Wildlife in culvert>

These passages are not only important to us, but also to our terrestrial and aquatic neighbors. Fish and wildlife utilize culverts the same way we utilize a bridge, so it is important to maintain that connection. Some aquatic wildlife need to migrate upstream to breed or locate food. In addition, terrestrial creatures use these culverts for safe passage beneath roads.

Deterioration:

<Videos of deterioration>

Culverts do not last forever, in fact, they normally only last about 50 years. In the Nashua River Watershed alone, 18.8 percent of culverts are already significantly deteriorated. This poses a serious structural hazard and puts the road at risk of failure. To prevent this hazard, it is important to understand the conditions of our local culverts.

Assessments:

<Videos of assessments>

Regular assessments of culverts provides vital data for repairing at-risk culverts, improving wildlife connection, and keeping our communities climate resistant. In Massachusetts, only around 40 percent of culverts have been formally assessed with the North Atlantic Aquatic Connectivity Collaborative standards. We should be aiming not only for one hundred percent assessed, but also for regular assessments every few years.

Well designed culverts:

<Videos and animation of a good culvert>

Appendix G: Video Script

A well designed culvert according to Massachusetts Stream Crossing Standards is wider than the river bed, has three sides, and a natural bottom. It is properly aligned so that it does not impact the natural flow of the body of water or interrupt wildlife movement through the bodies of water. It is essentially a miniature bridge with fill between it and the road. These standards pave the way for a climate resilient, future focused Massachusetts. Without these standards, stream crossings can and will fail minorly or catastrophically.

How to help:

<Local communities>

So what can you do to make a difference? Supporting local watershed organizations, regional watershed collaboratives, and spreading awareness is a fundamental step towards the future. Additionally, if you are curious about a culvert near you, you can check to see if it has been assessed on the North Atlantic Aquatic Connectivity Collaborative website.

<Assessments>

wwIf you are looking to get directly involved, you can contact your local North Atlantic Aquatic Connectivity Collaborative coordinators about getting trained to do assessments of culverts in your local community.

<Massachusetts State House>

Contacting your local representative to stress the importance of culverts and funding their repairs is one often overlooked action. Attending town meetings and speaking up about lack of funding for culverts or bringing attention to culverts that are in disrepair is also very helpful.

<Local Organizations>

Understanding the problem is half of the battle. One of the main barriers that we have found to mobilizing funding was a lack of awareness about the issue. Share this video to get the word out. You can visit the Nasha River Watershed Association or Massachusetts River Alliance websites to learn more.

<roll credits>

END OF SCRIPT

Extra not in video:

Undersized Culverts:

<Undersized culverts>

It is important for the passage to be properly sized for the flow it is expected to receive. If the culvert is too small, then debris is at risk of clogging the culvert. High flow events could overtop roadways and cause flooding. This also limits passage of wildlife, there is not enough space for them to pass through unimpeded. This barrier hurts vital migrations of wildlife and is detrimental to an ecosystem.

Barriers in Culverts:

<Videos and animation of barriers>

Appendix G: Video Script

Additionally, some installers artificially add barriers to culverts to block debris or wildlife such as beavers from blocking up inlets of culverts. These barriers not only struggle to perform that task, they also add major obstacles to wildlife and water attempting to traverse the culvert.

Perched Culverts:

<Videos and animation of perched culvert>

Another common obstacle is called perching. This is when the outlet of a culvert is too high above the water, this can lead to significant issues. In the Nashua River Watershed alone, four percent of surveyed crossings were like this. Perching leads to massive erosion and severs any potential for aquatic connectivity. Erosion as a result of perching or high flow rates is called a scour pool. This artificial body of water at the outlet has drastically different depth and width compared to the rest of the stream, and can be a structural hazard for roadways.

Skewed Culverts:

<Videos and animation of skewed culvert>

Another hazard culverts face is called skew. If the angle between the upstream flow and the inlet of the culvert is large enough, water has to take a sharp turn to enter the culvert. This heavily increases erosion at the inlet. While it is far cheaper to install culverts perpendicular to a roadway, in many cases this decreases the lifespan of the culvert. Additionally, this reduces aquatic connectivity for wildlife due to the turbulent flows.

Unnatural Culverts:

<Videos and animation of unnatural bottom>

Another barrier to connectivity that wildlife face when approaching a culvert is the stark contrast between the river bottom and the material of the culvert. Ideally, aquatic life should not be able to tell that they are entering or exiting a culvert. This promotes passage for many species. These natural bottoms also reduce velocity of water in the culvert which in turn reduces erosion and increases lifespan.

Appendix H: Story Board

Description: Below is the very first storyboard we made for our final video showing possible formatting and images to go with each specific part of the video