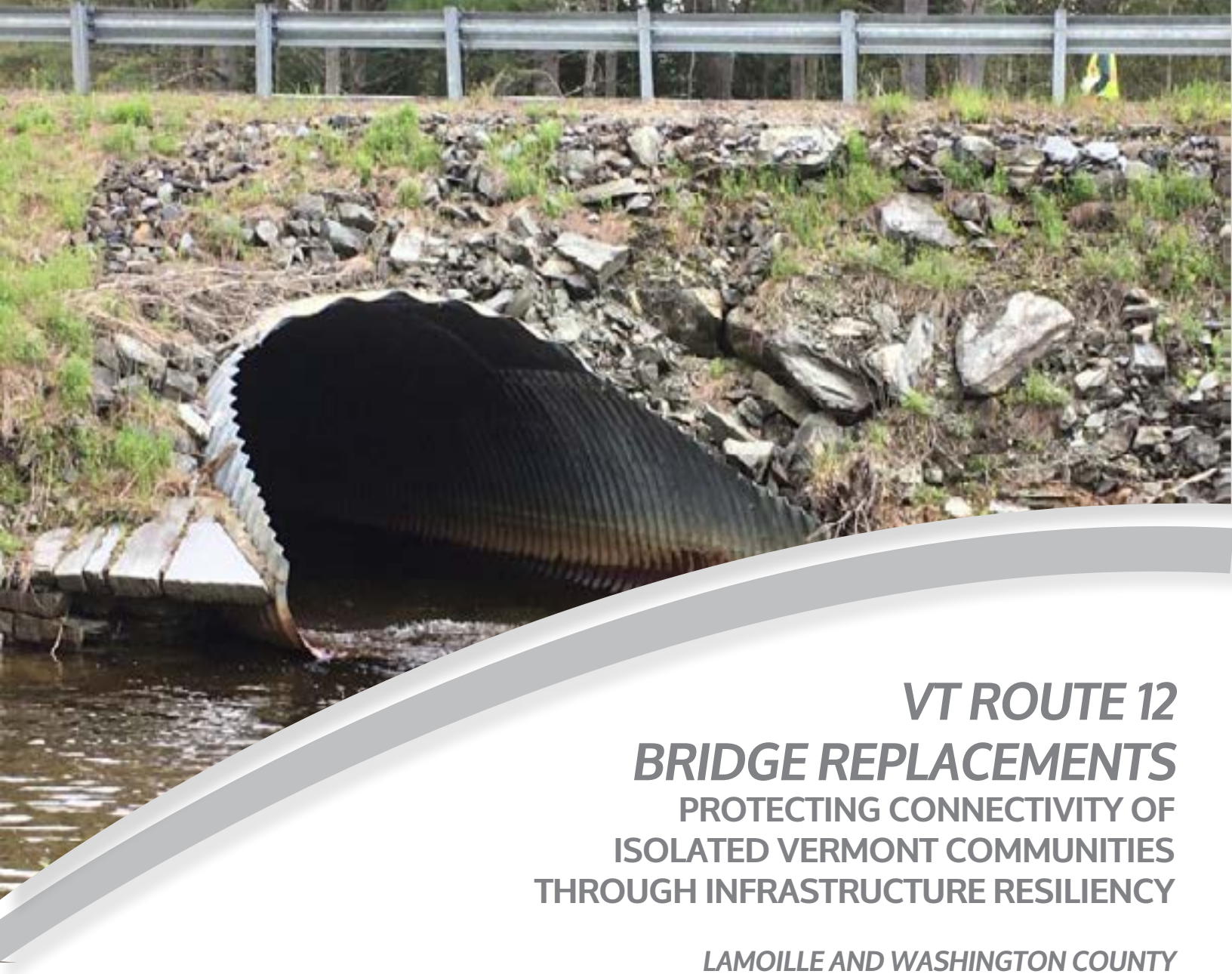


VT ROUTE 12 BRIDGE REPLACEMENTS

PROTECTING CONNECTIVITY OF ISOLATED VERMONT COMMUNITIES THROUGH INFRASTRUCTURE RESILIENCY

LAMOILLE AND WASHINGTON COUNTY
TOWNS OF ELMORE AND WORCESTER, VT

PROTECT GRANT APPLICATION
SUBMITTED BY:

VERMONT
AGENCY OF TRANSPORTATION

AUGUST 18, 2023

I. Project Description:

The Vermont Agency of Transportation (VTrans) is pleased to submit this application requesting $7.234 million of funding through FHWA's Promoting Resilient Operations for Transformative, Efficient, and Cost-Saving Transportation (PROTECT) Discretionary Grant Program (Please refer to Section II. Grant Funds, Sources and Uses of all Project Funding for a full breakdown of costs). The category of interest is the Resilience Improvement Grant. This grant application addresses the need to enhance the resiliency of five bridge structures located along an approximate 8.5 mile stretch of Vermont Route 12 (Route 12) in the Towns of Worcester and Elmore.

This project advances the broader efforts of VTrans to improve resilience across the transportation system. The Worcester-Elmore project was selected for advancement and represents an opportunity to enhance resiliency because it addresses several surface transportation assets with a high risk of failure, at the structures themselves or to the surrounding roadway infrastructure, due to increased flood risk and associated impacts of natural disasters and weather events of evermore severe frequencies and intensities.

Resilience is central to ensuring that VTrans meets their core mission to provide for the safe and efficient movement of people and goods in a socially, economically, and environmentally sustainable manner. This is recognized through both external collaboration and internal processes. From the hazards and mitigation strategies identified in *Vermont's State Hazard Mitigation Plan* and *Initial Climate Action Plan (CAP)* to the process of prioritizing and selecting VTrans projects, the State is focused on infrastructure and community resilience in the face of a changing climate. A comprehensive approach is essential; for example, better managing the resilience of water systems makes them less likely to damage transportation infrastructure while also supporting biodiversity; keeping many systems functioning well. This proposed project does both. It improves infrastructure resilience and provides for improved biodiversity by creating safer means of passage for a protected species.

Vermont's approach to resilience has primarily focused on fluvial erosion and deposition and

> *Vermont is experiencing climate-related events each year and those events are projected to increase in frequency, complexity, and severity. It is imperative that Vermont and Vermonters adapt to threats posed by climate change now and build resilience for the storms that we will inevitably face in coming decades. - 2021 CAP https://climatechange.vermont.gov/sites/climatecouncilsandbox/files/2021-12/Initial%20Climate%20Action%20Plan%20-%20Final%20-%2012-1-21.pdf*

inundation flooding. Its network of state and local highways, rail lines, and small cities and villages were built along rivers, often in steep, confined valleys. The Vermont State Hazard Mitigation Plan and the 2021 CAP identify flooding and fluvial erosion as the highest-ranking hazard in the state. Between 1973 and 2011, Vermont suffered approximately 25 disastrous floods of regional scale, the equivalent of one event every 18 months. This trend has continued as evidenced by more than ten federally declared disasters in Vermont for severe weather and flooding events since the 2011 Tropical Storm Irene (Irene). In response to these events, statewide stakeholders including VTrans formed the Resilient Vermont Project. It developed Vermont's Roadmap to Resilience in 2013 that included a vision for a resilient Vermont.

Irene poignantly demonstrated the need for Vermont to change course in climate adaptation. In the last 10 years, federal hazard mitigation funds have been leveraged to acquire and demolish almost 150 flood-vulnerable properties, implement almost 70 infrastructure improvement projects, and create or update 226 Local Hazard Mitigation Plans. The Emergency Relief and Assistance Fund statute, updated in 2014, incentivizes communities to increase their resilience to disasters through several actions that increase preparedness and break the cycle of disaster through hazard mitigation. In the time since, 43% of Vermont communities have undertaken four or more of these actions, qualifying them for at least a partial incentive.

Resilience for Vermont and VTrans did not start with Irene recovery. Historically the only consideration when designing/constructing a new bridge or culvert was its capacity to convey water. Bridges and culverts often functioned like a fire hose with water ponded at the inlet with high velocities through the structure causing erosion at the outlet. In the early 2000's, VTrans began to work with partners at the Agency of Natural Resources (ANR) to update our hydraulic design standard for bridges and culverts. The goal was to consider all the other natural processes that happen in a water way. Structures that span bank full width allow for more flow to pass at lower velocities and significantly reduce the likelihood of debris or sediment build up, making them more resilient to flooding. This project is a perfect example. Four of the five existing structures are sized well below bank full width, increasing water velocity, and allowing for deposition at the structures, as shown by the history of damage in the project area. The new structures installed through this project will all be larger than bank full width, building in resilience for more severe future storms and enhancing wildlife passage. However, as seen in the very recent floods with Vermont still in the midst of assessing and implementing recovery operations, more work to identify high risk assets is needed.

> *"Roadmap to Resilience" Vision*
> *"A resilient Vermont is better prepared for and able to more effectively manage and bounce back from natural disasters and climate-related shocks, and the risks they pose to our economy, environment, and social well-being.*
>
> *A resilient Vermont focuses on both proactively reducing our vulnerabilities and improving our response and recovery, to ensure that we are continually strengthening our resilience.*
>
> *We must be resilient at every level – from individual residents, households, and businesses and neighborhoods, to the entire community and state. There is a shared sense of responsibility for resilience at every level and across the public, private, and nonprofit sectors."*
>
> *Source::Vermont's Roadmap to Resilience (2013)*
> https://resilientvt.files.wordpress.com/2013/12/vermonts-roadmap-to-resilience-web.pdf

Vermont is committed to improving efficiency and effectiveness of state government and believes deeply in continuous improvement. To that end, VTrans, like many other states, is seizing the opportunity to develop a Resilience Improvement Plan to prioritize its resilience investments related to the 2021 IIJA PROTECT formula program. The VTrans Draft Resilience Improvement Plan (RIP) provides a comprehensive framework for how the Agency considers and incorporates resilience in the planning, scoping, design, and operations of our transportation infrastructure. In

	1. Less damage in the future.	Major natural events result in less damage to the transportation system in the future than in the past.
	2. Systems return to normal quickly.	The transportation system returns to normal quickly after major events.
	3. Vermont is resilient for all people.	All people have transportation options to safely evacuate before an incoming natural event or after if necessary.
	4. Essential freight moves.	Essential freight continues to arrive at key destinations for distribution and delivery to Vermonters.
	5. Resilience efforts are coordinated.	Resilience investments benefit transportation systems and Vermont's communities, environment, economy, and other critical infrastructure sectors.

VTrans' Resilience Improvement Plan Goals

doing so, the Resilience Improvement Plan aims to make our efforts to increase resilience more comprehensive, coordinated, equitable, and effective and does so through five primary goals.

The RIP uses a systematic approach and existing tools (Transportation Resilience Planning Tool and Reducing Repeat Damages Tool) to understand Vermont's priority vulnerabilities and risks to the transportation system. It includes multimodal elements of the transportation system as well as their interconnection with communities, the environment, vulnerable populations, and economy. Specifically, the Plan:

- Defines risks and vulnerabilities of concern,
- Identifies relationships with external and internal partners and their connection to resilience,
- Summarizes how resilience is addressed in existing Agency and State plans and capitalizes on opportunities for harmonization,
- Identifies processes and strategies to promote resilience,
- Develops a framework for project prioritization and implementation, and
- Establishes methods to measure performance.

The project being proposed for a PROTECT Discretionary Resilience Improvement Grant exemplifies many elements of the VTrans Draft RIP. Although further detailed throughout the application, this proposed project:

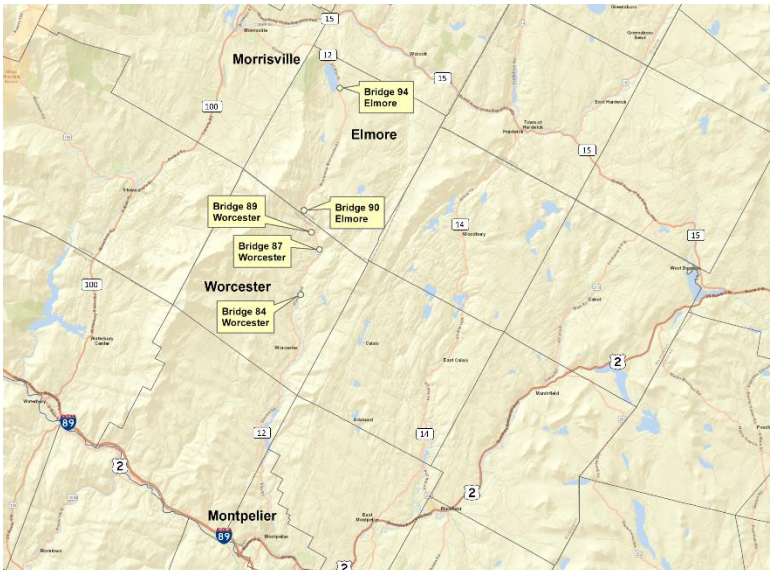
- aligns with the goals of the RIP,
- addresses areas of past repeat damages as federally required,
- provides for greater hydraulic capacity and movement of sediment and debris in high flow events,
- reduces phosphorous pollution in water bodies, and
- incorporates mitigation measures to increase safe passage of a protected species.

The project improves a series of assets along a highly travelled critical rural route, while supporting the concepts and intent of several other statewide plans. The design and construction of this project results in the ability to withstand and reduce the magnitude and/or duration of disruptive events, which includes the capability to anticipate, absorb, adapt to, and/or rapidly recover from such an event.

Route 12 (also known as Elmore Road in Worcester and Montpelier-Morrisville State Highway in Elmore) is a major collector state highway that runs north and south from Weathersfield to Morristown. In the case of this project, it is the single state highway that connects the Towns of Elmore and Worcester, and Vermont's capital region with Lamoille County. On a larger scale, this

single road connects the City of Montpelier, the Capital of the State of Vermont, with the Town of Morristown (Lamoille County's main commercial center).

The roadway has 11' lanes in each direction with 4' wide shoulders on the left and right. The highway carries anywhere from 1,100 to 1,700 vehicles per day. It was originally constructed in 1922 and is a vital connection for the Towns of Elmore and Worcester to each other and neighboring communities.



Structures Location Map

The Towns of Elmore and Worcester are separated from communities in the west by the Worcester Mountains and communities in the east by another ridge with a few connecting dirt roads that are unlikely to accommodate freight movement. Access to resources and neighboring communities is limited to the north and south exclusively by Route 12. As such, this state highway and the bridges that serve it are critical pieces of infrastructure to the Towns of Elmore and Worcester.

Running adjacent to Route 12, and even crossing under it several times, is the North Branch of the Winooski River. It begins in Elmore and flows through Worcester, Middlesex, and East Montpelier and enters the Winooski River in Montpelier. It is 18 miles long and passes through a retention dam built after the 1927 flood. It has a watershed area of 48,300 acres.

All five structures have completed scoping reports associated with them in Appendix A-E, and the final design plans are in Appendix F. All their information may be reviewed, but here is a synopsis of their specifications, history, and proposed design.

Bridge 84 (Worcester)

Existing Conditions:

Bridge 84 carries Route 12 across North Branch and is considered Structurally deficient due to the deck rating. The following is a list of deficiencies of Bridge 84 and Route 12 at this location:

- The deck is in poor condition (4/10). The concrete is showing signs of significant distress with widespread rust staining, concrete scaling, saturation leakage and efflorescence leakage. The poor deck condition radiates to the asphalt above which is also in poor condition with multiple patches, potholes, depressions and cracking. The fascia's are in poor condition with multiple areas of spalling with exposed thinning rebar, cracking and saturation leakage present.
- While the superstructure is rated as being in satisfactory condition (6/10) according to the bridge inspection report, the paint system has failed. The rolled beams are starting to peel,

flake and bubble. Bridge paint increases the resiliency of a bridge by protecting the beams from rust and salt in the air. Paint will need to be reapplied to protect the beams.

Bridge 84 over the North Branch

- The substructures are in satisfactory condition (6/10), with the following maintenance needs:
  - Backwall: The reinforced concrete curtain walls have areas of moderate concrete scaling with heavy efflorescence leakage.
  - Southern Abutment: The reinforced concrete abutment has a full height vertical crack.
- Route 12 through the project area and over the bridge is substandard in width by 8 feet.

Design:

A steel girder bridge structure is proposed for the replacement of the existing structure. The final design span of the proposed bridge will be 94' long (much larger than the stream's 66' bank full width) and will increase the lane widths from 10' to 11' and will include 4' shoulders for bicyclists and pedestrians. Widening the lanes and adding shoulders will provide safety benefits for all roadway users. Included in the final design are riparian plantings and stone fill armoring to stabilize the stream banks and roadway embankments.

Bridge 87 (Worcester)

Existing Conditions:

Bridge 87 carries Route 12 across Hardwood Brook. The following is a list of deficiencies of Bridge 87 and Route 12 at this location:

A wide bank full width constricted by the existing culvert.

- The existing culvert does not meet the calculated or measured bank full width of 19'. There is a large scour hole at the outlet, indicative of an undersized structure.
- The culvert has a history of getting plugged, overflow washing out the roadway shoulder and undermining pavement.
- While the culvert is in fair condition (5/10), several maintenance issues exist:
  - Barrel: On the outlet end, there is a large hole at the water line.
  - Invert: The invert of the culvert has deep pitting and heavy rust scaling in random spots. It is expected that holes will start to form in the near future.

Design:

A precast 4-sided concrete box structure is proposed for the replacement of the existing structure. The final design will replace the pipe-arch culvert with a 19' x 10' precast box culvert which will meet the ANR calculated bank full width of 19'. Included in the final design are riparian plantings and stone fill armoring to stabilize stream embankments.

Bridge 89 (Worcester)

The existing culvert constricts the stream at the outlet.

Existing Conditions:

Bridge 89 carries Route 12 across North Brook. The following is a list of deficiencies of Bridge 89 and Route 12 at this location:

- The existing culvert does not meet the calculated or measured bank full width of 42'.
- The culvert is in fair condition (5/10). The invert has some holes and undermining has started at the outlet.

Design:

A steel girder bridge structure is proposed for the replacement of the existing structure. As the roadway is significantly skewed in relation to the waterway the proposed final design will replace the existing pipe culvert with a 77' long steel girder bridge that will exceed the ANR calculated bank full width of 42'. Included in the final design are riparian plantings and stone fill armoring to stabilize stream embankments.

Bridge 90 (Elmore)

An undersized culvert and an inadequate alignment will cause debris build up at the inlet

Existing Conditions:

Bridge 90 carries Route 12 across an Unnamed Brook. The following is a list of deficiencies of Bridge 90 and Route 12 at this location:

- The existing culvert does not meet the calculated or measured bank full width of 23' and does not meet the minimum hydraulic standard.
- The culvert is in serious condition (3/10) and is beginning to show signs of collapse. There is heavy rust scaling and holes throughout the invert. The pipe buckled under the

roadway and cracks have formed in the pavement.

Design:

A steel girder bridge structure is proposed for the replacement of the existing structure due to the existing structure being undersized. As the roadway is significantly skewed in relation to the waterway, the proposed final design will replace the pipe culvert with a 40' long steel girder bridge which meets the ANR calculated bank full width of 23'. The channel will also be realigned to a more natural path to allow the passage of aquatic organisms. Included in the final design are riparian plantings and stone fill armoring to stabilize stream embankments.

Bridge 94 (Elmore)

A constricting existing culvert will be replaced with a 4-sided concrete box that meets the ANR bank full width.

Existing Conditions:

Bridge 94 carries Route 12 across an Unnamed Brook. The following is a list of deficiencies of Bridge 94 and Route 12 at this location:

- The existing culvert does not meet the calculated or measured bank full width of 11'.
- The culvert is in fair condition (5/10). There are holes throughout the invert up to 2-inches in diameter.
- The asphalt coating is wearing off. Additionally, the outlet of the pipe has moved up causing some deflection in the culvert.
- The stream at this location is experiencing high levels of erosion.
- The vertical alignment along Route 12 through the project area has a slightly substandard sag curve.

Design:

A precast 4-sided concrete box structure is proposed for the replacement of the existing structure. The proposed final design will replace the pipe culvert with an 11'x 10' box culvert which will meet the ANR calculated bank full width and enable the passage of aquatic organisms. Included in the final design are riparian plantings and stone fill armoring to stabilize stream embankments.

The five structures within this project have reached a level of disrepair such that each has been identified as a safety hazard to the traveling public if left untouched. They have all reached the end of their anticipated design life and need repair or replacement.

TABLE 1: STRUCTURE INFORMATION

Bridge	Town of Worcester			Town of Elmore	
	84	87	89	90	94
Existing Structure	Single span 84' long rolled steel beam bridge	14' corrugated metal pipe-arch culvert	15' diameter corrugated metal pipe culvert	6' diameter corrugated metal pipe culvert	6' diameter corrugated metal pipe culvert
Proposed Design	Steel Girder Bridge Structure	Precast 4-Sided Concrete Box	Steel Girder Bridge Structure	Steel Girder Bridge Structure	Precast 4-Sided Concrete Box
All proposed bridge designs meet or exceed the required bank full width					
Proposed Width (ft)	94	19	77	40	11
ANR Bank Full Width (ft)	66	19	42	23	11

History:

Both the Town of Elmore and Worcester have high transportation insecurity according to the USDOT Equitable Transportation Community (ETC) Explorer (https://experience.arcgis.com/experience/0920984aa80a4362b8778d779b090723/page/Homepage/). What this means is that a lack of reliable transportation can exacerbate symptoms of poverty and in some cases even cause poverty by making it difficult to secure employment or access services.

All existing culverts/bridges are in or outlet to the North Branch of the Winooski River. They are outside any currently mapped floodways except for BR 84 which is in a section of the North Branch of the Winooski River identified as Flood Zone AE (See flood maps in Appendix G). While the other culverts and bridges are not technically located in a flood zone, they do outlet to one. Zone AE are floodways that must be kept free of encroachment so that the 1% annual chance flood can be carried without substantial increases in flood heights.

According to the 2018 Vermont State Hazard Mitigation Plan (https://vem.vermont.gov/sites/demhs/files/documents/2018%20Vermont%20State%20Hazard%20Mitigation%20Plan%20-%20Final%20Adopted_Interactive.pdf), inundation flooding and fluvial erosion are among the highest ranking hazards in the regions the Towns of Elmore and Worcester occupy. Additionally, these five bridges are critical elements to the hazard mitigation plans for the Towns of Elmore (https://www.elmorevt.org/srcs/pdf/2017-haz-mit-fema-approv-v4-6.pdf) and Worcester (https://centralvtplanning.org/wp-content/uploads/2012/03/Worcester-VT_LHMP-2018-Final-01242019.pdf). If any one of the structures fail, VTrans has identified the vulnerabilities that these bridges protect and provided technical assistance to the Towns of Elmore and Worcester to support their local mitigation plans.

The Towns of Elmore and Worcester are rural communities that are largely residential with residents needing to travel to work. Additionally, their connection to neighboring communities through Route 12 is essential to residents who need resources and jobs for a better quality of life. The bridges on Route 12 are critical to this need, as well as to the safety of both communities and their connectivity to neighboring towns. There is a clear need to improve the resiliency of Route 12 and to maintain connectivity to the Towns of Elmore and Worcester and other communities in Lamoille County from isolation resulting from extreme weather events.

II. Grant Funds, Sources and Uses of all Project Funding

The project will be funded using a 70/30 split between the PROTECT Grant (70%) and other Federal/State funds (30%). Of the remaining 30%, 80% (24%) will be Federal funds and 20% (6%) will be State funds. It should be noted that sufficient contingency amounts to cover unanticipated cost increases have been budgeted and will be supplemented by the State of Vermont if necessary.

TABLE 2: DETAILED PROJECT BUDGET

Bridge	Activity	Cost	PROTECT Fund Request (70%)		Other Federal Funds (30%)	
			PROTECT Federal Share (80%)	Non Federal State Match (20%)	Federal Formula Funds Share (80%)	Non-Federal State Match (20%)
Worcester BF 0241(59) (BR 84)	Construction Cost	$ 2,306,000	$ 1,292,000	$ 323,000	$ 553,000	$ 138,000
	Construction Engineering Cost	$ 461,000	$ 258,000	$ 64,000	$ 111,000	$ 28,000
	Right of Way Cost	$ 46,000	$ 26,000	$ 6,000	$ 11,000	$ 3,000
Worcester BF 0241(56) (BR 87)	Construction Cost	$ 1,474,000	$ 825,000	$ 207,000	$ 354,000	$ 88,000
	Construction Engineering Cost	$ 295,000	$ 165,000	$ 41,000	$ 71,000	$ 18,000
	Right of Way Cost	$ 29,000	$ 16,000	$ 4,000	$ 7,000	$ 2,000
Worcester BF 0241(57) (BR 89)	Construction Cost	$ 3,245,000	$ 1,818,000	$ 454,000	$ 778,000	$ 195,000
	Construction Engineering Cost	$ 649,000	$ 363,000	$ 91,000	$ 156,000	$ 39,000
	Right of Way Cost	$ 65,000	$ 36,000	$ 9,000	$ 16,000	$ 4,000
Elmore STP CULV(64) (BR 90)	Construction Cost	$ 2,563,000	$ 1,436,000	$ 359,000	$ 615,000	$ 153,000
	Construction Engineering Cost	$ 513,000	$ 287,000	$ 72,000	$ 123,000	$ 31,000
	Right of Way Cost	$ 51,000	$ 29,000	$ 7,000	$ 12,000	$ 3,000
Elmore BF 0241(55) (BR 94)	Construction Cost	$ 1,000,000	$ 560,000	$ 140,000	$ 240,000	$ 60,000
	Construction Engineering Cost	$ 200,000	$ 112,000	$ 28,000	$ 48,000	$ 12,000
	Right of Way Cost	$ 20,000	$ 11,000	$ 3,000	$ 5,000	$ 1,000
	Total Cost	**$ 12,917,000**	**$ 7,234,000**	**$ 1,808,000**	**$ 3,100,000**	**$ 775,000**

Any previously incurred costs have not been included in the Detailed Project Budget, as they are not eligible for funding under the PROTECT Discretionary Grant Program. Of the remaining costs for this project, all are activities that are primarily for the purpose of resilience. As such, they are all eligible for funding under the PROTECT Discretionary Grant Program.

III. Merit Criteria

Criterion #1: Vulnerability and Risk

Climate change has manifested itself in Vermont in the form of extreme weather events. The Northeast has experienced a greater recent increase in extreme precipitation than any other region in the U.S. Between 1958 and 2012, the Northeast saw more than a 70% increase in the amount of precipitation falling in very heavy events (defined as the heaviest 1% of all daily events). The 2018 Vermont State Hazard Mitigation Plan (SHMP) identifies flooding and fluvial erosion as the highest-ranking hazard in the state.

This ranking was further solidified because of Tropical Storm Irene in 2011, as mentioned in this application's introduction. That storm event set historic records in the 24 hours it swept across the state of Vermont. Irene damaged 500 miles of roadway and 200 bridges and it cost approximately $850 million to repair the damage. As a result, the state of Vermont was forced to take a close look at its practices, including its design parameters, leading to changes in maintenance and design tactics that will create more resilient systems that can better accommodate and survive extreme weather events like Irene.

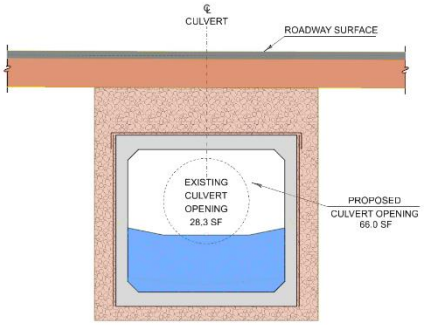
The Vermont Department of Public Safety acknowledges the significance of climate change and system impacts as an issue. VTrans takes these risks into consideration when they analyze a stream crossing. Waterway corridor bank full widths and scour depths are examined to ensure any new structure will be resilient, functional, and effective against high intensity storm events and flooding.

The five bridges to be replaced under this project are no exception. They are located on, or on a tributary to, the North Branch of the Winooski River, a FEMA Special Flood Hazard Area (SFHA) Zone AE (Appendix G), which corresponds to a 100-year flood elevation. All five bridges are designed to provide long term resiliency and address each element of vulnerability and risk detailed below:

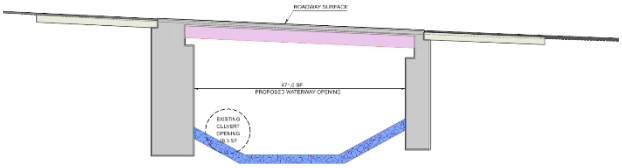
1. **Exposure** - The new bridges are designed to withstand current and future weather events, natural disasters, and the changing climatic conditions that the Towns of Elmore and Worcester are exposed to. The span of all proposed structures will be increased to accommodate bank full width (BFW) or greater so that the channels they cross will not be constricted.

Table 3 – Project Existing and Proposed Design Features

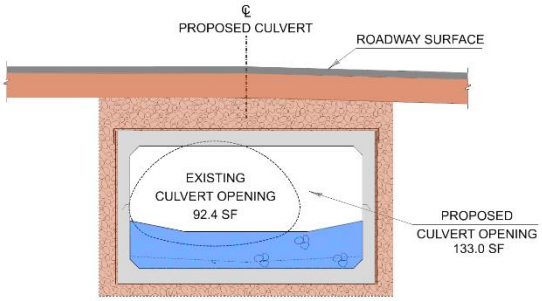
Town	Bridge Number	Existing Span (ft)	Existing Waterway Opening (sf)	BFW (ft)	Design Span (ft)	Design Waterway Opening Area (sf)	Waterway Opening Area Increase
Elmore	94	6	28.3	11	11	66	233%
Elmore	90	6	28.3	23	32	471	1664%
Worcester	87	14	94.2	19	19	133	141%
Worcester	89	15	240.5	42	65.2	961.4	400%
Worcester	84	84	1508	66	93.5	1586	105%



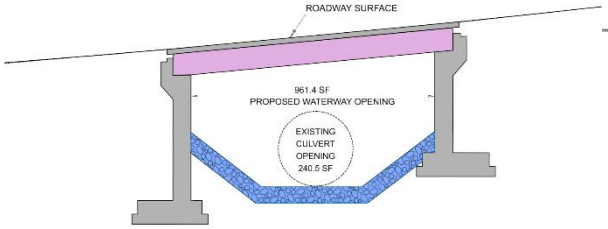
Worcester Bridge 94



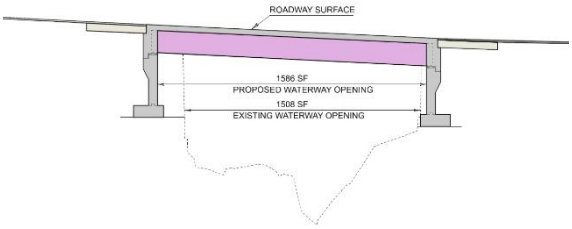
Elmore Bridge 90



Worcester Bridge 87



Worcester Bridge 89



Worcester Bridge 84

By increasing their spans, the design waterway openings will be larger, further bolstering their resilience to critical storm event exposure by accommodating a higher capacity.

While structure resilience is an important factor in bridge design, the consequence of that resilience needs to be considered. Waterways with higher capacities can sometimes cause inundation downstream during extreme storm events. The hydraulic analyses for each bridge investigated this issue and determined that the proposed waterway openings will not increase the 100-year base flood elevation at all sites. These hydraulic analyses are located in each structure's scoping report: https://mjinc.com/projects/public/elmore-worcester)

2. **Sensitivity** – The structures will be constructed to minimize sensitivities to impacts from extreme weather events. A scour analysis was performed for each bridge using a design event of Q100 and a check event of Q200 (as per the VTrans Hydraulics Manual, Table 7-1, HEC-18 Scour Design and Check Event Selection). All bridge designs minimize the impacts from potential extreme scour events by burying the structure foundation well below the calculated scour depths.

3. **Adaptive Capacity** – The ability of these projects to adjust to future impacts from extreme events is an important factor in providing longevity to the assets they are designed to protect. Stone fill armoring in the channel and on exposed slopes adjacent to the bridges will further protect them from fluvial erosion during large capacity storm events.

Additionally, these projects add further resilience by increasing the structure freeboard.

Table 4 – Project Existing and Proposed Freeboard

Town	Bridge Number	Existing Freeboard (ft)	Proposed Freeboard (ft)
Elmore	94	1.26	2.97
Elmore	90	-2.76	1.30
Worcester	87	1.29	1.95
Worcester	89	8.36	8.50
Worcester	84	13.07	13.34

More freeboard allows the crossing to have a higher clearance for debris and larger hydraulic capacity. This allows the structures to function under more extreme weather conditions.

The Vermont Transportation Resilience Planning Tool (TRPT) is a tool that determines risk by assessing a road, bridge, and culvert's vulnerability due to flood inundation, erosion, and deposition hazards in combination with the importance, or criticality, of an asset to resilient transportation network function and access to essential facilities. The goal of the TRPT is to improve the resilience of Vermont's highway network to floods and erosion by providing data and tools to inform planning and investment decisions. The need for the TRPT became apparent following the widespread damage to state and local roadways caused by flooding from Tropical Storm Irene and ongoing local damages that take place each year. It can be located here http://roadfloodresilience.vermont.gov/.

These bridges are located on medium to high-risk assets according to the TRPT. Additionally, all structures and roadway segments on Route 12 at these locations are designated as locally important. This designation is typically provided by stakeholders to identify roads and structures that are critical to local detour routes, access to a town highway maintenance facility, or an emergency shelter that would support response and recovery operations.

As such, the location and function of these bridge structures is important to the connectivity of transportation infrastructure during emergency events in the Towns of Elmore, Worcester and beyond.

In more recent history, July 2023, severe flooding occurred in Vermont of similar magnitude and impact to Irene. The Town of Worcester has been experiencing flooding. An event like this is a testament to the State of Vermont's need to address the resiliency in their structures and transportation assets.

TABLE 5: TRPT Asset Details

Bridge	Town of Worcester			Town of Elmore	
	84	87	89	90	94
Vulnerability	Low	Low*	Medium	Medium	Medium
Criticality	Medium	Medium	Medium	Medium	Medium
Route 12 Risk	Medium	Medium*	High	Medium	Medium
Locally Important	Yes	Yes	Yes	Yes	Yes

* All risk grades are based on a design 50-year flood event. The TRPT can also assess risk based on a design 100-year flood event which increases the risk to these assets by one grade (i.e. low to medium, medium to high)

VTrans strives to strengthen transportation assets against future vulnerabilities by including robust hydraulic analysis in their designs. In twelve years since Irene, infrastructure in Vermont has been carefully planned and thought out to boost its resiliency to extreme storm events. These five bridges are important structures that protect and connect the assets in the towns of Elmore and Worcester. The vulnerabilities and risks addressed by this project will align with the draft RIP's goal to have "Less damage in the future" and "Systems return to normal quickly".

Criterion #2: Criticality to Community

Route 12 is one of many state routes that are in steep sided valleys largely paralleling a significant river or stream. In this case the North Branch of the Winooski River, which originates in Elmore and flows in a southerly direction along VT Route 12, is directly adjacent to the roadway for much of its length. Both the river and the roadway converge with the Winooski River in the City of Montpelier. Several streams originating in the upland areas within Worcester and Elmore converge with the North Branch of the Winooski River in the Worcester Valley. Many of them cross under Route 12 before joining the river.

The five bridges to be replaced as part of this project are all located at crossings on VT Route 12. Two of the crossings are over the North Branch of the Winooski River while the other three cross tributaries of the river. VT Route 12 is the only state route in the Towns of Elmore and Worcester and is the only connection between the residents of these two towns and the rest of Vermont.

On the north, VT Route 12 connects with the town of Morrisville, a small but important regional location for common services, including a hospital (Copley Hospital), grocery stores, and generally available public and private service options. On the south the City of Montpelier provides many of these same services (the Berlin Hospital is just south of Montpelier). VT Route 12 is also one of the few routes that connect communities and towns through the Putnam State Forest (covering 13,633 acres of land in Lamoille and Washington County). This makes VT Route 12 a critical asset for emergency and evacuation needs throughout the Towns of Elmore, Worcester and beyond.

Destinations that these bridges provide access to:

- Elmore Fire Department (343 Beach Road)
- Elmore Town Offices (1175 VT Route 12)
- Elmore School (1199 VT Route 12, the last 1 room school in Vermont) also on Route 12.
- Worcester Town Clerks Office and Fire Department (20 Worcester Village Road, VT Route 12)
- Doty Memorial School (Worcester School, 24 Calais Road)

As stated in the Elmore Hazard Mitigation Plan (https://www.elmorevt.org/srcs/pdf/2017-haz-mit-fema-approv-v4-6.pdf) all three facilities in Elmore function as Emergency Operations Centers (EOC).

Vulnerable locations and populations include:

- Elmore State Park
- Elmore School
- Doty Memorial School
- Putnam State Forest

As the only state route in the area, VT Route 12 provides expeditious and safe access to all critical facilities and vulnerable populations in the Towns of Elmore and Worcester. The closest hospital to the north is Copley Hospital in the Town of Morristown and the closest south is Berlin Hospital in the Town of Berlin. Losing one (or more) of the assets protected by these five bridges can limit the access emergency vehicles have to vulnerable locations and populations. If this fragmentation occurs, it will also make it difficult for the Town of Elmore or the Town of Worcester to connect

with neighboring communities to rebuild when confronted with serious damage. This is likely why "locally important" was established in the TRPT for the locations in this project.

All five bridges have surpassed their design life and need rehabilitation or replacement. These bridges are important in addressing risks to these rural communities and the consequences will be severe if one of these assets is lost. As such, this project will address the draft RIP's goal of "Vermont is resilient for all people". It is critical that these bridges maintain a state of good repair.

The five bridges on VT Route 12 are critical in connecting the Towns of Elmore and Worcester with other municipalities in Washington and Lamoille County. During emergency operations, VT Route 12 is a key facility during evacuation plans. This transportation asset is also a principal route to tourists travelling around the neighboring rural communities while visiting the Putnam State Forest. The Town of Elmore and Wolcott have a special arrangement whereby both departments respond to each other's fire calls. The fragmentation of an asset failure will also put the Elmore residents at risk during an extreme event if the Town of Wolcott fire department cannot reach them.

As such, the failure of any one of these bridges has crucial repercussions that affect evacuation needs, economy from tourism, and the ability for this rural community to recover from extreme weather events.

Criterion #3: Design Elements

All five of the replacement structures have an anticipated design life of 75 years according to the project scoping reports. VTrans uses the general structure design life identified in the AASHTO LRFD Bridge Design Specifications which is 75 years. While the terms design life and service life are not synonymous, they should both be considered during design. Service life can be different because of the service life of different components in the bridge. For the sake of conservatism, the service life of these bridges will be assumed to be 75 years.

As current and future weather events become more intense and hazardous, the structures are less likely to accommodate the design storm. Design elements included in these five bridges are being implemented to improve resiliency to accommodate those future extreme events. These design elements will address each current or future vulnerability identified under Criterion #1 up to the anticipated service life of these assets.

1. Exposure
    a. As indicated in Table 3 in Merit Criteria 1: Vulnerability and Risk, all five new structures will meet or exceed the required bank full width of the streams. These designs will not constrict the stream crossings by allowing a higher capacity of flow to pass through these crossings which will protect these transportation assets during extreme weather events. The design storm flow used to analyze these crossings was a 2% AEP (Q50).
2. Sensitivity
    a. The hydraulic reports for each crossing included a scour analysis to determine scour depths. Scour calculations were developed for a design AEP of 4%, 2%, 1%, and 0.2%. All five proposed structure foundations will be buried well below the calculated scour depths by at least 6 feet below the streambed or to bedrock, allowing the designs to be less sensitive to large storm events.

3. Adaptive Capacity
    a. All five designs include stone fill armoring in the channel and on exposed slopes next to the proposed structures. This allows the crossings to be adaptive to extreme weather events by preventing fluvial erosion that can cause the structure and embankments to be undermined.
    b. Additionally, as represented in Table 4 in Merit Criteria 1: Vulnerability and Risk, the freeboard will be increased at each crossing and all new structures will meet or be greater than bank full width. Not only does this allow a higher capacity of flow to pass through the structure but it will also prevent debris from building up at the structure and prevent damage resulting from a constricted structure width.
    c. Each structure has a landscape plan to construct riparian buffer trees and shrubs to restore the natural streambanks. This design element further protects the exposed slopes and riparian zone from the effects of fluvial erosion by stabilizing the banks. Trees and shrubs can also provide shade, shelter, and food for fish and other aquatic organisms and provide wildlife habitat and corridors for terrestrial organisms.

The five bridges include riverbank protection measures by armoring the channel and exposed slopes with stone fill. Specifically, all exposed slopes will be armored with stone fill that is approved, hard, blasted, angular rock in various sizes. All channels will be armored with environmental stone (E-stone) which is stone fill but includes a higher density of well graded materials. The specifications of these materials are defined in the Vermont Agency of Transportation 2018 Specifications for Construction).

A higher flow rate requires a larger stone to provide stabilization measures as necessary to protect the stream bank against erosion following disturbance or encroachment. Consideration is also given when determining potential impacts to vegetated wetlands, aquatic organism passage, and riparian habitat when deciding where stone fill should be placed. (As defined in the VTrans Hydraulics Manual)

Funds provided by the PROTECT Grant will contribute to the resiliency of these bridges. By protecting this crossing against inundation, fluvial erosion, and other vulnerabilities generated by extreme weather events, this project further improves the safety of this asset throughout its anticipated design life.

Temperature variations and the application of deicing salts, to ensure safety of the traveling public, are challenging obstacles to a structure's expected life. VTrans has a Bridge Preservation Program whose goal is to review new designs and maintain bridges and culverts to provide 75 years of service before replacement is required (https://vtrans.vermont.gov/highway/structures-hydraulics/bridge-preservation).

Asset protection does not stop after the five bridges are constructed, and the Bridge Preservation Program works closely with VTrans Asset Management's Bridge Inspection Unit and the VTrans Maintenance and Operations Bureau to identify and develop cost effective and timely bridge preservation measures using proven and innovative techniques.

Table 6: Cyclical Maintenance Activity

Annual Goal	Performance Measure
50% (alternating)	Washing Bridge - State highway and Interstate bridges (that are "Washable" bridges)
100%	Sweeping Bridges - by June 1st (Also see Ped & Bike, Highway Sweeping locations for priorities due by May 31st)
20% (alternating)	Applying Preservative Materials – (often referred to as Silane)
10% (alternating)	Greasing Bearings and Beam Ends
20%	Crack Sealing bridge decks (including curbs and sidewalks)
10%	Cutting Brush around bridges
100%	Emergency Bridge Maintenance is addressed immediately
80%	Identified Maintenance Needs, Bridge Inspection Findings (BIFs) are completed annually. BIF's are more serious findings are not maintenance needs.

Cyclical activities such as bridge washing, cleaning and concrete waterproofing are performed on a regular basis and are combined with structural condition-based repairs to arrest continuing element deterioration and provide protection for underlying structural components.

Criterion #4: Public Engagement, Partnerships and Collaboration

Input from the rural communities of the Town of Elmore and Worcester was included throughout the scoping and design of these projects. Community members were engaged during Public Informational Meetings where members of the VTrans Structures Unit responsible for the design and implementation of the five projects answered questions posed by the public. The project histories, purpose and need statements, design alternatives, and overall design and construction approach were presented to inform the public and gather input and comment in each community. VTrans also communicated with the selectboard and staff of each community, asking a series of questions about each of the bridges to gain a firm understanding of how the community views each structure and to gain additional knowledge and information to inform the design and gather support and help determine the preferred alternatives.

VTrans also obtained input from the Regional Maintenance District 6 personnel. Employees in the District Maintenance and Fleet Division, with more than 500 employees, maintain the State of Vermont's transportation infrastructure for the benefit of the traveling public. Their duties include bridge maintenance, culvert replacement, snow removal, deicing Vermont roads, and are the first response during storm events. With locally based staff in the adjacent town of Morristown, they frequently provide invaluable information and insight into Vermont's transportation system assets, recurring maintenance issues and solutions, and the terrain that surrounds them.

This project is in the final plan stage and collaboration through the environmental process required partnership with Vermont Department of Environmental Conservation (DEC), ANR and the Army Corp of Engineers (ACOE). Additionally, the right-of-way process is close to completion which requires coordination with all abutting property owners.

VTrans also collaborated with Vermont Fish and Wildlife (VFW), ANR, and the Orianne Society in a huge partnership effort with this project as VT Route 12 bisects one of the largest unfragmented wildlife habitats in Vermont. The Orianne Society is a 501(c)3 nonprofit organization dedicated to the conservation of reptiles, amphibians and the ecosystems they inhabit (https://www.oriannesociety.org). They have been heavily involved in this project for pre and post construction GPS monitoring of critical species of interest. The structures being replaced are within some of the highest priority wildlife connectivity blocks in the state and each replacement structure includes provisions for the passage of wildlife to increase connectivity throughout this highway corridor.

VTrans will continue to implement a robust public outreach program throughout the life of the project. For example, VTrans' project information website, VTransparency, will be used to provide regular project updates in conjunction with project factsheets that will help keep the public informed on project status. Additionally, VTrans provides regular updates to the local and regional planning organizations and will hold a regional and local stakeholders meeting prior to construction to further educate the public on the project status. Last, VTrans is part of New England 511, https://newengland511.org/, which provides real time notifications to the traveling public about roadway conditions including construction and road closures throughout the state.

A project of this size in a rural community requires a robust coordination effort from VTrans. The various project stakeholders played an important role in the development of this project. Their contributions will continue through to project completion and beyond.

Criterion #5: Equity and Justice40

Both Elmore and Worcester have small populations, but most people within each town live along or near Route 12. As both towns have very little industry or businesses most residents commute south to Montpelier or north to the Morristown area. As such they are very dependent on Route 12 for access to their workplace, as well as hospitals, schools, shopping, and other services. According to the USDOT Equitable Transportation Community (ETC) Explorer (https://experience.arcgis.com/experience/0920984aa80a4362b8778d779b090723/page/Homepage/), the Towns of Elmore and Worcester are both considered "Disadvantaged" with regard to transportation insecurity. The website defines Transportation Insecurity as a condition that "occurs when people are unable to get to where they need to go to meet the needs of their daily life regularly, reliably, and safely." It also states that "A growing body of research indicates that transportation insecurity is a significant factor in persistent poverty."

These two towns rank relatively high as areas with Transportation Barriers using the *Climate and Economic Justice Screening Tool (CEJST)* provided by the White House Council on Environmental Quality. Both communities rely heavily on Route 12 as the primary transportation link to the jobs, health care, and goods and services that are primarily located beyond the borders of each town.

Losing the connectivity that these bridges provide would be devastating and would fragment these towns from not only each other, but the communities around them where people work and obtain resources to maintain their lives. Compromised access to good paying jobs and various economic and social services including health care, grocery stores, schools, and libraries harms the town's residents in many ways. Both towns would be unable to accomplish their goals and the community members will suffer detrimental social, economic, and health outcomes.

In addition, emergency services would be compromised by the loss of any one of these structures as available detour routes are very long; up to 60 miles if it is necessary to go around a break in the roadway corridor. For commuters, a break in the corridor could require a diversion of up to 40 miles in one direction to get to work. Finally, both towns do not have public transportation routes through their communities. The closest public transportation access is Rural Community Transit (RTC) on VT Route 15 and Green Mountain Transit (GMT) in the City of Montpelier.

The Vermont Agency of Transportation has conducted public outreach through each phase of the project to provide meaningful public engagement with both communities. VTrans engaged with

the leaders of both towns and the public, initially with questionnaires during the scoping phase and later with public information meetings in February of 2021 and 2022. VTrans also maintains a factsheet online for public and internal use and residents are encouraged to reach out to the Agency with any questions. Factsheets educate readers about the projects, project timeline and provide references and contacts.

The input from both towns indicate that the communities of Elmore and Worcester recognize the value these bridges provide to their homes and lives and the need to maintain them in a state of good repair. Improving the resilience of these assets will keep VT Route 12 open during extreme weather events. This bridge project increases the overall resilience of the entire Route 12 corridor and protect it against extreme weather vulnerabilities and risks (as mentioned in Merit Criteria 1: Vulnerabilities and Risks). They will help minimize the potential impacts of emergency events in these communities. In summary, many residents of both towns are employed outside of these communities. The average household income in these towns places them toward the lower end of Vermont communities overall, making the continued safe and efficient operation of vehicles along Route 12 critical to each community. An inadequate transportation system will impact a person's social, economic, and health outcomes as well as their quality of life. Both communities have town plans (Elmore and Worcester) with goals to improve and maintain their infrastructure to support multi-modal transportation and reasonable growth, both economic and residential, that is compatible with each town's rural character.

Criterion #6: Climate Change and Sustainability

When designing transportation assets to stand resilient to extreme events resulting from climate change, it only makes sense to limit our contribution to climate change in the process. There is a lot that can be done to limit the carbon footprint of a project and provide greener transportation systems and options in our communities. This is especially important when trying to maintain rural Vermont's nature and beauty.

This project will allow the Towns of Elmore and Worcester to continue their commercial and industrial development and expand the use of agricultural land. In doing so, the towns will become more self-sufficient without having to travel to neighboring communities for supplies and good-paying jobs. By leaving their communities, vehicular commuters suffer financially while also producing more greenhouse gas emissions from their vehicles.

This project's Bridge 84 in Worcester is widening its shoulders to accommodate bicycle traffic. The other four bridges already have 4-foot wide shoulders that meet the standards of the State of Vermont to accommodate bicycle passage. Constructing these resilient assets will promote and maintain multimodal transportation systems on VT Route 12, a scenic state road running through the Towns of Elmore and Worcester. This will further bolster a greener choice to be made by community members in the Towns of Elmore and Worcester while also helping the rural community economy by attracting bicycling tourism.

The Federal Flood Risk Management Standard (FFRMS), as established by the Federal Emergency Management Agency (FEMA), aims to improve the resilience of communities and federal assets against the impacts of flooding. These five bridges are being upgraded to be less vulnerable to flood hazards. As stated in Merit Criteria 1: Vulnerability and Risk, a hydraulic analysis was performed at each project location. All bridges have been designed to meet and exceed the

calculated bank full width. By increasing the bridge spans, flow capacity increases and results in the prevention of inundation flooding.

As mentioned in Merit Criteria 5: Equity and Justice40, VT Route 12 is a critical transportation asset because it is the only state highway through the two towns connecting them to neighboring communities. If one of these five bridges is out of commission, the greenhouse gas emissions produced because of detouring vehicular traffic would be detrimental to the environment. The communities most affected are the Towns of Elmore and Worcester due to the financial and environmental burden it would cause.

Large projects like these five bridges can cause harm to creature habitats because of their construction. However, as mentioned in Merit Criteria 4: Public Engagement Partnerships and Collaboration, there was a considerable effort to connect some of Vermont's highest priority habitat blocks using this project. Each of these replacement structures includes provisions for the passage of wildlife. Bridge 84, 89, and 90 include a wildlife shelf in their designs to accommodate wildlife passage. All bridges are designed to accommodate medium sized animals and aquatic organism passage.

The wildlife considerations that are being included in the Worcester – Elmore projects serve a wide range of species, from moose to reptiles listed as species of Greatest Conservation Need in Vermont's Wildlife Action Plan. These structures will provide habitat connectivity between massive habitat blocks that have been identified as priority areas in Vermont Conservation Design facilitating both local and landscape-level connectivity. Moreover, these crossings will provide passage for wood turtles (Glyptemys insculpta) in the core of their global range via turtle-specific shelves and barrier fencing. Wood turtle is a proposed Candidate Species for federal protection.

Additionally, as mentioned in Merit Criteria 3: Design Elements, each structure has a landscape plan to include riparian trees and shrubbery into the design. This will restore the natural streambanks by protecting the exposed slopes and riparian zone from fluvial erosion. Trees and shrubs can also provide shade, shelter, and food for fish and other aquatic organisms and provide wildlife habitat and corridors for terrestrial organisms.

There are two areas where the phosphorus reduction benefits that will be realized with the construction of the Worcester-Elmore structures can be accounted for under the 2016 VT Lake Champlain Phosphorus Total Maximum Daily Load (TMDL) and its implementation framework. The modern sizing and improved alignments of these structures will reduce scour and erosion, resulting in more resilient infrastructure and substantial improvements to stream flow and aquatic habitat. The phosphorus load reduction benefits of the project for the stream stability sector, estimated using the *Functioning Floodplains Initiative Tool (https://dec.vermont.gov/rivers/ffi)*,

are on the order of 54 lbs/yr (24 kg/yr). Improvements to the structures and related drainage assets (small culverts and swales) within each project's limits are also anticipated to bring 1.5 acres of paved road area into better alignment with the *VTrans Phosphorus Control Highway Drainage Management Standards*, achieving a developed lands phosphorus load reduction of 1.9 lbs/yr (0.87 kg/yr).

Habitat considerations, riparian plantings, and phosphorus load reductions are features in the project that align with the draft RIP's goal of "Resilience efforts are coordinated".

Criterion #7: Schedule and Budget

The schedule for this project will need to be clear and concise to ensure all necessary activities are completed in a timely manner and the risk of fund expiration is minimized. VTrans has extensive and successful experience delivering projects accurately and to the schedules they set.

All environmental permits and a Title 19 review have been completed. The right-of-way process and utility coordination still need to be completed and their timeframes are accounted for in Table 7: Project Schedule.

The primary purpose of this project is to address resiliency at these sites. As such, all construction costs needed to construct these bridges are eligible to be fully funded under the PROTECT Discretionary Grant Program.

TABLE 7: PROJECT SCHEDULE

CONSTRUCTION ACTIVITY	2023		2024				2025				2026				2027			
	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Funding Procurement, Funds Allocated	■	■	■	■														
Public Outreach	■	■	■	■	■	■	■	■	■	■	■	■	■	■				
Bid-Phase & Procurement					■	■												
Right-of-Way Clear		■	■	■	■													
Utilities Coordination, Relocation		■	■	■	■	■	■	■										
Contract Plans	■	■	■	■														
Construction							■	■	■	■	■	■	■	■				
Bridge Closure, Temporary Bridge Detour								■	■	■	■	■	■					

Grant Funds Obligation Deadline September 30 2026

TABLE 8: PROJECT BUDGET

Bridge	Town of Worcester			Town of Elmore		Total Cost
	84	87	89	90	94	
Construction Cost	$ 2,306,000	$ 1,474,000	$ 3,245,000	$ 2,563,000	$ 1,000,000	$ 10,588,000
Construction Engineering Cost	$ 461,000	$ 295,000	$ 649,000	$ 513,000	$ 200,000	$ 2,118,000
Right of Way Cost	$ 46,000	$ 29,000	$ 65,000	$ 51,000	$ 20,000	$ 211,000
PROTECT Fund Request	70% (80% Federal Share)					$ 7,234,000
Federal Formula Fund	30% (80% Federal Share)					$ 3,100,000
VTrans Share	20% of 70% PROTECT Fund Request					$ 1,808,000
VTrans Share	20% of 30% Federal Formula Fund Share					$ 775,000

Since the project is in the final design phase, the scheduled milestones are more predictable and less prone to change. The work described in the project application and estimates are best represented in the above schedule.

Criterion #8: Innovation

Vermont is among the states with the lowest Gross Domestic Product (GDP) in the United States according to the Bureau of Economic Analysis. As such, The State of Vermont continuously seeks out innovative techniques and methods to improve the resiliency of their transportation assets and reduce the financial burden to Vermont taxpayers.

The TRPT is an award winning innovative tool that VTrans has created to identify and track the resilience of Vermont's transportation systems. The TRPT has been developed for the entire state and is ready to be applied to inform project scoping, capital programming, and hazard mitigation planning for state and local highways. Its purpose is to identify vulnerabilities in a proactive manner to avoid or mitigate against the impacts of future damage in the most critical, highest risk locations. As represented in Table 5, the TRPT was used to identify these structures and the roadway segments they protect as medium to high risk assets. They are also identified as having high local importance.

Bridge 89 in Worcester will be constructed using a Bridge Expansion Joint System (SIKA EMSEAL). This innovative joint is designed to handle harsh environmental conditions which will increase the bridge resiliency against severe storm events. The seal's non-invasive anchoring detail provides for quick repairs, which would be helpful during emergency situations. This bridge expansion joint system will help to extend the service life of Bridge 89.

Vermont incorporates several innovative methods and materials into the design process. Stainless steel reinforcing bars are provided within the bridge deck, abutments, and piers to reduce rust induced failure, greatly increasing structure life. Even though epoxy coated reinforcing bars are common, they still rust at some point in time. Stainless steel bars do not rust easily providing increased service life at a minimal cost increase.

As stated in Merit Criteria 3 – Design Elements, all projects are utilizing stone fill armoring on exposed slopes and in the streams. Armoring these areas will reduce stream channel velocity, protect from fluvial erosion during critical storm events, and help accommodate aquatic organism passage. The size and composition of the material has been modified over the last few years in response to the extensive flooding that occurred during Tropical Storm Irene in 2011. That storm caused the Agency to reevaluate flood protection designs throughout the state leading to improvements in stone fill protection design. As part of this, stone lined ditches and upgraded stormwater infrastructure are also included in this project outside the stream footprint. Improved

stormwater management near the transportation asset further strengthens resiliency against extreme weather events.

As stated in Merit Criteria 4 – Public Engagement, Partnerships and Collaboration, VTrans consulted with the Orianne Society, a 501(c)3 nonprofit organization dedicated to the conservation of reptiles, amphibians and the ecosystems they inhabit (https://www.oriannesociety.org). These structures on VT Route 12 are within some of Vermont's highest priority wildlife blocks. The Orianne Society were heavily involved in this project for pre and post construction GPS monitoring of critical species of interest and their expertise contributed to the accommodation of wildlife crossings in the design of the five bridges.

The precast concrete box structures will be quicker and easier to construct than a large bridge structure. Precast elements are also long-lasting and generally require less maintenance over the life of a structurer than a steel beam bridge structure as they are shielded from salt spray and other environmental factors that can work to increase deterioration of exposed structural elements.

These five structures will also be built using accelerated bridge construction methods. VTrans has its own Accelerated Bridge Program (ABP) that delivers projects quickly and relies on accelerated bridge construction as a means to reduce road closure durations.

The five bridges are being consolidated under one "bridge bundle" project for bidding by the Agency of Transportation. This is an innovative best practice used by VTrans to allow the bridges to be constructed more efficiently and cost-effectively by a single contractor. This approach saves money by reducing construction costs by introducing economies of scale across the five bridge replacements.

IV. Benefit Cost Analysis

Executive (Project) Summary

This Benefit Cost Analysis (BCA) is being prepared for the Vermont Agency of Transportation (VTrans) for the removal and replacement of one (1) bridge and four (4) culverts on Route 12. Each structure crosses the North Branch of the Winooski River or a tributary of the river and all five structures will be increased in size to better handle the expected flows and improve resiliency. The project is planning to bundle all the plans for the replacement of all five structures within one construction contract to take advantage of the cost and construction efficiencies inherent in combining each replacement into one contract. This BCA was completed in accordance with the U.S. Department of Transportation's (USDOT) *Benefit-Cost Analysis Guidance for Discretionary Grant Programs (2023)* (https://www.transportation.gov/mission/office-secretary/office-policy/transportation-policy/benefit-cost-analysis-guidance). This BCA uses a 30-year evaluation period from the completion of the project. This analysis results in a Benefit to Cost Ratio of 3.58.

Methodology/Assumptions

The evaluation period for benefits and costs of this project excludes the development stages with design anticipated to be completed in 2024. Construction is anticipated to be completed over a two-year span from 2025 to 2026. This puts the project opening year in 2026 and extends through 30-years of operations until 2055.

USDOT-recommended monetized values for travel time savings and vehicle operations costs were used to calculate project benefits. All costs in the BCA are stated in 2021 dollars to be consistent with the latest USDOT BCA guidance. Future benefits and costs are discounted at 7% per USDOT guidance.

Two alternatives are compared as part of this BCA: a No Build Alternative and a Build Alternative. The No Build Alternative explores a scenario that assumes that the bridge and culvert replacement project will not be performed during the evaluation period and no additional repairs or rehabilitation will be performed on the respective structures. Based on the information presented in the 2020 Scoping Report for Bridge 84 (Appendix E) it is assumed that in 10 years the bridge will need to be closed. For this BCA, it is assumed that only emergency maintenance will be performed between the scoping report and the 10-year horizon and that the bridge will be fully closed to vehicles upon reaching the 10-year horizon in 2030.

The Build Alternative will replace five structures (Bridge 84, Bridge 87, Bridge 89, Bridge 90, & Bridge 94) along an approximately 8.5 mile stretch of Route 12 in Worcester and Elmore.

The five structures within this project have reached a level of disrepair such that each has been identified in their respective scoping reports as a safety hazard to the traveling public if left untouched. This BCA selected Bridge 84 as the basis for analysis as this bridge is at the southernmost end of the project and is noted to potentially require emergency repairs at any time. The remote, valley setting of Route 12, with no nearby state roads, means a closure of any of the five structures would result in a similar closure scenario.

Benefits

Using 2021 dollars as a baseline ($2021) discounted at 7 percent, the proposed bridge replacement project will provide approximately $17.4 million in economic benefits from reduced vehicle hours traveled (VHT), reduced vehicle miles traveled (VMT), and the residual value of the new structure as compared to the No-Build Alternative and are described below. Additional qualitative benefits include quality of life improvements, improved multi-modal access, and the health benefits which are known to accompany an increase in active transportation, as well as increased resiliency to extreme weather events as each structure will be improved to meet the bank full width. The following sections provide a detailed explanation of the quantifiable benefits associated with the proposed project.

Travel Time Savings

To calculate travel time savings we have chosen to use a simplified analysis assuming that only one of the bridges (Bridge 84) is no longer usable. This assumes that any one of the bridges could be rendered inoperable, but it would be very unlikely that two or more of the bridges would be out of service. Route 12 carries between 1,100 and 1,800 vehicles per day along the approximately 8.5 miles within the project limits, and approximately 1,500 vehicles per day across Bridge 84. To account for the changes in vehicle hours traveled (VHT) and vehicle miles traveled (VMT) as a result of the bridge closure, a detour using only state routes for the closure of Bridge 84 was used to calculate the additional time and distance per vehicle across the closure period. The travel time and travel distance values are representative of traffic across the entire project location and not exclusive to the area of the bridge closure. This simplified analysis does not include the increased delay and miles traveled experienced by all drivers across the roadway network as the detoured

traffic volumes use other roadways to complete their journeys. Therefore, the analysis should be considered a minimal representation of the additional time spent for the drivers needing to use the detour as it ignores the drivers along the detour route that experience more delay due to the added traffic resulting from the detour. The resulting net benefit of VHT across the 30-year evaluation is $17,441,866 in $2021, discounted 7%. The benefit of travel distance savings would begin in 2030 which is the assumed date the No-Build alternative would require the full bridge.

Travel Distance Savings

Comparing VMT outputs from the reduced capacity models shown above against the No Build Alternative yields the following results: when the bridge is fully closed, and all traffic must find alternative routes, VMT increases in 2030 by 7,379 miles per day and by 7,990 miles per day in 2043. The resulting net benefit of VMT across the 30-year evaluation is $9,666,482 in $2021, discounted 7%. The benefit of travel distance savings would begin in 2030 which is the assumed date the No-Build Alternative would require a new bridge.

Residual Value

The useful life of the proposed structures is expected to be 75 years, which adds 45 years of useful life to the structures beyond the BCA evaluation period. This results in a residual value of $6,500,000 in $2055 or $651,426 in $2021, discounted 7%.

Table 9: Daily Metrics

Vermont Route 12 Daily Metrics	No Build	Full Bridge Closure (2023)	Full Bridge Closure (2024)
Vehicle Miles Traveled (VMT)	41,134	48,513	52,530
Vehicle Hours Traveled (VHT)	890	1,099	1,190
Change in Delay vs No Build	0	209	227
Change in VMT vs No Build (Miles)	0	7,379	7,990

Some of the qualitative benefits such as increased wildlife connectivity and resiliency to extreme weather events are difficult to quantify and were therefore not considered in this BCA. These benefits can be assumed to make the current BCA ratio somewhat conservative.

Capital Costs/Build Alternative

The total project cost to remove and replace the five structures along Route 12 is estimated to be $10,590,000 ($2021). This amount includes new bridge and culvert construction, existing bridge and culvert removal, temporary bridge construction and removal, and streambed restoration. The estimated cost was developed by reviewing the respective estimates for each structure and combining them into a single cost. A detailed cost estimate for each project is available in Appendix H.

V. FHWA Priority Considerations:

Exceptional benefits under merit criteria #5 Equity and Justice40

The Towns of Elmore and Worcester both have high transportation insecurity according to the USDOT Equitable Transportation Community (ETC) Explorer (https://experience.arcgis.com/experience/0920984aa80a4362b8778d779b090723/page/Homepage/). The connectivity that these structures provide is essential to the development and livelihood of the residents. To lose these assets means both towns would be unable to accomplish their goals and the community members will suffer detrimental social, economic, and health outcomes.

Workforce Development, Job Quality, and Wealth Creation

VTrans submits all their projects to bid within the regulations and guidelines set by the federal government. As such, the Davis-Bacon prevailing wages are set and specified in the contract. VTrans also requires Equal Employment Opportunity (EEO) Certification as required by the Equal Employment Opportunity regulations of the Secretary of labor (41 CFR 60-1.7(b) (1)).

VTrans also ensures that their project contracts include Disadvantaged Business Enterprise (DBE) Program provisions that ensure that DBEs have an equal opportunity to compete fairly. Contracts will not be discriminated against on the basis of race, color, religion, sex or national origin for an award.

Additionally, ensuring the resilience of these structures will allow the communities in this rural area to continue expanding their access to goods and job opportunities. This project also maintains reasonable freight access to transportation insecure areas of Vermont.

Construction Readiness

The Elmore-Worcester Route 15 structures are in post-design and include resiliency measures in their design to adapt to future vulnerabilities and risks associated with extreme weather events caused by climate change. The project is ready to proceed to construction within 10 months of award from a PROTECT Discretionary Grant Program grant.

Funding Needs

PROTECT formula funding provides the State of Vermont with $37.3 over five years (~7.5 million per year). This project's estimated total cost is $12.9 million, $10.3 of which is a federal share that will fall under these formula funds, which exceeds the annual funds available. This amount, plus all other projects in Vermont that include resiliency in their design, exceeds the total amount of funds available.