



# REDUCING REPEAT DAMAGE OF VERMONT'S ROADS & STRUCTURES

*MAP-21 Part 667*

*July, 2022 - Final*



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## *Executive Summary*

**VTrans is working to reduce repeat storm damage to transportation assets to improve service, minimize costs, respect the environment, and provide for the safe and efficient movement of people and goods.** Staff have taken the MAP-21 Part 667 requirement as an opportunity to advance existing risk and resilience efforts.

This report builds on the 2019 initial Part 667 report. That initial report only had to cover the National Highway System (NHS). As required, this report expands to cover the full Vermont Federal Aid System (FAS). **217 locations seem to each have been damaged in multiple governor- or president-declared events between 2007 and 2021. 21 of these locations seem to have been damaged in three different declared events.**

The main data source is Detailed Damage Inspection Reports (DDIRs) for governor- or president-declared events in Vermont from 2007 through 2021. DDIR data is useful but requires damage is widespread and unusually expensive as described in the [FHWA Emergency Relief Program](#). This report incorporates additional data sources, including the [VTrans Transportation Resilience Planning Tool](#) (TRPT). Part 667 work will stay coordinated with the Vermont Asset Management Information System (VAMIS) for future efficiencies.

VTrans staff have been gathering and refining DDIR data for several years into a single, accessible master damage database (GDB\_Damage). Part 667 requires analysis of this data and exploring “if there are reasonable alternatives to roads, highways, and bridges that have required repair and reconstruction activities on two or more occasions due to emergency events.” (*Federal Register*, Volume 81 No. 95 October 24, 2018).

**A tool for exploring and discussing the analysis is the Reducing Repeat Damage Webtool** ([https://bit.ly/Repeat\\_Damage](https://bit.ly/Repeat_Damage)). It also provides context from related efforts, supports two-way communication with people familiar with locations, and captures knowledge before people change jobs or retire.

### Summary of Analysis

- 217 locations on the Federal Aid System (FAS) seem to each have been damaged in multiple governor- or president-declared events.
- 21 locations seem to each have been damaged in three different events (“triple-whammy” sites)
- 89 repeat damage sites are on heavily travelled or regionally important roads. For now this is measured as Interstates through Minor Arterials (functional class 1 through 4). The repeat damages were on Principal Arterials and Minor Arterials, and include nine triple-whammy sites.
- 13 repeat damage locations are on the NHS, a subset of the FAS that comprises approximately 27% of FAS mileage, including two triple-whammy sites.

Special mention location:

US 4 focused in Hartford has the greatest number of damaged sites near each other in Vermont based on DDIR analysis, including the only triple damage sites on the NHS. The repeat damage sites on US 4 are 46% of repeat damage sites on the NHS in Vermont.

### Repeat Damage Locations on the National Highway System (NHS)

The NHS is an essential part of regional and national movement of people and goods. All repeat damage sites on it are on Principal Arterials rather than Interstate Highways.

All repeat damage locations on the NHS bear exploration, but the following ones seem to be priorities:

- US 4, mainly in Hartford – ID 175 and 176 were damaged in three major events; corridor study is underway with reconstruction project programmed for late this decade (NH 020-2(51)).
- US 2 in St. Johnsbury just east of VT 18 access to I-91 (ID 33) and the other US 2 location near it (ID 32) – This is a confirmed problem area that doesn't seem to have work programmed.
- VT 117 approximately half a mile north of US 2 and the I-89 Exit 11-Richmond (ID 35) – This area came to light in newer analysis and is being explored further with district and CCRPC.

### Locations Damaged in Three Major Events on Heavily Travelled Roads

Repeat damage in three major events is a stronger indicator of need for further evaluation than in two major events, and especially when it occurs on roads that serve high volumes/regional needs. All the triple-whammy locations have some level of attention underway, from a corridor management plan to active construction.

### Most-Damaged Districts, Regions, River Basins, and Watersheds

VTrans Maintenance Districts

- District 4, which is headquartered in White River Junction - Over a third (39%) of all the repeat damages, 84 total including nine triple-whammy sites.
- The second most impacted is the reconstituted District 6.

Regional Planning Commission (RPC)

- Two Rivers-Ottawaquechee Regional Commission (TRORC) – Approximately 40% of all repeat damage sites, 87 repeat damage locations including 10 of the triple-whammy sites.
- No other RPC has close to that level of recorded damages.

River Basin

- White River - Approximately a third (36%) of the repeat damage locations are in this one of the 15 tactical river basins. It coincides with the District 4/TRORC areas identified above. Opportunity: the DEC plan for this river basin is being updated starting in summer, 2022. Staff from VTrans and DEC have already met once to enhance existing collaborative processes.

Watersheds

This is analysis of USGS HUC-12 geography to coordinate with TRPT. Only three of the 54 HUC-12 watersheds had 13 or more repeat damage sites.

- Headwaters White River
- Middle Branch Williams River
- Broadneck Brook-White River

### Ground-Truthing

Comments were provided on more than 40 repeat damage locations, mainly by VTrans district staff. They could be sorted into three general categories: Replace (10), System/Study (13), or Fixed (11). The Replace category were comments that described a specific need or recommendation, e.g. install a larger culvert or more frequently maintain ditches. The System/Study category refers to more-complex matters.

A sample of district staff comments follow.

- Replace - VT 58 in Irasburg, two locations about four miles apart (ID 151 and 174, a triple damage location on a major collector (functional class 5) road)
- Replace - VT 12 A in Roxbury (ID 163), triple damage location on a major collector (functional class 5) in a five-mile corridor with at least six repeat damage locations.
- System/Study - VT 12 in Elmore and Worcester (IDs 171 and 172): A systematic program in this corridor has the potential to reduce the high costs associated with emergency repairs. If the end goal is to protect the entire basin and reduce sediment further away from these mountain valley towns, we should start thinking bigger. The State is upsizing five of its undersized structures, but the small towns are struggling to keep up and replace theirs.
- System/Study: VT 15 east of Morrisville (ID 173): Damage usually appears directly downstream from the last repair. If we end where the stream is narrow and fast-moving there will be future damage. There is need to work further with DEC on these matters. [Follow up discussion added the recommendation for ongoing coordination with DEC to keep all involved on top of resources to share with municipalities.]

## Summary of Recommendations

The recommendations in the Part 667 report bring together various efforts underway at VTTrans as well as highlight additional opportunities to reduce risk and increase resilience. They support informed conscious decision-making. See the final section of the report for detail on each recommendation.

### Short-Term Next Steps

- Coordinate on projects underway to maximize their role reducing risk and severity of damage in major events.
- Enhance use of storm damage data “upstream” of this analysis, in Part 667 updates, and “downstream” in other processes.
- Continue and enhance efforts to communicate and coordinate.

### Long-Term Next Steps

- Act on additional locations identified through this Part 667 analysis to minimize likelihood that they will be damaged again, and if damaged then increase how quickly the facilities can be brought back into use.
- Better integrate risk management across AOT including reduction of repeat damage.
- Pursue continuous improvement at reducing repeat damage and increasing resilience as we look ahead to increased impacts from climate change.



## Introduction to MAP-21 Part 667

Part 667 requires that state departments of transportation (DOTs) “conduct statewide evaluations to determine if there are reasonable alternatives to roads, highways, and bridges that have required repair and reconstruction activities on two or more occasions due to emergency events.” (*Federal Register* Volume 91, No. 205 (October 24, 2016), p. 73268)

The first Part 667 report was due in 2019 eased in with only the National Highway System (NHS). In this report and going forward, the required network is the full Federal Aid System (FAS). The FAS includes roads with functional classes 1 (Interstate) through 5 (Major Collector), and Urban Minor Collectors. Rural Minor Collectors and Local Roads are not part of the federal aid system. A current web map is maintained at [this](#) ArcGIS Online location.

Other requirements of Part 667 may be summarized as

- Use data starting as close to 1997 as reasonably available through the end of December of the end of the year of analysis (in this case 2021)
- Emergency event refers to declaration by the governor or president
- Update analysis after additional emergency events or a minimum of every four years
- Include identification and consideration of alternatives that will mitigate or resolve the root causes of the recurring damage, the costs, and likely duration of the solutions.
- Consider the risk of recurring damage and cost of future repairs under current and future environmental conditions.
- Consider the results when developing projects.

The requirements were updated in a September, 2021 memo in the Policy and Guidance section of the [FHWA Emergency Relief](#) program web page that includes [flow diagrams](#) for Part 667 responsibilities regarding damage on the National Highway System (NHS) and off the NHS but still on the Federal Aid System (FAS).

Another area of development is in the Federal Planning factors. They now include resilience. The frequency of use of the terms “risk” and “resilience” raises some questions of how they differ and overlap. A simple way of thinking about this follows. **Risk** is more about the chance that infrastructure will be damaged and what that might cost. **Resilience** is more about having prepared systems to minimize the impact of those events and increase the speed with which they can bounce back to normal. They are interrelated.

Looking back in time, a related section of MAP-21 required development and maintenance of a Transportation Asset Management Plan (TAMP) that includes risk analysis. The 2018 TAMP drew on previous risk register work and referenced Part 667. The TAMP is being updated in 2022 and will incorporate this Part 667 work. In the meantime the existing enterprise-level risks at VTrans provide context for various efforts.

*Table 1: TAMP Enterprise-Level Risks*

Risk Focus Area	Issue	Fix
Extreme Weather Impacts	Risk management Not Yet Embedded into VTrans Culture	Identify a risk management champion for each asset group. Train how to incorporate risk management in VTrans processes emphasizing an integrated approach. Implement strategies from asset risk registers. Monitor new risks. Evaluate strategies.

Extreme Weather Impacts	Bridge System is Not Prepared for Climate Change	Identify bridges at risk due to extreme weather, in part using VTrans TRPT. Participate in evaluation of facilities repeatedly damaged by major events. Revise standards to become more resilient in the face of climate change and chance of seismic activity.
Extreme Weather Impacts	Lack of Preparedness for Climate Change Effects on Roads	Expand TRPT to statewide. Iteratively coordinate on TAMP and Part 667 work.
Information Management	Limited Access and Integration of Risk Data and Information	Improve access to risk management data and information; widely communicate availability and how to use it.
<b>Sustainable Transportation</b>	<b>Ineffective Collaboration in Enterprise-Level Risk Management</b>	<b>Act on enterprise level risk starting with a multidisciplinary VTrans meeting followed up annually; establish communication with traditional and new partners to minimize or mitigate risks.</b>

Source: [VTrans TAMP](#) (2018)

## Context of Storms and Responses

The main source of data for the analysis in this report was DDIRs prepared by VTrans for the FHWA Emergency Relief (ER) Program. For more detail see the [VTrans ER Guide](#) (note this link may only work for VTrans staff).

### FHWA and FEMA Storm Data

There was some further exploration of the events from postings for FEMA Major Disaster Declarations and counties eligible for Public Assistance (PA) funding. The research across programs is summarized in the table that follows. The relationship between the FHWA ER program and FEMA PA program will be explored further in future reports. A brief summary is that the FEMA PA program covers a wider range of private as well as public assets than the FHWA ER program. FEMA PA Category C includes permanent repairs to roads and bridges. The PA program is also the source of funding for repairs to rail lines damaged by these declared storm events. For more information, see <https://www.fema.gov/assistance/public/program-overview#eligibility>.

*Table 2: Exploring Correspondence of FHWA ER and FEMA PA Declaration Reports*

FHWA Declaration	Event Date	FEMA Declaration	Event Date
20-1	October 31-November 1, 2019	4474	October 31, 2019 – Nov 1, 2019
19-1	April 14-15 and 19-20	4445	April 15, 2019
	X	4380	May 4-5, 2018
	X	4356	October 29-30, 2017
17-1	June 29-July 1, 2017	4330	June 29-July 1, 2017
	X	4232	June 9, 2015
	X	4207	December 9-14, 2015
	X	4178	April 15-19, 2014
	X	4163	December 20-26, 2013
14-1*	July 8, 2014	x	x

\*Example of a major storm that was evaluated but didn't qualify for FHWA or FEMA funding

## Tropical Storm Irene

One element that complicated analysis of repeat damage is the multiple heavy storm events in 2011. The 2011 data includes records for the severe April through May storms that are documented as VT 11-01 (also entered as Irene\_Spring) and Tropical Storm Irene in August (VT 11-02). There were a variety of ways data was entered in this complicated period that make analysis of repeat damage separating those events difficult. The description in a Weather.gov article gives a sense of the intensity of weather events in that period, and how declared and undeclared events can mix:

From devastating flooding to record breaking snows, 2011 was a year of particularly active and tragic weather across Vermont and northern New York. At Burlington International Airport, it was the wettest year on record with 50.92" of precipitation. Burlington also had its 3rd snowiest winter on record with 128.4". ... The greatest snowstorm occurred on March 6-7th when 25.8" fell at Burlington, which was 3rd greatest snowstorm in history. The greatest 24-hour single day rainfall was 3.38" associated with Tropical Storm Irene on 28 August 2011. The combination of above normal snowpack and record-breaking rainfall caused several historical flooding events across our region. They include the heavy convective rainfall and flooding event on April 26th-27th, followed by a record Lake Champlain stage of 103.27 feet on 6 May 2011 breaking the previous record by over a foot. Another heavy convective rainfall episode on May 26th- 27<sup>th</sup> brought more flooding, followed by the historic and devastating flooding from Tropical Storm Irene on August 28th.

-Source: [https://www.weather.gov/media/btv/events/Top5\\_2011.pdf](https://www.weather.gov/media/btv/events/Top5_2011.pdf)

## Major Events 2007-2021

The major events in this report are listed below. The counties listed as eligible for FEMA PA funding are included. A publicly available resource for this information is <https://www.fema.gov/disaster/declarations>. The annual allocations of FHWA ER funds by state and event is available as of 2021 at the following link:

<https://www.fhwa.dot.gov/specialfunding/er/200929erfafunds.cfm>

- VT 07-1: four counties were damaged by severe storms, flash flooding, and flooding July 9 through 11, 2007 (Washington, Windsor, Orange, Caledonia and Orleans) – FEMA 1715-DR as amended
- VT 08-1: three counties were damaged by statewide damages from tornado, severe thunderstorms, heavy rain on July 18, 2008 (Caledonia, Grand Isle, and Lamoille) – FEMA-1784-DR
- VT 11-1 (also documented as 11\_Spring): Seven counties experienced severe storms and flooding during the period of April 23 to May 9, 2011 (Addison, Chittenden, Essex, Franklin, Grand Isle, Lamoille, and Orleans) – FEMA 1995-DR
- VT 11-2: 13 counties were damaged by Tropical Storm Irene during the period of August 27 to September 2, 2011 -FEMA-4022-DR
- VT 13-1: Extreme runoff and flooding following the heavy rains which fell during the periods of May 22 through 26, and June 25 through July 11, 2013.
  - Three counties damaged in severe storms and flooding during the period of May 22-26, 2013 (Chittenden, Essex, and Lamoille) – FEMA 4120
  - Seven counties damaged in severe storms and flooding during the period of June 25 to July 11, 2013 (Caledonia, Chittenden, Orange, Orleans, Rutland, Washington, and Windsor) – FEMA-4140-DR
- VT 14-1 (evaluated and numbered but didn't end up qualifying for FHWA or FEMA funding): Wind and rainstorms on July 14, 2014 caused damage to transportation facilities in Andover (Windsor), Chester (Windsor), and Londonderry (Windham),
- VT 17-1: Seven counties suffered substantial damage by flooding between June 29 and July 1, 2017 (Addison, Bennington, Caledonia, Orange, Rutland, Washington, and Windsor) – FEMA DR-4330

The following events occurred after the analysis for the 2019 report. They are incorporated in this current report.

- VT 19-1: Heavy rains and snowmelt from storms April 14-15 and April 19-20 caused serious damage in eight counties (Windham, Bennington, Windsor, Rutland, Orange, Washington, Caledonia, and Essex). It is FEMA DR 4445 for Public Assistance.
- VT 20-1 (the Halloween storm): Flooding and runoff as a result of extremely heavy rain and high winds from

October 31 - November 1, 2019 caused serious damage in six counties (Addison, Chittenden, Franklin, Lamoille, Orleans, and Washington).

- There was a substantial storm with heavy rains the last week of July 2021. The main damage was reported to be in Windham and Bennington counties, described by Ben Rose, VEM, as “...some of the worst flood damage in southern Vermont since 2005 in some communities.” As of January 2022 the impression is this will not however become a governor- or president-declared event.

Currently this Part 667 repeat damage analysis doesn’t include data gathered after large storms that don’t become declared events or even the more standard substantial events that Maintenance staff routinely repair. Incorporating these contents is a long-term recommendation.

## Concepts and Partners in Preventing Damage

FEMA training materials provide the high-level overview summarized below of how to reduce impact from major events. While the focus of this report is on preventing repeat damage to transportation facilities—and the resulting impacts for people, goods, and the environment—all the phases are important.

- Prevent when possible;
- Be prepared;
- Expedite responses; and
- Aid the recovery to normal services, completing a learning cycle.

Even in the one phase of preventing damages, there are many partners. A few partners and links to valuable resources to reduce repeat damage to roads and bridges are listed below.

*Table 3: Sample of Partners and Resources*

Organization	Description	How to Obtain Information
FHWA	Wide range of resources, grants, and trainings	<a href="https://highways.dot.gov/">https://highways.dot.gov/</a>
FEMA	Wide range of training, resources, and grants, including Building Resilient Infrastructure and Communities (BRIC) which can be used for pre-disaster planning efforts.	<a href="https://www.fema.gov/">https://www.fema.gov/</a>
FEMA/Natural Hazards Center Mitigation Matters Research Program	Webinars and reports on the communication and persuasion side of mitigation	<a href="https://hazards.colorado.edu/research/mitigation-matters">https://hazards.colorado.edu/research/mitigation-matters</a>
Vermont Emergency Management (VEM)	Wide range of resources, grants, and trainings; monthly newsletter; documents such as the State’s 2022-2025 Integrated Preparedness Plan; guidance for the annual Local Mitigation Planning Policy and Local Emergency Management Plan (LEMP)	<a href="https://vem.vermont.gov/">https://vem.vermont.gov/</a>
Vermont Agency of Transportation (VTrans)	Transportation Resilience Planning Tool (TRPT) VTransparency Resources Better Roads & Local Technical Assistance Program (LTAP) Center	<a href="https://vtrans.vermont.gov/planning/transportation-resilience">https://vtrans.vermont.gov/planning/transportation-resilience</a> <a href="https://vtransparency.vermont.gov/">https://vtransparency.vermont.gov/</a> <a href="https://vtrans.vermont.gov/highway/better-roads">https://vtrans.vermont.gov/highway/better-roads</a>
Vermont Agency of Commerce and Community Development (ACCD)	Programs to increase municipal resilience and grants, including <a href="#">Planning for Tomorrow’s Flood</a>	<a href="https://accd.vermont.gov/community-development/flood">https://accd.vermont.gov/community-development/flood</a>
Vermont Agency of Natural Resources (ANR)	Resources includes Flood Ready Vermont and tools for assessing and printing town’s flood hazards.	<a href="https://floodready.vermont.gov/">https://floodready.vermont.gov/</a>
Resilient Vermont	Wide range of resources	<a href="https://resilientvt.wordpress.com/resources/">https://resilientvt.wordpress.com/resources/</a>
Vermont Comprehensive Energy Plan	Coordinated, required approach managed by Department of Public Services that includes	<a href="https://publicservice.vermont.gov/publications-">https://publicservice.vermont.gov/publications-</a>

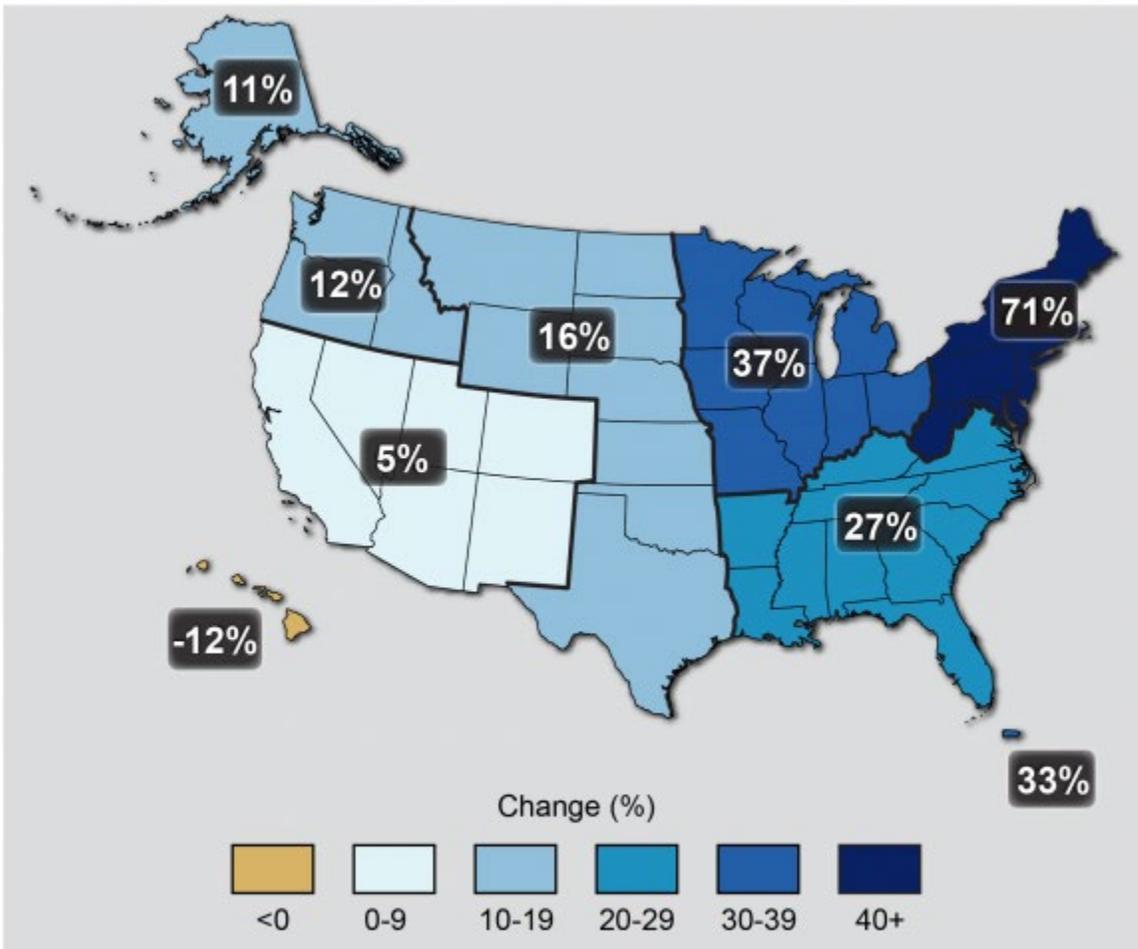
	ways to meet energy service needs in accordance with reducing greenhouse gas emissions	<a href="#">resources/publications/energy_plan</a>
Vermont – Climate Change and Climate Action Plan	Coordinated approach led by the Vermont Climate Council to manage impacts of climate change in Vermont	<a href="https://climatechange.vermont.gov/">https://climatechange.vermont.gov/</a>

Note: Links may change over time, but sources will likely be findable by searching online.

Beyond understanding resources and coordinating with partners, it is important for municipalities to adopt and adhere to local road standards and participate in opportunities available. Adopted local road standards help make the transportation system more resilient and reduce town share, and potentially state share for restoration work eligible with FEMA and FHWA. For more information, see the [VTrans Orange Book](#) and Vermont League of Cities and Towns website.

Increasingly there is need to consider climate change in the context of the transportation network. The figure below shows percent changes in the amount of precipitation falling in very heavy events (the heaviest one percent) from 1958 to 2012 for each region of the United States.

Figure 1: Observed Change in Very Heavy Precipitation, 1958-2012



Source: Melillo, Jerry M., Terese (T.C.) Richmond, and Gary W. Yohe, Eds., 2014: *Highlights of Climate Change Impacts in the United States: The Third National Climate Assessment*. U.S. Global Change Research Program. P. 6.  
<https://www.globalchange.gov/browse/reports/highlights-climate-change-impacts-united-states-third-national-climate-assessment>

## VTrans Approach

The VTrans approach to fulfilling Part 667 regulations and reducing repeat damage to transportation assets is summarized in the following list of steps.

1. Prepare Data
2. Conduct Analysis
3. Gather Knowledge
4. Draw Conclusions
5. Consider Strategies and Work Underway
6. Take Short-Term Steps
7. Start Longer-Term Steps

Each of these steps is explored in its own section of this report.

## Prepare Data

As is often the case, gathering, cleaning, and managing the data has been the bulk of the effort.

### Detailed Damage Inspection Reports (DDIRs)

The initial Part 667 report started in 2018 with gathering over 1,000 Detailed Damage Inspection Reports (DDIRs) going as far back as reasonably possible. This involved bringing together spreadsheets, scanned files, paper reports, and GIS data. It was inherently messy from a data and mapping perspective. It resulted in a GIS database of points and lines representing DDIRs from 2007 through 2017 on the Federal Aid System (FAS).

Data gathering, coordination, and location refinements continued after the 2019 Part 667 report was completed, working toward a comprehensive database of storm damage to transportation assets. The data is additionally being used in the TRPT when there is opportunity and for Maintenance Bureau needs. The gathering has included reviews of the Incident Command Center (ICC) directory folders and substantial scanning of paper files. Some damage sites in the master database are off the FAS or are for events that did not receive an emergency declaration from a governor or president. There has been a significant amount of effort to improve the location and accuracy of the sites that represent point and segment locations, and have expanded attributes regarding each site.

VTrans requested and received a database of over 8,500 FEMA Public Assistance (PA) sites as well. They are largely off the FAS. There are various future applications of the data being explored. One is that the FEMA data includes damage to rail lines.

As part of work with damage data, a governance structure was developed and implemented. There is now a standardized dataset of points and lines that provides a single location accessible for State uses. The point data layer includes all sites. When damage is over a larger segment of a highway, a line feature has also been created. The data is currently accessible to all GIS users within VTrans and can be provided outside VTrans upon request. A subset of the data was shared as a feature service with the TRPT– Data Review Application for Regional Planning Commissions that are reviewing damage sites for the TRPT project. The GIS data within VTrans is located in the enterprise GIS in ArcSDE as the following data layers: GDB\_GEN - DamageData\_Line\_Master and

GDB\_GEN – DamageData\_Point\_Master. Having one well-managed source will streamline future efforts to reduce repeat damage. In all, a sustainable and high-quality data source has come into existence for Vermont transportation management in part from the Part 667 requirement.

In 2018, a spreadsheet of several hundred DDIRs from Tropical Storm Irene was compiled. The geodatabase of damage data has 1436 points and 883 line segments that represent DDIRs, FEMA PAs and other storm damage from undeclared events. More than 8,500 FEMA PA records were received in 2020. They have not been fully included in the master damage data layer as of mid-2021, as it will require significant review and effort add only the unique sites to the master data layer. Only a few locations are on the FAS; these are roads that have since been incorporated in the FAS. However, potential future uses of the major storm events are discussed in long-term steps. DDIR data from major events since 2017 through the end of 2021 have also been added since the previous analysis.

With the DDIRs accurately mapped, VTrans Mapping Section staff converted and prepared the data for Part 667 analysis. A 0.1-mile buffer was created for each point and line to account for minor differences in reporting locations and to convert all items into polygons. To analyze repeat damage, ArcGIS geoprocessing tools were used to “dissolve” (merge) any overlapping damage polygons from the same emergency event into single non-overlapping polygons. The remaining overlapping polygons therefore reflected different emergency events. The “Union” of these dissolved damage polygons provided the polygon overlap depth (i.e. number of overlapping polygons) at any location, corresponding to the number of distinct emergency events impacting an area. All scripts were documented.

Locations of damage from storms since 2018 have been added to the damage data layers in the GIS.

Gathering, cleaning, mapping, and reviewing DDIR data on the Vermont FAS using data from 2007 through 2021 identifies

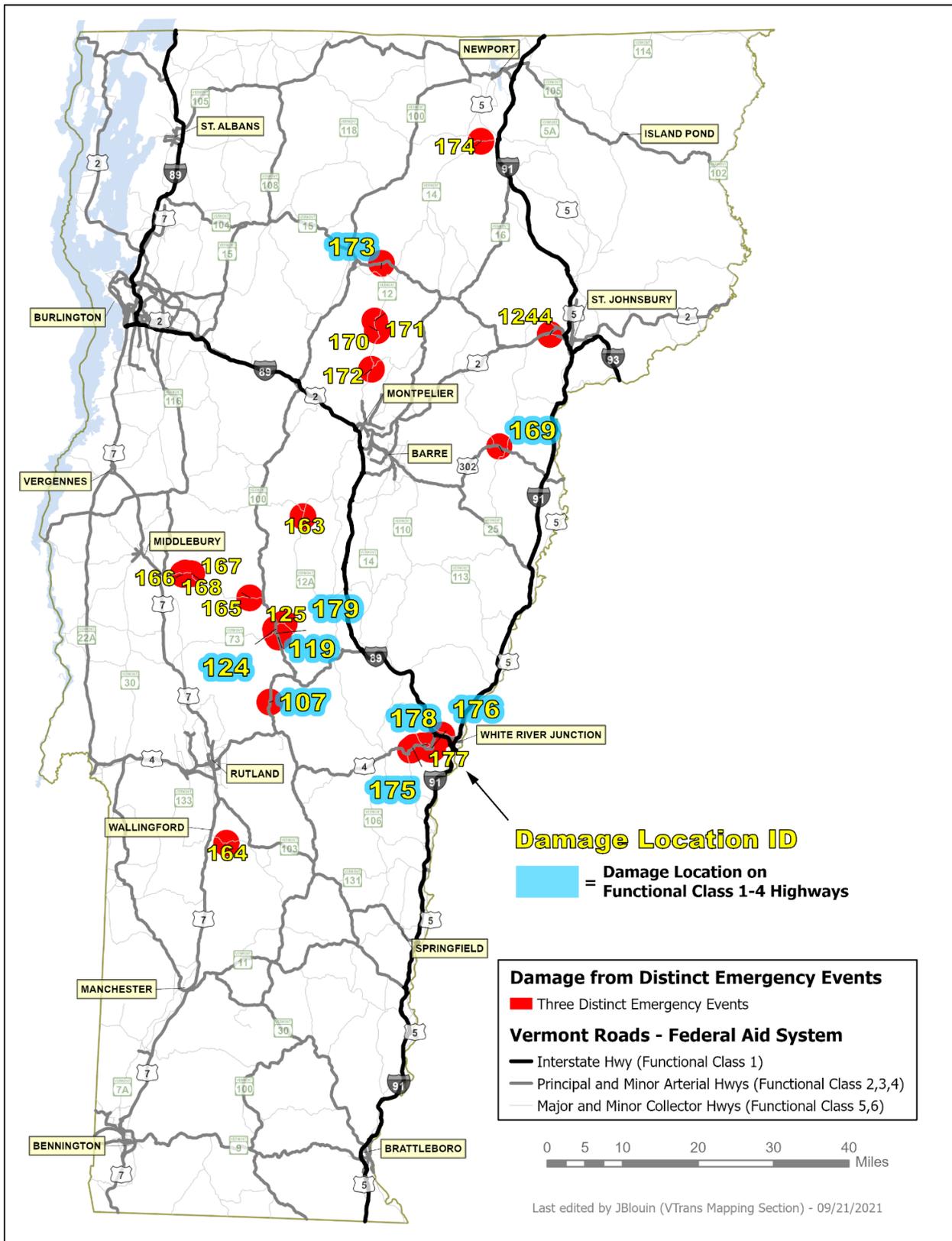
- 21 locations seem to each have been damaged in three different events
- 217 locations seem to each have been damaged in two different events

Information about the 21 locations damaged in three different storms follows in a table. A map of them follows. The best way to explore the full set of repeat damage sites is through the [Reducing Repeat Damage Webtool](https://bit.ly/Repeat_Damage)[https://bit.ly/Repeat\\_Damage](https://bit.ly/Repeat_Damage). Further analysis, ground-truthing, and exploration of how to reduce future repeat damage follow in the subsequent sections.

Table 4: Locations Damaged in Three Major Storms

ID	FHWA ER Events	District	Town(s)	County	RPC(s)	Road Name(s)	Functional Class	On NHS
107	VT11-2, VT13-1, VT19-1	3	PITTSFIELD	RUTLAND	TRORC	VT ROUTE 100	4	Not on NHS
119	VT11-2, VT13-1, VT19-1	4	ROCHESTER	WINDSOR	TRORC	VT ROUTE 100 S	4	Not on NHS
124	VT11-2, VT13-1, VT19-1	4	ROCHESTER	WINDSOR	TRORC	VT ROUTE 100 S, S MAIN ST	4	Not on NHS
125	VT11-2, VT17-1, VT19-1	4	ROCHESTER	WINDSOR	TRORC	BETHEL MOUNTAIN RD	5	Not on NHS
163	VT07-1, VT11-2, VT13-1	6	ROXBURY	WASHINGTON	CVRPC	ROXBURY RD	5	Not on NHS
164	VT08-1, VT11-2, VT17-1	3	WALLINGFORD	RUTLAND	RRPC	VT ROUTE 140 E	5	Not on NHS
165	VT08-1, VT11-2, VT17-1	4	HANCOCK	ADDISON	TRORC	VT ROUTE 125	5	Not on NHS
166	VT08-1, VT11-2, VT17-1	5	RIPTON	ADDISON	ACRPC	VT ROUTE 125	5	Not on NHS
167	VT08-1, VT11-2, VT17-1	5	RIPTON	ADDISON	ACRPC	VT ROUTE 125	5	Not on NHS
168	VT08-1, VT11-2, VT17-1	5	RIPTON	ADDISON	ACRPC	VT ROUTE 125	5	Not on NHS
169	VT11-1, VT11-2, VT17-1	7	GROTON VILLAGE	CALEDONIA	NVDA	SCOTT HWY	4	Not on NHS
170	VT11-1, VT11-2, VT20-1	6	WORCESTER	WASHINGTON	CVRPC	ELMORE RD	5	Not on NHS
171	VT11-1, VT11-2, VT20-1	6	ELMORE	LAMOILLE	LCPC	VT ROUTE 12	5	Not on NHS
172	VT11-1, VT13-1, VT20-1	6	WORCESTER	WASHINGTON	CVRPC	WORCESTER VILLAGE RD	5	Not on NHS
173	VT11-1, VT11-2, VT20-1	6	MORRISTOWN, WOLCOTT	LAMOILLE	LCPC	VT ROUTE 15, VT ROUTE 15 E	4	Not on NHS
174	VT11-1, VT11-2, VT20-1	9	IRASBURG	ORLEANS	NVDA	VT ROUTE 58 E	5	Not on NHS
175	VT11-2, VT13-1, VT17-1	4	HARTFORD	WINDSOR	TRORC	WOODSTOCK RD	3	NHS - Principal Arterial
176	VT11-2, VT13-1, VT17-1	4	HARTFORD	WINDSOR	TRORC	WOODSTOCK RD	3	NHS - Principal Arterial
178	VT11-2, VT13-1, VT17-1	4	HARTFORD	WINDSOR	TRORC	WOODSTOCK RD	4	Not on NHS
179	VT11-2, VT13-1, VT20-1	4	ROCHESTER	WINDSOR	TRORC	VT ROUTE 100 S	4	Not on NHS
1244	VT11-1, VT11-2, VT19-1	7	DANVILLE	CALEDONIA	NVDA	PARKER RD	5	Not on NHS

Figure 2: Locations of Repeat Damage on the Federal Aid System



## Transportation Resilience Planning Tool (TRPT)

The [Transportation Resiliency Planning Tool](#) is a VTrans undertaking to *proactively explore where damage is likely* based on stream, soil, rock, and infrastructure characteristics that also folds in DDIRs. It is enhanced by the data-cleaning, and analysis underway. With Joe Segale as a champion this analysis is part of how resilience is included in the new VTrans Project Selection and Project Prioritization (VPSP2). It started with three case study watersheds and a statewide flood vulnerability layer. Phases two and three are expanding it to cover the whole state. It includes general strategies for different types of situations. TRPT analysis is considered in Part 667 work, for example it is displayed in the Reducing Repeat Damage webtool. The TRPT work led to FEMA funding to make a repeatedly damaged part of VT 9 more resilient.

To understand the differences, Part 667 is a federal requirement. It requires analysis of **FAS highway assets that have been damaged** and rebuilt in governor- or president-declared storm events. There are specific action-oriented elements required to be included in the report that gets reviewed and approved by FHWA-Vermont Division. DOTs need to update and submit reports after declared events and at least every four years.

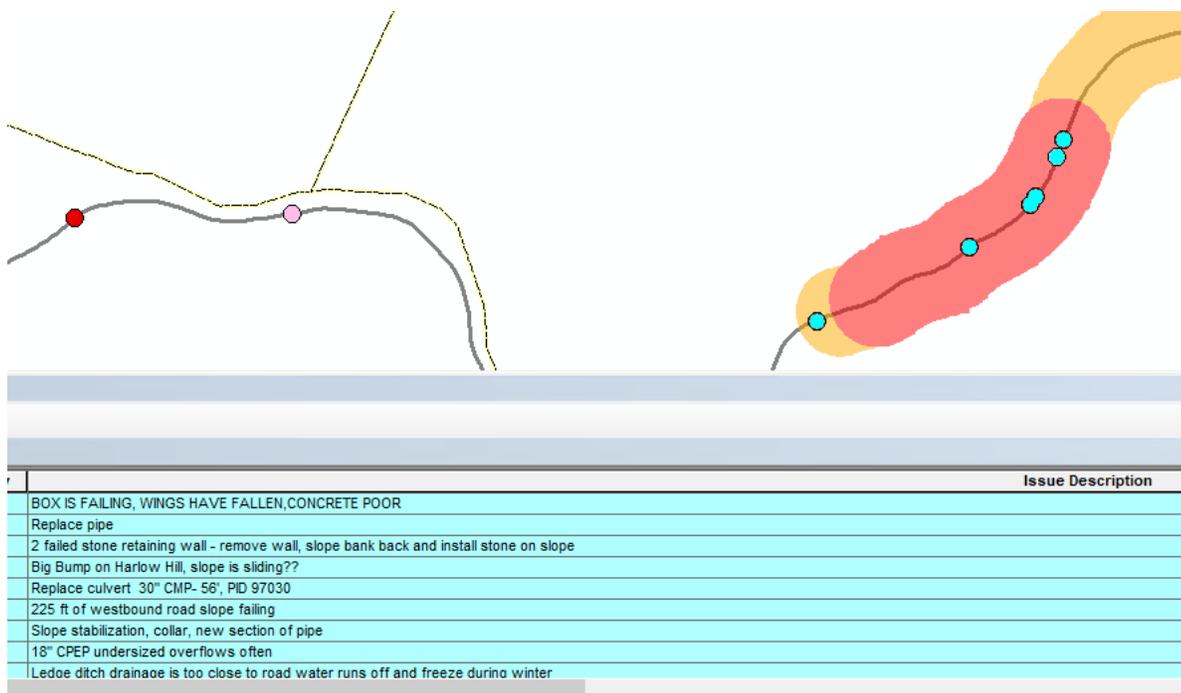
Some future steps to continue to gain value from combining TRPT and Part 667 ongoing requirements are

- Figure out how to regularly integrate the latest Part 667 DDIR analysis into TRPT.
- Explore areas identified as high risk in TRPT with current DDIR analysis, such as the US 2 corridor between Montpelier and Burlington.

## District Corridor Needs and Other Maintenance Data

The Maintenance Bureau has developed an ongoing repository of needs that is a valuable source to check issues identified in DDIR analysis and learn from the observation of people who know the area well. The District Corridor Needs map generally focuses on issues on the large scale for the maintenance budget of a district and on the small scale of capital projects. It is included as a layer in the Reducing Repeat Damage Webtool.

Figure 3: Screenshot of Corridor District Needs with Repeat Damage Locations



## Conduct Analysis

Once the data was ready two next steps proceeded in an iterative manner. One was analysis of the data using pivot tables in Excel, ArcGIS, and additional data sources such as TRPT. The other, covered later in the report, was ground-truthing and discussing the data.

The analysis that follows explores the data by

- Road functional class
- National Highway System (NHS) status
- VTrans maintenance district
- Regional Planning Commission (RPC)
- River basin and watersheds
- “Triple-whammy sites” – locations damaged in three different declared events

### Analysis by Road Functional Class

Two questions to explore in terms of repeat damage to the road network are

- Does any functional class of road show particular trends in terms of repeat damage?
- Is it efficient to focus first on the roads that carry the most traffic/focus on regional movements?

Two ways to think about the public road network are by mileage or by level of use as measured by Vehicle Miles Travelled (VMT). The table that follows summarizes both. It highlights that **the Federal Aid System is only 28% of road mileage but carries 81% of the annual VMT**. Roads not on the FAS are still important for local movement and connectivity.

*Table 5: Mileage and Annual VMT by Functional Class of the Public Road System*

Functional Class	Mileage	% of Miles	Annual VMT (millions)	% of Annual VMT
1: Interstate	320	2.3%	1,814	24.7%
2: Primary Arterial-Other Free/Expressway	16	0.1%	65	0.9%
3: Principal Arterial	457	3.2%	1,336	18.2%
4: Minor Arterial	882	6.3%	1,313	17.9%
5: Major Collector	2,232	15.8%	1,393	19.0%
6: Urban Minor Collector	32	0.2%	24	0.3%
FAS (Subtotal)	3,940	28.0%	5,945	80.9%
6: Rural Minor Collector	890	6.3%	190	2.6%
7: Local	9,261	65.7%	1,211	16.5%
Total Public Roads	14,091	100.0%	7,346	100.0%

The FAS does not include Rural Minor Collectors or Local roads

Mileage per Road Centerline Data (RDS) Summary per 4/21/2021 e-mail from Johnathan Croft

The FAS network is a useful focus for reducing repeat damage given its importance for moving people and goods. Further, on the FAS a subset of the larger roads carry a high percent of all the mileage. **Interstates**

**(functional class 1) through Minor Arterial roads (functional class 4) are less than half of the FAS miles (43%) but carry three-quarters of the annual VMT on the FAS (76%).**

*Table 6: Mileage and Annual VMT by Group of Functional Classes of the Federal Aid System*

Part of FAS	Mileage FAS	Percent of FAS	Annual VMT	Percent of VMT
Total FAS	3,940	100%	5,945	100%
Percent of FAS that is class 5 or 6	2,264	57%	1,417	24%
Functional Class 1-4	1,676	43%	4,528	76%

The next figure and table explore where there seems to have been repeat damages from governor- or president-declared events by functional class. The table shows number of locations damaged in two different governor- or president-declared events in the column headed with “2x”, three different events (“3x”), and in total. The category of functional classes 1 through 4 was defined as the high-volume or regionally important roads, however all the damages occurred on functional classes 3 (Principal Arterial) or 4 (Minor Arterial) roads. They constitute 34% of the FAS mileage and carry 45% of the AADT.

While it is possible that damage on high-volume, high visibility roads would receive more focus, this analysis reflects the data that is available. Future steps include expanding to use data from a broader range of storms. Where damage was reported as affecting more than one road it can show as affecting multiple functional classes.

Figure 4: Number of Repeat Damages by Functional Class of Road with District Boundaries

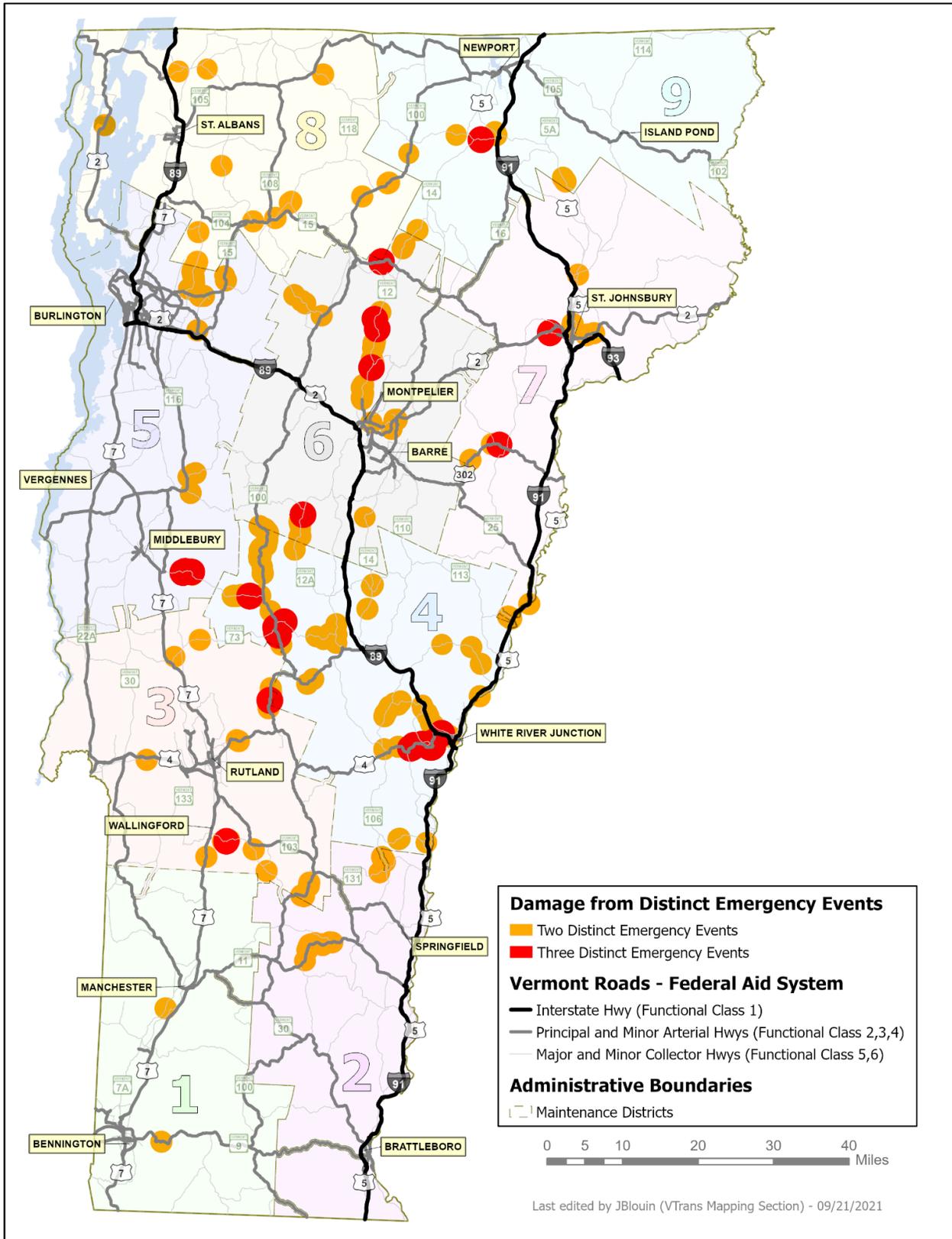


Table 7: Repeat Damage by Functional Class of Road

Functional Class	2x	3x	Total
FC 3	13	2	15
FC 3, 4	1		1
FC 4	63	7	70
FC 4, 5	3		3
FC 5	115	12	127
FC 5	1		1
<b>Grand Total</b>	<b>196</b>	<b>21</b>	<b>217</b>

The subset of high-volume/regionally important roads had 80 locations with damage from two governor- or president-declared events and nine with three governor- or president-declared events between 2007 and 2021. The damages were all on Principal Arterials or Minor Arterials. This is 41% of the repeat damage locations on a part of the road network that makes up 34% of the FAS mileage and 45% of the annual VMT. As a result these damages affected a high percent of travel.

**If there is need to start by focusing on a subset of repeat damage locations, the 80 locations on high-volume road sections with particular focus on the nine locations damaged in three different storms seems like a supportable approach coordinated with other considerations.**

### Analysis by Locations on the NHS

**The NHS is approximately one-quarter (27%) of the FAS miles in Vermont, consisting of the interstate system plus strategic connections to other transportation facilities.** As described in the 2019 Transportation Asset Management Plan (TAMP), “VTrans owns or maintains 1,016 (96%) of these miles and municipalities are responsible for 47 (4%) of the through-lane miles. Of the 47 miles owned or managed by municipalities, 25 (53%) miles lie within the Chittenden County Metropolitan Area. Nearly 13% of the total NHS mileage is located there. VTrans coordinates with CCRPC and the municipalities to manage assets in this one metropolitan area of the state.” (p. 12). Parts of US 4, US 2, US 7, and VT 100 are on the NHS.

**Thirteen repeat damage locations are on the NHS.** All of them are functional class 3 Principal Arterials. The Location IDs are 7, 29, 30, 33, 35, 85, 89, 153, 155, 156, 175, 176, and 724. Location 153 is only partially on the NHS. Locations 175 and 176 were damaged in three major events. In subsequent analysis it is noted if the location is on the NHS.

Figure 5: Repeat Damage Locations on the NHS

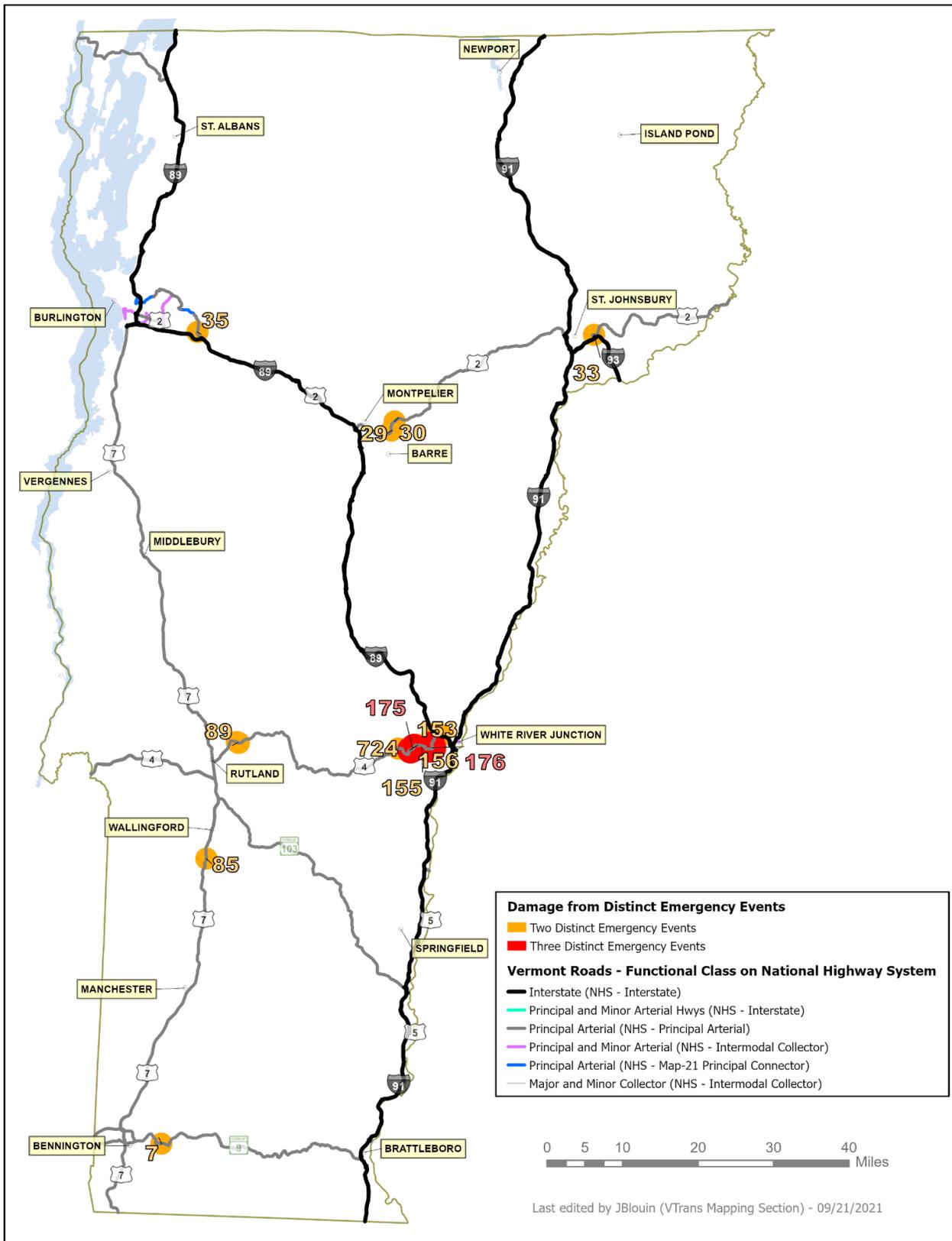


Table 8: Locations on the NHS Damaged in Multiple Major Events

Location ID	Location Notes	District	Town	RPC
7	VT 9, east of Woodland Hollow where VT 9 curves south by City Stream	1	WOODFORD	BCRC
29	US 2 north of Packard Rd and Muddy Brook Rd, near Anderson Eqmt, halfway between River Road and VT 14 along the Winooski River	7	EAST MONTPELIER	CVRPC
30	US 2 just west of VT14 S near stream between Mekkelsen RV and E Montpelier Home Center along the Winooski River	7	EAST MONTPELIER	CVRPC
33	US 2 northeast of Rt 18 access to I-91, Just NE of damage on non-NHS section of US 2 (ID 32)	7	ST. JOHNSBURY	NVDA
35	VT 117 just north of US 2 and the I-89 Exit 11 (Richmond)	5	JERICO	CCRPC
85	US 7 north of Dugway Rd. Note VRS rail line on other side of 7	3	WALLINGFORD	RRPC
89	US 4 near Journey's End Rd west of Appalachian Trail (AT) crossing	3	MENDON	RRPC
153	US 4 near Greenbrier Rd	4	HARTFORD	TRORC
155	US 4 between damage ID 175 and 176	4	HARTFORD	TRORC
156	US 4 adjoining just east of ID 175	4	HARTFORD	TRORC
175 – Triple damage	US 4 western triple-whammy site east of Taftsville, southeast of Chester Arthur Rd	4	HARTFORD	TRORC
176 – Triple damage	US 4 eastern triple-whammy site near Hathaway Rd, east of Deweys Mill Rd	4	HARTFORD	TRORC
724	US 4 (E. Woodstock Rd) between Briton Ln and Powder Ln	4	POMFRET, WOODSTOCK	TRORC

The dark outline around six rows of the table with the 13 repeat damage locations on the NHS in Vermont emphasizes US 4 in Hartford. Most of these locations were explored in the 2019 Part 667 NHS report. Some additional areas on the NHS don't come through as much in other types of analysis in this report and are explored in the material that follows. All the NHS locations are explored further in this report.

Following are notes on two of the NHS damage locations.

- US 2 in St. Johnsbury (ID 33) near the I-91 Interchange. There is exploration of this locations in the 2019 Part 667 NHS report and there are more current comments later in this report on it and nearby locations on the section of US 2 not on the NHS (ID 32).
- An additional location that came to light with ongoing analysis is ID 35 on VT 117 in Jericho (Chittenden County) approximately half a mile north of US 2 and the I-89 Exit 11 (Richmond). There should be further research on this location with district staff (requested) and coordination with the Chittenden County Regional Planning Commission (CCRPC). [Follow-up: CCRPC staff raised the question of whether the 2018 paving project STP 2931(1) addressed flood resilience.]

**The minority of the 13 locations of repeat damage on the NHS that are not already being fixed should be studied for how to reduce the risk of repeat damage or the impact in the event it occurs. The two that have been damaged in three different governor- or president-declared events are near each other on US 4.**

## Analysis by VTrans Maintenance District

Two questions to explore in terms of repeat damage by district are

- Does any district show particular trends in terms of repeat damage?
- If so, what approach might that suggest?

**Over a third (39%) of all the repeat damages on the Vermont FAS between 2007 and 2021 occurred in District 4: White River Junction.** This is a district with many bridges and culverts, and so it starts with more potential for damage sites. The repeat damage locations by district are shown in the map that follows and then a table. The table shows number of locations damaged in two different governor- or president-declared events, in three events, and total. The 84 total repeat damage events that occurred primarily in District 4 include 9 triple damage sites. The second most-impacted is the newly reconstituted District 6.

Figure 6: Repeat Damage Locations by VTrans District

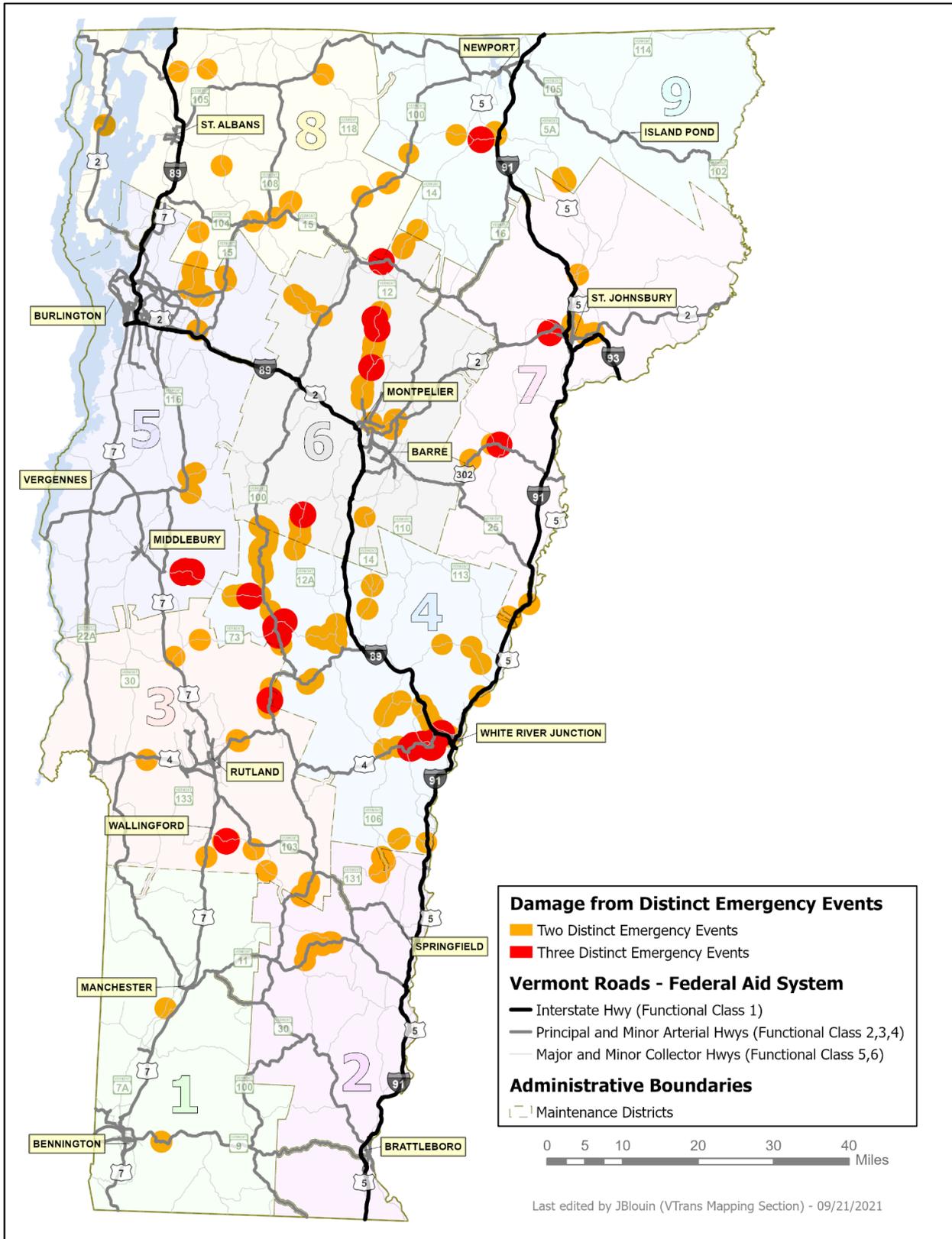


Table 9: Number of Repeat Damages by VTrans District

VTrans District	2x	3x	Total
1	2		2
2	14		14
3	23	2	25
4	75	8	83
5	17	3	20
5, 8	1		1
7	10	2	12
8	13		13
9	8	1	9
6	30	5	35
3, 4	1		1
4, 6	2		2
<b>Grand Total</b>	<b>196</b>	<b>21</b>	<b>217</b>

A simple map of District 4 follows. This small map orients less-familiar viewers to this district’s outline around I-91 and the interchange with I-89. Subsequent explorations show the complex topography and hydrology of this area. **If there is need to start by focusing on a subset of VTrans maintenance districts, a starting point would be District 4, with additional consideration of other factors.**

Figure 7: Birds-eye Map of VTrans District 4



### Analysis by Regional Planning Commission (RPC)

The RPCs are valuable partners in understanding and reducing repeat damage through their staff work and their role as liaison with their municipalities. The analysis by RPC is similar to that by district. **There are 87 repeat damage locations identified directly within the Two Rivers-Ottawaquechee Regional Commission (TRORC) area. This is 40% of the 218 damage locations on the Vermont FAS between 2007 and 2021.** In addition, 10 of the 22 locations damaged three times are in this region. This RPC covers much of the area within District 4. A map of its member municipalities is shown on the front page of <https://www.trorc.org/>. The distribution of repeat damage sites by RPC follows as a map and then a table.

Figure 8: Repeat Damage by Regional Planning Commission (RPC)

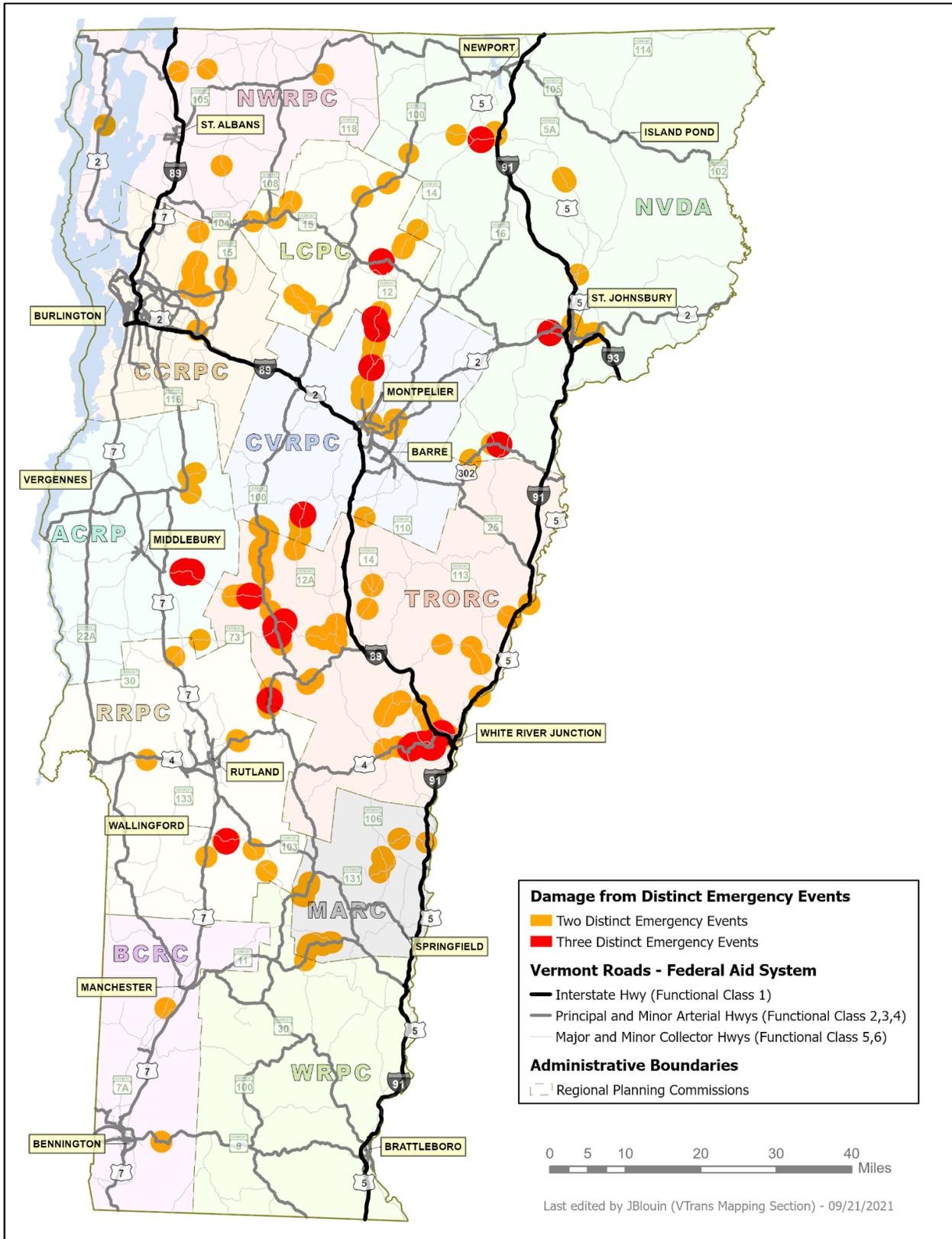


Table 10: Number of Repeat Damages by Regional Planning Commission (RPC)

RPC	2x	3x	Total
ACRPC	13	3	16
BCRC	2		2
CCRPC	9		9
CVRPC	18	3	21
LCPC	18	2	20
NRPC	5		5
NVDA	18	3	21
RRPC	11	1	12
RRPC, TRORC	1		1
TRORC	77	9	86
WRC	1		1
MARC	21		21
TRORC, CVRPC	2		2
<b>Grand Total</b>	<b>196</b>	<b>21</b>	<b>217</b>

If there is need to start by focusing on a subset of RPCs, it would be TRORC in coordination with District 4, along with consideration of other factors.

### Analysis by River Basin and Watershed

Efficiently reducing repeat damage to transportation facilities in Vermont includes acting not just of the location but exploring how to manage the force of the incoming water that is often the reason for the damage. There may be efficient opportunities upriver or more broadly in the watershed. The geography first explored was Tactical River Basins. These are the geography used for planning by the Vermont Agency of Natural Resources (ANR) Department of Environmental Conservation (DEC). For more information, visit <https://dec.vermont.gov/water-investment/watershed-planning/tactical-basin-planning>.

The Tactical River Basins are also a geography used in the TRPT. Wherever reasonable these two efforts are aligned and coordinated.

Two questions to explore in terms of repeat damage by tactical river basin are

- Does any basin show particular trends in terms of repeat damage?
- If so, what approaches might that suggest?

Approximately a third (36%) of the repeat damage locations are in one of the 15 tactical river basins, that of the White River which also runs through the areas identified so far in this analysis. This was 79 repeat damage sites including 8 triple damage sites. The repeat damage locations are shown in a map and then a table that follows.

Figure 9: Repeat Damages by River Basin

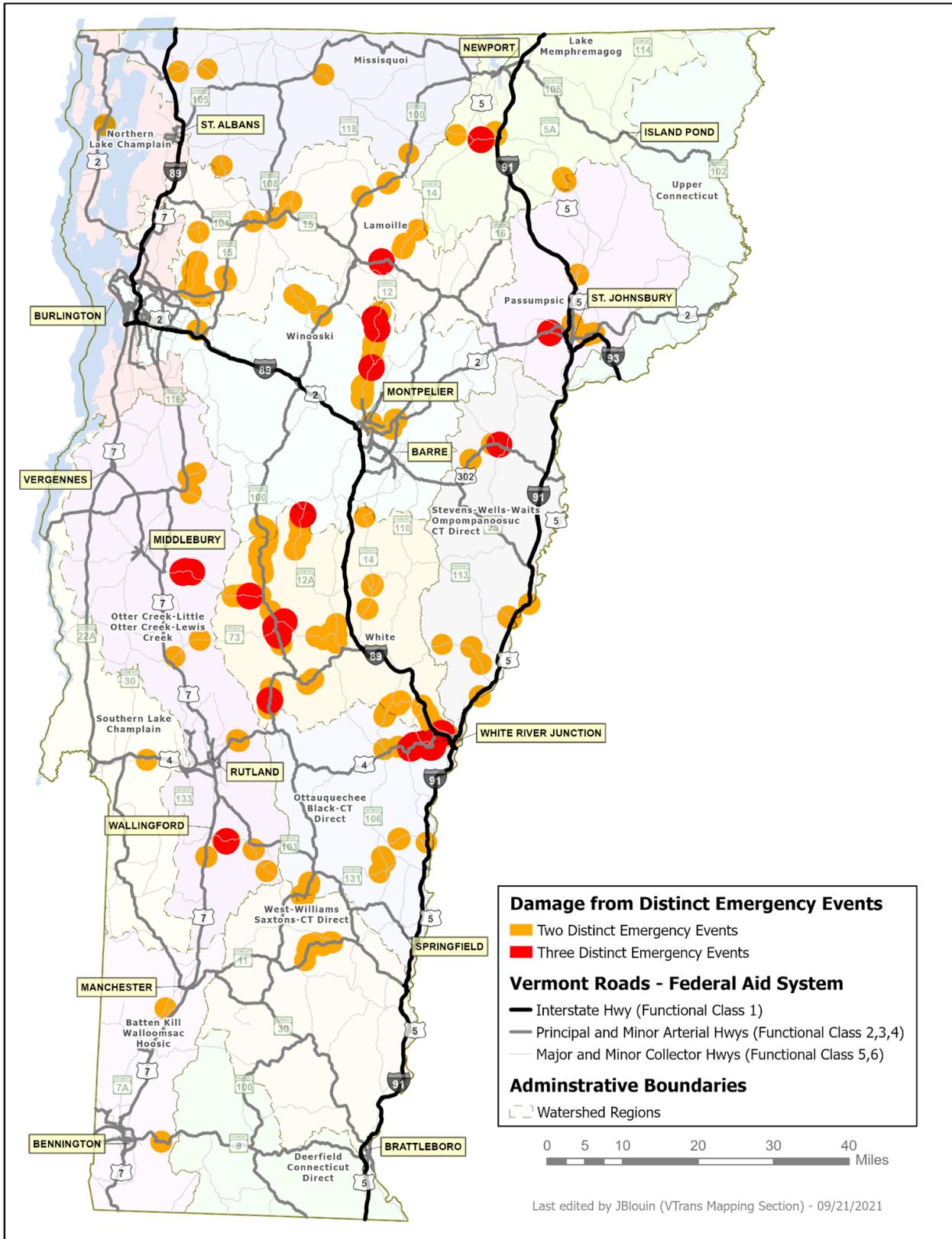
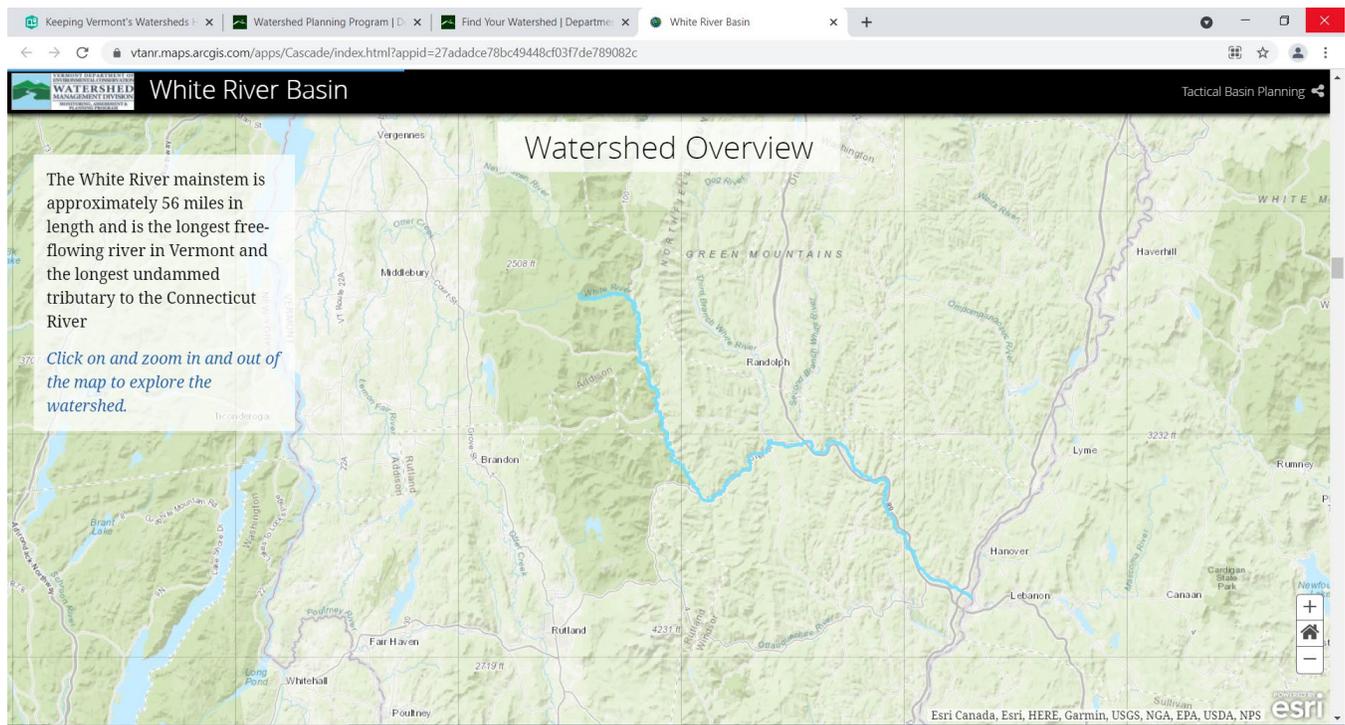


Table 11: Number of Repeat Damages by River Basin

Tactical River Basin	2x	3x	Total
Batten Kill-Walloomsac-Hoosic	2		2
Lake Memphremagog	6	1	7
Lamoille	19	1	20
Missisquoi	5		5
Northern Lake Champlain	1		1
Otter Creek-Little Otter Creek-Lewis Creek	22	4	26
Passumpsic	6	1	7
White	71	8	79
White, Winooski	1		1
Winooski	22	3	25
Stevens-Wells-Waits-Ompompanoosuc	7	1	8
Ottauquechee-Black	14	2	16
West-Williams-Saxtons	13		13
Lower Connecticut	2		2
Ottauquechee-Black, White	1		1
Upper Connecticut	3		3
Poultney-Mettawee	1		1
<b>Grand Total</b>	<b>196</b>	<b>21</b>	<b>217</b>

The White River Tactical Basin (Basin 9) is part of the broader Connecticut River Drainage Basin. For more information, including its Tactical Basin Plan, visit <https://dec.vermont.gov/water-investment/watershed-planning/tactical-basin-planning/basin9>. The tactical plan includes recommended strategies developed with partners and funding sources. An overview of this river follows, excerpted from the storymap at that site.

Figure 10: Screenshot of White River Tactical Basin Area



If there is need to start by focusing on one tactical river basin, a starting point would be the White River Basin in coordination with Vermont DEC, along with consideration of other factors.

The DEC Watershed Planner for the White River Tactical Basin is Danielle Owczarski. Her contact information is [Danielle.Owczarski@vermont.gov](mailto:Danielle.Owczarski@vermont.gov) or 802-490-6176. A listing of when tactical plans will be updates is [2019-2024 Monitoring Assessment and Planning Rotation Table](#). **The White River Tactical Plan will be updated starting in mid-2022, presenting an opportunity to work together on strategies. Staff from VTrans and DEC met in April 2022 and will continue coordinating.** Various sections of VTrans will meet in June to prepare for a broader meeting with DEC staff. Also, the meeting with DEC is leading to discussions with the White River Partnership and the White River culvert prioritization group (USFS, USFWS, VFWD, TRORC, and others). Some of this work focuses on Aquatic Organism Passage (AOP) and local roads but there may be opportunities where their priority culverts are near to or affect VTrans assets.

The TRPT uses a finer grain analysis of watersheds, the 12-digit Hydrologic Unit Code (HUC-12) of the USGS. The boundaries are available at <https://www.usgs.gov/core-science-systems/ngp/national-hydrography>. Only three of the 54 HUC-12 watersheds had 13 or more repeat damage locations. They are in the table that follows.

Table 12: HUC-12 Watersheds with Most Repeat Damages

HUC-12 Name	2x	3x	Grand Total
Headwaters White River	12	1	13
Middle Branch Williams River	13		13
Broadneck Brook-White River*	15	4	19

\*This watershed rose to the top as a result of the VT 19-1 event.

One of the four initial case study watersheds for the TRPT was the “Upper White River.” It seems likely this is the same as the “Headwaters of the White River” noted above, but this is being further explored. Analysis of all the watersheds for TRPT is wrapping up in spring 2022. More information will be added as implementation of Part 667 work progresses and in the next report.

### Analysis by “Triple-whammy” Sites

There are 21 locations that seem to have been damaged in not just two but three major storms between 2007 and 2021. The locations were included in a table at the end of the earlier Data section. These locations are more geographically spread out than the other explorations of all repeat damage sites although US 4 remains the most impacted corridor.

One consideration with the triple damage data is the two major events of 2011 could have some mixing of damages. In part as a result, it may also be useful to review in which events locations were damaged. Where that isn’t already noted it can be viewed in the [Reducing Repeat Damage Webtool](#).

Another consideration is there are other areas of Vermont that don’t come through the analysis methodology as triple damage sites but that have many repeat damage sites in close proximity. An example is VT 100 centered in Pittsfield along the Tweed River: it has seven repeat damage locations in approximately four miles.

Even with the above considerations, the triple damage data can guide further exploration in some ways that seem promising to reduce future repeat damage and the levels of negative impacts they have on Vermont. The rest of this section includes

- Analysis of corridors with high numbers of triple damages
- Analysis of the highest volume triple damage locations (based on functional class at this point)
- Analysis of specific triple damage locations – in this report they are three high-volume triple damage locations but could in the future be ones with upcoming capital projects.

### **Corridors with High Numbers of Triple Damages**

There are a few roads with high counts of triple damage locations, and they each had many double damages along them as well. They offer a diverse set of corridors that seem worthy of further investigation to improve resilience. They are described in summary below and then with a bit more detail. The table provides examples of some data one might consider in thinking about other damage locations noted in this report. **More information is available in the related spreadsheet, including for each record a link to the Reducing Repeat Damage webtool survey for AOT and RPC staff to provide on-the-ground knowledge and to further explore existing data.**

1. US 4 - 9 damage locations (3 triple damages), 7 of 9 in Hartford in District 4, 7 locations on or partially on NHS, mostly FC 3 Principal Arterial
2. VT 125 – 19 damage locations (4 triple damage), all in Hancock or Ripton in District 5, none on NHS, all FC 5 Major Collector
3. VT 100 (recognizing this is on the order of 200 miles) - 39 repeat damage locations (4 triple damage), 5 districts, 6 RPCs, none on NHS, mostly FC 4 Minor Arterial

#### US 4 Corridor

US 4 in the Hartford area has been the stand-out damage area of Part 667 analysis. The table below draws together information from the DDIRs along it to help figure out productive strategies. This is data on an

approximately ten-mile corridor with relatively high travel volumes and importance due to being on the NHS. The AADTs in this area are in the 7,000-10,000 range. It provides access to the interstate system and New Hampshire. There are additional DDIR sites nearby, plus locations identified in district corridor needs. As shown in the table that follows, it has varying characteristics even before considering topography or hydrology.

*Table 13: Repeat Damage in US 4 Corridor*

Damage Count	ID	District	Town	RPC	Road Name	TRPT Tactical Basin	Funct. Class	NHS Code	Notes
3	175	4	HARTFORD	TRORC	WOODSTOCK RD	Ottauquechee-Black	3	7	E of Taftsville, SE of Chester Arthur Rd
3	176	4	HARTFORD	TRORC	WOODSTOCK RD	Ottauquechee-Black	3	7	Near Hathaway Rd, E of Dewey's Mill Rd
3	178	4	HARTFORD	TRORC	WOODSTOCK RD	White	4	0	Between I-89 and I-91 interchanges
2	89	3	MENDON	RRPC	US ROUTE 4	Otter Creek-Little Otter Creek-Lewis Creek	3	7	
2	153	4	HARTFORD	TRORC	WOODSTOCK RD	Ottauquechee-Black, White	3, 4	0, 7	
2	154	4	HARTFORD	TRORC	WOODSTOCK RD	White	4	0	Just east of ID 178
2	155	4	HARTFORD	TRORC	WOODSTOCK RD	Ottauquechee-Black	3	7	Section between 175 & 176
2	156	4	HARTFORD	TRORC	WOODSTOCK RD	Ottauquechee-Black	3	7	Just east of 175
2	724	4	POMFRET, WOODSTOCK	TRORC	E WOODSTOCK RD	Ottauquechee-Black	3	7	

VT 125 Corridor

This much-impacted corridor is interesting as an example of a corridor much different than US 4 in terms of level of use and roadway characteristics. No part of the approximately 15-mile section is on the NHS. All of it is functional class 5. AADTs are in the 1,500 to 2,500 range.

Table 14: Repeat Damage on VT 125

Damage Count	ID	District	Town	RPC	Hwy Number	TRPT Tactical Basin
3	165	4	HANCOCK	TRORC	VT-125	White
3	166	5	RIPTON	ACRPC	VT-125	Otter Creek-Little Otter Creek-Lewis Creek
3	167	5	RIPTON	ACRPC	VT-125	Otter Creek-Little Otter Creek-Lewis Creek
3	168	5	RIPTON	ACRPC	VT-125	Otter Creek-Little Otter Creek-Lewis Creek
2	12	4	HANCOCK	TRORC	VT-125	White
2	13	4	HANCOCK	TRORC	VT-125	White
2	14	4	HANCOCK	TRORC	VT-125	White
2	15	4	HANCOCK	TRORC	VT-125	White
2	16	4	HANCOCK	TRORC	VT-125	White
2	17	4	HANCOCK	TRORC	VT-125	White
2	18	4	HANCOCK	TRORC	VT-125	White
2	19	4	HANCOCK	TRORC	VT-125	White
2	20	5	RIPTON	ACRPC	VT-125	Otter Creek-Little Otter Creek-Lewis Creek
2	21	5	RIPTON	ACRPC	VT-125	Otter Creek-Little Otter Creek-Lewis Creek
2	22	5	RIPTON	ACRPC	VT-125	Otter Creek-Little Otter Creek-Lewis Creek
2	23	5	RIPTON	ACRPC	VT-125	Otter Creek-Little Otter Creek-Lewis Creek
2	24	5	RIPTON	ACRPC	VT-125	Otter Creek-Little Otter Creek-Lewis Creek
2	129	5	RIPTON	ACRPC	VT-125	Otter Creek-Little Otter Creek-Lewis Creek
2	130	5	RIPTON	ACRPC	VT-125	Otter Creek-Little Otter Creek-Lewis Creek

VT 100 Corridor

VT 100 is an important north-south route that runs the length of Vermont through many conditions. Its characteristics vary widely. It includes sections in a variety of asset conditions with regard to ability to withstand major storm events. It may present an interesting opportunity to work in a coordinated manner among districts, AOT bureaus (for example Operations and Safety), RPCs, DEC, and other partners.

Table 15: Repeat Damage on VT 100

Damage Count	ID	District	Town	RPC	Road Name	TRPT Tactical Basin
3	107	3	PITTSFIELD	TRORC	VT ROUTE 100	White
3	119	4	ROCHESTER	TRORC	VT ROUTE 100 S	White
3	124	4	ROCHESTER	TRORC	VT ROUTE 100 S, S MAIN ST	White
3	179	4	ROCHESTER	TRORC	VT ROUTE 100 S	White
2	98	3	KILLINGTON	RRPC	VT ROUTE 100 N	White
2	101	3	KILLINGTON, PITTSFIELD	RRPC, TRORC	VT ROUTE 100, VT ROUTE 100 N	White
2	105	3	PITTSFIELD	TRORC	VT ROUTE 100	White
2	108	3	PITTSFIELD	TRORC	VT ROUTE 100	White
2	110	3	PITTSFIELD	TRORC	VT ROUTE 100	White
2	1021	3	PITTSFIELD	TRORC	VT ROUTE 100	White
2	1245	3	PITTSFIELD	TRORC	VT ROUTE 100	White
2	576	3	LUDLOW	MARC	VT ROUTE 100 S	Ottawaquechee-Black
2	577	3	LUDLOW	MARC	VT ROUTE 100 S	Ottawaquechee-Black
2	582	3	LUDLOW	MARC	VT ROUTE 100 S	Ottawaquechee-Black
2	585	3	LUDLOW	MARC	VT ROUTE 100 S	Ottawaquechee-Black
2	131	4	GRANVILLE	TRORC	VT ROUTE 100	White
2	132	4	GRANVILLE	TRORC	VT ROUTE 100	White
2	133	4	GRANVILLE	TRORC	VT ROUTE 100	White
2	135	4	GRANVILLE	TRORC	VT ROUTE 100	White
2	136	4	GRANVILLE	TRORC	VT ROUTE 100	White, Winooski
2	123	4	ROCHESTER	TRORC	VT ROUTE 100 S, BRANDON MOUNTAIN RD	White
2	122	4	ROCHESTER	TRORC	VT ROUTE 100 S	White
2	126	4	ROCHESTER	TRORC	VT ROUTE 100 N	White
2	157	4	ROCHESTER	TRORC	VT ROUTE 100 S	White
2	818	4	ROCHESTER	TRORC	VT ROUTE 100 S	White
2	826	4	ROCHESTER	TRORC	VT ROUTE 100 S	White
2	836	4	ROCHESTER	TRORC	VT ROUTE 100 S	White
2	847	4	ROCHESTER	TRORC	VT ROUTE 100 N, N MAIN ST	White
2	849	4	ROCHESTER	TRORC	VT ROUTE 100 N	White
2	1030	4	ROCHESTER	TRORC	VT ROUTE 100 S	White
2	1246	4	ROCHESTER	TRORC	S MAIN ST	White
2	1255	4	ROCHESTER	TRORC	VT ROUTE 100 S	White
2	1267	4	ROCHESTER	TRORC	VT ROUTE 100 S	White
2	61	8	EDEN	LCPC	VT ROUTE 100	Lamoille
2	62	8	EDEN	LCPC	VT ROUTE 100	Lamoille
2	149	9	LOWELL	NVDA	VT ROUTE 100	Missisquoi
2	109	3, 4	PITTSFIELD, STOCKBRIDGE	TRORC	VT ROUTE 100	White
2	138	4, 6	GRANVILLE, WARREN	TRORC, CVRPC	VT ROUTE 100	Winooski
2	139	4, 6	GRANVILLE, WARREN	TRORC, CVRPC	VT ROUTE 100	Winooski

### High-Volume Triple-Damage Locations

Following is an exploration of the locations damaged three times focusing on those that affect travel the most—that are on Principal Arterial (functional class 3) or Minor Arterials (functional class 4) roads. **These high-use locations have blue halo formatting around their location id in in the map.** They are listed in the table that follow. The high-volume triple-whammy locations are concentrated in the previously identified District 4/TROTC/White River area but also include locations on VT 100 (multiple), VT 15, and US 302.

Figure 11: Repeat Damage Locations Focusing on High-Volume Roads

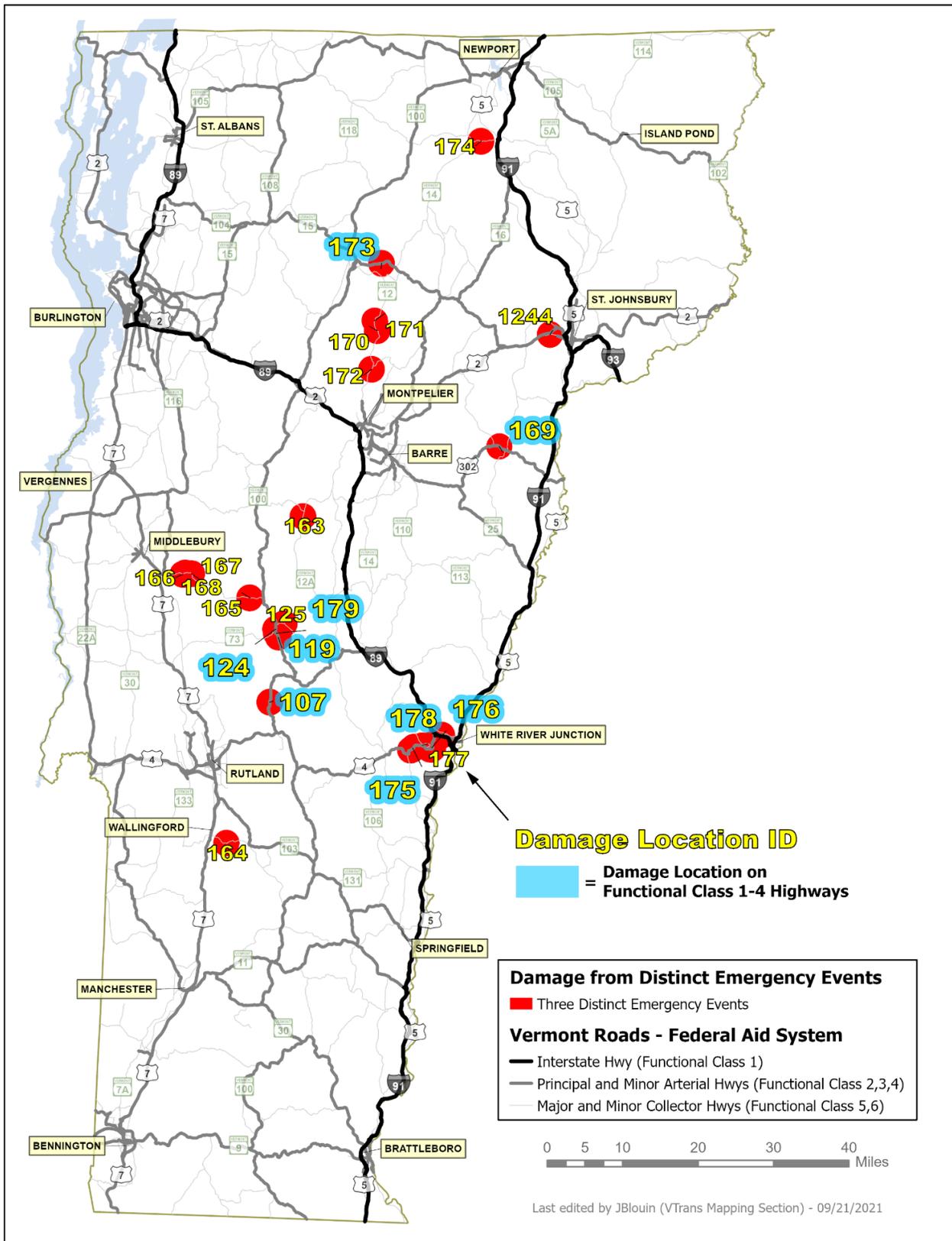


Table 16: Locations on High-Volume Roads Damaged in Three Events 2007-2021

Repeat Damage ID	FHWA ER Events	Damage Record IDs	District	County	RPC	Hwy Number	Tactical Basin(s)	Functional Class
107	VT11-2, VT13-1, VT19-1	55,309,2131	3	RUTLAND	TRORC	VT-100	White	4
119	VT11-2, VT13-1, VT19-1	99,295,1497	4	WINDSOR	TRORC	VT-100	White	4
124	VT11-2, VT13-1, VT19-1	99,1931,2879	4	WINDSOR	TRORC	VT-100	White	4
169	VT11-1, VT11-2, VT17-1	239,1781,2200	7	CALEDONIA	NVDA	US-302	Stevens-Wells-Waits-Ompompanoosuc	4
173	VT11-1, VT11-2, VT20-1	4,143,1474,2448	6	LAMOILLE	LCPC	VT-15	Lamoille	4
175	VT11-2, VT13-1, VT17-1	103,118,249	4	WINDSOR	TRORC	US-4	Ottauquechee-Black	3
176	VT11-2, VT13-1, VT17-1	103,118,202	4	WINDSOR	TRORC	US-4	Ottauquechee-Black	3
178	VT11-2, VT13-1, VT17-1	103,118,1464	4	WINDSOR	TRORC	US-4	White	4
179	VT11-2, VT13-1, VT20-1	99,1459,2100,2471	4	WINDSOR	TRORC	VT-100	White	4

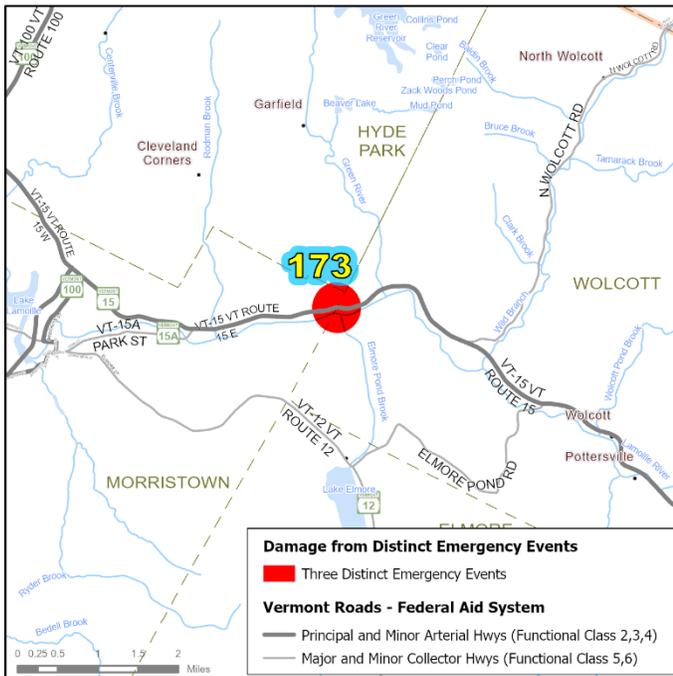
### Exploring Specific Triple Damage Locations

As noted, the high-volume triple-whammy locations are concentrated in the District 4/TROTC/White River area but also include additional locations on VT 100 (multiple), VT 15, and US 302. A detail map of the last two that have been further examined follow and there should be further coordination on Location ID 179 on VT 100 (see the extended exploration of VT 100). District staff commented on each of the three areas in the Knowledge Gathering section of this report. Regarding the US 302 site (ID 169), the comment is on the adjacent Locations 27, that it needs systematic study, and 28, a successfully fixed damage site nearby.

#### Repeat Damage ID 173: VT 15 in Lamoille County

This is the area of VT 15 where the Lamoille River runs close by the road and Elmore Pond Brook connects. There are additional repeat and single damage areas around it. The Lamoille Valley Rail Trail is just to the south along the river.

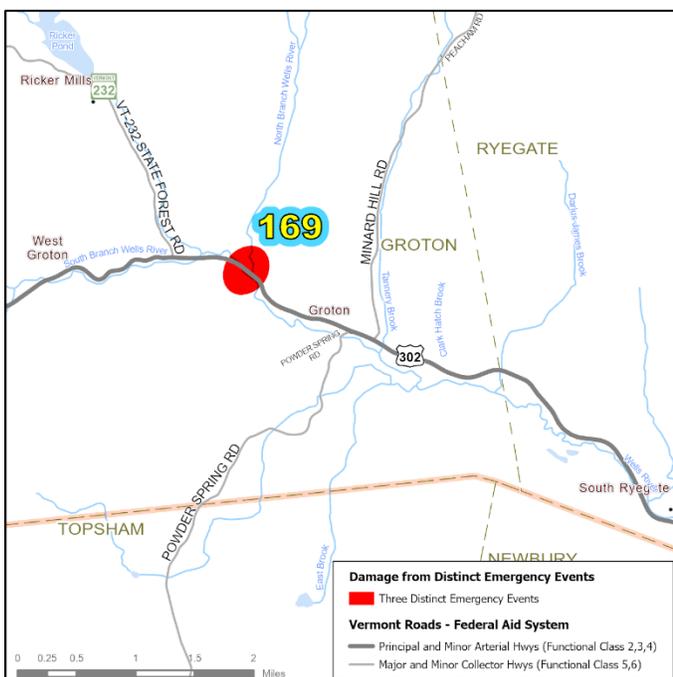
Figure 12: Repeat Damage ID 173: VT 15 in Lamoille County



Repeat Damage ID 169: US 302 in Caledonia County

The North Branch of the Wells River joins the Wells River in this area where the Wells River runs closely along Scott Memorial Highway. There are additional repeat and single damage areas on either side of this triple damage area.

Figure 13: Repeat Damage ID 169: US 302 in Caledonia County



The locations damaged in three major events on roads that carry relatively high volumes of vehicles are largely in the same part of Vermont identified with the larger dataset. **Three additional locations on VT 15 in Lamoille County, US 302 in Caledonia County, and VT 100 in Windsor County may be useful to explore further.**

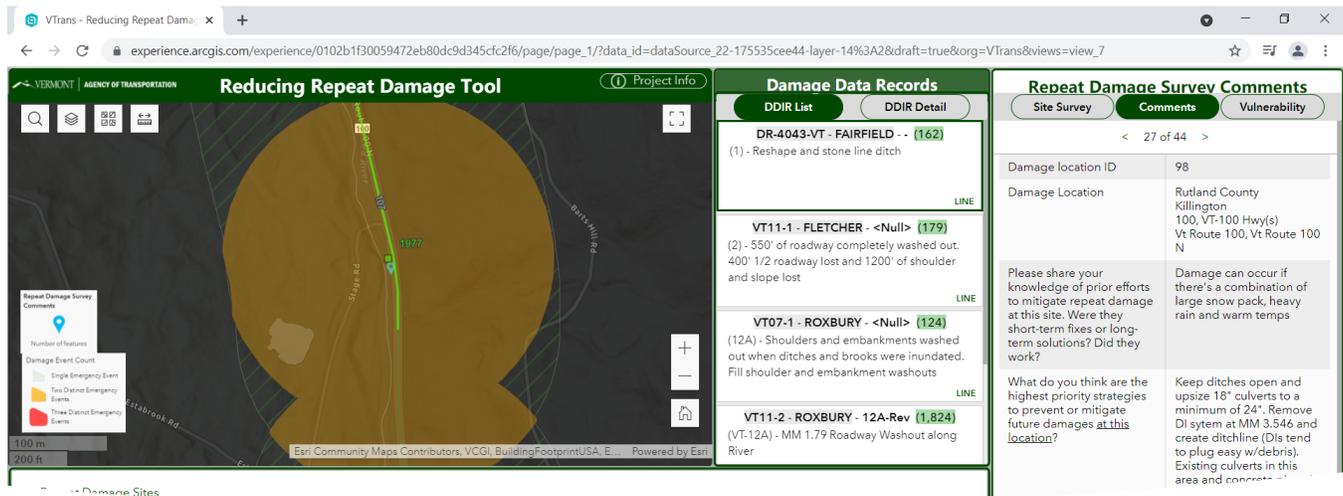
## Gather Knowledge

This update of the report ended up spread over a longer period of time than had been expected. However, this allowed for more discussion and development. There was a multi-agency kick-off meeting, several presentations at VTrans Maintenance Managers meetings, and several presentations at Transportation Planning Initiative (TPI) meetings focused on RPCs. There were coordinating meetings with Asset Management staff that helped refine the relationship between this analysis and VAMIS. There was coordination with staff involved with TRPT. This longer duration also supported development and use of an interactive webtool that will continue to be used. The webtool is intended for use by State agency and RPC staff. Almost all the comments are from VTrans District staff, reflecting extensive outreach to them. ANR/DEC and RPC staff members were invited to use the webtool and this invitation is ongoing. The webtool is not protected but it is not advertised except for in Part 667 e-mails and discussions.

The [Reducing Repeat Damage Webtool](#) presents mapped DDIRs from 2007 on, analysis of where there is repeated damage, TRPT analysis, VTrans maintenance corridor needs, capital projects, and knowledge about how to reduce future damage from people with on-site knowledge. Some of its uses are to

- Share data, including an overview of the process and the DDIR data in Excel format for those who prefer it that way as part of serving a variety of audiences.
- Ground-truth data using interactive survey tools for gathering and sharing comments
- Provide analysis and support its use; the analysis files can also be pulled into other maps such as District Corridor Needs
- Gather knowledge before people retire or change jobs (succession planning) about what happened during events, strategies that seem useful to explore when there are funds, and effectiveness of strategies that were applied.
- Increase efficiency in preparing updates of the Part 667 report
- Encourage very basic benefit-cost analysis for taking action and also if no action is taken.
- Encourage creative thinking about how to reduce repeat damage, for example by looking upstream and up-watershed for opportunities to dissipate floodwater energy.

Figure 14: Sample Screenshot of Reducing Repeat Damage Webtool



The webtool incorporates an interactive survey (currently through a Survey123 widget) to gather knowledge from people with experience at the locations. Clicking on a repeat damage location opened a blank survey for the visitor to fill out. The questions document what is known, foster discussion about what to do, and at a very basic level prepare for the benefit-cost analysis required for FEMA and other grants. This was partially successful. Some staff completed all the questions and some what they were comfortable answering. To foster participation, an Excel spreadsheet with more basic questions was also sent to each district Project Manager (PM), General Manager (GM), and District Transportation Administrator (DTA). The results were imported into the webtool but have less information. Following are the questions in the survey.

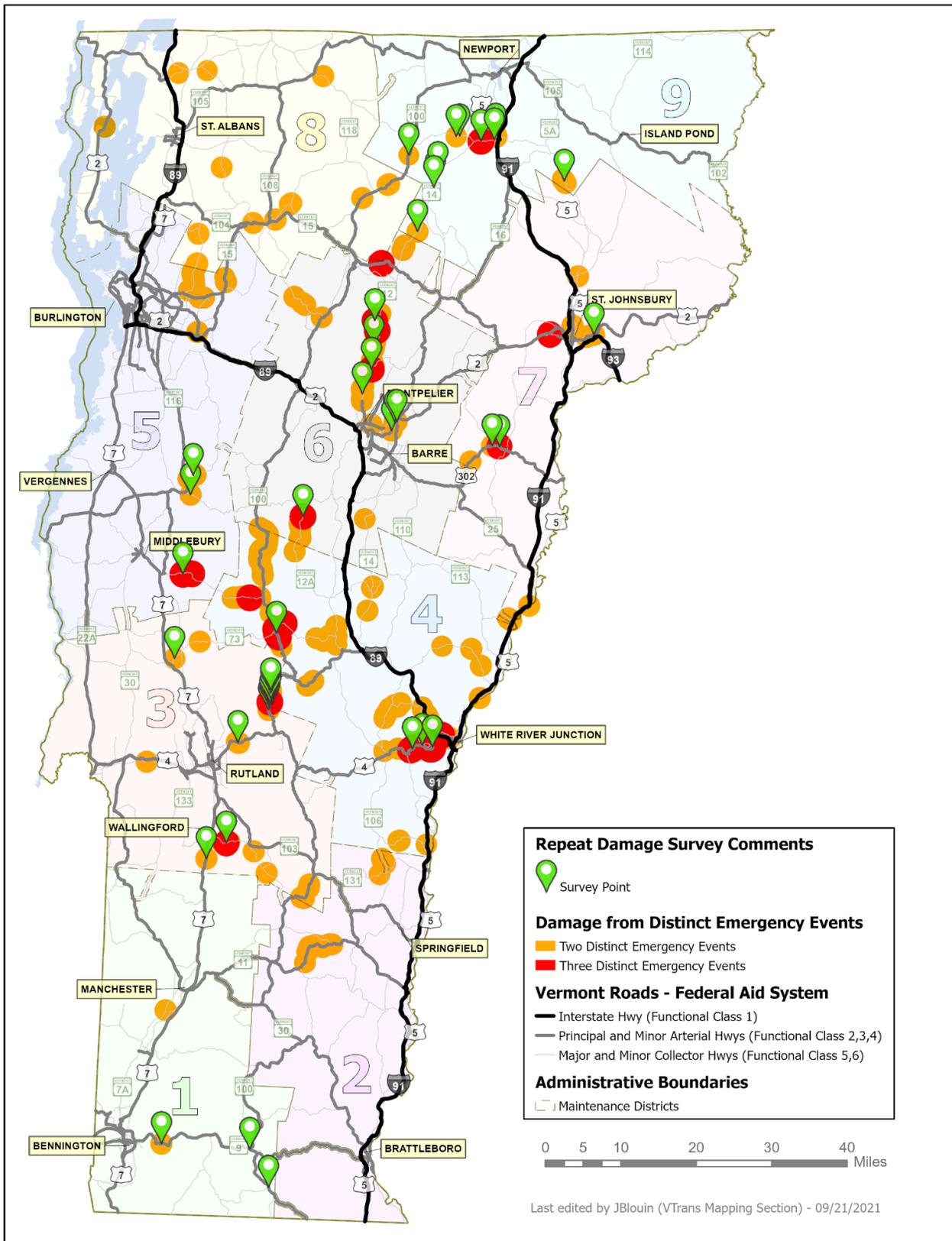
#### Repeat Damage Webtool Survey Questions

1. Please share your knowledge of prior efforts to mitigate repeat damage at this site. Were they short-term fixes or long-term solutions? Did they work?
2. What do you think are the highest priority strategies to prevent or mitigate future damages at this location?
3. What do you think are the highest priority strategies in the greater area?
4. What do you think are the most important potential next steps in mitigating repeat damage at this site?
5. What is your sense of level of cost to do them?
6. What is your sense of level of cost if these steps are not taken?
7. What is your sense of timeframe to complete?
8. Damage site image upload (optional)
9. Name (optional)
10. Agency or RPC
11. Phone number (optional)
12. Additional comments, suggestion, feedback

#### Knowledge Gathered Using Webtool

The requests resulted in comments on 44 locations. These locations are shown in the map that follows. This isn't a scientific sample but is still helpful to have. The best way to explore specific locations is by using the Repeat Damage Webtool.

Figure 15: Locations of Comments in Webtool (2021)



The responses seemed to more-or-less fall into five categories:

1. Replace – These are described as a specific need or recommendation, e.g. install a larger culvert (10 locations)
2. System – These are described as complex situations that need study (13 locations)
3. Fixed-The work was intended to be permanent and seems successful though monitoring will continue (11 locations)
4. Unconfirmed -These are noted as possible data issues or not significant locations and have been set aside for now (2 locations)
5. *Unconstrained* – These are comments that are not repeat damage sites as measured by DDIRs but may well be needs. These seven locations are not included in totals.

## Highlights of Comments

Following are highlights by category of comments gathered using the webtool.

### *Replace* (10 locations)

- Next steps would include checking district corridor needs and asset inventories.
- Special mention
  - US 4 (ID 175 and 176) and US 302 (ID 27 and 169) triple-whammy sites
  - VT 58 in Irasburg, two locations about four miles apart, ID 151 and ID 174, a triple damage location on a FC 5 road
  - VT 12 A in Roxbury (ID 163), triple damage location on a functional class 5 road in a five-mile corridor with at least six repeat damage locations.

### *System/Study Needed* (13 locations)

- Consider proactive ITS planning in locations that flood regularly
- Summary of comments about VT 12 in Elmore and Worcester (Location IDs 171 and 172): A systematic statewide program to upsize structures in this corridor, as well as a brush clearing, and ditch, and de-berming funding program has the potential to reduce the high costs associated with emergency repairs. The corridor seems to show area need to upsize the entire drainage system to the true hydraulic need. If the end goal is to protect the entire basin we need to start thinking bigger: the State is well on its way to upsizing five of the many undersized State structures but the small towns are struggling to keep up and replace theirs. Maybe with good records they can apply for FEMA 404 mitigation to upsize or some other kind of funding but when we find an area or corridor need like this (versus a few single point undersized culverts) we will need to help these small towns if we truly intend to reduce sediment further away from these mountain valley towns. [Note: also Better Roads grant opportunities]
- Summary of comments about VT 15 east of Morrisville (Location ID 173): After review of damage at each location, it appears that damage usually appears directly downstream from the last repair. An area to explore is the criteria of where AOT ends the repair. If we end where the stream is narrow and fast-moving there will be future damage. There is need to work with DEC on these matters.

### *Fixed* (11 locations) – Here are some of the main strategies used.

- Slope stabilization and bank armoring, use of heavy rip-rap and boulders
- Coordination with ANR and DEC staff
- Replacement of culverts and widening of ditches

## Comments by Category

This section conveys comments by category of Replace, System/Study, or Fixed.

The locations that seem to fall in the Replace or System categories were discussed with Asset Management staff. The table that follows briefly identifies them. They may best be explored in the Repeat Damage Webtool.

**Elements that may be of particular interest are highlighted in yellow.**

### Comment: Replace

These are repeat damage locations that seem to a person familiar with the situation to suggest some relatively straightforward projects to reduce the likelihood of third or fourth repeat damages. They have not been checked further. Some contain more systematic or complex elements that would need further study. **A next step would be further review with the district corridor needs layer, capital projects, and asset management data.** They are Location IDs 27, 101, 108, 109, 151, 163, 174, 175, 176, and 179.

*Table 17: Repeat Damage Locations Where Suggestion is "Replace"*

ID	Description	Strategies	County	Town(s)	Hwy
163 – triple-whammy on FC 5	Is this location still prone to damage? Yes	Replaced Undersized Town Highway Bridge	WASHINGTON	ROXBURY	VT-12A
27* *This location is adjacent to "triple-whammy" Location ID 169	BR 36 is hydraulically undersized. Dependent on a rain event, either the North Branch of the Wells River causes scour along the abutments or it causes the material to fill back in further decreasing the opening. District 7 has had to clean material from the bridge several times. The town also has had to do multiple repairs to the intersection with Branch Brook Road and US 302 because water did not stay in the stream banks and ran across the lawn and the town highway. In addition, the Wells River is extremely close to US 302. The proximity causes slope failures. The district repairs as they appear.	Replacement of BR 36 with a structure that is properly sized hydraulically.	CALEDONIA	GROTON	302
101		Keep ditches open and upsize 18" culverts to a minimum of 24"	RUTLAND	KILLINGTON, PITTSFIELD	VT-100
108	Damage can occur if there's a combination of large snowpack, heavy rain and warm temps	Replace CMP culvert at mile marker 1.154 w/ concrete box	RUTLAND	PITTSFIELD	VT-100
109	1 culvert upsized to 24" and remaining culvert and ditch lines widened and cleaned out	Possibly upsize 18" culvert to 24" and replace 48" box culvert w/ larger one to help control runoff from the watershed	RUTLAND	PITTSFIELD	VT-100
179 – Triple-whammy	Is this location still prone to damage? Yes	Undersized box culverts, replace with larger culverts	WINDSOR	ROCHESTER	VT-100

174	Short term minor repairs. Long-term solution would be a culvert replacement.	Existing 48" CMP is undersized, which causes road/slope damage during heavy rain events. Damage has not been significant enough to consider replacement under any ER event with consideration to a cost/benefit analysis. The drainage area appears to be greater than 1 sq mi	ORLEANS	IRASBURG	VT-58
151	Long-term fixes. The two site do overlap but they were different specific locations for the damage. VT20-1 one was at the inlet of the culvert mainly rather than the toe of slope failure as reported in VT 11-2	Culvert should really be upsized with concrete head and wingwall	ORLEANS	IRASBURG	VT-58
175*– Triple-whammy	Is this location still prone to damage? Yes	New Culverts and Slope Stabilization	WINDSOR	HARTFORD	US-4
176*– Triple-whammy	Is this location still prone to damage? Yes	New Culverts and Slope Stabilization	WINDSOR	HARTFORD	US-4

\*While there are some straightforward concepts to explore for US 4 in Hartford, this is a complex area that also needs study including repeat damage locations 153, 154, 155, 156, 175, 176, and 178.

**Comment: Needs a Systematic Approach**

These are locations that seem, to a person familiar to the situation, to suggest need for potentially complex or systematic approaches to mitigate risk or impact of repeat damage. These more-substantial comments are formatted to provide more space. The locations have not yet been checked further. The Location IDs are 30, 33, 47, 98, 105, 107, 114, 141, 143, 166, 171, 172, and 173. **As noted, the US 4 corridor in the Hartford area needs systematic study.**

*Table 18: Repeat Damage Locations Where Comments Suggest a Systematic Approach*

Location ID		30
Prior efforts to mitigate repeat damage		This is a former District 6 route. District 7 took over maintenance of this area in 2011. <b>The Winooski River is very close to the slope of US 2 and causing erosion to the toe of slope and instability.</b> Work was done by District 6 forces to address the inlet of the cross culvert in this area. In the summer of 2018, District 7 brought in a contractor to reconstruct the slope between Mekkelsen Campers and East Montpelier Building Supply. The work done are more likely to be short term repairs.
Priority to prevent or mitigate future damages at this location		Culvert upsizing and lengthening to be able to get road width and have stable slopes.
County		WASHINGTON
Town(s)		EAST MONTPELIER
Hwy Number(s)		<b>US-2</b>

Note: this location is within a mile of two other locations damaged in two events, ID 29 and 31, plus single damage areas all around there. The other two have long-term fixes. [This has been discussed further with district staff and seems to have been fixed for the long term.]

Location ID		33
Prior efforts to mitigate repeat damage		<b>This area is a perpetual problem for the district.</b> There is a large field (farmer still plants crops) above US 2 that drains down the hillside. US 2 is located in a narrow area, between the Moose River and the hillside going up to the field. Water flows down toward US 2 carrying a great deal of sediment. The culverts going under US 2 and ditch line get plugged. This causes the road to be covered with tree debris and mud. <b>This happens frequently. Everything done by the district is reactive and very short term</b> as we usually are trying to open the road back up.
Priority to prevent or mitigate future damages at this location		There needs to be additional ROW purchased and a means designed to <b>capture the water, enabling the sediment to settle and to control flow/path.</b>
Priority strategies in the greater area?		<b>The entire area needs to be evaluated with a subsequent corridor project.</b> There is a retaining wall that is failing on VT 18 between US 2 and I93. In addition, the area between VT 18 and the new bridge (BR 108) has a couple of failing retaining walls and drainage issues. The district and the Soils & Foundation section did survey the area and a design was done to remove the most westerly (US 2) retaining wall and to reconstruct the slope. <b>Work was not done due to utilities being in the way and the cost to do the work.</b>

Most important potential next steps	Address the drainage runoff in the field above. By channeling it and upgrading the drainage under and along US 2 will help relieve some of the continued issues.
County	CALEDONIA
Town(s)	ST. JOHNSBURY
Hwy Number(s)	<b>US 2</b>

<b>Location ID</b>	<b>47</b>
Prior efforts to mitigate repeat damage	Let's cross-tab this with the upcoming scoping task for multiple bridges on Rt 12. Coordinate efforts.
Most important potential next steps	In the short-term, <b>variable message boards</b> might be productive
County	WASHINGTON
Town(s)	WORCESTER
Hwy Number(s)	<b>VT 12</b>

<b>Location ID</b>	<b>98</b>
Prior efforts to mitigate repeat damage	Damage can occur if there's a combination of large snowpack, heavy rain and warm temps
Priority to prevent or mitigate future damages	Keep ditches open and upsize 18" culverts to a minimum of 24". Remove DI system at MM 3.546 and create ditch line (DIs tend to plug easy w/debris). Existing culverts in this area and concrete pipes in poor condition. Need replacement of HDPE
County	RUTLAND
Town(s)	KILLINGTON
Hwy Number(s)	<b>VT-100</b>

DI=Drainage Inlet; HDPE=High Density Polyethylene drainage pipe [confirm these]

<b>Location ID</b>	<b>105</b>
Prior efforts to mitigate repeat damage	Damage can occur if there's a combination of large snowpack, heavy rain and warm temps. Issue is V100 is very close to the Tweed River on the west and steep slopes on the east. <b>Not enough room in existing ditches to move water runoff.</b>
Priority to prevent or mitigate future damages <u>at this location</u>	Need to move V100 to the east (away from brook), create larger ditch lines on the east, upsize culverts and armor west side with very large stone
County	RUTLAND
Town(s)	PITTSFIELD
Hwy Number(s)	<b>VT-100</b>

<b>Location ID</b>	<b>107</b>
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Prior efforts to mitigate repeat damage at this site	Damage from events of VT19-1. <b>Can't really fix site as area is confluence of Tweed River and unnamed waterway</b> that empties into the Tweed from the west. This brook drains a very large, steep sloped watershed and V100 is right next to this area.
Priority to prevent or mitigate future damages <u>at this location</u>	Need to move V100 to the east (away from brook), create larger ditch lines on the east, upsize culverts and armor west side with very large stone
County	RUTLAND
Town(s)	PITTSFIELD
Hwy Number(s)	<b>VT-100</b>

<b>Location ID</b>	<b>114</b>
Prior efforts to mitigate repeat damage	Issue is V0730 is very close to the Neshobe River on the north and steep slopes (ledge) on the south. In addition, this area is a place where the Neshobe River turns sharply to the west. <b>Not enough room in existing ditches to move water runoff.</b>
Priority to prevent or mitigate future damages <u>at this location</u> ?	Need to move V073 to the south (away from brook)
County	RUTLAND
Town(s)	BRANDON
Hwy Number(s)	<b>VT-73</b>

<b>Location ID</b>	<b>141</b>
Prior efforts to mitigate repeat damage at this site	Intense rainfall storms in a short duration cause damage along this route. <b>Water gets very high in elevation with a high velocity.</b>
Priority to prevent or mitigate future damages <u>at this location</u>	<b>Increasing floodplains</b> where we can and armoring as high as the river banks with boulders 4-5'+
Priority strategies <u>in the greater area</u>	NA this is a river that is intense. There is a development close to the river the more towards Lincoln center you get; however, there is areas that floodplains can be created.
Potential next steps	Creation of floodplains and armoring.
County	ADDISON
Town(s)	BRISTOL
Hwy Number(s)	<b>TH-3</b>

<b>Location ID</b>	<b>143</b>
Prior efforts to mitigate repeat damage at this site	Many sections along the road <b>eroded due to plugged ditches or culverts</b> that then pushed the water onto the road and down slopes or the water ran along the edge of pavement. The eroded sections were repaired with stone however that seems like a <b>short-term fix.</b>

Priority to prevent or mitigate future damages <u>at this location</u>	Upsizing culverts, widening and deepening of ditches and controlled turn outs onto heavily armored banks where there is curb board under guardrail.
Most important potential next steps	Upsizing culverts, widening and deepening of ditches and controlled turn outs onto heavily armored banks where there is curb board under guardrail.
County	ADDISON
Town(s)	BRISTOL
Hwy Number(s)	<b>VT-17</b>

<b>Location ID</b>	<b>166</b>
Prior efforts to mitigate repeat damage at this site	This site is known as "Big Ben". Many times the water has rose to an elevation and with a high velocity that would cause some of the stacked rocks to become dislodged which impacts that stability of this section. The main fix that occurred after Irene has for the most part stayed intact. Smaller sections of this wall have been repaired during events following Irene.
Priority to prevent or mitigate future damages <u>at this location</u>	This sectioned is armored with some of the largest rocks that have blasted in nearby quarries. In my opinion the only way to increase stability is by fixing this structure with dowels or a wall that is fixed. To avoid damage in this whole stretch completely would be to build a new road where it has already been cleared for power lines which would connect VT 125 near Old Town Road to just East of Upper Plains. This would completely mitigate damages from this intense river.
Priority strategies <u>in the greater area</u>	N/A. This River is intense and in short duration storms with precipitations in the 4-5" margin this river will dislodge and carry away boulders the size of cars with ease.
Most important potential next steps	Discontinuing this route and building a route on the Old Town Road converting that to a state highway. There would be a lot of permitting and it would be costly but in the long run we wouldn't have damage area every significant weather event.
County	ADDISON
Town(s)	RIPTON
Hwy Number(s)	<b>VT-125</b>

<b>Location ID</b>	<b>171</b>
Prior efforts to mitigate repeat damage at this site	Part of this improvement process has begun downstream in the TO Worcester with replacing large multiplates with bridges BF 0241(57). [Also see Notes field]
Priority strategies <u>in the greater area</u>	By systematically upsizing structures, outflow velocities will be reduced. Having a robust brush clearing plan, and a ditching and de-berming plan (statewide programing?), shoulder and edge of pavement wash out damage would be reduced as well.
Notes	VT 12 south of Lake Elmore: "The 2 remaining you commented on along VT 12 in Elmore and Worcester show us, in my technical opinion, an <b>area need to upsize the entire drainage system to the true hydraulic need.</b> If the end goal is to protect the entire basin we need to start thinking bigger. Meaning the State is well on their way to upsizing 5 of the many undersized State structures but the small Towns ae struggling to keep up and replace theirs. Maybe with good records they can apply for FEMA 404 mitigation to upsize or some other kind of funding but <b>when we find an area or corridor need like this (Versus a few single point undersized culverts) we will need to help these small towns</b> if we truly intend to reduce sediment further away from these mountain valley Towns.
County	LAMOILLE

Town(s)	ELMORE
Hwy Number(s)	VT-12

Note: This comment led to the long-term recommendation of ongoing coordination with DEC to keep all involved on top of resources to share with municipalities such as Better Roads grant opportunities as well as the FEMA 404 mitigation opportunities.

<b>Location ID</b>	<b>172</b>
Prior efforts to mitigate repeat damage at this site	In each of these three ER events, the trend is shoulder washouts and plugged culverts. [Also see Notes field]
Priority strategies in the greater area	As previously mentioned, a systematic statewide program to upsize structures in this corridor, as well as a brush clearing, and ditch, and de-berming funding program has the potential to reduce the high costs associated with emergency repairs.
Notes	VT 12 in Worcester north of Putnamville: "The 2 remaining you commented on along VT 12 in Elmore and Worcester show us, in my technical opinion, an area need to upsize the entire drainage system to the true hydraulic need. If the end goal is to protect the entire basin we need to start thinking bigger. Meaning the State is well on their way to upsizing 5 of the many undersized State structures but the small Towns are struggling to keep up and replace theirs. Maybe with good records they can apply for FEMA 404 mitigation to upsize or some other kind of funding but when we find an area or corridor need like this (Versus a few single point undersized culverts) we will need to help these small towns if we truly intend to reduce sediment further away from these mountain valley Towns."
County	WASHINGTON
Town(s)	WORCESTER
Hwy Number(s)	VT 12

<b>Location ID</b>	<b>173</b>
Prior efforts to mitigate repeat damage at this site	After review of damage at each location, it appears that damage usually appears directly downstream from the last repair.
Priority strategies in the greater area	A possible solution for slope resiliency could be systematic program for repair in advance of emergency repairs
Notes:	This is VT 15 east of Morrisville, physically north of Lake Elmore. Follow-up note: "Fantastic note about VT 15 Morristown Wolcott sites that the damage appears to be in the same location but is not repetitive. The repair is actually proving to work but right after the repair ends the current condition fails again! That is important information and the right people have a better shot at engineering a better solution. Example would be the criteria of where we end the repair. If we end where the stream is narrow and fast-moving you can count on future damage. I see a need to work with DEC here as I am used to stopping at the right-of-way limit because that is what we have always done! DEC has more jurisdiction when the river heads on to private lands."
County	LAMOILLE
Town(s)	MORRISTOWN, WOLCOTT
Hwy Number(s)	VT-15

**Comment: Fixed**

It is important to recognize locations that people familiar with them agree are fixed for the long term. We all tend to move from

one emergency to another without celebrating successes or learning from them as much as would likely be valuable. The repeat damage locations on the FAS with completed long-term fixes are described in the table that follows.

Table 19: Fixed Repeat Damage Locations on the FAS

Location ID	Prior efforts to mitigate repeat damage	Strategies to prevent or mitigate future damages at this location	Strategies in the greater area	Potential next steps	County	Town(s)	Hwy Number(s)
7	After TS Irene this site was fixed to a long-term extent. Since then we have had no issues in this location. Although, we haven't experienced any large or intense rain falls in this area since Irene. The fix last in 2012 what to excavate the slope and place heavy rip rap to stabilize the slope. The rip rap was placed with a stone key at the bottom. The District worked with the ANR Stream Alterations Engineer to design the fix. City stream is a steep mountain stream that is encroached by VT 9 narrowing the channel increasing water velocity generating more power in the waterway.	I believe this has been accomplished already. IF this fails in the future more stone fill should be placed making sure the stones are large enough to stay. Unfortunately, this stream is encroached by Route for miles. It is my assumption that if it fails it will be in a new location along this reach. The stream will continue to find the weak spot.	Making sure this area is well observed and fixing small washouts. This area is difficult to see from the roadway and small easy fixes can go some time without being identified.	Monitoring that site to make sure the fix continues to be stable.	BENNINGTON	WOODFORD	VT-9
28* *Note this is near IDs 27 and 169, a "triple-whammy" site.	This area is confined with the Wells River being located close the roadway. The river channel has degraded due to the steepness of the terrain. The area then flattens out at the Valley Grill (alluvial fan). In May of 2011, much of the river channel ended up downstream at the Valley Grill parking lot/area. Working with the River Management Engineer (Barry Cahoon) a long-term plan was developed to line the river channel with LARGE boulders and to lock them in so that they could not move. Fisheries was not happy with this work as the water of the Wells flowed	Now that the channel is stabilized with five-foot (plus) rock, it should not erode which is why the road slope was failing. Not sure if there really is anything more that could/should be done.		Road relocation seems to be the only way to permanently mitigate damages to this area. Not sure that is reasonable. The Wells River seems to be in currently in a stable state.	CALEDONIA	GROTON	US-302

	under/through the rock for the remainder of the summer. Since, the channel has filled in with gravel and water is flowing normally.						
29 – on NHS <i>Double check if really holding up</i>	This area had a long history of an unstable fill slope. This was a former District 6 route and they had rebuilt the western portion of the slope prior to 2011. The 2011 storms caused failure of the eastern end of the slope. Soils and Foundations Engineer (then Chad Allen) developed a design to stabilize the area. District 7 contracted to reconstruct the slope. This was a long-term solution, and the slope is holding up very well.		This is a fairly new section of US 2, reconstructed with wide shoulders and travel lanes. The Winooski River does run along portions of US 2 and there is some slope failures/erosion that have occurred (or are currently).		WASHINGTON	EAST MONTPELIER	US-2
31	This area was being maintained by District 6 when damages occurred. At the time, the district did some substantial slope work. Since 2011, the area was part of the East Montpelier bridge project. Long term repairs.				WASHINGTON	EAST MONTPELIER	US 2, VT-14
85 – on NHS	Agency replaced 2 small culverts w/ a large box culvert sized for the waterway. Armoring of slopes was also included.	Agency replaced 2 small culverts w/ a large box culvert sized for the waterway. Armoring of slopes was also included.			RUTLAND	WALLINGFORD	7, 7S

<b>89 – on NHS</b>	The stone armoring and associated repairs installed in this area after TS Irene has proven successful.	The stone armoring and associated repairs installed in this area after TS Irene has proven successful.			RUTLAND	MENDON	US-4
<b>110</b>	Repairs from TS Irene made w/ large stone to armor embankment	The stone armoring installed at this river bend after TS Irene has proven successful.			RUTLAND	PITTSFIELD	VT-100
<b>148</b>	Prior efforts did not appear to be sufficient	Proper bank stabilization done in this location. This is proposed as a permanent project under VT 20-1.		Engineered stream bank stabilization project	ORLEANS	CRAFTSBURY	TH-3
<b>149</b>	Very minimal damage in the location. Bridge is scheduled to be replaced which should eliminate issues here	stream bank armoring with bridge project			ORLEANS	LOWELL	VT-100
<b>152</b>	For VT 20-1 I can say that the efforts for mitigating the problem were considered long-term. We have not experienced any problems to-date (12-31-2020). There could potential mitigation solution well outside of the ROW that have not been identified at this point.	Look for ways to control storm water during heavy rain events. This would require work outside of ROW and has not been explored yet. Damage and cost have not been considerable enough to trigger this effort		have not identified any potential mitigation strategies here. The damage has not been severe enough to pursue work beyond the existing ROW	ORLEANS	IRASBURG	US-5
<b>164</b>	District opened/widened ditches, replaced culverts w/ larger ones and continues to monitor the beaver dam above (north of) this area for any beaver activity/waterbody accumulation	District opened/widened ditches, replaced culverts w/ larger ones and continues to monitor the beaver dam above (north of) this area for any beaver activity/waterbody accumulation			RUTLAND	WALLINGFORD	VT-140

## Consider Alternatives and Strategies

Reducing repeat damage and overall risk management cross many parts of VTrans. This work also needs to be coordinated with other state agencies and other organizations to be most effective.

Vermont has many commendable programs and projects underway to reduce the likelihood of repeat damage to transportation facilities and to minimize the impacts of major events. In Part 667.3 the terminology for these efforts is “reasonable alternatives.”

23 CFR Part 667.3 defines “reasonable alternatives” as options that could partially or fully achieve the following:

1. Reduce the need for Federal funds to be expended on emergency repair and reconstruction activities;
2. Better protect public safety and health and the human and natural environment; and
3. Meet transportation needs as described in the relevant and applicable Federal, State, Local, and tribal plans and programs. Relevant and applicable plans and programs include the Long-Range Statewide Transportation Plan, Statewide Transportation Improvement Plan (STIP), Metropolitan Transportation Plan(s), and Transportation Improvement Program(s) (TIP) that are developed under part 450 of this title.

VTrans considers the results of Part 667 analysis in developing projects as described in Part 667.9(a), Consideration of Evaluations. That section requires that

The State DOT shall consider the results of an evaluation prepared under this part when developing projects. State DOTs and metropolitan planning organizations are encouraged to include consideration of the evaluations during the development of transportation plans and programs, including TIPs and STIPs, and during the environmental review process under part 771 of this title.

VTrans considers the following approach within available resources and in a context on continuous improvement:

- root causes of the recurring damage
- identification and consideration of alternatives that will mitigate or resolve the root causes, general costs, and likely duration of the solutions.
- risk of recurring damage and cost of future repairs under current and future environmental conditions
- potential realistic next steps; we want to make conscious choices, including that in some places we accept the risk because the ways to reduce or minimize it are so expensive

This chapter describes some of the strategies or alternatives in use and then transitions to the short- and long-term recommendations.

### Strategies in Use

Some strategies that have been implemented or have been in increasing use are noted below. They have been helping reduce risk, cost of repairs, and increasing the value of Vermont’s transportation system.

These strategies include

- Enhanced asset management, in use and also efforts are underway to include risk in the Bridge Management System (BMS) by considering hydrologic adequacy in analysis

- Changes to design guidelines in various assets to become more resilient
- Focused maintenance
- Enhanced Agency-wide attention to safety, ITS, complete streets, and risk—for example the completion of the [VTrans FHWA Emergency Recovery \(ER\) Guidance](#) document which includes the Part 667 Reducing Repeat Damage work.
- Enhanced coordination with partners such as ANR/DEC and RPCs and other governmental, non-profit, and for-profit entities
- Investment in tools and processes such as roll-out of the Geocortex inline tool, Congestion Management System (CMS), and VAMIS
- Furthering good practices and pursuing Innovation in planning such as the TRPT, corridor management plans, New Project Summaries (NPSs), and the update of the full suite of modal plans (transit, rail, freight, bicycling and walking, and the ITS Master Plan); in particular, Asset Management staff see a productive path forward of using the Part 667 work in the NPS process and review of undersized small culverts so they can be programmed for replacement ahead of paving projects when reasonable.
- Furthering research to enhance practices through VTrans Accelerated Innovation Deployment (AID) Grants or State Transportation Innovation Council (STIC) Incentive awards, for example the effectiveness evaluation in [“Quantifying Gully Erosion and Potential for Sediment and Phosphorus Pollution Reductions Achieved by Erosion Remediation Projects on Vermont’s Roads”](#)
- Completing permanent repairs in repeat damage locations using non-traditional funding such as through use of FEMA BRIC funding for VT 9.

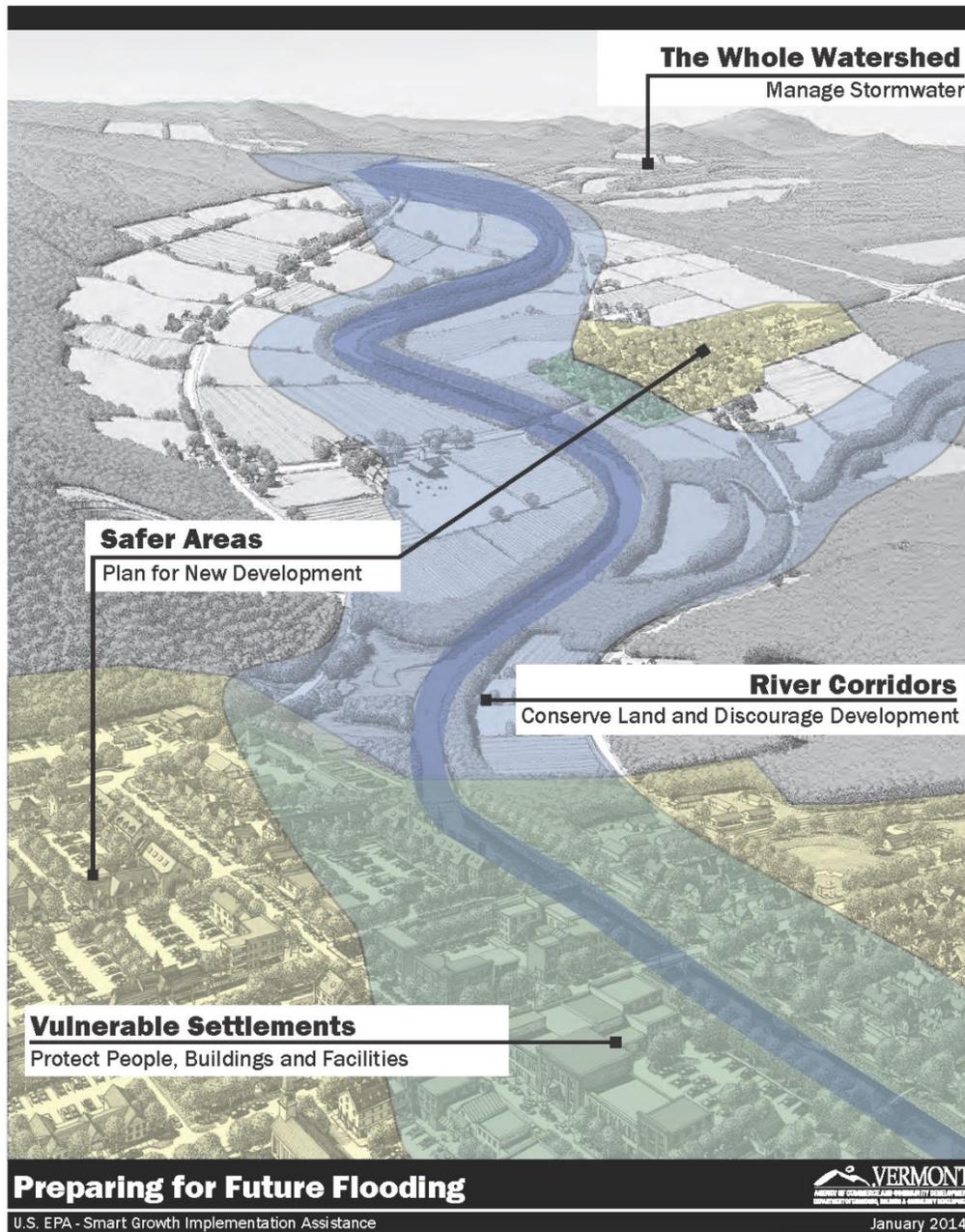
Some successful long-term specific strategies used at repeat damage locations highlighted in comments by district staff are

- Upsizing culverts and bridges to meet hydrologic needs
- slope stabilization
- armoring vulnerable streambanks
- strong coordination with ANR/DEC staff especially between district staff and DEC River Management Engineers.

While recognizing that reconversion of flood plains can be expensive and labor-intensive, it is a strategy in use and that has additional benefits. Such projects must be permanent to qualify for use of ER funds. Such projects are allowed in the 2021 Infrastructure Investment and Jobs Act (IIJA). A successful example was along the former Lamoille Valley railroad. For more information see [Evaluating Effectiveness of Floodplain Sites along the Lamoille Valley Rail Trail: A Blueprint for Future Rail-River Projects](#) (VTrans, 2020).

Reducing repeat damage of roads and bridges connects to the broader range of strategies for making Vermont more resilient especially in the context of the larger and more frequent storms likely with climate change. A range of resources were noted early in this report, and the figure below is a summary of some broader strategies.

*Figure 16: Smart Growth Approaches for Disaster-Resilient Communities*



Source: Community Resilience, Smart Growth Implementation Assistance (SGIA) at <https://accd.vermont.gov/community-development/flood/community-resilience> (accessed 2/9/2022)

### Investments Underway and Status of Needs

After analysis of all repeat damage locations, there was additional exploration of locations damaged repeatedly on the NHS and in three events. This included exploring the information in district corridor needs and programmed capital projects to understand what has been addressed and where there may be gaps or lessons learned. The latest district corridor needs and capital projects can be viewed in the Reducing Repeat Damage webtool and in other locations.

The exploration bears out the impression of staff that work is underway on many of the key needs

although there is more to do.

## NHS Locations Status

The NHS is important for regional movement of people and goods, plus the low number of these sites makes follow-up exploration manageable. This initial exploration combines data and comments by people who know the locations with whether action is planned if needed. These locations are all NHS Principal Connectors (NHS code of 7) Principal Arterials (Functional Class 3). The exploration shows progress but also some potential opportunities. Both are explored below, first in summary then in a table. This is a starting point for further work. The two locations to highlight for more exploration are

- ID 30 - US 2 in East Montpelier just west of Rt 14S near stream between Mekkelsen RV and E Montpelier Home Center – unclear if fully and permanently fixed. Close by there was suggestion to also follow up with district staff about ID 29 – US 2 north of Packard Rd and Muddy Brook Rd, near Anderson Eqmt, halfway between River Road and VT 14. [Follow-up is that these areas have permanent fixes.]
- ID 33 – US 2 northeast of Rt 18 access to I-91, Just NE of damage on non-NHS section of US 2 (ID 32), a nearby related section of steep slope.

Table 20: Status of Repeat Damage Sites on NHS

**Green** - Permanent fix that seem to be working

**Yellow** - People familiar with the sites suggest there are some straightforward opportunities

**Blue** - Locations that are complex and seem to call for study or systemic approach

Location ID	Location Notes	Survey Notes	District	Town	RPC
7	VT 9, east of Woodland Hollow where VT 9 curves south by City Stream	Fixed (FEMA project)	1	WOODFORD	BCRC
29	US 2 north of Packard Rd and Muddy Brook Rd, near Anderson Eqmt, halfway between River Road and VT 14	Fixed	7	EAST MONTPELIER	CVRPC
30	US 2 just west of Rt 14S near stream between Mekkelsen RV and E Montpelier Home Center – [follow up: distract staff say it has permanent fixes]	Fixed [per district follow-up May, 2022]	7	EAST MONTPELIER	CVRPC
33	US 2 northeast of Rt 18 access to I-91, Just NE of damage on non-NHS section of US 2 (ID 32)	System – No known long-term work planned	7	ST. JOHNSBURY	NVDA
35	VT 117 approximately half a mile north of US 2 and the I-89 Exit 11 (Richmond) – this location identified late in update.	No comments – This location needs review.	5	JERICHO	CCRPC
85	US 7 north of Dugway Rd. Note VRS rail line on other side of 7	Fixed	3	WALLINGFORD	RRPC
89	US 4 near Journey's End Rd west of AT crossing	Fixed	3	MENDON	RRPC
153	US 4 near Greenbrier Rd	Study with US 4 area	4	HARTFORD	TRORC
155	US 4 between damage ID 175 and 176	Study with US 4 area	4	HARTFORD	TRORC
156	US 4 adjoining just east of ID 175	Study with US 4 area	4	HARTFORD	TRORC
175	US 4 western triple-whammy site east of Taftsville, southeast of Chester Arthur Rd	Replace/Study with US 4 area	4	HARTFORD	TRORC

176	US 4 eastern triple-whammy site near Hathaway Rd, east of Deweys Mill Rd	Replace/Study with US 4 area	4	HARTFORD	TRORC
724	US 4 approximately 1.2 miles west of Taftsville -- still within bounds of corridor study.	Location damaged in VT 11-2 and 19-1 so no comments available yet.	4	POMFRET, WOODSTOCK	TRORC

### High-Volume Road Location Status

Another way to explore status is through review of where there are projects programmed or planned so that further attention may be considered if not already part of the effort or otherwise a consideration for future harmonization opportunities.

The table below lists the Roadway or State Highway Bridge projects programed in the FY2022 Capital Program in locations damaged in three different governor- or president-declared events. This will change over time. The latest information on these identified investments and newer FY2023 projects is available through the Repeat Damage Webtool, VTransparency, and elsewhere.

*Table 21: FY2022 Major Capital Investments in Locations Damaged in Three Events*

Note: Highlighted ID denotes on the NHS

Capital Projects Layer	Damage ID	Highway	Begin Town	Project Number	Work Description
Pre-Construction	175, 176	US-4	Woodstock	NH 020-2(51)	Roadway - Reconstruction
Pre-Construction	178	US-4	Hartford	STP 020-2(52)	Roadway - Reconstruction
Scoping	107	VT-100	Killington	STP CULV(88)	Culvert - Reconstruction
Pre-Construction	119, 124, 179	VT-100	Stockbridge	STP CULV(85)C/2	Culvert - Rehabilitation
Design	170	VT-12	Worcester	BF 0241(57)	Culvert - Reconstruction
Active	166, 167, 168	VT-125	Ripton	ER STP 0174(19)	Slope Repair/Stabilization

AOT Capital Program accessed 1/13/2022

It seems worthwhile for all project managers to check if they are doing work in locations with known previous damages and resilience vulnerabilities if this is not already a standard step, and then considering how to prepare for a future of increasingly strong and frequent storms.

VTrans district staff maintain a database of needs as noted in the Data section. It includes overall needs, top two priority level needs, and completed items. This database helps highlight locations with needs that are at the top of or beyond the funding controlled by districts for maintenance purposes. This is not a completely investigated list, but it illustrates considerations. Note the start of informal consideration of important considerations that are also needed for various funding programs in the last four columns.

Table 22: Maintenance District Needs in Vicinity of Triple Damage Sites

ID	Highway	Issue Description	Actions Needed	Actions Taken	Failure Probability	Failure Impact	Remaining Service Life	Detour
175	US-4	Bottom culvert rotted out	Culvert replacement			High		
175	US-4	2 failed stone retaining wall - remove wall, slope bank back and install stone on slope						
175	US-4	Last 5 sections separated and material around pipe washing in - need fix before shoulder and bank collapse	Culvert replacement	Monitoring		High		
175	US-4	Holes in bottom of culvert and slope washing	Culvert replacement	Monitoring		High		
175	US-4	Holes in bottom of culvert	Culvert replacement			High		
178	US-4	Culvert	PID 31647 Bottom culvert rotten, holes thru ribs, road is settling, sinkholes inlet each side pipe, road settling again	Culvert needs to be lined - every rib has holes	MRA	High	High	1-3 years
179	VT-100	Bottom rotted and sinkhole	Replacement	Monitor	High		0-1 years	
166	VT-125	Ledge falling damaging roads and guardrail	Ledge scaling	Cleaned out roadway	High	Med	1-3 years	>50 miles
166	VT-125	8	Rock wall and key needs to be established. Area for repair should be longer than area damaged.	None				
166	VT-125	9	Build slope with type IV from existing toe. Place grubbing at the top	None				
167	VT-125	4	Couple spots that have washed out need to be touched back up with type IV	None				
168	VT-125	1	Build up from key with type IV replace guardrail and pave where road undermined.	12 minus was placed in west bound for two way traffic				
168	VT-125	Ledge needs to be brought back	Ledge evaluation and erosion control		Med	Med		
164	VT-140	Drainage/Slope issue water sits, needs better drainage, multi accidents	keep an eye on	built stone wall , ditching completed				

District Corridor Needs database accessed 1/13/2022

## Potential Additional Funding Sources

Resources are always a limitation on what can be done, with the most common one being funding. Funding for transportation improvements is described in various resources, including the Vermont AOT Capital Program, State Transportation Improvement Program (STIP), and VTrans grant listings. Many of these funding sources face constraints because they require a 20% state match for Federal funds or are entirely state funds. Below are a few possible funding sources to reduce risk and increase the resilience of the transportation network that may be less constrained.

- VEM coordinates various funding opportunities such as
  - FEMA Section 404 – Hazard Mitigation Grant Program that is used to provide protection to undamaged parts of a facility or to prevent or reduce damages caused by future disasters.
  - FEMA BRIC funds, particularly pre-disaster planning grants. **Note that there is now support to scope projects, e.g. develop benefit-cost analysis, alternatives analysis, designs and a budget for**

the preferred alternative – <https://vem.vermont.gov/funding/mitigation>

Figure 17: Sample Funding Information from VEM Newsletter

VEM News

April 2022

## \$11-million in Hazard Mitigation Grants Available

\$11.1 million is available to Vermont communities from the federal Hazard Mitigation Grant Program (HMGP) (<https://vem.vermont.gov/disaster-based-funding>). The deadline to apply for a grant is June 30, 2022.

Eligible projects under the program include buyouts of properties under a risk of flooding, floodplain restoration, culvert or bridge upsizing, and floodproofing of municipal buildings. If you are interested in developing an application or have questions, please reach out to [stephanie.a.smith@vermont.gov](mailto:stephanie.a.smith@vermont.gov) as soon as possible.

One of the programmatic requirements is completion and approval of a Benefit Cost Analysis (BCA). To better support applications,

Vermont Emergency Management has hired a contractor to develop BCAs. VEM is currently soliciting projects that are ready to develop a sub application but missing a BCA. If you have a project that might be a good fit, please fill out the BCA Assistance Intake Form (found at <https://vem.vermont.gov/contact-us/newsletter/links>) and return it to [dps.hazardmitigation@vermont.gov](mailto:dps.hazardmitigation@vermont.gov) with the subject: BCA Development Application.

Applications will be accepted on a rolling basis until all funds are used. Submit applications as soon as possible to allow for time to complete the BCA before the June 30, 2022 deadline.

Source: VEM News, April 2022 available at <https://vem.vermont.gov/contact-us/newsletter>

- VTrans offers the Better Road program grants promote the use of erosion control and maintenance techniques that save money while protecting and enhancing water quality - <https://vtrans.vermont.gov/highway/better-roads>
- VTrans offers additional support programs through the Municipal Assistance program - <https://vtrans.vermont.gov/highway/local-projects>
- Less-traditional funding sources may have opportunities and should be explored in coordination with DEC and other partners - <https://anrweb.vt.gov/DEC/cleanWaterDashboard/ReportViewer.aspx?ViewParms=True&Report=FundingOpportunities>.
- FHWA Rebuilding American Infrastructure with Sustainability and Equity (RAISE) discretionary grant program (previously known as TIGER grants)- <https://www.transportation.gov/RAISEgrants>

The 2021 Infrastructure Investment and Jobs Act (IIJA) also known as Bipartisan Infrastructure Law (BIL) is still being explored as of February, 2022 but seems to offer promise for efforts to reduce risk and increase resilience of the transportation system. Some key points from the AASHTO summary cited below are that it allows

- Use of ER program funding for protective features designed to mitigate the risk of recurring damage or the cost of future repairs from extreme weather events, flooding, or other natural disasters.
- Expands the definition of a comparable facility to include a facility that incorporates economically justifiable improvements designed to mitigate the risk of recurring damage from extreme weather events, flooding, or other natural disasters. (Sec. 11106. Emergency relief)
- **Extends the deadline for projects to be 100 percent federal-share from 180 to 270 days, as well as allowing for both permanent and temporary repairs to be 100 percent federal-share under the Emergency**

**Relief program. (Sec. 11107. Federal share payable) – This last bullet is highlighted in this report because it is a significant change and offers important opportunities.**

Some resources to explore these matters in addition to the IJIA language include

- AASHTO Comprehensive Analysis of the Bipartisan Infrastructure Bill IJIA, September 15, 2021 - <https://policy.transportation.org/wp-content/uploads/sites/59/2021/09/2021-09-15-AASHTO-Comprehensive-Analysis-of-IJIA-FINAL.pdf>
- FHWA BIL site: <https://www.fhwa.dot.gov/bipartisan-infrastructure-law/funding.cfm>
- Congressional Research Service “Extreme Weather and Lifeline Infrastructure Resilience: Provisions in the Infrastructure Investment and Jobs Act (IJIA) <https://crsreports.congress.gov/product/pdf/IF/IF12034>]

## Take Short-Term Steps

The Part 667 report includes short-term and long-term steps that are coordinated with other VTrans efforts and support conscious decision-making. There are a variety of actions underway or that can start in 2022. These short-term steps generally fall into three groups that are summarized in the text box and then detailed below it.

---

*Coordinate on projects already underway to maximize their role to reduce the risk and severity of damage in major events – start with repeat damage locations on NHS or at triple damage sites.*

*Enhance use of storm damage data upstream, in Part 667, and downstream including in project development and in coordination with other agencies.*

*Continue and enhance efforts to communicate and coordinate.*

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### *Coordinate on projects already underway to maximize their role to reduce the risk and severity of damage in major events.*

1. *Coordinate with VTrans staff doing work relating to repeat damage sites on the NHS.*
  - a. US 4 corridor study and preparation for projects – US 4 in the Hartford area is on the NHS and is the only corridor with triple damages. Coordination is important with the slab removal and roadway reconstruction project being programmed for late this decade (NH 020-2(51).
  - b. US 2 in St. Johnsbury just east of VT 18 access to I-91 (ID 33) and the other US 2 location near it (ID 32) – This is a long-standing confirmed problem area.
  - c. VT 117 approximately half a mile north of US 2 and the I-89 Exit 11-Richmond (ID 35) – This area should be explored further with district and CCRPC. [Checking with district; CCRPC staff ask if the 2018 paving project STP 2931(1) improved resilience?]
  
2. *Coordinate with staff doing work relating to repeat damage sites on high-volume roads, starting with those that have been damaged three times or repeatedly in short distances.* Many have some level of attention, but further review may reduce likelihood of future damage.
  - a. VT 15 east of Morrisville (ID 173) – Review areas downstream of completed repairs.
  - b. VT 100 in Pittsfield (Rutland County) and Rochester (Windsor County) – Multiple locations including IDs 107, 119, 124, and 179.
  - c. US 302 in Groton (Caledonia County) where Wells River runs along Scott Memorial Highway (ID 169).
  - d. Follow up comments about potential value of coordinated approach on VT 12A in Elmore and Worcester (ID 171 and 172) [Checking with district.]

3. *Communicate at “heads-up” e-mail level with project managers of potentially related projects relating to all repeat damage locations.* This analysis can be used like the HSIP lists or top 200 culverts list—as places to be aware of and explore how to include/harmonize as projects come along. This could be cc’d to district staff as early notice that opportunity to review will be coming.

***Enhance use of storm damage data upstream, in Part 667, and downstream and in other processes.***

4. *Upstream recommendations improve flow and use of data from initial damage assessments with refinements in the VTrans ER Guide and coordination with related efforts, such as VAMIS, VPINS, and district maintenance. These were based on discussion among Planning, AM, and Maintenance staff:*
  - a. Enhance standard processes in [VTrans ER Guide](#) with overview of flow of DDIR data beyond ER program use. Add step of communicating to other staff who need to know when there has been a disaster declaration by the office of the governor or president and when there are new DDIRs. Add that the State Maintenance Engineer managing the DDIR Working Group will communicate with PPAID Mapping Staff at the 180-day meeting on status of DDIRs or as appropriate.
  - b. Explore whether MATS has identified work done and VPINS has identifies upcoming work that can now or in the future be leveraged to identify opportunities for projects to reduce risk of repeat damage. This is being explored by staff from Mapping, Planning, Asset Management, and F&A.
  - c. Enhance existing coordination between Part 667 work and district maintenance processes. Participate in a Maintenance Project Manager meeting each year that includes support for at least annual district staff comments on two or three repeat damage sites to retain knowledge and be better prepared with understanding of permanent needs. Coordinate with the district corridor needs webmap. Communicate regularly how the contents provided by district staff gets used. This is being discussed among Maintenance PMs, Asset Management, and Planning staff.
  - d. It would support district work, emergency response, reducing repeat damage, asset management, and efficient processes to continue and enhance ongoing internal training on use of Survey123. This should be complimented by steadily implementing biannual trainings on the FHWA ER Manual, VTrans ER Manual, and project management/damage assessment related to ER events. This would be a suite of trainings at different levels, from high-level through district technician training in Survey123.
5. *Downstream opportunities build on the required Part 667 work to maximize value and effect through coordination with VAMIS, TRPT, project selection, and coordination with partners.*
  - a. Stay engaged as VAMIS Operations Management (OM) module develops the DDIR performance measurement dashboard to aim for consistency and contents useful for Part 667 updates.
  - b. Continue bringing together TRPT and DDIR analysis. Review areas identified as high risk in TRPT such as US 2 between Montpelier and Burlington. Explore how to include ongoing DDIR analysis in TRPT and VPSP2 project analysis. Continue to build Part 667 analysis into New Project Summaries—this is seen as a valuable implementation step.
  - c. Coordinate with STIP updates per the [FHWA memo](#) of September 23, 2021.

6. *Explore additional funding sources in collaboration with other efforts.* Opportunities include work with VEM on FEMA BRIC grants, with DEC, exploring FHWA RAISE grants, collaboration with less-usual partners, and options in the IJJA such as to fund permanent repairs with 100% federal funds.
  - a. Discuss whether to explore FEMA BRIC scoping funding for some repeat damage locations in coordination with TRPT and others.
  - b. Consider the range of strategies available, and whether use of some less-common strategies would provide access to additional funding to reduce risk.
  - c. Coordinate with DEC Tactical Basin Plans and funding opportunities with them
  - d. Explore funding and opportunities from the IJJA; be prepared to perform permanent betterments during the extended 270-day period during which 100% federal funding is available through this act (see Sec. 11107. Federal share payable)
  - e. Manage expectations.

***Continue and enhance efforts to communicate and coordinate.***

7. *Improve and encourage use of the Reducing Repeat Damage webtool and report*
  - a. Review and refine the Part 667 webtool. Review survey. Make the survey function more crowdsource-style so that knowledgeable staff can “thumbs-up” or add to the comments of their colleagues. Enhance its role of storing knowledge before staff change jobs or retire. Use it to capture contents that can be used in discussion of betterments and other projects.
8. *Coordinate with partners.*
  - a. Provide draft report to VEM, DPS, and others, coordinate as appropriate
  - b. Participate in 2022 DEC update of White River Tactical Plan and other ANR/DEC efforts. – A first VTrans/DEC staff meeting was held in April, 2022 with another meeting of multiple parts of VTrans and DEC planned for early summer.
  - c. Discuss Part 667 and other risk management coordination with RPCs at Transportation Planning Initiative (TPI) meetings. – Ongoing
  - d. Continue to coordinate with FHWA-Vermont Division and learn from Part 667 work completed in other states.

## Start Longer-Term Steps

Longer-Term steps will generally take more than a year but can start in 2022. This list will continue to evolve as VTrans stays with the momentum of two Part 667 reports and continued enhancement of risk management and increasing resilience. The longer-term steps are summarized in the text box and then detailed below it.

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*Act on additional locations identified through this Part 667 analysis.*

*Better integrate risk management and resilience planning across AOT*

*Continuous improvement at reducing repeat damage and increasing resilience as we look ahead to increased impacts from climate change.*

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*Act on additional locations identified through this Part 667 analysis to minimize likelihood that they will be damaged again, and if damaged then increase how quickly the facilities can be brought back into use.*

9. *Hold a multidisciplinary discussion of the complex "System" category of repeat damage locations. Focus on those in locations with upcoming projects, on the NHS, or carrying higher travel volumes.*
  
10. *Encourage recognition of repeat damage locations where long-term fixes seem to be successful and explore where they were not to learn how to improve. Integrate other lessons learned in Vermont, explore the boundary between areas suitable for periodic maintenance actions and where to explore more substantial projects. Coordinate on retention of knowledge, communication, and learning.*

*Better integrate risk management across AOT including reduction of repeat damage.*

11. *Improve coordination of managing risks and enhancing resilience across AOT. Follow-up the policy statement supporting coordinated risk, asset, and performance management in in the TAMP.*
  - a. *Arrange periodic meetings of the Risk Management Leadership Team*
  - b. *Evaluate progress and effectiveness of Part 667 action items, refresh and prioritize, refine staff assignments for example through use of a table of task, lead staff, and timeline.*
  - c. *Provide Part 667 information to related climate change efforts such as Global Warming Solutions Act (GWSA) Rural Resilience Sub-Committee – liaison Joe Segale added Part 667 report and webtool to list of activities related to resilience.*
  - d. *Support ongoing training for district staff and coordination with DEC staff on resources useful to maintain VTrans assets and to communicate to municipalities as part of systematic effort to reduce damage and resulting flow of sediment. This could include inviting DEC staff to an annual agenda item at a Maintenance staff meeting summarizing tools and grants.*
  - e. *Consider recommendations from NCHRP 08-151 Building Risk-Management Momentum in Agencies (liaison Zoe Neaderland) and other national reports.*

*Pursue continuous improvement at reducing repeat damage and increasing resilience as we look ahead to increased impacts from climate change.*

12. Explore the potential to combine additional data sources for better understanding of repeat damage locations, to support basic cost/benefit analysis, and to gain knowledge.
  - a. Make sure the master damage database (GDB\_Damage) stays current after DDIRs are completed and refresh repeat damage analysis. Discuss whether it changes are significant enough to refresh the Part 667 report, hold for more damage, or wait for four-year update.
  - b. Explore automation of analysis summary tables for Part 667 updates through PPAID Mapping efforts or VAMIS, such as repeat damage locations by district, RPC, river basin, and HUC-12 watershed, NHS, and high-volume roads.
  - c. Enhance use of full, current DDIR analysis in TRPT when a maintenance process is developed.
  - d. When there is enough maturity of the resources, explore ways to leverage Survey123 data collected for Initial Damage Assessments, MATS, VPINS, and other data sources to support reducing repeat damage. This may be done through continued coordination with VAMIS and the DDIR working group.
  
13. Explore matters that should over time help provide even better results such as
  - Cost of future repairs under current and future environmental conditions.
  - Was a project done in response to event damage or is it coincidentally in the same area?
  - How much was spent on storm-related repairs not just in terms of ER investments?
  - Were more repairs needed in the same location after subsequent events/major storms (i.e. sense of whether the strategy worked)?
  - What do we know about locations and amounts of spending due to major storms that didn't become declared events (i.e. didn't result in DDIRs)?
  - Are storm-related costs changing over time?
  - Other questions that will arise as we all continue to work in this field.

File information:

This is the final report that has been reviewed with no further comments by FHWA-Vermont staff. ZN 8/4/2022

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