Transportation **Asset Management Plan**

December 2022

Right Asset, Right Treatment, Right Time

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Executive Summary

VTrans' mission is to provide for the safe and efficient movement of people and goods. Asset management is an integral part of that mission, helping taxpayer investments deliver the highest returns by cost-effectively preserving and strategically improving our transportation assets. Simply put, asset management helps us make the right investments on the right assets at the right time.

Federal regulations require that states develop and regularly update a Transportation Asset Management Plan (TAMP) for pavements and bridges on the National Highway System (NHS). This document is intended to meet the letter and spirit of those requirements, but it does not stand alone. Rather, it is part of a broader effort to use the latest technologies and best practices to assess current and future performance, manage risks, and make investments that maximize the life of our infrastructure assets.

VTrans is responsible for 3,135 miles of pavements and 2,802 bridges. Of those totals, 1,141 miles and 484 bridges are on the NHS. Collectively, these NHS assets are worth more than $8 billion.

Vermont is meeting federal performance requirements and state performance targets for its pavements except for the percentage of NHS and statewide pavement in Good condition, which are just below state and federal targets. Vermont is meeting all federal performance requirements and state performance targets for its bridges.

Analyses indicate that approximately $180 million per year over the next ten years is appropriate to achieve overall pavement objectives and meet desired performance targets. Approximately $140 million per year over the next ten years is appropriate to achieve overall bridge objectives and performance targets.

Good asset management requires the consideration and mitigation of risks. This TAMP describes how VTrans identifies asset-related risks and offers strategies to manage them. Significant financial risks include high inflation and a reliance on revenues tied to traditional, but likely changing, fuel use. Also of particular concern are the impacts of, and resiliency to, climate change and extreme weather events.

Section 1: TAMP Objective and Integration with Other Plans

This Transportation Asset Management Plan (TAMP) documents the inventory, condition, and performance targets of the Vermont Agency of Transportation's (VTrans') bridges and pavements. It presents life cycle management strategies to maximize performance and minimize risks as well as financial planning and investment strategies to keep these critical assets in a state of good repair.

In 2012, Congress passed legislation requiring states to prepare TAMPs for pavements and bridges on the National Highway System (NHS), and to update the plan every four years. This 2022 TAMP update builds on the strengths of VTrans' initial 2018 TAMP.

While this TAMP addresses pavements and bridges, VTrans embraces an asset management approach for all its assets. The pavement and bridge management systems discussed herein fall under the umbrella of VTrans' Vermont Asset Management Information System (VAMIS), which is recognized as a national model.

The objective of this TAMP is to identify and help implement cost-effective strategies to preserve, improve the condition, and ensure the resiliency of transportation assets. It advances VTrans' mission, vision, and goals, and aligns with the strategic planning documents that guide Vermont's transportation priorities and investments (Figure 1-1).

First among these planning documents is the 2040 Vermont Long-Range Transportation Plan (LRTP). The LRTP serves as the framework that guides multimodal transportation decision making and investment over a 20-year horizon. The LRTP established a vision for Vermont's transportation system: "A safe, reliable and multimodal transportation system that grows the economy, is affordable to use and operate, and serves vulnerable populations."

Mission
Through excellent customer service, provide for the safe and efficient movement of people and goods.

Vision
A safe, reliable, and multimodal transportation system that grows the economy, is affordable to use and operate, and serves vulnerable populations

Related Strategic Goal
Grow Vermont's economy by providing a safe, reliable, and efficient transportation system in a state of good repair.

The TAMP aligns with Goal 2 of the LRTP, "Preserve and improve the condition and performance of the multimodal transportation system." The TAMP also aligns with the LRTP objective to "make strategic investments to preserve and improve conditions of highways, railroads, airports, bike-paths, trails, sidewalks, and public transit infrastructure."

Separate from the LRTP, VTrans has an Agency Strategic Plan which includes goals and objectives. The TAMP aligns with the key indicators in the Agency

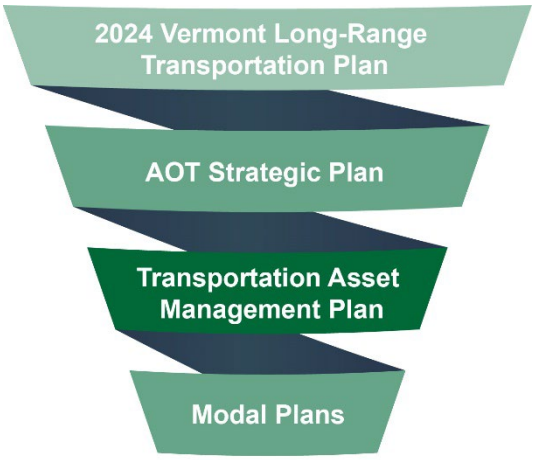


Figure 1-1: Hierarchy of Strategic Plans

Strategic Plan for sustaining the condition of VTrans' bridges[1] and roads.[2]

The TAMP focuses on bridges and pavements, while separate Modal Plans address public transit, airport systems, freight, rail, and bicycle and pedestrian travel. However, the TAMP and Modal Plans integrate where modal transportation needs overlap with the roadway network. VTrans' Transit TAMP update was completed in September 2022.

As the LRTP notes, the highway network is the state's most critical transportation asset, providing access and mobility to Vermonters, businesses, and tourists travelling by motor vehicle, transit, bike, or foot. Highways link to the rail lines that crisscross the state. Highways carry passengers to Vermont's 16 public-use airports, including Burlington International (BTV), which serves over half a million passengers annually. Regional public transportation services operate along many of the roadways. The highway network links at least 99 park and ride lots and facilitates intercity bus travel. The TAMP identifies and documents the strategies VTrans will implement to keep its highway assets in good repair so it can continue to support these diverse transportation needs.

Finally, this TAMP is aligned with Federal Highway Administration (FHWA) performance reporting requirements as well as state statutory requirements to report bridge and pavement conditions annually to Vermont's General Assembly.

[1] AOT Strategic Plan 2018-2023 Key Indicator: No more than 10% of the bridges on the state highway system will be structurally deficient for any year. (Note that the term structurally deficient is no longer used.)

[2] AOT Strategic Plan 2018-2023 Key Indicator: No more than 25% of pavement on the state highway system will be Very Poor for any year.

Section 2: Pavement and Bridge Inventories

A complete and accurate inventory is the foundation of good asset management. Knowing the number, type, size, age, and condition of its pavements and bridges enables VTrans to effectively manage these critical assets and forecast investment needs. This section describes the state's inventory of pavements and bridges on and off the National Highway System (NHS).

Pavements

VTrans owns and maintains 3,100 centerline miles of paved public roads. Table 2-1 summarizes the miles of state-managed pavements and the annual vehicle miles travelled (AVMT) on them. Although the NHS constitutes only 36 percent of the total miles, it carries 56 percent of the traffic volume.

Description	Miles	% Miles	AVMT	% AVMT
NHS-Interstate	699	22%	2.9 billion	56%
NHS-State	407	13%		
NHS-Municipality	35	1%		
Non-NHS-State	1994	64%	2.3 billion	44%
Totals:	**3135**	**100%**	**5.2 billon**	**100%**

Table 2-1: Centerline miles and traffic volumes on the Vermont highway system. Source: VTrans, 2022

Bridges

There are 2,802 bridges[3] in Vermont, including 484 on the NHS. VTrans manages 468 of those, with the remainder managed by towns or by adjacent jurisdictions at border crossings. Of the 2,318 bridges not on the NHS, 661 bridges are on state highways and managed by VTrans. 1,657 are on town highways and managed by towns. Table 6-2 provides a summary of ownership of Vermont's NHS and non-NHS bridges by count and by total bridge deck area.

[3] This TAMP uses the definition of bridges as set forth in 23 CFR 650.305: "…a structure including supports erected over a depression or an obstruction, such as water, highway, or railway, and having a track or passageway for carrying traffic or other moving loads, and having an opening measured along the center of the roadway of more than 20 feet between under copings of abutments or spring lines of arches, or extreme ends of openings for multiple boxes; it includes multiple pipes, where the clear distance between openings is less than half of the smaller contiguous opening." Structures, including culverts, with spans 20 feet or less are considered short structures and are not covered by this TAMP.

All Bridges		
Bridge Ownership	**Count**	**Deck Area (SFT)**
NHS (State)	468	4,437,629
NHS (Other)	16	103,002
Non-NHS (State)	661	2,981,687
Non-NHS (Town)	1,657	2,620,654
Total Bridges	**2,802**	**10,142,972**

Table 2-2: All Bridges (Count and Deck Area)

Table 2-3 is a summary of Vermont's 2022 submittal of the NHS bridge inventory, as reported in FHWA's National Bridge Inventory (NBI) data.[4] It shows that Vermont has a total of 484 interstate and non-interstate NHS bridges covering a deck area of more than 4.5 million square feet. Of these, approximately 64 percent by deck area and 65 percent by count are on the interstate. VTrans has maintenance responsibility for 97 percent of all NHS bridges.

NHS Bridges		
Bridge Ownership by Facility Type	**Count**	**Deck Area (SFT)**
Interstate (State)	314	2,917,862
Non-Interstate (State)	154	1,519,767
Non-Interstate (Town)	16	103,002
Total NHS Bridges	**484**	**4,540,631**

Table 2-3: NHS Bridges (Count and Deck Area)

[4] FHWA National Bridge Inventory Data for Vermont accessed at https://www.fhwa.dot.gov/bridge/nbi/disclaim.cfm?nbiYear=2022/delimited&nbiSt=VT22

Section 3: Data Collection, Performance Measures, Targets, and Trends

Federal regulations established consistent national performance measures and performance targets for interstate pavements and NHS bridges.[5] Although no national targets are established for non-interstate NHS pavements, states must also establish state level performance targets for these roads. States may adopt additional measures and targets to serve their own needs. VTrans has adopted measures and targets to meet both federal and state requirements. The measures and targets are aligned with the agency's mission, goals, and objectives.

States are required to coordinate with their metropolitan planning organizations (MPOs) on the selection of targets to ensure consistency.[6] Vermont has one MPO, the Chittenden County Regional Planning Commission (CCRPC) as well as ten regional planning commissions (RPCs) that support coordination with municipalities statewide. VTrans coordinated with CCRPC to establish the 2018 measures and targets. The CCRPC Board of Directors adopted the 2018 measures and targets in October 2018. The targets in this 2022 TAMP have been updated in coordination with CCRPC and the RPCs.

Pavement Data Collection

VTrans collects pavement condition data following national standards. Sophisticated equipment including lasers, cameras, and sensitive measuring devices are used to capture pavement distress data. Condition data is aggregated and maintained in 0.1-mile analysis segments. Interstate data is collected and reported annually, while non-interstate NHS data is collected at least biennially.[7] The pavement condition data feeds VTrans' pavement management system (PMS), currently the Deighton Total Infrastructure Management System (dTIMS).

Pavement Performance Measures

VTrans has three measures to report pavement conditions:

- Federal measure of Good and Poor condition for both the interstate and non-interstate NHS.
- Overall Network Pavement Condition (ONPC)
- Travel-weighted Average Condition Index (TWACI).

The federal required measure for pavements in Good and Poor condition is based on the pavement's roughness, percentage of cracking, rutting on asphalt pavements, and faulting on concrete pavement. With almost 99.9 percent of Vermont's pavement being asphalt, measures of asphalt pavements are most pertinent to VTrans. Asphalt pavements are assessed by their degree of roughness, cracking, and rutting. Each distress condition is rated Good, Fair, or Poor. If two or more of the distress conditions are rated Poor, then that pavement

[5] 23 CFR Part 490.105
[6] 23 U.S.C. 135(d)(2)(B)(i)(II)
[7] 23 CFR Part 490

segment is rated Poor.

VTrans has used the ONPC and the TWACI for more than 20 years, long before FHWA developed its national reporting requirements. These measures provide more insight into the pavements' performance and support VTrans' management of these assets.

The ONPC is computed using an internal VTrans Composite Pavement Condition Index (CPCI), rated on a 0-100 scale. The ONPC summarizes the condition of pavement network based on the proportion of miles in various condition states. Table 3-1 below shows VTrans' Pavement Condition Designation and the relationship to the CPCI score. (Note that the federal distress definition protocols and federal categories of Good, Fair, and Poor do not correlate exactly to the state distress definition protocols and state categories of Good, Fair, Poor, and Very Poor.)

Pavement Condition Designation	CPCI Score
Good	80-100
Fair	65-80
Poor	40-65
Very Poor	0-40

Table 3-1: VTrans Pavement Condition Designations and Relation to CPCI Score

The Travel Weighted Average Condition Index (TWACI) combines the CPCI for each 0.1-mile segment with a weighting factor based on the traffic volume carried by the segment.

VTrans reports to FHWA using the federally required pavement measures and uses the two state measures for statewide reporting.

The federally required measures for pavement condition reporting are:

1. The percentage of interstate pavements in Good condition
2. The percentage of interstate pavements in Poor condition
3. The percentage of non-interstate NHS pavements in Good condition
4. The percentage of non-interstate NHS pavements in Poor condition

The two VTrans state-specific measures are:

1. The Overall Network Pavement Condition Index (ONPC) across the entire VTrans managed network
2. The Travel Weighted Average Condition Index (TWACI) across the entire VTrans managed network

Pavement Performance Targets

The federal minimum acceptable condition is that no more than five (5) percent of interstate pavements be in Poor condition. Furthermore, state DOTs must establish 2-year and 4-year pavement targets toward achieving or maintaining the federal minimum requirements. Performance reports are submitted to FHWA annually showing pavement conditions in comparison to these targets.

VTrans' federally required targets for pavements are shown in Table 3-2.

Federal Pavement Condition Measures	VTrans Targets
Interstate Pavements in Good Condition	28% Minimum
Interstate Pavements in Poor Condition	4.9% Maximum
Non-Interstate NHS in Good Condition	30% Minimum
Non-Interstate NHS in Poor Condition	9.9% Maximum

Table 3-2: VTrans Pavement Conditions Targets based on the Federal Measures

The targets for the ONPC and the TWACI are shown in Table 3-3. Performance using these measures is tracked and reported annually.

Statewide Pavement Condition Measures	VTrans Targets
Percent of Very Poor Pavements based on Overall Network Pavement Condition Rating	Not to exceed 25 percent Very Poor
Travel Weighted Average Condition Index	Minimum pavement condition index of 70 across the entire VTrans managed network

Table 3-3: VTrans' Statewide Targets for Pavements using the Overall Network Pavement Condition and the Travel Weighted Average Condition Index

Pavement Performance Trends

Figure 3-1 shows the conditions of Vermont's interstate and non-interstate NHS pavements based upon the federal requirements. It shows that VTrans is meeting or exceeding its targets for the proportion of NHS pavements in Poor condition, and meets the minimum acceptable condition that no more than five (5) percent of interstate pavements be in Poor condition.

Vermont is not currently meeting its targets for the proportion of its NHS pavements in Good condition. Many NHS pavement segments have recently dropped to just below the federal threshold between Good and Fair. Much of the drop is due to minor rutting distresses, which will be addressed through preservation treatments.

NHS Interstate
VTrans Target:
Maximum 4.9% Poor
Minimum 28% Good

NHS Non-Interstate
VTrans Target:
Maximum 9.9% Poor
Minimum 30% Good

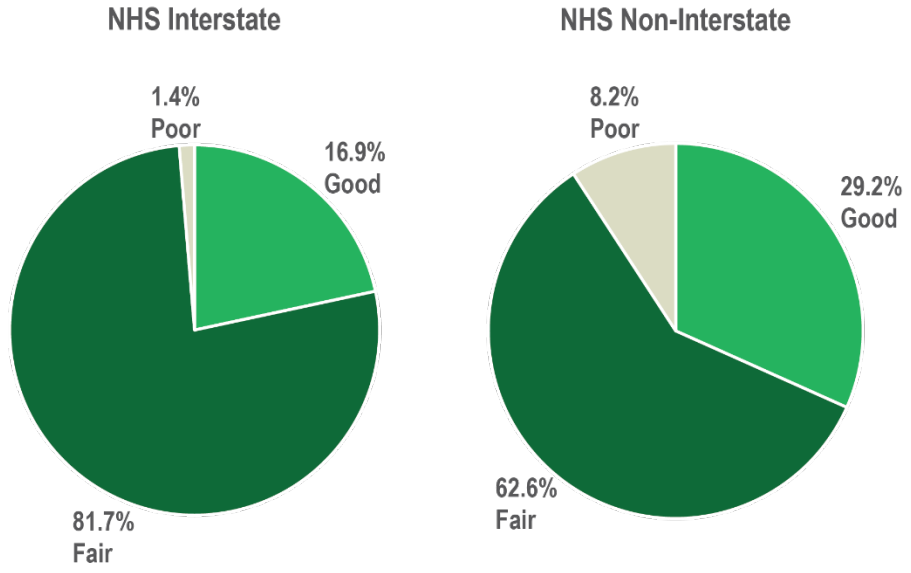


Figure 3-1: Conditions of the Interstate and Non-Interstate NHS Pavements based on the FHWA measures.

In addition to the federal requirements, VTrans uses the percent of Very Poor pavements as measured by the ONPC and the TWACI to inform investment decisions. These two measures help ensure that routes most used by the traveling public are maintained in good condition, and that even lesser used routes are kept in serviceable condition.

The conditions of the state-maintained pavement network using these measures are shown in Figures 3-2 and 3-3. Figure 3-2 illustrates that Vermont has improved and achieved its target for Very Poor pavement for many years. (Again, note that the federal distress definition protocols and federal categories of Good, Fair, and Poor do not correlate exactly to the state distress definition protocols and state categories of Good, Fair, Poor, and Very Poor.)

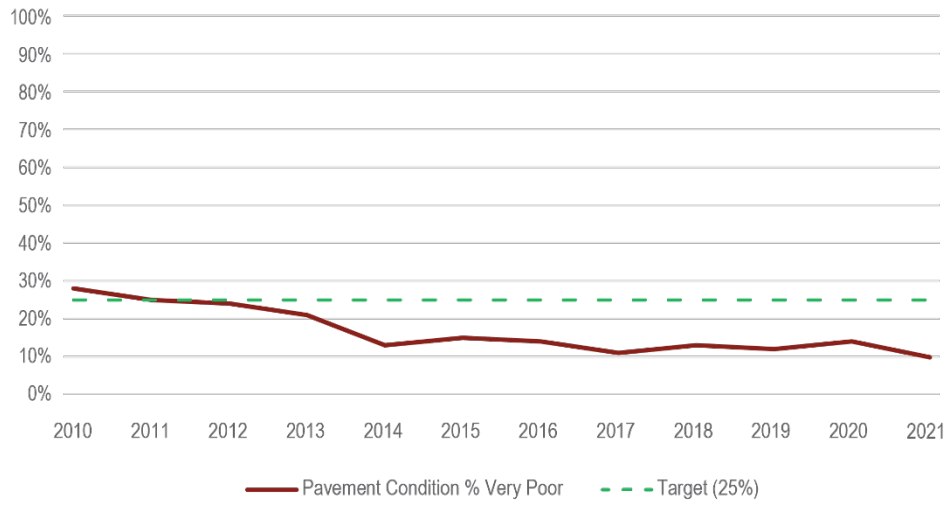


Figure 3-2: Trend of Very Poor pavement over time as a percent of the state network. The dotted line represents the 25% target.

Figure 3-3 shows the fluctuation in the network wide TWACI from 2011 through 2021, at times meeting, and at times falling just below the target of 70 on a 100-point scale.

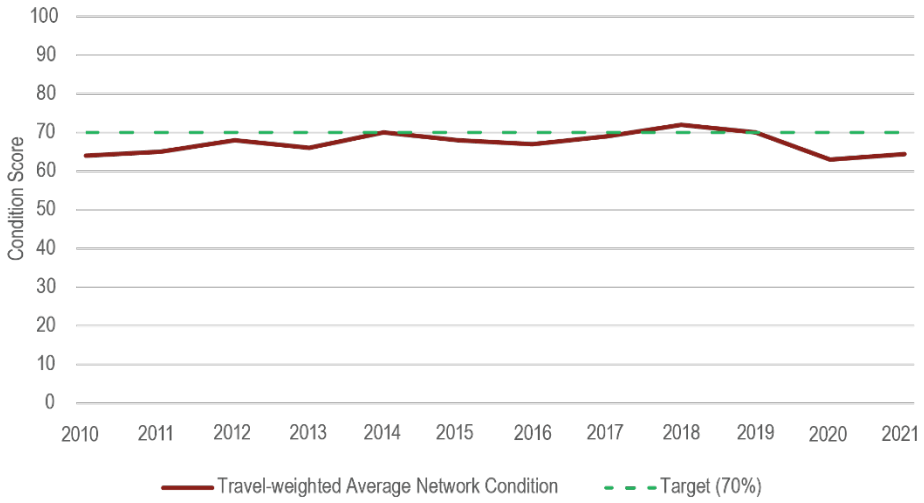


Figure 3-3: Trend of the Travel-weighted Average Network Condition Index between 2010 and 2021. The dotted line represents the 70% target.

The performance of Vermont's pavements, as measured by both the federal requirement of NHS pavements in Good condition and the state TWACI measure, indicates the need for ongoing investment in the network, particularly in the commitment to preservation strategies that keep good pavements in good condition. This approach is discussed in this TAMP's Life-cycle Planning Section.

VTrans bridge inspectors at work.

Bridge Data Collection

Bridge data are collected based upon federal standards that govern inspector qualifications, inspection processes, frequency, inventory management, documentation, and response to critical findings. VTrans is in compliance with all bridge data collection and inspection federal regulations.

VTrans inspects each bridge at least every 24 months. VTrans will inspect a bridge at least annually if it is rated in "serious" condition for its deck, superstructure, substructure, or scour.

Like most states, VTrans has been collecting, analyzing and making decisions for decades based on component-level data (e.g., deck, superstructure, substructure). However, VTrans has moved to collecting more granular, "element-level" data required by FHWA (e.g., bridge joint, paint, approach rail). VTrans is in its fifth season of gathering the element-level data for NHS bridge inventory.

As is the case with pavement data, bridge condition data feeds VTrans' bridge management system (BMS), currently the Deighton Total Infrastructure Management System (dTIMS).

Bridge Performance Measures

Consistent with FHWA National Bridge Inventory Standards requirements, VTrans reports biennially on the condition of bridges on the NHS[8], categorizing them as being in either Good, Fair, or Poor condition. Summary condition ratings are determined from a combination of ratings of a bridge's deck, superstructure, and substructure components, which are each rated on a 0-9 scale. The lowest

[8] 23 CFR Part 490

condition rating of the three components determines whether the overall bridge is rated as Good, Fair, or Poor. A similar 0-9 rating describes the condition of culverts and buried structures.

In addition to reporting to the FHWA, VTrans annually reports its bridge conditions to the state legislature. These measures are also used by VTrans to establish targets and assess progress toward achieving the agency's objectives. VTrans tracks progress over time and uses this information to evaluate what investment levels are appropriate to meet its goals.

Bridge Performance Targets

VTrans' TAMP uses the federal performance measures[9] and tracks the percentage of NHS bridges in Good and Poor condition. The federal minimally acceptable condition is that no more than 10 percent of NHS bridges be in Poor condition, as determined by deck area. Per federal requirements, State DOTs must also establish 2-year and 4-year bridge targets, and annually report progress towards meeting them. Table 3-4 provides VTrans' current targets.

NHS Bridge Condition Measures	VTrans Targets
NHS Bridges classified in Good Condition	35.0% Minimum
NHS Bridges classified in Poor Condition	6.0% Maximum

Table 3-4: VTrans Bridge Condition Targets by Deck Area based on the Federal Measures

Bridge Performance Trends

Figure 3-4 shows the condition of the 484 NHS bridges in Vermont. Both performance targets are currently being met.

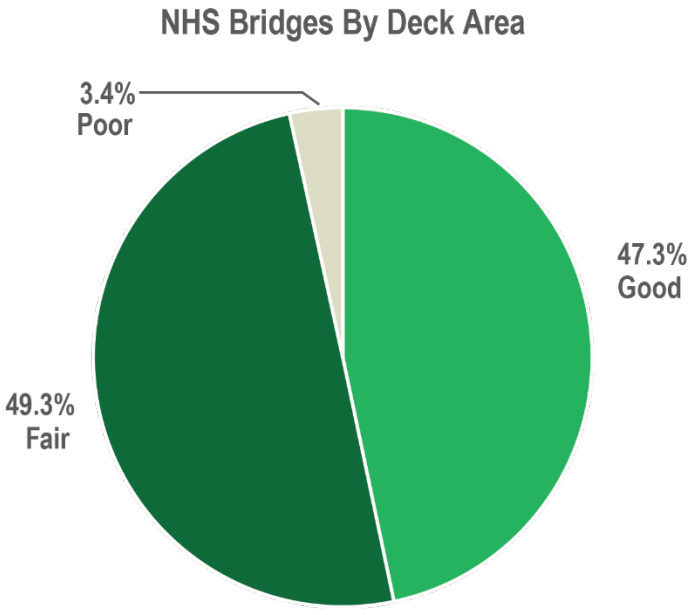


Figure 3-4: Condition of the NHS bridges by Percentage and Deck Area

[9] 23 CFR Part 490

VTrans has significantly improved the condition of its bridges over the past decade. In 2006, 11 percent of Vermont's interstate highway bridges were rated Poor. By 2017, the percentage had been reduced to less than 2 percent. Figure 3-5 shows the proportion of NHS bridges in Poor condition by deck area improving from almost 6 percent in 2010 to just over 3 percent in 2021.

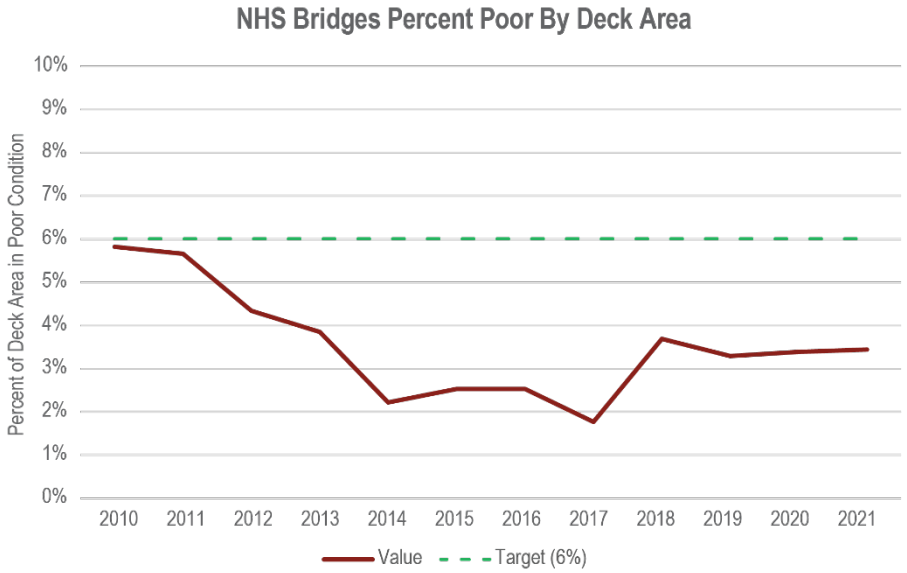


Figure 3-5: Percentage of NHS bridges in Poor condition over time as measured by total deck area. The dotted line represents the 6% target.

The VTrans target for non-NHS bridges is to have no more than 10 percent by deck area in Poor condition. Figure 3-6 shows the State-managed non-NHS bridges in Poor condition by deck area improving from a high of more than 11 percent in 2010 to under 6 percent in 2021.

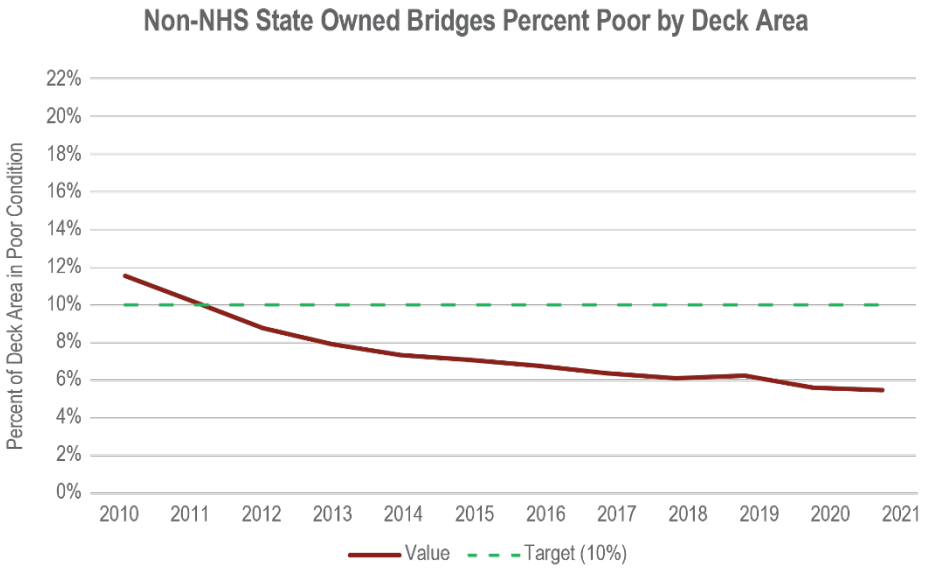


Figure 3-6: Percentage of non-NHS State-managed bridges in Poor condition over time by deck area. The dotted line represents the 10% target.

Similar condition improvement trends can be seen in Figure 3-7 for the Town-owned non-NHS bridges. Conditions are well below the 12% performance target and have remained below 3% since 2016.

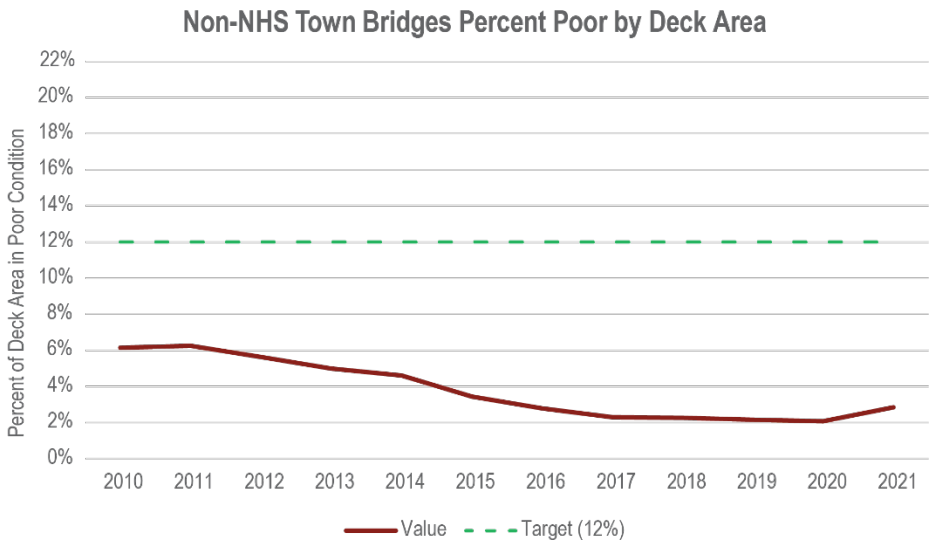


Figure 3-7: Percentage of Town-owned non-NHS bridges in Poor condition over time by deck area. The dotted line represents the 12% target.

Vermont is meeting both its federal and state performance targets for bridges. The level of investment necessary to sustain this performance is described in the Financial Plan and Investment Strategy Sections of this TAMP.

Section 4: Life-cycle Planning

This section describes VTrans' life-cycle planning activities for its pavements and bridges to maximize their long-term performance and meet federal requirements.

Federal regulation 23 CFR 515.7(b) defines life-cycle planning as a "process to estimate the cost of managing an asset class, or asset sub-group over its whole life with consideration for minimizing cost while preserving or improving the condition." Per 515.7(b), a life-cycle planning process shall, at a minimum, include the following:

1. State targets for asset conditions for each asset class or asset sub-group
2. Identification of deterioration models for each asset class (method used)
3. Potential work types across the whole life of assets with their relative unit cost
4. A strategy for managing each asset class or sub-group by minimizing life-cycle costs, while achieving the State DOT targets for asset condition for NHS pavements and bridges.

Life-cycle planning is a systematic approach to cost-effectively manage assets by using proactive investment strategies throughout their lifespan. Unlike "worst-first" strategies that focus only on fixing assets at the end of their useful service life, strategies of timely preservation followed by rehabilitation are more cost-effective and deliver better performance.

VTrans uses its Vermont Asset Management Information System (VAMIS) to conduct life-cycle planning of all its pavements and bridges. VAMIS includes dTIMS for its PMS and BMS. The dTIMS analyses take into consideration asset conditions, their likely deterioration, and estimated treatment costs. Within financial constraints provided, dTIMS recommends optimized strategies of maintenance, preservation, rehabilitation, and reconstruction that cost-effectively improve or sustain conditions. VTrans' processes meet all the requirements of 23 CFR 515.17(b). VTrans' PMS and BMS meet all the requirements of 23 CFR 515.17, the minimum standards for developing and operating bridge and pavement management systems.

Figure 4-1, from dTIMS documentation, is an illustration of the logic used. It shows deterioration over time as well as the condition improvements and cost reductions achieved by timely preservation using different treatments. This example shows pavement deteriorating to Very Poor condition when timely and cost-effective treatments are not performed. The example also illustrates that through timely lower cost preservation methods (overlay and surface treatments) conditions can be improved and maintained over a longer period of time at lower costs. Similar logic is applied to bridges and other assets.

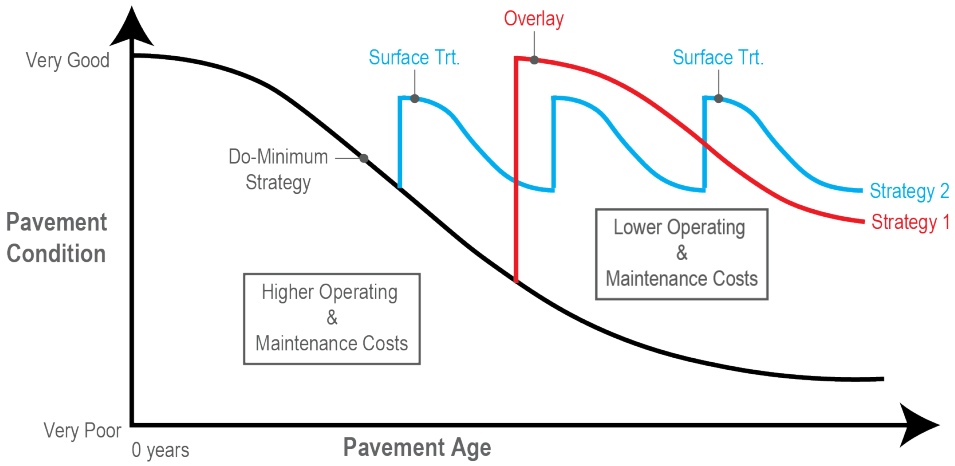


Figure 4-1: PMS logic showing the impact of various treatment options to a pavement deterioration curve. Source dTIMS.

An Overview of the VTrans Life-cycle Process

The agency process for life-cycle planning includes the following steps:

1. Capture asset inventory and conditions
2. Review asset condition targets
3. Compare asset conditions to targets
4. Update asset deterioration models and treatment triggers
5. Update unit costs for maintenance, preservation, rehabilitation, and reconstruction treatments
6. Update committed paving and bridge projects within the management systems
7. Analyze investment scenarios that optimize performance and forecast network asset conditions
8. Select investment strategies that best meet condition targets
9. Implement selected investment strategies through the Vermont Project Selection and Priortization Process[10] (VPSP2) which emphasizes performance, asset preservation, safety, community support, and extreme weather resilience.

The life-cycle planning processes implemented by VTrans over recent decades has resulted in significant improvements to Vermont's pavements and bridges over time, as detailed in Section 3.

Pavement Life-cycle Planning

Pavement Deterioration and Improvement Modelling

Pavements deteriorate differently over time based on their age, design type, underlying subbase materials, and traffic. Often, the life of pavements in Good or Fair condition can be extended using relatively inexpensive preservation treatments such as crack sealing and thin overlays. Once pavements are substantially deteriorated, they require more extensive rehabilitation treatments such as milling and reclaiming. Severely deteriorated pavements may require full

[10] More information about the VPSP2 process can be found at: https://vtrans.vermont.gov/project-selection

reconstruction.

VTrans' PMS has over thirty deterioration models and treatment triggers for various pavement types, functional classes, traffic volumes, and other factors. The PMS accesses the pavement history and condition database to conduct analyses on pavements, typically using one mile analysis segments.

The PMS applies appropriate deterioration models to the pavement segments in the analysis, and based on all possible combinations of treatment options, recommends an annual program of treatments that optimizes the specified annual funding over the analysis period. Those treatments are categorized as one of five work types: maintenance, preservation, rehabilitation, reconstruction, and initial construction. Based on years of experience with these analyses, VTrans has learned that allocating approximately 25 percent of the funding to preservation treatments provides the best long-term network-wide performance, while providing a stable annual work program that matches contractor capacity. Similarly, allocating approximately 5 percent to maintenance paving provides serviceability on poor roads that otherwise would not trigger improvements. VTrans does not use the PMS to recommend investments for initial construction of new roads.

Figures 4-2, 4-3 and 4-4 are screenshots from the PMS illustrating the use of inventory data, deterioration models, triggers and treatments while conducting scenario analyses for life-cycle planning.

Figure 4-2 shows an example of an analyzed pavement section, in this case, a one-mile section of northbound Interstate 89 at mile-marker 33, with an AADT of 8759.

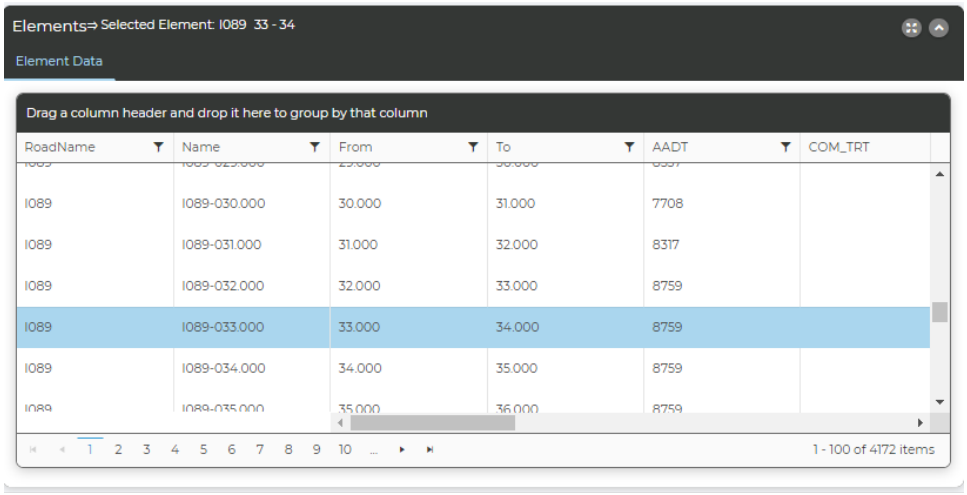


Figure 4-2: Identification of the pavement section analyzed using PMS

Figure 4-3 shows an example of the results of analyses conducted by the PMS on the pavement segment identified in Figure 4-2 using a site-specific deterioration model, with its appropriate triggers and treatments. In the example shown in Figure 4-3, the pavement has a CPCI rating of approximately 83 in 2021 indicating that it is in Good condition. The "Do Nothing" scenario is represented by the red curve. The green line illustrates the treatment considered to prolong the life of the pavement. The analysis shows that a preservation treatment when its CPCI drops to about 66 in 2025 would improve its condition to Good with a CPCI of almost 96. This treatment will keep the pavement in relatively Good condition for nine years. A second treatment is recommended when the CPCI drops to below 80 in year 2034, at which point an overlay will result in an improvement of the condition to Good with a CPCI of approximatley 96.

Figure 4-3: An example of one of many treatment strategies for a pavement in Good to Fair condition generated by PMS

Figure 4-4 shows the treatment options analyzed and their costs. TNOL is Thin Overlay and OVL is Overlay. Similar treatment and cost information is identified for each of the many strategies analyzed for each pavement segment.

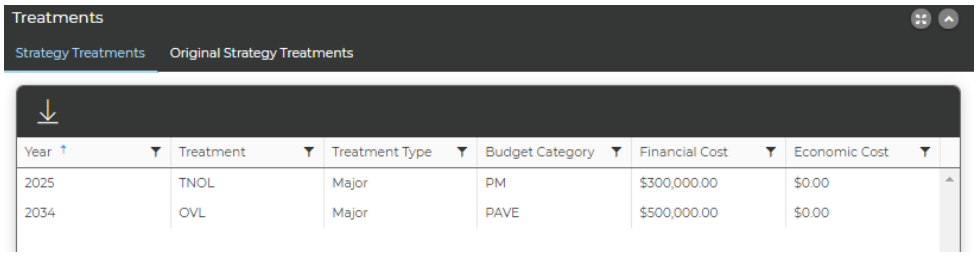


Figure 4-4: Treatment types and costs generated by PMS using life-cycle planning

Pavement Work Types and Unit Costs

Table 4-1 shows the relationship of work types used by the PMS to the pavement treatments typically used in project designs (initial construction is not a treatment option used by the PMS).

Work Type	Treatments
Rehabilitation	"Mill and fill" paving 2" +/-
	Pulverize and overlay or reclaim
	Major rehabilitation
Reconstruction	Reconstruction
Preservation	Thin pavement overlay
Maintenance	Overlay of poor pavement to provide serviceability

Table 4-1: Crosswalk between work types and pavement treatments

Table 4-2 shows the current unit cost of various pavement treatments by work type and pavement type (Interstate, State NHS and Non-NHS and Class 1 NHS and Non-NHS) for a one mile road segment with two lanes, referred to as a 2-lane mile. This information is used by the PMS to analyze and compare the cost of treatments generated for each pavement segment.

Pavement Treatment Costs by Work Type (Millions)						
Code	Type	Class1-NHS-2Lanes	Class1-Non-NHS-2Lanes	Interstate-NHS-2Lanes	State-NHS-2Lanes	State-Non-NHS-2Lanes
OVL	Rehabilitation	$1.30	$0.85	$0.50	$0.55	$0.43
PAO	Rehabilitation	$15.00	$15.00	$1.25	$0.85	$0.75
REC	Reconstruction	$15.00	$15.00	$7.50	$5.00	$4.00
TNOL	Preservation	$0.50	$0.50	$0.30	$0.25	$0.20
RDWY_3R	Rehabilitation				$3.00	$2.50
DIST_LEV	Maintenance				$0.15	$0.15

Legend
OVL "mill and fill" paving, 2" +/-
PAO Pulverize and overlay, or reclaiming
REC Reconstruction via our Roadway Program
TNOL Thin pavement overlay
RDWY_3R Major rehabilitation
DIST_LEV Overlay of poor pavement to provide serviceability

Table 4-2: VTrans cost per 2-lane mile by work type and pavement class

Optimization for Pavement Life-cycle Planning

Figure 4-5 is a screen shot of an Efficiency Chart generated by the PMS based on the optimization of several strategies analyzed for the example pavement section.

Figure 4-5: PMS cost benefit analysis results for multiple investment strategies for one pavement segment

Various strategies involving combinations of treatments are analyzed for every pavement segment in the entire analysis network. The green circles in Figure 4-5 represent the benefits and costs of over 200 different strategies for the example pavement segment. The black circle shows a near-optimal strategy (the strategy illustrated in Figures 4-3 and 4-4) that was identified as the best choice based on total program funding constraints. The management system does not always pick the most efficient strategy, but rather it picks a combination of strategies on the efficiency frontier, meaning those generating the highest benefits relative to their

costs. This is one of many strategies that fit together to collectively make up the optimal program of project candidates within the financial constraints.

VTrans subject matter experts review the annual program of recommended investment strategies generated by the PMS and, based on engineering judgement and preliminary field reviews including the identification of logical project limits and schedule coordination, make recommendations for future project candidates. Those recommendations are incorporated into the VPSP2 process.

Bridge Life-cycle Planning

Bridge Deterioration and Improvement Modelling

Like the PMS, the BMS enables VTrans to analyze numerous treatment scenarios for each bridge on its network at different funding levels. As with pavements, the goal of life-cycle planning for bridges is to identify the optimal combination of strategies within the financial constraints that sustain bridges in Good condition, rehabilitate bridges in Fair condition, and replace (or retire) bridges in Poor condition.

The BMS triggers and resets are more basic compared to what the PMS uses for pavements. The bridge deterioration model has a step function for the substructure, superstructure, and the bridge deck components, each rated on a scale of 0 to 9. Each bridge component remains in a rating for several years before dropping.

These condition ratings and their step function deterioration curves are artifacts of traditional component level bridge inspection requirements. As noted previously, VTrans has moved to element level inspection data for its bridges and is in the process of incorporating additional treatments into the BMS. These changes will improve the optimization and the investment strategies recommended by the BMS.

As of 2022, VTrans' preservation treatments for bridges modeled in the BMS are limited to joint and wearing surface replacements. These treatments do not typically improve the overall bridge condition, but they do slow deterioration. With increasing element level bridge data, VTrans is expanding the modeling and implementation of additional preservation treatments, including means to better track routine activities such as washing.

The BMS analyzes each bridge in the network. It looks at the condition of the bridge components, deterioration models, and viable treatment types. For each funding level, the BMS generates multiple combinations of treatments and predicts deterioration for each option. Figures 4-6, 4-7, and 4-8 illustrate the use of inventory data, deterioration models, triggers and treatments while conducting scenario analyses for life-cycle planning using a simple example.

Figure 4-6 shows a specific bridge analyzed, in this case, bridge number 26N on Interstate 91, at mile-marker 41.265.

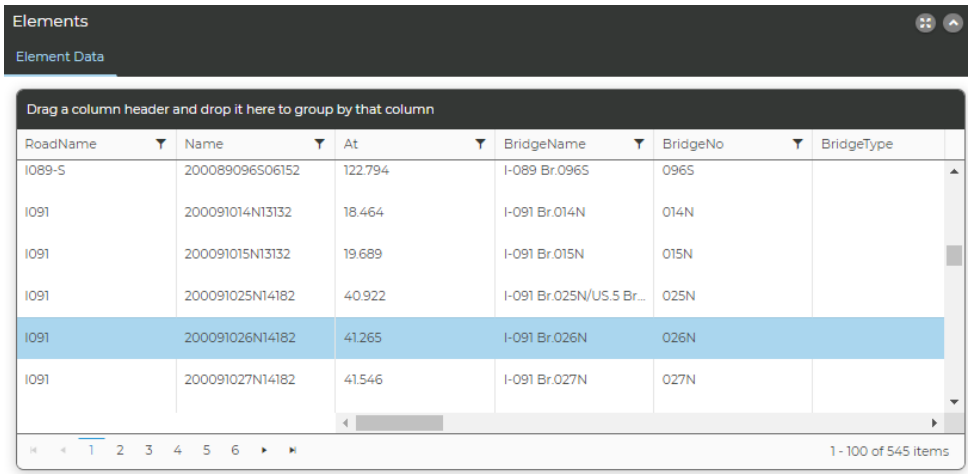


Figure 4-6: Representative bridge selected for example BMS analysis.

Figure 4-7 is an example of one of several options generated for a treatment strategy for the bridge identified in Figure 4-6. The example shows the bridge deteriorating in 2031. The green line in Figure 4-7 represents the result of one recommended strategy for the bridge alongside a “Do nothing” strategy (shown by the red line). This example strategy recommends a bridge replacement in 2032 when the composite bridge value drops below 64. The replacement resets the condition and brings the bridge back to condition index value of almost 90.

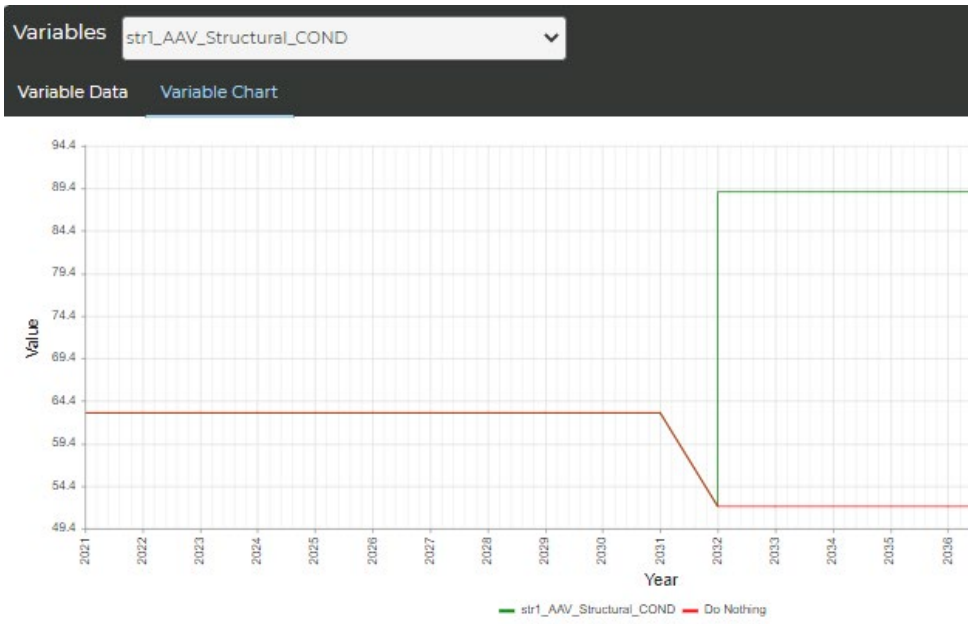


Figure 4-7: BMS analysis for the representative bridges showing the condition for one treatment strategy versus no action taken

The treatment option and its associated cost generated by the BMS is shown in Figure 4-8 for the scenario analyzed. Similar treatment and cost information is identified for each of the scenarios analyzed for each bridge.

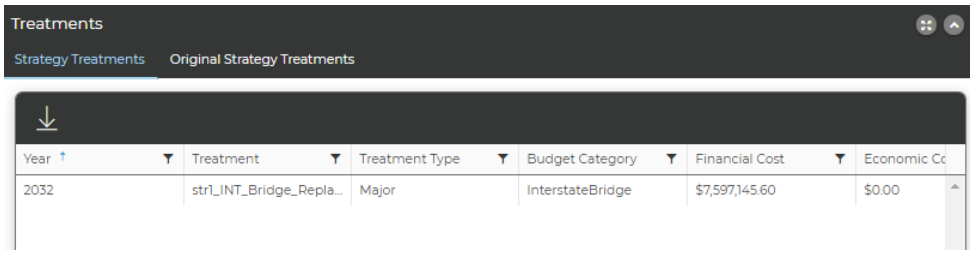


Figure 4-8: Bridge treatment option and cost analyzed using BMS

Bridge Work Types and Unit Costs

Table 4-3 shows the unit cost of treatments for work types included in the BMS. These costs are used by the BMS in forecasting and recommending investment strategies. VTrans updates these unit costs periodically. Additional preservation and rehabilitation treatment models are under development.

Bridge Treatment Cost Estimates (Dollars)			
Work Type	**Treatment Description**	**Deck Area ≤8000 sq ft**	**Deck Area > 8000 sq ft**
Preservation	Joint Replacement, per linear foot of joint	$230	$230
Preservation	Wearing Surface Repave/Replacement, per square foot of deck area	$10	$10
Rehabilitation	Deck Rehabilitation, per square foot of deck area	$872	$374
Rehabilitation	Major Rehabilitation, per square foot of deck area	$952	$563
Reconstruction	Per square foot of deck area	$999	$683

Table 4-3: Bridge treatment cost per sq. ft of deck area by bridge category

Optimization for Bridge Life-cycle Planning

Figure 4-9 illustrates the benefits verses costs for various treatment strategies generated for the example bridge. Each circle represents a treatment strategy. In this simple example only nine strategies were analyzed. The black circle represents the optimized strategy, illustated in Figures 4-6 and 4-7. This strategy is the best choice based on total program funding constraints. As part of the optimization process, the BMS identifies a combination of treatment strategies for all bridges that collectively deliver the most network-wide benefits for the total available funding.

Figure 4-9: BMS LCP analysis showingstrategies for bridge replacement, associated costs and benefits and the optimal selection

As with pavements, VTrans subject matter experts review the annual program of recommended investment strategies generated by the BMS and make recommendations for planning and programming of future project candidates. Those recommendations are incorporated into the VPSP2 process.

Life-cycle Performance Modelling

VTrans uses its PMS and BMS to predict future network-wide conditions based on the models' optimized programs of committed and recommended treatments under various investment scenarios. These predictions aid in the identification and selection of appropriate investment strategies.

An example of such modelling is summarized in Figure 4-10, which shows an example of predicted network-wide pavement conditions under various funding scenarios. The horizontal axis represents annual investment levels and the vertical axes indicate pavement performance levels using VTrans' two performance measures: Percent Very Poor (red) and the Travel Weighted Average Condition Index (green).

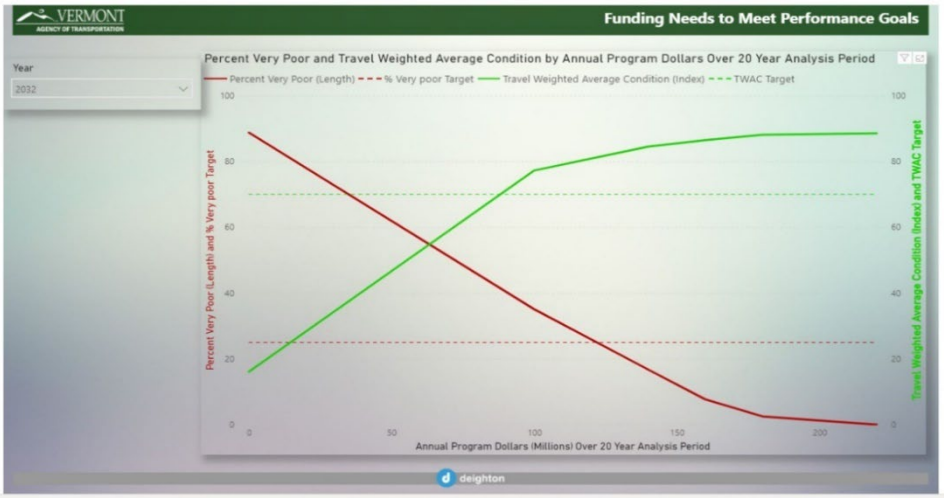


Figure 4-10: Example performance projections of all funding scenarios analyzed for pavements over a 20-year analysis period

The dotted green horizontal line shows the state target of 70 for the Travel Weighted Average Condition Index (TWACI) pavement measure. The dotted red horizontal line shows the target of 25 percent Very Poor pavements measured by

the Composite Pavement Condition Index (CPCI). The solid green and red lines show the projected pavement program performance relative to these two measures with different levels of funding over a 20-year analysis period.

Analyses such as this are used by VTrans to inform decisions on the amount to invest in various assets.

Section 5: Risk Management and Resilience

The achievement of TAMP objectives is subject to many threats, uncertainties, and opportunities. Among the risks most likely to affect the achievement of TAMP objectives are a changing climate with increased storm intensity, a volatile economy with record inflation, and evolving policies such as vehicle electrification incentives which may affect revenues. In addition, social and political expectations could change and alter the assumptions upon which this plan is built, and unpredictable events such as pandemics or international crises could affect public travel patterns, revenues, and expenses.

VTrans is committed to understanding and managing its transportation risks. This is critical to achieving desired asset conditions, maximizing system performance, and providing a safe and reliable network for its transportation users. The risk management process prepares decision makers to respond if the plan assumptions change.

VTrans considers risks in its VPSP2 project selection and prioritization process, its Transportation Resilience Planning Tool (TRPT), and the state's Climate Action Plan. These efforts will help to ensure that asset risks are identified, evaluated, prioritized, mitigated, and communicated to stakeholders. Within its TAMP development process, VTrans has identified the following six categories of risks that could impact VTrans' bridge and pavement objectives:

- **Pavement risks:** including poor-quality materials or construction, shortages of material and contractors, pavement condition deteriorating faster than anticipated, overweight vehicles, studded tire use, and incomplete condition data to support the selection of optimum treatments.
- **Bridge risks:** including the effects of historic underinvestment, deferred maintenance, and overweight trucks that can accelerate bridge deterioration. Additional risks come from the less comprehensive data available for short structures, i.e., bridges and culverts with spans less than 20 feet.
- **Extreme weather and climate risks:** including higher temperatures, increased freeze-thaw frequency, and more intense storms that can threaten the transportation system's resilience.
- **Workforce risks:** including a loss of institutional knowledge, uncertainty about competencies needed to fill critical functions, and an inability to attract and retain a knowledgeable workforce.
- **Data and knowledge risks:** including failures to maintain important data sets, not assessing data quality, missing key data variables, and relying on inconsistent data in the evaluation of treatment alternatives.
- **Inflation and funding risks:** including rapidly rising construction prices and variable state revenues and federal funding.

This section focuses on network level bridge and pavement risks. It does not address risks to project scopes and schedule, highway safety, or environmental quality. VTrans has other processes to manage those risks.

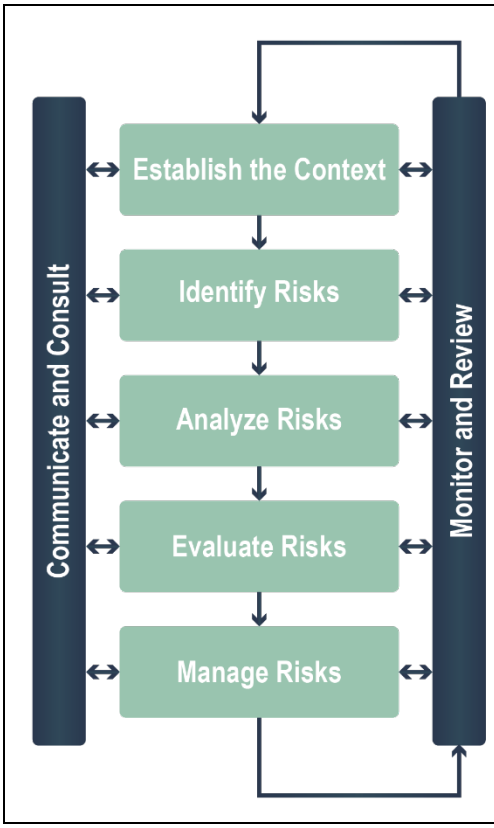
This section discusses how VTrans:

- Satisfies the federal asset management regulation in 23 CFR Part 515, which requires states to have processes to identify risks to NHS bridge and pavement conditions, assess and prioritize those risks, identify mitigation plans, and monitor the top priority risks.
- Complies with the 23 CFR Part 667 requirements, which require states to conduct statewide evaluations to identify alternatives to sites damaged more than once during federal or state emergencies. This section references a detailed VTrans report entitled, "Reducing Repeat Damage of Vermont's Roads & Structures."
- Satisfies a new provision Congress enacted that requires states' risk management plans to address resiliency. To address resilience, VTrans developed the TRPT, which identifies high-risk locations and potential mitigation measures for bridges, culverts, and road embankments that are vulnerable to damage from floods.
- Supports other state resilience efforts such as the Vermont statute requiring resilience as a criterion within its VPSP2[11], and the transportation components of the Initial Vermont Climate Action Plan.

The Risk and Resilience Management Process

VTrans used nationally recognized best practices in developing its TAMP's risk management plan. It followed the process required in 23 CFR 515.7(c) that identifies specific steps. The steps resemble those in the international risk management standard developed by the International Organization for Standardization, (ISO 31000), and in the AASHTO Guide for Enterprise Risk Management. Detailed documentation about how VTrans complied with the 23 CFR Part 515 risk management analysis is available in Appendix A. Figure 5-1 illustrates the steps and process used by VTrans.

[11] FHWA-HEP-21-036 - Incorporating Resilience into Agency Initiatives: Vermont Agency of Transportation



1. Establish the context by reviewing the TAMP objectives and current social, economic, climatic events
2. Identify risks to the TAMP objectives
3. Analyze the risks for their likelihood, impact, and consequence
4. Evaluate and prioritize risk for mitigation
5. Manage the risks based on priority and implement mitigation strategies
6. Monitor, review and revise risk priorities and mitigation strategies
7. Communicate and consult with stakeholders who help identify changes in the risk environment

Figure 5-1: ISO/AASHTO risk management process which guided VTrans' risk management analysis.

Risk Management for the TAMP

As part of is TAMP update, VTrans followed a risk management plan development process structured to capture insights from multiple subject matter experts (SMEs) and to produce a robust, certifiable risk process. The process included the preparation of a detailed risk register which identified risks as well as mitigation strategies for substantive risks.

Developing the Risk Register

Figure 5-2 shows the six steps that VTrans used to develop a risk register for the 2023-2032 TAMP.

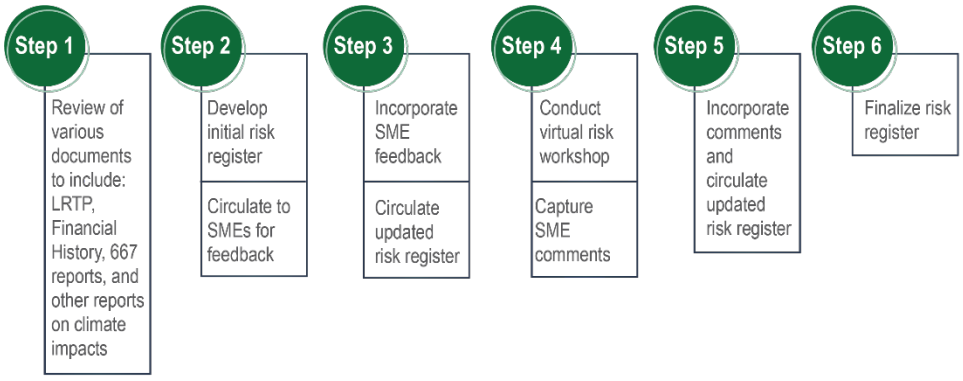


Figure 5-2: VTrans Risk Register Development Process for the 2023-2032 TAMP

For Step 2, a draft risk register identified numerous potential risks to achieving the VTrans TAMP objectives, including those previously identified during the original

2018 TAMP development process. The draft risk register was circulated among 24 VTrans subject matter experts (SMEs) for review. It also was circulated to the Vermont FHWA Division and the Chittenden County Regional Planning Commission (CCRPC). Comments were solicited and SMEs were asked to add, delete, and/or amend risks and the likelihood and impact values associated with each risk.

For Step 4, a risk workshop engaged the SMEs to collaboratively refine and assess the risks to the TAMP objectives, prioritize them, and identify risk-response strategies. Following the steps in 23 CFR 515.7(c) and the AASHTO risk management guide, the SME participants:

- Reviewed the initial risks and modified them to develop a final set of risk statements. A total of 45 risks were selected.
- Developed consensus values for the likelihood and impact. Both likelihood and impact were rated on a 1-5 scale. A score of 5 indicated the most likely and the most impactful. The two ratings were multiplied to generate a Risk Value ranging from 1 to 25. Based on the computation, the highest potential Risk Value that any risk receives is 25.
- Prioritized the risks based on the Risk Value.
- Discussed, refined, and developed risk mitigation strategies for all the top priority risks. A total of 129 mitigation strategies are included in the final risk register.

Table 5-1 includes the highest ranked risks identified in the risk register developed as part of the risk management exercise (provided in Appendix B), plus three additional highly ranked risks identified subsequent to the risk management exercise, (denoted with *). Risks were identified in six categories: resilience and extreme weather; bridges; pavements; workforce and knowledge management; information and data risks; and funding and economics.

Risk Statement	Types of Response/Mitigation
Resilience and Extreme Weather Risks	
If climate change brings more extreme weather to Vermont, then the higher temperatures, freeze-thaw cycle frequency, and storm frequency will increase stresses on bridges that shorten their life span.	Identify at-risk bridges and develop resilience plans for them Revise bridge standards to prepare for climate change Train staff to use climate-change analysis tools
If flooding increases, then transportation system resiliency may decrease.	Monitor, forecast, and implement resilience strategies Ensure frequent scour inspections Capitalize on the VTrans Transportation Resilience Planning Tool

If VTrans does not conduct routine maintenance on their assets, keeping them functioning properly and in good condition, then we risk losing out on federal ER funding when facilities are damaged in an ER-eligible storm event due to the asset being in poor condition prior to the event.	Maintain assets in good condition Use the VAMIS backlog list to prioritize maintenance Align budgets with routine maintenance needs Encourage maintenance/asset management collaboration
Bridge Risks	
If the state does not remain vigilant to plan for and address the needs of the state's short structures inventory (i.e., large culverts 6'-20') over the next 10 years, then there is an increased risk of impact to the safety and mobility of the traveling public due to unplanned closures.	Identify, inspect, and assess the short structures Dedicate funding for such high-priority assets Review climate impacts on short structures
*Increased deterioration associated with heavy trucks, including those in excess of federal bridge formula requirements.	Evaluate the impacts of overweight trucks and potentially reconsider the current exemption from federal bridge formula requirements.
If we do not address short structures that have outlived their expected life, then these tend to deteriorate quickly and pose increasing risk of roadway or slope failure.	Allocate funding for the older short structures Strengthen inspection
Pavement Risks	
*Increased deterioration associated with heavy trucks, including those in excess of federal bridge formula requirements.	Evaluate the impacts of overweight trucks and potentially reconsider the current exemption from federal bridge formula requirements.
If construction is poor quality, then the intended service life will be reduced, and public perception will be jeopardized.	Consider incentives/disincentives Require specifications within limits Adequate staff construction oversight Offer, require inspection training
Workforce and Knowledge Management Risks	
If VTrans does not develop retention strategies and succession planning strategies, then the agency will continue to lose institutional knowledge that can result in poor decisions and lower quality work.	Use bureau-level workforce assessment of needs Use individual development plans Aggressively recruit

If VTrans does not identify mission-critical job functions and competencies needed to perform them and staff skills and gaps, then the agency will not know where its greatest workforce risks are.	Conduct bureau-level job needs assessments Identify needed competencies Develop plans to improve, sustain needed skills
Information and Data Risks	
If SMEs do not maintain their source data sets, then VAMIS will not generate appropriate recommendations.	Maintain in VAMIS the links between asset condition, project development, and inventory Simplify data collection, entry Develop data management plans Allocate necessary resources
If data is missing key analysis variables such as project completion dates, pavement distresses, and bridge element conditions, then management system analyses will not select appropriate treatments and life-cycle cost analyses cannot provide accurate benefit-cost analysis.	Develop plan to collect missing data Identify data needed for benefit/cost analysis Assess effort needed for desired data Plan for acquiring needed data
Funding and Economics	
If inflation continues at its current high levels, then our investment strategies will be inadequate to achieve our condition targets.	Closely monitor prices Develop contingency plans to adopt less-expensive treatments
*Revenue uncertainty associated with the increased electrification of vehicles relative to the historic reliance on fuel taxes.	Consider changes to transportation revenue sources, including possible mileage-based taxes or fees.

Table 5-1: Highly ranked risks and responses/mitigation strategies

Monitoring and Managing the Risks

Risks change over time, so ongoing monitoring of risks is an important step in the risk management process. This update of this risk registry was prompted as part of the TAMP update process. VTrans recognizes there is room for improvement in its regular and formal reassessment of and documentation of risks and their mitigations.

Ongoing Coordination and Communication

Periodic coordination and communication of the “risk environment” with key stakeholders such as the FHWA Division, the CCRPC, and internal VTrans offices and districts is important to ensure a common understanding of risks and mitigation efforts. VTrans uses the Transportation Resilience Planning Tool and Reducing Repeated Damage Risk tools on an on-going basis to proactively monitor and manage the highest priority asset risks. These tools are discussed in more detail in the later in this section.

Extreme Weather and Resilience

When Congress enacted the Bipartisan Infrastructure Law (BIL) in 2021, it amended the federal asset management plan statute to specifically require the TAMP's risk management analysis to consider extreme weather and resilience. Independent of that requirement, extreme weather and resilience have never been far from mind in Vermont.

Vermont is a mountainous state, with communities often built-in river valleys surrounded by rugged hills. The most common natural disasters are floods and their related impacts such as slope failures. A catastrophic flood in 1927 destroyed many of Vermont's bridges. More recently, in 2011, Tropical Storm Irene severely damaged large portions of Vermont's highway network. These and other localized but damaging storms have focused VTrans on improving the resilience of the highway network and have prompted VTrans to integrate mitigations for extreme weather and resilience into its planning, programming, and project development process.

VTrans updated its Part 667, Reducing Repeat Damage Plan, in 2022. As of mid-2022, VTrans is developing a Resilience Improvement Plan as described in IIJA PROTECT guidance released in 2022. The agency has developed a Transportation Resilience Planning Tool (TRPT) that identifies bridges, culverts, and road embankments vulnerable to damage from floods. At the time of project identification and prioritization, resilience considerations are one of eight criteria scored in the VPSP2 process.

In addition to focusing on pavements and bridges, VTrans is prioritizing attention to vulnerable and undersized culverts due to their critical role in maintaining network resiliency. The priority is pertinent to the TAMP in that funding for culverts often competes with funding available for pavements and bridges.

Part 667 Efforts

23 CFR Part 667 states that each state shall 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. By November 2018, each state was to analyze all sites on the NHS that were damaged more than once since January 1, 1997. The analysis for all non-NHS roads was required by November 2020. The Part 667 related analysis of damaged sites was limited only to damages that occurred during emergencies that were officially declared by the President or Governor.

FHWA does not review or approve the list of Part 667 sites. However, an evaluation is required for listed sites prior to projects being added to the STIP. The evaluation includes consideration of alternatives that will mitigate or resolve the root cause of the recurring damage. FHWA has indicated that it is important for agencies to keep a current list of damaged sites and to update the list after each emergency declared by the Governor or President. The last governor declared emergency event that resulted in Emergency Relief Program eligible sites occurred in October 2019.

VTrans has embraced the Part 667 requirements as an opportunity to advance risk and resilience management efforts. The agency has developed two tools to inform decisions related to asset risk and resiliency. One is the Reducing Repeat Damage Tool[13] and the other is the Vermont Transportation Resilience Planning Tool.

The Reducing Repeat Damage Webtool

As part of the Part 667 process, VTrans staff developed a web-based Reducing Repeat Damage Webtool. Previously completed Detailed Damage Inspection Reports (DDIRs) of sites damaged during governor or president-declared events were compiled into this single, accessible database. The effort identified 217 locations on the Federal Aid System (FAS) damaged in multiple emergency events. Of those locations, 21 were damaged three times, and 13 sites were on the NHS. The Part 667 process influenced this TAMP's identification of climate change and extreme weather as a risk by identifying sites for further analysis and establishing a database that will be maintained with future events. A more detailed discussion of the Repeat Damage analysis, tool, and mitigation actions can be found on VTrans' website at the following link: *https://bit.ly/Repeat_Damage*

The Transportation Resilience Planning Tool

As part of its comprehensive approach to managing the risks from extreme weather and climate change, VTrans has developed the TRPT. This web-based application identifies bridges, culverts, and road embankments that are vulnerable to damage from floods; estimates risk based on the vulnerability and criticality of roadway segments; and identifies potential mitigation measures based on the factors driving vulnerability.

The TRPT allows a user to identify the vulnerability of a road, bridge, or culvert to flood inundation, erosion, and deposition hazards. The tool also assesses the criticality of an asset by its importance in moving goods and people or accessing key destinations such as hospitals. It also combines the vulnerability and criticality to support prioritization of at-risk assets as well as mitigation strategies. Finally, the TRPT also suggests an initial list of mitigation strategies to reduce the risks.

Figure 5-3 provides an example of the information provided by TRPT. This example shows a site with a vulnerability score of 10 out of 10 on Route 73 in the town of Rochester. The TRPT indicates that it faces risks from erosion and deposition with a negligible risk from inundation. The TRPT suggests 20 potential mitigation strategies that could be considered if a project were to be developed at that location. This is one of many examples of assets that can be reviewed using the TRPT Tool.

The TRPT complements the Part 667 process, proactively identifying vulnerabilities to avoid or mitigate against the impacts of future damage.

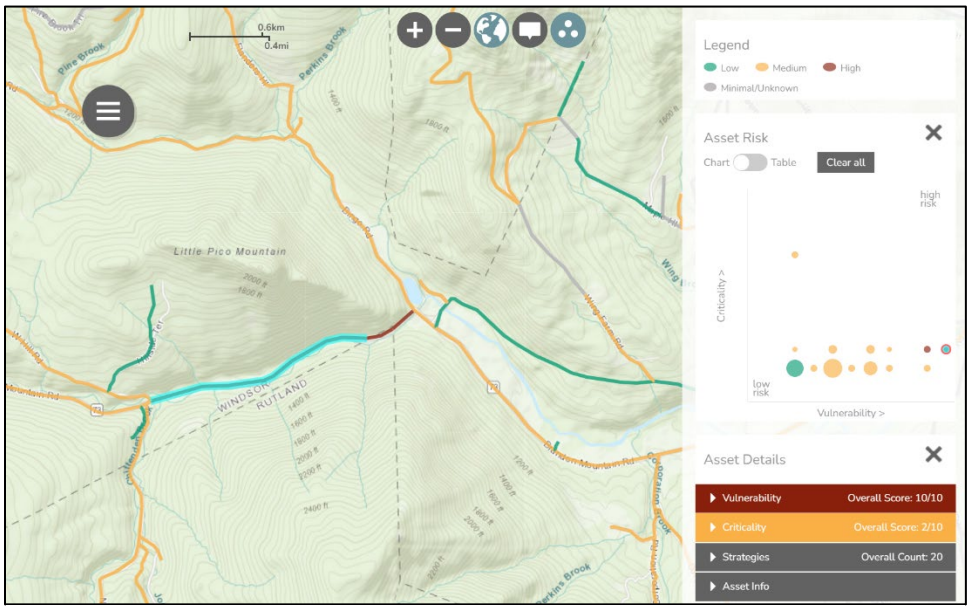


Figure 5-3: A screen capture of the TRTP analysis for Route 73 near Rochester.

Additional Steps to Manage Risks from Extreme Weather and Climate Change

Other steps that VTrans has taken to reduce the risk of extreme weather and climate risks include:

- Updating of its Hydraulics Manual, Hydraulic Standards, and Town Highway Road and Bridge Standards.
- Contributing to the Vermont Hazard Mitigation Plan developed by the Vermont Emergency Management agency.
- Collaborating with the Vermont Agency of Natural Resources and other state agencies to improve natural disaster-related emergency response through coordinated collection of damage information.
- Incorporating resilience scoring and weighting into the VPSP2 project selection and prioritization process.
- Adopting and implementing an incident management system to facilitate communication and coordination within VTrans and externally with partner agencies and the State Emergency Operations Center.
- Developing a Continuity of Operations Plan which involves assessing all agency mission-essential functions and analyzing how to continue carrying out these functions safely, efficiently, and effectively in the long term.

Financial Risks

The financial risks identified in the VTrans Risk Register include increased costs, reduced revenues, or both. The Financial Plan section of this TAMP describes

various inflation and revenue assumptions, 10-year cost and revenue projections during the TAMP period, and the related uncertainties that can impact the projections derived from those assumptions. It presents a high-level sensitivity analysis that shows the impact of uncertainties associated with key parameters

such as inflation and revenues on the financial plan. The impacts of these uncertainties are demonstrated through estimates of the variability in funding gaps under various assumptions of inflation and revenues over the ten-year plan period.

Section 6: Financial Planning

This asset management financial plan describes VTrans' current understanding of available funding, the financial needs to keep its pavements and bridges in a state of good repair, and funding gaps that may impact the achievement of performance objectives.

VTrans' activities are supported by state and federal funds allocated across several programs to achieve a complex set of performance objectives. These objectives include attaining performance targets, increasing resilience in a changing climate, promoting active transportation and supporting local communities, and complying with state and federal requirements. This financial plan considers how VTrans balances these competing needs with its investments in NHS pavements and bridges, as required in the TAMP.

Specifically, this Financial Plan:

- Presents an estimate of the total revenues that VTrans expects to receive from FY 2023 through FY 2032
- Estimates the funds projected to be available for pavements and bridges
- Estimates funding needs to keep NHS pavements and bridges in a state of good repair
- Estimates the funding gaps between the revenues likely to be available for pavements and bridges relative to their needs
- Discusses the uncertainties surrounding the 10-year forecast, including uncertainties regarding economic growth, fuel consumption, and inflation
- Documents compliance with the FHWA regulations for developing the asset management financial plan
- Documents the alignment of the TAMP with the State Transportation Improvement Plan and other planning documents.

Additional information on the VTrans financial planning process is provided in Appendix C.

Federal Requirements

The FHWA asset management rule requires a financial plan that spans ten years or longer. The rule states that the plan must present "a State DOT's estimates of projected available financial resources and predicted expenditures in major asset categories that can be used to achieve State DOT targets for asset condition during the plan period, highlighting how resources are expected to be allocated based on asset strategies, needs, shortfalls, and agency policies." Plans also must specify the estimated funding levels that are expected to be reasonably available by fiscal year. The DOTs are to show how these projected funds will be allocated to NHS pavements and bridges by the five federal work types: initial construction, maintenance, preservation, rehabilitation, and reconstruction.

Linkages to Planning and Programming

The TAMP financial plan links the LRTP to the programming objectives in the Statewide Transportation Improvement Program (STIP). The first four years of this financial plan align with the four-year STIP. The remaining six years of the financial plan are built upon our best available estimates of forecasted revenues and longer-term pavement and bridge needs.

Revenue Sources and Trends

Overview

VTrans has a total transportation budget of $838.1 million in its State Fiscal Year (SFY) 2023 budget, funded through a combination of federal, state, local, and internal service sources. Figure 6-1 shows the SFY 2023 budget by funding source, illustrating that VTrans relies heavily on federal funding to maintain and operate its transportation system.

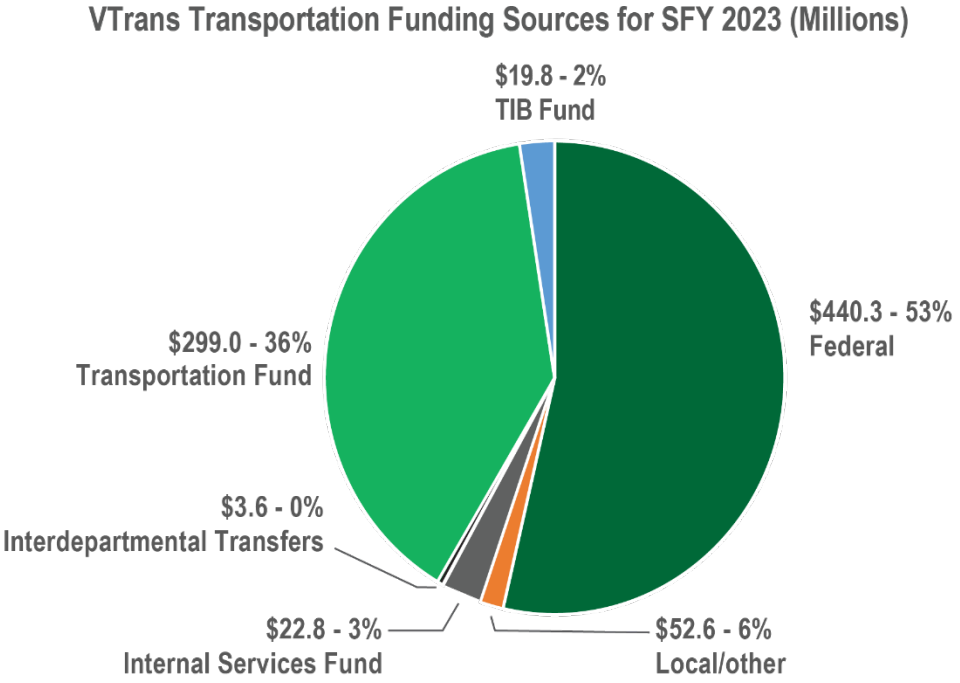


Figure 6-1: Sources of Transportation Funding in Vermont, SFY 2023 (Millions)

State Funding Sources and Trends

State transportation revenues for VTrans currently come from two funds – the Transportation Fund and the Transportation Infrastructure Bond (TIB) Fund. The Transportation Fund has the following six sources of revenue:

1. A fixed cent-per-gallon gasoline tax
2. A fixed cent-per-gallon diesel fuel tax
3. A gasoline percentage-of-price assessment with a minimum and maximum cent-per-gallon equivalent
4. A motor vehicle purchase and use tax (6 percent split - 4 percent to the Transportation Fund and 2 percent to the Education Fund)
5. Motor vehicle fees
6. Other revenue (other small transportation related taxes and fees)

The TIB Fund has two sources of revenue:

1. Assessments on gasoline sales
2. Assessments on diesel sales

The gasoline and diesel taxes and assessments currently applicable in Vermont are summarized in Table 6-1.

Consumption Based Revenue Breakdown (in cents/gallon)								
Fuel Type	Tax	Transportation Fund Assessment			TIB Assessment			Cleanup Fee
		%	Min	Max	%	Min	Fixed	
Gasoline	12.10	4%	13.40	18.00	2%	3.90		1.00
Transportation Fund	11.345							
DUI Fund	0.380							
Fish & Wildlife Fund	0.375							
Cleanup Fund								1.00
Diesel	28.00						3.00	1.00

Table 6-1: Gasoline diesel levies in Vermont as applicable to the Transportation Fund and the TIB Fund.

Figure 6-2 shows the historical contribution of revenues to the Transportation Fund since 2000. Revenues have risen from approximately $180 million in FY 2000 to approximately $283 million in FY 2021. Of note are a drop in FY 2009 associated with the "great recession", and a drop in FY 2020 associated with the COVID pandemic. Also noteworthy is the decline of gasoline and diesel revenues since 2014, due in large part to increased vehicle fuel efficiency. More details can be found in Appendix D.

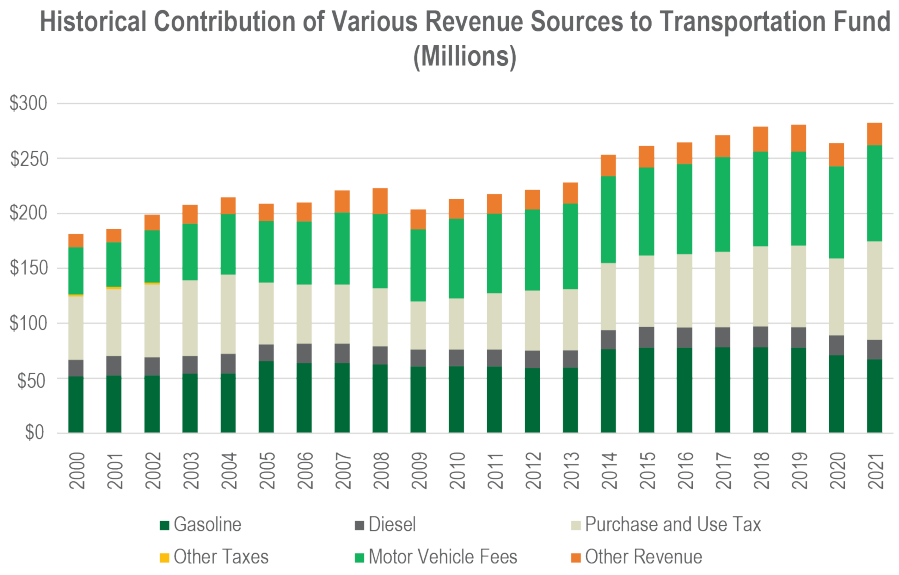


Figure 6-2: Breakdown of Historical Vermont Transportation Fund Revenues. (Source: Vermont Legislative Joint Fiscal Office)

Federal Sources and Trends

VTrans historically receives federal funds for managing aviation, transit, rail, roads and bridges, and other assets. The bulk of funding available for pavements and bridges come from FHWA formula funds.

Figure 6-3 shows the total federal transportation revenues for Vermont over the last 20 years. Federal funding was at its peak from 2013 through 2015 due to several Emergency Relief (ER) and Federal Emergency Management Agency (FEMA) projects resulting from Tropical Storm Irene and funds provided through the American Recovery and Reinvestment Act. Funding then normalized through 2020 and increased in 2021 with the arrival of COVID stimulus funds. Except for the short-term increased funding observed between 2013 and 2015, these funds have shown a steady annual increase with a 20-year Compound Average Growth Rate (CAGR) of approximately 3.8 percent.

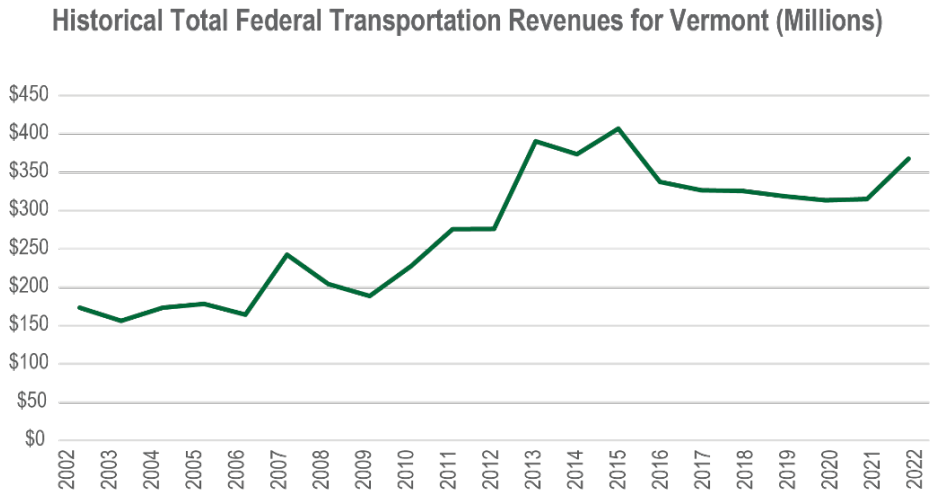


Figure 6-3: Federal Revenues from 2002 through 2021

Historical Expenditures on Pavements and Bridges

Figure 6-4 shows the program expenditures over the last six fiscal years for the paving and roadway programs. Note that some of the expenditures in the roadway program were utilized for other activities such as slope stabilization, traffic management improvements, and culvert repairs which do not significantly impact system-wide pavement conditions. During this period, approximately $137 million was invested annually in these programs.

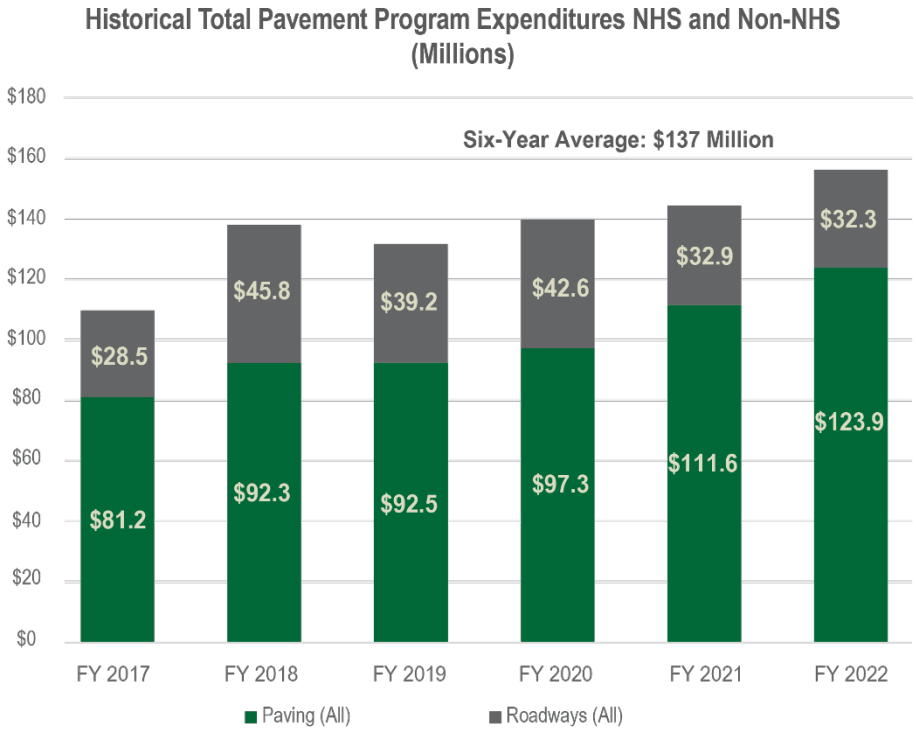


Figure 6-4: Historical Pavement Expenditures

Figure 6-5 shows the total bridge program expenditures for the last six fiscal years on NHS and non-NHS bridges. During this period, an average of approximately $100 million was invested annually in all bridges.

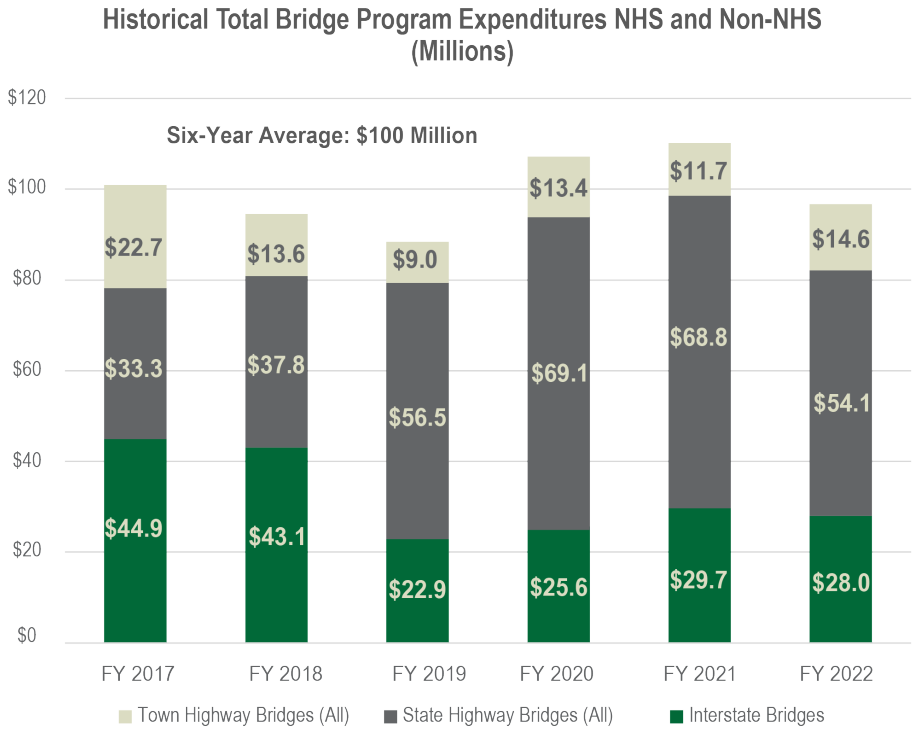
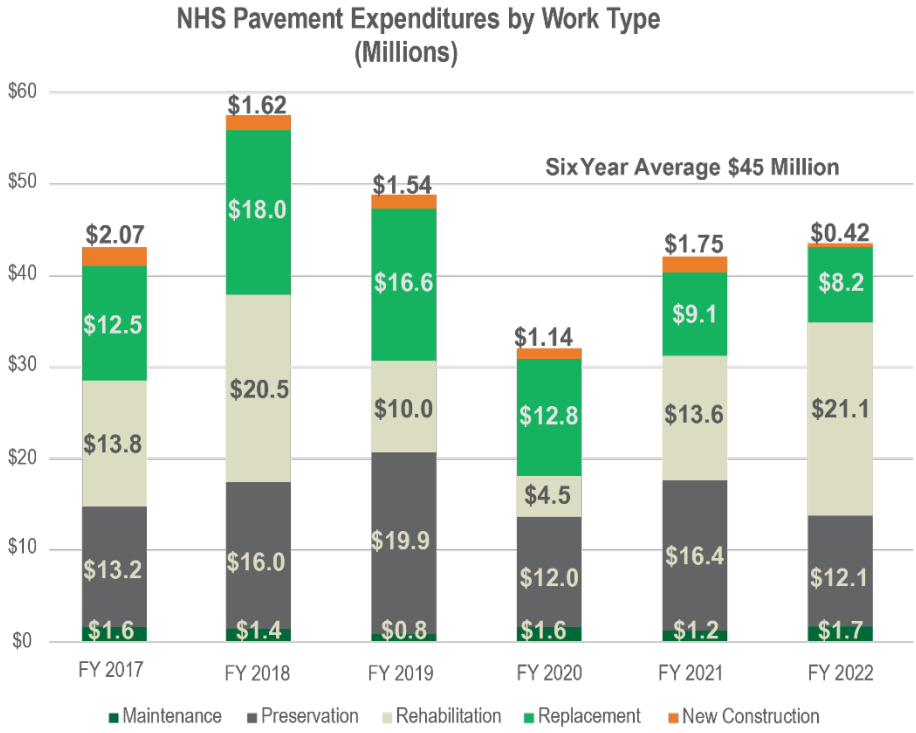


Figure 6-5: Historical Total Bridge Expenditures

Historical NHS Pavement and Bridge Expenditures by Work Types

VTrans invests in a mix of maintenance, preservation, rehabilitation, and reconstruction treatments. This "mix of fixes" illustrates the application of life-cycle strategies to treat assets with lower cost maintenance, preservation, and rehabilitation strategies before they require more expensive reconstruction or replacement.

Figures 6-6 and 6-7 show the historical annual average expenditures by VTrans over the last six fiscal years for NHS pavements and NHS bridges by the federal work types. The six-year average proportional spending by work type is also shown, since individual project spending within a given year causes significant year-to-year variability.



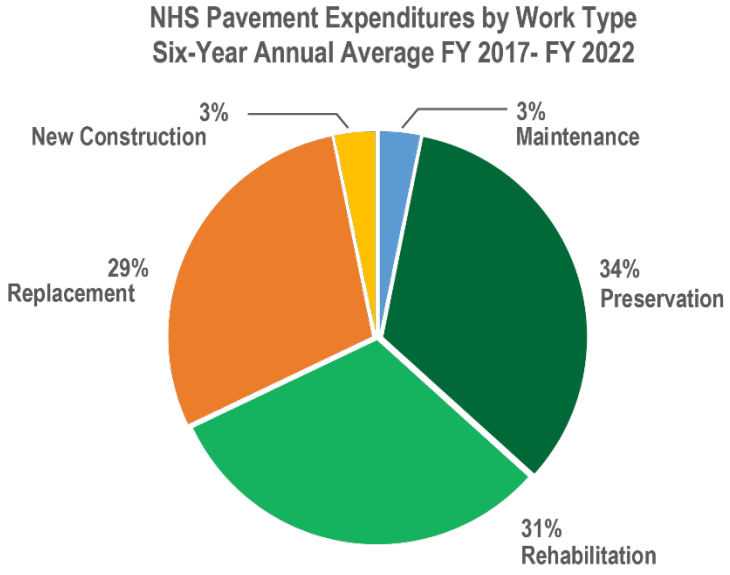
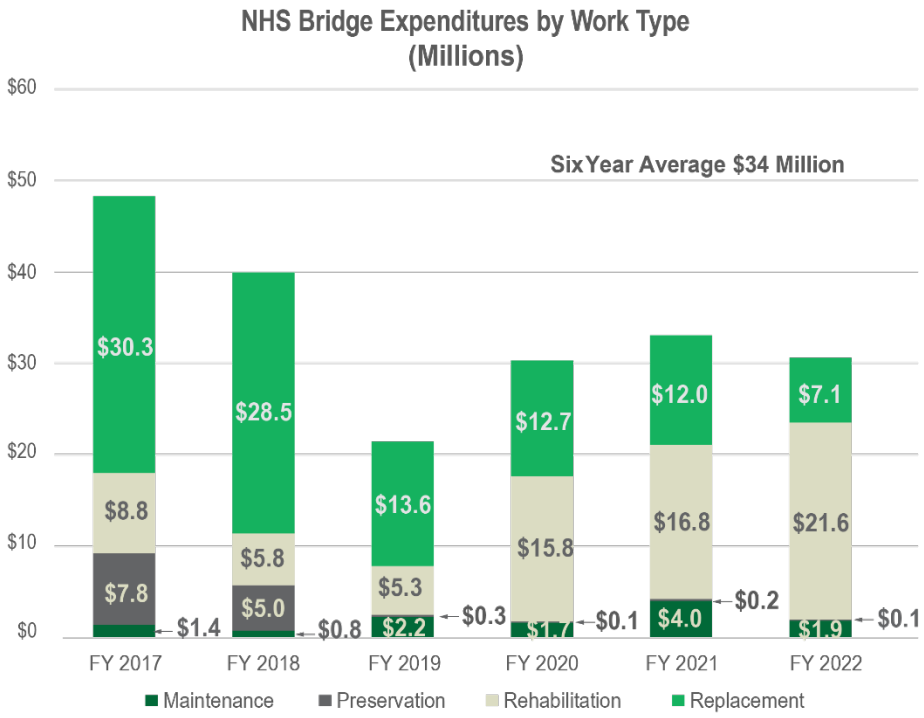


Figure 6-6: Historical NHS pavement expenditures by work type



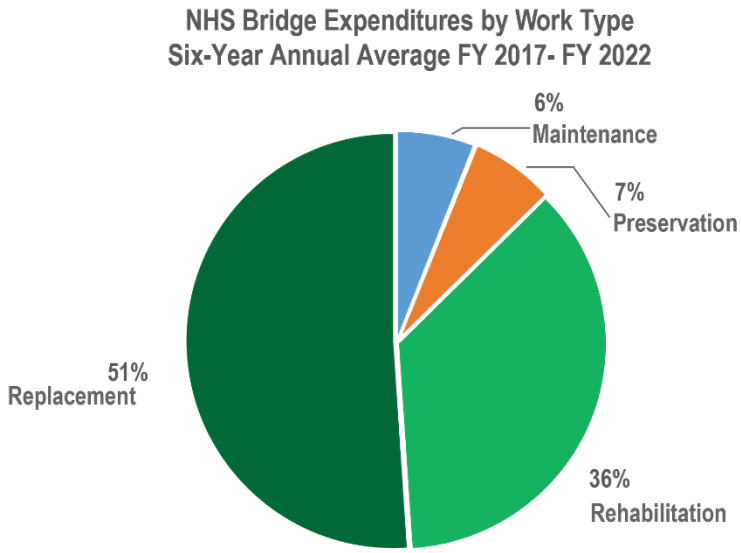


Figure 6-7: NHS Historical Bridge Expenditures by Work Type

Projected Total Revenues

Over the 10-year period of this TAMP, VTrans Office of Financial Management projects total revenues of approximately $8.4 billion from state and federal sources. Federal funds are expected to continue to be the dominant source, driven in the coming years by the state apportionments outlined in the Infrastructure Investment and Jobs Act of 2021 (IIJA).

Vermont anticipates that Federal funds will contribute approximately 57 percent of the total revenues for the 10 years, while the State's Transportation and TIB funds are projected to contribute approximately 39 percent of the total 10-year revenues.

Figure 6-8 illustrates these current projections.

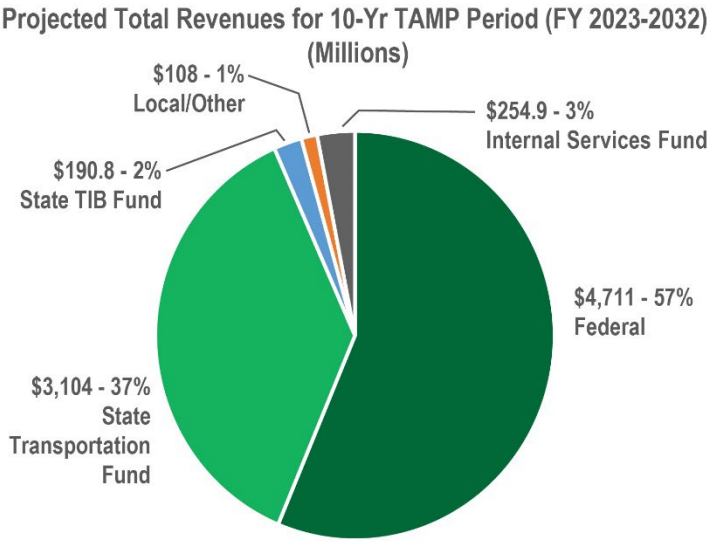


Figure 6-8: Total Revenues from All Sources of Transportation Funding in Vermont for FY 2023 - 2032

Figure 6-9 illustrates the year-by-year projections, with the projected average annual revenue from state sources (Transportation Fund and TIB Fund) at approximately $329 million, and the projected annual average federal revenue at $471 million. The FY 2023 amounts reflect those of the approved Capital Program. The amounts for the remaining nine years from FY 2024 through FY 2032 are based on the estimated revenue projections from federal, state, and other sources.

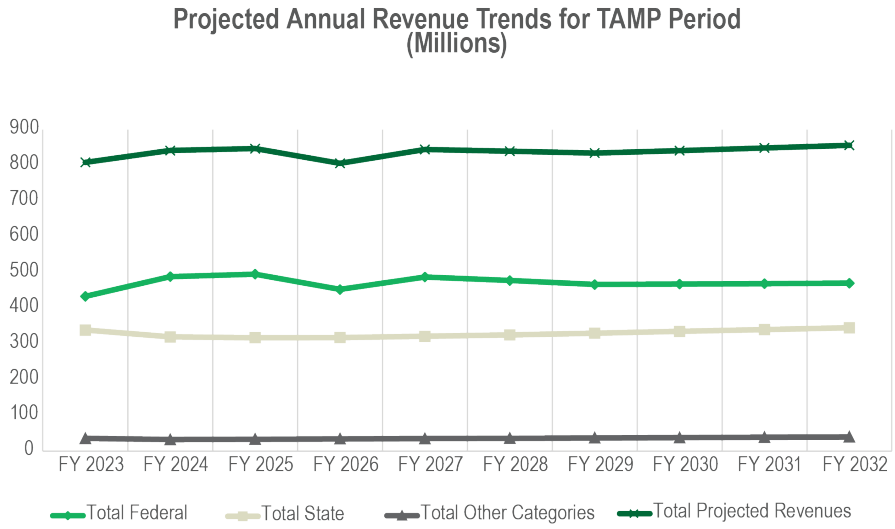


Figure 6-9: Annual revenue projection trends for FY 2023 – 2032

Note that for many decades, growing fuel consumption generated small but predictable annual fuel-tax revenues. In recent years, apart from the drastic impact from COVID-19 and related travel reductions, fuel sales in Vermont have declined because of fuel efficiency standards and shifts to electric vehicles. However, total revenues have been sustained by increases in the motor fuel tax rates, new assessments placed on fuel and vehicles, and increases in FHWA funds. With the

encouragement of more electric vehicle usage in line with the 2021 Vermont Climate Action Plan, the number of electric vehicles in Vermont is expected to increase. This shift will necessitate a new revenue source in the future.

VTrans Methodology for Allocating Revenues to Various Programs

As noted earlier in this TAMP, VTrans' long-range vision is to have *"A safe, reliable, and multimodal transportation system that grows the economy, is affordable to use and operate, and serves vulnerable populations."* To achieve this vision, VTrans makes strategic investments to preserve and improve the conditions of highways, railroads, airports, bike paths, trails, sidewalks, and public transit infrastructure in the state.

Achieving the vision requires that funding decisions balance the needs of roads and bridges along with all the other important transportation priorities. For example, the roads and bridges will not be safe if snow and ice are not removed during winter. Similarly, investing in traffic control devices and safety are critical to ensuring the safety and efficiency of the highway network. Investing in public transit and other modes are important to mobility, quality of life, and emissions reductions. Each of these programs represent important priorities that VTrans must balance with the needs of the pavement and bridge programs.

The total FY 2023 revenues of $838 million fund a wide variety of needs. Based on recent years' investment allocations, approximately $541 million is estimated to be necessary to meet needs other than the paving, roadway, and bridge programs.

Projected Funding Availability for Pavements and Bridges

With $541 million of the SFY 2023 budget allocated to other needs, $279 million of total is available for the paving, roadway, and bridge programs.

Figure 6-10 shows the annual funds estimated to be available for NHS and non-NHS pavements and bridges over the 10-year TAMP period. These amounts are based on the paving, roadway, and bridge program budget amounts in VTrans' approved FY 23 Capital Program which includes projections for fiscal years 2024 through 2026. Fiscal years 2027 through 2032 are derived from the average of years 2024 through 2026, increased annually by an inflation factor of 1.5 percent.

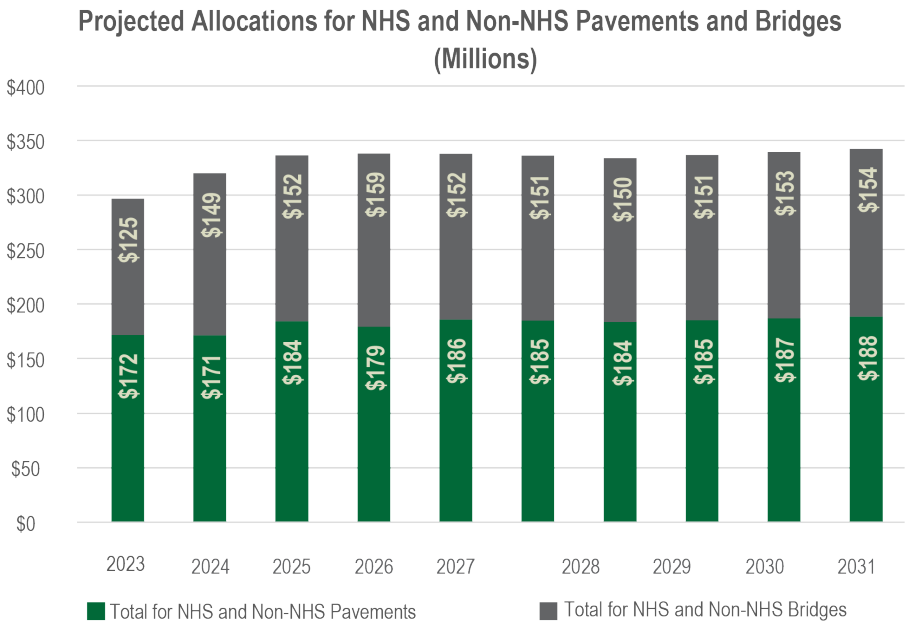


Figure 6-10: Projected funding allocations for all NHS and non-NHS pavements and bridges

Estimated Funding Needs for Pavements and Bridges

Funding needs, as described here, are the levels of funding necessary to meet existing commitments and the performance targets discussed in Section 3. They are based on PMS and BMS modelling as well as SME judgements of factors beyond the consideration of the models.

Pavement Needs

Figure 6-11 shows the projected funding needs for NHS and non-NHS pavements. This includes funds allocated to the dedicated paving program as well as to the roadway program for pavement related activities.

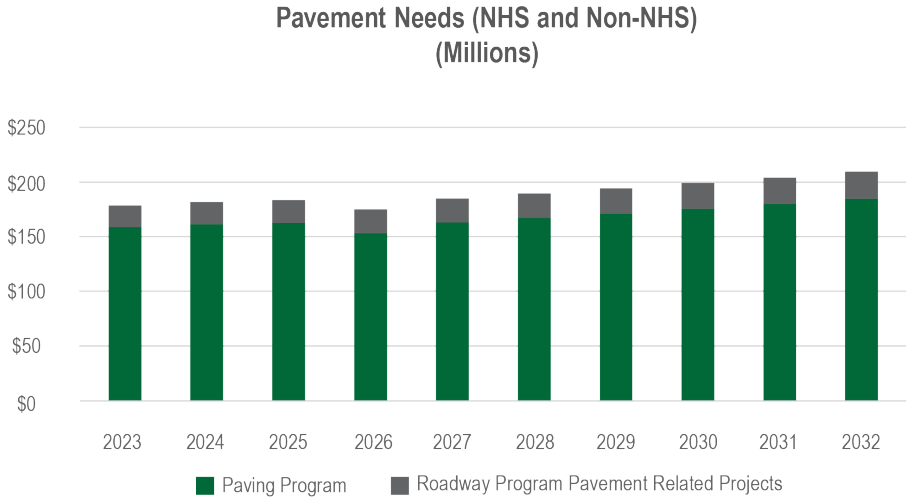


Figure 6-11: Projected needs for all pavements and roadways

The pavement needs for FY 2023 to FY 2026 are based the projects identified in the approved FY 2023 Capital Program, which includes cost estimates of committed projects ready for construction and those anticipated to be ready for construction in fiscal years 2023 through 2026. The FY 2023 Capital Program was developed based on historic trends, PMS analyses of varied scenarios to identify

the funding necessary to achieve performance targets, and the project selection process, as discussed in the Life-cycle Planning Section. Beyond FY 2026, the pavement needs were estimated by escalating the average estimated needs of the previous four years by 2.5 percent annually. The roadway program amounts are based on the amounts projected to be available for that program's pavement related work in FY 2023, escalated annually by 2.5 percent for the remaining nine years of the 10-year period.

Figure 6-11 shows the total estimated pavement needs increasing from approximately $179 million to approximately $210 million during the 10 years of the TAMP. These amounts represent the level of investment anticipated to be necessary to meet the federal and state performance targets for pavements.

Bridge Needs

Figure 6-12 shows the estimated needs for VTrans' bridge programs over the TAMP period. Bridge program needs are based on the funding levels in the approved FY 2023 Capital Program, adjusted upward for the purposes of the TAMP to reflect:

- The acknowledged need to do additional culvert work
- The need to develop and implement additional bridge preservation strategies
- A "bulge" of older bridges reaching the end of their design lives
- Acute current inflation of bridge construction costs relative to recent years

The figure shows the total needs increasing from approximately $165 million in FY 2023 to approximately $208 million in FY 2032, assuming an annual escalation of approximately 2.5 percent.

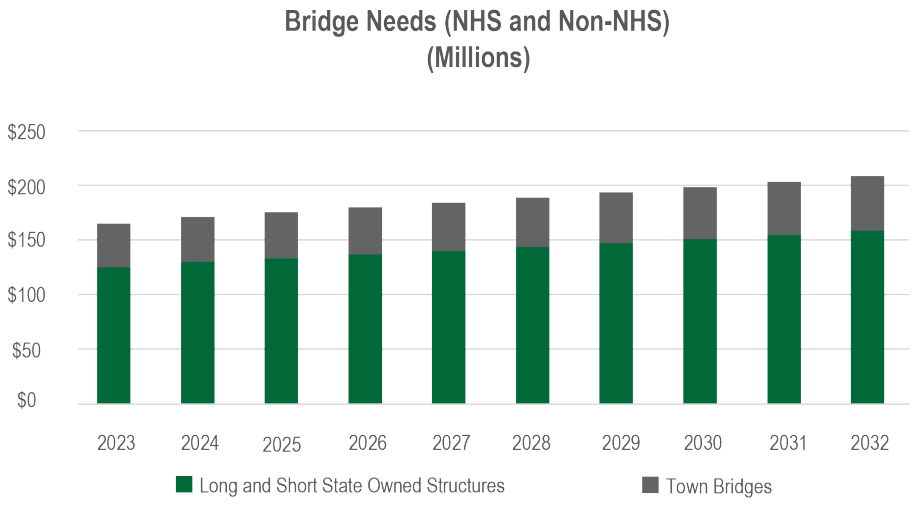


Figure 6-12: Projected needs for NHS and non-NHS bridges

These amounts represent the level of investment necessary to continue to meet the federal and state performance targets for bridges, including short structures.

Estimated Funding Gaps

Funding gaps are the differences between projections of available funding and the identified funding needs.

Figure 6-13 compares the annual estimated funding needs to achieve pavement performance objectives (shown in Figure 6-11) with the revenues expected to be available for pavements over the next ten years (shown in Figure 6-10). The projected gaps for pavements vary between a surplus of $4 million and a shortfall of $22 million for a total gap of $82 million over the 10-year TAMP period.

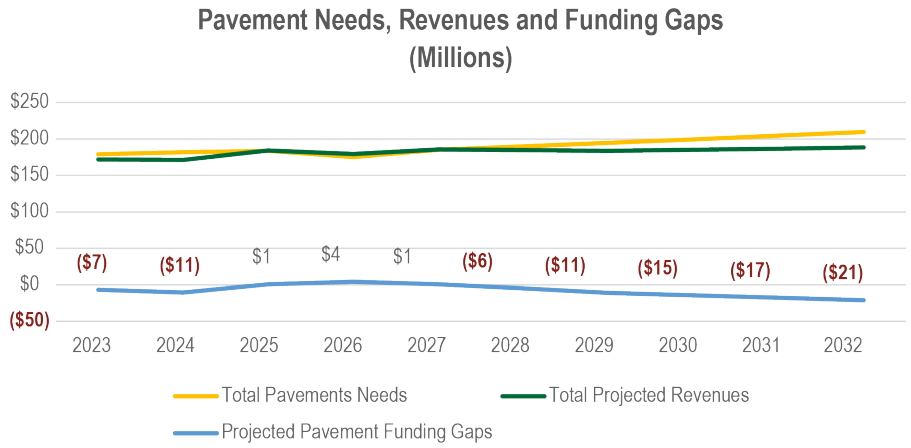


Figure 6-13: Annual funding gap between the estimated pavement allocations and estimated pavement needs

Figure 6-14 compares the annual estimated funding needs to achieve bridge performance objectives (shown in Figure 6-12) with the revenues expected to be available for bridges over the next ten years (shown in Figure 6-10). It shows an estimated annual funding gap for bridges ranging from $21 to $54 million during the 10-year TAMP period. This results in a total gap of $371 million over the 10-year TAMP period.

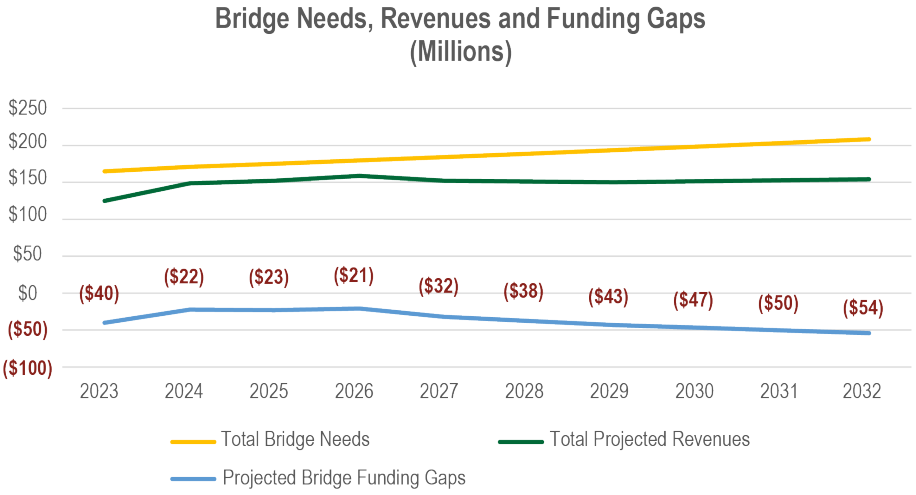


Figure 6-14: Annual funding gap between the estimated bridge allocations and estimated bridge needs

Figure 6-15 summarizes the estimated combined annual funding gap for pavements and bridges for the 10-year TAMP period. It shows a total need of $3.77 billion for all pavements and bridges. The estimated 10-year revenues for all pavements and bridges are $3.32 billion. This results in an estimated funding gap of $453 million over the TAMP period, with annual amounts varying between shortfalls of $17 million and $75 million.

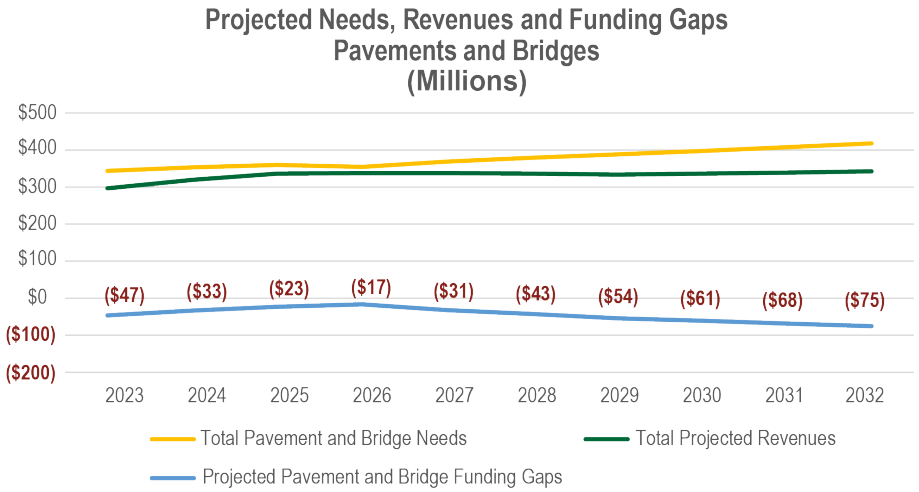


Figure 6-15: Estimated annual funding gap for pavements and bridges.

VTrans acknowledges that additional funds will be required to meet all its internal state of good repair targets over the ten-year period of the TAMP analysis and even more so over the longer term. In particular, interstate era pavements and bridges that are reaching the end of their service lives will require major rehabilitation and/or replacement projects within and beyond the horizon of this TAMP. Quantification of revenues and needs beyond the ten- year horizon of the this TAMP will be considered through the Long-Range Transportation Planning process.

Risks and Sensitivities

Key factors that influence this financial plan include uncertainties related to inflation and its impact on needs, as well as uncertainties that can impact projected revenues. Also, improved reliability of VTrans' project delivery process in recent years has strained funding commitments relative to the availability of federal funds. Changes to the VTrans budgeting process are under consideration that would focus more specifically on federal funding constraints. This may drive changes to the assumptions about available future revenues and the financial needs for currently committed projects whose schedules may be impacted.

A high-level sensitivity analysis was performed to evaluate the impact of variations in revenues and inflation rates on the projected funding gaps to illustrate the uncertainties in the financial projections. Revenues were varied in increments of 5 percent above and below the projected values up to 15 percent. Inflation rates were increased in increments of 1 percent, up to 6 percent over the base case assumption of 2.5 percent. Figure 6-16 summarizes the results of the sensitivity analysis. The analysis shows the projected funding gaps (base case values) and the upper and lower bounds of those projected values (for the assumptions listed) for each year of the TAMP. Additional details of various risks to the financial plan and the sensitivity analysis are provided in Appendix E.

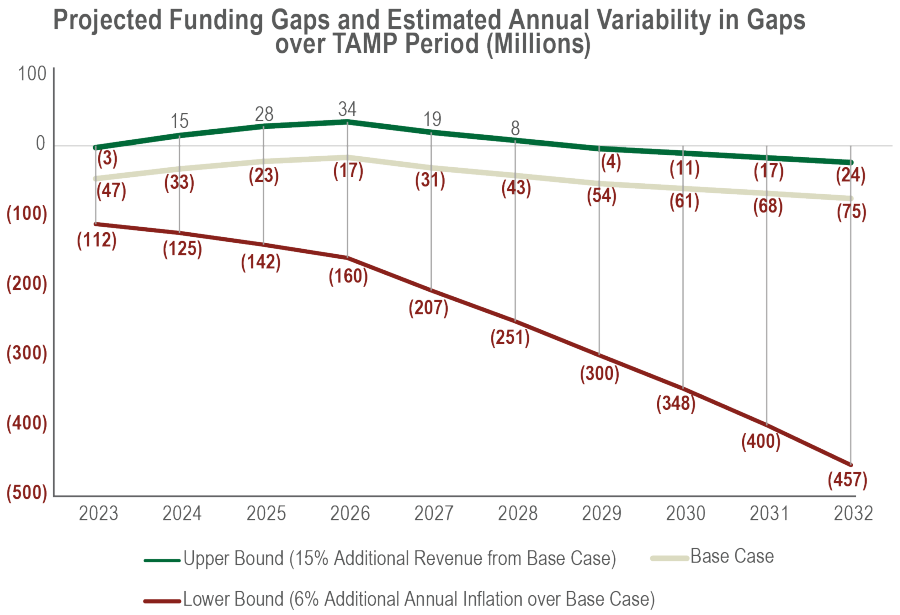


Figure 6-16: Projected Funding Gaps along with upper and lower bounds under various revenue and inflation assumptions (Source of Methodology: Starlsis Corporation, 2022)

Asset Valuation

Asset valuation is the assignment of monetary value to physical assets. An asset valuation analysis is another way to look at current and future funding gaps between resources and needs.

The following asset valuation analysis assesses the depreciated replacement costs of VTrans pavement and bridge assets and the degree to which its investments are adequate to sustain the long-term condition of the highway network. This analysis satisfies the FHWA requirement in 23 CFR 515.7(d)(4) that TAMPs include an estimate of the value of the agency's NHS pavement and bridge assets and the annual investments needed to maintain their value.

Basis for the Analysis

For the asset valuation analysis, VTrans computed the following measures using industry standard terms.

Replacement Value: The current cost to replace an asset in "as new" condition. The replacement value is computed based on current costs in Vermont to replace a lane-mile of NHS pavement or a square-foot of NHS bridge deck area to an "as new" condition.

Depreciated Replacement Cost: The Replacement Value depreciated by a condition-based Discount Factor to reflect the already consumed economic benefits of an asset.

Discount Factor: Factor(s) based on VTrans' typical pavement and bridge deterioration models.

Asset Consumption Ratio: The ratio of Depreciation Replacement Cost to Replacement Value, describing the remaining value of an asset considering its current condition.

Asset Sustainability Ratio: Estimated expected annual investment in an asset divided by the annual investment required to offset asset depreciation. A 100% ASR would mean that investments are expected to be made at a level which offsets

the ongoing depreciation.

NHS Pavement Valuation

The results of the pavement valuation analysis are shown in Table 6-2. Details on how the Depreciated Replacement Cost was computed is provided in Appendix F.

Key Pavement Asset Valuation Figures and Ratios ($ in millions)	
NHS Lane Miles	2,187
Replacement Cost per Mile	$3.4
Total Replacement Cost	$7,512
Depreciated Replacement Cost (DRC)	$5,452
Asset Consumption Ratio (ACR)	73%
Average Annual NHS Pavement Investment Allocation (Appendix E, Table E-11)	$57.5
Annual Investment Needed to Offset Depreciation	$83
Asset Sustainability Ratio (ASR) for NHS Pavements	69%

Table 6-2: NHS pavement asset values, ACR and ASR

NHS Bridge Valuation

The results of the bridge valuation analysis are shown in Table 6-3. Details on how the Depreciated Replacement Cost was computed is provided in Appendix F. This analysis uses 2021 submittal data.

Key Bridge Asset Management Figures and Ratios ($ in millions except where stated)	
Number of NHS Bridges	484
Area in Sq Ft	4,534,399
Replacement Cost $ per Sq Ft (not in millions)	$773
Total Replacement Cost	$3,504
Depreciated Replacement Cost (DRC)	$2,584
Asset Consumption Ratio (ACR)	74%
Average Annual Investment Allocation for NHS Bridges (Appendix E, Table E-12)	$71
Annual Investment Needed to Offset Depreciation	$87
Asset Sustainability Ratio (ASR)	82%

Table 6-3: NHS bridge asset values, ACR and ASR

Overall Asset Valuation

The key asset valuation data for NHS pavements and bridges combined is summarized in Table 6-4.

Key Asset Valuation Data for NHS Pavements and Bridges ($ in millions)	
Total Replacement Cost of NHS Bridge and Pavement Assets	$11,016
Depreciated Replacement Cost of NHS Bridge and Pavement Assets (DRC)	$8,036
Asset Consumption Ratio (ACR)	73%
Average Annual Investment Allocation for NHS Pavements and Bridges	$128
Annual Investment Needed to Offset Depreciation	$170
Asset Sustainability Ratio (ASR)	76%

Table 6-4: Asset Valuation analysis results for NHS pavements and bridges in Vermont

Figure 6-17 shows the impact to the ASR under different revenue growth

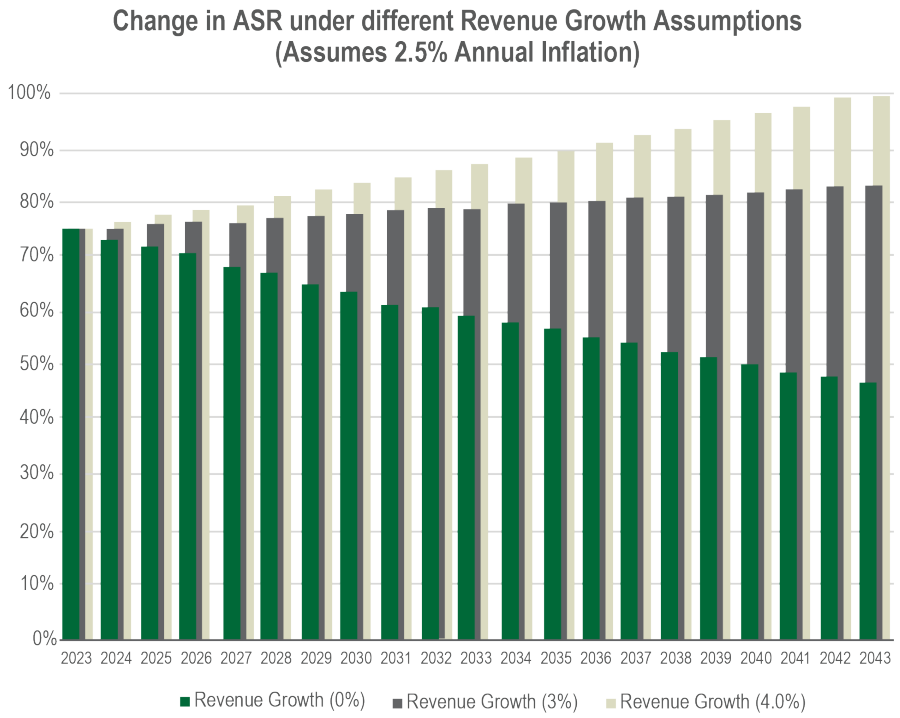


Figure 6-17: Estimated Change in ASR for different revenue growth assumptions assuming an annual inflation rate of 2.5 percent

assumptions with an annual inflation of 2.5 percent. It shows that the bridge and pavement annual allocations would have to increase by 4.0 percent annually over 20 years to achieve an ASR of 100%.

Section 7: Investment Strategies

VTrans uses asset management principles to guide its investments in its network of pavements and bridges. It considers projected funding levels and anticipated costs and applies a life-cycle planning approach to sustain and improve the condition of pavements and bridges over their entire life. This analysis, selection, and investment process ensures that performance gaps are minimized and that asset risks are managed through the implementation of appropriate projects.

Federal regulation 23 CFR 515[12] [13] requires State DOTs to establish a process for developing investment strategies that support progress toward:

- Achieving and sustaining the desired state of good repair over the life cycle of the assets;
- Improving or preserving the condition of the assets and performance of the NHS relating to physical assets;
- Achieving state DOT targets for asset condition and performance of the NHS in accordance with 23 USC 150(d); and
- Achieving the national goals identified in 23 USC 150(b).

This section describes VTrans' approach to selecting the optimal investment strategies to meet these objectives.

The VTrans Process

VTrans develops its investment strategies using the following process:

- **Estimate anticipated available funding:** Estimate annual investment levels for pavements and bridges.
- **Use life-cycle planning:** Consider treatment alternatives and predict future network conditions at various funding levels using the pavement and bridge management systems.
- **Assess risks:** Identify locations and assets that are at particular risk due to condition, weather vulnerability, structure type and design, and evaluate them using various tools and methodologies such as inspection findings, the Transportation Resilience Planning Tool (TRPT), and risk workshops
- **Analyze performance gaps:** Consider the gaps and trends in achieving performance objectives based on funding, competing interests, and other limitations.
- **Refine investment strategies:** Identify optimized strategies of treatment recommendations that best meet condition and performance objectives.
- **Select projects:** Management system recommendations and subject matter expertise are combined with community input through the VPSP2 process[14]. That process evaluates and quantifies the safety, mobility, connectivity, resiliency, environment, asset management recommendations, economic access, and health access concerns and identifies a single "transportation value" which helps identify and prioritize potential projects. Selected projects are programmed, and design commences.

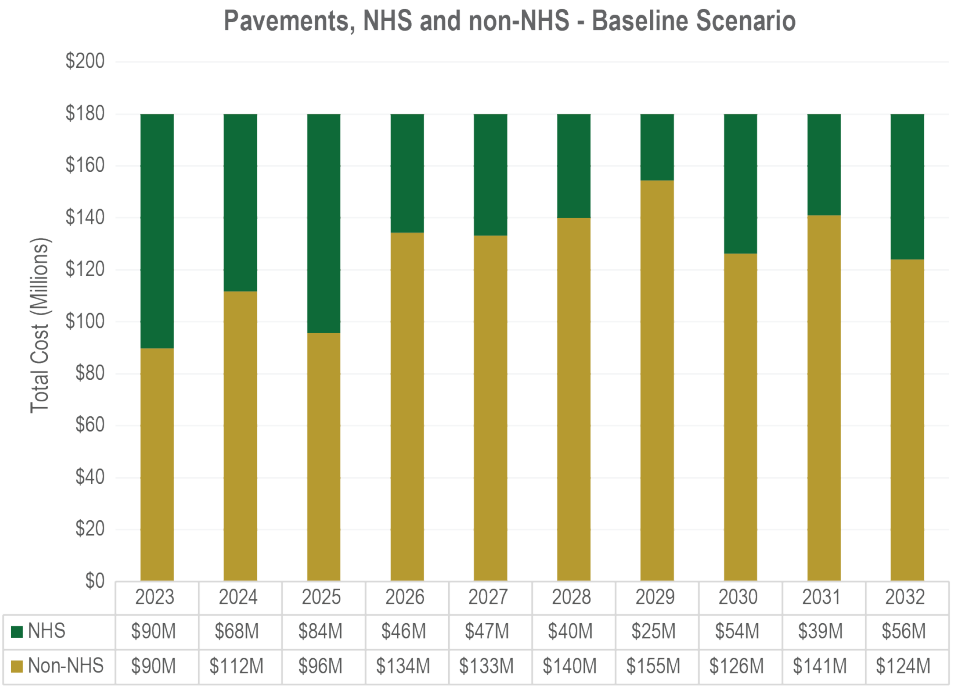
[12] 23 CFR 515.7(e)
[13] 23 CFR 515.9 (f)
[14] More information about the VPSP2 process can be found at: https://vtrans.vermont.gov/project-selection

Pavement Investment Strategies

To develop the pavement investment strategies described in this TAMP, VTrans used its PMS to analyze its overall pavement network. Information particular to the NHS subset has been filtered out and is presented here.

This TAMP presents a baseline funding scenario of $180 million annually for the years 2023 through 2032. The $180 million scenario was selected as it best matched the pavement network needs identified in the Financial Planning section as the level appropriate to meet performance targets.

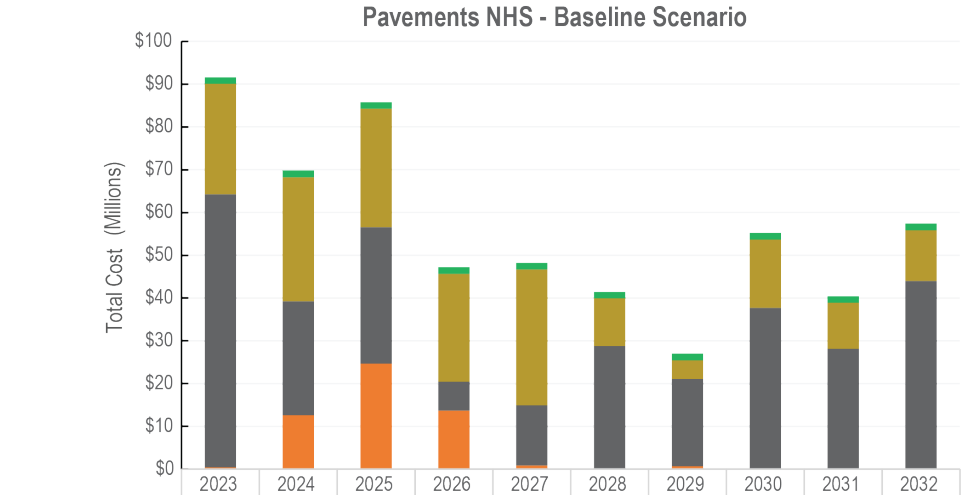
Figure 7-1 shows how the PMS allocates a $180 million annual investment among NHS and non-NHS pavements over the years 2023 through 2032.



	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
NHS	$90M	$68M	$84M	$46M	$47M	$40M	$25M	$54M	$39M	$56M
Non-NHS	$90M	$112M	$96M	$134M	$133M	$140M	$155M	$126M	$141M	$124M

Figure 7-1: Baseline pavement investments ($180 million) in the entire network (NHS + Non-NHS)

Figure 7-2 shows the NHS portion of the annual projected investment by the five federal work types using the baseline scenario. The analysis shows an average investment of approximately $21 million annually in preservation and maintenance, $30 million in rehabilitation and $5 million in reconstruction. Annual variations result from construction schedules of committed projects and the optimized timing of triggered treatments. VTrans remains committed to prioritizing investments in timely and cost-effective preservation and rehabilitation treatments.



	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Maintenance	$2M	$2M	$2M	$2M	$2M	$2M	$2M	$2M	$2M	$2M
Preservation	$26M	$29M	$28M	$25M	$32M	$11M	$4M	$16M	$11M	$12M
Rehabilitation	$64M	$27M	$32M	$7M	$14M	$29M	$20M	$38M	$28M	$44M
Reconstruction	$437K	$13M	$25M	$14M	$873K	$0K	$687K	$0K	$0K	$0K
New Construction	$0K	$0K	$0K	$0K	$0K	$0K	$0K	$0K	$0K	$0K

Figure 7-2: Projected NHS Investment by federal work types over the 10-year analysis period in the Baseline scenario.

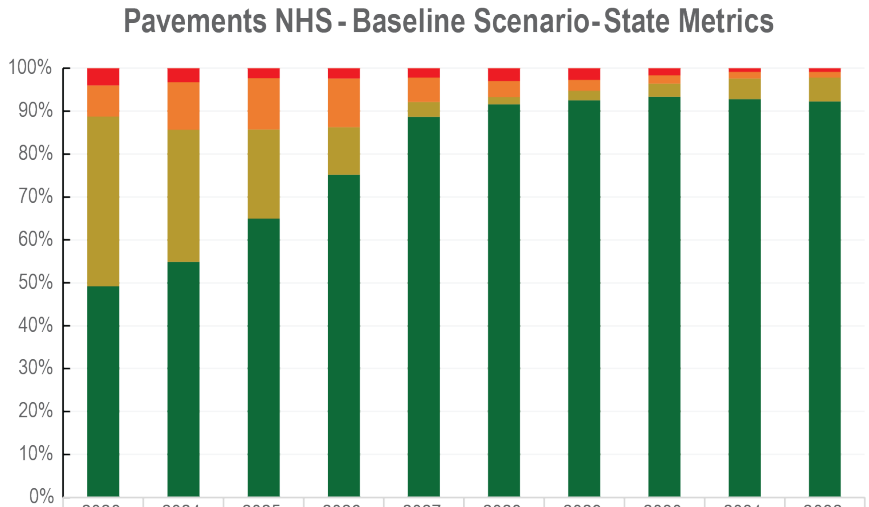
Projected NHS Pavement Performance

State measures and targets

PMS analysis of the selected baseline investment strategies were used to generate projected performance outcomes. Since the PMS weighs traffic volumes in its development of treatment recommendations, it tends to favor investments on the most utilized roads like the NHS, resulting in very good conditions on that subset.

Figure 7-3 shows the projected Overall Network Pavement Condition (ONPC) of NHS pavements using the baseline funding scenario. Under that scenario,

State Performance Target:
Maximum 25% Very Poor



	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
% Very Poor	4.0%	3.3%	2.4%	2.4%	2.1%	3.0%	2.7%	1.7%	0.9%	0.8%
% Poor	7.3%	11.1%	11.9%	11.3%	5.7%	3.7%	2.5%	1.9%	1.5%	1.3%
% Fair	39.5%	30.7%	20.8%	11.1%	3.5%	1.7%	2.3%	3.0%	4.8%	5.6%
% Good	49.2%	54.9%	64.9%	75.2%	88.7%	91.6%	92.5%	93.4%	92.8%	92.3%

Figure 7-3: Projected NHS pavement conditions for baseline investment scenario

Vermont's performance target of having less than 25% in Very Poor condition is well exceeded on the NHS network.

As is the case with the ONPC, under the baseline scenario, Vermont's TWACI performance target of greater than 70 on a 100 point scale are expected to be exceeded on the NHS. Figure 7-4 shows the projected TWACI of NHS pavements under the baseline funding scenario.

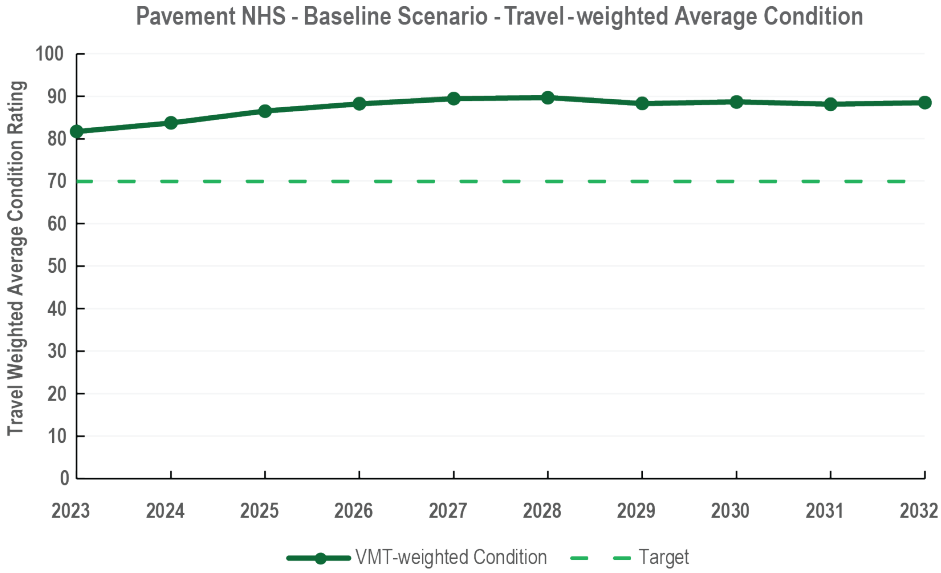


Figure 7-4: Annual Projected Travel Weighted Average Condition over the TAMP period

Federal measures and targets

As noted in section 3, federal pavement performance measures are calculated differently than state measures. While VTrans' PMS cannot specifically predict conditions using the federal measures, good estimates can be made using the projected state measure performance combined with expert judgement about how the measures are correlated.

Table 7-1 shows the measures, targets, and projected NHS pavement conditions in the year 2032, based on the baseline ($180m) investment scenario. Under the baseline funding scenario, federal performance targets are expected to be met.

Federal Pavement Condition Measures	VTrans Targets	Projected 2032 Conditions
Interstate Pavements in Good Condition	28% Minimum	>40%
Interstate Pavements in Poor Condition	4.9% Maximum	<2%
Non-Interstate NHS in Good Condition	30% Minimum	>35%
Non-Interstate NHS in Poor Condition	9.9% Maximum	<8%

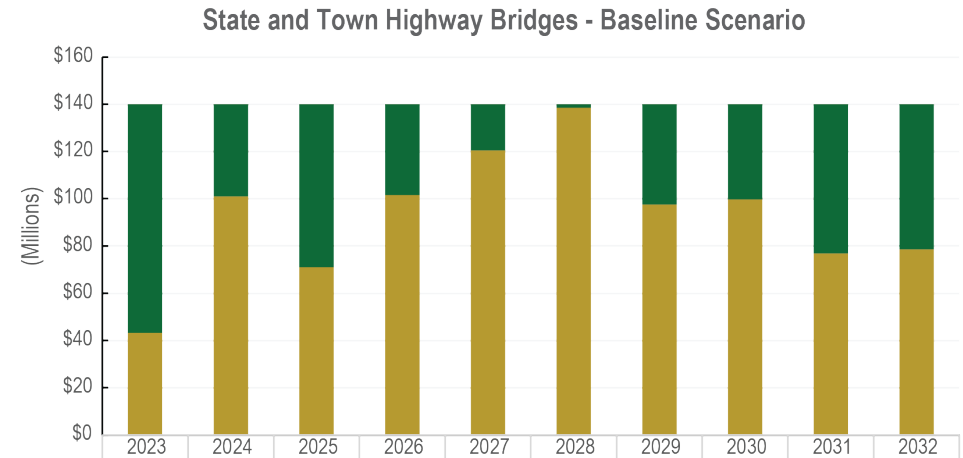
Table 7-1: Federal Pavement Condition Measures, Targets and Projected 2032 Conditions

Bridge Investment Strategies

Similar to pavements, VTrans developed the bridge investment strategies described in this TAMP using its BMS to analyze its overall bridge network, and then filtered out and is reporting the information pertinent to the NHS subset of bridges.

The bridge program needs identified in the Financial Planning section to meet performance targets are approximately $165 million annually in the near term. Those programs address short as well as long structures. Since this TAMP focuses only on long structures, it has been judged that approximately $140 million of that $165 million annual bridge program investment is the appropriate amount to model in the consideration of long-structures alone.

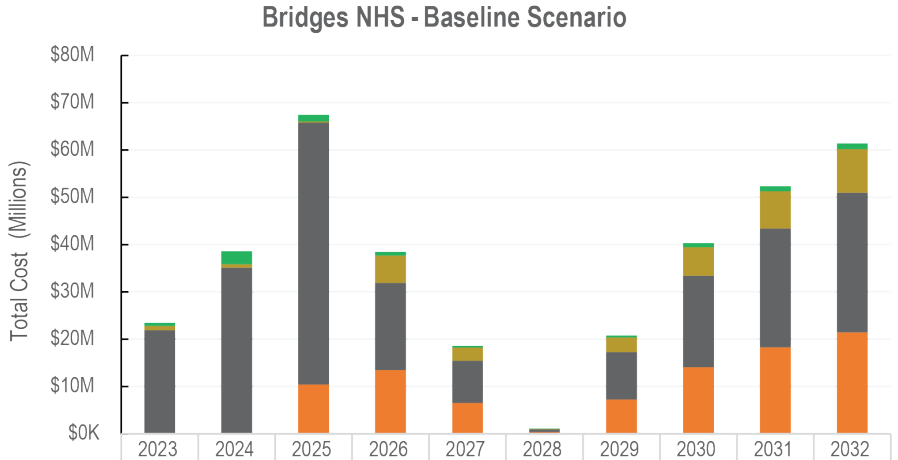
As such, $140 million was selected as the baseline scenario for long-structure bridges. Figure 7-5 shows how the BMS allocates that $140 million annual investment among NHS and non-NHS bridges over the years 2023 through 2032.



	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
NHS	$97M	$39M	$69M	$38M	$19M	$1M	$42M	$40M	$63M	$61M
Non-NHS	$43M	$101M	$71M	$102M	$121M	$139M	$98M	$100M	$77M	$79M

Figure 7-5: Annual projected investments in all bridges for the 10-year analysis period.

Figure 7-6 shows the BMS recommended breakdown of investment by federal work type for NHS bridges using the baseline scenario. As with pavements, annual variations result from the construction schedules of committed projects and the optimized timing of triggered treatments. Here too, VTrans remains committed to prioritizing investments in timely and cost-effective preservation and rehabilitation treatments.



	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Maintenance	$707K	$3M	$1M	$769K	$372K	$22K	$416K	$806K	$1M	$1M
Preservation	$875K	$685K	$249K	$6M	$3M	$165K	$3M	$6M	$8M	$9M
Rehabilitation	$22M	$35M	$55M	$18M	$9M	$528K	$10M	$19M	$25M	$29M
Reconstruction	$0K	$0K	$10M	$13M	$7M	$385K	$7M	$14M	$18M	$21M
New Construction	$0K	$0K	$0K	$0K	$0K	$0K	$0K	$0K	$0K	$0K

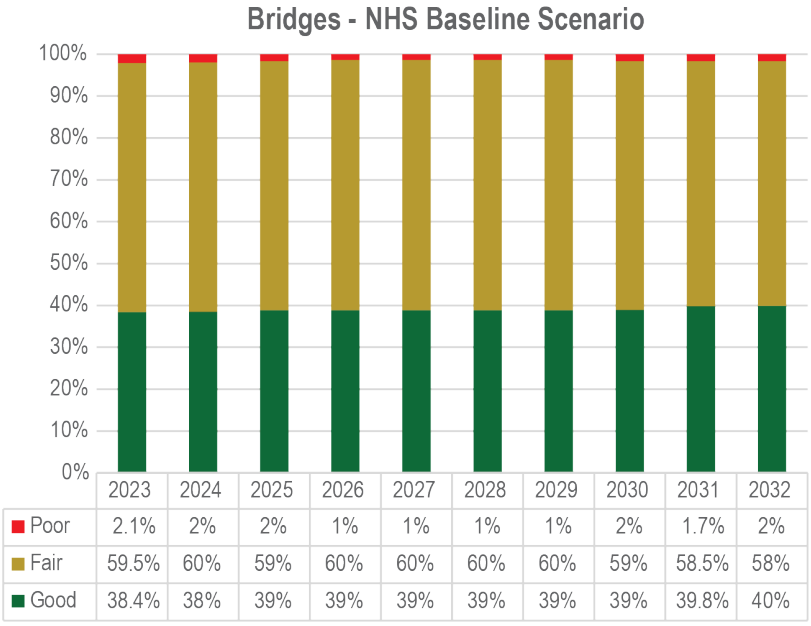
Figure 7-6: Annual projected NHS bridge investments by federal work types for the 10-year analysis period.

Projected NHS Bridge Performance

State and federal measures and targets

The BMS analysis of the selected baseline investment strategy generates projected performance outcomes. As the PMS does for pavements, the BMS weighs traffic volumes in its development of treatment recommendations, and therefore tends to favor investments on the most utilized roads like the NHS, which results in very good conditions on that subset.

Figure 7-7 shows the projected NHS bridge conditions under the baseline funding scenario. Vermont's performance targets of having a minimum of 35 percent of bridges in good condition, and a maximum of 6 percent in poor conditions are projected to be met on the NHS subset of the network. The federal minimally acceptable condition of having no more than 10 percent of NHS bridges in Poor condition is also projected to be met.



	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Poor	2.1%	2%	2%	1%	1%	1%	1%	2%	1.7%	2%
Fair	59.5%	60%	59%	60%	60%	60%	60%	59%	58.5%	58%
Good	38.4%	38%	39%	39%	39%	39%	39%	39%	39.8%	40%

Figure 7-7: Projected NHS bridge conditions based on selected investment strategy.

Performance Gap Analysis

Since VTrans set its baseline investment scenarios to meet the performance-based needs of its pavement and bridge assets, this TAMP analysis does not project any performance gaps.

As noted in the Financial Planning section, there is a financial gap between the revenues anticipated to be available for pavements and bridges and the performance-based asset needs from which the baseline scenarios were identified. Within the 10-year window of the TAMP, PMS and BMS analyses using funding scenarios closer to the funding levels anticipated to be available show little difference from the needs-based analyses. They continue to show that state and federal performance targets will be met on the NHS. This is due to the management systems allocation of resources to more heavily trafficked roads, and to the lag time between investments and condition changes, particularly for bridges.

Future funding at levels below the identified needs will likely result in performance measures not being met on non-NHS pavements and bridges, long-term declines beyond the 10-year window of this TAMP, and increased problems with short structures and culverts that are not considered in the analyses.

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