REPORT TO THE LEGISLATURE PURSUANT TO ACT 41, SECTION 40 (2023)

Report on Increasing Gross Weight Limits on Highways

December 29, 2023

submitted to

The Vermont House and Senate Committees on Transportation

Vermont Agency of Transportation
Policy, Planning, and Intermodal Development Division

VERMONT
AGENCY OF TRANSPORTATION

Report Preparation

This report was prepared by Cambridge Systematics, Inc. for the Vermont Agency of Transportation (VTrans).

The following organizations were consulted in the preparation of this report:

- Vermont Agency of Transportation
- Vermont Agency of Transportation, Department of Motor Vehicles
- Vermont Department of Forest Parks and Recreation
- Vermont Forest Products Association
- Vermont League of Cities and Towns
- Vermont Truck & Bus Association
- Professional Logging Contractors of the Northeast

Authorizing Legislation

Act 41, *An Act Relating to Miscellaneous Changes to Laws Related to Vehicles*, enacted June 1, 2023, contains the following provision in Section 40:

> REPORT ON INCREASING GROSS WEIGHT LIMITS ON HIGHWAYS THROUGH SPECIAL ANNUAL PERMIT
>
> (a) The Secretary of Transportation or designee, in collaboration with the Commissioner of Forests, Parks and Recreation or designee; the Executive Director of the Vermont League of Cities and Towns or designee; and the President of the Vermont Forest Products Association or designee and with the assistance of the Commissioner of Motor Vehicles or designee, shall examine adding one or more additional special annual permits to 23 V.S.A. § 1392 to allow for the operation of motor vehicles at a gross vehicle weight over 99,000 pounds and shall file a written report on the examination and any recommendations with the House and Senate Committees on Transportation on or before January 15, 2024.
>
> (b) At a minimum, the examination shall address:
>
> 1) allowing for a truck trailer combination or truck tractor, semi-trailer combination transporting cargo of legal dimensions that can be separated into units of legal weight without affecting the physical integrity of the load to bear a maximum of 107,000 pounds on six axles or a maximum of 117,000 pounds on seven axles by special annual permit;
> 2) limitations for any additional special annual gross vehicle weight permits based on highway type, including limited access State highway, nonlimited access State highway, class 1 town highway, and class 2 town highway;
> 3) limitations for any additional special annual gross vehicle weight permits based on axle spacing and axle-weight provisions;

4) reciprocity treatment for foreign trucks from a state or province that recognizes Vermont vehicles permitted at increased gross weights;

5) permit fees for any additional special annual gross vehicle weight permits;

6) additional penalties, including civil penalties and permit revocation, for gross vehicle weight violations; and

7) impacts of any additional special annual gross vehicle permits on the forest economy and on the management and forest cover of Vermont's landscape.

Table of Contents

List of Tables

List of Figures

Executive Summary

Purpose

Act 41, Section 40 enacted on June 1, 2023, requires the Vermont Agency for Transportation to submit a report to the legislature on the impacts of increasing the permissible gross vehicle weight of motor vehicles handling divisible loads from 99,000 pounds to 107,000 pounds over six axles and 117,000 pounds over seven axles on an annual special permit basis. This report addresses the seven topics specified in the legislation.

Issue and Context

Increasing truck size and weight limits is a complex issue, raising concerns regarding the distribution of costs and benefits, and varying impacts from the near-term to the long-term. Since the early 2010s, Vermont was granted authority to allow trucks with gross vehicle weights (GVW) of up to 99,000 pounds on state and federal highways for divisible loads on an annual permit basis, with few restrictions or requirements.

Allowing higher truck weights can bring significant productivity benefits to particular industries and the vehicle operators that serve them. However, they will also result in a broad range of direct and indirect impacts. Most directly, these include the effects on roadway pavements and structures, the design and condition of which varies greatly in their ability to handle heavy trucks. Accommodating safe and efficient vehicle operations over Vermont's publicly maintained roadway infrastructure requires maintenance, rehabilitation, and if not treated in time, full replacement. The costs of these activities are borne by the public through user fees such as fuel taxes, vehicle registrations and truck weight permits, as well as general revenues and municipal property taxes. Other related impacts include safety, changes in truck traffic volumes, enforcement/ compliance, climate/carbon effects, vehicle emissions, noise, vibration, and modal diversion. Complicating the situation is the varying standards of the adjacent states and Canadian provinces.

Given the study's short duration, the quantitative analysis focused on estimating the direct impacts on Vermont's highway structures and pavements, along with revenue strategies (topics 1 and 2). Other impacts (topics 3-7) were only examined qualitatively, informed by the literature review and conversations with stakeholders specified in the enabling legislation, including the Vermont Department of Forests, Parks, and Recreation, the Vermont Forest Products Association, and the Vermont League of Cities and Towns. Overall, this report serves to outline the general scope of the issue, potential impacts, and identify areas for further examination.

Approach

To effectively assess the potential impacts and costs of operating 107,000 and 117,000 pound vehicles (referred to as **study vehicles** in this report) over Vermont's highway network, two series of scenarios involving various authorization schemes were developed:

- One series (signified by the numerals 1 through 4) utilized examples identified through the literature review to develop four operating authorizations for using state highways, encompassing both limited-access and non-limited access.

- The second series (signified by the letters "A" through "C") identified potential operating authorizations for usage of class 1 and 2 town highways.

This approach yields a potential of twelve combinations of operating authorizations. Practically, however, only seven combinations were suitable for further examination. *The inclusion of any specific scenario for examination does not imply a preference.* The dual purpose of these scenarios is to allow for a deeper examination of cost components as well as provide operating cases similar to those found in other states that border Canada.

Table ES.1 Summary Matrix of Scenarios

State (column) + local (row) scenario matrix	**Scenario 2** All state highways within 30 air miles of the NY or QC border	**Scenario 3** Selected state highways with either high daily truck traffic or connectivity to a state border	**Scenario 4** **All State Highways**
Scenario NULL **No local routes**	Calculations use only Scenario 2	Calculations use only Scenario 3	Calculations use only Scenario 4
Scenario A **Limited Distance of 1 air mile**	+ All class 1 and class 2 local roads located within 1 air mile of those state roads	+ Class 1 and class 2 local roads located within 1 air mile of high truck traffic state network	+ Class 1 and class 2 local roads located within 1 air mile of those state roads
Scenario B **Town Decision**	+ All class 1 and class 2 local roads within 30 air miles where the town has opted into including the road	+ All class 1 and class 2 local roads where the town has opted into including the road	+ Class 1 and class 2 local roads where the town has opted into including the road
Scenario C **All Class 1 and 2 Local Roads**	+ Class 1, and class 2 local roads, within 30 air miles of the NY or QC border	+ All class 1 and class local roads in the state.*	+ All class 1 and class 2 local roads

Note: *This scenario is counter-intuitive and is omitted in calculations.

Summary of Findings

Challenges

Key challenges in executing this report related to the availability of data:

- Segment-level vehicle class-based traffic data is available only for state roads. Most local roads lack any form of traffic data. From stakeholder interviews, the nature of potential truck travel using study vehicles varied substantially with respect to origin and destination and the number of trips. Not having specific volumes by highway segment, however, affects the ability to properly model the potential impacts of study vehicle traffic on pavement.

- Short structure bridges lacked several key attributes such as inventory operating ratings and deck area.

Methodology

Structures

The various structural capacity ratings for the individual structures were used to identify structures with capacity restrictions. The structures that would require replacement or posting to prevent overloading by study vehicles were identified as requiring replacement. Structures that could handle the additional loading but would deteriorate at an accelerated rate with the study vehicles were identified and their rate of deterioration was estimated and used to project the year of replacement for both the current and possible future loadings, referred to as “base case vs. study case.” VTrans’ unit costs for structure replacement were applied to estimate replacement costs and a discount rate of 2.5 percent was used to account for when the structures would require replacement to accommodate current vehicles versus with the addition of the study vehicles.

Pavements

The pavement analysis relied on several databases which contained pavement width, number of lanes, condition, roadway type, year of last treatment, and traffic volumes. GIS analysis was used to identify roadways near the state border and local roadways near state highways. Assumptions on pavement type by highway functional class and truck volumes by vehicle class were used to estimate the deterioration of the pavement over time. The timing and type of treatments were decided based on the current pavement condition, estimated deterioration, and roadway functional class. Then, VTrans’ pavement treatment unit costs were applied to compare treatment costs with current vehicles and the addition of the study vehicles.

Results

Structures

By combining the inventory and operating ratings, the appropriate actions for each bridge structure were developed to determine which structures could handle various vehicle weights and which structures would likely suffer deterioration from the additional loads. The 80,000- and 99,000-pound GVWR vehicles were included to demonstrate the number of structures already deficient for legal loads in Vermont. The cost of upgrading all bridges to current legal loads of 99,000 pounds is estimated at $3.3 billion, and the incremental cost for upgrading bridges to accommodate the study vehicles would be $1.3 billion ($ 2023) over the next 20 years (Table ES.2).

Table ES.2 Structures 20-year Cost Estimation Cumulative by GVWR, $ Millions (2023)

Structure Type	80,000 GVWR Vehicle	99,000 GVWR Vehicle	107,000 GVWR Vehicle	117,000 GVWR Vehicle
Base Case Total Costs, Millions (2023$)				
Long Structure (Federal Aid)	$1,778	$2,994	N/A	N/A
Short Structure (Federal Aid)	$0	$0	N/A	N/A
Town Structure (Local)	$199	$270	N/A	N/A
Total	$1,977	$3,264	$0	$0
Incremental Costs (for 107,000 and 117,000-pound vehicles), Millions (2023$)				
Long Structure (Federal Aid)	$5.3	$15	$428	$909
Short Structure (Federal Aid)	$0	$0	$357	$357
Town Structure (Local)	$0	$0	$20	$54
Total	$5.3	$15	$805	$1,320
Average Annual Uniform Cost	$0.34	$0.94	$52	$85

Pavements

The overall costs for pavements are presented in Table ES.3. Two sets of results are shown, the base case reflecting continued retention of current weight limits, and the addition of study vehicles on the state highway network and class I and 2 local roads (Scenario 4C). The analysis assumed high-order treatments (level and overlay or mill and fill/reclaim) for federal aid road segments in very poor condition. Local roads were assumed to require no treatment in the base case; accommodating study vehicles over paved roads was assumed to require upgrades that permit increasing the weight capacity to the required levels. Retaining weight limits at their current levels would incur an estimated cost of $992 million over the next 20 years. Increasing weight limits to accommodate study vehicles would add $8.5 billion in maintenance and capital costs. The annual incremental cost to accommodate the study vehicles would amount to $548 million.

Table ES.3 Pavements 20-year Cost Estimation Cumulative by GVWR, $ Millions (2023)

Road Type	Treatments		All Treatments
	High-Order	Other	
Base Case Costs, $ Millions (2023)			
Federal Aid Road	$992	$0	$992
Paved Local Road	N/A	$0	$0
Gravel Local Road	$0	$0	$0
Total	$992	$0	$992
Incremental Costs, $ Millions (2023)			
Federal Aid Road	$5,260	$1,478	$6,738
Paved Local Road	$0	$1,627	$1,627
Gravel Local Road	$0	$186	$186
Total	$5,260	$3,291	$8,551
Average Annual Uniform Cost	$337	$211	$548

The combined incremental infrastructure capital costs for each of the scenarios are summarized in Table ES.4. The cost for the most restrictive scenario is $2.2 billion or $143 million per year to allow the study vehicles to travel on state highways with high truck volumes without accessing local roadways. For the most comprehensive scenario that allows study vehicles on state highways and class 1 and 2 local roads, the estimated total cost amounts to $9.9 billion or $633 million per year.

Table ES.4 20-Year Total Pavement and Structure Costs by Scenario, $ Millions (2023)

	Scenario 2 – Border-radius	**Scenario 3 –** Highways with High Truck Volumes	**Scenario 4 –** All-State Highways
Scenario NULL – No local roads	$4,078	$2,218	$8,005
Scenario A – Includes local roads within 1 mile of state highways	$4,918	$2,719	$9,348
Scenario B – Town Decision		Undefined	
Scenario C – Includes all Class 1 and 2 Local Roads	$5,246		$9,871

Other impacts of increasing weight limits were analyzed qualitatively. It is likely that variations of axle weights and spacings for the study vehicles within the limits of 107,000 pounds for six axles and 117,000 pounds for seven axles will produce modest differences in the estimated costs. Furthermore, variations in axle weights and spacings for seven-axle vehicles would highlight the need for VTrans to commit resources to develop and implement additional structure load rating models for seven-axle vehicles.

Economically, the existing permit scheme for 99,000-pound trucks is not revenue-neutral. The reviewed literature suggests that in other states permit costs are only a fraction of the likely infrastructure impacts. It appears that a similar situation would occur in Vermont. Additional enforcement resources including both staff and camera-based weigh-in-motion systems would be needed to improve the efficacy of enforcement on the state network. Further study should be undertaken to determine the violation penalty amounts, but citation penalties should be increased, and at a minimum be based off of exceeding the vehicle's non-permitted registered weight, typically 80,000 pounds.

Issues for Consideration

Due to the short timeline and available data, the work performed for this report may not be sufficient to provide a foundation for a well-informed decision. However, based on available data it is evident that the cost impacts to the state resulting from increasing maximum truck weight limits are considerable irrespective of the type of access that may be provided to study vehicles. Costs that would have to be borne by the state for improving bridges and pavements on state highways over a period of 20 years would range from $2.2 to $8.0 billion, with over 80 percent of these costs associated with improving pavements. Including local roads in the access schemes substantially raises the total cost from $2.7 billion for an approach that limits local road access to within 1 air mile of the high truck volume road network, to $9.9 billion if access to all class 1 and class 2 local roads is permitted. While incorporating variations in axle configurations and associated loadings into the analysis will change these results, the differences will likely be modest compared to the overall cost implications.

No U.S border state incorporates access to municipal roads in their state agency overweight truck operations and permitting schemes, and the ability of permit fees to offset these costs is far from sufficient. To fully cover these costs, annual permits would have to cost well in excess of any overweight permit fees charged by other states. Furthermore, permit fees would be even higher if the cost of improving local roads is also incorporated.

From a market perspective, increasing the weight limits would result in cost savings to shippers and carriers, including the forest products industry, and bring some degree of consistency with current weight limits in New York state, Quebec, and Ontario. This would also enable a portion of trips between New York state and eastern Canada at higher weights to shift from routes that bypass Vermont to ones that pass through Vermont. However, the available information was not sufficient to develop any actionable estimates of these impacts.

Recommendations

While the analysis utilized all the available information from VTrans, along with stakeholder interviews and the literature review, there is room for future advancement in addressing the seven topics specified in the legislation along with other impacts that may result from increasing truck weights. These include the following:

1. **Improving reporting and goal-setting,** particularly with respect to examining how increasing weight limits would affect Vermont's statewide target measures and compliance with federal asset performance rules.
2. **Acquire additional data** on travel patterns, design of existing infrastructure, and revenues obtained in other states from various permitting or vehicle registration schemes.
3. **Examination of collateral impacts**, including potential for induced truck traffic, traffic shifts, and modal diversion from rail to highway, along with environmental and community effects.
4. A **more comprehensive stakeholder engagement** approach than was feasible in this report's time frame and resources would be appropriate.
5. Concerning **technology**, the most pressing challenge is to incorporate the findings and open issues from this report into Vermont's procurement of a permit review and issuance system.
6. **Data analysis** could benefit from additional refinements, particularly in estimating the impacts of different axle configurations on roadway infrastructure, deterioration rates for different types of bridges and pavements, and expanding pavement treatment options and costs.
7. **Enforcement of weight limits** is very limited, particularly along the town highway network. Additional analysis is needed to develop strategies for enhancing Vermont's enforcement capacity to meet the challenge of higher permit weights.

1.0 Purpose

1.1 Authorizing Legislation

Act 41, Section 40, *Report on Increasing Gross Weight Limits on Highways Through Special Annual Permit*, enacted on June 1, 2023, requires the Vermont Agency for Transportation to submit a report to the Legislature on the impacts of increasing the permissible gross vehicle weight of motor vehicles from 99,000 pounds to 107,000 pounds over six axles and 117,000 pounds over seven axles on an annual special permit basis. In this report, we will refer to these configurations and limits as the **study vehicles**. The legislation required that the study address seven topics and called for participation by specific Vermont state agencies and external parties.

1.2 Overview

Increasing truck size and weight is a complex issue, raising concerns about the distribution of costs and benefits, and how impacts may occur from the near-term to the long-term. It has been the repeated subject of federal studies, the most recent of which was completed in 2016 with inconclusive and controversial results; a previous effort in 2000 resulted in a similar outcome, with the net effect of leaving it to the states to undertake a piecemeal approach to increasing weight limits for select traffic. Since the early 2010's, Vermont and Maine were granted authority to allow trucks with gross vehicle weights of up to 99,000 pounds on interstate highways with few restrictions or requirements for divisible loads over 80,000 pounds, the federal standard. With Vermont being a small state with a substantial volume of through-traffic, the situation is complicated by the varying standards of the adjacent Canadian provinces, as well as the other adjacent states of New York, Massachusetts, and New Hampshire. Some sections of New York, Maine, Quebec, and Ontario highways allow trucks weighing more than 99,000 pounds on a permit basis, which can place certain Vermont industries at a competitive disadvantage. One such industry is producers of forest products, which engage in extensive trade with adjacent states and provinces.

Allowing higher truck weights can bring significant productivity benefits to particular industries and the vehicle operators that serve them. However, they will also result in a broad range of direct and indirect impacts that can affect highway infrastructure. Most directly, these include the effects on roadway pavements and structures, the design and condition of which varies greatly in their ability to handle heavy trucks. Preventing deterioration on Vermont's publicly maintained roadway infrastructure requires maintenance, rehabilitation, and if not treated in time, full replacement. The costs of these activities are borne by the public through user fees such as fuel taxes, vehicle registrations and truck weight permits, as well as general revenues and municipal property taxes. In this case, the revenue source that is being considered to offset the increased costs from increasing weight limits is permits. The potential approaches of structure and fees for permits can vary considerably.

Other impacts from allowing increased truck weights include safety, changes in truck traffic volumes, enforcement/compliance, climate/carbon effects, vehicle emissions, noise, vibration, and modal diversion.

The central focus of this report is to address the seven topics specified in the legislation. Utilizing methodologies identified through the literature review and available data provided by VTrans and other sources, the potential impacts were examined through this lens using a range of scenarios that reflect various approaches taken by adjacent states that border on Canada. Given the study's short duration, the quantitative analysis focused on estimating the direct impacts on Vermont's highway structures and pavements, along with revenue strategies. Other impacts were only examined in a qualitative manner, informed by the literature review and stakeholder conversations. Overall, this report serves as a starting point to understanding the issue and identifying areas that should be further examined.

1.3 Report Organization

The sections that follow this introduction are as follows:

- **Section 2** summarizes a review of select literature on the impacts of increasing truck weights, user fee models, roadway maintenance funding schemes, methodologies for allocating maintenance costs, and other impacts.
- **Section 3** assesses existing conditions using available data on Vermont's road network, including utilization for goods movement, bridge and pavement conditions, safety, and permit practices. Included are cost estimates of bridge and pavement needs for the various scenarios, along with permit fee options and their fiscal impacts.
- **Section 4** addresses the seven study topics that were part of the legislative charge. Each item reviews the topic, and provides a response based on the analysis conducted as part of Section 3 as well as additional information gained through stakeholder discussion, the literature review, and consultant knowledge.
- **Section 5** provides findings and a set of recommendations for consideration by the legislature as it considers how to move forward.

2.0 Literature Review

For this project, the consultant conducted a brief review of existing literature on truck gross vehicle weight (GVW) limits and their impacts on roadway safety, infrastructure wear-and-tear, and infrastructure maintenance costs. The literature review focused on case studies from the United States, with a limited examination of some international examples. Previous pilot programs and studies in Vermont and New England were also reviewed to evaluate the region's recent experience with setting vehicle weight limits and registration fees.

These studies consistently find that increasing weight limits on trucks correlate with an increase in the wear-and-tear on roadways and structures, but these may be partially offset by a near-term reduction in total truck Vehicle Miles Traveled (VMT) depending on how carriers and markets respond. Furthermore, they generally found that user fees for higher weight trucks were not commensurate with the associated wear and tear. Studies have not been able to examine safety impacts as directly, as vehicle size and weight data is not often recorded on crash reports. However, higher-weight vehicles carry greater safety risks, as they generate more force at a given speed and have longer stopping distances.

Appendix A contains detailed discussion of the reviewed literature, while the remainder of this section summarizes the key findings of the literature.

2.1 National and International Perspectives

In 2016, the U.S. Department of Transportation (USDOT) Federal Highway Administration (FHWA) released a Comprehensive Truck Size and Weight Limits Study to assess impacts on public infrastructure and public finance associated with increased truck weight limits. Study findings indicate that truck VMT and bridge maintenance costs are consistently reduced across all scenarios. However, pavement lifecycle cost changes vary by scenario; total higher weight limits distributed across more trailers have a lower impact on pavement cost increases than lower weight limits with fewer trailers. The study did not result in any policy actions due to a lack of political consensus that was in part driven by broad criticism of the study methodology. This included a National Academy of Sciences review that concluded that the study was rather incomplete in its assessment of the impacts. Key omissions included the effects of higher weight trucks on infrastructure outside of the interstate highway system or national network, expected bridge structural costs, crash and casualty frequency and associated costs. Furthermore, units of measure were inconsistent, which made assessing trade-offs between various categories of costs and benefits impossible.

In 2020, the Florida Department of Transportation sponsored a study to assess the financial implications of overweight permitted vehicles and their impacts on road and bridge condition. The study found that permit fees levied on five- and six-axle trucks greater than 112,000 pounds did not cover the infrastructure costs on a per-mile basis and that the gap between cost and revenue increased as truck weight increased. An example of the growing gap between revenue and cost at higher truck weights is presented in Table below.

Table 2.1 Gap between Infrastructure costs and Permit Revenue

Gross Vehicle Weight Group (pounds)	12-Month Permit Fee	Annual Estimated Bridge & Pavement Costs	Gap
80,000 – 90,000	$240	$1,830	-$1,790
95,000 – 112,000	$280	$5,060	-$4,780

Gross Vehicle Weight Group (pounds)	12-Month Permit Fee	Annual Estimated Bridge & Pavement Costs	Gap
112,000 – 122,000	$310	$6,890	-$6,580
122,000 – 132,000	$330	$7,820	-$7,490
142,000 – 152,000	$360	$9,760	-$9,400
152,000 – 162,000	$400	$11,110	-$10,710
162,000 – 199,000	$500	$13,710	-$13,210

Source: Ali, Nowak, Stallings, et al. "Impact of Heavy Trucks and Permitted Overweight Loads on Highways and Bridges on and in the Future versus Permit Fees, Truck Registration Fees, and Fuel Taxes." Florida International University and Auburn University. July 2020.

International studies were less comprehensive in their assessment of truck weight limits, although benefits were identified. A 2020 study of increasing maximum truck weight in Finland from 60 metric tons (132,300 pounds) to 76 metric tons (167,800 pounds) between 2013 and 2017 found that this change reduced total truck VMT by 4 percent. The reduction in truck VMT generated significant cost savings for carriers and generated positive environmental benefits from reduced carbon dioxide (CO_2) emissions equal to 3.6 percent of total road freight emissions in 2017. However, impacts on infrastructure conditions were not analyzed.

2.2 Recent History in Vermont and New England

Focusing on the context of Vermont and New England, the research team reviewed recent legislative reports on oversize/ overweight truck permitting and the forest industry in the region.

In 2009, federal legislation established a pilot program for Vermont and Maine to allow six-axle trucks that weigh up to 99,000 pounds and 100,000 pounds, respectively, to operate on non-tolled Interstate highways. After six months, USDOT conducted a study of the program's impacts on bridge and road conditions. The study focused on modeled data from the National Bridge Inventory (NBI) and inspection records rather than empirical data, noting that "it may take many years before any measurables to the structures and pavements could be physically observed." USDOT concluded that the presence of heavier trucks will reduce the margin of safety on structures, which, while keeping structures above the minimum required by AASHTO Bridge Design Specifications, raises the risk of accelerating deterioration which will necessitate more frequent bridge inspection and maintenance activities.

A 2019 Vermont Agency of Transportation research report for the State Legislature studied options for weight-based annual motor vehicle registration fees to establish greater equity in the allocation of maintenance costs to road users by GVW. The study evaluates the revenue and cost impacts associated with four modeled registration fees. The findings demonstrate that heavier vehicles' registration fees are too low relative to their impact on infrastructure. Under the scenario that assigns fees based on total cost allocation, registration fees for trucks weighing between 80,000 pounds and 99,000 pounds should be 400 percent higher than the existing fees, demonstrating the scale of impact of these heavier vehicles.

The most recent study, issued in January 2021, examined the impact of allowing vehicles that may operate on State highways without a permit (up to 80,000 pounds) to operate on class 2 town highways. Class 2 town highways are predominantly two-lane paved roads in towns and villages that connect residential roads to the state highway network and currently have a GVW limit of 24,000 pounds The study findings indicate that this policy change would have substantial impacts on infrastructure condition and municipal finances. Because many class 2 town highways are not designed to accommodate heavy vehicles, reconstructing these roadways to support 80,000-pound vehicles would cost $3.15 billion over a 20-year implementation period. Since the majority of class 2 town highways are not located on the Federal-aid roadway system and thus ineligible for federal funds, a significant portion of these costs would have to be borne by local property taxes; the average municipal tax rate would have to increase by 22 percent to pay for this infrastructure program.

In 2020, the Maine Forest Products Council (MFPC) sponsored a study of opportunities and best practices for the forest industry that included an analysis of wheel configurations and weight limits for peer states and provinces involved in the forest products industry. The study found that Vermont has one of the lower GVW weight limits for trucks with five or more axles, and that many states offer exceptions to GVW limits for certain vehicle configurations or goods transport, including forest products, and for winter months when the risk of muddy road conditions is lower.

2.3 Divisible Load Permit Requirements and Axle Configurations in Other States

States take varying approaches to axle configurations and permit requirements for divisible loads over 80,000 pounds. These differ across states both because of inclusion of “grandfather rights” that pre-date Federal regulation, and exemptions in Federal legislation for states with historical divisible load limits on Interstate and other primary highways, as well as varying legislative requirements on state highways. While Typical approaches to permitting overweight loads include blanket multi-trip permits, radius permits where multiple trips are allowed within a set number of miles from a particular location, and trip permits that entail permission to operate between a specific origin and destination. Table 2.2 shows axle configuration requirements and permit types for select states and provinces located near Vermont.

Table 2.2 Axle Configurations and Permit Requirements for Divisible Loads of over 80,000-Pounds GVW in the New England States, New York, Quebec and Ontario[1]

Jurisdiction	Maximum Weight (pounds) and Axle Configuration(s)	Permit Type
Vermont	90,000 pounds (45 tons) gross weight over 5 axles or 99,000 pounds over 6 axles with minimum 51 feet between first and last axle.	Annual permit, applicable to state DOT highways, with restrictions
Maine	“Canadian Weight” limits	Permitting commercial vehicles at Canadian weight limits to travel from designated points at the Canadian border to Baileyville, Madawaska, and Van Buren. All three routes are less than 15 miles in length.
Massachusetts	99,000 pounds gross	Permits will only authorize travel on specifically designated state highways or ways determined by the Department to be through routes that have bridges, structures, and pavements of a sufficient capacity

[1] See Table A.3 in Appendix A for a more comprehensive overview of permit requirements in border states, including the associated references.

Jurisdiction	Maximum Weight (pounds) and Axle Configuration(s)	Permit Type
New Hampshire	99,000 pounds gross weight	Annual permit
New York	100,000 pounds gross. 22,400 pounds per single axle and 36,000 pounds per tandem axle	Annual permit, applicable to state DOT highways, with restrictions
Ontario	171,000 pounds (78 tons), with a maximum of 42,000 pounds on any 2 consecutive axels less than 6ft apart	The annual permit also allows travel on toll highways provided that the commercial vehicle has a valid transponder.
Quebec	148,000 pounds (67.5 tons), with a maximum of 42,000 pounds on any 2 consecutive axels less than 6ft apart	The use of such vehicles is limited to divided highways and short road sections along these highways.

3.0 Existing conditions

3.1 Highway Network Classification

Table summarizes Vermont's road network by VTrans road class and functional class, and differentiates roads included in the legislative request from the town highway classes not included.[2]

Table 3.1 Classification of Roads by VTrans Road Class and Functional Class

Route miles (VTrans road class by Functional class)	Not part of a classification system	Interstate	Principal Arterial – other freeways and	Principal Arterial – other	Minor Arterial	Major Collector	Minor Collector	Local	Grand Total
State vs local responsibility		Federal Aid Highway system					If Urban = Federal Aid road	Local Road	
Interstate		722[1]							**722**
US Highway			3	322	99	195			**618**
State Highway			19	138	668	937	10	0	**1,771**
Class 1 Town Highway			0	48	55	38			**142**
Class 2 Town Highway			6	6	67	998	821	858	**2,756**
Study Area Subtotal		**722**[1]	**28**	**515**	**888**	**2,167**	**831**	**858**	**6,009**
Class 3 & 4 town highway	1,558			1	5	64	76	8279	**9,983**
Other government roads	931								**931**
Private roads	3,023								**3,023**
Others (incl. proposed/ discontinued roads)	395	1		2				1	**399**
Subtotal	**5,908**	**1**		**3**	**5**	**64**	**76**	**8,280**	**14,336**
Total	**5,908**	**723**[1]	**6**	**517**	**893**	**2,231**	**907**	**9,138**	**20,345**

Note: [1]Interstate miles are directional. There are 320 route-miles of Interstate in Vermont.
Source: VTrans Road Centerline Spatial Data.

This translates to 6,009 route miles of roads where the study vehicles would potentially operate based on the legislative report parameters. The largest classes are class 2 town highways at 46 percent (2,756 miles) and 29 percent are state highways. Beyond these 6,009 miles, the remaining 14,336 miles not considered in the analysis consist largely of class 3 and 4 town highways, private roads or special government highways, forests trails, etc.

Seventy-two percent of the 6,009 miles relevant to this report are federal aid roads. A large share consists of state and federal highways. Approximately 1,200 miles of class 1 and 2 town highways are federal aid highways. Therefore, there is overlap between aid and ownership. For this report, a simplified categorization scheme was developed whereby all federal aid roads are referred to as "state highways" and all remaining

[2] The VTrans road class is defined in the VTrans Road Centerline Spatial Data by the field AOTCLASS which contains the official highway classification as assigned by VTrans. The classification of town highways is defined in Vermont State Statutes in 19 V.S.A. § 302 (https://legislature.vermont.gov/statutes/section/19/003/00302, see also Appendix G)." "VTRANS Road Centerline Spatial Data User Guide." December 2018.

class 2 town highways are referred to as "local roads." Class 3 and class 4 town highways are not considered in the analysis given the specificity of the legislative charge and are not a part of the "local roads" category in this report. Table details the route-miles of roads by VTrans road class and Federal Aid System.

Table 3.2 Roads by VTrans Road Class and Federal Aid System

Route miles (VTrans road class by federal aid highways)	**Not included**	**Federal aid roads**	**Local roads**	**Total**
Interstate		722[1]		**722**[1]
US Highway		618		**618**
State Highway		1,762	8	**1,771**
Class 1 Town Highway		142		**142**
Class 2 Town Highway	6	1,097	1,654	**2,756**
Subtotal	**6**	**4,341**	**1,662**	**6,009**
Class 3 & 4 Town Highway	9,983			**9,983**
Other government roads	931			**931**
Private roads	3,023			**3,023**
Others (incl. proposed/discontinued roads)	399			**399**
Subtotal	14,336			**14,336**
Total	**14,342**	**4,341**	**1,662**	**20,345**

Note: [1]Interstate miles are directional. There are 320 route-miles of Interstate highway in Vermont.
Source: VTrans Road Centerline Spatial Data.

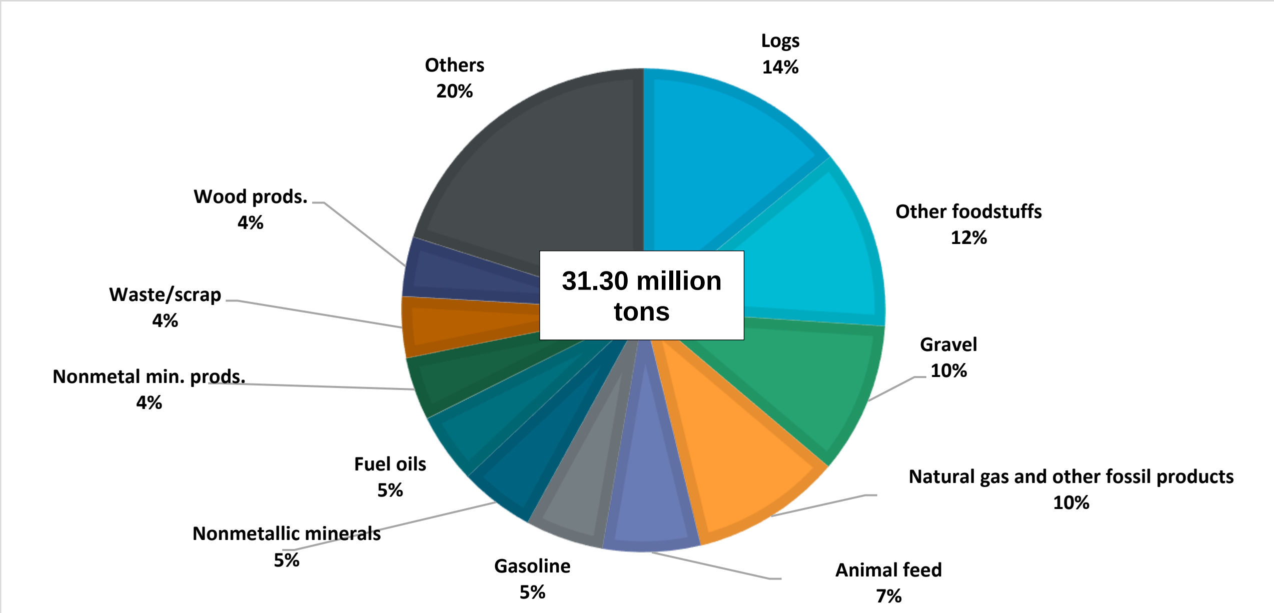
3.2 Highway Network Usage for Freight

3.2.1 Freight Volumes

Located between the Canadian border and the densely developed northeastern region of the United States, Vermont's highway network provides a critical link between major regional markets. This section examines the demand for goods movement by highway in the state by analyzing the commodity flows driving that demand. This examination relies on disaggregated data from the FHWA Freight Analysis Framework version 5.1 (FAF5).[3] With a base year of 2017, FAF5 provides estimates for tonnage and value of goods transported across the nation and is commonly used by many state and regional agencies for freight planning. Figure demonstrates the proportion of truck shipments by commodity and tonnage. *This analysis does not consider through flows – those that neither originate nor terminate in Vermont.*

[3] https://ops.fhwa.dot.gov/freight/freight_analysis/faf/

Figure 3.1 Tonnage by Commodity Shipped by Truck, 2017

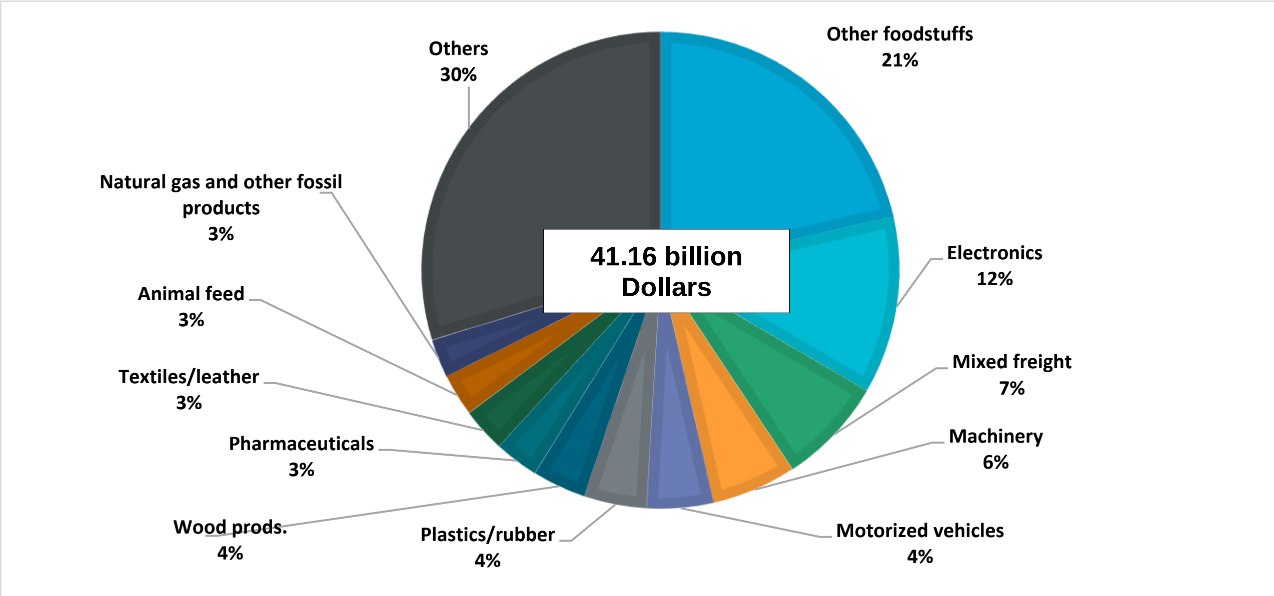


Source: FHWA Freight Analysis Framework 5.

Thirty-one million tons of freight with either an origin and/or destination in Vermont were handled over Vermont roads in 2017. The distribution of products carried is diverse. However, some products such as logs (14 percent) take up a significant share of the demand. The top ten products constitute more than 75 percent of all truck freight volume: logging and wood products at 18 percent, Fossil fuels, Gasoline, and Fuel oils is 20 percent, and Gravel, nonmetallic minerals, and mineral products are 19 percent. Thus, over half of total volume shipped by truck entails the haulage of bulk goods that could potentially utilize higher load limits.

Bulk goods generally have a lower value than finished products. This is reflected in the distribution of truck traffic commodity by value. The state shipped $41 billion worth of freight in 2017. The largest share was Food products at 21 percent. Other high value goods, including electronics, machinery, and motor vehicles also had a significant share. Figure demonstrates the proportion of truck shipments by commodity and value.

Figure 3.2 Value of Commodities Shipped by Truck, 2017



Source: FHWA Freight Analysis Framework 5.

It is also important to note the distinction in truck freight movement within and outside the state. 13.75 million tons of the 31 million tons shipped began and ended their trip in Vermont. This indicates that approximately 45 percent of all truck freight moves within the state. Thirty percent of truck volume is exported, and 25 percent is brought into the state. However, intra-state's large share is substantially smaller when measured in terms of value, accounting for only 21 percent at $8.77 billion of the total $41 billion. Exports make up 41 percent and imports the remaining 38 percent.

Overall, the FAF data indicates that Vermont's roads carry a large volume of relatively low value bulk goods within the state. Given the size of the state, these can be assumed to be relatively short trips. Most of the inter-state traffic consists of higher value commodities, including consumer goods and other foodstuffs. Table details the truck freight flows for imports and exports in 2017.

Table 3.3 Truck Freight Flows, Imports, and Exports (2017)

In Million Tons	To Vermont	To Other states	Total
From Vermont	13.7	9.6	23.4
From Other states	7.9		7.9
Total	**21.6**	**9.6**	**31.3**
In Billion $	**To Vermont**	**To Other states**	**Total**
From Vermont	8.8	17.0	25.8
From Other states	15.4		15.4
Total	**24.1**	**17.0**	**41.2**

Source: FHWA Freight Analysis Framework 5.

3.2.2 Truck Traffic Volumes and Network Usage

Truck traffic count data provides insight on the level of trucking activity across the state. This can be one factor in determining which portions of the highway freight network experience wear-and-tear and where investments should be focused. The volume of traffic on a roadway is expressed as Annual Average Daily Traffic (AADT). The FHWA defines AADT as “the total traffic volume passing a point of a road in both directions for a year divided by the number of days in the year”.[4] Similarly, the volume of truck movements on a road can also be measured as AADT. Annual Average Daily Truck Traffic (AADTT) is computed in the same manner as AADT except that only volumes related to trucks are used to make the calculation.

The map in Figure below indicates the annual average daily truck traffic (AADTT) for the state using data from the 2020 Highway Performance Monitoring System (HPMS). Although the network is fragmented, most of the major highways are represented. I-91 coming north from Massachusetts, and then following I-89 appears to be the busiest corridor. Most of the network has at least 1,000 trucks passing through each day. I-91 north of White River Junction and towards Quebec carries 500 – 1,000 trucks each day. Similarly, US- 7, which parallels the New York border in western Vermont, carries 500 – 1,000 trucks for most of its length. Apart from I-89, there are few major highway segments with substantial east – west traffic. US-4 in the middle of the state has sections with higher truck traffic, while State Highway 9, which parallels the Massachusetts border between Brattleboro, Bennington, and Hoosick, New York (the shortest route between New York and New Hampshire) carries fewer than 500 trucks each day. Note that “truck traffic” in this figure includes vehicles registered at lower weights and thus includes those trucks whose owners are highly unlikely to purchase a permit for the study vehicles.

3.3 Bridge Impacts

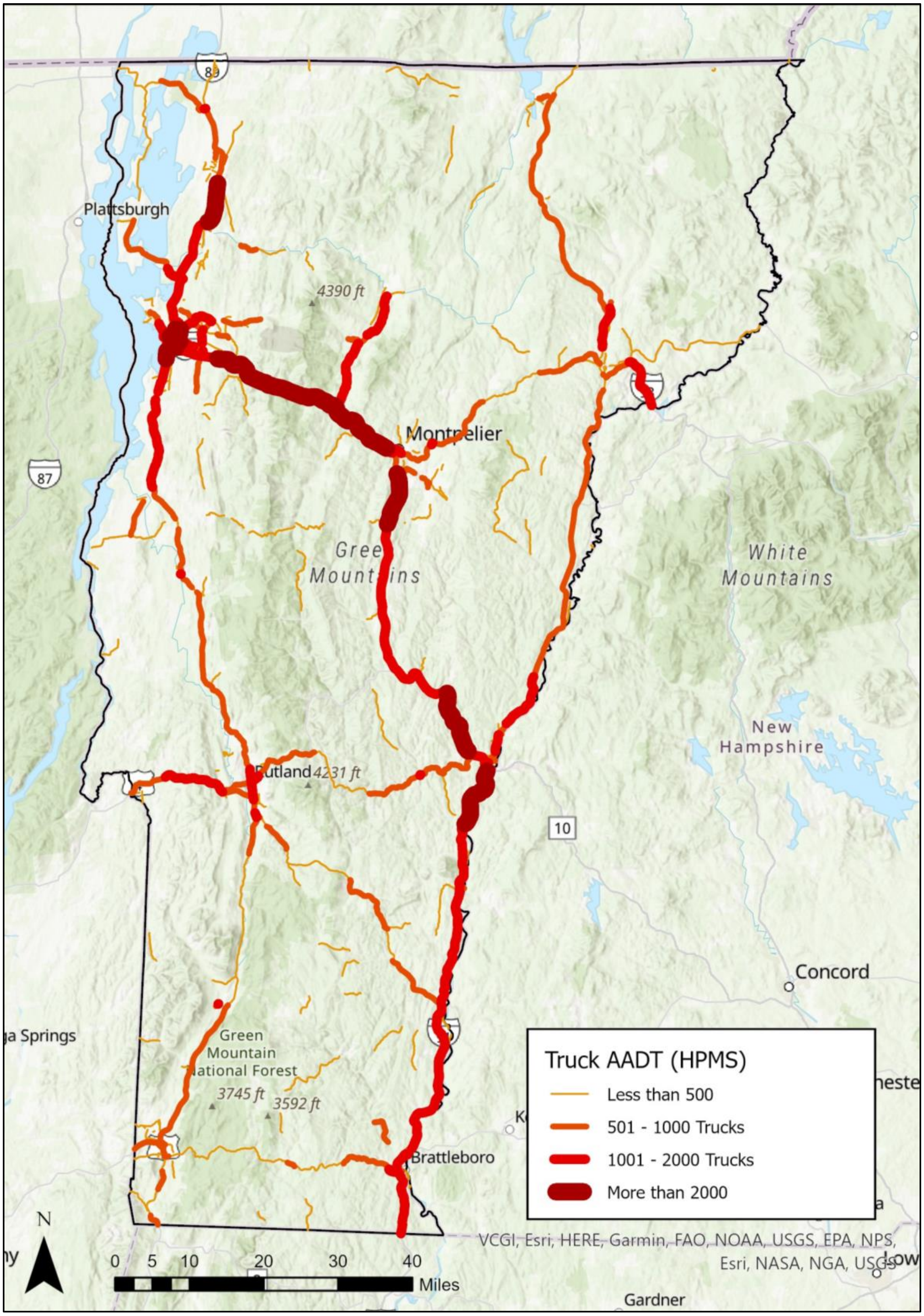
One of the key infrastructure elements known to be affected by increasing weights are the nation’s bridges, and Vermont’s bridges are no exception. Their age, design, and present condition all determine if and how study vehicles could hasten deterioration or risk catastrophic situations. Therefore, it is important to consider Vermont’s current bridge infrastructure.

Based on data provided by VTrans, there are 4,159 structures various classifications and ownerships of which 3,021 structures were included in the analysis. VTrans classifies structures in three ways: Long, Short and Town. Asset Class is the official VTrans structure class from the structure database. Long Structures have a maximum span length greater than 20 feet and short structures have a maximum span length less than 20 feet in length. Both long and short structures are considered part of the federal aid system. Town structures are bridges on local roads across all categories, of which this report only examined structures on class 2 local roads.[5] Structures lacking route information were removed from consideration, as were those located on class 3 and 4 town highways.

[4] *Traffic Computation Method (FHWA-PL-18-027),* Federal Highway Administration, August 2018.

[5] Town structures with a route name starting with “C2” were identified as Class 2 town highway structures.

Figure 3.3 Annual Average Daily Truck Traffic, 2020



Source: Highway Performance Monitoring System, 2020.

The ability for structures to carry motor vehicles with a GVW over 99,000 pounds and to bear a maximum of 107,000 pounds on six axles or a maximum of 117,000 pounds on seven axles were determined by evaluating the available structure ratings. The available **operating ratings** were used to determine the overall maximum permissible load level to which the structure may be subjected for a limited number of times. Many structures had multiple operating ratings available, but some only had one or none. When available, the six-axle rating was utilized to assess maximum structure capacity, but in the cases where a six-axle rating was not available, the general operating rating was examined. The **inventory rating** was used to determine the capacity of the load level that can safely use an existing structure for an indefinite period of time. Combining the operating and inventory ratings together, the structures were grouped into several categories:

- **Legal loads not allowed:** Structures with an operating rating below 80,000 or 99,000 pounds were considered structures that could not safely support current legal loads. These structures would require replacement to handle the study vehicles or would have to be posted.

- **Study vehicles not allowed:** Structures with an operating rating below 107,000 or 117,000 pounds were considered structures that could not safely support the study vehicles. These structures would require replacement to handle the study vehicles or would have to be posted.

- **Study vehicles allowed with monitoring and restrictions:** Structures with an operating rating above 107,000 or 117,000 pounds but an inventory rating below 107,000 or 117,000 pounds. These structures would have to be posted or monitored and restrictions would need to be established for the study vehicles to utilize. The addition of study vehicles to these structures would accelerate their deterioration and advance the timeline for replacement.

- **Study vehicles allowed without restrictions:** Structures with an inventory rating greater than 107,000 or 117,000 pounds were considered structures that would not be adversely affected by allowing vehicles of that weight, respectively. Replacement costs were not estimated for these structures.

The short structures in the database, with lengths of less than 20 feet, had insufficient operating and inventory rating information.[6] Short structures lacking rating data followed a different decision path: short structures with a cover depth less than 10 feet or unknown cover depth would be considered as requiring replacement for the study vehicles but sufficient for legal loads, and short structures with a cover depth greater than 10 feet were assumed as not requiring replacement as the embankment weight above the structure is assumed to greatly exceed any variation in traffic live loading.

Table below summarizes the number of structures and deck areas by roadway classification. There are 78 local road structures and 106 federal aid structures with operating ratings of less than 99,000 pounds; these 184 structures could not handle current legal loads and would require replacement or posting for the study vehicles. In addition, there are 26 local structures and 1,025 federal aid structures that can carry current legal loads but would be unable to carry the study vehicles. In total, there are 1,051 structures that could not carry the study vehicles, of which nine percent by deck area are on local roads.

[6] Cover depth is associated with the distribution of live load. Around 10 feet, it was assumed the design of the structure itself would be governed by the dead load and a change in live load would not affect it.

Table 3.4 Structures and Associated Deck Area by Rating Category for Federal, State, Class 1, and Class 2 Town Highways

Rating Category	Number of Structures (and Deck Area in Thousand square feet)		
	On Local Roads	On Federal Aid	Total
80,000 Not Allowed	46 (61)	37 (75)	83 (136)
99,000 Not Allowed	32 (54)	69 (169)	101 (224)
Total – Legal Loads Not Allowed	**78 (115)**	**106 (244)**	**184 (360)**
107,000 Not Allowed	12 (21)	42 (100)	54 (121)
117,000 Not Allowed	14 (33)	33 (81)	47 (114)
Short Structures with Cover Depth <10 feet or Unknown	0 (0)	950 (383)	950 (383)
Total – Study Vehicles Not Allowed	**26 (54)**	**1,025 (564)**	**1,051 (618)**
107,000 and 117,000 Allowed with Restrictions	195 (387)	948 (5,773)	1,143 (6,160)
Replacement Required	**299 (556)**	**2,079 (6,582)**	**2,378 (7,138)**
Short Structures with Cover Depth >10 feet	0 (0)	314 (122)	314 (122)
Study Vehicles Allowed Unrestricted	33 (76)	296 (2,103)	329 (2,179)
Total – Study Vehicles Allowed Unrestricted	**33 (76)**	**610 (2,225)**	**643 (2,301)**
Grand Total	**332 (632)**	**2,689 (8,807)**	**3,021 (9,439)**

Note: [1]Short structures with a cover distance greater than 10 feet were assumed as unaffected by live loads and not detrimentally affected by the addition of the study vehicles. Similarly, short structures with a cover distance unknown or less than 10 feet were considered as requiring replacement for the study vehicles.

Source: VTrans.

Structures where the vehicle loads were between the inventory and operating ratings were assumed to experience accelerated deterioration which would result in replacement occurring sooner than planned. There are 83 and 101 structures with operating ratings less than 80,000 and 99,000 pounds, respectively; these 184 structures could not handle current legal loads and would require replacement or posting for the study vehicles. In addition, there are 1,051 structures (includes 950 short structures with a cover depth less than 10 feet) that can carry current legal loads but would be unable to carry the study vehicles.

There are a total of 1,143 structures that could support both of the study vehicles but would experience accelerated deterioration, thus advancing their replacement. In contrast, there are only 643 structures eligible for unrestricted movement of study vehicles without replacement (including 314 short structures with a cover depth greater than 10 feet). In total, there are 2,378 structures that would require replacement to accommodate the study vehicles, including 950 short structures.

To support only the 107,000-pound vehicle, 2,225 structures would require replacement, and to support both the 117,000-pound vehicle an additional 153 structures (total of 2,378 structures) would require replacement. Table 3.5 details the specifics between the operating and inventory ranges among structures in Vermont.

Table 3.5 Inventory and Operating Ratings for Structures

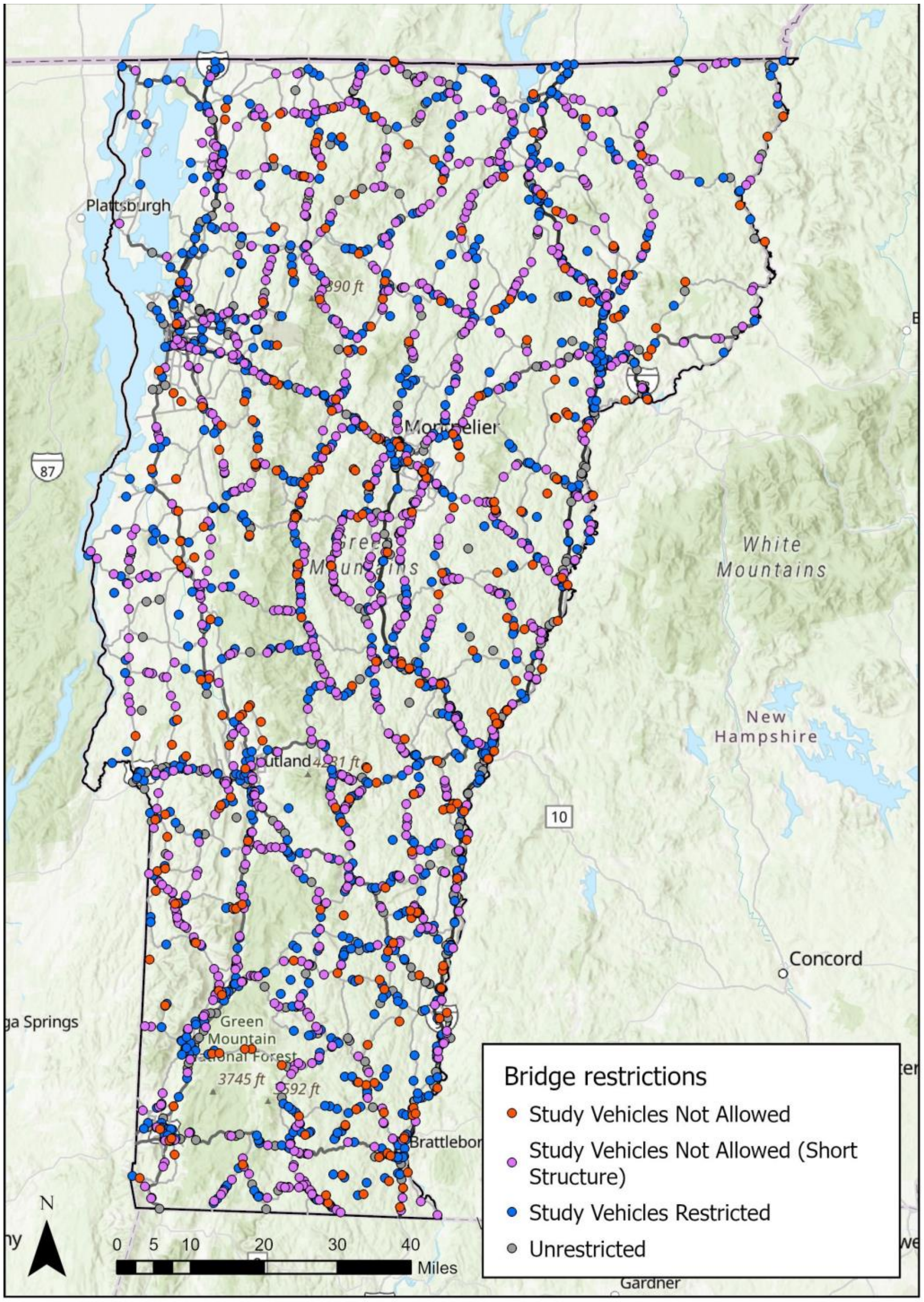
GVWR (pounds) per Operating Rating	Number of Structures (and Deck Area in Thousand square feet)						
	Short Structures[1]	Long and Town Structures by GVWR (pounds) per Inventory Rating					Total
		80,000+ Restricted	99,000+ Restricted	107,000+ Restricted	117,000+ Restricted	Study Vehicles Unrestricted	
80,000+ Not Allowed (79,999 Max Allowed)		83 (136)					83 (136)
99,000+ Not Allowed (98,999 Max Allowed)		101 (224)					101 (224)
Subtotal – Legal Loads Not Allowed (98,999 Max Allowed)		**184 (360)**					**184 (360)**
107,000+ Not Allowed (106,999 Max Allowed)	950 (383)	54 (121)					1,004 (504)
117,000+ Not Allowed (116,999 Max Allowed)		47 (114)					47 (114)
Subtotal – Study Vehicles Not Allowed	**950 (383)**	**101 (235)**					**1,051 (618)**
Legal Loads and Study Vehicles Allowed with Restrictions		495 (2,104)	376 (2,211)				**871 (4,315)**
Study Vehicles Allowed with Restrictions (Legal Loads Unrestricted)				119 (798)	153 (1,047)		**272 (1,845)**
Subtotal – Study Vehicles Allowed with Restrictions		**495 (2,104)**	**376 (2,211)**	**119 (798)**	**153 (1,047)**		**1,143 (6,160)**
Total – Replacement Required for 107,000	**950 (383)**	**780 (2,699)**	**376 (2,211)**	**119 (798)**			**2,225 (6,097)**
Total – Replacement Required for 117,000	**950 (383)**	**780 (2,699)**	**376 (2,211)**	**119 (798)**	**153 (1,047)**		**2,378 (7,138)**
Study Vehicles Allowed Unrestricted	314 (122)					329 (2,178)	643 (2,300)
Grand Total	**1,264 (505)**	**780 (2,699)**	**376 (2,211)**	**119 (798)**	**153 (1,047)**	**329 (2,178)**	**3,021 (9,439)**

Note: [1]Short structures with a cover distance greater than 10 feet were considered unaffected by live loads and assumed would not be detrimentally affected by the addition of the study vehicles. Similarly, short structures with a cover distance unknown or less than 10 feet were considered as requiring replacement for the study vehicles.

Source: VTrans

The map in Figure below shows geographically the locations of the structures by rating capacity. Operating rating is used to describe the maximum possible load that a structure can carry, but allowing vehicles above the inventory rating will reduce the life of those structures.

Figure 3.4 Map of Structures by Rating Capacity



Source: VTrans.

3.4 Pavement Impacts

Similar to Vermont's bridge infrastructure, it is important to quantitatively consider the impacts of increased truck weights on Vermont's pavement infrastructure. Unlike structures where a load rating is used and the volume of traffic is not as critical, assessing the impact on pavements requires converting current and study vehicles into "equivalent axle loads" and identifying how those axle loads hasten the deterioration of the pavement. Accelerated deterioration across Vermont's network will increase ongoing maintenance as well as the frequency and cost of replacement.

Pavement conditions vary by surface type. VTrans classifies pavement surfaces into five categories, ranging from paved to impassable. In this report, only paved and gravel roads are considered, as only 6 route miles of class 2 highways are neither paved nor gravel. Omitting those 6 route miles yields 6,003 miles of paved or gravel roads where the impact of increased truck weight limits was analyzed. Of this selection, 90 percent of the route miles are paved roads and 10 percent are gravel. Nearly all gravel roads are class 2 town highways as seen in Table .

Table 3.6 Paved and Gravel Roads, Route-Miles

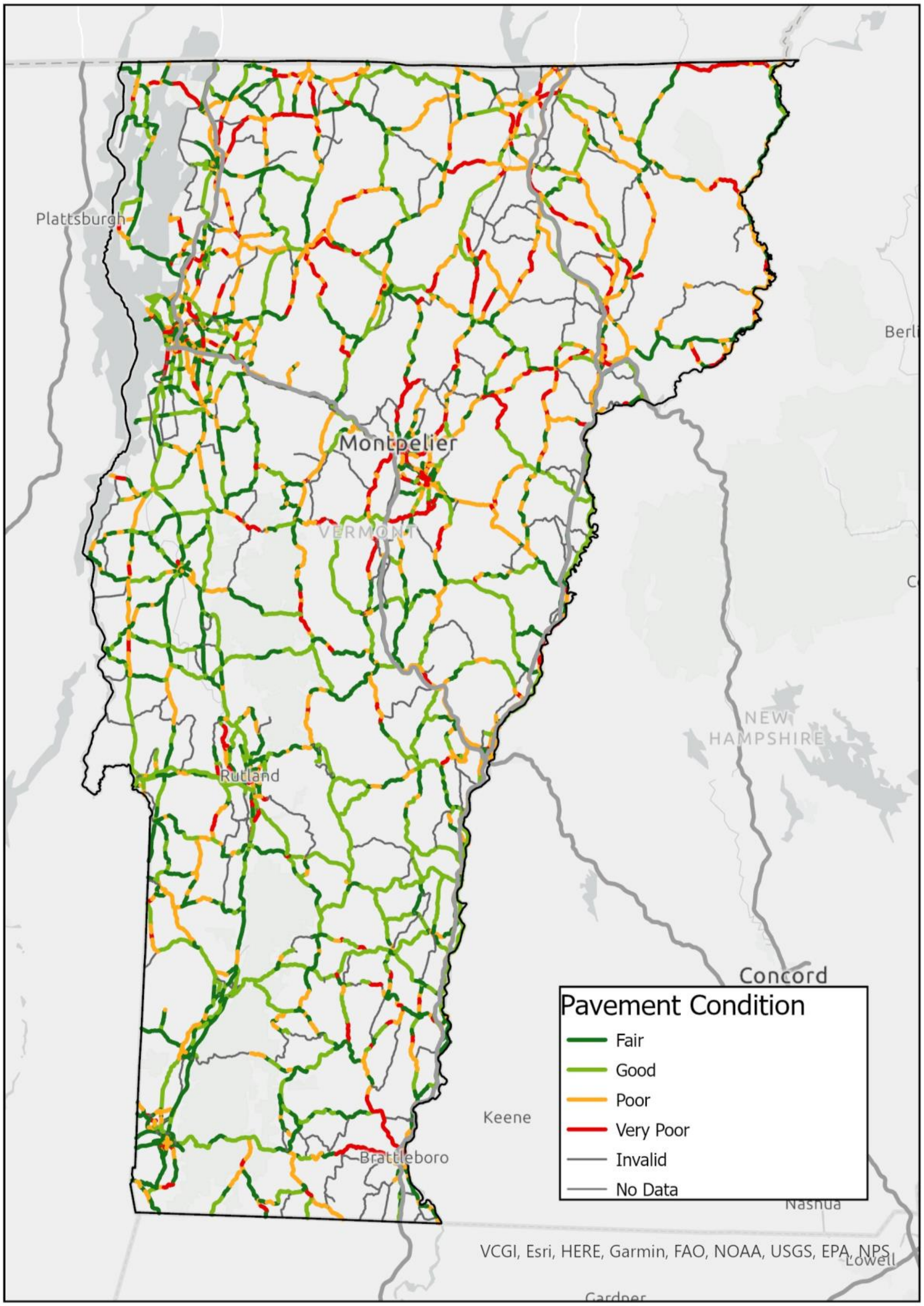
Route miles	Paved	Gravel	Total	Soil or graded and drained earth	Unimproved /primitive	Impassable or untraveled	Unknown	Grand Total
Interstate	722		**722**					**722**
US Highway	618		**618**					**618**
State Highway	1,767	3	**1,771**					**1,771**
Class 1 Town Highway	142		**142**					**142**
Class 2 Town Highway	2,177	574	**2,751**	6				**2,756**
Total	**5,426**	**577**	**6,003**	**6**				**6,009**
Class 3 & 4 town highway	2,147	5,390	7,537	1,480	278	688		**9,983**
Other Government roads	33	180	213	47	22	45	604	**931**
Private roads	136	615	751	89	129	3	2,051	**3,023**
Others (incl. proposed/ discontinued roads)	5	30	35	10	9	35	311	**399**
Total	**2,322**	**6,214**	8,536	**1,626**	**438**	**770**	**2,966**	**14,336**
Grand Total	**7,748**	**6,791**	**14,539**	**1,631**	**438**	**770**	**2,966**	**20,345**

Source: VTrans.

Most of the federal aid road pavements are in good or fair condition. However, 32 percent of roads are in poor or very poor condition, and another 6 percent lack data (Figure). Most of the class 2 town highways that are not part of the federal aid system have an invalid or unknown pavement condition.[7] Table and Table detail the pavement condition of federal aid and local roadways.

[7] Invalid data occurs for several reasons such as the roadway was under construction, located in an area declared as a disaster zone, or too deteriorated to measure, among other reasons. https://www.federalregister.gov/documents/2017/01/18/2017-00550/national-performance-management-measures-assessing-pavement-condition-for-the-national-highway

Figure 3.5 Vermont Federal Aid Highways Existing Pavement Conditions



Source: VTrans.

Table 3.7 Pavement Conditions - Federal Aid Roads, by Route-Mile

Federal Aid Roads	Good	Fair	Poor	Very Poor	Invalid	Unknown	Total
Interstate	262	285	93	1	60	22	722
US Highway	218	187	134	50	22	7	618
State Highway	590	481	455	193	20	24	1,762
Class 1 Town Highway	25	55	38	19	2	3	142
Class 2 Town Highway	250	353	274	130	71	19	1,097
Total	1,345	1,360	993	393	176	75	4,341

Source: VTrans.

Table 3.8 Pavement Conditions - Local Roads, by Route-Mile

Local Road route miles	Good	Fair	Poor	Very Poor	Invalid	Unknown	Total
Interstate							0
US Highway							**0**
State Highway	3	1	1		2	1	8
Class 1 Town Highway							0
Class 2 Town Highway	3	0	2	0	778	871	1,654
Total	**6**	**1**	**3**	**0**	**780**	**872**	**1,662**

Source: VTrans.

3.5 Safety

Any assessment of truck movement warrants an inquiry into its associated road safety. The Federal Motor Carrier Safety Administration (FMCSA) compiles information on roadway crashes annually. Data collected includes location, vehicle type, and crash severity. To compare results across states, crashes are normalized by Truck Vehicle Miles Travelled (TVMT) using FHWA's Highway statistics for truck traffic.

Data from pre-pandemic 2019 indicates that Vermont has a relatively low number of truck crashes per million TVMTs at just over 0.314. Compared to Vermont, Massachusetts had twice as many crashes, while New York had nearly three times as many crashes at 0.861 per million TVMTs. When compared to all its neighboring states, Vermont had the fewest truck-related crashes per million TVMTs.

However, when comparing fatalities in crashes involving trucks, Vermont is significantly higher at 0.017 fatalities per million TVMT. This is the highest rate among its peer states and double the fatality rate in Massachusetts. These statistics indicate that while Vermont experiences a relatively low number of truck-related crashes, those that do occur are severe. Numerous factors could impact these results, ranging from higher speeds to weather impacts, higher weights, more points of conflict, differences in highway design, differences in enforcement, and user behavior. Table details the truck crashes across New York and the New England states in 2019.

Table 3.9 2019 Truck Crash Statistics Across States

State	All Crashes	Fatal Crashes	Truck VMT	Crashes/ million TVMT	Fatalities / million TVMT
Vermont	182	10	580	0.314	0.017
New York	7,560	127	8,777	0.861	0.014
New Hampshire	469	8	859	0.546	0.009
Massachusetts	2,243	29	3,586	0.626	0.008
Maine	861	19	1,617	0.533	0.012

Source: FHWA Highway Statistics Series 2019, FMCSA's Motor Carrier Management Information System. https://ai.fmcsa.dot.gov/gis/tools/safetyevent/

3.6 Enforcement

Weight enforcement on state and Federal highways is conducted by the Vermont Department of Motor Vehicles (DMV) through a mix of fixed and mobile activities. Vermont has fifty-two locations where infrastructure exists or can be brought in to weigh trucks, although several of these locations are on parallel sides of a single divided highway. At two of these sites, the scales are in-ground, at the other locations officers utilized portable scales. Each of these locations is integrated with the Drivewyze commercial system allowing bypass for customers of Drivewyze in good standing. In addition, portable scales can be used in other general enforcement situations. A limited number of officers are trained to utilize these scales and write citations based on their results. The vast majority of enforcement activities are conducted on the state highway network, although when staff resources are available local municipalities may coordinate to have DMV enforcement staff travel to a location on the local highway network.

Staff time at any particular location is limited based on available resources. Citation issuances across the state by the DMV staff are low when compared to truck volumes. A total of 179 citations were issued for all size and/or weight infractions in 2022. Of those citations, 98 were for vehicles weighed by DMV staff with recorded gross weights between 100,000 and 127,000 pounds. The amount of traffic observed (but not necessarily weighed) during DMV enforcement operations is not known, thus it is not possible to establish a ratio of total traffic currently operating above the current 99,000-pound permit weight but at levels consistent with the study vehicles.

One approach to partially augment this information is to consider the state’s continuous counter data equipped with weigh-in-motion technology. In Vermont, these counter locations are not directly used for enforcement citation purposes, although their data may inform enforcement staff allocation decisions. Continuous counters with weight classification can identify potential locations where vehicles are frequently traveling above legal weights, although some of these vehicles may be in possession of valid non-divisible load permits for those weights.

3.7 Permit Issuance

The current process for issuance of permits for 99,000-pound divisible load vehicles on state highways, as well as all non-divisible load permits on state highways, is managed by the Department of Motor Vehicles. Vermont lags behind most other states in technology for allowing motor carriers to apply for and receive permits through an automated system, although efforts are ongoing to specify, acquire, and implement an automated system for permit processes. The specification of permits for study vehicles appears to be sufficiently straightforward such that any current efforts could be modified to include permits for study vehicles.

Presently, permits for 99,000-pound divisible load vehicles are issued annually on a calendar year basis at a cost of $560.00. It is obtained by downloading an editable file in PDF format from the Department of Motor Vehicles website and returning a printed version of the completed file to the agency along with payment. Permits ordered at any point in the year expire on December 31 of that year.

Off the state highway network, motor carriers must obtain individual permits for 99,000-pound divisible load vehicles from each town in which they intend to conduct business. Permits vary in cost up to $10 per carrier depending on the number of vehicles included and are valid until March 31st of each year. The specific application, town review, and issuance processes vary by town, and it appears that the carrier labor cost for acquisition is far greater than the cost of the permits themselves. In addition, many towns do not issue permits, allowing an unknown number of carriers and trips to utilize their network at higher weights.

Neither the state nor the local permits have conditions for notifying the relevant issuing agency as to when a trip is made using the permit. As a result, there is no data about vehicle trips or mileage volume utilizing these permits. When combined with the limited amount of DMV enforcement presence on local roads, there is also insufficient information about actual compliance levels of the permit issuance process and the current practice appears to be akin to an honor system.

3.8 Industry Impacts

3.8.1 Forest Products

The forest products sector utilizes a complex supply chain, starting with timber extraction, continuing through various intermediate production processes, and concluding with the manufacturing and distribution of various end products. Outputs include an extraordinarily broad range that ranges from pellet fuels to finished lumber and other building materials, paper, and furniture. Each of these products has unique characteristics, with Vermont's economy having some degree of involvement in the creation of each. Furthermore, Vermont's forest products sector is closely linked to that of the New England states, New York, and the Canadian province of Quebec.

With its extensive forest cover, Vermont has long had a robust timber production industry, which relies on first-mile transportation from the wood lot to the initial stage of processing and production. The high density of fresh-cut timber makes it a suitable commodity for handling in high-weight shipments over the existing 99,000-pound weight limit. With Quebec and New York allowing trucks over Vermont's 99,000-pound weight limit, this does place Vermont's timber industry at a competitive disadvantage in some circumstances.

Data on revenue and cost impacts from higher-weight truck operations in forest production was found to be scant. However, according to an analysis conducted by the Professional Logging Contractors of the Northeast in 2019, Canadian loggers could handle orders of 4 to 16 tons more per load than Maine trucks, with a difference in revenue of US $200 – US $800.[8] With Maine's conditions not being identical to those in Vermont, and the weight limits that are being considered lower (117,000 pounds vs.140,000 pounds on

[8] Testimony of Dana Doran, Before the Joint Standing Committee on Transportation Regarding LD 1598, An Act to Provide Equity for Commercial Vehicles on Roads and Bridges in Maine Thursday, May 9, 2019.

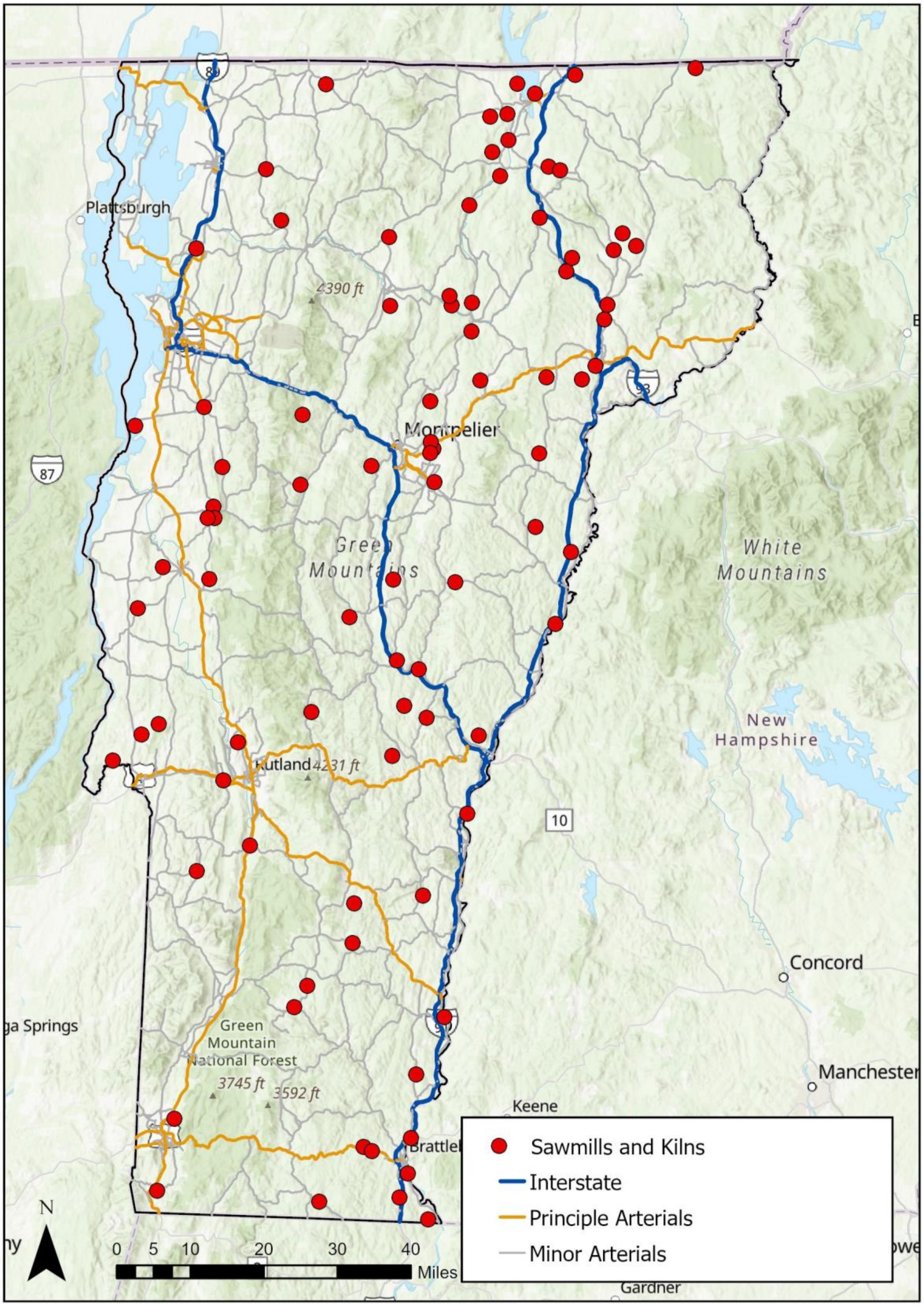
seven axles for Canadian trucks entering Maine to select locations), the difference would fall towards the lower end of the range in reported cost impacts.

Timber production occurs in many regions of Vermont. Accessing these woodlands requires the use of all levels of Vermont’s state and local roadways. Destinations vary from in-state sawmills to out-of-state paper mills and other processors. For example, Figure illustrates the locations of kilns and sawmills across Vermont.

3.8.2 Other Industries

Increased truck weights for divisible loads would be utilized by other industries in addition to the forest products industry. Likely users include any sector that ships heavy bulk commodities, including sand, gravel, aggregates, stone, cement, municipal solid waste (MSW), construction and demolition (C&D), petroleum products, along with various inputs and outputs associated with agriculture. Collectively, shippers of these commodities are likely to take advantage of increased truck weights beyond the present 99,000 pounds for divisible loads, but the available data for this report precludes estimating the degree to which they may do so.

Figure 3.6 Location of Sawmills and Kilns across Vermont



Source: Vermont Government, Working Lands Enterprise Initiative, [Vermont Forest & Wood Products Directory (Asset Map) - Google My Maps]

4.0 Responses to Study Topics

This section addresses the seven topics that are included in the legislative language in Section 40:

At a minimum, the examination shall address:

1. allowing for a truck trailer combination or truck tractor, semi-trailer combination transporting cargo of legal dimensions that can be separated into units of legal weight without affecting the physical integrity of the load to bear a maximum of 107,000 pounds on six axles or a maximum of 117,000 pounds on seven axles by special annual permit;
2. limitations for any additional special annual gross vehicle weight permits based on highway type, including limited access State highway, non-limited-access State highway, class 1 town highway, and class 2 town highway;
3. limitations for any additional special annual gross vehicle weight permits based on axle spacing and axle-weight provisions;
4. reciprocity treatment for foreign trucks from a state or province that recognizes Vermont vehicles permitted at increased gross weights;
5. permit fees for any additional special annual gross vehicle weight permits;
6. additional penalties, including civil penalties and permit revocation, for gross vehicle weight violations; and
7. impacts of any additional special annual gross vehicle permits on the forest economy and on the management and forest cover of Vermont's landscape.

As explained earlier in section 3.4, for the purposes of this report the road network is classified based on federal aid designation. Roads that are part of the federal aid system are referred to as "State Highways" and the rest are "Local roads". Additionally, class 3 or class 4 town highways are not included in the analyses, as the legislative request specifically identifies that only class 1 and class 2 local roads be considered. Table details the route miles of federal aid and local roads by VTrans road class.

Table 4.1 Federal Aid (State highways) and Local Road Classification

Route miles (VTrans road class by federal aid highways)	**Federal aid roads**	**Local roads**	**Total**
Interstate	722		**722**
US Highway	618		**618**
State Highway	1,762	8	**1,771**
Class 1 Town Highway	142		**142**
Class 2 Town Highway	1,097	1,654	**2,750**
Total	**4,341**	**1,662**	**6,003**

Source: VTrans.

For brevity, vehicles permitted "to bear a maximum of 107,000 pounds on six axles or a maximum of 117,000 pounds on seven axles" are referred to as ***study vehicles***. For each of the topics, responses are constrained by the lack of specific available information. For example, VTrans maintains structure load rating evaluations for operating and inventory ratings for six-axle vehicles (suitable for the 107,000-pound study load) but does not maintain such rating data for seven-axle vehicles. Therefore, a heuristic approach with assumptions was utilized for evaluating the heavier study vehicle.

4.1 Prelude to Study Topics 1 through 3: Scenario Development

To effectively assess the potential impacts and costs of the study vehicles, two series of scenarios of operating authorization were developed. One series (signified by the numerals 1 through 4) utilized the previously discussed literature review to develop four operating authorizations for using State highways, encompassing both limited-access and non-limited access. The second series (signified by the letters "A" through "C") identified potential operating authorizations for usage of class 1 and 2 town highways.

This approach yields a potential of twelve combinations of operating authorizations, to enable the development of a range of responses. Practically, however, only seven combinations were suitable for further examination. *The inclusion of any specific scenario for examination does not imply a preference.* The dual purpose of these scenarios is to allow for a deeper examination of cost components as well as provide operating cases similar to those found in other Canadian-border states.

4.1.1 Scenarios for access to State highways

In developing scenarios for operating authorization, the first question was "Which precedents exist in other states' legislation allowing divisible loads similar to the study vehicles on that state's highway system?"

For the Canadian-bordering states examined in the literature review, the most restrictive precedent was a limited bi-directional trip on a specific route or path, from a specific state border crossing to a specific business location. Examples of these route-specific permits (**Scenario 1**) exist in several states including Maine, for various distances up to 30 route miles. The specific business locations were those that drew substantial traffic from neighboring states or provinces and included manufacturing or processing facilities as well as intermodal facilities. At most three routes and destinations were identified in any one state's legislation.

Through stakeholder interviews, an attempt was made to identify specific business locations within Vermont with a high volume of interstate or international traffic where operating authorization for such permits for study vehicles would be perceived as having high stakeholder utility. However, it became clear that key business locations within Vermont were fluid and not suitable to such a strict definition. For example, a particular section of a state forest might be logged for a few months, and then once logging is completed, the action will shift to another location.

As a result, Scenario 1 was expanded to a wider level of operating authorization access (**Scenario 2**), allowing for any business locations within thirty (30) air miles of state highway border crossings into the two jurisdictions currently allowing higher weights: New York State and Quebec. Scenario 2 is much less restrictive geographically than Scenario 1, as shown at the end of this subsection as Figure where the shaded area would have operating authorization. Consideration was given to allowing motor carriers a single job permit route of their choice within the shaded area, but both the enforcement challenges (study topic 6) and cost allocation of such an approach were seen as infeasible. Instead, Scenario 2 would allow businesses near the New York State and Quebec borders to seamlessly compete with businesses on the other side of those borders. For example, a Vermont carrier near the New York State border could pair a

Vermont permit under Scenario 2 with a New York State “statewide” permit for either study vehicle to potentially expand their business range.

Returning to other states’ permit operating authorizations, the approach favored by states such as North Dakota is to allow permits for either study vehicle as well as some heavier vehicles (up to 129,000 pounds of gross weight) on a narrowly defined but contiguous series of state highways. These permits allow movement across the state to all neighboring states and provinces, but only on either major roads or roads connecting to a neighboring state or province. North Dakota’s map showing authorized highways is shown at the end of this subsection as Figure 4.2.

The approach of a restrictive but widely reaching network led to an analysis of Vermont’s highway network for the highest volume truck traffic segments (**Scenario 3**). The analysis identified State, US, and Interstate Highways where part of the highway contained a top-quintile level of truck traffic as per VTrans’ GIS data. The next step was to include the entire identified highway statewide since daily truck traffic is estimated and therefore subject to variation. Finally, additional state highway segments were added to ensure contiguousness as well as connectivity to Massachusetts, New Hampshire, New York State, and Quebec. Note that no analysis was conducted to address potential issues such as congestion, air quality, safety, or economic development; the purpose of the scenario was *strictly* to identify any difference in implementation costs if a future operation authorization focused on high-truck-traffic State highways.

The least restrictive operating authorization for State highways (**Scenario 4**) is to allow access to all State highways where the current 99,000-pound gross weight permit is authorized. This scenario is both a strict reading of this report’s enabling legislation as well as being similar at a state highway level to both Michigan (where implementation is through weight-based registration) and New York (where implementation is through a permit valid on State highways excluding certain structures and toll segments).

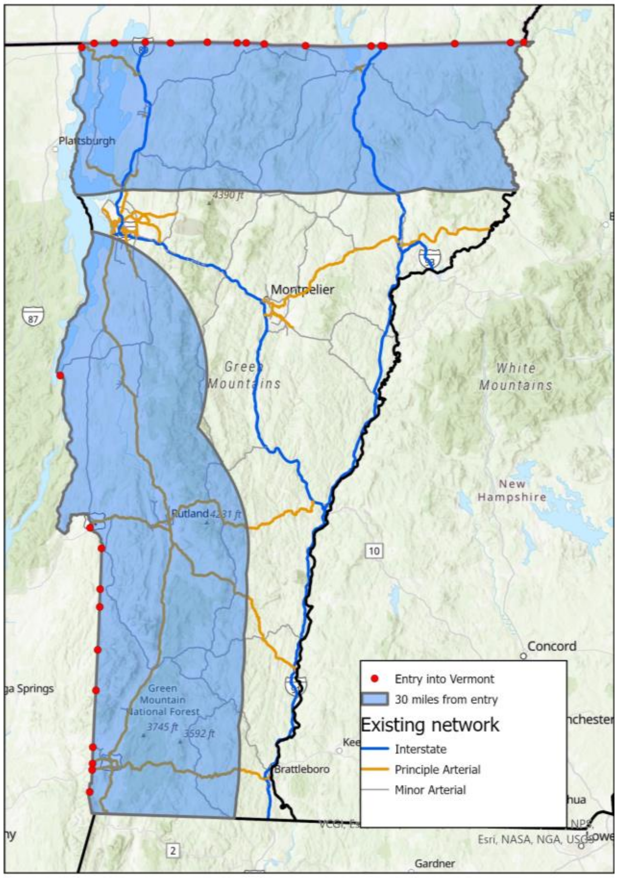
Table summarizes the four state highway scenarios identified in this subsection, of which Scenarios 2, 3, and 4 were analyzed.

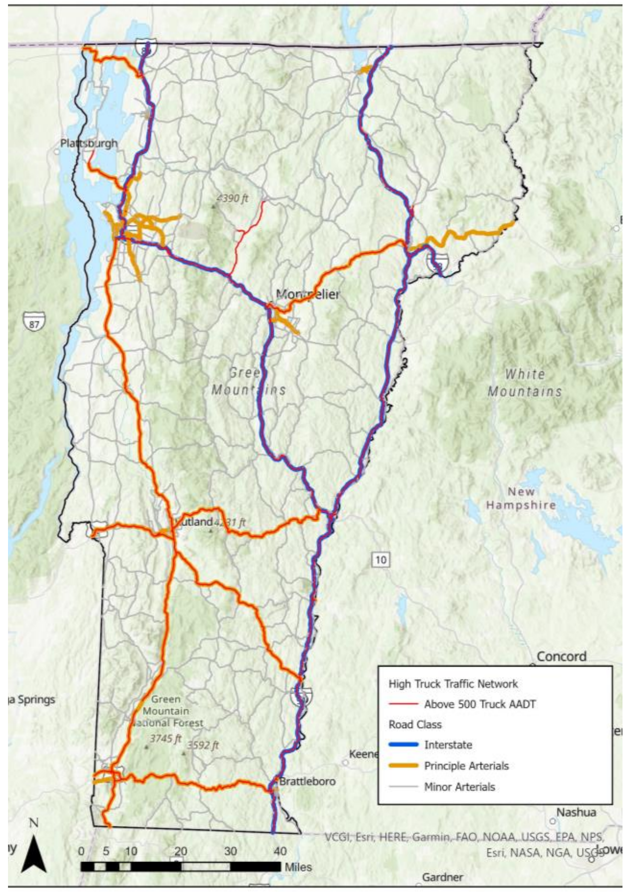
Table 4.2 Scenarios for State Highway Network

Scenario 1 – Single route	(NOT ANALYZED) Bi-directional travel authorized on specific State highways between a specific state border crossing and a specific authorized destination within 30 miles of that border
Scenario 2 – Border-radius	Travel authorized on all State, US, and Interstate highways within 30 air miles of the borders of Vermont with either New York or Quebec, including both limited-access and non-limited access highways
Scenario 3 – Limited High Truck Traffic Highways	Travel authorized on a specified set of State, US, and Interstate highways already serving higher volumes of Vermont’s daily truck traffic, including both limited-access and non-limited access highways
Scenario 4 – All State Highways	Travel authorized on all State, US, and Interstate highways within Vermont currently authorized by the 99,000-pound permit, including both limited-access and non-limited access highways

Source: Cambridge Systematics

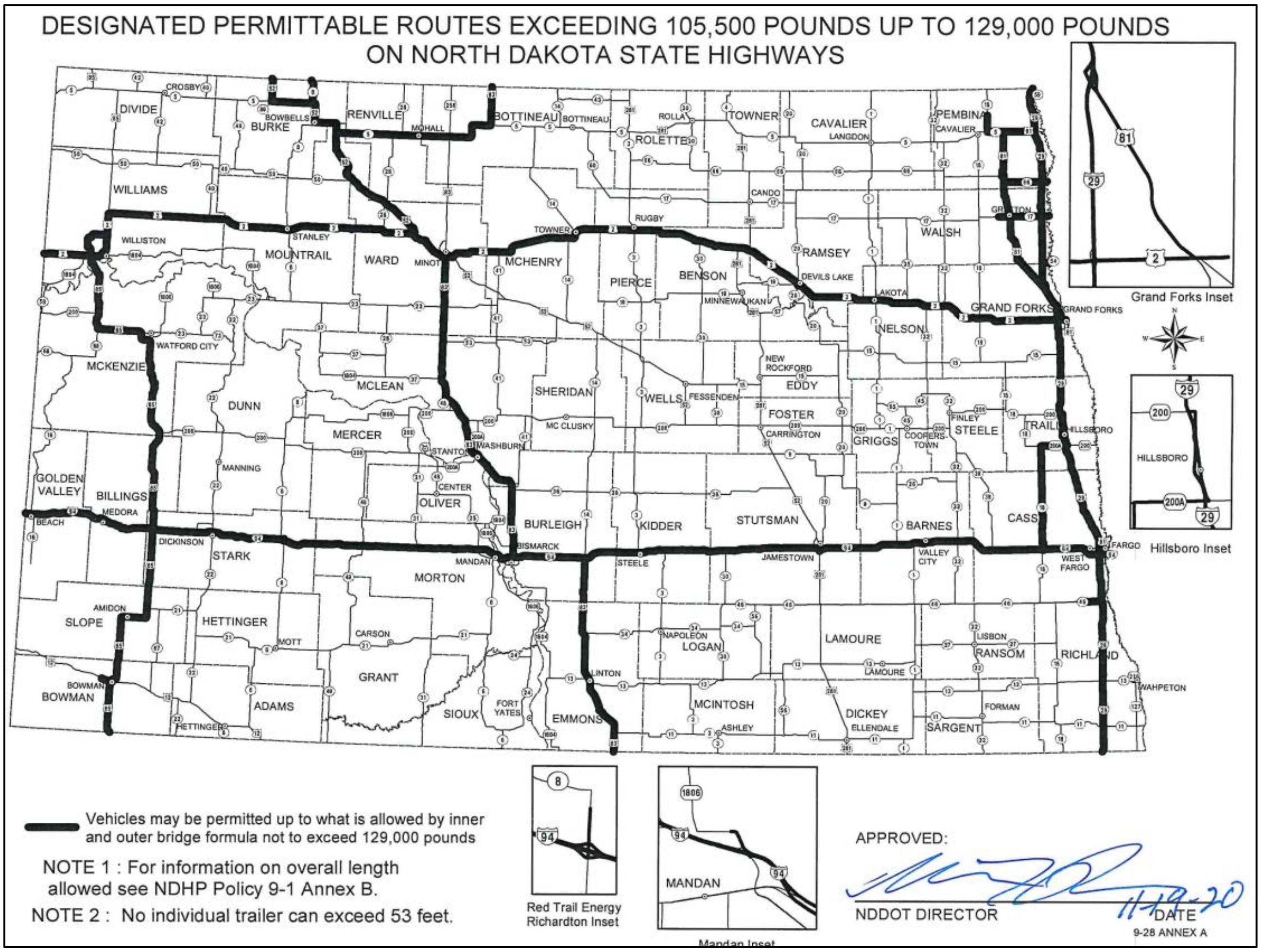
Figure 4.1 Scenario 2 (30 Air Miles from Border) and Scenario 3 (High Truck Traffic Network)





Source: Cambridge Systematics.

Figure 4.2 North Dakota Divisible Load Permit Routes



Source: https://www.dot.nd.gov/roadreport/loadlimit/loadlimitinfo.htm#truckroutingmaps, NDDOT - North Dakota Load Restrictions Info.

4.1.2 Scenarios for access to class 1 and 2 town highways

After developing scenarios 1 through 4 for State operating authorization, the next question was to explore how various operating authorization scenarios on class 1 and class 2 town highways would affect implementation costs and other issues. None of the state permit schemes for states bordering Canada that were reviewed included local road access on the permit or registration. Therefore, a spectrum of alternatives for such operating authorization of study vehicles on class 1 and 2 town highways in Vermont was developed.

The most restrictive approach would be to prohibit the travel of study vehicles on class 1 and 2 town highways. Besides its contrariness to study question 2, the dual-level scenario approach effectively partitions the potential implementation costs between state and local highways in each scenario, thus providing a clearer understanding of the potential cost impacts on the different jurisdictions.

Vermont's local highway network contains a mix of highway designs along with varying distances from the edges of the local highway network to a state highway. One guiding principle identified in the stakeholder interviews was that the shortest safe class 1 and class 2 route to a state highway should be taken, even if the total trip length increases:

- **Local Scenario A** considers situations where businesses are extremely close to the State network, but a short distance of the local highway is needed to access it. While various buffer distances could be considered (stakeholders discussed distances of up to ten miles on local roads), the purpose of the scenario is to understand how the local road coverage matches up to the state highway network. For this purpose, a buffer distance of one air mile from an authorized state highway was utilized. Any class 1 or class 2 town highways within this distance would be included in this operating authorization. The analysis showed that a substantial percentage of class 1 and class 2 lane miles across Vermont fall within one air mile of a state highway. When considering parcels where the closest road is neither a State nor federal highway, the mean and median straight-line distance are both less than a mile and the 90^{th} percentile distance is 1.6 miles. Furthermore, using air miles instead of route miles adjusts for cases where local roads are located on frontage to limited-access highways such as Interstates 89 and 91. As a result, this scenario covers the concept of a mandated operating authorization while covering a majority of class 1 and class 2 town highway lane miles, but limits longer trips on class 1 and class 2 town highways.

- **Local Scenario B** allows for each town to "opt-in" and choose to include none, any, or all class 1 and class 2 roads into the operating authorization. There would still be a single permit for the study vehicles, but the operating authorization would include the appropriate state scenario (2 through 4) and then the class 1 and class 2 town highways where the town has opted to include the highways. Since there is no information available on which towns would opt-in with which specific highways, cost calculations could not be made for this scenario.

- **Local Scenario C** mandates that all class 1 and class 2 town highways are included in the operating authorization. This scenario is the strict interpretation of study question 2.

Table summarizes the town highway scenarios. Table shows the matrix of combinations of scenarios between State highway scenarios and town highway scenarios. **The combination of Scenario 4 and Scenario C comprises the strict interpretation of the language of study question 2**.

Table 4.3 Scenarios for Local Roads

Scenario NULL – no local routes	No travel authorized on any class 1 or class 2 town highway
Scenario A – Limited Distance of 1 air mile	Travel authorized on all class 1 and class 2 town highways located within one (1) air mile of an authorized state highway
Scenario B – Town Decision	Travel authorized on any class 1 and class 2 town highway where the town has "opted-in" and included the highway in the operating authorization
Scenario C – All Class 1 and 2 Local Roads	Travel authorized on all class 1 and class 2 town highways

Source: Cambridge Systematics.

Table 4.4 Summary matrix of Scenarios

State (column) and local (row) scenario matrix	Scenario 2 Border-radius	Scenario 3 Limited High Truck Traffic Highways	Scenario 4 All State Highways
Scenario NULL **No local routes**	Calculations use only Scenario 2	Calculations use only Scenario 3	Calculations use only Scenario 4
Scenario A **Limited Distance of 1 air mile**	All state highways within 30 air miles of the NY or QC border, plus all class 1 and class 2 local roads located within 1 air mile of those state roads	Selected state highways with either high daily truck traffic or connectivity to a state border, plus all class 1 and class 2 local roads located within 1 air mile of those state roads	All state highways plus all class 1 and class 2 local roads located within 1 air mile of those state roads
Scenario B **Town Decision**	All state highways within 30 air miles of the NY or QC border, plus all class 1 and class 2 local roads within 30 air miles where the town has opted into including the road	Selected state highways with either high daily truck traffic or connectivity to a state border, plus all class 1 and class 2 local roads where the town has opted into including the road	All state highways, plus all class 1 and class 2 local roads where the town has opted into including the road
Scenario C **All Class 1 and 2 Local Roads**	All state highways, class 1 town highways, and class 2 town highways, within 30 air miles of the NY or QC border	*NOTE: This scenario is counter-intuitive and is omitted in calculations.* Selected state highways with either high daily truck traffic or connectivity to a state border, plus all class 1 and class 2 town highways in the state	All state highways, class 1 town highways, and class 2 town highways

Source: Cambridge Systematics.

4.2 Study Topic 1: Allowing for a truck trailer combination to bear a maximum of 107,000 pounds on six axles or 117,000 pounds on seven axles

4.2.1 Available data

- **Road Network Data.** The available road network data for both state highways and local roads is discussed in Section 3.4. For this topic, 6,003 route miles of road network are relevant.
- **Pavement Data.** Pavement surface data including pavement type is available for all roads within the 6,003 route miles. Road width and number of lanes are also available to estimate the total impacted surface area. Current pavement replacement and maintenance costs were obtained from VTrans engineering staff. Costs for different pavement treatments are also identified.
- **Structure Data.** The location and current condition (as of the previous inspection data) are known for each structure. For most structures, structure load rating data for a six-axle vehicle is known. Finally,

the structure replacement cost provided by VTrans was used to estimate the structure replacement cost.

- **Limited Traffic Data.** Vehicle class-based traffic data from 2018 was utilized. This segment-level data in AADT is available only for state roads. Most local roads lack any form of traffic data.

4.2.2 Data Limitations

- **Overall truck traffic data**. For this report, truck traffic data was obtained from the FHWA's Highway Performance Monitoring System (HPMS). This data is limited to state and federal highways. The data is an estimate and is incomplete in some parts of the network. Truck traffic data on local roads was unavailable.

- **Specific demand for travel using study vehicle specifications**. In multiple interviews with stakeholders, assertions were made that the nature of the related truck travel using potential study vehicles varied substantially with respect to both origin and destination, as well as the number of trips where either the origin or destination was on a state road, a class 1 or class 2 town highway, or on a class 3 or class 4 highway not in the legislative request. Not having specific demand values per highway segment affects the ability to properly model the potential impacts of study vehicle traffic on pavement.

- **Impact on road surfaces**. While assumptions could be made about categories of impacts, these assumptions are incomplete and can limit the qualitative findings.

- **Pavement details and type.** As the majority of the pavement in Vermont is flexible and there is extremely limited usage of rigid pavements, it was assumed all the pavement is flexible, and the needed design factors for estimating truck impacts were assumed using guidelines from the VTrans Pavement Design Manual.

- **Pavement deterioration modeling.** The timing of pavement treatments depended on the current pavement condition and the year of the last treatment. The year of the last treatment is an incomplete field and roughly half of the segments were missing data.

- **Short Structures.** Short structures lacked several important fields such as inventory operating ratings and deck area.

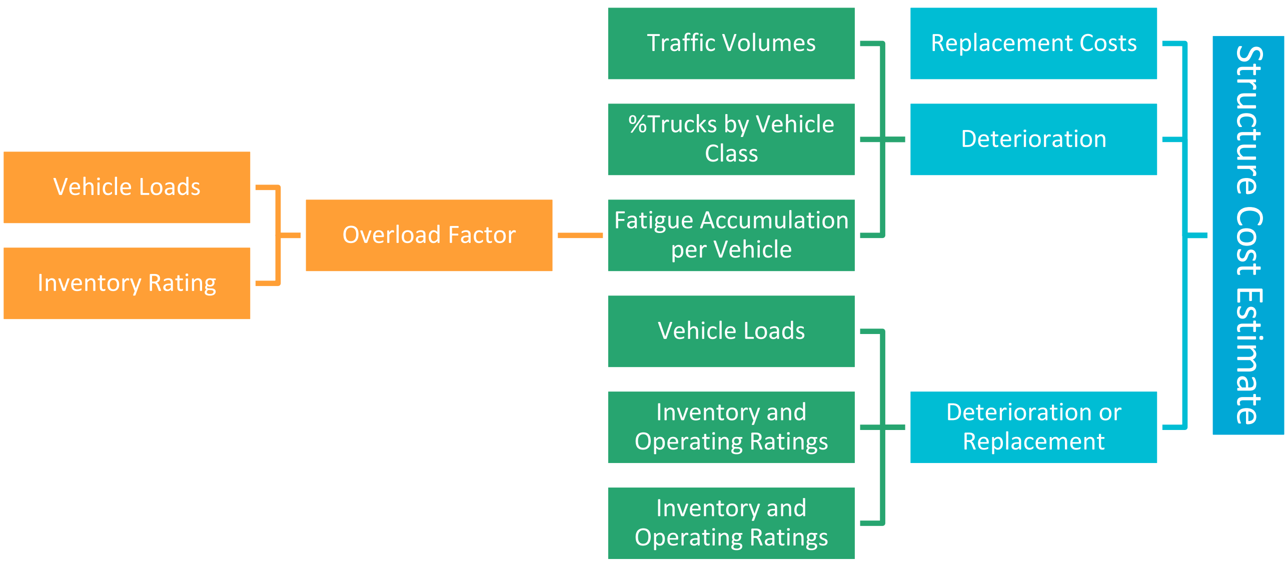
- **Freeze data**. The available data does not take into account how various highway segments in Vermont may freeze at different intervals throughout the state.

4.2.3 Methodology

Structures

The structures were analyzed using several steps. First, the Vermont structure database was used and filtered to remove the structures that do not carry a roadway, and GIS analysis was used to identify the bridges near the borders of Vermont or on local roadways near state highways. Then, the various structural capacity ratings for the individual structures were used to identify structures with capacity restrictions. The structures that would require replacement or posting to prevent overloading by study vehicles were identified as requiring replacement. Structures that could handle the additional loading but would deteriorate at an accelerated rate with the study vehicles were identified and their rate of deterioration was estimated and used to identify the year of replacement for both the current and possible future loadings, referred to as “base case vs. study case.” VTrans’ unit costs for structure replacement were applied to estimate replacement costs and a discount rate of 2.5 percent was used to account for when the structures would require replacement with current vehicles versus with the addition of the study vehicles. The overall workflow for the analysis is summarized in Figure .

Figure 4.3 Bridge Analysis Workflow



Source: Cambridge Systematics.

To determine which bridges would require immediate replacement to support heavier vehicle loads and which bridges would require deterioration estimation, the inventory and operating databases were used. The structures were categorized and assigned appropriate outcomes as outlined below:

- **Requiring immediate replacement:** If the vehicle weight exceeds the structure operating rating, then the vehicle would not be allowed. These structures were considered as requiring replacement or posting as the heavier loads exceeded the maximum safe loads on the structure and would induce an unsafe level of strain.

- **Advanced deterioration estimated:** If the vehicle weight exceeds the inventory rating but does not exceed the operating rating then the vehicle would be allowed with restriction, i.e. allowed by “permit” only.[9] For these structures, the vehicle overload and estimated truck traffic by class were used to estimate the structure deterioration over time for both the base case and the study case.

- **Replacement not estimated:** If the vehicle weight exceeds the inventory rating, then the vehicle would be allowed without restriction (other than the state and local regulations). The inventory rating

[9] “Permit” in this context is being used liberally to indicate that the vehicle should only be allowed with caution, therefore, should require some type of oversight to be allowed on the bridge.

was used to determine the maximum vehicle weight that could travel without restriction. Replacement costs were not estimated for these structures.

- **Short Structures:** Short structures were treated differently than long structures as the short structures do not have rating capacity data. Decisions about short structures therefore followed a different decision tree: if the span length was less than 10 feet, then it was determined the structure would be replaced and if the span length were greater than 10 feet it was assumed the structure would not be replaced.

For replacement estimations, where the deck area was available, the existing deck area was increased by 25 percent before applying a replacement cost of $1000 per square foot. For the short structures lacking deck measurements, their deck measurements were assumed to be the average of the minimum and maximum short structure lengths (13 feet) or typical roadway width of 24 feet.[10,11]

For the structures with estimated deterioration, the relationship between the study vehicle weights and structure capacity was used to estimate the amount of fatigue damage per vehicle, the details are explained further in the Appendix. This relationship was used to determine the amount of fatigue damage per study vehicle.[12] This fatigue damage per vehicle was then combined with the traffic counts to determine how many cycles could be expected per day. The known average daily truck traffic (ADTT) from the bridge database was segmented into an estimated number of vehicles by functional and vehicle class.[13] It was assumed in the base case that the maximum vehicle load for class 10, 12, and 13 was 99,000 pounds. For the deterioration estimation, it was assumed that the maximum possible load for class 10 and 13 increased to 117,000. Class 12 was assumed to increase to 107,000 pounds as that class of vehicles is defined as having only six axles. As such, the resulting percentage of truck traffic by weight range is summarized in Table for the base case, and Table assuming 107,000- and 117,000-pound vehicles allowed.

Table 4.5 ADTT Distribution by Functional Class and GVWR range, Base Case

Functional Class Highway	Less than 80,000	80,000 or more but less than 99,000	99,000 or more but less than 107,000	107,000 or more but less than 117,000	117,000
1 Rural	67.46%	23.95%	8.60%	0.00%	0.00%
2 Rural	78.25%	18.62%	3.13%	0.00%	0.00%
4 Rural	82.33%	13.28%	4.39%	0.00%	0.00%
5 Rural	91.18%	5.83%	2.99%	0.00%	0.00%
6 Rural	96.49%	1.10%	2.40%	0.00%	0.00%

[10] Legislative Study on Oversize/Overweight Vehicle Permit Issues, Vermont Agency of Transportation, January 2021.

[11] VTrans provided a unit replacement cost of $1000-$2000 per square foot of deck area for structures. This unit cost was estimated from bridge projects from 2020 onward and has increased from the prior unit cost used in prior studies of $650.

[12] The overload factor is calculated as actual total gross weight of the vehicle divided by the operating rating. IRC: SP: 37 [3]

[13] Report to the Legislature Pursuant to Act 59 of H.529 Section 47. “Weight-Based Annual Registration Report,” Vermont Agency of Transportation, December 2019.

Functional Class Highway	Less than 80,000	80,000 or more but less than 99,000	99,000 or more but less than 107,000	107,000 or more but less than 117,000	117,000
7 Rural	94.24%	4.36%	1.40%	0.00%	0.00%
1 Urban	74.89%	20.42%	4.69%	0.00%	0.00%
2 Urban	84.33%	13.27%	2.40%	0.00%	0.00%
3 Urban	83.87%	13.01%	3.11%	0.00%	0.00%
4 Urban	92.86%	4.98%	2.17%	0.00%	0.00%
5 Urban	96.84%	2.00%	1.16%	0.00%	0.00%
7 Urban	97.18%	2.43%	0.40%	0.00%	0.00%

Source: Cambridge Systematics. Legislative Study on Oversize/Overweight Vehicle Permit Issues, Vermont Agency of Transportation, January 2021

Table 4.6 ADTT Distribution by Functional Class and GVWR range, Study Vehicles

Functional Class Highway	Less than 80,000	80,000 or more but less than 99,000	99,000 or more but less than 107,000	107,000 or more but less than 117,000	117,000
1 Rural	67.46%	23.95%	0.00%	0.12%	8.48%
2 Rural	78.25%	18.62%	0.00%	0.02%	3.11%
4 Rural	82.33%	13.28%	0.00%	0.01%	4.39%
5 Rural	91.18%	5.83%	0.00%	0.00%	2.99%
6 Rural	96.49%	1.10%	0.00%	0.00%	2.40%
7 Rural	94.24%	4.36%	0.00%	0.53%	0.86%
1 Urban	74.89%	20.42%	0.00%	0.43%	4.26%
2 Urban	84.33%	13.27%	0.00%	0.01%	2.39%
3 Urban	83.87%	13.01%	0.00%	0.04%	3.07%
4 Urban	92.86%	4.98%	0.00%	0.09%	2.08%
5 Urban	96.84%	2.00%	0.00%	0.61%	0.56%
7 Urban	97.18%	2.43%	0.00%	0.00%	0.40%

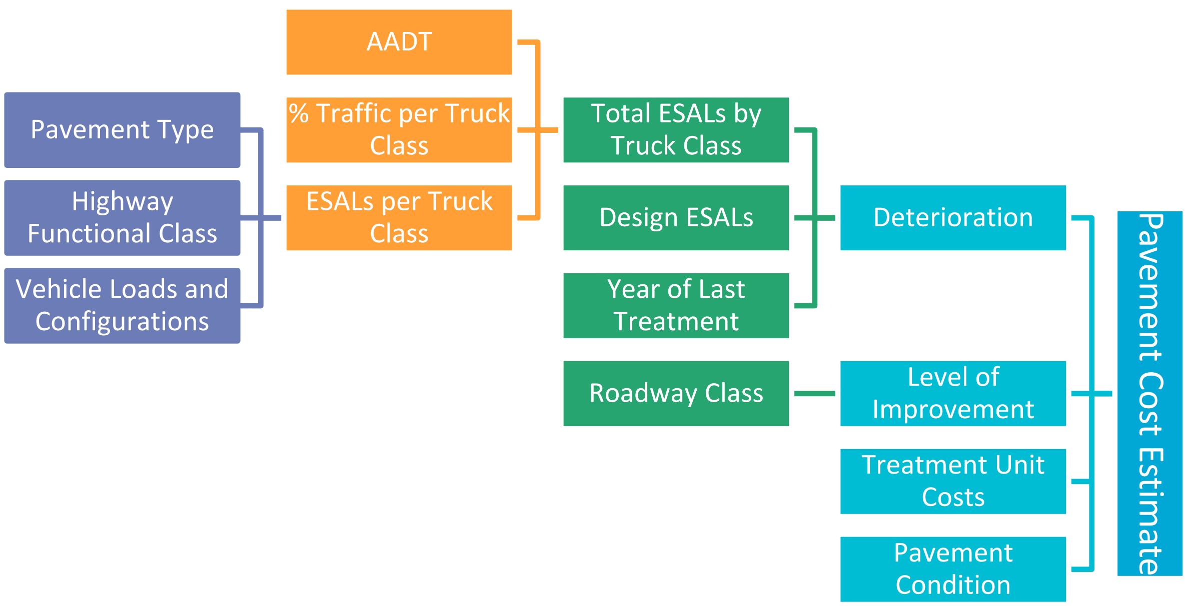
Source: Cambridge Systematics. Legislative Study on Oversize/Overweight Vehicle Permit Issues, Vermont Agency of Transportation, January 2021

The fatigue accumulation with the ADTT in the base case and the ADTT assuming 107,000- and 117,000-pound vehicles was used to compare the difference between when the existing structure would need to be replaced without increasing the traffic and when the existing structure would need to be replaced due to advanced deterioration. If the number of years exceeded 30 years, then 30 years was used. It was assumed that the structure would be replaced when the fatigue life of the structure had been exceeded. The replacement cost was applied in the year of replacement and discounted back to the present day using a discount rate of 2.5 percent. As the pavements and bridges have different lifecycles, consistent with the behavior of the respective infrastructure, the 30-year bridge costs were converted into a uniform annual series that would be consistent with the 20-year time horizon for pavements. The difference in cost between the increased weights and the base case was used to summarize the estimated costs due to the advanced deterioration of the structures.

Pavements

The pavement analysis relied on several databases which contained pavement width, number of lanes, condition, roadway type, year of last treatment, and traffic volumes. GIS analysis was used to identify roadways near the state border and local roadways near state highways. Assumptions on pavement type by highway functional class and truck volumes by vehicle class were used to estimate the deterioration of the pavement over time. The timing and type of treatments were decided based on the current pavement condition, estimated deterioration, and roadway functional class. Then, VTrans pavement treatment unit costs were applied to estimate treatment costs, and a discount rate of 2.5 percent was used to account for when the treatments would occur with current vehicles versus with the addition of the study vehicles. The overall workflow for the pavement analysis is shown in Figure .

Figure 4.4 Pavement Analysis Workflow



Source: Cambridge Systematics.

The pavement loading is quantified in terms of Equivalent Single Axle Loads (ESALs) to convert any truck into an equivalent number of single 18,000-pound axles. This conversion into ESALs depends on pavement design, vehicle axle configurations, and axle loads. Lacking appropriate pavement data for the roadway segments analyzed, the pavement design for Vermont roadways was assumed to be flexible and the pavement section modulus was assumed to vary by roadway class and surface type (i.e., paved vs. unpaved). Details on the pavement design factors utilized and assumed are provided in Appendix B.

For the axle configuration and load assumptions, a truck configuration (gross weight, number of axles, and weight per axle) was assumed for the study vehicles and each truck class based on New York state's axle loading limits. The least egregious axle loads for each weight class were assumed for ESAL calculations. This gives us the minimum impact that can be expected from a study vehicle. Details of assumed axle loading are in Table B.4 in the appendix. Using the pavement and vehicle assumptions, the number of ESALs per vehicle by truck class was calculated. A summary of the number of ESALs by truck class is shown in Table and the assumed percent of AADT by vehicle class and roadways are shown in Table . The assumed truck configurations used to calculate the ESALs can be found in Appendix B.

Table 4.7 ESALs per Truck by Vehicle Class and Pavement Type

Pavement Type	Roadway Type	Class 6	Class 7	Class 8	Class 9	Class 10	Class 11	Class 12	Class 13
Base Case									
Flexible	Federal Aid	2.4	3.0	5.2	2.5	3.2	5.0	4.0	2.6
Flexible	Class 2	2.3	3.0	5.5	2.4	3.2	5.0	3.9	2.4
Flexible	Unpaved	2.2	3.0	5.8	2.3	3.2	5.0	3.8	2.2
Study Vehicles									
Flexible	Federal Aid	2.4	3.0	5.2	2.5	3.9	5.0	5.1	4.3
Flexible	Class 2	2.3	3.0	5.5	2.4	3.9	5.0	5.1	4.2
Flexible	Unpaved	2.2	3.0	5.8	2.3	4.0	5.0	5.1	4.1

Source: Cambridge Systematics.

Table 4.8 Distribution of Truck Traffic by Vehicle Class and Roadway Classes, % of AADT

Roadway Class	Other Classes	Class 6	Class 7	Class 8	Class 9	Class 10	Class 11	Class 12	Class 13	Total % Truck
Rural										
Interstate	94%	1.3%	0.2%	1.1%	2.6%	0.9%	0.0%	0.0%	0.1%	11%
Principal Arterial	96%	1.1%	0.3%	1.0%	1.6%	0.3%	0.0%	0.0%	0.0%	9%
Principal Arterial – other	97%	0.9%	0.1%	0.9%	1.0%	0.3%	0.0%	0.0%	0.0%	8%
Minor Arterial	98%	0.9%	0.1%	0.6%	0.4%	0.2%	0.0%	0.0%	0.0%	7%
Major Collector	98%	1.0%	0.1%	0.5%	0.1%	0.2%	0.0%	0.0%	0.0%	7%
Minor Collector	98%	1.0%	0.1%	0.6%	0.3%	0.1%	0.0%	0.0%	0.0%	7%
Urban										
Interstate	95%	1.2%	0.3%	0.9%	1.9%	0.3%	0.1%	0.0%	0.1%	10%
Principal Arterial	98%	0.6%	0.1%	0.6%	0.8%	0.1%	0.0%	0.0%	0.0%	6%
Principal Arterial – other	97%	0.8%	0.1%	0.6%	0.9%	0.2%	0.0%	0.0%	0.0%	7%
Minor Arterial	98%	0.6%	0.1%	0.5%	0.3%	0.1%	0.0%	0.0%	0.0%	6%

Roadway Class	Other Classes	Class 6	Class 7	Class 8	Class 9	Class 10	Class 11	Class 12	Class 13	Total % Truck
Major Collector	99%	0.5%	0.1%	0.4%	0.1%	0.0%	0.0%	0.0%	0.0%	5%
Minor Collector	99%	0.7%	0.0%	0.3%	0.2%	0.0%	0.0%	0.0%	0.0%	8%

Source: Cambridge Systematics.

The allowable weight limit on state and class 1 town highways without an overweight permit is 80,000 pounds. The allowable weight limit on class 2 town highways is 24,000 pounds without an overweight permit from the local jurisdiction. Most class 2 town highways do not have engineered road subgrades and pavements. To account for an effective increase in allowable gross weight limit from 24,000 to 117,000 pounds, the analysis assumed that the local roadways would be upgraded and that based on previous literature the cost of these improvements would be $1.4 million per mile for paved roads and $500,000 per mile for gravel roads. There were no treatments applied to local roadways in the base case.

While local roadways were assumed to be upgraded before allowing the study vehicle loads, federal aid roadways have stronger subgrades and are typically designed to handle 80,000-pound vehicles. It was therefore assumed that if the pavement is in good condition today, a treatment would be applied at some point in the future. The timing of the treatment was estimated by determining when the original pavement design ESALs will be exhausted. The design ESALs are a part of pavement design and are estimated for each roadway using the functional class, pavement type (paved or gravel), and traffic volumes. The remaining life can be estimated by determining the cumulative ESALs for the overall traffic and the year of last treatment but at most 20 years. The number of design ESALs used for the pavement is summarized in Table by roadway type.

Table 4.9 Design ESALs by Roadway Type

Roadway Type	AADT	Design ESALs
Gravel	4-200	25,000-130,000
Local Paved	0-150	75,000-150,000
Federal Aid	Any	Calculated by combining the traffic per vehicle by class with the number of ESALs per vehicle by class.
Any	Unknown	0

Source: Cambridge Systematics, adapted from VTrans, "Pavement Design Guide." March 12, 2002.

In the base case, it was assumed that when the remaining ESALs have been consumed, the pavement would be repaired by level and overlay at a cost of $350,000 per mile. For the study vehicles, it was assumed that when the remaining ESALs have been absorbed the pavement would require mill and fill or reclamation at $2.2 million per mile. However, in either case, it was assumed that if the current pavement has a composite pavement condition index (CPCI) of very poor or if condition and traffic data were missing the treatment would occur in year zero. The application of these treatments for gravel, local, and federal aid roadways is summarized in Table .

Table 4.10 Pavement Treatment Unit Costs

Class	Treatment	Year of Treatment	Cost per Mile
Current Traffic			
Gravel Roadway	None	N/A	$0
Local Roadways	None	N/A	$0
Federal Aid	Level and Overlay	Estimated by design life in ESALs. If CPCI is very poor or unknown, then in year 0.	$350,000
Study Vehicle Traffic			
Gravel Roadway	Upgrade	Year 0	$500,000
Local Roadways	Upgrade	Year 0	$1,400,000
Federal Aid	Mill and Fill/Reclaim	Estimated by design life in ESALs. If CPCI is very poor or unknown, then in year 0.	$2,200,000

Source: Cambridge Systematics. VTrans.

4.2.4 Findings

Structures

By combining the inventory and operating ratings, the appropriate actions for each bridge structure were developed to determine which structures could handle various vehicle weights and which structures would likely suffer deterioration from the additional loads. The results of this decision process using the bridge ratings and vehicle loads are demonstrated in Table . For example, there are 83 structures with an operating rating below 80,000 pounds which indicates that an 80,000-pound vehicle should not be allowed across those bridges. There are 495 structures that could allow vehicles between 80,000 and 117,000 pounds but only with monitoring and restrictions in place. There are 119 bridges that can handle 99,000-pound vehicles without any restrictions but would require monitoring and restrictions for 107,000- and 117,000-pound vehicles. There are 329 structures that could freely allow 107,000- and 117,000-pound vehicles without reducing the life of the structure. For this study, it is assumed that:

- Where there is no restriction, there is no need for replacement or deterioration to be estimated (vehicle load below inventory rating);
- Where a vehicle is not allowed, the structure must be replaced before allowing that vehicle to cross (vehicle load exceeds operating rating);
- Where a vehicle is restricted, deterioration will be modeled to estimate at which point in the future the bridge would require replacement (vehicle load between inventory and operating ratings). Costs of replacement in future years were discounted to present value using a discount rate of 2.5 percent.

Table 4.11 Structure Restrictions by Gross Vehicle Weight Rating (GVWR), by Structure Type, Count, and Deck Area

<table>
<tr><th rowspan="2">80,000 GVWR Vehicle</th><th rowspan="2">99,000 GVWR Vehicle</th><th rowspan="2">107,000 GVWR Vehicle</th><th rowspan="2">117,000 GVWR Vehicle</th><th colspan="2">Long Structure</th><th colspan="2">Short Structure</th><th colspan="2">Town Structure</th><th colspan="2">All Structures</th></tr>
<tr><th>#</th><th>Deck Area (square feet)</th><th>#</th><th>Deck Area (square feet)</th><th>#</th><th>Deck Area (square feet)</th><th>#</th><th>Deck Area (square feet)</th></tr>
<tr><td colspan="4">Not Allowed</td><td>37</td><td>75,222</td><td>-</td><td>-</td><td>46</td><td>60,724</td><td>83</td><td>135,947</td></tr>
<tr><td>Restricted</td><td colspan="3">Not Allowed</td><td>69</td><td>169,270</td><td>-</td><td>-</td><td>32</td><td>54,260</td><td>101</td><td>223,530</td></tr>
<tr><td colspan="2">Restricted</td><td colspan="2">Not Allowed</td><td>42</td><td>100,377</td><td>-</td><td>-</td><td>12</td><td>20,727</td><td>54</td><td>121,104</td></tr>
<tr><td colspan="3">Restricted</td><td>Not Allowed</td><td>33</td><td>81,064</td><td>-</td><td>-</td><td>14</td><td>32,848</td><td>47</td><td>113,912</td></tr>
<tr><td colspan="4">Restricted</td><td>391</td><td>1,902,177</td><td>-</td><td>-</td><td>104</td><td>202,123</td><td>495</td><td>2,104,300</td></tr>
<tr><td>No restriction</td><td colspan="3">Restricted</td><td>316</td><td>2,096,269</td><td>-</td><td>-</td><td>60</td><td>114,660</td><td>376</td><td>2,210,928</td></tr>
<tr><td colspan="2">No restriction</td><td colspan="2">Restricted</td><td>106</td><td>771,536</td><td>-</td><td>-</td><td>13</td><td>26,824</td><td>119</td><td>798,360</td></tr>
<tr><td colspan="3">No restriction</td><td>Restricted</td><td>135</td><td>1,003,547</td><td>-</td><td>-</td><td>18</td><td>43,804</td><td>153</td><td>1,047,351</td></tr>
<tr><td colspan="4">No restriction</td><td>296</td><td>2,102,523</td><td>-</td><td>-</td><td>33</td><td>75,601</td><td>329</td><td>2,178,123</td></tr>
<tr><td colspan="4">No rating data (short bridges)</td><td>-</td><td>-</td><td>1,264</td><td>505,394</td><td>-</td><td>-</td><td>1,264</td><td>505,394</td></tr>
<tr><td colspan="4">Grand Total</td><td>1,425</td><td>8,301,985</td><td>1,264</td><td>505,394</td><td>332</td><td>631,570</td><td>3,021</td><td>9,438,949</td></tr>
</table>

Source: Cambridge Systematics. VTrans.

Using those above assumptions as a guide, Table summarizes the total cost of structure replacement by the maximum weight of the study vehicles. The 80,000- and 99,000-pound GVWR vehicles were included to demonstrate the number of structures that are already deficient for some legal loads in Vermont. For example, given an 80,000-pound vehicle, it would cost $2.0 billion ($ 2023) to upgrade all the structures to that capacity. By allowing 80,000- and 99,000-pound vehicles on all structures, it would cost an additional $1.3 billion (2023$) or $3.3 billion ($ 2023) when considering upgrades for 80,000- and 99,000-pound vehicles together. Allowing 107,000- and 117,000-pound vehicles would cost $4.6 billion ($ 2023); however, considering that there was already $3.3 billion estimated for upgrading all bridges to current legal loads of 99,000 pounds, the incremental cost for upgrading bridges (Federal Aid and Local) to accommodate 107,000- and 117,000-pound vehicles would be $1.3 billion ($ 2023). More details regarding the structure count and deck area replaced and deteriorated by vehicle load are provided in the Appendix.

Table 4.12 Structure 20-year Cost Estimation Cumulative by GVWR, $ Millions (2023)

Structure Type	80,000 GVWR Vehicle	99,000 GVWR Vehicle	107,000 GVWR Vehicle	117,000 GVWR Vehicle
Base Case Total Costs, Millions (2023$)				
Long Structure (Federal Aid)	$1,778	$2,994	N/A	N/A
Short Structure (Federal Aid)	$0	$0	N/A	N/A
Town Structure (Local)	$199	$270	N/A	N/A
Total	$1,977	$3,264	$0	$0
Study Vehicle Total Costs, Millions (2023$)				
Long Structure (Federal Aid)	$1,784	$3,009	$3,422	$3,903
Short Structure (Federal Aid)	$0	$0	$357	$357
Town Structure (Local)	$199	$270	$291	$324
Total	$1,983	$3,279	$4,070	$4,585
Incremental Costs (for 107,000- and 117,000-pound vehicles), Millions (2023$)				
Long Structure (Federal Aid)	$5.3	$15	$428	$909
Short Structure (Federal Aid)	$0	$0	$357	$357
Town Structure (Local)	$0	$0	$20	$54
Total	$5.3	$15	$805	$1,320
Average Annual Uniform Cost	$0.34	$0.94	$52	$85

Source: Cambridge Systematics.

After estimating the replacement, deterioration, and costs of all structures, the results were summarized into the various scenarios previously described. Table and Table detail the number of structures and deck area included in each scenario. There is a marginal difference between the number of structures and deck area between Scenario A and Scenario C owing to the majority of class 1 and 2 local roads being within 1 air mile of state highways. Scenario 4C – All State Highways and class 1 and 2 Local Roads - is the most inclusive of the scenarios and accounts for 3,021 structures.

Table 4.13 Structure Count, by Scenario

	Scenario 2 – Near Border	**Scenario 3 –** Highways with High Truck Volumes	**Scenario 4–** All State Highways
Scenario NULL – No local routes	1,314	573	2,689
Scenario A – Includes local routes within 1 mile of state highways	1,439	715	2,928
Scenario B – Town Decision	Undefined		
Scenario C – Includes all class 1 and 2 Local Roads	1,488		3,021

Source: Cambridge Systematics.

Table 4.14 Structure Deck Area, by Scenario (Million square feet)

	Scenario 2 – Near Border	**Scenario 3 –** Highways with High Truck Volumes	**Scenario 4–** All State Highways
Scenario NULL – No local routes	3.5	3.1	8.8
Scenario A – Includes local routes within 1 mile of state highways	3.7	3.4	9.3
Scenario B – Town Decision	Undefined		
Scenario C – Includes all class 1 and 2 Local Roads	3.8		9.4

Source: Cambridge Systematics.

Table summarizes the incremental cost of upgrading the structures to accommodate 107,000 and 117,000-pound vehicles and Table converts the incremental cost into a uniform annual series for a 20-year period. For example, allowing 107,000- and 117,000-pound vehicles on all state highways and no local roads would cost an additional $1.27 billion in total or $81 million annually.

Table 4.15 Incremental Structure Costs, $ Millions (2023$)

	Scenario 2 – Near Border	**Scenario 3 –** Highways with High Truck Volumes	**Scenario 4–** All State Highways
Scenario NULL – No local routes	$550	$447	$1,266
Scenario A – Includes local routes within 1 mile of state highways	$570	$467	$1,313
Scenario B – Town Decision		Undefined	
Scenario C – Includes all class 1 and 2 Local Roads	$574		$1,320

Source: Cambridge Systematics.

Table 4.16 Incremental Average Annual Costs for 20 years, $ Millions (2023$)

	Scenario 2 – Near Border	**Scenario 3 –** Highways with High Truck Volumes	**Scenario 4–** All State Highways
Scenario NULL – No local routes	$35	$29	$81
Scenario A – Includes local routes within 1 mile of state highways	$37	$30	$84
Scenario B – Town Decision		Undefined	
Scenario C – Includes all class 1 and 2 Local Roads	$37		$85

Source: Cambridge Systematics.

Pavements

The overall costs for pavements by VTrans road class and treatment type are shown in Table , which also shows the costs associated with the current traffic (base case) and with the addition of the study vehicles to the traffic mix (scenario). Without the addition of the study vehicles, the base case estimates current traffic would cost $992 million over the next 20 years and the additional of the study vehicles would increase that cost to $9.5 billion over the next 20 years, which is an incremental cost of $8.6 billion over 20 years or $548 million per year to accommodate the heavier traffic.

Table 4.17 Pavement 20-year Cost Estimation Cumulative by GVWR, $ Millions (2023)

Base Case Costs, $ Millions (2023)	Treatments		All Treatments
	Level and Overlay	None	
Federal Aid Road	$992	$0	$992
Paved Local Road	N/A	$0	$0
Gravel Local Road	$0	$0	$0
Total	$992	$0	$992
Scenario Costs, $ Millions (2023)	**Mill and Fill/Reclaim**	**Upgrade**	**All Treatments**
Federal Aid Road	$6,251	$1,478	$7,730
Paved Local Road	$0	$1,627	$1,627
Gravel Local Road	$0	$186	$186
Total	$6,251	$3,291	$9,542
Incremental Costs, $ Millions (2023)			
Federal Aid Road	$5,260	$1,478	$6,738
Paved Local Road	$0	$1,627	$1,627
Gravel Local Road	$0	$186	$186
Total	$5,260	$3,291	$8,551
Average Annual Uniform Cost	$337	$211	$548

Source: Cambridge Systematics.

The extent of affected pavement lane-miles across each scenario is summarized in Table .[14] At the state level, a comprehensive approach would allow the study vehicles on all state highways, affecting 8,707 lane-miles of pavement. Limiting the study vehicles to state highways within a 30-mile distance from the border reduces the affected lane-miles by 50 percent. Only allowing the study vehicles on high truck traffic state highways would impact 74 percent less pavement than if all state highways were to accommodate the study vehicles.

At the local level, allowing the study vehicles on all state highways **and** class 1 and class 2 local roadways, a total of 10,688 lane-miles would be affected, of which 8,707 lane-miles are state highways and 1,981 lane-miles are local roads. Limiting the study vehicles to state highways and local roads within a 30-mile distance from adjacent state borders reduces the affected lane-miles by 50 percent. Allowing the study vehicles on high truck traffic state highways and nearby local roads affects only 533 lane miles of local roads and 2,194 lane miles of state highways.

[14] Lane miles are calculated by multiplying the route miles for each segment by the "Through Lanes" field in the VT_RoadWidth dataset. DataDictionary_RoadWidth.pdf (vermont.gov)

Table 4.18 Cumulative Pavement Lane-Miles by Scenario

	Scenario 2 – Near Border	**Scenario 3 –** Highways with High Truck Volumes	**Scenario 4 –** All State Highways
Scenario NULL – No local routes	4,580	2,194	8,707
Scenario A – Includes local roads within 1 mile of state highways	5,368	2,727	10,047
Scenario B – Town Decision		Undefined	
Scenario C – Includes all class 1 and 2 Local Roads	5,754	Combination not considered	10,688

Source: Cambridge Systematics.

Using the methodology previously discussed in Section 4.2.3, appropriate treatment costs were applied in the base case to state highways and to the study case in the year of treatment and discounted back to present day using a discount rate of 2.5 percent. The total costs for the base case and study case are summarized in Table and Table . Table presents the total incremental costs and Table presents the incremental costs as a uniform annual series. For example, it was estimated that state highways would require $992 million to address very poor pavements without changing vehicle weight limits. The incremental cost to accommodate heavier-weight vehicles would be $6.7 billion for the necessary pavement improvements, or $432 million annually over a period of 20 years. Limiting the study vehicles to state highways within a 30-mile distance from the border reduces the cost by 50 percent. The least expensive option state highway scenario is focusing on high truck traffic state highways, which is 74 percent lower than all state highways.

For class 1 and 2 local roadways, no treatments were assumed to be necessary for the current traffic, but allowing the study vehicles would require an additional $1.8 billion to upgrade the roadways for the heavier traffic—the incremental costs required for allowing the study vehicles on both state highways and local roads is $8.6 billion ($7.7 billion for the pavement improvements and upgrades for state highways and $1.8 billion for local roadways) or $548 million per year. Limiting the study vehicles to state highways and local roads within a 30-mile distance from the border reduces the affected lane miles by 50 percent. The least expensive option is allowing the study vehicles on high truck traffic state highways and nearby local roads, which is 74 percent lower than all state highways.[15]

Table 4.19 Pavement Base Cost Estimates by Scenario, $ Millions (2023$)

	Scenario 2 – Border-radius	**Scenario 3 –** Highways with High Truck Volumes	**Scenario 4 –** All State Highways
Scenario NULL – No local roads	$512	$333	$992
Scenario A – Includes local roads within 1 mile of state highways	$512	$333	$992
Scenario B – Town Decision		Undefined	
Scenario C – Includes all class 1 and 2 Local Roads	$512	Combination not considered	$992

Source: Cambridge Systematics.

[15] For more information on the treatment improvements assumed in the base case and study options, please refer to the Methodology section in Section 4.2.3.

Table 4.20 Pavement Study Cost Estimates by Scenario, $ Millions (2023$)

	Scenario 2 – Border-radius	**Scenario 3 –** Highways with High Truck Volumes	**Scenario 4 –** All State Highways
Scenario NULL – No local roads	$4,039	$2,105	$7,730
Scenario A – Includes local roads within 1 mile of state highways	$4,860	$2,585	$9,026
Scenario B – Town Decision		Undefined	
Scenario C – Includes all class 1 and 2 Local Roads	$5,183	Combination not considered	$9,542

Source: Cambridge Systematics.

Table 4.21 Pavement Incremental Cost Estimates by Scenario, $ Millions (2023$)

	Scenario 2 – Border-radius	**Scenario 3 –** Highways with High Truck Volumes	**Scenario 4 –** All State Highways
Scenario NULL – No local roads	$3,528	$1,771	$6,738
Scenario A – Includes local roads within 1 mile of state highways	$4,349	$2,252	$8,034
Scenario B – Town Decision		Undefined	
Scenario C – Includes all class 1 and 2 Local Roads	$4,671	Combination not considered	$8,551

Source: Cambridge Systematics.

Table 4.22 Pavement Average Annual Costs by Scenario, $ Millions (2023$)

	Scenario 2 – Border-radius	**Scenario 3 –** Highways with High Truck Volumes	**Scenario 4 –** All State Highways
Scenario NULL – No local roads	$226	$114	$432
Scenario A – Includes local roads within 1 mile of state highways	$279	$144	$515
Scenario B – Town Decision		Undefined	
Scenario C – Includes all class 1 and 2 local roads	$300	Combination not considered	$548

Source: Cambridge Systematics.

Structures and Pavements Combined

Combining the incremental cost estimates for structures and pavements, the structural work was converted from a 30-year base period to a 20-year base period using the uniform annual average estimate. For incremental costs of pavement and structures combined, the incremental cost for the most restrictive scenario is $2.2 billion or $143 million per year to allow the study vehicles to travel on state highways with high truck volumes without accessing local roadways. The total costs for the most comprehensive scenario are $9.9 billion or $633 million per year for allowing the study vehicles on both state highways and local roads. The results for the total costs are summarized in Table and Table .

Table 4.23 20-Year Total Pavement and Structure Costs Estimates by Scenario, $ Millions (2023$)

	Scenario 2 – Border-radius	**Scenario 3 –** Highways with High Truck Volumes	**Scenario 4 –** All State Highways
Scenario NULL – No local roads	$4,078	$2,218	$8,005
Scenario A – Includes local roads within 1 mile of state highways	$4,918	$2,719	$9,348
Scenario B – Town Decision		Undefined	
Scenario C – Includes all class 1 and 2 Local Roads	$5,246		$9,871

Source: Cambridge Systematics.

Table 4.24 Average Annual Costs of Pavement and Structure Estimates by Scenario, $ Millions (2023$)

	Scenario 2 – Border-radius	**Scenario 3 –** Highways with High Truck Volumes	**Scenario 4 –** All State Highways
Scenario NULL – No local roads	$262	$142	$513
Scenario A – Includes local roads within 1 mile of state highways	$316	$174	$600
Scenario B – Town Decision		Undefined	
Scenario C – Includes all class 1 and 2 local roads	$337		$633

Source: Cambridge Systematics.

4.3 Study Topic 2: Limitations based on highway type

4.3.1 Available data

- **Roadway functional class by VTrans road class**, i.e., class 1 Town Highway, class 2 Town Highway, State Highway, etc.
- **Pavement surface type**, i.e., paved or gravel roads, by roadway functional class.

4.3.2 Data Limitations

- **Pavement surface type** is limited to distinguishing between paved or gravel roadways, there is no detailed information on pavement structure, design capacity, or subbase, i.e., flexible versus rigid, pavement thickness, etc.
- **Distribution of truck traffic across vehicle classes** was estimated but is unknown, therefore cannot confidently estimate the number of trucks by vehicle class per roadway by functional class.
- **Lacking dimensional data** of existing roadways by roadway classification**.**

4.3.3 Methodology

For bridges and pavements, the life cycle structural impacts due to the increased weight of the study vehicles were measured and shared by the highway functional class. The study vehicles will have impacts on the infrastructure beyond the structural impacts of the vehicle loads. The vehicle sizes, noise, and emissions will also have impacts on the infrastructure and communities—especially for those town highways that are currently limited to 24,000-pound vehicles. We are not assuming any changes in equipment configuration from the current industry standards. The horizontal and vertical clearances, turning radii, curbs, bicycle lanes, and pedestrian crossings each have the potential to be inadequate for larger trucks. Therefore, the impacts of the study vehicles by highway functional class go beyond the structural capacity and life cycle of the roadways and extend into the communities and neighborhoods traversed by the roadways.

4.3.4 Findings

The physical constraints differ across highway functional classes and vary depending on the individual roadways. The existing configuration and nearby property usage of the roadways, particularly, the town highways currently limited to 24,000-pound vehicles, will greatly vary the potential impact of the study vehicles. While additional weight has a significant impact on pavement and structure life cycle, the dimensions of the trucks also have impacts on the ability of the study vehicles to safely navigate the existing infrastructure specifically on roadways which currently do not allow large trucks.

4.4 Study Topic 3: Limitations based on vehicle axle weights and spacings

4.4.1 Available data

VTrans regulations specify the maximum gross weight each class of truck can carry and associated axle requirements up to 99,000 pounds with a permit for non-divisible loads. For axle load distribution of 107,000 pounds and 117,000 pounds, we can assume similar regulations regarding axle load distribution as for New York State non-divisible loads.

- **Network data** of available roads for each scenario.
- **Structure load rating data** for most structures for six-axle loads.
- **Structure lengths** to provide a framework for which structures need more detailed analysis for longer weight and spacing calculations.
- **Pavement algorithms** used to calculate equivalent single axle loads (ESALs) for different vehicle configurations.
- **Calculations of impacts on structures and pavements** as found above in the responses for Study Topics 1 and 2.

- **Examples of potential six and seven-axle loads** from similar divisible load permits, namely the Statewide permits from New York State for vehicles similar to the study vehicles.

4.4.2 Data Limitations

- **Specific suggestions of variations** in potential loading of axle weights and spacings for alternatives.

- **Highway geometry**, specifically geometries of turning movements where vehicle configurations at the higher end of legal length may encounter challenges.

- **Induced demand on Vermont highways.** As a result of allowing higher weights, it is likely that some traffic would utilize Vermont as a through state. Unfortunately, there is not sufficient data to analyze the likely volume and apply that volume to earlier calculations.

There is no clear market study on demand for higher weight limits that highlights a share of mode shift from 99,000 pounds to 117,000 pounds. To estimate the severity of impact, we need to assume a share of mode shift to higher weight limits.

Given that Vermont already requires a permit for 99,000-pound trucks on six axles, it is very likely that existing trucks would quickly shift to 107,000 pounds on six axles if permitted. This would be case 1. Case 2 assumes that all 99,000-pound trucks will shift to 117,000 pounds on seven axles. This captures the highest impact case for modeling. In reality, the impact would fall somewhere between the results of Cases 1 and 2. Meanwhile, additional traffic could be added due to induced demand, but insufficient information is available to calculate that potential effect.

4.4.3 Methodology

Without specific suggestions of alternative variations of axle weights and spacings from industry groups, it is challenging to conduct a quantitative analysis to fully answer this question. However, what can be identified are the factors that would need to be addressed when using an alternative distribution of weights and spacings and applying that distribution to the quantitative analysis found to this point in this report.

We first consider structures and remind the reader that there are a small number (under 100) structures with calculated six-axle load ratings between 107,000 and 117,000 pounds and that these are the structures where we have specific concerns about distributions of seven axles at weights between those weight boundaries. The length of the overall vehicle, the combinations of the axle groupings, and the distribution of weights on each grouping are important. We would not expect that alternative variations of axle weights should disproportionately load weight on the rear axles in a 1-3-3 or 1-2-2-2 distribution of axles across the length of the seven-axle vehicle, and any disproportionate suggestions should be considered with some suspicion. It is likely that any seven-axle variations provided in the future would require a more detailed structure load rating analysis on the structures where the current six-axle load rating is currently between 107,000 and 117,000 pounds.

The class of trucks, the gross weight of the truck, and its axle configuration all affect the impact on pavement condition. To estimate the impacts of aggregated traffic volume, the different types of trucks were converted into a standardized unit of impact called Equivalent Single Axle Load (ESAL). These ESAL conversions by truck class are summarized in Table .

Table 4.25 ESAL for Different Axle Configurations for Base and Study Vehicles

Truck Class	Base Case			107,000-pound Study Vehicle			107,000- and 117,000-pound Study Vehicles		
	Gross Weight (lb)	# Axles	ESAL	Gross Weight (lb)	# Axles	ESAL	Gross Weight (lb)	# Axles	ESAL
Class 13	99,000	7	**2.62**	107,000	7	**3.47**	117,000	7	**4.28**
Class 12	99,000	6	**4.03**	107,000	6	**5.10**	107,000	6	**5.10**
Class 11	90,000	5	**5.00**	90,000	5	**5.00**	90,000	5	**5.00**
Class 10	99,000	6	**3.21**	107,000	6	**3.89**	117,000	7	**3.72**
Class 9	80,000	5	**2.45**	80,000	5	**2.45**	80,000	5	**2.45**
Class 8	80,000	4	**5.25**	80,000	4	**5.25**	80,000	4	**5.25**
Class 7	80,000	5	**3.03**	80,000	5	**3.03**	80,000	5	**3.03**
Class 6	66,000	4	**2.40**	66,000	4	**2.40**	66,000	4	**2.40**

Source: Cambridge Systematics.

4.4.4 Findings

This study question is largely addressed in a qualitative manner. The analysis assumes that the vehicle remains at legal length, similar to the study vehicles. Given this assumption, it is likely that variations of axle weights and spacings for the study vehicles within the limits of 107,000 pounds gross for six axles and 117,000 pounds gross for seven axles will produce minor differences in the findings identified earlier in this section.

Specifically, variations in axle weights and spacings for seven-axle vehicles would highlight the need for VTrans to commit resources to develop and implement additional structure load rating models for seven-axle vehicles. In earlier sections, we have heuristically worked around the lack of such ratings by considering structure length for structures with a six-axle load rating between 107,000 and 117,000 pounds, but additional load rating analysis on a sample of structures should be conducted in the future to validate these heuristics.

Conversely, it appears that as long as alternative variations maintain a similar or lower amount of ESALs, the calculations for Study Topics 1 and 2 for pavement impacts would not be substantially different for any alternatives.

4.5 Study Topic 4: Reciprocity for trucks registered outside of Vermont

Study topic 4 asks what the impacts are of allowing or prohibiting reciprocity for trucks registered outside of Vermont. The carriers operating such trucks are highly likely to be members of the International Registration Plan which allows a carrier to register a commercial motor vehicle in multiple jurisdictions.

4.5.1 Available data

- **Overall commercial registration data,** including how many vehicles registered in Vermont are also registered in neighboring states.

- **Potentially,** permit volume data for New York State's statewide permits for six and seven-axle divisible load vehicles. This data was not obtained for this report, but it would likely be provided by the New York State Department of Transportation to VTrans if other data limitations were mitigated.

4.5.2 Data Limitations

- **Travel patterns including route and mode choice.** For example, we are not aware of how many holders of New York State seven axle statewide permits currently cross into Canada at Interstate 87 and then head to points east from there. Similarly, we do not know how many trips are not taken (or where rail is utilized instead) because of the current cost of bypassing Vermont with heavier six or seven-axle loads.

- **Induced demand on Vermont highways.** As a result of allowing higher weights, it is likely that some traffic would utilize Vermont as a through state. Unfortunately, there is not sufficient data to analyze the likely volume and apply that volume to earlier calculations.

4.5.3 Methodology

Conceptually, allowing the study vehicles to operate throughout Vermont on state highways with a time-based permit would allow Vermont motor carriers to compete for additional interstate/international business, but would also allow businesses based in other states to both compete in Vermont as well utilize Vermont as a through-state in Scenarios 3 and 4: utilizing highways without sufficient corresponding economic benefits.

Unfortunately, there is insufficient data currently available to develop any type of quantitative answer to this study topic. At best, it is reasonable to assume that there will likely be more traffic at higher weights than would simply result from the shifting of existing shipments moving at the 99,000-pound gross weight limit to study vehicles.

Limiting a future permit to only intrastate moves is problematic and impractical, particularly from an enforcement perspective. Enforcement staff would have to monitor state border crossings and intercept vehicles exceeding 99,000 pounds. A potentially more enforceable approach would involve limiting access to Interstate 89 and 91 and potentially limiting the number of border crossings in New York State and Quebec. In some ways, this would be the converse of Scenario 3, as the routes with the current highest truck traffic are likely to be the routes of disproportionate interest to out-of-state carriers not planning to stop in Vermont.

4.5.4 Findings

There is insufficient data to answer this question quantitatively. Qualitatively, it is likely that current trips between eastern Quebec or the Atlantic Maritimes and areas of New York State may see a diversion away from New York/Quebec border crossings to Vermont. The anticipated completion of Autoroute 35, which will link the Montreal region with Vermont at Highgate Springs, will play a significant role in this. Unfortunately, VTrans is not in possession of sufficient data about trip volumes at these higher study vehicle weights to be able to put any arithmetic around the answer beyond “there will be some.” Additional study including data collection and stakeholder outreach would need to be taken to answer this part of the topic quantitatively.

Scenario 2, however, will have the most minimal impact on this topic. The reduced impact is because there is no way to legally get from the 30-mile radius of the New York border crossings and the 30-mile radius of the Quebec border crossings. Therefore, Scenario 2 will likely increase demand for cross-border trips with both jurisdictions, to a level that we cannot model today, but it should not increase demand for diverting current Quebec to New York trips to become Quebec to Vermont to New York trips.

4.6 Study Topic 5: Permit fees for study vehicles

A definition left unspecified in the language of this study topic is whether the permit should be revenue-neutral, as in the quantitative impacts on structures and pavements should be fully offset by permit fees. Today, the 99,000-pound permit is not revenue-neutral on town highways, annual fees of under $25 per municipality cannot be considered to offset the pavement damage in many if not all circumstances.

4.6.1 Available data

- **Expected structure and pavement costs** for each scenario, as per the findings of study questions 1 and 2.

4.6.2 Data Limitations

- **An accurate volume estimate** of how many carriers currently operating with the 99,000-pound permit would “buy up” to a permit for a study vehicle.
- How many **carriers based outside of Vermont** would wish to buy a permit for a study vehicle?
- How trips would be taken, such as the **number of miles per permit** on state roads versus class 2 town highways.
- **An estimate of the cost of and timeframe for system implementation at the state level.** Given the fact that Vermont is in the process of developing a migration path to true online permitting for non-divisible load permits, adding the permits for the study vehicles should not be a substantial increase.
- Current data on how many permits are issued by each town.
- **Data on positive business impacts** should a permit for study vehicles be approved.

4.6.3 Methodology

The available data is sufficient to develop a rough estimate of the costs associated with pavement and bridge infrastructure. This information in turn could be used to estimate the marginal implementation cost for issuing permits for the study vehicles to the scope of the planned state permit system for oversize/overweight vehicles. However, there is no available data that can be used to estimate the number of vehicles where a permit may be an attractive business decision if priced properly. Therefore, we have a denominator (cost to the State to be recouped in a revenue-neutral situation) without a numerator (number of purchases).

Additionally, the population of out-of-state vehicles who would be candidates for purchasing a permit for a study vehicle likely varies by scenario. Finally, we do not have an estimate of the potential benefits to Vermont businesses that a new permit may generate nor a proposed method for aligning those benefits in a scenario where less than cost-neutral fees would be charged.

4.6.4 Findings

Study topics 1 and 2 address the estimated total infrastructure costs to Vermont. It is likely that some industries would see economic benefits that might offset a portion of those costs, but that amount cannot be estimated at the present time.

The reviewed literature identified that in Florida, current permit costs are only a fraction of likely infrastructure impacts (shown in Table). It appears that a similar situation would occur in Vermont.

One additional topic is the duration of any future permit. In most conversations with stakeholders, we have seen an assumption for either a permit of 365 days of duration or a permit for the remainder of a calendar year. We suggest further study on the travel patterns to determine if there are shorter durations with higher relevance to some industry segments, such as weekly or calendar month permits.

4.7 Study Topic 6: Enforcement of (and penalties for) gross vehicle weight violations

4.7.1 Available data

- **Citations issued by the Vermont DMV** for violations above 100,000-pound gross vehicle weight for calendar year 2022.
- **Locations where Vermont DMV** is able to establish weight enforcement using fixed or portable scales.
- **Current Vermont DMV enforcement staffing levels,** as well as staff diverted from weight enforcement to other enforcement activities due to staffing shortages.
- **Weigh in motion data** from selected Vermont locations.
- **Current penalties** for gross vehicle weight violations.

4.7.2 Data Limitations

- Citation or weigh-in-motion data for **class 2 town highways**.
- **Travel patterns** for each of the scenarios considered.

- **Additional induced demand** which would need to have an additional enforcement focus.

4.7.3 Methodology

There are two parts to the challenge for this study question: 1) finding and citing carriers not following the law, and 2) determining the appropriate penalty for a citation should it become a conviction.

Due to the continued law enforcement shortage in Vermont, Vermont DMV continues to assist other agencies with calls for service. This includes participation in the Governor's 10 Point Public Safety Plan, which shifted primary responsibility for all CMV crashes during regular operating hours from the Vermont State Police to Vermont DMV. Additionally, it requires staff on stand-by status 24/7 to respond to calls for service. Inspectors are regularly pulled from proactive size & weight enforcement to respond to calls for service as primary case officers and assist federal, state, and local law enforcement efforts. Vermont DMV has staff assigned to the Chittenden County Gun Violence Task Force, another task from the Governor's 10 Point Public Safety Plan.

Without an accurate estimate of demand or travel patterns for each scenario, it is challenging to estimate the additional enforcement resources needed to adequately monitor and enforce the terms and conditions of a new permit for study vehicles. Vermont officers issued 98 citations in 2022 for vehicles that exceeded the current 99,000-pound permits. The highest weight identified in a citation was just under 127,000 pounds.

In September 2022, each of the two fixed-scale sites was operated for limited hours. While we cannot qualitatively predict how many hours should be needed given a new permit, Vermont’s scale hours are less than many other states without excess weight divisible load permits. A benchmarking of Vermont's enforcement labor budget against other states for size and weight enforcement would be a helpful future exercise.

Weigh-in-motion technology is of potential assistance here, as long as the vehicles are traveling on the roads with weigh-in-motion stations. Once an online permit system is in place direct camera-based enforcement and citations could theoretically be added, although numerous challenges would need to be overcome. The larger issue, however, is that this technology cannot realistically be distributed to hundreds of locations across the state network. As a result, weigh-in-motion as a tool to leverage enforcement resources is only a factor in Scenario 3.

Meanwhile, enforcement at a local level is more sporadic, as few towns have the resources and training to properly weigh and cite vehicles. Depending on the scenario, enforcement may be challenging. In addition, the study questions consider class 1 and 2 town highways, but not class 3 and 4. Several stakeholders have asserted that trip origins are typically on class 3 and 4 roads. Enforcing permits in these situations would strain local enforcement resources.

Regarding the penalty for a citation, it was the belief of many stakeholders that the lack of enforcement resources makes the case that the penalty should be a multiplier of both the eventual fee for the combination of state and local permits, but also a multiplier of what the penalty would currently be for violators considering the difference between the vehicle gross weight and either 99,000 (current permit) or 80,000 pounds (no permit).

4.7.4 Findings

We can only address this topic qualitatively. Further study should be undertaken to determine the specific amount, but additional enforcement resources including both staff and camera-based weigh-in-motion systems would be needed to improve the efficacy of enforcement on the state network for all of Scenarios 2 through 4. Citation penalties should be increased, and at a minimum be based on exceeding the vehicle's non-permitted registered weight, typically 80,000 pounds. Enforcement on class 2 town highways will continue to be a challenge. It may be appropriate to fund training of local enforcement agencies on weight enforcement.

4.8 Study Topic 7: Impact of permits for study vehicles on the forest economy

4.8.1 Available data

- **Statement provided by the Vermont Department of Forests, Parks & Recreation** on the nature of the forest products industry in the state and the benefits from increased truck weights.

- **Informational handouts and testimony before the Maine Legislature** on the benefits and challenges of higher truck weights from the Professional Logging Contractors Northeast Association.

4.8.2 Data Limitations

- **No independent analysis could be conducted** on the state of the forest products industry and the direct and indirect economic effects of increasing truck weights, which directly affects the structure and revenue potential of a permit scheme. Data for this purpose would have to be developed, which was not possible within the constraints of this report.

4.8.3 Methodology

The study team interviewed the stakeholders specified in the enabling legislation, which consisted of representatives from the Vermont Department of Forests, Parks, and Recreation, and the Vermont Forest Products Association. In addition, the team also interviewed representatives of the Vermont Truck and Bus Association and the Professional Logging Contractors Northeast Association.

The information provided was largely qualitative in nature, and thus it was not possible to estimate the financial impacts of increasing truck weights.

4.8.4 Findings

The Vermont Department of Forests, Parks, and Recreation provided the following information:

> Vermont's forest products sector, like most other sectors of the state's economy, is facing increasing challenges to business viability and profitability that highlight the importance of operational efficiency. A prime opportunity to improve efficiency is in the transportation of Vermont's forest products. Forest products such as sawlogs, veneer logs, and pulpwood logs are produced as a part of sustainable forest management practices in Vermont. The ability to

profitably harvest, transport, and process these forest products is critical to the continued sustainable management of Vermont's forests. Vermont's forest products sector is part of a regional forest economy that depends on interstate and international transportation of logs and other forest products. Interstate and international transportation of forest products is particularly important to Vermont because nearly all pulpwood produced in the state is transported to New York and Quebec. In addition, a significant portion of the sawlogs and veneer logs produced in Vermont are transported to Quebec.

The issues below highlight some opportunities to improve efficiency in the transportation of forest products through legislative reform:

- **Excess Weight Permit Modernization**: Currently, Vermont permits overweight loads of up to 99,000 lbs on six axles. While this is comparable to some neighboring states, the same six-axle truck can obtain an excess weight permit for 107,000 lbs in New York or 110,000 lbs in Quebec. Notably, both New York and Quebec offer additional excess weight permits of 117,000 lbs and 129,000 lbs, respectively, for divisible loads on seven axles – a configuration that is not recognized in Vermont and would be limited to 99,000 lbs. In practice, what constitutes a single load in New York or Quebec requires multiple trucks and, often as a consequence, multiple trips in Vermont. The current situation results in increased truck traffic, road noise, and transportation congestion on Vermont roads connecting forestry operations to the processing destinations in New York and Quebec. For Vermont forest landowners and forest products businesses, the need to send multiple truckloads to New York and/or Quebec means that the already thin profit margins for forest management are further reduced. This not only jeopardizes the economic viability of entire forestry operations but also intensifies labor challenges for forest products transportation companies.

- **Additional Axle and Trailer Configurations**: Increasing the weight or volume of timber one truck can carry can lead to efficiency gains and lead to reduced emissions per unit volume of timber moved. Allowing double trailers to haul divisible loads on predetermined routes that can accommodate these larger vehicles without compromising public safety is an idea worth exploring to determine its feasibility on the most common hauling routes for timber in Vermont. Additionally, it may also be worthwhile to explore the feasibility of raising the maximum permitted excess weight for seven-axle trucks operating in Vermont, in alignment with some neighboring jurisdictions.

5.0 Findings and Recommendations for Consideration

5.1 Findings

Significant increases in permissible truck weights can have far-reaching impacts. The work performed for this report may not be sufficient to provide a foundation for a well-informed decision. Nevertheless, some conclusions can be drawn, based on the available information and analysis techniques.

Given the tight time constraints and available data, the focus of the quantitative analysis was on the costs resulting from the accelerated wear on bridges and pavements that the state of Vermont would bear, along with the potential permit revenues that may help mitigate some of these costs. From that perspective, it is evident that the cost impacts to the state resulting from increasing the maximum truck weight for divisible loads to 107,000 or 117,000 pounds are considerable irrespective of the type of access that may be provided to these heavier trucks. Utilizing as scenarios several common strategies used by other US-Canada border states, total costs to the state for improving bridges and pavements on state highways over a period of 20 years would range from $2.2 to $8.0 billion. Notably, over 80 percent of these costs would be associated with improving pavements. The least costly would be a defined truck network that provides cross-state routes with connections to adjacent states. Given Vermont's compact size, limiting access to locations within 30 miles of border states and provinces would result in modest savings over opening access to the entire state highway network.

A unique aspect of Section 40 of Act 41 is a requirement that the report examine access to class 1 and class 2 municipal roads. No US border state incorporates access to municipal roads in their state agency overweight truck operations and permitting schemes, since their handling is legally the responsibility of local governments. Typically, these roads have posted weight limits of 24,000 pounds or less and are built and maintained to lower standards than state highways, thus necessitating more costly improvements to accommodate 107,000- and 117,000-pound trucks. Including local roads in the access schemes substantially raises the public cost, from $2.7 billion (inclusive of costs to improve state highways) for a scheme limiting local road access to within 1 air mile of the high truck volume road network, to $9.9 billion if access to the entire class 1 and class 2 local roads is permitted. Not included in these estimates are upgrades to 8,279 miles of class 3 and 4 roads, which the forest products industry heavily utilizes.

The ability of permit fees to offset the costs of upgrading highways to accommodate 107,000- and 117,000-pound trucks is far from sufficient. To fully cover these costs, annual permits would have to cost well in excess of any overweight permit fees charged by other states. Furthermore, fees would be even higher if the cost of improving local roads is also incorporated.

Other impacts from increasing truck weights were evaluated on a largely qualitative basis. Some key findings are as follows:

1. **Safety impacts from increased truck weights are unclear**. Experience in other states is not necessarily applicable to Vermont, and the available crash data does not provide a means to conduct a robust statistical assessment. However, heavier-weight trucks can increase the severity of crashes simply due to the physics of the heavier vehicles.

2. **Compliance with federal asset performance rules**. Under federal rulemaking, VTrans is required to ensure that no more than 5 percent of interstate pavements and 10 percent of National Highway System bridge deck areas are in poor condition. Under a regime of increased truck weights, meeting these asset rules will require expending more federal funds on this part of the highway network.
3. **Enforcement of weight limits** calls for an examination of penalty fee structures and enforcement strategies to monitor and ensure compliance on state highways and local roads. Without adequate enforcement, increased truck weights could have a disproportionate impact on roadway wear and tear as well as safety.
4. **The specific impacts of increased weights from different truck configurations** on roads and bridges could not be quantified due to the lack of available data on the actual usage of different truck configurations operating over Vermont's roads.
5. **Impacts on Vermont industry and motor carriers**. Increased weight limits for divisible loads would clearly result in cost savings to shippers and carriers, including the forest products industry, and bring some degree of consistency with current weight limits in New York state, Quebec, and Ontario. However, the available information was not sufficient to develop any actionable estimates, and it is unclear whether the economic benefits that would accrue to the affected private parties exceed the public costs associated with increasing weight limits beyond 99,000 pounds.
6. **Collateral impacts from increasing truck weight.** In addition to safety, increasing truck weights may cause other disbenefits that include greenhouse gas emissions, community impacts such as noise and vibration, and diversion of trucks from New York and Quebec through Vermont. These effects are highly dependent on the degree to which heavier trucks are adopted, including the use of Vermont roads for through traffic, and the resulting changes in truck volumes.
7. **Impacts on modal competition**. Increases in highway weight limits may result in a mode shift from freight rail, with concomitant direct and indirect impacts, including affecting the economic viability of Vermont's rail system. Vermont has invested significant funding in upgrading its state-owned rail system and private railroads have also made significant investments.

5.2 Recommendations

As explained in Section 4, there are substantial gaps in both data. While the analysis utilized all the available information from VTrans, along with stakeholder interviews and a review of prior relevant literature, there is room for future advancement in addressing some of the issues that arose in the analysis. These topics are arranged below in multiple categories:

1. With respect to **data**, there is a need to collect more data on travel patterns, the design of existing infrastructure, and revenues obtained in other states from similar permits or vehicle registrations.
   a. **Travel patterns**: how motor carriers currently use Vermont's state and local networks including origin and destination information, which commodities in addition to forest products would be likely to take advantage of higher weight limits, how new or induced demand might arise from in- and out of state carriers for trips through Vermont under various scenarios, and how rail traffic might be affected. Incorporate AADT growth estimates for both base case and study cases. Additionally, it would be appropriate to incorporate truck volume changes due to the introduction of the study vehicles and then reapply the study methodology to update the expected infrastructure impacts.

b. Additional data regarding the potential **assignment of truck traffic into classes utilized in the analysis** may allow the process to be more highly customized and better reflect current traffic, as data from 2018 was currently utilized. The future scenario of truck traffic may change due to the change in the vehicle maximum weights, but there is no current data about how the percent by class might change.

c. **Vermont infrastructure**: sampling of local road pavement infrastructure to obtain more accurate estimates of typical local road design characteristics, understanding where adding in-road weigh-in-motion with vehicle identification cameras would generate better estimates of violations and assist with more efficient enforcement.

d. **Revenues:** benchmark Vermont revenues for the current 99,000-pound permit against the permits for divisible loads between 99,000 and 129,000 pounds for states considered in the literature review, consider alternate forms of structuring permit costs. Conduct additional analysis around alternative permit durations, such as monthly, as well as for the impacts of suspending or reducing permit costs during periods of heavy freeze.

2. With respect to **stakeholder engagement**, a more comprehensive listening session approach than was feasible in this report's time frame and resources would be appropriate.

   a. **In-state sessions** should engage a mix of industries including those for which study vehicle weights would be beneficial as well as those which typically operate at or under 80,000 pounds and do not currently purchase the 99,000-pound permit. Similarly, a mix of municipalities, trade and community associations, and economic development organizations should be included.

   b. **Outside Vermont**, outreach should be conducted in New York State and Quebec to obtain perspectives regarding their current weight limits and associated permits or registrations. In addition, regional and national associations with vehicle size and weight in their scope should be engaged, including the Commercial Vehicle Safety Alliance's committee on size and weight, the Specialized Carriers and Rigging Association's national transportation committee, and the Northwest Passage pooled fund cooperative program which includes representatives from the five contiguous western states bordering Canada.

3. With respect to **technology**, the most pressing challenge is to incorporate the findings and open issues from this report into Vermont's procurement of a permit review and issuance system. This challenge is heightened by the patchwork approach to collecting fees and issuing permits at the municipal level. Both the current 99,000-pound permit and any future divisible load permits with access to mixed state and town highway trips would benefit from inclusion in a system, including apportionment of revenues back to participating municipalities and notifying those municipalities about current permittees.

4. With respect to enhancing **analysis** techniques, there are a number of opportunities for incremental improvement:

   a. The advanced **deterioration of the structures** due to the heavier loads could be refined by using current conditions and fatigue critical members as specified in the bridge database. Structure maintenance could be added, as right now the analysis is only assuming replacement.

b. **Bridge load rating analysis with the seven-axle study vehicle** for a sample of the bridges with operating ratings between 107,000 and 117,000 pounds. These were the bridges for which assumptions needed to be made in Section 4.2.

c. Pavement: The advanced **deterioration of the pavement** due to the heavier loads could be done with a more sophisticated approach using the current condition as specified in the pavement database. Given more data about the pavement, could better estimate ESALs for specific roadways.

d. The available **pavement treatments** should be further examined to consider potential additional appropriate alternatives depending on the type of roadway and the VTrans Level of Improvement guidelines. VTrans guidelines state that "it is desirable to intervene early in the life cycle and to slow the rate at which pavement deteriorates. The goal is to apply low-cost treatments to those pavements that have good subgrade support and adequate subbase, timely enough to defer more expensive treatments. Crack-filling, thin overlays, chip seals, fog seals, slurry seals, and micro surfacing are appropriate preventive maintenance treatments."[16] Therefore, it is possible that with the study vehicles, VTrans may opt for low-cost treatments early in the study period rather than waiting for deterioration to reach the point of needing more costly improvements such as mill and fill or reclaiming. This presents an alternative analysis case where the life cycle cost of doing maintenance treatments more frequently due to the heavier trucks could be compared to the current frequency of maintenance treatments with current traffic.

e. **Class 3 and 4 Town Highways** were not specified in the legislative request, and current levels of available data regarding those highways would have been difficult to incorporate. Should data on these town highways become available, it would be appropriate to extend the town highway scenarios to include variations where class 3 and 4 town highways were included.

f. Regarding the local road scenario (b) for towns to **opt into usage of class 1 and 2 town highways**, between four and seven case studies would be appropriate to understand how towns where a permit would be beneficial to the local economy would have infrastructure impacts from such as permit.

g. Through the stakeholder conversations, it became evident that **enforcement of weight limits** is very limited, particularly on town highways. It appears current operations at the study vehicle weights but without a corresponding permit does occur; while this may be acceptable with current weight limits, without more consistent enforcement efforts, operating with higher weights is not likely to change. Additional analysis is needed to develop strategies for enhancing Vermont's size and weight enforcement capacity to meet the challenge of higher permit weights.

5. Finally, with respect to improving **reporting and goal-setting**:

   e. Associate the estimated future structure and pavement condition with **Vermont's statewide targets measures** and use them to report on how the truck weight limits would affect the state's goals. Vermont's state-specific measures are:

[16] VTrans. "Pavement Management Manual." 1998.

  - Maximum 25 percent very poor Overall Network Pavement Condition Index (ONPC) across the entire VTrans managed network, and

  - The Travel Weighted Average Condition Index (TWACI) minimum pavement condition index of 70 across the entire VTrans managed network.

f. Additional analysis would allow a better understanding of how permits for study vehicles would affect **Vermont's federal measures and corresponding state goals**. For example, Vermont's federally required measures for pavement condition reporting are:

  - Minimum 28 percent of interstate pavements in Good condition,

  - Maximum 4.9 percent of interstate pavements in Poor condition,

  - Minimum 30 percent non-interstate NHS pavements in Good condition, and

  - Maximum 9.9 percent of non-interstate NHS pavements are in Poor condition.

Appendix A. Literature Review

For this project, the team conducted a brief review of existing literature on truck weight limits and their impacts on roadway safety, infrastructure wear-and-tear, and infrastructure maintenance costs. Additionally, the team reviewed existing permit legislation (including fees) for divisible loads in excess of 80,000 pounds of gross vehicle weight in selected states and provinces, as well as a cursory review of current trends in the forestry industry.

The literature review focused on case studies from the United States, with a limited examination of some international examples. Previous Vermont pilot programs and studies were also reviewed to evaluate Vermont's recent experience with setting vehicle weight limits and registration fees. These studies consistently find that increasing weight limits on trucks correlate with an increase in the wear-and-tear on roadways and bridges, but these may be offset to some degree by a near-term reduction in total truck VMT depending on how carriers and markets respond to the increase in permitted vehicle weight.[17] Furthermore, they generally found that user fees for higher weight trucks were not commensurate with the associated wear and tear.

Studies have not been able to examine safety impacts directly, as vehicle size and weight data are not often recorded on crash reports. However, it is understood as a principle of physics that higher-weight vehicles carry greater safety risks, as they generate more force at a given speed and have longer stopping distances. The longer stopping distances of heavy trucks are incorporated into traffic safety management and public education practices, encouraging truck drivers to maintain longer distances from other vehicles in front of them and encouraging other drivers to expect slower stopping time from trucks.

A.1 National and International Perspectives

In 2016, the U.S. Department of Transportation Federal Highway Administration released a Comprehensive Truck Size and Weight Limits Study to provide Congress with an overview of impacts on public infrastructure and public finance associated with increased truck weight limits but did not make policy recommendations for adjusting truck weight limits for interstate highways. The study used Freight Analysis Framework (FAF) data and pavement and bridge rating modeling software to assess how increases in truck weight limits would allow carriers to consolidate loads onto fewer trucks or shift freight from freight rail to trucks.

Study findings relevant to this effort, presented in Table A.1 below, indicate that truck vehicle miles traveled (VMT) and bridge maintenance costs are consistently reduced across all scenarios. However, pavement lifecycle cost changes vary by scenario, with heavier five-axle trucks contributing to increases in maintenance costs under the models. While multi-trailer trucks also lead to an increase in maintenance costs, total higher weight limits distributed across more trailers have a lower impact on pavement cost increases than lower weight limits with fewer trailers.

The 2016 study did not result in any policy actions due to a lack of political consensus that was in part driven by broad criticism of the study methodology. This included a National Academy of Sciences review

[17] Maine and Vermont Interstate Highway Heavy Truck Pilot Program 6-Month Report - FHWA Freight Management and Operations (2012). https://ops.fhwa.dot.gov/freight/sw/reports/me_vt_pilot_2012/#s1.

that concluded that the study was rather incomplete in its assessment of the impacts. Key omissions included the effects of higher weight trucks on infrastructure outside of the interstate highway system or national network, expected bridge structural costs, crash and casualty frequency, and associated costs. Furthermore, units of measure were inconsistent which made assessing trade-offs between various categories of costs and benefits impossible.[18]

Table A.1 Scenario Results for Heavier Trucks Compared to Control Vehicle, 2016

Truck Configuration Scenario	Modal Shift		Bridge Cost Savings (One-Time)	Pavement Changes in Life Cycle Costs
	Truck VMT	Total Logistics Costs		
Single trailer five-axle truck 88,000 pounds	-0.6%	-1.4%	$0.4b	+0.4% to +0.7%
Single trailer six-axle truck 91,000 pounds	-1.0%	-1.4%	$1.1b	-2.4% to -4.2%
Single trailer six-axle truck 97,000 pounds	-2.0%	-3.2%	$2.2b	-2.6% to -4.1%
Two 33-ft. trailers 80,000 pounds	-2.2%	-6.3%	$1.1b	+1.8% to +2.7%
Three 28-ft. trailers 105,500 pounds	-1.4%	-5.1%	$0.7b	+0.1% to +0.2%
Three 28-ft. trailers 129,000 pounds	-1.4%	-5.3%	$5.4b	+0.1% to +0.2%

Source: FHWA Comprehensive Truck Size and Weight Limits Study, April 2016.

In 2020, the Florida Department of Transportation sponsored a study to assess the financial implications of overweight permitted vehicles and their impacts on road and bridge conditions in Florida and to develop proposed permit fees to account for these costs.[19] The study found that permit fees levied on many five- and six-axle trucks greater than 112,000 pounds did not cover the costs of roadway infrastructure wear-and-tear on a per-mile basis and that the gap between cost and revenue increased as truck weight increased. An example of the growing gap between revenue and cost at higher truck weights is presented in Table A.2 below:

[18] National Academies of Sciences, Engineering, and Medicine, *Review of U.S. Department of Transportation Truck Size and Weight Study - Second Report: Review of USDOT Technical Reports*. Washington, DC: The National Academies Press, 2015. https://doi.org/10.17226/22092.

[19] Hesham Ali, Andrzej S. Nowak, J. Michael Stallings, Jacek Chmielewski, Sylwia Stawska, Anjan Ramesh Babu, Farshad Haddadi, “Impact of Heavy Trucks and Permitted Overweight Loads on Highways and Bridges,” Florida International University, July 2020.

Table A.2 Multi-Trip 12-Month Permit Fee Structure per Truck

Gross Vehicle Weight Group (lb)	12-Month Permit Fee	Annual Estimated Bridge and Pavement Costs	Gap
80,000 – 90,000	$240	$1,830	-$1,790
95,000 – 112,000	$280	$5,060	-$4,780
112,000 – 122,000	$310	$6,890	-$6,580
122,000 – 132,000	$330	$7,820	-$7,490
142,000 – 152,000	$360	$9,760	-$9,400
152,000 – 162,000	$400	$11,110	-$10,710
162,000 – 199,000	$500	$13,710	-$13,210

Source: Impact of Heavy Trucks and Permitted Overweight Loads on Highways and Bridges – July 2020

To better align fees with the costs generated by these vehicles, the study recommended a fee structure that would increase single-trip permits by a factor of 1.6, multi-trip 12-month permits by a factor of 1.5, and multi-trip 3-month permits by a factor of 2.7. The report argued that this was necessary to reflect the current actual cost of damage to Florida's roads and bridges by heavy trucks.

International studies were less comprehensive in their assessment of truck weight limits, although benefits were identified. A 2020 study of increasing maximum truck weight in Finland between 2013 and 2017 found that an increase in the maximum weight limit reduced total truck VMT by 4 percent.[20] Specifically, Finland increased the weight limit from 60 metric tons (132,300 pounds) to 76 metric tons (167,800 pounds), leading to an increase in 7-, 8-, and 9-axle vehicles This reduction in truck VMT generated significant cost savings for carriers and generated positive environmental benefits from reduced carbon dioxide (CO_2) emissions equal to 3.6 percent of total road freight emissions in 2017. However, impacts on infrastructure conditions were not analyzed.

Additionally, the research team located a 2019 country-by-country listing of maximum permitted truck weights across Europe. For five-axle trucks, the majority of countries set a weight limit of 40 to 44 metric tons, or 88,000 pounds to 97,000 pounds The full listing is provided on the OECD International Transport Forum's website for reference.

A.2 Recent History in Vermont

Focusing on the Vermont context, the research team reviewed recent legislative reports on oversized/overweight truck permitting under Vermont's existing or previous standards.

In 2009, federal legislation established a pilot program for Vermont and Maine to apply their state commercial vehicle weight limits to their Interstate system highways, allowing six-axle trucks that weigh up to 99,000 pounds and 100,000 pounds, respectively, to operate on non-tolled Interstate highways. After six months, USDOT conducted a study of the pilot program's impacts on bridge safety and weight. Due to the rapid turnaround between the program's initiation and the release of the report, the study

[20] Heikki Liimatainen, Markus Pöllänen and Lasse Nykänen, "Impacts of increasing maximum truck weight – case of Finland," European Transport Research Review. - https://doi.org/10.1186/s12544-020-00403-z.

focused on modeled data rather than empirical data, noting that "it may take many years before any measurables to the bridges and pavements could be physically observed."[21]

To accommodate the limited study timeframe, USDOT reviewed National Bridge Inventory (NBI) data and inspection records and drew on national data on the relationship between truck weight, axle load distribution, and infrastructure impact. These findings provided benchmarks of infrastructure wear and tear attributable to heavier trucks. From these benchmarks, USDOT concluded that the presence of heavier trucks will reduce the margin of safety on bridges, which, while keeping bridges above the minimum required by AASHTO Bridge Design Specifications, raises the risk of accelerating deterioration which will necessitate more frequent bridge inspection and maintenance activities. The heavier axle loads will reduce pavement life, but the specific distribution of trucks across the non-interstate roadways may reduce the overall burden.

Subsequent to the six-month report, the FHWA also conducted a one-year assessment, the Vermont Pilot Program Report.[22] Many of the same limitations that arose with the six-month study, also occurred with the 1-year study, in that the evaluation period was too short to draw any substantive conclusions, and that data was lacking to assess many of the impacts. The executive summary states that *"While the study made the most of available models and data, a 1-year time period is simply insufficient to make any meaningful conclusions relative to the full consequences of a permanent change in vehicle weight restrictions in Vermont, or elsewhere."*

A 2019 Vermont Agency of Transportation research report for the State Legislature studied options for weight-based annual motor vehicle registration fees to establish greater equity in the allocation of maintenance costs to road users by gross vehicle weight.[23] The study evaluates the revenue and cost impacts associated with four modeled registration fee scenarios, ranging from a scenario that assigns fees based on total cost responsibility to a scenario that assumes lower-weight vehicles cause a minimal amount of damage to roads and reassigns the scaling of fees based on weight from that minimal level.

While the study does not quantify the wear-and-tear caused by heavier vehicles, the findings consistently demonstrate that heavier vehicles' registration fees are too low, particularly for gas and diesel vehicles, relative to the costs associated with their impact on infrastructure. Specifically, under the scenario that assigns fees based on total cost allocation, registration fees for trucks weighing between 80,000 pounds and 90,099 pounds should be 400 percent higher than its existing fee, demonstrating the scale of impact of these heavier vehicles.

The most recent study, issued in January 2021 in response to Section 26(b) of Act 149 (2020), examined the potential impact of allowing vehicles that may operate on State highways without a permit (those up to 80,000 pounds) to operate on class 2 town highways, which are predominantly two-lane paved roads in

[21] Maine and Vermont Interstate Highway Heavy Truck Pilot Program (2010) - US Department of Transportation.

[22] Vermont Pilot Program Report, US Department of Transportation, 2011, US Department of Transportation, Federal Highway Administration https://ops.fhwa.dot.gov/freight/sw/reports/vt_pilot_2012/index.htm.

[23] Weight-Based Annual Registration Report (2019) - Vermont Agency of Transportation - https://legislature.vermont.gov/assets/Legislative-Reports/Weight-Based-Registration-Legislative-Report-12-13-2019-Final.pdf

towns and villages that connect traffic from residential roads to the state highway network.[24] Under current policy, class 2 town highways have a gross vehicle weight limit of 24,000 pounds. This policy change was studied to assess opportunities for simplifying the permit regimen across the state.

The study findings indicate that this policy change would have substantial impacts on infrastructure conditions and municipal finances and would likely face opposition from local municipalities. Because many class 2 town highways are not designed to accommodate heavy vehicles, reconstructing these roadways to support 80,000-pound vehicles would cost $105 million per year or $3.15 billion in total over a 30-year implementation period. Since class 2 highways are not eligible for Federal funds, a significant portion of these costs would have to be borne by local property taxes; the average municipal tax rate would have to increase by 22 percent to pay for this infrastructure program. In addition to the political costs associated with such an increase, municipal representatives also expressed a preference to maintain control of where and when trucks can travel on class 2 highways and the establishment of the new 80,000-pound permit would reduce that local control.

A.3 Divisible Load Permits over 80,000 Pounds in Selected States

Many states issue permits for divisible loads for weights over 80,000 pounds. The permit structures differ in these states both because of the inclusion of “grandfather rights” and exemptions in Federal legislation for states with historical divisible load weight limits on Interstate and related highways, as well as different types of legislation on state highways.

Examples of types of permits include:

- Blanket multi-trip permits, allowing multiple trips for a period of time on any authorized highway in the state;
- Radius permits, allowing multiple trips for a period of time for all authorized highways within a set number of miles from a business operations site; and
- Trip permits, allowing either single or multiple trips from a specific origin to a specific destination.

A subset of trip permits is used to permit travel on a very specific route, frequently a route dedicated to higher weights for a business purpose. An example of this type of permit may be from an intermodal facility or a shipping port to a particular destination or border.

The team searched for relevant divisible permit regulations for gross vehicle weights exceeding 99,000 pounds for the following sets of states:

- States bordering Vermont: New York, Massachusetts, New Hampshire;
- States bordering Canadian provinces: Washington, Idaho, Montana, North Dakota, Minnesota, Michigan, Maine; and

[24] Legislative Study on Oversize/Overweight Vehicle Permit Issues (2020)- Vermont Agency of Transportation - https://legislature.vermont.gov/assets/Legislative-Reports/Oversize-Overweight-Vehicle-Permit-Study-Act.-149-2020-Sec.-26b.pdf.

- The Canadian provinces of Ontario and Quebec.

Table A.3 summarizes the available permits for these states. The table is organized alphabetically by state or province, and then by permit type as some states have multiple permits.

Table A.3 Permit Requirements for Divisible Loads of over 80,000-Pound Gross Vehicle Weight in Selected States and Provinces

Jurisdiction	Maximum Weight (pounds) and Axle Configuration(s)	Permit Type	Notes
Idaho[25]	129,000 pounds	Travel with a permit on a specified subset of the highway network, map available from the Idaho Transportation Department	Authorized by IDAPA 39.03.06
Maine[26]	"Canadian Weight" limits	Permitting commercial vehicles at Canadian weight limits to travel from designated points at the Canadian border to Baileyville, Madawaska, and Van Buren. All three routes are less than 15 miles in length.	Permits for vehicles with 6 axles cost $10/month, with 7 axles the cost is $40/month.
Massachusetts[27]	99,000 pounds gross	Permits will only authorize travel on specifically designated state highways or ways determined by the Department to be through routes that have bridges, structures, and pavements of a sufficient capacity	$50.00 per every 1,000 pounds exceeding the Federal Bridge Formula
Michigan	Divisible loads are considered legal and not require a permit if the vehicle meets the Federal Bridge Formula, with a limit of 11 axles	N/A	
Minnesota[28]	The gross weight of 106,000 pounds for transporting	Operate only on: • US Highway 75 in Crookston,	$850 annual fee

[25] Idaho DMV - 39.03.06 – Rules Governing Special Permits for Extra-Length/Excess Weight, Up to 129,000 Pound Vehicle Combinations - https://adminrules.idaho.gov/rules/current/39/390306.pdf.

[26] Bureau of Motor Vehicles, State of Maine, Canadian Weight Limit Permits - https://www.maine.gov/sos/bmv/commercial/canadian.html.

[27] Section 8.05 - Approval or Disapproval of Overweight Reducible Load Permit Applications, 700 Mass. Reg. 8.05 - https://casetext.com/regulation/code-of-massachusetts-regulations/department-700-cmr-department-of-transportation/title-700-cmr-800-permitting-operation-and-transport-of-overdimensional-loads-and-certain-vehicle-trailer-combinations-on-certain-massachusetts-department-of-transportation-roadways/section-805-approval-or-disapproval-of-overweight-reducible-load-permit-applications.

[28] Permit Types - Oversize/Overweight Permits - MnDOT (state.mn.us)

Jurisdiction	Maximum Weight (pounds) and Axle Configuration(s)	Permit Type	Notes
	soybean meal	MN to US Highway 2 • US Highway 2 from Crookston to the North Dakota border.	
	7 axles with gross weight 108,000 pounds to haul earthmover tires	Allowed only on specific highways	$850 annual fee
	Twin trailers up to 105,500 pounds gross weight specific for canola hauling permit	Annual permit allowed only on specific routes between Hallock	$850 annual fee
Montana	Limits are 102,500 pounds on 6 axles, and 124,600 pounds on 7 axles	For divisible loads permits are available for three single specific highways of between 10 and 35 miles in length linking the Canadian border with specific locations in Montana.	Not available
New Hampshire[29]	99,000 pounds gross weight	Annual permit	$378 annual fee
New York[30]	100,000 pounds gross. 22,400 pounds per single axle and 36,000 pounds per tandem axle	Annual permit, applicable to state DOT highways, with restrictions[31]	$360 annual permit fee
Washington[32]	20,000 pounds per single axle and 37,500 pounds per tandem axle	Annual route specific permit (Canadian border to Sumas, Washington on SR 9)	$14 Annual
	20,000 pounds per single axle and 37,500 pounds per tandem axle	Monthly/Annual route specific permit (Canadian Border to Oroville Rail Yard on US 97)	$100 Monthly or $10000 Annually
Ontario[33]	171,000 pounds (78 tons), with a maximum of 42,000 pounds on any 2 consecutive axels less than 6ft apart	The annual permit also allows travel on toll highways provided that the commercial vehicle has a valid transponder.	$744 CAD ($547 USD)

[29] Overweight Certification | New Hampshire Division of Motor Vehicles - https://www.dmv.nh.gov/vehicles-boats-or-titles/vehicle-registrations/overweight-certification

[30] NYSDOT - NY Permits - https://www.dot.ny.gov/portal/page/portal/nypermits

[31] Large Truck Restrictions (ny.gov) - https://www.dot.ny.gov/portal/page/portal/nypermits/large-truck-restrictions

[32] Permit types & descriptions | WSDOT (wa.gov) - https://wsdot.wa.gov/travel/commercial-vehicles/commercial-vehicle-permits/permit-types-descriptions

[33] Get an oversize/overweight permit | ontario.ca - https://www.ontario.ca/page/get-oversizeoverweight-permit#section-1

Jurisdiction	Maximum Weight (pounds) and Axle Configuration(s)	Permit Type	Notes
Quebec[34]	148,000 pounds (67.5 tons), with a maximum of 42,000 pounds on any 2 consecutive axels less than 6ft apart	The use of such vehicles is limited to divided highways and short road sections along these highways.	These are part of a special class of regulations for Road trains. And cost $742 CAD ($546 USD)
Vermont[35]	90,000 pounds (45 tons) gross weight over 5 axles or 99,000 pounds over 6 axles with minimum 51 feet between first and last axle.	Annual permit, applicable to state DOT highways, with restrictions	Trucks must be registered to 80,000 pounds to be eligible for the 90,000- or 99,000-pound permits.

The key trends in the states reviewed are as follows:

- No state web site indicated that local roads were covered by any provisions for permit-issued weights for divisible load vehicles, although Michigan DOT’s website specifies that local jurisdictions have the option to issue permits for loads over 80,000 pounds which are legal on Michigan’s state highways.

The two most common implementations of higher weight permits for divisible loads were

- to allow traffic on a specific single highway between a state border and a point of interest such as an intermodal facility or an industrial facility; or

- to allow traffic on a limited subsets of state highways, typically represented with a published map.

Multiple states referenced “Canadian Vehicles” as nomenclature for any vehicle configuration which would be considered legal on most Canadian provincial highways, while other states referenced vehicles “meeting the Federal Bridge Formula.”

Two states of note are Michigan and New York, discussed below.

Michigan does not issue permits for divisible load vehicles on state highways. Instead, all divisible load vehicles are allowed within a length and axle envelope as long as the Federal Bridge Formula is maintained for the vehicle. As a practical matter since vehicles are limited to eleven axles, the maximum gross weight on a single vehicle is 154,000 pounds, shown in the figure below. The concept is that a single 154,000-pound vehicle may replace two “national standard” 80,000-pound vehicles at five axles each. Away from the state highway network, local units of government may require permits for vehicles traveling on local roads.

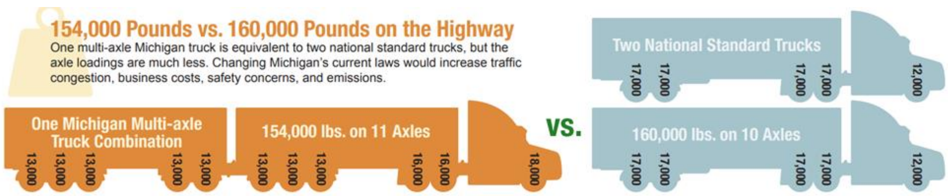
[34] Road train over 25 meters long - Transports et Mobilité durable Québec (gouv.qc.ca) - https://www.transports.gouv.qc.ca/en/camionnage/permis-speciaux/train-routier-plus-25m/Pages/train-routier-plus-25m.aspx

[35] Special Excess Weight Permits | Vermont Department of Motor Vehicles https://dmv.vermont.gov/CVO/permits/special-excess-weight-permit

Because Michigan does not issue permits at the state level, it captures revenue from these heavier vehicles through increased user fees, with some discounts for specific commodities. The Michigan DOT brochure from which the figure below is obtained states that vehicle registration for an 80,000-pound five-axle vehicle is $1,992 while the vehicle registration for a 164,000-pound, 11-axle truck is $3,741.

The Michigan DOT does place additional restrictions on specific highways, both for highway-specific issues as well as for seasonal frost restrictions. The agency publishes and maintains a GIS-based Michigan Truck Operations map to assist motor carriers in identifying these additional restrictions, which can be found on the Michigan DOT website.[36] An example of legal divisible loads in Michigan is shown in Figure A.1.

Figure A.1 Example of Legal Divisible Load Vehicle in Michigan



Source: Michigan Department of Transportation, "Truck Weights in Michigan" brochure.[37]

New York State has a long-standing program of divisible load permits. The permits are classified into four "Statewide" and four "Downstate" permits, with the latter being restricted to a subset of seven counties closer to New York City and to carriers possessing what the state calls "grandfather rights." The figure below shows examples of two relevant statewide permits, with configurations similar to those being considered in the legislative request for this study. The NYSDOT web site specifically stipulates that the permits "are not valid for operation over local roads or on roads and bridges operated by the Metropolitan Bridge Authority (MTA), Bridge Authority and the New York City" Department of Transportation. An example of divisible load permits in New York for six- and seven5 ax-axle vehicles is shown in Figure A.2.

Figure A.2 Example of divisible load permits in New York State for 6- and 7-axle vehicles

Type 7 (F2) - *This permit type is Large Through Truck Restricted.*		**Max. Axle and Grouping Weights in Lbs.**	
Fee	$750.00 (6 axles)	Steering axle	22,400
	$900.00 (7 or more axles)	Any other Single axle	25,000
Min. Axles	6	Tandem Group	48,000
Min. Wheelbase	36 ½ feet	Tridem Group	58,000
Max. Gross Vehicle Weight	107,000 Lbs.	Quad	63,000
Max. Trailer Length	53 Feet		

Use of 53 foot trailers is limited to Designated Qualifying and Access highways only. The kingpin distance shall not exceed 43 feet. Measured from the center of the kingpin to the center of the rearmost (last) axle. See Trailer Options for additional information and fees.

Type 9 (F2) - *This permit type is Large Through Truck Restricted.*		**Max. Axle and Grouping Weights in Lbs.**	
Fee	$900.00	Tractor steering axle	13,000
Min. Axles	7	Truck steering axle	17,000
Min. Wheelbase	43 feet	Any other Single axle	18,000
Max. Gross Vehicle Weight	117,000	Tandem Group	42,000
Max. Trailer Length	53 feet	Tridem Group	54,000
		Quad	63,000

Use of 53 foot trailers is limited to Designated Qualifying and Access highways only. The kingpin distance shall not exceed 43 feet. Measured from the center of the kingpin to the center of the rearmost (last) axle. See Trailer Options for additional information and fees.

[36] https://www.michigan.gov/mdot/-/media/Project/Websites/MDOT/Travel/Map/Truck-Operators-Map/Truck-Operators-Map.pdf

[37] https://www.michigan.gov/media/Project/Websites/MDOT/Programs/Planning/Transportation-Funding/Truck-Weights-In-Michigan.pdf

Source: New York State Department of Transportation, web page titled Types of Statewide Divisible Load Permits and Fees, Perm 69 (SW) (01/2020). Retrieved from a link from https://www.dot.ny.gov/nypermits/divisible-load-permits

Canadian Provinces

The standard legal truck weight limit without any permit in Canadian provinces is typically higher than the standard 80,000-pound limit in the US. Ontario's limits are based on axle load without a total gross weight limit. The legal weight limits without permits in the province of Ontario are shown in Table A.4.

Table A.4 Ontario Legal Weight Limits Without Permits

Axle group	Axle spread	Weight limit
Steer Axle		16,976 lb
Tandem Drive (dual)	48 - 71 in	39,683 lb
Tanden Drive (dual)	71 - 73 in	42,108 lb
Trailer Tandem	48 - 122 in	42,108 lb

The Province of Quebec has two set of truck weight limits for normal periods and thaw periods, as shown in Table A.5 and Table A.6, below.

Table A.5 Quebec Legal Weight Limits Without Permits (Normal)

Axle group	Axle spread	Weight limit
Steer Axle		19,842 lb
Tandem Drive (dual)	40 - 73 in	39,683 lb
Trailer Tandem	40 - 121 in	39,683 lb
Gross vehicle weight		89,287 lb

Table A.6 Quebec Legal Weight Limits Without Permits (Thaw Periods)

Axle group	Axle spread	Weight limit
Steer Axle		19,842 lb
Tandem Drive (dual)	40 - 73 in	34,172 lb
Trailer Tandem	40 - 121 in	34,172 lb
Gross vehicle weight		87,082 lb

Appendix B. Structures & Pavement Data Analysis Parameters

B.1 Structures

Table B.1 summarizes the number of structures, deck area, and costs for the structures requiring replacement or posting depending on the vehicle weight, and Table B.2 summarizes the number of structures estimated, deck area, and costs for the structures expected experience deterioration (as opposed to replacement). The 80,000- and 99,000-pound GVWR vehicles were included to demonstrate the number of structures that are already deficient for current legal vehicles in Vermont.

Table B.1 Structures for Replacement Cumulative by GVWR, 20 years

Structure Type	80,000 GVWR Vehicle	99,000 GVWR Vehicle	107,000 GVWR Vehicle	117,000 GVWR Vehicle
Number of structures				
Long Structure	37	106	148	181
Short Structure	N/A	N/A	950	950
Town Structure	46	78	90	104
Total	83	184	1,188	1,235
Deck Area, square feet				
Long Structure	75,222	244,493	344,870	425,934
Short Structure	N/A	N/A	383,000	383,000
Town Structure	60,724	114,984	135,711	168,559
Total	135,947	359,477	863,581	977,493
Base Case Replacement Costs, Millions (2023$)				
Long Structure	$70	$228	N/A	N/A
Short Structure	N/A	N/A	N/A	N/A
Town Structure	$57	$107	N/A	N/A
Total	$127	$335	N/A	N/A
Study Vehicle Replacement Costs, Millions (2023$)				
Long Structure	$70	$228	$321	$397
Short Structure	N/A	N/A	$357	$357
Town Structure	$57	$107	$126	$157
Total	$127	$335	$805	$911

Source: Cambridge Systematics. VTrans.

Table B.2 Deterioration Estimations Cumulative by GVWR, 20 years

Structure Type	80,000 GVWR Vehicle	99,000 GVWR Vehicle	107,000 GVWR Vehicle	117,000 GVWR Vehicle
Number of structures				
Long Structure	535	782	846	948
Short Structure	N/A	N/A	N/A	N/A
Town Structure	162	190	191	195
Total	697	972	1,037	1,143
Deck Area, square feet				
Long Structure	2,252,888	4,179,887	4,851,046	5,773,529
Short Structure	N/A	N/A	N/A	N/A
Town Structure	309,958	370,358	376,454	387,410
Total	2,562,846	4,550,244	5,227,500	6,160,939
Base Case Deterioration Costs, Millions (2023$)				
Long Structure	$1,708	$2,766	N/A	N/A
Short Structure	N/A	N/A	N/A	N/A
Town Structure	$142	$163	N/A	N/A
Total	$1,851	$2,930	N/A	N/A
Study Vehicle Deterioration Costs, Millions (2023$)				
Long Structure	$1,714	$2,781	$3,101	$3,507
Short Structure	N/A	N/A	N/A	N/A
Town Structure	$142	$163	$164	$167
Total	$1,856	$2,944	$3,265	$3,674

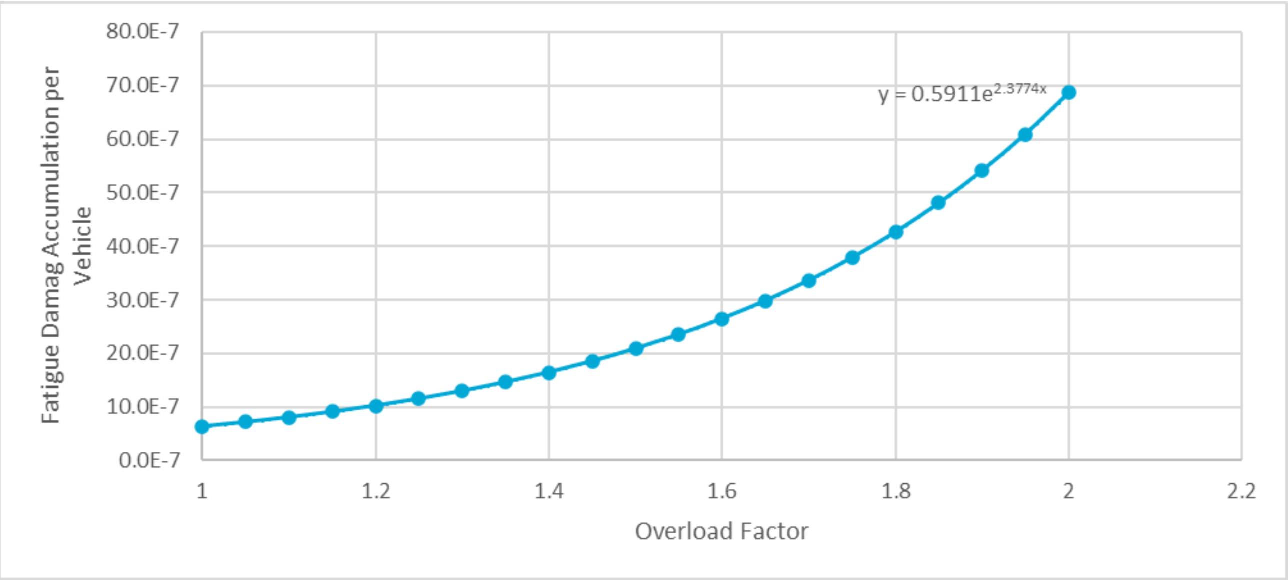
Source: Cambridge Systematics. VTrans.

A quick calculation of fatigue cycles and fatigue damage accumulation was used to estimate the number of cycles a bridge could handle before fatigue would deem the structure unsuitable or unsafe for loading and would require replacement. Using WIM data and a theoretical structure, Aggarwal and Parameswaran established the exponential relationship between the overload factor and the fatigue accumulation per vehicle.[38] For this study, we estimated the overload factor as the gross vehicle weight rating divided by the inventory rating. Figure B.1 demonstrates the relationship used between the

[38] Aggarwal, V., Parameswaran, L. (2015). "Effect of Overweight Trucks on Fatigue Damage of a Bridge." In: Matsagar, V. (eds) Advances in Structural Engineering. Springer, New Delhi. https://doi.org/10.1007/978-81-322-2187-6_190

overload factor and fatigue damage accumulation per vehicle. The sum of cycles by all vehicles was estimated on an annual basis and when the fatigue damage accumulation exceeded 1.0 it was determined the structure would be due for replacement.

Figure B.1 Fatigue Damage Accumulation per Vehicle vs. Overload Factor



Source: Aggarwal, V., Parameswaran, L. (2015). Effect of Overweight Trucks on Fatigue Damage of a Bridge. In: Matsagar, V. (eds) Advances in Structural Engineering. Springer, New Delhi. https://doi.org/10.1007/978-81-322-2187-6_190

B.2 Pavement

The structural numbers (S_n) and terminal serviceability coefficients (P_t) used to estimate the ESALs per vehicle were assumed based on the roadway class and surface type. The technical assumptions are shown in Table B.3.

Table B.3 Pavement Coefficient Assumptions

Class	Structural Numbers (S_n)	Terminal Serviceability Coefficient (P_t)	Pavement
Federal Aid Road	3.0	2.5	Flexible
Paved Local Road	3.0	2.0	Flexible
Gravel Local Road	1.0	1.0	Flexible

Source: Cambridge Systematics. VTrans, "Pavement Design Guide." March 12, 2002.

The calculation of ESALs followed AASHTO guidelines and was calculated using the following equations:

$$ESAL = \frac{1}{LEF} = \frac{1}{\left(\frac{L_{18} + Axle_{18}}{L_x + Axle_x}\right)^{4.79} \times \frac{10^{\frac{G}{\beta_x}}}{10^{\frac{G}{\beta_{18}}}} \times {Axle_x}^{4.33}}$$

here:

$$L_{18} = 18\ kips$$
$$L_x = axle\ load\ being\ evaluated$$
$$Axle_{18} = 1$$
$$Axle_x = \begin{cases} 1, single\ axle \\ 2, tandem\ axle \\ 3, triple\ axle \end{cases}$$
$$G = \log\left(\frac{4.2 - P_t}{4.2 - 1.5}\right)$$
$$\beta_{18} = 0.4 + \frac{0.081 \times (L_{18} + Axle_{18})^{3.23}}{(S_n + 1)^{5.19} \times Axle_{18}{}^{3.23}}$$
$$\beta_x = 0.4 + \frac{0.081 \times (L_x + Axle_x)^{3.23}}{(S_n + 1)^{5.19} \times Axle_x{}^{3.23}}$$
$$P_t = terminal\ serviceability\ index, ranges\ between\ 0\ and\ 4, and\ 2\ to\ 3\ is\ typical.$$
$$S_n = structural\ number, ranges\ between\ 1\ and\ 5, 3\ to\ 5\ is\ typical.$$

The results of the ESAL calculations per truck class and the axle and axle group loading assumptions are summarized in Table B.4.

Table B.4 ESAL per Vehicle by Truck Class

Truck Class	Gross Weight (lb)	Number of Axles	Axle Groups	Axle Group Count per Vehicle	Axle Group Load (lb)	ESAL per Vehicle		
						Federal Aid Road	Paved Local Road	Gravel Road
Class 13	117,000	7.0	Tridem	0	0	4.3	4.2	4.1
			Tandem	2	36,000			
			Single	3	15,000			
Class 12	107,000	6.0	Tridem		0	5.1	5.1	5.1
			Tandem	1	39,000			
			Single	4	17,000			
Class 13	99,000	7.0	Tandem	2	29,000	2.6	2.4	2.2
			Single	2	16,000			
			Steer	1	9,000			
Class 12	99,000	6.0	Tandem	1	36,000	4.0	3.9	3.8
			Single	3	17,000			
			Steer	1	12,000			
Class 11	90,000	5.0	Tridem	0	0	5.0	5.0	5.0
			Tandem	0	0			
			Single	5	18,000			
Class 10	117,000	7.0	Tridem	2	48,500	3.7	3.7	3.7
			Tandem	0	0			
			Single	1	20,000			
Class 10	107,000	6.0	Tridem	1	60,000	3.9	3.9	4.0

Truck Class	Gross Weight (lb)	Number of Axles	Axle Groups	Axle Group Count per Vehicle	Axle Group Load (lb)	ESAL per Vehicle		
						Federal Aid Road	Paved Local Road	Gravel Road
			Tandem	1	34,000			
			Single	1	13,000			
Class 10	99,000	6.0	Tridem	1	54,600	3.2	3.2	3.2
			Tandem	1	36,400			
			Single	1	8,000			
Class 9	80,000	5.0	Tridem	0	0	2.5	2.4	2.3
			Tandem	2	34,000			
			Single	1	12,000			
Class 8	80,000	4.0	Tandem	1	41,000	5.2	5.5	5.8
			Single	1	22,000			
			Single	1	17,000			
Class 7	80,000	5.0	Tandem	1	26,000	3.0	3.0	3.0
			Tandem	1	34,000			
			Single	1	20,000			
Class 6	66,000	4.0	Tridem	0	0	2.4	2.3	2.2
			Tandem	1	34,000			
			Single	2	16,000			

Source: Cambridge Systematics.

Vermont uses the Composite Pavement Condition Index (CPCI) to report the overall condition of pavement as a combination of the four distress indices. Pavement is considered in very poor condition when the CPCI falls below 40. Pavement quality by CPCI index is listed below:

- Good (80-100): Like new pavement with few defects perceived by drivers.
- Fair (65-79): Slight rutting, and/or cracking, and/or roughness becomes noticeable to drivers.
- Poor (40-64): Multiple cracks are apparent, and/or rutting may pull at the wheel, and/or roughness causes drivers to make minor corrections.
- Very Poor (0-39): Significant cracks may cause potholes, and/or rutting pulls at the vehicle, and/or roughness is uncomfortable to occupants. Drivers may need to correct to avoid road defects.