REPORT TO THE LEGISLATURE PURSUANT TO ACT 59 OF H.529 SECTION 47

Weight-Based Annual Registration Report

December 2019

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

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Authorizing Legislation

Sec. 47. WEIGHT-BASED ANNUAL REGISTRATION REPORT

The Agency of Transportation, in consultation with the Joint Fiscal Office, shall complete a study and submit a written report to the House and Senate Committees on Transportation on or before December 15, 2019 concerning the feasibility of implementing an annual motor vehicle registration fee system that addresses road maintenance cost allocations for road traveling motor vehicles based on vehicle weight. Such a registration fee system could be in addition to or in lieu of existing motor vehicle registration fees. The study and report shall, at a minimum, identify, analyze, and make recommendations on: the current motor vehicle registration fee structure, any benefits to establishing a new system that better allocates costs based on vehicle weight; any anticipated implementation difficulties; ways to measure vehicle weight; what types of road traveling motor vehicles could and should be subject to such a registration fee; how to calculate registration fees to bet account for weight-based wear on Vermont roads; and how other States have implemented weight-based registration fees.

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Executive Summary

Purpose

Act 59 (H.529 Section 47, Weight-Based Annual Registration Report) requires the Agency of Transportation (VTrans) to submit a report to the legislature on the feasibility of implementing an annual motor vehicle registration fee system that addresses road maintenance cost allocations for on-road motor vehicles based on gross vehicle weight.

This report briefly covers the following contents:

- An overview of how vehicle weights and axle distributions affect roadway pavement and bridges.
- Exploration of how other governments (state and Federal, domestic and international) charge registration fees for commercial and personal vehicles.
- Description and evaluation of four registration scenarios for potential further discussion by the Vermont Legislature.
- General information for advancing the consideration of weight-based annual registration program designs for application in Vermont.

What is Weight-Based Registration?

Weight-based registration is a registration fee system that addresses road maintenance cost allocations for on-road motor vehicles based on gross vehicle weight. Vehicle weight impacts roadway pavement and bridges, and vehicle weight per axle is an important factor in determining how fast this infrastructure deteriorates. Mitigating deterioration on Vermont's state-owned and Interstate infrastructure requires activity from VTrans: maintenance, rehabilitation, and if not treated in time, replacement of infrastructure. The costs of these activities are distributed to users of the system, including both registered Vermont vehicles as well as those from outside of Vermont. Registration fees are one manner in which these costs can be recaptured. While there is an administrative cost component to vehicle registration, fees generally do rise across the United States as gross vehicle weight increases. Vermont's current fee structure does present a relationship between gross vehicle weight and registration fee. The rationale behind those fees, however, is not explicitly based on equity ratio, or specifically based on maintenance costs.

Summary of Findings from Other Programs and Research

Existing programs on weight-based registration fees for passenger and commercial vehicles were reviewed, which included all states with existing or proposed weight-based fee structures. Utilizing a mix of domestic and international sources, there are three classes of previous work regarding weight-based registrations:

- Studies comparing the relative infrastructure damage expected to occur for various vehicle configurations, typically normalizing vehicle configurations into what are referred to as Equivalent Single-Axle Loads (ESAL);
- Studies investigating highway cost allocation in general; and

- Studies investigating alternative roadway costs allocation schemes, such as ton-mile fee structures.

Vermont is one of many states which legislates sliding scales for registration fee based on gross vehicle weight. Vermont currently charges automobiles and trucks up to 6,099 pounds a flat fee which varies by the vehicle fuel source. The state registration fee for trucks is based on loaded weight, with higher weights having higher fees. Notably, motor homes and school buses, which can weigh upwards of 20,000 pounds, are charged the same as lightweight passenger vehicles.

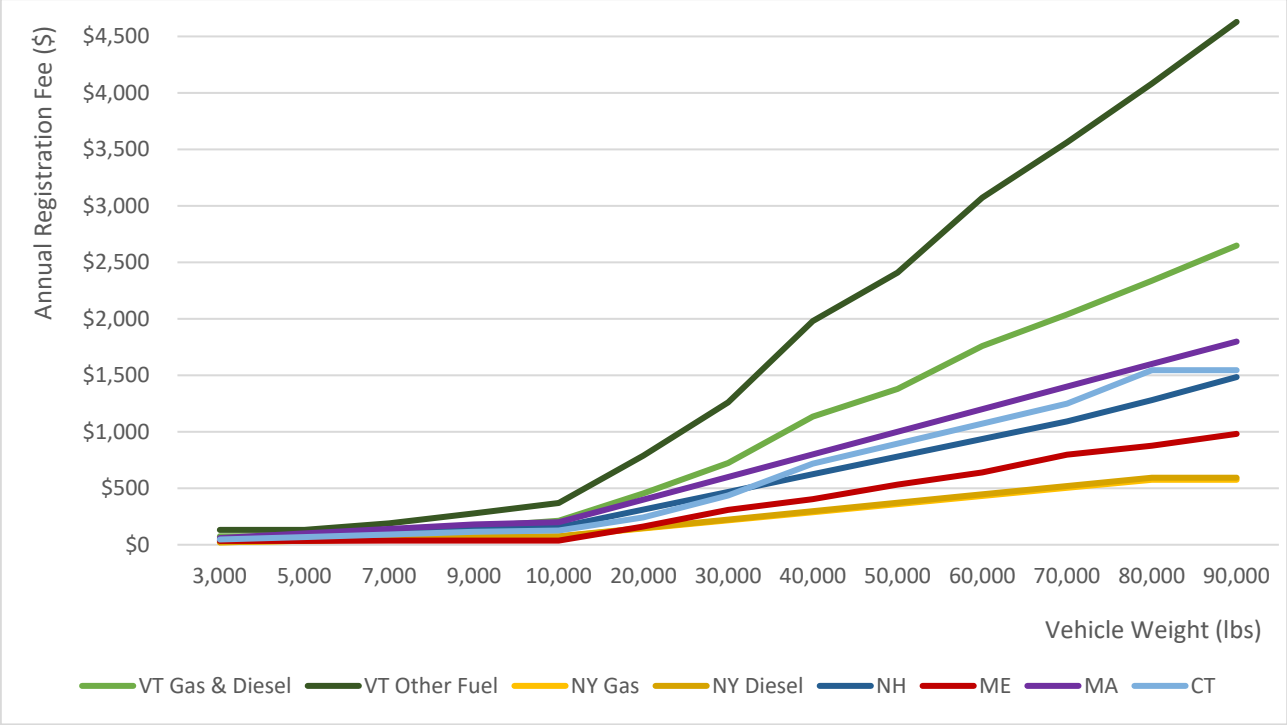
Similar to Vermont, most states charge flat fees for automobiles and a tiered fee for trucks. Passenger automobiles generally weigh 3,000 to 6,000 pounds depending on size and model (compact cars versus sport utility vehicles) while truck weight varies significantly depending on number of axles as well as type and quantity of load, which necessitates a tiered-fee structure. Some states charge certain fees for farm vehicles and/or a separate flat fee for heavy single unit trucks that ranges between $300 to over $1,000.

Figure ES.1 and Figure ES.2 show the annual registration fee for passenger and commercial vehicles, for Vermont and nearby states, consisting of New York, New Hampshire, Maine, Massachusetts, and Connecticut. With the exception of New Hampshire and Maine, all states utilize a flat fee structure for passenger vehicles. For commercial vehicles, all states utilized some type of weight-based fee structure. It should be noted that the charts below only include registration fees and are not representative of the total commercial vehicle operating cost for each state which in addition to the registration fee includes, sales tax, title fee, plates, fuel tax rate per mile, commercial vehicle tax use, among others.

Figure ES.1 Annual Registration Fee, Passenger Vehicles

Source: New York DMV, Vermont DMV, New Hampshire Title XXI, Maine DMV, Massachusetts Registry of Motor Vehicles, Connecticut DMV.

Figure ES.2 Annual Registration Fee, Commercial Vehicles



Source: New York DMV, Vermont DMV, New Hampshire Title XXI, Maine DMV, Massachusetts Registry of Motor Vehicles, Connecticut DMV.

The Federal Highway Administration (FHWA) and Transportation Research Board's (TRB) NCHRP have examined the relationship between vehicle weight and highway maintenance costs and provide detailed information on highway cost allocation. A Highway Cost Allocation Study (HCAS) is designed to determine the fair share that each class of road user should pay for the construction, maintenance, operation, improvement, and related costs of state highways, roads, and streets. Through a comparison of user fees paid and cost responsibilities estimated within the HCAS, these studies assess equity, usually for a projected period, and may provide recommended adjustments to existing user fees and tax rates to bring about a closer match between payments and cost responsibilities for each vehicle class. The NCHRP synthesis examines the history and evolution of HCAS practice and assembles the state of HCAS practice as of 2008, when the report was developed. It highlights work that has been performed in 11 states including Vermont. Oregon conducted the first HCAS in 1937, and since then 30 states have performed HCAS across the nation. Significant advancements in the practice occurred as the result of federal HCAS completed in 1965, 1982 and 1997.

The Federal HCAS tool includes the National Pavement Cost Model (NAPCOM) to predict the impact that vehicle use will have on pavement damage based on the relationships between axle weights and pavement damage and assigns cost responsibility based on established allocation factors. Vermont has completed three HCASs in 1990, 1993 and 2006. In the latest study the state used the Federal method. That study allocated 25.7 percent of the costs to heavy-trucks. The key allocators used (or measure used to allocate costs to highway-user classes) were vehicle miles travelled (VMT), average daily traffic (ADT) and Equivalent Single-Axle Loads (ESAL). The types of revenues examined were State and Federal funds. In the absence of a more comprehensive pavement model, some states have historically used more

straightforward measures that are designed to vary in proportion to the damage caused to the roadway system by vehicle classes. These allocators include: Axle Miles of Travel (AMT), Axle Weight or Axle Load, Ton-Miles, ESAL and ESAL-Miles. It is not the overall weight of a vehicle that determines its effect on the infrastructure, rather it is the weight per axle and the distance between those axles that determines the effect that a vehicle has on a bridge and on pavement.

An “Equity ratio” is the concept that a set of vehicles can be compared, even if they are vastly different such as a Nissan Altima sedan, a large pick-up truck such as a Ford F-350, a box truck used in local deliveries, and an over-the-road truck. The equity of highway user charges typically is measured in HCASs as the ratio of the shares of revenues contributed by each vehicle class to the shares of highway costs that vehicle class occasions. This ratio is often called a revenue/cost ratio or an "equity ratio." An equity ratio greater than 1.0 means overpayment; less than 1.0 means underpayment of Federal highway user fees. When estimating the distribution of 2000 Federal cost responsibility by broad groups of vehicles it was found that automobiles which account for 70 percent of all vehicles and about two-thirds of all travel are responsible for 44 percent of Federal program costs followed by combination trucks, pick-ups and vans, and single unit trucks. It should be noted that the vehicle mix has changed considerably since 2000, with the extensive shift from cars to light duty pick-ups and sport utility vehicles, which tend to be heavier than automobiles. Evaluating relationships between Federal user fees and Federal highway cost responsibility is essential for evaluating the equity of the Federal highway user fee structure. However, comparisons of total user fee payments and total highway cost responsibility for all levels of government are important in evaluating overall subsidies to various classes of vehicles that might give them a competitive advantage over other modes of transportation.

Other jurisdictions have considered or implemented equity-based approaches to registration fees, with some including a distance component. The strictly weight based fees implemented elsewhere can be applied to Vermont’s mix of registered vehicles to understand how those structures compare in terms of fee per vehicle and total revenue generated, and can also be normalized to develop an estimated revenue-neutral adjustment to Vermont’s current registration fee structure. Weight and distance approaches can also be applied and normalized, but some assumptions will need to be made about typical distances traveled in Vermont by each class of registered vehicle. Finally, the equity structure identified by FHWA in terms of ESALs can be utilized to calculate the current registration fee per ESAL for Vermont’s registered vehicles, and potential normalizations can be identified.

Scenarios for Consideration in Vermont

Primarily on the basis of the literature review, Cambridge Systematics (CS) the study consultant selected to use the Federal Highway Administration’s Highway Cost Allocation Tool (HCAS tool or the tool) to answer the question posed by the legislation. Developed in 2000, HCAS is an Excel software package designed to perform state highway cost allocation studies. In calculating the appropriate cost allocation between users, the HCAS tool considers state, local, and federal revenues, highway user taxes and fees, and maintenance expenditures. The maintenance expenditures and capital budgeting is used as a cost basis, and the tool distributes Vermont’s pavement and bridge maintenance costs across vehicles of different weights in proportion to their calculated responsibility for pavement and bridge damage.

The model developed by CS for VTrans considers four pricing scenarios:

- **Scenario 1** assumes that each weight class has a registration fee with complete equity to its cost responsibility and that the total registration fee collected may change (either up or down) from the total fee currently collected;

- **Scenario 2** is completely revenue-neutral, reallocating existing registration fee revenue based on HCAS results of maintenance needs generated;

- **Scenario 3** is also revenue-neutral and assumes that the minimum registration fee should be $76 (the lowest registration fee in Vermont today) and that the other registration fees should increase in value if needed, such that heavier weight classes are always more than lower weight classes;

- **Scenario 4** assumes that the relatively minimal damage caused by vehicles under 6,000 pounds is a negligible portion of the current registration fee for those vehicles, when compared to other portions of a registration fee's justification. Thus, these fees are kept identical at today's fee of $76, and other fees are scaled up proportionately. This scenario is not expected to be revenue-neutral for the entire set of registered vehicles.

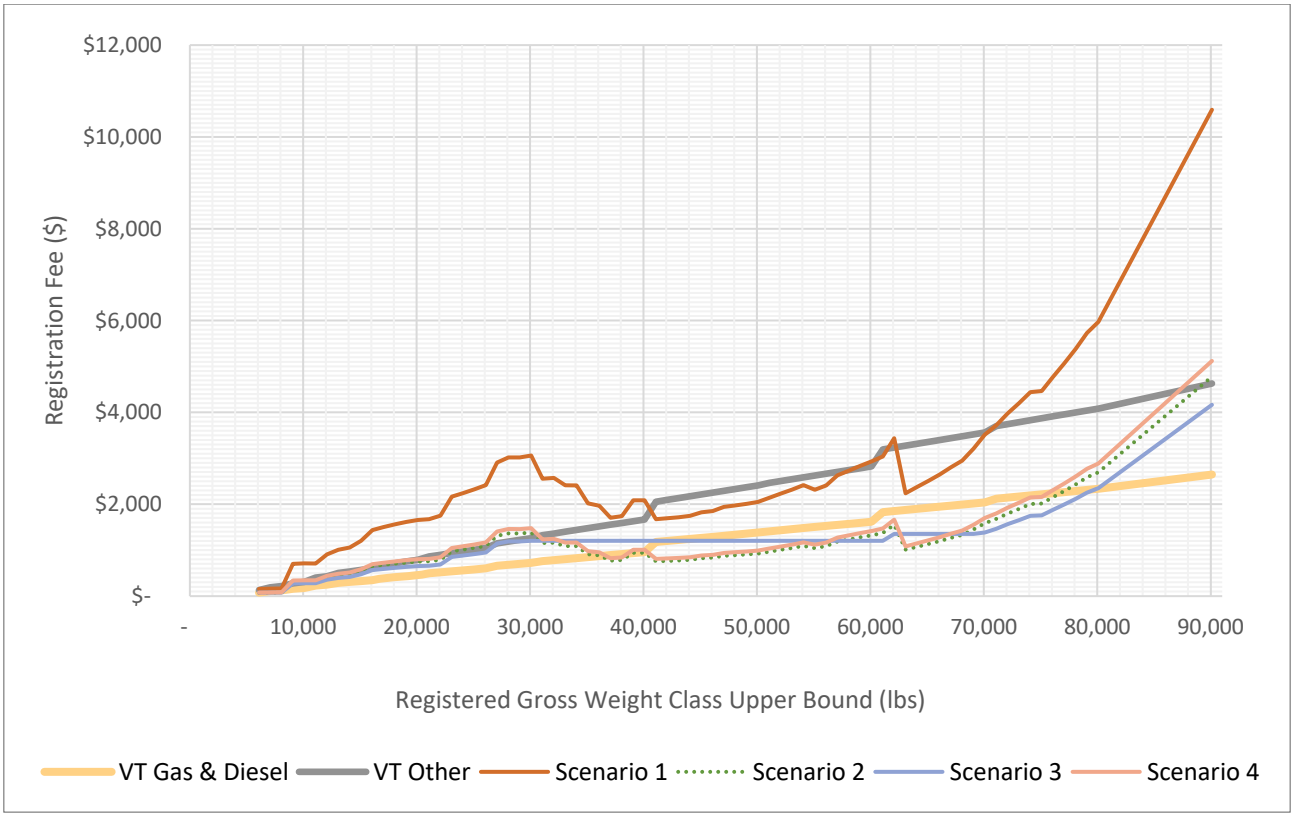
The process to analyze the impacts of alternative registration fee structures requires data about Vermont's registered vehicles, its fee structure, its bridge and pavement program, and its system mileage. The analyses undertaken are aggregate in nature, and thus does not provide data about specific vehicles, specific maintenance events caused by weight, or specific driving behavior on a particular roadway. Vermont provided the following inputs: number of truck registration in Vermont by gross vehicle weight rating (GVWR), the registration fee table by GVWR, the annual vehicle miles travelled (VMT) in Vermont by functional class, the distribution of VMT by functional class and vehicle class, the expenditures for bridges and pavements in Vermont, the system mileage by rigid and flexible pavement, and the actual registration fee revenue. Using these inputs, the HCAS Tool output the cost responsibility by GVWR, which was normalized and applied to the registration structure given by Vermont.

Scenario Results

Under each scenario the lowest weight class has the highest total cost responsibility even though per unit it has the least impact on the roads. This weight class includes automobiles, buses, and trucks with a GVWR less than 6,099 pounds. The high total cost responsibility for this lightest weight class is a result of their high volume. At the other end of the spectrum, the heaviest trucks, between 80,000 and 90,000 pounds are less numerous, but their per unit effect on the roads is much greater than other categories (while their cost ratio is lower than many of the categories). Cost responsibility can also be viewed on a per mile basis. Vehicles less than 8,099 pounds cause damage costing less than one dollar per mile, while vehicles between 80,000 and 90,000 pounds cause damage costing between $40 and $125 per mile. These costs are figured as a percent of total of Vermont's pavement and bridge costs.

In determining the registration fee that could be charged based on vehicle weight class, the registration fee is representative of both the damage per mile that vehicle does to the pavement and bridges and the assumptions on the distance that each vehicle class travels on an annual basis. The resulting registration fee for all four scenarios is shown in Figure ES.3, and the current fee schedule is lightly shown on the chart for comparison. Overall, cost responsibility increases with weight, but the reduced precision in the correlation between cost responsibility and weight is indicative of the complex relationship between the impact of the vehicles, the number of vehicles, and the varying relationship between vehicle type, weight, and axle distribution. It is the weight and distribution of the axles, as well as the distance between axles that ultimately determines how well weight is distributed, and how damaging a vehicle is to the infrastructure.

Figure ES.3 Proposed Registration Fee – All Scenarios



Source: CS, Weight-Based Model.

Scenario 1 assumes that the cost responsibility calculated will be 100 percent fulfilled by registration fees. When using the registration fees proposed in Scenario 1, the overall revenue that would be collected matches the five-year average expenditures by Vermont on pavement and bridges, $156.3 million. The equity ratio shows the registration fee accounts for 100 percent of the cost responsibility of the weight class. The equity ratio is the balance between the projected revenue and the full cost responsibility of that RGW. Given that there are other revenue sources than registration fees, such as fuel taxes, the next two scenarios will normalize the registration fees to match the current revenue rather than the expenditures.

Scenario 2 is a result of normalizing the initial cost responsibility results by Vermont's current registration fee revenue. The fee for each weight class is multiplied by 45 percent, which is the ratio between Vermont's current registration revenue and the Vermont's five-year average annual bridge and pavement expenditures. With the same equity ratio across each weight class, some weight classes would pay almost 200 percent of the current fee table. In addition, the fee class does not increase continually and the lowest fee is less than the current fee table—these aspects will be controlled in Scenario 3.

Scenario 3 is a result of smoothing the initial cost responsibility results by applying a factor so that fees continue to increase in value with weight, and such that the minimum fee is equivalent to the current minimum registration fee, $76. The equity ratio in this scenario varies as a result of the registration fee controls that were applied. Each weight class pays between 61 to 168 percent of their cost responsibility.

Scenario 4 assumes that the relatively minimal damage caused by vehicles under 6,099 pounds is a negligible portion of the current registration fee for those vehicles, when compared to other portions of a registration fee's justification. Starting with the fees as calculated for Scenario 1 with 100 percent equity, all fees are scaled by the same factor such that the fee from the first weight class of vehicles under 6,099 pounds is the same as the average fee as calculated using the existing registrations and assumptions. Accordingly, this scenario has an equity value of 0.48 for each weight class, such that the first weight class is $76 which is equivalent to the current fee charged. Each weight class pays between 64 to 207 percent of their cost responsibility. Scenario 4 is not normalized against the existing revenue. The total new revenue calculated for Scenario 4 is $75.6 million. The $75.6 million represents the new revenue that Vermont would collect if Scenario 1 were scaled equally until the first weight category were $76.

Issues for Consideration

The analysis conducted considered currently available information either from VTrans or other data sources or information from the current literature. The analysis required several sets of assumptions about data quality, owner behavior, and implementation feasibility. Some of these assumptions were embedded in the configuration data for the HCAS tool, others were based on the judgement of the project staff. While the report provides a framework suitable for continued discussion of potential registration fee changes, it also points out areas where additional research and outreach may be required.

The following topics were identified during the analysis process and should be considered when drawing conclusions from this report. Some of these issues may warrant future policy analysis. None of these issues invalidates the validity of evaluating potential fee changes or fee structure changes based on how registered weight affects bridge and pavement costs. But each of these issues poses a confounding topic that should be considered in the deliberation process, and several of these issues require additional data to properly evaluate their potential impacts.

1. **Data Quality and Availability**

   A full analysis of potential alternative structures for registration fees, such as controlling for distance or focusing on maximum axle loadings instead of gross weight, required data unavailable at the present time. Data was available for information on categories of registered vehicles. It was not possible to obtain individual vehicle information for each registered vehicle, such as the number of axles, the registered location of the vehicle, and the number of miles driven for each vehicle inside of Vermont. Such information could be obtained by using Vermont weigh-in-motion data (WIM). Without that information, it was imperative to utilize the assumptions about vehicle class distributions found in the HCAS. Since the HCAS was developed in 2000, it is desirable that the data utilized be updated and the models recalculated before any action is considered. The HCAS makes a series of assumptions about the distribution of the commercial vehicle inventory within a state. These assumptions affect the precision of the results. While we have presented the actual results of the models and Scenarios 1-4 in the report, we caution the reader to not think of the results as point estimates but instead as ranges.

   VTrans has accurate data on maintenance expenditures. The definition of "maintenance" however, differs in slight ways in different interpretations, such as the HCAS tool. Reasonable assumptions were made in translating VTrans' known expenditures to those required in the model. For the purpose of this report maintenance refers to state bridge and pavement expenditures. In reality, other VTrans programs, such as highway safety and roadway, may include project components which contribute to highway maintenance. These were not included because a direct link is difficult to establish without an in-depth

analysis of hundreds of projects. In addition, the data is focused on actual budgeted and expended funds, not total bridge and pavement needs, which are likely significantly higher than what is currently budgeted and expended on state highways and bridges.

2. Potential Vehicle Owner Adjustments to a Revised Fee Structure

The HCAS model assumes that owner and driver behavior is static, that is to say that changes to cost allocation will not cause changes in behavior. We caution the reader that for substantial changes in cost allocation, this may not be true. One example of a class of vehicle owner whose behavior could possibly change is the out-of-state owner who conducts occasional business in Vermont. Changes in registration fees or fee structures (such as shifting to a distance-based or class-based structure) could change owner behavior about the desirability to operate vehicles in Vermont, especially for travel where both origin and destination are outside of the state.

The International Registration Plan (IRP) stipulates that commercial vehicles that cross state and national lines have their registration fees apportioned to each jurisdiction that the vehicles uses for travel. In Vermont, a commercial carrier must register a fleet with the IRP if the fleet travels in Vermont and in at least one other state in IRP jurisdiction (with some exceptions). With the IRP, any commercial vehicle that travels through Vermont will end up paying Vermont a portion of Vermont's registration fee for that weight class. What is unknown and requires further study is how owner behavior of these vehicles with regards to picking business destinations and routes will change as fees change.

3. Alternative Structures to Registered Weight

The underlying HCAS analysis considers the class of the vehicle for cost allocation, and then translates allocations back to registered weights through assumptions about distributions. This is an intriguing concept, to our knowledge no state has a fee structure strictly on vehicle class (such as the classes found in Table 3.11). It is unlikely that either VTrans (for intrastate vehicles) or the International Registration Program (for interstate and Canadian commercial vehicles) have sufficient data to model the usage of vehicles by registered class, and field data collection would likely be needed to make sufficient assumptions.

Similarly, VTrans does not currently have sufficient data to fully consider the impacts of fee structures in the form of "$x plus $y per mile," and how those parameters would change with registered weight. In the oversize/overweight realm, some states such as Tennessee do charge a "ton-mile" fee on trip permits for overweight vehicles, typically 3-5 cents per mile per ton over legal weight. But we caution the reader that those permits are for known single trips where the purchaser discloses the route utilized, and that while some engineering analysis may have been done to reach these mileage coefficients, some of these fees have been in place for over fifty years.

However, it is common practice to both display bridge weight limits by number of axles and to charge tolls based on the number of axles. A registration fee structure could be revised to charge trucks by their GVWR as well as the number of axles.

Any analysis of distance based structures should consider both individual vehicle records as well as the possibility of travel behavior changes. The HCAS tool utilized for this report is not sufficiently robust to take these kind of changes into account even if the underlying data was available.

4. Implications for Government Operations

A change in the registration fees by registered fees would have minimal impact on the systems utilized to issue registration credentials to vehicle owners. A change in the overall structure of the fees, either to a class-based system or a distance-based surcharge system, would have substantial impacts. The system which VTrans utilizes for passenger car and intrastate commercial vehicle registrations is of advanced age, and changes to such a system would be very difficult to ascertain and test. Meanwhile, structural changes to fees for intrastate vehicles would require participation from all US states and Canadian provinces, and changes to every one of those systems.

A substantial increase in fees for a particular subset of vehicles is likely to have a corresponding increase of compliance challenges as owners under-register their vehicles' weights, especially for commercial vehicles conducting shorter trips or with a substantial amount of empty back-haul after deliveries. Adding changes to fee structure itself, such as a distance surcharge or a fee for different numbers of axles, is likely to exacerbate compliance challenges as well as adding in a layer of accidental non-compliance by owners who do not understand the revised fee structure.

Having neighboring states with lower registration fees would not encourage carriers to register their vehicles in another state since with IRP apportionment, a carrier pays registration based on the mileage travelled in each jurisdiction. However, higher fees in Vermont could drive decisions on where fleets are headquartered and how through traffic is routed. Fleets registered in Vermont provide ancillary benefits such as maintenance needs providing repair business to Vermont establishments. Carriers could choose to avoid driving through a state in order to avoid paying fees for that state—this would also reduce the damage on a state's roadways. However, increased shipping fees could be passed onto Vermont residents and businesses, causing overall higher shipping costs for Vermont. Higher shipping costs for companies in Vermont could have a negative impact on business competitiveness. Knowing whether the magnitude of a registration fee will be enough to affect business decisions would require analyses beyond the scope of the authorizing legislation.

5. Impact with Regards to Buses

The HCAS tool utilized in the analysis methodology does not take bus types into account. There are three categories of buses which will need to be considered: school buses, urban transit buses, and long-distance passenger buses. The latter category are typically interstate registered vehicles and the former categories are intrastate registered vehicles. All three types of buses have very different loading factors when compared to trucks of similar weight, and their parameters are likely to be in contradiction to the inputs found in the HCAS tool. The operating characteristics of these three types of commercial vehicles are sufficiently different as well, most specifically the operation weights at various load factors and the amount of driving done on state-maintained versus locally-maintained roads. As a result, they cannot realistically either be combined into one category, or combined in an maintenance equity based fee structure.

1.0 Purpose

1.1 Authorizing Legislature

Act 59 (H.529 Section 47, Weight-Based Annual Registration Report) requires the Agency of Transportation (VTrans) to submit a report to the legislature on the feasibility of implementing an annual motor vehicle registration fee system that addresses road maintenance cost allocations for on-road motor vehicles based on gross vehicle weight.

1.2 Overview

Vehicle weight impacts roadway pavement and bridges, and vehicle weight per axle is an important component affecting its rate of deterioration. The impact of weight is non-linear and studies have shown it to be exponential, and the power of the exponent has been estimated at around four. This means a doubling in vehicle weight per axle increases the damage by a factor of around 16. Preventing deterioration on Vermont's state-maintained roadway infrastructure requires activity from VTrans: maintenance, rehabilitation, and if not treated in time, full replacement.

The costs of these activities are distributed to users of Vermont's roadway network, including both registered Vermont vehicles as well as those from outside of Vermont. Registration fees are one manner in which these costs can be recaptured. While there is an administrative cost component to vehicle registration, fee structures in most states rise with increasing gross vehicle weight. Vermont is no exception, and Vermont's full fee table for registration is found for reference at the end of this document.

This document assists VTrans in fulfilling Act 59 (H.529 Section 47, Weight-Based Annual Registration Report) by reviewing current data and literature regarding registration fee data, maintenance cost data for bridges and pavements, and studies analyzing maintenance cost allocation based on weight. Based on the literature review, the Federal Highway Administration's Highway Cost Allocation Tool (HCAS) was selected to quantify the potential impacts of different registered weights on maintenance needs. These impacts were then used to compose four scenarios of alternative registration fee structures:

- **Scenario 1** assumes that each weight class has a registration fee with complete equity to its cost responsibility and that the total registration fee collected may change (either up or down) from the total fee currently collected;
- **Scenario 2** is completely revenue-neutral, reallocating existing registration fee revenue based on HCAS results of maintenance needs generated;
- **Scenario 3** is also revenue-neutral and assumes that the minimum registration fee should be $76 (the lowest registration fee in Vermont today) and that the other registration fees should increase in value if needed, such that heavier weight classes are always more than lower weight classes;
- **Scenario 4** assumes that the relatively minimal damage caused by vehicles under 6,000 pounds is a negligible portion of the current registration fee for those vehicles, when compared to other portions of a registration fee's justification. Thus, these fees are kept identical at today's fee of $76, and other fees are scaled up proportionately. This scenario is not expected to be revenue-neutral for the entire set of registered vehicles.

This approach provides three potential fee structures for consideration, in addition to information about fee structures in other states which have pursued a partial approach towards maintenance-based fee allocation.

1.3 Report Organization

The remainder of this report is organized as follows:

- **Section 2** summarizes a select review of the literature on vehicle registration and user fee models, roadway maintenance funding schemes, and methodologies for allocating maintenance costs based on vehicle weights.
- **Section 3** enumerates the data obtained for the analysis that was conducted for this study, and describes the parameters required by the FHWA HCAS model;
- **Section 4** presents the analysis conducted using HCAS to obtain the relative contributions which vehicles at different weights and numbers of axles contribute to bridge and pavement maintenance damage, and utilizes the results to generate the resulting fee structure for each of the four scenarios described earlier; and,
- **Section 5** contains findings and discusses potential considerations involved in the implementation of a new fee structure.

2.0 Literature Review

At the outset of this project, the team conducted a review of the existing literature on vehicle registration and user fees models, roadway maintenance funding schemes, and methodologies for estimating the impact of motor vehicle weight on roadway wear and the allocation of maintenance costs to users. The project team analyzed passenger automobiles, farm vehicles, and trucks, but excluded all types of buses because of inconclusive research behind varied weight distributions across different types of buses, routes, and/or service provided. The review largely focused on the US experience, with a limited examination of some illustrative international examples.

Existing programs on weight-based registration fees for passenger and commercial vehicles were reviewed, which included all states with existing or proposed weight-based fee structures. Also included was a wider review of literature on highway cost allocation. Few published reports describing experiences with weight-based registration schemes are available, as these activities are commonly conducted within each state's Department of Transportation.

Recent registration fee data in Vermont and selected other states was reviewed, as was literature on the relationship between vehicle weight, registration fees, and infrastructure maintenance costs. Utilizing a mix of domestic and international sources, the literature review identified three classes of previous work:

- Studies comparing the relative infrastructure damage expected to occur for various vehicle configurations, typically normalizing vehicle configurations into what are referred to as Equivalent Single-Axle Loads (ESAL);
- Studies investigating highway cost allocation in general; and
- Studies investigating alternative roadway costs allocation schemes, such as ton-mile fee structures.

Each of these elements are reviewed in the sections that follow.

2.1 Current Registration Fees for Vermont and Other States

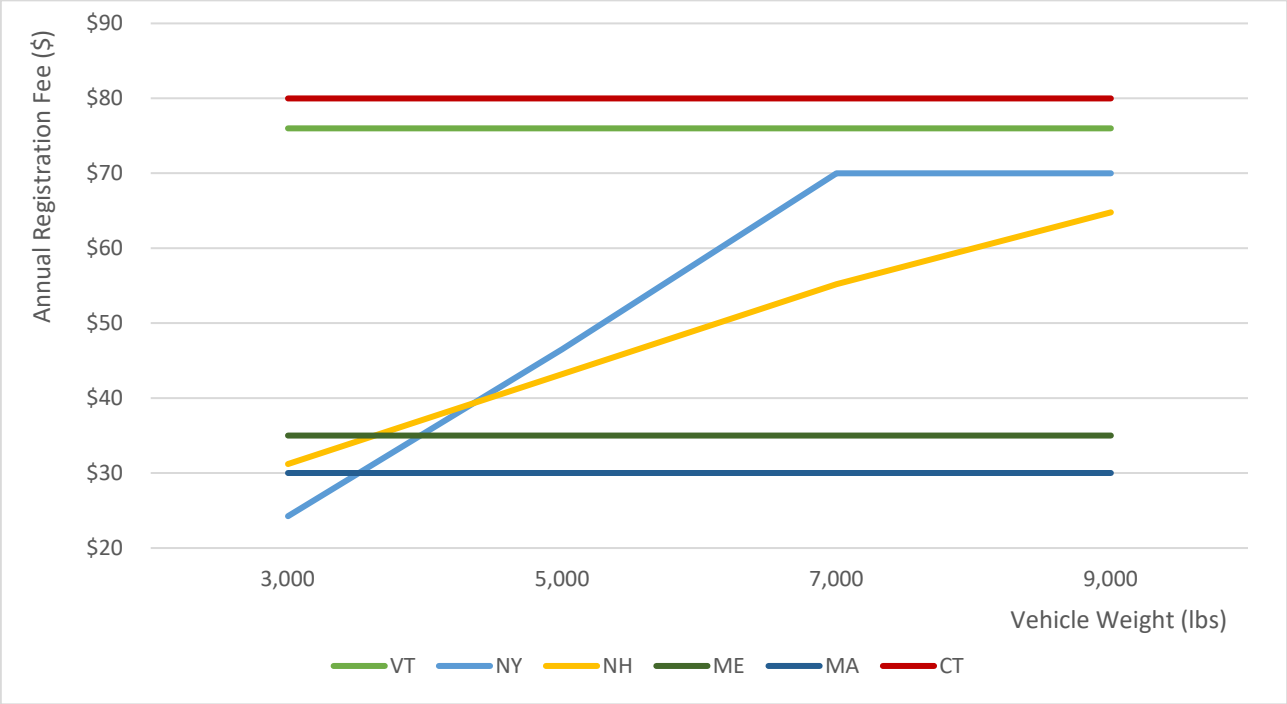
Vermont is one of many states which legislates sliding scales for registration fee based on gross vehicle weight. Vermont currently charges automobiles and trucks up to 6,099 pounds a flat fee which varies by the vehicle fuel source. The state registration fee for trucks is based on loaded weight, with higher weights having higher fees. Notably, motor homes and school buses, which can weigh upwards of 20,000 pounds, are charged the same as lightweight passenger vehicles.

Similar to Vermont, most states charge flat fees for automobiles and a tiered fee for trucks because passenger automobiles generally weigh 3,000 to 6,000 pounds depending on size and model (compact cars versus sport utility vehicles) while truck weight varies significantly depending on number of axles as well as type and quantity of load, which necessitates a tiered-fee structure. Some states charge certain fees for farm vehicles and/or a separate flat fee for heavy single unit trucks that ranges between $300 to over $1,000.

Figure 2.1, Table 2.1, Figure 2.2, and Table 2.2 show the annual registration fee for passenger and commercial vehicles, for Vermont and nearby states, consisting of New York, New Hampshire, Maine, Massachusetts, and Connecticut. With the exception of New Hampshire and Maine, all states utilize a flat fee structure for passenger vehicles. For commercial vehicles, all states utilized some type of weight-based fee

structure. It should be noted that the charts below only include registration fees and are not representative of the total commercial vehicle operating cost for each state which in addition to the registration fee includes, sales tax, title fee, plates, fuel tax rate per mile, commercial vehicle tax use, among others.

Figure 2.1 Annual Registration Fee, Passenger Vehicles



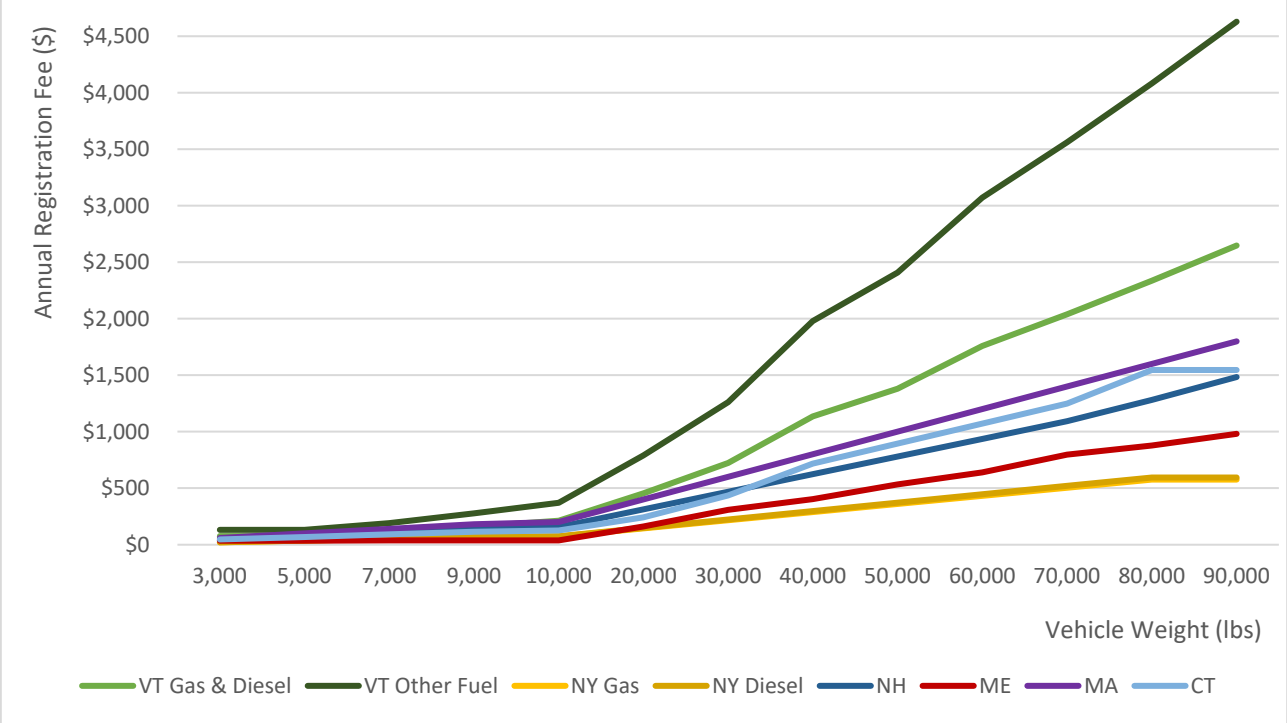
Source: New York DMV, Vermont DMV, New Hampshire Title XXI, Maine DMV, Massachusetts Registry of Motor Vehicles, Connecticut DMV.

Table 2.1 Annual Registration Fee, Passenger Vehicles

GVWR (lbs)	Vermont	New York	New Hampshire	Maine	Massachusetts	Connecticut
3,000	$76	$24	$31	$35	$30	$80
5,000	$76	$47	$43	$35	$30	$80
7,000	$76	$70	$55	$35	$30	$80
9,000	$76	$70	$65	$35	$30	$80

Source: New York DMV, Vermont DMV, New Hampshire Title XXI, Maine DMV, Massachusetts Registry of Motor Vehicles, Connecticut DMV.

Figure 2.2 Annual Registration Fee, Commercial Vehicles



Source: New York DMV, Vermont DMV, New Hampshire Title XXI, Maine DMV, Massachusetts Registry of Motor Vehicles, Connecticut DMV.

Table 2.2 Annual Registration Fee, Commercial Vehicles

GVWR (lbs)	Vermont Gas & Diesel	Vermont Other Fuel	New York Gas	New York Diesel	New Hampshire	Maine	Massachusetts	Connecticut
3,000	$76	$132	$22	$22	$41	$35	$60	$47
5,000	$76	$132	$36	$36	$72	$35	$100	$68
7,000	$109	$190	$51	$51	$103	$37	$140	$91
9,000	$159	$277	$65	$67	$140	$37	$180	$114
10,000	$212	$370	$72	$74	$156	$37	$200	$126
20,000	$455	$790	$144	$149	$312	$161	$400	$242
30,000	$724	$1,261	$216	$223	$468	$308	$600	$436
40,000	$1,135	$1,980	$288	$297	$624	$403	$800	$718
50,000	$1,380	$2,409	$360	$372	$780	$533	$1,000	$895
60,000	$1,759	$3,072	$432	$446	$936	$640	$1,200	$1,072
70,000	$2,039	$3,562	$504	$520	$1,092	$797	$1,400	$1,249
80,000	$2,337	$4,083	$576	$595	$1,280	$877	$1,600	$1,546
90,000	$2,649	$4,629	$576	$595	$1,484	$982	$1,800	$1,546

Source: New York DMV, Vermont DMV, New Hampshire Title XXI, Maine DMV, Massachusetts Registry of Motor Vehicles, Connecticut DMV.

2.2 Overweight Vehicles

Vehicles operating above 80,000 pounds register at 80,000 and obtain a special use permit typically referred to as an Oversize/Overweight permit. These permits are available from the Department of Motor Vehicles[1] and are available both in single-trip and annual versions, and in special configurations for various vehicle types and for certain highways such as US Route 4 from the New Hampshire State line to the junction of VT Route 100 South. For vehicles carrying gross weights over 80,000 pounds, there are differentiations based on whether the load is considered "divisible," and whether the state's laws predate federal legislation. At these weights, there is a mix of vehicle registration and special Oversize/Overweight operating permitting.

Vehicles which obtain Overweight permits are generally registered at the maximum allowable non-permitted rate (in Vermont it would be either 80,000 or 90,000 pounds). Trip, multi-trip, or time-based permits are then issued by the appropriate state agency to allow travel above those weights. Depending on the state or province, the pricing of those permits may or may not capture the estimated damage of that vehicle based on the increased weight. Since these vehicles are registered at lower weights than their permit, the analysis in this report takes into account only the registered weight and registration fee of the vehicle, not the permitted weight and associated permit fee.

2.3 Weight-Based Registration and Highway Cost Allocation

Vehicle weight impacts roadway pavement and bridges, and vehicle weight per axle is an important factor in determining how fast this infrastructure deteriorates. Mitigating deterioration on Vermont's state-owned and Interstate infrastructure requires activity from VTrans: maintenance, rehabilitation, and if not treated in time, replacement of infrastructure.

The costs of these activities are distributed to users of the system, including both registered Vermont vehicles as well as those from outside of Vermont. Registration fees are one manner in which these costs can be recaptured. While there is an administrative cost component to vehicle registration, fees generally do rise across the United States as gross vehicle weight increases. Vermont is no exception, and Vermont's full fee table for registration is found for reference at the end of this section.

The Federal Highway Administration (FHWA) and Transportation Research Board's (TRB) NCHRP have examined the relationship between vehicle weight and highway maintenance costs and provide detailed information on highway cost allocation. Sources reviewed in depth are summarized next, with reviews of the two underlying topics of road users and costs and equity ratio calculations, followed by a review of states using equity calculations as part of their fee-setting approach.

2.3.1 Road Users and Costs

The following documents provide background on road user costs:

- National Cooperative Highway Research Program (NCHRP) **Synthesis 378: State Highway Cost Allocation Studies**[2]

[1] http://dmv.vermont.gov/CVO/permits

[2] http://www.trb.org/Publications/Blurbs/160297.aspx

- Federal Highway Administration (FHWA) **Comprehensive Truck Size and Weight Study** (2000 and 2016)[3]

- **Maine and Vermont Interstate Highway Heavy Truck Pilot Program: 6-Month Report** (2010), and **Vermont Pilot Program Report** (2010)

A Highway Cost Allocation Study (HCAS) is designed to determine the fair share that each class of road user should pay for the construction, maintenance, operation, improvement, and related costs of state highways, roads, and streets. Through a comparison of user fees paid and cost responsibilities estimated within the HCAS, these studies assess equity, usually for a projected period, and may provide recommended adjustments to existing user fees and tax rates to bring about a closer match between payments and cost responsibilities for each vehicle class. The NCHRP synthesis examines the history and evolution of HCAS practice and assembles the state of HCAS practice as of 2008, when the report was developed. It highlights work that has been performed in 11 states including Vermont. Oregon conducted the first HCAS in 1937, and since then 30 states have performed HCAS across the nation. Significant advancements in the practice occurred as the result of federal HCAS completed in 1965, 1982 and 1997.

Vermont has completed three HCAS, in 1990, 1993 and 2006. In the latest study the state used the Federal method. That study allocated 25.7 percent of the costs to heavy-trucks. The key allocators used (or measure used to allocate costs to highway-user classes) were vehicle miles travelled (VMT), average daily traffic (ADT) and Equivalent Single-Axle Loads (ESAL). The types of revenues examined were State and Federal funds.

Vehicle Classes

The 1997 Federal HCAS examined a broad spectrum of vehicle types and weight classes. 20 vehicle types were included, as shown in Figure 2.3.

[3] https://www.fhwa.dot.gov/reports/tswstudy/Vol1-Summary.pdf & https://ops.fhwa.dot.gov/freight/sw/map21tswstudy/index.htm

Figure 2.3 FHWA HCAS Vehicle Class Categories Table

Table I-1. HCAS Vehicle Class Categories		
VC	**Acronym**	**Description**
1	AUTO	Automobiles and Motorcycles
2	LT4	Light trucks with 2-axles and 4 tires (Pickup Trucks, Vans, Minivans, etc.)
3	SU2	Single unit, 2-axle, 6 tire trucks (includes SU2 pulling a utility trailer)
4	SU3	Single unit, 3-axle trucks (includes SU3 pulling a utility trailer)
5	SU4+	Single unit trucks with 4- or more axles (includes SU4+ pulling a utility trailer)
6	CS3	Tractor-semitrailer combinations with 3-axles
7	CS4	Tractor-semitrailer combinations with 4-axles
8	CS5T	Tractor-semitrailer combinations with 5-axles, two rear tandem axles
9	CS5S	Tractor-semitrailer combinations with 5-axles, two split (>8 feet) rear axles
10	CS6	Tractor-semitrailer combinations with 6-axles
11	CS7+	Tractor-semitrailer combinations with 7- or more axles
12	CT34	Truck-trailers combinations with 3- or 4-axles
13	CT5	Truck-trailers combinations with 5-axles
14	CT6+	Truck-trailers combinations with 6- or more axles
15	DS5	Tractor-double semitrailer combinations with 5-axles
16	DS6	Tractor-double semitrailer combinations with 6-axles
17	DS7	Tractor-double semitrailer combinations with 7-axles
18	DS8+	Tractor-double semitrailer combinations with 8- or more axles
19	TRPL	Tractor-triple semitrailer or truck-double semitrailer combinations
20	BUS	Buses (all types)

Source: National Cooperative Highway Research Program (NCHRP) Synthesis 378: State Highway Cost Allocation Studies.

In addition, these vehicle types were further examined by weight in 5,000-lb increments. Ultimately, the Federal HCAS examined vehicles in 12 vehicle classes. States have historically examined far fewer vehicle classes based on both weight and configuration. For example, the 2006 Vermont HCAS examined 20 broad vehicle classes without consideration of weight: passenger cars, pickups and vans, 3 single-unit truck configurations, 14 combination-truck configurations, and buses. Other states have established vehicle classes based on both axle configuration and registered vehicle weight.

Functional Classes of Road

Historically, the 12 functional classes of road systems defined by AASHTO and FHWA have served as the standard treatment of functional classes in HCASs.

- Rural: Interstate, other principal arterials, minor arterials, major collectors, minor collectors, and local.
- Urban: Interstate, other freeways and expressways, other principal arterials, minor arterials, collectors, and local.

The Arizona HCAS simplifies the cost allocation procedure by assuming that expenditures on urban roads are driven by congestion and should be allocated based on relative shares of VMT, whereas expenditures on rural roadway systems are driven by the strength requirements caused by heavy truck traffic and, therefore, should be allocated based on vehicle axle loads and mileage.

Cost Allocators

The Federal HCAS tool includes the National Pavement Cost Model (NAPCOM) to predict the impact that vehicle use will have on pavement damage based on the relationships between axle weights and pavement damage and assigns cost responsibility based on established allocation factors. In the absence of a more comprehensive pavement model, some states have historically used more straightforward measures that are designed to vary in proportion to the damage caused to the roadway system by vehicle classes. These allocators include: Axle Miles of Travel (AMT), Axle Weight or Axle Load, Ton-Miles, ESAL and ESAL-Miles.

Weight Fees

A “Special Vehicle Analysis Workbook” was developed and refined in studies conducted for several states (including Vermont), and incorporated into FHWA’s State HCAS tool. The workbook provides estimates of cost responsibility and revenue generated for a user-specified vehicle based on the results of the state’s HCAS. The workbook can be used to answer many types of “what-if” questions for any selected vehicle, e.g., “How much should the registration fee be increased (or decreased) in order to have a truck at ‘x’ registered gross weight cover at least 95 percent of its cost responsibility”?

Infrastructure Costs – Pavement

The table below shows the relative pavement damage caused by the different scenario vehicles analyzed in this study. Pavement damage is expressed in terms of load equivalency factors per 100,000 pounds of cargo. This measure reflects both absolute pavement damage caused by each vehicle at the maximum weight at which it can operate, as well as the benefits of moving the same volume of cargo in fewer trips. It also shows that pavement impacts vary by type of pavement. Figure 2 shows that pavement damage varies depending on the specific vehicles and weights at which they are allowed to operate. Among the combination vehicles, many can haul the same quantity of cargo as the five-axle semitrailer configuration with less pavement damage, but relative damage depends on the types of axles on each vehicle (single, tandem, or tridem) and the type of pavement upon which the vehicle is operating. Among the single unit trucks, adding an axle can reduce pavement costs per unit of cargo carried for any of the configurations and weights considered in this analysis.

Figure 2.4 FHWA Theoretical Load Equivalency Factors

Table 6. Theoretical Load Equivalency Factors per 100,000 pounds of Payload Carried By Study Vehicle Configurations

Configuration	Gross Vehicle Weight (pounds)	Empty Weight (pounds)	Payload Weight (pounds)	No. Of Vehicles per 100,000 pounds of payload	Load Equivalency Factors***		
					Rigid Pavement Fatigue (10-inch thickness)	Flexible Pavement (5-inch wearing surface)	
						Fatigue	Rutting
Three-Axle Single Unit Truck	54,000	22,600	31,400	3.18	13.4	17.8	13.0
Four-Axle Single Unit Truck	64,000	26,400	37,600	2.66	9.6	14.4	12.2
	71,000	26,400	44,600	2.24	9.2	14.6	11.2
Five-Axle Semitrailer	80,000	30,500	49,500	2.02	5.7	9.3	10.3
Five-Axle Semitrailer (10-foot Spread)	80,000	30,500	49,500	2.02	6.3	12.2	10.9
Six-Axle Semitrailer	90,000	31,500	58,500	1.71	3.8	7.5	9.6
	97,000	31,500	65,500	1.53	4.1	8.4	9.2
STAA Double (five-axle)	80,000	29,300	50,700	1.97	8.3	9.9	9.7
B-Train Double (eight-axle)	124,000	38,700	85,300	1.17	3.9	7.0	7.6
	131,000	38,700	92,300	1.08	4.1	7.7	7.5
Rocky Mt.Double (seven-axle)	120,000	43,000	77,000	1.30	7.8	9.9	9.5
Turnpike Double (nine-axle)	148,000	46,700	101,300	0.99	5.0	7.7	7.2
Triple (seven-axle)	114,000 (LTL)*	44,500	69,500	1.44	8.6	9.8	9.6
	132,000 (TL)**	44,500	87,500	1.14	11.6	11.8	9.0

*LTL= Less-than-truckload
**TL= Truckload
***(based on 18,000-pound single axle with dual tires)

Source: Federal Highway Administration (FHWA) Comprehensive Truck Size and Weight Study (2000 and 2016).

Infrastructure Costs – Bridges

The Federal Bridge Formula controls vehicle weights to protect the nation's bridges. In particular it limits the weight on groups of axles depending on the distance between those axles. The two most typical bridge designs are HS-20 which is common on higher class highways and H-15 which is typical of bridges on lower class highways. The bridge formula is intended to assure that stresses placed on HS-20 bridges do not exceed the design stress by more than five percent and stresses on H-15 bridges are no more than 30 percent greater than the design stress. Design stresses are well below stresses at which a bridge will fail, but prolonged repetitions of high stresses can cause bridge deterioration to accelerate.

The bridge formula approximates the five percent and 30 percent overstress criteria discussed above. The bridge analysis conducted for this study uses those criteria directly, estimating the stresses imposed by different scenario vehicles on a sample of bridges from the National Bridge Inventory. If stresses from scenario vehicles exceed the five percent or thirty percent criteria, those bridges are assumed to require replacement.

Passenger-Car Equivalents (PCEs)

Passenger car equivalents (PCEs) are used to establish the additional capacity that vehicles take on the road depending on their length, acceleration capabilities, and the type of traffic on the roadway type. A PCE is reported as a ratio between the vehicle and the standard passenger car, and is used to determine, for example, that a truck is equivalent to three passenger cars on a typical road. Figure 2.5 lists the FHWA vehicle passenger car equivalents for rural and urban highways. While three PCE is the typical value considered for trucks, on rural highways with steep grades the value can vary quite drastically, with a 120 foot long truck having as much as a 14.7 PCE. PCEs are generally used to establish capacity needs.

Figure 2.5 FHWA Vehicle Passenger Car Equivalents

Table 7. Vehicle Passenger Car Equivalents -- Rural Highways

Roadway Type	Grade		Vehicle Weight to Horsepower Ratio (pounds/horsepower)	Truck Length (feet)		
	Percent	Length (miles)		40	80	120
Four-Lane Interstate	0	0.50	150	2.2	2.6	3.0
			200	2.5	3.3	3.6
			250	3.1	3.4	4.0
	3	0.75	150	9.0	9.6	10.5
			200	11.3	11.8	12.4
			250	13.2	14.1	14.7
Two-Lane Highway	0	0.50	150	1.5	1.7	Not Simulated
			200	1.7	1.8	Not Simulated
			250	2.4	2.7	Not Simulated
	4	0.75	150	5.0	5.4	Not Simulated
			200	8.2	8.9	Not Simulated

Table 8. Vehicle Passenger Car Equivalents -- Urban Highways

Roadway Type	Traffic Flow Condition	Grade	Vehicle to Horsepower Ratio (pounds/horsepower)	Truck Length		
				40	80	120
Interstate	Congested	0	150	2.0	2.5	2.5
			200	2.5	3.0	3.0
			250	3.0	3.0	3.0
	Uncongested	0	150	2.5	2.5	3.0
			200	3.0	3.5	3.5
			250	3.0	3.5	4.0
Freeway and Expressway	Congested	0	150	1.5	2.5	2.5
			200	2.0	2.5	2.5
			250	2.0	3.0	3.0
	Uncongested	0	150	2.0	2.0	2.0
			200	2.5	2.5	2.5
			250	3.0	3.0	3.0
Other Principal Arterial	Congested	0	150	2.0	2.0	2.5
			200	2.0	2.0	3.0
			250	3.0	3.0	4.0
	Uncongested	0	150	3.0	3.0	3.5
			200	3.5	3.5	3.5
			250	3.5	4.0	4.0

Source: Federal Highway Administration (FHWA) Comprehensive Truck Size and Weight Study (2000 and 2016).

Pavement and Bridge Damage Specific to Vermont

The final report for the Maine and Vermont Interstate Highway Heavy Truck Pilot Program presents a methodology for evaluating the road (pavement) durability using pavement analysis and bridge durability using bridge fatigue evaluation. Vermont's final pilot program report was published after the full one year pilot period was complete, but with highly incomplete data. The results of the bridge analysis showed that Vermont bridges on average are more susceptible to increases in axle loads due to their overall short lengths. However, the pilot program impact on interstate bridges was negligible as they were already designed for higher loads. The results from the pavement analysis showed that pavement was also more affected by axle-load limits than gross vehicle weights. Early analysis established that tandem axles weighing more than 34,000 pounds cause significant damage, and overall, the higher axle weights of the trucks increased pavement damage on Vermont interstates by 12 percent. Pavement thickness is a key variable to a road's ability to carry heavy axle loads. The methodology for evaluating the degradation of the bridges and pavement is useful to evaluating the effect that trucks have on pavement.

The evaluation of pavement damage in the pilot program used weigh-in-motion data and truck vehicle miles travelled (VMT) estimates to determine the life-cycle costs of the trucks added to interstates in the pilot program. The analysis steps were to assess the shifts in traffic and axle loads, calculate overall measures of relative pavement damage using the National Pavement Cost Model, evaluate distress levels on Vermont Highways, with relative importance of each type of distress, and estimate pavement cost impacts combining weight relative damage for each distress type by the relative impact of each distress on pavement costs. As such, FHWA vehicle classes were assigned pavement damage potentials, which are listed in the table below, and which also accounts for the increase in heavy truck volume on the interstate. As pavement thickness and design determines how well it can handle axle weights, the table below lists damage potential for interstate pavements separately from non-interstate pavements. The overall increase in damage to the interstate considering the pavement, distress types, and increase in truck volumes was estimated to be 12 percent for all trucks on the interstate, with a negligible decrease in pavement damage on non-interstate roads.

The pilot program evaluated how the weight increases change the pavement damage factors for each FHWA vehicle class. Pavement damage factors for the most prevalent truck, FHWA Class 10, increased by 66 percent for a 10,000 pound increase in allowed weight.

The pilot program also calculated rough estimates of cost increases in maintenance resulting from increased weights using national averages and detailed analysis done by other states for pavement-related costs of truck travel. The study determined that a fully loaded, 80,000 pound 5-axle combination truck (FHWA Class 9) incurs 21.5 cents of pavement costs per mile on the interstate system and 32.9 cents per mile on non-interstate roads. The typical pilot vehicle was a 99,000 pound 6-axle truck (FHWA Class 10) and required pavement expenditures of 34.5 cents per mile on the interstate system and 53.6 cents per mile on non-interstate roads. This is a 32 percent increase in costs per ton-mile for the 99,000 pound 6-axle truck than a fully loaded 5-axle vehicle.

2.3.2 Equity Ratio

“Equity ratio” is the concept that a set of vehicles can be compared, even if they are vastly different such as a Nissan Altima sedan, a large pick-up truck such as a Ford F-350, a box truck used in local deliveries, and an over-the-road truck. The following report considers the establishment of equity ratios as found in the following documentation:

- FHWA Highway Cost Allocation Study (1997)[4]
- Victoria Transport Policy Institute. Distance-Based Pricing - Mileage-Based Insurance, Registration and Taxes (2019)[5]
- Iowa Department of Transportation. Summary of State Use of Weight-Distance Tax (2011)[6]

[4] https://www.fhwa.dot.gov/policy/hcas/final/execsum.cfm

[5] https://www.vtpi.org/tdm/tdm10.htm

[6] https://iowadot.gov/transportation2020/material/june27/Weight%20Distance%20and%20Electric%20Vehicle%20Fee%20Summary.pdf

Federal Highway Program Cost Categories

Federal highway program costs are divided into several cost categories, each of which is allocated among vehicle classes in a different manner:

- Pavement costs associated with constructing new lanes on a new location are divided into base facility costs related to providing added capacity to safely accommodate future traffic volumes and load related costs required to accommodate the expected axle loadings from future traffic. Base facility costs are allocated to vehicles on the basis to each vehicle's VMT weighted by its passenger car equivalents (PCEs), a measure used by traffic engineers to compare the influence of different types of vehicles on highway capacity. Costs for the additional pavement thickness needed to accommodate anticipated traffic are allocated based on the latest American Association of State Highway and Transportation Officials (AASHTO) pavement design procedures.

- Costs for pavement reconstruction, rehabilitation, and resurfacing (3R), which are estimated to represent 25 percent of total Federal obligations in 2000, are allocated to different vehicle classes on the basis of each vehicle's estimated contribution to pavement distresses that necessitate the improvements. The same general approach is used as in the 1982 Federal HCAS, but new pavement distress models were developed for this study that reflect the latest theoretical advances in understanding factors that influence pavement distress.

- Costs of constructing new bridges are allocated to vehicles using an incremental approach similar to that used in the 1982 Federal HCAS. As with new pavements, costs for constructing the base facility of a new bridge are allocated to all vehicle classes in proportion to their PCE-VMT. Incremental costs to provide the additional strength needed to support heavier vehicles are assigned to vehicle classes on the basis of the additional strength required on account of their weight and axle spacings.

- System enhancement costs neither increase the number of lane-miles of highway capacity nor improve the physical condition of the highway system. These costs include (1) transportation system management (TSM) projects; (2) safety improvement projects; (3) Intelligent Transportation System (ITS) projects; (4) transit facilities; (5) bicycle and pedestrian facilities; (6) environmentally-related costs including costs of mitigate adverse environmental impacts during planning, design, right-of-way, and construction; and (7) other system enhancements. Several different factors are used to allocate system enhancement costs among vehicle classes. Many of these costs were so small in the 1982 Federal HCAS that they were not treated explicitly, and new allocators had to be selected.

- Other attributable costs include grading and drainage; pavement width; ridesharing programs and facilities; and special truck facilities such as weigh stations. These costs are allocated on the basis of the relationships between the cost element and specific vehicle characteristics and are allocated to only the vehicle classes responsible for the costs.

When estimating the distribution of 2000 Federal cost responsibility by broad groups of vehicles it was found that automobiles which account for 70 percent of all vehicles and about two-thirds of all travel are responsible for 44 percent of Federal program costs followed by combination trucks, pick-ups and vans, and single unit trucks. It should be noted that the vehicle mix has changed considerably since 2000, with the extensive shift from cars to light duty pick-ups and sport utility vehicles, which tend to be heavier than automobiles.

The linkage between highway user fees and highway program financing is central to HCASs which seek to determine whether fees paid by each vehicle class cover infrastructure and other transportation agency costs occasioned by those vehicles. The estimated 2000 Federal Highway User Fee distribution by vehicle class indicated that passenger vehicles, which accounted for 93 percent of total highway travel, pay 64 percent of total Federal highway user fees. Combination trucks, on the other hand, pay over 25 percent of total highway user fees even though they travel less than 5 percent of total mileage.

The equity of highway user charges typically is measured in HCASs as the ratio of the shares of revenues contributed by each vehicle class to the shares of highway costs that vehicle class occasions. This ratio is often called a revenue/cost ratio or an "equity ratio." An equity ratio greater than 1.0 means overpayment; less than 1.0 means underpayment of Federal highway user fees.

Evaluating relationships between Federal user fees and Federal highway cost responsibility is essential for evaluating the equity of the Federal highway user fee structure. However, comparisons of total user fee payments and total highway cost responsibility for all levels of government are important in evaluating overall subsidies to various classes of vehicles that might give them a competitive advantage over other modes of transportation. In fact, State and local governments collect three-quarters of total highway user revenues (HUR) and the equity of their user fee structures is a very important component of overall user fee equity.

An important fact is the prominence of fuel taxes in the Federal highway user fee structure compared to State and local user fees. Fuel taxes account for almost 90 percent of Federal user fees compared to only half of State HURs and only one-third of local HURs. Vehicle registration fees account for one-third of State HURs and over 40 percent of local highway user revenue, compared to less than 3 percent for the Federal counterpart to the registration fee, the heavy vehicle use tax (HVUT). While fuel taxes vary by extent of use and registration fees do not, truck registration fees generally are graduated by weight and can reflect the large differences in cost responsibility of heavy trucks compared to lighter trucks.

States and Nations Utilizing Equity to Set Vehicle Fees

Weight-Based Fee

Two examples of unique weight-based fees include Wisconsin and Oregon. Wisconsin charges fees annually broken down by weight, vehicle class, and vehicle purpose as well as different fees for trucks depending on cargo and purpose, plus a $100 surcharge for any electric vehicles.[7] Oregon charges different weight-based registration fees depending on weight, length of registration (1/4 to a full year), and overall combined weight if over 26,001 pounds such a tow trucks.[8]

According to the Victoria Transport Policy Institute, a $0.035/mile weight-distance fee causes a 5.9 percent reduction in miles traveled.[9]

Delaware, a state with a substantial number of trips both starting and ending at state borders, has a simple tiered fee structure that adds $16.80 to their $20 flat fee for each additional 1,000 pounds after trucks exceed

[7] https://wisconsindot.gov/Pages/dmv/vehicles/title-plates/fee-chart.aspx

[8] https://www.oregon.gov/ODOT/Forms/Motcarr/9922.pdf

[9] https://www.vtpi.org/tdm/tdm10.htm

5,000 pounds and also charges a separate fee for heavy single unit trucks that is on the higher end of the spectrum ($876.80).

Internationally, both New Zealand and Switzerland charge drivers weight-based fees. New Zealand has charged diesel drivers road usage fees based on vehicle weights as well as VMT since 1978, and these drivers pay fees on all vehicles over 3.5 tons. Drivers of electric vehicles have to pay starting on June 30, 2020, and all fee revenue funds road construction as well as maintenance.[10]

Weight-Distance Tax

Kentucky, New Mexico, New York, and Oregon charge a weight-distance tax with different base rates per mile based on a vehicle's weight and use tax revenues to fund local roadway repairs. Fee parameters vary by state; for example New Mexico offers a 66 percent discount for one-way travel.[11]

A miles traveled fee alongside a weight-based fee like New Mexico, New York, Oregon, and/or Kentucky could provide Vermont with additional revenue specific to roadways used as well as potentially incentivize drivers to stick to truck-only routes which would help Vermont focus roadway repairs on truck routes. For example, Idaho charges trucks between 60,000 and 106,000 pounds a $4,500 fee depending on miles traveled.

Switzerland has charged a Heavy Vehicle Fee (HVF) since 2001 after a public referendum passed in 1998 requires heavy trucks (over 3.5 tons) to pay based on gross weight, kilometers driven, and emissions. Switzerland, which hosts two of Europe's busiest trans-alpine freight corridors, implemented the HVF to reduce freight truck traffic and increase freight railroad traffic.. Once collected, data is electronically sent to the Swiss Customs Agency and then used to bill the vehicle owner. Interestingly, truck volumes increased on cross-Alpine routes once the HVF was in place because the Swiss also increased road maximum vehicle weights to 40 tons from 28 tons. However, between 2000 and 2005, overall volume of goods transported on Alpine roads grew 3 percent but truck trips dropped 14 percent which illustrated pricing has a direct impact on truck volumes.[12] The HVF was not focused on increasing revenue, and instead focused on reducing trucks on highways. While policy makers hoped for a modal switch, trucks have continued to drive but with changed routes.

Impact

Vermont's current fee structure does present a relationship between gross vehicle weight and registration fee. The rationale behind those fees, however, is not explicitly based on equity ratio, or specifically based on maintenance costs. The literature demonstrates that sufficient information exists on vehicle equity ratio to enable calculations given assumptions regarding how much of the current Vermont fees must be utilized for non-maintenance administrative, technology and compliance functions. Care must be taken to understand whether 100% of the maintenance fees are to be captured by vehicle registration, or whether other sources such as fuel taxes also play a role in maintenance funding.

[10] http://www.fuelsfix.com/2019/04/paying-for-the-roads-electric-vehicle-road-usage-and-registration-fees/

[11] https://iowadot.gov/transportation2020/material/june27/Weight%20Distance%20and%20Electric%20Vehicle%20Fee%20Summary.pdf

[12] https://www.vtpi.org/tdm/tdm10.htm & www.zoll.admin.ch

Other jurisdictions have considered or implemented equity-based approaches to registration fees, often including a distance component. The strictly weight based fees implemented elsewhere can be applied to Vermont's mix of registered vehicles to understand how those structures compare in terms of fee per vehicle and total revenue generated, and can also be normalized to develop an estimated revenue-neutral adjustment to Vermont's current registration fee structure. Weight and distance approaches can also be applied and normalized, but some assumptions will need to be made about typical distances traveled in Vermont by each class of registered vehicle. Finally, the equity structure identified by FHWA in terms of ESALs can be utilized to calculate the current registration fee per ESAL for Vermont's registered vehicles, and potential normalizations can be identified.

3.0 Data and Analysis Parameters

3.1 Methodology Utilized

Primarily on the basis of the literature review, CS selected to use the Federal Highway Administration's Highway Cost Allocation Tool (HCAS tool or the tool) to answer the question posed by the legislation. Developed in 2000, HCAS is an Excel software package designed to perform state highway cost allocation studies. The HCAS tool considers state, local, and federal revenues to be the highway user taxes and fees and the expenditures to be the maintenance and capital budgets at the state, federal, and local levels.

This section presents how the HCAS tool was used to calculate the costs responsibility by weight class or vehicle. A companion document to HCAS and produced by the FHWA, "Guidelines for Conducting A State Highway Cost Allocation Study Using the State HCAS Tool", contains general guidelines for the conduct of a highway cost allocation study. In order to streamline the use of the tool, default data was used whenever Vermont-specific data was not readily available. The tool contains default data that reflects a combination of national averages and specific individual states. Throughout the tool, there are "switches" that can be flipped in order to indicate whether to use default data or user input data. When entering inputs, care must be taken, as the HCAS tool uses Visual Basic for Applications (VBA) and is very sensitive to small changes to the spreadsheets such as moving cells or changing font or cell colors. The model developed by CS walks the user clearly through the inputs that were used to run the HCAS tool.

The model developed by CS for VTrans considers four pricing scenarios, which will be presented in Section 4:

- **Scenario 1** assumes that each weight class has a registration fee with complete equity to its cost responsibility and that the total registration fee collected may change (either up or down) from the total fee currently collected;
- **Scenario 2** is completely revenue-neutral, reallocating existing registration fee revenue based on HCAS results of maintenance needs generated;
- **Scenario 3** is also revenue-neutral and assumes that the minimum registration fee should be $76 (the lowest registration fee in Vermont today) and that the other registration fees should increase in value if needed, such that heavier weight classes are always more than lower weight classes;
- **Scenario 4** assumes that the relatively minimal damage caused by vehicles under 6,000 pounds is a negligible portion of the current registration fee for those vehicles, when compared to other portions of a registration fee's justification. Thus, these fees are kept identical at today's fee of $76, and other fees are scaled up proportionately. This scenario is not expected to be revenue-neutral for the entire set of registered vehicles.

Finally, for fee structures from other jurisdictions, we applied those structures to Vermont's registered vehicles in two ways: first as is, and second adjusting the fees to keep the registration program revenue-neutral.

3.2 Data Collected

The process to analyze the impacts of alternative registration fee structures requires data about Vermont's registered vehicles, its fee structure, its maintenance program, and its system mileage. The analyses being

undertaking are aggregate in nature, and thus we do not have data about specific vehicles, specific maintenance events caused by weight, or specific driving behavior on a particular roadway.

The majority of inputs to the model were provided by VTrans. These inputs include:

- Number of truck registrations in Vermont by gross vehicle weight rating (GVWR) (Table 3.1) and number of auto and bus registrations in Vermont (Table 3.3)
- Registration fee table by GVWR (Table 3.2)
- Annual vehicle miles travelled (VMT) in Vermont by functional class in 2018 (Table 3.4)
- Vermont system mileage in Vermont in 2018 (Table 3.5)
- The distribution of VMT by functional class and vehicle class (Table 3.6)
- Maintenance expenditures for bridges and pavements (Table 3.7)
- System mileage by rigid and flexible pavement (Table 3.8)
- Actual total vehicle registration fee revenue ($70,549,346)
- Annual miles travelled per vehicle (Table 3.10)

The following data was not available from VTrans but was available in the HCAS tool for use in estimating revenue. The following data was collected from the HCAS tool:

- Percentage of vehicles in each gross weight range that use gasoline, diesel or other fuel (Table 3.9)
- Cost Responsibility by weight class
- Annual mileage travelled by vehicle class

The actual truck registrations shown in Table 3.1 were received in gross vehicle weight rating categories. These truck GVWR categories are further elaborated in Figure 3.1. These GVWR categories have a greater range and do not correspond to the registration fee table shown in Table 3.2. In order to calculate revenue, the categories used for the registration fee table were used for the analysis, and the number of registrations in each category were allocated across narrower ranges that match the registration fee table.

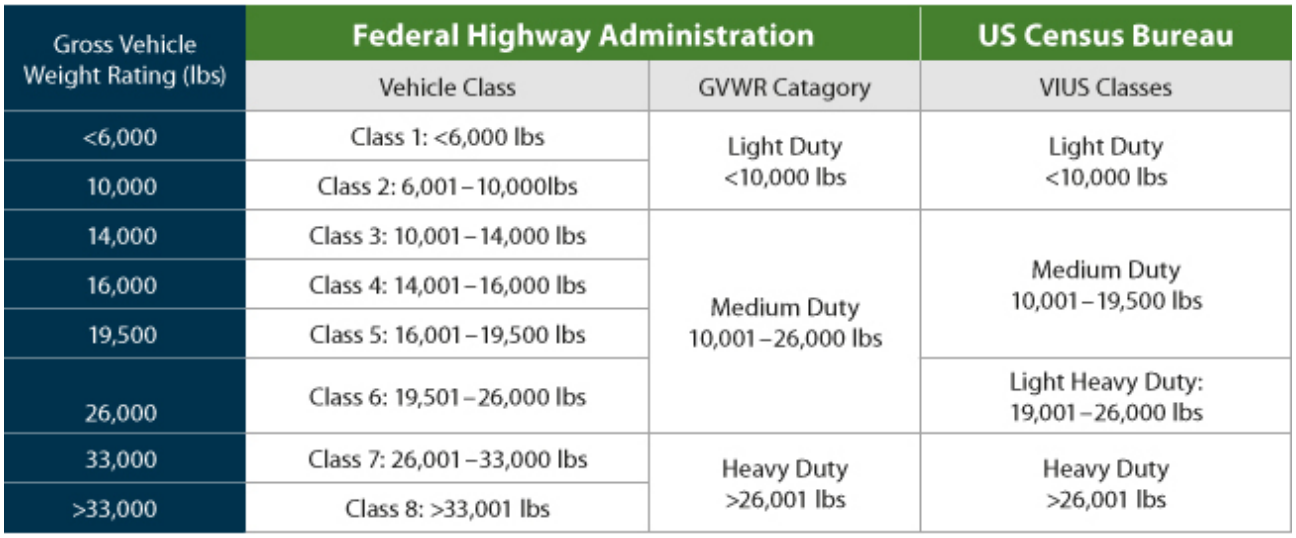
Table 3.1 Vermont Truck Registrations, GVWR

Gross Vehicle Weight Rating (GVWR)	Number of Registrations
Class 1- GVWR ranges from 0 to 6,099 pounds	105,160
Class 2- GVWR ranges from 7,000 to 10,000 pounds	25,470
Class 3- GVWR ranges from 10,001 to 14,000 pounds	8,676
Class 4- GVWR ranges from 14,001 to 16,000 pounds	1,943
Class 5- GVWR ranges from 16,001 to 19,500 pounds	2,088

Gross Vehicle Weight Rating (GVWR)	Number of Registrations
Class 6- GVWR ranges from 19,501 to 26,000 pounds	3,843
Class 7- GVWR ranges from 26,001 to 33,000 pounds	1,467
Class 8- GVWR is anything above 33,000 pounds	6,249
Total	**154,896**

Source: VTrans, DMV

Figure 3.1 FHWA Vehicle Class by Gross Vehicle Weight Rating



Source: https://afdc.energy.gov/data/10380

The registration fee table is shown in Table 3.2. The registration fees differ by vehicle weight and fuel source. Automobiles and school buses have the same fees. However, non-school buses are registered based on weight, and would be assigned a fee based on GVWR unlike school buses which pay a flat fee equivalent to the fee paid by automobiles and trucks less than 6,099 pounds.

Table 3.2 Vehicle Annual Registration Fees in Vermont

Vehicle Classification	Gas	Diesel	Other Fuel
Auto, Jitney (Up to 7 Passenger), Motorhome, Off-Highway Tractors, School Bus, Street Rod	$76.00	$76.00	$132.00
Trucks – Loaded Weight (in pounds)			
Up to 6,099	$76.00	$76.00	$132.00
6,100-7,099	$109.00	$109.00	$190.00
7,100-8,099	$124.00	$124.00	$216.00
8,100-9,099	$159.00	$159.00	$277.00
9,100-9,999	$176.00	$176.00	$307.00
10,000-10,099	$212.00	$212.00	$370.00

Vehicle Classification	Gas	Diesel	Other Fuel
10,100-11,099	$229.00	$229.00	$400.00
11,100-12,099	$247.00	$247.00	$431.00
12,100-13,099	$287.00	$287.00	$501.00
13,100-14,099	$306.00	$306.00	$534.00
14,100-15,099	$326.00	$326.00	$569.00
15,100-16,099	$345.00	$345.00	$603.00
16,100-17,099	$386.00	$386.00	$674.00
17,100-17,999	$407.00	$407.00	$711.00
18,000-18,099	$413.50	$407.00	$717.50
18,100-19,099	$433.50	$427.00	$752.50
19,100-20,099	$454.50	$448.00	$789.50
20,100-21,099	$495.50	$489.00	$861.50
21,100-22,099	$516.50	$510.00	$897.50
22,100-23,099	$538.50	$532.00	$936.50
23,100-24,099	$559.50	$553.00	$973.50
24,100-25,099	$580.50	$574.00	$1,009.50
25,100-25,999	$602.50	$596.00	$1,048.50
26,000	$637.50	$631.00	$1,109.50
26,001-26,099	$637.50	$637.50	$1,109.50
26,100-27,099	$659.50	$659.50	$1,148.50
27,100-28,099	$680.50	$680.50	$1,184.50
28,100-29,099	$702.50	$702.50	$1,223.50
29,100-30,099	$723.50	$723.50	$1,260.50
30,100-31,099	$759.50	$759.50	$1,323.50
31,100-32,099	$781.50	$781.50	$1,361.50
32,100-33,099	$803.50	$803.50	$1,400.50
33,100-34,099	$825.50	$825.50	$1,438.50
34,100-35,099	$847.50	$847.50	$1,477.50
35,100-36,099	$869.50	$869.50	$1,515.50
36,100-37,099	$891.50	$891.50	$1,554.50
37,100-38,099	$912.50	$912.50	$1,590.50
38,100-39,099	$934.50	$934.50	$1,629.50
39,100-39,999	$956.50	$956.50	$1,667.50
40,000-40,099	$1,134.50	$1,134.50	$1,979.50
40,100-41,099	$1,177.50	$1,177.50	$2,054.50
41,100-42,099	$1,200.50	$1,200.50	$2,094.50
42,100-43,099	$1,222.50	$1,222.50	$2,133.50

Vehicle Classification	Gas	Diesel	Other Fuel
43,100-44,099	$1,245.50	$1,245.50	$2,173.50
44,100-45,099	$1,267.50	$1,267.50	$2,212.50
45,100-46,099	$1,290.50	$1,290.50	$2,252.50
46,100-47,099	$1,312.50	$1,312.50	$2,290.50
47,100-48,099	$1,335.50	$1,335.50	$2,331.50
48,100-49,099	$1,357.50	$1,357.50	$2,369.50
49,100-50,099	$1,379.50	$1,379.50	$2,408.50
50,100-51,099	$1,412.50	$1,412.50	$2,465.50
51,100-52,099	$1,435.50	$1,435.50	$2,506.50
52,100-53,099	$1,457.50	$1,457.50	$2,544.50
53,100-54,099	$1,480.50	$1,480.50	$2,584.50
54,100-55,099	$1,503.50	$1,503.50	$2,625.50
55,100-56,099	$1,525.50	$1,525.50	$2,663.50
56,100-57,099	$1,548.50	$1,548.50	$2,703.50
57,100-58,099	$1,571.50	$1,571.50	$2,744.50
58,100-59,099	$1,593.50	$1,593.50	$2,782.50
59,100-59,999	$1,616.50	$1,616.50	$2,822.50
60,000-60,099	$1,758.50	$1,758.50	$3,071.50
60,100-61, 099	$1,828.50	$1,828.50	$3,193.50
61,100-62,099	$1,851.50	$1,851.50	$3,234.50
62,100-63,099	$1,874.50	$1,874.50	$3,274.50
63,100-64,099	$1,898.50	$1,898.50	$3,316.50
64,100-65,099	$1,921.50	$1,921.50	$3,356.50
65,100-66,099	$1,945.50	$1,945.50	$3,398.50
66,100-67,099	$1,968.50	$1,968.50	$3,438.50
67,100-68,099	$1,992.50	$1,992.50	$3,480.50
68,100-69,099	$2,015.50	$2,015.50	$3,521.50
69,100-70,099	$2,038.50	$2,038.50	$3,561.50
70,100-71,099	$2,118.50	$2,118.50	$3,701.50
71,100-72,099	$2,142.50	$2,142.50	$3,743.50
72,100-73,099	$2,166.50	$2,166.50	$3,785.50
73,100-74,099	$2,191.50	$2,191.50	$3,829.50
74,100-75,099	$2,215.50	$2,215.50	$3,871.50
75,100-76,099	$2,239.50	$2,239.50	$3,913.50
76,100-77,099	$2,263.50	$2,263.50	$3,955.50
77,100-78,099	$2,287.50	$2,287.50	$3,997.50
78,100-79,099	$2,312.50	$2,312.50	$4,040.50

Vehicle Classification	Gas	Diesel	Other Fuel
79,100-80,099	$2,336.50	$2,336.50	$4,082.50
80,100-90,099	$2,648.50	$2,648.50	$4,628.50

Source: Vermont DMV Registration Fees https://dmv.vermont.gov/registrations/fees

Note: School buses and autos are assumed to fall under the first category, but non-school buses will be allocated based on GVWR.

Table 3.3 lists the current registrations for trucks, automobiles, school buses, and non-school buses. Since the number of non-school buses registered is less than 15 percent of the bus registrations, the calculations were simplified and all buses were treated as school buses for purposes of revenue calculations. This simplification did not affect the distribution of buses for purposes of cost responsibility. The total revenue that Vermont received for vehicle registrations was reported to be $70,549,346. As the relation between the number of registrations, fees paid, and revenue collected cannot be directly aligned, the model combines the information received to create an assumption on how registrations are distributed across weight classes. Model results for estimated registration revenue were within two percent of actual revenue. Revenue inputs are further discussed in in Section 3.3.

Table 3.3 Vermont Vehicle Registrations, Vehicle Types

Vehicle Type	Number of Registrations
Automobiles	437,835
Trucks	154,896
School Buses	1969
Non-School Buses	309
Total	**595,009**

Source: VTrans

The next group of required data consisted of vehicle miles travelled (VMT), and how they are allocated across roadway functional classes and vehicle types. Table 3.4 details VMT in Vermont by functional class and rural and urban roadways for the year 2018. Table 3.5 details across the same categories for system mileage, reporting the total number of miles that fall into each functional class. System mileage and VMT are both important inputs into the FHWA HCAS tool, as they are used to calculate the share of cost responsibility by vehicle type. Since vehicle types are assumed to carry a certain range of weights, and different types of roadways are known to handle different ranges of weights, the system mileage, VMT, and functional class will be combined to evaluate the overall effect that a vehicle type has on the pavement.

Table 3.4 Vermont Annual Vehicle Miles Travelled (VMT) by Functional Class, 2018

Functional Class	Rural Annual VMT (millions)	Urban Annual VMT (millions)
1 Interstate	1,246.2	579.2
2 PA- Other Free/Expressway	5.1	59.6
3 Principal Arterial	771.8	568.5

Functional Class	Rural Annual VMT (millions)	Urban Annual VMT (millions)
4 Minor Arterial	966.3	336.4
5 Major Collector	1,100.0	259.2
6 Minor Collectors	1.2	25.3
7 Local	922.6	301.2
Total	**5,013.2**	**2,129.4**

Source: HPMS 2018, Extent and Travel Report.

Table 3.5 Vermont System Length in Miles by Functional Class, 2018

Functional Class	Rural Mileage	Urban Mileage
1 Interstate	256.0	64.3
2 PA- Other Free/Expressway	1.7	16.0
3 Principal Arterial	329.6	126.5
4 Minor Arterial	734.5	148.1
5 Major Collector	1972.0	246.8
6 Minor Collectors	902.7	32.1
7 Local	8397.9	861.4
Total	**12594.3**	**1495.2**

Source: HPMS 2018, Extent and Travel Report.

VTrans provided the share of daily VMT by vehicle type and functional class. The amount of VMT on each functional class that is comprised of various vehicle classes is shown in Table 3.6. The vehicle types used correspond to the classification shown in Figure 3.2.

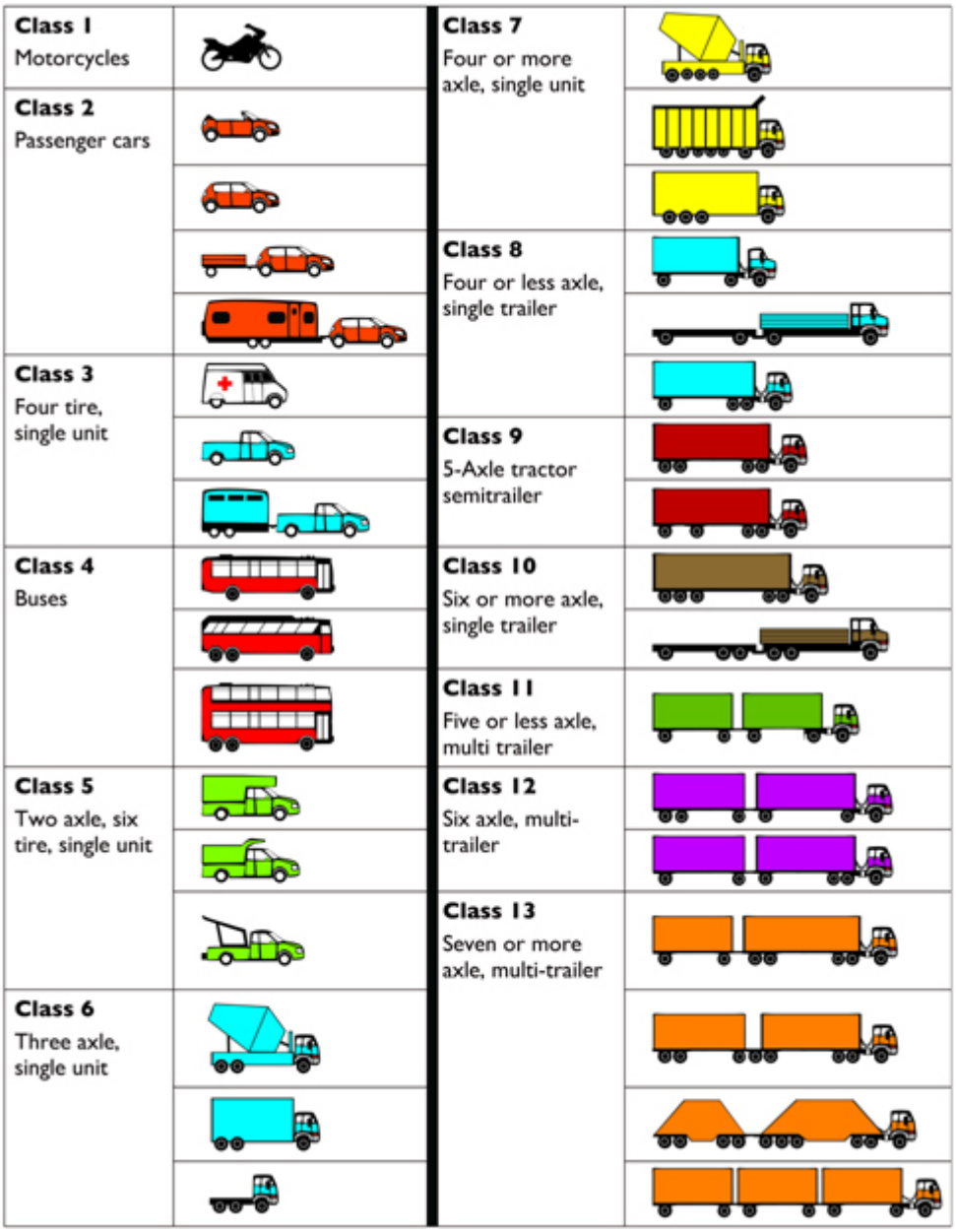
Table 3.6 Average Daily Vehicle Class Percentages by Functional Classification, 2018

	RURAL	FC1 AVG	FC2 AVG	FC3 AVG	FC4 AVG	FC5 AVG	FC6 AVG	FC7 AVG
Class 1	MC	1.29%	1.27%	1.52%	2.14%	1.95%	1.65%	1.43%
Class 2	Car	70.33%	71.74%	69.76%	69.46%	69.26%	68.73%	67.86%
Class 3	Pickup	17.20%	19.04%	18.94%	20.53%	22.14%	22.36%	23.27%
Class 4	Bus	0.95%	1.06%	0.80%	0.69%	0.54%	0.50%	0.53%
Class 5	2A SU	4.02%	3.58%	3.84%	3.84%	3.84%	4.88%	4.75%
Class 6	3A SU	1.32%	1.14%	0.96%	0.94%	0.93%	1.00%	1.01%
Class 7	>3A SU	0.19%	0.38%	0.18%	0.13%	0.13%	0.09%	0.08%
Class 8	<5A 2U	1.06%	0.84%	1.09%	0.88%	0.62%	0.53%	0.64%
Class 9	5A 2U	2.63%	0.92%	2.36%	1.04%	0.39%	0.08%	0.32%
Class 10	>5A 2U	0.89%	0.01%	0.51%	0.34%	0.19%	0.17%	0.06%
Class 11	<6A >2U	0.05%	0.01%	0.01%	0.00%	0.00%	0.00%	0.00%
Class 12	6A >2U	0.01%	0.00%	0.00%	0.00%	0.00%	0.00%	0.04%
Class 13	>6A >2U	0.05%	0.01%	0.02%	0.01%	0.00%	0.00%	0.00%

	RURAL	FC1 AVG	FC2 AVG	FC3 AVG	FC4 AVG	FC5 AVG	FC6 AVG	FC7 AVG
	URBAN	FC1 AVG	FC2 AVG	FC3 AVG	FC4 AVG	FC5 AVG	FC6 AVG	FC7 AVG
Class 1	MC	0.92%	1.05%	1.50%	1.36%	1.11%	1.22%	1.62%
Class 2	Car	73.45%	76.13%	74.57%	74.57%	74.54%	74.63%	73.04%
Class 3	Pickup	16.07%	16.53%	16.80%	18.15%	19.35%	18.66%	17.77%
Class 4	Bus	1.02%	0.65%	0.72%	0.63%	0.44%	0.58%	1.21%
Class 5	2A SU	3.72%	3.31%	3.75%	3.69%	3.47%	3.65%	5.12%
Class 6	3A SU	1.21%	0.60%	0.76%	0.61%	0.41%	0.61%	0.70%
Class 7	>3A SU	0.30%	0.13%	0.12%	0.09%	0.06%	0.17%	0.03%
Class 8	<5A 2U	0.91%	0.62%	0.63%	0.48%	0.44%	0.35%	0.31%
Class 9	5A 2U	1.88%	0.82%	0.92%	0.29%	0.13%	0.07%	0.18%
Class 10	>5A 2U	0.34%	0.14%	0.20%	0.10%	0.04%	0.01%	0.03%
Class 11	<6A >2U	0.07%	0.01%	0.00%	0.01%	0.00%	0.00%	0.00%
Class 12	6A >2U	0.04%	0.00%	0.00%	0.01%	0.01%	0.06%	0.00%
Class 13	>6A >2U	0.07%	0.01%	0.02%	0.02%	0.01%	0.00%	0.00%

Source: VTrans

Figure 3.2 FHWA 13 Vehicle Category Classification



Source: Federal Highway Administration https://www.fhwa.dot.gov/policyinformation/tmguide/tmg_2013/vehicle-types.cfm

Actual maintenance expenditures are utilized to calculate cost responsibility. VTrans provided five years of data, from 2015 to 2019, and a five year average was calculated, as shown in Table 3.7. Pavement data was further broken down into rigid and flexible pavement using the inputs in Table 3.8 which details the percent of the overall system mileage that is rigid or flexible pavement.

Table 3.7 Bridge and Pavement Maintenance Expenditures, 2015-2019

	SFY 2015	SFY 2016	SFY 2017	SFY 2018	SFY 2019	5-Year Average
Bridges	$102,839,940	$73,977,145	$64,873,213	$57,230,473	$76,043,717	$74,992,898
Paving	$88,719,614	$63,026,701	$85,366,694	$89,226,665	$80,124,474	$81,292,830
Combined	$191,559,554	$137,003,846	$150,239,907	$146,457,138	$156,168,191	$156,285,727

Source: VTrans

Table 3.8 Rigid and Flexible Pavement Share of Total Miles

Pavement	Percent of Total
% Rigid	9.05%
% Flexible	90.95%
Total	**100.%**

Source: VTrans

As the registration fee table takes into account the fuel source of the vehicle, Table 3.9 lists the FHWA assumptions provided as default data in the HCAS tool. These distributions are assumed to be generally applicable to VTrans being that lighter vehicles are mostly fueled by gasoline and heavier vehicles by diesel. The default registered gross weight categories in the HCAS tool do not align with the categories in the fee table and this table was converted for the revenue calculations in Section 3.3.

Table 3.9 Vehicle Fuel Source by Registered Gross Weight Range

Registered Gross Weight Range	Diesel	Gasoline	Other	Total
0 – 8,000	1.70%	98.10%	0.20%	100%
8,000 – 10,000	28.00%	67.50%	4.50%	100%
10,000 – 12,000	30.00%	65.00%	5.00%	100%
12,000 – 14,000	32.00%	62.50%	5.50%	100%
14,000 – 16,000	34.00%	60.30%	5.70%	100%
16,000 – 18,000	36.00%	58.20%	5.80%	100%
18,000 – 20,000	38.00%	56.15%	5.86%	100%
20,000 – 22,000	40.00%	54.20%	5.80%	100%
22,000 – 24,000	43.00%	51.30%	5.70%	100%
24,000 – 26,000	47.00%	47.50%	5.50%	100%
26,000 – 28,000	52.00%	43.00%	5.00%	100%
28,000 – 30,000	60.00%	35.75%	4.26%	100%
30,000 – 32,000	70.00%	27.00%	3.00%	100%
32,000 – 34,000	82.00%	16.00%	2.00%	100%

Registered Gross Weight Range	Diesel	Gasoline	Other	Total
34,000 – 36,000	88.00%	10.60%	1.40%	100%
36,000 – 38,000	92.00%	7.00%	1.00%	100%
38,000 – 40,000	94.00%	5.20%	0.80%	100%
40,000 – 42,000	95.00%	4.30%	0.70%	100%
42,000 – 44,000	95.50%	3.90%	0.60%	100%
44,000 – 46,000	96.00%	3.50%	0.50%	100%
46,000 – 48,000	96.50%	3.03%	0.48%	100%
48,000 – 50,000	97.00%	2.56%	0.44%	100%
50,000 – 52,000	97.50%	2.09%	0.42%	100%
52,000 – 54,000	98.00%	1.62%	0.38%	100%
54,000 – 56,000	98.40%	1.25%	0.36%	100%
56,000 – 58,000	98.70%	0.98%	0.32%	100%
58,000 – 60,000	98.90%	0.81%	0.30%	100%
60,000 – 62,000	99.00%	0.74%	0.26%	100%
62,000 – 64,000	99.10%	0.67%	0.24%	100%
64,000 – 66,000	99.20%	0.60%	0.20%	100%
66,000 – 68,000	99.30%	0.53%	0.18%	100%
68,000 – 70,000	99.40%	0.46%	0.14%	100%
70,000 – 72,000	99.50%	0.39%	0.12%	100%
72,000 – 74,000	99.60%	0.32%	0.08%	100%
74,000 – 76,000	99.70%	0.25%	0.06%	100%
76,000 – 78,000	99.80%	0.18%	0.02%	100%
78,000 – 80,000	99.90%	0.10%	0%	100%
80,000 – 82,000	100.00%	0%	0%	100%

Source: HCAS Tool, “Def_Data.xls”.

3.3 Preparing the Model Inputs

This section details how the data called was adapted and analyzed for use in HCAS. The inputs necessary for the model to calculate cost responsibility, revenue, and equity are the following:

- Cost responsibility by registered gross weight (RGW)[13] from the HCAS tool
- Revenue estimated from number of registrations and registrations fees by RGW and fuel source

[13] While gross vehicle weight rating (GVWR) and registered gross weight (RGW) could be used interchangeable, GVWR is used to refer to the original weight categories from the Vermont registration data or Vermont registration fee table. RGW is used to refer to the modified list of weight ranges used in the HCAS tool and with subsequent calculations from the HCAS tool.

The inputs required above are achieved by some manipulation of the actual and given data to fit the HCAS data structures and by running the tool itself. These model inputs are further discussed in this section.

3.3.1 Cost Responsibility from the HCAS Tool

In order to utilize the HCAS tool, the following inputs were developed:

- VMT by vehicle, roadway functional classes, and RGW
- State being examined (Vermont)
- Annual mileage in state by vehicle and RGW (used both default and data and some calculated values)
- User-defined registered weight classes (set to match the simplified fee table)
- Expenditures by roadway functional class and maintenance type
- Choose whether to allocate costs based on overall LEFS by highway system or by specifying distress shares for each pavement type (chose LEFS)
- Choose whether to allocated axle-related maintenance by axles, tires, or weight (used axles)
- System miles by roadway functional class
- Annual average mileage by 20-vehicle class
- Out-of-state vehicles (assumed to be null)
- Average registration fee by 20-vehicle class

A selection of these inputs into the HCAS tool are detailed below.

Annual Mileage

The HCAS Tool provided default values for the average annual mileage by vehicle, but with the given number of registrations and VMT for the automobile and bus categories, these two values were calculated manually. The truck categories remaining were calculated given the default ratios in the default data and the actual VMT. The tool average annual mileage by vehicle and by RGW is summarized in Table 3.10 by showing the average annual mileage by vehicle, which is a weighted average of VMT by vehicle.

Table 3.10 Average Annual Mileage by Vehicle

Vehicle	Average Annual Mileage
Auto	11,800
LT4	11,697
SU2	10,428
SU3	10,428
SU4	10,428
CS3	9,987
CS4	9,987
CS5T	9,987
CS5S	9,987
CS6	11,258
CS7	10,031
CT4	9,987
CT5	9,987
CT6	9,987
DS5	9,987
DS6	9,987
DS7	10,031
DS8	10,031
TRP	10,031
BUS	23,314

Source: HCAS Tool

VMT by Vehicle, Roadway Functional Classes, and RGW

There are three different vehicle class categories used between the VMT data and HCAS tool. The VMT given by VTrans uses a 13-vehicle class structure, as discussed in Section 3.2. The HCAS tool uses a 12-vehicle class, and Table 3.11 details how the FHWA 13-class categories were reduced to 12 classes. In short, FHWA Class 1 and Class 2 were combined into the HCAS Auto category.

Table 3.11 Crosswalk between HCAS 12-Vehicle and FHWA 13-Vehicle Class Categories

HCAS 12 Class	HCAS 12 -Class Description	FHWA 13-Class	FHWA 13-Class Description
Auto	Motorcycles and Passenger Cars	Class 1, Class 2	Motorcycles and Passenger Cars
LT4s	Light Duty, Four tire single unit trucks	Class 3	Four tire, single unit
Bus	Buses	Class 4	Buses
SU2	Single unit, two axles	Class 5	Two-axle, six tire, single unit
SU3	Single unit, three axles	Class 6	Three-axle, single unit
SU4	Single unit, four or more axles	Class 7	Four or more axles, single unit
CB3&4	Tractor-semitrailer combinations with 3- or 4-axles	Class 8	Four or less axle, single trailer
CB5	Tractor-semitrailer combinations with 5-axles	Class 9	5-axle tractor semitrailer
CB6+	Tractor-semitrailer combinations with 6- or more axles	Class 10	Six or more axle, single trailer
DS5	Tractor-double semitrailer combinations with 5 axles	Class 11	Five or less axle, multi trailer
DS6	Tractor-double semitrailer combinations with 6 axles	Class 12	Six axle, multi trailer
DS7+	Tractor-double semitrailer combinations with 7- or more axles	Class 13	Seven or more axle, multi-trailer

Source: HCAS Model. FHWA.

The HCAS tool also transforms the 12-vehicle class structure into a 20-vehicle class structure by expanding CB3&4, CB5, CB6+, and DB7 as shown in Table 3.12. Of these three vehicle categories, the 12-vehicle class structure is how the output data will be presented, however, understanding that the data is transformed several times is important to recognize.

Table 3.12 VMT Split Factors to go from 12 Vehicle Classes to 20

HPMS Vehicle	HMS Vehicle Description	HCAS Vehicle
7	CB3&4	CS3 (#6) CS4 (#7) CT4 (#12)
8	CB5	3S2 (#8) CS5 (#9) CT5 (#13)
9	CB6+	CS6 (#10) CS7+(#11) CT6+(#14)
12	DB7	DS7 (#17) DS8+(#18) TS (#19)

Source: HCAS Tool.

The HCAS Tool also uses only six functional classes for roadways rather than the seven functional classes reported in the VMT data. Table 3.13 shows how the seven categories are reduced to six categories differently between urban and rural roads.

Table 3.13 Conversion between 7 Functional Classes to 6 Functional Classes

7-Functional Classes	6-Functional Classes (Urban)	6-Functional Classes (Rural)
1 Interstate	Urb Int	Rur Int
2 PA- Other Free/Expressway	Urb OFE	Rur OPA
3 Principal Arterial	Urb OPA	Rur OPA
4 Minor Arterial	Urb MA	Rur MajC
5 Major Collector	Urb Coll	Rur MnC
6 Minor Collectors	Urb Coll	Rur Loc
7 Local	Urb Int	Rur Int

Source: HCAS Tool.

The average annual VMT by 12-vehicle class and roadway functional classification was calculated by combing the given VMT by roadway functional class and the VMT split between roadway and vehicle class. The actual VMT by functional class in Table 3.4 was multiplied with the VMT splits in Table 3.6 to create the average annual VMT by vehicle class per functional class in Table 3.14. This table was used to replace the default data in the FHWA HCAS tool.

Table 3.14 Average Annual VMT by 12-Vehicle Class and Functional Classification, 2018 (millions)

RURAL	FC1 AVG	FC2 AVG	FC3 AVG	FC4 AVG	FC5 AVG	FC6 AVG	FC7 AVG	TOTAL
Auto	893	4	550	692	783	1	639	**3562**
LT4s	214	1	146	198	244	0	215	**1018**
Bus	12	0	6	7	6	0	5	**36**
SU2	50	0	30	37	42	0	44	**203**
SU3	16	0	7	9	10	0	9	**53**
SU4	2	0	1	1	1	0	1	**7**
CB3&4	13	0	8	8	7	0	6	**43**
CB5	33	0	18	10	4	0	3	**68**
CB6+	11	0	4	3	2	0	1	**21**
DS5	1	0	0	0	0	0	0	**1**
DS6	0	0	0	0	0	0	0	**1**
DS7+	1	0	0	0	0	0	0	**1**
Total	**1246**	**5**	**772**	**966**	**1100**	**1**	**923**	**5013**

URBAN	FC1 AVG	FC2 AVG	FC3 AVG	FC4 AVG	FC5 AVG	FC6 AVG	FC7 AVG	TOTAL
Auto	431	46	432	255	196	19	225	**1605**
LT4s	93	10	95	61	50	5	54	**368**
Bus	6	0	4	2	1	0	4	**17**
SU2	22	2	21	12	9	1	15	**83**
SU3	7	0	4	2	1	0	2	**17**
SU4	2	0	1	0	0	0	0	**3**
CB3&4	5	0	4	2	1	0	1	**13**
CB5	11	0	5	1	0	0	1	**19**
CB6+	2	0	1	0	0	0	0	**4**
DS5	0	0	0	0	0	0	0	**0**
DS6	0	0	0	0	0	0	0	**0**
DS7+	0	0	0	0	0	0	0	**1**
Total	**579**	**60**	**569**	**336**	**259**	**25**	**301**	**2129**

Source: VTrans

Expenditures

CS investigated the feasibility and impacts of a registration fee structure that considers maintenance cost allocation. Maintenance is this context refers to VTrans' paving and bridge expenditures. Expenditures collected in Section 3.2 are expanded across functional class, and across flexible and rigid pavement. In order to distribute the maintenance expenditures listed in Table 3.7, the VMT by functional class was used as a proxy to scale the expenditures in relation to the traffic levels by functional class. In addition, pavement expenditures were separated by flexible and rigid pavement by using the percentages in Table 3.8. Together, these two steps produced the results shown in Table 3.15 which details the maintenance expenditures that are then utilized as an input to the HCAS tool.

Table 3.15 5-Year Average Maintenance Expenditures by Functional Class, Bridges, Flexible Pavements, and Rigid Pavements ($millions)

	Rur Int	Rur OPA	Rur MA	Rur MajC	Rur MnC	Rur Loc	Total
Bridges	$13.1	$8.2	$10.1	$11.5	$0.0	$9.7	$52.6
Pavement – Flexible	$12.9	$8.0	$10.0	$11.4	$0.0	$9.6	$51.9
Pavement – Rigid	$1.3	$0.8	$1.0	$1.1	$0.0	$1.0	$5.2
Rural Subtotal	$27.3	$17.0	$21.1	$24.1	$0.0	$20.2	$109.7
	Urb Int	**Urb OFE**	**Urb OPA**	**Urb MA**	**Urb Coll**	**Urb Loc**	**Total**
Bridges	$6.1	$0.6	$6.0	$3.5	$3.0	$3.2	$22.4
Pavement – Flexible	$6.0	$0.6	$5.9	$3.5	$2.9	$3.1	$22.0
Pavement – Rigid	$0.6	$0.1	$0.6	$0.3	$0.3	$0.3	$2.2
Urban Subtotal	$12.7	$1.3	$12.4	$7.4	$6.2	$6.6	$46.6
Total	$39.9	$18.3	$33.6	$31.4	$6.3	$26.8	$156.3

Source: VTrans and CS processing based on VMT and pavement type distribution.

Cost Responsibility

After modifying the HCAS tool inputs, the software is run to calculate the cost responsibility of the vehicles by vehicle class and RGW. For input into the legislative model, only the cost responsibility by RGW is actually necessary as the registration fee table is split by RGW. These values by RGW and vehicle class are shown in Table 3.16 and Table 3.17.

Table 3.16 Cost Responsibility by RGW per HCAS Tool

RGW Range	Bridges ($millions)	Pavement ($millions)	Cost Responsibility ($millions)	Cost Responsibility per Mile (¢)	Unit Cost Responsibility ($)
UP TO 6,099	$38.6	$6.3	$44.8	1 ¢	$106
6,100-7,099	$6.4	$1.1	$7.5	1 ¢	$108
7,100-8,099	$5.9	$1.1	$7.0	1 ¢	$111
8,100-9,099	$0.6	$0.6	$1.2	4 ¢	$472
9,100-10,099	$0.6	$0.6	$1.2	4 ¢	$477
10,100-11,099	$0.6	$0.7	$1.2	5 ¢	$476
11,100-12,099	$0.6	$0.9	$1.5	6 ¢	$609
12,100-13,099	$0.4	$0.7	$1.1	6 ¢	$676
13,100-14,099	$0.4	$0.8	$1.2	7 ¢	$711
14,100-15,099	$0.4	$0.9	$1.3	7 ¢	$809
15,100-16,099	$0.4	$1.1	$1.4	9 ¢	$965
16,100-17,099	$0.2	$0.7	$0.9	10 ¢	$1,009
17,100-17,999	$0.2	$0.7	$0.9	10 ¢	$1,049
18,100-19,099	$0.2	$0.7	$0.9	10 ¢	$1,085
19,100-20,099	$0.2	$0.7	$0.9	11 ¢	$1,114
20,100-21,099	$0.2	$0.8	$1.0	11 ¢	$1,125
21,100-22,099	$0.3	$0.8	$1.1	11 ¢	$1,175
22,100-23,099	$0.3	$0.8	$1.2	11 ¢	$1,454
23,100-24,099	$0.4	$0.9	$1.3	11 ¢	$1,506
24,100-25,099	$0.5	$1.2	$1.6	12 ¢	$1,562
25,100-25,999	$0.5	$1.2	$1.6	12 ¢	$1,622
26,100-27,099	$0.3	$0.7	$1.1	13 ¢	$1,953
27,100-28,099	$0.4	$0.8	$1.1	13 ¢	$2,029
28,100-29,099	$0.4	$0.9	$1.3	14 ¢	$2,027
29,100-30,099	$0.4	$1.0	$1.3	14 ¢	$2,056
30,100-31,099	$0.3	$1.0	$1.3	15 ¢	$1,717
31,100-32,099	$0.3	$1.0	$1.3	15 ¢	$1,728
32,100-33,099	$0.2	$0.7	$0.9	15 ¢	$1,620
33,100-34,099	$0.1	$0.7	$0.8	15 ¢	$1,617

RGW Range	Bridges ($millions)	Pavement ($millions)	Cost Responsibility ($millions)	Cost Responsibility per Mile (¢)	Unit Cost Responsibility ($)
34,100-35,099	$0.1	$0.2	$0.3	13 ¢	$1,355
35,100-36,099	$0.1	$0.3	$0.3	12 ¢	$1,321
36,100-37,099	$0.2	$0.4	$0.6	11 ¢	$1,145
37,100-38,099	$0.2	$0.4	$0.6	11 ¢	$1,169
38,100-39,099	$0.1	$0.3	$0.4	12 ¢	$1,400
39,100-39,999	$0.1	$0.3	$0.4	12 ¢	$1,400
40,100-41,099	$0.0	$0.1	$0.2	11 ¢	$1,124
41,100-42,099	$0.1	$0.2	$0.2	11 ¢	$1,139
42,100-43,099	$0.2	$0.5	$0.8	11 ¢	$1,152
43,100-44,099	$0.2	$0.6	$0.8	11 ¢	$1,174
44,100-45,099	$0.5	$1.2	$1.7	12 ¢	$1,226
45,100-46,099	$0.4	$1.1	$1.6	12 ¢	$1,244
46,100-47,099	$0.2	$0.4	$0.6	13 ¢	$1,304
47,100-48,099	$0.2	$0.5	$0.6	13 ¢	$1,326
48,100-49,099	$0.2	$0.6	$0.8	13 ¢	$1,349
49,100-50,099	$0.2	$0.6	$0.8	13 ¢	$1,376
50,100-51,099	$0.1	$0.3	$0.4	14 ¢	$1,437
51,100-52,099	$0.1	$0.3	$0.4	15 ¢	$1,499
52,100-53,099	$0.1	$0.5	$0.6	15 ¢	$1,557
53,100-54,099	$0.2	$0.5	$0.7	16 ¢	$1,623
54,100-55,099	$0.2	$0.5	$0.7	15 ¢	$1,554
55,100-56,099	$0.2	$0.5	$0.7	16 ¢	$1,619
56,100-57,099	$0.0	$0.1	$0.2	17 ¢	$1,767
57,100-58,099	$0.0	$0.1	$0.2	18 ¢	$1,834
58,100-59,099	$0.1	$0.2	$0.3	19 ¢	$1,905
59,100-59,999	$0.1	$0.2	$0.3	19 ¢	$1,969
60,100-61,099	$0.0	$0.0	$0.1	20 ¢	$2,043
61,100-62,099	$0.0	$0.1	$0.1	23 ¢	$2,308
62,100-63,099	$0.1	$0.1	$0.2	15 ¢	$1,503
63,100-64,099	$0.1	$0.2	$0.2	16 ¢	$1,595
64,100-65,099	$0.1	$0.4	$0.6	17 ¢	$1,685
65,100-66,099	$0.1	$0.4	$0.6	18 ¢	$1,778
66,100-67,099	$0.1	$0.2	$0.3	19 ¢	$1,883
67,100-68,099	$0.1	$0.2	$0.3	20 ¢	$1,982
68,100-69,099	$0.1	$0.3	$0.4	22 ¢	$2,158
69,100-70,099	$0.1	$0.4	$0.4	24 ¢	$2,363

RGW Range	Bridges ($millions)	Pavement ($millions)	Cost Responsibility ($millions)	Cost Responsibility per Mile (¢)	Unit Cost Responsibility ($)
70,100-71,099	$0.0	$0.1	$0.1	26 ¢	$2,500
71,100-72,099	$0.0	$0.1	$0.1	28 ¢	$2,673
72,100-73,099	$0.0	$0.0	$0.1	30 ¢	$2,823
73,100-74,099	$0.0	$0.0	$0.1	32 ¢	$2,983
74,100-75,099	$0.0	$0.1	$0.1	33 ¢	$3,000
75,100-76,099	$0.0	$0.1	$0.1	35 ¢	$3,209
76,100-77,099	$0.0	$0.1	$0.1	37 ¢	$3,405
77,100-78,099	$0.4	$1.4	$1.8	38 ¢	$3,616
78,100-79,099	$3.9	$14.7	$18.6	40 ¢	$3,849
79,100-80,099	$3.6	$13.9	$17.5	42 ¢	$4,011
80,100-90,099	$2.2	$7.4	$9.6	124 ¢	$7,117
Total	$75.0	$81.3	$156.3	2 ¢ average	$256 average

Source: CS. HCAS Tool.

Table 3.17 Cost Responsibility by Vehicle Class per HCAS Tool

Vehicle Class	Bridges ($thousands)	Pavement ($thousands)	Cost Responsibility ($thousands)	Cost Responsibility per Mile (Cents per mile)	Unit Cost Responsibility ($)
Auto	$38.1	$5.9	$44.0	1 ¢	$100
LT4	$12.7	$2.5	$15.2	1 ¢	$129
SU2	$6.5	$17.9	$24.5	9 ¢	$892
SU3	$2.2	$6.7	$9.0	13 ¢	$1,345
SU4+	$0.5	$1.6	$2.1	20 ¢	$2,109
CS3	$0.7	$1.7	$2.4	11 ¢	$1,056
CS4	$1.3	$3.1	$4.5	14 ¢	$1,360
3S2	$5.8	$24.1	$29.9	39 ¢	$3,928
CS5	$0.5	$1.6	$2.0	33 ¢	$3,247
CS6	$1.4	$5.0	$6.4	47 ¢	$4,887
CS7+	$1.2	$4.0	$5.2	1357 ¢	$6,098
CT4-	$0.0	$0.0	$0.1	16 ¢	$1,563
CT5	$0.4	$1.8	$2.2	47 ¢	$4,721
CT6+	$0.1	$0.2	$0.3	26 ¢	$2,011
DS5	$0.1	$0.2	$0.4	33 ¢	$3,256
DS6	$0.2	$0.3	$0.5	71 ¢	$5,740
DS7	$0.1	$0.2	$0.4	794 ¢	$8,553
DS8+	$0.3	$0.4	$0.7	3544 ¢	$7,790

Vehicle Class	Bridges ($thousands)	Pavement ($thousands)	Cost Responsibility ($thousands)	Cost Responsibility per Mile (Cents per mile)	Unit Cost Responsibility ($)
TS	$0.1	$0.1	$0.2	1165 ¢	$5,990
Bus	$2.6	$3.8	$6.4	12 ¢	$2,820
Total	$75.0	$81.3	$156.3	2 ¢ average	$256 average

Source: CS. HCAS Tool.

When calculating cost responsibility, the HCAS Tool calculates the number of registrations per weight class by analyzing the given VMT by vehicle class, the average mileage per vehicle class, and the distribution of vehicle classes across weight categories. However, when calculating revenue scenarios, the estimate of registrations by weight class in Vermont which is based on actual data should be used. The unit cost responsibility shown in Table 3.16 is the cost responsibility per vehicle as assumed by the HCAS Tool. This unit cost can be applied against the estimate registrations for Vermont which has been validated against actual revenue, in order to calculate the total cost responsibility. This total cost responsibility using the number of registrations estimated from Vermont data comes to be $105.0 million, which is 67 percent of the total maintenance expenditures. The unit cost responsibility can then be scaled up such that the total cost responsibility per the Vermont data is equal to the maintenance expenditures reported by Vermont. These results are shown in Table 3.18. The calculations behind the number of registrations based on the Vermont registration data is explained in Section 3.3.2.

Note that the unit cost responsibility is not strictly increasing with registered weight. As registered weight increases, the HCAS made assumptions about the distribution of configuration classes, and thus potentially the expected number of vehicle axles. Since each class has different cost responsibility, it is possible that a heavier vehicle in gross vehicle weight is actually lighter on a per-axle basis, and thus would bear less cost responsibility.

Table 3.18 Cost Responsibility Specific to Vermont

RGW Range	Unit Cost Responsibility from HCAS tool ($)	Cost Responsibility for Vermont Registrations ($millions)	Cost Responsibility for Vermont Normalized with Maintenance Expenditures ($millions)	Unit Cost Responsibility Vermont Normalized with Maintenance Expenditures ($)
UP TO 6,099	$106	$46.4	$69.1	$157
6,100-7,099	$108	$6.0	$8.9	$160
7,100-8,099	$111	$6.4	$9.6	$165
8,100-9,099	$472	$4.0	$6.0	$703
9,100-10,099	$477	$3.8	$5.6	$710
10,100-11,099	$476	$1.0	$1.5	$709
11,100-12,099	$609	$1.3	$2.0	$906
12,100-13,099	$676	$1.5	$2.2	$1,006
13,100-14,099	$711	$1.5	$2.2	$1,058
14,100-15,099	$809	$0.8	$1.2	$1,204
15,100-16,099	$965	$0.9	$1.4	$1,437

RGW Range	Unit Cost Responsibility from HCAS tool ($)	Cost Responsibility for Vermont Registrations ($millions)	Cost Responsibility for Vermont Normalized with Maintenance Expenditures ($millions)	Unit Cost Responsibility Vermont Normalized with Maintenance Expenditures ($)
16,100-17,099	$1,009	$0.6	$0.9	$1,502
17,100-17,999	$1,049	$0.6	$0.9	$1,562
18,100-19,099	$1,085	$0.7	$1.0	$1,615
19,100-20,099	$1,114	$0.7	$1.0	$1,658
20,100-21,099	$1,125	$0.7	$1.0	$1,674
21,100-22,099	$1,175	$0.7	$1.1	$1,749
22,100-23,099	$1,454	$1.1	$1.6	$2,164
23,100-24,099	$1,506	$1.2	$1.7	$2,241
24,100-25,099	$1,562	$1.3	$1.9	$2,325
25,100-25,999	$1,622	$1.2	$1.9	$2,414
26,100-27,099	$1,953	$0.8	$1.3	$2,907
27,100-28,099	$2,029	$0.9	$1.3	$3,020
28,100-29,099	$2,027	$0.9	$1.3	$3,017
29,100-30,099	$2,056	$0.9	$1.3	$3,060
30,100-31,099	$1,717	$0.5	$0.7	$2,556
31,100-32,099	$1,728	$0.5	$0.7	$2,572
32,100-33,099	$1,620	$0.3	$0.5	$2,411
33,100-34,099	$1,617	$0.2	$0.3	$2,407
34,100-35,099	$1,355	$0.2	$0.2	$2,017
35,100-36,099	$1,321	$0.2	$0.2	$1,966
36,100-37,099	$1,145	$0.2	$0.2	$1,704
37,100-38,099	$1,169	$0.2	$0.2	$1,740
38,100-39,099	$1,400	$0.2	$0.3	$2,083
39,100-39,999	$1,400	$0.2	$0.3	$2,084
40,100-41,099	$1,124	$0.1	$0.2	$1,673
41,100-42,099	$1,139	$0.1	$0.2	$1,695
42,100-43,099	$1,152	$0.1	$0.2	$1,714
43,100-44,099	$1,174	$0.1	$0.2	$1,747
44,100-45,099	$1,226	$0.1	$0.2	$1,824
45,100-46,099	$1,244	$0.1	$0.2	$1,852
46,100-47,099	$1,304	$0.1	$0.2	$1,940
47,100-48,099	$1,326	$0.1	$0.2	$1,973
48,100-49,099	$1,349	$0.1	$0.2	$2,007
49,100-50,099	$1,376	$0.2	$0.2	$2,048
50,100-51,099	$1,437	$0.2	$0.2	$2,139

RGW Range	Unit Cost Responsibility from HCAS tool ($)	Cost Responsibility for Vermont Registrations ($millions)	Cost Responsibility for Vermont Normalized with Maintenance Expenditures ($millions)	Unit Cost Responsibility Vermont Normalized with Maintenance Expenditures ($)
51,100-52,099	$1,499	$0.2	$0.2	$2,232
52,100-53,099	$1,557	$0.2	$0.3	$2,317
53,100-54,099	$1,623	$0.2	$0.3	$2,416
54,100-55,099	$1,554	$0.2	$0.3	$2,313
55,100-56,099	$1,619	$0.2	$0.3	$2,409
56,100-57,099	$1,767	$0.2	$0.3	$2,630
57,100-58,099	$1,834	$0.2	$0.3	$2,729
58,100-59,099	$1,905	$0.2	$0.3	$2,836
59,100-59,999	$1,969	$0.2	$0.3	$2,930
60,100-61,099	$2,043	$0.2	$0.3	$3,041
61,100-62,099	$2,308	$0.3	$0.4	$3,436
62,100-63,099	$1,503	$0.2	$0.2	$2,238
63,100-64,099	$1,595	$0.2	$0.3	$2,374
64,100-65,099	$1,685	$0.2	$0.3	$2,507
65,100-66,099	$1,778	$0.2	$0.3	$2,646
66,100-67,099	$1,883	$0.2	$0.3	$2,803
67,100-68,099	$1,982	$0.2	$0.3	$2,949
68,100-69,099	$2,158	$0.2	$0.4	$3,212
69,100-70,099	$2,363	$0.3	$0.4	$3,517
70,100-71,099	$2,500	$0.3	$0.4	$3,721
71,100-72,099	$2,673	$0.3	$0.4	$3,978
72,100-73,099	$2,823	$0.3	$0.5	$4,201
73,100-74,099	$2,983	$0.3	$0.5	$4,440
74,100-75,099	$3,000	$0.3	$0.5	$4,465
75,100-76,099	$3,209	$0.4	$0.5	$4,776
76,100-77,099	$3,405	$0.4	$0.6	$5,067
77,100-78,099	$3,616	$0.4	$0.6	$5,381
78,100-79,099	$3,849	$0.4	$0.6	$5,729
79,100-80,099	$4,011	$0.4	$0.7	$5,969
80,100-90,099	$7,117	$7.8	$11.6	$10,592
Total	$256 average	$105.0	$156.3	$263 average

Source: CS. HCAS Tool. VTrans.

3.3.2 Revenue from Registrations

The estimated revenue is calculated by multiplying the number of registrations by the corresponding fee. In order to estimate the overall revenue, data from several tables are combined. To start, the registration fee table (Table 3.2) was simplified to aid input into the Highway Cost Allocation tool. There were several weight class ranges that were a singular value or for a 100 pound range, but more so, the tool limits the number of ranges to 80, precipitating the need to reduce and simplify the fee table categories. Next, as actual registrations as listed in Table 3.1 and Table 3.3 did not line up with the registration fee table in Table 3.2, the actual registrations were linearly reassigned to expanded weight categories. An excerpt of the conversion matrix used for this calculation was shown in Table 3.19.

Table 3.19 Conversion Matrix Used for Interpolating Number of Registrations to Registration Fee Table Weight Classes, excerpt

From Row to Column	0 - 6,099	6,100 - 7,099	7,100 - 8,099	8,100 - 9,099	9,100 - 10,099	Total
0 - 6,099	100%	0%	0%	0%	0%	100%
7,000 to 10,000	0%	3%	33%	33%	30%	100%
10,001 to 14,000	0%	0%	0%	0%	2%	100%
14,001 to 16,000	0%	0%	0%	0%	0%	100%
16,001 to 19,500	0%	0%	0%	0%	0%	100%
19,501 to 26,000	0%	0%	0%	0%	0%	100%
26,001 to 33,000	0%	0%	0%	0%	0%	100%
above 33,000	0%	0%	0%	0%	0%	

Source: HCAS Tool.

After establishing the number of registrations in each weight class range, the number of registrations is calculated by fuel source (gas, diesel, and other fuel). In Section 2.0, the vehicle fuel types by vehicle weight were listed by the HCAS default weight categories. Table 3.20 is an excerpt of the conversion matrix used to convert between the default data ranges in the HCAS tool to the categories used in the registration fee table. This conversion matrix can also be used for the conversion of any numerical data between the two ranges as specified. The ratios in Table 3.9 were used to assume the number of registrations per weight category to apply against the registration fee table which varied by fuel source.

Table 3.20 Conversion Matrix Used for Interpolating Default Data to User-Specified Registered Gross Weight Classes, Excerpt

From Row to Column	0 - 8,000	8,000 - 10,000	10,000 - 12,000	12,000 - 14,000	Total
UP TO 6,099	100%				100%
6,100 - 7,099	100%				100%
7,100 - 8,099	99%	1%			100%
8,100 - 9,099		100%			100%
9,100 - 9,999		99%	1%		100%

From Row to Column	0 - 8,000	8,000 - 10,000	10,000 - 12,000	12,000 - 14,000	Total
10,000 - 10,099			100%		100%
10,100 - 11,099			99%	1%	100%
11,100 - 12,099	100%				100%

Source: HCAS Tool.

Table 3.21 displays output from combining the conversion matrix in Table 3.20 with the fuel distribution information in Table 3.9. This information is used to estimate the number of registered vehicles by fuel source that can be applied against the registration fee table in order to estimate the current revenue from vehicle registrations.

Table 3.21 Registration Table by Vehicle Fuel Source and RGW

Weight Class Range	Fee (Gas)	Fee (Diesel)	Fee (Other)	Diesel	Gas	Other
UP TO 6,099	$76.00	$76.00	$$132.00	2%	98%	0%
6,100-7,099	$$109.00	$$109.00	$$190.00	2%	98%	0%
7,100-8,099	$$124.00	$$124.00	$$216.00	2%	98%	0%
8,100-9,099	$$159.00	$$159.00	$$277.00	28%	68%	5%
9,100-10,099	$$176.00	$$176.00	$$307.00	28%	67%	5%
10,100-11,099	$$229.00	$$229.00	$$400.00	30%	65%	5%
11,100-12,099	$$247.00	$$247.00	$$431.00	30%	65%	5%
12,100-13,099	$$287.00	$$287.00	$$501.00	32%	63%	6%
13,100-14,099	$$306.00	$$306.00	$$534.00	32%	62%	6%
14,100-15,099	$$326.00	$$326.00	$$569.00	34%	60%	6%
15,100-16,099	$$345.00	$$345.00	$$603.00	34%	60%	6%
16,100-17,099	$$386.00	$$386.00	$$674.00	36%	58%	6%
17,100-17,999	$$407.00	$$407.00	$$711.00	36%	58%	6%
18,100-19,099	$$433.50	$$427.00	$$752.50	38%	56%	6%
19,100-20,099	$$454.50	$$448.00	$$789.50	38%	56%	6%
20,100-21,099	$$495.50	$$489.00	$$861.50	40%	54%	6%
21,100-22,099	$$516.50	$$510.00	$$897.50	40%	54%	6%
22,100-23,099	$$538.50	$$532.00	$$936.50	43%	51%	6%
23,100-24,099	$$559.50	$$553.00	$$973.50	43%	51%	6%
24,100-25,099	$$580.50	$$574.00	$$1,009.50	47%	48%	6%
25,100-25,999	$$602.50	$$596.00	$$1,048.50	47%	47%	5%
26,100-27,099	$$659.50	$$659.50	$$1,148.50	52%	43%	5%
27,100-28,099	$$680.50	$$680.50	$$1,184.50	52%	43%	5%
28,100-29,099	$$702.50	$$702.50	$$1,223.50	60%	36%	4%

Weight Class Range	Fee (Gas)	Fee (Diesel)	Fee (Other)	Diesel	Gas	Other
29,100-30,099	$$723.50	$$723.50	$$1,260.50	60%	36%	4%
30,100-31,099	$$759.50	$$759.50	$$1,323.50	70%	27%	3%
31,100-32,099	$$781.50	$$781.50	$$1,361.50	70%	27%	3%
32,100-33,099	$$803.50	$$803.50	$$1,400.50	82%	16%	2%
33,100-34,099	$$825.50	$$825.50	$$1,438.50	82%	16%	2%
34,100-35,099	$$847.50	$$847.50	$$1,477.50	88%	11%	1%
35,100-36,099	$$869.50	$$869.50	$$1,515.50	88%	11%	1%
36,100-37,099	$$891.50	$$891.50	$$1,554.50	92%	7%	1%
37,100-38,099	$$912.50	$$912.50	$$1,590.50	92%	7%	1%
38,100-39,099	$$934.50	$$934.50	$$1,629.50	94%	5%	1%
39,100-39,999	$$956.50	$$956.50	$$1,667.50	94%	5%	1%
40,100-41,099	$$1,177.50	$$1,177.50	$$2,054.50	95%	4%	1%
41,100-42,099	$$1,200.50	$$1,200.50	$$2,094.50	95%	4%	1%
42,100-43,099	$$1,222.50	$$1,222.50	$$2,133.50	96%	4%	1%
43,100-44,099	$$1,245.50	$$1,245.50	$$2,173.50	96%	4%	1%
44,100-45,099	$$1,267.50	$$1,267.50	$$2,212.50	96%	4%	1%
45,100-46,099	$$1,290.50	$$1,290.50	$$2,252.50	96%	3%	0%
46,100-47,099	$$1,312.50	$$1,312.50	$$2,290.50	97%	3%	0%
47,100-48,099	$$1,335.50	$$1,335.50	$$2,331.50	97%	3%	0%
48,100-49,099	$$1,357.50	$$1,357.50	$$2,369.50	97%	3%	0%
49,100-50,099	$$1,379.50	$$1,379.50	$$2,408.50	97%	3%	0%
50,100-51,099	$$1,412.50	$$1,412.50	$$2,465.50	98%	2%	0%
51,100-52,099	$$1,435.50	$$1,435.50	$$2,506.50	98%	2%	0%
52,100-53,099	$$1,457.50	$$1,457.50	$$2,544.50	98%	2%	0%
53,100-54,099	$$1,480.50	$$1,480.50	$$2,584.50	98%	2%	0%
54,100-55,099	$$1,503.50	$$1,503.50	$$2,625.50	98%	1%	0%
55,100-56,099	$$1,525.50	$$1,525.50	$$2,663.50	98%	1%	0%
56,100-57,099	$$1,548.50	$$1,548.50	$$2,703.50	99%	1%	0%
57,100-58,099	$$1,571.50	$$1,571.50	$$2,744.50	99%	1%	0%
58,100-59,099	$$1,593.50	$$1,593.50	$$2,782.50	99%	1%	0%
59,100-59,999	$$1,616.50	$$1,616.50	$$2,822.50	99%	1%	0%
60,100-61,099	$$1,828.50	$$1,828.50	$$3,193.50	99%	1%	0%
61,100-62,099	$$1,851.50	$$1,851.50	$$3,234.50	99%	1%	0%
62,100-63,099	$$1,874.50	$$1,874.50	$$3,274.50	99%	1%	0%
63,100-64,099	$$1,898.50	$$1,898.50	$$3,316.50	99%	1%	0%
64,100-65,099	$$1,921.50	$$1,921.50	$$3,356.50	99%	1%	0%

Weight Class Range	Fee (Gas)	Fee (Diesel)	Fee (Other)	Diesel	Gas	Other
65,100-66,099	$$1,945.50	$$1,945.50	$$3,398.50	99%	1%	0%
66,100-67,099	$$1,968.50	$$1,968.50	$$3,438.50	99%	1%	0%
67,100-68,099	$$1,992.50	$$1,992.50	$$3,480.50	99%	1%	0%
68,100-69,099	$$2,015.50	$$2,015.50	$$3,521.50	99%	0%	0%
69,100-70,099	$$2,038.50	$$2,038.50	$$3,561.50	99%	0%	0%
70,100-71,099	$$2,118.50	$$2,118.50	$$3,701.50	100%	0%	0%
71,100-72,099	$$2,142.50	$$2,142.50	$$3,743.50	100%	0%	0%
72,100-73,099	$$2,166.50	$$2,166.50	$$3,785.50	100%	0%	0%
73,100-74,099	$$2,191.50	$$2,191.50	$$3,829.50	100%	0%	0%
74,100-75,099	$$2,215.50	$$2,215.50	$$3,871.50	100%	0%	0%
75,100-76,099	$$2,239.50	$$2,239.50	$$3,913.50	100%	0%	0%
76,100-77,099	$$2,263.50	$$2,263.50	$$3,955.50	100%	0%	0%
77,100-78,099	$$2,287.50	$$2,287.50	$$3,997.50	100%	0%	0%
78,100-79,099	$$2,312.50	$$2,312.50	$$4,040.50	100%	0%	0%
79,100-80,099	$$2,336.50	$$2,336.50	$$4,082.50	100%	0%	0%
80,100-90,099	$$2,648.50	$$2,648.50	$$4,628.50	100%	0%	0%

Source: VTrans, HCAS Tool.

To calculate revenue, the number of registrations by fuel source are multiplied by their corresponding registration fee. The results of the revenue calculation are shown in Table 3.22. The calculated revenue is 98 percent of the actual revenue reported by Vermont.

Table 3.22 Number of Registrations and Fees by Weight Class, Estimated Revenue

Weight Class Range	Fee, Gas, ($)	Fee, Diesel ($)	Fee, Other ($)	Estimated Registrations (thousands)	Estimated Revenue, Gas ($thousands)	Estimated Revenue, Diesel ($thousands)	Estimated Revenue, Other ($thousands)	Estimated Revenue, Total ($thousands)
UP TO 6,099	$76	$76	$132	439	$32,727	$567	$116	$33,410
6,100-7,099	$109	$109	$190	56	$5,943	$103	$21	$6,067
7,100-8,099	$124	$124	$216	58	$6,362	$698	$189	$7,249
8,100-9,099	$159	$159	$277	9	$918	$381	$107	$1,407
9,100-10,099	$176	$176	$307	8	$938	$393	$112	$1,442
10,100-11,099	$229	$229	$400	2	$325	$150	$44	$520
11,100-12,099	$247	$247	$431	2	$350	$163	$48	$560
12,100-13,099	$287	$287	$501	2	$391	$200	$60	$651
13,100-14,099	$306	$306	$534	2	$393	$203	$60	$657
14,100-15,099	$326	$326	$569	1	$201	$113	$33	$347
15,100-16,099	$345	$345	$603	1	$203	$116	$34	$352

Weight Class Range	Fee, Gas, ($)	Fee, Diesel ($)	Fee, Other ($)	Estimated Registrations (thousands)	Estimated Revenue, Gas ($thousands)	Estimated Revenue, Diesel ($thousands)	Estimated Revenue, Other ($thousands)	Estimated Revenue, Total ($thousands)
16,100-17,099	$386	$386	$674	1	$135	$83	$23	$241
17,100-17,999	$407	$407	$711	1	$141	$88	$25	$254
18,100-19,099	$434	$427	$753	1	$146	$98	$26	$270
19,100-20,099	$455	$448	$790	1	$152	$103	$27	$282
20,100-21,099	$496	$489	$862	1	$163	$119	$31	$313
21,100-22,099	$517	$510	$898	1	$174	$128	$32	$334
22,100-23,099	$539	$532	$937	1	$210	$174	$40	$424
23,100-24,099	$560	$553	$974	1	$218	$184	$41	$443
24,100-25,099	$581	$574	$1,010	1	$223	$217	$45	$485
25,100-25,999	$603	$596	$1,049	1	$218	$218	$44	$480
26,100-27,099	$660	$660	$1,149	0	$122	$148	$25	$296
27,100-28,099	$681	$681	$1,185	0	$124	$155	$26	$305
28,100-29,099	$703	$703	$1,224	0	$109	$183	$22	$314
29,100-30,099	$724	$724	$1,261	0	$105	$184	$21	$311
30,100-31,099	$760	$760	$1,324	0	$55	$143	$10	$209
31,100-32,099	$782	$782	$1,362	0	$54	$147	$10	$211
32,100-33,099	$804	$804	$1,401	0	$27	$136	$5	$168
33,100-34,099	$826	$826	$1,439	0	$15	$80	$3	$97
34,100-35,099	$848	$848	$1,478	0	$11	$89	$1	$101
35,100-36,099	$870	$870	$1,516	0	$11	$92	$3	$105
36,100-37,099	$892	$892	$1,555	0	$8	$108	$2	$118
37,100-38,099	$913	$913	$1,591	0	$9	$112	$2	$122
38,100-39,099	$935	$935	$1,630	0	$8	$131	$0	$139
39,100-39,999	$957	$957	$1,668	0	$7	$131	$0	$138
40,100-41,099	$1,178	$1,178	$2,055	0	$6	$123	$0	$129
41,100-42,099	$1,201	$1,201	$2,095	0	$5	$126	$0	$131
42,100-43,099	$1,223	$1,223	$2,134	0	$5	$128	$1	$134
43,100-44,099	$1,246	$1,246	$2,174	0	$5	$131	$1	$137
44,100-45,099	$1,268	$1,268	$2,213	0	$5	$133	$1	$139
45,100-46,099	$1,291	$1,291	$2,253	0	$5	$136	$1	$142
46,100-47,099	$1,313	$1,313	$2,291	0	$4	$139	$1	$144
47,100-48,099	$1,336	$1,336	$2,332	0	$4	$141	$1	$147
48,100-49,099	$1,358	$1,358	$2,370	0	$4	$144	$1	$149
49,100-50,099	$1,380	$1,380	$2,409	0	$4	$147	$1	$151
50,100-51,099	$1,413	$1,413	$2,466	0	$3	$151	$0	$155
51,100-52,099	$1,436	$1,436	$2,507	0	$3	$154	$0	$157

Weight Class Range	Fee, Gas, ($)	Fee, Diesel ($)	Fee, Other ($)	Estimated Registrations (thousands)	Estimated Revenue, Gas ($thousands)	Estimated Revenue, Diesel ($thousands)	Estimated Revenue, Other ($thousands)	Estimated Revenue, Total ($thousands)
52,100-53,099	$1,458	$1,458	$2,545	0	$3	$156	$1	$160
53,100-54,099	$1,481	$1,481	$2,585	0	$3	$159	$0	$162
54,100-55,099	$1,504	$1,504	$2,626	0	$2	$162	$0	$165
55,100-56,099	$1,526	$1,526	$2,664	0	$2	$165	$0	$167
56,100-57,099	$1,549	$1,549	$2,704	0	$2	$168	$0	$169
57,100-58,099	$1,572	$1,572	$2,745	0	$2	$170	$0	$172
58,100-59,099	$1,594	$1,594	$2,783	0	$1	$173	$0	$174
59,100-59,999	$1,617	$1,617	$2,823	0	$1	$176	$0	$177
60,100-61,099	$1,829	$1,829	$3,194	0	$0	$200	$0	$200
61,100-62,099	$1,852	$1,852	$3,235	0	$0	$203	$0	$203
62,100-63,099	$1,875	$1,875	$3,275	0	$2	$204	$0	$205
63,100-64,099	$1,899	$1,899	$3,317	0	$1	$206	$0	$208
64,100-65,099	$1,922	$1,922	$3,357	0	$1	$209	$0	$210
65,100-66,099	$1,946	$1,946	$3,399	0	$1	$212	$0	$213
66,100-67,099	$1,969	$1,969	$3,439	0	$1	$214	$0	$215
67,100-68,099	$1,993	$1,993	$3,481	0	$1	$217	$0	$218
68,100-69,099	$2,016	$2,016	$3,522	0	$1	$219	$0	$221
69,100-70,099	$2,039	$2,039	$3,562	0	$1	$222	$0	$223
70,100-71,099	$2,119	$2,119	$3,702	0	$0	$232	$0	$232
71,100-72,099	$2,143	$2,143	$3,744	0	$0	$234	$0	$234
72,100-73,099	$2,167	$2,167	$3,786	0	$0	$237	$0	$237
73,100-74,099	$2,192	$2,192	$3,830	0	$0	$240	$0	$240
74,100-75,099	$2,216	$2,216	$3,872	0	$0	$242	$0	$242
75,100-76,099	$2,240	$2,240	$3,914	0	$0	$245	$0	$245
76,100-77,099	$2,264	$2,264	$3,956	0	$0	$248	$0	$248
77,100-78,099	$2,288	$2,288	$3,998	0	$1	$250	$0	$250
78,100-79,099	$2,313	$2,313	$4,041	0	$0	$253	$0	$253
79,100-80,099	$2,337	$2,337	$4,083	0	$0	$256	$0	$256
80,100-90,099	$2,649	$2,649	$4,629	1	$0	$2,899	$0	$2,899
Total				595	$51,275	$16,763	$1,297	$69,336

Source: VTrans, HCAS Tool.

The estimated registrations, calculated revenue, and calculated cost responsibility will be combined to model projected revenue with given fees in Section 4.0.

4.0 Weight-Based Allocation Model

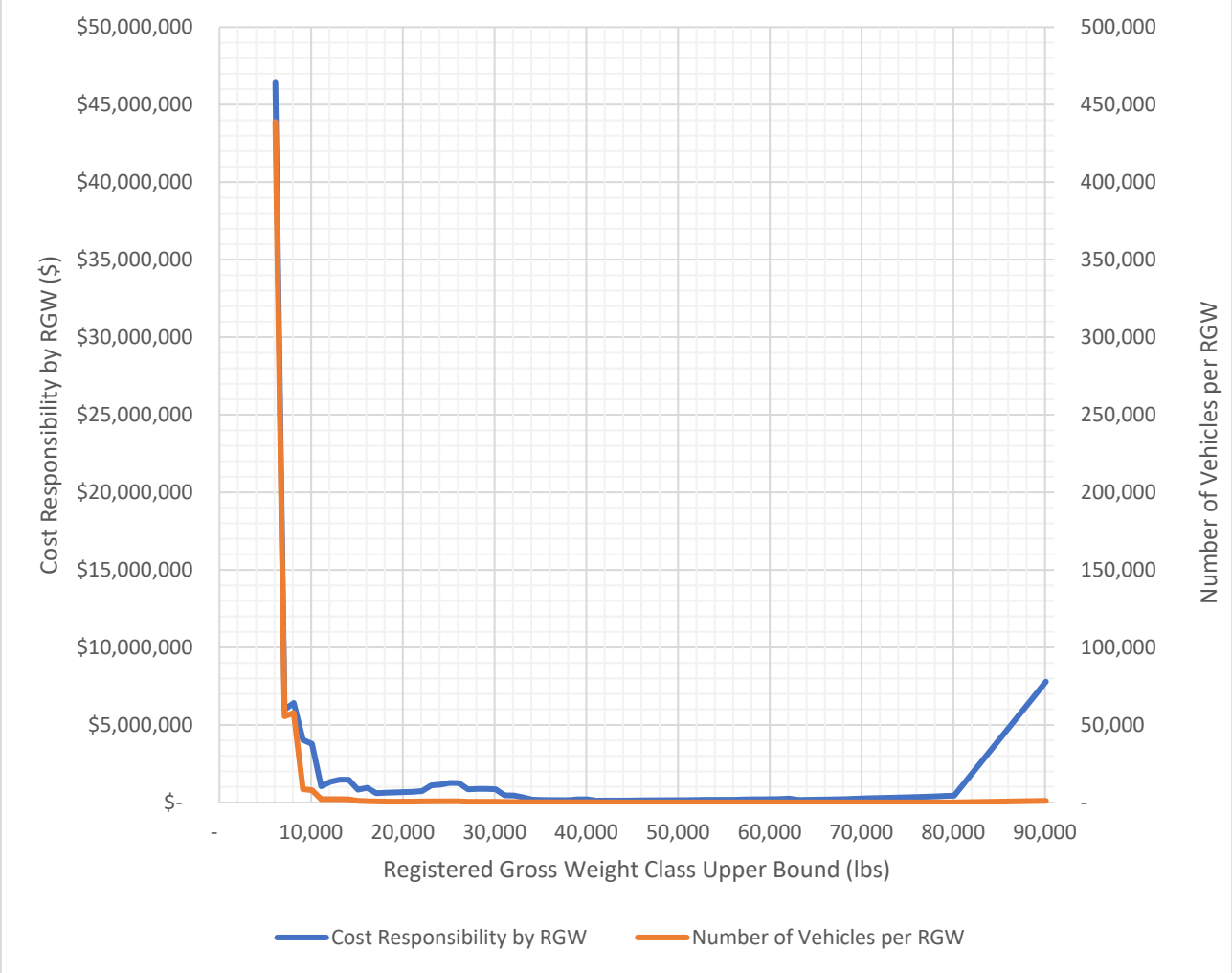
This section presents the overall results of the costs responsibility distribution and the results of the specific scenarios considered. The cost structures were used to produce a revenue matrix with today's registration revenue, and each fee structure obtained from the calculations. The total registration revenue of each alternative is highly unlikely to equal today's registration revenue in Vermont. Therefore, adjusted cost structures were used to normalize each structure to produce the same revenue that is being generated today. This approach will provide the legislature with an assessment of how the scenarios normalize today's existing revenue.

A heuristic objective function score for each alternative, called an equity score, was calculated based on how closely each vehicle class' adjusted registration fee matches up with their expected maintenance allocation from the literature.

4.1 Results of the Weight-Based Allocation Model

The cost responsibility results are a compilation of vehicle types, miles travelled by each vehicle type, the distribution of vehicles across weight classes, the load equivalency factors of the vehicles, and the actual expenditures reported by VTrans. Together these factors assign a level of responsibility for maintenance on highway bridges and pavements. Figure 4.1 shows how this total cost responsibility varies with gross vehicle registered weight. The noise and bumps in the correlation between cost responsibility and weight is indicative of the complex relationship between the impact of the vehicles, the number of vehicles, and the varying relationship between vehicle type, weight, and axle distribution. The high initial cost responsibility is a result of the high volume of automobiles, and the bump around 80,000 pounds is indicative of the rising impact of heavy vehicles buffered by the assumptions made for the number of registrations by weight class.

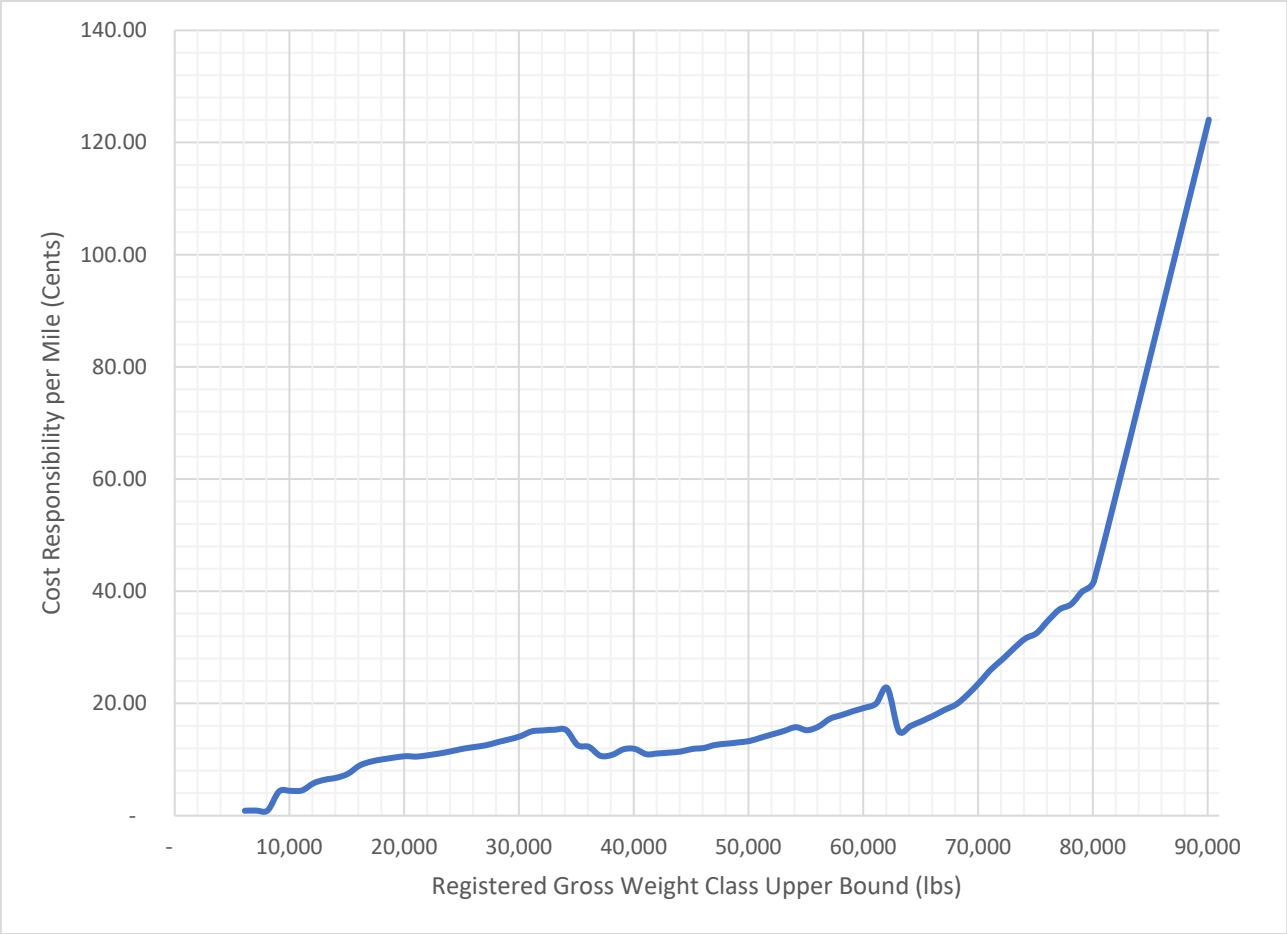
Figure 4.1 Total Cost Responsibility for All Vehicles by Weight Class



Source: CS, Weight-Based Model.

In order to normalize the data, it is helpful to consider the cost responsibility per mile, shown in Figure 4.2. This chart logically shows a progression in cost responsibility with increasing weight, again with some noise due to the complex relationship between the vehicle class, axle spacing, and weight.

Figure 4.2 Cost Responsibility per Mile by RGW (cents per mile)



Source: CS, Weight-Based Model.

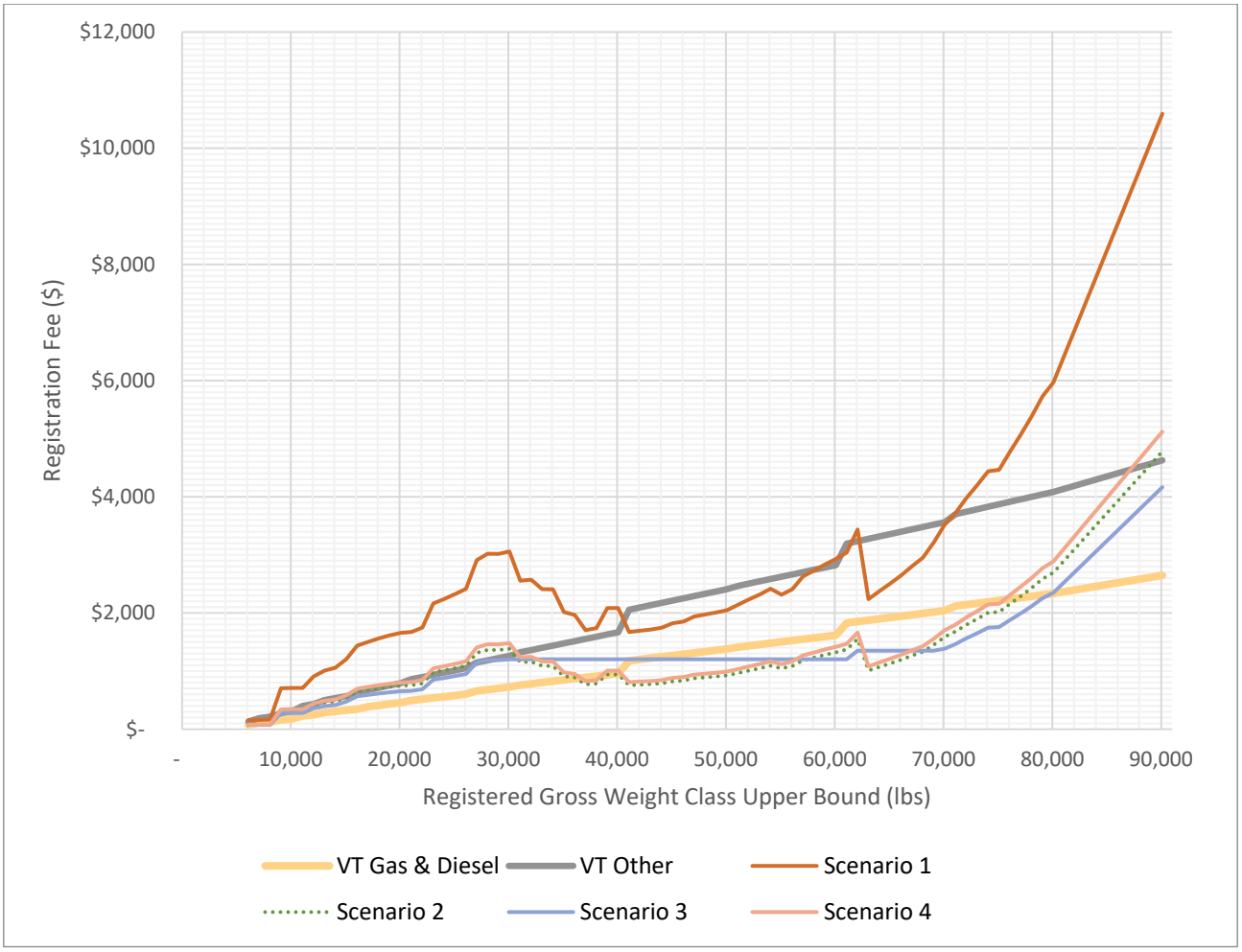
In calculating the proposed registration fees, only one registration fee per weight category is presented. Certainly, an independent fee by fuel source could be calculated back out of the proposed registration fees, but this was not necessary for understanding the relationship between registration fees and weight and would indeed introduce more assumptions into the analysis.

The model developed by CS for VTrans considers four pricing scenarios. Figure 4.3 shows the current registration fees for gas and diesel and other fuels, alongside the results for each of these proposed registration fee scenarios, which are discussed further in the next sections:

- **Scenario 1** assumes that each weight class has a registration fee with complete equity to its cost responsibility and that the total registration fee collected may change (either up or down) from the total fee currently collected;
- **Scenario 2** is completely revenue-neutral, reallocating existing registration fee revenue based on HCAS results of maintenance needs generated;
- **Scenario 3** is also revenue-neutral and assumes that the minimum registration fee should be $76 (the lowest registration fee in Vermont today) and that the other registration fees should increase in value if needed, such that heavier weight classes are always more than lower weight classes;

- **Scenario 4** assumes that the relatively minimal damage caused by vehicles under 6,000 pounds is a negligible portion of the current registration fee for those vehicles, when compared to other portions of a registration fee's justification. Thus, these fees are kept identical at today's fee of $76, and other fees are scaled up proportionately. This scenario is not expected to be revenue-neutral for the entire set of registered vehicles.

Figure 4.3 Proposed Registration Fee – All Scenarios

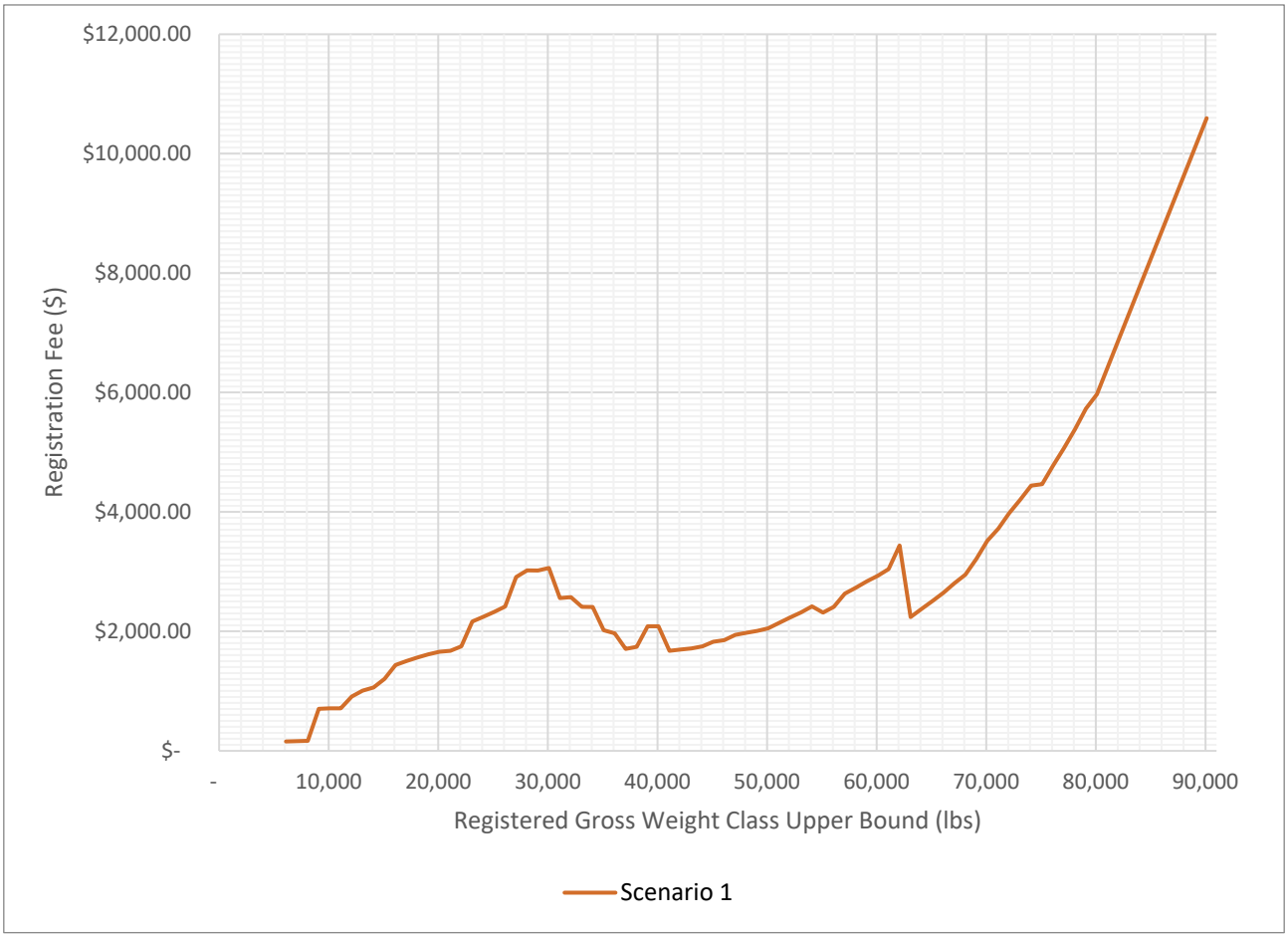


Source: CS, Weight-Based Model.

4.1.1 Scenario 1 – 100 Percent Equity

Scenario 1 presents the initial cost responsibility results as a function of the traffic in each weight class. Figure 4.4 shows the proposed registration fees by weight class. This scenario assumes that the costs responsibility calculated will be 100 percent fulfilled by registration fees, without considering other avenues of revenue collection such as gas taxes. When using the registration fees proposed in Scenario 1, the overall revenue that would be collected matches the five-year average expenditures by Vermont on pavement and bridges, $156.3 million.

Figure 4.4 Scenario 1 – Proposed Registration Fee



Source: CS, Weight-Based Model.

The proposed fee, projected revenue, equity ratio, and percentage of the original registration fee is shown in Table 4.1. The equity ratio is the balance between the projected revenue and the full cost responsibility of that RGW. The equity ratio shows the registration fee accounts for 100 percent of the cost responsibility of the weight class. Given that there are other revenue sources than registration fees, such as fuel taxes, the remaining scenarios will normalize the registration fees to match the current revenue rather than the expenditures.

Table 4.1 Scenario 1 – Registration Fee Table

RGW	Proposed Fee ($)	Projected Revenue ($millions)	Equity Ratio	% of Original Fee	Affected Vehicle Owners (thousands)
UP TO 6,099	$157	$69.1	1.00	207%	439
6,100-7,099	$160	$8.9	1.00	147%	56
7,100-8,099	$165	$9.6	1.00	132%	58
8,100-9,099	$703	$6.0	1.00	428%	9
9,100-10,099	$710	$5.6	1.00	390%	8

RGW	Proposed Fee ($)	Projected Revenue ($millions)	Equity Ratio	% of Original Fee	Affected Vehicle Owners (thousands)
10,100-11,099	$709	$1.5	1.00	298%	2
11,100-12,099	$906	$2.0	1.00	354%	2
12,100-13,099	$1,006	$2.2	1.00	337%	2
13,100-14,099	$1,058	$2.2	1.00	332%	2
14,100-15,099	$1,204	$1.2	1.00	354%	1
15,100-16,099	$1,437	$1.4	1.00	399%	1
16,100-17,099	$1,502	$0.9	1.00	373%	1
17,100-17,999	$1,562	$0.9	1.00	368%	1
18,100-19,099	$1,615	$1.0	1.00	359%	1
19,100-20,099	$1,658	$1.0	1.00	352%	1
20,100-21,099	$1,674	$1.0	1.00	325%	1
21,100-22,099	$1,749	$1.1	1.00	326%	1
22,100-23,099	$2,164	$1.6	1.00	388%	1
23,100-24,099	$2,241	$1.7	1.00	387%	1
24,100-25,099	$2,325	$1.9	1.00	387%	1
25,100-25,999	$2,414	$1.9	1.00	387%	1
26,100-27,099	$2,907	$1.3	1.00	425%	0
27,100-28,099	$3,020	$1.3	1.00	428%	0
28,100-29,099	$3,017	$1.3	1.00	417%	0
29,100-30,099	$3,060	$1.3	1.00	411%	0
30,100-31,099	$2,556	$0.7	1.00	330%	0
31,100-32,099	$2,572	$0.7	1.00	322%	0
32,100-33,099	$2,411	$0.5	1.00	296%	0
33,100-34,099	$2,407	$0.3	1.00	288%	0
34,100-35,099	$2,017	$0.2	1.00	237%	0
35,100-36,099	$1,966	$0.2	1.00	224%	0
36,100-37,099	$1,704	$0.2	1.00	190%	0
37,100-38,099	$1,740	$0.2	1.00	190%	0
38,100-39,099	$2,083	$0.3	1.00	223%	0
39,100-39,999	$2,084	$0.3	1.00	218%	0
40,100-41,099	$1,673	$0.2	1.00	142%	0
41,100-42,099	$1,695	$0.2	1.00	141%	0
42,100-43,099	$1,714	$0.2	1.00	140%	0
43,100-44,099	$1,747	$0.2	1.00	140%	0
44,100-45,099	$1,824	$0.2	1.00	143%	0
45,100-46,099	$1,852	$0.2	1.00	143%	0

RGW	Proposed Fee ($)	Projected Revenue ($millions)	Equity Ratio	% of Original Fee	Affected Vehicle Owners (thousands)
46,100-47,099	$1,940	$0.2	1.00	147%	0
47,100-48,099	$1,973	$0.2	1.00	147%	0
48,100-49,099	$2,007	$0.2	1.00	148%	0
49,100-50,099	$2,048	$0.2	1.00	148%	0
50,100-51,099	$2,139	$0.2	1.00	151%	0
51,100-52,099	$2,232	$0.2	1.00	155%	0
52,100-53,099	$2,317	$0.3	1.00	158%	0
53,100-54,099	$2,416	$0.3	1.00	163%	0
54,100-55,099	$2,313	$0.3	1.00	154%	0
55,100-56,099	$2,409	$0.3	1.00	158%	0
56,100-57,099	$2,630	$0.3	1.00	170%	0
57,100-58,099	$2,729	$0.3	1.00	174%	0
58,100-59,099	$2,836	$0.3	1.00	178%	0
59,100-59,999	$2,930	$0.3	1.00	181%	0
60,100-61,099	$3,041	$0.3	1.00	166%	0
61,100-62,099	$3,436	$0.4	1.00	186%	0
62,100-63,099	$2,238	$0.2	1.00	119%	0
63,100-64,099	$2,374	$0.3	1.00	125%	0
64,100-65,099	$2,507	$0.3	1.00	130%	0
65,100-66,099	$2,646	$0.3	1.00	136%	0
66,100-67,099	$2,803	$0.3	1.00	142%	0
67,100-68,099	$2,949	$0.3	1.00	148%	0
68,100-69,099	$3,212	$0.4	1.00	159%	0
69,100-70,099	$3,517	$0.4	1.00	173%	0
70,100-71,099	$3,721	$0.4	1.00	176%	0
71,100-72,099	$3,978	$0.4	1.00	186%	0
72,100-73,099	$4,201	$0.5	1.00	194%	0
73,100-74,099	$4,440	$0.5	1.00	203%	0
74,100-75,099	$4,465	$0.5	1.00	202%	0
75,100-76,099	$4,776	$0.5	1.00	213%	0
76,100-77,099	$5,067	$0.6	1.00	224%	0
77,100-78,099	$5,381	$0.6	1.00	235%	0
78,100-79,099	$5,729	$0.6	1.00	248%	0
79,100-80,099	$5,969	$0.7	1.00	255%	0
80,100-90,099	$10,592	$11.6	1.00	400%	1

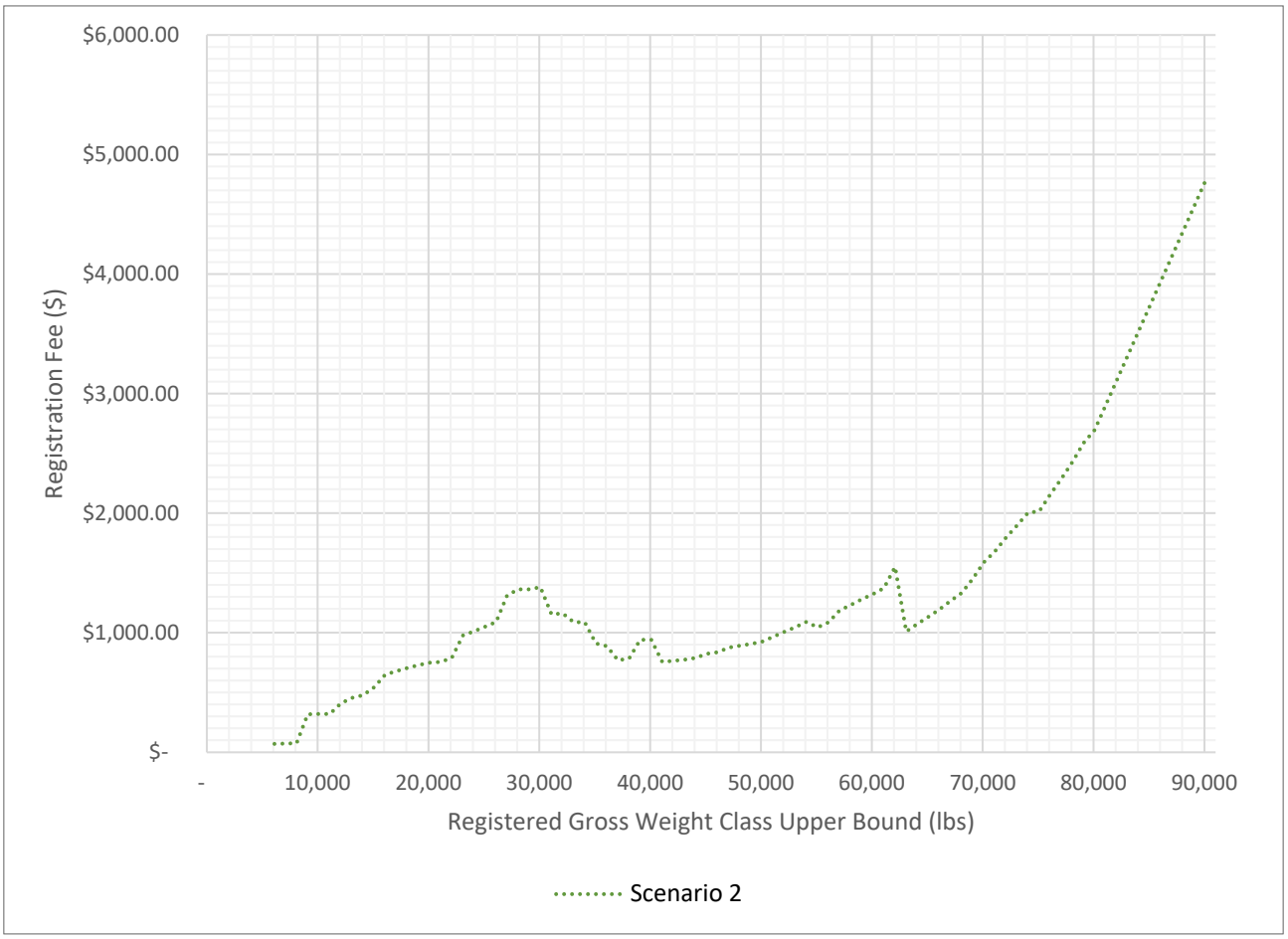
RGW	Proposed Fee ($)	Projected Revenue ($millions)	Equity Ratio	% of Original Fee	Affected Vehicle Owners (thousands)
Total		$156.3	1.00		

Source: CS, Weight-Based Model.

4.1.2 Scenario 2 – Revenue Neutral

Scenario 2 is a result of normalizing the initial cost responsibility results by Vermont's current revenue. The fee for each weight class is multiplied by 45 percent, which is the ratio between Vermont's current registration revenue and the Vermont's five-year average for maintenance expenditures. The proposed fee by weight class is shown in Figure 4.5.

Figure 4.5 Scenario 2 – Proposed Registration Fee



Source: CS, Weight-Based Model.

The proposed fee, projected revenue, equity ratio, and percentage of the original registration fee is shown in Table 4.2. The equity ratio and percent of original fee shows that with the same equity ratio across each weight class, some weight classes are paying almost 200 percent of the original fee table. In addition, the fee

class does not increase continually and the lowest fee is less than the original fee table—these aspects will be controlled in Scenario 3.

Table 4.2 Scenario 2 – Registration Fee Table

RGW	Proposed Fee ($)	Projected Revenue ($millions)	Equity Ratio	% of Original Fee	Affected Vehicle Owners (thousands)
UP TO 6,099	$71	$31.2	0.45	93%	439
6,100-7,099	$72	$4.0	0.45	66%	56
7,100-8,099	$75	$4.3	0.45	60%	58
8,100-9,099	$317	$2.7	0.45	193%	9
9,100-10,099	$321	$2.5	0.45	176%	8
10,100-11,099	$320	$0.7	0.45	135%	2
11,100-12,099	$409	$0.9	0.45	160%	2
12,100-13,099	$454	$1.0	0.45	152%	2
13,100-14,099	$478	$1.0	0.45	150%	2
14,100-15,099	$544	$0.6	0.45	160%	1
15,100-16,099	$649	$0.6	0.45	180%	1
16,100-17,099	$678	$0.4	0.45	168%	1
17,100-17,999	$705	$0.4	0.45	166%	1
18,100-19,099	$729	$0.4	0.45	162%	1
19,100-20,099	$748	$0.4	0.45	159%	1
20,100-21,099	$756	$0.5	0.45	147%	1
21,100-22,099	$789	$0.5	0.45	147%	1
22,100-23,099	$977	$0.7	0.45	175%	1
23,100-24,099	$1,012	$0.8	0.45	175%	1
24,100-25,099	$1,049	$0.8	0.45	175%	1
25,100-25,999	$1,090	$0.8	0.45	175%	1
26,100-27,099	$1,312	$0.6	0.45	192%	0
27,100-28,099	$1,363	$0.6	0.45	193%	0
28,100-29,099	$1,362	$0.6	0.45	188%	0
29,100-30,099	$1,381	$0.6	0.45	185%	0
30,100-31,099	$1,154	$0.3	0.45	149%	0
31,100-32,099	$1,161	$0.3	0.45	145%	0
32,100-33,099	$1,088	$0.2	0.45	134%	0
33,100-34,099	$1,087	$0.1	0.45	130%	0
34,100-35,099	$911	$0.1	0.45	107%	0
35,100-36,099	$887	$0.1	0.45	101%	0
36,100-37,099	$769	$0.1	0.45	86%	0

RGW	Proposed Fee ($)	Projected Revenue ($millions)	Equity Ratio	% of Original Fee	Affected Vehicle Owners (thousands)
37,100-38,099	$785	$0.1	0.45	86%	0
38,100-39,099	$941	$0.1	0.45	101%	0
39,100-39,999	$941	$0.1	0.45	98%	0
40,100-41,099	$755	$0.1	0.45	64%	0
41,100-42,099	$765	$0.1	0.45	64%	0
42,100-43,099	$774	$0.1	0.45	63%	0
43,100-44,099	$789	$0.1	0.45	63%	0
44,100-45,099	$823	$0.1	0.45	65%	0
45,100-46,099	$836	$0.1	0.45	65%	0
46,100-47,099	$876	$0.1	0.45	67%	0
47,100-48,099	$891	$0.1	0.45	66%	0
48,100-49,099	$906	$0.1	0.45	67%	0
49,100-50,099	$925	$0.1	0.45	67%	0
50,100-51,099	$965	$0.1	0.45	68%	0
51,100-52,099	$1,007	$0.1	0.45	70%	0
52,100-53,099	$1,046	$0.1	0.45	72%	0
53,100-54,099	$1,091	$0.1	0.45	74%	0
54,100-55,099	$1,044	$0.1	0.45	69%	0
55,100-56,099	$1,088	$0.1	0.45	71%	0
56,100-57,099	$1,187	$0.1	0.45	77%	0
57,100-58,099	$1,232	$0.1	0.45	78%	0
58,100-59,099	$1,280	$0.1	0.45	80%	0
59,100-59,999	$1,323	$0.1	0.45	82%	0
60,100-61,099	$1,373	$0.2	0.45	75%	0
61,100-62,099	$1,551	$0.2	0.45	84%	0
62,100-63,099	$1,010	$0.1	0.45	54%	0
63,100-64,099	$1,072	$0.1	0.45	56%	0
64,100-65,099	$1,132	$0.1	0.45	59%	0
65,100-66,099	$1,195	$0.1	0.45	61%	0
66,100-67,099	$1,265	$0.1	0.45	64%	0
67,100-68,099	$1,331	$0.1	0.45	67%	0
68,100-69,099	$1,450	$0.2	0.45	72%	0
69,100-70,099	$1,588	$0.2	0.45	78%	0
70,100-71,099	$1,680	$0.2	0.45	79%	0
71,100-72,099	$1,796	$0.2	0.45	84%	0
72,100-73,099	$1,897	$0.2	0.45	88%	0

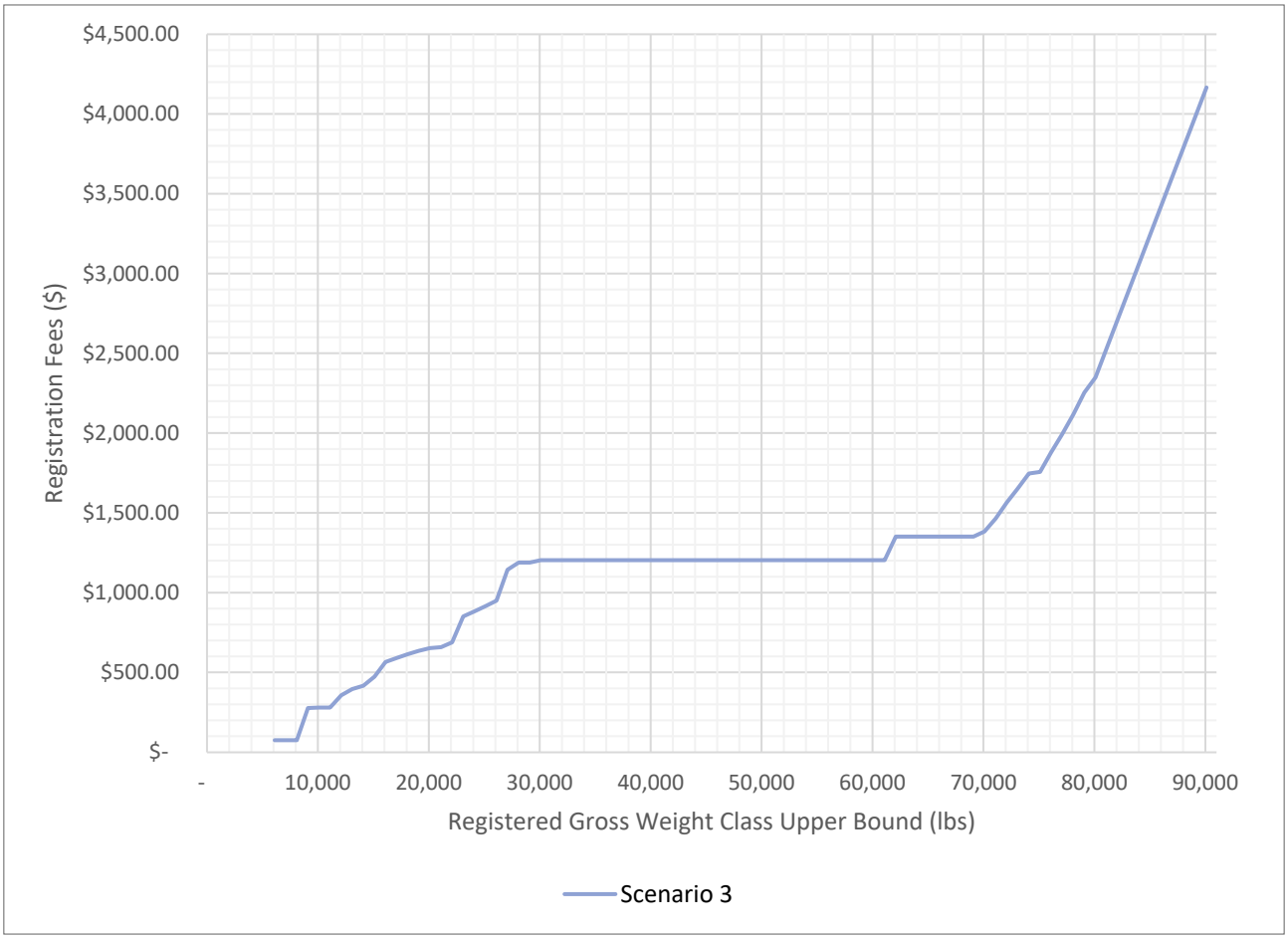
RGW	Proposed Fee ($)	Projected Revenue ($millions)	Equity Ratio	% of Original Fee	Affected Vehicle Owners (thousands)
73,100-74,099	$2,004	$0.2	0.45	91%	0
74,100-75,099	$2,015	$0.2	0.45	91%	0
75,100-76,099	$2,156	$0.2	0.45	96%	0
76,100-77,099	$2,287	$0.3	0.45	101%	0
77,100-78,099	$2,429	$0.3	0.45	106%	0
78,100-79,099	$2,586	$0.3	0.45	112%	0
79,100-80,099	$2,695	$0.3	0.45	115%	0
80,100-90,099	$4,782	$5.2	0.45	181%	1
Total		$70.5	0.45		

Source: CS, Weight-Based Model.

4.1.3 Scenario 3 – Smoothed Revenue Neutral

Scenario 3 is a result of smoothing the initial cost responsibility results by applying a factor so that fees continue to increase in value with weight, and such that the minimum fee is equivalent to the current minimum registration fee, $76.00. The correlation between weight and registration fee is shown in Figure 4.6.

Figure 4.6 Scenario 3 – Proposed Registration Fee



Source: CS, Weight-Based Model.

The proposed fee, projected revenue, equity ratio, and percentage of the original registration fee is shown in Table 4.3. The equity ratio in this scenario varies as a result of the registration fee controls that were applied. Each weight class pays between 61 to 168 percent of their cost responsibility.

Table 4.3 Scenario 3 – Registration Fee Table

RGW	Proposed Fee ($)	Projected Revenue ($millions)	Equity Ratio	% of Original Fee	Affected Vehicle Owners (thousands)
UP TO 6,099	$76	$33.4	0.48	100%	439
6,100-7,099	$76	$4.2	0.47	70%	56
7,100-8,099	$76	$4.4	0.46	61%	58
8,100-9,099	$276	$2.4	0.39	168%	9
9,100-10,099	$279	$2.2	0.39	153%	8
10,100-11,099	$279	$0.6	0.39	118%	2
11,100-12,099	$357	$0.8	0.39	139%	2

RGW	Proposed Fee ($)	Projected Revenue ($millions)	Equity Ratio	% of Original Fee	Affected Vehicle Owners (thousands)
12,100-13,099	$396	$0.9	0.39	133%	2
13,100-14,099	$416	$0.9	0.39	131%	2
14,100-15,099	$474	$0.5	0.39	139%	1
15,100-16,099	$565	$0.6	0.39	157%	1
16,100-17,099	$591	$0.4	0.39	147%	1
17,100-17,999	$614	$0.4	0.39	145%	1
18,100-19,099	$635	$0.4	0.39	141%	1
19,100-20,099	$652	$0.4	0.39	138%	1
20,100-21,099	$658	$0.4	0.39	128%	1
21,100-22,099	$688	$0.4	0.39	128%	1
22,100-23,099	$851	$0.6	0.39	153%	1
23,100-24,099	$882	$0.7	0.39	152%	1
24,100-25,099	$915	$0.7	0.39	152%	1
25,100-25,999	$950	$0.7	0.39	152%	1
26,100-27,099	$1,144	$0.5	0.39	167%	0
27,100-28,099	$1,188	$0.5	0.39	168%	0
28,100-29,099	$1,188	$0.5	0.39	164%	0
29,100-30,099	$1,204	$0.5	0.39	162%	0
30,100-31,099	$1,204	$0.3	0.47	155%	0
31,100-32,099	$1,204	$0.3	0.47	151%	0
32,100-33,099	$1,204	$0.2	0.50	148%	0
33,100-34,099	$1,204	$0.1	0.50	144%	0
34,100-35,099	$1,204	$0.1	0.60	141%	0
35,100-36,099	$1,204	$0.1	0.61	137%	0
36,100-37,099	$1,204	$0.2	0.71	134%	0
37,100-38,099	$1,204	$0.2	0.69	131%	0
38,100-39,099	$1,204	$0.2	0.58	129%	0
39,100-39,999	$1,204	$0.2	0.58	126%	0
40,100-41,099	$1,204	$0.1	0.72	102%	0
41,100-42,099	$1,204	$0.1	0.71	100%	0
42,100-43,099	$1,204	$0.1	0.70	98%	0
43,100-44,099	$1,204	$0.1	0.69	96%	0
44,100-45,099	$1,204	$0.1	0.66	95%	0
45,100-46,099	$1,204	$0.1	0.65	93%	0
46,100-47,099	$1,204	$0.1	0.62	91%	0
47,100-48,099	$1,204	$0.1	0.61	90%	0

RGW	Proposed Fee ($)	Projected Revenue ($millions)	Equity Ratio	% of Original Fee	Affected Vehicle Owners (thousands)
48,100-49,099	$1,204	$0.1	0.60	88%	0
49,100-50,099	$1,204	$0.1	0.59	87%	0
50,100-51,099	$1,204	$0.1	0.56	85%	0
51,100-52,099	$1,204	$0.1	0.54	84%	0
52,100-53,099	$1,204	$0.1	0.52	82%	0
53,100-54,099	$1,204	$0.1	0.50	81%	0
54,100-55,099	$1,204	$0.1	0.52	80%	0
55,100-56,099	$1,204	$0.1	0.50	79%	0
56,100-57,099	$1,204	$0.1	0.46	78%	0
57,100-58,099	$1,204	$0.1	0.44	77%	0
58,100-59,099	$1,204	$0.1	0.42	76%	0
59,100-59,999	$1,204	$0.1	0.41	74%	0
60,100-61,099	$1,204	$0.1	0.40	66%	0
61,100-62,099	$1,352	$0.1	0.39	73%	0
62,100-63,099	$1,352	$0.1	0.60	72%	0
63,100-64,099	$1,352	$0.1	0.57	71%	0
64,100-65,099	$1,352	$0.1	0.54	70%	0
65,100-66,099	$1,352	$0.1	0.51	69%	0
66,100-67,099	$1,352	$0.1	0.48	69%	0
67,100-68,099	$1,352	$0.1	0.46	68%	0
68,100-69,099	$1,352	$0.1	0.42	67%	0
69,100-70,099	$1,384	$0.2	0.39	68%	0
70,100-71,099	$1,464	$0.2	0.39	69%	0
71,100-72,099	$1,565	$0.2	0.39	73%	0
72,100-73,099	$1,653	$0.2	0.39	76%	0
73,100-74,099	$1,747	$0.2	0.39	80%	0
74,100-75,099	$1,756	$0.2	0.39	79%	0
75,100-76,099	$1,879	$0.2	0.39	84%	0
76,100-77,099	$1,993	$0.2	0.39	88%	0
77,100-78,099	$2,117	$0.2	0.39	93%	0
78,100-79,099	$2,253	$0.2	0.39	97%	0
79,100-80,099	$2,348	$0.3	0.39	101%	0
80,100-90,099	$4,167	$4.6	0.39	157%	1
Total		$70.5	0.45		

Source: CS, Weight-Based Model.

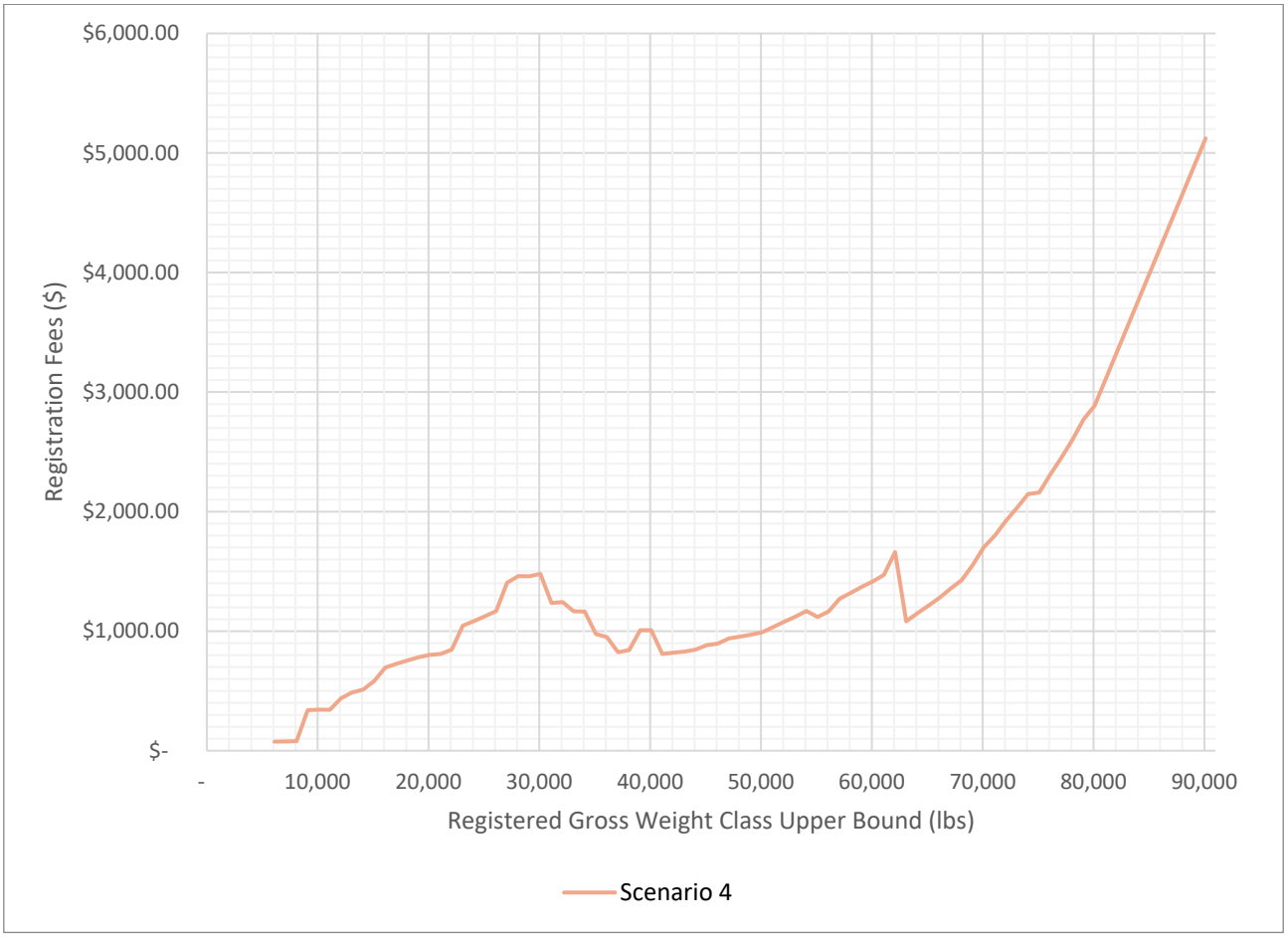
4.1.4 Scenario 4 – Up to 6,099 Weight Class Scaled to $76.11 Fee

Scenario 4 assumes that the relatively minimal damage caused by vehicles under 6,099 pounds is a negligible portion of the current registration fee for those vehicles, when compared to other portions of a registration fee's justification. Starting with the fees as calculated for Scenario 1 with 100 percent equity, all fees are scaled by the same factor such that the fee from the first weight class of vehicles under 6,099 pounds is the same as the average fee as calculated using the existing registrations and assumptions. Accordingly, this scenario has an equity value of 0.48 for each weight class, such that the first weight class has a fee that is 100 percent of the original fee. The fees for Scenario 4 are shown in Figure 4.7.

The proposed fee, projected revenue, equity ratio, and percentage of the original registration fee is shown in Table 4.4. The equity ratio in this scenario is the same as a result of the 48 percent factor applied against Scenario 1, such that the fee from the first weight class matches the actual average fee calculated. Each weight class pays between 64 to 207 percent of their cost responsibility.

Scenario 4 is not normalized against the existing revenue. The total revenue calculated for Scenario 4 is $75.6 million. The $75.6 million represents the revenue that Vermont would received if they scaled Scenario 1 equally until the first weight category were $76.

Figure 4.7 Scenario 4 – Proposed Registration Fee



Source: CS, Weight-Based Model.

Table 4.4 Scenario 4 – Registration Fee Table

RGW	Proposed Fee ($)	Projected Revenue ($millions)	Equity Ratio	% of Original Fee	Affected Vehicle Owners (thousands)
UP TO 6,099	$76	$33.4	0.72	100%	439
6,100-7,099	$77	$4.3	0.72	71%	56
7,100-8,099	$80	$4.6	0.72	64%	58
8,100-9,099	$340	$2.9	0.72	207%	9
9,100-10,099	$343	$2.7	0.72	189%	8
10,100-11,099	$343	$0.7	0.72	144%	2
11,100-12,099	$438	$1.0	0.72	171%	2
12,100-13,099	$487	$1.1	0.72	163%	2
13,100-14,099	$512	$1.1	0.72	161%	2
14,100-15,099	$582	$0.6	0.72	171%	1
15,100-16,099	$695	$0.7	0.72	193%	1
16,100-17,099	$726	$0.4	0.72	180%	1
17,100-17,999	$755	$0.5	0.72	178%	1
18,100-19,099	$781	$0.5	0.72	174%	1
19,100-20,099	$802	$0.5	0.72	170%	1
20,100-21,099	$809	$0.5	0.72	157%	1
21,100-22,099	$846	$0.5	0.72	158%	1
22,100-23,099	$1,047	$0.8	0.72	188%	1
23,100-24,099	$1,084	$0.8	0.72	187%	1
24,100-25,099	$1,124	$0.9	0.72	187%	1
25,100-25,999	$1,167	$0.9	0.72	187%	1
26,100-27,099	$1,406	$0.6	0.72	205%	0
27,100-28,099	$1,460	$0.6	0.72	207%	0
28,100-29,099	$1,459	$0.6	0.72	201%	0
29,100-30,099	$1,480	$0.6	0.72	199%	0
30,100-31,099	$1,236	$0.3	0.72	159%	0
31,100-32,099	$1,244	$0.3	0.72	156%	0
32,100-33,099	$1,166	$0.2	0.72	143%	0
33,100-34,099	$1,164	$0.1	0.72	139%	0
34,100-35,099	$975	$0.1	0.72	114%	0
35,100-36,099	$950	$0.1	0.72	108%	0
36,100-37,099	$824	$0.1	0.72	92%	0
37,100-38,099	$841	$0.1	0.72	92%	0
38,100-39,099	$1,007	$0.1	0.72	108%	0

RGW	Proposed Fee ($)	Projected Revenue ($millions)	Equity Ratio	% of Original Fee	Affected Vehicle Owners (thousands)
39,100-39,999	$1,008	$0.1	0.72	105%	0
40,100-41,099	$809	$0.1	0.72	69%	0
41,100-42,099	$820	$0.1	0.72	68%	0
42,100-43,099	$829	$0.1	0.72	68%	0
43,100-44,099	$845	$0.1	0.72	68%	0
44,100-45,099	$882	$0.1	0.72	69%	0
45,100-46,099	$896	$0.1	0.72	69%	0
46,100-47,099	$938	$0.1	0.72	71%	0
47,100-48,099	$954	$0.1	0.72	71%	0
48,100-49,099	$971	$0.1	0.72	71%	0
49,100-50,099	$991	$0.1	0.72	72%	0
50,100-51,099	$1,034	$0.1	0.72	73%	0
51,100-52,099	$1,079	$0.1	0.72	75%	0
52,100-53,099	$1,120	$0.1	0.72	77%	0
53,100-54,099	$1,168	$0.1	0.72	79%	0
54,100-55,099	$1,119	$0.1	0.72	74%	0
55,100-56,099	$1,165	$0.1	0.72	76%	0
56,100-57,099	$1,272	$0.1	0.72	82%	0
57,100-58,099	$1,320	$0.1	0.72	84%	0
58,100-59,099	$1,371	$0.2	0.72	86%	0
59,100-59,999	$1,417	$0.2	0.72	88%	0
60,100-61,099	$1,471	$0.2	0.72	80%	0
61,100-62,099	$1,661	$0.2	0.72	90%	0
62,100-63,099	$1,082	$0.1	0.72	58%	0
63,100-64,099	$1,148	$0.1	0.72	60%	0
64,100-65,099	$1,212	$0.1	0.72	63%	0
65,100-66,099	$1,280	$0.1	0.72	66%	0
66,100-67,099	$1,356	$0.1	0.72	69%	0
67,100-68,099	$1,426	$0.2	0.72	72%	0
68,100-69,099	$1,553	$0.2	0.72	77%	0
69,100-70,099	$1,701	$0.2	0.72	83%	0
70,100-71,099	$1,799	$0.2	0.72	85%	0
71,100-72,099	$1,923	$0.2	0.72	90%	0
72,100-73,099	$2,032	$0.2	0.72	94%	0
73,100-74,099	$2,147	$0.2	0.72	98%	0
74,100-75,099	$2,159	$0.2	0.72	97%	0

RGW	Proposed Fee ($)	Projected Revenue ($millions)	Equity Ratio	% of Original Fee	Affected Vehicle Owners (thousands)
75,100-76,099	$2,309	$0.3	0.72	103%	0
76,100-77,099	$2,450	$0.3	0.72	108%	0
77,100-78,099	$2,602	$0.3	0.72	114%	0
78,100-79,099	$2,770	$0.3	0.72	120%	0
79,100-80,099	$2,887	$0.3	0.72	124%	0
80,100-90,099	$5,122	$5.6	0.72	193%	1
Total		$75.6	0.48		

Source: CS, Weight-Based Model.

5.0 Issues for Consideration

In this section, we identify some of the issues that arose during both the literature review and analysis processes described above. These issues should be considered when drawing conclusions from our analysis, and some of these issues may warrant future policy analysis.

5.1 Data Availability

Data was available for information on categories of registered vehicles. Given the complexity of Vermont's vehicle registration systems for passenger vehicles and for intrastate commercial vehicles, and Vermont's participation in the International Registration Program for apportioned registration of interstate and Canadian commercial vehicles, it was not possible to obtain individual vehicle information for each registered vehicle, such as the number of axles and the registered location of the vehicle.

Without that information, it was imperative to utilize the assumptions about vehicle class distributions found in the HCAS. Since the HCAS was developed in 2000, it is desirable that the data utilized be updated and the models recalculated before any legislative action is considered, or that Vermont weigh-in-motion data be used as it provides vehicle counts in terms of axles and weight. Using weigh-in-motion data for the analysis would be more effective than using the FHWA default assumptions.

VTrans has accurate data on maintenance expenditures. The definition of "maintenance" however, differs in slight ways in different interpretations, such as the HCAS tool. Reasonable assumptions were made in translating VTrans' known expenditures to those required in the model. For the purpose of this report maintenance refers to state bridge and pavement expenditures. In reality, other VTrans programs, such as highway safety and roadway, may include project components which contribute to highway maintenance. These were not included because a direct link is difficult to establish without an in-depth analysis of hundreds of projects. Such an analysis should be undertaken when VTrans updates its highway cost allocation study. In addition, the data is focused on actual budgeted and expended funds, not total bridge and pavement needs, which are likely significantly higher than what is currently budgeted and expended on state highways and bridges.

5.2 Data Precision, Accuracy, and Sensitivity

The HCAS makes a series of assumptions, some of which are shown in the tables of Section 3, about the distribution of the commercial vehicle inventory within a state. While these assumptions are reasonable and based on previous research and data collection, they still present a negative impact when considering the precision of the results. While we have presented the actual results of the models and Scenarios 1-4 in Section 4, we caution the reader to not think of the results above as point estimates but instead as ranges.

A simple example to illustrate such a phenomenon: Suppose we ask the reader to multiply a number "between 10 and 12" by a number "between 50 and 55." Depending on which numbers the reader picks, the answer could be anywhere from 500 to 660, a 32% range.

Many of the inputs to the HCAS utilized a point estimate of a value, such as the distribution of a 45,000 pound gross vehicle weight vehicle into corresponding vehicle classes. Therefore, the reader should assume that without additional Vermont-specific data collection, there is variance in the generated results.

5.3 Potential Vehicle Owner Adjustments to a Revised Fee Structure

The HCAS model assumes that owner and driver behavior is static, that is to say that changes to cost allocation will not cause changes in behavior. We caution the reader that for substantial changes in cost allocation, this may not be true. One example of a class of vehicle owner whose behavior could possibly change is the out-of-state owner who conducts occasional business in Vermont. Changes in registration fees or fee structures (such as shifting to a distance-based or class-based structure) could change owner behavior about the desirability to operate vehicles in Vermont, especially for travel where both origin and destination are outside of the state.

5.4 Vehicle Class versus Registered Weight

The underlying HCAS analysis considers the class of the vehicle for cost allocation, and then translates allocations back to registered weights through assumptions about distributions. This is an intriguing concept, to our knowledge no state has a fee structure strictly on vehicle class (such as the classes found in Table 3.11). It is unlikely that either VTrans (for intrastate vehicles) or the International Registration Program (for interstate and Canadian commercial vehicles) have sufficient data to model the usage of vehicles by registered class, and field data collection would likely be needed to make sufficient assumptions.

However, it is common practice to both display bridge weight limits by number of axles and to charge tolls based on the number of axles. A registration fee structure could be revised to charge trucks by their GVWR as well as the number of axles.

5.5 Distance Traveled Versus Registered Weight

Similarly, VTrans does not currently have sufficient data to fully consider the impacts of fee structures in the form of “$x plus $y per mile,” and how those parameters would change with registered weight. In the oversize/overweight realm, some states such as Tennessee do charge a “ton-mile” fee on trip permits for overweight vehicles, typically 3-5 cents per mile per ton over legal weight. But we caution the reader that those permits are for known single trips where the purchaser discloses the route utilized, and that while some engineering analysis may have been done to reach these mileage coefficients, some of these fees have been in place for over fifty years.

Any analysis of distance based structures should consider both individual vehicle records as well as the possibility of travel behavior changes. The HCAS tool utilized for this report is not sufficiently robust to take these kind of changes into account even if the underlying data was available.

5.6 Interstate Commercial Vehicle Apportionment and Compliance

The International Registration Plan (IRP) stipulates that commercial vehicles that cross state and national lines have their registration fees apportioned to each jurisdiction that the vehicles uses for travel. In Vermont, a commercial carrier must register a fleet with the IRP if the fleet travels in Vermont and in at least one other state in IRP jurisdiction (with some exceptions). With the IRP, any commercial vehicle that travels through Vermont will end up paying Vermont a portion of Vermont’s registration fee for that weight class. For example, if a diesel-operated vehicle with GVWR of 80,000 pounds has a total mileage of 100,000 miles and 40,000 of those miles occurred on Vermont roads in 2018, then the vehicle owner would pay 40 percent of the Vermont registration for 2019 registration, which would be $1,059.60 (40 percent of $2,649). Compliance

with the IRP is enforced through penalties and auditing. Under audit, carriers registered with the IRP are required to provide documentation of distance records supporting the current and three previous registration years. If a carrier cannot or does not provide adequate records confirming the miles travelled in each jurisdiction, a penalty for having inadequate records may be issued. The first finding of inadequate records results in a penalty of 20 percent additional fees, a second offense results in a 50 percent penalty, and a third offense results in a 100 percent penalty with prohibition from IRP apportionment for one year. In 2019, 3 percent of the 1,874 fleets registered in Vermont in 2018 were audited. Of these audits, 76 percent resulted in changes but 12 percent of the fleets audited had inadequate records resulting in the collection of $5,395.32 in penalties. Nationally, 3 percent of fleets were audited, 85 percent of the audits resulted in changes, and 33 percent of the audits had inadequate assessments and $3.3 million in penalties were collected. Vermont fleets performed better than the national average in audits. The IRP is an apportionment agreement that allows carriers to pay portions of the state registration fees in which they operate, regardless of where the vehicle itself is registered. [14]

Having neighboring states with lower registration fees would not encourage carriers to register their vehicles in another state since with IRP apportionment, a carrier pays registration based on the mileage travelled in each jurisdiction. However, higher fees in Vermont could drive decisions on where fleets are headquartered and how through traffic is routed. Fleets registered in Vermont provide ancillary benefits such as maintenance needs providing repair business to Vermont establishments. Carriers could choose to avoid driving through a state in order to avoid paying fees for that state—this would also reduce the damage on a state's roadways. However, increased shipping fees could be passed onto Vermont residents and businesses, causing overall higher shipping costs for Vermont. Higher shipping costs for companies in Vermont could have a negative impact on business competitiveness. Knowing whether the magnitude of a registration fee will be enough to affect business decisions would require analyses beyond the scope of the authorizing legislation.

5.7 Credentialing Implications

A change in the registration fees by registered fees would have minimal impact on the systems utilized to issue registration credentials to vehicle owners. A change in the overall structure of the fees, either to a class-based system or a distance-based surcharge system, would have substantial impacts. The system which VTrans utilizes for passenger car and intrastate commercial vehicle registrations is of advanced age, and changes to such a system would be very difficult to ascertain and test. Meanwhile, structural changes to fees for intrastate vehicles would require participation from all US states and Canadian provinces, and changes to every one of those systems.

5.8 Compliance and Enforcement Implications

A substantial increase in fees for a particular subset of vehicles is likely to have a corresponding increase of compliance challenges as owners under-register their vehicles' weights, especially for commercial vehicles conducting shorter trips or with a substantial amount of empty back-haul after deliveries. Adding changes to fee structure itself, such as a distance surcharge or a fee for different numbers of axles, is likely to exacerbate compliance challenges as well as adding in a layer of accidental non-compliance by owners who do not understand the revised fee structure.

[14] https://dmv.vermont.gov/sites/dmv/files/documents/CVO-181-IRP_IFTA_Manual.pdf

Enforcement is the ability of Vermont's law enforcement agencies to identify the vehicle owners who have either inadvertently or deliberately failed to comply with any laws involving the revised fee structure. As compliance decreases, the need for increased effective enforcement increases, and thus the need for enforcement labor increases. One example of an enforcement challenge is when conducting a roadside traffic stop or crash investigation. Proficiency with portable commercial vehicle scales is required if concerns about registered versus actual weight arise, and may require enforcement officers with proficiency in utilizing this equipment. Wide variations in fees or fee structures for higher registered weight will put more pressure on roadside enforcement personnel should non-compliance increase.

5.9 Buses

The HCAS tool utilized in the analysis methodology does not take bus types into account. There are three categories of buses which will need to be considered: school buses, urban transit buses, and long-distance passenger buses. The latter category are typically interstate registered vehicles and the former categories are intrastate registered vehicles. All three types of buses have very different loading factors when compared to trucks of similar weight, and their parameters are likely to be in contradiction to the inputs found in the HCAS tool. The operating characteristics of these three types of commercial vehicles are sufficiently different as well, most specifically the operation weights at various load factors and the amount of driving done on state-maintained versus locally-maintained roads. As a result, they cannot realistically either be combined into one category, or combined in an maintenance equity based fee structure.

5.10 Issue Summary

None of these issues invalidates the validity of evaluating potential fee changes or fee structure changes based on how registered weight affects maintenance costs. But each of these issues poses a confounding topic that should be considered in the deliberation process, and several of these issues require additional data to properly evaluate their potential impacts.