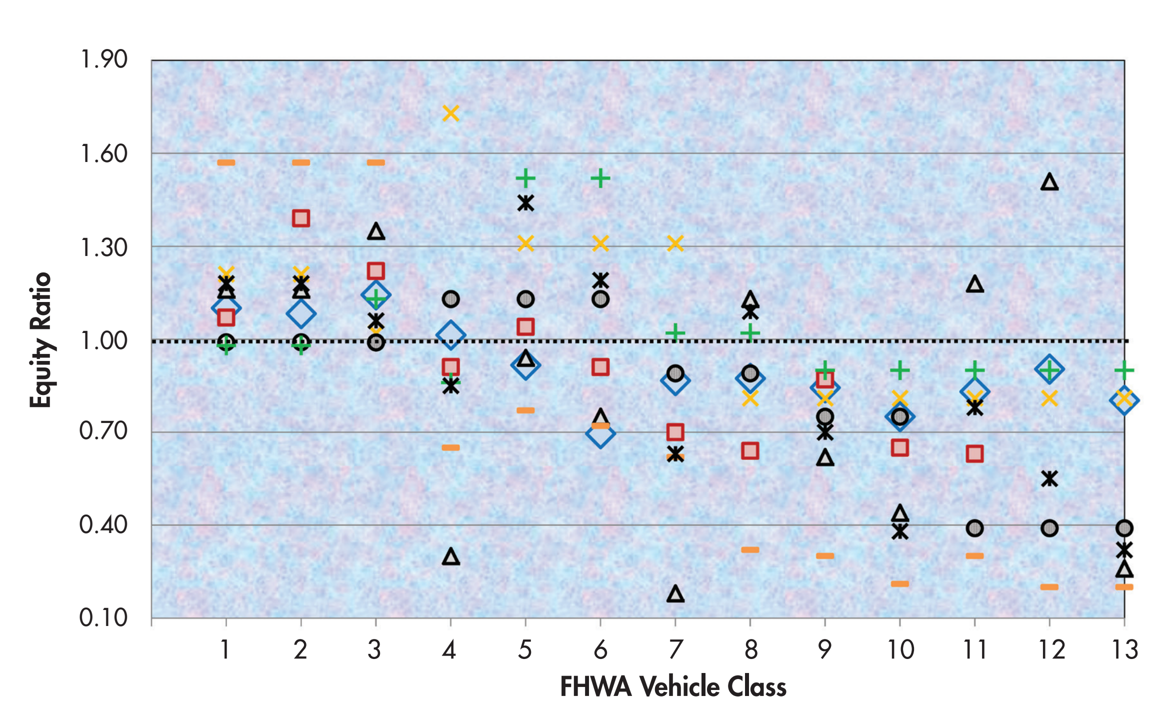
JOINT TRANSPORTATION RESEARCH PROGRAM

INDIANA DEPARTMENT OF TRANSPORTATION AND PURDUE UNIVERSITY

Indiana State Highway Cost Allocation and Revenue Attribution Study and Estimation of Travel by Out-of-State Vehicles on Indiana Highways



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JOINT TRANSPORTATION RESEARCH PROGRAM

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16. Abstract

This study was commissioned by INDOT to investigate the cost responsibility and the revenue contribution of highway users with regard to the upkeep of Indiana's state and local highway infrastructure (pavements, bridges, safety assets, and mobility assets). The costs consisted of expenditures on construction, preservation, maintenance, and operations of the highway infrastructure. For revenues, user and non-user sources were considered. The highway users were represented by the 13 FHWA vehicle classes, and the study was based on 2009-2012 data on expenditures and revenues. The study framework duly recognized the dichotomy between attributable and common costs. For allocating the attributable costs to the vehicle classes, ESALs, AASHTO loading equivalents, and PCEs were used; for allocating common costs, VMT was used. For each vehicle class, the share of revenue contribution was compared to the share of cost responsibility to determine respective equity ratios and thus to ascertain the extent to which vehicles in each class may be underpaying or overpaying their cost responsibilities at the current time. The study also determined the distribution of fuel purchases and travel by out-of-state vehicles on Indiana's highways; this analysis was required to further refine the results of the cost allocation and also to quantify the magnitude of any imbalance between the out-of-state travel and share of consumption on Indiana's infrastructure and the revenue from such out-of-state vehicles.

The outcome of this research is a systematic documentation of the sources and extents of highway revenues and the areas of expenditures at the local and state levels in Indiana. Pavement and bridge expenditures were found to have a dominant share of the overall expenditures on Indiana's highway system. Classes 2 (automobiles) and 9 (5-axle combination trucks) were found to have a dominant share of the cost responsibilities. It was determined that the user revenue sources contributed approximately 63.5% of the total state funding for highway expenditures and 36.5% were from non-user revenue sources. The inability of user revenue sources to cover the total highway expenditure and the consequent partial reliance on non-user sources seem to constitute a rather unstable funding situation particularly because the non-user sources are characterized by significant variability. On the basis of the expenditures and revenues associated with the various user groups (vehicle classes) over the analysis period, this study found that inequities exist, albeit in varying degrees, among the highway user groups. Of the 13 vehicle classes, classes 1–4 were found to be overpaying their cost responsibilities while classes 5–13 are underpaying. For example, vehicle class 2 is overpaying its cost responsibility by 10% while vehicle class 9 is underpaying by 19%. The results of the equity analysis are generally consistent with those of studies carried out at other states. Also, it was estimated that the travel by out-of-state vehicles on Indiana's interstates, NHS non-interstates, non-NHS and local roads are 21%, 10%, 9%, and 7% respectively, of the total travel as a percentage of VMT on those families of highway systems.

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EXECUTIVE SUMMARY

INDIANA STATE HIGHWAY COST ALLOCATION AND REVENUE ATTRIBUTION STUDY AND ESTIMATION OF TRAVEL BY OUT-OF-STATE VEHICLES ON INDIANA HIGHWAYS

This study was commissioned by INDOT to investigate the cost responsibilities and revenue contributions of highway users with regard to the upkeep of the highway infrastructure. The costs consisted of expenditures on construction, preservation, maintenance, and operation of the infrastructure at both state and local levels. For revenues, user and non-user sources at federal, state, and local levels were considered. User sources included fuel tax, motor carrier surcharge tax, motor carrier fuel use tax, vehicle registration fees, driver license fees, taxes on truck and trailer sales, tires, and heavy vehicle use, county motor vehicle excise surtaxes, and wheel taxes. The asset types included pavements, bridges, and safety and mobility assets. The highway users were represented by the 13 FHWA vehicle classes, and the study was based on 2009–2012 data on expenditures and revenues. The study framework duly recognized the dichotomy between attributable and common costs: for allocating the attributable costs to the vehicle classes, ESALs, AASHTO load equivalency factors, and PCEs were used; for allocating common costs, VMT was used. For each vehicle class, the share of revenue contribution was compared to the share of cost responsibility to determine the equity ratio and thus to ascertain the extent to which vehicles in each class may be underpaying or overpaying their cost responsibilities. The study also determined the distribution of fuel purchases and travel by out-of-state vehicles on Indiana highways.

Pavement and bridge expenditures were found to represent a dominant share of the overall expenditures. With regard to vehicle class, classes 2 and 9 were found to dominate the cost responsibility. Of the total revenue, approximately 64% was from user sources while 36% were from non-user sources. On the basis of the expenditures and revenues associated with various vehicle classes, inequities were found to exist, albeit in different directions and degrees, among the highway user groups. Of the 13 vehicle classes, classes 1–4 were found to be overpaying their cost responsibilities while classes 5–13 are underpaying. For example, vehicle class 2 is overpaying its cost responsibility by 10% while vehicle class 9 is underpaying by 19%. The results of the equity analysis are consistent with those of studies carried out at other states. It was also estimated that the travel by out-of-state vehicles on Indiana's interstates, NHS non-interstates, non-NHS and local roads, as a percentage of total travel on these road classes, is approximately 21%, 10%, 9%, and 7% respectively, of the total travel as a percentage of VMT on those families of highway systems.

In Indiana, as in most other states, highways are financed primarily by taxes and fees paid by the state's highway users. However, in recent years, funding from user fees had declined steadily and a significant portion of the highway had to be augmented by non-user sources of revenue, such as federal economic stimulus and Indiana's Major Moves funds. The present study quantifies the extent of non-user revenues needed to support highway construction and maintenance activities at the state and local levels. The results of the study can be used to revise the existing user fee structure and or to assess new sources of revenue. A basic principle of user-fee structure design is that efforts must be made to achieve not only equity among the users but also adequacy of the revenue amount. Therefore, the study results can be used directly to perform an evaluation of the alternatives for restructuring the user fees in Indiana. The information of the extent of travel by out-of-state vehicles on Indiana highways can serve as a critical input in reviewing any change in user fees by addressing the question of whether revenues from any individual highway revenue mechanism should come solely from Indiana residents or all road users in the Indiana.

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PART 1. BACKGROUND

1.1 Study Motivation and Objectives

The current federal transportation act, Moving Ahead for Progress in the 21st Century (MAP-21), requires the USDOT to establish performance measures for state highway agencies (SHAs) that must be met and reported biennially to the USDOT as a requirement for continued federal aid funding for surface transportation projects. To achieve these targets, SHAs are required to conduct a biennial assessment of revenues obtained directly or indirectly from users and other sources. This assessment is important for determining the sources and extents of such revenues and the areas of expenditures as required at the federal level. Also, this information can assist SHAs in the restructuring of existing user-based tax structures in order to ensure revenue and expenditure equity among highway infrastructure users. A basic principle of user tax equity and a balanced tax structure is to ensure that the revenue derived from each user is equal to the public costs of providing highway services to that user. Although, in practice, it is difficult to achieve such a balance, an examination of the relationship between highway service costs and highway use is the first step in designing an equitable tax structure. In Indiana, as in most states, the construction and maintenance of that state's roads and highways are financed primarily by taxes and fees paid by the state's highway users. Secondly, periodic studies of highway cost allocation for Indiana's state highways are needed in order for INDOT to stay current with evolving and emerging developments in expenditure patterns, traffic distributions, and construction technology and materials. Only a detailed analysis of the costs and revenues associated with all vehicle classes can ensure that fair and equitable pricing and financing can be achieved to deliver efficient and equitable highway services.

A companion issue addressed in this highway cost and revenue study is an assessment of the extent of travel by out-of-state vehicles on Indiana highways; such analysis can serve as a critical input in the assessment of highway financing equity by addressing the question of whether any additional highway revenue should come from general revenue sources contributed solely by Indiana residents or from road users through fuel taxes and other road-use-related fees.

Therefore, the primary objective of this study is to compare the cost responsibility and the revenue contribution of each category of highway users (individual vehicle classes) for the construction, preservation, maintenance, and operation of highways in Indiana on the basis of recent expenditure patterns and revenue types. An additional objective is to determine the distribution of fuel purchases and travel by out-of-state and in-state vehicles on Indiana's highways.

1.2 Report Organization

This report has two volumes each with 8 parts. Volume I presents an overview of the literature, methodology and key findings. Volume II presents detailed descriptions of the data, methodology, analysis and results.

Part 1 of the report details the motivation and objectives of the current study and presents a review of the relevant literature. Part 2 describes how the system usage, in terms of traffic volumes, classifications, and weights, were assessed. Parts 3 and 4 present the expenditures for state and local routes, respectively. Part 5 presents the revenue analysis. The results obtained from Parts 3, 4, and 5 were used to carry out the equity analysis which is described in Part 6. Part 7 presents the data collection, analysis, and results for the estimation of travel by out-of-state vehicles. Part 8 is a summary.

1.3 Review of the Literature

The study examined the methodologies and outcomes from the past cost allocation studies at the federal and state levels. The literature review on VMT estimation methodologies was helpful in identifying which methods are appropriate for estimating out-of-state vehicle travel. For pavement cost allocation, Table 1.1 presents a synthesis of the methodologies used in the literature. Some of the most common pavement cost

TABLE 1.1
Summary of Major Studies on Highway Pavement Cost Allocation Methodologies.

Study	New-Pavement Cost Allocation	M&R Cost Allocation for Existing Pavements
1965 Federal HCAS	Traditional Incremental Method	VMT or incremental method Maintenance cost not considered
1982 Federal HCAS	Minimum Pavement Thickness Method	Individual Distress Models Maintenance cost not considered
1984 Indiana HCAS	Thickness Incremental Method	Performance-Based Approach Concept of PSI—ESAL loss was introduced Costs estimated using proportionality assumption
1997 Federal HCAS	Minimum Pavement Thickness Method	NAPCOM—Individual Distress Models
1999 Arizona HCAS	Simplified Model for HCASs (Arizona SMHCAS), Carey (2001)	
2013 Oregon HCAS	Minimum Pavement Thickness Method	NAPCOM—Individual Distress Models

TABLE 1.2
Summary of Major Studies on Highway Bridge Cost Allocation Methodologies.

State (Year)	Cost Category	Methodology and/or Cost Allocator
INDIANA (1984)	Bridge Construction Superstructure	Incremental design (heavier to lighter)
	Pile	Length related to loading (25% load-related)
	Pier and abutment	Related to deck width
	Other substructure components	Common costs
	Excavation and backfill	Related to deck width
	Drainage pipe	Related to deck width
	Railing	75% to GVW
	Miscellaneous	Common costs
	Bridge Replacement	Same as bridge construction
	Bridge Rehabilitation	Same as bridge construction
	Culvert Construction	Common costs
	Sign Structure Construction	Related to vehicle size
FHWA (1997)	Bridge Construction Construction Preliminary engineering Right of way Other	 Incremental design / VMT Common cost / VMT Common cost / VMT Common cost / VMT
	Bridge Replacement	Load-related (deficient load-bearing capacity): Incremental design using special bridge replacement function Non-load-related: VMT
	Major Bridge Rehabilitation	13 types of rehabilitation considered Load-related: Incremental design Non-load-related: VMT
	Other Bridge Costs	Common cost / VMT
ARIZONA (2000)	Capacity-Driven Expenditures (Urban)	VMT
	Strength-Driven Expenditures (Rural)	ESAL-Mile
	Common Costs	VMT
TEXAS (2002)	Bridge Costs (construction, rehabilitation, maintenance)	Incremental design 5 climatic regions VMT
MARYLAND (2009)	New Bridge Bridge Replacement	Load-related: Incremental design PCE-miles
	Major Bridge Rehabilitation	
	Minor Rehabilitation and Repair	PCE-miles
NEVADA (2009) & IDAHO (2010)	New Bridge	Incremental design
	Bridge Replacement	Load-related (deficient load-bearing capacity): Incremental design Allocated to vehicles that operate at weights over the load-bearing capacities of the bridges to be replaced
	Bridge Rehabilitation	Load-related: VMT by weight Non load-related: VMT by vehicle class

TABLE 1.2
(Continued)

State (Year)	Cost Category	Methodology and/or Cost Allocator
MINNESOTA (2012)	New Bridge Bridge Replacement	Incremental design / PCE-miles Load-related (based on inventory rating): Incremental design / PCE-miles
	Bridge Repair Special Bridge	Load-related: Incremental design
OREGON (2013)	New Structures	Bridge Split
	Replacement Structures	Bridge Split
	Structures Rehabilitation	Bridge Split
	Structures Maintenance	All VMT
	Bridge—All Vehicles Share (no added capacity)	All VMT
	Bridge—Over 10,000 Vehicles Share	Over 10 VMT
	Bridge—Over 50,000 Vehicles Share	Over 50 VMT
	Bridge—Over 80,000 Vehicles Share	Over 80 VMT
	Bridge—Over 106,000 Vehicle Share	Over 106 VMT
	Bridge—All Vehicles Share (added capacity)	Congested PCE
	Bridge Replacement with Capacity	Bridge Split

allocators used in past highway cost allocation studies include axle-miles of travel, axle-load-miles, ton-miles, and ESAL-miles. One ESAL is the pavement damage caused by a single axle load at 18,000 lbs. One ESAL-mile is equivalent to one single axle load traveling over one mile.

For bridge cost allocation, Table 1.2 presents a synthesis of bridge cost allocation methodologies that have been used in the literature. Generally, there seems to be relatively little advancements in the state of the art regarding bridge cost allocation methodology. For allocating the costs of new bridge construction, the incremental method has widely been used. In this procedure, the first cost increment for a new bridge identifies the cost of building the bridge to support its own weight, withstand other non-load-related stresses, and carry the lightest vehicle traffic only. This common cost is assigned to all vehicle classes on the basis of their VMT. Subsequent increments identify the added cost of accommodating additional weights. For bridge rehabilitation cost allocation, past studies considered load and non-load shares for major rehabilitation while minor rehabilitation was assumed to be non-load-related and thus allocated using VMT.

For cost allocation of expenditures related to safety and mobility assets on the highway, most past studies considered the agency costs related to safety and mobility assets as common costs and therefore allocated these costs among the various highway user groups (vehicle classes) on the basis of their contributions to VMT and/or VMT weighted by their passenger car equivalent (PCE). VMT estimation techniques include those based on traffic data and those not based on traffic data.

PART 2. ASSESSMENT OF SYSTEM USAGE

A reliable assessment of system usage is an indispensable component of cost allocation studies. In the current study, highway system usage is quantified in terms of the vehicle miles traveled (VMT) and the vehicle weight (measured either in gross vehicle weight (GVW), or equivalent single axle loads (ESAL)).

The source data for the current study includes 2009–2012 AADT based on short-term traffic counts for each state route segment and a sample of local (county and municipality) segments. In addition to the AADT data, continuous counts generated from automated traffic recorder (ATR) and weigh-in-motion (WIM) detectors were used to estimate location-specific and road functional class-specific distributions of vehicle class and weight for each of the 13 FHWA vehicle classes (Figure 2.1).

For all state route segments and a sample of local route segments, data on the following traffic characteristics were collected: location/district, route, starting milepost, ending milepost, AADT, truck AADT, road functional group, and national highway system (NHS) classification. The traffic database contained over 8,000 route segments with corresponding short-term traffic counts; these included over 6,000 mainline route segments covering approximately 11,000 centerline-miles and 2,000 ramp segments. For the state route segments, the VMT values were determined on the basis of segment-specific traffic counts. The distribution of vehicle classes at each segment was

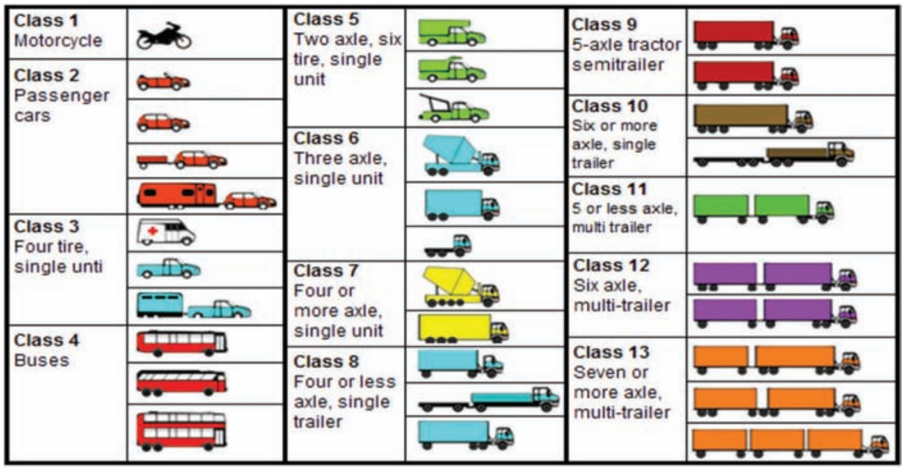

Figure 2.1 FHWA vehicle classification system. (Source: FHWA Office of Highway Policy Information.)

interpolated from traffic stream data obtained from the limited number of continuous count stations. Individual segments were then summed to provide an assessment of the total state route VMT for each vehicle class.

The total VMT for all state routes is presented in Table 2.1 (more detailed results are presented in Volume II of this report). The total VMT for local routes was estimated as the difference between the total state route VMT and the estimated state-wide VMT back-calculated from data on fuel sales and fleet fuel efficiency. With regard to the local traffic stream characteristics, the number of local route segments with AADT data was rather limited; therefore, these segments collectively served as a sample for determining the traffic stream characteristics for the entire population of local routes.

Overall, from the traffic volume analysis, and with data on the inventory sizes in terms of mileage of highway segments, it was determined that the amount of travel on the state highway system in 2012 is as follows: NHS-Interstate–16.7 billion VMT; NHS-Non-Interstate–12.7 billion VMT; Non-NHS–9.8 billion VMT. The total travel on the local highway system in 2012 is 31.1 billion VMT. Table 2.1 presents the road inventory and annual VMT by road jurisdiction and functional class.

Lastly, the distribution of gross vehicle weight (GVW) was estimated for interstates and other principal arterials from data obtained from 33 WIM locations in Indiana. FHWA vehicle class 9 (5-axle, 2-unit trucks) comprise the majority of the truck traffic stream for both road functional classes. The GVW distribution for class 9 trucks is characterized by two peaks: the first peak shows that 7.7% of the trucks fall into the 32–36 kip bin which corresponds to a typical, unloaded class 9 vehicle; and the second peak indicates that 9.4% are running at or above 80 kips, which corresponds to a fully-loaded truck. For other principal arterials, the peak in the 32–36 kip range is more pronounced at 11.8%, meaning more trucks are running unloaded. The detailed results for all the heavy vehicle classes are presented in Volume II of this report.

PART 3. COST ALLOCATION FOR STATE ROUTES

The study analyzed the trends in the state highway pavement and bridge expenditures, and the total cost responsibility and average unit cost for each vehicle class and expenditure type were established. The detailed results for all expenditure types are provided in Volume II of this report.

3.1 Pavement Expenditures on State Routes

3.1.1 Allocation of Expenditures on New Pavement Construction

The expenditures associated with new pavement construction are categorized as: (a) pavement-related expenditures, (b) grading and earthwork expenditures, (c) shoulder expenditures, (d) right-of-way (ROW)

TABLE 2.1
Annual VMT by Road Functional Class.

	Centerline-Miles				Annual VMT (billions)			
	2009	2010	2011	2012	2009	2010	2011	2012
State: NHS-Interstate	1,418.0	1,443	1,445	1,525	15.68	15.70	16.62	16.69
State: NHS-Non-Interstate	3,364.4	3,307.3	3,241.1	3,108	14.96	14.38	13.15	12.67
State: Non-NHS	6,770.6	6,787.8	6,840.8	6,962	8.06	8.06	8.55	9.81
Local	84,617	84,617	84,689	84,848	32.66	35.61	34.39	32.07
Total	96,170	96,155	96,216	96,443	71.36	73.75	72.70	71.24

expenditures, (e) drainage and erosion control expenditures, and (f) miscellaneous.

ROW, drainage and erosion control, and miscellaneous expenditures are considered common costs and therefore were allocated to the vehicle classes on the basis of their VMT contributions. For new pavement construction expenditures, the methodology developed by the 1997 and 2000 FHWA HCAS was adopted and the analysis was conducted on a project-by-project basis. The pavement-related expenditures were separated into (1) the expenditures of a base facility which serves as a "platform" for the remaining facility, and (2) the expenditures of the remaining facility which provides the strength to carry the projected traffic loading over the pavement life. The base facility expenditures were attributed to vehicle classes on the basis of VMT, after this was adjusted for vehicle width, while the expenditures on the remaining facility were attributed on the basis of ESAL-miles (ESAL-miles were also adjusted for vehicle width). This approach used AASHTO's 1993 Guide for Design of Pavement Structures' pavement design method to assign these costs to the vehicle classes. This design method, rather than the MEPDG, was considered appropriate for this study because the new pavements constructed during the period 2009–2012 were planned and designed several years earlier using the design principles of AASHTO (1993); secondly, to date, no HCAS has incorporated MEPDG for attributing pavement expenditures in spite of earnest efforts by a number of researchers in that direction.

3.1.2 Allocation of Expenditures on Pavement Rehabilitation

For allocating pavement rehabilitation costs, the expenditures associated with such contracts were divided into the following categories: (a) pavement-related expenditures, (b) grading and earthwork expenditures, (c) shoulder expenditures, (d) drainage and erosion control expenditures and (f) miscellaneous expenditures. Preservation needs are driven by pavement damage due to traffic and climatic conditions. Thus, a portion of the pavement-related expenditures is attributed to load (traffic) using FHWA's NAPCOM models and the remaining attributed to non-load and therefore allocated to vehicles on the basis of their respective VMTs.

3.1.3 Allocation of Expenditures on Pavement In-House Maintenance

The costs associated with in-house pavement maintenance are divided into pavement-related expenditures and shoulder expenditures. The expenditures were divided into load-related and non-load expenditures for the appropriate allocation of these costs. The load and non-load splits of pavement damage developed by the 1984 Indiana HCAS were adopted in the present study. The portion of the in-house pavement-related maintenance expenditures attributed to non-load-related factors was treated as a common cost and therefore was allocated on the basis of VMT. The load-related maintenance expenses were allocated on the basis of ESAL-miles. Shoulder expenditures were allocated on the basis of PCE-miles.

3.1.4 Allocation of Other Pavement Expenditures

Pavement expenditures that are not related to new road construction, pavement rehabilitation, or pavement maintenance (e.g., roadside work and facilities, demolition, ITS-related pavement work, slope correction, and drainage ditch correction contracts) were all placed in a single category referred to as "other pavement project expenditures." These pavement expenditures were considered as a common cost and therefore were allocated among the vehicle classes on the basis of their VMT contributions.

3.1.5 Results

Overall, it was determined that the pavement cost responsibility distributions varied significantly among the different highway functional classes and vehicle classes. Vehicle class 2 had the highest cost responsibility with respect to pavement expenditures because of their higher volume on State highways contrary to the remaining vehicle classes. Of the truck classes, vehicle class 9 was observed to have the highest cost responsibility. For example, Figure 3.1 shows that for state routes, on average, vehicle classes 1–3 had the lowest unit cost ($/VMT) while vehicle class 7 had the highest unit cost.

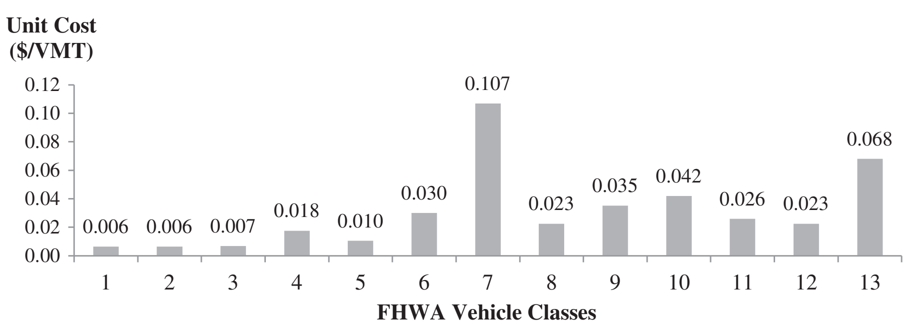

Figure 3.1 Average annual unit cost for pavement expenditures on state routes, 2009–2012.

3.2 Bridge Expenditures on State Routes

Bridge expenditures are allocated to different vehicle classes because they induce different live-load moments (and thus, different stress levels) in load-bearing members of a bridge. As the live-load moments increase, stronger load-bearing members are required to keep strains within acceptable limits. Thus, bridge construction becomes more costly when heavier vehicles must be accommodated. Each vehicle class is made to pay its share of the costs incurred to accommodate the stress corresponding to its weight. Also, after construction, heavier vehicles tend to contribute more to bridge wear and tear.

3.2.1 Correlation between AASHTO Vehicles and Study Vehicles (FHWA Vehicles)

As the bridges are designed according to AASHTO design vehicles, the correlation between AASHTO vehicles and the FHWA vehicles is a key issue in the analysis. The AASHTO standard trucks specified in the AASHTO bridge specification are trucks with configurations that would simulate the most severe live loads on a structure. The trucks are designated either with an H prefix followed by a number indicating the total weight (tons) of a two-axle single-unit truck, or with a HS prefix followed by a number indicating the weight (tons) of a tractor-trailer combination truck. However, in the present study, vehicles were classified using the FHWA vehicle classification scheme. The detailed steps in developing such the FHWA-AASHTO correlation are presented in the appendix to this report.

3.2.2 New Bridge Construction Cost Allocation

The incremental method was used in the present study for allocating the costs of new bridge construction. In this procedure, the first cost increment, which is the cost of building a new bridge to support its own weight and to carry the lightest vehicle traffic (Weight Group 1) only, was assigned to all vehicle classes on the basis of the VMT share of each vehicle class. Next, the second cost increment, which identifies the additional cost of building the bridge to accommodate the second lightest weight group (Group 2), was assigned to all weight groups excluding the lightest group (Group 1) based on the relative shares of VMT of Group 2 and above. The second cost increment was assigned to Group 2 and above instead of Group 2 only because all the heavier groups also benefit from this cost increment. Then, similarly, the third cost increment, which is the additional cost to accommodate the third lightest weight group (Group 3), was assigned to all weight groups excluding Group 1 and 2, based on the relative shares of VMT of Group 3 and above. This process continued until the last cost increment was assigned to the heaviest weight group.

3.2.3 Bridge Replacement Cost Allocation

For allocating bridge replacement costs, the bridge sufficiency rating formula was used. The sufficiency rating of a bridge is low when the bridge has inadequate load-bearing capacity or other problems such as inadequate width. For vehicles whose loading regimes exceed the bridge load-bearing capacity, the fraction of costs to be allocated is calculated as the ratio of the partial sufficiency rating reduction (that is, arising from lowered load-bearing capacity) to the total reduction in sufficiency rating. The detailed methodology is presented in Volume II of this report.

3.2.4 Bridge Rehabilitation Cost Allocation

The ratio of load-related and non-load-related shares of bridge rehabilitation expenditures is a key input in bridge rehabilitation cost allocation. In the present study, the following load-related shares, which represent a combination of the 1997 FHWA study and 1999 Oregon study estimates, were used: deck overlay – 70%, other superstructure rehabilitation – 30%, substructure rehabilitation – 15%, bridge painting – 0%. The share of load-related rehabilitation costs was allocated to all vehicle classes following the same procedures that were developed for new bridge construction. The non-load share was allocated (across the vehicle classes) as a common cost using VMT as the allocator.

3.2.5 Results

It was found that the bridge cost responsibility distribution varies significantly among the different highway functional classes and vehicle classes. Vehicle class 2 had the highest cost responsibility with respect to bridge expenditures because of their higher volume on state routes. Of the truck classes, vehicle class 9 was observed to have the highest cost responsibility. With respect to bridge unit cost (i.e., the cost incurred to bridges for every mile driven on state routes), vehicle classes 1–3 had the lowest unit cost (approximately 0.3 cents/VMT) while vehicle class 13 had the highest unit cost (approximately 3.5 cents/VMT). Figure 3.2 presents the average annual unit cost ($/VMT) for bridge expenditures on state routes during the study period (2009–2012). Volume II of this report presents more detailed results of the analysis.

3.3 Safety, Mobility, and Other Expenditures

3.3.1 Methodology

The expenditures on safety, mobility, and other related work are typically included and analyzed as common costs in most highway cost allocation studies. However, in some studies, certain expenditure items, such as mobility and right-of-way, were considered as being related to vehicle size (e.g., PCE-weighted VMT is typically used as the allocator for such costs that are attributable to vehicle size). In the present study, both VMT and PCE-weighted VMT (PCE-miles) were used as allocators with respect to different expenditure categories.

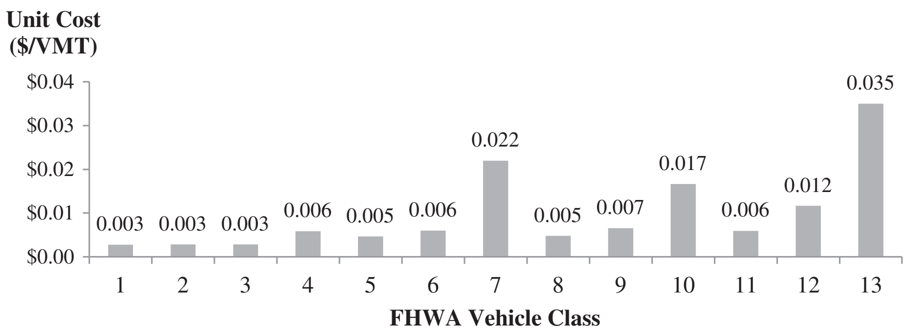

Figure 3.2 Average annual unit cost for bridge expenditures on state routes, 2009–2012.

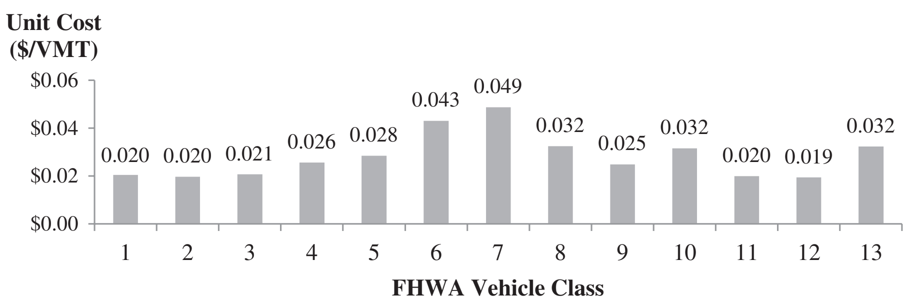

Figure 3.3 Average annual unit cost for safety, mobility and other expenditures on state routes, 2009–2012.

3.3.2 Results

It was found that the cost responsibility and unit cost ($/VMT) distributions varied among the different highway classes and vehicle classes. Specifically, the unit cost for Non-NHS was found to be higher than those of the other two highway functional classes. Smaller vehicles were found to have a lower unit cost ($/VMT) because certain costs were allocated as vehicle size-attributable costs using PCE-miles as the allocator. Figure 3.3 presents the average annual unit cost ($/VMT) for safety, mobility and other expenditures on state routes during the study period (2009–2012). More detailed analysis and results can be found in Volume II of this report.

PART 4. COST ALLOCATION FOR LOCAL ROUTES

There are three main sources of data related to expenditures on local routes: County Operational Reports, City Operational Reports, and the INDOT Site Manager database. Data from all the three sources were used to carry out the cost allocation for local routes. For counties lacking expenditure data, the average expenditures from all other "similar "Indiana counties with data were used to impute the missing data. Only 40 cities submitted City Operational Reports to LTAP during 2009–2012; for cities lacking full information but with at least one report submitted to LTAP, the average of the reported expenditures was used to impute the missing data. The expenditure items of interest extracted from the reports were the "Maintenance and Repair" and "Construction and Reconstruction" expenditures. For each of these expenditure items, there were four listed funding sources: (1) Motor Vehicle Highway Fund, (2) Local Road and Street Fund, (3) Cumulative Bridge Fund, and (4) Other Funds.

4.1 Pavement Expenditures on Local Routes

4.1.1 Allocation of New Road Construction Expenditures

The general methodology used for the state route cost allocation was adopted here albeit with some modifications. For allocating the new road construction expenditures, the facility was divided into a base facility and a remaining facility. The base facility expenditures were attributed using VMT shares, except shoulder expenditures which were attributed using PCE-miles. The remaining expenditures were allocated to vehicle classes on the basis of ESAL-miles.

4.1.2 Allocation of Road Rehabilitation Expenditures

Using the methodology for the state highway cost allocation with appropriate adjustments due to data limitations, the load-related expenditure percentages presented in the 1997 FHWA HCAS were adopted for the present study and were used to estimate the load-related and non-load-related expenditures. The portion of the expenditures attributed to non-load-related factors was allocated on the basis of VMT. On the other hand, the portion of the expenditures attributed to load-related factors was allocated using the distress-based NAPCOM cost model introduced by FHWA (1997).

4.1.3 Allocation of Road Maintenance Expenditures

As was done for the state highway system, for the local roads, a portion of the pavement-related expenditures was attributed to load-related factors (traffic), and allocated on the basis of ESAL-miles; the remaining part was attributed to non-load-related factors (weather and climatic conditions, for example), and allocated on the basis of VMT. The load-related expenditure percentages presented in the 1984 Indiana HCAS were adopted by the present study and were used to estimate the load-related and non-load-related shares of pavement expenditures.

4.1.4 Allocation of Traffic and Safety Expenditures

Traffic and safety projects were incorporated into the road expenditures category for the local route cost allocation due to the classification of expenditures that appears in county and city operational reports. These expenditures were treated as common costs and thus were allocated on the basis of VMT.

4.1.5 Results

Figure 4.1 presents the average unit cost per vehicle class for all road expenditures on local routes for 2009–2012. For example, vehicle classes 7 and 13 were found to have an average unit cost of $0.504 per VMT which is the highest among the 13 vehicle classes. This result suggests, for example, that an average vehicle of class 7 or 13 traveling one mile on a local route consumes $0.504: this amount represents its share of the responsibility of the total cost of new road construction, road rehabilitation, and maintenance, and traffic and safety projects that were implemented on local routes within the analysis period. Vehicle classes 1–3 were found to have the least unit cost, on average.

4.2 Bridge Expenditures on Local Routes

From a theoretical perspective, the same methodology used for allocating state route expenditures is applicable to the local route expenditures. However, due to the lack of detailed information for local projects, a few assumptions were made in order to apply the former's methodology to local routes.

4.2.1 Analysis for the Different Project Types

The bridge-related expenditures for local routes were separated into load-related costs and common costs and therefore analyzed differently. The load-related costs included the expenditures on bridge construction and reconstruction and an estimated proportion of the load-related bridge rehabilitation expenditures. The common costs consisted of the bridge maintenance and repair expenditures and an estimated proportion of the non-load-related bridge rehabilitation expenditures.

In the analysis for bridges on local routes, replacement and reconstruction were treated the same way as new construction. This was because the inventory rating and sufficiency rating information, which was typically needed in the methodology for bridge replacement cost allocation, were not available in the operational reports provided by local authorities.

In the study methodology developed for state routes, different incremental factors were established for bridges with different material types, structure types, and span lengths. However, such information was unavailable for local projects in the operational reports; therefore, the analysis was carried out using the proportions of the different bridge types and the average span lengths.

4.2.2 Results

It was found that vehicle classes 2 and 3 have the highest cost responsibility (almost 85% of total costs) in terms of bridge-related expenditures on local routes primarily due to their higher VMT on local routes compared with other vehicle classes. With respect to the unit cost, vehicle classes 12 and 13 were found to assume significantly higher unit costs (0.42 and 0.39 $/VMT, respectively). Apart from the fact that these vehicle classes are associated with the heaviest loads, their relatively lower VMTs on local routes is a plausible reason for their higher unit costs compared with other vehicle classes. Figure 4.2 presents the average annual unit cost ($/VMT)

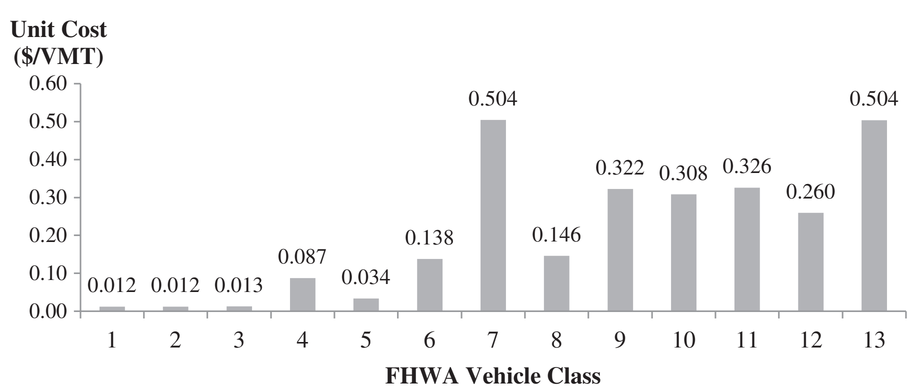

Figure 4.1 Average annual unit cost ($/VMT) for road expenditures on local routes, 2009–2012.

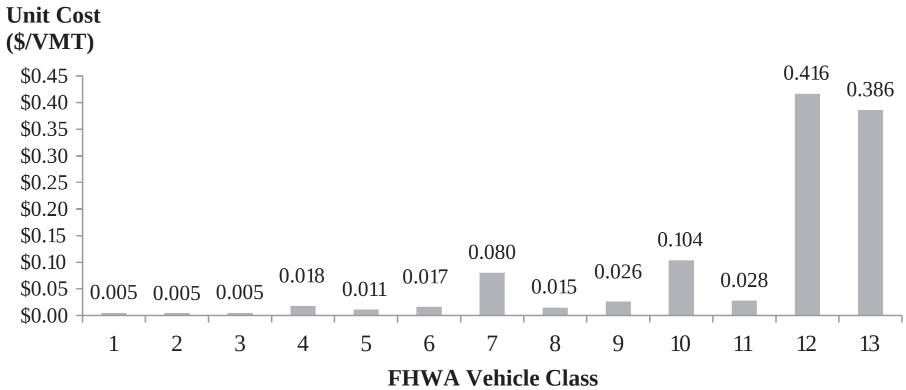

Figure 4.2 Average annual unit cost ($/VMT) for bridge expenditures on local routes, 2009–2012.

for bridge expenditures on local routes during the study period (2009–2012). More detailed analysis and results can be found in Volume II of this report.

PART 5. REVENUE ANALYSIS

5.1 Background

Highway revenues are used to fund the construction, reconstruction, rehabilitation, and maintenance of Indiana state and local roads. For the purposes of the present study, two revenue sources are considered – user and non-user sources; also, the highway user revenue sources include: gasoline tax, diesel tax, motor carrier surcharge tax, motor carrier fuel use tax, vehicle registration fees, driver license fees, international registration plan, oversize/overweight permit fees, commercial vehicle excise tax, wheel tax, motor vehicle excise tax and excise surtax, heavy vehicle use tax, tax on sales of trucks and trailers, and tax on tires. Highway non-user revenue sources include: Federal Stimulus (funds from the American Recovery and Reinvestment Act of 2009), toll lease money (Major Moves), General Fund transfers, and other miscellaneous taxes including property tax, income tax, and state court fees.

Data on highway user and non-user revenues from fiscal years 2009 to 2012 were collected from the Indiana Department of Transportation (INDOT), Indiana Department of Revenue, Annual Operational Reports from counties and cities, and the Indiana Handbook of Taxes, Revenues, and Appropriations and the Highway Statistics series published by the FHWA. Table 5.1 presents the historical total revenues for Indiana's highway construction and preservation (rehabilitation and maintenance) activities from 2009 to 2012.

TABLE 5.1
Four-Year Total Annual Highway Revenues in $ Millions: FY 2009–FY 2012.

Revenue Source	Level				%
	Federal	State	Local	Total	
User	905.95	1,192.01	69.47	2,167.42	63.5
Non-User	154.31	644.70	446.90	1,245.91	36.5
Total	1,060.26	1,836.71	516.37	3,413.33	100
%	31.1	53.8	15.1	100	

5.2 User Revenue Attribution

Revenue attribution is the process by which the total user revenue generated from a given source is distributed among the users (vehicle classes) of the system according to their relative contributions. In the context of the current study, each of the 13 FHWA vehicle classes is an individual user group. Therefore, for a given source or level of government, revenue attribution was carried out by determining how much of the total user generated revenue came from each vehicle class. Then for a vehicle class, the results were summed up for all revenue sources and for all levels of government to yield the total revenue that was attributed to each vehicle class. The highway user revenue was broadly categorized into three levels: state, local and federal. The state-level user revenue sources include gasoline tax, diesel tax, registration fees, international registration plan, motor carrier fuel use tax, motor carrier surcharge tax, and oversize/overweight permits, and the revenue amounts, including the four-year average values, for the four fiscal years (FY 2009–FY 2012) are presented in Table 5.2. For example, the four-year average gasoline tax revenue is $539.5 million.

The local-level user revenue sources include commercial vehicle excise tax, wheel tax, motor vehicle excise tax and excise surtax. Revenues collected from the commercial vehicle excise tax and motor vehicle excise tax were not used for highway purposes. However, these two revenue sources were included in the equity analysis because these amounts were contributed directly by the highway users for their use of the highway and therefore needs to be considered as highway user contributions to ensure fairness. A significant part of the local-level user revenues was from the motor vehicle excise tax, with an average of $639.7 million per year for the four fiscal years. The third level is the federal revenue. The revenue collected at the federal level was distributed to both state and local agencies. For example, in FY 2009, of the $878.9 million collected at the federal level, $659.2 million went to the state while $219.7 million went to the local agencies.

TABLE 5.2
Highway User Revenues in Indiana: FY 2009–FY 2012.

Level	Revenue Source	Revenue ($M)				
		2009	2010	2011	2012	4-Year Average
State	Gasoline tax	540.5	536.5	547.6	533.2	539.5
	Diesel tax	217.1	207.9	218.3	226.9	217.6
	Registration fees	278.9	278.4	279.3	299.9	284.1
	International registration plan	85.5	82.9	89.1	90.9	87.1
	Motor carrier fuel use tax	1.4	1.9	1.3	0.6	1.3
	Motor carrier surcharge tax	97.3	86.9	94.8	95.5	93.6
	Transfers and refunds	(51.7)	(42.3)	(39.3)	(46.7)	(45.0)
	Oversize/overweight permits	13.4	12.4	13.5	16.1	13.8
	Subtotal	***1,182.42***	***1,164.6***	***1,204.6***	***1,216.4***	**1,192.0**
Local	Commercial vehicle excise tax	60.0	60.2	61.2	61.3	60.7
	Wheel tax	8.6	8.8	7.3	7.7	8.1
	Motor vehicle excise tax	662.8	624.1	621.2	650.7	639.7
	Excise surtax	57.5	59.5	63.1	65.4	61.4
	Subtotal	***788.89***	***752.62***	***752.79***	***785.08***	**769.84**
Federal	Gasoline tax	496.8	549.6	509.4	450.4	501.6
	Diesel tax	263.1	274.5	292.5	254.2	271.1
	Heavy vehicle use tax	36.2	34.4	13.2	54.6	34.6
	Excise tax on trucks and trailers	71.0	60.7	87.3	122.4	85.3
	Tires	11.8	12.4	15.9	13.3	13.4
	Subtotal	***878.91***	***931.58***	***918.38***	***894.91***	**905.95**
Total		***2,850.22***	***2,848.82***	***2,875.74***	***2,896.41***	***2,867.80***

It was determined that the user revenue sources contributed approximately 63.5% of the total state funding for highway expenditures and 36.5% were from non-user revenue sources. The inability of user revenue sources to cover the total highway expenditure and the partial reliance on non-user sources are rather unsettling particularly because the non-user sources are characterized by significant variability.

PART 6. EQUITY ANALYSIS

This part compares, for each vehicle class, the share of user revenue contributed and the share of cost responsibility to determine the user equity ratio. This is done in a bid to ascertain the extent to which each vehicle class is paying their fair share of costs for highway upkeep (Sinha et al., 1984, FHWA, 1999, Balducci et al., 2009). User equity ratios are computed for reasons that include possible revision of the highway user fee structures. In the State of Indiana, the highway taxation structure is based on the entire highway system, and not separately for state highways and local routes. Consequently, the user equity ratios were considered for the Indiana highway system (all state and local highways and roads). From the outcome of the equity analysis, recommendations are made for possible actions that could help address any inequities so that each vehicle class comes closer to paying its fair share of the highway infrastructure consumption.

6.1 Equity Ratio Results

The equity ratios for Indiana's highway system are presented in Table 6.1 and illustrated in Figure 6.1. The results indicate that vehicle classes 1–4 (motorcycles, automobiles, sport utility vehicles, and buses) have equity ratios greater than unity, while the remaining vehicle classes (5–13) have equity ratio values less than unity. From the table, it can be observed that automobiles (vehicle class 2) contributed approximately 47% of the highway user revenue for Indiana's highway system; the cost responsibility for that vehicle class was approximately 43%. Thus, the equity ratio for vehicle class 2 is 1.10, indicating that vehicle class 2, as a group, is slightly overpaying its cost responsibility. For vehicle class 9, the equity ratio is 0.81, indicating that vehicle class 9 is underpaying its cost responsibility. In general, the results suggest that passenger vehicles (light vehicles) are subsidizing the cost responsibilities of the heavier vehicles on Indiana's highway system. Generally, the results of the equity analysis were found to be consistent with those of studies carried out at other states.

Although vehicle class 2 contributed approximately 47% of the revenue, it carried approximately 63% of the total VMT on Indiana highway system, while vehicle class 9, contributed approximately 20%, it carried 6.95% of the total VMT. As a group, small passenger vehicles (1–3) contributed just about 68% of the total user revenue and carried approximately 88% of the total VMT. Assuming the revenue contributions and

TABLE 6.1
User Equity Ratios for the Indiana State and Local Routes: FY 2009–FY 2012.

Vehicle Class	VMT (%)	Revenue Contribution (in millions)	% Revenue Contribution (R)	Cost Responsibility (in millions)	% Cost Responsibility (C)	Equity Ratio (R/C)
1	0.55	$12.13	0.42	$9.17	0.38	1.12
2	62.50	$1,360.19	47.43	$1,044.46	43.12	1.10
3	25.01	$591.89	20.64	$430.38	17.77	1.16
4	0.19	$10.79	0.38	$8.85	0.37	1.03
5	2.52	$89.06	3.11	$80.82	3.34	0.93
6	0.95	$63.61	2.22	$80.73	3.33	0.67
7	0.30	$89.00	3.10	$86.16	3.56	0.87
8	0.70	$40.41	1.41	$41.68	1.72	0.82
9	6.95	$582.25	20.30	$609.30	25.16	0.81
10	0.10	$10.56	0.37	$11.92	0.49	0.75
11	0.16	$7.63	0.27	$8.10	0.33	0.80
12	0.06	$3.51	0.12	$3.39	0.14	0.88
13	0.03	$6.76	0.24	$7.07	0.29	0.81
Total	**100**	**$2,867.80**	**100**	**$2,422.04**	**100**	

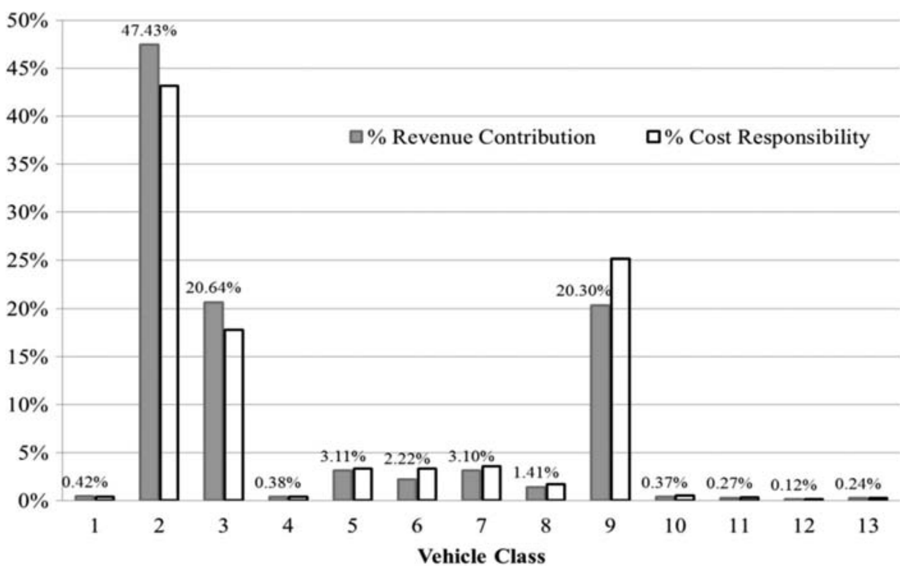

Figure 6.1 Revenue contribution and cost responsibility (state and local routes): FY 2009–FY 2012.

cost responsibilities remain the same, the equity ratios will be different for different VMT distributions. The study also established and investigated a number of scenarios for addressing the equity issue.

In the present study, overhead costs were not included due to the unavailability of the data in consistent manner from the agencies that were engaged in the execution of highway projects or in administering highway revenue collection programs, such as INDOT, cities and counties, INDOR and BMV. Overhead costs are common costs and thus would be allocated on the basis of VMT. The inclusion of overhead costs, assuming the percentage overhead is uniform across all government levels and all project types, is not expected to significantly affect the relative equity ratios across the vehicle classes. Thus, the exclusion of overhead costs from the analysis can be considered justifiable.

PART 7. TRAVEL BY OUT-OF-STATE VEHICLES

7.1 Background

The fuel consumed from vehicle travel on a given state's road network could have been purchased in that state or in a neighboring state. For example, a commuter living and working in different states will be contributing to the highway damage (and hence, repair expenditures) of both states in a certain ratio and would be contributing to the revenue base of the two states in a ratio that is not necessarily the same as the damage share across the states. For certain states, such imbalance may be very significant (i.e., more fuel is purchased in their state then is consumed in the state or vice-versa, compared to the ratio of highway asset damage). In preparation for possible future implementation of direct user charging such as the VMT fee, INDOT seeks to quantify the magnitude of such imbalances. The analysis is herein carried out for gasoline and diesel vehicles separately.

7.2 Gasoline Vehicles

7.2.1 Sample Design and the Amount of Fuel Sales

For determining the amount of fuel sales, a statistical sampling technique was adopted. The criteria for stratification included urban/rural, interstate/non-interstate, and proximity to the state border. The expectation is that the percentage of out-of-state drivers and fuel sales is likely to be different at gas stations along interstates compared to non-interstates, and also different for those close to the state border compared to those far from the state border. Also, it is expected that urban and rural locations would also yield different results. After establishing the sampling strata, the sample sizes in each stratum were determined. In the context of the present study, the "sample" refers to the required number of fuel purchase transactions that need to be sampled in each stratum. The sample size depends on the population size, the expected chance of the outcome, the confidence level, and the confidence interval.

Based on the sample size requirements, it was determined that for each stratum, 25 fuel stations needed to be sampled for one hour each at locations spread randomly across the state. The sample size computations and sampling locations are provided in Volume II of this report. At each sampling location, the type of vehicle fueling during the sampling period was recorded. Each stratum met the sampling requirement of 323 observations and thus provided a confidence level within 95% with a confidence interval of $\pm 5\%$. The amount of gasoline purchased per transaction was recorded where possible.

7.2.2 Amount of Travel

The amount of fuel purchased was used to estimate the amount of travel made on Indiana roadways by out-of-state vehicles. The percentage of gasoline sold to out-of-state drivers was calculated at each fuel collection location. This value was then weighted by the average gasoline fuel efficiencies of the given road functional classification to provide an assessment of the percent of travel completed by out-of-state drivers at each data collection location. To obtain a reliable estimate at the state level, spatial analysis using Kriging estimation was carried out. This yielded segment-specific splits of in-state vs. out-of-state travel that were then multiplied by the segment VMT to yield values for in-state and out-of-state VMT. These values were summed over the entire state to yield travel splits for each highway functional classes.

The results showed that NHS routes saw the highest percentage of out-of-state VMT with 21.09% and 9.85% for NHS interstate and non-interstates, respectively. The non-NHS state and local routes saw 8.55% and 7.20% out-of-state drivers, respectively. These values were then weighted according to relative distribution of VMT across the highway functional class, and a value of 11.12% was obtained as the percent of VMT in Indiana can be attributed to out-of-state gasoline vehicles.

7.3 Diesel Vehicles

In the previous section where we discussed the estimation of the travel by out-of-state gasoline vehicles, it can be seen that an extensive data collection is needed for such analysis. This is because nearly 100% of the gasoline VMT can be attributed to personal vehicles; there is no centralized database for measuring individual travel by this class of vehicles. On the other hand, travel using diesel fuel is dominated by commercial vehicles. Drivers of commercial vehicles are required to submit travel data to IFTA (not because they use diesel but because they are commercial vehicles); such reporting is necessary so that taxes can be accurately dispersed to the states in which the vehicles traveled. For this reason, the travel by out-of-state diesel vehicles on Indiana highways was determined separately for vehicles that submit travel data to IFTA compared to those that do not.

From the analysis carried out in this study, the total diesel VMT in Indiana was found to be 7.78 billion miles in 2012; out of this, 0.28 billion miles were driven by passenger vehicles, 0.02 billion miles were driven by commercial carriers that only operate in Indiana, 5.74 billion miles were driven by carriers that are Indiana-based or based in other jurisdictions, leaving a balance of 1.74 billion VMT (Table 7.1). The lack of MCFT or MCST records for the remaining VMT suggests that this travel may be attributed to class 5 (single unit, six tires) recreational vehicles (RVs) and pick-up trucks or tax exempt vehicles that include vehicles operated by government agencies, school buses, casual or charter buses, intercity buses, farm vehicles, and trucks with dealer registration plates. There is inadequate data to determine what percent of the 1.74 billion VMT is attributable to out-of-state vehicles; therefore, the value used for passenger vehicles was applied. Such an assumption can be considered appropriate because the majority of this VMT is expected to originate from the class 5 vehicles which have similar travel patterns to passenger vehicles. IFTA data was not available during the study period; therefore the percentage of inter-state commercial vehicle VMT attributed to out-of-state vehicles was estimated to be between 49% and 79% based on previous research.

7.4 Summary of Travel by Out-of-State Vehicles

The percentage of all gasoline VMT attributed to out-of-state vehicles was determined to be 11.12% using fuel purchase data collected at various locations across Indiana and spatial interpolation. This analysis was then paired with previous research regarding out-of-state commercial VMT in Indiana to provide an assessment of the total VMT attributable to out-of-state vehicles

TABLE 7.1
Annual VMT by Out-of-State Vehicles.

Vehicle Class	Total VMT (billions)	% Attributable to Out-of-State Vehicles	Out-of-State VMT (billions)
1	0.39	11.12%	0.04
2	44.59	11.12%	4.96
3	17.74	11.12%	1.97
4	0.16	0.00%	0.00
5	2.16	11.12%	0.24
6	0.90	49.2% to 79.2%	0.44 to 0.71
7	0.29	49.2% to 79.2%	0.14 to 0.23
8	0.44	49.2% to 79.2%	0.22 to 0.35
9	4.34	49.2% to 79.2%	2.14 to 3.44
10	0.07	49.2% to 79.2%	0.03 to 0.06
11	0.10	49.2% to 79.2%	0.05 to 0.08
12	0.04	49.2% to 79.2%	0.02 to 0.03
13	0.02	49.2% to 79.2%	0.01 to 0.02
Vehicle Class 1–3 Total	62.71	11.12%	6.974464
Vehicle Class 4–13 Total	8.53	38.6% to 60.4%	3.29 to 5.15
All Classes Total	71.24	14.4% to 17.0%	10.27 to 12.13

(Table 7.1). It was estimated that 10.27 billion to 12.13 billion of Indiana's 71.24 billion VMT in 2012 can be attributed to out-of-state vehicles.

PART 8. REPORT SUMMARY

The objective of this study was to investigate the cost responsibility and the revenue contribution of highway users, in terms of the vehicle classes, for the construction, preservation, maintenance, and operation of highways in Indiana. The study scope covered the state and local highway systems, expenditure patterns and revenue types spanning the analysis period (2009 to 2012), and expenditure on different asset types related to pavements, bridges, safety, and mobility. The second objective of the study was to determine the distribution of fuel purchases and travel by out-of-state vehicles on Indiana's highways.

This study discussed the background and the objective for conducting a HCAS in the state of Indiana and the relevance of estimating the extent of out-of-state vehicle travel. It also provided a detailed literature review covering the methodologies for highway cost allocation methodologies at the federal and state levels and for travel estimation. Traffic volume data collected from temporary count stations were used to calculate the VMT along state routes. It was found that from 2009 to 2012, the annual VMT on state routes fluctuated between 38.1 and 39.2 billion miles. Data collected from the limited number of permanent count stations and Kriging estimation was used to distribute the VMT across the 13 FHWA vehicle classes. Kriging estimation, a spatial analysis process, yielded statewide maps of the traffic stream composition. Thirty-three (33) weigh-in-motion stations provided data that could be used to develop vehicle weight distributions. Average weight distributions were developed for each truck class for interstate and non-interstate highways. Since count stations do not cover the local routes, direct calculation of VMT from AADT data was not practical; as such, local route VMT was back-calculated from gasoline and diesel sales data. The annual VMT for local routes was found to vary between 32.1 and 35.61 billion yielding a total (state-local) system usage of 71.24 to 73.75 billion during the study period.

All the state route expenditures were classified by highway functional class (Interstate, Non-Interstate NHS, and Non-NHS), expenditure area (pavement, bridge, safety, mobility and others), project type within each expenditure area (construction, rehabilitation, maintenance, etc.), and expenditure item within each expenditure area (pavement, shoulder, structure, grading, earthwork, signing, ROW, etc.). For new pavement construction, the methodology developed in the 1997 and 2000 FHWA HCAS was adopted and the analysis was conducted on a project-by-project basis. The base facility expenditures was allocated among the vehicle classes on the basis of VMT adjusted for vehicle width while the expenditures of the remaining facility were allocated on the basis of ESAL-miles adjusted for vehicle width. For allocating pavement rehabilitation expenditures, the portion of the expenditures that was related to damage by non-load factors was allocated using VMT, and the rest were allocated using NAPCOM, FHWA's distress-based model. For allocating pavement maintenance expenditures, a load and non-load split was also used. New bridge construction expenditures were allocated using the incremental factors developed for different AASHTO design loadings. A correlation between AASHTO vehicles and FHWA vehicles was established and thus the allocation results were obtained for FHWA vehicle classes. Bridge replacement expenditures were analyzed in a similar manner except that the bridge sufficiency rating formula was taken into account in the procedure. For bridge rehabilitation, the estimated load-related share of the expenditures was allocated using the incremental methods, while the estimated non-load-related share was analyzed as common costs and was therefore allocated using VMT. In-house bridge maintenance expenditures were also allocated as common costs. The final products of this part of the report were the state route total cost responsibilities and average unit costs ($/VMT) for each expenditure type and functional class for the analysis period 2009–2012.

For the allocation of local road expenditures, the methodology used for the state route pavement cost allocation was adopted with some modifications due to differences in the road geometry and data limitations. Similarly, the allocation of local bridge expenditures used the methodology for state route bridge cost allocation with some assumptions and simplifications due to data availability issues. For the local route cost allocation, the main sources of data related to road and bridge expenditures were County Operational Reports, City Operational Reports, and the INDOT Site Manager database.

The pavement and bridge expenditures were found to have a dominant share of the overall expenditures on Indiana's highway system. In this study, the expenditures were allocated to the vehicle classes on the basis of whether they were common costs and thus attributed to the vehicle classes on the basis of their VMT contributions, or whether they were related to load or capacity consumption and thus attributed to the vehicle classes on the basis of their equivalent loads or passenger-car equivalents.

Overall, it was determined that as a group, vehicle class 2 had the highest cost responsibility with respect to all project types obviously because of their higher volume on state and local routes compared to the remaining vehicle classes. Of the truck classes, vehicle class 9 was observed to have the highest cost responsibility due to the combined effect of their high loading intensity and road usage levels compared to the remaining truck classes. Figure 8.1 presents the analysis results of the average unit cost ($/VMT) of each vehicle class by expenditure type for all state and local routes in Indiana over the study period. It can be observed that vehicle classes 1–3 had the lowest unit cost (approximately 2.5 cents/VMT), while vehicle class 7 had the highest unit cost (40 cents/VMT).

The revenue sources, during the study period, consisted of user sources that included taxes on gasoline, motor carrier surcharge, and motor carrier fuel use, truck and trailer sales, tire sales, heavy vehicle use; county motor vehicle excise surtaxes and wheel taxes; and fees on vehicle registration and driver licenses. Non-user revenue sources include toll road lease funds (Major Moves), Federal Stimulus (funds from the American Recovery and Reinvestment Act), General Funds, property taxes, bond proceeds. The revenue analysis period was from 2009 to 2012, using the state's fiscal year (July to June). The 4-year average highway user revenues were attributed to each vehicle class on the basis of a number of factors including VMTs, fleet fuel efficiencies, and number of registered vehicles. It was determined that the user revenue sources contributed approximately 64% of the total state funding for highway expenditures and 36% were from non-user revenue sources. The inability of user revenue sources to cover the total highway expenditure and consequently, the partial reliance on non-user sources, are considered problematic particularly because the non-user sources are characterized by significant variability and therefore, uncertainty.

On the basis of the expenditures and revenues associated with the various user groups (vehicle classes) over the analysis period, the study found that inequities exist, albeit in varying degrees, among the highway user groups. Of the 13 vehicle classes, classes 1–4 were found to be overpaying their cost responsibilities while classes 5–13 are underpaying. For example, vehicle class 2 is overpaying its cost responsibility by 10% while vehicle class 9 is underpaying by 19%. A comparison of equity ratios from other states was carried out: it was observed that this study's results are consistent with the findings of studies at other states. Also, scenario analysis was carried out to assess the impact of revenue increases on the equity ratios.

This study also included an analysis of the extent of travel by out-of-state vehicles on Indiana highways.

Figure 8.1 Average unit cost of all expenditures for state and local routes combined, 2009–2012.

Two methodologies were developed; the first used gasoline transaction data to estimate the extent of travel by out-of-state passenger vehicles; the second used Department of Revenue data on diesel sales to estimate the travel by out-of-state heavy vehicles. In order to account for variation in gasoline purchasing characteristics, data collection was stratified across rural and urban locations as well as interstate and non-interstate locations. The number of transactions and the amount of fuel purchased per transaction was used to determine the volume percentage of gasoline sales, by out-of-state vehicles. Since the vehicle stream composition for in-state and out-of-state vehicles was nearly identical, it was considered appropriate to use the split of fuel sales as a measure of the split of vehicle travel. In order to account for variability in fuel purchasing characteristics across the state, the spatial analysis of the in-state out-of-state split was carried out using Kriging estimation. It was determined that percent of passenger vehicle VMT that can be attributed to out of state vehicles was 21.1%, 9.9%, 8.6%, and 7.2% for interstates, NHS non-interstates, non-NHS and local routes respectively.

Summing up, this report yielded a detailed methodological framework for allocating highway expenditures and attributing revenues to each of the FHWA vehicle classes. The analysis results provided a clear quantitative understanding of the extent of costs incurred by various vehicle classes and the revenues they contribute. This research product is intended to serve as a data-based decision support resource in the development of strategies regarding highway financing in Indiana. Specifically, the study product facilitates an assessment of the appropriateness of the types and rates of current taxes and fees, and provides a data-based and objective platform to devise future funding types and user rates to meet the financing needs of coming years. Possible options involving highway user taxes and fees can be evaluated in terms of resulting user equity and system financial efficiency. The study on the extent of travel attributable to out-of-state vehicles on Indiana highways provided updated information that is useful in making decisions associated with additional or alternative sources of additional highway revenue, such as the VMT fee for in-state vehicles.

APPENDIX: FULL REPORT

Navigating through This Appendix

This Appendix is divided into eight parts, each covering a specific aspect of the study. Within each part there are numbered chapters and sections. Chapter numbering restarts at the beginning of each part. Tables and figures in this report use the following numbering system: "Figure X.Y.Z" where X is the part, Y is the chapter number within each part, and Z is the order that the figure appears in the chapter.

Part	Topics Covered
PART 1	Background - Historical Context - Study Objectives - Literature Review
PART 2	Assessment of System Usage - Traffic Volume and Gross Vehicle Weight Distributions - Truck Traffic Stream Composition - Annual VMT
PART 3	State Routes Cost Allocation - Pavement Expenditures - Bridge Expenditures - Safety, Mobility, and Other Expenditures
PART 4	Local Routes Cost Allocation - Road Expenditures - Bridge Expenditures
PART 5	Revenue Analysis - Highway Revenues - User Revenue and its Attribution to the vehicle Classes
PART 6	User Equity Analysis - User Equity Results - Scenario Analysis of Possible Initiatives to Improve Equity
PART 7	Travel by Out-of-State Vehicles on Indiana Highways - Travel by Out-of-State Gasoline Vehicles - Travel by Out-Of-State Diesel Vehicles
PART 8	Report Summary

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PART 1. BACKGROUND

1. PREFACE

1.1 Historical Context

The 2012 federal transportation law, Moving Ahead for Progress in the 21st Century (MAP-21), requires the U.S. Department of Transportation (USDOT) to establish performance measures for state highway agencies (SHAs) that must be met and reported biennially to the USDOT as a requirement for continued federal aid funding for surface transportation projects. To achieve these targets, SHAs are required to conduct a biennial assessment of their revenues obtained directly or indirectly from users and the agency. This assessment is important not only for determining the sources and extents of such revenues and the areas of expenditures as required at the federal level, but also for assisting SHAs in the restructuring their existing user-based tax structures in order to ensure revenue and expenditure equity among highway infrastructure users. A basic principle of user tax equity and a balanced tax structure is to ensure that the revenue derived from each user is equal to the public costs of providing highway services to that user. Although, in practice, it is difficult to achieve such a balance, an examination of the relationship between highway service costs and highway use is the first step in designing an equitable tax structure. In Indiana, as in most states, the construction and maintenance of Indiana's highways are financed primarily by taxes and fees paid by the state's highway users.

In carrying out highway cost allocation (HCA) for any state, it is useful to examine what other states have done. There is marked variation in the frequency and scope of the highway cost allocation studies (HCAS) conducted by the various SHAs. Certain states, such as Oregon, conduct such studies biennially (ECONorthwest, 2009, 2011b, 2013); others, including Indiana, conduct these studies less regularly. Indiana carried out its first HCAS in 1984 (Sinha et al., 1984) and updated it in 1989 (Sinha, Saha, Fwa, Tee, & Michael, 1989). The Indiana studies considered both state and local routes and found significant imbalance between the cost responsibilities and revenue payments by the different vehicle classes. In Indiana's 1984 study, it was determined that passenger vehicles and single-unit trucks were overpaying their cost responsibilities by 25% and 24% respectively, while buses and combination trucks were underpaying their cost responsibilities by 2% and 46%, respectively. As a result of the 1984 study, the Indiana state legislature carried out a major overhaul of the highway taxation structure. Until now, no cost allocation study has been undertaken for Indiana's state and local highways since the 1984 study.

A periodic study of highway cost allocation for Indiana's state and local highways is needed in order for INDOT to stay current with evolving and emerging developments in expenditure patterns, traffic distributions, and construction technology and materials. In addition, updated research findings on the relationships between infrastructure damage, traffic loading, and climate severity reinforce the need for regular updates of HCAS. Only a detailed analysis of the recent and appropriate costs and revenues properly allocated to the vehicle classes can ensure that fair and equitable pricing and financing can be achieved for highway transportation.

A companion issue addressed in this highway cost and revenue study is an assessment of the extent of travel by out-of-state vehicles on Indiana highways; such an analysis, which could serve as a critical input in the assessment of highway financing equity, can help address issues associated with measuring and projecting highway revenues from revenue sources contributed solely by Indiana residents compared to those from all users of the highway network.

1.2 Study Objectives

The primary objective of this study is to compare the cost responsibility and the revenue contribution for each category of highway users (individual vehicle classes) with regard to the construction, preservation, maintenance, and operation of highways in Indiana on the basis of recent expenditure patterns and revenue types. The developed framework is intended to help assess the efficiency and equity of all possible alternative revenue sources. An additional objective is to determine the distribution of fuel purchases and travel by out-of-state and in-state vehicles on Indiana's highways.

1.3 Organization of the Report

This report is organized in eight parts. Part 1 discusses the basis for conducting a HCAS in the state of Indiana and the relevance of estimating the extent of out-of-state vehicle travel. Also, Part 1 provides a detailed literature review covering highway cost allocation methodologies at the federal and state levels and travel estimation. Part 2 discusses the quantification of the highway system usage in terms of vehicle miles traveled and vehicle weight distribution as well as the usage of each highway functional class by each vehicle class. Part 3 describes the study methodologies for cost allocation as well as the data collection, analyses, and results for state routes only; and Part 4 discusses these topics for local routes only. Part 5 presents the highway revenue sources and revenue attributions for each of the identified vehicle classes for state and local routes. Part 6 presents the equity analysis which combines the information on revenue contribution and cost responsibility for each vehicle class to provide a revenue-to-cost ratio for each vehicle class. Part 7 presents an analysis on the extent of travel by out-of-state vehicles on Indiana roadways. Part 8 summarizes the report.

2. LITERATURE REVIEW

2.1 Introduction

To clarify the various aspects and issues associated with highway cost allocation and VMT estimation, a comprehensive review of past research was carried out. This chapter presents the significant outcomes from these studies in order to shed more light on the existing methodologies used for cost allocation at the federal and state levels. This chapter also serves as a basis for identifying and evaluating the drawbacks of the existing methodologies and how the proposed methods can help to ensure effective, equitable, and efficient allocation of the revenues and expenditures across the vehicle classes. This literature review was also helpful in identifying which methods are appropriate for estimating the out-of-state vehicle travel.

2.2 Review of Pavement Cost Allocation Methods

Pavement cost allocation studies estimate the cost responsibility of individual vehicle classes for the construction, preservation, and maintenance of highway pavements based on recent expenditure patterns. The first known highway cost allocation study (HCAS) was conducted by Oregon in 1937 (ODOT, 1980). Oregon remained at the forefront of HCAS development and implementation, conducting five more studies before the release of the 1982 Federal Highway Cost Allocation Study (HCAS) (Balducci & Stowers, 2008). At the federal level, the first HCAS was carried out in 1956 (U.S. Congress, 1961). A brief discussion of the methods used in the past to allocate pavement expenditures or pavement damage to highway users is presented in the following sections.

2.2.1 Traditional Incremental Approach

This approach assigns responsibility for highway costs by first determining the costs of constructing and maintaining facilities for the lightest vehicle class and then increasing the structural capacity of the facility in increments that meet the needs of progressively larger and heavier vehicles. The traditional incremental approach was most widely-used for HCAS (Balducci & Stowers, 2008). However, its use declined later as researchers realized that this method implicitly and unduly assigns the benefit of scale economies to heavy vehicles. In this approach, the pavement thickness required to sustain the increased loading from a vehicle class is determined using the AASHTO pavement design equations and added to pavement designed to sustain the lightest vehicle class. The process ends when all vehicle classes are taken into account. The issue with this approach is that the AASHTO equations assume a non-linear relationship between pavement thickness and traffic load. It has been shown that changing the order in which the vehicle classes are incrementally added can produce significantly different results (Fwa & Sinha, 1985b), as discussed in detail in Section 2.2.2. Before the 1982 Federal HCAS, the methodology used by most states was an incremental approach known as the traditional incremental method (Balducci & Stowers, 2008). This methodology was developed for the Oregon HCAS (Oregon, 1980) and refined in the Federal HCAS published in 1965.

2.2.2 Allocating the Costs of New Construction: The Thickness Incremental Approach

In 1984, the Indiana Department of Transportation (INDOT) conducted a HCAS to determine the cost responsibility of different vehicle classes for highway use. As part of that study, Fwa and Sinha (1985b) proposed a thickness incremental approach for allocating the costs of new pavement construction. The method considers increments of pavement thickness (instead of increments of traffic loading) and is considered advantageous because it directly incorporates the non-linearity of the thickness-cost relationship and therefore corrects for the bias associated with returns to scale.

The thickness incremental approach, as presented in the Indiana HCAS (1984), involves a non-iterative procedure. First, the pavement thickness is decomposed into a minimum thickness and an excess thickness (the difference between the actual and minimum thicknesses); with the minimum thickness defined as per AASHTO (1981), and the excess thickness divided into a number of equal increments. In the case of flexible pavements, each increment is assumed to comprise the thickness of the surface, base, and subbase materials in the same proportions as is the total excess thickness being allocated. The cost associated with the minimum thickness is estimated and allocated to all vehicle classes on the basis of vehicle miles traveled (VMT). Then, the cost of each incremental thickness is estimated. Using the AASHO Road Test equivalent single axle load (ESAL) equations (HRB, 1962), the ESAL contribution of each vehicle class is estimated. Then, for each vehicle class, the cost responsibility factor is estimated as follows (Sinha et al., 1984):

$$F(i,j) = P(i) \times \frac{ESAL(i,j)}{\sum_{r=1}^{M}[P(r) \times ESAL(r,j)]} \quad (1.1)$$

where $F(i, j)$ is the cost responsibility factor of vehicle class i for thickness increment j, $P(i)$ is the proportion of vehicle class i in traffic stream, $ESAL(i, j)$ is the ESAL of vehicle class i for thickness increment j, r refers to a vehicle class, and M is the total number of vehicle classes.

Using the cost responsibility factors, the incremental thickness cost for each vehicle class i is estimated as follows:

$$c(i,j) = F(i,j) \times Cd(j) \quad (1.2)$$

where $c(i, j)$ is the cost allocated to vehicle class i for thickness increment j, and $Cd(j)$ is the incremental cost for thickness increment j.

After the cost for each vehicle class and each increment is estimated, the total cost for a vehicle class is given as follows:

$$C(i) = Cm(i) + \sum_{j=1}^{N} c(i,j) \quad (1.3)$$

where $C(i)$ is the total cost responsibility of vehicle class i, $Cm(i)$ is the cost responsibility of vehicle class i for the minimum thickness, and N is the total number of thickness increments.

2.2.3 Allocating the Costs of Maintenance and Rehabilitation: The Performance-Based Approach

As part of the 1984 Indiana HCAS, Fwa and Sinha (1985b) proposed an aggregate damage model that relates pavement performance to maintenance, thus facilitating the allocation of rehabilitation and routine maintenance costs. The Present Serviceability Index (PSI)—the ESAL loss—was developed to represent the aggregate pavement damage due to loading under different levels of maintenance, including zero maintenance. Based on this approach, a zero-maintenance performance curve is derived by considering actual pavement performance curves and their corresponding maintenance cost (Figure 1.2.1). The pavement damage represented by the zero-maintenance curve is the total damage caused by the combined actions of all load-related and non-load-related factors, assuming no maintenance was conducted on the pavement. The pavement damage due to load factors is bounded between the no-loss line (referring to a pavement maintained at its initial condition) and the design equation curve (referring to the expected damage of the pavement based on AASHTO) and is represented by area A in Figure 1.2.1; the pavement damage due to the non-load factors and the interaction between the load-related and non-load-related factors is bounded between the design equation curve and the zero-maintenance curve (represented by area B in Figure 1.2.1).

A proportionality assumption is used to estimate the relative responsibilities of the load-related and non-load-related effects. This assumption implies that the greater the effect of traffic, the greater its share is in the "interaction effects" (i.e., the interaction between the load-related and non-load-related factors), as illustrated in Figure 1.2.2. The load and non-load-related cost shares are estimated using the following equations (Fwa & Sinha, 1985a, 1986):

$$\frac{a}{(a+b+c+d)} = \frac{b}{(b+c+d)} \tag{1.4}$$

$$\frac{d}{(a+b+c+d)} = \frac{c}{(a+b+c)} \tag{1.5}$$

These equations assume that the load share of the interaction damage is directly proportional to the load share of the overall damage. A similar assumption is made for the non-load share. The load-related share was found to be 70%. The expenditures related to load (traffic) were allocated on the basis of ESALs while those related to non-load factors (such as climate and construction quality) were allocated on the basis of VMT. Traffic loading, environmental effects, pavement characteristics, and routine maintenance were identified as the four major factors that influence pavement performance.

2.2.4 Allocating the Cost of Highway Rehabilitation and New Construction: The Federal Approach

The Federal Approach for cost allocation for new pavement construction is often referred to as the Minimum Pavement Thickness Method. The cost of a minimum practical pavement (as defined by AASHTO (1981, 1993)) is allocated among all vehicle classes as a common cost on the basis of VMT, while the cost of all pavement thickness greater than the minimum is allocated to vehicles in proportion to their ESAL contributions.

Following the guidelines of the Congressional Budget Office (1979), the Federal Highway Administration (FHWA) developed a damage-function approach for allocating highway rehabilitation costs. The mechanistic pavement distress models developed for the 1982 Federal HCAS were based on a small number of hypothetical pavement sections (FHWA, 1997). The original models were improved using data on actual pavement sections in the Highway Performance Monitoring System (HPMS) database. The 1997 Federal HCAS used a similar approach with several key refinements but, the most important of which was the National Pavement Cost Model (NAPCOM). NAPCOM uses individual distress models for flexible and rigid pavements. For flexible pavements, NAPCOM has individual distress models for traffic-related Present Serviceability Rating (PSR) loss, subgrade-related PSR loss, fatigue cracking, thermal cracking, rutting, and loss of skid resistance. For rigid pavements, NAPCOM has individual distress models for traffic-related PSR loss, faulting, loss of skid resistance, fatigue cracking, spalling, and soil-induced swelling and depression. NAPCOM also helped to develop load equivalency factors (LEF) at the national and state levels using data from HPMS pavement sections. The pavement deterioration curves developed using NAPCOM have a gentler slope compared to the slope associated with AASHTO's 4th power relationship. In NAPCOM, separate pavement wear relationships for each of the different distresses were developed, instead of a single pavement deterioration relationship based on a single criterion such as the PSI used by AASHTO.

In NAPCOM, the pavement deterioration analysis is applied to a large number of representative pavement

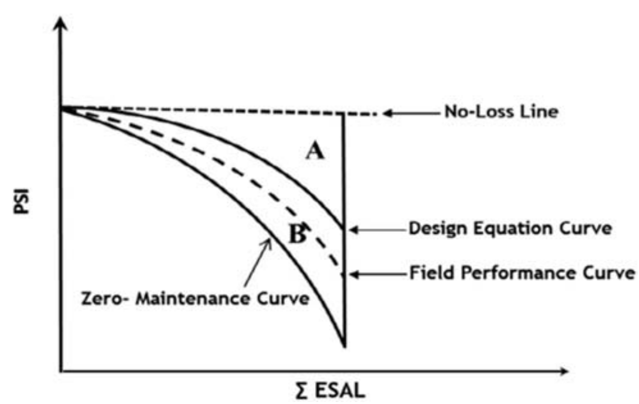


Figure 1.2.1 Total pavement damage as defined by zero-maintenance pavement performance curve (Fwa & Sinha, 1985b).

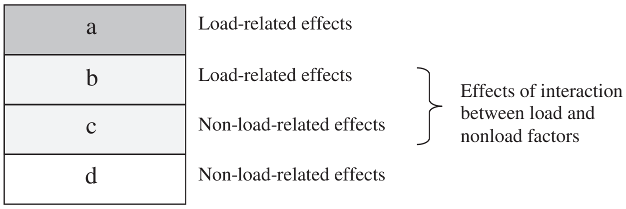


Figure 1.2.2 Responsibilities of load- and non-load-related effects by proportionality assumption (adapted from Fwa & Sinha, 1985b).

sections to determine the pavement condition at the end of each analysis year. When a pavement section reaches the threshold level of any specific distress, its contribution to rehabilitation and reconstruction decisions and vehicle responsibility for the distress in question are recorded. NAPCOM then outputs the vehicle class responsibilities for 20 different vehicle classes and for 10 different road functional classes. The number of lanes, pavement type and thickness, pavement condition, average daily traffic (ADT), percentage of heavy vehicles, and estimated 20-year traffic levels needed for NAPCOM are extracted from the HPMS pavement section data. Additional data items like the number of freeze-thaw cycles, the freezing index, the modulus of the subgrade reaction, and the thickness of the base layer are obtained from other sources. For pavement analysis, NAPCOM uses the PSR and International Roughness Index (IRI) data of the HPMS pavement sections to estimate the age of different pavement sections (as PSR and IRI are the only two pavement condition data that are reported by HPMS).

NAPCOM uses an overall pavement condition rating (OPCR) which is calculated by applying a "deduction point" for different distress levels. The current deterioration levels of a pavement segment are multiplied with the maximum deduction points allowed for a particular distress and subtracted from 100. A pavement is considered a candidate for rehabilitation when the OPCR is 10 or less. The various deduction points considered in NAPCOM are summarized in Table 1.2.1.

Although NAPCOM uses data from HPMS pavement sections, any missing pavement information is imputed for pavement damage cost (PDC) estimation purposes. The damage cost estimated by NAPCOM could be considered aggregate because it uses the total value of the annual highway expenditure by road functional class and the VMT by vehicle configuration

TABLE 1.2.1
Deduction Point System used in NAPCOM.

Distress Type	Flexible Pavement	Rigid Pavement
PSR Loss	50	50
Cracking	25	30
Rutting	30	—
Skid Resistance Loss	20	20
Faulting	—	30
Spalling	—	10
Swelling and Depression	—	20

and road functional class. Also, NAPCOM is not tailored to be consistent with specific maintenance strategies typically used by highway agencies. Last but not least, highway agencies use different trigger criteria for maintenance and rehabilitation decision making.

A new version of NAPCOM was completed in 2010 (ECONorthwest, 2011b). Although the updated model's fundamental concepts of incremental allocation of non-load-related and load-related costs have remained the same, there are certain differences. The new pavement distress models for load-related costs have been updated. Also, the load-related costs are allocated using results from newer empirical models that have been calibrated to pavement distress data (ECONorthwest, 2011b). The new 2010 NAPCOM model was used to develop the pavement factors for the 2011 Oregon DOT HCAS (ECONorthwest, 2011a). Similar to the vehicle-weight pavement factors developed in past studies, pavement factors were established for each of the 2,000-lb. increments of declared vehicle weight. Weigh-in motion (WIM) data were also used to construct a correlation between operating weight and declared weight (ECONorthwest, 2011b).

2.2.5 Pavement Cost Allocation Based on Marginal Pavement Damage Cost

Empirical Approach. The empirical approach for marginal pavement damage cost (MPDC) estimation first uses econometric models (developed from field data) to describe the rehabilitation and maintenance expenditures; then the model is differentiated with respect to the traffic variable to yield the marginal cost with respect to that variable (Ahmed et al., 2012). Through a study that investigated possible causes of pavement maintenance expenditures, Gibby, Kitamura, and Zhao (1990) suggested that the impact of climate is only minimal and that load is by far a major factor of pavement damage and hence, expenditure. Martin (1994) investigated load-related pavement maintenance and construction expenditures conducted a study for the Australian Road Research Board (ARRB) and found that 50% of pavement maintenance expenditures as well as 45% of pavement construction and replacement costs were load-related. He maintained that the study's maintenance expenditure models implicitly accounted for weather effects because they included a variable representing the pavement age; however, the relative effects of different weathering sources (freeze-thaw cycles, precipitation, etc.) could not be ascertained. Hajek, Tighe, and Hutchinson (1998) used simulated data on pavement costs to investigate the effects of truck weight regulations on rehabilitation and maintenance expenditures in Ontario; in the annualized cost (of rehabilitation and maintenance) model, a key explanatory variable was the annual ESALs, and the function was differentiated with respect to that variable to yield the pavement damage cost per ESAL-distance. Li and Sinha (2000) used data from Indiana to estimate load and non-load shares for pavement M&R expenditures; separate estimates were developed for flexible, rigid, and composite pavements. Ghaeli, Hutchinson, Haas, and Gillen (2000) used the Ontario Pavement Analysis of Costs (OPAC) model to estimate pavement M&R costs per ESAL-km for the Ontario Ministry of Transportation. Last but not least, Ahmed et al. (2012), using data from INDOT's historical M&R and reconstruction practices, developed life-cycle M&R strategies over an infinite analysis period for estimating the MPDC associated with overweight trucks. That study showed that not considering the reconstruction or maintenance costs could result in underestimation of the actual PDC by 79% and 83% respectively.

Engineering Approach. In the so-called "engineering approach" for estimating the marginal cost of pavement damage, a relationship is estimated to describe the repair cost as a function of traffic or usage, and the result is then extended to represent for the entire network of pavement assets. The underlying intention is to derive a function that estimates the traffic load-caused rehabilitation expenditures. For estimating the marginal cost of pavement damage, most previous studies used for the analysis, only a single type of rehabilitation treatment. Newbery (1988) first established a theorem for estimating the marginal overlay cost using an infinite analysis period for the data analysis. The average MPDC was estimated for an additional ESAL using roughness as the performance indicator and the author concluded that both the MPDC and congestion cost considered together could assist an agency with designing an efficient road user charging system. Small, Winston, and Evans (1989) added to Newbery's (1988) work by estimating a MPDC that accounted for both weathering and traffic, concluding that the climate-load interaction impacts pavement damage: climate makes pavements more vulnerable to damage by heavy loads. Vitaliano and Held (1990) assumed that 50% of pavement deterioration is caused by traffic and 50% by climate (an assumption based on Paterson (1987) and conducted a "theoretical" analysis for a single pavement segment to establish a function for the present cost of rehabilitation over an infinite analysis period. In 1996, the results of the Transportation Research Board (TRB) study "Paying Our Way" were published (TRB, 1996). The main focus of that study was to investigate whether freight shippers were incurring the full social cost for their use of the public infrastructure (highways, railroads, and waterways) or whether they were being subsidized. For highways, the study considered the marginal cost of externalities including congestion, crashes, air pollution, energy security, and noise, in addition to the MPDC. Anani and Madanat (2010) adopted a formulation similar to those used by Newbery (1988), Small et al. (1989), and Vitaliano and Held (1990) but considered both rehabilitation and routine maintenance costs in their estimation of MPDC. It can be argued that their formulation, while an improvement over previous work, is still not consistent with realistic highway agency maintenance practices because it incorporates only two levels of pavement treatment, applies treatments only at fixed intervals and does not account for routine maintenance and reconstruction costs.

2.2.6 Attributable and Common Cost Components

The primary objective of a HCAS is to evaluate the equity and efficiency of highway user charges based on the costs assigned to different vehicle classes (FHWA, 1997). In order to achieve equity, it is important to define the expenditures that are attributable and those that are common. Attributable expenditures are those caused by traffic or vehicle use and can be assigned to each user (vehicle class) on the basis of the user characteristics (Sinha et al., 1984). Attributable costs include (1) costs that are entirely attributable to a single vehicle class, (2) costs that are attributable to a group of vehicle classes, and (3) costs that are occasioned by the entire traffic as a whole. A cost allocator that includes vehicle class characteristics such as gross weight, axle weight, or width has the potential to provide more detailed allocation.

Common highway pavement costs are those costs that are shared by all vehicles irrespective of vehicle class or weight and are typically related to weather, climate, and other factors such as poor construction quality and errant engineering design. As these costs are not caused by traffic or vehicle use, equity criteria are not directly applicable and there is no single cost allocator that can be used for their distribution. Many previous state HCASs, as well as the FHWA HCAS, allocated the common costs on the basis of vehicle-miles or passenger car equivalence (PCE)-miles. PCE can be defined as the impact that a given vehicle class has on traffic compared to a single car (TRB, 2000). There is no single methodology to calculate PCE; headway, speed, delay, vehicle hours and travel time are typically included in the calculation. Torbic, Elefteriadou, Ho, and Wang (1997) developed PCE values that would be more suitable for allocating capacity-related costs in a HCAS; using traffic simulation models, weighted-average PCEs were estimated for 20 vehicle classes, 30 operating weight groups, and 12 facility types.

Typically, the damage of highway pavement elements results from the interaction of several factors, and it is difficult to measure the exact impact of each factor (Sinha et al., 1984). As such, the definition of attributable and common pavement costs may differ across certain cost allocation studies.

2.2.7 Measures of Road Usage

After identifying the attributable and common costs, the next step is to select suitable cost allocators to distribute these costs among vehicle classes. Due to the different nature and causes of various expenditure items, a single cost allocator cannot be used for all expenditure items. Cost allocators should allow equitable distribution of highway costs among vehicle classes in proportion to their responsibility for occasioning these costs (Sinha et al., 1984). Some of the most common pavement cost allocators used in past HCASs include (Balducci & Stowers, 2008):

- Axle Miles of Travel (AMT): This is defined as VMT multiplied by the number of axles.
- Axle-Load-Miles: This is product of the gross load carried by an axle and the distance traveled.
- Ton-Miles: This is defined as VMT multiplied by tonnage.
- ESAL-Miles: One ESAL is the pavement damage caused by a single axle load at 18,000 lbs. ESAL-miles are equivalent to single-axle loads multiplied by the miles traveled.

2.3 Review of Bridge Cost Allocation Methods

According to FHWA (1997), new bridge construction costs typically represent approximately 15% of new highway system capacity costs; also, bridge improvements constitute approximately 1/3 of all highway system preservation costs. Therefore, an accurate assessment of bridge costs is important in any study of highway cost allocation. The rationale for assigning bridge costs to different vehicle classes is similar to that for pavements: different vehicle classes induce different live-load moments and thus different levels of stress in the load-bearing members of a bridge. For higher levels of live-load moments, stronger load-bearing members are required to keep stresses within acceptable limits. Thus, bridge construction is costlier when heavier vehicles must be accommodated. Each vehicle class should pay their share of the costs incurred to accommodate their level of weight. Also, heavier vehicles tend to contribute more to the wear and tear of bridges. Hence, the impact of heavy vehicles needs to be appropriately considered when the costs of bridge replacement, rehabilitation, and maintenance are being allocated.

2.3.1 Vehicle Classifications Used in Previous Bridge Cost Allocation Studies

The primary objective of a HCAS is to achieve equity among different highway users. Therefore, the cost responsibility of different vehicle classes needs to be compared with their respective revenue contributions. For this reason, the establishment of vehicle classes is one of the key prerequisites for a HCAS. The damage caused to bridges is associated with the weight (axle loading) and configuration (axle spacing) of vehicles (Tee, Sinha, & Ting, 1986). Balducci and Stowers (2008) stated that the availability of data (e.g., VMT distribution of various vehicle classes) and the state's tax structure are the two principal criteria used to establish which vehicle classification scheme is appropriate for the analysis. The vehicle classifications must be consistent with the requirements of revenue allocation, VMT estimation, axle loading, spacing identification, and so on. The Indiana HCAS carried out by Sinha et al. (1984, 1989) placed vehicles in 14 classes (Table 1.2.2); nine of these were further subdivided on the basis of their gross operating weights in 2500-lb. increments. FHWA (1997) examined as many as 20 vehicle classes. Table 1.2.3 lists the 20 broad vehicles classes used in the 1997 FHWA study; these vehicle classes were further divided into subgroups by 5,000-lb. weight increments. In the present study, a different vehicle classification system, that is, the thirteen vehicle classes defined by FHWA, was used (see Figure 1.2.3).

TABLE 1.2.2
Vehicle Classification in 1984 Indiana HCAS (Sinha et al., 1984).

Vehicle Class	Description
1	Small passenger automobiles
2	Standard and compact passenger automobiles and pickup trucks
3	Buses
4	Two-axle trucks (2S and 2D)
5	Automobiles with one-axle trailers
6	Three-axle single-unit trucks
7	2S1 tractor-trailers
8	Automobiles with two-axle trailers
9	Four-axle single-unit trucks
10	3S1 tractor-trailers
11	2S2 tractor-trailers
12	3S2 tractor-trailers
13	Other five-axle vehicles
14	Vehicles with six or more axles

2.3.2 Highway Classification Systems Used in Previous Bridge Cost Allocation Studies

Vehicle class distribution typically varies across the highway classes. For example, the percentage of truck traffic on a local road is typically lower than that on an interstate highway. Also, bridges located on higher road classes tend to have higher design standards and specifications, for example, stronger structural elements and wider lanes in order to withstand heavier axle loadings and to accommodate higher traffic volumes. Therefore, such bridges are generally expected to have different cost functions for purposes of the incremental analysis. Typically, one or more bridges are selected to represent each bridge family (design type, material type, and highway class). The bridge families should not be too many; otherwise, a large number of representative bridges will be needed.

According to the 1984 Indiana HCAS, the two important criteria to establish an appropriate highway classification scheme for a HCAS are (i) data availability and (ii) the required reliability of the cost-allocation results. Table 1.2.4 and Table 1.2.5 list the highway classification used in the 1984 Indiana HCAS and other HCASs, respectively.

2.3.3 Methodology for Bridge Cost Allocation

Since the completion of the 1997 FHWA HCAS, there have been no major methodological breakthroughs. FHWA developed the federal method in 1982 and improved it in 1997. Since then, the federal method has largely replaced the traditional incremental

TABLE 1.2.3
Vehicle Classification in 1997 Federal HCAS (FHWA, 1997).

Vehicle Class	Notation	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, 3axle 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) rear axles
10	CS6+	Tractor-semitrailer combinations with 6 or more 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)

method (FHWA, 2000b). However, for bridge cost allocation, the federal method is different from the incremental method only with respect to costs of bridge replacement and repair. Although the federal method results in somewhat higher bridge costs being allocated to heavy vehicles compared to the incremental method, the difference is modest compared with the case for pavements (FHWA, 2000b). Apart from the federal method and the incremental method, several nontraditional allocation methods have been developed (e.g., Castano-Pardo & Garcia-Diaz, 1995; Ghaeli, 1997; Villarreal-Cavazos, 1985). However, none of the nontraditional methods have been used in HCAS in practice.

Although little improvement has been made in terms of bridge cost allocation methodology, there have been improvements in other related aspects which could possibly be incorporated into the methodology for bridge cost allocation. For example, fairly recent and ongoing Joint Transportation Research Program (JTRP) studies at Purdue University (Prakash et al., 2016; Wood, Akinci, Liu, & Bowman, 2007) that examined the effects of overweight loads on bridges can help evaluate the responsibility of heavy vehicles in bridge replacement and rehabilitation cost allocation. Enhanced bridge life-cycle cost models (Chandler, 2004; Elbehairy, 2007; Hu, Wang, Liu, & Gao, 2011) may provide a better understanding of the roles of load factors versus non-load

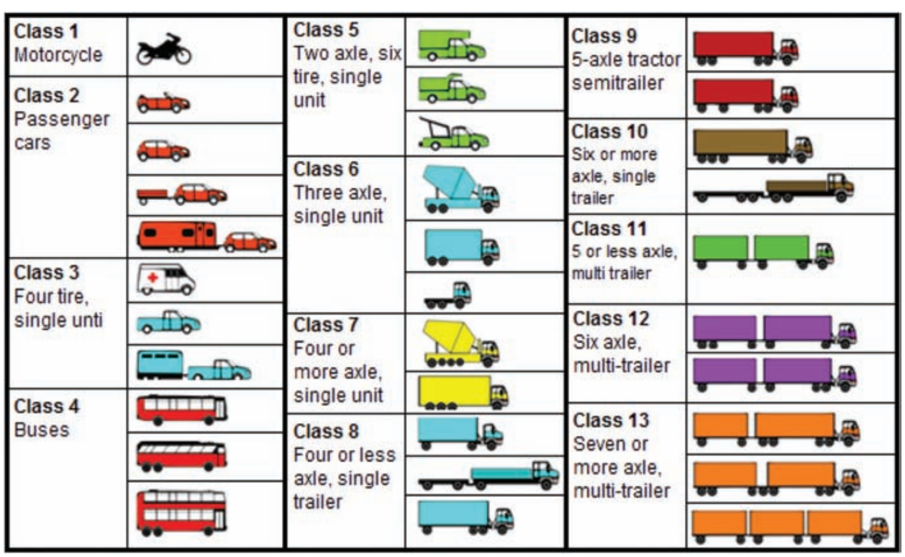


Figure 1.2.3 FHWA vehicle classification (OHPI, 2013b).

TABLE 1.2.4
Highway Classification in 1984 Indiana HCAS (Sinha et al., 1984).

Highway Class	Description
1	Interstate Urban
2	Interstate Rural
3	State Routes Primary
4	State Routes Secondary
5	County Roads
6	City Streets

TABLE 1.2.5
Highway Classification in 1997 FHWA, 1999 Arizona, 2000 Kentucky, and 2007 Oregon HCASs.

Highway Class	Rural	Highway Class	Urban
1	Interstate	7	Interstate
2	Other Principal Arterials	8	Other Freeways and Expressways
3	Minor Arterials	9	Other Principal Arterials
4	Major Collectors	10	Minor Arterials
5	Minor Collectors	11	Collectors
6	Local	12	Local

factors in terms of bridge consumption. In addition, only a few studies have minimally addressed fatigue impact in bridge cost allocation (Fu et al., 2003; Laman & Ashbaugh, 1998). Making use of these individual improvements appropriately for bridge cost allocation are potential tasks for any future research associated with the present study.

New Bridge Construction Cost Allocation. The federal method and incremental method do not differ when dealing with new construction cost. Both have been widely used by highway agencies for bridge cost allocation (e.g., FHWA, 1982, 1997; Indiana, 1984 and 1988; Kentucky, 1992; Texas, 2002; Nevada, 2009; Oregon, 2009 and 2013; ITD, 2010; Minnesota, 2012). However, there exist variations in the approaches used to develop the various bridge cost functions in the allocation process (Tee et al., 1986).

In the federal method, the initial increment for a new bridge is associated with the cost of constructing the bridge not only to support its own weight and the lightest vehicle weight group, but also to resist other non-load-related forces such as wind and seismic forces (ECONorthwest, 2009). This first increment cost is treated as a common cost that is assigned to all the vehicle classes on the basis of their relative shares of VMT, or in cases where capacity issues need to be considered, PCE-miles. The second increment is associated with the additional cost of constructing the bridge to accommodate the second lightest weight group; this cost is allocated to only those vehicles whose gross vehicle weights (GVW) exceed or equal the second lightest weight, on the basis of their relative shares of VMT or PCE-miles (the lightest weight group is excluded). Similarly, the additional cost of the third increment is assigned to those vehicles whose gross vehicle weights (GVW) exceed or equal the third lightest weight, and so on.

Sinha et al. (1984) developed procedures for allocating the costs of the superstructure, substructure, drainage systems, etc. Costs of all superstructure elements, such as piles, piers, and abutments are load-related as well as part of the substructure costs. These load-related costs are allocated using the incremental method. Some other costs that are regarded as common costs are allocated on the basis of the common-cost allocators such as VMT.

Although the basic concept of the incremental method is clear, some issues exist in its application. The first issue is the correlation between AASHTO design vehicles and study vehicles. The basic AASHTO design loads are not the same as the loads of trucks operating on the highways; rather, they are index loadings used to specify the design criteria, and their configurations are designed to simulate the maximum or severe live loads that operate on bridges (Tee et al., 1986). A number of past studies (FHWA, 1982; WisDOT, 1982) used gross vehicle weight (GVW) to establish the relationship between AASHTO vehicles and study vehicles. However, they did not consider the axle load distribution and axle spacing.

The 1982 Maryland HCAS developed a more rational method by incorporating both axle loading and spacing in its analysis (Schelling & Saklas, 1982). However, it was limited to simply-supported single-span bridge structures only. Extending their model to continuous spans may yield biased estimates. Sinha et al. (1984) introduced the equivalent load approach which developed and utilized the correlation between AASHTO design trucks and operating trucks by equating the maximum moments produced on the critical points of continuous-span bridges with varying span lengths. FHWA (1997) also refined its method by considering the simply-supported and continuously-supported spans separately and comparing the live load moment of the study vehicles and design vehicles.

The second issue is the inherent weakness of the traditional incremental method (i.e., the economies of scale which also exist in pavement cost allocation). The economies-of-scale concept suggests that the relationship between the incremental load and the incremental cost is non-linear, and heavier vehicles benefit from such economies of scale. Tee et al. (1986) proposed a multi-increment methodology and reduced the economies-of-scale problem without requiring a large number of design computations. Using regression, they developed cost functions from which the multi-increments of costs can easily be estimated.

Bridge Replacement Cost Allocation. In the incremental method, the bridge replacement cost is allocated in the same way as the bridge construction cost, as was done in Sinha et al. (1984). In the federal method, FHWA (1982) developed a more elaborate way of dealing with the bridge replacement cost through incorporating the Bridge Sufficiency Rating Formula as follows:

$$\begin{array}{ll} B = 0.3254 \times (32.4 - IR)^{1.5} & \text{for IR} < 32.4 \\ B = 0 & \text{otherwise} \end{array} \tag{1.6}$$

where B is the loss of sufficiency points due to inadequate load-carrying capacity; and IR is the inventory rating. A bridge loses points if its load-bearing capacity is inadequate or if it has other non-load-related problems, such as scouring around piers or width inadequacy to accommodate current traffic levels.

For bridge replacement, the points lost due to inadequate load-bearing capacity are expressed as a fraction of the total points lost to determine the share of the bridge replacement costs to be allocated to vehicles that operate at weights over the load-bearing capacities of the bridges to be replaced (FHWA, 2000b).

In the 1997 Federal HCAS, the determination of the share of bridge replacement costs to be allocated to vehicles exceeding the load-bearing capacity of the bridges to be replaced was based on FHWA's Bridge Needs and Investment Process (BNIP) rather than the NBI Sufficiency Ratings (FHWA, 2000b).

Bridge Rehabilitation Cost. The 1997 Federal HCAS split bridge rehabilitation costs into two categories: major and minor bridge rehabilitation. Like bridge replacement costs, the allocation of costs for major rehabilitation was based on the BNIP. Minor rehabilitation costs were assumed to be non-load-related and were allocated based on VMT (FHWA, 2000b).

Load-related and non-load-related proportions of costs are also a significant parameter in major rehabilitation cost allocation. The FHWA (2000b) and ITD (2010) studies suggested that in order to determine what percentage of the costs is load-related for a given program subcategory and highway class, one should estimate the fraction by which the costs for the program category would be reduced if all the vehicles in the highway class are automobiles or other very light vehicles. For example, if the costs for a program category would be reduced by 10% if all the vehicles are automobiles, then 10% of the costs are load-related and 90% are non-load-related.

The Federal HCAS (FHWA, 1997) used the following estimates of load-related shares for bridge repairs: rehabilitate or replace deck—20 percent, rehabilitate or replace deck and superstructure—30 percent, rehabilitate substructure—15 percent. In addition, the Oregon HCAS (1999) estimated the load-related shares of bridge repair expenditures as follows: bridge raising—0 percent, bridge rail replacement and modifications—0 percent, cathodic protection—0 percent, deck replacement and bridge strengthening—50 percent, deck joint repair and replacement—70 percent, deck overlay—70 percent, other repairs and rehabilitation—0 percent.

Nontraditional Methods. Several nontraditional allocation methods have been developed on the basis of concepts from the theory of cooperative games (von Newman and Morgenstern, 1944). The key concept used in such procedures was that of a coalition (Lee & Garcia-Diaz, 2007). Another nontraditional procedure, known as the generalized method, was proposed by Villarreal-Cavazos (1985). The method considered all possible coalitions of vehicle classes and satisfied three properties: completeness, marginality, and rationality. The application of nonatomic game theory to cost allocation was proposed by Castano-Pardo and Garcia-Diaz (1995). This approach considered each vehicle passage over the facility as a player. Also, a cost allocation procedure based on the second-best pricing method (i.e., Ramsey pricing) was proposed by Ghaeli (1997) whereby a large share of the costs that can be allocated to more than one vehicle class, is allocated to the class that is willing and able to pay more. As mentioned earlier, these non-traditional methods offer some innovative contribution to the methodology; however, they have not been applied thus far in practice, perhaps due to their conceptual or computational complexity.

Table 1.2.6 summarizes the cost categories, cost allocation methodology, and/or cost allocators used in a number of representative state HCAS for bridges.

2.4 Highway Safety and Mobility Considerations in Highway Cost Allocation

Safety measures can be considered as an explicit and/or implicit requirement in the highway developmental process. Past empirical studies (Fitzpatrick & Wooldridge, 2001; Harwood, Rabbani, Richard, McGee, & Gittings, 2003; Lee & Mannering, 2002; Milton & Mannering, 1998; Sinha, Kaji, & Liu, 1981) have shown that, apart from human, environmental, policy, vehicular, and enforcement factors, engineering factors play a significant role in highway safety. The rate and severity of crashes can be significantly reduced if safety measures are considered at the early stages of the highway infrastructure development process. For highway segments with known safety problems, there is a need to identify safety defects and take remedial measures. The expenditures on highway assets with the goal of enhancing safety are categorized as safety asset expenditures. Examples of highway safety assets include guard rails, crash barriers, pavement markings, traffic signals, and stop signs. When crashes occur, state property is often damaged and needs repair or replacement. For example, in Indiana, approximately 4,000 cases of motor vehicle crashes per year occur along the state highways (Farnsworth, Brennan, & Bullock, 2011); the replacement of any damaged assets is considered an agency expenditure that is mostly borne by INDOT at the current time.

A safety requirement in the geometric design of highways is to ensure that horizontal and vertical curves comply with adequate sight and passing distances for road users. Although there is a minimum requirement for sight and passing sight distances, the highway infrastructure is designed or redesigned with higher standards for curves in order to accommodate the movements of larger and heavier vehicles, leading to higher costs. Although this implicit

TABLE 1.2.6
Review of Bridge Cost Allocation Methodology of Various States.

State (Year)	Cost Category	Methodology and/or Cost Allocator
INDIANA (1984)	Bridge Construction Superstructure	 Incremental design (heavier to lighter)
	Pile	Length related to loading (25% load-related)
	Pier and abutment	Related to deck width
	Other substructure components	Common costs
	Excavation and backfill	Related to deck width
	Drainage pipe	Related to deck width
	Railing	75% to GVW
	Miscellaneous	Common costs
	Bridge Replacement	Same as bridge construction
	Bridge Rehabilitation	Same as bridge construction
	Culvert Construction	Common costs
	Sign Structure Construction	Related to vehicle size
FHWA (1997)	Bridge Construction Construction Preliminary engineering Right of way Other	 Incremental design / VMT Common cost / VMT Common cost / VMT Common cost / VMT
	Bridge Replacement	Load-related (deficient load-bearing capacity): Incremental design using special bridge replacement function Non-load-related: VMT
	Major Bridge Rehabilitation	13 types of rehabilitation considered Load-related: Incremental design Non-load-related: VMT
	Other Bridge Costs	Common cost / VMT
ARIZONA (2000)	Capacity-Driven Expenditures (Urban)	VMT
	Strength-Driven Expenditures (Rural)	ESAL-Mile
	Common Costs	VMT
TEXAS (2002)	Bridge Costs (construction, rehabilitation, maintenance)	Incremental design 5 climatic regions VMT
MARYLAND (2009)	New Bridge Bridge Replacement Major Bridge Rehabilitation	Load-related: Incremental design PCE-miles
	Minor Rehabilitation and Repair	PCE-miles
NEVADA (2009) & IDAHO (2010)	New Bridge	Incremental design
	Bridge Replacement	Load-related (deficient load-bearing capacity): Incremental design Allocated to vehicles that operate at weights over the load-bearing capacities of the bridges to be replaced

TABLE 1.2.6
(Continued)

State (Year)	Cost Category	Methodology and/or Cost Allocator
	Bridge Rehabilitation	Load-related: VMT by weight Non load-related: VMT by vehicle class
MINNESOTA (2012)	New Bridge	Incremental design / PCE-miles
	Bridge Replacement	Load-related (based on inventory rating): Incremental design / PCE-miles
	Bridge Repair Special Bridge	Load-related: Incremental design
OREGON (2013)	New Structures	Bridge Split
	Replacement Structures	Bridge Split
	Structures Rehabilitation	Bridge Split
	Structures Maintenance	All VMT
	Bridge—All Vehicles Share (no added capacity)	All VMT
	Bridge—Repair Work Associated with Vehicles ≥ 10,000 lbs Vehicles	VMT of vehicles in weight group
	Bridge—Repair Work Associated with Vehicles ≥ 50,000 lbs Vehicles	VMT of vehicles in weight group
	Bridge—Repair Work Associated with Vehicles ≥ 80,000 lbs Vehicles	VMT of vehicles in weight group
	Bridge—Repair Work Associated with Vehicles ≥ 106,000 lbs Vehicle	VMT of vehicles in weight group
	Bridge—All Vehicles Share (added capacity)	Congested PCE
	Bridge Replacement with Capacity	Bridge Split

expenditure is traditionally considered a part of pavement expenditures according to previous studies (FHWA, 1997; ECONorthwest, 2013; Sinha et al., 1984), the safety requirement is implicitly met. Similarly, the vertical or horizontal clearance of a bridge may have to be increased in order to accommodate oversize vehicles. The cost of the extra clearance provided can be considered as a safety-related expenditure. It is often difficult to break down project expenditure items into such detail that captures such specific expenditures. Thus, expenditures such as the costs of increased clearance are typically considered a part of bridge expenditures. Past HCAS studies analyzed projects that had been executed either at the state or federal level (FHWA, 1997; ECONorthwest, 2013; Sinha et al., 1989), and considered safety implicitly or may have excluded safety altogether. The justification for such exclusion is the difficulty in drawing a distinction between those expenditures that should be assigned directly to pavements/bridges and those that should be safety-related.

Typically, a small number of highway projects are considered as mobility projects. The objectives of a mobility project include enhancing travel time reliability and reducing congestion. Mobility projects may include lane addition, installation of ITS (intelligent transportation systems) features, and construction of a new road in a network to enhance mobility.

In the past reports of research carried out at the state and federal levels (Balducci & Stowers, 2008; Balducci, Stowers, Mingo, Cohen, & Wolff, 2009; ECONorthwest, 2009, 2013; FHWA, 1982, 1997; Gupta & Chen, 2012; Luskin, Garcia-Diaz, Lee, Walton, & Zhang, 2002; Sinha et al., 1984; Sinha et al., 1989), the agency costs related to safety and mobility assets were considered common or non-attributable costs. Common costs are distributed to all vehicle classes by dividing the total common costs by the total unit of travel. In most of the previous studies, the unit of travel was the VMT. The justification for the use of common costs was the difficulty in attributing a specific safety or mobility improvement to a particular vehicle class. In the present study, the common cost approach is used for allocating safety/mobility/other costs, and both VMT and PCE-miles are used as the travel unit for the allocation.

2.5 Traffic Volume and Gross Vehicle Weight

Traffic volumes and traffic stream characteristics are driving factors in the planning, design, and performance of highway systems. Traffic studies are carried out to quantify existing traffic conditions for roadways where data are available, to estimate existing traffic conditions for roadways with limited data, and to forecast future traffic conditions for planned or existing roadways. The type and extent of the traffic data collected depends on the study purpose but the data typically includes traffic volume, traffic stream composition, vehicle weights, and axle spacing. These traffic characteristics then can be averaged or summed over the entire system to provide an assessment of the travel at the city, county, and/or state levels. The current cost allocation study uses a combination of location-specific assessments and network-level totals to allocate highway costs and revenues to the vehicle classes defined by the FHWA.

2.5.1 Vehicle Miles Traveled

The extent of road usage by vehicle class and road functional classification can be evaluated on the basis of the VMT. The annual VMT for a given road segment can be calculated as the product of the annual average daily traffic (AADT) and the corresponding segment length.

$$VMT_{ij} = AADT_{ij} \times Length_j \tag{1.7}$$

where VMT_{ij} is the vehicle miles traveled for vehicle class i for segment j, $AADT_{ij}$ is the annual average daily traffic for vehicle class i for segment j, and $Length_j$ is the length of road segment j. Agencies at all levels of government use the VMT as an input in planning and performance modeling, to assess the current state of the road network, and to evaluate vehicle-induced environmental impacts (Fricker & Kumapley, 2002). Furthermore, the HPMS requires that states provide the VMT for all federal-aid roadways prior to distribution of federal transportation funds. Historically, states have used a combination of permanent traffic count stations, temporary traffic counts, and expansion factors to develop segment VMTs on the basis of vehicle type and road functional class. The quality of these counts is dependent on the quality and extent of data collection. Typically, data collection along state routes is of a higher quality compared to local routes. At the national level, the HPMS data, of which VMT is a key component, is used by numerous agencies for purposes ranging from transit planning to national defense.

Traffic Counts. Due in part to the HPMS requirements, all state and local route segments receiving federal aid are covered by count stations. As seen in Table A.1, the AADT, number of single-unit trucks, and number of combination trucks are considered Full Extent (FE) data and therefore need to be reported for the entire road system receiving federal aid. AADT is determined using a combination of permanent and temporary count stations.

Data are reported to the HPMS in accordance with the FHWA roadway classification system. Historically, separate roadway classes have been designated for rural and urban segments based on the mobility and accessibility afforded by the road segment (FHWA, 1989, 2012a; Fricker & Kumapley, 2002). However, in 2008, the FHWA moved away from this approach in favor of a seven-classification structure where roads are classified based on mobility and accessibility regardless of whether they are in an urban or rural location (FHWA, 2008; OHPI, 2008, 2013a). If a distinction between urban and rural is needed, FHWA suggests that states apply an urban or rural classification to each segment using the urban area boundaries (UAB) developed by the U.S. Census Bureau. The UAB can be applied to the segments using GIS and spatial analysis (OHPI, 2013a).

Traffic Counting Equipment

Permanent (Long-Term) Count Stations. Automatic traffic recorders (ATR) record traffic data daily. At a minimum, FHWA suggests that permanent count stations collect a full day of data for each day of the week for every month of the year (OHPI, 2013a). These values then are used to develop adjustment factors to be applied to short-term counts. The adjustment factors that can be calculated include (OHPI, 2013a): day of the week, month of the year, season, and weekday vs. weekend.

Adjustment factors can be developed for individual road segments. Preferably, the individual adjustment factors should be based on nearby permanent stations along similar road functional classes. Several methodologies have been proposed to improve the accuracy of this process, including a weight distance approach, a neural network approach, non-parametric hierarchical cluster analysis, and parametric modeling (Jin & Fricker, 2008; Sharma, Lingras, Xu, & Liu, 1999; Zhao, Li, & Chow, 2004).

In addition to ATR stations, vehicle weigh-in-motion (WIM) detectors can be used to collect long-term traffic count data. Most WIM detectors measure the dynamic tire pressures of vehicles in motion, which are subsequently converted to tire loads of the static vehicle (OHPI, 2013a). There are a number of WIM technologies currently in use in the United States, including fiber optic cables, hydraulic and mechanical load cells, capacitance mats, and strain gauges. However, the most prevalent WIM instruments are piezo-electric and bending plate systems (OHPI, 2013b). In most cases, WIM technology is coupled with presence detectors (loop-detectors). The WIM detector data are used to estimate: annual growth trends, axle adjustment factors, daily and seasonal adjustment factors, and vehicle weight distributions. Vehicle weight distributions for vehicle classes are important inputs in asset deterioration and cost modeling.

Temporary (Short-Term) Count Stations. At the time of the study, Indiana had 106 permanent (long-term) count stations located on the state network, which consists of over 8,000 pavement segments (FHWA, 2008). The segments without permanent count stations are covered by temporary count locations collecting a minimum of 48 hours of data. This data is averaged to a 24-hour period and then adjusted using expansion factors to estimate the AADT for the road segment (FHWA, 2008; OHPI, 2013b). In Indiana, there are roughly 30,000 temporary count locations where traffic volumes are measured in a 3-year cycle using single or dual road tube counters.

2.5.2 Vehicle Miles Traveled (VMT) Estimation

There are a number of approaches used to estimate VMT for road segments or networks without traffic counts. These methods include fuel sales and fleet fuel economies, the licensed driver travel approach, odometer readings, travel simulation modeling, regression estimation, and state-level ratios of local VMT to collector

VMT (EPA, 1999; ICF Consulting, 2004). Some of these approaches, such as fuel sales and odometer readings, are aggregate in nature and therefore lend themselves to macro-level (network- or state-level) estimation. Others, such as travel simulations, are more suited for micro-level (project-level) estimation. At the current time, there is a concurrent VMT study by the Joint Transportation Research Program (JTRP) titled "SPR-3829: Estimation and Prediction of Statewide Annual VMT by Vehicle Class and Highway Category Funding" that investigates VMT estimation methodologies in greater detail.

Sampling. Agencies with limited resources may implement a sampling schedule in which AADT measurements are made across a relatively small number of road segments for a given road functional classification. The validity of this approach relies on the closeness of the mean AADT of the sample to the population AADT (Mohamad, 1997). Typically, at the county level, this process is carried out using simple random sampling because the systems can be considered relatively homogenous. In heterogeneous systems (e.g., state roads and U.S. routes), stratified random sampling is used to ensure that representative estimates are developed. Previous studies have stratified the sampling process at the state level according to population density, per capita income, road surface type, and roadway mileage (Fricker & Saha, 1987; Mohamad, 1997).

Fuel Sales. VMT estimation based on fuel sales largely depends on reliable determination of the traffic stream vehicle composition (VMT mix) and fleet fuel efficiencies (Vasudevan & Nambisan, 2013). These estimates may be susceptible to fluctuations in the fuel price. Fleet fuel efficiencies and average traffic stream composition are applied to the fuel tax records reported to the state to estimate statewide VMT.

Statewide VMT Ratios. State-level ratios of local road VMT to collector VMT are reported in the HPMS. These ratios are developed using available local traffic counts collected by regional transportation agencies reported to the state. Counties that lack the resources to collect local traffic data can multiply the statewide ratios to the county's total VMT for collector roads to provide an estimation of the county's total VMT for local routes (EPA, 1999; ICF, 2004).

Travel Demand Modeling. There are various applications of the traditional four-step travel demand model used to estimate AADT and VMT on local routes where the cost of operating permanent or temporary count stations would be prohibitive. All approaches employ a combination of trip generation, trip distribution, mode choice, and trip assignment (Wang, 2012; Zhong & Hanson, 2009).

Regression-Based Approaches. Regression-based approaches use one or more explanatory variables to predict VMT for a given road segment. Equations are developed on the basis of road location and functional classification for segments where VMT data are available (road segments with available VMT data are typically higher road functional classes). The developed regression models are then applied to determine the VMT at sections where VMT is unknown (Castro-Netoa, Jeongb, Jeongb, & Hana, 2009; Eom, Park, Heo, & Huntsinger, 2006; Fricker & Saha, 1987; Mohamad, 1997; Mohamad, Sinha, Kuczek, & Scholer, 1998; Seaver, Chatterjee, & Seaver, 2000). A second group of regression models utilize projections of statewide data, such as the number of licensed drivers, to estimate statewide VMT (Kumapley & Fricker, 1994).

2.5.3 Traffic Stream Composition by Vehicle Class and Weight

All states reporting to the HPMS utilize the 13 vehicle classes designated by FHWA, shown in Figure 1.2.3 (EPA, 1999; OHPI, 2011b). For general reporting purposes, vehicle classes 1–3 are automobiles, vehicle classes 4–7 are single-unit trucks and buses, and vehicle classes 8–13 are combination trucks.

It can be difficult to ascertain the distribution of VMT across the vehicle classes (also termed the VMT mix) without data from permanent (long-term) ATR or WIM stations. Mobile 6, an environmental assessment tool developed by the EPA, utilizes a default VMT mix based on national urban data. The default values can be updated if additional data are available. A simple approach to updating the default values is to calculate the ratio of the percent of all heavy trucks (class 6 and above) in the traffic stream to the current national average and then multiply the ratio with the default VMT mix values (FHWA, 2013a). A more in-depth approach involves estimating the VMT mix as a function of the roadway characteristics, such as the number of lanes, link speed, and traffic zones (Changra et al., 2000; Wand & Kockelman, 2009).

Research is limited regarding sampling procedures to obtain estimates for the VMT mix (distribution) across vehicle classes. One approach is to apply the Sample Panel (SP) sections used by the HMPS to sample other traffic factors (K factor and directional factor) to sample VMT by vehicle class (OHPI 2013b). The precision required for sampling depends on the road functional class (see Table 1.2.7). A confidence-precision measurement of 90-5 means that 90% of the time the estimate is expected to fall within $\pm 5\%$ of the true value.

A second approach to estimate VMT mix for locations without VMT mix data is to use a geostatistical weight-distance-based algorithm. One such method is Kriging estimation, which utilizes the spatial distance and autocorrelation between data collection sites and the location of interest to impute the unobserved data values from the known data (Cressie, 1993; Wackernagle, 1995). This methodology is discussed in Chapter 1 of Part 7.

The estimated VMT mix can be further refined to provide not only an estimate of the VMT for a given vehicle class, but also of the distribution of vehicle weights within the class. WIM data can be used to

TABLE 1.2.7
Confidence Interval and Precision Levels for AADT Sampling (Source: HPMS Field Manual 2013).

	Interstate	Other Freeway and Expressway	Other Principal Arterial	Minor Arterial	Major Collector	Minor Collector
Rural	90-5	90-5	90-5	90-10	80-10	—
Small Urban	90-5	90-5	90-5	90-10	80-10	80-10
Urbanized< 200,000 population	80-10	80-10	80-10	80-10 or 70-15	80-10 or 70-15	80-10 or 70-15
Urbanized≥ 200,000 population	90-10	90-10	80-10	90-10	80-10	80-10

develop these weight distributions for each vehicle class. However, the number of WIM stations across a state is typically limited and thus mostly confined to the highest classification of roads. Therefore, it is difficult to estimate vehicle weight distributions for lower class roadways without making numerous assumptions.

2.6 VMT and Fuel Sales Attributable to Out-of-State Vehicles

VMT and fuel sales attributable by vehicle origin (within-state vs. out-of-state) were determined separately for inter-state commercial vehicles from all other vehicles. Estimation of inter-state commercial vehicle VMT is relatively straightforward assuming data from the International Fuel Tax Agreement (IFTA) is available. IFTA is an agreement between the Canadian provinces and the lower 48 U.S. states. The agreement allows fuel tax paid by inter-state and inter-country commercial vehicles to be apportioned to the states/provinces in relation to the extent of travel in each region (IFTA, n.d.). If IFTA data is not available, estimation of the split of commercial vehicle VMT may become cost prohibitive due to the extensive roadway monitoring that would be required for data collection. The International Registration Plan (IRP) is similar to IFTA, except that instead of covering fuel taxes, it covers the "payment of apportionable fees on the basis of the total distance operated in all jurisdictions" (IRP, n.d.). These two sources provide information on the amount of fuel sold and amount of travel on Indiana highways by inter-state commercial vehicles.

Conversely, limited research has been conducted to estimate the in-state/out-of-state split of VMT for all other vehicles (Sinha, 1979); that research found a roughly 70/30 in-state to out-of-state split. Subsequent studies have relied solely on these estimates (Office of the Governor, 2012). Over thirty years have passed since any original analysis on the split has been carried and it is considered timely and appropriate to address this issue at the current time for the purposes of the present study.

2.7 Summary of Past Cost Allocation Studies at the State and Federal Levels

2.7.1 Federal HCAS

In 1982, the USDOT carried out a spearheading HCAS to allocate the costs of federal highway programs to the different vehicle classes. That study was aimed at evaluating the equity of the federal user fee structure and the making of recommendations for any needed changes. The analysis was conducted on the basis of highway functional class (local routes, collectors, other arterials, and interstates) and location type (urban/rural). Mathematical modeling was carried out to estimate the contribution of vehicle load to different pavement distresses. Unlike the 1965 Federal HCAS which used the traditional incremental method for allocating the costs of new pavements, the 1982 study allocated new pavement costs to the different vehicle classes using the Minimum Pavement Thickness Method; also, the 1982 study did not account for the maintenance cost (FHWA, 1982).

The most recent major HCAS at the federal level was carried out in 1997; this was updated through an addendum in 2000. That study aimed at estimating the cost responsibilities of the vehicle classes for the federal highway program costs and evaluating whether different vehicle classes were paying a fair share of their cost responsibility. For allocating the pavement costs, maintenance expenditures were also considered in addition to the expenditures on new or rehabilitated pavements. The cost allocation approach for new pavements used in the 1997 Federal HCAS was similar to that used in the 1982 Federal HCAS; specifically, the base facility cost was allocated to the various vehicle classes on the basis of their VMT weighted by their PCEs (the PCE is considered a measure of the influence of different types of vehicles on highway capacity). The cost of the additional pavement thickness needed to accommodate the anticipated traffic was allocated based on the AASHTO pavement design procedures. For the rehabilitation cost allocation, the federal study used NAPCOM, and the pavement deterioration analysis was conducted using HPMS pavement section data. The load-related expenditures were allocated using NAPCOM while the non-load portion of the expenditures was allocated on the basis of VMT. The 1997 Federal study also considered marginal social costs (i.e., air pollution, noise, congestion, crashes and waste disposal) (Bruzelius, 2004; FHWA, 1997).

With regard to bridge cost allocation, both the 1982 and the 1997 Federal HCAs followed the similar basic principle of incremental bridge design. However, the 1997 Federal HCAS carried out a few noteworthy enhancements; for example: a) the 1997 HCA study identified costs for four bridge project types whereas the 1982 HCA study identified three, b) there were 8 increments for the design (and hence, cost) in the 1982 study but 10 increments for the 1997 study. In the 1982 study, the bridges were assumed to be simply-supported, the single-unit truck was simplified to act as a point load, and the combination truck was assumed to yield moments that were simple multiples of those of single-unit trucks; on the other hand, in the 1997 HCAS, the live load moments were calculated for each highway functional class, bridge support type, and vehicle class and weight group (FHWA, 1997). Also, in the 1997 study, the costs associated with environmental, safety, TSM (Transportation System Management), and other improvements, in addition to those of pavement and bridge projects, were classified as system enhancement costs. The costs of construction projects related to safety and TSM improvements were allocated on the basis of PCE-weighted VMT; other costs within this general category were allocated on the basis of VMT because these costs are basically unrelated to the characteristics of different vehicle classes (FHWA, 1997). Further, in the 1997 study, certain costs that were occasioned uniquely, for example, truck-related projects, transit projects funded from Federal-aid highway funds, and ridesharing/HOV projects, were analyzed on a separate basis.

2.7.2 State HCAS Model Tool by FHWA

A highway cost allocation tool in the form of a spreadsheet was developed by FHWA to facilitate state HCAS. The tool is based on the methodology used in the Federal HCAS but offers a high level of flexibility to the users. For example, the common cost for pavements can be allocated on the basis of VMT, PCE, or PCE-weighted VMT. In the guidelines that accompany the tool, use of the peak period PCE-weighted VMT is suggested in order to allocate the common costs to vehicles for all projects for which capacity improvement is the primary basis for the investment. VMT is suggested for all other projects (FHWA, 2000b).

The Federal HCAS approach is used in the tool to allocate the cost of new pavements. The expenditure for the constructed pavement (after subtracting the minimum thickness) is allocated on the basis of ESALs, while the minimum thickness expenditure is treated as a common cost. Regarding pavement rehabilitation, the load-related costs are allocated on the basis of ESALs and the non-load- related costs are considered common costs. Last but not least, the pavement maintenance expenditures are categorized into specific types of maintenance activities. Then, they are allocated on the basis of ESALs, VMT, axle-miles, or other vehicle characteristics based on the best available results from research on pavement maintenance costs in relation to axle loads and other factors (FHWA, 2000b).

2.7.3 Indiana HCAS

In 1984, the Indiana Department of Transportation sponsored a highway cost allocation study to establish the cost responsibilities of the different vehicle classes. Instead of the traditional incremental method, the thickness incremental method was used. First, the base facility cost (assuming a minimum pavement thickness based on the AASHTO guidelines) was allocated to all vehicles on the basis of VMT. Then the remaining pavement thickness was divided into increments that were added to the base facility successively and the cost for each increment allocated appropriately. After all the increments were added, the total cost responsibility of each vehicle class was computed as an addition to its cost responsibility associated with all the base facility and all the thickness increments (Fwa & Sinha, 1985b; Sinha et al., 1984). The pavement rehabilitation cost allocation method used in the 1982 Federal HCAS did not explicitly consider the effect of maintenance costs in its analysis or the interaction between different distresses (Fwa & Sinha, 1986). These limitations were identified by Fwa and Sinha (1986) who proposed a performance-based approach for relating pavement performance to pavement preservation.

With regard to cost allocation for bridges, the 1984 Indiana HCAS included five types of structural expenditures, i.e., bridge construction, bridge rehabilitation, bridge replacement, culvert construction, and sign structure construction. The bridge construction, rehabilitation and replacement costs were allocated through the incremental method. The AASHTO design vehicles and the observed vehicles were related according to the bending moment they created on a continuous bridge of typical spans and a computer program was used to obtain this correlation. Five types of bridges, (reinforced concrete slab, prestressed concrete I-beam, prestressed concrete box-beam, steel beam, and steel girder) were analyzed differently; specific incremental cost factors were established for superstructure and substructure separately for different types of bridges. Culvert costs were treated as common costs. For sign structures, a number of vehicle-size-related responsibility factors were developed.

2.7.4 Arizona HCAS

In 1999, Arizona sponsored the development of SMHCAS (Simplified Model for Highway Cost Allocation Studies). First, SMHCAS assumed that a majority of construction in urbanized areas takes place for the purpose of adding road capacity; for this reason, expenditures were allocated on the basis of VMT. For projects in rural areas on the other hand, it was assumed that construction mainly occurs because of the need for preservation. The expenditure data were placed in three categories: capacity-driven, strength-driven, and common expenditures. This distinction was made to ensure a more equitable distribution of system-wide common costs (e.g., highway signs and safety improvements). The capacity-driven expenditures were distributed according to the urban VMT only; the preservation expenditures were allocated on the basis of vehicle weight (ESAL-miles) on rural highways; and the common expenditures were allocated according to the total VMT share.

2.7.5 Oregon HCAS

In 1937, the first HCAS in the nation was carried in Oregon; and to date, the state has conducted 18 highway cost allocation studies. The latest study (ECONorthwest, 2013) used the FHWA road classification system. Also, all vehicles less than 10,000 lbs. GVW were placed in a light or "basic" vehicles group while all other vehicles were classified as heavy vehicles. The costs of new pavement construction were allocated using the incremental method. For allocation of the load-related portion of maintenance and rehabilitation, the 2010 NAPCOM cost equations were used. Pavement factors were developed in 2,000-lb. increments of declared vehicle weight. In addition to the use of data from Oregon's special weighing program, WIM data were used to construct a distribution of operating weight to declared weight. The non-load-related or common costs were allocated using a number of cost allocators. For bridge cost allocation, the widely used incremental, design-based allocation methodology was also adopted by Oregon. Regarding bridge replacement costs, Oregon HCAS defined that a replacement bridge with more lanes than the bridge it replaced was considered as modernization (new construction or reconstruction), while bridge replacement that did not add capacity was considered preservation (rehabilitation).

2.7.6 HCAS at Other States

According to the NCHRP report by Balducci and Stowers (2008), from 1982 to 2007, 26 states are known to have conducted HCASs. Aside from the four HCASs mentioned in the previous sections, some other relatively significant HCASs conducted by different states include:

- *California HCAS:* Although California has carried out only two cost allocation studies (1984–1987 & 1995–2000), both these studies made significant contributions to HCA literature, in terms of the definitions of the basic cost allocation principles and methodology, and the justification of carrying out periodic HCA studies to reflect changing conditions (Balducci & Stowers, 2008). Using the Federal and incremental method, the California HCA study found that the share of heavy-vehicle cost responsibility was approximately 19%.
- *Texas HCAS:* The 2002 Texas HCAS (Luskin et al., 2002) identified five climatic regions through various climatic factors and statistical analysis, and the costs associated with pavement deterioration were allocated differently for the different climatic regions. The methodology included the Federal method, modified incremental analysis, and generalized method.
- *Kentucky HCAS:* Kentucky had conducted nine HCASs since early 1980s but stopped in 2000 due to some issues regarding the low tax rate for the weight-distance tax relative to heavy-truck cost responsibility (Balducci & Stowers, 2008; Deacon, Pigman, & Stamatiadis, 1992; Osborne, Pigman, & Thompson, 2000). Results from the study indicated that the cost responsibility for cars and motorcycles was 44.06% and 27.06% for heavy trucks over 60,000 pounds. The equity ratios were found to be 0.98, 0.86 and 0.90 for cars, buses and heavy trucks, respectively.
- *Nevada, Idaho and Vermont HCAS:* Nevada, Idaho and Vermont also conducted relatively frequent HCASs since 1980s till recent years. Their analysis found the cost responsibility share of heavy vehicles ranged from approximately 25% to 40%. In Nevada HCAS and Idaho HCAS, the state, federal and local funds were investigated for revenue attribution.

2.8 Chapter Summary

This chapter presented a review of the literature related to cost allocation methodologies. Table 1.2.8 summarizes past pavement cost allocation methodologies. A major issue with most HCAS is that while estimating the cost responsibility factor for different vehicle classes, the allocated costs are not decomposed by the capacity-driven and strength-driven expenditures; this dichotomy reflects an agency's objective in carrying out any project. By failing to distinguish between capacity-driven and strength-driven expenditures, the road-user charges estimated by these studies include costs that are not directly related to pavement damage and thus cannot be used fairly as a basis for establishing road-user charges to cover the pavement consumption cost. In summary, there have been

TABLE 1.2.8
Summary of Significant Highway Cost Allocation Studies.

Study	Cost Allocation for New Pavement Construction	Cost Allocation for Pavement M&R
1965 Federal HCAS	Traditional Incremental Method	VMT or incremental method Maintenance cost not considered
1982 Federal HCAS	Minimum Pavement Thickness Method	Individual Distress Models Maintenance cost not considered
1984 Indiana HCAS	Thickness Incremental Method	Performance-Based Approach Concept of PSI–ESAL loss was introduced Costs estimated on the basis of proportionality assumption
1997 Federal HCAS	Minimum Pavement Thickness Method	NAPCOM—Individual Distress Models
1999 Arizona HCAS	Simplified Model for HCASs (Arizona SMHCAS)	
2013 Oregon HCAS	Minimum Pavement Thickness Method	NAPCOM—Individual Distress Models

incremental improvements in pavement cost allocation methodologies since the release of the 1982 FHWA HCAS and the 1984 Indiana HCAS. Several states not discussed in this section have adopted one of the state or federal methodologies discussed previously in this section.

For bridge cost allocation, previous studies followed the methodology developed by FHWA in 1982 and improved in 1997. However, there is room for improvement if the necessary data can be obtained; for example, more comprehensive or complete incremental factors can be developed in terms of different bridge types, highway classes, span lengths, etc. Also, the load-related and non-load-related shares of bridge rehabilitation costs can be more accurately calibrated using controlled field experiments or advanced statistical techniques. Also, it is worth considering whether the fatigue impact on bridges induced by heavy vehicles can be incorporated into the allocation of costs for bridge replacement and rehabilitation.

In terms of cost allocation for safety, mobility, and other projects, some previous HCASs did not separate them as a specific cost category but included them implicitly within the pavement and bridge expenditures. For HCASs that considered them explicitly, they were typically analyzed as common costs which were allocated on the basis of VMT and/or VMT adjusted by vehicle size (e.g., PCE-miles).

This Part of the report also discussed the methodologies used by transportation agencies to carry out traffic studies in order to assess the extent of travel on their network. Travel volumes and traffic stream composition provide vital inputs to project- and system-level planning, design, and operations management. This chapter detailed how traffic characteristics can be measured using a combination of continuous and short-term traffic counts. To determine the traffic characteristics for locations with missing traffic data, there are a number of estimation techniques, including fuel sales-based estimates and travel demand modeling according to the four-step process. The international databases, IFTA and IRP, as well as data obtained from statewide sampling, can provide additional data items such as traffic stream distributions by vehicle class and vehicle weight and the VMT attributable to out-of-state traffic. The next Part of the report discusses how the current study collected and analyzed traffic data for 2009–2012 across all road functional classes in Indiana.

PART 2. ASSESSMENT OF SYSTEM USAGE

1. DATA COLLECTION

1.1 Introduction

The main objective of highway cost allocation and revenue attribution studies is to identify and assign the costs incurred to, and the revenue generated from users on the basis of their system usage. Thus, a reliable assessment of system usage is an indispensable component of any study on cost allocation or revenue attribution. In the context of the current study, highway system usage is quantified in terms of the vehicle miles traveled (VMT) and the vehicle weight (measured either in gross vehicle weight (GVW) or equivalent single axle loads (ESAL)). The current chapter discusses the traffic data that are used to quantify the usage of each functional class of road by each of the FHWA 13 vehicle classes. For a description of the 13 FHWA vehicle classes, please refer to Part 2, Chapter 2.

1.2 Traffic Volume Data Description

This study includes the collection of traffic-related data to be used in the allocation of asset costs to the road users. This source data includes 2009–2012 AADT based on short-term traffic counts for each state route roadway asset and a sample of local (county and municipality) roadway assets. A state route roadway asset is defined as a section of road with a specific start and end milepost, which is reported to HPMS. In addition to the AADT data, ATR and WIM data were used to estimate location-specific and road functional class-specific distributions of vehicle class and weight.

In order to develop a comprehensive travel database for use in the cost allocation, data on the following traffic characteristics were collected for each state route road segment: location/district, route, starting milepost, ending milepost, AADT, truck AADT, road functional group, and national highway system (NHS) classification. In addition, data on the distribution of vehicle classes and vehicle weights were collected for a limited number of road segments. The database of state routes includes over 8,000 pavement segments covered by short-term traffic counts, which includes over 6,000 roadway segments covering approximately 11,000 centerline-miles of mainline segments and an additional 2,000 ramp segments.

1.2.1 AADT Data

INDOT assigns a unique ID to each road and ramp segment reported to the HPMS. The AADT data corresponding to each ID were obtained from the INDOT Interactive Traffic Count Map (INDOT, n.d.a). The 2009 AADT reporting system included two AADT values, total AADT (FHWA vehicle classifications 1–13), and commercial vehicle AADT (classes 4–13). Since 2011, separate AADT values for single-unit trucks (classes 4–7) and combination trucks (classes 8–13) were reported.

1.2.2 Functional Classification

Assets in the same functional classification can generally be considered to have similar design and construction features. Therefore, it is appropriate to group assets by road functional classification for data analysis and data reporting purposes.

FHWA Road Functional Class. Prior to 2008, the FHWA classification hierarchy was based on location (urban and rural), mobility, and accessibility (FHWA, 1989). After 2008, a new classification was adopted where roadways were classified only on the basis of mobility and accessibility (FHWA, 2008; OHPI, 2008, 2013b). The new classification is presented in Table 2.1.1 and Table 2.1.2.

National Highway System (NHS) Classification Data. Road segments can be grouped according to their NHS classification. The NHS consists of all interstates, major arterials, and other selected routes designated as critical to the nation's economy, defense, and mobility (FHWA, 2013a). The NHS in Indiana (Figure 2.1.1) consists of several subsystems including: the Eisenhower Interstate

TABLE 2.1.1
Pre-2008 FHWA Highway Functional Classification (Fricker & Kumapley, 2002; OHPI, 2011a).

Area	Functional Class	HMPS Code
Rural	Principal Arterials	
	Interstate	1
	Other Principal Arterials	2
	Minor Arterials	6
	Collectors	
	Major	7
	Minor	8
	Local	9
Urban	Principal Arterials	
	Interstate	11
	Other Freeways and Expressways	12
	Other Principal Arterials	14
	Minor Arterials	16
	Collectors	17
	Local	19

TABLE 2.1.2
Current FHWA Highway Functional Classification (OHPI, 2008).

Description	HPMS Code
Interstate	1
Principal Arterial—Other Freeways and Expressways	2
Principal Arterial—Other	3
Minor Arterial	4
Major Collector	5
Minor Collector	6
Local	7

Figure 2.1.1 Indiana's National Highway System (FHWA, 2013a).

System, other Principal Arterials, Strategic Highway Network (STRAHNET), major STRAHNET Connectors, and intermodal Connectors.

STRAHNET consists of the highways critical to the nation's strategic defense. Major STRAHNET connectors connect military installations with STRAHNET. The intermodal connectors connect the four subsystems and major intermodal hubs. The extent of the NHS system expanded greatly in 2012 as a result of the Moving Ahead for Progress in the 21st Century Act (MAP-21) classifying all principal arterials as NHS routes (FHWA, 2013b; OHPI, 2013a). Nationwide, nearly 60,000 route-miles were added to the NHS, increasing the existing NHS by 34%. Indiana saw greater-than-average expansion, from 2,902 route-miles pre-MAP-21 to the current 4,819 route-miles, an increase of 66% (Table 2.1.3).

1.2.3 Traffic Count Station Technology

Automated Traffic Recorder (ATR) Data. ATRs are permanent count stations that record traffic volumes according to the 13 FHWA vehicle classes. At the time of the study, Indiana had 66 ATR stations across different road functional classes stored in the Traffic Count Database System (TCDS) (INDOT, n.d.b). The average vehicle class distribution for each road function class is summarized in Table 2.1.4. The spread of this data (maximum, minimum, and inter-quartile range) is

TABLE 2.1.3
Updated NHS due to MAP-21 (FHWA, 2013b).

	Pre MAP-21 NHS	Non-NHS Principal Arterial System	Post MAP-21 NHS	Percent Increase
Indiana	2,902	1,917	4,819	66.1%
US Total	163,742	59,926	223,668	36.6%

TABLE 2.1.4
ATR Data: Average Vehicle Class Distribution by Road Functional Class.

	Road Functional Class				
Vehicle Class	**Interstate**	**Principal Arterial (Frwy/Expwy)**	**Other Principal Arterial**	**Minor Arterial**	**Major Collector**
1	0.23%	0.29%	0.40%	0.54%	0.57%
2	68.01%	74.80%	72.84%	66.77%	61.08%
3	12.91%	18.47%	19.10%	23.41%	26.01%
4	0.17%	0.08%	0.08%	0.07%	0.05%
5	0.92%	0.85%	0.82%	1.27%	1.14%
6	0.58%	1.12%	0.48%	0.96%	1.27%
7	0.12%	0.49%	0.10%	0.35%	0.44%
8	1.02%	0.46%	0.49%	0.81%	0.62%
9	13.87%	2.45%	4.37%	5.14%	5.96%
10	0.18%	0.04%	0.09%	0.08%	0.10%
11	0.54%	0.03%	0.11%	0.02%	0.02%
12	0.21%	0.02%	0.03%	0.01%	0.01%
13	0.09%	0.02%	0.05%	0.03%	0.03%
Unclassified	1.17%	0.88%	1.05%	0.54%	2.69%
Total	100.00%	100.00%	100.00%	100.00%	100.00%
# of Locations	16	1	15	5	13

TABLE 2.1.5
WIM Data: Average Vehicle Class Distribution by Road Functional Class.

	Road Functional Class			
Vehicle Class	**Interstate**	**Other Principal Arterial**	**Minor Arterial**	**Major Collector**
1	0.53%	0.81%	0.59%	0.44%
2	46.44%	48.56%	52.89%	51.90%
3	24.63%	29.90%	36.12%	39.86%
4	0.45%	0.42%	0.43%	0.21%
5	5.89%	5.20%	4.62%	3.93%
6	0.60%	0.64%	0.39%	0.43%
7	0.08%	0.24%	0.04%	0.09%
8	1.16%	1.18%	0.82%	0.60%
9	16.25%	11.29%	2.88%	1.62%
10	0.17%	0.16%	0.11%	0.01%
11	0.54%	0.15%	0.02%	0.01%
12	0.20%	0.04%	0.01%	0.00%
13	0.02%	0.02%	0.04%	0.00%
Unclassified	3.03%	1.40%	1.05%	0.89%
Total	100.00%	100.00%	100.00%	100.00%
# of Locations	18	13	1	1

presented in Addendum A. There are 16, 16, 5, and 13 ATRs located on the interstates, principal arterials, minor arterials, and major collectors, respectively.

1.2.4 Weigh in Motion (WIM) Data

WIM detectors are used to collect long-term traffic counts similar to the counts obtained from ATR stations. However, WIM detection works by measuring the dynamic tire pressures of vehicles in motion which, once converted to static tire loads, can be used to develop the distribution of vehicle weights (OHPI, 2013b). Both vehicle class distributions and vehicle weight distributions are important in accurately allocating the costs of transportation infrastructure. At the time of the present study, there were 39 WIM stations in Indiana, of which 18 are at interstates, 13 are at other principal arterials, one each is at minor arterials and major collectors, and six which did not have reliable data available for the study period. The average vehicle class distributions are presented in Table 2.1.5 with detailed summaries (minimum, maximum, and inter-quartile range) presented in Addendum A.

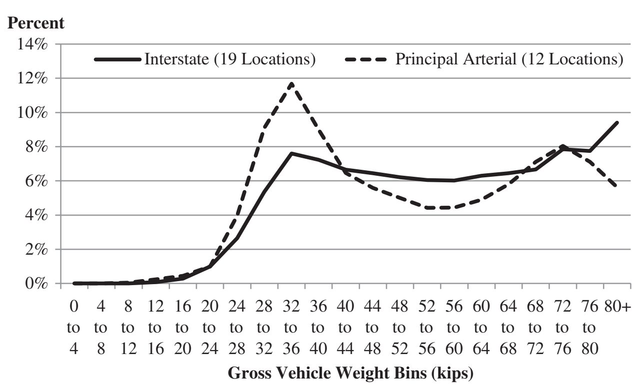


Figure 2.1.2 Average GVW distribution for FHWA vehicle class 9 (5 axles, 2 units).

Weight can be an important factor in the allocation of costs for heavy vehicles due to the wide distribution of GVW. Vehicle class 9 (five-axle, single trailer) comprises the greatest percentage of heavy vehicles in the traffic stream and therefore the distribution of class 9 weights can be considered the most influential. Figure 2.1.2 presents the class 9 vehicle weight distributions for interstates and other principal arterials. Two peaks are evident for the interstate data. The first peak shows that 7.7% of the trucks fall into the 32–36 kip bin which corresponds to a typical, unloaded class 9 vehicle; and the second peak indicates that 9.4% are running at or above 80 kips, which corresponds to a fully loaded truck. For other principal arterials, the peak in the 32–36 kip range is more pronounced at 11.8%, meaning more trucks are running unloaded.

2. METHODOLOGY

2.1 Traffic Volume and Gross Vehicle Weight Distributions

Traffic data were collected at over 8,000 pavement segment locations in Indiana using short-term counts, compared to less than 100 segments which were counted using continuous counts. This means that for most segments, only the total AADT and truck AADT are known. Continuous count stations collect data that can be used to calculate traffic volume distributions (the percentage of each vehicle class in the traffic stream), which were then used to determine the VMT mix. Of all the long-term count stations, only the 33 WIM stations collect data that can be used to calculate distributions of GVW. These distributions were important inputs in pavement and bridge cost allocation because certain categories of pavement and bridge costs were allocated on the basis of either the 13 FHWA vehicle classes or on the basis of GVW. Furthermore, accurate estimates of traffic volume and vehicle weight distributions are important inputs in other agency business, such as deterioration and performance modeling, planning and design, environmental impact assessment, and the allocation of federal funds. These interactions are illustrated in Figure 2.2.1.

Chapter 1 of the current Part of this report provided an overview of the average values obtained from the permanent count stations. However, applying the average values from a limited number of locations to all the other locations could lead to misspecification. The continuous count stations were spread out over four road functional classes, the majority of which were located in urban areas (Figure 2.2.2) and at interstates and principal arterials (Table 2.2.1).

The clustering of count stations in urban areas is expected to skew the average network-level estimates. Furthermore, applying average values to specific project locations, which was required for certain cost allocation procedures, may likewise lead to skewed results. Therefore, there was a need to not only investigate if the data was skewed but also correct for it.

2.2 Traffic Volume Distribution by Vehicle Class

The traffic volume for a FHWA vehicle class i for road segment j for road functional classification k can be calculated as follows:

$$AADT_{ijk} = (P_{ijk})(AADT_{jk}) \tag{2.1}$$

where $AADT_{ijk}$ is the annual average daily traffic for FHWA vehicle class i for road segment jk where j is the road ID and k is the road functional class, P_{ijk} is the percent of FHWA vehicle class i in the traffic stream for road segment jk, and $AADT_{jk}$ is the annual average daily traffic for road segment jk.

The VMT for a given FHWA vehicle class for a given road segment is defined as:

$$VMT_{ijk} = (AADT_{ijk})(L_{jk}) \tag{2.2}$$

where VMT_{ijk} is the vehicle miles traveled for FHWA vehicle class i for road segment jk and L_{jk} is the length of road segment jk in centerline-miles.

The total VMT for FHWA vehicle class i for road functional class k is defined as:

$$VMT_{ik} \sum_{j=1}^{n} VMT_{ijk} \tag{2.3}$$

where VMT_{ik} is the VMT for vehicle class i for road functional class k.

Conversely, if VMT_{ijk} is unknown for some road segments, an estimate for the total VMT for FHWA vehicle class i for road functional class k is defined as:

$$VMT_{ik} = (P_{ik})(L_k) \tag{2.4}$$

where P_{ik} is the is the average percent of FHWA vehicle class i for road functional class k, and L_k is the total lane-miles of road functional class k. The average percentage of each FHWA vehicle class for each road functional class obtained from the continuous count stations (WIM or ATR) is presented in Table 2.2.2. For the purpose of traffic volume distribution analysis, data from three road functional class groups were investigated: interstates, other principal arterials, and minor arterial and major collectors.

The variability associated with the mean values presented in Table 2.2.2 is presented in Figure 2.2.3. The spread between the maximum and minimum values for a given vehicle class can be as much as 50 percentage points. The inter-quartile range, the difference between the third quartile (Q3) and the first quartile (Q1), is as much as 24 percentage points. This variation justifies the need for additional analysis.

Continuous count data that can yield traffic volume distributions by vehicle class were available for only 88 out of over 8,000 road segments. The short-term counts for the 8,000 plus road segments provided values for the total AADT and the truck AADT (vehicle classes 4–13).

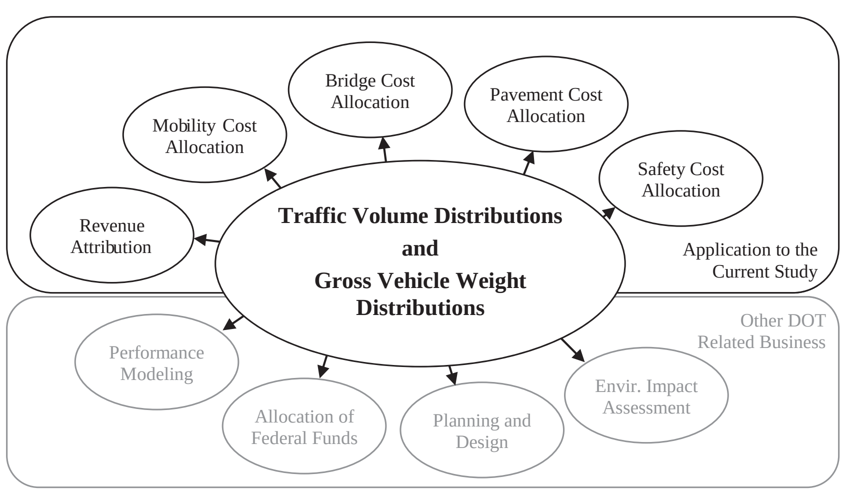


Figure 2.2.1 Traffic volume and GVW distribution use.

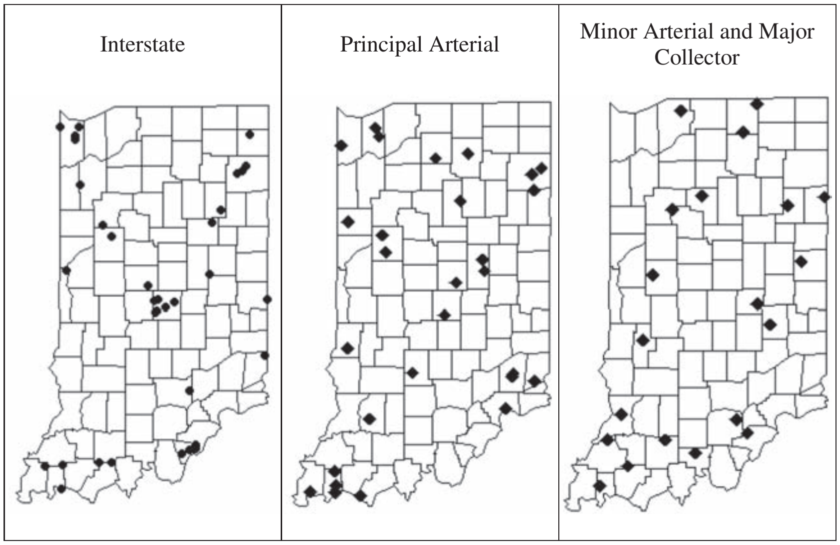


Figure 2.2.2 Spatial distribution of continuous traffic count stations.

From these two values, the AADT for small automobiles (vehicle classes 1–3) was calculated as follows:

$$AADT_A = AADT_{Total} - AADT_T \tag{2.5}$$

From these two values, $AADT_A$ is the AADT for vehicle classes 1–3, $AADT_{Total}$ is the total AADT, and $AADT_T$ is the AADT for vehicle classes 4–13.

Additionally, a methodology was developed to determine the distribution of VMT for the truck traffic stream. This methodology yields the percentage of each truck class relative to the total truck traffic. Since class 9 (two-unit five-axle) is the dominant truck class in the traffic stream, spatial analysis was carried out to determine the percentage of this class of trucks in the truck traffic stream. The spatial analysis was expected to yield road segment-specific estimates of the class 9 truck percentages that can then be used in conjunction with the average truck traffic distributions to obtain the percentages for all other truck classes.

2.3 Spatial Analysis of Traffic Volume Distributions by Vehicle Class

The previous section showed that significant variance exists in traffic volume distributions. To account for such variance and to provide segment-specific (project-level) estimates and reliable network-level estimates of the truck traffic distributions, Ordinary Kriging estimation was implemented.

2.3.1 Ordinary Kriging Assumptions

Ordinary Kriging estimation, a geostatistical spatial estimation methodology, is just one of several distance-based algorithms that could be implemented to derive the percentage of each truck class. Kriging estimation has the benefit of accounting for the clustering of data collection sites that is observed in the long-term traffic count locations (refer back to Figure 2.2.2). Kriging estimation is accomplished using the distance and auto-correlation between data collection sites to impute unknown values into a random field. Ordinary Kriging, which is one of several Kriging estimation methodologies, is distinguished from the others because it assumes that the mean is unknown but is constant over a small distances (termed the "local neighborhood"); the Simple Kriging assumes the mean is known and constant over all data points; and the Universal Kriging assumes the mean is the trend over small distances (Cressie, 1990, 1993; Wackernagle, 1995).

Ordinary Kriging estimation assumes that the data are omni-directional (i.e., only the distance between points is considered, not the direction (north, east, etc.)). Therefore, any trends that are a result of directional influences need to be removed first. This trend analysis is presented in

TABLE 2.2.1
Distribution of Continuous Count Stations across Functional Classes.

Long-Term Count Type	Interstate	Other Principal Art.	Minor Arterial	Major Collector	Total
ATR	16	16	5	13	50
WIM	18	13	1	1	33
Total	34	29	6	14	88

TABLE 2.2.2
Average Traffic Distribution by Vehicle Class at ATR and WIM Stations.

FHWA Vehicle Class	Road Functional Class		
	Interstate	Principal Arterials	Minor Arterial/Major Collector
Class 1	0.40%	0.59%	0.57%
Class 2	57.71%	62.75%	62.82%
Class 3	19.63%	24.23%	27.05%
Class 4	0.33%	0.23%	0.08%
Class 5	3.69%	2.82%	1.51%
Class 6	0.60%	0.58%	1.13%
Class 7	0.10%	0.18%	0.39%
Class 8	1.12%	0.81%	0.69%
Class 9	15.44%	7.50%	5.59%
Class 10	0.18%	0.12%	0.10%
Class 11	0.55%	0.13%	0.02%
Class 12	0.21%	0.03%	0.01%
Class 13	0.05%	0.04%	0.03%

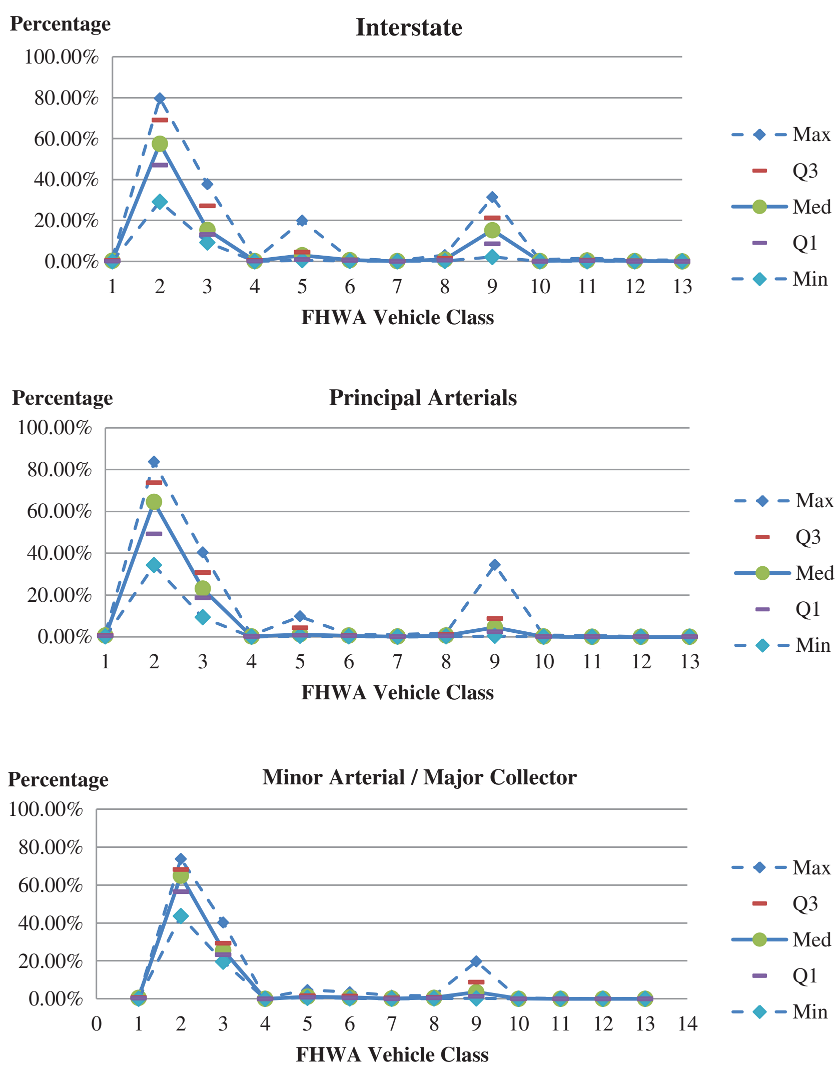


Figure 2.2.3 Variability observed in vehicle class distributions.

Addendum A. Few to no trends were apparent in the class 9 percentages for any of the three road functional classes under investigation. This can be expected because, in general, one would not expect a change in the percentage of class 9 trucks in the truck traffic stream as one moves across the state in any direction. Rather, changes in the percentage of class 9 trucks would be the result of local shifts in socio-economic conditions.

2.3.2 Ordinary Kriging Model Framework

Estimates of unknown values using Kriging are obtained from weighted linear combinations of known values defined as (Cressie, 1990, 1993; Wackernagle, 1995):

$$\hat{Z} = \sum_{1}^{n} w_j v \tag{2.6}$$

where $\hat{Z}$ is the predicted value, v is the known value and wj is the weight.

In Ordinary Kriging, the value of v is unknown, therefore, a stationary random function $Z(x_i)$ is applied:

$$\hat{Z}(x_0) = \sum_{i=1}^{n} w_i(x_0) Z(x_i)$$

where $Z(x_i)$ is the value, x_0 is the location of the unobserved value, x_i is the location of the observed value, and w_i are the weights.

The weights are a function of distance accounting for spatial clustering of data collection locations. The error is defined as:

$$\varepsilon(x_0) = \hat{Z}(x_0) - Z(x_0) \tag{2.8}$$

To ensure the model is unbiased, the sum of the weights is set equal to one:

$$\sum_{i=1}^{n} w_i(x_0) = 1 \tag{2.9}$$

We therefore seek to minimize the error variance:

$$minimize\ E\left[\varepsilon(x_0)^2\right] \tag{2.10}$$

The covariance is defined as:

$$Cov\{x_j, x_i\} = E\left(\varepsilon(x_i)\varepsilon(x_j)\right) \tag{2.11}$$

An assumption of intrinsic stationarity means the expected value between two points h distance apart is equal to zero:

$$E[Z(x+h) - Z(x)] = 0 \tag{2.12}$$

The variance between two points h distance apart is defined as:

$$Var[Z(x+h) - Z(x)] = E[(Z(x+h) - Z(x))^2] = 2\gamma(h) \tag{2.13}$$

where $2\gamma(h)$ is the variogram.

Estimated Variogram. The variogram is the variance of the difference between points separated by the same Euclidean distance h. The exponential semi-variogram (variogram divided by two) used in the current research takes the form (Cressie, 1990, 1993; Wackernagle, 1995):

$$\gamma(h) = C_0 + C_1(1 - \exp\left(\frac{-3|h|}{a}\right) \tag{2.14}$$

where C_0 is the nugget effect (difference in sample values separated by extremely small distances), C_1 is the partial sill (difference between the nugget effect (C_0) and the maximum variogram value (sill)), and a is the range (the distance between two points at which the variogram no longer increases). The Matérn variogram used in the current research takes the form:

$$\gamma(h) = C_0 + C_1\left(1 - \frac{1}{2^{v-1}\Gamma(\mathrm{v})}\left(\frac{h}{a}\right)^{v} K_v\left(\frac{h}{a}\right)\right) \tag{2.15}$$

where K_v is the modified Bessel function of the second kind of the order v, Γ is the gamma function, and v is the smoothness parameter. It is important to note that the Matérn variogram is the same as the exponential variogram when the smoothness parameter (v) is 0.5 (Minasny & McBratney, 2005).

2.3.3 Mean Square Prediction Error

The mean squared prediction error (MSPE) was used as a measure of goodness of fit. The MSPE was calculated by sequentially removing one known data point at a time from the dataset, estimating the percentage of class 9 trucks for that data point, then replacing the removed data point. The MSPE is defined as:

$$MSPE = \frac{\sum_{i=1}^{n}(Y_i - \hat{Y}_i)}{n} \tag{2.16}$$

where Y_i is the actual percentage of class 9 trucks for permanent count station location i, $\hat{Y}_i$ is the predicted percentage of class 9 trucks for location i, and n is the number of continuous count station locations.

2.4 Location-Specific Adjustments to Truck Volume Distributions

The Kriging analysis detailed in Section 2.3 of this Part of the report yielded road segment-specific estimates of the percentage of class 9 trucks in the truck traffic stream. The next step was to adjust the percentage of the other truck classes accordingly. Table 2.2.3 provides the average distributions of truck classes as a percentage of the total truck volume for interstates, principal arterials, and minor arterials/major collectors.

On average, class 9 trucks comprise approximately 70% of the truck traffic for interstates. If the estimate for the percentage of class 9 trucks for a given location is greater than the mean value, then the percentage of each of the nine

TABLE 2.2.3
Average Distribution of Truck Classes in the Truck Traffic Stream.

FHWA Vehicle Class	Road Functional Class		
	Interstate	Principal Arterials	Minor Arterial/Major Collector
Class 4	1.48%	1.85%	0.84%
Class 5	16.57%	22.67%	15.81%
Class 6	2.69%	4.66%	11.83%
Class 7	0.45%	1.45%	4.08%
Class 8	5.03%	6.51%	7.23%
Class 9	69.33%	60.29%	58.53%
Class 10	0.81%	0.96%	1.05%
Class 11	2.47%	1.05%	0.21%
Class 12	0.94%	0.24%	0.10%
Class 13	0.22%	0.32%	0.31%
Total	100.00%	100.00%	100.00%

other truck classes can be reduced according to their relative mean distributions. Conversely, if the estimate of class 9 trucks is less than the average value, then the percentage of all other trucks classes can be increased according to the relative distribution. Figure 2.2.4 and Figure 2.2.5 provide examples in which the percentage of class 9 trucks is greater than and less than the state average, respectively, and the resulting distribution of the truck traffic stream.

2.5 Gross Vehicle Weight (GVW) Distributions

Load-related allocation of bridge and pavement costs requires knowledge of the distribution of gross vehicle weight (GVW). The 33 WIM detectors in Indiana continuously collect GVW data that are then summed into daily reports. These reports can be used to estimate vehicle weight distributions. Data were available for 2013, therefore, an assumption must be made that the GVW distribution remains stable over time. Furthermore, due to data quality issues, WIM data were not always available for each day of the year. The consistency in the data therefore was investigated to determine if there were differences in the data collected for different days of the week and months of the year and for weekdays versus weekends. This analysis was carried out for class 9 and class 5 trucks as they comprise the vast majority (75%–85%) of the truck traffic stream and therefore generally have the greatest impact on highway cost allocation.

2.5.1 Class 9 Truck GVW Distribution Variance

Class 9 trucks, characterized by five axles and two units, comprise the majority of the truck traffic stream. Figure 2.2.6 shows the relative consistency in the GVW distributions for traffic at a representative interstate segment and principal arterial segment. The slight variation between weekday and weekend distributions was investigated further. This comparison is presented in Figure 2.2.6 and Figure 2.2.7.

The GVW bins corresponding to unloaded class 9 trucks appear to be less populated for both the interstate and other principal arterial compared. Lastly, monthly trends were investigated and are presented in Figure 2.2.8. Consistency is apparent in most of the GVW bins, the only exception appears in the 76–80 kip and 80+ kips bins. However, if these two bins were combined into a single bin, the discrepancy of the data between these two bins diminishes.

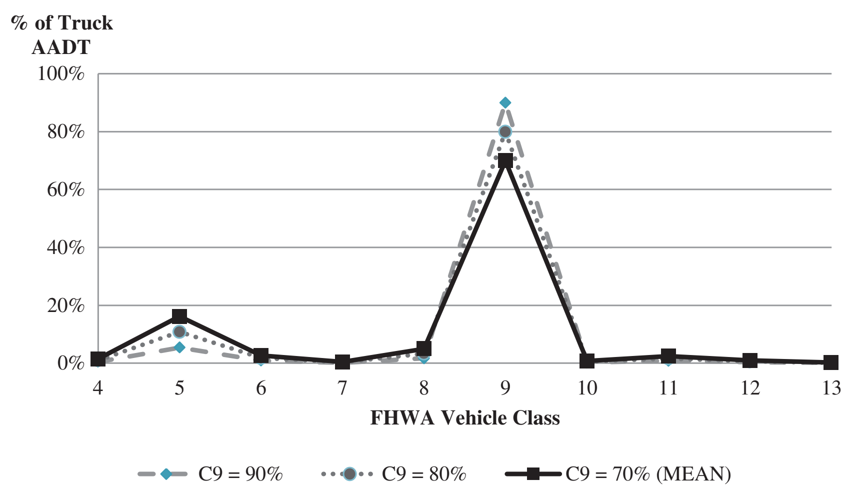


Figure 2.2.4 Distribution of truck AADT when the percentage of class 9 trucks is greater than the state average.

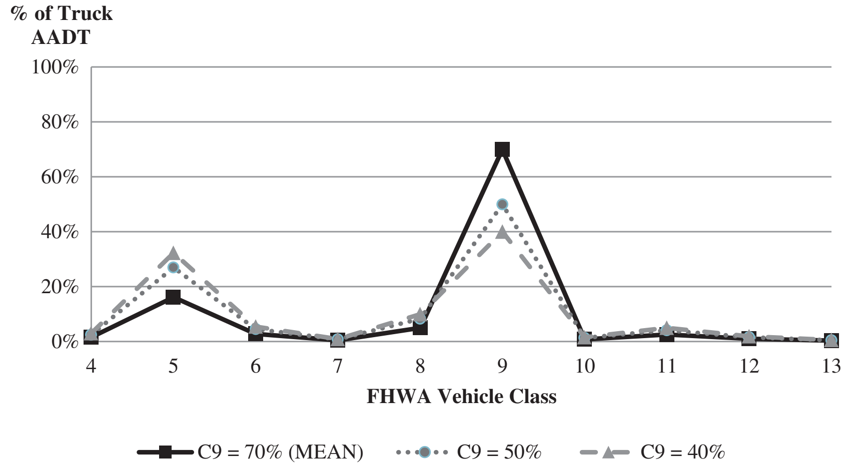


Figure 2.2.5 Distribution of truck AADT when the percentage of class 9 trucks is less than the state average.

2.5.2 Class 5 Truck Gross Vehicle Weight Distribution Variance

Class 5 trucks (single unit, two axles) comprise the second most dominant truck class. Figure 2.2.9, Figure 2.2.10, and Figure 2.2.11 present the distribution of class 5 GVW by day of the week, weekday versus weekend, and month of the year, respectively. Unlike the distribution of class 9 GVW, the distribution of class 5 GVW is much more consistent. This may be attributed to the lower average GVW for class 5. The only real difference observed was between the weekday and weekend travel, with higher GVW on the weekdays for both interstates and other principal arterials.

2.6 Traffic Data Summary

Accurate assessments of road usage are required to properly attribute the highway costs to the users of the infrastructure. To this end, this section covered the acquisition and analysis of statewide traffic data for Indiana. The report presented the

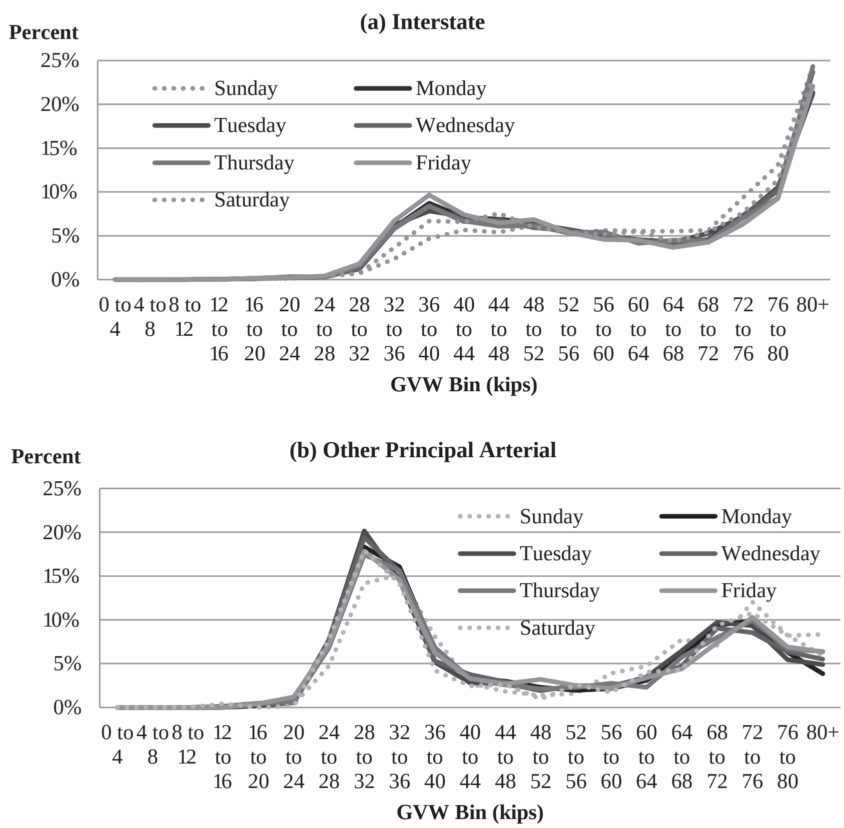


Figure 2.2.6 Class 9 GVW distributions by day of the week for Interstate and other principal arterials.

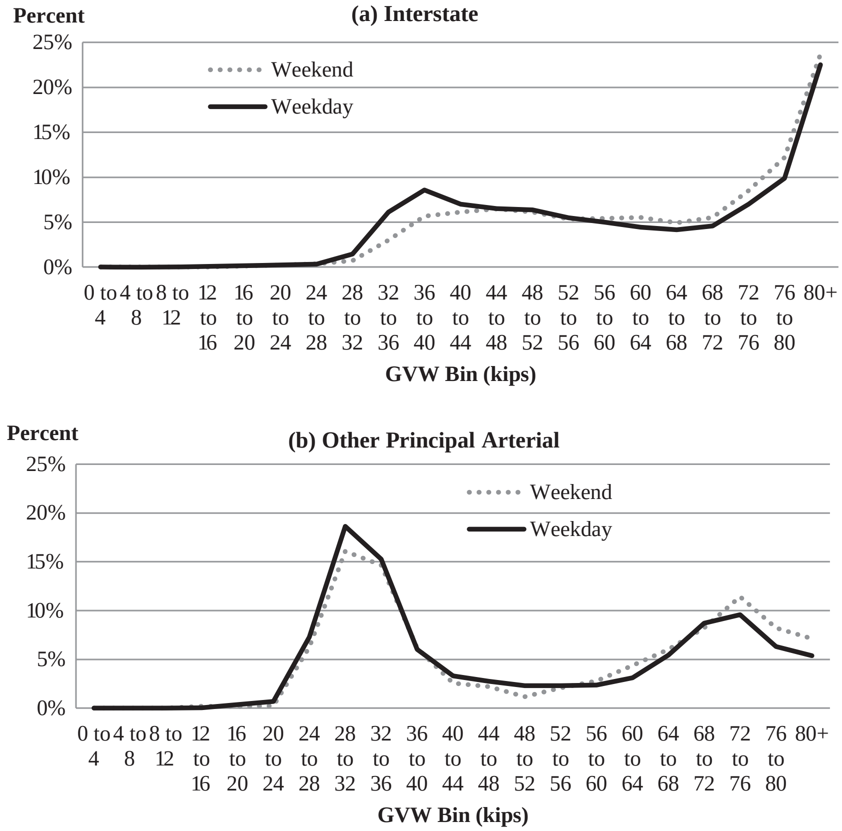


Figure 2.2.7 Class 9 GVW distributions by weekday and weekend for Interstates and other principal arterials.

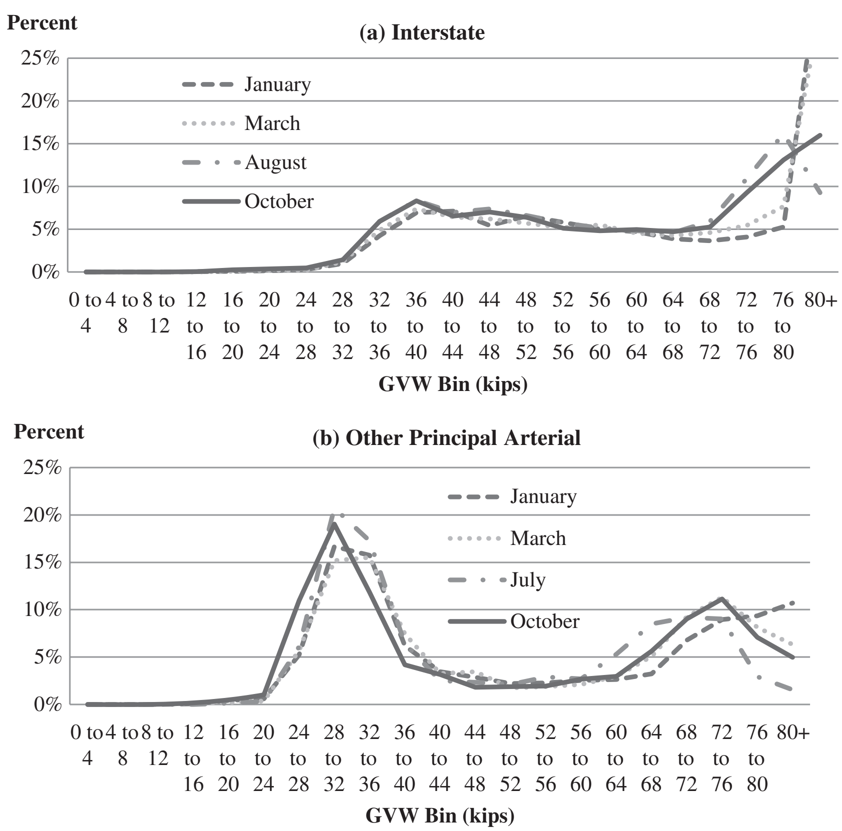


Figure 2.2.8 Class 9 GVW distributions by month for interstates and other principal arterials.

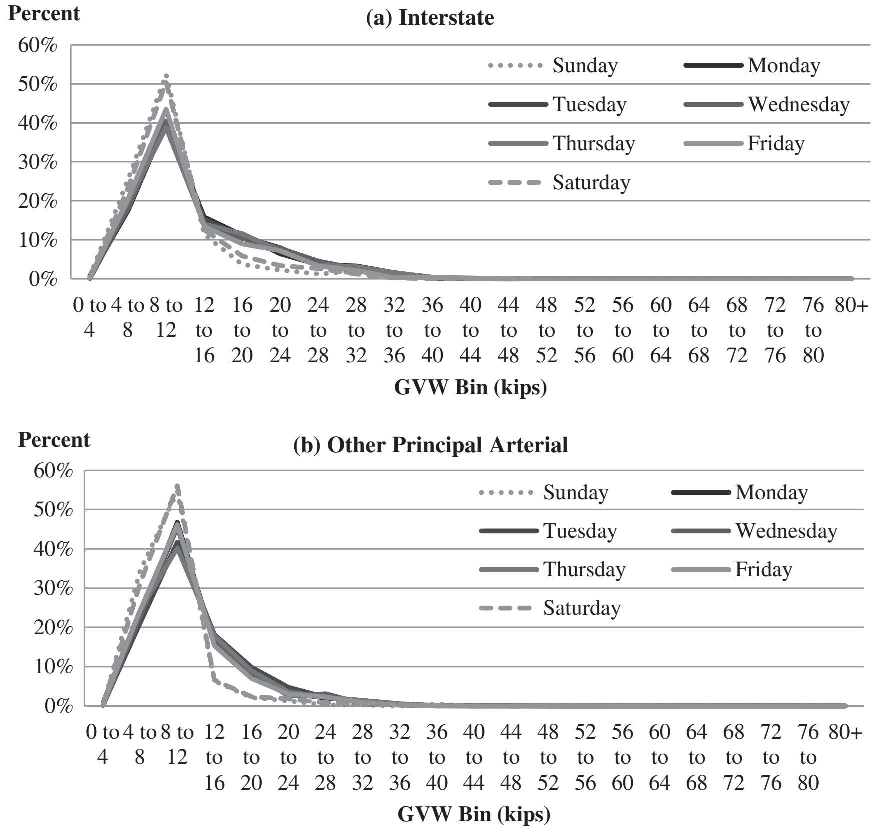


Figure 2.2.9 Class 5 GVW distributions by day of the week for Interstates and other principal arterials.

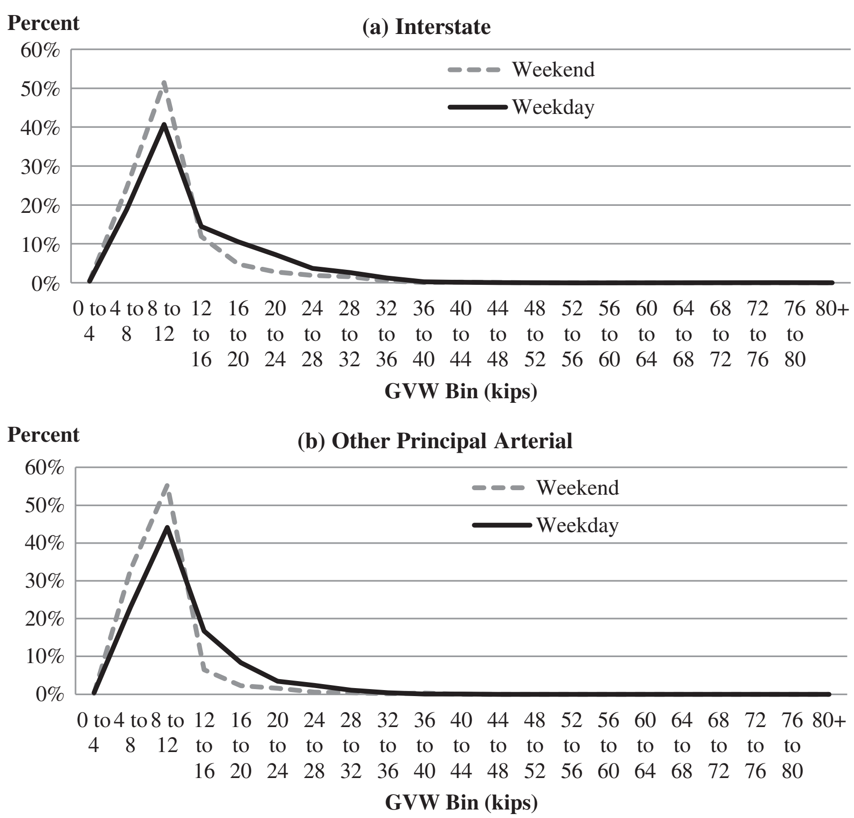


Figure 2.2.10 Class 5 GVW distributions by weekday and weekend for Interstates and other principal arterials.

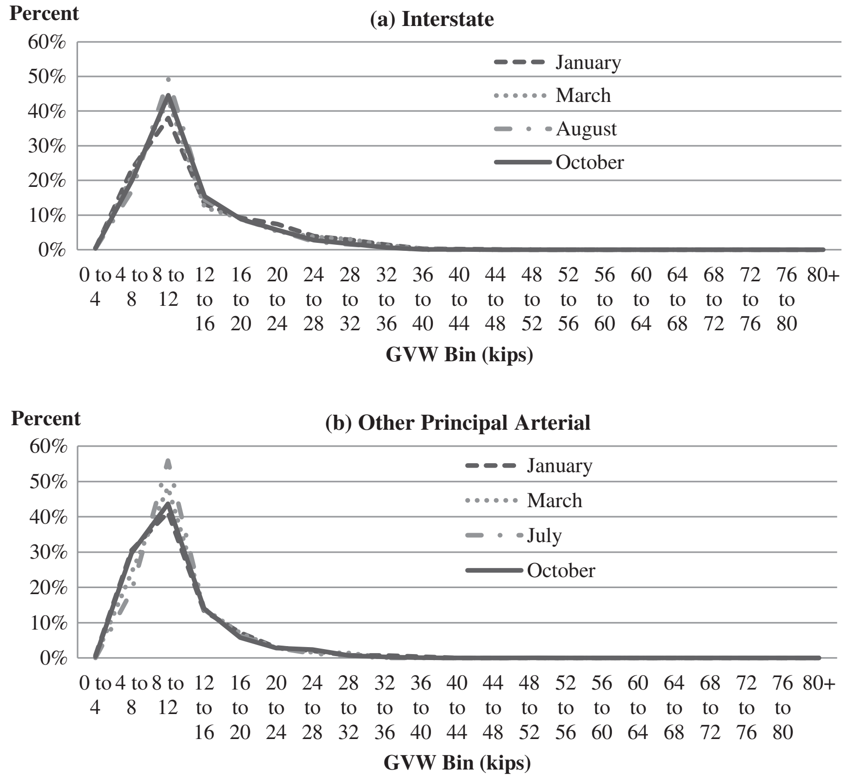


Figure 2.2.11 Class 5 GVW distributions by month for Interstates and other principal arterials.

types of traffic data collected in Indiana, including annual average daily traffic counts obtained from short-term count stations, vehicle class distributions obtained from ATRs, and vehicle weight distributions collected from WIM detectors. The variance in the vehicle class distribution and GVW distribution data was analyzed; and to address this variance, a methodology was presented to attribute the fewer than 100 ATR and WIM data locations to the over 8,000 pavement segments using a combination of average values and geostatistical spatial estimation. The results are segment-specific vehicle class distribution estimates and therefore more accurate distributions of traffic volume and gross vehicle weight for each vehicle class and for each road functional class.

3. STATE ROUTE TRAFFIC ANALYSIS AND RESULTS

3.1 Introduction

The previous sections laid out the data requirements and methodological framework that were used to determine the traffic stream characteristics for the state and local routes. This includes both an assessment of the distribution of vehicle classes and the distribution of GVW within a given vehicle class. This chapter details these factors for the state route network. The final analysis is conducted according to the NHS classification of roadways in order to facilitate the subsequent cost allocation and revenue attribution. At the state level, the classification is: NHS Interstate, NHS non-Interstate, and non-NHS.

3.2 Truck Traffic Stream Composition

As detailed in the previous chapter, spatial analysis using Kriging estimation was used in the present study to determine route segment-specific estimates of the percentage of class 9 trucks (two units, five axles) in the truck traffic stream. These location-specific estimates were then used to adjust the average truck traffic stream distributions for each route segment on the state network.

3.2.1 Spatial Analysis Results

Kriging analysis was carried out with four combinations of estimators and covariance models for each of the three functional classes of roads (interstates, principal arterials, and minor arterials/major collectors). Weighted least squares (WLS) and maximum likelihood (ML) estimators were used and were each paired with the Matérn and exponential covariance models. The four resulting semi-variograms (variogram divided by two) are presented in Figure 2.3.1.

The specifications for the interstate, principal arterial, and minor arterial/major collector semi-variograms are presented in Figure 2.3.1 and their corresponding MSPEs are presented in Addendum A. It was determined that

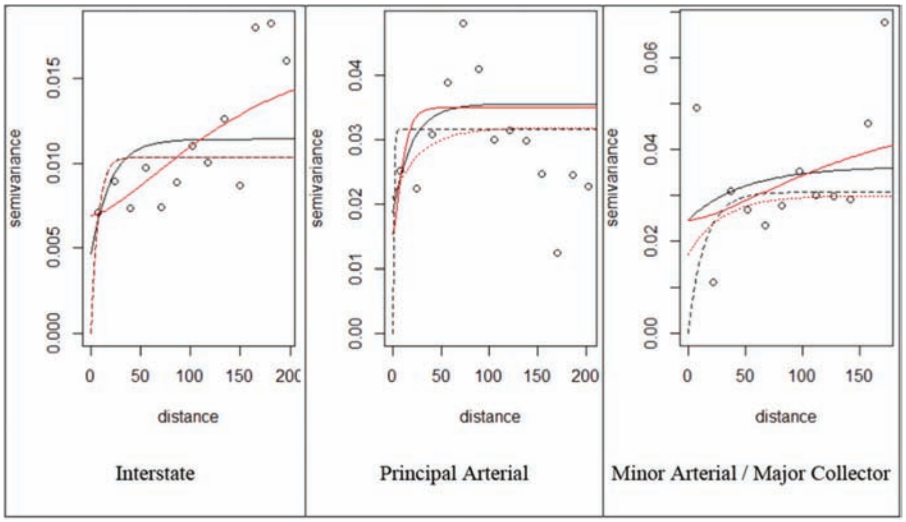


Figure 2.3.1 Semi-variogram functions.

the best estimators and covariance models were the ML estimator and exponential covariance model, the ML estimator and the Matérn covariance model, and the WLS estimator and exponential covariance model, for the interstate, principal arterial, and minor arterial/major collector, respectively.

The best combination of estimator and covariance models were used to estimate the percentage of class 9 trucks in the truck traffic stream for every road segment in Indiana reported to HPMS, including state and local segments. Additionally, maps depicting statewide estimates were developed. These maps are presented in Figure 2.3.2 with the location of each data collection site and each state route pavement segment location superimposed on the image (local route segments were not included for image clarity). The accompanying maps of the standard errors that arise during estimation are presented in Addendum A. It can be noticed that the standard errors increase for the estimation points that are located farther from sites of data collection availability.

Figure 2.3.2 shows that the estimate of class 9 trucks in the interstate truck traffic stream typically varies between 40% and 80%. The standard errors were consistently between 0.01 and 0.03, except across interstate 80/90 in northern Indiana, where the lack of WIM locations results in standard errors of 0.04. The percentage of class 9 for other principal arterials was lower than the interstate estimates and varies between 30% and 75%. The standard errors were greater than experienced in the interstates estimation, ranging between 0.04 and 0.08, due to the higher variance in other principal arterial data. The estimate of class 9 trucks for minor arterials and major collectors was lower than both interstates and principal arterials, with standard errors similar to the principal arterial data.

3.3 Annual VMT

Annual VMT is a measure of the total traffic experienced over a given length of roadway. The results of the truck traffic stream composition were matched with each state route segment ID. Equations 2.1 through 2.5 were then used to calculate the annual VMT for each of the 13 FHWA vehicle classes for each state route segment for each year, which subsequently were applied in the cost allocation for the highway pavements and bridges. The individual VMTs for the individual road segments were

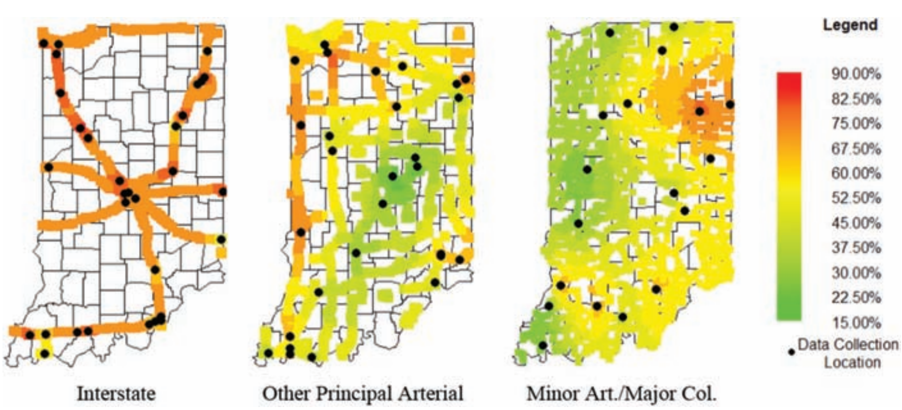


Figure 2.3.2 Estimated share percentage of class 9 trucks in the truck traffic stream.

summed to determine the total statewide VMT; an example using 2009 data is provided in Table 2.3.1.

Prior to finalizing the annual VMT data, an adjustment was necessary to account for segments with missing data or duplicate data. This was accomplished by comparing the number of centerline miles with the data to the known number of centerline miles for each NHS classification. This process is illustrated in Table 2.3.2.

The adjustment factors were applied to the data to yield the finalized state route annual VMT, which is summarized in Table 2.3.3, with a detailed breakdown by year and NHS road functional classification available in Addendum A.

3.4 Gross Vehicle Weight (GVW)

Section 2.5 of Part 2 presented the variance in GVW distributions for class 5 and 9 trucks by the day of the week and the month of the year. It also showed that the interstate and principal arterial GVW distributions varied from each other. In order to obtain a reliable estimate of the class 5 and class 9 GVW distributions, an entire week of data was sampled from each WIM location. The average distributions resulting from this sampling are presented in Figure 2.3.3, Figure 2.3.4, and Figure 2.3.5 for NHS interstates, NHS non-interstates, and non-NHS, respectively. Tables detailing these values are provided in Addendum A.

TABLE 2.3.1
Annual VMT by Vehicle Class and NHS Road Functional Class Example.

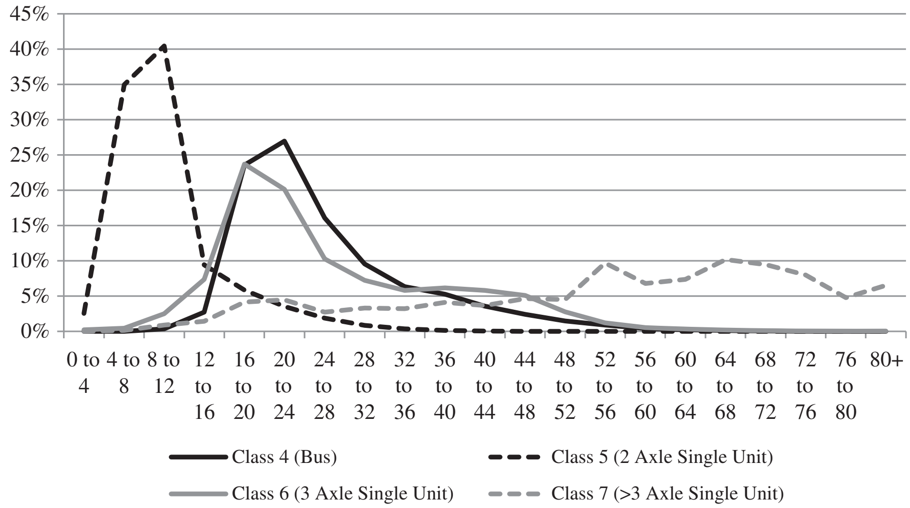
	2009 Annual VMT (in billions)													
NHS Class	**Class 1**	**Class 2**	**Class 3**	**Class 4**	**Class 5**	**Class 6**	**Class 7**	**Class 8**	**Class 9**	**Class 10**	**Class 11**	**Class 12**	**Class 13**	**Total**
NHS Interstate (mainline)	0.05	7.72	2.62	0.06	0.61	0.10	0.02	0.19	3.12	0.03	0.09	0.04	0.01	14.65
NHS Non-Interstate (mainline)	0.09	9.17	3.54	0.04	0.52	0.11	0.03	0.15	1.16	0.02	0.02	0.01	0.01	14.86
Non-NHS (mainline)	0.05	4.98	2.14	0.01	0.17	0.13	0.04	0.08	0.43	0.01	0.00	0.00	0.00	8.04
Mainline Total	**0.18**	**21.9**	**8.30**	**0.11**	**1.30**	**0.33**	**0.09**	**0.41**	**4.70**	**0.06**	**0.12**	**0.04**	**0.02**	**37.55**
NHS Interstate (ramp)	0.00	0.62	0.21	0.00	0.03	0.01	0.00	0.01	0.14	0.00	0.00	0.00	0.00	1.03
NHS Non-Interstate (ramp)	0.00	0.06	0.02	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.10
Non-NHS (ramp)	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Ramps Total	**0.00**	**0.69**	**0.24**	**0.00**	**0.03**	**0.01**	**0.00**	**0.01**	**0.15**	**0.00**	**0.00**	**0.00**	**0.00**	**1.14**
NHS-Interstate	0.06	8.34	2.83	0.06	0.64	0.11	0.02	0.20	3.26	0.03	0.10	0.04	0.01	15.68
NHS Non-Interstate	0.09	9.23	3.56	0.04	0.52	0.11	0.03	0.15	1.17	0.02	0.02	0.01	0.01	14.96
Non-NHS	0.05	4.99	2.15	0.01	0.17	0.13	0.04	0.08	0.43	0.01	0.00	0.00	0.00	8.06
State Route Total	**0.19**	**22.6**	**8.54**	**0.11**	**1.33**	**0.34**	**0.09**	**0.42**	**4.85**	**0.06**	**0.12**	**0.04**	**0.02**	**38.70**

TABLE 2.3.2
Adjustment Factors for Annual VMT.

	Centerline-Miles [Calculated from AADT data]				**Centerline-Miles [Actual]**				**Adjustment Factor [Calculated/Actual]**			
NHS Class	2009	2010	2011	2012	2009	2010	2011	2012	2009	2010	2011	2012
NHS Interstate (mainline)	998.8	1003.9	1012.1	1012.2	987.0	1015.0	1014.0	1014.0	1.01	0.99	1.00	1.00
NHS Non-Interstate (mainline)	3352.6	3242.6	3125.0	2909.8	3262.4	3203.3	3135.1	3000.0	1.03	1.01	1.00	0.97
Non-NHS (mainline)	6919.8	6840.5	6788.9	7113.3	6733.6	6757.7	6810.9	6932.0	1.03	1.01	1.00	1.03
Mainline Total	**11271**	**11087**	**10926**	**11035**	**10983**	**10976**	**10960**	**10946**				
NHS Interstate (ramp)	526.7	442.0	473.6	473.1	431.0	428.0	431.0	511.0	1.22	1.03	1.10	0.93
NHS Non-Interstate (ramp)	117.0	115.6	172.3	111.3	102.0	104.0	106.0	108.0	1.15	1.11	1.63	1.03
Non-NHS (ramp)	5.2	5.3	54.5	29.0	37.0	30.0	30.0	30.0	0.14	0.18	1.82	0.97
Ramps Total	**648.9**	**563.0**	**700.5**	**613.3**	**570.0**	**562.0**	**567.0**	**649.0**				

TABLE 2.3.3
State Route Annual VMT by NHS Road Functional Class.

		Centerline-Miles				Annual VMT [billions]			
Mainline or Ramps	**NHS Class**	**2009**	**2010**	**2011**	**2012**	**2009**	**2010**	**2011**	**2012**
Mainline	NHS-Interstate	987.0	1015.0	1014.0	1014.0	14.65	14.95	15.81	15.68
Mainline	NHS-Non-Interstate	3262.4	3203.3	3135.1	3000.0	14.86	14.29	12.92	12.56
Mainline	Non-NHS	6733.6	6757.7	6810.9	6932.0	8.04	8.04	8.49	9.78
Mainline Total		**10983**	**10976**	**10960**	**10946**	**37.55**	**37.28**	**37.22**	**38.02**
Ramps	NHS-Interstate	431.0	428.0	431.0	511.0	1.03	0.75	0.81	1.01
Ramps	NHS-Non-Interstate	102.0	104.0	106.0	108.0	0.10	0.10	0.22	0.11
Ramps	Non-NHS	37.0	30.0	30.0	30.0	0.02	0.01	0.06	0.03
Ramps Total		**570.0**	**562.0**	**567.0**	**649.0**	**1.14**	**0.86**	**1.09**	**1.15**
Both	NHS-Interstate	1418.0	1443	1445	1525	15.68	15.70	16.62	16.69
Both	NHS-Non-Interstate	3364.4	3307.3	3241.1	3108	14.96	14.38	13.15	12.67
Both	Non-NHS	6770.6	6787.8	6840.8	6962	8.06	8.06	8.55	9.81
State Route Total		**11553**	**11538**	**11527**	**11595**	**38.70**	**38.14**	**38.31**	**39.17**



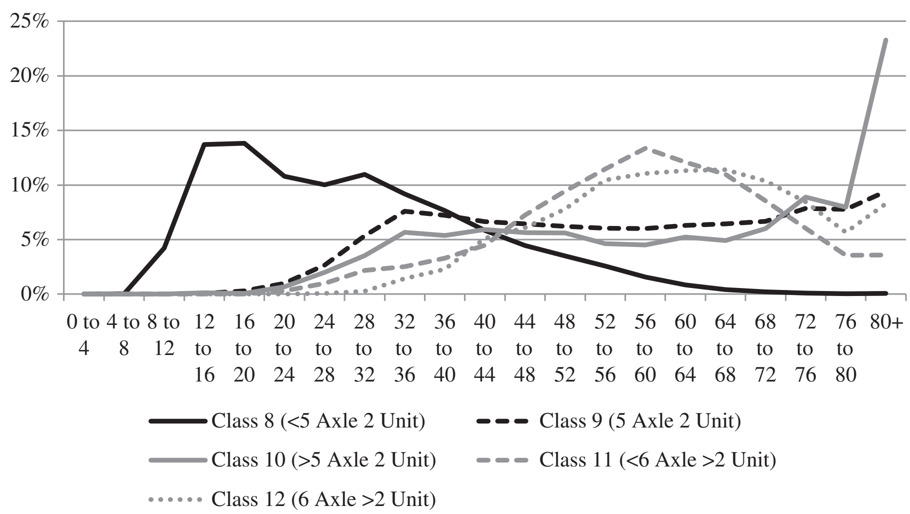


Figure 2.3.3 Average GVW distributions for NHS Interstates (19 WIM locations).

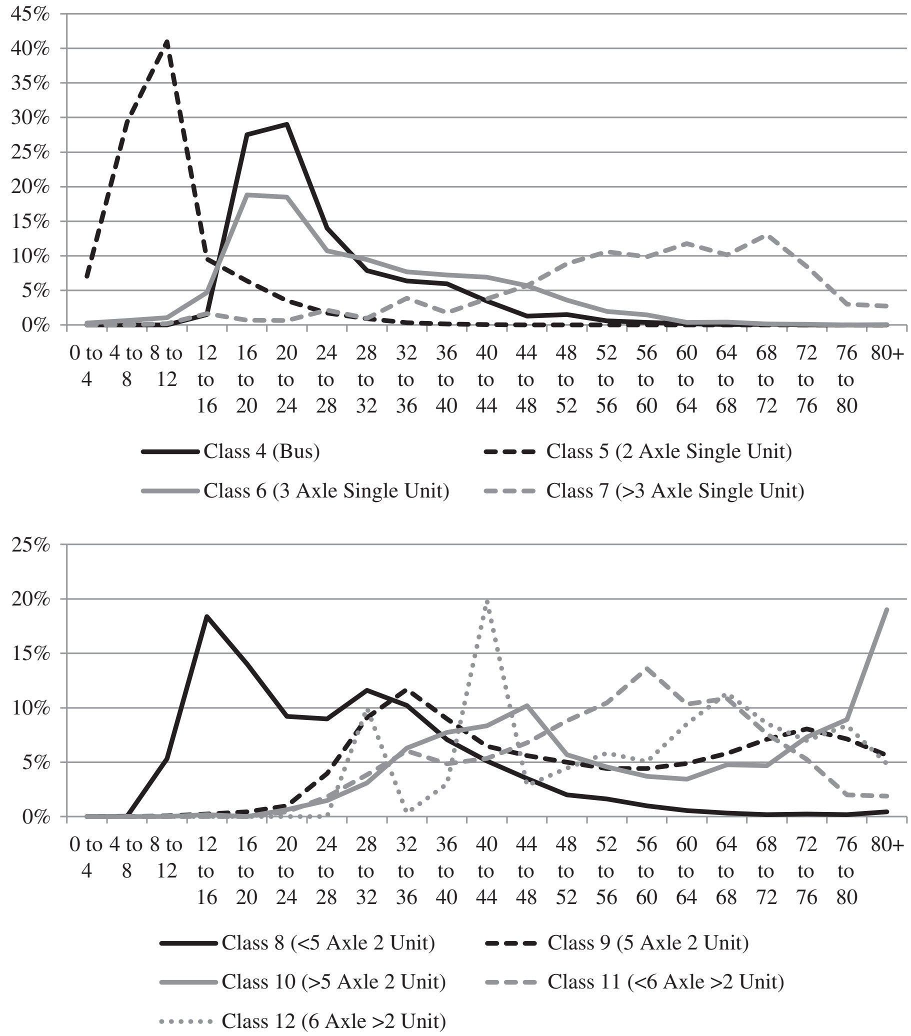


Figure 2.3.4 Average GVW distributions for NHS Non-Interstates (12 WIM locations).

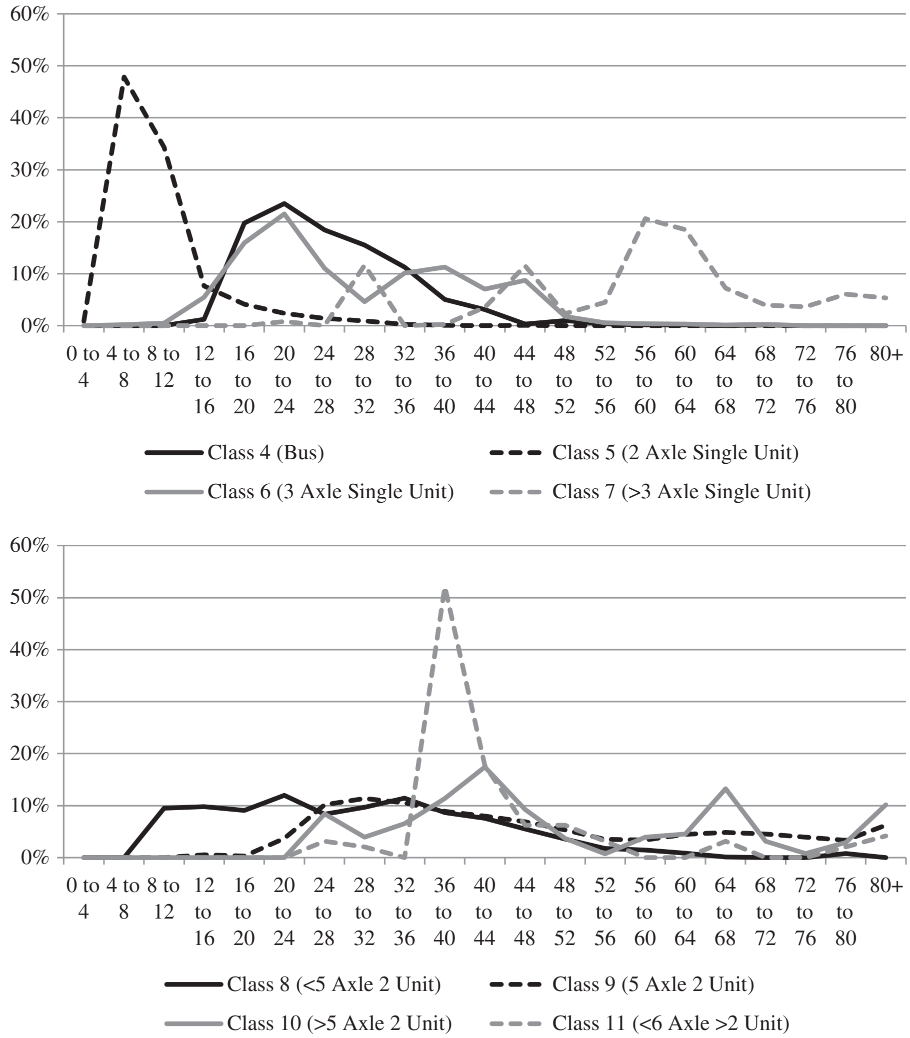


Figure 2.3.5 Average GVW distributions for non-NHS (2 WIM locations).

4. LOCAL ROUTE TRAFFIC ANALYSIS AND RESULTS

4.1 Introduction

The previous chapter laid out the process by which the VMT for individual route segments was determined for roads on the state network. It then detailed how these values were summed and adjusted to yield the annual VMT values for each year (2009–2012), road functional class (NHS interstate, NHS non-interstate, and non-NHS), and FHWA vehicle class (1–13). The process used segment-specific traffic counts. However, at the local level, the percentage of road segments with AADT counts is limited, therefore, a different approach was needed. The limited number of route segments with AADT data for local routes was used as a sample to determine the average traffic stream composition. Next, the total VMT was back-calculated from fuel sales data.

4.2 Back-Calculation of VMT from Fuel Data

4.2.1 Fuel Data

The back-calculation of VMT from fuel sales data does not yield segment-specific VMT and vehicle class distributions; however, it can provide a reliable estimate for the network-level VMT. In order to back calculate the VMT for local routes, the amount of fuel sold (Table 2.4.1) and average fuel efficiencies (Table 2.4.2 and Table 2.4.3) were needed (BTS 2014; EIA, 2014a, 2014b).

These values were used to determine what percentage of the fuel purchased was consumed for travel on state routes, the remainder of which is assumed to have been consumed for travel on local routes. The calculation for the gasoline consumed on state routes is:

$$G_{lmn} = (VMT_{lmn})(Fuel\ Eff\ Gas_{ln})(P_{ln}) \qquad (2.17)$$

where G_{lmn} is the gasoline consumed by FHWA vehicle class l, for travel on highway class m, in year n, VMT_{lmn}

TABLE 2.4.1
Fuel Consumption by Year (Billions of Gallons Sold) in Indiana.

	2009	2010	2011	2012
Gasoline	2.99	3.07	2.93	2.89
Diesel	1.20	1.33	1.37	1.34

TABLE 2.4.2
Average Fuel Efficiency by Year, Gasoline.

Year	FHWA Vehicle Class												
	1	2	3	4	5	6	7	8	9	10	11	12	13
2009	42.50	23.50	17.30	7.20	9.37	6.34	6.34	5.36	5.36	5.36	5.36	5.36	5.36
2010	42.50	23.30	17.20	7.20	9.37	6.34	6.34	5.36	5.36	5.36	5.36	5.36	5.36
2011	42.50	23.20	17.10	7.20	9.33	6.35	6.35	5.36	5.36	5.36	5.36	5.36	5.36
2012	42.50	23.20	17.10	7.20	9.42	6.33	6.33	5.36	5.36	5.36	5.36	5.36	5.36

TABLE 2.4.3
Average Fuel Efficiency by Year, Diesel.

Year	FHWA Vehicle Class												
	1	2	3	4	5	6	7	8	9	10	11	12	13
2009	42.50	23.50	17.30	7.20	13.80	8.55	8.55	6.06	6.06	6.06	6.06	6.06	6.06
2010	42.50	23.30	17.20	7.20	13.80	8.55	8.55	6.06	6.06	6.06	6.06	6.06	6.06
2011	42.50	23.20	17.10	7.20	13.82	8.56	8.56	6.07	6.07	6.07	6.07	6.07	6.07
2012	42.50	23.20	17.10	7.20	13.79	8.54	8.54	6.06	6.06	6.06	6.06	6.06	6.06

is the VMT, *Fuel Eff Gas* is the fuel efficiency for gasoline, and P is the percent of vehicles that run on gasoline. Table 2.4.4 presents the values of P, for each year and vehicle class.

The calculation for the diesel consumed on state routes is:

$$D_{lmn} = (VMT_{lmn})(Fuel\ Eff\ Diesel_{ln})(1 - P_{ln}) \tag{2.18}$$

where D_{lmn} is the diesel and *Fuel Eff Diesel* is the fuel efficiency for diesel.

The calculations for the gallons consumed on local routes are:

$$G_{local,n} = Total\ Gas_n - \sum_l \sum_m G_{lmn} \tag{2.19}$$

$$D_{local,n} = Total\ Diesel_n - \sum_l \sum_m D_{lmn} \tag{2.20}$$

where $G_{local,n}$ and $D_{local,n}$ are the gallons of gasoline and diesel consumed for travel on local routes in year n and *Total Gas* and *Total Diesel* is the total gasoline and diesel consumed in the state (provided in Table 2.4.5 and Table 2.4.6).

4.2.2 Local Traffic Stream Distribution

Similar to the state routes, there were a limited number of local route segments that had corresponding AADT

TABLE 2.4.4
Percent of Vehicles that Run on Gasoline, by Vehicle Class.

Year	FHWA Vehicle Class												
	1	2	3	4	5	6	7	8	9	10	11	12	13
2009	100.0%	99.6%	99.6%	5.0%	39.0%	18.4%	18.4%	18.4%	2.6%	2.6%	2.6%	2.6%	2.6%
2010	100.0%	99.6%	99.6%	5.0%	39.0%	18.4%	18.4%	18.4%	2.6%	2.6%	2.6%	2.6%	2.6%
2011	100.0%	99.6%	99.6%	5.0%	39.1%	17.8%	17.8%	17.8%	2.6%	2.6%	2.6%	2.6%	2.6%
2012	100.0%	99.5%	99.5%	5.0%	39.0%	19.0%	19.0%	19.0%	2.6%	2.6%	2.6%	2.6%	2.6%

TABLE 2.4.5
Gasoline Consumption by NHS Road Functional Class.

		Gallons Consumed (billions)			
State or Local	**NHS Classification**	**2009**	**2010**	**2011**	**2012**
State	NHS-Interstate	0.57	0.58	0.68	0.67
State	NHS-Non-Interstate	0.64	0.61	0.58	0.55
State	Non-NHS	0.35	0.36	0.39	0.43
Local	—	1.43	1.52	1.29	1.24
Total Gallons		2.99	3.07	2.93	2.89

TABLE 2.4.6
Diesel Consumption by NHS Road Functional Class.

State or Local	NHS Classification	Gallons Consumed (billions)			
		2009	2010	2011	2012
State	NHS-Interstate	0.63	0.61	0.41	0.47
State	NHS-Non-Interstate	0.26	0.26	0.16	0.19
State	Non-NHS	0.11	0.11	0.09	0.14
Local	—	0.20	0.35	0.72	0.54
Total Gallons		1.20	1.33	1.37	1.34

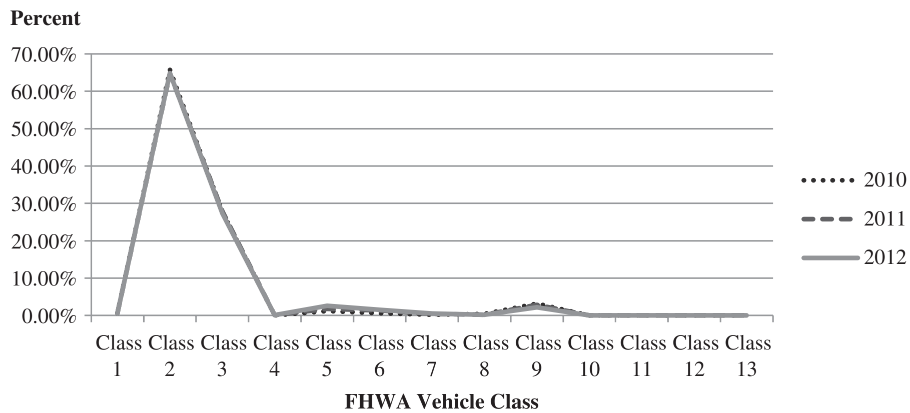


Figure 2.4.1 Average vehicle class distributions for local routes.

TABLE 2.4.7
Annual VMT by NHS Road Functional Class.

State/ Local	NHS Class	Centerline-Miles				Annual VMT [billions]			
		2009	2010	2011	2012	2009	2010	2011	2012
State	NHS-Interstate	1418.0	1443	1445	1525	15.68	15.70	16.62	16.69
State	NHS-Non-Int.	3364.4	3307.3	3241.1	3108	14.96	14.38	13.15	12.67
State	Non-NHS	6770.6	6787.8	6840.8	6962	8.06	8.06	8.55	9.81
Local	—	84617	84617	84689	84848	32.66	35.61	34.39	32.07
	Total	96170	96155	96216	96443	71.36	73.75	72.70	71.24

data and geographic locations. As such, the methodology introduced in Part 2, Section 2 was applied to a sample of local route segments. This methodology yielded a vehicle class distribution that was dominated by automobiles (Figure 2.4.1). It may be noticed that there were no local continuous count station data available for 2009; however, the lack of variation between years 2010 and 2012 provides confidence that it is appropriate to apply the 2010 distributions to the 2009 data.

4.3 Annual VMT

The final step is to calculate the local VMT for each year using the fuel consumption data and local route vehicle distributions. The equation to calculate the local VMT is:

$$Total\ VMT_{local,n} = (G_{local,n})(WGE_n) + (D_{local,n})(WDE_n) \tag{2.21}$$

where WGE_n and WDE_n are the average gasoline and diesel fuel efficiencies, respectively, for year n (weighted by vehicle class distribution and percent of vehicles that run on gasoline and diesel). A summary of these data is presented in Table 2.4.7 and further detail is available in Addendum A.

5. SUMMARY OF SYSTEM USAGE

Part 2 of this report detailed the process of acquiring and analyzing the traffic data that were subsequently used in the cost allocation and revenue attribution. The study methodology to determine the traffic volume and gross vehicle weight distributions were presented for state and local routes. For roads on the state network the methodology relied on a combination of segment-specific short-term traffic counts and spatial analysis of continuous count stations. It was determined that the distribution of heavy trucks is not constant across state routes. Class 9 trucks comprise the majority of the truck traffic, accounting for over 90% of the truck traffic for some locations along the interstates. Unlike roads on the state network, traffic data were not collected for every local route segment. Therefore the total VMT for local routes was back-calculated from fuel sales data. Then, the local routes that had traffic data available were used as a sample to determine the vehicle class distribution.

PART 3. STATE ROUTES COST ALLOCATION

1. COST ALLOCATION FOR PAVEMENT EXPENDITURES ON STATE ROUTES

This chapter discusses the cost allocation methodology, data, analysis, and results related to new construction, rehabilitation, maintenance, and other pavement expenditures on Indiana's state routes. Section 1.1 presents the methodology for the different expenditure types; Section 1.2 discusses the state route pavement expenditures data; and the methodology used for the cost allocation and the results, specifically, the total cost responsibility and average unit cost for each vehicle class and expenditure type, are presented in Section 1.3. The unit cost for a given vehicle class is defined as the overall cost (in dollars at the reported year) per VMT. The detailed results for all expenditure types are provided in Addendum B. It should be noted that these pavement cost allocation results are significantly influenced by the distribution (across repair categories) of projects implemented during the years 2009–2012. For example, typically, a large portion of the expenditures related to rehabilitation projects is attributed to trucks, while the opposite holds for new construction projects. It is therefore of paramount importance that this study is updated frequently to alleviate the bias that the different distributions of future projects could be introduced by the allocated costs.

1.1 Study Methodology for Pavement Cost Allocation

1.1.1 Allocation of New Pavement Construction Expenditures

For the purposes of this study, the expenditures associated with new pavement construction are divided into the following expenditure categories: (a) pavement-related expenditures, (b) grading and earthwork expenditures, (c) shoulder expenditures, (d) right-of-way (ROW) expenditures, (e) drainage and erosion control expenditures, and (f) miscellaneous expenditures.

ROW, drainage and erosion control, and miscellaneous expenditures are considered common expenditures and are discussed in Chapter 3 of this Part of the report. For new pavement construction, the cost allocation methodology presented in the 1997 and 2000 FHWA HCAS was used in the present study. FHWA (1997, 2000) separated new pavement construction costs into (i) a base facility cost that serves as a "platform" for the remaining facility and (ii) the cost of the remaining facility that provides the strength to carry the projected traffic loading over the pavement life. A detailed discussion of the methodology follows. To illustrate the methodology, an example is also presented in Section 1.3 of this Part of the report.

Base Facility Expenditures Allocation. The base facility, as first explained by FHWA (1997), is not bound by a strict definition and can be defined appropriately depending on the given context of the analysis. In the present study, the base facility is defined to include grading and earthwork, subgrade, and shoulders, as well as part of the pavement layers as follows:

- Flexible pavements: 1 inch of surface hot-mix asphalt (HMA) course, 3 inches of base HMA course, and 4 inches of compacted aggregate (or subbase) course
- Rigid pavements: 5 inches of PCC concrete slab

FHWA (1997, 2000b) allocated the base facility costs on the basis of PCE-miles. The objectives of the present study do not include a detailed estimation of PCE, as that would require collecting data on vehicle speed, directional flow rate, and roadway grade for the Indiana road network (Ahmed et al., 2011). Therefore, only average PCE factors obtained from the Highway Capacity Manual 2000 (TRB, 2000) were used. Moreover, in terms of new pavement construction expenditures, the cost increase due to the presence of trucks is mainly related to the extra lane width required to accommodate truck traffic. The cost increase due to the extra pavement thickness required to accommodate truck traffic was considered not for the base facility but for the remaining facility. Thus, an appropriate vehicle width adjustment factor was estimated and used for the case of new pavement construction expenditures (excluding shoulder expenditures). Table 3.1.1 summarizes the current design criteria in terms of lane width.

Although a 9-ft lane would be adequate for vehicle classes 1–3, safety concerns, especially the risks of run-off and lane-departure crashes, necessitate the construction of lane widths at least 10 ft. even at arterials and collectors with low truck traffic (AASHTO, 2011). Therefore, the vehicle width adjustment factors proposed for the new pavement construction base facility expenditures allocation were estimated assuming that a 10-ft lane is appropriate for vehicle classes 1–3.

To account for the effect of scale economies in the estimation of adjustment factors, pavement cost functions were used. Irfan, Khurshid, Ahmed, and Labi (2012) developed cost functions for four pavement preservation treatments using data from Indiana. Among the analyzed treatments, structural HMA overlay is the most structurally-intense treatment and therefore the most relevant to this analysis of new pavement construction. The cost function from Irfan et al. (2012) was used only for accounting for economies of scale in the present study.

TABLE 3.1.1
Acceptable Ranges of Lane Width, ft (AASHTO, 2011).

Type of Road	Rural	Urban
Freeway	12	12
Arterial	11 to 12	10 to 12
Collector	10 to 12	10 to 12
Local	9 to 12	9 to 12

The selected cost function is as follows (Irfan et al., 2012):

$$TC = 0.026 \times length^{0.624} \times N^{0.818} \times \ln IRI^{5.946} \quad (3.1)$$

where TC is the total cost of the preservation treatment, *length* is the total length of the treated section (mi), N is the number of lanes, and IRI is the pre-treatment condition of the pavement.

To estimate the width adjustment factor for interstates, two hypothetical projects (Project 1 and Project 2) were assumed. The projects are identical except for lane width; Project 1 has one lane, 10 ft. wide, while Project 2 has one lane, 12 ft. wide or effectively, 1.2 lanes.

The total costs (TC) for the two projects can be estimated as follows:

$$\boldsymbol{TC}\ 1 = 0.026 \times length^{0.624} \times \boldsymbol{N_1}^{0.818} \times \ln IRI^{5.946} \quad (3.2)$$

$$\boldsymbol{TC}\ 2 = 0.026 \times length^{0.624} \times \boldsymbol{N_2}^{0.818} \times \ln IRI^{5.946} \quad (3.3)$$

Taking the ratio of the total costs, the following equation holds:

$$\frac{TC\,1}{TC\,2} = \left(\frac{N_1}{N_2}\right)^{0.818} \rightarrow \frac{TC\,1}{TC\,2} = \left(\frac{1}{1.2}\right)^{0.818} \rightarrow TC\,2 = 1.16 \times TC\,1 \quad (3.4)$$

From the above estimation, it follows that the vehicle width adjustment factor for Interstates is 1.16. It can be seen that, without taking into account economies of scale, the vehicle width adjustment factor would have been estimated as 12ft/10ft = 1.20; however, using 1.20 as the width adjustment factor would lead to overestimating the cost increase due to truck traffic. Applying the same estimation procedure for the non-Interstate routes which have an average lane width of 11 ft., the vehicle width adjustment factor was estimated at 1.08. Similarly, if economies of scale were not taken into account, the vehicle width adjustment factor would have been estimated as 11ft/10ft = 1.10, which is an overestimation of the impact of truck traffic. The results for the vehicle width adjustment factors are summarized in Table 3.1.2.

To properly estimate the base facility cost responsibility of vehicle classes 4–13, it is imperative to choose appropriate width adjustment factors. Underestimating or overestimating the cost increase due to truck traffic could result in a significant decrease or increase in the cost responsibility of vehicle classes 4–13, particularly because the base facility typically accounts for up to 80% of the total project cost (FHWA, 1997).

The same methodology cannot be easily applied for the shoulder expenditures, however, because there is significant variation in the proposed shoulder widths. The shoulder widths proposed by AASHTO (2011) are between 4 and 12 ft. for Interstates and between 2 and 8 ft. for non-Interstates. Furthermore, the data contained no information on the actual shoulder widths of the new pavement construction projects. On the basis of the assumption that larger vehicles require wider shoulders and therefore cause increased shoulder expenditures, PCE can be considered as a surrogate for the effect of vehicle size on shoulder expenditures. Therefore, in this study, shoulder expenditures are allocated on the basis of PCE-miles, while the rest of the base facility expenditures are allocated on the basis of VMT adjusted for vehicle width.

Allocation of the Expenditures for the Remaining Facility. The expenditures for the remaining facility, which are considered as the load-related portion of the new pavement construction expenditures, are allocated on the basis of the relative ESALs of each vehicle class (FHWA, 2000). This approach utilizes the pavement design method outlined in the *1993 AASHTO Guide for Design of Pavement Structures* to assign the costs regarding new pavement construction to the responsible vehicle classes. The AASHTO (1993) pavement design method was considered appropriate for this study because the new pavements constructed during the period 2009–2012 were planned and designed several years earlier using the design principles of AASHTO (1993). Future pavement cost allocation studies should consider revising the approach used in this study because new pavements are currently designed using the Mechanistic-Empirical Pavement Design Guide (MEPDG) which significantly differs from AASHTO (1993). To date, no HCAS has incorporated MEPDG for attributing pavement expenditures; however, there have been preliminary efforts by researchers in this direction (Hong, Prozzi, & Prozzi, 2007) and further work is expected in the near future.

Estimation of Pavement Design ESALs (AASHTO, 1993). As a first step in the estimation of pavement design ESALs, the total thickness for each pavement course is determined for a given construction project. The actual thickness of the asphalt, PCC concrete, and aggregate base/subbase layers (for the case of flexible pavements), and the concrete slab thickness (for the case of rigid pavements) are estimated using the available

TABLE 3.1.2
Proposed Vehicle Width Adjustment Factors for Allocating the Costs of New Pavement Construction Base Facility.

Road Functional Class	Average Lane Width (AASHTO, 2011)	Width Adjustment Factor (without economies of scale)	Width Adjustment Factor (with economies of scale)
Interstates	12 ft	1.20	1.16
State Route Non-Interstate	11 ft	1.10	1.08

data. Average values (estimated for each highway class) are used in situations of missing information. Using the pavement design equations from the *1993 AASHTO Guide for Design of Pavement Structures*, the total number of ESALs over the pavement life for a given construction project are estimated.

For flexible pavements, the following equation is used for estimating the total number of ESALs over the pavement life (AASHTO, 1993):

$$log_{10}(W_{18}) = (Z_R \times S_o) + 9.36 log_{10}(SN+1) - 0.20 + \frac{log_{10}\left(\frac{\Delta PSI}{4.2-1.5}\right)}{0.40 + \frac{1094}{(SN+1)^{5.19}}} + 2.32 log_{10}(M_R) - 8.07 \quad (3.5)$$

where W_{18} = predicted number of 18-kip ESALs, Z_R = standard normal deviate, S_o = standard error of traffic prediction and performance prediction, SN = structural number, ΔPSI = design serviceability loss, which is the difference between the initial design serviceability index, p_o, and design terminal serviceability index, p_t, and M_R = effective resilient modulus of subgrade material (in psi).

For rigid pavements, the total number of ESALs is estimated using the following equation (AASHTO, 1993):

$$log_{10}(W_{18}) = (Z_R \times S_o) + 7.35 log_{10}(D+1) - 0.06 + \frac{log_{10}\left(\frac{\Delta PSI}{4.5-1.5}\right)}{1 + \frac{1.624 \times 10^7}{(D+1)^{8.46}}} + (4.22 - 0.32 p_t) \times log_{10}\left[\frac{S_c' \times C_d \times (D^{0.75} - 1.132)}{215.63 \times J \times \left(D^{0.75} - \frac{18.42}{\left(\frac{E_c}{k}\right)^{0.25}}\right)}\right] \quad (3.6)$$

where W_{18} = predicted number of 18-kip ESALs, Z_R = standard normal deviate, S_o = standard error of traffic prediction and performance prediction, D = concrete slab thickness (in inches), ΔPSI = design serviceability loss, which is the difference between the initial design serviceability index, P_o, and design terminal serviceability index, P_t, S'_c = estimated mean value for PCC modulus of rupture (in psi), C_d = drainage coefficient, J = load transfer coefficient, E_c = PCC elastic modulus (in psi), and k = effective modulus of subgrade reaction (in pci).

To estimate the total ESALs using the above formulas, the recommendations of AASHTO (1993) and the Indiana practices (INDOT, 2013) were followed. The concept of reliability in the design process is taken into account by Z_R and S_o. A reliability level for the pavement design, which defines the standard normal deviate (Z_R), can be selected from the ranges presented in Table 3.1.3.

Table 3.1.3 presents the suggested reliability levels on the basis of the road functional classification. The standard error (S_o) accounts for variation in both traffic prediction and pavement performance prediction; and the proposed value by AASHTO (1993) for S_o is 0.35 and 0.45 for rigid and flexible pavements, respectively.

Pavement condition is measured by the Present Serviceability Index (PSI), which ranges from 0 (failed) to 5 (perfect). The PSI for a new pavement (P_o) is assumed to be 4.2 for flexible pavements and 4.5 for rigid pavements. For the terminal serviceability index (P_t), a value of 2.5 is suggested for the design of major highways and 2.0 for minor highways (AASHTO, 1993).

For the ESAL estimation of flexible pavements, the pavement structural number (SN), a measure of pavement thickness and strength, is established as follows:

$$SN = \sum_i a_i D_i \quad (3.7)$$

where a_i is the structural layer coefficient of the ith layer and D_i is the thickness of the ith layer. For purposes of the present study, the following layer coefficients were assumed (AASHTO, 1993): asphalt concrete course: a = 0.44, compacted aggregate base: a = 0.14, and subbase course: a = 0.12.

The last factor to be determined for flexible pavement ESAL estimation is the resilient modulus (M_R), which is a measure of the subgrade material stiffness. Since information regarding the moisture conditions and the structural strength of the subgrade material was not available, an average value of 10,000 psi was assumed for M_R (INDOT, 2013).

For rigid pavement ESAL estimation, several assumptions needed to be made regarding the strength of the concrete slab and the subgrade as well other pavement and environmental characteristics. The PCC modulus of rupture (S'_c), which is a design input, is the mean value of the modulus of rupture estimated 28 days after construction using third-point loading (AASHTO, 1993). The default value for S'_c is 700 psi (INDOT, 2013). The value of the drainage coefficient (C_d) depends on the quality of the drainage and the percent of time the concrete pavement is normally exposed to moisture levels close to saturation during the year. Since there was no information on the previously-mentioned drainage characteristics, the value of the coefficient was assumed to be 1.0 (AASHTO, 1993).

TABLE 3.1.3
Suggested Reliability Levels by Functional Classification (AASHTO, 1993).

Functional Classification	Recommended Level of Reliability [%] Urban	Rural
Interstate and Other Freeways	85–99.9	80–99.9
Principal Arterials	80–99	75–95
Collectors	80–95	75–95
Local	50–80	50–80

The load transfer coefficient (J) represents the ability of a concrete pavement to distribute the load across discontinuities and depends on the pavement and shoulder type. The load transfer coefficient values recommended by AASHTO (1993) are presented in Table 3.1.4.

The PCC elastic modulus (E_c) is a measure of the stress-strain behavior of concrete and can be estimated using information on the PCC compressive strength. Compressive strength data for the constructed rigid pavement concrete were not available for this study; therefore, the average value of 4,000,000 psi was assumed (INDOT, 2013). Lastly, the effective modulus of subgrade reaction (k) represents the level of support of the PCC slab by the subgrade, and the average value of 250 pci, which corresponds to a "fair" soil quality (AASHTO, 1993), was used.

Estimation of ESAL Contribution of Each Vehicle Class. After estimating the total number of ESALs over the pavement life for a given project, the ESAL contribution of each vehicle class needs to be estimated. The ESAL contribution of a vehicle class is the number of ESALs a vehicle class offers on the basis of traffic distribution and the Load Equivalence Factor (LEF) for this vehicle class and pavement thickness. LEFs represent the relationship of any axle load and configuration with the standard 18-kip single axle load (ESAL). LEF for each axle load and configuration was estimated using the method described in the *1993 AASHTO Guide for Design of Pavement Structures, Volume 2*. The following equation is used for flexible pavements (AASHTO, 1993):

$$log_{10}\left[\frac{w_{tx}}{w_{t18}}\right] = 4.79log_{10}[L_{18}+L_{2s}] - 4.79log_{10}[L_x+L_{2x}] + 4.33log_{10}L_{2x} + \frac{G_t}{\hat{a}_x} - \frac{G_t}{\hat{a}_{18}} \quad (3.8)$$

where $\frac{w_{tx}}{w_{t18}}$ = inverse of the LEF ratio, $L_{18} = 18$ (standard axle load in kips), L_x = axle load being evaluated (in kips), L_2 = code for axle configuration [1 for single axle; 2 for tandem axle; 3 for triple axle; s for single axle], L_{2x} = code for axle configuration being evaluated, $G_t = \log_{10}\left(\frac{4.2-p_t}{4.2-1.5}\right)$ which is a function of the ratio of loss in serviceability at time t, to the potential loss taken at a point where p_t = 1.5, p_t = terminal serviceability index, $\hat{a}_x = 0.40 + \left[\frac{0.081(L_x+L_{2x})^{3.23}}{(SN+1)^{5.19}{L_{2x}}^{3.23}}\right]$ which is a function that determines the relationship between serviceability and axle load applications, $\hat{a}_{18} = 0.40 + \left[\frac{0.081(18+1)^{3.23}}{(SN+1)^{5.19}1^{3.23}}\right]$, and SN = structural number.

For rigid pavements, the following equation is used for the LEF estimation (AASHTO, 1993):

$$log_{10}\left[\frac{w_{tx}}{w_{t18}}\right] = 4.62log_{10}[L_{18}+L_{2s}] - 4.62log_{10}[L_x+L_{2x}] + 3.28log_{10}L_{2x} + \frac{G_t}{\hat{a}_x} - \frac{G_t}{\hat{a}_{18}} \quad (3.9)$$

where $\frac{w_{tx}}{w_{t18}}$ = inverse of the LEF ratio, L_{18} = 18 (standard axle load in kips), L_x = axle load being evaluated (in kips), L_2 = code for axle configuration [1 for single axle; 2 for tandem axle; 3 for triple axle; s for single axle], L_{2x} = code for axle configuration being evaluated, $G_t = \log_{10}\left(\frac{4.5-p_t}{4.5-1.5}\right)$ which is a function of the ratio of loss in serviceability at time t, to the potential loss taken at a point where p_t = 1.5, p_t = terminal serviceability index, $\hat{a}_x = 0.40 + \left[\frac{3.63(L_x+L_{2x})^{5.20}}{(D+1)^{8.46}{L_{2x}}^{3.52}}\right]$ which is a function that determines the relationship between serviceability and axle load applications, $\hat{a}_{18} = 0.40 + \left[\frac{3.63(18+1)^{5.20}}{(D+1)^{8.46}1^{3.52}}\right]$, and D = depth of concrete slab (in inches).

For a given pavement project, the ESAL contribution of each vehicle class can be estimated using the VMT distribution across the 13 vehicle classes (as defined by FHWA) for a given road functional class (estimated using Indiana data) and the average number of single, tandem, tridem, and quad axles per vehicle class and per load-class from FHWA (2010); and the LEF ratios can be estimated based on AASHTO (1993). Specifically, for vehicle class i, the number of ESALs for axle-load range k, and axle configuration l is estimated as follows:

$$ESAL_{ikl} = AADT_i \times [\text{average number of } l \text{ axles}]_i \times [\% \text{ of } l \text{ axles in axle load range } k]_i \times LEF_{kl} \quad (3.10)$$

The total ESALs for vehicle class i can be estimated as the sum of $ESAL_{ikl}$ over each load range and axle type. The ESAL contribution by vehicle class i was calculated

TABLE 3.1.4
Load Transfer Coefficient for Various Pavement and Shoulder Types and Design Conditions (AASHTO, 1993).

	Shoulder			
	Asphalt		PCC	
Pavement Type	Load Transfer Devices	No Load Transfer Devices	Load Transfer Devices	No Load Transfer Devices
Plain Jointed / Jointed Reinforced	3.2	3.8–4.4	2.5–3.1	3.6–4.2
Continuously Reinforced	2.9–3.2	—	2.3–2.9	—

by multiplying the ESAL contribution of a vehicle class by the pavement design ESALs (W_{18}) estimated for the project in question. For each vehicle class, the number of ESALs covered by the base facility is subtracted from the total ESALs, thus estimating the ESALs to be covered by the remaining facility. At the next step, the distribution of ESAL contribution is adjusted to account for vehicle width. The reasons for this adjustment, as well as the estimation of the vehicle width adjustment factors, were presented in the previous section. Last, the cost responsibility for the remaining facility is estimated based on the adjusted ESAL distribution.

In the present study, pavement reconstruction projects were treated similar to new pavement construction; therefore, the reconstruction expenditures were allocated using the same methodology described in this section.

1.1.2 Allocation of Pavement Rehabilitation Expenditures

The expenditures associated with a pavement rehabilitation project were divided into the following categories: (a) pavement-related expenditures, (b) grading and earthwork expenditures, (c) shoulder expenditures, (d) drainage and erosion control expenditures and (f) miscellaneous.

The need for preservation typically originates from two events that occur in parallel: pavement damage due to traffic and pavement damage due to climatic conditions. For this reason, a portion of the pavement-related expenditures is attributed to load on the basis of traffic volume, vehicle class distribution, and vehicle weight distribution; the remaining part is attributed to non-load due to for example, weather and climatic conditions and is therefore allocated among all vehicles on the basis of VMT. The proportion of pavement rehabilitation costs attributable to load-related factors by route type, as proposed by FHWA (1997), is presented in Table 3.1.5.

The load shares presented in Table 3.1.5 were adopted for the present study and were used to estimate the load and non-load pavement-related expenditures. Since there is limited information on the type of the underlying pavement, the load share percentage was chosen by the type of rehabilitation treatment applied on the pavement (flexible or rigid). The portion of the pavement-related expenditures attributed to non-load-related factors was allocated on the basis of VMT; for the load-related expenditures, the National Pavement Cost Model (NAPCOM) was used.

FHWA (1997) introduced the distress-based model NAPCOM for the allocation of pavement rehabilitation costs. NAPCOM uses individual distress models for flexible and rigid pavements. For flexible pavements, NAPCOM has individual distress models for traffic-related PSR loss, expansive-clay-related PSR loss, fatigue cracking, thermal cracking, rutting, and loss of skid resistance; for rigid pavements, the distress models include traffic-related PSR loss, faulting, loss of skid resistance, fatigue cracking, spalling, and soil-induced swelling and depression. The NAPCOM parameters and distress shares differ by road functional class on the basis of the old FHWA road classification system: urban/rural interstate, urban freeway, urban/rural other principal arterial (OPA), urban/rural minor arterial, urban/rural major collector, urban/rural minor collector, and urban/rural local route.

Since the previously-mentioned distress data were not available for the projects analyzed in the present study, the average parameters for Indiana included in the FHWA software package developed for state HCAS were used. A detailed presentation of NAPCOM can be found in Appendix A of the 2010 Idaho Cost Allocation Study (ITD, 2010). The analytical details of that model are not presented in this report due to space limitations. It also is noted that the performance-based approach used in the last INDOT HCAS for the allocation of maintenance and rehabilitation costs was not used in the present study because it would require extensive recalibration efforts. The approaches proposed by FHWA were used instead.

Grading and earthwork expenditures were allocated based on VMT while shoulder expenditures were allocated

TABLE 3.1.5
Proportion of Pavement Rehabilitation Expenditures Attributed to Load-Related Factors for Flexible and Rigid Pavements (Source: FHWA, 1997).

Functional Highway Class		Flexible Pavements [%]	Rigid Pavements [%]
Rural	Interstate	89.0	90.7
	Other Principal Arterials	87.9	84.3
	Minor Arterials	87.8	86.3
	Major Collectors	85.3	85.5
	Minor Collectors	85.3	85.5
	Local	85.3	85.5
	Interstate	89.9	92.1
Urban	Other Freeways/Expressways	89.4	89.0
	Major Arterials	88.5	87.2
	Minor Arterials	87.3	83.7
	Collectors	86.1	79.5
	Local	86.1	79.5

on the basis of PCE-miles. PCE can be considered a surrogate for the effect of vehicle size on shoulder expenditures based on the assumption that larger vehicles require wider shoulders and therefore incur higher expenditures. Drainage and erosion control and miscellaneous expenditures are considered common expenditures and are discussed in Chapter 3 of this Part of the report.

1.1.3 Allocation of Pavement In-House Maintenance Expenditures

The expenditures associated with pavement in-house maintenance are divided into the following categories: (a) pavement-related expenditures and (b) shoulder expenditures.

As mentioned in the previous section, pavement maintenance and rehabilitation expenses are incurred for the damage caused by traffic and climatic conditions. For this reason, the pavement-related expenditures were divided into load-related and non-load expenditures for the appropriate allocation of expenditures. The load shares developed for the 1984 Indiana HCAS were adopted by the present study and are presented in Table 3.1.6. As shown in Table 3.1.6, the 1984 Indiana HCAS developed different load shares for northern and southern Indiana, but an average load share was used for the purposes of the present study. It also is noted that the 1997 and 2000 FHWA HCAS did not develop load shares for maintenance activities.

The load shares presented in Table 3.1.6 and adopted by the present study, were used to estimate the load-related and non-load-related pavement maintenance expenditures. Since there is limited information on the type of underlying pavement, the load share percentage was chosen by the type of maintenance treatment applied on the pavement (flexible or rigid). The portion of the pavement-related expenditures attributed to non-load-related factors was treated as common costs and therefore was allocated on the basis of VMT. Based on the suggestions incorporated in the FHWA software package developed for State HCASs, the load-related portion of the expenses can be attributed on the basis of LEF or ESAL-miles. The present study allocated the load-related expenses on the basis of ESAL-miles because ESALs take into account the vehicle class distribution as well as the LEF for each vehicle class. Similar to the new pavement construction and pavement rehabilitation methodologies, the shoulder expenditures were allocated on the basis of PCE-miles.

TABLE 3.1.6
Proportion of Pavement In-House Maintenance Expenditures Attributed to Load-Related Factors for Flexible and Rigid Pavements (Source: Sinha et al., 1984).

	Flexible Pavements [%]	Rigid Pavement [%]
Northern Indiana	87.0	66.0
Southern Indiana	98.0	70.0
Average	92.0	68.0

1.1.4 Allocation of Other Pavement Project Expenditures

Pavement expenditures that are not related to new road construction, pavement rehabilitation, or pavement maintenance (e.g., roadside work and facilities, demolition, ITS-related pavement work, slope correction, and drainage ditch correction contracts) are all grouped into a single category that was termed "Other Pavement Project Expenditures." These expenditures were considered a common cost and were attributed to all vehicle classes on the basis of VMT.

1.2 Data for Pavement Cost Allocation

This section describes the sources for data and their use in the pavement cost allocation process. Figure 3.1.1 presents the pavement expenditures for each analysis year and the average expenditure for the analysis period (2009–2012) in the state of Indiana. All expenditures shown are in dollars at the respective year. As Figure 3.1.1 indicates, there was a decreasing trend in the total expenditures for pavements, starting with approximately $491,000,000 in 2009 and ending with approximately $282,000,000 in 2012.

For the purposes of the present study, the expenditures were categorized in terms of the highway class: Interstates, non-Interstate NHS, and non-NHS. The pavement expenditures by year and functional class are presented in Table 3.1.7.

Figure 3.1.2 presents the pavement expenditures by year and functional class for the analysis period. It can be seen that on average, the total Interstate expenditures were less than the total non-Interstate NHS or non-NHS expenditures.

1.2.1 Pavement Contract Expenditures

The expenditures related to new pavement construction, pavement reconstruction, rehabilitation, and other pavement contracts were extracted from the INDOT Site Manager database. These expenditures were related to the contracts that were let between 2009 and 2012 and refer to activities that included pavement work but excluded the bridge wearing surface and approaches. The expenditures in a specific year constitute the sum of all contracts let that year. Also, the "Average" column that appears in some of the graphs within this section

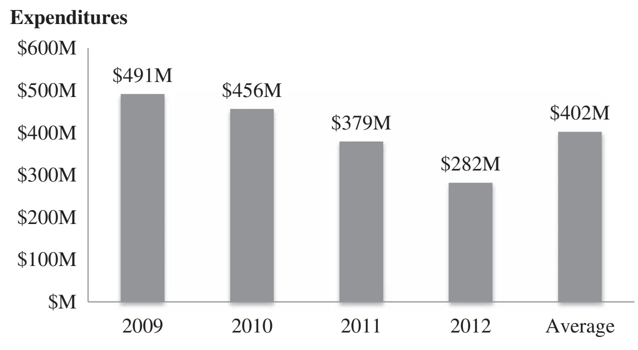


Figure 3.1.1 Pavement expenditures by year.

TABLE 3.1.7
Pavement Expenditures by Year and Functional Class ($ at respective year).

Functional Class	2009	2010	2011	2012	Total
Interstates	$112,531,771	$175,068,557	$125,857,299	$79,248,773	$492,706,399
Non-Interstate NHS	$172,721,461	$152,334,795	$138,232,885	$101,986,606	$565,275,746
Non-NHS	$206,186,485	$128,800,405	$115,347,513	$100,666,706	$551,001,109
All Routes	$491,439,716	$456,203,757	$379,437,697	$281,902,085	$1,608,983,254

refers to an annual average estimated on the basis of the analysis period (2009–2012). Lastly, all expenditures shown are in dollars at the respective years of reporting.

For a more appropriate and equitable cost allocation, the pavement contract expenditures were categorized into the following three expenditure categories:

- *Pavement-Related Expenditures:* Expenditures related to the pavement layers: surface, intermediate base, aggregate base, and subbase.
- *Grading and Earthworks Expenditures:* Expenditures related to grading and earthwork activities in pavement projects.
- *Shoulder Expenditures:* Expenditures related to paved shoulders.

Table 3.1.8 shows the three expenditure categories and the expenditure items that are included in each category. The names of the expenditure items were extracted from the INDOT Site Manager database.

The contribution of each expenditure category to the total pavement contract expenditures for different work types are discussed below.

New Pavement Construction and Reconstruction Expenditures. New pavement construction and reconstruction expenditures include the following major work-type categories as they appear in INDOT Site Manager Database: (1) (new) road construction, (2) added travel lanes/auxiliary lanes, (3) interchange construction, and (4) pavement replacement.

The new pavement construction and reconstruction expenditures are presented as a single category here because they were analyzed using the same methodology, as mentioned in Section 1.1.1 of this Part of the report. In this section, "new pavement construction" refers to both new pavement construction and pavement reconstruction expenditures. Tables 3.1.9, 3.1.10, and 3.1.11 present the new pavement construction expenditures for Interstates, non-Interstate NHS, and non-NHS highways, respectively, by expenditure type and year.

Figures 3.1.3, 3.1.4, and 3.1.5 show the new pavement construction expenditure types as a percentage of total expenditures for Interstates, non-Interstate NHS, and non-NHS, respectively. The presented percentages were estimated based on the average expenditures over the analysis period.

Comparing Figures 3.1.3, 3.1.4, and 3.1.5, it can be seen that Interstates had the highest percentage of pavement-related expenditures. For all route types, the pavement-related expenditures ranged between 46.1% and 52.3% of the total expenditures, grading and earthwork expenditures ranged between 47.6% and 53.8% of the total expenditures, and shoulder expenditures were 0.1%–0.2% of the total expenditures.

New pavement construction expenditures were also divided into new flexible pavement construction and new rigid pavement construction in order to allow the application of the different equations and parameters for flexible and rigid pavements as described in

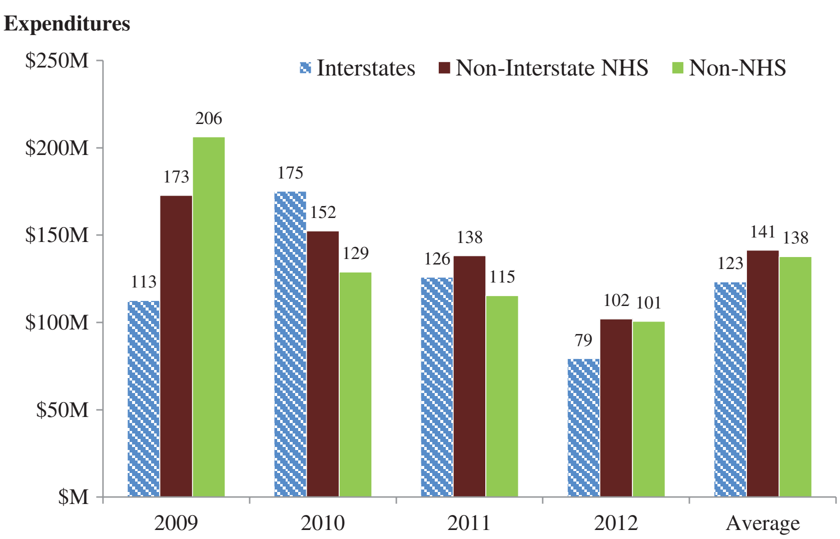


Figure 3.1.2 Comparison of pavement expenditures by year and route type ($ at respective year).

TABLE 3.1.8
Pavement Contract Expenditure Categories and Expenditure Items.

Pavement Contract Expenditure Categories	Expenditure Items
Pavement-Related Expenditures	Annual Routine Maintenance
	Base Seal
	Bituminous Patching Mixtures
	Cellular Concrete Fill
	Cold Mix Asphalt Pavement
	Compacted Aggregate Base, Surface or Shoulder
	Compacted Aggregate Base
	Concrete Floor Slabs
	Concrete Header
	Concrete Repair by Epoxy Injection
	Continuously Reinforced Cement Concrete Pavement
	Fog Seal
	Grated Box End Sections
	HMA Partial Depth Patching
	Hot Mix Asphalt Pavement
	Micro-Surfacing
	PCCP Joints
	PCCP Patching
	Pneumatically Placed Mortar
	Portland Cement Concrete Pavement
	Portland Cement Concrete Sealers
	Portland Cement Treated Base
	Precast and Prestress Concrete Structural Member
	QC/QA Hot Mix Asphalt Pavement
	Reconditioning
	Reconstructed Expansion Joint
	Reinforcing Steel
	Seal Coat
	Sealing Cracks and Joints
	Structural Concrete
	Structural Expansion Joints
	Subbase
	Surfaces for Approaches
	Tack Coat
	Ultrathin Bonded Wearing Course
	Undersealing
	Widening and Patching
Grading and Earthworks Expenditures	Chemical Modification of Subgrade Soils
	Clearing and Grubbing
	Curbing
	Drilled Shaft
	Dust Palliative
	Excavation and Embankment
	Flowable Mortar
	Gabions
	Geotechnical Instrumentation
	Mechanically Stabilized Earth Retaining Wall
	Modular Concrete Gravity Wall
	Piling
	Riprap and Slopewall
	Special Fill an Backfill ("B" Borrow)
	Stockpiled Materials
	Stockpiled Selected Materials
	Structure Excavation
	Subgrade
Shoulder Expenditures	Bituminous Shoulders
	Finishing Shoulders, Ditches, and Slopes
	Milled Shoulder Corrugations

TABLE 3.1.9
New Pavement Construction Expenditures for Interstates by Year and Expenditure Type ($ at respective year).

Expenditure Type	2009	2010	2011	2012	Total
Pavement-Related	$38,054,175	$49,001,311	$36,210,863	$21,836,295	$145,102,643
Grading and Earthworks	$32,202,367	$63,729,272	$19,395,373	$16,556,383	$131,883,394
Shoulder	$0	$124,219	$183,105	$23,922	$331,246
Total	$70,256,541	$112,854,801	$55,789,341	$38,416,600	$277,317,283

TABLE 3.1.10
New Pavement Construction Expenditures for Non-Interstate NHS by Year and Expenditure Type ($ at respective year).

Expenditure Type	2009	2010	2011	2012	Total
Pavement-Related	$52,820,716	$49,481,469	$37,087,078	$17,257,323	$156,646,587
Grading and Earthworks	$61,895,876	$39,589,845	$45,593,162	$36,048,115	$183,126,998
Shoulder	$55,337	$252,391	$142,903	$0	$450,630
Total	$114,771,928	$89,323,705	$82,823,144	$53,305,438	$340,224,215

TABLE 3.1.11
New Pavement Construction Expenditures for Non-NHS by Year and Expenditure Type ($ at respective year).

Expenditure Type	2009	2010	2011	2012	Total
Pavement-Related	$62,371,501	$26,353,224	$22,201,006	$6,265,653	$117,191,385
Grading and Earthworks	$48,897,548	$22,035,889	$28,829,698	$32,288,358	$132,051,493
Shoulder	$373,571	$68,511	$0	$32,025	$474,108
Total	$111,642,621	$48,457,624	$51,030,705	$38,586,036	$249,716,985

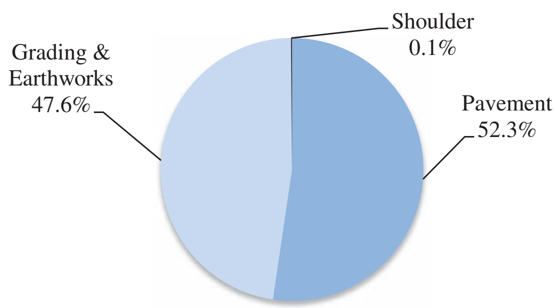


Figure 3.1.3 Expenditure type as a percentage of the total new pavement construction expenditures, 2009–2012, Interstates.

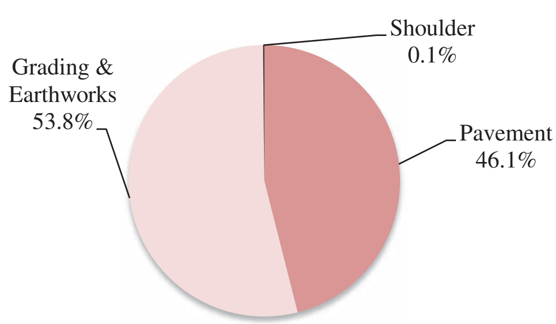


Figure 3.1.4 Expenditure type as a percentage of the total new pavement construction expenditures, 2009–2012, Non-Interstate NHS.

Section 1.1.1 of this Part of the report. Figures 3.1.6, 3.1.7, and 3.1.8 show the new pavement construction expenditures by pavement construction type (flexible or rigid) for Interstates, non-Interstate NHS, and non-NHS highways, respectively.

Comparing Figures 3.1.6, 3.1.7, and 3.1.8, it can be observed that most new-pavement Interstate construction projects in 2009–2012 involved rigid pavement while the contrary is true for the non-Interstate routes.

The following section discusses the pavement rehabilitation expenditures on State routes; this data were extracted from the INDOT Site Manager Database for 2009–2012.

Pavement Rehabilitation Expenditures. Pavement rehabilitation expenditures include four major work-type

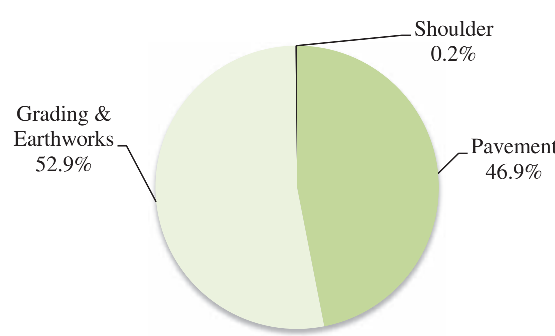


Figure 3.1.5 Expenditure type as a percentage of the total new pavement construction expenditures, 2009–2012, Non-NHS.

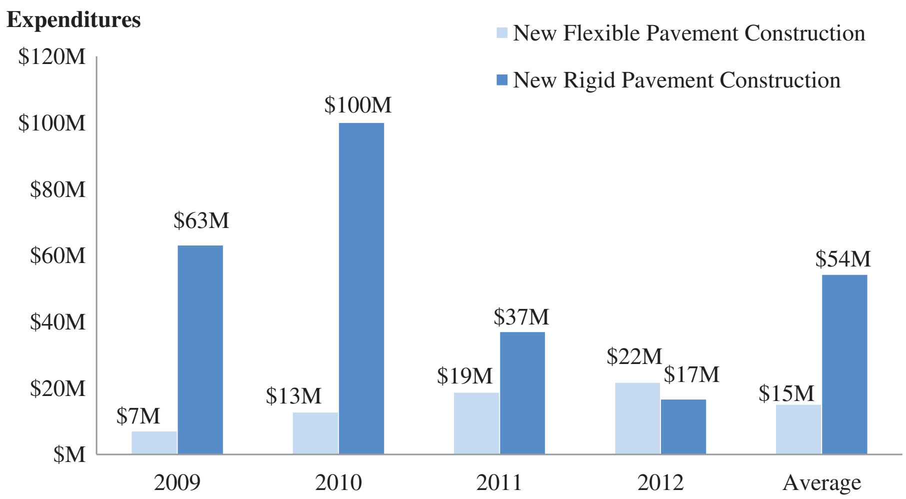


Figure 3.1.6 New pavement construction expenditures by year and pavement construction type ($ at respective year), Interstates.

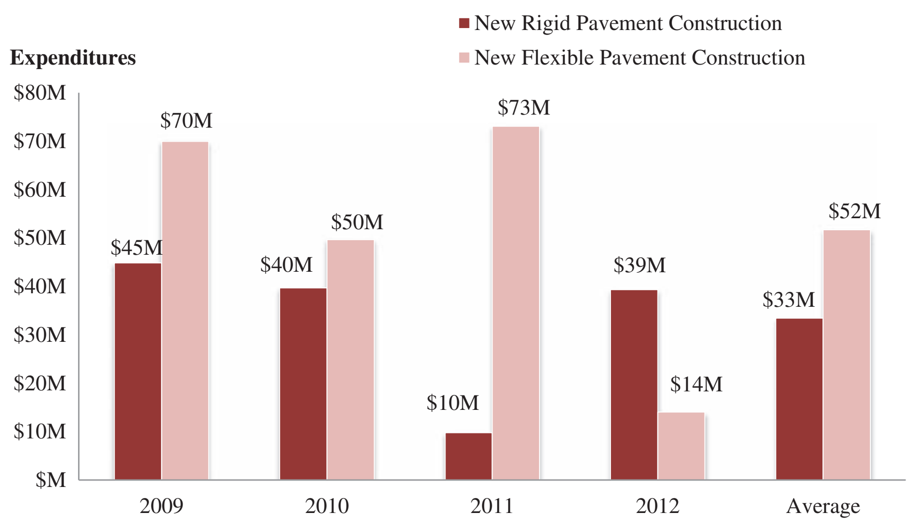


Figure 3.1.7 New pavement construction expenditures by year and pavement construction type ($ at respective year), Non-Interstate NHS.

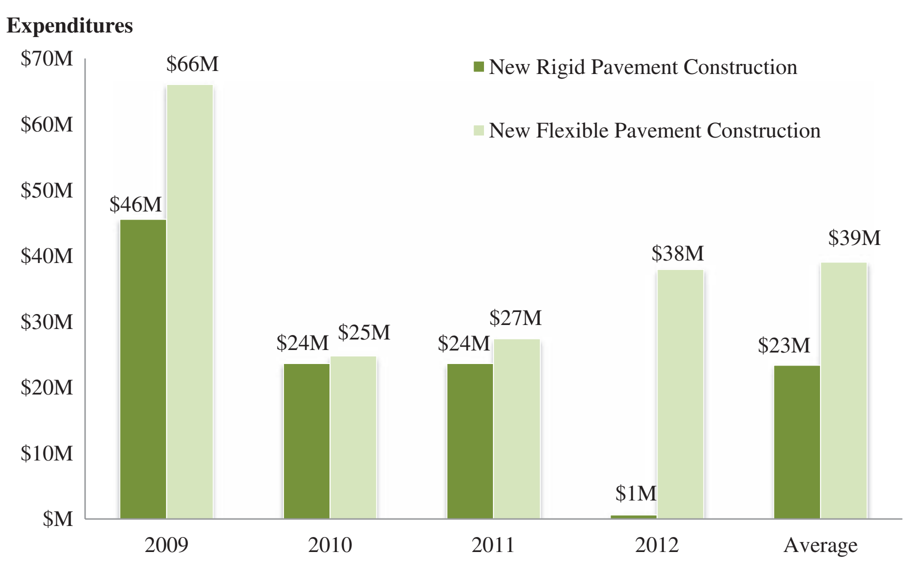


Figure 3.1.8 New pavement construction expenditures by year and pavement construction type ($ at respective year), Non-NHS.

TABLE 3.1.12
Pavement Rehabilitation Expenditures by Year and Expenditure Type ($ at respective year), Interstates.

Expenditure Type	2009	2010	2011	2012	Total
Pavement-Related	$20,174,680	$31,325,797	$45,383,653	$34,075,071	$130,959,202
Grading and Earthworks	$102,029	$468,390	$734,148	$286,633	$1,591,201
Shoulder	$225,211	$74,863	$134,731	$112,202	$547,008
Total	$20,501,920	$31,869,051	$46,252,532	$34,473,907	$133,097,410

TABLE 3.1.13
Pavement Rehabilitation Expenditures by Year and Expenditure Type ($ at respective year), Non-Interstate NHS.

Expenditure Type	2009	2010	2011	2012	Total
Pavement-Related	$41,166,191	$50,610,579	$37,449,067	$27,958,000	$157,183,837
Grading and Earthworks	$1,681,344	$3,135,226	$4,879,817	$4,747,557	$14,443,945
Shoulder	$22,155	$108,195	$108,495	$39,853	$278,698
Total	$42,869,690	$53,854,000	$42,437,379	$32,745,410	$171,906,480

TABLE 3.1.14
Pavement Rehabilitation Expenditures by Year and Expenditure Type ($ at respective year), Non-NHS.

Expenditure Type	2009	2010	2011	2012	Total
Pavement-Related	$69,768,018	$53,625,571	$23,205,899	$26,289,500	$172,888,988
Grading and Earthworks	$928,365	$1,175,614	$2,083,926	$1,210,351	$5,398,256
Shoulder	$23,158	$33,176	$21,968	$8,383	$86,686
Total	$70,719,541	$54,834,361	$25,311,794	$27,508,233	$178,373,930

categories as they appear in the INDOT Site Manager Database: (1) road rehabilitation (3R/4R standards), (2) road rehabilitation (partial 3R standards), (3) pavement repair or rehabilitation, and (4) patch and rehabilitate pavement. For each of these four categories, the expenditures were further categorized into pavement-related, grading and earthworks, and shoulder expenditures (drainage and miscellaneous expenditures are discussed in Chapter 3 of this Part of the report).

Tables 3.1.12, 3.1.13, and 3.1.14 show the pavement rehabilitation expenditures for Interstates, non-Interstate NHS routes, and non-NHS routes, respectively, by expenditure type and year.

Figures 3.1.9, 3.1.10, and 3.1.11 show the pavement rehabilitation expenditure types as a percentage for Interstates, non-Interstate NHS routes, and non-NHS routes, respectively. The presented percentages were estimated based on the average expenditures over the analysis period.

As expected, pavement rehabilitation projects were found to include a much higher percentage of pavement-related expenses compared to new pavement construction projects. For all route types, the pavement-related expenditures ranged between 91.4% and 98.4% of the total expenditures, grading and earthwork expenditures ranged between 1.2% and 8.4% of the total expenditures, and shoulder expenditures were 0.1%–0.4% of the total expenditures.

Furthermore, pavement rehabilitation expenditures are divided into flexible and rigid rehabilitation expenditures so that the different NAPCOM equations and parameters can be applied to the analysis for flexible and rigid

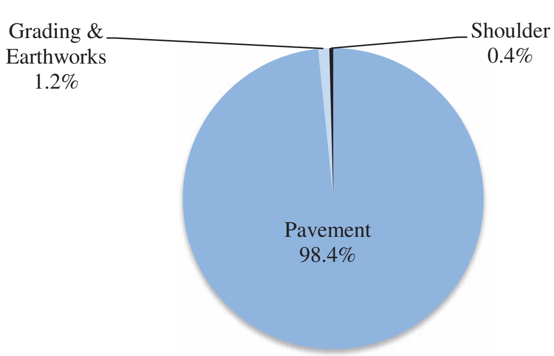


Figure 3.1.9 Expenditure type as a percentage of the total pavement rehabilitation expenditures, 2009–2012, Interstates.

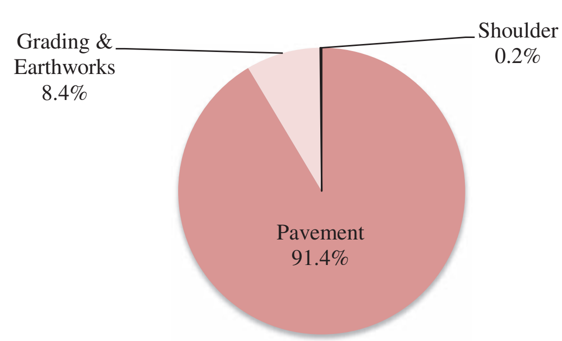


Figure 3.1.10 Expenditure type as a percentage of the total pavement rehabilitation expenditures, 2009–2012, Non-Interstate NHS.

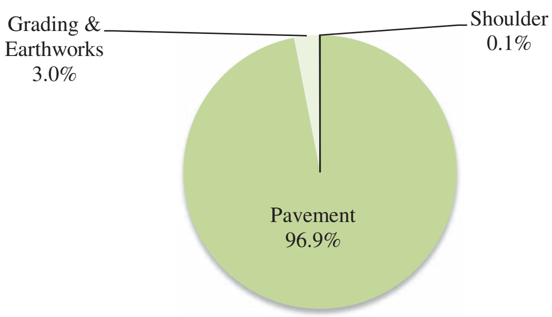


Figure 3.1.11 Expenditure type as a percentage of the total pavement rehabilitation expenditures, 2009–2012, non-NHS.

pavements as described in Section 1.1.2 of this Part of the report. Figures 3.1.12, 3.1.13, and 3.1.14 present the pavement rehabilitation expenditures by "construction" type (flexible or rigid) for Interstates, non-Interstate NHS, and non-NHS respectively. It should be noted here that the term construction type ("flexible" and "rigid") refers to the dominant material used for each contract and not the existing pavement surface type prior to the rehabilitation.

Comparing Figures 3.1.12, 3.1.13, and 3.1.14, it can be seen that most rehabilitation expenditures—91.6% in total—involved flexible materials such as asphalt overlays. Also, there was significant fluctuation from year to year of the let contract amount of flexible rehabilitation projects. On average, INDOT spent approximately $33,000,000 on Interstate routes, $43,000,000 on non-Interstate NHS routes, and $45,000,000 on non-NHS routes per year for pavement rehabilitation.

Other Pavement Project Expenditures. Pavement-related expenditures that are a component of roadside work and facilities, demolition, intelligent transportation systems, slide correction, and drainage ditch correction contracts were grouped into one category called "Other Pavement Project Expenditures." These expenditures are presented in Table 3.1.15 and Figure 3.1.15 by year and functional class.

Figure 3.1.15 illustrates that the amounts spent on other pavement expenditures were on average higher for Interstates. However, there was significant variation among the different years.

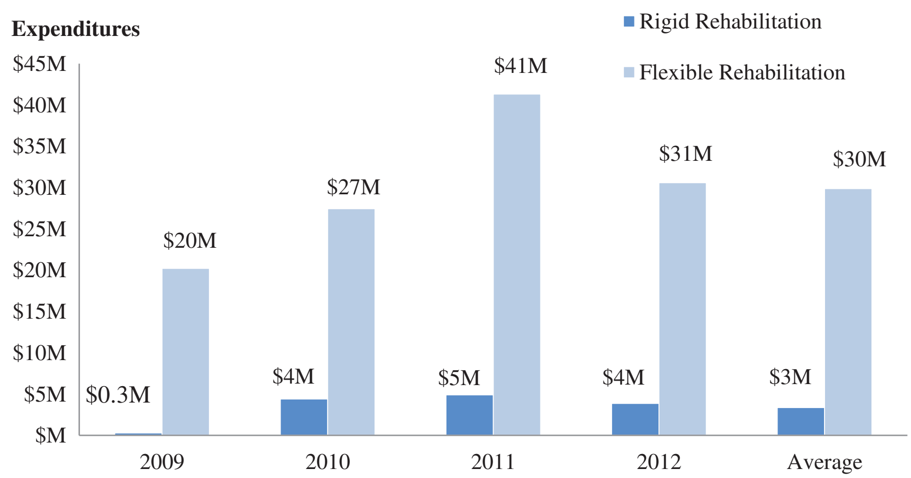


Figure 3.1.12 Pavement rehabilitation expenditures by year and pavement construction type ($ at respective year), Interstates.

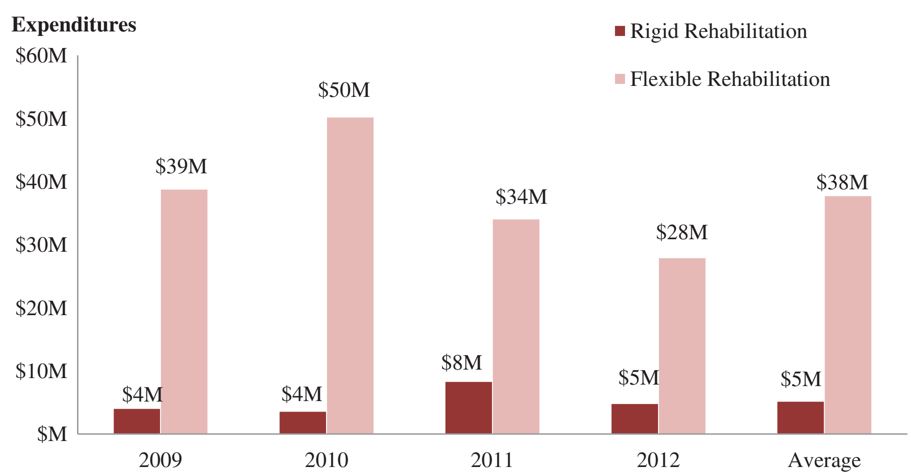


Figure 3.1.13 Pavement rehabilitation expenditures by year and pavement construction type ($ at respective year), Non-Interstate NHS.

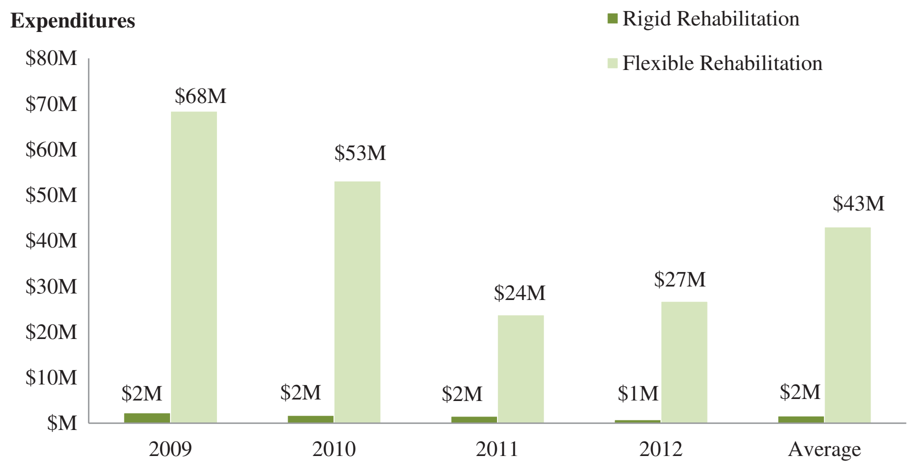


Figure 3.1.14 Pavement rehabilitation expenditures by year and pavement construction type ($ at respective year), Non-NHS.

1.2.1 In-House Pavement Maintenance Expenditures

Data on the pavement-related in-house maintenance expenditures were extracted from the INDOT In-House Maintenance Database for the years 2009–2012; and Table 3.1.16 the in-house pavement maintenance activities that were conducted during that time. The expenditures for these activities are presented in Table 3.1.17 and Figure 3.1.16 for each year and route type; all expenditures shown are in dollars at the respective year of reporting.

As Figure 3.1.16 indicates, the expenditures for in-house maintenance activities did not differ significantly across the years. The distribution of the maintenance expenditures with respect to the route type was related to the distribution of the road miles of the different route types. For example, the Interstate network (which has the least inventory size compared to other functional classes) had the least amount of maintenance expenditures.

1.3 Analysis and Results

1.3.1 New Pavement Construction Expenditures Analysis and Results

This chapter discussed the analysis and results of new pavement construction cost allocation for state routes. A detailed illustration was provided to demonstrate the methodology adopted in the present study. Then, the results for the analysis period (2009–2012) were presented. The detailed results are presented in Addendum B.

Example of New Pavement Construction Cost Allocation. In this section, the data from a concrete pavement replacement contract let in 2009 are used to demonstrate the new pavement cost allocation methodology used in the present study. Table 3.1.18 provides some general information about the contract, including the exact location of the project.

The VMT distribution in the location of the contract is presented in Table 3.1.19, along with the adjusted (for vehicle width) VMT. The distribution of the ESAL contribution of each vehicle class was estimated using the available site-specific traffic information (VMT distribution and AADT) as well as the LEF estimated using AASHTO (1993), Equation 3.1.8, for the given contract (13-in. PCCP). The distribution of the ESAL contribution and the adjusted (for vehicle width) distribution of the ESAL contribution of each vehicle class are also presented in Table 3.1.19.

Figure 3.1.17 illustrates a two-way comparison of the different traffic distribution types employed in the new pavement cost allocation methodology, generated for the project location used in the example. Figure 3.1.17(a) compares the VMT and the ESAL distribution. Looking solely at the number of vehicles in each vehicle class for the given project (VMT distribution), it can be observed that classes 2 and 3 had the highest percentages; however, looking at the combined effect of traffic and pavement damage (ESAL distribution), class 9 dominated with 82.3%. Figure 3.1.17(b) includes a similar comparison between the adjusted (for vehicle width) distributions. Comparing Figures 3.1.17(a) and 3.1.17(b), it can be seen that the effect of the adjustment factors is relatively small; the adjusted distributions are close to the original ones. In Figure 3.1.17(b), the percentages of classes 1–3 appear

TABLE 3.1.15
Other Pavement Expenditures by Year and Functional Class ($ at respective year).

Functional Class	2009	2010	2011	2012	Total
Interstates	$17,455,865	$27,528,524	$20,695,006	$3,551,875	$69,231,270
Non-Interstate NHS	$7,937,449	$3,297,891	$7,538,348	$7,565,877	$26,339,564
Non-NHS	$6,777,647	$7,083,404	$21,673,498	$11,510,538	$47,045,086
All Routes	$32,170,962	$37,909,818	$49,906,851	$22,628,289	$142,615,921

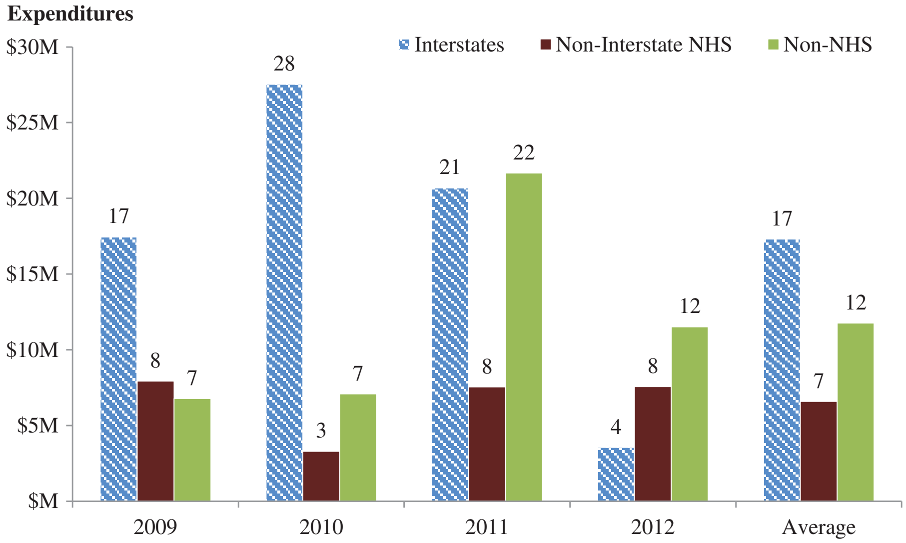


Figure 3.1.15 Comparison of other pavement project expenditures by year and functional class ($ at respective year).

a little lower while the percentages of classes 4–13 appear a little higher compared to Figure 3.1.17(a).

This example focuses on pavement-related expenditures, a portion of which was considered part of the base facility. For every new pavement construction project, the pavement-related expenditures are grouped into rigid items, flexible items, and approaches, as shown in Table 3.1.20. Since this was a PCCP replacement project, the rigid items (specifically, the 13-in. concrete slab) constituted the largest portion of the pavement-related expenditures. The analysis therefore focused on the rigid items, then the expenditures for flexible items were allocated using the average distributions developed in the analysis of all the flexible pavement contracts.

The total ESALs consumed during the life of a 13-in. PCCP were estimated using the rigid pavement design equation from AASHTO (1993) (Equation 3.1.5); the parameters were chosen based on the recommendations provided by AASHTO (1993) and Indiana practices (INDOT, 2013). The input information to the rigid pavement design equation is presented in Table 3.1.21. The total ESALs during the pavement life were calculated as 65,670,929. To calculate the ESALs provided only by the base facility, the same input information shown in Table 3.1.21 was inserted in the rigid pavement design equation; the only difference was that the concrete slab thickness in inches was 5 (instead of 13). The total ESALs consumed by the base facility consumes was calculated as 290,950.

Using the adjusted VMT distribution for vehicle width and the cost of the base facility, the cost responsibility of each vehicle class for the rigid items of the base facility was estimated (Table 3.1.22). The cost of the rigid items of the base facility was estimated as a percentage of the total cost of the rigid items for the given contract, assuming a direct relationship with the thickness of the base and the total facility. Therefore, for this contract, the cost of the rigid items of the base facility was 38.46% of the total cost of all the rigid items.

TABLE 3.1.16
Pavement-Related In-House Maintenance Activities

Blading Shoulders
Clipping Shoulders
Deep Patching
Full Width Shoulder Seal Coat
Joint and Bump Repair
Mainline Crack Filling
Mainline Crack Route and Seal
Mainline Fog Seal
Mainline Seal Coat
Other Roadway/Shoulder
Recondition Shoulders
Shallow Patching
Shoulder Crack Filling
Shoulder Crack Route and Seal
Shoulder Fog Seal
Spot Paving
Spot Repair of Unpaved Shoulders
Spot Repair of Unpaved Shoulders

TABLE 3.1.17
Pavement-Related In-House Maintenance Expenditures by Year and Functional Class ($ at respective year).

Functional Class	2009	2010	2011	2012	Total
Interstates	$4,064,340	$2,656,242	$2,856,126	$2,407,529	$11,984,237
Non-Interstate NHS	$6,358,748	$5,255,781	$4,824,964	$6,860,409	$23,299,902
Non-NHS	$14,144,933	$15,959,392	$14,865,892	$19,786,662	$64,756,879
All Routes	$24,568,021	$23,871,415	$22,546,982	$29,054,600	$100,041,018

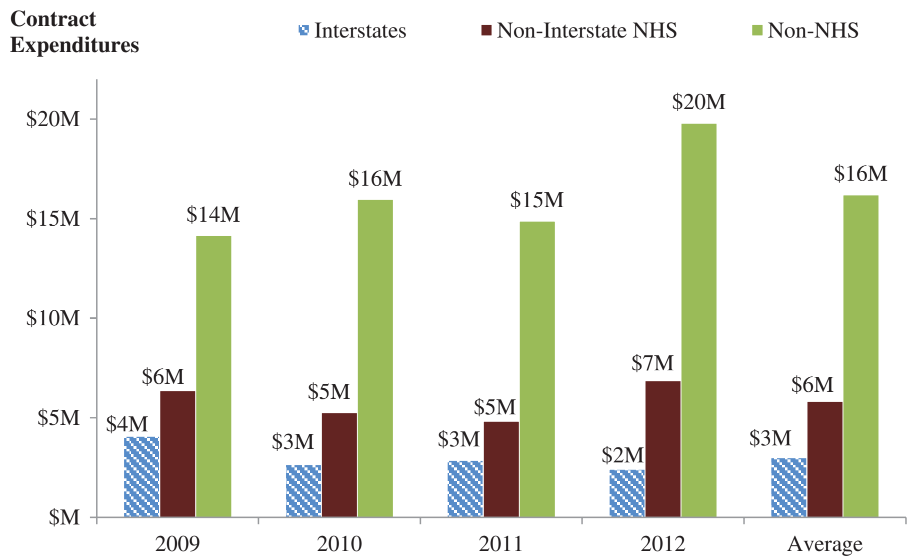


Figure 3.1.16 Pavement-related in-house maintenance expenditures by year and functional class ($ at respective year).

Moving to the estimation of the pavement-related cost responsibility for the rigid items of the remaining facility, the ESALs provided by the remaining facility were first estimated by subtracting the ESALs provided by the base facility from the ESALs provided by the entire facility (total ESALs) as shown in Table 3.1.23. Using the estimated ESALs provided by the remaining facility, the distribution of ESAL contribution was updated and later adjusted using the vehicle width adjustment factors. The process of estimating this updated and adjusted (for vehicle width) ESAL distribution is presented in Table 3.1.23.

Using the adjusted ESAL distribution for vehicle width and the cost of the remaining facility, the cost responsibility of each vehicle class for the rigid items of the remaining facility was estimated and is presented in Table 3.1.24. Figure 3.1.18 presents the cost responsibility for each vehicle class for the pavement-related rigid items of the base and the remaining facility.

As expected, vehicle classes 2 and 3 were found to be responsible for most of the base facility cost while class 9 was responsible for most of the remaining facility cost. After all the projects were analyzed, the cost responsibility was summed up for all projects and then the total cost responsibility for each vehicle class was divided by the VMT to obtain a unit cost ($/VMT) for that class.

New Pavement Construction Cost Allocation Results. This section presents the total vehicle class cost responsibilities and the average unit costs for the 2009–2012 period and the different functional classes. The detailed results (for each year) are presented in Addendum B.

The methodology that provided these results is explained in depth in of this Part of the report, Section 1.1.1 and is demonstrated using an example in Section 1.3.1. The methodology presented in the 1997 and 2000 FHWA HCAS was adopted and the analysis was conducted on a project-by-project basis.

As explained in Section 1.1.1 of this Part of the report, a facility was divided into the base and the remaining facility. The base facility includes the earthworks and grading and shoulder expenditures as well as part of the pavement expenditures as follows:

- Flexible pavements: 1 inch of surface HMA course, 3 inches of base HMA course, and 4 inches of compacted aggregate (or subbase) course
- Rigid pavements: 5 inch PPCP slab

TABLE 3.1.18
General Contract Information—Methodology Illustration.

Contact ID	IR-30710
Letting Date	11/6/2009
Program Class	Major Moves—Major New
Project Type	Pavement Replacement—Concrete
Route	Interstate 465
County	Marion
Milepost	From 031+00 to 034+00

TABLE 3.1.19
Contract-Specific Traffic Information—Example of Methodology.

Vehicle Classes	VMT	Adjusted VMT	ESALs	Adjusted ESALs
1	0.47%	0.46%	0.00003%	0.00003%
2	68.06%	67.16%	1.88%	1.63%
3	23.07%	22.77%	3.02%	2.62%
4	0.11%	0.13%	0.69%	0.69%
5	1.23%	1.40%	2.75%	2.77%
6	0.20%	0.23%	1.49%	1.50%
7	0.03%	0.04%	1.01%	1.02%
8	0.38%	0.43%	2.19%	2.20%
9	6.11%	6.99%	82.30%	82.86%
10	0.06%	0.07%	0.89%	0.89%
11	0.19%	0.21%	2.28%	2.29%
12	0.07%	0.08%	1.00%	1.01%
13	0.02%	0.02%	0.52%	0.52%
Total	100.00%	100.00%	100.00%	100.00%

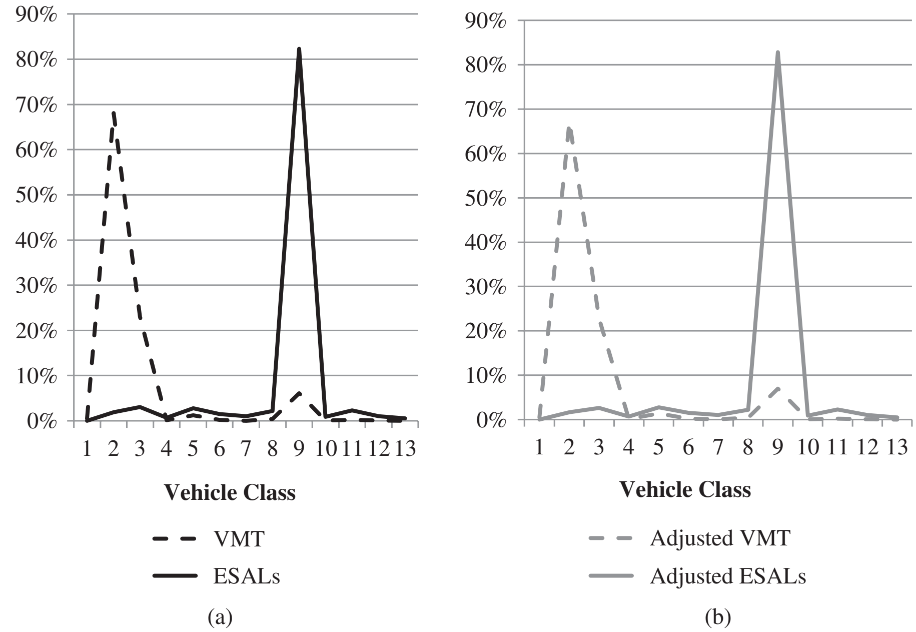


Figure 3.1.17 Comparison between VMT/adjusted VMT and ESAL/adjusted ESAL distributions—example of methodology.

The remaining part of the pavement forms the remaining facility expenditures. The base facility expenditures were attributed on the basis of the adjusted (for vehicle width) VMT distribution, apart from the shoulder expenditures that were attributed on the basis of PCE-miles. The remaining facility expenditures were attributed on the basis of the adjusted (for vehicle width) ESAL distribution. The total cost responsibility for the base and the remaining facility and the unit cost for the analysis period for Interstates are presented in Table 3.1.25. The cost responsibility for the 13 vehicle classes is presented in Figures 3.1.19 and 3.1.20 for flexible and rigid pavement construction, respectively.

Comparing Figures 3.1.19 and 3.1.20, it can be seen that most of the new Interstate pavements constructed are rigid pavements. As expected, the highest cost responsibility for the base facility was attributed to automobiles (vehicle class 2), while vehicle class 9 was responsible for the largest portion of the remaining facility expenditures. The total unit cost per vehicle class for the new pavement construction expenditures (flexible and rigid) throughout the analysis period is presented in Figure 3.1.21. As shown in Figure 3.1.21, vehicle class 7 had the highest unit cost, followed by vehicle class 13. The results indicate that although the cost responsibility of these two classes was low (because there are relatively few of these vehicles in the traffic stream), their impact on pavement consumption was high.

The total cost responsibility for the base and the remaining facility and the unit cost for the analysis period for Non-Interstate NHS are presented in Table 3.1.26. The

TABLE 3.1.20
Pavement-Related Expenditures—Example of Methodology.

Pavement-Related Expenditure Category	Expenditure Item	Expenditure [$ 2009]
Rigid Items	QC/QA PCCP, 13 IN	$9,441,965
	PCCP Joints	$1,588,603
	PCC Sealers	$180,952
	Reinforcing Steel	$186,457
	Subbase	$2,652,006
	Other PCCP Items	$88,059
	Total	$14,138,042
Flexible Items	Milling	$34,791
	HMA Pavement	$350,963
	Tack Coat	$8,118
	Total	$393,872
Total Cost		$14,531,915

TABLE 3.1.21
Input Information to the AASHTO (1993) Rigid Pavement Design (Equation 3.1.5)—Example of Methodology.

Variable Symbol	Variable Description	Value
D	Concrete slab thickness (in inches)	13
p_o	PSI for typical new road	4.5
p_t	PSI in terminal condition for major highways	2.5
J	Load transfer coefficient	3.2
Z_R	Standard normal deviate	-1.645
S_o	Standard error of traffic prediction and performance prediction	0.35
S'_c	Estimated mean value for PCC modulus of rupture (in psi)	700
C_d	Drainage coefficient	1
E_c	PCC elastic modulus (in psi)	4,000,000
k	Effective modulus of subgrade reaction	250

TABLE 3.1.22
Pavement-Related Cost Responsibility for the Rigid Items of the Base Facility—Example of Methodology

Vehicle Classes	Adjusted VMT [%]	Cost Responsibility [$ 2009]
1	0.46%	$25,245
2	67.16%	$3,652,088
3	22.77%	$1,238,022
4	0.13%	$6,875
5	1.40%	$76,276
6	0.23%	$12,670
7	0.04%	$2,026
8	0.43%	$23,431
9	6.99%	$380,212
10	0.07%	$3,700
11	0.21%	$11,628
12	0.08%	$4,392
13	0.02%	$1,146
Total		$5,437,709

cost responsibility for the 13 vehicle classes is presented in Figures 3.1.22 and 3.1.23 for construction of flexible and rigid pavements, respectively, on non-Interstate NHS.

Comparing Figures 3.1.22 and 3.1.23, it can be seen that the majority of new pavement construction on non-Interstate NHS routes involved the construction of flexible pavements, however, the difference between rigid and flexible pavement construction was smaller than that observed for Interstates. Also, the remaining facility expenditures were lower for the non-Interstate NHS compared to Interstates. The highest cost responsibility for the base facility was attributed to automobiles (vehicle class 2) while vehicle class 9 was responsible for the largest portion of the remaining facility expenditures. The unit cost per vehicle class for the new pavement construction expenditures on non-Interstate NHS highways throughout the analysis period is presented in Figure 3.1.24.

TABLE 3.1.23
Process of Estimating the Updated and Adjusted (for Vehicle Width) Distribution of ESAL Contribution—Example of Methodology.

Vehicle Classes	ESAL Distribution	Total ESALs (for the Entire Facility)	ESALs Provided by Base Facility	ESALs Provided by Remaining Facility	Updated ESAL Distribution	Updated Adjusted ESAL Distribution
1	0.00003%	22	22	—	0.00%	0.00%
2	1.88%	1,235,171	196,305	1,038,866	1.59%	1.38%
3	3.02%	1,981,559	66,546	1,915,014	2.93%	2.54%
4	0.69%	450,681	370	450,312	0.69%	0.69%
5	2.75%	1,804,139	4,100	1,800,039	2.75%	2.77%
6	1.49%	978,367	681	977,686	1.50%	1.50%
7	1.01%	665,378	109	665,269	1.02%	1.02%
8	2.19%	1,437,697	1,259	1,436,438	2.20%	2.21%
9	82.30%	54,045,383	20,437	54,024,946	82.63%	83.15%
10	0.89%	581,337	199	581,138	0.89%	0.89%
11	2.28%	1,495,921	625	1,495,296	2.29%	2.30%
12	1.00%	655,787	236	655,551	1.00%	1.01%
13	0.52%	339,486	62	339,424	0.52%	0.52%
Total	100%	65,670,929	290,950	65,379,979	100%	100%

TABLE 3.1.24
Pavement-Related Cost Responsibility for the Rigid Items of the Remaining Facility—Example of Methodology.

Vehicle Classes	Updated Adjusted ESAL Distribution	Cost Responsibility [$ 2009]
1	0.00%	—
2	1.38%	$119,924
3	2.54%	$221,065
4	0.69%	$60,300
5	2.77%	$241,039
6	1.50%	$130,920
7	1.02%	$89,085
8	2.21%	$192,350
9	83.15%	$7,234,364
10	0.89%	$77,819
11	2.30%	$200,232
12	1.01%	$87,783
13	0.52%	$45,452
Total	100.00%	$8,700,334

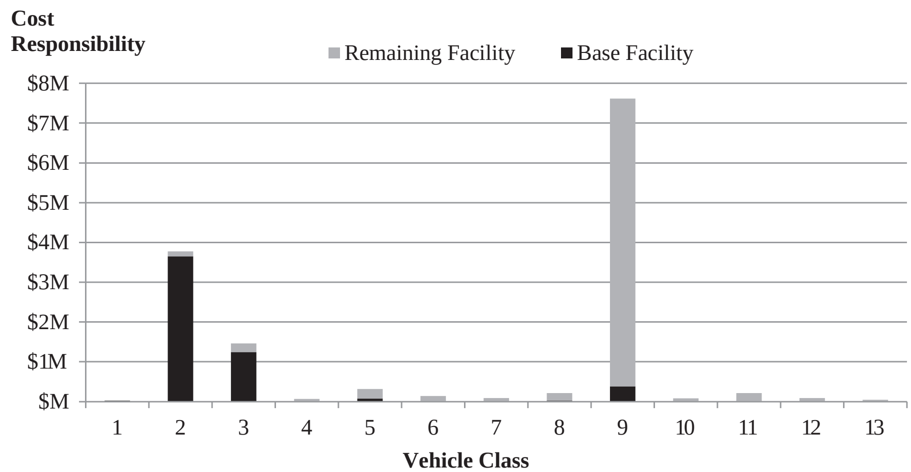


Figure 3.1.18 Cost responsibility of the rigid items of the base and the remaining facility for each vehicle class—methodology illustration example.

TABLE 3.1.25
Cost Responsibility and Unit Cost for New Pavement Construction on Interstates, 2009–2012.

	Cost Responsibility for the Years 2009–2012			
Vehicle Classes	**Base Facility**	**Remaining Facility**	**Total**	**Unit Cost [$/VMT]**
1	$740,808	$0	$740,808	$0.0029
2	$107,169,982	$327,610	$107,497,592	$0.0029
3	$36,329,578	$1,003,733	$37,333,311	$0.0030
4	$732,510	$753,185	$1,485,695	$0.0072
5	$8,130,098	$3,144,461	$11,274,558	$0.0049
6	$1,350,468	$1,500,055	$2,850,523	$0.0075
7	$215,913	$999,739	$1,215,652	$0.0201
8	$2,256,181	$1,743,561	$3,999,741	$0.0059
9	$38,018,035	$67,342,864	$105,360,899	$0.0097
10	$356,314	$605,858	$962,172	$0.0090
11	$1,119,634	$1,847,879	$2,967,513	$0.0089
12	$422,934	$744,278	$1,167,212	$0.0092
13	$110,302	$351,305	$461,607	$0.0140
Total	$196,952,756	$80,364,527	$277,317,283	

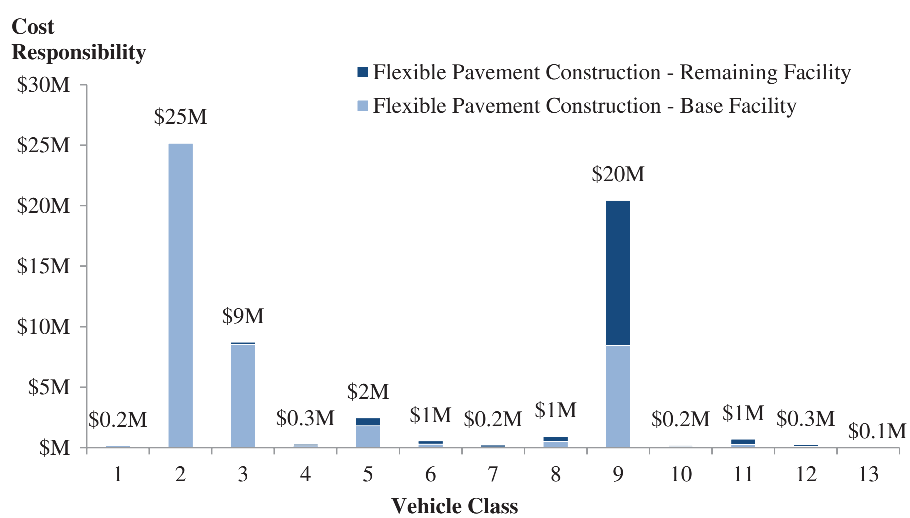


Figure 3.1.19 Total vehicle class cost responsibility for new flexible pavement construction on Interstates, 2009–2012.

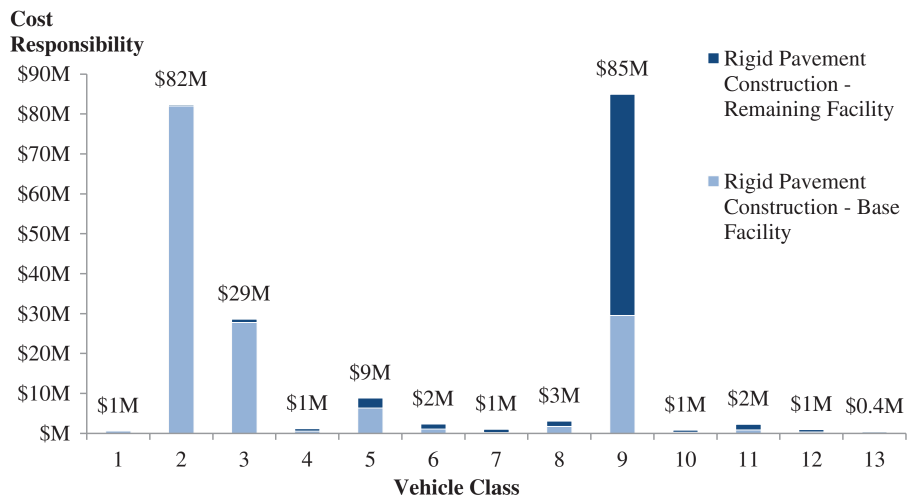


Figure 3.1.20 Total vehicle class cost responsibility for new rigid pavement construction on Interstates, 2009–2012.

Comparing Figures 3.1.21 and 3.1.24, it can be seen that although the shapes of the two unit cost distributions of the different classes are similar, the unit cost values were nearly double that of each vehicle class. This difference was due to the higher VMT of the Interstate network because the costs were shared by a greater number of vehicles and therefore the cost per VMT was lower.

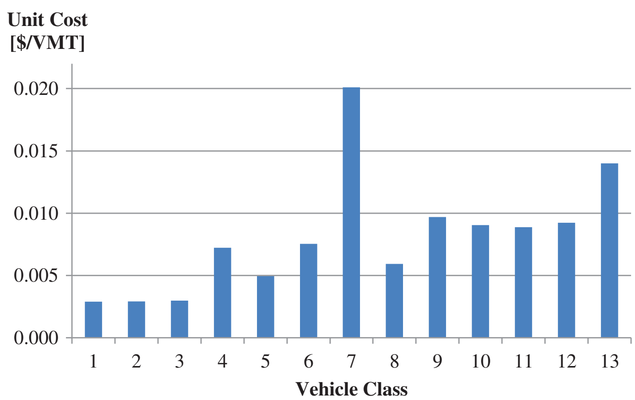


Figure 3.1.21 Average unit cost for new pavement construction on Interstates, 2009–2012.

The total cost responsibility for the base and the remaining facility and the unit cost for the analysis period for Non-NHS highway pavements are presented in Table 3.1.27. Also, the cost responsibilities of the 13 vehicle classes are presented in Figures 3.1.25 and 3.1.26 for flexible and rigid pavement construction, respectively.

Comparing Figures 3.1.25 and 3.1.26, it can be seen that the majority of new pavement construction on non-NHS routes involved the construction of flexible pavements. Similar to the other two functional classes examined, the highest cost responsibility for the base facility was attributed to automobiles (vehicle class 2) as this was the class with the highest VMT, while vehicle class 9 was responsible for the largest part of the remaining facility expenditures. The unit cost per vehicle class for the new pavement construction expenditures on non-NHS routes throughout the analysis period is presented in Figure 3.1.27.

TABLE 3.1.26
Cost Responsibility and Unit Cost for New Pavement Construction on Non-Interstate NHS, 2009–2012.

Vehicle Classes	Cost Responsibility for the Years 2009–2012			Unit Cost [$/VMT]
	Base Facility	Remaining Facility	Total	
1	$1,505,615	$0	$1,505,615	$0.0047
2	$160,580,406	$2,173,246	$162,753,652	$0.0047
3	$62,015,936	$5,301,756	$67,317,692	$0.0051
4	$782,950	$1,447,353	$2,230,303	$0.0139
5	$9,438,433	$7,154,515	$16,592,947	$0.0086
6	$1,943,109	$3,632,308	$5,575,417	$0.0141
7	$601,010	$4,558,990	$5,160,000	$0.0422
8	$2,595,746	$3,988,300	$6,584,047	$0.0118
9	$18,183,778	$50,010,615	$68,194,393	$0.0184
10	$383,763	$1,079,068	$1,462,831	$0.0178
11	$402,972	$1,308,820	$1,711,791	$0.0198
12	$101,343	$320,778	$422,122	$0.0195
13	$114,003	$599,404	$713,407	$0.0292
Total	$258,649,063	$81,575,152	$340,224,215	—

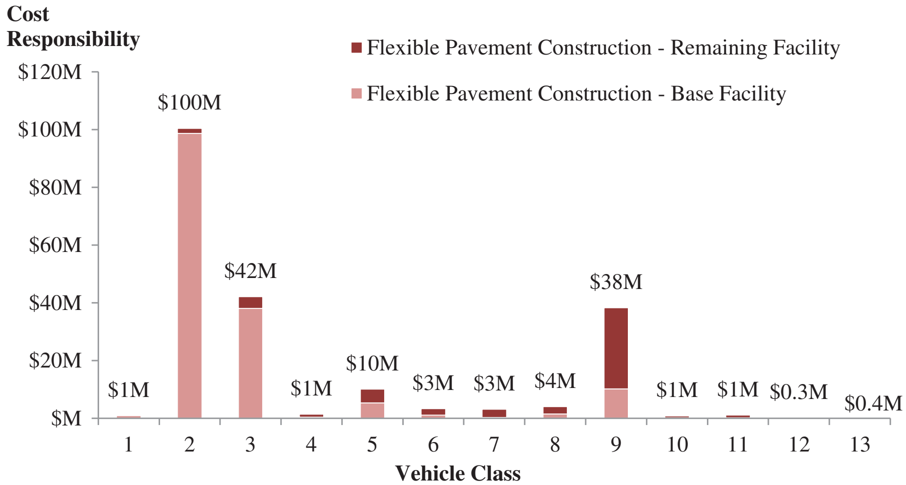


Figure 3.1.22 Total vehicle class cost responsibility for new flexible pavement construction on Non-Interstate NHS, 2009–2012.

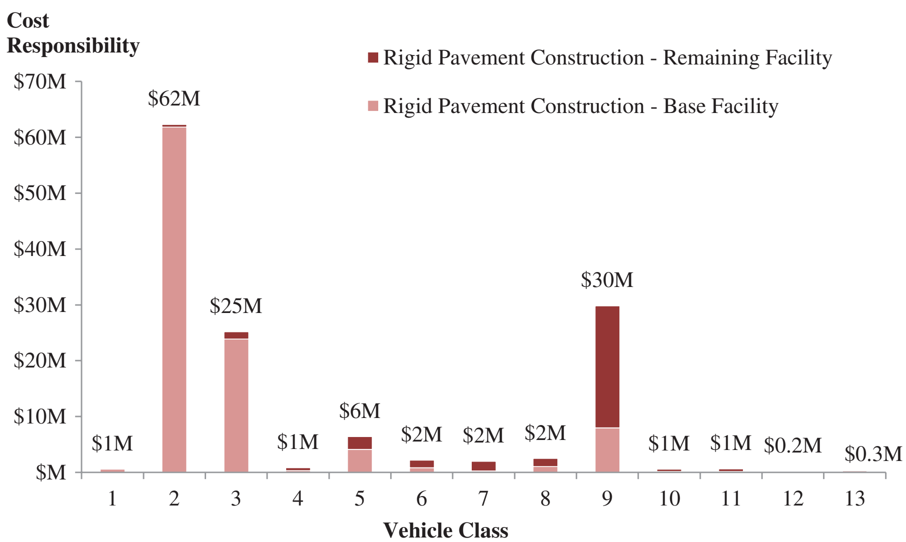


Figure 3.1.23 Total vehicle class cost responsibility for new rigid pavement construction on Non-Interstate NHS, 2009–2012.

Comparing the unit costs for the different functional classes, it can be observed that the lowest unit costs appear for the Interstates, while the highest unit costs appear for the Non-NHS. This difference occurs partially because for the non-NHS, the expenditures were shared among fewer vehicles compared to the Interstates and therefore, the cost per VMT was higher.

1.3.2 Pavement Rehabilitation Expenditures Analysis and Results

This section discusses the analysis and results of pavement rehabilitation cost allocation for state highways. The results presented here are for the entire analysis period (2009–2012) while the detailed results by year and functional class can be found in Addendum B.

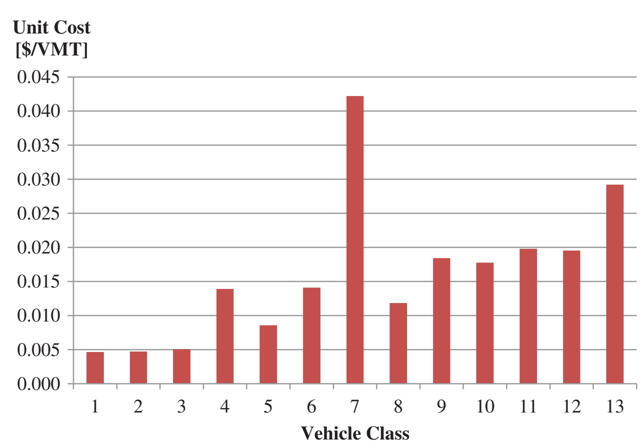


Figure 3.1.24 Average unit cost for new pavement construction on Non-Interstate NHS routes, 2009–2012.

TABLE 3.1.27
Cost Responsibility and Unit Cost for New Pavement Construction on Non-NHS, 2009–2012.

Vehicle Classes	Cost Responsibility for the Years 2009–2012			Unit Cost [$/VMT]
	Base Facility	Remaining Facility	Total	
1	$1,052,816	$0	$1,052,816	$0.0054
2	$116,332,516	$1,597,591	$117,930,106	$0.0055
3	$49,529,515	$4,196,479	$53,725,994	$0.0058
4	$244,816	$641,051	$885,867	$0.0202
5	$4,236,252	$4,017,954	$8,254,205	$0.0104
6	$2,983,643	$5,879,727	$8,863,370	$0.0150
7	$1,023,397	$8,128,827	$9,152,225	$0.0448
8	$1,775,934	$3,683,344	$5,459,279	$0.0163
9	$9,188,962	$32,339,595	$41,528,557	$0.0250
10	$251,816	$1,001,599	$1,253,415	$0.0265
11	$79,041	$618,308	$697,349	$0.0722
12	$27,714	$195,770	$223,484	$0.0653
13	$83,319	$606,998	$690,317	$0.0439
Total	$186,809,742	$62,907,243	$249,716,985	—

As explained in Section 1.1.2 of this Part of the report, pavement preservation is necessary because of the pavement damage due to traffic and pavement damage due to climatic conditions and other non-load factors. For this reason, in pavement rehabilitation cost allocation, a portion of the pavement-related expenditures is attributed to load-related factors (traffic). The remaining portion is attributed to non-load-related factors (for example, weather and climatic conditions) and for this reason is attributed to all vehicles on the basis of VMT.

As mentioned in Section 1.1.2 in this Part of the report, the load-related expenditure percentages (load shares) presented in the 1997 FHWA HCAS were adopted in the present study and were used to estimate the load-related and non-load-related pavement, grading, and earthwork expenditures. The portion of the pavement-related expenditures attributed to non-load-related factors was allocated on the basis of VMT. On the other hand, the portion of the previously-mentioned expenditures attributed to load-related factors was allocated using the distress-based NAPCOM that was introduced for the first time by FHWA (1997). The distress data required as input by NAPCOM were not available from INDOT for the projects analyzed in the present study; therefore, the average parameters included in the FHWA software package developed for State HCASs were used. Grading and earthwork expenditures were allocated on the basis of VMT while shoulder expenditures are allocated on the basis of PCE-miles and are considered part of the non-load-related expenditures.

The total cost responsibility for the non-load and load-related expenditures and the unit cost for the analysis period for Interstates are presented in Table 3.1.28. Also, the cost responsibility for the 13 vehicle classes is presented in Figures 3.1.28 and 3.1.29 for flexible and rigid pavement rehabilitation contracts, respectively.

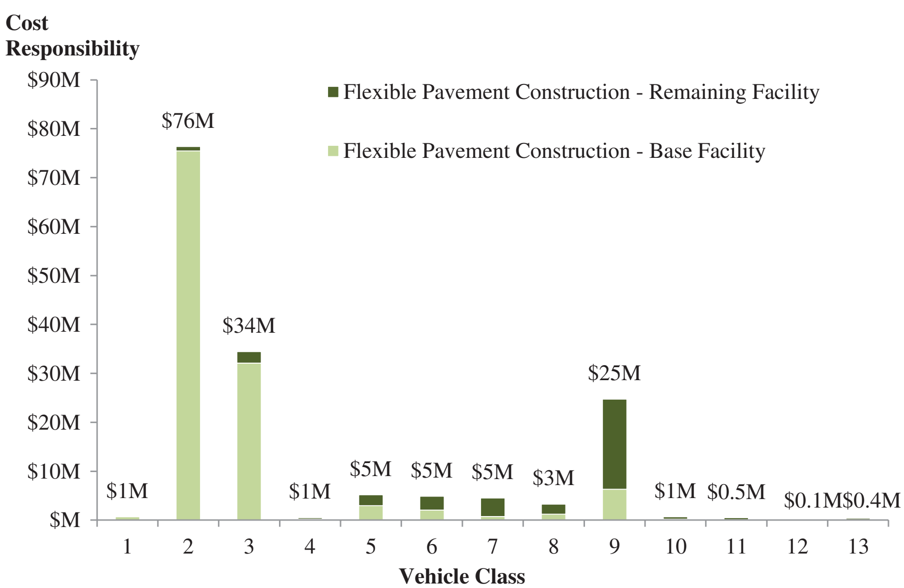


Figure 3.1.25 Total vehicle class cost responsibility for new flexible pavement construction on Non-NHS, 2009–2012.

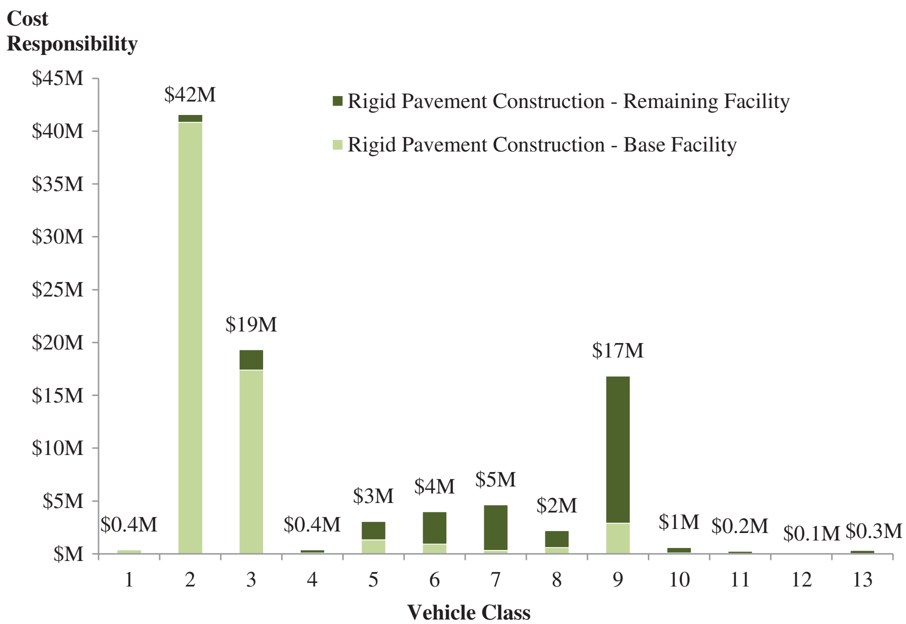


Figure 3.1.26 Total vehicle class cost responsibility for new rigid pavement construction on Non-NHS, 2009–2012.

Comparing Figures 3.1.28 and 3.1.29, it can be seen that most rehabilitation contracts on Interstates involve flexible rehabilitation expenditures. It should be noted here that the terms "flexible" and "rigid" refer to the type of rehabilitation and dominant material type used for each contract and not to the underlying pavement. Automobiles (vehicle class 2) had the highest cost responsibility for the non-load-related expenditures, while vehicle class 9 was responsible for the largest portion of the load-related expenditures. The unit cost per vehicle class for the pavement rehabilitation expenditures on Interstates throughout the analysis period is presented in Figure 3.1.30.

As shown in Figure 3.1.30, vehicle classes 7 and 13 had the highest unit cost, followed by vehicle class 9. It can be seen that although the cost responsibility of classes 7 and 13 was among the lowest (because there are relatively few of these vehicles in the traffic stream), their impact on pavement consumption was relatively high.

The total cost responsibility for the non-load and load-related expenditures and the unit cost for the analysis period for non-Interstate NHS routes are presented in Table 3.1.29. The cost responsibility for each vehicle class is presented in Figures 3.1.31 and 3.1.32 for flexible and rigid rehabilitation contracts on non-Interstate NHS routes, respectively.

It can be seen that flexible rehabilitation expenditures constitute the majority of pavement rehabilitation expenditures on non-Interstate NHS routes. In both figures, vehicle class 2 had the highest cost responsibility for the non-load-related expenditures while vehicle class 9 was responsible for the largest portion of the load-related expenditures. The unit cost per vehicle class for the total pavement rehabilitation expenditures on non-Interstate NHS routes throughout the analysis period, is presented in Figure 3.1.33.

The total cost responsibility for the non-load and load-related expenditures and the unit cost for the analysis period for Non-NHS routes are presented in Table 3.1.30. Also, the cost responsibility per vehicle class is presented in Figures 3.1.34 and 3.1.35 for flexible and rigid rehabilitation contracts, respectively.

Similar to Interstate and non-Interstate NHS highway pavements, the majority of rehabilitation expenditures on non-NHS involved flexible rehabilitation contracts. Also, similar to the other two functional classes examined, the highest cost responsibility for the non-load-related expenditures was attributed to automobiles (vehicle class 2) as this was the class with the highest VMT while vehicle class 9 was responsible for the largest part of the load-related expenditures. The unit cost per vehicle class for the pavement rehabilitation expenditures on non-NHS routes throughout the analysis period is presented in Figure 3.1.36.

It can be seen that Interstates had the lowest unit costs while the non-NHS routes had the highest unit costs.

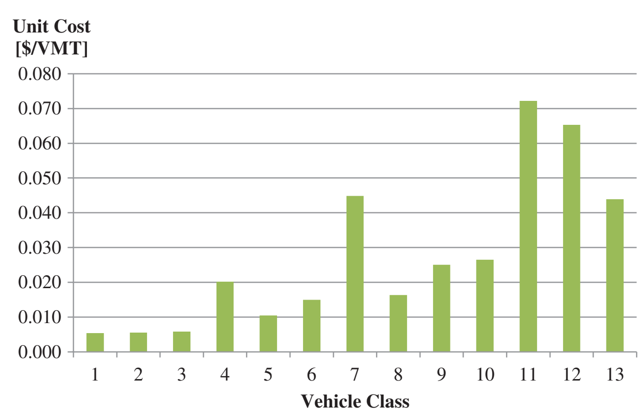


Figure 3.1.27 Average unit cost for new pavement construction on Non-NHS, 2009–2012.

TABLE 3.1.28
Cost Responsibility and Unit Cost for Pavement Rehabilitation on Interstates, 2009–2012.

	Cost Responsibility for the Years 2009–2012			
Vehicle Classes	Non-Load-Related Expenditures	Load-Related Expenditures	Total	Unit Cost [$/VMT]
1	$61,895	$43,429	$105,324	$0.0004
2	$8,954,097	$6,282,743	$15,236,840	$0.0004
3	$3,035,351	$2,295,226	$5,330,578	$0.0004
4	$48,596	$417,275	$465,871	$0.0023
5	$542,616	$1,565,303	$2,107,919	$0.0009
6	$90,132	$1,458,388	$1,548,520	$0.0041
7	$14,410	$802,918	$817,329	$0.0135
8	$156,968	$2,349,147	$2,506,115	$0.0037
9	$2,528,527	$97,714,518	$100,243,045	$0.0092
10	$24,790	$885,793	$910,583	$0.0086
11	$77,896	$2,490,293	$2,568,189	$0.0077
12	$29,425	$779,678	$809,103	$0.0064
13	$7,674	$440,321	$447,995	$0.0136
Total	$15,572,377	$117,525,034	$133,097,410	

This result can be explained partially by the fact that, for the non-NHS routes, the expenditures were shared among fewer vehicles and therefore, the cost per VMT was higher compared to Interstates. The same observation was made for the unit costs of new pavement construction expenditures.

1.3.3 Other Pavement Contract Expenditures Analysis and Results

As explained in Section 1.1.4, pavement expenditures related to roadside work and facilities, demolition, intelligent transportation systems, slide correction, and drainage ditch correction contracts were all grouped into the "Other Pavement Project Expenditures" category. These pavement expenditures are considered a common cost and attributed to all vehicle classes on the basis of VMT. Table 3.1.31 the total cost responsibility and the unit costs per vehicle class for the other pavement contract expenditures and the three functional classes examined.

As these expenditures are treated as common costs, the unit cost was the same for all vehicle classes under the same functional class. The detailed results for each year and functional class are presented in Addendum B.

1.3.4 Pavement In-House Maintenance Expenditures Analysis and Results

This section discusses the analysis and results of pavement in-house maintenance cost allocation for state routes for the entire analysis period (2009–2012). The detailed results are presented in Addendum B of this report.

Similar to pavement rehabilitation cost allocation, a portion of the in-house pavement-related expenditures

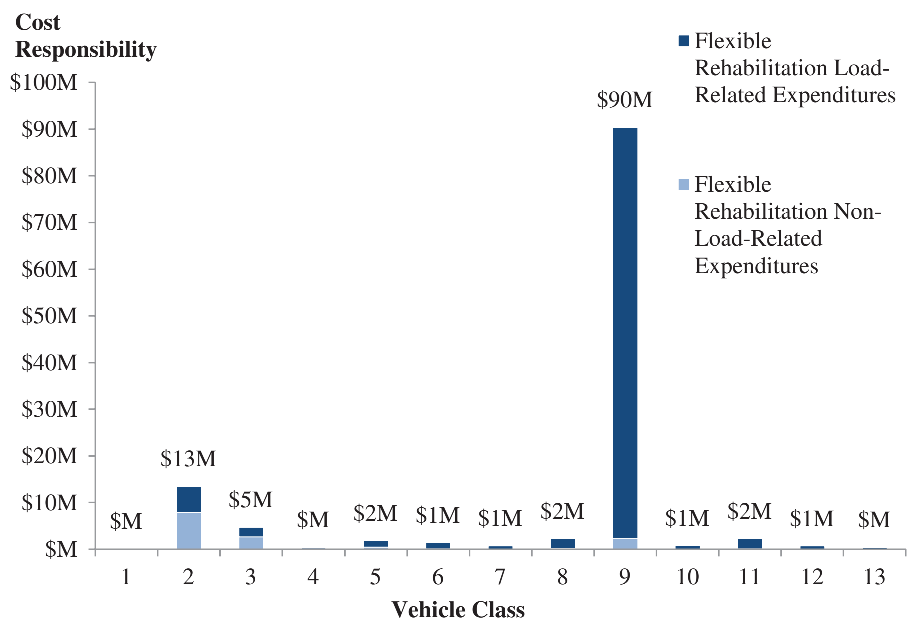


Figure 3.1.28 Total vehicle class cost responsibility for flexible pavement rehabilitation on Interstates, 2009–2012.

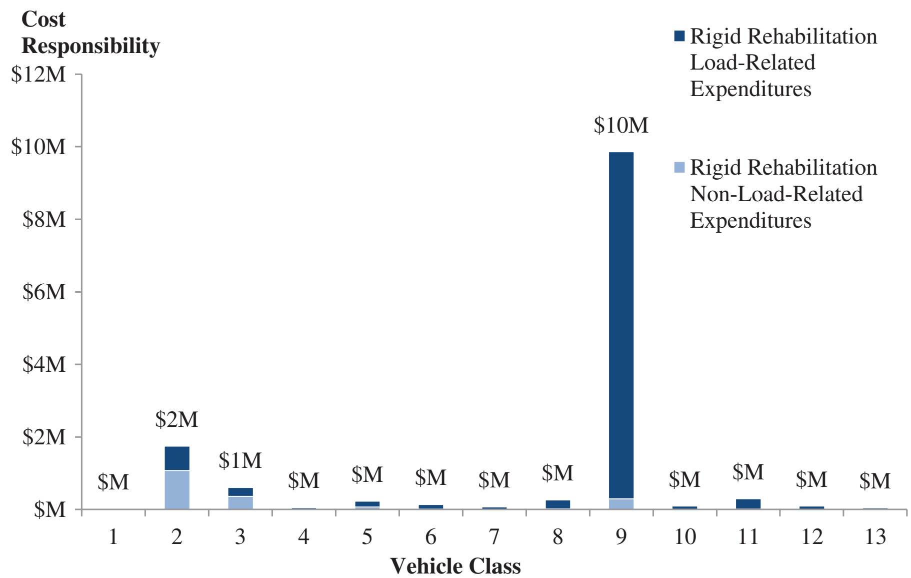


Figure 3.1.29 Total vehicle class cost responsibility for rigid pavement rehabilitation on Interstates, 2009–2012.

are attributable to load-related factors (traffic volume, vehicle class distribution, and vehicle weight distribution) while the remaining portion is attributable to non-load-related factors (weather and climatic conditions, primarily). The load-related expenditure percentages (load shares) estimated by the 1984 Indiana HCAS were adopted by the present study and were used to estimate the load-related and non-load-related pavement.

For many of the pavement in-house maintenance activities found in the INDOT In-House Maintenance Database, it could not be identified whether the activities were carried out on a flexible/composite or rigid pavement. In those cases, the percentage of flexible rehabilitation activities from the Site Manager Database was used as a proxy to develop an estimate of the percentage of the in-house flexible pavement maintenance activities.

The portion of the pavement-related expenditures attributed to non-load-related factors was treated as a common cost and therefore was allocated on the basis of VMT. Based on the suggestions incorporated in the FHWA software package developed for State HCASs, the load-related portion of the expenses was attributed on the basis of LEF or ESAL-miles. The present study attributed the load-related expenses on the basis of ESAL-miles because ESALs take into account the vehicle class distribution as well as the LEF for each vehicle class. Similar to the new pavement construction and pavement rehabilitation methodologies, the allocation of shoulder expenditures was conducted on the basis of PCE-miles.

The total cost responsibility for the non-load and load-related expenditures and the unit cost for the analysis period for the Interstate, non-Interstate NHS, and non-NHS routes are presented in Tables 3.1.32., 3.1.33 and 3.1.34, respectively.

The total cost responsibility of each vehicle class for the Interstate, non-Interstate NHS, and non-NHS routes is presented in Figures 3.1.37, 3.1.38 and 3.1.39, respectively.

As expected, vehicle class 2 was responsible for the highest percentage of the non-load-related expenditures while class 9 was found to be responsible for the majority of the load-related expenditures. The average unit costs per vehicle class for pavement in-house maintenance expenditures for Interstates, non-Interstate NHS and non-NHS routes are presented in Figures 3.1.40, 3.1.41 and 3.1.42, respectively.

The unit cost distributions presented in Figures 3.1.40, 3.1.41, and 3.1.42 appear similar. However, focusing on the unit cost of a single vehicle class across the different functional classes, it can be seen that the unit cost differed significantly by functional class. It is reasonable to conclude that the variation in the unit costs was due to the combined effect of the variations in expenditures and VMT across the different functional classes. Last but not least, vehicles in classes 7 and 13 appear to have the two

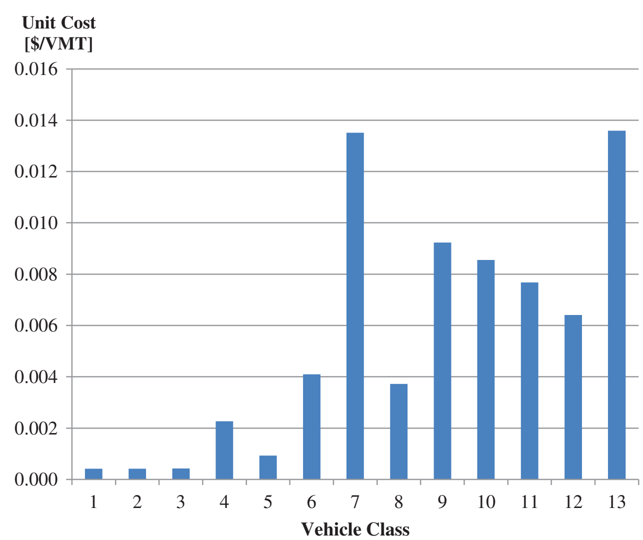


Figure 3.1.30 Average unit cost for pavement rehabilitation, 2009–2012, Interstates.

TABLE 3.1.29
Cost Responsibility and Unit Cost for Pavement Rehabilitation on Non-Interstate NHS, 2009–2012.

Vehicle Classes	Cost Responsibility for the Years 2009–2012 Non-Load-Related Expenditures	Load-Related Expenditures	Total	Unit Cost [$/VMT]
1	$195,757	$170,159	$365,916	$0.0011
2	$20,858,113	$18,130,606	$38,988,718	$0.0011
3	$8,053,033	$7,488,180	$15,541,213	$0.0012
4	$97,126	$832,620	$929,746	$0.0058
5	$1,170,112	$3,161,470	$4,331,582	$0.0022
6	$239,382	$4,261,328	$4,500,710	$0.0114
7	$74,036	$4,633,537	$4,707,572	$0.0385
8	$339,991	$4,375,920	$4,715,911	$0.0085
9	$2,201,690	$91,003,429	$93,205,119	$0.0252
10	$50,273	$1,841,033	$1,891,306	$0.0230
11	$52,776	$1,462,119	$1,514,895	$0.0175
12	$13,204	$309,894	$323,097	$0.0149
13	$14,919	$875,774	$890,694	$0.0364
Total	$33,360,411	$138,546,068	$171,906,480	

highest unit costs, which means that they caused the greatest damage, individually, to the pavement; this observation is consistent across the functional classes.

1.3.5 Total Pavement Cost Allocation Results

The pavement cost allocation analysis for state routes is herein summarized with the presentation of the total cost responsibility and average unit cost results for pavement new construction, rehabilitation, maintenance, and other projects for 2009–2012. Figures 3.1.43, 3.1.44, and 3.1.45 present the cost responsibility per vehicle class for the total pavement expenditures on Interstate, Non-Interstate NHS, and non-NHS routes, respectively, over the 2009–2012 period.

Overall, vehicle class 2 had the highest total cost responsibility with respect to pavement expenditures on state highways. Among the truck classes, vehicle class 9 had the highest cost responsibility due to its high load and VMT compared to the remaining truck classes. The cost responsibility distributions varied among the different route types. This variation reflects not only the variation in VMT distributions but also the differences in pavement design across the three different functional classes.

The average unit cost per vehicle class for the total pavement expenditures on Interstates, Non-Interstate NHS, and non-NHS routes are presented in Figures 3.1.46, 3.1.47, and 3.1.48, respectively.

The average annual unit cost reflects the pavement consumption that was incurred by each vehicle class. For example, for vehicle class 7, an average unit cost of $0.14 per VMT implies that an average class 7 vehicle traveling one mile on a given route type consumes $0.14 that reflects its share of the money spent on pavement construction, rehabilitation, maintenance,

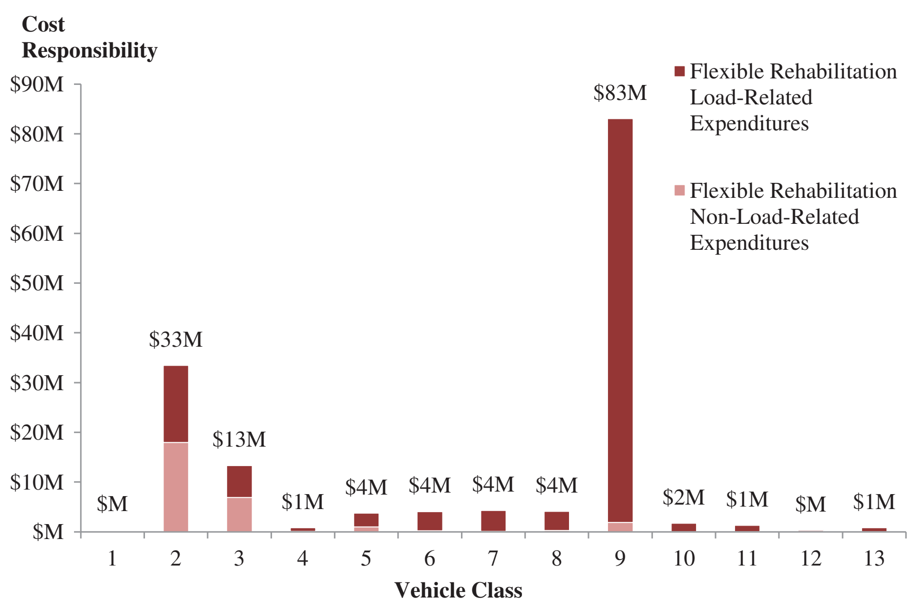


Figure 3.1.31 Total vehicle class cost responsibility for flexible rehabilitation on Non-Interstate NHS pavements, 2009–2012.

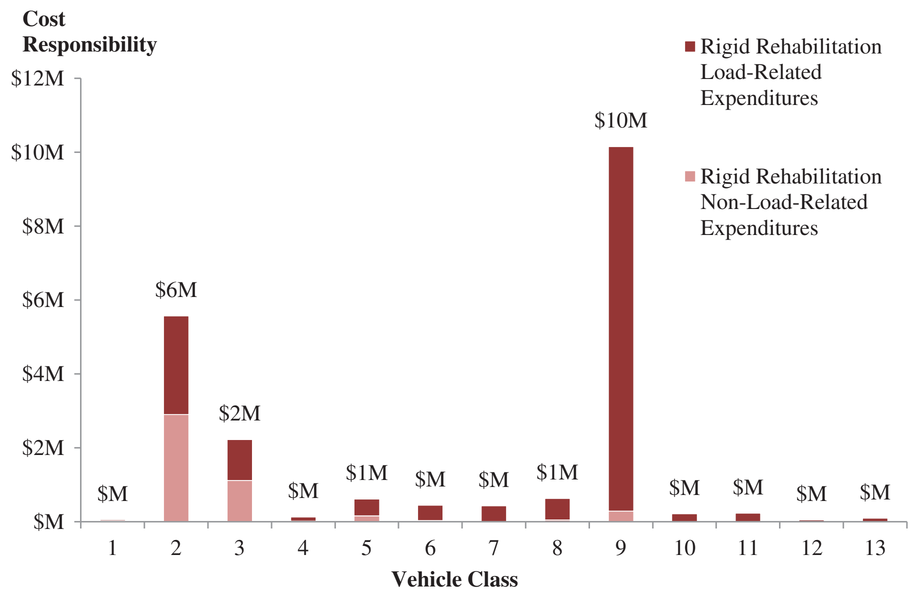


Figure 3.1.32 Total vehicle class cost responsibility for rigid rehabilitation on Non-Interstate NHS pavements, 2009–2012.

and other projects that take place on that specific route type. Vehicle class 7 was found to have the highest unit cost for Interstate and non-Interstate NHS while vehicle class 11 had the highest unit cost for non-NHS. Vehicle classes 1–3 consistently had the lowest average annual unit costs.

Table 3.1.35 shows the cost responsibility of each vehicle class by project type for all state routes. Also, Figure 3.1.49 presents the average unit cost for all pavement expenditures on state routes.

1.4 Chapter Summary

This chapter discussed the pavement cost allocation methodology, data, analysis, and results related to new construction, rehabilitation, maintenance, and other expenditures on Indiana state routes. The data was collected for the years 2009–2012. The methodology was presented and explained for the different expenditure types in Section 1.1 of this Part of the report. For new pavement construction, the methodology developed by the 1997 and 2000 FHWA HCAS was adopted and the analysis was conducted on a project-by-project basis. The base facility expenditures were attributed to vehicle classes on the basis of the VMT adjusted for vehicle width while the expenditures on the remaining facility were attributed on the basis of ESAL-miles adjusted for vehicle width. Regarding the allocation of rehabilitation expenditures, a portion of the expenditures that was related to damage by non-load factors was attributed based on VMT; and the remaining expenditures were attributed using the FHWA's distress-based model (NAPCOM). A load and non-load split was also used for the allocation of pavement maintenance expenditures. In Section 1.2 of this Part of the report, the relevant data provided by INDOT were presented and categorized on the basis of the methodology. Section 1.3 of this Part of the report discussed the analysis and presented the total cost responsibilities and average unit costs for each expenditure type and functional class. The detailed results for each year are presented in Addendum B.

Overall, it was determined that the cost responsibility distributions varied among the different functional classes. Vehicle class 2 had the highest cost responsibility with respect to pavement expenditures; of the truck classes, vehicle class 9 was observed to have the highest cost responsibility.

With respect to unit costs, vehicle classes 1–3 consistently had the lowest unit costs while, on average, vehicle class 7 had the highest unit cost for Interstates and non-Interstate NHS routes; vehicle class 11 had the highest unit cost for non-NHS highway pavements.

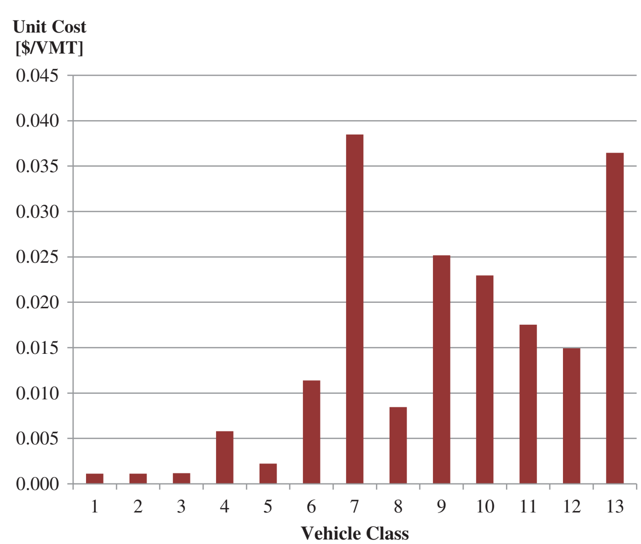


Figure 3.1.33 Average unit cost for pavement rehabilitation, 2009–2012, Non-Interstate NHS.

TABLE 3.1.30
Cost Responsibility and Unit Cost for Pavement Rehabilitation on Non-NHS, 2009–2012.

Vehicle Classes	Cost Responsibility for the Years 2009–2012: Non-Load-Related Expenditures	Load-Related Expenditures	Total	Unit Cost [$/VMT]
1	$162,378	$262,792	$425,171	$0.0022
2	$17,823,004	$28,844,694	$46,667,697	$0.0022
3	$7,673,543	$12,889,493	$20,563,036	$0.0022
4	$35,155	$333,154	$368,309	$0.0084
5	$634,388	$1,996,021	$2,630,409	$0.0033
6	$474,179	$10,089,417	$10,563,596	$0.0178
7	$163,579	$12,362,065	$12,525,644	$0.0613
8	$278,938	$4,820,049	$5,098,987	$0.0152
9	$1,425,255	$74,983,157	$76,408,412	$0.0461
10	$39,378	$1,776,640	$1,816,017	$0.0384
11	$8,041	$246,746	$254,787	$0.0264
12	$2,849	$73,725	$76,574	$0.0224
13	$13,097	$962,195	$975,292	$0.0620
Total	$28,733,783	$149,640,146	$178,373,930	

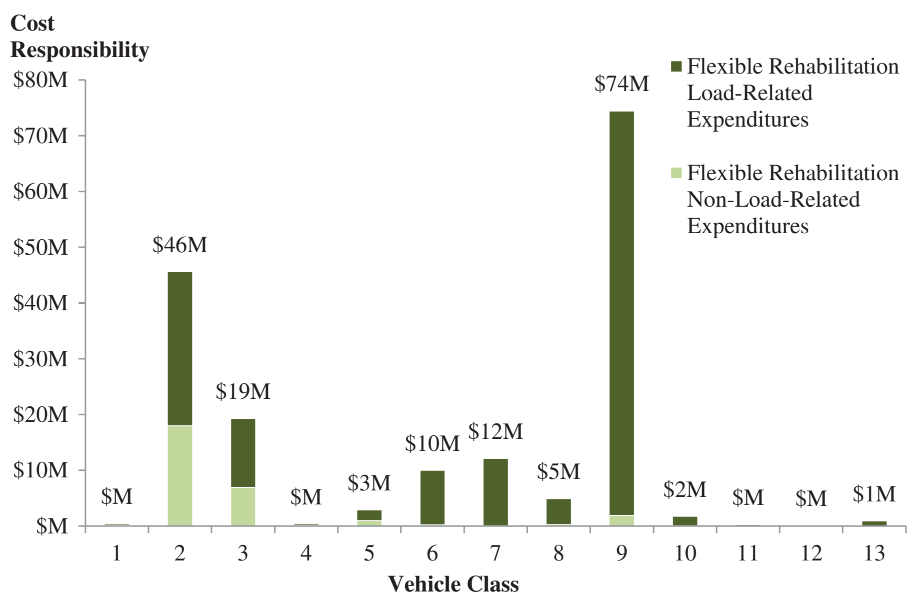


Figure 3.1.34 Total vehicle class cost responsibility for flexible rehabilitation on Non-NHS pavements, 2009–2012.

Figure 3.1.35 Total vehicle class cost responsibility for rigid rehabilitation on Non-NHS pavements, 2009–2012.

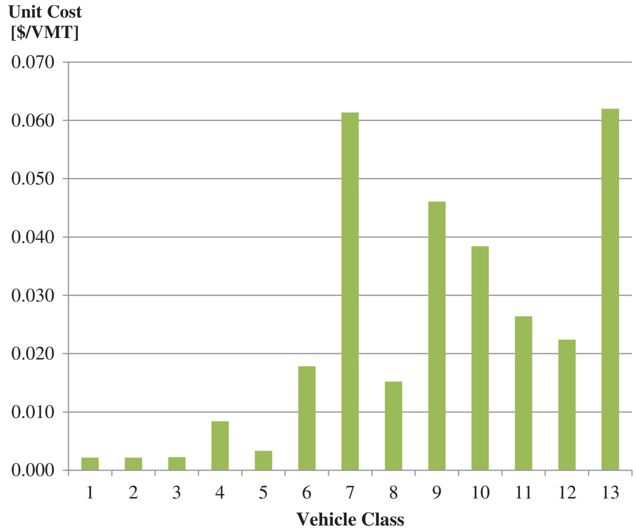


Figure 3.1.36 Average unit cost for pavement rehabilitation, 2009–2012, Non-NHS.

TABLE 3.1.31
Cost Responsibility and Unit Cost for Other Pavement Contract Expenditures for the Years 2009–2012, All Route Types.

	Interstates		Non-Interstate NHS Routes		Non-NHS Routes	
Vehicle Class	Cost Responsibility	Unit Cost [$/VMT]	Cost Responsibility	Unit Cost [$/VMT]	Cost Responsibility	Unit Cost [$/VMT]
1	$268,595	$0.0011	$154,911	$0.0005	$267,533	$0.0014
2	$38,856,640	$0.0011	$16,505,937	$0.0005	$29,365,035	$0.0014
3	$13,172,022	$0.0011	$6,372,717	$0.0005	$12,642,867	$0.0014
4	$231,341	$0.0011	$76,685	$0.0005	$57,168	$0.0013
5	$2,566,703	$0.0011	$923,849	$0.0005	$1,031,621	$0.0013
6	$426,348	$0.0011	$189,001	$0.0005	$771,094	$0.0013
7	$68,164	$0.0011	$58,454	$0.0005	$266,007	$0.0013
8	$745,083	$0.0011	$265,561	$0.0005	$454,857	$0.0014
9	$12,232,859	$0.0011	$1,689,992	$0.0005	$2,085,577	$0.0013
10	$117,669	$0.0011	$39,267	$0.0005	$64,212	$0.0014
11	$369,749	$0.0011	$41,222	$0.0005	$13,113	$0.0014
12	$139,670	$0.0011	$10,313	$0.0005	$4,645	$0.0014
13	$36,426	$0.0011	$11,653	$0.0005	$21,357	$0.0014
Total	$69,231,270		$26,339,564		$47,045,086	

TABLE 3.1.32
Cost Responsibility and Unit Cost for Pavement In-House Maintenance on Interstates, 2009–2012.

	Cost Responsibility for the Years 2009–2012			
Vehicle Classes	Non-Load-Related Expenditures	Load-Related Expenditures	Total	Unit Cost [$/VMT]
1	$8,740	$150	$8,890	$0.0000
2	$1,264,447	$21,668	$1,286,114	$0.0000
3	$428,635	$12,103	$440,738	$0.0000
4	$7,697	$37,069	$44,766	$0.0002
5	$94,533	$107,813	$202,346	$0.0001
6	$15,703	$120,862	$136,565	$0.0004
7	$2,511	$79,298	$81,809	$0.0014
8	$28,102	$269,827	$297,929	$0.0004
9	$451,244	$9,547,025	$9,998,269	$0.0009
10	$4,438	$82,931	$87,369	$0.0008
11	$13,946	$324,574	$338,520	$0.0010
12	$5,268	$88,323	$93,590	$0.0007
13	$1,374	$42,156	$43,530	$0.0013
Total	$2,326,637	$10,733,798	$13,060,436	

TABLE 3.1.33
Cost Responsibility and Unit Cost for Pavement In-House Maintenance on Non-Interstate NHS, 2009–2012.

Vehicle Classes	Cost Responsibility for the Years 2009–2012			Unit Cost [$/VMT]
	Non-Load-Related Expenditures	Load-Related Expenditures	Total	
1	$32,493	$1,244	$33,737	$0.0001
2	$3,462,178	$132,542	$3,594,720	$0.0001
3	$1,336,700	$84,388	$1,421,088	$0.0001
4	$28,054	$151,946	$180,000	$0.0011
5	$337,974	$475,244	$813,218	$0.0004
6	$69,143	$662,484	$731,627	$0.0018
7	$21,384	$838,065	$859,450	$0.0070
8	$92,431	$1,034,569	$1,127,000	$0.0020
9	$599,228	$16,438,328	$17,037,556	$0.0046
10	$13,667	$322,902	$336,569	$0.0041
11	$14,348	$417,234	$431,582	$0.0050
12	$3,590	$75,421	$79,011	$0.0037
13	$4,056	$155,873	$159,929	$0.0065
Total	$6,015,245	$20,790,242	$26,805,487	

TABLE 3.1.34
Cost Responsibility and Unit Cost for Pavement In-House Maintenance on Non-NHS, 2009–2012.

Vehicle Classes	Cost Responsibility for the Years 2009–2012			Unit Cost [$/VMT]
	Non-Load-Related Expenditures	Load-Related Expenditures	Total	
1	$87,782	$4,501	$92,283	$0.0005
2	$9,635,188	$494,035	$10,129,223	$0.0005
3	$4,148,349	$350,168	$4,498,516	$0.0005
4	$35,033	$196,225	$231,258	$0.0053
5	$632,192	$912,257	$1,544,449	$0.0019
6	$472,537	$4,500,744	$4,973,281	$0.0084
7	$163,013	$6,267,616	$6,430,628	$0.0315
8	$265,972	$3,783,256	$4,049,227	$0.0121
9	$1,325,082	$40,790,744	$42,115,826	$0.0254
10	$37,547	$931,190	$968,737	$0.0205
11	$7,668	$242,931	$250,598	$0.0259
12	$2,716	$61,806	$64,522	$0.0189
13	$12,488	$504,070	$516,558	$0.0328
Total	$16,825,567	$59,039,541	$75,865,108	

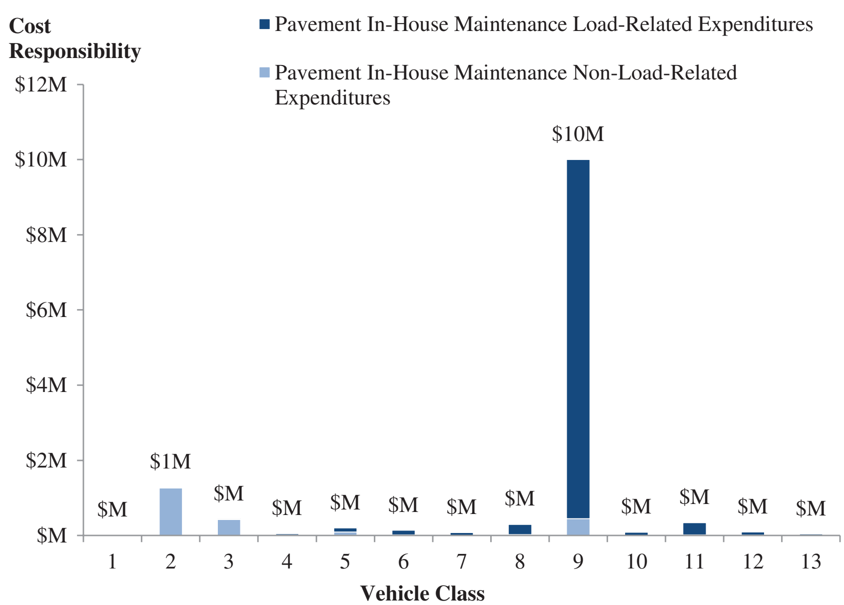


Figure 3.1.37 Total vehicle class cost responsibility for pavement in-house maintenance, 2009–2012, Interstates.

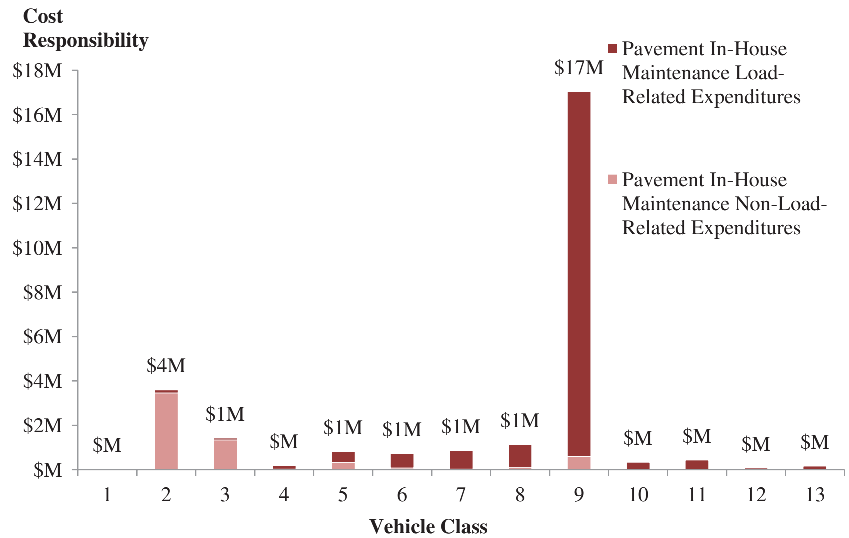


Figure 3.1.38 Total vehicle class cost responsibility for pavement in-house maintenance, 2009–2012, Non-Interstate NHS.

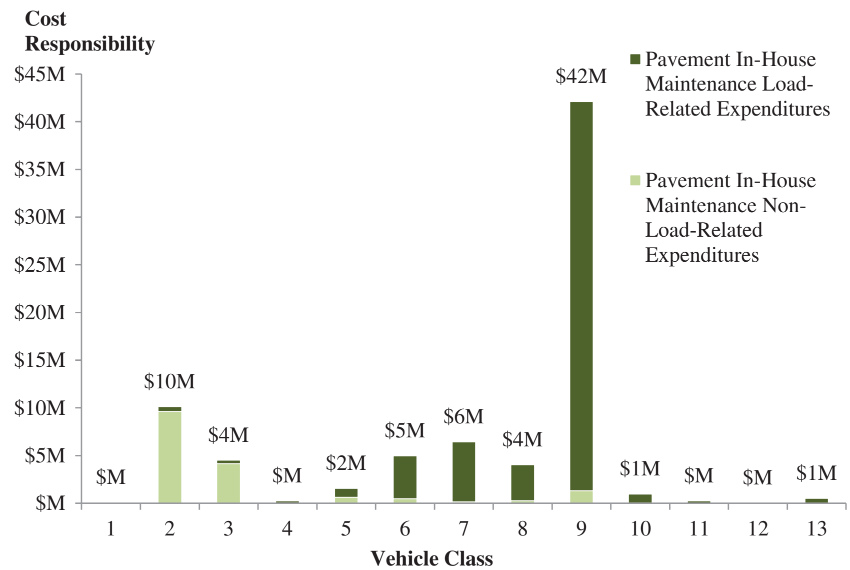


Figure 3.1.39 Total vehicle class cost responsibility for pavement

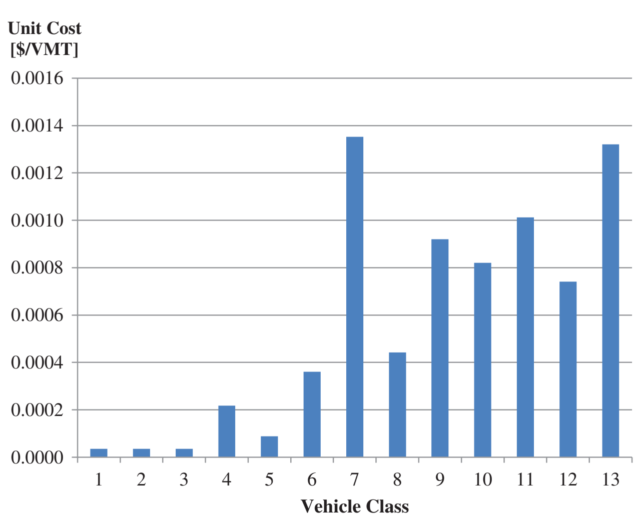


Figure 3.1.40 Average annual unit cost for pavement in-house maintenance, 2009–2012, Interstates.

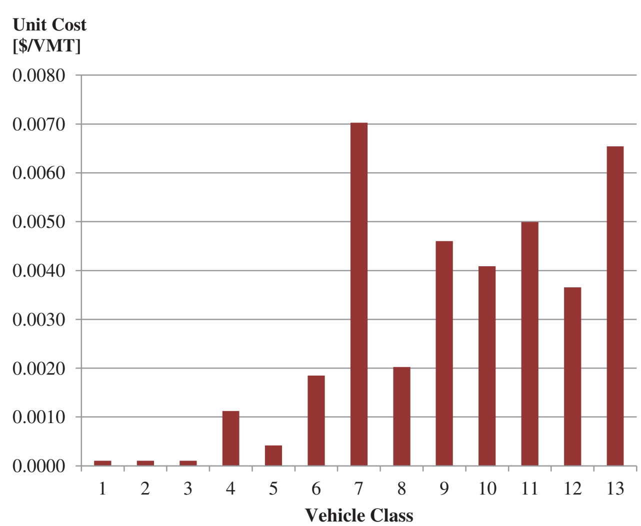


Figure 3.1.41 Average annual unit cost for pavement in-house maintenance, 2009–2012, Non-Interstate NHS.

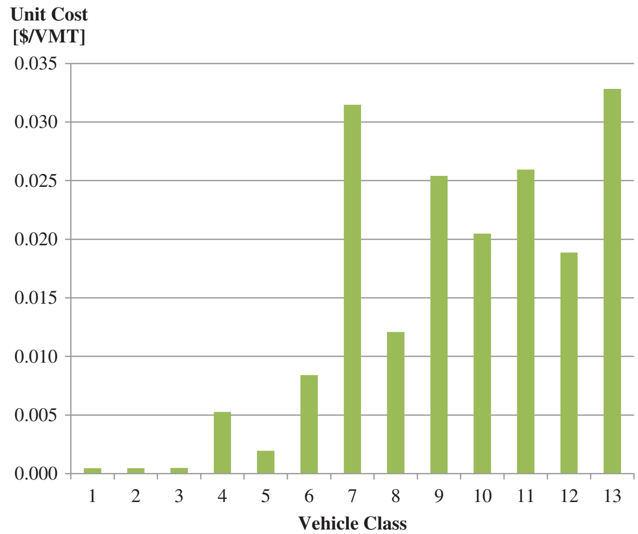


Figure 3.1.42 Average annual unit cost for pavement in-house maintenance, 2009–2012, Non-NHS.

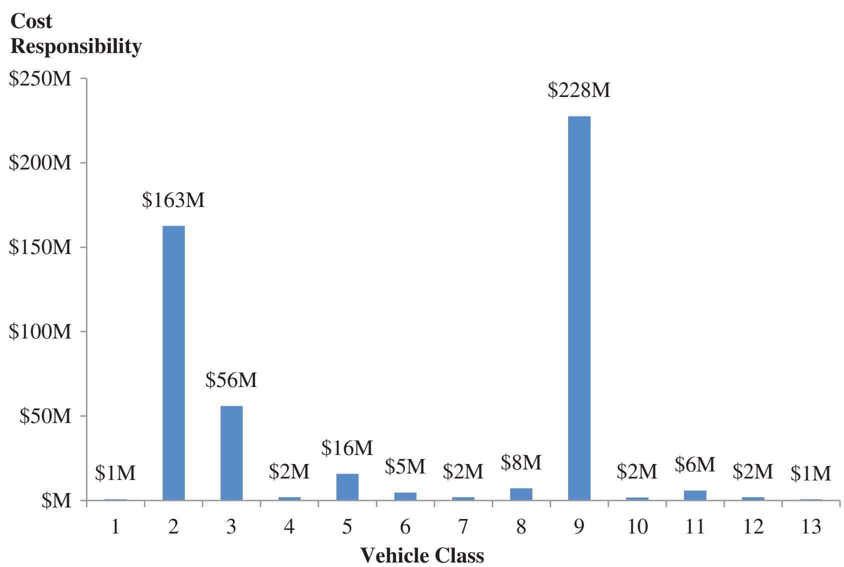


Figure 3.1.43 Total vehicle class cost responsibility for pavement expenditures, 2009–2012, Interstates.

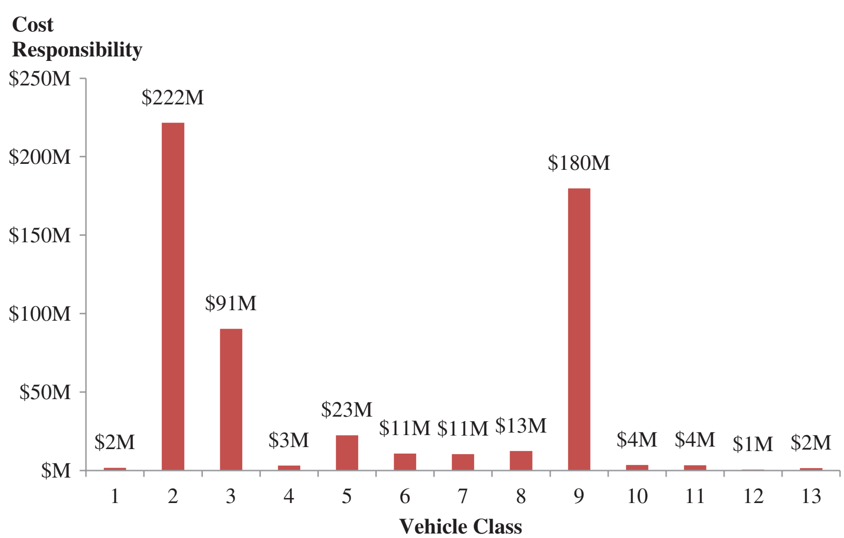


Figure 3.1.44 Total vehicle class cost responsibility for pavement expenditures, 2009–2012, Non-Interstate NHS.

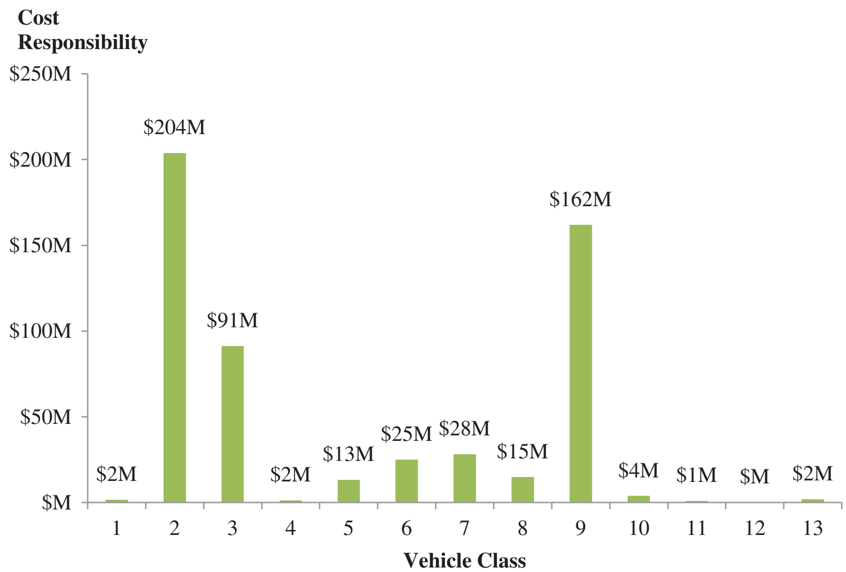


Figure 3.1.45 Total vehicle class cost responsibility for pavement expenditures, 2009–2012, Non-NHS.

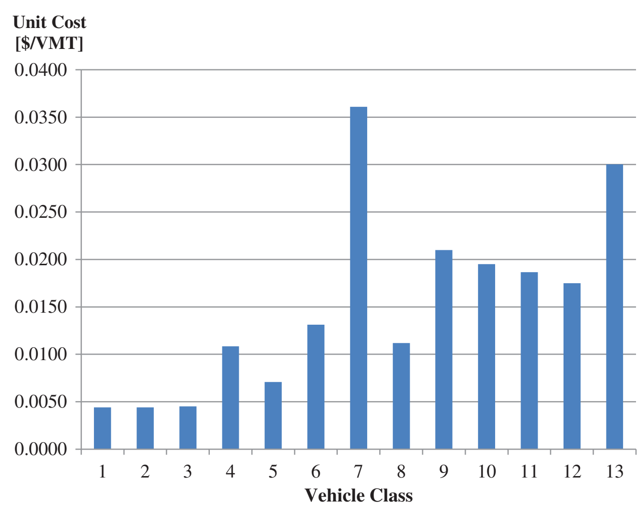


Figure 3.1.46 Average annual unit cost for pavement expenditures, 2009–2012, Interstates.

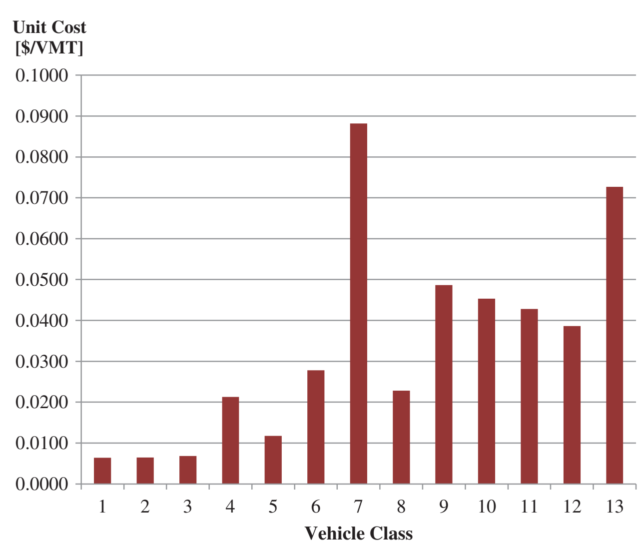


Figure 3.1.47 Average annual unit cost for pavement expenditures, 2009–2012, Non-Interstate NHS.

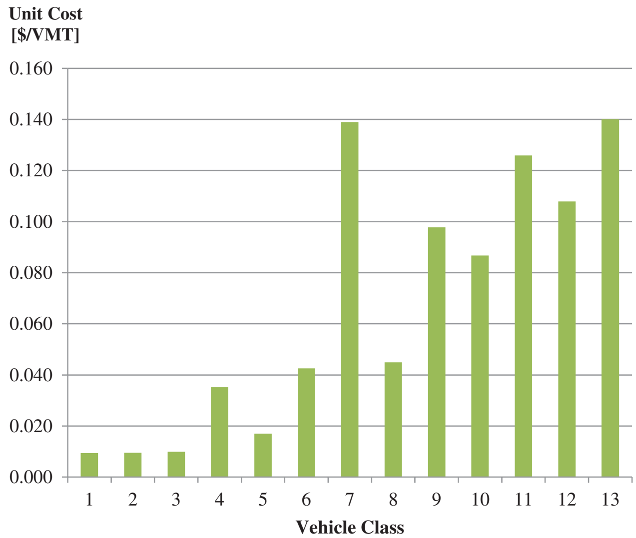


Figure 3.1.48 Average annual unit cost for pavement expenditures, 2009–2012, Non-NHS.

TABLE 3.1.35
Cost Responsibility by Pavement Project Type for All State Routes, 2009–2012

	Cost Responsibility for the Years 2009–2012				
Vehicle Class	**New Pavement Construction**	**Pavement Rehabilitation**	**Pavement In-House Maintenance**	**Other Pavement Projects**	**Total**
1	$3,299,239	$896,410	$134,911	$691,039	$5,021,599
2	$388,181,350	$100,893,255	$15,010,058	$84,727,612	$588,812,275
3	$158,376,997	$41,434,827	$6,360,343	$32,187,606	$238,359,772
4	$4,601,865	$1,763,926	$456,024	$365,194	$7,187,010
5	$36,121,711	$9,069,909	$2,560,013	$4,522,173	$52,273,807
6	$17,289,310	$16,612,826	$5,841,473	$1,386,444	$41,130,052
7	$15,527,877	$18,050,545	$7,371,887	$392,626	$41,342,935
8	$16,043,067	$12,321,013	$5,474,157	$1,465,501	$35,303,737
9	$215,083,848	$269,856,576	$69,151,651	$16,008,429	$570,100,503
10	$3,678,419	$4,617,906	$1,392,675	$221,149	$9,910,149
11	$5,376,653	$4,337,871	$1,020,700	$424,084	$11,159,308
12	$1,812,818	$1,208,774	$237,123	$154,628	$3,413,343
13	$1,865,331	$2,313,981	$720,017	$69,437	$4,968,765
Total	$867,258,484	$483,377,820	$115,731,031	$142,615,921	$1,608,983,254

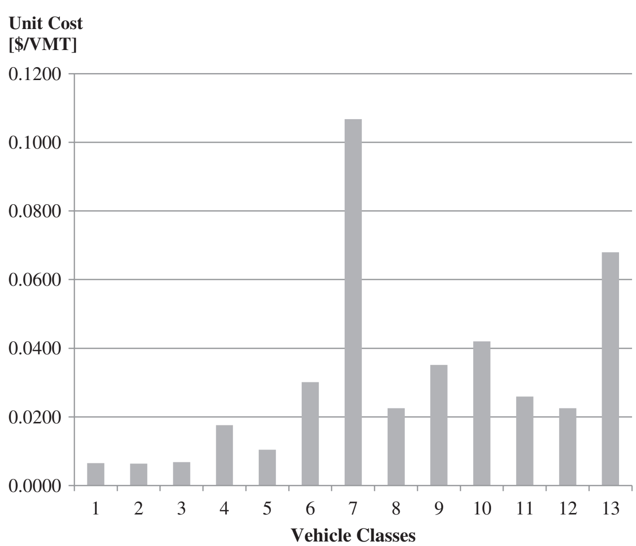


Figure 3.1.49 Average annual unit cost for pavement expenditures on state routes, 2009–2012.

2. COST ALLOCATION FOR BRIDGE EXPENDITURES ON STATE ROUTES

Bridge expenditure is a significant part of highway cost allocation. According to the FHWA (1997), new bridge construction costs typically represent approximately fifteen percent of overall costs for new system capacity; also, approximately one-third of total system preservation costs are spent on bridge improvements. Bridge expenditures are allocated to different vehicle classes, for reasons similar to that of pavements: different vehicle classes induce different live-load moments (and thus different stress levels) in load-bearing members of a bridge, and as the live-load moments increase, stronger load-bearing members are required to keep strains within acceptable limits. Thus, bridge construction becomes more costly when heavier vehicles must be accommodated. Each vehicle class should pay its share of the costs incurred to accommodate the stress corresponding to its weight. Also, after construction, heavier vehicles tend to contribute more to the wear and tear of a bridge. Therefore, the contribution of heavy vehicles needs to be considered appropriately when the expenditures for bridge replacement and rehabilitation are being allocated.

For new bridge construction and bridge replacement, the load-related expenditures (structures and bridge approaches) are allocated using the incremental method, while the non-load related expenditures (grading and earthwork) are analyzed as common costs. Heavy vehicles bear more cost responsibilities in load-related expenditures than they do in common expenditures. Thus, any change in the mix of bridge project types would change the cost responsibilities of different vehicle classes. For example, if there is significantly more bridge construction compared to bridge rehabilitation in a particular year, there will be relatively larger amount of common cost items such as grading and earthwork, and thus the cost responsibility of heavy vehicles is likely to be less in that year. Therefore, the highway cost allocation study needs to be repeated periodically to mitigate the effect of varying distributions of project types on the respective vehicle class cost responsibilities.

2.1 Study Methodology for Bridge Cost Allocation

2.1.1 Correlation between AASHTO Vehicles and Study Vehicles

As indicated in the literature review chapter of this report, the correlation between AASHTO vehicles and the vehicles used in the present study is one of the issues to be addressed as part of the analysis. The AASHTO standard trucks specified in the AASHTO bridge specifications (AASHTO, 2002) are trucks with configurations that would impose the most severe live loads on a structure. The trucks are designated either with an H prefix followed by a number indicating the total weight (tons) of a two-axle single-unit truck, or with a HS prefix followed by a number indicating the weight (tons) of a tractor-trailer combination truck. However, the vehicles in the present study follow the FHWA vehicle classification. Therefore, it was necessary to establish the correlation between the AASHTO design vehicles and the study (FHWA) vehicles.

Both Sinha et al. (1984) and FHWA (1997) used a similar "equivalent live load moments" approach to establish such correlation by calculating the live load moments as a function of the operating weight for each vehicle class on various types of bridges. Sinha et al. (1984) developed a computer program that moved across continuous span bridges such that each axle in turn fell at the critical point of equal continuous spans. As each axle was positioned, the moment at the critical point was calculated for the whole vehicle on the bridge. These moments were then compared with the moments produced by the AASHTO design loadings. The correlation between H and HS trucks, obtained through this process, was $H = 0.68HS$, with $r^2 = 0.89$.

The present study utilized the FHWA 13-class vehicle classification system, which is inconsistent with that used in 1984 Indiana study. Thus, adjustments were made to match the vehicle weight groups in the 1984 study to that of the present study.

Table 3.2.1 presents the weight groups by gross vehicle weight (GVW) in kilo-pounds (kips), and the equivalent AASHTO design loadings, for the 13 FHWA vehicle classes. The loading imposed by the first three vehicle classes, (i.e., motorcycles, passenger cars, and other two-axle, four-tire single-unit vehicles) were all treated as the base load without discrimination. Vehicle classes 10, 12, and 13 correspond to Type 14 (i.e., six or more axles) in the 1984 study and were bundled together as they have similar weight distributions. The overweight vehicles (trucks over 80,000 lbs. often in Classes 9 to 13) were aggregated to form a single weight group and designated as 80.0+; this was done because the weight distribution data available at the time of the study did not contain details regarding vehicles above 80,000 lbs.

Table 3.2.2 is a rearrangement of the information in Table 3.2.1 and establishes an inverse form of relationship between the study vehicle weight groups and the AASHTO design loadings. The number before the comma in the parentheses refers to the FHWA vehicle class, and the number after the comma indicates the weight group (which is defined in Table 3.2.1).

2.1.2 New Bridge Construction Cost Allocation

The incremental method was used in the present study for allocating the costs of new bridge construction. In this procedure, the first cost increment, which is the cost of building a new bridge to support its own weight and to carry the lightest vehicle traffic (Group 1) only, was assigned to all vehicle classes on the basis of the VMT share of each vehicle class. Next, the second cost increment, which identifies the additional cost of building the bridge to accommodate the second lightest weight group (Group 2), was assigned to all weight groups excluding the lightest group (Group 1) based on the

TABLE 3.2.1
Study Vehicle Classification and Equivalent AASHTO Designation

FHWA	Vehicle Classification	Weight Group	GVW (kips)	Equivalent AASHTO Design Loadings
1	Motorcycles	1	6	H4.0 (HS 2.7)
2	Passenger Cars	1		
3	Other Two-Axle, Four-Tire Single Unit Vehicles	1		
4	Buses	1	0–20.0	HS7
		2	20–25.0	HS9
		3	25–30.0	HS12
		4	30.0+	HS14
5	Two-Axle, Six-Tire, Single-Unit Trucks	1	5–10.0	H8.9 (HS6.0)
		2	10–15.0	H9.4 (HS6.4)
		3	15–20.0	H13.0 (HS8.8)
		4	20–25.0	H15.3 (HS10.4)
		5	25–30.0	H17.7 (HS12.0)
		6	30.0+	HS13.0
6	Three-Axle Single-Unit Trucks	1	10–15.0	HS6.0
		2	15–20.0	HS7.0
		3	20–25.0	HS8.0
		4	25–30.0	HS10.0
		5	30–35.0	HS11.0
		6	35–40.0	HS13.0
		7	40.0+	HS14.0
7	Four or More Axle Single-Unit Trucks	1	0–30.0	HS13.0
		2	30–60.0	HS23.0
		3	60.0+	HS24.0
8	Four or Fewer Axle Single-Trailer Trucks	1	0–20.0	HS6.0
		2	20–25.0	HS7.0
		3	25–30.0	HS8.0
		4	30–35.0	HS9.0
		5	35–40.0	HS10.0
		6	40–45.0	HS11.0
		7	45–50.0	HS12.0
		8	50–55.0	HS14.0
		9	55.0+	HS15.0
9	Five-Axle Single-Trailer Trucks	1	20–25.0	HS7.0
		2	25–30.0	HS8.0
		3	30–35.0	HS9.0
		4	35–40.0	HS10.0
		5	40–45.0	HS11.0

TABLE 3.2.1
(Continued)

FHWA	Vehicle Classification	Weight Group	GVW (kips)	Equivalent AASHTO Design Loadings
		6	45–50.0	HS12.0
		7	50–55.0	HS13.0
		8	55–60.0	HS14.0
		9	60–65.0	HS15.0
		10	65–70.0	HS17.0
		11	70–75.0	HS18.0
		12	75–80.0	HS19.0
		13	80.0+	HS24.0
11	Five or fewer Axle Multi-Trailer Trucks	1	0–40.0	HS11.0
		2	40–70.0	HS17.0
		3	70.0+	HS19.0
10 12 13	Six or More Axle Single-Trailer Trucks Six-Axle Multi-Trailer Trucks Seven or More Axle Multi-Trailer Trucks	1	0–40.0	HS11.0
		2	40–60.0	HS19.0
		3	60–80.0	HS24.0
		4	80.0+	HS26.0

relative shares of VMT of Group 2 and above. The second cost increment was assigned to Group 2 and above instead of Group 2 only because all the heavier groups also benefit from this cost increment. Then, similarly, the third cost increment, which is the additional cost to accommodate the third lightest weight group (Group 3), was assigned to all weight groups excluding Group 1 and 2, based on the relative shares of VMT of Group 3 and above. This process continued until the last cost increment was assigned to the heaviest weight group.

Simplified Example Illustrating New Bridge Cost Allocation. Suppose the VMT (or AADT) proportions of vehicle classes A, B and C (A the lightest and C the heaviest) on a given bridge are 50%, 30%, and 20%, respectively. The base construction cost to support the bridge own weight and carry the lightest vehicle class A is assumed as $100,000 solely for illustration purposes. Also, assume that the additional cost of strengthening the bridge to accommodate the second lightest vehicle class B is $50,000; and another $30,000 is needed to make the bridge stronger to carry the heaviest vehicle class C. Given the above assumptions, the cost responsibilities of the three vehicle classes can be calculated as:

Class A: \$100,000 $\times$ 50% / 100% = \$50,000
Class B: \$100,000 $\times$ 30% / 100% + \$50,000 $\times$ 30% / (30% + 20%) = \$60,000
Class C: \$100,000 $\times$ 20% / 100% + \$50,000 $\times$ 20% / (30% + 20%) + \$30,000 = \$70,000

Total cost responsibility = 50,000+60,000+70,000 = \$180,000 = Total bridge construction cost

In the present study, 13 vehicle classes are used, so 13 cost responsibilities are calculated, in the manner just illustrated.

TABLE 3.2.2
AASHTO Design Loadings and Corresponding Study Vehicle Weight Groups

AASHTO Design Loadings	Weight Groups
HS2.5	(1,1), (2,1), (3,1)
HS6	(5,1), (5,2), (6,1), (8,1)
HS7	(4,1), (6,2), (8,2), (9,1)
HS8	(6,3), (8,3), (9,2)
HS9	(4,2), (5,3), (8,4), (9,3)
HS10	(5,4), (6,4), (8,5), (9,4)
HS11	(6,5), (8,6), (9,5), (10,1), (11,1), (12,1), (13,1)
HS12	(4,3), (5,5), (8,7), (9,6)
HS13	(5,6), (6,6), (7,1), (9,7)
HS14	(4,4), (6,7), (8,8), (9,8)
HS15	(8,9), (9,9)
HS17	(9,10), (11,2)
HS18	(9,11)
HS19	(9,12), (10,2), (11,3), (12,2), (13,2)
HS23	(7,2)
HS24	(7,3), (9,13), (10,3), (12,3), (13,3)
HS26	(10,4), (12,4), (13,4)

Incremental Cost Factors. In applying the incremental method, a key consideration to be determined are the incremental cost factors for each weight group. The factors developed in the 1984 Indiana HCAS were relatively outdated and not comprehensive enough. As such, as part of the present study, the Purdue research team contacted Dr. Jose Weissmann (of the University of Texas at San Antonio) who subsequently shared the data on incremental cost factors used in the 1997 FHWA HCAS. These data were partly published in a paper by Weissmann, Reed, Robert, and Feroze (1994).

The data furnished by Weissmann et al. (1994) consists of 960 bridge type, load, and span combinations, including 11 bridge types ranging in span from 9 m to 72 m (30 ft. to 240 ft.) and designed for loads ranging from H2.5 to HS25. The bridge types include reinforced concrete slab (simple and continuous), prestressed concrete slab (simple and continuous), reinforced concrete T-beam (simple and continuous), prestressed concrete beam (precast), prestressed concrete multi-cell box girders, steel I-beam (rolled), steel I-girder (simple), and steel I-girder (continuous). Indiana state route bridges are consistent with these material and design types.

Table 3.2.3 presents the data for the prestressed concrete slab (simply-supported) bridge with a 50-ft. feet span, as an example to illustrate the incremental factor data. The unit total cost, unit superstructure cost, and unit substructure cost for different AASHTO design loadings are presented. The three rightmost columns list the unit cost ratios of other loadings with respect to HS20.

In the present study, only the column titled "HS20 Ratio of Total Cost" was used. Superstructure and substructure were not analyzed separately because the available contract cost data did not distinguish between superstructure costs and substructure costs. In addition, although the unit cost information in Table 3.2.3 developed in the 1990s, it can be reasonably expected that the cost ratios will remain unchanged with time and thus are still valid for use in the present study.

As shown in Table 3.2.2, appropriate values of the incremental factors are needed to reflect the continuous nature of HS loadings rather than the discrete values shown in Table 3.2.3. Thus, using the equation H = 0.68HS mentioned earlier in this chapter, all the H loadings in Table 3.2.3 converted to HS loadings. Then, regression analysis was conducted with respect to "HS loadings" and "HS20 Ratio of Total Cost." For the particular example shown in Table 3.2.3:

HS20 Ratio of Total Cost = 0.0116 HS + 0.7645, with $r^2 = 0.9833$.

Eighty (80) different regression equations were thus developed for each combination of bridge type and span length. Some of the regression equations have other functional forms, such as logarithmic and polynomial functions, depending on the goodness of fit. Using these regression equations, the HS20 Ratio of Total Cost for the HS loadings in Table 3.2.2 established for each combination of bridge type and span length.

Steps for Allocating New Bridge Construction Costs. The following steps illustrate how the cost allocation for new bridge construction was carried out:

- Step 1: From the Site Manager database, the construction expenditures on bridge structures, grading and earthwork, and approach pavements and wearing surface, respectively, were identified for each bridge contract.
- Step 2: Using the NBI number of each bridge, the material type, structure type, length of maximum span, structure length, inventory rating, sufficiency rating, and traffic volume, were determined from the NBI database and the INDOT bridge inspection file.
- Step 3: Using the route and milepost information of each bridge, the traffic distribution (percentage of AADT) across the 13 vehicle classes on that particular bridge and the bridge functional class were identified using the algorithm developed in Part 2 of this report.
- Step 4: The traffic distribution for each weight group under each vehicle class was identified based on the

TABLE 3.2.3
Incremental Cost Factor for Prestressed Concrete Slab (Simply Supported) with 50 ft. Span.

AASHTO Loading	Total Cost ($/sqft)	Super-Structure ($/sqft)	Sub- Structure ($/sqft)	Total Cost HS20 Ratio	Super- Structure HS20 Ratio	Sub-Structure HS20 Ratio
HS 25	47.46	37.23	10.23	1.055	1.051	1.068
HS 22.5	45.49	35.41	10.08	1.011	1.000	1.052
HS 20	45.00	35.41	9.58	1.000	1.000	1.000
HS 17.5	42.79	33.61	9.18	0.951	0.949	0.958
HS 15	42.54	33.61	8.92	0.945	0.949	0.931
H 20	42.23	32.57	8.75	0.938	0.920	0.913
H 15	40.32	31.75	8.57	0.896	0.897	0.895
H 10	38.12	29.98	8.14	0.847	0.847	0.850
H 5	36.16	28.29	7.88	0.804	0.799	0.823
H 2.5(38')	34.51	26.86	7.65	0.767	0.759	0.799
H 2.5(32')	34.17	27.23	6.94	0.640	0.648	0.610
H 2.5(26')	35.57	27.94	7.63	0.541	0.540	0.545

Source: Weissmann et al. (1994).

average vehicle weight distribution results for each bridge functional class.

- Step 5: Based on the corresponding relationship between the AASHTO vehicle and the study vehicle shown in Table 3.2.2, the traffic distribution for each HS loading in Table 3.2.2 determined.
- Step 6: Based on the information found for each bridge in Step 2, the corresponding HS20 Ratio of Total Cost established in Section 2.1.2.1 was determined.
- Step 7: Following the principle of the incremental method, both the traffic distribution and HS20 Ratio of Total Cost were used to calculate the cost share of each HS loading.
- Step 8: The cost share of HS loadings was converted back to the cost share of FHWA vehicle classes, using Tables 3.2.1 and 3.2.2.
- Step 9: The structure-related construction expenditures in Step 1 were multiplied by the cost share in Step 8 to obtain the structure-related construction cost responsibilities for each vehicle class.
- Step 10: The expenditures on grading and earthwork in Step 1 were considered common costs and were allocated using the PCE-miles contributed by each vehicle class.
- Step 11: The expenditures on approach pavements and wearing surface were allocated using the methods for pavement cost allocation presented in Chapter 1 of this Part of the report.
- Step 12: The three cost responsibilities from Steps 9, 10, and 11 were added to yield the total cost responsibilities for each vehicle class; and
- Step 13: For each vehicle class, the total cost responsibility was multiplied by its total VMT to obtain the unit construction cost ($/VMT) for the vehicle class.

2.1.3 Bridge Replacement Cost Allocation

For bridge replacement cost allocation, FHWA (1982) used the Bridge Sufficiency Rating Formula:

$$\begin{aligned} &B = 0.3254 \times (32.4 - IR)^{1.5} \text{ for } IR < 32.4 \\ &B = 0 \text{ otherwise} \end{aligned} \tag{3.11}$$

where B is the loss of sufficiency points due to inadequate load-carrying capacity, and IR is the inventory rating. A bridge loses points if its load-bearing capacity is inadequate or if it has other non-load-related problems such as scouring around piers or width inadequacy to accommodate current traffic levels.

For bridges to be replaced, the points lost due to inadequate load-bearing capacity are expressed as a fraction of the total points lost to determine the share of bridge replacement costs to be allocated to vehicles that operate at weights exceeding the load-bearing capacities of the bridges to be replaced (FHWA, 1997). Therefore, after identifying the sufficiency rating before the bridge is replaced (SR), the value of “B/SR” indicates the share of bridge replacement costs to be allocated to the vehicles that operate at weights exceeding the load-bearing capacities of the bridges to be replaced. The incremental factors for these vehicles are the same as those developed for new bridge construction in Section 2.1.2 of this Part of the report.

After allocating the “B/SR” portion, the remaining share of replacement expenditures was allocated to all vehicle classes following the same procedures developed for new bridge construction in Section 2.1.2 of this Part of the report.

The 1997 Federal HCAS used bridge condition data from the Bridge Needs and Investment Process (BNIP) instead of the NBI Sufficiency Ratings. However, as the BNIP data were not available for the present study, the sufficiency rating formula was used.

2.1.4 Bridge Rehabilitation Cost Allocation

The load-related and non-load-related share of expenditures is a key input in bridge rehabilitation cost allocation. The FHWA (1997) and ITD (2010) studies suggested that, in determining the percentage of costs that are load-related for a given program subcategory and highway class, one should estimate the fraction by which the costs for the program category would be reduced if all the vehicles in the highway class were automobiles or other very light vehicles. For example, if the costs for a program category would be reduced by 10% if all the vehicles are automobiles, then 10% of the costs are load-related and 90% are non-load-related.

In the literature review chapter (Part 1, Section 2.3) of this report, the load and non-load shares used in the 1997 FHWA and 1999 Oregon HCASs were presented. In the present study, considering the quality of the contract cost data, the following load-related shares, which represent a combination of the 1997 FHWA study and 1999 Oregon study estimates, were used: deck overlay—70%, other superstructure rehabilitation—30%, substructure rehabilitation—15%, bridge painting—0%.

Further, the share of load-related rehabilitation costs was allocated to all vehicle classes following the same procedures developed for new bridge construction. The non-load share was allocated as common costs using PCE-miles as the allocator.

2.2 Data for Bridge Cost Allocation

Data on the expenditures related to new bridge construction, bridge replacement, and bridge rehabilitation contracts on state routes were extracted from the INDOT Site Manager database for the period 2009–2012. The expenditures for a reported year constitute the expenditures of contracts that were let in that year. The in-house bridge maintenance expenditures were obtained from a separate database provided by INDOT.

2.2.1 Bridge-Related Contract Expenditures

The bridge-related contract expenditures were placed in three categories: bridge structures, grading and earthwork, and approach pavements, and wearing surfaces because the expenditures in different categories were intended to be allocated using different methods. The bridge structure category includes expenditures on decks (excluding wearing surface), superstructures, and substructures; these expenditures were allocated using the incremental method. The grading and earthwork category contains the expenditures related to grading and earthwork for both the bridge itself and its approaches; such expenditures were treated as common costs. The approach pavements and wearing surfaces category comprises all the expenditures related to pavements in bridge projects: pavements on the approaches or bridge wearing surfaces; these expenditures were allocated using the Pavement Thickness Incremental Approach as done for pavement cost allocation in Chapter 1 of this Part of the report.

Table 3.2.4 lists the three bridge expenditure categories and their corresponding expenditure items in detail. The description of each expenditure item was taken from INDOT Site Manager database.

A series of tables and figures are presented herein to describe expenditures from different perspectives. It should be noted that all the expenditures shown in Section 2.2.1 are bridge-related contract expenditures for state routes. Also, the expenditure amounts are not in constant dollars but rather are in unadjusted dollars at the respective year of reporting.

Figure 3.2.1 presents the bridge-related contract expenditures by year. It can be seen that the expenditures continually increased from 2009 to 2011 but decreased dramatically in 2012 to only about a half of the 2011 expenditures.

Table 3.2.5 and Figure 3.2.2 present the bridge-related contract expenditures by year and highway class. The expenditures were found to vary greatly with the year and the highway class.

Table 3.2.6 and Figure 3.2.3 present the bridge-related contract expenditures by year and expenditure category. Not surprisingly, expenditures on bridge structures accounted for approximately two-thirds of all bridge-related expenditures. Of the three categories, the expenditures on approaches and wearing surfaces accounted for the least expenditures.

Table 3.2.7 and Figure 3.2.4 present the bridge-related contract expenditures by year and project type. Expenditures on new bridge construction and bridge replacement were the highest compared to other bridge project types. The expenditure items that constituted each project type are presented in Section 2.3 of this Part of the report.

The three pie charts in Figures 3.2.5, 3.2.6 and 3.2.7 present more explicitly the percentages of the average expenditures in 2009–2012 by highway class, expenditure category, and project type, respectively.

2.2.2 Bridge-Related In-House Maintenance Expenditures

The expenditure items in the bridge-related in-house maintenance expenditures include bridge cleaning, bridge repair, bridge flushing, temporary bridge decks patching, permanent bridge decks patching, bridge improvements, and other bridge maintenance. These routine maintenance expenditures were allocated to all vehicle classes as common costs.

Table 3.2.8 presents the in-house maintenance expenditures by year and highway class, and Figure 3.2.8 illustrates this information. It can be seen that the maintenance expenditures remained stable over the four years, with a slight decrease in 2011 and a slight increase in 2012.

2.2.3 Summary of Bridge-Related Expenditures on State Routes

This section summarizes the bridge-related contract expenditures and in-house maintenance expenditures together. Table 3.2.9 the expenditures broken down by highway classes, years, and project types. Figure 3.2.9 shows the total bridge-related expenditures for the study period. Figure 3.2.10 illustrates both the contract expenditures and the in-house maintenance expenditures for each of the four years.

2.3 Analysis and Results

The cost allocation analysis for bridges was conducted using the methodology presented in Section 2.1 of this Part of the report. As mentioned earlier, bridge contract expenditures were separated into structure expenditures, grading and earthwork expenditures, and approaches and wearing surfaces expenditures. Most of the structure expenditures were load related, except for the non-load-related bridge rehabilitation expenditures which were treated as common costs. Also, the grading, earthwork and in-house maintenance expenditures were considered common costs. The analysis of expenditures on approach pavements and wearing surface was carried out using the pavement cost allocation methodology.

2.3.1 Load-Related Cost Allocation

Due to the differences in cost allocation methods across project types, the bridge structure-related expenditures were further categorized into new bridge construction expenditures, bridge replacement expenditures, and bridge rehabilitation/repair expenditures. The expenditures for each project type were determined using the column describing the work type of the contracts in INDOT's Site Manager database. The work type details are presented in Table 3.2.10.

In the present study, the expenditures on bridge deck reconstruction, bridge widening, and added travel lanes at bridges were all considered as bridge replacement expenditures because the method for bridge rehabilitation/repair cost allocation is suitable only for non-construction projects. Thus, the method for bridge replacement cost allocation was considered more appropriate for analyzing the aforementioned expenditures.

In the incremental method, the traffic distribution of the FHWA vehicle classes needed to be correlated to the AASHTO design vehicles, and vice versa.

TABLE 3.2.4
Bridge-Related Contract Expenditure Categories and Items.

Bridge Expenditure Categories	Bridge Expenditure Items
Bridge Structure	Bearing Assembly
	Concrete Floor Slabs
	Concrete for Patching Bridge Structures
	Concrete Header
	Concrete Repair by Epoxy Injection
	Painting of Structural Steel
	Piling
	Pneumatically Placed Mortar
	Precast and Prestressed Concrete Structural Member
	Reconstructed Expansion Joint
	Reinforcing Steel
	Repointing Masonry in Structures
	Steel Structures
	Stockpiled Materials
	Structural Concrete
	Structural Expansion Joints
	Timber Structures
Grading and Earthwork	Cellular Concrete Fill
	Chemical Modification of Subgrade Soils
	Clearing and Grubbing
	Drilled Shaft
	Excavation and Embankment
	Finishing Shoulders, Ditches, and Slopes
	Flowable Mortar
	Gabions
	Geotechnical Instrumentation
	Mechanically Stabilized Earth Retain Wall
	Riprap and Slopewall
	Special Fill and Backfill ("B" Borrow)
	Stockpiled Selected Materials
	Structure Excavation
Approach Pavements and Wearing Surface	Subgrade
	Bituminous Shoulders
	Cold Mix Asphalt Pavement
	Compacted Aggregate Base, Surface or Shoulder
	Compacted Aggregate Base
	Continuously Reinforced Cement Concrete Pavement
	Curbing
	Fog Seal
	HMA Partial Depth Patching
	Hot Mix Asphalt Pavement
	Latex Modified Concrete Bridge Deck Overlay
	Milled Shoulder Corrugations
	PCCP Joints
	PCCP Patching
	Portland Cement Concrete (PCC) Pavement, PCC Sealers
	Portland Cement Treated Base
	Prime Coat
	QC/QA Hot Mix Asphalt Pavement
	Reconditioning
	Seal Coat
	Subbase
	Surfaces for Approaches
	Tack Coat
	Widening and Patching

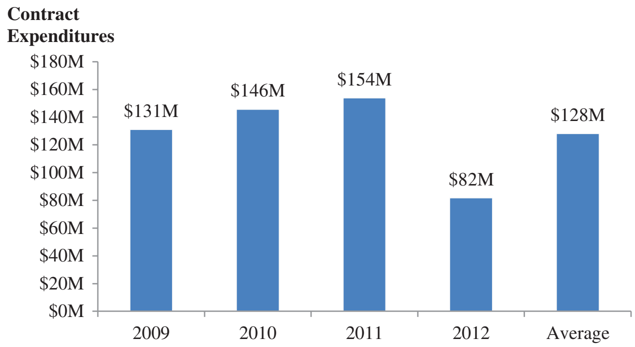


Figure 3.2.1 Bridge-related contract expenditures by year.

Therefore, the weight distribution of each FHWA class was needed. Table 3.2.11 adjusted from the results developed by the Purdue research team to accommodate the bin of 5 kips needed for subsequent analysis. In this table, the percentages in the column of each highway class for each vehicle class add up to 100%. For example, for Vehicle Class 4, the four percentages for the Interstate class add up to 100%.

The procedures demonstrated in Sections 2.1.2, 2.1.3, and 2.1.4 were used to carry out the load-related cost allocation and the results are shown in the subsequent tables and figures. Table 3.2.12 the results of the allocated cost responsibilities of 13 vehicle classes in terms of structure expenditures, approach pavements and wearing surfaces expenditures, and total load-related expenditures (the sum of the previous two expenditures) that were incurred on Interstates only. This table also shows the cost responsibility percentage of each vehicle class. In addition, the unit load-related cost ($/VMT) shown in the last column was calculated by dividing the total load-related cost responsibility by the total four-year Interstate VMT of each vehicle class. Note that the cost responsibilities in Table 3.2.12 represent the sum of the costs over four years. Due to space limitation, the results of cost responsibility and unit cost for the four individual years are not presented in this table but can be found in Addendum C of this report. Tables 3.2.13 and 3.2.14 illustrate similar results for Non-Interstate NHS and Non-NHS, respectively.

It can be observed from the load-related unit costs, that vehicle classes 1–3 have a lower unit cost compared to heavier vehicles. The unit costs for vehicle classes 1–3 are identical because they were converted to the same AASHTO loading in the analysis. The variation of unit costs among trucks (Class 4 and above) can be partly

TABLE 3.2.5
Bridge-Related Contract Expenditures by Year and Highway Class

Highway Class	2009	2010	2011	2012	Average
Interstates	$55,024,837	$57,846,592	$94,940,275	$10,932,082	$54,685,946
Non-Interstate NHS	$32,755,260	$69,161,478	$28,956,220	$42,489,428	$43,340,596
Non-NHS	$43,180,978	$18,620,561	$29,991,037	$28,379,986	$30,043,140

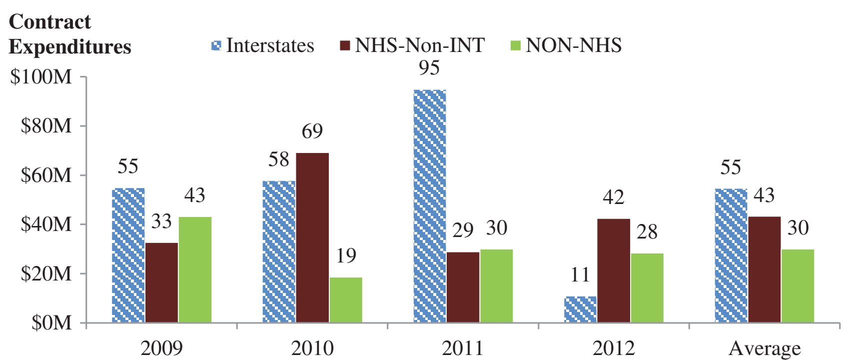


Figure 3.2.2 Bridge-related contract expenditures by year and highway class.

TABLE 3.2.6
Bridge-Related Contract Expenditures by Year and Expenditure Category.

Expenditure Category	2009	2010	2011	2012	Average
Bridge Structures	$87,170,854	$95,180,213	$88,859,883	$59,082,110	$82,573,265
Grading and Earthwork	$25,762,723	$35,375,214	$54,579,062	$15,343,825	$32,765,206
Approach Pavements and Wearing Surface	$18,027,498	$15,062,743	$10,448,587	$7,375,560	$12,728,597

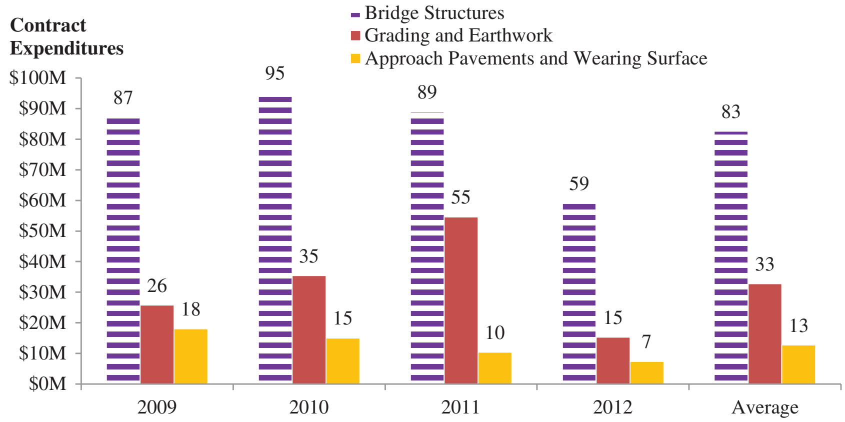


Figure 3.2.3 Bridge-related contract expenditures by year and expenditure category.

TABLE 3.2.7
Bridge-Related Contract Expenditures by Year and Project Type.

Project Type	2009	2010	2011	2012	Average
Bridge Construction	$50,737,805	$67,008,416	$97,157,051	$49,432,987	$66,084,065
Bridge Replacement	$71,934,670	$71,810,123	$43,367,233	$30,553,686	$54,416,428
Bridge Rehab/Repair	$8,288,600	$6,810,092	$13,363,247	$1,814,822	$7,569,190

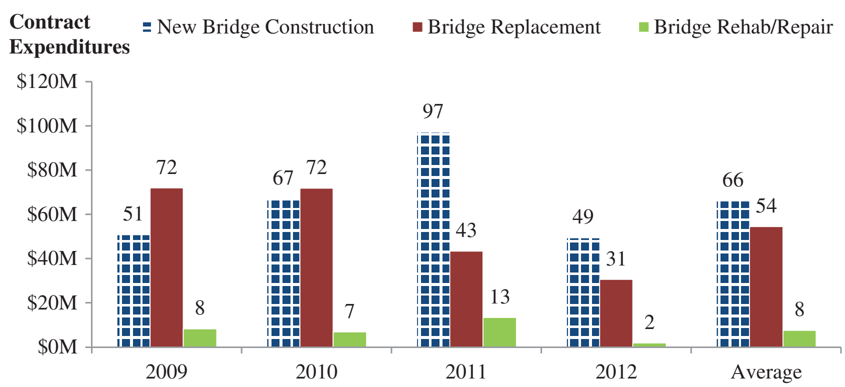


Figure 3.2.4 Bridge-related contract expenditures by year and project type.

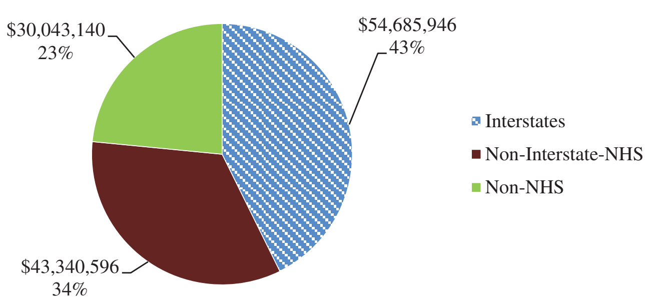


Figure 3.2.5 Four-year average bridge-related contract expenditure percentages by highway class.

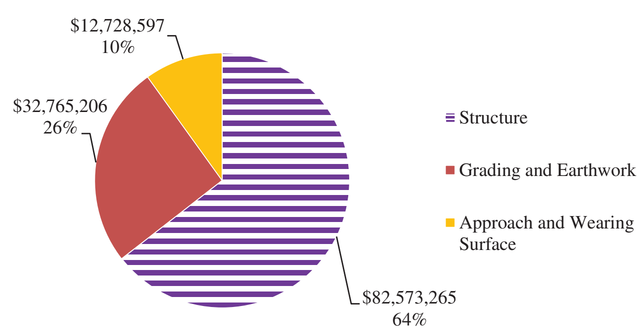


Figure 3.2.6 Four-year average bridge-related contract expenditure percentages by expenditure category.

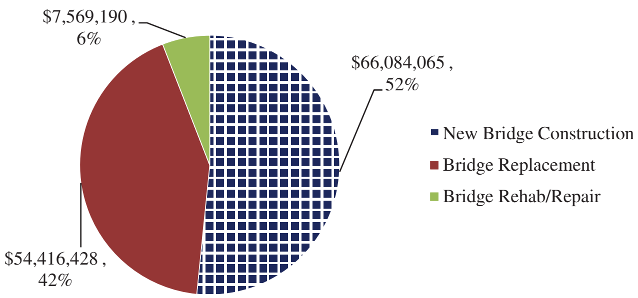


Figure 3.2.7 Four-year average bridge-related contract expenditure percentages by project type.

attributed to the variation in their traffic distribution and their VMT.

2.3.2 Common Cost Allocation

The common cost for bridges consists of three parts: grading and earthwork expenditures, the non-load-related bridge rehabilitation and repair expenditures, and in-house maintenance expenditures. However, these costs cannot be considered strictly common with respect to every vehicle class because certain cost items are expected to be related to vehicle size. Specifically, grading and earthwork expenditures will likely be lower if a bridge is built for autos only, because the size of bridge will be smaller than a normal bridge for all vehicle classes. This is consistent with the Federal HCAS where the grading expenditures were allocated by PCE-weighted VMT. For the non-load-related bridge rehabilitation costs which are considered to be largely incurred by the environment, trucks may also play a more significant role than autos because the loading from trucks can have stronger interactive effects with the environment compared to autos. For in-house maintenance costs which mostly consist of bridge cleaning, bridge flushing and temporary patching, trucks can also be considered to be contributing more compared to autos due to their larger size. Although these implicit effects are difficult to be quantified, PCE-weighted VMT (or PCE-miles) is the commonly-used allocator to account for the effect of vehicle size.

The PCE units for the Interstates were acquired from the results of a study by Sinha et al. (2011). The estimated PCE values for single-unit and combination truck for basic urban freeways in Indiana were 1.35 and 1.60 respectively. The PCE units for the non-Interstate NHS and non-NHS used in the present study were adjusted from Table 3.2.15, which appears in the Highway Capacity Manual 2000 (TRB, 2000). Given Indiana's terrain, an estimated PCE unit for trucks for both non-Interstate NHS and non-NHS was 2.20 (average of 1.9 and 2.5). Table 3.2.16 the PCE units used in the present study. The PCE-weighted VMT (PCE-miles) was calculated as the actual VMT multiplied by the corresponding PCE unit.

Table 3.2.17 and Figure 3.2.11 present a summary of the total common costs. Table 3.2.18 the results of the common cost responsibility and the unit common cost for bridges. Again, the common cost responsibilities in this table are the sum of the costs for four years. The details of the common cost responsibility and unit common cost for the four individual years

TABLE 3.2.8
Bridge-Related In-house Maintenance Expenditures by Year and Highway Class.

Highway Class	2009	2010	2011	2012	Average
Interstates	$960,582	$1,086,442	$797,737	$1,162,455	$1,001,804
Non-Interstate NHS	$471,706	$487,900	$402,399	$516,819	$469,706
Non-NHS	$1,003,779	$891,901	$821,845	$922,243	$909,942
Total	$2,436,067	$2,466,244	$2,021,981	$2,601,516	$2,381,452

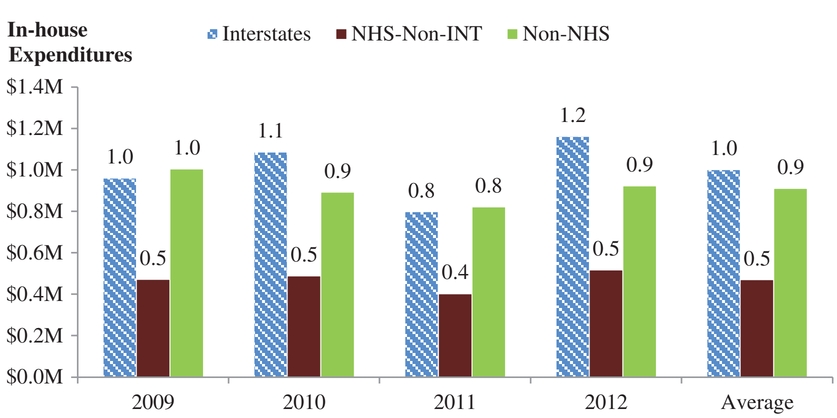


Figure 3.2.8 Bridge-related in-house maintenance expenditures by year and highway class.

TABLE 3.2.9
Bridge-Related Expenditures on State Routes by Year, Highway Class, and Project Type.

Highway Class	Year	New Bridge Construction	Bridge Replacement	Bridge Rehab/Repair	In-House Maintenance	Subtotal
Interstates	2009	$17,318,111	$31,516,679	$6,190,047	$960,582	$55,985,419
	2010	$32,606,145	$21,162,014	$4,078,432	$1,086,442	$58,933,034
	2011	$70,563,096	$11,430,485	$12,946,695	$797,737	$95,738,012
	2012	$8,003,241	$2,837,728	$91,113	$1,162,455	$12,094,536
Non-Interstate NHS	2009	$15,073,733	$16,657,099	$1,024,428	$471,706	$33,226,967
	2010	$32,652,304	$35,450,464	$1,058,710	$487,900	$69,649,378
	2011	$16,368,656	$12,585,638	$1,925	$402,399	$29,358,619
	2012	$26,060,771	$15,510,895	$917,762	$516,819	$43,006,246
Non-NHS	2009	$18,345,961	$23,760,892	$1,074,125	$1,003,779	$44,184,757
	2010	$1,749,967	$15,197,644	$1,672,950	$891,901	$19,512,462
	2011	$10,225,299	$19,351,110	$414,628	$821,845	$30,812,882
	2012	$15,368,976	$12,205,063	$805,947	$922,243	$29,302,228
Subtotal		$264,336,260	$217,665,712	$30,276,761	$9,525,807	**$521,804,540**

can be found in Addendum C of this report. It can be seen that the unit common costs were slightly different for each vehicle class because the unit common cost was calculated as the total common cost responsibility over four years divided by the total four-year VMT of that vehicle class. From the unit common cost results for each individual year, the values for the different vehicle classes are observed to be identical.

Table 3.2.19 summarizes the total load-related cost responsibility and common cost responsibility of each vehicle class for all state route classes for the four years (2009–2012).

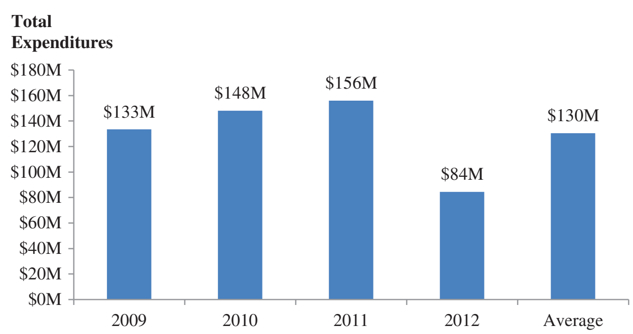


Figure 3.2.9 Total bridge-related expenditures on state routes by year.

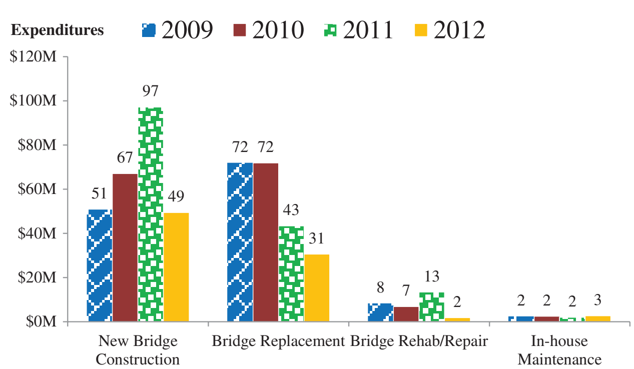


Figure 3.2.10 Bridge-related expenditures on state routes by year and project type.

2.3.3 Summary of Bridge Cost Allocation Results

The overall results for the allocation of load-related and common costs are presented in this section. As an illustration, Table 3.2.20 the cost responsibility and its share and the unit cost for the 13 FHWA vehicle classes for Interstates only. The cost responsibility is reflected in the sum of the load-related and common costs, which is the total cost over four years. The details for each year can be found in Addendum C of this report. The

TABLE 3.2.10
Constituent Work Types of Each Bridge Project Type.

Project Type	Work Type Included
Bridge Structure	New Bridge, Other Construction New Bridge Construction New Bridge, Concrete Construction New Bridge, Special New Bridge, Steel Construction New Road Construction
Bridge Replacement	Bridge Replacement, Concrete Bridge Deck Reconstruction Replace Superstructure Bridge Replacement Bridge Widening Bridge Reconstruction Bridge Replacement, Steel Added Travel Lanes Small Structure, Replacement Bridge Replacement, Other Construction
Bridge Rehabilitation/ Repair	Bridge Maint/Repair Substructure Repair and Rehabilitation Bridge Painting Bridge Channel Correction

Source: INDOT Site Manager database (2009–2012).

TABLE 3.2.11
Adjusted Weight Distribution of FHWA Vehicles for Different Highway Classes.

Single-Unit Trucks

Vehicle Class	GVW (kips)	Interstate	Non-Int-NHS	Non-NHS
4	0–20.0	26.64%	29.03%	20.95%
	20–25.0	30.99%	32.54%	28.13%
	25–30.0	16.82%	14.43%	21.59%
	30.0+	25.55%	24.00%	29.33%
5	0–10.0	57.74%	56.85%	65.90%
	10–15.0	27.29%	27.64%	22.90%
	15–20.0	8.19%	8.75%	6.03%
	20–25.0	3.98%	3.92%	2.76%
	25–30.0	1.85%	1.76%	1.52%
	30.0+	0.95%	1.07%	0.90%
6	0–15.0	8.70%	5.54%	4.78%
	15–20.0	25.53%	19.99%	17.28%
	20–25.0	22.69%	21.16%	24.29%
	25–30.0	11.30%	12.78%	10.58%
	30–35.0	7.96%	10.51%	9.91%
	35–40.0	7.62%	9.16%	13.81%
	40.0+	16.20%	20.86%	19.35%
7	0–30.0	15.40%	5.84%	6.67%
	30–60.0	38.26%	44.98%	48.60%
	60+	46.34%	49.18%	44.73%
8	0–20.0	31.79%	37.79%	28.34%
	20–25.0	13.30%	11.47%	14.08%
	25–30.0	12.99%	12.54%	11.10%
	30–35.0	12.36%	13.45%	13.42%
	35–40.0	9.94%	9.62%	11.49%
	40–45.0	6.95%	5.98%	8.92%
	45–50.0	5.10%	3.63%	5.91%
	50–55.0	3.69%	2.22%	3.08%
	55.0+	3.88%	3.31%	3.66%

Combination Trucks

Vehicle Class	GVW (kips)	Interstate	Non-Int-NHS	Non-NHS
9	0–25.0	2.05%	2.74%	7.05%
	25–30.0	4.67%	7.52%	13.33%
	30–35.0	8.38%	13.31%	13.58%
	35–40.0	9.13%	11.91%	11.50%
	40–45.0	8.26%	7.87%	9.74%
	45–50.0	7.94%	6.69%	7.85%
	50–55.0	7.64%	5.82%	5.29%
	55–60.0	7.53%	5.54%	4.29%
	60–65.0	7.91%	6.35%	5.69%
	65–70.0	8.17%	7.91%	5.90%
	70–75.0	9.22%	9.59%	5.25%
	75–80.0	9.72%	9.13%	4.31%
	80.0+	9.40%	5.63%	6.21%
10	0–40.0	17.40%	19.42%	30.24%
	40–60.0	26.30%	32.47%	35.01%
	60–80.0	33.01%	29.09%	24.56%
	80+	23.29%	19.01%	10.19%
11	0–40.0	9.27%	17.05%	57.29%
	40–70.0	73.29%	69.99%	36.46%
	70+	17.44%	12.96%	6.25%
12	0–40.0	4.02%	13.35%	0.00%
	40–60.0	40.52%	38.05%	0.00%
	60–80.0	47.18%	43.75%	25.00%
	80+	8.28%	4.85%	75.00%
13	0–40.0	0.43%	0.00%	0.00%
	40–60.0	17.75%	32.90%	0.00%
	60–80.0	19.97%	18.47%	37.50%
	80+	61.85%	48.62%	62.50%

TABLE 3.2.12
Load-Related Cost Responsibility and Unit Cost for Interstate Bridges.

FHWA Vehicle Class	Cost Responsibility for Structures	Cost Responsibility for Approaches and Wearing Surface	Total Load-Related Cost Responsibility	Share of Load-Related Cost Responsibility	Unit Load-Related Cost ($/VMT)
1	$488,942	$19,633	$508,575	0.33%	$0.0039
2	$70,733,474	$2,865,018	$73,598,493	47.58%	$0.0039
3	$23,977,957	$1,062,883	$25,040,841	16.19%	$0.0039
4	$564,648	$78,697	$643,345	0.42%	$0.0049
5	$5,568,703	$473,965	$6,042,668	3.91%	$0.0044
6	$1,013,075	$149,992	$1,163,067	0.75%	$0.0048
7	$351,354	$79,624	$430,979	0.28%	$0.0089
8	$1,293,567	$233,557	$1,527,124	0.99%	$0.0038
9	$36,137,986	$6,176,536	$42,314,522	27.35%	$0.0055
10	$895,343	$62,583	$957,926	0.62%	$0.0105
11	$882,907	$215,401	$1,098,308	0.71%	$0.0048
12	$710,190	$80,030	$790,219	0.51%	$0.0078
13	$543,865	$32,960	$576,825	0.37%	$0.0191

TABLE 3.2.13
Load-Related Cost Responsibility and Unit Cost for Non-Interstate NHS Bridges.

FHWA Vehicle Class	Cost Responsibility for Structures	Cost Responsibility for Approaches and Wearing Surface	Total Load-Related Cost Responsibility	Share of Load-Related Cost Responsibility	Unit Load-Related Cost ($/VMT)
1	$524,123	$53,456	$577,579	0.45%	$0.0027
2	$55,872,926	$5,967,574	$61,840,500	48.06%	$0.0027
3	$21,578,423	$2,858,954	$24,437,376	18.99%	$0.0028
4	$552,549	$204,590	$757,138	0.59%	$0.0057
5	$5,100,526	$1,204,546	$6,305,072	4.90%	$0.0042
6	$1,361,242	$516,793	$1,878,034	1.46%	$0.0057
7	$2,388,689	$575,373	$2,964,062	2.30%	$0.0252
8	$1,216,604	$642,050	$1,858,654	1.44%	$0.0043
9	$17,213,072	$7,228,327	$24,441,399	18.99%	$0.0076
10	$1,564,018	$162,905	$1,726,923	1.34%	$0.0219
11	$406,377	$197,363	$603,740	0.47%	$0.0079
12	$285,668	$47,439	$333,107	0.26%	$0.0164
13	$867,262	$85,140	$952,402	0.74%	$0.0399

TABLE 3.2.14
Load-Related Cost Responsibility and Unit Cost for Non-NHS Bridges.

FHWA Vehicle Class	Cost Responsibility for Structures	Cost Responsibility for Approaches and Wearing Surface	Total Load-Related Cost Responsibility	Share of Load-Related Cost Responsibility	Unit Load-Related Cost ($/VMT)
1	$341,196	$51,116	$392,313	0.43%	$0.0028
2	$37,220,636	$5,874,537	$43,095,173	47.27%	$0.0028
3	$15,667,472	$3,108,214	$18,775,686	20.60%	$0.0028
4	$229,857	$124,758	$354,615	0.39%	$0.0088
5	$2,133,752	$909,703	$3,043,455	3.34%	$0.0046
6	$1,904,119	$1,073,429	$2,977,549	3.27%	$0.0058
7	$3,169,833	$1,288,423	$4,458,256	4.89%	$0.0226
8	$849,613	$742,573	$1,592,186	1.75%	$0.0056
9	$7,819,819	$6,265,620	$14,085,439	15.45%	$0.0093
10	$680,307	$181,896	$862,203	0.95%	$0.0190
11	$85,011	$119,285	$204,296	0.22%	$0.0220
12	$371,664	$36,305	$407,969	0.45%	$0.1201
13	$804,858	$105,461	$910,319	1.00%	$0.0587

unit cost was calculated by dividing the cost responsibility by the four-year total VMT of each vehicle class. Figures 3.2.12 and 3.2.13 show the cost responsibility and unit cost, respectively.

Tables 3.2.21 and 3.2.22 and Figures 3.2.14, 3.2.15, 3.2.16, and 3.2.17 present similar results for non-Interstate NHS and non-NHS.

Tables 3.3.23, 3.3.24, and 3.3.25 present detailed four-year total cost responsibility results and four-year average unit cost results for Interstates, Non-Interstate NHS, and Non-NHS, respectively.

Table 3.2.26 presents the bridge cost responsibility results for all state route classes by project type for the total four years (2009–2012). Figure 3.2.18 presents the average unit cost of each vehicle class for all state route classes.

Table 3.2.27 and Figure 3.2.19 present additional information on the proportion of load-related costs and common costs in the total bridge-related expenditures.

TABLE 3.2.15
Passenger Car Equivalents for Trucks.

Two-Way Flow Rates	Type of Terrain		
(pch)	Level	Rolling	Mountainous
– 600	1.7	2.5	7.2
>600–1200	1.2	1.9	7.2
>1200	1.1	1.5	7.2

TABLE 3.2.16
Adjusted Passenger Car Equivalents (PCE) for Different Highway Classes.

Vehicle	PCE		
Class	Interstate	Non-Interstate NHS	Non-NHS
1–3	1	1	1
4–7	1.35	2.2	2.2
8–13	1.6	2.2	2.2

TABLE 3.2.17
Total Common Costs for Bridges by Year and Highway Class.

	2009	2010	2011	2012	Average
Interstates	$11,086,202	$14,472,465	$49,742,105	$2,047,035	$19,336,952
Non-Interstate NHS	$10,634,642	$20,271,907	$7,387,039	$10,244,267	$12,134,464
Non-NHS	$10,327,317	$6,225,800	$8,804,085	$6,139,355	$7,874,139
Subtotal	$32,048,161	$40,970,172	$65,933,229	$18,430,657	$39,345,554

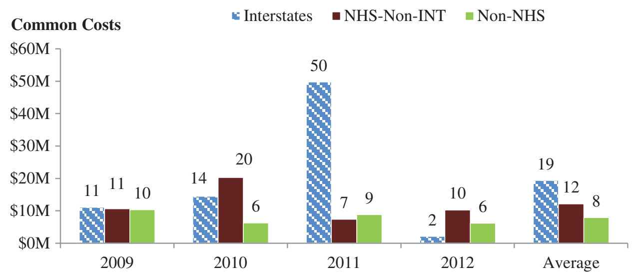


Figure 3.2.11 Total common costs for bridges by year and highway class.

TABLE 3.2.18
Bridge Common Cost Responsibility and Unit Common Cost.

	Interstates		Non-Interstate NHS		Non-NHS	
FHWA Vehicle Class	**Common Cost Responsibility**	**Unit Common Cost ($/VMT)**	**Common Cost Responsibility**	**Unit Common Cost ($/VMT)**	**Common Cost Responsibility**	**Unit Common Cost ($/VMT)**
1	$280,601	$0.0011	$244,351	$0.0008	$158,566	$0.0008
2	$40,593,482	$0.0011	$26,035,922	$0.0008	$17,404,537	$0.0008
3	$13,760,794	$0.0011	$10,052,115	$0.0008	$7,493,376	$0.0008
4	$290,102	$0.0014	$272,541	$0.0017	$74,816	$0.0017
5	$3,218,649	$0.0014	$3,283,394	$0.0017	$1,350,085	$0.0017
6	$534,641	$0.0014	$671,718	$0.0017	$1,009,133	$0.0017
7	$85,478	$0.0014	$207,748	$0.0017	$348,124	$0.0017
8	$1,013,584	$0.0015	$930,875	$0.0017	$595,276	$0.0018
9	$16,667,854	$0.0015	$6,480,050	$0.0017	$2,927,419	$0.0018
10	$160,073	$0.0015	$137,644	$0.0017	$84,035	$0.0018
11	$502,993	$0.0015	$144,497	$0.0017	$17,161	$0.0018
12	$190,002	$0.0015	$36,151	$0.0017	$6,079	$0.0018
13	$49,553	$0.0015	$40,848	$0.0017	$27,950	$0.0018

TABLE 3.2.19
Total Bridge Load-related Cost and Common Cost Responsibility for State Routes.

Vehicle Class	Load-related Cost Responsibility	Common Cost Responsibility	Total Cost Responsibility
1	$1,478,467	$722,283	$2,200,749
2	$178,534,166	$88,164,344	$266,698,510
3	$68,253,903	$32,900,977	$101,154,881
4	$1,755,098	$508,662	$2,263,760
5	$15,391,195	$6,300,465	$21,691,660
6	$6,018,650	$1,898,051	$7,916,701
7	$7,853,297	$543,173	$8,396,470
8	$4,977,964	$2,099,210	$7,077,174
9	$80,841,360	$23,018,024	$103,859,384
10	$3,547,053	$316,614	$3,863,667
11	$1,906,344	$596,270	$2,502,614
12	$1,531,296	$215,124	$1,746,419
13	$2,439,547	$99,021	$2,538,567
Total	$374,528,339	$157,382,218	$531,910,557

TABLE 3.2.20
Bridge Cost Responsibility and Unit Cost for Interstates.

FHWA Vehicle Class	Cost Responsibility	Cost Responsibility Share	Unit Cost ($/VMT)
1	$789,176	0.34%	$0.0031
2	$114,191,975	49.21%	$0.0031
3	$38,801,635	16.72%	$0.0031
4	$933,447	0.40%	$0.0045
5	$9,261,317	3.99%	$0.0041
6	$1,697,708	0.73%	$0.0045
7	$516,457	0.22%	$0.0085
8	$2,540,709	1.09%	$0.0038
9	$58,982,376	25.42%	$0.0054
10	$1,118,000	0.48%	$0.0105
11	$1,601,301	0.69%	$0.0048
12	$980,222	0.42%	$0.0078
13	$626,378	0.27%	$0.0190
Total	$232,040,699	100.00%	

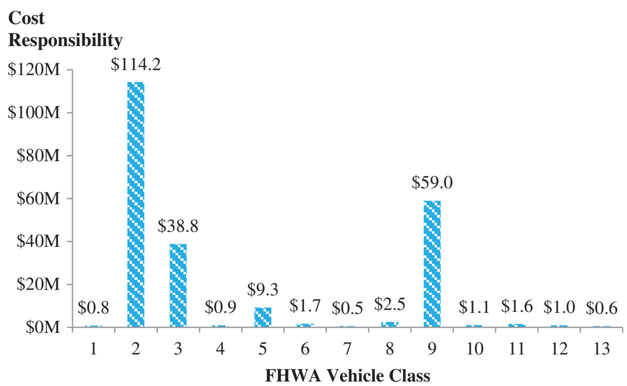


Figure 3.2.12 Bridge cost responsibility for Interstates.

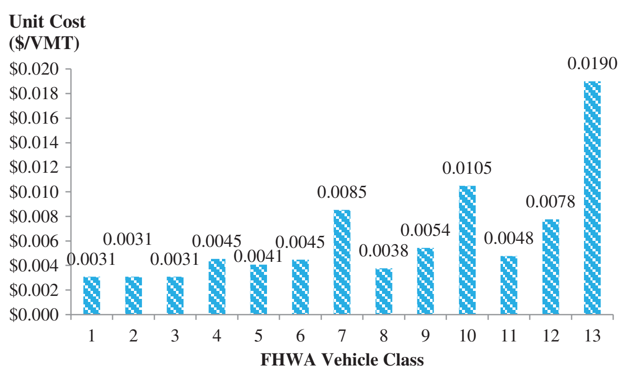


Figure 3.2.13 Bridge unit cost ($/VMT) for Interstates.

2.4 Chapter Summary

In this chapter, the methodological framework for bridge cost allocation was established, including the correlation between the present study vehicle (FHWA) and the AASHTO design vehicle, the step-by-step process for new bridge construction cost allocation, and the additional considerations for bridge replacement and rehabilitation cost allocation. Specifically, the load-related expenditures for new bridge construction, bridge replacement, and bridge rehabilitation and repair were analyzed using the incremental method. The non-load-related expenditures for these bridge projects were treated as common costs and PCE-weighted VMT (PCE-miles) was used as the allocator. Then, the bridge-related expenditures obtained from the INDOT databases were summarized and presented from different perspectives, such as highway class, project type, and expenditure category, using a series of tables and charts. Further, these bridge-related expenditures were analyzed separately as load-related costs and common costs. The results were then combined and finally allocated to the different FHWA vehicle classes. The cost responsibility and unit cost results were illustrated using a number of tables and graphs.

TABLE 3.2.21
Bridge Cost Responsibility and Unit Cost for Non-Interstate NHS

FHWA Vehicle Class	Cost Responsibility	Cost Responsibility Share	Unit Cost ($/VMT)
1	$821,930	0.46%	$0.0025
2	$87,876,422	49.59%	$0.0026
3	$34,489,491	19.46%	$0.0026
4	$1,029,679	0.58%	$0.0064
5	$9,588,466	5.41%	$0.0050
6	$2,549,752	1.44%	$0.0064
7	$3,171,810	1.79%	$0.0259
8	$2,789,529	1.57%	$0.0050
9	$30,921,449	17.45%	$0.0084
10	$1,864,567	1.05%	$0.0226
11	$748,238	0.42%	$0.0087
12	$369,258	0.21%	$0.0171
13	$993,250	0.56%	$0.0406
Total	$177,213,843	100.00%	

TABLE 3.2.22
Bridge Cost Responsibility and Unit Cost for Non-NHS.

FHWA Vehicle Class	Cost Responsibility	Cost Responsibility Share	Unit Cost ($/VMT)
1	$550,878	0.45%	$0.0028
2	$60,499,710	49.32%	$0.0028
3	$26,269,062	21.42%	$0.0029
4	$429,431	0.35%	$0.0098
5	$4,393,539	3.58%	$0.0055
6	$3,986,681	3.25%	$0.0067
7	$4,806,380	3.92%	$0.0235
8	$2,187,463	1.78%	$0.0065
9	$17,012,858	13.87%	$0.0103
10	$946,238	0.77%	$0.0200
11	$221,457	0.18%	$0.0229
12	$414,048	0.34%	$0.1210
13	$938,270	0.76%	$0.0597
Total	$122,656,016	100.00%	

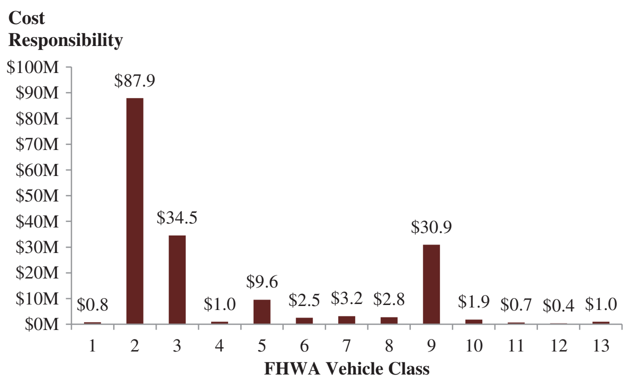


Figure 3.2.14 Bridge cost responsibility for Non-Interstate NHS.

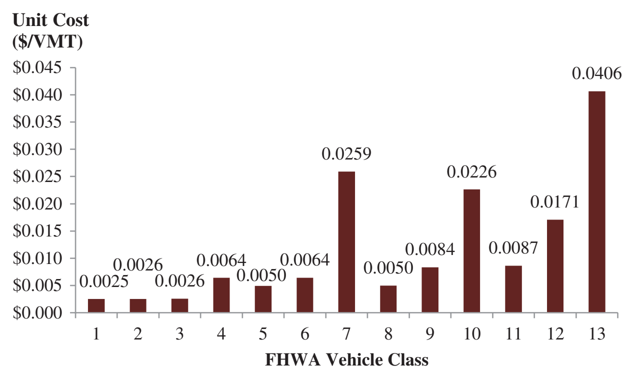


Figure 3.2.15 Bridge unit cost ($/VMT) for Non-Interstate NHS.

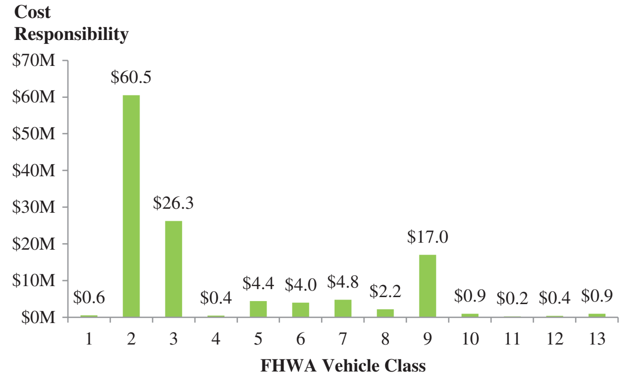


Figure 3.2.16 Bridge cost responsibility for Non-NHS.

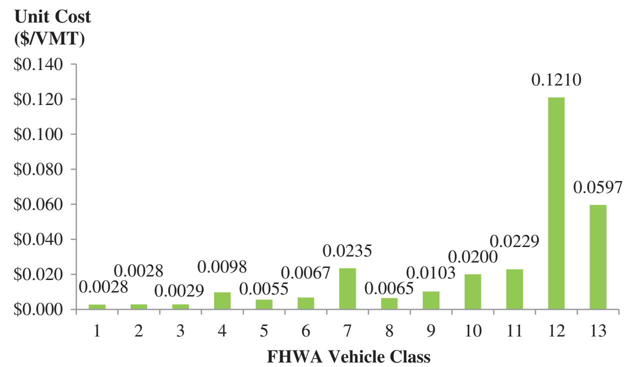


Figure 3.2.17 Bridge unit cost ($/VMT) for Non-NHS.

TABLE 3.2.23
Bridge Cost Responsibility and Unit Costs by Project Type, Interstates.

2009–2012	**New Bridge Construction**		**Bridge Replacement**		**Bridge Rehab/Repair**		**In-House Maintenance**		**Bridge Total**	
Veh. Class	**Cost Resp. (million $)**	**Unit Cost ($/VMT)**	**Cost Resp. (million $)**	**Unit Cost ($/VMT)**	**Cost Resp. (million $)**	**Unit Cost ($/VMT)**	**Cost Resp. (million $)**	**Unit Cost ($/VMT)**	**Cost Resp. (million $)**	**Unit Cost ($/VMT)**
1	$0.45	$0.0018	$0.25	$0.0010	$0.08	$0.0003	$0.01	$0.00006	$0.79	$0.0032
2	$65.09	$0.0018	$36.05	$0.0010	$11.04	$0.0003	$2.02	$0.00006	$114.19	$0.0032
3	$22.10	$0.0018	$12.28	$0.0010	$3.74	$0.0003	$0.68	$0.00006	$38.80	$0.0032
4	$0.53	$0.0024	$0.31	$0.0015	$0.08	$0.0004	$0.02	$0.00006	$0.93	$0.0043
5	$5.38	$0.0022	$2.83	$0.0012	$0.89	$0.0003	$0.17	$0.00006	$9.26	$0.0038
6	$0.96	$0.0024	$0.55	$0.0014	$0.16	$0.0004	$0.03	$0.00006	$1.70	$0.0042
7	$0.25	$0.0041	$0.22	$0.0036	$0.04	$0.0006	$0.00	$0.00006	$0.52	$0.0083
8	$1.22	$0.0016	$0.97	$0.0014	$0.28	$0.0003	$0.06	$0.00006	$2.54	$0.0033
9	$31.20	$0.0026	$21.59	$0.0019	$5.22	$0.0004	$0.96	$0.00006	$58.98	$0.0050
10	$0.47	$0.0042	$0.56	$0.0052	$0.08	$0.0006	$0.01	$0.00006	$1.12	$0.0101
11	$0.72	$0.0019	$0.69	$0.0020	$0.16	$0.0004	$0.03	$0.00006	$1.60	$0.0043
12	$0.41	$0.0030	$0.48	$0.0037	$0.08	$0.0005	$0.01	$0.00006	$0.98	$0.0073
13	$0.26	$0.0077	$0.33	$0.0098	$0.04	$0.0010	$0.00	$0.00006	$0.63	$0.0186
Total	**$129.06**		**$77.09**		**$21.88**		**$4.01**		**$232.04**	

Resp: Responsibility.

TABLE 3.2.24
Bridge Cost Responsibility and Unit Costs by Project Type, Non-Interstate NHS

2009–2012	New Bridge Construction		Bridge Replacement		Bridge Rehab/Repair		In-House Maintenance		Bridge Total	
Veh. Class	Cost Resp. (million $)	Unit Cost ($/VMT)	Cost Resp. (million $)	Unit Cost ($/VMT)	Cost Resp. (million $)	Unit Cost ($/VMT)	Cost Resp. (million $)	Unit Cost ($/VMT)	Cost Resp. (million $)	Unit Cost ($/VMT)
1	$0.44	$0.0013	$0.36	$0.0012	$0.02	$0.0001	$0.01	$0.00003	$0.82	$0.0025
2	$46.76	$0.0014	$38.39	$0.0012	$1.71	$0.0001	$1.02	$0.00003	$87.88	$0.0026
3	$18.20	$0.0013	$15.24	$0.0012	$0.67	$0.0001	$0.39	$0.00003	$34.49	$0.0026
4	$0.52	$0.0029	$0.47	$0.0026	$0.02	$0.0001	$0.01	$0.00003	$1.03	$0.0057
5	$5.28	$0.0023	$3.97	$0.0018	$0.22	$0.0001	$0.13	$0.00003	$9.59	$0.0042
6	$1.30	$0.0028	$1.15	$0.0026	$0.07	$0.0001	$0.03	$0.00003	$2.55	$0.0056
7	$1.03	$0.0077	$2.09	$0.0168	$0.05	$0.0003	$0.01	$0.00003	$3.17	$0.0248
8	$1.29	$0.0019	$1.37	$0.0022	$0.10	$0.0001	$0.04	$0.00003	$2.79	$0.0043
9	$14.31	$0.0042	$15.22	$0.0038	$1.15	$0.0003	$0.24	$0.00003	$30.92	$0.0083
10	$0.57	$0.0065	$1.27	$0.0151	$0.03	$0.0003	$0.01	$0.00003	$1.86	$0.0219
11	$0.28	$0.0041	$0.43	$0.0047	$0.03	$0.0003	$0.01	$0.00003	$0.75	$0.0091
12	$0.11	$0.0068	$0.25	$0.0113	$0.01	$0.0002	$0.00	$0.00003	$0.37	$0.0184
13	$0.28	$0.0113	$0.70	$0.0282	$0.01	$0.0004	$0.00	$0.00003	$0.99	$0.0400
Total	$90.36		$80.91		$4.06		$1.88		$177.21	

Resp: Responsibility.

TABLE 3.2.25
Bridge Cost Responsibility and Unit Costs by Project Type, Non-NHS.

2009–2012	New Bridge Construction		Bridge Replacement		Bridge Rehab/Repair		In-House Maintenance		Bridge Total	
Veh. Class	Cost Resp. (million $)	Unit Cost ($/VMT)	Cost Resp. (million $)	Unit Cost ($/VMT)	Cost Resp. (million $)	Unit Cost ($/VMT)	Cost Resp. (million $)	Unit Cost ($/VMT)	Cost Resp. (million $)	Unit Cost ($/VMT)
1	$0.22	$0.0012	$0.30	$0.0016	$0.01	$0.0001	$0.02	$0.00011	$0.55	$0.0029
2	$23.83	$0.0011	$33.12	$0.0016	$1.55	$0.0001	$2.00	$0.00011	$60.50	$0.0029
3	$10.01	$0.0011	$14.72	$0.0017	$0.67	$0.0001	$0.86	$0.00011	$26.27	$0.0030
4	$0.17	$0.0036	$0.24	$0.0051	$0.01	$0.0002	$0.01	$0.00010	$0.43	$0.0090
5	$1.77	$0.0020	$2.34	$0.0025	$0.12	$0.0001	$0.16	$0.00010	$4.39	$0.0047
6	$1.38	$0.0021	$2.36	$0.0035	$0.13	$0.0002	$0.12	$0.00010	$3.99	$0.0059
7	$1.51	$0.0072	$3.15	$0.0150	$0.10	$0.0005	$0.04	$0.00010	$4.81	$0.0227
8	$0.75	$0.0020	$1.30	$0.0034	$0.07	$0.0002	$0.07	$0.00011	$2.19	$0.0057
9	$5.16	$0.0029	$10.87	$0.0061	$0.64	$0.0003	$0.34	$0.00011	$17.01	$0.0094
10	$0.32	$0.0066	$0.59	$0.0120	$0.02	$0.0004	$0.01	$0.00011	$0.95	$0.0191
11	$0.06	$0.0055	$0.16	$0.0162	$0.00	$0.0003	$0.00	$0.00011	$0.22	$0.0221
12	$0.13	$0.0381	$0.28	$0.0812	$0.00	$0.0007	$0.00	$0.00011	$0.41	$0.1202
13	$0.29	$0.0182	$0.63	$0.0397	$0.01	$0.0008	$0.00	$0.00011	$0.94	$0.0588
Total	$45.59		$70.07		$3.35		$3.64		$122.66	

Resp: Responsibility.

TABLE 3.2.26
Bridge Cost Responsibility Results for State Routes by Project Type, 2009–2012.

Vehicle Class	New Bridge Construction	Bridge Replacement	Bridge Rehab/Repair	In-House Maintenance	Bridge Total
1	$1,106,803	$907,006	$106,472	$41,704	$2,161,985
2	$135,677,736	$107,558,320	$14,298,531	$5,033,520	$262,568,107
3	$50,304,318	$42,237,041	$5,081,519	$1,937,310	$99,560,188
4	$1,222,107	$1,017,707	$118,059	$34,684	$2,392,557
5	$12,423,858	$9,143,977	$1,218,641	$456,847	$23,243,323
6	$3,633,765	$4,066,860	$359,212	$174,304	$8,234,141
7	$2,796,332	$5,453,613	$190,688	$54,015	$8,494,648
8	$3,259,429	$3,642,097	$451,248	$164,926	$7,517,700
9	$50,667,974	$47,685,898	$7,017,270	$1,545,542	$106,916,683
10	$1,363,252	$2,418,780	$122,244	$24,529	$3,928,805
11	$1,061,983	$1,281,189	$190,487	$37,337	$2,570,996
12	$656,211	$1,009,256	$84,719	$13,342	$1,763,527
13	$837,098	$1,654,370	$58,682	$7,749	$2,557,898
Total	$265,010,865	$228,076,113	$29,297,771	$9,525,807	$531,910,557

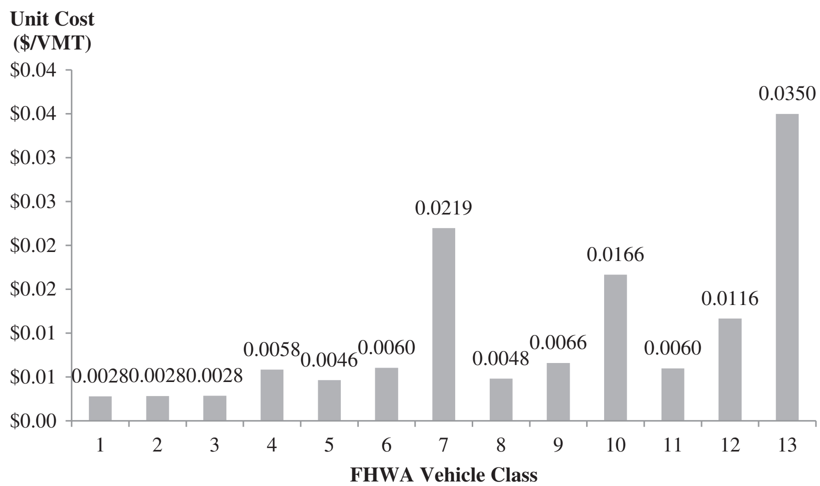


Figure 3.2.18 Average annual unit cost ($/VMT) for bridge expenditures on state routes, 2009–2012.

TABLE 3.2.27
Proportion of Load-Related Costs and Common Costs with respect to Total Expenditures.

	2009	2010	2011	2012	Average
Total Expenditures	$133,397,142	$148,094,874	$155,909,512	$84,403,011	$130,451,135
Load-Related Expenditures %	76.9%	73.2%	57.8%	78.1%	70.4%
Common Expenditures %	23.1%	26.8%	42.2%	21.9%	29.6%

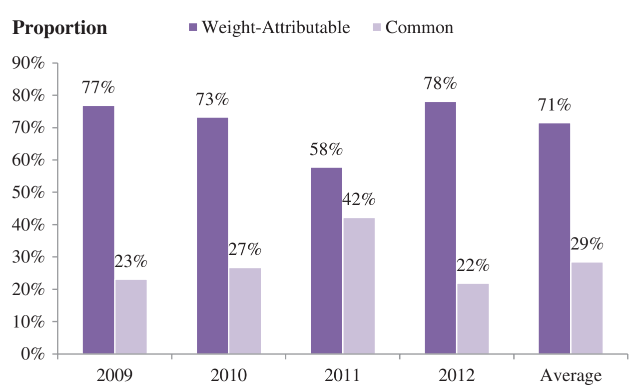


Figure 3.2.19 Percentages between load-related costs and common costs.

3. COST ALLOCATION FOR SAFETY, MOBILITY, AND OTHER EXPENDITURES ON STATE ROUTES

In the 1997 FHWA HCAS, safety, mobility, and other related expenditures were considered under "system enhancement costs." In the present study, mobility projects are similar to the project types categorized as Transportation System Management (TSM) projects and Intelligent Transportation System (ITS) projects in the 1997 FHWA HCAS. Also, it was pointed out in the 1997 FHWA HCAS that the distinction between safety improvements and mobility improvements is blurred, "since traffic operations improvements often improve safety and safety improvements may enhance traffic operations." The 2009 Oregon HCAS, which divided the expenditures into very detailed categories, included items such as traffic service improvements, safety improvements, preliminary and construction engineering, right-of-way (and utilities) and grading and drainage.

3.1 Study Methodology for Safety, Mobility, and Other Cost Allocation

As stated in Chapter 2 of Part 1, expenditures on safety, mobility, and other related work are typically included and analyzed as common costs in all highway cost allocation studies. However, in some studies, certain expenditure items, such as mobility and right-of-way, can be considered as being related to vehicle size (e.g., PCE-weighted VMT is typically used as the allocator for such costs that are attributable to vehicle size). In such cases, the common cost comprises "truly" common cost which is allocated simply based on VMT and vehicle size-attributable cost which is allocated based of PCE-weighted VMT (or PCE-miles).

FHWA (1997) indicated that "traffic operations/TSM projects are undertaken primarily to improve highway level of service, reduce congestion, and otherwise improve highway system efficiency…construction costs are [therefore] allocated on the basis of PCE-weighted VMT to reflect the contribution of different vehicle classes to congestion and diminished level of service." In the 2009 Oregon study, traffic service improvements costs were also allocated by PCE-weighted VMT. Thus, in the present study, following the common practice, the mobility-related costs are allocated by PCE-weighted VMT (or PCE-miles).

With regard to safety-related costs, FHWA (1997) explained that "while the relationship between PCEs, level of service, and safety improvements is not as clear as for TSM improvements, large trucks contribute more to the need for certain safety improvements than do automobiles and light trucks, and some additional safety improvement costs may be incurred to accommodate the operational characteristics of heavy trucks." Thus, in FHWA (1997), construction costs for safety improvements also are allocated using PCE-weighted VMT. The 2009 Oregon study also used "congested PCE" as the allocator for safety improvements. In the present study, as the safety-related items mostly consist of cable barriers, guard rails, bridge railings, overhead sign structures, etc., it makes sense that these safety projects are attributable to vehicle size, that is, larger and stronger safety facilities must be built to accommodate larger vehicles, and thus more costs are incurred due to larger vehicles. Therefore, the safety-related costs are also allocated by PCE-miles.

For the remaining cost categories, the right-of-way expenditures were allocated based on PCE-miles, as with the 2009 Oregon study. The expenditures on drainage and erosion control, in-house maintenance, preliminary engineering, utilities and railroad, and other projects were also considered as being directly or indirectly related to vehicle size, because it can be expected that these expenditures are higher when larger and heavier vehicles need to be accommodated. The remaining expenditure types were categorized as miscellaneous items regarded as strictly common costs, and therefore allocated using VMT as the allocator.

As already mentioned in Part 2, Section 2.2.3, the PCE units for Interstates were acquired from the results of a study by Sinha et al. (2011). The estimated PCE values for single-unit and combination truck for basic urban freeways in Indiana were 1.35 and 1.60 respectively. The PCE units for the non-Interstate NHS and non-NHS used in the present study were adjusted from Table 3.3.1 which appears in the *Highway Capacity Manual 2000* (TRB, 2000). Given the terrain of Indiana, 2.20 (average of 1.9 and 2.5) was used as an estimated PCE unit for trucks for both non-Interstate NHS and non-NHS. Table 3.3.2 the PCE units used in the present study. The PCE-weighted VMT (PCE-miles) was calculated as the actual VMT multiplied by the corresponding PCE unit.

3.2 Data for Safety, Mobility, and Other Cost Allocation

3.2.1 Safety, Mobility, and Other-Related Contract Expenditures

Contract expenditures related to safety, mobility, drainage and erosion control, other construction/earthwork pro-

TABLE 3.3.1
Passenger Car Equivalents for Trucks.

Two-Way Flow Rates (pch)	Type of Terrain		
	Level	Rolling	Mountainous
– 600	1.7	2.5	7.2
>600–1200	1.2	1.9	7.2
>1200	1.1	1.5	7.2

TABLE 3.3.2
Adjusted Passenger Car Equivalents (PCE) for Different Highway Classes.

Vehicle Class	PCE		
	Interstate	Non-Interstate NHS	Non-NHS
1–3	1	1	1
4–7	1.35	2.2	2.2
8–13	1.6	2.2	2.2

TABLE 3.3.3
Expenditure Items for Safety Projects.

Description
Bridge railings
Cable barrier system
Delineators
Fences
Ground mounted signs
Guard rail
Highway illumination
Overhead sign structures
Pavement traffic marking
Traffic controls for construct. and maintenance
Traffic signals

jects, and miscellaneous items were obtained from the INDOT Site Manager database. The expenditures obtained were for 2009–2012. The expenditure items for safety projects are presented in Table 3.3.3 and the relevant earthworks associated with the safety items are presented in Table 3.3.4. Intelligent Transportation System (ITS) expenditures were considered in the present study as mobility expenditures; and any relevant expenditure items associated with ITS installation, operations, and management were also considered as mobility expenditures as presented in Table 3.3.5. Drainage and erosion control expenditures are presented in Table 3.3.6, and the relevant construction and earthwork expenditures associated with drainage and erosion control are presented in Table 3.3.7. There were other construction and earthwork projects that were not considered as part of the above-mentioned categories; those projects were categorized as "other" projects (see Table 3.3.8). The remaining expenditure items were considered as miscellaneous and are presented in Table 3.3.9.

TABLE 3.3.4
Relevant Earthwork Expenditures for Safety Projects.

Description
Annual routine maintenance
Clearing and grubbing
Concrete barrier
Concrete floor slabs
Concrete header
Curbing
Excavation and Embankment
Flowable mortar
Gabions
Geotechnical instrumentation
Piling
Pneumatically placed mortar
Reinforcing steel
Riprap and slopewall
Special fill and backfill ("B" Borrow)
Steel structures
Stockpiled materials
Structural concrete
Structure excavation
Subbase
Subgrade
Surfaces for approaches
Temporary traffic signals
Widening and patching

TABLE 3.3.5
Expenditure Items and Relevant Earthwork Expenditures for Mobility Projects.

Description
Annual routine maintenance
Drilled shaft
Excavation and embankment
Ground mounted signs
Pneumatically placed mortar
Riprap and slopewall
Special fill and backfill ("B" Borrow)
Stockpiled materials
Subbase
Subgrade
Surfaces for approaches
Traffic signals
Widening and patching

TABLE 3.3.6
Expenditure Items for Drainage and Erosion Control Projects.

Description
Automatic drainage gates
Concrete box culverts & retaining walls
Culvert, storm & sanitary sewers
Detention ponds
Erosion control
Geocomposite pavement edge drain
Jacked pipe
Manholes, inlets and catch basins
Paved side ditch or concrete gutter
Shoulder drains
Structure plate pipe, pipe-arches & arches
Three-sided structures
Tile drains
Underdrains
Water main items

TABLE 3.3.7
Relevant Earthworks Expenditures for Drainage and Erosion Control Projects.

Description
Clearing and grubbing
Curbing
Excavation and embankment
Riprap and slopewall
Subgrade
Reconditioning
Special fill and backfill ("B" Borrow)
Steel structures
Stockpiled selected materials
Structure excavation
Surfaces for approaches
Widening and patching

TABLE 3.3.8
Expenditure Items for Other Projects.

Description
Annual routine maintenance
Clearing and grubbing
Concrete floor slabs
Concrete header
Curbing
Drilled shaft
Excavation and embankment
Flowable mortar
Gabions
Geotechnical instrumentation
Mechanically stabilized earth retaining wall
Piling
Pneumatically placed mortar
Recast and prestress concrete structural member
Reconditioning
Reinforcing steel
Riprap and slopewall
Special fill and backfill ("B" Borrow)
Steel structures
Stockpiled materials, stockpiled selected materials
Structural concrete, structural expansion joints
Structure excavation
Subbase, subgrade
Surfaces for approaches
Widening and patching

Tables 3.3.10 to 3.3.14 and Figures 3.3.1 to 3.3.5 present detailed information on safety, mobility, and other contract expenditures for the different highway classes, from 2009 to 2012. There were no recorded expenditures with regard to mobility contract expenditures for 2012. For 2010, the only mobility expenditure data available were for Interstates, while in 2011, the only mobility expenditure data available were for non-NHS.

3.2.2 Safety, Mobility, and Other-Related In-House Maintenance Expenditures

Data on in-house maintenance expenditures related to safety, mobility, and others were obtained from INDOT for the calendar years of 2009–2012. The expenditures are presented in Table 3.3.15 and Figure 3.3.6. The amounts shown are the dollar values at the respective years. It can be seen that the in-house maintenance expenditures for non-Interstates were relatively higher than that for Interstates.

3.2.3 Expenditures on Right-of-Way, PE, Utilities, and Railroad

The annual expenditures on right-of-way acquisition are presented in Table 3.3.16 and Figure 3.3.7 by highway class. Generally, it can be observed that the total annual expenditure on ROW acquisition continued to increase. Also, non-Interstate ROW expenditures were significantly higher than for Interstates. Expenditure data on Preliminary Engineering (PE) for highway-related projects for 2009–2012 were also obtained from INDOT, and these annual expenditures by highway class are presented in Table 3.3.17 and Figure 3.3.8. This expenditure category was considered as a common cost. Utilities and railroad expenditures related to highway development in Indiana for 2009–2012 were obtained from INDOT and the annual expenditures by highway class are presented in Table 3.3.18 and Figure 3.3.9.

3.3 Analysis and Results

Based on the methodology proposed in Section 3.1 of this Part of the report, different expenditures were allocated using either PCE-weighted VMT or VMT. Tables 3.3.19, 3.3.20, and 3.3.21 present the results for the different expenditure categories for Interstates, non-Interstate NHS, and non-NHS, respectively.

Table 3.3.22 summarizes the allocation results for the total expenditures on safety, mobility, and others. The cost responsibility reflects the four-year total expenditures. The results for individual years can be found in Addendum C of this report. The unit cost was calculated as the cost responsibility divided by the total four-year VMT of the corresponding vehicle class. Figure 3.3.10 and 3.3.11 also illustrate the analysis results. Similarly, Table 3.3.23 and 3.3.24 and Figures 3.3.12 to 3.3.15 present the results for non-Interstate NHS and non-NHS.

Table 3.3.25 presents the cost responsibility results for safety, mobility and others for all state routes in Indiana from 2009 to 2012. Figure 3.3.16 presents the average unit cost of each vehicle class for all state route classes.

TABLE 3.3.9
Expenditure Items for Miscellaneous Projects.

Description
Architectural features
Control of Work
Crossovers, driveways and mailbox install
Field offices and laboratories
Final trimming and cleaning
Herbicide treatment
Legal relations-responsibility to public
Measurement and payment
Mobilization and demobilization
Monuments, markers and parking barriers
Owner and contractors liability insurance
Partnership overhead
Planting trees, shrubs, and vines
Prosecution and progress
Removal of structures and obstructions
Repointing masonry in structures
Roadside mowing
Scope of work
Seeding and sodding
Sidewalks, curb ramps, and steps
Steel structures
Temporary bridges and approaches
Timber structures

TABLE 3.3.10
Safety-Related Contract Expenditures by Year and Highway Class.

Highway Class	2009	2010	2011	2012	Average
Interstates	$41,782,839	$38,094,271	$32,624,188	$11,811,439	$31,078,184
Non-Interstate NHS	$27,279,301	$21,647,557	$29,258,605	$19,257,679	$24,360,786
Non-NHS	$81,567,350	$58,419,586	$47,521,192	$33,702,357	$55,302,621
Total	$150,629,490	$118,161,414	$109,403,986	$64,771,475	$110,741,591

TABLE 3.3.11
Mobility-Related Contract Expenditures by Year and Highway Class.

Highway Class	2009	2010	2011	2012	Average
Interstates	$1,973,643	$4,083,680	$0	$0	$1,514,331
Non-Interstate NHS	$0	$0	$0	$0	$0
Non-NHS	$4,011,707	$0	$848,279	$0	$1,214,997
Total	$5,985,350	$4,083,680	$848,279	$0	$2,729,327

TABLE 3.3.12
Drainage and Erosion Control Related Contract Expenditures by Year and Highway Class.

Highway Class	2009	2010	2011	2012	Average
Interstates	$24,207,737	$32,606,619	$36,421,055	$9,953,396	$25,797,202
Non-Interstate NHS	$36,334,159	$27,917,203	$35,001,460	$20,930,700	$30,045,880
Non-NHS	$81,764,406	$58,902,697	$55,492,213	$41,555,048	$59,428,591
Total	$142,306,301	$119,426,520	$126,914,728	$72,439,144	$115,271,673

TABLE 3.3.13
"Other Projects" Contract Expenditures by Year and Highway Class.

Highway Class	2009	2010	2011	2012	Average
Interstates	$3,533,737	$658,419	$6,189,163	$1,056,994	$2,859,578
Non-Interstate NHS	$452,991	$368,824	$1,960,463	$3,283,324	$1,516,401
Non-NHS	$13,333,647	$16,649,681	$17,829,946	$13,751,349	$15,391,156
Total	$17,320,375	$17,676,924	$25,979,572	$18,091,668	$19,767,135

TABLE 3.3.14
Miscellaneous Contract Expenditures by Year and Highway Class.

Highway Class	2009	2010	2011	2012	Average
Interstates	$69,322,441	$275,149,317	$91,095,991	$21,686,821	$114,313,643
Non-Interstate NHS	$47,891,735	$150,517,554	$54,748,164	$36,417,216	$72,393,667
Non-NHS	$121,488,785	$164,270,705	$84,335,136	$58,313,520	$107,102,037
Total	$238,702,960	$589,937,577	$230,179,292	$116,417,557	$293,809,346

3.4 Chapter Summary

In this chapter, the allocators for expenditures on safety, mobility, and other projects were determined using outcomes from the 1997 FHWA HCAS and the 2009 Oregon HCAS. A series of tables and figures presented the expenditures of various categories by year and highway class. Next, these expenditures were analyzed using either PCE-miles or VMT. The results were then combined and allocated to the different FHWA vehicle classes. The cost responsibility and unit cost results for the different highway classes were presented.

It was found that the cost responsibility distributions varied among the different highway classes. Specifically, the unit cost for Non-NHS was found to be higher than the other two highway functional classes. With respect to small vehicles (i.e., vehicle classes 1–3), the unit costs ($/VMT) were found to be 0.0122, 0.0149, and 0.0406 for Interstates, Non-Interstate NHS, and Non-NHS, respectively. With respect to single-unit trucks (i.e., vehicle

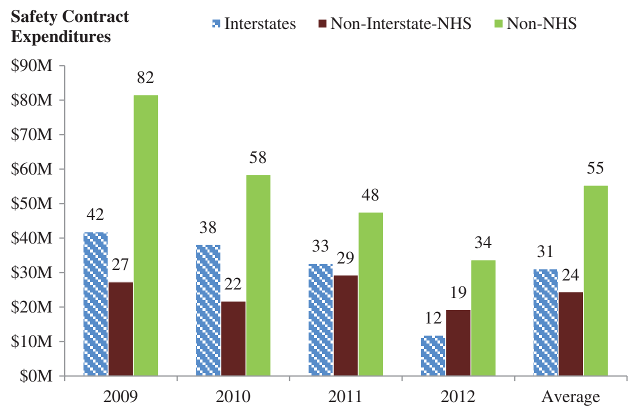


Figure 3.3.1 Safety-related contract expenditures by year and highway class.

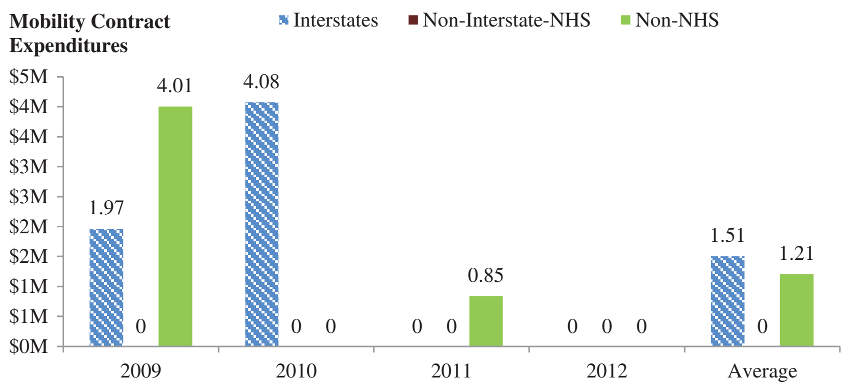


Figure 3.3.2 Mobility-related contract expenditures by year and highway class.

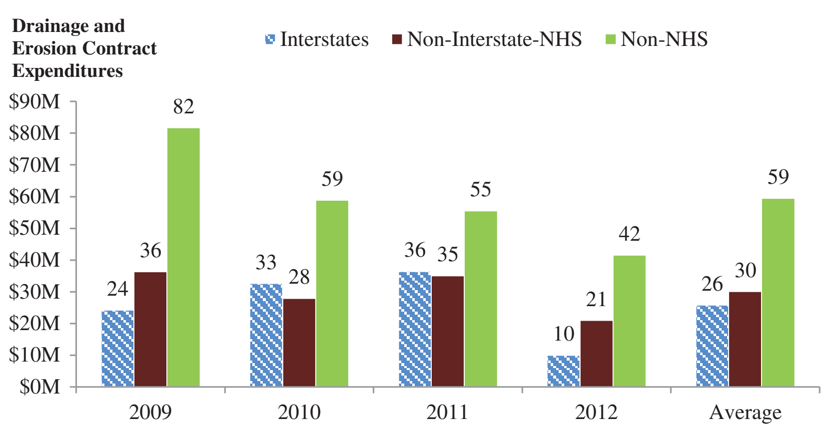


Figure 3.3.3 Drainage and erosion control related contract expenditures by year and highway class.

classes 4–7), the unit costs ($/VMT) were found to be approximately 0.0153, 0.0261, and 0.0722 for Interstates, Non-Interstate NHS, and Non-NHS, respectively. For combination trucks (i.e., vehicle classes 8–13), the unit costs ($/VMT) were found to be approximately 0.0167, 0.0264, and 0.0740 for Interstates, Non-Interstate NHS, and Non-NHS, respectively. Smaller vehicles were found to have a lower unit cost because certain costs were allocated as vehicle size-attributable costs using PCE-miles as the allocator.

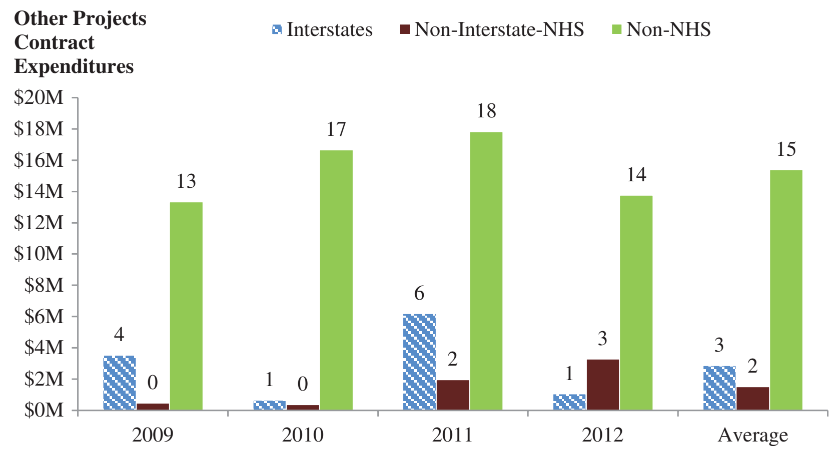


Figure 3.3.4 Other projects contract expenditures by year and highway class.

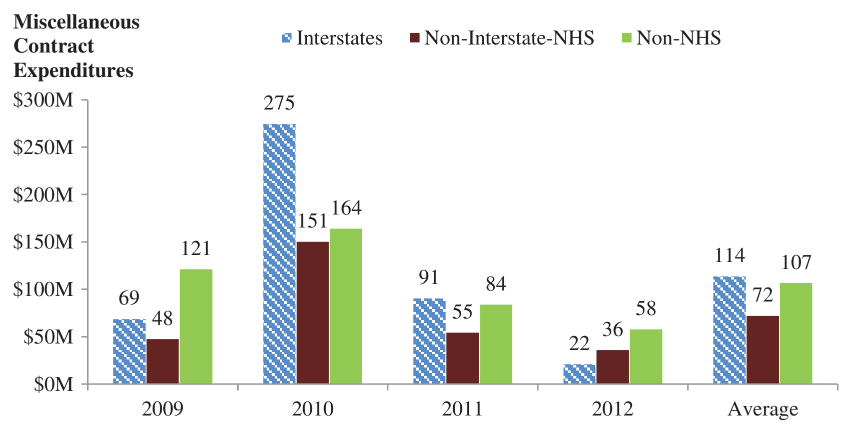


Figure 3.3.5 Miscellaneous contract expenditures by year and highway class.

TABLE 3.3.15
Safety, Mobility, and Other-Related In-House Maintenance Expenditures by Year and Highway Class.

Highway Class	2009	2010	2011	2012	Average
Interstates	$5,964,321	$7,297,290	$5,858,937	$7,314,260	$6,608,702
Non-Interstate NHS	$9,982,244	$9,792,720	$9,848,843	$10,766,436	$10,097,561
Non-NHS	$16,690,326	$14,960,351	$14,401,968	$16,076,334	$15,532,245
Total	$32,636,891	$32,050,361	$30,109,748	$34,157,029	$32,238,508

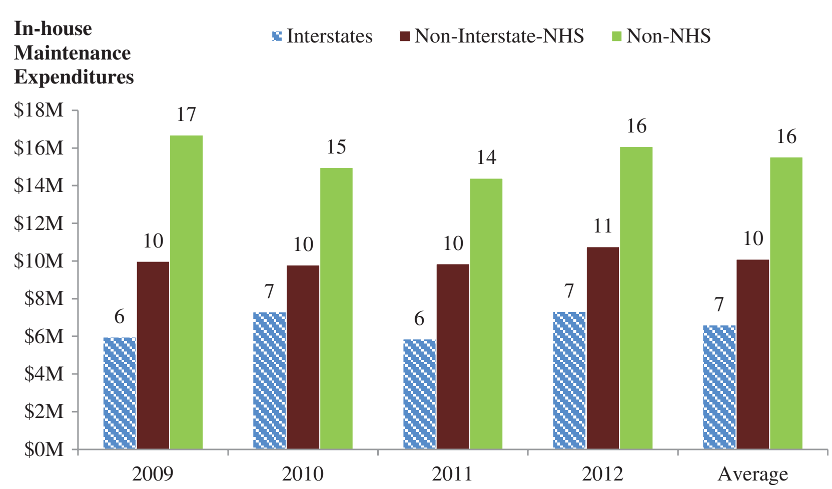


Figure 3.3.6 Safety, mobility, and other-related in-house maintenance expenditures by year and highway class.

TABLE 3.3.16
Right-of-Way Expenditures by Year and Highway Class.

Highway Class	2009	2010	2011	2012	Average
Interstates	$20,006,644	$15,839,046	$879,861	$3,249,537	$9,993,772
Non-Interstate NHS	$22,535,518	$20,602,537	$40,364,379	$16,703,056	$25,051,372
Non-NHS	$34,714,586	$84,509,394	$81,841,097	$106,558,338	$76,905,854
Total	$77,256,748	$120,950,978	$123,085,337	$126,510,932	$111,950,998

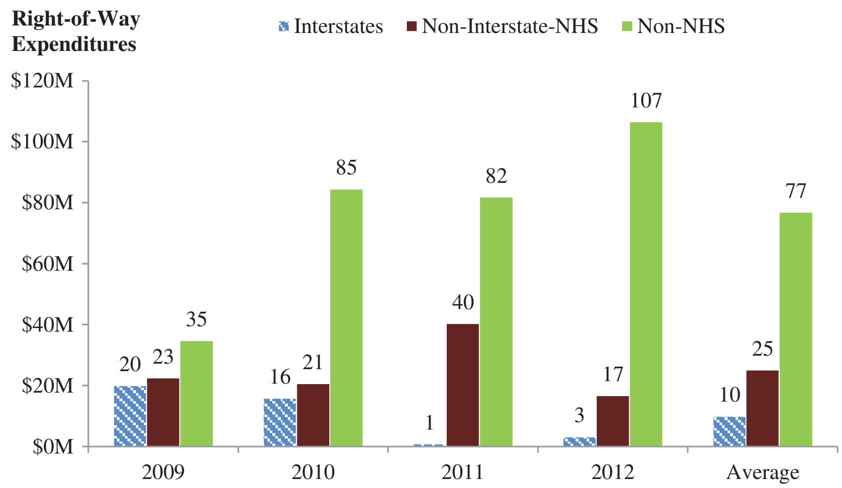


Figure 3.3.7 Right-of-way expenditures by year and highway class.

TABLE 3.3.17
Preliminary Engineering Expenditures by Year and Highway Class.

Highway Class	2009	2010	2011	2012	Average
Interstates	$41,522,342	$10,401,508	$5,576,509	$7,653,832	$16,288,548
Non-Interstate NHS	$39,756,683	$38,701,322	$28,337,301	$41,861,743	$37,164,262
Non-NHS	$4,276,545	$8,608,896	$14,298,682	$13,163,051	$10,086,794
Total	$85,555,570	$57,711,727	$48,212,492	$62,678,626	$63,539,604

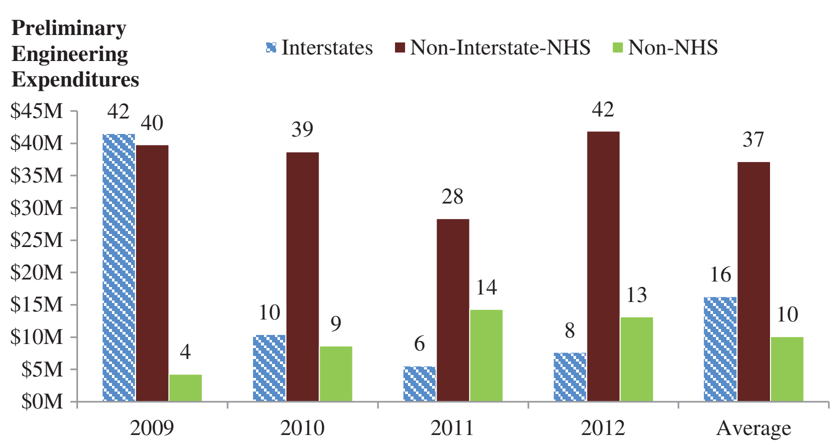


Figure 3.3.8 Preliminary engineering expenditures by year and highway class.

TABLE 3.3.18
Utilities and Railroad Expenditures by Year and Highway Class.

Highway Class	2009	2010	2011	2012	Average
Interstates	$8,027,471	$7,090,453	$5,135,392	$1,076,443	$5,332,440
Non-Interstate NHS	$19,501,447	$12,102,867	$30,999,688	$34,040,693	$24,161,174
Non-NHS	$15,695,106	$41,466,125	$56,060,804	$42,245,200	$38,866,809
Total	$43,224,023	$60,659,445	$92,195,885	$77,362,336	$68,360,422

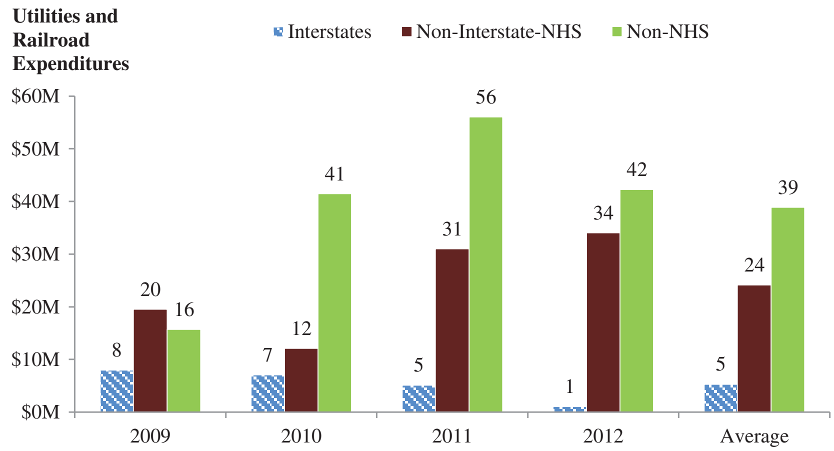


Figure 3.3.9 Utilities and railroad expenditures by year and highway class.

TABLE 3.3.19
Safety, Mobility and Other Cost Responsibility for Interstates.

Vehicle Class	Safety	Mobility	Drainage and Erosion Control	Other Projects	Miscellaneous
1	$425,065	$19,481	$359,151	$41,041	$1,753,350
2	$61,492,557	$2,818,225	$51,957,004	$5,937,265	$253,650,593
3	$20,845,376	$955,351	$17,612,917	$2,012,675	$85,985,075
4	$492,035	$25,588	$400,779	$43,161	$1,555,972
5	$5,459,061	$283,900	$4,446,592	$478,870	$17,263,317
6	$906,789	$47,158	$738,611	$79,544	$2,867,561
7	$144,977	$7,540	$118,089	$12,717	$458,466
8	$1,893,677	$103,360	$1,511,070	$155,419	$5,116,126
9	30,966,834	$1,704,677	$24,698,950	$2,539,217	$84,048,075
10	$299,065	$16,323	$238,640	$24,545	$807,979
11	$939,741	$51,293	$749,871	$77,127	$2,538,887
12	$354,981	$19,375	$283,259	$29,134	$959,047
13	$92,580	$5,053	$73,874	$7,598	$250,122

Vehicle Class	In-House Maintenance	Preliminary Engineering	Right-of-Way	Utility and Railway
1	$92,190	$215,393	$130,242	$72,153
2	$13,336,777	$31,160,092	$18,841,629	$10,438,039
3	$4,521,037	$10,562,967	$6,387,128	$3,538,393
4	$100,187	$266,532	$165,947	$85,784
5	$1,111,564	$2,957,135	$1,841,156	$951,767
6	$184,639	$491,201	$305,829	$158,095
7	$29,520	$78,533	$48,896	$25,276
8	$392,787	$1,065,939	$670,573	$330,999
9	$6,316,322	$17,407,156	$10,986,527	$5,434,490
10	$62,032	$168,342	$105,902	$52,274
11	$194,921	$528,974	$332,773	$164,259
12	$73,630	$199,816	$125,703	$62,048
13	$19,203	$52,113	$32,784	$16,182

TABLE 3.3.20
Safety, Mobility and Other Cost Responsibility for Non-Interstate NHS.

Vehicle Class	Safety	Mobility	Drainage and Erosion Control	Other Projects	Miscellaneous
1	$497,811	$0	$613,173	$31,290	$1,689,708
2	$53,042,262	$0	$65,334,219	$3,333,994	$180,040,230
3	$20,478,895	$0	$25,224,652	$1,287,210	$69,511,081
4	$528,777	$0	$649,523	$35,557	$835,121
5	$6,370,354	$0	$7,825,023	$428,367	$10,060,987
6	$1,303,249	$0	$1,600,845	$87,636	$2,058,279
7	$403,068	$0	$495,108	$27,104	$636,583
8	$1,883,559	$0	$2,321,747	$117,305	$2,935,795
9	$12,208,475	$0	$15,223,481	$671,884	$20,674,229
10	$278,512	$0	$343,305	$17,345	$434,101
11	$292,380	$0	$360,399	$18,209	$455,716
12	$73,148	$0	$90,165	$4,556	$114,011
13	$82,654	$0	$101,882	$5,148	$128,827

Vehicle Class	In-House Maintenance	Preliminary Engineering	Right-of-Way	Utility and Railway
1	$205,535	$752,976	$516,370	$496,449
2	$21,899,965	80,230,460	$55,019,844	$52,897,175
3	$8,455,278	$30,975,888	$21,242,412	$20,422,879
4	$225,441	$841,243	$528,709	$542,161
5	$2,715,970	$10,134,741	$6,369,534	$6,531,599
6	$555,634	$2,073,368	$1,303,081	$1,336,236
7	$171,846	$641,249	$403,016	$413,270
8	$777,945	$2,852,976	$1,950,802	$1,869,240
9	$5,082,490	19,053,444	$12,119,084	$11,414,515
10	$115,031	$421,855	$288,455	$276,395
11	$120,759	$442,860	$302,818	$290,157
12	$30,211	$110,795	$75,759	$72,592
13	$34,138	$125,193	$85,604	$82,025

TABLE 3.3.21
Safety, Mobility and Other Cost Responsibility for Non-NHS.

Vehicle Class	Safety	Mobility	Drainage and Erosion Control	Other Projects	Miscellaneous
1	$1,111,598	$24,532	$1,194,661	$309,711	$2,424,120
2	122,011,557	$2,692,687	$131,128,706	$33,994,556	$266,077,051
3	$52,531,041	$1,159,314	$56,456,353	$14,636,068	$114,557,218
4	$520,334	$10,721	$563,165	$147,909	$515,312
5	$9,389,656	$193,459	$10,162,554	$2,669,088	$9,299,017
6	$7,018,381	$144,603	$7,596,091	$1,995,033	$6,950,632
7	$2,421,156	$49,884	$2,620,450	$688,234	$2,397,784
8	$4,175,343	$91,099	$4,489,793	$1,165,363	$4,144,671
9	$21,082,932	$472,994	$22,482,673	$5,693,933	$21,100,823
10	$589,433	$12,860	$633,823	$164,514	$585,103
11	$120,368	$2,626	$129,433	$33,595	$119,484
12	$42,639	$930	$45,850	$11,901	$42,325
13	$196,048	$4,277	$210,812	$54,718	$194,607

Vehicle Class	In-House Maintenance	Preliminary Engineering	Right-of-Way	Utility and Railway
1	$311,133	$202,843	$1,537,735	$783,552
2	$34,150,660	$22,264,506	$168,785,334	$86,004,461
3	$14,703,277	$9,585,794	$72,669,094	$37,028,491
4	$152,389	$100,294	$778,684	$377,958
5	$2,749,933	$1,809,853	$14,051,689	$6,820,412
6	$2,055,462	$1,352,791	$10,503,059	$5,097,977
7	$709,080	$466,677	$3,623,277	$1,758,667
8	$1,175,757	$765,931	$5,838,844	$2,949,192
9	$5,854,199	$3,624,494	$28,509,325	$13,976,577
10	$165,981	$108,126	$824,269	$416,337
11	$33,895	$22,081	$168,324	$85,020
12	$12,007	$7,822	$59,626	$30,117
13	$55,206	$35,963	$274,155	$138,475

TABLE 3.3.22
Safety, Mobility and Other Cost Responsibility and Unit Cost for Interstates.

FHWA Vehicle Class	Cost Responsibility	Cost Responsibility Share	Unit Cost ($/VMT)
1	$3,108,065	0.36%	$0.0122
2	$449,632,181	52.58%	$0.0122
3	$152,420,920	17.82%	$0.0122
4	$3,135,985	0.37%	$0.0153
5	$34,793,361	4.07%	$0.0153
6	$5,779,428	0.68%	$0.0153
7	$924,015	0.11%	$0.0153
8	$11,239,949	1.31%	$0.0167
9	$184,102,247	21.53%	$0.0167
10	$1,775,102	0.21%	$0.0167
11	$5,577,846	0.65%	$0.0167
12	$2,106,993	0.25%	$0.0167
13	$549,508	0.06%	$0.0167

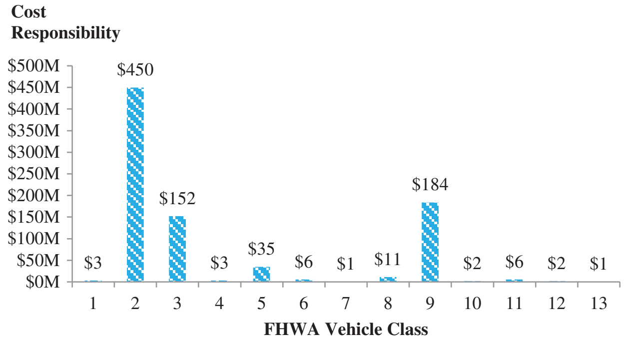


Figure 3.3.10 Safety, mobility, and other cost responsibilities for Interstates.

TABLE 3.3.23
Safety, Mobility and Other Cost Responsibility and Unit Cost for Non-Interstate NHS.

FHWA Vehicle Class	Cost Responsibility	Cost Responsibility Share	Unit Cost ($/VMT)
1	$4,803,311	0.53%	$0.0149
2	$511,798,149	56.92%	$0.0149
3	$197,598,294	21.98%	$0.0149
4	$4,186,533	0.47%	$0.0261
5	$50,436,576	5.61%	$0.0261
6	$10,318,328	1.15%	$0.0261
7	$3,191,243	0.35%	$0.0261
8	$14,709,369	1.64%	$0.0264
9	$96,447,601	10.73%	$0.0264
10	$2,175,000	0.24%	$0.0264
11	$2,283,298	0.25%	$0.0264
12	$571,238	0.06%	$0.0264
13	$645,471	0.07%	$0.0264

TABLE 3.3.24
Safety, Mobility and Other Cost Responsibility and Unit Cost for Non-NHS

FHWA Vehicle Class	Cost Responsibility	Cost Responsibility Share	Unit Cost ($/VMT)
1	$7,899,884	0.52%	$0.0406
2	$867,109,518	57.07%	$0.0406
3	$373,326,650	24.57%	$0.0406
4	$3,166,767	0.21%	$0.0722
5	$57,145,659	3.76%	$0.0722
6	$42,714,027	2.81%	$0.0722
7	$14,735,208	0.97%	$0.0722
8	$24,795,993	1.63%	$0.0740
9	$122,797,951	8.08%	$0.0740
10	$3,500,447	0.23%	$0.0740
11	$714,827	0.05%	$0.0740
12	$253,216	0.02%	$0.0740
13	$1,164,262	0.08%	$0.0740

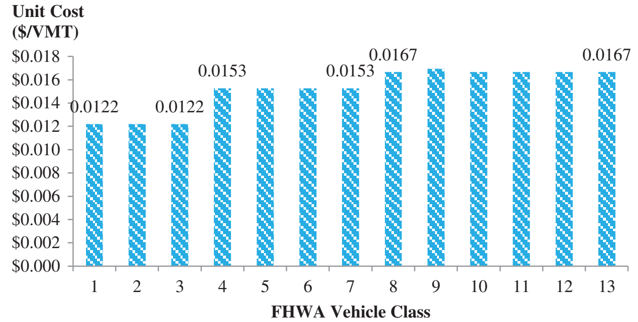


Figure 3.3.11 Safety, mobility, and other unit cost ($/VMT) for Interstates.

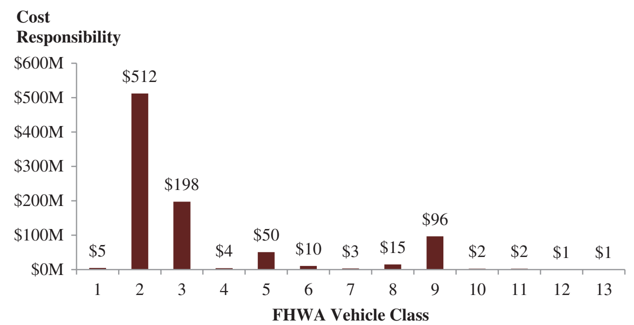


Figure 3.3.12 Safety, mobility, and other cost responsibilities for Non-Interstate NHS.

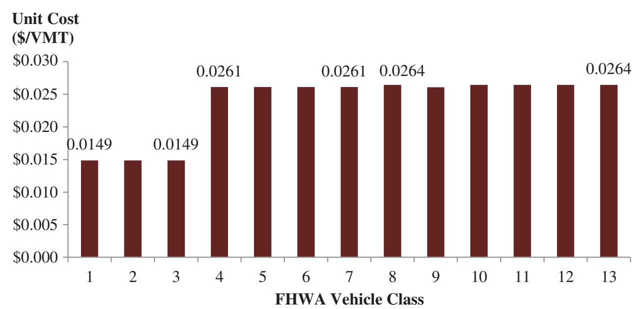


Figure 3.3.13 Safety, mobility, and other unit cost ($/VMT) for Non-Interstate NHS.

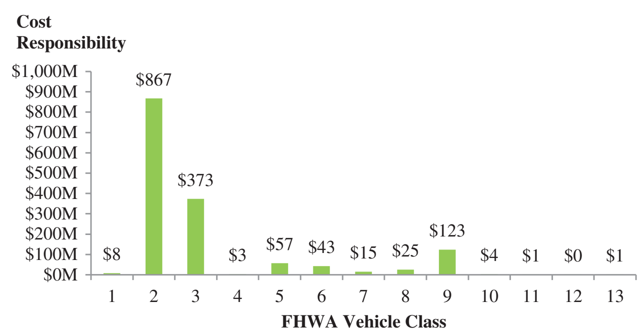


Figure 3.3.14 Safety, mobility, and other cost responsibilities for Non-NHS.

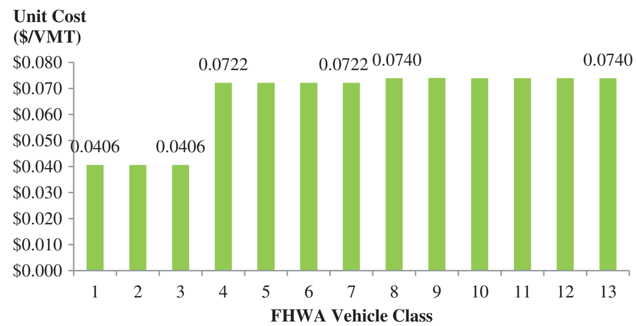


Figure 3.3.15 Safety, mobility, and other unit cost ($/VMT) for Non-NHS.

TABLE 3.3.25
Safety, Mobility and Other Cost Responsibility for State Routes, 2009–2012.

Vehicle Class	Safety	Mobility	Drainage and Erosion Control	Other Projects	Miscellaneous
1	$2,034,473	$44,013	$2,166,984	$382,042	$5,867,178
2	$236,546,376	$5,510,912	$248,419,929	$43,265,815	$699,767,874
3	$93,855,313	$2,114,664	$99,293,922	$17,935,952	$270,053,373
4	$1,541,146	$36,309	$1,613,467	$226,628	$2,906,405
5	$21,219,071	$477,359	$22,434,169	$3,576,325	$36,623,321
6	$9,228,419	$191,760	$9,935,547	$2,162,212	$11,876,473
7	$2,969,201	$57,424	$3,233,647	$728,055	$3,492,832
8	$7,952,579	$194,459	$8,322,610	$1,438,086	$12,196,592
9	$64,258,241	$2,177,671	$62,405,105	$8,905,034	$125,823,127
10	$1,167,009	$29,184	$1,215,769	$206,404	$1,827,183
11	$1,352,489	$53,919	$1,239,703	$128,931	$3,114,087
12	$470,767	$20,306	$419,273	$45,590	$1,115,384
13	$371,281	$9,331	$386,569	$67,464	$573,556
Total	$442,966,365	$10,917,309	$461,086,693	$79,068,539	$1,175,237,386

Vehicle Class	In-House Maintenance	Preliminary Engineering	Right-of-Way	Utility and Railway
1	$608,858	$1,171,212	$2,184,347	$1,352,153
2	$69,387,403	$133,655,058	$242,646,806	$149,339,675
3	$27,679,593	$51,124,649	$100,298,635	$60,989,763
4	$478,018	$1,208,069	$1,473,340	$1,005,904
5	$6,577,466	$14,901,728	$22,262,379	$14,303,778
6	$2,795,734	$3,917,360	$12,111,969	$6,592,309
7	$910,446	$1,186,459	$4,075,189	$2,197,213
8	$2,346,489	$4,684,846	$8,460,220	$5,149,431
9	$17,253,010	$40,085,094	$51,614,936	$30,825,582
10	$343,044	$698,323	$1,218,626	$745,006
11	$349,575	$993,915	$803,916	$539,437
12	$115,848	$318,433	$261,088	$164,757
13	$108,546	$213,269	$392,543	$236,683
Total	$128,954,030	$254,158,415	$447,803,994	$273,441,690

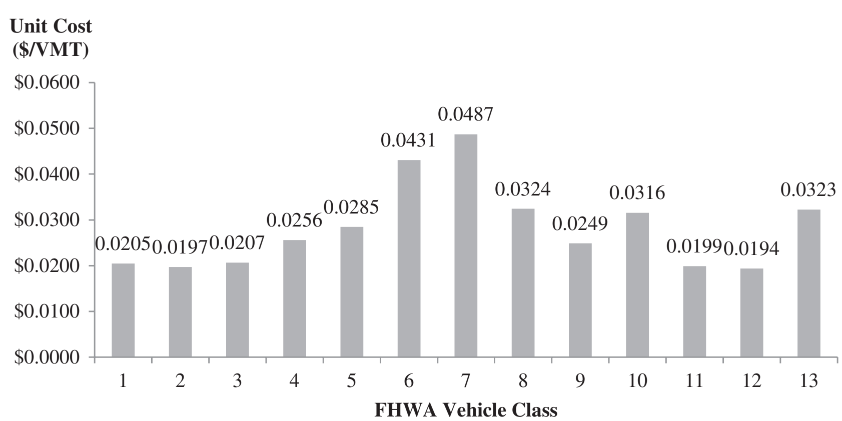


Figure 3.3.16 Average annual unit cost ($/VMT) for safety, mobility, and other expenditures on state routes, 2009–2012.

4. SUMMARY OF STATE ROUTES COST ALLOCATION

Part 3 of this report discussed the cost allocation methodology, data, analysis, and results related to pavement, bridge, safety, mobility and other expenditures on Indiana state routes. The methodology was presented and explained for the different expenditure types in different chapters of this Part. For new pavement construction, the methodology developed for the 1997 and 2000 FHWA HCAS was adopted and the analysis was conducted on a project-by-project basis. For allocating pavement rehabilitation expenditures, those related to damage by non-load factors were attributed based on VMT; and the remainder was attributed using the distress-based FHWA model, NAPCOM. A load and non-load split also was used for the allocation of pavement maintenance expenditures. For bridge cost allocation, the load-related expenditures for new bridge construction, bridge replacement, and bridge rehabilitation and repair were analyzed using the incremental method; the non-load-related expenditures for these bridge projects were treated as common costs and allocated using VMT. PCE-mile was used as the allocator for safety, mobility and ROW expenditures; and VMT was used for all remaining expenditure types.

Table 3.4.1 summarizes the cost responsibility of each FHWA vehicle class by project type for all state routes in Indiana from 2009 to 2012.

Overall, it was determined vehicle class 2 had the highest cost responsibility with respect to all project types. Of the truck classes, vehicle class 9 was observed to have the highest cost responsibility.

Figure 3.4.1 presents the analysis results of average unit cost ($/VMT) of each vehicle class by expenditure type for all state routes in Indiana over the study period. It can be observed that vehicle classes 1–3 had the lowest unit cost (approximately 3 cents/mile) while vehicle class 7 had the highest unit cost (approximately 18 cents/mile).

TABLE 3.4.1
Summary of Cost Responsibility by Vehicle Class and Project Type for State Routes, 2009–2012.

Vehicle Class	New Pavement & Bridge Construction and Reconstruction	Pavement & Bridge Rehab and Repair	Pavement & Bridge In-House Maintenance	Safety, Mobility & Other Expenditures[a]	Total
1	$5,313,048	$1,002,882	$176,614	$16,502,300	$22,994,844
2	$631,417,406	$115,191,786	$20,043,578	$1,913,267,459	$2,679,920,229
3	$250,918,356	$46,516,346	$8,297,653	$755,533,470	$1,061,265,824
4	$6,841,678	$1,881,986	$490,709	$10,854,479	$20,068,852
5	$57,689,546	$10,288,550	$3,016,860	$146,897,769	$217,892,726
6	$24,989,935	$16,972,038	$6,015,776	$60,198,226	$108,175,976
7	$23,777,821	$18,241,233	$7,425,902	$19,243,092	$68,688,048
8	$22,944,592	$12,772,261	$5,639,083	$52,210,811	$93,566,748
9	$313,437,720	$276,873,845	$70,697,193	$419,356,228	$1,080,364,986
10	$7,460,451	$4,740,150	$1,417,204	$7,671,697	$21,289,502
11	$7,719,825	$4,528,358	$1,058,036	$9,000,056	$22,306,276
12	$3,478,284	$1,293,493	$250,465	$3,086,075	$8,108,316
13	$4,356,798	$2,372,663	$727,766	$2,428,678	$9,885,905
Total	$1,360,345,462	$512,675,591	$125,256,838	$3,416,250,341	$5,414,528,232

[a]Other expenditures include: safety, mobility, drainage and erosion control, miscellaneous, preliminary engineering, ROW, utility and railway, other in-house maintenance and other projects.

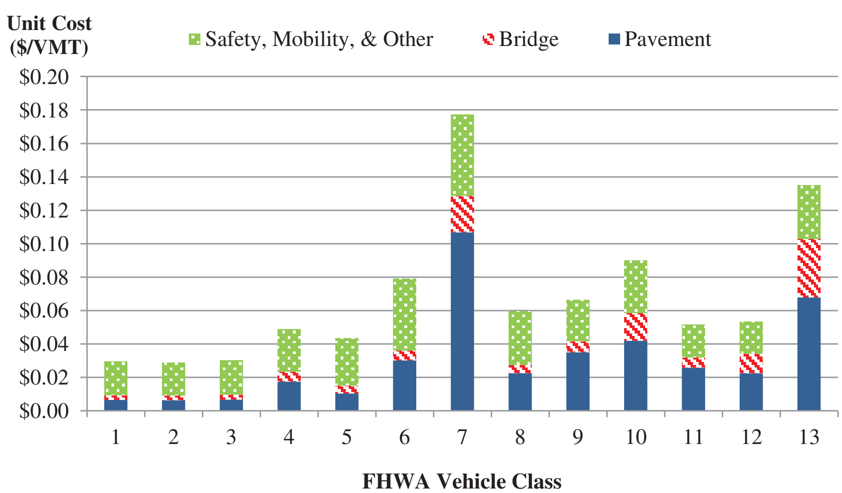


Figure 3.4.1 Average unit cost ($/VMT) of all expenditures for state routes, 2009–2012.

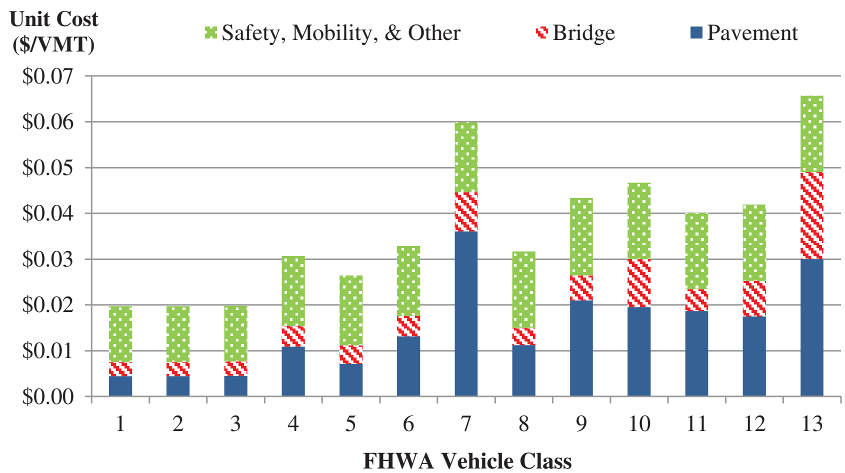


Figure 3.4.2 Average unit cost ($/VMT) of all expenditures for Interstates, 2009–2012.

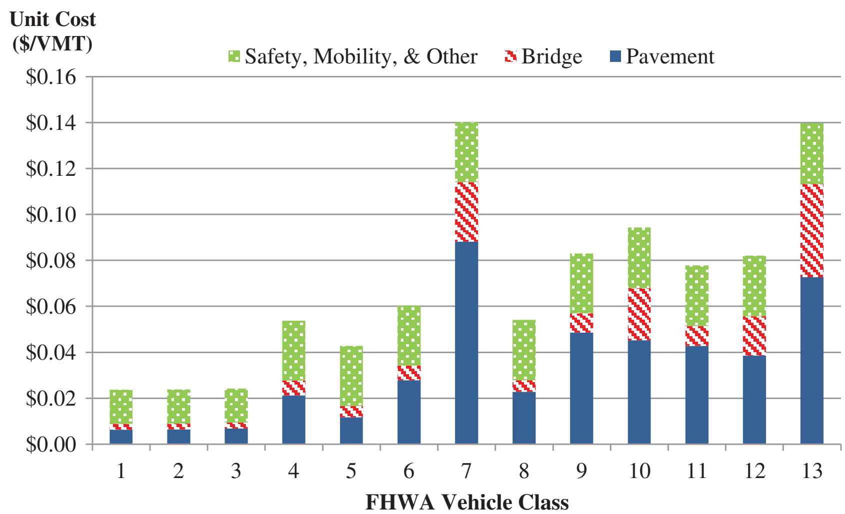


Figure 3.4.3 Average unit cost ($/VMT) of all expenditures for Non-Interstate NHS 2009–2012.

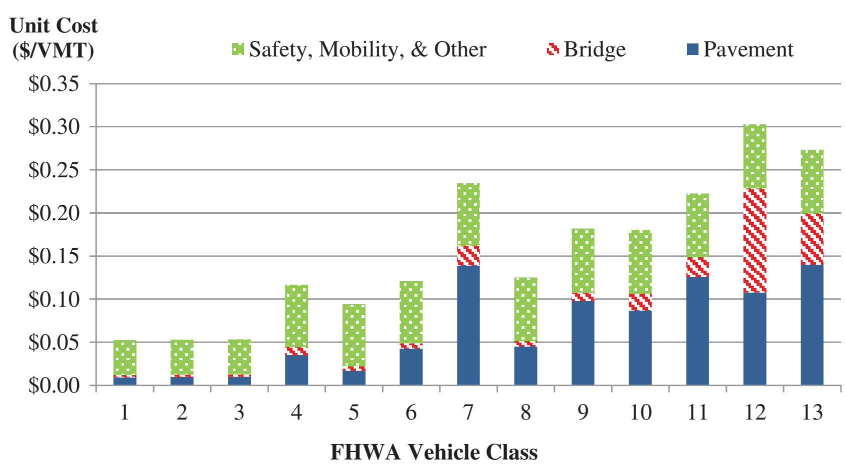


Figure 3.4.4 Average unit cost ($/VMT) of all expenditures for Non-NHS 2009–2012.

Figures 3.4.2 to 3.4.4 illustrate the average unit cost ($/VMT) of each vehicle class by expenditure type for Interstates, non-Interstate NHS, and Non-NHS, respectively. It was found that the unit cost distributions vary among the different highway functional classes. Vehicle classes 1–3 consistently had the lowest unit cost. Vehicle class 13 had slightly higher unit costs than vehicle class 7 for the Interstates, while these two vehicle classes had almost identical unit cost for the non-Interstate NHS. With respect to the non-NHS, vehicle classes 12 turned out to have the highest unit cost, while vehicle class 13 had the second highest unit cost.

PART 4. LOCAL ROUTES COST ALLOCATION

1. COST ALLOCATION FOR ROAD EXPENDITURES ON LOCAL ROUTES

This chapter discusses the cost allocation methodology, data, analysis, and results related to road construction, rehabilitation, maintenance, and traffic and safety expenditures on the local route system in Indiana. The methodology for the different expenditure types is presented in Section 1.1. Section 1.2 discusses the available data on local road expenditures, while Section 1.3 presents the analysis process as well as the total cost responsibility and average unit cost per vehicle class and expenditure category. The detailed results per year for all expenditure types are presented in Addendum B. It is worth noting that the categories prepared for the state route analysis (pavement, bridge, and safety/mobility/other expenditures) could not be applied in the analysis for local routes. This is because expenditures are divided into two main categories (road expenditures and bridge expenditures) in the local (county and city) operational reports that serve as the information sources for the present study. Specifically, the construction and reconstruction expenditures in the "road" expenditures category include not only new road construction and road rehabilitation projects but traffic and safety projects as well. Also, the maintenance and repair expenditures in the "road" expenditures category include only in-house road maintenance expenditures.

1.1 Study Methodology for Cost Allocation for Local Roads

1.1.1 Allocation of New Road Construction Expenditures

Generally, the methodology used for the state route cost allocation (the 1997 and 2000 FHWA HCAS), which is explained in depth in Section 1.1.1 of Part 3, was adopted for the local roads with some modifications because of differences between state and local road geometry and data limitations. This was done on a project-by-project basis where possible.

As explained in Section 1.1.1 of Part 3, for the allocation of new road construction expenditures, each facility was divided into a base facility and a remaining facility. The base facility includes the earthworks and grading and shoulder expenditures, as well as a portion of the pavement expenditures as follows:

- Flexible pavements: 1 inch of surface HMA course, 3 inch base HMA course, and 4 inch compacted aggregate (or subbase) course.
- Rigid pavements: 5 inch PCC slab.

The remaining part of the pavement forms the remaining facility expenditures.

The base facility expenditures were allocated on the basis of VMT, except the shoulder expenditures which were allocated on the basis of PCE-miles. The remaining facility expenditures were allocated to vehicle classes based on their ESAL contributions. Due to date limitations, the cost allocation methodology was applied on a project-by-project basis for some categories (but not all) of new road construction expenditures.

1.1.2 Allocation of Road Rehabilitation Expenditures

The methodology used for the state route cost allocation was adopted for the local routes with some adjustments due to data limitations. As explained in Section 1.1.2 of Part 3, the need for preservation originates from pavement damage due to traffic loading and climatic conditions. For this reason, in road rehabilitation cost allocation, a portion of the expenditures is attributed to load-related factors (traffic); the remaining part is credited to non-load-related factors (weather and climatic conditions) and allocated to the vehicle classes on the basis of their VMT contributions.

As mentioned in Section 1.1.2 of Part 3, the load-related expenditure percentages (load shares) presented in the 1997 FHWA HCAS were adopted for the present study and were used to estimate the load-related and non-load-related expenditures. The portion of the expenditures attributed to non-load-related factors was allocated on the basis of VMT. On the other hand, the portion of the expenditures attributed to load-related factors was allocated using the distress-based NAPCOM cost model introduced by FHWA (1997). The input distress data required by NAPCOM were not available from INDOT; therefore, the average default parameters in the FHWA HCAS software package developed for states were used. In the methodology developed for the state routes, expenditures were categorized into different expenditure types (pavement, grading and earthworks, shoulder, etc.); however, for the case of local roads such categorization could not be used due to data unavailability.

1.1.3 Allocation of Road Maintenance Expenditures

Regarding the allocation of road maintenance expenditures, the methodology used for the state route cost allocation (discussed in Section 1.1.3 of Part 3) was adopted for the local roads. Similar to the pavement rehabilitation cost allocation, a portion of the pavement-related expenditures was attributed to load-related factors (traffic) while the remaining part is attributed to non-load-related factors (weather and climatic conditions). The load-related expenditure percentages (load shares) presented in the 1984 Indiana HCAS were adopted by the present study and were used to estimate the load-related and non-load-related shares of pavement expenditures.

The portion of the expenditures attributed to non-load-related factors was treated as a common cost and therefore was allocated on the basis of VMT. Based on the suggestions incorporated in the FHWA software package developed for State HCAS, the load-related portion of the expenditures can be allocated using LEF-miles or ESAL-miles. This study allocated the load-related expenditures on the basis of ESAL-miles because, for each vehicle class, ESALs take into account the volume distribution as well as the LEF.

1.1.4 Allocation of Traffic and Safety Expenditures

Local route traffic and safety projects were incorporated into the road expenditures category for the local route cost allocation due to the classification of expenditures that appears in county and city operational reports (discussed in detail in Section 1.2 of this Part of the report). These expenditures were treated as common costs and thus were allocated on the basis of VMT. Certain items of safety expenditure, such as guardrails, can be said to be related to vehicle size and therefore more appropriately allocated using PCE-miles; however, for local roads, the lack of detailed data precluded the identification of such detailed expenditure types and therefore did not allow for further exploration of the relationships between these expenditure types and vehicle classes.

1.2 Data for Local Road Cost Allocation

This section describes the local route data sources and their use in the cost allocation process. There are three main sources of data related to expenditures: County Operational Reports, City Operational Reports, and the INDOT Site Manager database. Data from all three sources were used to carry out the cost allocation for local roads. A detailed description of the data is presented in the subsequent chapter. Note that the data presented in Sections 1.2.1 and 1.2.2 refer to road and bridge expenditures, while the data presented in Sections 1.2.3 and 1.2.4 refer to road expenditures only.

1.2.1 County Operational Reports

Information on new construction, rehabilitation and maintenance activities that occurred in Indiana counties during 2009–2012 was retrieved from County Operational Reports made available by the Local Technical Assistance Program (LTAP). The expenditure items of interest extracted from the reports were the "Maintenance and Repair" and "Construction and Reconstruction" expenditures. For each of these expenditure items, there were four listed funding sources: (1) Motor Vehicle Highway Fund, (2) Local Road and Street Fund, (3) Cumulative Bridge Fund, and (4) Other Funds. It should be noted that the expenditures included in a County Operational Report for a given year reflect the expenses that occurred in that specific year and not the total expense of the projects let that year.

The set of County Operational Reports received from LTAP was incomplete. Ideally, four reports should have been received for each county (one for each of the years 2009, 2010, 2011, and 2012). However, for 32 counties, there was a missing report for at least one year. Of these 32 counties, eight had no report. Since it is important to have a full sample of the expenditures at the county level, appropriate methods were used to impute the missing data: (a) for counties that lacked full information but had at least one report, the average of the annual expenditures for the available reports were used to estimate the missing expenditures; (b) for counties that lacked expenditure information (no reports received from that specific county from LTAP), the average expenditures from all other similar Indiana counties weighted by area, population, and location were used to generate an estimate of the missing data. In the imputation process, the location of the county was taken into account by separating the counties as metropolitan or non-metropolitan. The eight counties that did not have any expenditure information were:

- Clay, Delaware, Newton, Ohio, and Washington: These counties are part of Indiana's Metropolitan Statistical Areas (MSAs). The average expenditures from all the other counties in Indiana's MSAs, weighted by area and population, were used to impute the missing expenditures.
- Cass, Crawford, and Franklin: These counties are not part of Indiana's MSAs. The average expenditures from all the other counties that are not part of Indiana's MSAs, weighted by area and population, were used to impute the missing expenditures.

The U.S. Census Bureau (2010) defined Indiana's MSAs, a map of which is presented in Figure 4.1.1. Also, data on county areas and populations were retrieved from the U.S. Census Bureau (2010).

Figure 4.1.2 presents the total maintenance and repair expenditures for Indiana counties during 2009–2012 as well as the different funds that were utilized. Similarly, Figure 4.1.3 presents the total construction and reconstruction county expenditures for 2009–2012.

In Figures 4.1.2 and 4.1.3, the first eight bars from the top represent the eight counties that initially lacked expenditure information because they did not submit any report to LTAP. The total expenditures for all counties per year are presented in Table 4.1.1.

Other important information obtained from the County Operational Reports was the percentage split of funds between road and bridge projects. This information was needed to separate the two expenditure types (road and bridge) because their cost allocation methodologies are different. The average percentage per fund is presented in Table 4.1.2.

It is worth noting that the categories prepared for the state route analysis (pavement, bridge and safety/mobility/other expenditures) could not be applied in the analysis for local roads. This is because in the operational reports, expenditures are divided into two main categories: road expenditures and bridge expenditures. With regard to Construction & Reconstruction expenditures, the road expenditures category includes not only new road construction and road rehabilitation projects but also traffic and safety projects. With regard to Maintenance & Repair, road expenditures include only in-house road maintenance expenditures. The same division of expenditures is

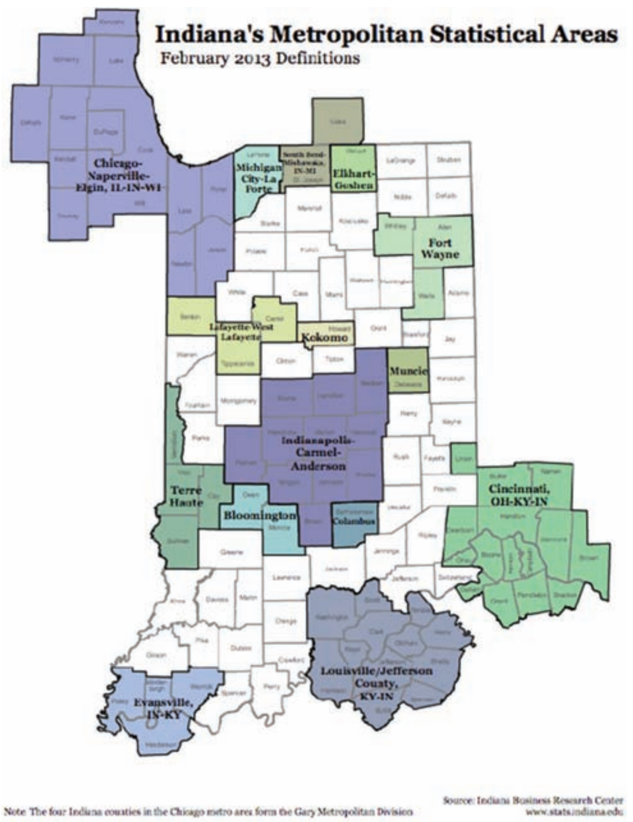


Figure 4.1.1 Indiana's metropolitan statistical areas. (Source: Indiana Office of Management and Budget, http://www.stats.indiana.edu.)

adopted in this study for the analysis of local road expenditures.

1.2.2 City Operational Reports

Information on new construction, rehabilitation and maintenance activities that occurred in Indiana cities during 2009–2012 was retrieved from City Operational Reports. The Local Technical Assistance Program (LTAP, 2009) provided the City Operational Reports that were available. The expenditure items of interest extracted from the reports were the "Maintenance and Repair" and "Construction and Reconstruction" expenditures. For each of these expenditure items, there were four listed funding sources: (1) Motor Vehicle Highway Fund, (2) Local Road and Street Fund, (3) Cumulative Bridge Fund, and (4) Other Funds. It should be noted that the expenditures included in a City Operational Report for a given year reflect the expenses that occurred (and not the total expense of the projects let) that year.

Cities submit their operational reports voluntarily to LTAP. Only 40 cities submitted City Operational Reports to LTAP during 2009–2012. For a city that did not submit all but submitted at least one report to LTAP, the average of the known expenditures for the years of submission was used to impute the unknown expenditures for the years of non-submission. Figure 4.1.4 presents the total Maintenance and Repair expenditures for the 40 Indiana cities during the years 2009–2012 as well as the different funding sources. Similarly, Figure 4.1.5 presents the total Construction and Reconstruction expenditures for the same group of cities and time period.

The set of City Operational Reports received from LTAP contained incomplete information regarding expenditures in Indiana cities and towns. Therefore, it was necessary to supplement the information received from LTAP; this was accomplished after discussions with INDOT. INDOT provided a complete dataset containing the amount of funding appropriated to local governments for the years 2013 and 2014; this helped to develop expenditure estimates for the cities and towns that had not submitted reports to LTAP. Comparing the expenditures and revenues from the City Operational Reports, it was found that the Maintenance and Repair and the Construction and Reconstruction expenditures constituted 77.87% of the total revenue. This percentage was applied to the average amount of funds given to local governments (average of 2013 and 2014 revenue) to develop an average annual estimate of the expenditures for the cities and towns that had not submitted reports to LTAP (approximately 509 cities and towns). Using this approach, the expenditures for 509 cities and towns in Indiana were estimated. Table 4.1.3 all the information received for city/town expenditures in Indiana.

The percentage split of funding between road and bridge projects was determined from the City Operational Reports. This information was important because it allowed for the distinction of the two expenditure types (road and bridge) and therefore the application of the appropriate methodology for the cost allocation. The average percentage split for each funding source is presented in Table 4.1.4.

1.2.3 INDOT Site Manager Database

The INDOT Site Manager database, which is the main source of data for the state route expenditures, also contains detailed information for the contracts let for local roads and streets. The expenditures are related to the contracts that were let between 2009 and 2012. These are amounts paid to contractors for work including material, labor, equipment, and other resources for road construction, road rehabilitation, and traffic and safety projects. Only 20% of these expenditures are funded by the local governments and thus are included in the County and City Operational Reports. In this section, the total road expenditures extracted from the INDOT Site Manager database are presented; however, only 80% of the Site Manager contract expenditures are included in the cost allocation for local routes (which is also reflected in Section 1.2.4).

Figure 4.1.6 shows the road expenditures for each year and the average expenditure for the analysis period (2009–2012) for the local routes, as extracted from the INDOT Site Manager. All expenditures are shown in dollars at the respective year. As seen in the figure, there was a decreasing trend of the total road expenditures,

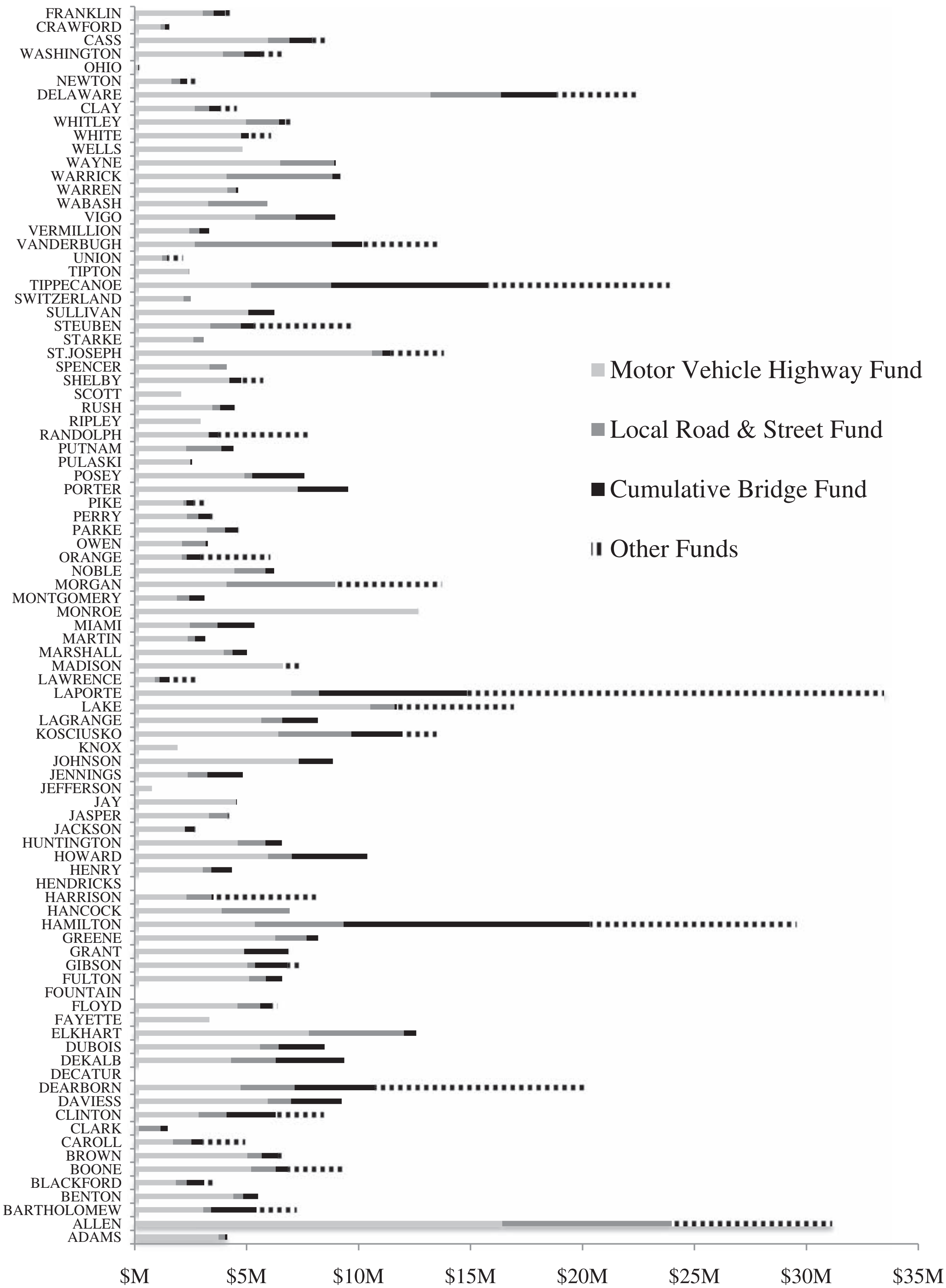


Figure 4.1.2 Total maintenance and repair expenditures by county and revenue source, 2009–2012.

Figure 4.1.3 Total construction and reconstruction expenditures by county and revenue source, 2009–2012.

TABLE 4.1.1
Total County Expenditures per Year.

Year	Maintenance & Repair	Construction & Reconstruction
2009	$194,280,066	$206,873,126
2010	$170,474,618	$220,071,151
2011	$156,363,083	$203,728,954
2012	$146,532,406	$219,838,898
Total	$667,650,174	$850,512,129

approximately $370,000,000 in 2009 and ending with approximately $120,000,000 in 2012.

1.2.4 Summary of Road Expenditures

The road expenditures were placed into the following four categories: (1) New Road Construction, (2) Road Rehabilitation, (3) Traffic and Safety, and (4) Road Maintenance. Three main data sources: County Operational Reports, City Operational Reports, and the INDOT Site Manager were used in order to create a complete dataset for each of the previously-mentioned categories (with the exception of road maintenance, for which no data were provided through Site Manager). Note that detailed information, such as work type, and specific expenditure items were only available for the contracts included in Site Manager.

New road construction and reconstruction expenditures include the following major work types as they appear in Site Manager: (1) (New) Road Construction, (2) Added Travel Lanes/Auxiliary Lanes, (3) Interchange Construction, and (4) Road Replacement.

The new road construction and reconstruction expenditures are presented as a single category here because they are analyzed using the same methodology, as mentioned in Section 1.1.1. In this Section, "new road construction" refers to both new road construction and road reconstruction. Table 4.1.5 the new road construction expenditures by data source and year.

Road rehabilitation expenditures include four major work types as they appear in INDOT's Site Manager Database: (1) Road Rehabilitation (3R/4R Standards), (2) Road Rehabilitation (Partial 3R Standards), (3) Pavement Repair or Rehabilitation, and (4) Patch and Rehabilitate Pavement. Traffic and safety projects are those related to intelligent transportation systems, signals, signs, pavement markings, intersection improvements, guardrails, and other relevant projects. Lastly, the road maintenance expenditures contain the expenses included in the Maintenance and Repair category that appears in both the County and City Operational Reports. The expenditures refer to maintenance activities that are carried out in-house. Tables 4.1.6, 4.1.7, and 4.1.8 present the road maintenance, road rehabilitation, and the traffic and safety expenditures, respectively, by year and data source.

TABLE 4.1.2
Percentage Split of Funds for Road and Bridges Projects by Funding Source, County Operational Reports.

Fund	Percentage for Road Projects
Motor Vehicle Highway Fund	96%
Local Roads & Streets Fund	93%
Cumulative Bridge Fund	0%
Other Funds	78%

Figure 4.1.7 presents the total road expenditures for the analysis period by expenditure type and data source. The majority of the expenditures were related to road rehabilitation, followed by road maintenance. The figure presents the complete road expenditure data that were analyzed for the cost allocation. The cost allocation analysis and results of the road expenditures exhibited in Figure 4.1.7 is presented in Section 1.3.

1.3 Analysis and Results

1.3.1 New Road Construction Expenditures Analysis and Results

This section discussed the process used to analyze the new road construction expenditures as well as the total cost responsibility and the average unit cost for the analysis period (2009–2012). The detailed results are presented in Addendum B.

The general methodology for the new road construction cost allocation is explained in depth in Section 1.1.1 of Part 3 and was demonstrated through an example in Section 1.3.1 of Part 3 of this report. In Section 1.1.1 of this Part of the report, it was mentioned that the general methodology was slightly modified to accommodate data restrictions; further details on this modification were provided in this Section.

Information on new road construction expenditures was retrieved from three different data sources: County Operational Reports, City Operational Reports and the INDOT Site Manager database. Section 1.2 fully described the operations that had to be conducted in order to produce a complete dataset and Table 4.1.5 the road expenditures discussed in this chapter.

The new road construction contracts on local routes included in the Site Manager database was the only information source that could provide enough detail to allow the application of the present study's general methodology for new construction cost allocation. The expenditures retrieved from the County and City Operational Reports do not include any information about the materials used or the design of the facility. For this reason, the contracts of interest included in Site Manager were treated as a sample and used to provide cost responsibility distributions that were later applied to the remaining new road construction expenditures.

First, the contracts included in the Site Manager database were analyzed on a project-by-project basis. To complete this task, the methodology, which is presented in the 1997 and 2000 FHWA HCAS and

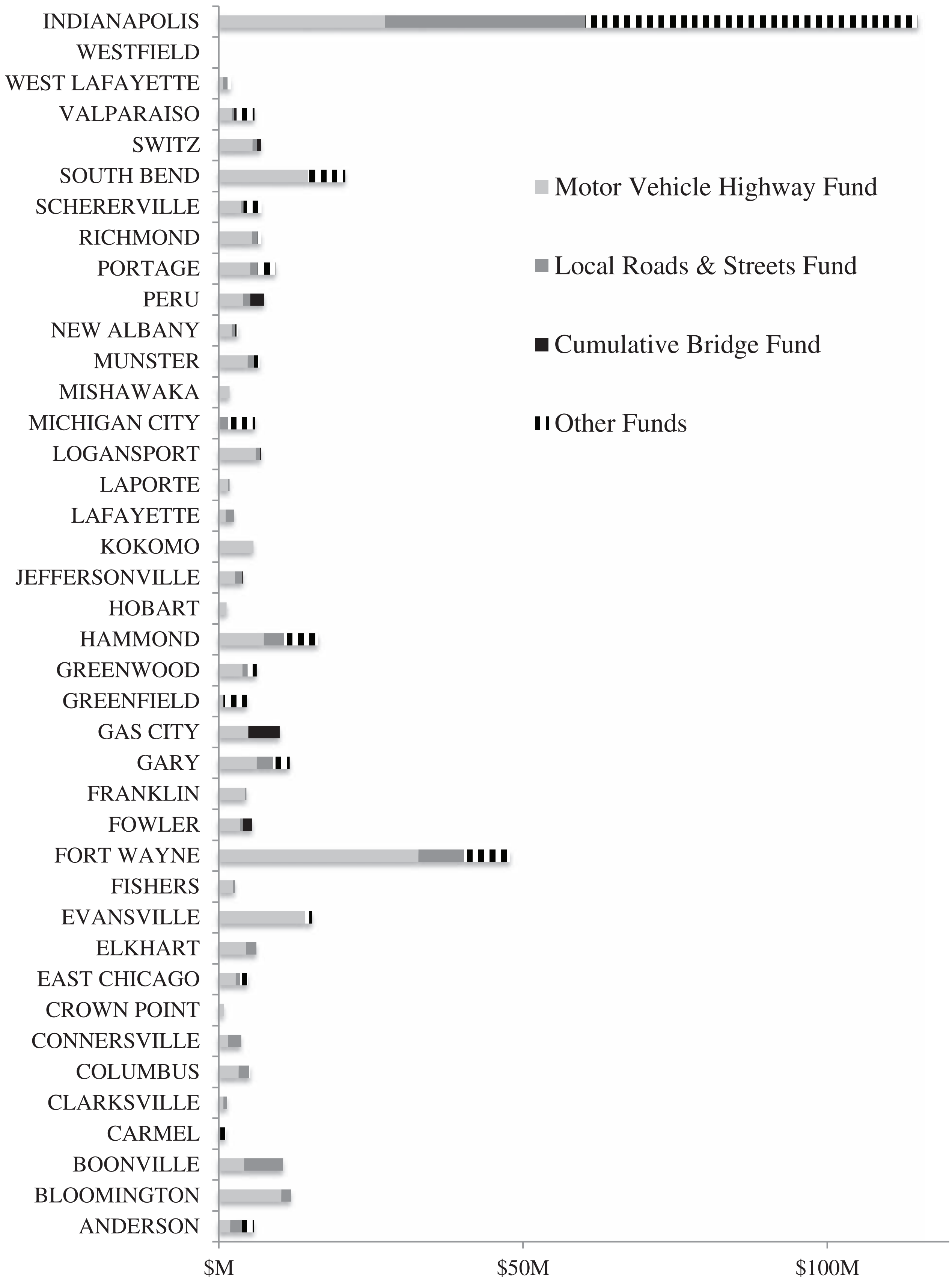


Figure 4.1.4 Total maintenance & repair expenditures for a sample of cities by funding source, 2009–2012.

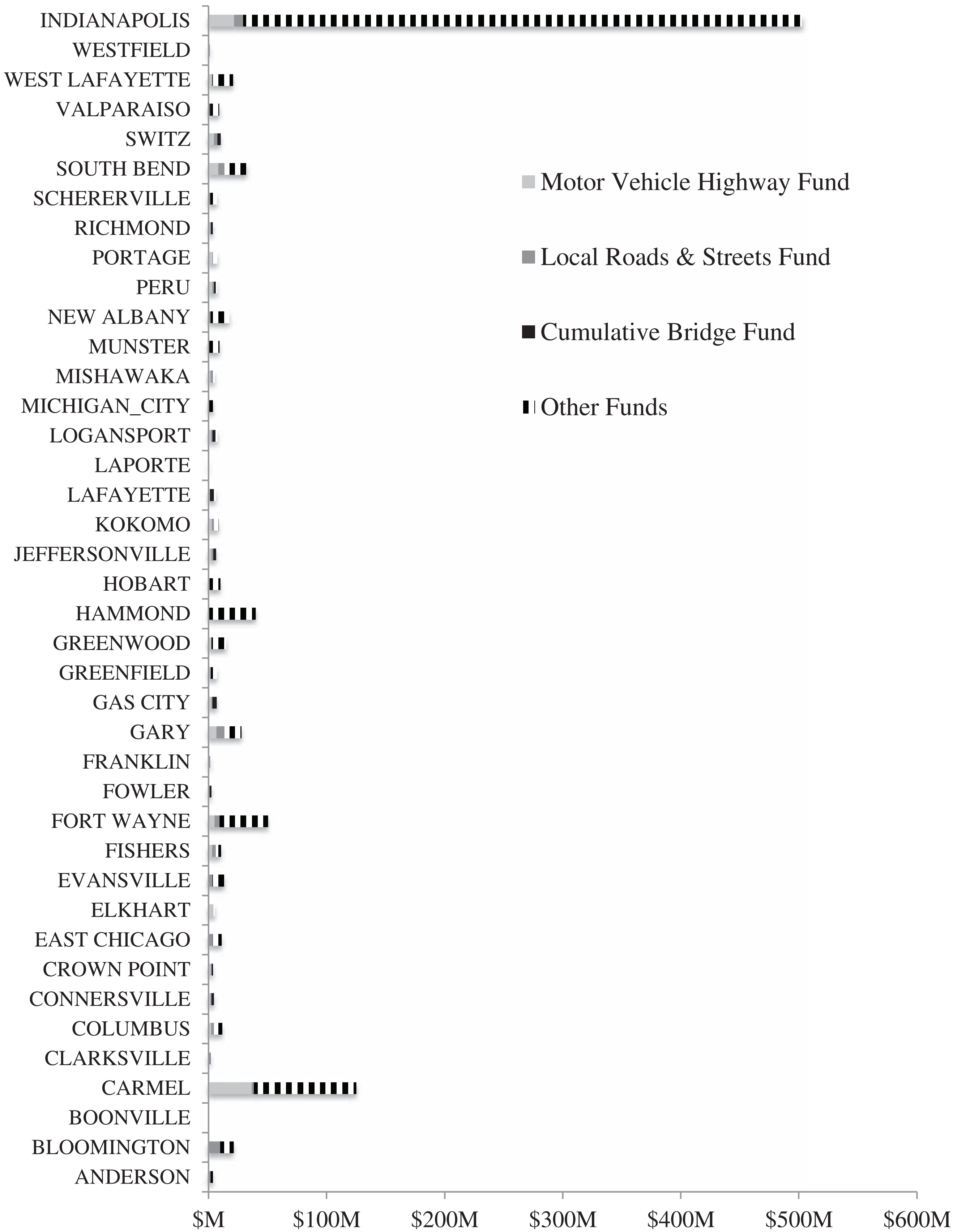


Figure 4.1.5 Total construction & reconstruction expenditures for a sample of cities by funding source, 2009–2012.

TABLE 4.1.3
Total City/Town Expenditures in Indiana.

Data Received, Source	Estimated Total Expenditures for 2009–2012
City Operational Reports from 40 Indiana Cities, LTAP	$1,437,975,687
Funds Distributed to Local Governments on 2013 and 2014, INDOT	$238,343,529
Total City/Town Expenditures for 2009–2012	$1,676,319,216

TABLE 4.1.4
Percentage Split of Funds for Road and Bridges Projects by Funding Source, City Operational Reports

Funding Source	Percentage for Road Projects
Motor Vehicle Highway Fund	97%
Local Roads & Streets Fund	96%
Cumulative Bridge Fund	0%
Other Funds	99.5%

explained in Section 1.1.1 of Part 3, was applied. The significant results from this analysis are as follows:

- Percentage split of expenditures on flexible versus rigid new road construction
- Percentage split of expenditures on the base facility versus the remaining facility, separately for flexible and rigid pavements, new road construction
- Cost responsibility distributions for the base facility and the remaining facility separately for flexible and rigid pavements, new road construction

It was estimated that 74% of the new road construction contract expenditures in Site Manager represented flexible construction while 26% represented rigid construction. Also, it was found that for flexible pavements, the base facility for road construction accounted for 70.7% of the total facility cost, compared to 73.6% in the case of rigid pavement road construction. These results, along with the cost responsibility distributions estimated for flexible and rigid road construction, were applied to the expenditures retrieved from the County and City Operational Reports. The total cost responsibility and the average unit cost per vehicle class for the analysis period are presented in Table 4.1.9. The cost responsibility per vehicle class for flexible and rigid road construction for the entire analysis period is presented in Figures 4.1.8 and 4.1.9, respectively. As expected, the highest cost responsibility for the base facility was attributed to automobiles (vehicle class 2), while vehicle class 9 was responsible for the largest part of the remaining facility expenditures. The average unit cost per vehicle class for the new road construction expenditures throughout the analysis period is presented in Figure 4.1.10.

As shown Figure 4.1.10, vehicle class 7 had the highest unit cost, followed by vehicle class 13. The results indicate that although the cost responsibility of these two classes was very low (possibly because there were relatively few of these vehicles in the traffic stream), their impact on road consumption was high.

1.3.2 Local Road Rehabilitation Expenditures Analysis and Results

This section discusses the process utilized to analyze the local road rehabilitation expenditures as well as the total cost responsibility and the average unit cost for the analysis period (2009–2012). Detailed results per year can be found in Addendum B.

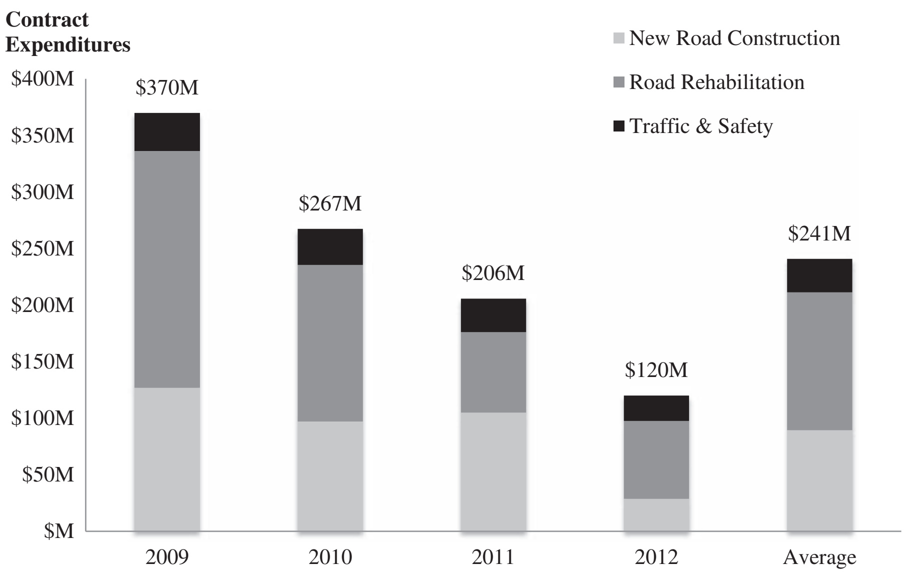


Figure 4.1.6 Road contract expenditures on local routes by year. Source: INDOT Site Manager Database.

TABLE 4.1.5
Local Routes New Road Construction Expenditures by Year and Data Source.

Year	Data Sources: County Operational Reports[a]	City Operational Reports[a]	Site Manager Database[b]	Total
2009	$47,292,414	$81,902,055	$101,439,214	$230,633,682
2010	$48,737,209	$108,915,782	$77,641,559	$235,294,550
2011	$48,231,654	$101,132,570	$83,899,266	$233,263,491
2012	$53,987,504	$136,685,356	$22,841,390	$213,514,250
Total	$198,248,781	$428,635,763	$285,821,429	$912,705,973

[a]Refers to the final dataset after developing estimates for the missing information.
[b]Refers to 80% of the road expenditures for local routes that appear in Site Manager.

TABLE 4.1.6
Local Routes Road Rehabilitation Expenditures by Year and Data Source.

Year	Data Sources: County Operational Reports[a]	City Operational Reports[a]	Site Manager Database[b]	Total
2009	$64,545,863	$111,781,963	$167,452,256	$343,780,082
2010	$66,517,756	$148,650,970	$110,672,461	$325,841,187
2011	$65,827,762	$138,028,250	$56,865,019	$260,721,031
2012	$73,683,490	$186,551,576	$55,106,465	$315,341,532
Total	$270,574,872	$585,012,759	$390,096,201	$1,245,683,832

[a]Refers to the final dataset after developing estimates for the missing information.
[b]Refers to 80% of the road expenditures for local routes that appear in Site Manager.

TABLE 4.1.7
Local Routes Traffic and Safety Expenditures by Year and Data Source.

Year	Data Sources: County Operational Reports[a]	City Operational Reports[a]	Site Manager Database[b]	Total
2009	$15,559,273	$26,945,894	$26,906,700	$69,411,867
2010	$16,034,612	$35,833,450	$25,496,173	$77,364,235
2011	$15,868,284	$33,272,762	$23,664,676	$72,805,722
2012	$17,761,967	$44,969,680	$17,968,115	$80,699,762
Total	$65,224,136	$141,021,786	$94,035,664	$300,281,586

[a]Refers to the final dataset after developing estimates for the missing information.
[b]Refers to 80% of the road expenditures for local routes that appear in Site Manager.

TABLE 4.1.8
Local Routes Road Maintenance Expenditures by Year and Data Source.

Year	Data Sources: County Operational Reports[a]	City Operational Reports[a]	Total
2009	$157,543,589	$113,465,947	$271,009,536
2010	$131,287,755	$124,693,534	$255,981,288
2011	$128,746,714	$118,574,917	$247,321,631
2012	$116,341,946	$103,315,508	$219,657,454
Total	$533,920,004	$460,049,905	$993,969,910

[a]Refers to the final dataset after developing estimates for the missing information.

The methodology for the road rehabilitation cost allocation was explained briefly in Section 1.1.2 of this Part of the report and in greater detail in Section 1.1.2 of Part 3. Road rehabilitation expenditures were retrieved from three different data sources: County Operational Reports, City Operational Reports, and the INDOT Site Manager database. Section 1.2 fully described the modifications that were utilized in order to produce a complete dataset; Table 4.1.6 the road expenditures discussed in this section.

The local road rehabilitation data included in Site Manager allow for the distinction between flexible and rigid rehabilitation contracts; and the expenditures retrieved from the County and City Operational

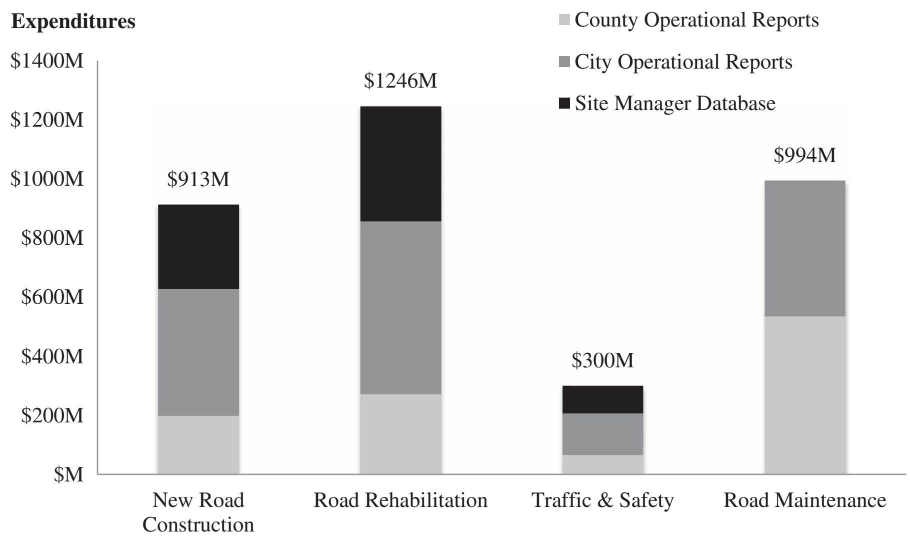


Figure 4.1.7 Road expenditures for local routes by expenditure type and data source.

Reports did not include any information on the materials used or the design of the facility. For this reason, the contracts of interest found in Site Manager were treated as a sample and therefore, were used to provide an estimate of the percentage of expenditures for flexible and rigid rehabilitation.

It was estimated that 98.2% of the road rehabilitation contract expenditures in Site Manager were for flexible rehabilitation while 1.8% were for rigid rehabilitation. These percentages were applied to the expenditures data retrieved from the County and City Operational Reports.

The portion of the expenditures attributed to non-load-related factors (65% for flexible rehabilitation and 21.4% for rigid rehabilitation) was allocated on the basis of VMT while the remaining expenditures, which were attributed to load-related factors, were allocated using the NAPCOM model developed by FHWA (1997). The distress data required as input for NAPCOM were not available from INDOT; therefore, the average parameters included in the FHWA software package developed for State HCASs were used.

The total cost responsibility and the average unit cost per vehicle class for the analysis period are presented in Table 4.1.10. The cost responsibility per vehicle class for flexible and rigid rehabilitation for the analysis period is presented in Figures 4.1.11 and 4.1.12, respectively.

Comparing Figures 3.1.28 and 3.1.29, it can be seen that, in rigid rehabilitation, a lower percentage was attributable to non-load-related factors compared to flexible rehabilitation. Apart from this difference, the cost responsibility distributions did not have any other significant differences. It should be noted here that the

TABLE 4.1.9
Cost Responsibility and Unit Cost for New Road Construction on Local Routes 2009–2012.

Vehicle Classes	Cost Responsibility for the Years 2009–2012			Unit Cost [$/VMT]
	Base Facility	Remaining Facility	Total	
1	$3,897,029	$0	$3,897,029	$0.0048
2	$425,817,749	$6,703,111	$432,520,860	$0.0049
3	$180,486,634	$19,798,289	$200,284,923	$0.0054
4	$689,794	$2,656,532	$3,346,326	$0.0234
5	$11,005,096	$17,305,105	$28,310,201	$0.0124
6	$6,652,935	$24,024,069	$30,677,005	$0.0223
7	$2,273,929	$33,020,285	$35,294,214	$0.0749
8	$2,160,234	$9,671,643	$11,831,877	$0.0266
9	$18,752,681	$141,342,565	$160,095,246	$0.0414
10	$308,676	$2,603,505	$2,912,181	$0.0458
11	$132,436	$1,331,689	$1,464,125	$0.0537
12	$37,948	$374,628	$412,576	$0.0529
13	$99,726	$1,559,684	$1,659,410	$0.0808
Total	$652,314,866	$260,391,107	$912,705,973	

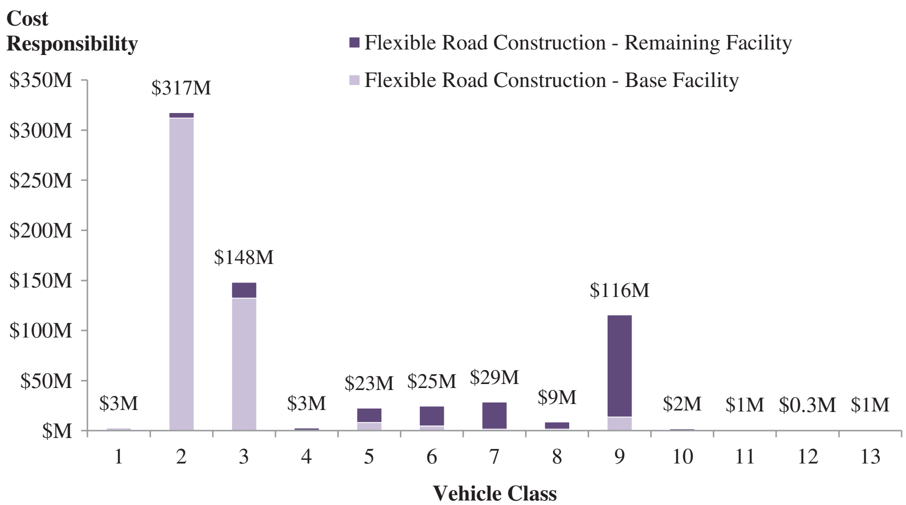


Figure 4.1.8 Total cost responsibility per vehicle class for new flexible road construction on local routes, 2009–2012.

terms "flexible" and "rigid" refer to the type of rehabilitation and main type of materials used for each contract and not to the type of the underlying pavement. The highest cost responsibility for the non-load-related expenditures was attributed to automobiles (vehicle class 2) which simply reflects the fact that automobiles make up the largest percentage of the traffic stream, while vehicle class 9 was responsible for the largest part of the load-related expenditures. The average unit cost per vehicle class for the road rehabilitation expenditures on local roads for 2009–2012 is presented in Figure 4.1.13. Vehicle classes 7 and 13 had the highest unit cost, followed by vehicle class 9. It can be seen that although the cost responsibility of classes 7 and 13 was among the lowest (because there are relatively few of these vehicles in the traffic stream), their road consumption share was relatively high.

1.3.3 Road Maintenance Expenditures Analysis and Results

This section discusses the process utilized to analyze the road maintenance expenditures as well as the total cost responsibility and the average unit cost for the analysis period (2009–2012). The detailed results per year can be found in Addendum B.

The methodology for the road maintenance cost allocation was explained in Section 1.1.3 of this Part of the report and in greater detail in Section 1.1.3 of Part 3. Road maintenance expenditures were retrieved from two different data sources: County Operational Reports and City Operational Reports. Section 1.2 fully describes the process conducted in order to produce a complete dataset and Table 4.1.8 the road expenditures discussed in this section.

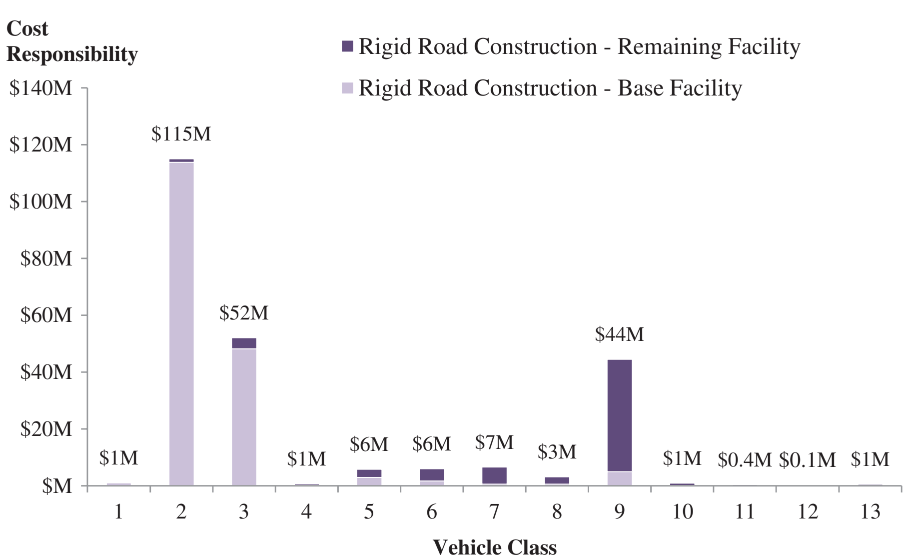


Figure 4.1.9 Total cost responsibility per vehicle class for new rigid road construction on local routes, 2009–2012.

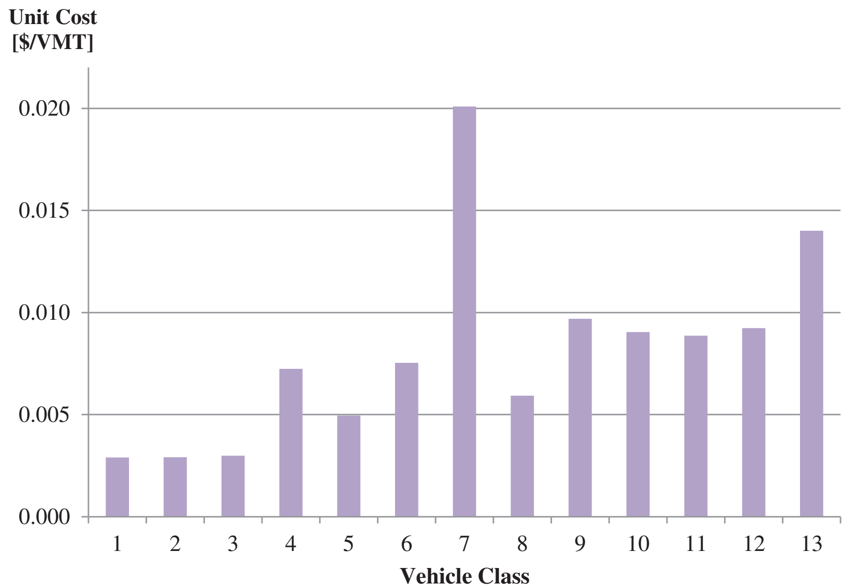


Figure 4.1.10 Average unit cost for new road construction on local routes, 2009–2012.

The maintenance expenditures retrieved from the County and City Operational Reports did not include any information on the road type or the type of maintenance activities applied. Therefore, estimates of expenditures associated with flexible and rigid maintenance activities were needed. For this reason, the percentage of flexible versus rigid rehabilitation expenditures estimated in the previous section based on the Site Manager contracts was used here as well: 98.2% of the maintenance expenditures representing flexible maintenance activities while 1.8% representing rigid maintenance activities. These percentages were applied to the expenditures retrieved from the County and City Operational Reports.

The portion of the expenditures attributed to non-load-related factors (72.8% of the expenditures for flexible rehabilitation and 64.3% of expenditures for rigid rehabilitation) was allocated on the basis of VMT while the remaining expenditures, which were attributed to load-related factors, were allocated on the basis of ESAL-miles. The total cost responsibility and the average unit cost per vehicle class for the analysis period are presented in Table 4.1.11. The total cost responsibility per vehicle class for road maintenance for the analysis period is presented in Figure 4.1.14. As expected, vehicle class 2 was responsible for the highest percentage of the non-load-related expenditures because this class contributed the largest portion of VMT. Also, class 9 was found to be responsible for the majority of the load-related expenditures because this class contributed the most ESAL-miles. The average unit cost per vehicle class for the road maintenance expenditures on

TABLE 4.1.10
Cost Responsibility and Unit Cost for Road Rehabilitation on Local Routes, 2009–2012.

	Cost Responsibility for the Years 2009–2012			
Vehicle Classes	**Non-Load-Related Expenditures**	**Load-Related Expenditures**	**Total**	**Unit Cost [$/VMT]**
1	$1,044,162	$2,525,882	$3,570,044	$0.0044
2	$114,060,746	$275,912,247	$389,972,993	$0.0044
3	$48,298,226	$121,511,532	$169,809,757	$0.0046
4	$186,054	$3,452,961	$3,639,015	$0.0255
5	$2,946,193	$17,803,041	$20,749,234	$0.0091
6	$1,753,758	$71,604,483	$73,358,241	$0.0532
7	$598,969	$88,217,159	$88,816,127	$0.1885
8	$590,837	$18,293,220	$18,884,057	$0.0425
9	$5,015,813	$458,070,251	$463,086,063	$0.1197
10	$84,459	$7,134,637	$7,219,096	$0.1136
11	$36,871	$2,245,723	$2,282,594	$0.0838
12	$10,526	$530,091	$540,617	$0.0693
13	$27,260	$3,728,734	$3,755,994	$0.1830
Total	$174,653,873	$1,071,029,959	$1,245,683,832	

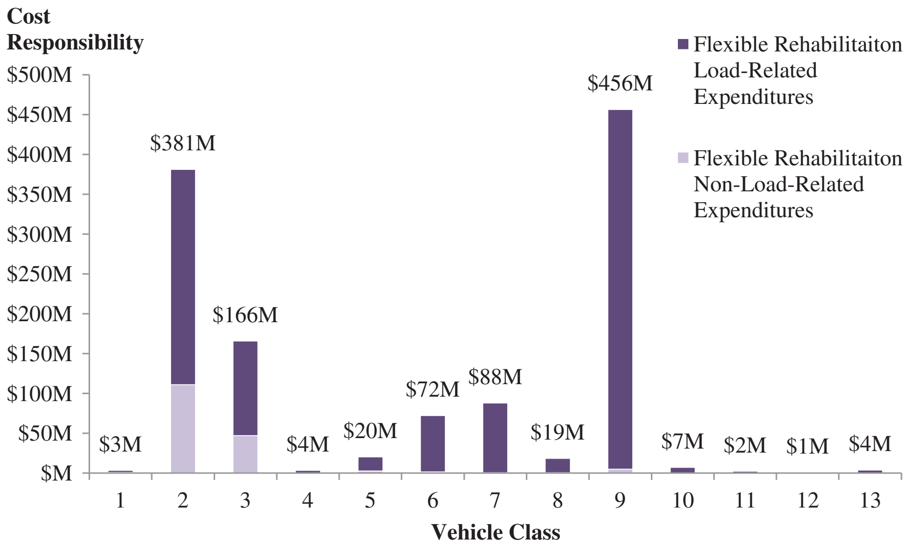


Figure 4.1.11 Total cost responsibility per vehicle class for flexible rehabilitation on local routes, 2009–2012.

local routes 2009–2012 is presented in Figure 4.1.15. The average unit cost per vehicle class for road maintenance was found to be similar to the average unit cost per vehicle class for road rehabilitation. However, the two unit cost distributions differed significantly with respect to the unit cost of the higher vehicle classes.

1.3.4 Traffic and Safety Expenditures Analysis and Results

Traffic and safety projects are related to intelligent transportation systems, signals, signs, pavement markings, intersection improvements, guardrails, and other related projects. The traffic and safety expenditures presented in Table 4.1.7 discussed in this section. These expenditures were treated as common costs and were allocated using VMT. The total cost responsibility and the average unit cost per vehicle class for the analysis period are presented in Table 4.1.12. The expenditures were allocated using VMT; as such, the cost responsibility distribution followed the VMT distribution and the unit cost was the same across the vehicle classes for each year. The average unit cost was found to be approximately $0.002 per VMT.

1.3.5 Overall Cost Allocation Results for Local Roads

The road cost allocation analysis for local routes is concluded by summarizing the cost responsibility and unit cost results for road new construction,

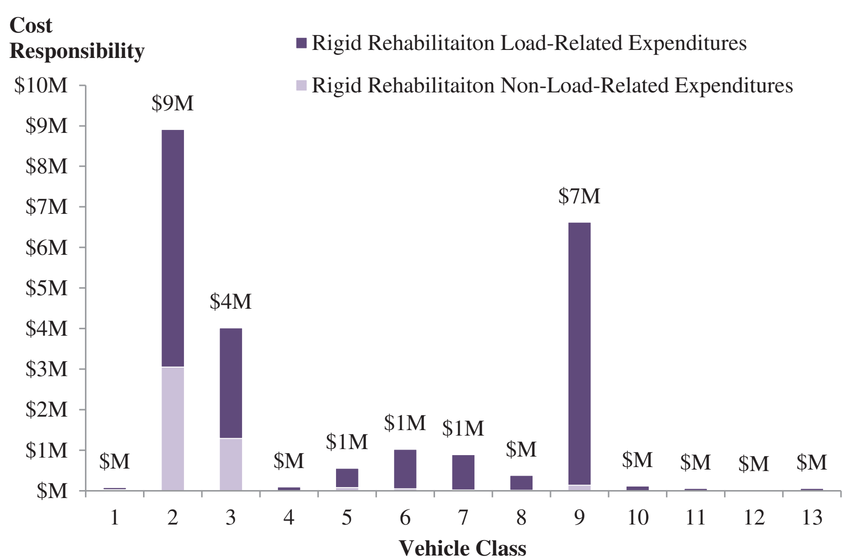


Figure 4.1.12 Total cost responsibility per vehicle class for rigid rehabilitation on local routes, 2009–2012.

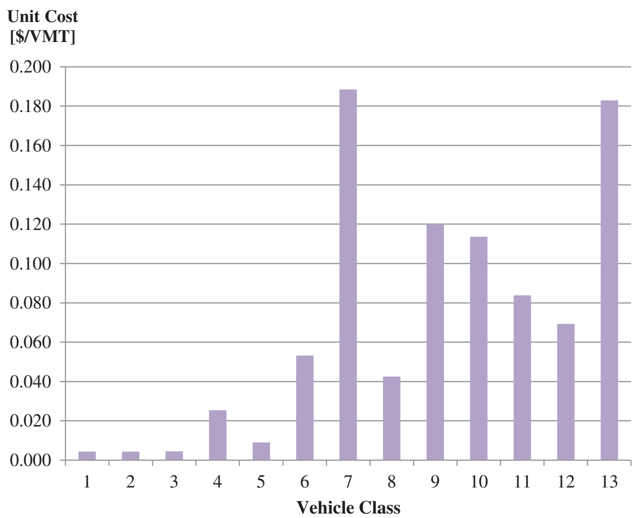


Figure 4.1.13 Average unit cost for road rehabilitation on local routes, 2009–2012.

rehabilitation, maintenance and traffic and safety projects. The total cost responsibility of each vehicle class by project type is presented in Table 4.1.13. Figure 4.1.16 presents the cost responsibility per vehicle class for all road expenditures on local roads for 2009–2012. Vehicle classes 2 and 3 were observed to have the highest cost responsibility with respect to road expenditures because of their increased presence on local routes compared with the remaining vehicle classes. Vehicle class 9 had the highest cost responsibility among the classes that represent truck traffic, which was due to the combined effect of their high load and high road usage compared to the remaining truck classes. The average unit cost per vehicle class for the total road expenditures on local routes is presented in Figure 4.1.17.

The unit cost presented in Figure 4.1.16 reflects the annual road consumption incurred by each vehicle class on average. Based on the average unit cost results for road expenditures, vehicle classes 7 and 13 had an average unit cost of $0.50 per VMT which is the highest among the 13 vehicle classes; the results suggest that an average vehicle of class 7 or 13 traveling one mile on a local road would have to pay $0.50 to cover the cost of new road construction, road rehabilitation, and maintenance, and traffic and safety projects that take place on local routes. Vehicle classes 1–3 had the lowest average unit cost.

1.4 Chapter Summary

This chapter discussed the cost allocation methodology, data, analysis, and results related to new road construction, road rehabilitation, road maintenance, and safety and traffic projects on Indiana local roads. The methodology for the different expenditure types is presented in Section 1.1. For new road construction, the methodology developed for the 1997 and 2000 FHWA HCAS was adopted, and the analysis was conducted on a project-by-project basis where feasible. The base facility expenditures were allocated to the vehicle classes based on VMT, while the remaining facility expenditures were allocated on the basis of ESAL-miles. Regarding the allocation of rehabilitation expenditures, a portion of the expenditures that were related to damage by non-load factors was allocated using VMT, while the rest of the expenditures were allocated using the distress-based FHWA model, NAPCOM. A load and non-load split was also used for the allocation of pavement maintenance expenditures; for the load-related expenditures, the allocation was done using ESAL-miles.

In Section 1.2, the relevant data provided by INDOT were presented. There are three main sources of data related to expenditures: County Operational Reports, City Operational Reports, and the INDOT

TABLE 4.1.11
Cost Responsibility and Unit Cost for Road Maintenance on Local Routes for the Years 2009–2012.

Vehicle Classes	Cost Responsibility for the Years 2009–2012			Unit Cost [$/VMT]
	Non-Load-Related Expenditures	Load-Related Expenditures	Total	
1	$501,270	$126,493	$627,763	$0.0008
2	$54,770,712	$13,820,107	$68,590,820	$0.0008
3	$23,212,470	$9,624,836	$32,837,306	$0.0009
4	$87,708	$5,099,730	$5,187,438	$0.0363
5	$1,397,093	$20,944,149	$22,341,242	$0.0098
6	$841,848	$82,227,071	$83,068,918	$0.0603
7	$287,692	$112,007,940	$112,295,632	$0.2383
8	$282,596	$33,052,937	$33,335,533	$0.0750
9	$2,423,795	$612,953,720	$615,377,515	$0.1591
10	$40,386	$9,263,778	$9,304,164	$0.1464
11	$17,428	$5,047,516	$5,064,943	$0.1859
12	$4,988	$1,050,888	$1,055,876	$0.1353
13	$13,043	$4,869,716	$4,882,760	$0.2379
Total	$83,881,028	$910,088,881	$993,969,910	

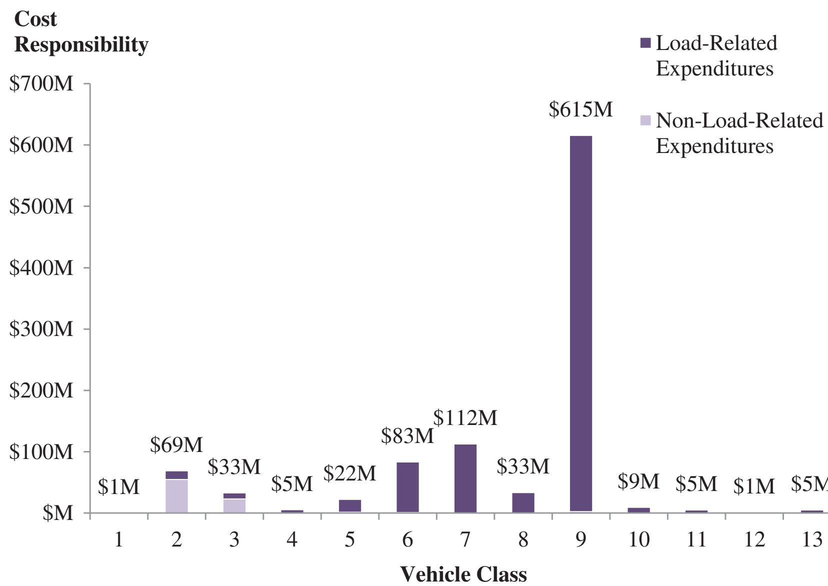


Figure 4.1.14 Total cost responsibility per vehicle class for road maintenance on local routes, 2009–2012.

Site Manager database. Data from all three data sources were used for the local routes cost allocation.

Section 1.3 discussed the analysis and presented the total cost responsibilities and average unit costs for each local expenditure type for 2009–2012. The detailed results are presented in Addendum B. The results show that vehicle classes 2 and 3 accumulated the highest cost responsibility with respect to road expenditures likely because of their increased presence on local routes compared to the remaining vehicle classes. Vehicle class 9 had the highest cost responsibility among the classes that represent truck traffic, which could be due to the combined effect of high load and high level of road usage of class 9 compared to the other truck classes.

With respect to average unit costs for all local road expenditures, vehicle classes 1–3 had the lowest unit costs while vehicle classes 7 and 13 had an average unit cost of $0.5 per VMT, which was the highest among the 13 vehicle classes.

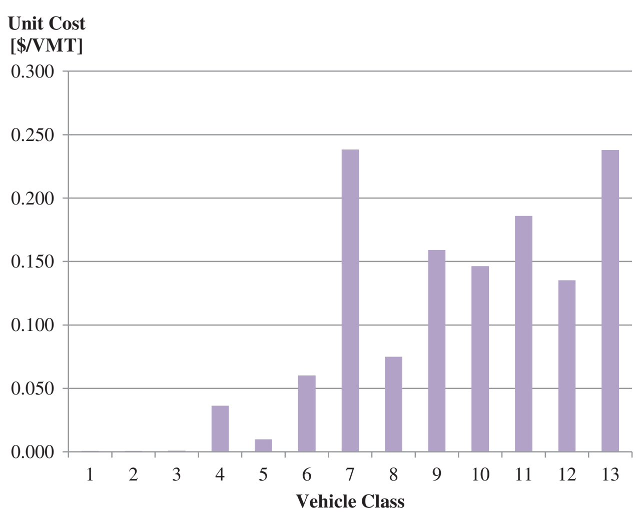


Figure 4.1.15 Average unit cost for road maintenance on local routes, 2009–2012.

TABLE 4.1.12
Cost Responsibility and Unit Cost for Traffic & Safety Projects on Local Routes, 2009–2012.

Vehicle Class	Cost Responsibility	Unit Cost [$/VMT]
1	$1,793,631	$0.0022
2	$195,966,216	$0.0022
3	$83,033,961	$0.0022
4	$325,461	$0.0023
5	$5,186,146	$0.0023
6	$3,127,399	$0.0023
7	$1,068,795	$0.0023
8	$974,191	$0.0022
9	$8,544,856	$0.0022
10	$139,199	$0.0022
11	$59,658	$0.0022
12	$17,098	$0.0022
13	$44,974	$0.0022
Total	$300,281,586	

TABLE 4.1.13
Cost Responsibility by Project Type for Road Expenditures on Local Routes, 2009–2012

Vehicle Class	New Road Construction	Road Rehabilitation	Road Maintenance	Traffic/Safety Projects	Total
1	$3,897,029	$3,570,044	$627,763	$1,793,631	$9,888,466
2	$432,520,860	$389,972,993	$68,590,820	$195,966,216	$1,087,050,889
3	$200,284,923	$169,809,757	$32,837,306	$83,033,961	$485,965,947
4	$3,346,326	$3,639,015	$5,187,438	$325,461	$12,498,240
5	$28,310,201	$20,749,234	$22,341,242	$5,186,146	$76,586,823
6	$30,677,005	$73,358,241	$83,068,918	$3,127,399	$190,231,563
7	$35,294,214	$88,816,127	$112,295,632	$1,068,795	$237,474,768
8	$11,831,877	$18,884,057	$33,335,533	$974,191	$65,025,657
9	$160,095,246	$463,086,063	$615,377,515	$8,544,856	$1,247,103,680
10	$2,912,181	$7,219,096	$9,304,164	$139,199	$19,574,640
11	$1,464,125	$2,282,594	$5,064,943	$59,658	$8,871,320
12	$412,576	$540,617	$1,055,876	$17,098	$2,026,167
13	$1,659,410	$3,755,994	$4,882,760	$44,974	$10,343,139
Total	$912,705,973	$1,245,683,832	$993,969,910	$300,281,586	$3,452,641,300

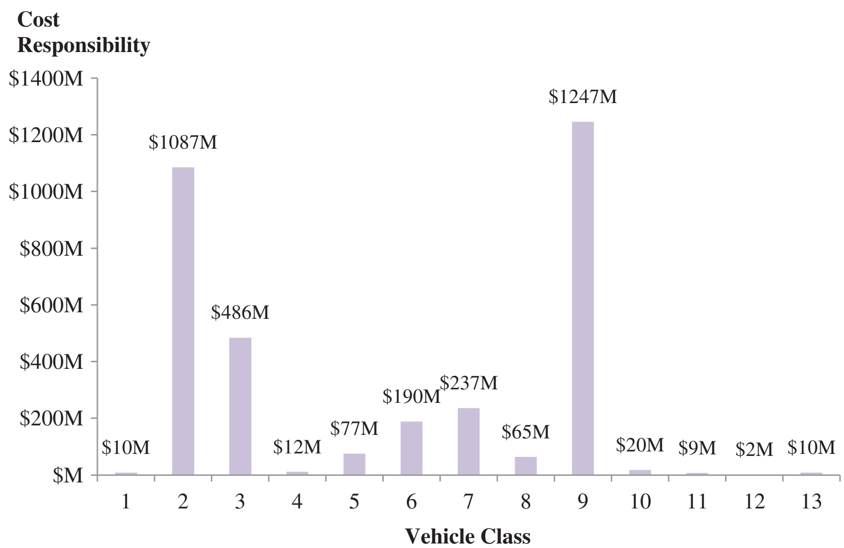


Figure 4.1.16 Total cost responsibility per vehicle class for road expenditures on local routes, 2009–2012.

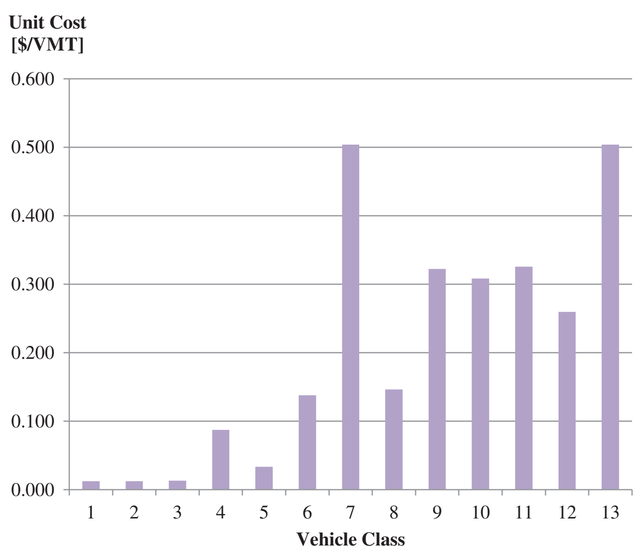


Figure 4.1.17 Average unit cost for road expenditures on local routes, 2009–2012.

2. COST ALLOCATION FOR BRIDGE EXPENDITURES ON LOCAL ROUTES

In this chapter, the bridge-related expenditures incurred by local authorities are analyzed. From a theoretical perspective, the same methodology used for allocating state route expenditures was applicable to the local route expenditures. However, due to the lack of detailed information for local projects, some assumptions were made in order to apply the state route methodology to local routes.

2.1 Study Methodology for Cost Allocation for Local Bridges

The bridge-related expenditures for local routes were separated into load-related costs and common costs and therefore analyzed differently. The load-related costs include the expenditures on bridge construction and reconstruction and an estimated proportion of the load-related bridge rehabilitation expenditures. The common costs consist of the bridge maintenance and repair expenditures and an estimated proportion of the non-load-related bridge rehabilitation expenditures. Detailed descriptions of these data are presented in Section 2.2 of Part 4.

In the analysis for bridges on local routes, replacement and reconstruction were treated the same way as new construction. This is because the inventory rating and sufficiency rating information, which are typically needed in the methodology for bridge replacement cost allocation was not available in the operational reports provided by local authorities.

In the study methodology developed for state routes, different incremental factors were established for bridges with different material types, structure types, and span lengths. However, as such information was unavailable for local projects in the operational reports, the analysis was carried out using the proportion of different bridge types and average span lengths.

Site Manager contains contract expenditures for a number of local projects for which the bridge material types are known. Therefore, these bridge projects were used as samples to estimate the cost percentages of each material type of bridge, and the following estimation was obtained: reinforced concrete bridge projects accounted for 20% of the total expenditures on local bridges, prestressed concrete bridge projects accounted for 45%, and steel bridge projects accounted for 35%. To estimate the average span length and average structure length, all local route bridges in the NBI database were investigated, and the following results were acquired: the average length of span is 45 ft., 48 ft., and 48 ft. for reinforced concrete, prestressed concrete, and steel bridges, respectively; the average structure length was 105 ft., 120 ft., and 120 ft. for reinforced concrete, prestressed concrete, and steel bridges, respectively. The estimation of span length and structure length was necessary to determine the incremental cost allocation factors for local bridges.

With regard to the traffic distribution and vehicle weight distribution, the AADT information was not available for every local road segment. Therefore, an average level of AADT percentages for local routes developed by the Purdue research team was used in the analysis (Table 4.2.1). The weight distribution is taken from the Non-NHS column of Table 3.2.11. The correlation between AASHTO design vehicles and FHWA vehicles was not affected, and Tables 3.2.1 and 3.2.2 remained applicable.

With all the expenditures categorized and the necessary estimation and assumptions made, the load-related expenditures were allocated following a procedure similar to that proposed in Section 2.1.2 of Part 3; and the common costs were allocated based on the PCE-weighted VMT (PCE-miles) of the different vehicle classes. The details of the analysis and results are presented in Section 2.3 of this Part of the report.

2.2 Data for Local Bridge Cost Allocation

The sources of expenditures for local routes were described in Chapter 1 of this Part of the report. Thus, in this section, only the bridge-related expenditures are presented and illustrated. The bridge-related local expenditures were mostly obtained from the annual operational reports submitted by county and city authorities. In addition, 80% of the bridge-related expenditures on local routes in Site Manager were also included for the reason explained in the pavement chapter (Chapter 1 of this Part of the report). From the county and city annual operational reports, data on the "maintenance and repair" expenditures and "construction and reconstruction" expenditures under "operating disbursements" were extracted. The percentage splits between pavement and bridge expenditures were estimated using detailed information about the different sources of funds. A breakdown of these expenditures from various funds is shown in Tables 4.2.2 and 4.2.3.

As mentioned earlier, 80% of the bridge-related expenditures on local routes in Site Manager were

TABLE 4.2.1
AADT Percentages of Different Vehicle Classes for Local Routes.

Vehicle Class	2009	2010	2011	2012
1	0.60%	0.60%	0.59%	0.59%
2	65.73%	65.73%	64.75%	64.87%
3	27.73%	27.73%	27.88%	27.31%
4	0.08%	0.08%	0.10%	0.16%
5	1.22%	1.22%	1.79%	2.59%
6	0.63%	0.63%	1.34%	1.52%
7	0.21%	0.21%	0.46%	0.52%
8	0.47%	0.47%	0.19%	0.17%
9	3.19%	3.19%	2.85%	2.22%
10	0.068%	0.068%	0.027%	0.025%
11	0.032%	0.032%	0.006%	0.010%
12	0.009%	0.009%	0.002%	0.003%
13	0.022%	0.022%	0.009%	0.008%

TABLE 4.2.2
Local Bridge-Related Expenditures from County Operational Reports.

Year	Motor Vehicle Highway	Local Road & Street	Cumulative Bridge	Other Funds	Total Funds
Maintenance and Repair Expenditures by Funding Source					
2009	$3,662,729	$1,774,937	$18,723,358	$9,652,239	$33,813,263
2010	$3,557,733	$1,648,358	$27,206,174	$3,639,289	$36,051,554
2011	$3,447,973	$1,498,814	$16,870,742	$4,240,066	$26,057,595
2012	$3,055,180	$1,252,560	$19,175,030	$4,695,534	$28,178,304
Total	$13,723,615	$6,174,668	$81,975,304	$22,227,129	**$124,100,716**
Construction and Reconstruction Expenditures by Funding Source					
2009	$2,031,091	$1,793,478	$54,738,136	$19,224,676	$77,787,380
2010	$1,780,499	$2,171,210	$63,797,576	$42,687,951	$110,437,236
2011	$1,648,007	$1,830,447	$48,075,377	$46,538,439	$98,092,270
2012	$1,680,562	$1,907,329	$47,020,119	$68,318,615	$118,926,625
Total	$7,140,160	$7,702,464	$213,631,209	$176,769,680	**$405,243,512**

TABLE 4.2.3
Local Bridge-Related Expenditures from City Operational Reports.

Year	Motor Vehicle Highway	Local Road & Street	Cumulative Bridge	Other Funds	Total Funds
Maintenance and Repair Expenditures by Funding Source					
2009	$1,864,489	$958,554	$3,225,572	$151,636	$6,200,250
2010	$2,032,034	$1,006,788	$3,069,316	$175,016	$6,283,155
2011	$1,833,564	$949,858	$2,912,194	$183,382	$5,878,999
2012	$1,807,359	$867,240	$3,499,130	$120,924	$6,294,653
Total	$7,537,446	$3,782,441	$12,706,212	$630,958	**$24,657,057**
Construction and Reconstruction Expenditures by Funding Source					
2009	$1,060,174	$912,863	$4,565,942	$826,343	$7,365,321
2010	$1,407,259	$911,140	$7,258,145	$1,135,837	$10,712,380
2011	$912,182	$778,754	$6,330,655	$1,126,882	$9,148,474
2012	$1,078,715	$677,899	$6,365,897	$1,593,259	$9,715,770
Total	$4,458,330	$3,280,656	$24,520,639	$4,682,321	**$36,941,946**

included. Table 4.2.4 presents these expenditures. The column "Other" refers to the safety, mobility, and other related expenditures in the local bridge projects.

Table 4.2.5 summarizes the total bridge-related expenditures on local routes extracted from different data sources for the study period. The procedures for estimating and extrapolating the missing data are described in Section 1.2 of Part 4.

Table 4.2.6 and Figure 4.2.1 present the bridge-related expenditures on local routes by year and by project type with all three data sources combined. The column "Other" refers to the safety, mobility, and other related expenditures in the local bridge projects.

2.3 Analysis and Results

The construction and reconstruction expenditures from the county and city operational reports, the expenditures on bridge construction and replacement from Site Manager, and 30% of the bridge rehabilitation/repair expenditures (which were estimated as the load-related rehabilitation/repair expenditures) from

TABLE 4.2.4
Local Bridge-Related Local Expenditures from Site Manager Database.

Year	New Bridge Construction	Bridge Replacement	Bridge Rehab/Repair	Other	Total
2009	$32,780,457	$22,495,954	$1,543,631	$21,879,927	$78,699,969
2010	$12,711,422	$19,680,266	$4,223,299	$31,841,108	$68,456,096
2011	$12,886,215	$25,880,321	$1,561,265	$15,261,409	$55,589,210
2012	$10,705,391	$9,971,633	$1,234,861	$5,379,185	$27,291,071
Total	$69,083,485	$78,028,174	$8,563,056	$74,361,629	**$230,036,345**

TABLE 4.2.5
Total Bridge-Related Expenditures on Local Routes by Data Source.

Expenditure Source	2009	2010	2011	2012	Average
County	$111,600,643	$146,488,790	$124,149,865	$147,104,929	$127,413,099
City	$13,565,571	$16,995,535	$15,027,473	$16,010,423	$15,196,193
Site Manager	$78,699,969	$68,456,096	$55,589,210	$27,291,071	$67,581,758
Total	$203,866,183	$231,940,421	$194,766,548	$190,406,423	**$210,191,051**

TABLE 4.2.6
Bridge Cost Responsibility for Local Routes by Project Type, 2009–2012.

Vehicle Class	Bridge Construction and Reconstruction	Bridge Rehabilitation	Bridge Maintenance and Repair	Others	Bridge Total
1	$2,360,198	$273,403	$825,940	$414,763	$3,874,304
2	$257,878,872	$29,869,405	$90,226,459	$45,310,685	$423,285,421
3	$109,284,174	$12,653,566	$38,211,106	$19,191,487	$179,340,333
4	$1,970,455	$139,200	$318,068	$139,286	$2,567,010
5	$16,256,242	$1,769,871	$5,036,415	$2,186,438	$25,248,966
6	$17,393,089	$1,284,559	$2,997,685	$1,277,681	$22,953,015
7	$35,137,264	$1,290,128	$1,023,807	$435,970	$37,887,169
8	$4,593,392	$380,894	$1,045,452	$599,843	$6,619,581
9	$82,704,522	$4,545,975	$8,791,097	$4,642,444	$100,684,039
10	$6,138,699	$213,459	$149,454	$85,809	$6,587,422
11	$619,527	$33,290	$65,397	$38,621	$756,835
12	$3,125,715	$95,531	$18,660	$10,955	$3,250,861
13	$7,616,421	$232,320	$48,231	$27,646	$7,924,619
Total	$545,078,571	$52,781,603	$148,757,773	$74,361,629	$820,979,575

Site Manager, were treated as load-related costs and analyzed using the incremental method developed for state routes in Chapter 2 of Part 3. Some input parameters needed for the incremental method were estimated from the data or assumed (as mentioned in the methodology section of this chapter).

The maintenance and repair expenditures from the county and city operational reports were treated as commons costs and allocated based on the PCE-weighted VMT of different vehicle classes. Also, 70% of the bridge rehabilitation/repair expenditures (which were estimated as the non-load-related rehabilitation/repair expenditures) from Site Manager and the "other" expenditures from Site Manager were allocated as common costs.

Table 4.2.7 summarizes the allocation results for the local expenditures. The cost responsibility is for the four-year total expenditures. The detailed results for the individual years can be found in Addendum C of this report. Figure 4.2.2 also presents the results. Figure 4.2.3 presents the results of the unit cost, which was calculated as the cost responsibility divided by the total four-year VMT of the corresponding vehicle class.

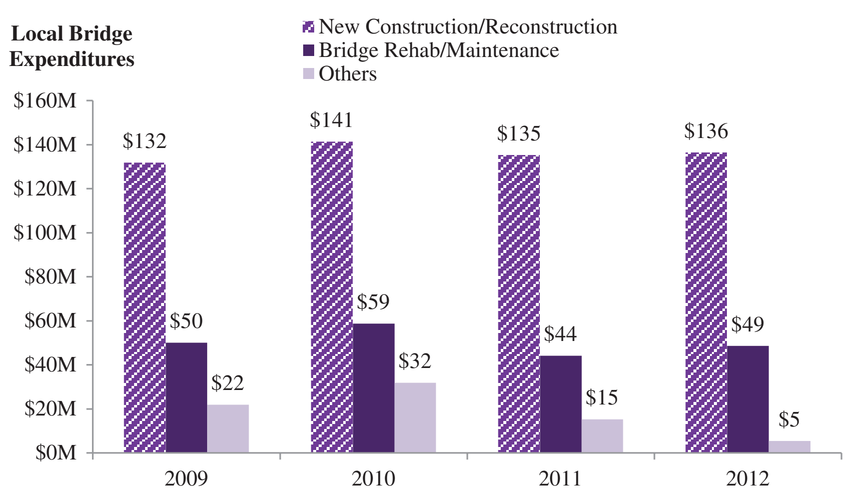


Figure 4.2.1 Total bridge-related expenditures on local routes by project type.

TABLE 4.2.7
Total Bridge-Related Expenditures on Local Routes by Project Type.

Year	Bridge New Construction and Reconstruction	Bridge Rehab and Maintenance	Other	Total
2009	$131,913,843	$50,072,414	$21,879,927	$203,866,183
2010	$141,426,343	$58,672,970	$31,841,108	$231,940,421
2011	$135,283,206	$44,221,934	$15,261,409	$194,766,549
2012	$136,455,179	$48,572,058	$5,379,185	$190,406,422
Total	$545,078,571	$201,539,375	$74,361,629	**$820,979,575**

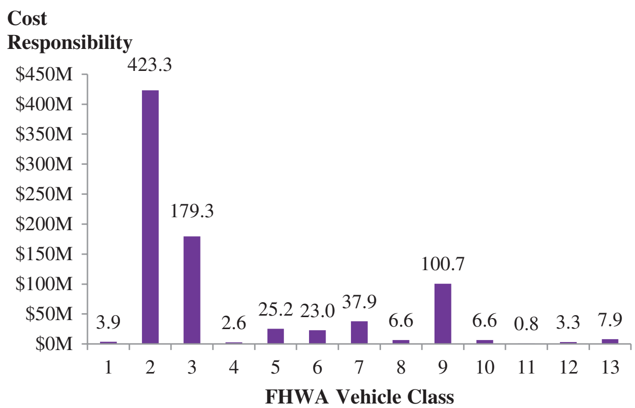


Figure 4.2.2 Bridge cost responsibility and share for local routes.

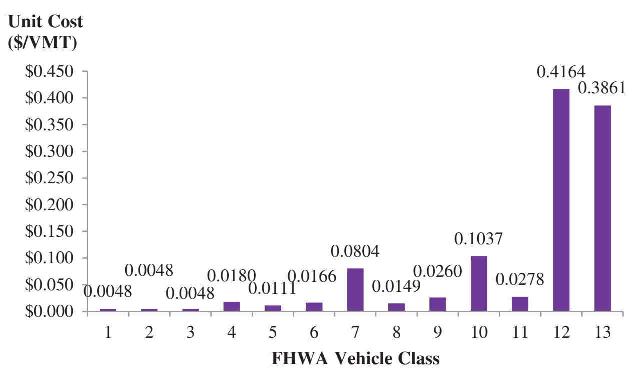


Figure 4.2.3 Bridge unit cost ($/VMT) for local routes.

2.4 Chapter Summary

In this chapter, the bridge-related expenditures for local routes were analyzed. The bridge-related expenditures obtained from various sources were summarized and analyzed separately as load-related costs and common costs. The results were then combined and allocated to the different FHWA vehicle classes. The cost responsibility and unit cost results are presented in Section 2.3 of this Part of the report.

It was found that vehicle classes 2 and 3 bear the highest cost responsibility (almost 85% of total costs) in terms of bridge-related expenditures on local routes primarily due to their higher VMT on local routes compared with other vehicle classes. With respect to the unit cost, vehicle classes 12 and 13 were found to assume significantly higher unit cost values (0.42 and 0.39 $/VMT, respectively). Apart from the fact that these vehicle classes are associated with the heaviest loads, their relatively lower VMTs on local routes is a plausible reason for their higher unit costs compared to the other vehicle classes.

3. SUMMARY OF LOCAL ROUTES COST ALLOCATION

Part 4 discussed the cost allocation methodology, data, analysis, and results related to road and bridge on Indiana local routes. The methodology was presented and explained for the different expenditure types in different Sections of this Part. For new road construction, the methodology developed for the 1997 and 2000 FHWA HCAS was adopted, and the analysis was conducted on a project-by-project basis where feasible. Regarding the allocation of rehabilitation expenditures, a portion of the expenditures (which were related to damage by non-load factors) was attributed based on VMT while the rest of the expenditures were attributed using the distressed-based FHWA model (NAPCOM). A load and non-load split was also used for the allocation of pavement maintenance expenditures; the load-related expenditures were allocated on the basis of ESAL-miles. For bridge cost allocation, the load-related expenditures for new bridge construction, reconstruction, rehabilitation and repair were analyzed using the incremental method. The non-load-related expenditures for these bridge projects were treated as common costs allocated using VMT.

Table 4.3.1 summarizes the cost responsibility of each FHWA vehicle class by project type for local routes in Indiana from 2009 to 2012. The results show that vehicle class 9 had the highest cost responsibility among the classes that represent truck traffic, which is due to the combined effect of high load and high level of road usage of class 9 compared to the remaining truck classes.

Figure 4.3.1 presents the analysis results of average unit cost ($/VMT) of each vehicle class by expenditure type for local routes in Indiana over the study period. It can be observed that vehicle classes 12 and 13 had the two highest average unit costs. The average unit costs are much higher compared to those for the state routes, partially due to the low volume of trucks on local routes. For example, for vehicle class 13, the average unit cost for local routes is almost $0.9 per VMT but is approximately $0.13 per VMT for state routes.

TABLE 4.3.1
Summary of Cost Responsibility by Vehicle Class and Project Type for Local Routes, 2009–2012.

Vehicle Class	New Road & Bridge Construction/ Reconstruction	Road & Bridge Rehabilitation	Road & Bridge Maintenance/ Repair	Traffic, Safety and Other Expenditures	Total
1	$6,257,227	$3,843,447	$1,453,703	$2,208,394	$13,762,770
2	$690,399,733	$419,842,398	$158,817,279	$241,276,901	$1,510,336,310
3	$309,569,096	$182,463,323	$71,048,412	$102,225,448	$665,306,280
4	$5,316,781	$3,778,215	$5,505,506	$464,747	$15,065,250
5	$44,566,444	$22,519,105	$27,377,657	$7,372,584	$101,835,790
6	$48,070,094	$74,642,800	$86,066,604	$4,405,081	$213,184,577
7	$70,431,478	$90,106,256	$113,319,439	$1,504,764	$275,361,937
8	$16,425,269	$19,264,951	$34,380,985	$1,574,034	$71,645,239
9	$242,799,769	$467,632,038	$624,168,612	$13,187,300	$1,347,787,719
10	$9,050,881	$7,432,555	$9,453,618	$225,008	$26,162,061
11	$2,083,652	$2,315,884	$5,130,340	$98,278	$9,628,155
12	$3,538,291	$636,148	$1,074,536	$28,054	$5,277,028
13	$9,275,831	$3,988,315	$4,930,991	$72,621	$18,267,758
Total	$1,457,784,544	$1,298,465,435	$1,142,727,682	$374,643,215	$4,273,620,876

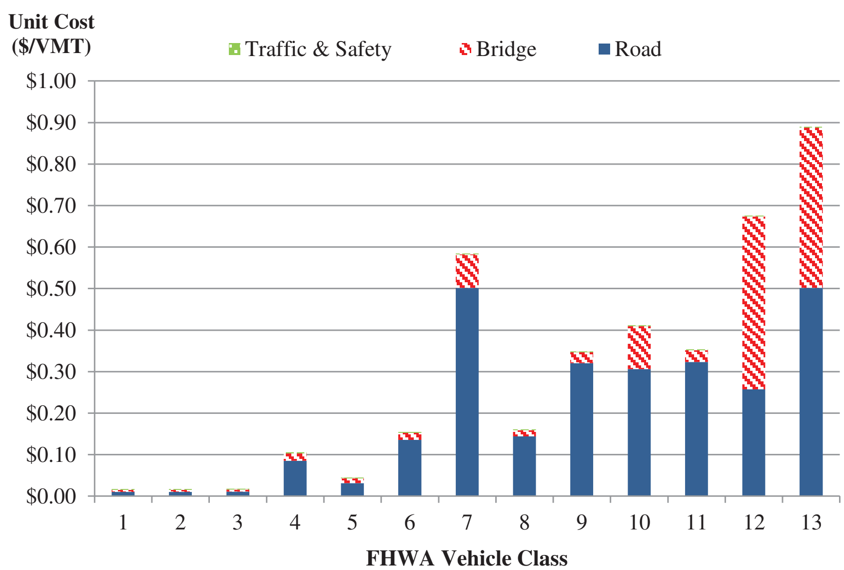


Figure 4.3.1 Average unit cost ($/VMT) of all expenditures for local routes, 2009–2012.

PART 5. REVENUE ANALYSIS

1. INTRODUCTION

This part of the report presents an analysis of all highway-related revenues in the State of Indiana in the 2009–2012 fiscal year periods. Three governmental levels of revenue collection—federal, state, and local—were considered. Also, for each of these three levels, the revenues were further reported for two source categories—user and non-user.

1.1 Highway Revenues

Highway revenues are used to fund the construction, reconstruction, rehabilitation, and maintenance of Indiana state and local road systems. For the purpose of the present study, two revenue sources are considered—user and non-user. The user sources include: gasoline tax, diesel tax, motor carrier surcharge tax, motor carrier fuel use tax, vehicle registration fees, driver license fees, international registration plan, oversize/overweight permit fees, commercial vehicle excise tax, wheel tax, motor vehicle excise tax and excise surtax, heavy vehicle use tax, tax on sales of trucks and trailers, and tax on tires. The non-user revenue sources include: federal stimulus (the American Recovery and Reinvestment Act of 2009), toll road lease money (Major Moves), General Fund transfers, and other miscellaneous taxes including property tax, income tax, and state court fees.

The data on highway user and non-user revenues from the 2009–2012 fiscal years were collected from the Indiana Department of Transportation (INDOT), Indiana Department of Revenue, Annual Operational Reports from counties and cities, and the Indiana Handbook of Taxes, Revenues, and Appropriations and the Highway Statistics series published by the FHWA.

1.1.1 State-Level Highway Revenues

Figure 5.1.1 presents a graphical representation of Indiana's highway funding structure at the state level. As shown in the figure, all the highway revenues go into intermediate repositories (funds and accounts) from which they are distributed according to the legislative formulae shown in the figure. The major fund and account are the State Highway Fund and the Motor Vehicle Highway Account. The state-level highway user revenue sources include gasoline tax, diesel tax, motor carrier surcharge tax, motor carrier fuel use tax, vehicle registration fees, driver license fees, the international registration plan (IRP), and oversize/overweight permit fees. The fuel tax is collected at the time of purchase. As of January 1, 2014, the gasoline tax rate was 18 cents per gallon and the diesel tax rate was 16 cents per gallon. Diesel tax is imposed on diesel fuel purchased and consumed in the state.

The motor carrier surcharge tax, an extra tax charged for diesel fuel on all heavy commercial vehicles, with GVW in excess of 26,000 lbs., in the State of Indiana, is paid by trucking companies to the Indiana Department of Revenue. The current tax rate is 11 cents per gallon and has been in effect since 1988. Motor carriers that purchase fuel outside Indiana but travel on Indiana roads are expected to pay the motor carrier fuel use tax (MCFUT) for the miles traveled in Indiana. Trucks that purchase diesel fuel in Indiana but travel outside of Indiana typically file claims for reimbursement of taxes paid on diesel fuel consumed out of state (ILSA, 2013).

Vehicle registration for passenger vehicles is a flat fee paid annually to register automobiles and light trucks (under 7,000 lbs.), while registration fees for heavier vehicles (including trucks, tractors, and buses) are based on gross registered weight (ILSA, 2013). As a part of registration, commercial vehicle excise tax and motor vehicle excise tax are also collected but are not used for highway maintenance and improvement. Also, at the state level, non-user highway revenue sources including toll road lease money (Major Moves), state court fees, General Fund transfers, and other miscellaneous amounts are used to support highway infrastructure maintenance and improvement.

The state-level user and non-user highway revenues generated during the study period (FY 2009–FY 2012) are illustrated graphically in Figure 5.1.2. It can be observed from the figure that, on average, gasoline tax revenue was $539.5 million, diesel tax revenue $217.5 million and non-user revenue $644.7 million. The revenue from non-user sources constituted a dominant source of revenue at the state level, followed by the gasoline tax, the registration fees, diesel tax, motor carrier surcharge tax, and International Registration Plan, in that order. The oversize-overweight permit and the motor carrier fuel use tax were the smallest sources of revenue. For each source, the annual amounts across the four years were generally found to be stable; the only exception was the non-user source; for this revenue source, there was marked fluctuation across the years. From the perspective of INDOT, these trends of state-level revenue may be a cause for concern, specifically, the dominance of non-user revenue and more importantly, the uncertainty associated with this dominant source.

1.1.2 Local-Level Highway Revenues

Figure 5.1.3 graphically presents local highway revenues. At the local level, highway user revenue sources include county motor vehicle excise surtax and wheel tax. The county motor vehicle excise surtax is imposed on vehicles (motorcycles, passenger cars, and trucks with a gross weight of 11,000 lbs. or less) owned by residents in counties that impose the tax. The annual tax is $7.50 (minimum) to $25.00 (maximum) (ILSA, 2013). The local option wheel tax is imposed at the county level on buses, recreational vehicles, semi-trailers, tractors, trailers over 3,000 pounds, and trucks

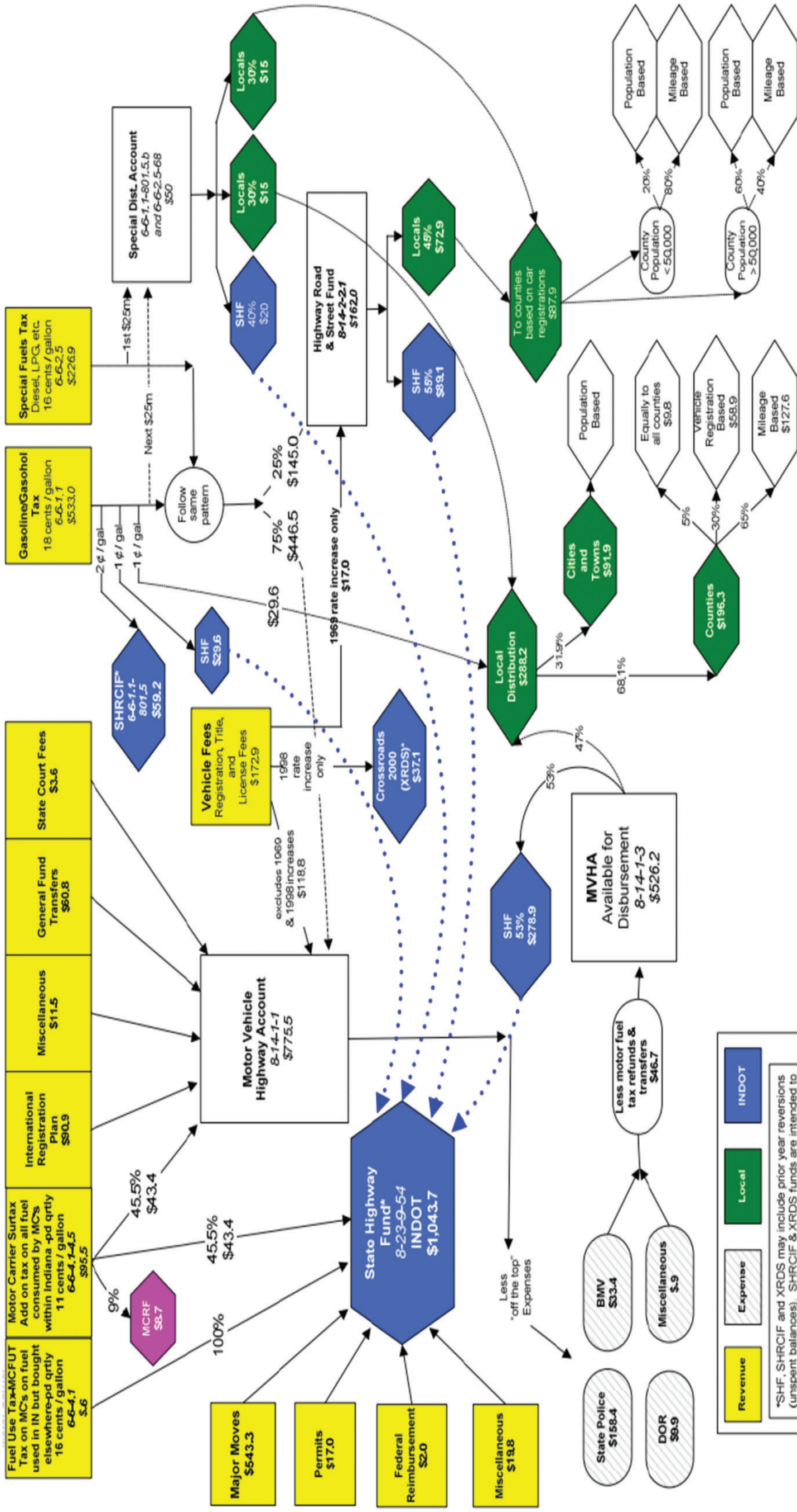


Figure 5.1.1 Indiana highway funding chart (ILSA, 2013).

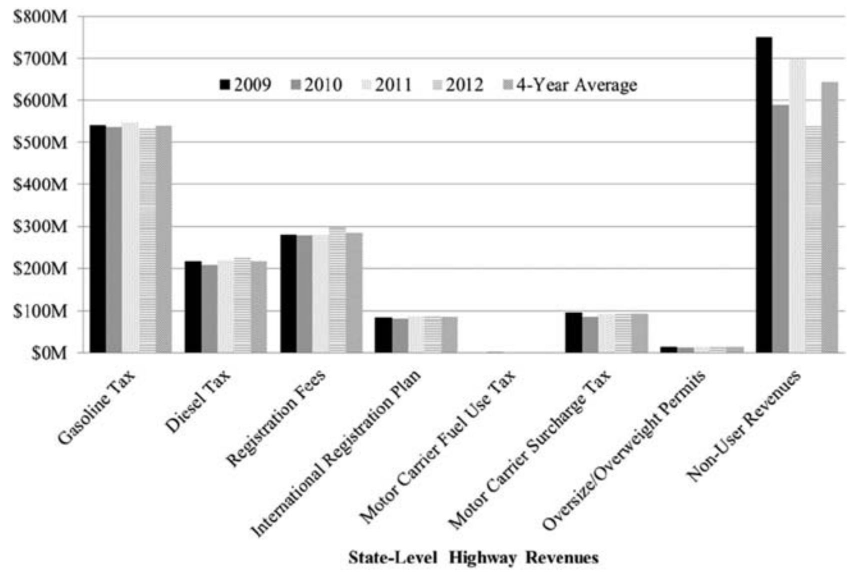


Figure 5.1.2 State level highway revenues by source.

not subject to the county motor vehicle excise surtax, and the annual tax per vehicle ranges from $5 to $40. During the analysis period, the revenue from the four-year average excise surtax was $61.4 million and wheel tax was $8.1 million. The local highway activities were funded from a variety of non-user revenue sources including the local share of the toll road lease money (Major Moves), General Funds, state court fees, financial institution tax, income and other taxes, tax increment financing, liquor and cigarette tax, property tax, bond proceeds, and others. Similar to the situation for the state-level revenue, the dominant source of revenue for local highway related activities is the non-user sources (approximately $447 million annually, on average). This too is particularly troubling because that source is also characterized by the largest amount of variability and therefore is least certain.

1.1.3 Federal-Level Highway Revenues

At the federal level, revenue sources include both user and non-user categories. These revenues supported state and local level highway projects and the amounts are presented in Table 5.1.1. Federal level user revenues consist of gasoline tax, diesel tax, heavy vehicle use tax, tax on sales of trucks and trailers, and tax on tires. The federal gasoline tax rate is 18.4 cents per gallon and 24.4 cents for diesel. For heavy vehicles, there are other

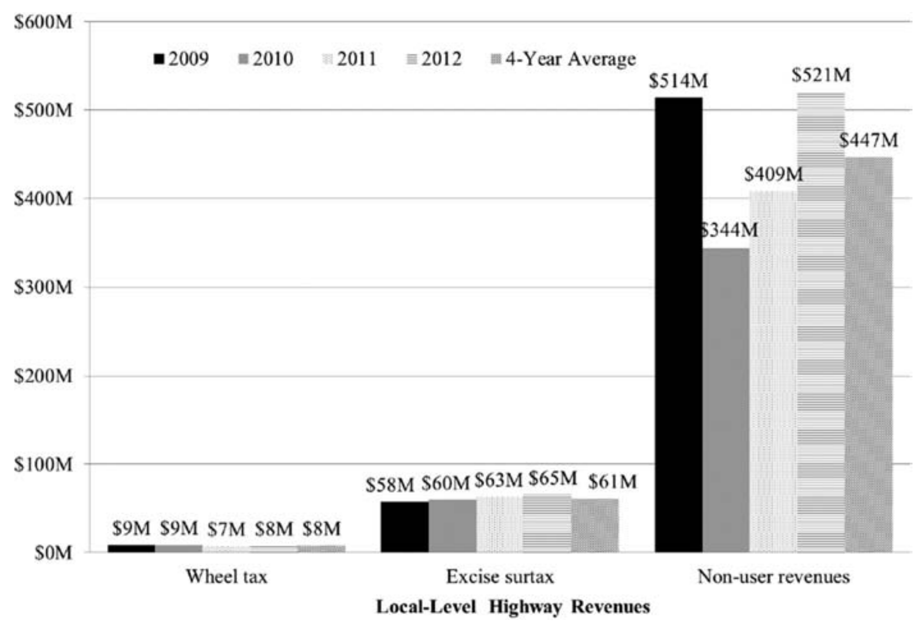


Figure 5.1.3 Local-level highway revenues by source.

TABLE 5.1.1
Federal-level Highway Revenues ($ millions).

Level	Source	2009	2010	2011	2012	4-Year Average
State	User	659.2	698.7	688.8	671.2	679.5
	Non-User	219.7	196.0	15.8	1.4	108.2
Local	User	219.7	232.9	229.6	223.7	226.5
	Non-User	0.0	183.4	0.6	0.4	46.1
Total		1,098.6	1,311.0	934.8	896.7	1,060.3

non-fuel based federal fees, which include a two percent tax truck retail sales (GVW above 33,000 lbs.), truck trailer sales (GVW over 26,000 lbs.), a graduated tax on heavy tires of 15 cents per lb. over 40 lbs., plus 30 cents per lb. over 70 lbs., plus 50 cents per lb. over 90 lbs. A heavy vehicle use tax is applied to trucks 55,000 lbs. and over GVW, which is $100 plus $22 per 1,000 lbs. in excess of 55,000 lbs., with a maximum of $550 per truck (FHWA, 2013c). These contributions are placed in the Highway Trust Fund (HTF) and federal legislation requires that the money from the HTF be returned to states for highway and other surface transportation programs at the state and local levels. The federal level non-user highway revenues during the analysis period came from the Federal Stimulus (American Recovery and Reinvestment Act), as shown in Table 5.1.1.

The federal level user revenues were attributed according to the distribution by user revenue source (gasoline tax, diesel tax, heavy vehicle use tax, excise tax on trucks and trailers, and tires). The distributions are shown in Table 5.1.2 and graphically illustrated in Figure 5.1.4. The user revenues collected at the federal level were distributed to both state and local agencies. For example, in FY 2009, of the $878.9 million of the federal level user revenues that came to Indiana, $659.2 million went to the state while $219.7 million went to the local agencies.

1.1.4 Total Annual Highway Revenues

A summary of the total user and non-user highway revenues is presented in Table 5.1.3. From the table, it can be observed that 63.5% of highway revenues that supported the construction, reconstruction, rehabilitation,

TABLE 5.1.2
Distributions of Federal-level User Revenues by Source.

Revenue Source	Yearly Revenue (%) 2009	2010	2011	2012	4-Year Average
Gasoline tax	56.53	59.00	55.47	50.33	55.33
Diesel tax	29.93	29.47	31.85	28.41	29.92
Federal heavy vehicle use tax	4.12	3.70	1.43	6.10	3.84
Federal excise tax on trucks and trailers	8.08	6.51	9.51	13.67	9.44
Tires	1.34	1.33	1.73	1.49	1.47
Total	100	100	100	100	100

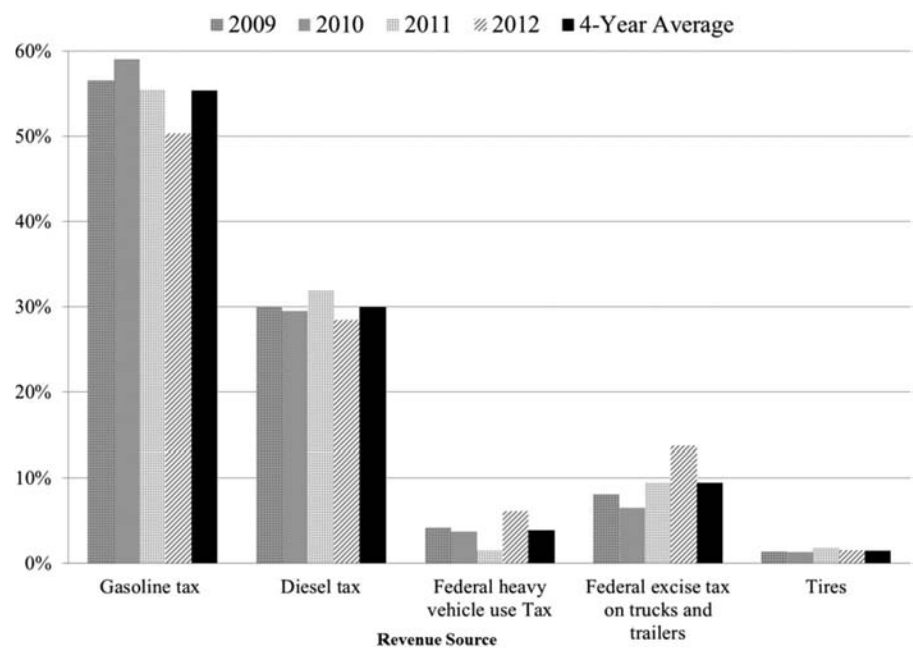


Figure 5.1.4 Graphical presentation of federal-level user revenues by source.

TABLE 5.1.3
Four-Year Total Annual Highway Revenues in $ millions: FY 2009–FY 2012.

Revenue Source	Level				%
	Federal	State	Local	Total	
User	905.95	1,192.01	69.47	2,167.42	63.5
Non-User	154.31	644.70	446.90	1,245.91	36.5
Total	1,060.26	1,836.71	516.37	3,413.33	100
%	31.1	53.8	15.1	100	

and maintenance of Indiana state and local roads and highways came from highway users, while the remaining 36.5% was from non-user sources. State-level highway revenues supported 53.8% of the costs, while 31.1% and 15.1% came from the federal and local levels, respectively. The values in the table do not include revenue amounts from commercial vehicle excise tax and motor vehicle excise tax because revenues from these two sources were not designated by the legislators for highway maintenance and improvement. However, these were included in the user equity analysis (see discussion in Section 1.2 of Part 5) because highway users directly contributed these revenues.

1.2 User Revenue and Its Attribution to the Vehicle Classes

Revenue attribution is the process by which the user revenues are distributed among the users (vehicle classes) of the roads and highways. In the present study, each of the 13 FHWA vehicle classes is an individual user group. Therefore, for a given source and for a given level of government, the amount of the total user revenue contributed by each vehicle class was first determined. Then for a vehicle class, the results were summed up for all the revenue sources and for all the government levels to yield the total revenue that was attributed to each vehicle class. As stated earlier, the highway user revenues were broadly categorized into three levels: state, local and federal. The user revenue amounts from all sources, including the four-year average values, for the four fiscal years (FY 2009–FY 2012) are presented in Table 5.1.4.

The state-level user revenue sources include gasoline tax, diesel tax, registration fees, international registration plan, motor carrier fuel use tax, motor carrier surcharge tax, and oversize/overweight permits. The yearly average over the 4-year period was $1,192 million. A significant part of the state-level user revenue came from gasoline tax ($539.5 million).

The local-level user revenue sources include commercial vehicle excise tax, wheel tax, motor vehicle excise tax and excise surtax. Revenues collected from the commercial vehicle excise tax and motor vehicle excise tax are not intended for (and were not used) for highway purposes. However, these two revenue sources are included in the equity analysis because these amounts were contributed directly by the highway users for their use of the highways and therefore should be considered as highway user contributions as a matter of fairness. A significant part of the local-level user revenues was from

TABLE 5.1.4
Highway User Revenues in Indiana: FY 2009–FY 2012.

Level	Revenue Source	Revenue ($M)				
		2009	2010	2011	2012	4-Year Average
State	Gasoline tax	540.5	536.5	547.6	533.2	539.5
	Diesel tax	217.1	207.9	218.3	226.9	217.6
	Registration fees	278.9	278.4	279.3	299.9	284.1
	International registration plan	85.5	82.9	89.1	90.9	87.1
	Motor carrier fuel use tax	1.4	1.9	1.3	0.6	1.3
	Motor carrier surcharge tax	97.3	86.9	94.8	95.5	93.6
	Transfers and refunds	(51.7)	(42.3)	(39.3)	(46.7)	(45.0)
	Oversize/overweight permits	13.4	12.4	13.5	16.1	13.8
	Subtotal	***1,182.42***	***1,164.6***	***1,204.6***	***1,216.4***	1,192.0
Local	Commercial vehicle excise tax	60.0	60.2	61.2	61.3	60.7
	Wheel tax	8.6	8.8	7.3	7.7	8.1
	Motor vehicle excise tax	662.8	624.1	621.2	650.7	639.7
	Excise surtax	57.5	59.5	63.1	65.4	61.4
	Subtotal	***788.89***	***752.62***	***752.79***	***785.08***	769.84
Federal	Gasoline tax	496.8	549.6	509.4	450.4	501.6
	Diesel tax	263.1	274.5	292.5	254.2	271.1
	Heavy vehicle use tax	36.2	34.4	13.2	54.6	34.6
	Excise tax on trucks and trailers	71.0	60.7	87.3	122.4	85.3
	Tires	11.8	12.4	15.9	13.3	13.4
	Subtotal	***878.91***	***931.58***	***918.38***	***894.91***	905.95
Total		***2,850.22***	***2,848.82***	***2,875.74***	***2,896.41***	***2,867.80***

TABLE 5.1.5
Highway User Revenue Contribution by Vehicle Class.

Vehicle Class	Revenue Contribution (in millions)	% Revenue Contribution (R)
1	$12.13	0.42
2	$1,360.19	47.43
3	$591.89	20.64
4	$10.79	0.38
5	$89.06	3.11
6	$63.61	2.22
7	$89.00	3.10
8	$40.41	1.41
9	$582.25	20.30
10	$10.56	0.37
11	$7.63	0.27
12	$3.51	0.12
13	$6.76	0.24
Total	$2,867.80	100

the motor vehicle excise tax, with an average of $639.7 million per year for the four fiscal years.

By far the largest portion of the federal level highway user revenue came from fuel taxes, as shown in Table 5.1.4. Of the total 4-year average of $905.95 million, the gasoline tax revenue was $501.6 million, while the diesel tax revenue was $271.1 million per year.

Highway revenues from fuel-related sources [gasoline, diesel, motor carrier surcharge tax (MCST) and motor carrier fuel use tax (MCFUT)] were attributed to the relevant vehicle classes on the basis of their VMT, fleet fuel efficiency and the tax rates, as shown below:

$$FR_i = \frac{VMT_i}{FFE_i} \times TR_k \tag{5.1}$$

where FR_i: Fuel revenue from vehicle class *i,*
VMT_i: Vehicle-miles of travel by vehicle class *i*,
FFE_i: Fleet fuel efficiency for vehicle class *i*,
TR_k: Tax rate for fuel type *k*.

The fleet fuel efficiencies were computed using the framework developed in a previous study (Agbelie, Bai, Labi, & Sinha, 2010), and the recently published fleet fuel efficiency values of the Transportation Energy Data Book from Oak Ridge National Laboratory (Davis, Diegel, & Boundy, 2014). Thus, the average fleet fuel efficiency values used for revenue attribution were as follows: 43.4 mpg (vehicle class 1), 23.4 mpg (vehicle class 2), 17.2 mpg (vehicle class 3), 7.2 mpg (vehicle class 4), 7.3 mpg (vehicle class 5), 7.1 mpg (vehicle class 6), 6.9 mpg (vehicle class 7), 6.1 mpg (vehicle classes 8 and 9), 6.0 mpg (vehicle class 10), 5.9 mpg (vehicle class 11), 5.7 mpg (vehicle class 12) and 5.6 mpg (vehicle class 13).

For each vehicle class, the revenues from vehicle registration fees, commercial vehicle excise tax, wheel tax, motor vehicle excise tax, excise surtax and license fees were attributed on the basis of the number of registered vehicles and fees. The attribution of revenue from the international registration plan was carried out using the number of Indiana-registered vehicles registered with a GVW exceeding 26,000 lbs. (that is, FHWA vehicles classes 7 and above). Oversize/overweight permit revenue was attributed to vehicle classes 5 to 13 on the basis of weight distributions using permit data provided by INDOR. The average distribution of overweight trucks by vehicle class, during 2009 to 2012, were as follows: class 5 (0.02%), classes 6, 8, 11, and 12 (0%), class 7 (1.48%), class 9 (7.08%), class 10 (27.14%), and class 13 (64.28%) (Everett et al., 2014).

Table 5.1.5 presents the results of the highway user revenue attribution by vehicle class. From the table, it can be observed that vehicle class 2 contributed approximately 47% of the highway user revenue while 20% came from vehicle class 9.

1.3 Summary of the Revenue Analysis

Using revenue data for the 2009–2012 fiscal years (July to June), the study analyzed the revenues from various sources that were used to fund the construction, reconstruction, rehabilitation, and maintenance of Indiana state and local roads and highways within that period. These revenue sources were categorized by source type (user and non-user) and government level of collection (federal, state, and local). Of the total revenue, 63.5% was from highway users while the remaining 36.5% was from non-user sources. The inability of user revenue sources to cover the total highway expenditure and the partial reliance on non-user sources is rather troubling particularly because the non-user sources are characterized by significant variability. Also, 53.8% of all revenues was generated at the state level, 31.1% at the federal level, and 15.1% at the local level. In addition to providing a breakdown of the revenue amounts generated by the user and non-user sources at each of the three levels of government, this Part of the report also documents how the four-year average user revenues were attributed to each vehicle class on the basis of considerations including fleet fuel efficiencies, VMTs, and number of registered vehicles. The revenue attribution analysis indicated that vehicle class 2 contributed approximately 47% of the highway user revenue while about 20% came from vehicle class 9. In the next Part of the report (Part 6), these revenue contribution values are considered together with the expenditures to assess the user revenue equity across the vehicle classes.

PART 6. USER EQUITY ANALYSIS

1. INTRODUCTION

In this Part of the report, the results from Parts 2–4 (allocation of state and local expenditures to the vehicle classes) and Part 5 (attribution of revenues to the vehicle classes) are used as inputs for user revenue equity analysis. The equity analysis is done by comparing for each vehicle class, the share of user revenue contributed and the share of cost responsibility. The purpose of this exercise is to determine the extent to which each vehicle class is paying its fair share of costs for highway upkeep (Sinha et al., 1984; FHWA, 1999). User equity ratios are used for revising highway user fee structures. In the State of Indiana, the highway taxation structure is based on the entire highway system, and not separately for state highways and local routes. Consequently, the user equity ratios were determined for the entire Indiana highway system (all state and local highways and roads). Using the results of the analysis, possible options to address current inequities can be examined so that each vehicle class would come closer to paying its fair share of the highway infrastructure consumption.

1.1 Computation of User Equity Ratios

Equity ratio is the revenue-to-cost ratio, that is, division of the percentage share of revenue contribution by the percentage share cost responsibility, as shown in Equation 6.1. For example, for a vehicle class with an equity ratio less than unity (1.00), the implication is that the vehicle class is underpaying its cost responsibility, while an equity ratio of unity (1.00) indicates that the share of the revenue is the same as the cost responsibility.

$$ER_i = \frac{RCP_i}{CRP_i} \tag{6.1}$$

where ER_i: Equity ratio of vehicle class i,
RCP_i: Percentage revenue contribution of vehicle class i, (Figure 6.1.1) and
CRP_i: Percentage share of cost responsibility of vehicle class i (Figure 6.1.1).

1.2 User Equity Results

The equity ratios for Indiana's highway users are presented in Table 6.1.1. The results indicate that vehicle classes 1–4 (motorcycles, automobiles, sports utility vehicles, and buses) have equity ratios greater than unity, while the remaining vehicle classes (5–13) have equity ratio values less than unity. From the table, it can be observed that in Indiana, automobiles (vehicle class 2) contributed approximately 47% of the highway user revenue while the cost responsibility for that vehicle class was approximately 43%. Thus, the equity ratio for vehicle class 2 is 1.10, indicating that vehicle class 2, as a group, is slightly overpaying its cost responsibility. For 5-axle combination trucks (vehicle class 9), the equity ratio is 0.81, indicating that this class is underpaying its cost responsibility. In general, the results suggest that passenger vehicles (light vehicles) are subsidizing the cost responsibilities of the heavier vehicles on Indiana's highway system.

The results of any cost allocation study are intended to assess possible future fees, among other objectives. As such, it is useful to examine the impact of any changes in future conditions on the stability of the cost allocation results. These include changes in the following: VMT levels and their distribution, revenue distribution across user and non-user sources, fuel efficiencies (average or relative levels across vehicle classes), highway expenditure and highway asset cohort

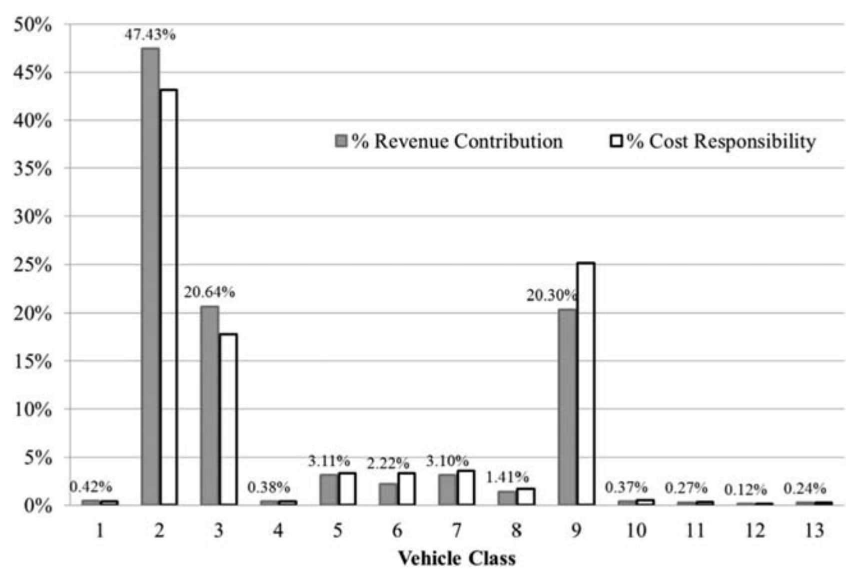


Figure 6.1.1 Percent revenue contribution and cost responsibility (Indiana state and local routes) by vehicle class: FY 2009–FY 2012.

TABLE 6.1.1
User Equity Ratios for the Indiana State and Local Routes by Vehicle Class: FY 2009–FY 2012.

Vehicle Class	VMT (%)	Revenue Contribution (in millions)	% Revenue Contribution (R)	Cost Responsibility (in millions)	% Cost Responsibility (C)	Equity Ratio (R/C)
1	0.55	$12.13	0.42	$9.17	0.38	1.12
2	62.50	$1,360.19	47.43	$1,044.46	43.12	1.10
3	25.01	$591.89	20.64	$430.38	17.77	1.16
4	0.19	$10.79	0.38	$8.85	0.37	1.03
5	2.52	$89.06	3.11	$80.82	3.34	0.93
6	0.95	$63.61	2.22	$80.73	3.33	0.67
7	0.30	$89.00	3.10	$86.16	3.56	0.87
8	0.70	$40.41	1.41	$41.68	1.72	0.82
9	6.95	$582.25	20.30	$609.30	25.16	0.81
10	0.10	$10.56	0.37	$11.92	0.49	0.75
11	0.16	$7.63	0.27	$8.10	0.33	0.80
12	0.06	$3.51	0.12	$3.39	0.14	0.88
13	0.03	$6.76	0.24	$7.07	0.29	0.81
Total	100	$2,867.80	100	$2,422.04	100	

distribution by age (which would affect the relative expenditures across reconstruction and preservation projects), and so on. In the context of this study, one of the most likely changes in the operating conditions will be related to the vehicle miles of travel. Although vehicle class 2 contributed approximately 47% of the revenue, it was responsible for approximately 63% of the total VMT on Indiana highway system. Also, vehicle class 9 contributed approximately 20% of the revenue but was responsible for 6.95% of the total VMT. As a group, vehicle classes 1–3 contributed just about 68% of the total user revenue and were responsible for approximately 88% of the total VMT. Therefore, even assuming all other factors remaining the same, the equity ratios will be different if there is a change in the VMT distribution.

In the present study, overhead costs were not included due to the unavailability of the data in consistent manner from the agencies that were engaged in the execution of highway projects or in administering highway revenue collection programs, such as INDOT, cities and counties, INDOR and BMV. These costs mainly involve buildings and grounds, personnel, and equipment related to highways, and for a state agency these costs can be about 20% of the total costs (Sinha et al., 2005). Overhead costs are common costs and thus would be allocated on the basis of VMT. The inclusion of overhead costs, assuming the percentage overhead is uniform across all government levels and all project types, is not expected to significantly affect the relative equity ratios across the vehicle classes. Thus, overhead costs were excluded from the analysis.

1.3 Comparison of User Equities across States

Figure 6.1.2 presents the equity ratio results from the present study, and from previous cost allocation studies in Indiana and other states. The dividing line on equity ratio of 1 indicates the separation between vehicle classes which are overpaying (above the line) and underpaying (below the line). The methodology for equity computation is the same across the past studies that were reviewed. The results of the present study compare well with those of the past studies in Indiana and at other states. The implication of the results is also consistent with earlier studies: the lower vehicle classes are overpaying while the upper classes are underpaying.

1.4 Scenario Analysis of Possible Initiatives to Improve User Equity

To evaluate possible options for improving the equity values of vehicle classes currently underpaying, two scenarios were considered. The first scenario is an increase in diesel tax rate for vehicle classes 5 to 13. The justification for using vehicle classes 5 through 13 is because these classes are currently underpaying their cost responsibilities. The sub-scenarios under the first scenario include an increase in diesel tax rate by 5 cents, 10 cents, 15 cents, and 20 cents. Possible impacts of these sub-scenarios are shown in Table 6.1.2. For example, a 20-cent increase in diesel tax rate would bring vehicle class 9 to an equity ratio of 0.93 and vehicle class 2 to an equity ratio of 1.03.

The second scenario considers a third-tier fee structure in addition to current registration fees and fuel taxes. The mileage-based approach involves a VMT fee for only single-unit trucks (vehicle classes 5 to 7) and combination trucks (vehicle classes 8 to 13). This scenario considers three sub-scenarios. The first sub-scenario within this scenario is a 1 cent per mile fee for single-unit trucks and 2 cents per mile fee for combination trucks. The second sub-scenario has 1.5 cents per mile fee and 3 cents per mile fee for single-unit and combination trucks, respectively. In the third sub-scenario, the single-unit truck fee is 2 cents

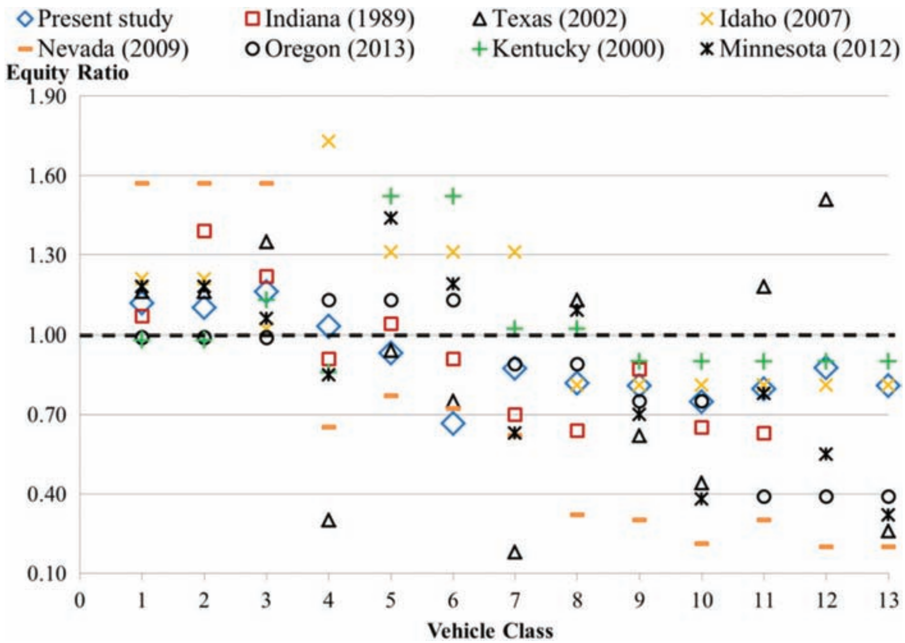


Figure 6.1.2 Comparison of equity ratios across states.

TABLE 6.1.2
Increases in Diesel Tax Rate Scenario.

Vehicle Class	Equity ratio based on increase in Diesel tax rate by			
	5 cents	10 cents	15 cents	20 cents
1	1.11	1.09	1.06	1.04
2	1.09	1.07	1.05	1.03
3	1.15	1.13	1.11	1.09
4	0.97	0.96	0.94	0.92
5	0.97	1.05	1.13	1.21
6	0.68	0.70	0.73	0.75
7	0.87	0.86	0.85	0.84
8	0.85	0.90	0.95	1.00
9	0.83	0.86	0.89	0.93
10	0.75	0.75	0.75	0.75
11	0.81	0.85	0.88	0.91
12	0.89	0.91	0.94	0.96
13	0.80	0.80	0.79	0.78

per mile, while 4 cents per mile is considered for combination trucks.

The results from this scenario analysis are presented in Table 6.1.3. For the three sub-scenarios, vehicle class 9 increases its equity ratio from 0.81 (Table 6.1.1) to 0.90 (sub-scenario 1), 1.10 (sub-scenario 2) and 1.37 (sub-scenario 3). In general, most of the single-unit truck and combination truck classes were found to exceed the equity ratio of 1 when the third sub-scenario is considered.

Similar analyses can be conducted considering scenarios involving change in registration fees, inflation indexing of fuel taxes, and other scenarios. The two scenarios analyzed here are for illustrative purposes.

1.5 Summary of the Equity Analysis

The equity analysis identified the extent to which each vehicle class is underpaying or overpaying its cost

TABLE 6.1.3
Mileage-Based Scenario.

Vehicle Class	Equity ratio due to an Additional VMT Fee for Single-Unit Trucks (SUT) and Combination Trucks		
	Sub-scenario 1: 1 ¢/mile for SUT & 2 ¢/mile for Combination Trucks	Sub-scenario 2: 1.5 ¢/mile for SUT & 3 ¢/mile for Combination Trucks	Sub-scenario 3: 2 ¢/mile for SUT & 4 ¢/mile for Combination Trucks
1	1.06	1.06	1.06
2	1.05	1.05	1.05
3	1.11	1.11	1.11
4	0.98	0.98	0.98
5	1.07	1.34	1.70
6	0.70	0.80	0.94
7	0.85	0.88	0.92
8	0.97	1.27	1.65
9	0.90	1.10	1.37
10	0.81	0.97	1.17
11	0.99	1.33	1.78
12	1.02	1.31	1.69
13	0.82	0.90	1.01

responsibility. Of the 13 vehicle classes, classes 1–4 were found to be overpaying their cost responsibilities while classes 5–13 are underpaying. For example, vehicle class 2 is overpaying its cost responsibility by 10% while vehicle class 9 is underpaying by 19%. These results of the equity analysis are similar to those of studies carried out by other states. In order to increase the equity values for single-unit and combination trucks, two scenarios were considered. The first scenario is an increase in diesel tax rate for vehicle classes 5 to 13. The sub-scenarios under the first scenario include an increase in diesel tax rate by 5 cents, 10 cents, 15 cents, and 20 cents. For example, a 20-cent increase in diesel tax rate would bring vehicle class 9 to an equity ratio of 0.93 and vehicle class 2 to an equity ratio of 1.03. The second scenario which was mileage-based considered three sub-scenarios. For the three sub-scenarios, vehicle class 9 increases its equity ratio from 0.81 to 0.90 (sub-scenario 1), 1.10 (sub-scenario 2) and 1.37 (sub-scenario 3). The two scenarios mentioned here are for illustrative purposes only.

PART 7. TRAVEL BY OUT-OF-STATE VEHICLES ON INDIANA HIGHWAYS

This Part of the report presents the methodological framework, data collection, and data analysis to assess the extent of travel by out-of-state vehicles on Indiana roadways. An assessment of the "split", in other words, the amount of travel (or fuel sales) by out-of-state vehicles as a percentage of the total travel or fuel sales in the state is important in any cost allocation study. This is because for certain existing or possible future user-based revenue generation mechanisms, the amount of revenues to be generated is influenced by the amount of travel (or fuel sales) by out-of-state vehicles. For example, if the VMT fee is implemented in Indiana (but not in its neighboring states) and charged to vehicles registered in Indiana, the state would lose revenue from the out-of-state vehicles. The level of the split and hence the degree of dereliction of revenue contribution, is expected to be different for the different vehicle classes. The absence of this revenue will affect the equity ratios across the vehicle classes. Also, a determination of the split can help determine the extent to which out-of-state vehicles may be underpaying or overpaying relative to their system usage. Previous studies on cost allocation at other states did not address the issue of out-of-state vehicles; therefore, there was no opportunity to benchmark the findings of this analysis with other work.

The analysis for the split of travel (in-state vs. out-of-state) was carried out in two parts; the first part investigated the split for gasoline vehicles and the second determined the split for diesel vehicles. The extent of travel by out-of-state diesel vehicles can be determined most reliably using travel data on commercial diesel vehicles that are reported to the International Fuel Tax Agreement (IFTA); this data were not available at the time of writing of this report, therefore, the data analysis focused on non-commercial diesel vehicles. For commercial diesel vehicles, the findings of previous research studies were applied. The extent of travel by out-of-state gasoline vehicles was determined using a process that involved sampling consumer purchases of gasoline at fuel stations in various locations across the state.

1. TRAVEL BY OUT-OF-STATE GASOLINE VEHICLES

Vehicles that travel on Indiana's road network may be using fuel that was purchased in Indiana or at other states. For example, a commuter that lives and works in different states will use the roads in both states but may be purchasing fuel mostly in one of the two states. This means the commuter contributes to the load-related pavement and bridge costs and non-load-related safety and mobility costs of both states, but only one state receives the gas tax revenues. Historically, the assumption has been that these situations balance out, that is, that the amount of fuel purchased in the state is roughly equivalent to the amount of fuel consumed from all vehicle miles traveled in the state. In other words, while it is true that some fuel consumed in a given state is purchased outside of the state, the inverse may also be true. However, for some states some imbalance may exist, (i.e., more fuel is purchased in their state than is consumed in the state or vice-versa).

1.1 Methodology

The methodology presented in this section was used to investigate the percent of fuel sales attributable to out-of-state vehicles. The results provided an estimate of the percent of Indiana fuel sales attributable to vehicles registered in Indiana compared to those registered outside the state (in this report, this is referred to as the fuel sales split). The process included sampling fuel sales across the state. The sampling procedure included: stratification, sample size determination, and data collection.

The analysis depended on the observed variance in the data and on a number of assumptions based on previous research, specifically, the initial assumption of the split of VMT by in-state and out-of-state vehicles: 70% to 30%. Once the data collection is completed, the assumptions were reassessed to determine if further data collection was required. It was expected that the split of fuel sales (and hence consumption) by in-state and out-of-state vehicles is consistent at fuel stations that have similar fuel sales volumes. It was expected that the out-of-state share is lower for local stations with smaller annual sales and higher for stations with large annual sales: therefore, proper stratification and sampling location design were carried out to ensure that these factors were duly accounted for. As the collected data yielded definitive spatial trends, there was the opportunity to model the data using the Kriging methodology presented in Section 2.3 of Part 2.

1.1.1 Stratification

Ideally, any sample drawn from a population must be adequately representative of the population. In this case, the population in question was all fuel sales transactions in Indiana for a given year and the statistic of interest is the split of fuel sales attributable to out-of-state-vehicles. It was expected that this split would be consistent for stations with similar fuel sales volumes. The stations were stratified based on road functional class and rural/urban class as follows: rural interstate, urban interstate, rural non-interstate, and urban non-interstate. The expectation was that the percentage of out-of-state vehicles and fuel sales would be higher at stations along interstates and/or at stations closer to the state border compared to those at non-interstates and/or farther from the state border. In addition, it was expected that urban and rural locations would yield different splits.

1.1.2 Sample Size

After the strata had been established, the next step was to determine the sample size. In this case, the sample is the required number of fuel purchase transactions that need to be sampled from each stratum. The sample size depends on the size of the population, the expected chance of the outcome, the confidence level, and the confidence interval.

The population was the number of fuel sales transactions in Indiana for each stratum. The total amount of fuel sold in Indiana in 2011 amounted to 2.93 billion gallons of gasoline, not including special fuels (OHPI, 2012). The average amount of fuel purchased per transaction was 12 gallons; therefore, there were approximately 244 million fuel sales transactions in Indiana in 2011. The expected chance of the outcome (in this case, the chance that the fuel was purchased by an out-of-state vehicle) was estimated as 30% based on previous research (Office of the Governor, 2012; Sinha, 1979). The confidence level is the measure of reliability of the result; the current methodology provided estimates for three separate confidence levels: 90%, 95%, and 99%. Lastly, the confidence interval is the range of values for which the estimate falls given the confidence level. For example, a confidence level of 90% and a confidence interval of 5% means that 90% of the time, the result is expected to be within +/–5% of the population estimate. The formula to calculate the sample size for an infinite population is:

$$n = Z^2(p)(1-p) \tag{7.1}$$

where n is the sample size, Z is the values of the standard normal distribution that corresponds to the given confidence level (for example, $Z = 1.645$ for a 90% confidence level), and p is the probability of the expected outcome (in this case, $p = 0.3$). The calculated value for n can be corrected if the population is finite using the equation:

$$n_{finite} = {}^{n}\!/_{1} + \frac{n-1}{N} \tag{7.2}$$

where N is the population size. It may be noticed that for large populations (size greater than 100,000), n_{finite} reduces to n. Therefore, even if one stratum (urban interstate, rural interstate, urban non-interstate, or rural non-interstate) accounts for only 1% of the fuel sold in the state, it would not impact the sample size calculations. Table 7.1.1 provides the sample size required for 15 combinations of confidence level and confidence interval.

The required number of transactions per hour per station was determined using the following equation:

$$T = \frac{TT}{N*OD*OH} \tag{7.3}$$

where T is the average number of fuel sale transactions per hour per station, TT is the total annual statewide transactions (244 million), N is the number of stations (2,738 (Census, 2007)), OD is the number of operating days per year (365), and OH is the number of operating hours per day (18). The value of T was determined to be 15 transactions per hour, per station. This can be considered a conservative estimate of the transaction rate. Applying a transaction rate yielded the number of sampling hours required to obtain the required sample size. Table 7.1.2 presents the number of sampling hours.

The sampling locations were stratified to form strata of minimum within-strata heterogeneity.

1.2 Data Collection

The percent of fuel sold to out-of-state vehicles was determined at each sampling location. This could be done in any one of two ways. First, there was the opportunity for corporate cooperation. The large fuel companies, such as Mobil or Shell, can collect large amounts of fuel sales data from their customers. The sources of these data are fuel sale loyalty cards, credit card receipts, and credit fraud protection records (many pay-at-the-pump locations require a driver to input the zip code associated with the credit card prior to fueling). From this approach, there is an opportunity to collect large amounts of data that would yield very accurate estimates. However, due to issues associated with consumer privacy and corporate competitiveness, corporate cooperation was considered unrealistic. Therefore, the chosen approach was to manually monitor each transaction to determine the amount of fuel sold and to record the state of origin from the license plate of the vehicle purchasing the fuel.

1.2.1 Sampling

Based on the sample size requirements laid out in Part 7, Section 1.1.1, it was determined that for each

TABLE 7.1.1
Sensitivity of Fuel Transaction Sample Requirements to Confidence Level and Confidence Interval.

Confidence Interval (±)	Confidence Level 90%	95%	99%
10%	57	81	139
5%	227	323	557
2%	1,421	2,017	3,484
1%	5,683	8,067	13,935
0.50%	22,731	32,269	55,741

TABLE 7.1.2
Sensitivity of Fuel Sampling Hours to Confidence Level and Confidence Interval.

Confidence Interval (±)	Confidence Level 90%	95%	99%
10%	3.72	5.29	9.13
5%	14.90	21.15	36.53
2%	93.10	132.17	228.30
1%	372.40	528.67	913.20
0.50%	1,489.59	2,114.70	3,652.81

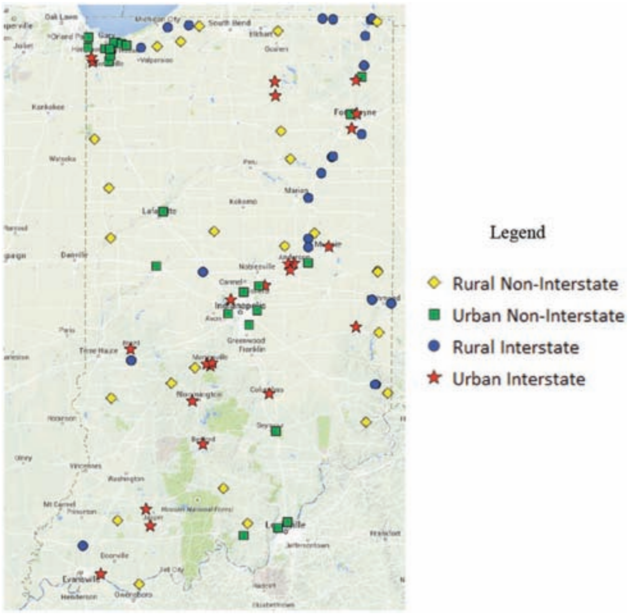


Figure 7.1.1 Sampling locations for fuel data collection.

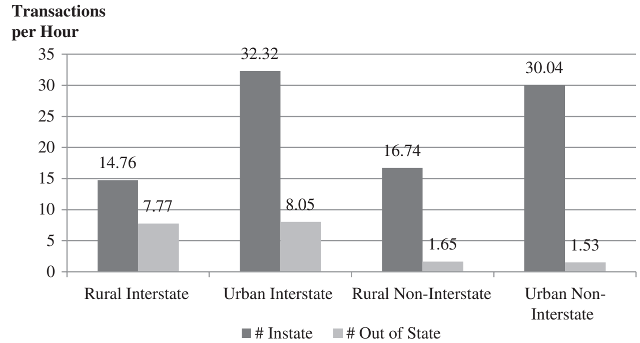


Figure 7.1.2 Average transaction rate by strata and vehicle origin.

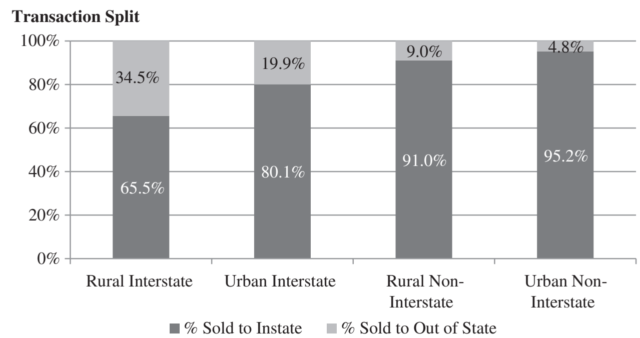


Figure 7.1.3 Transaction split by strata and vehicle origin.

stratum, 25 fuel stations would need to be sampled for one hour each, at station locations spread randomly across the state. The locations of these stations are provided in Figure 7.1.1. At each sampling location, the origin of each vehicle fueling during the one-hour period was recorded. The total number of transactions sampled is provided in Table 7.1.3 (vehicles whose origin was unable to be determined were labeled as a "missed count"). Each stratum met the sampling requirement of 323 samples to provide a confidence level of 95% with a confidence interval of 5%. Also, the number of gallons of gasoline purchased per transaction was recorded where possible.

The distribution of gasoline sales (Figure 7.1.2) is the product of the number of transactions per hour (Figure 7.1.3) and the average amount of fuel purchased (Figure 7.1.4).

The results, presented in Figure 7.1.5, show that rural interstates experienced the greatest percentage split of gasoline sales by out-of-state vehicles (37.1% on average). This value decreased to 20.1%, 11.9%, and 4.8% for urban interstates, rural non-interstates, and urban non-interstates, respectively. There are approximately 2,700 gas stations in Indiana of which approximately 4.9%, 20.9%, 17.0% and 57.1% can be classified (based on their locations) as rural interstates, urban interstates, rural non-interstates, and urban non-interstates, respectively. Taking into account the distribution of fuel stations across the strata, Table 7.1.4 shows that estimate for the amount of gasoline sold to out-of-state vehicles is 10.83%. Part 7, Section 1.3 compares this value to the interpolated estimate of out-of-state VMT for each road segment in the state and the corresponding statewide average was calculated from the segment-specific estimates.

1.3 Summary of Travel by Out-of-State Gasoline Vehicles

The amount of fuel purchased was used to estimate the amount of travel made on Indiana roadways by out-of-state vehicles. The percentage of gasoline sold to out-of-state vehicles was calculated at each fuel collection location. This value was then weighted by the

TABLE 7.1.3
Number of Transactions Sampled.

	In-State Count	Out-of-State Count	Missed Count	Total
Rural: Non-Interstate	347	33	9	389
Rural: Interstate	258	130	14	402
Urban: Non-Interstate	613	33	31	677
Urban: Interstate	514	131	28	673

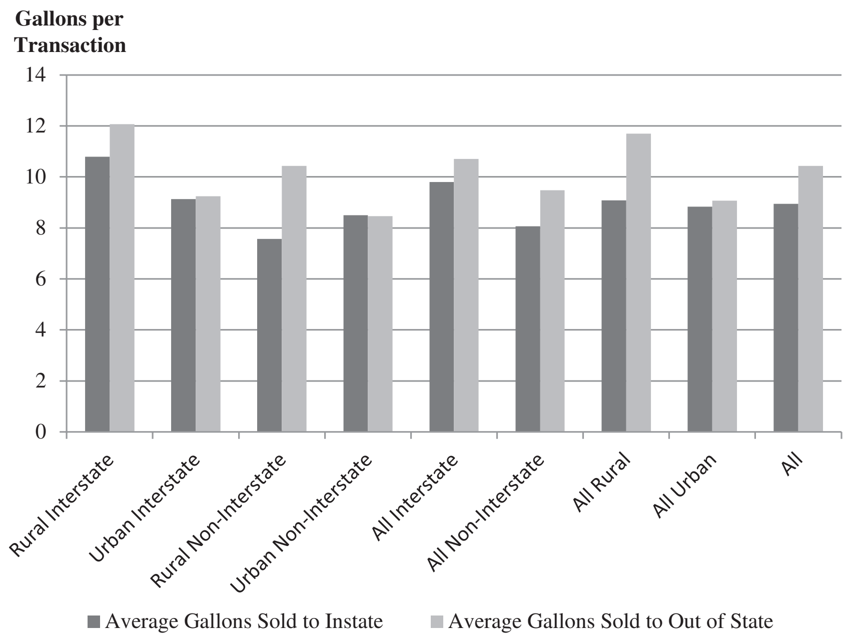


Figure 7.1.4 Average number of gallons of gasoline purchased per transaction by strata and vehicle origin.

TABLE 7.1.4
Statewide Estimate of Gasoline Sold to Out-of-State Vehicles.

	% of Gasoline Sold at Sampling Locations			% of Gasoline Sold at All Fuel Stations in Indiana	
Stratum	**In State**	**Out of State**	**Distribution of All Fuel Station Locations**	**In State**	**Out of State**
Rural Interstate	62.95%	37.05%	4.93%	3.10%	1.83%
Urban Interstate	79.86%	20.14%	20.94%	16.72%	4.22%
Rural Non-Interstate	88.07%	11.93%	17.00%	14.97%	2.03%
Urban Non-Interstate	95.18%	4.82%	57.14%	54.39%	2.76%
Total			100.00%	89.17%	10.83%

average gasoline fuel efficiency of vehicles on the given road functional classification (based on the distribution of gasoline vehicles) to provide an assessment of the percent of travel completed by out-of-state vehicles at each data collection location. To obtain a reliable estimate at the state level, spatial analysis was carried out using Kriging estimation. This yielded segment-specific splits of in-state vs. out-of-state travel that could then be multiplied by the segment VMT to yield values for in-state and out-of-state VMT. These values were then summed over the entire state to yield travel splits for each of the highway functional classes.

The average results are presented in Figure 7.1.6, with the specific route estimates presented in Figure 7.1.7 and Figure 7.1.8 (the standard errors are presented in Addendum A). The NHS routes saw the highest percentage of out-of-state VMT with 21.09% and 9.85% for NHS interstate and non-interstates, respectively. The non-NHS state and local routes serve 8.55% and 7.20% out-of-state vehicles, respectively. Table 7.1.5 shows how these values were then weighted according to the relative distribution of VMT across the highway functional classes. This yielded a value of 11.12% for the VMT in Indiana that can be attributed to out-of-state vehicles.

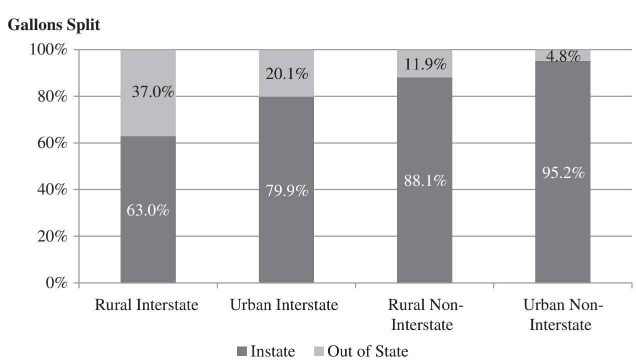


Figure 7.1.5 Split of gallons sold by strata and vehicle origin.

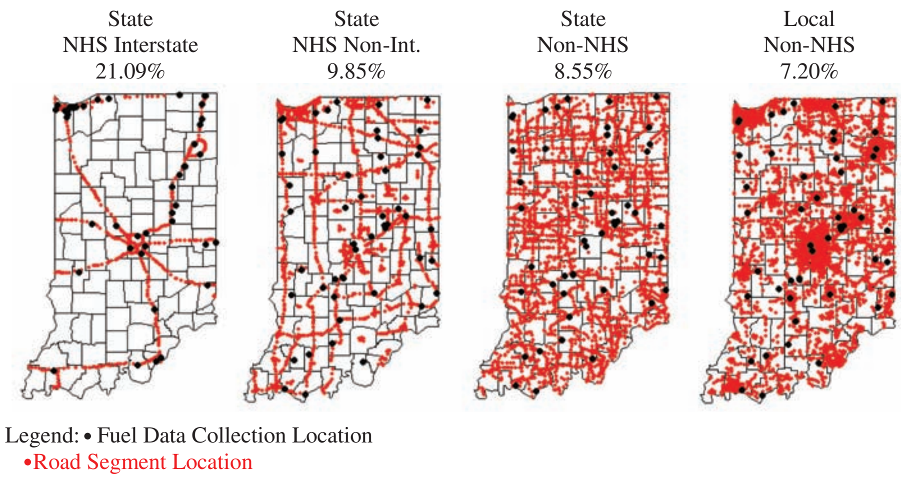


Figure 7.1.6 Percent of VMT by out-of-state drivers by highway functional class (for gasoline).

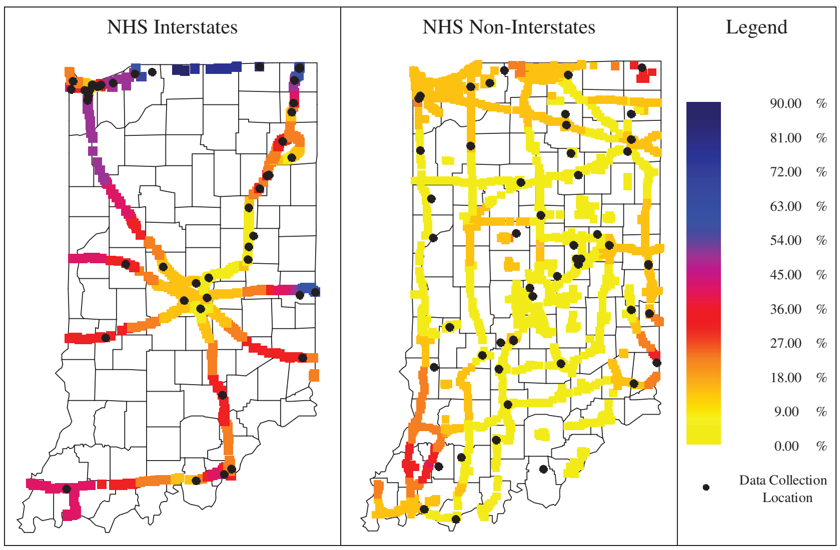


Figure 7.1.7 Percent of VMT by out-of-state drivers on NHS (for gasoline).

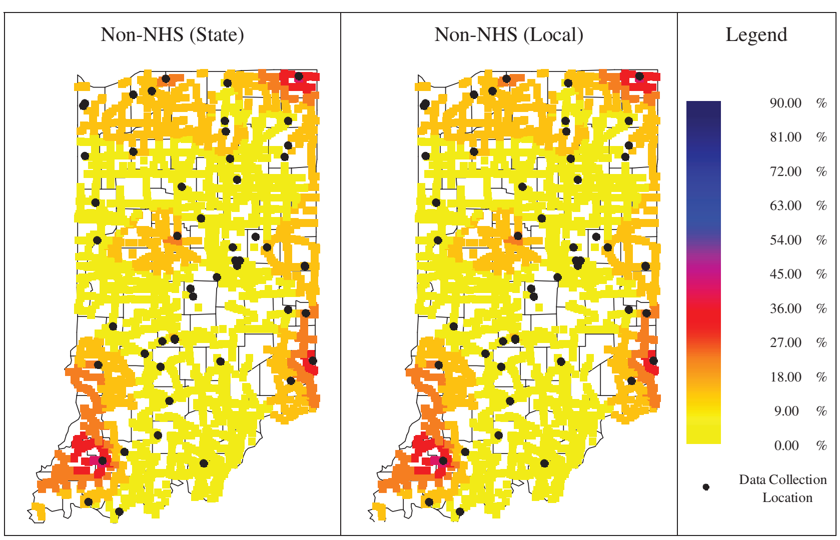


Figure 7.1.8 Percent of VMT by out-of-state drivers on Non-NHS (for gasoline).

TABLE 7.1.5
VMT by Out-of-State Gasoline Vehicles.

State/ Local	NHS Class	2012 VMT Distribution	% Out-of-State
State	NHS-Interstate	23.43%	21.09%
State	NHS-Non-Interstate	17.78%	9.85%
State	Non-NHS	13.77%	8.55%
Local	—	45.02%	7.20%
	State-wide	100.00%	11.12% (average)

2. TRAVEL BY OUT-OF-STATE DIESEL VEHICLES

The previous chapter detailed the extensive process of collecting gasoline purchasing data. These data were required in order to determine the extent of travel on Indiana roadways by out-of-state gasoline vehicles (which are predominately passenger vehicles). Conversely, using diesel purchases as a proxy for travel, for purposes of determining the in-state and out-of-state split is less accurate because the majority of the VMT by diesel vehicles can be attributed to commercial vehicles most of which are long-haul carriers. However, inter-state commercial vehicle VMT is reported to IFTA and IRP by the individual carriers thereby generating a record of the total VMT in a state by commercial vehicles registered outside of the state.

2.1 Travel by Out-of-State Diesel Personal Vehicles

Table 7.2.1 summarizes the total and diesel vehicle VMT for the 13 FHWA vehicle classes. This table was constructed using the fuel efficiency data originally presented in Table 2.4.2 and Table 2.4.3, the fuel split data presented in Table 2.4.4, and the VMT data presented in Table 2.4.7. It may be recalled from Part 2 that diesel vehicles only account for approximately 3.6% of VMT by passenger vehicles (FHWA vehicle class 1–3). Due to the rather small amount of diesel VMT, the data collection did not yield a significant sample size; therefore the state-wide estimate for VMT attributable to out-of-state gasoline vehicles (11.12%) that was determined in Chapter 1 of this Part of the report, was applied. This is deemed appropriate because there was no evidence to suggest that drivers of gasoline and diesel personal vehicles have different travel behavior in terms of their propensity to travel intra- versus inter-state.

2.2 Travel by Out-of-State Diesel Commercial Carriers

The vast majority (96.4%) of the VMT by diesel vehicles can be attributed to commercial vehicles (vehicle classes 4–13). Commercial vehicles that only travel on Indiana highways are subject to the Intrastate Motor Carrier Fuel Tax (MCFT). The total VMT for these vehicles can be back-calculated using the following equation:

$$VMT_{MCFT} = (MCFT/Rate_{MCFT})(MPG) \quad (7.4)$$

where VMT_{MCFT} is the VMT on Indiana highways for commercial vehicles that only travel on Indiana highways, $MCFT$ is the total motor carrier fuel tax collected, $Rate_{MCFT}$ is the MCFT per-gallon rate

TABLE 7.2.1
Total and Diesel VMT in 2012.

Vehicle Class	Total VMT (gasoline and diesel) (billions)	% Diesel VMT	Diesel VMT (billions)
1	0.39	0.00%	0.00
2	44.59	0.46%	0.20
3	17.74	0.46%	0.08
4	0.16	95.00%	0.15
5	2.16	69.59%	1.51
6	0.90	85.19%	0.77
7	0.29	85.19%	0.25
8	0.44	82.82%	0.36
9	4.34	97.71%	4.24
10	0.07	97.71%	0.06
11	0.10	97.71%	0.10
12	0.04	97.71%	0.04
13	0.02	97.71%	0.02
Vehicle Class 1–3 Total	62.71	0.45%	0.28
Vehicle Class 4–13 Total	8.53	0.88%	7.50

TABLE 7.2.2
Annual VMT by Out-of-State Diesel Vehicles.

	2012 VMT by all Diesel Vehicles(in Billions)	% Attributable to Out-of-State Vehicles	2012 VMT by Out-of-State Vehicles (in Billions)
Class 1–3 Passenger Vehicles	0.28	11.12%	0.03
Class 4 Buses	0.15	0.00%	0.00
Class 5 and Tax Exempt	1.59	11.12%	0.18
Class 6–13 Intrastate Only Commercial Vehicles	0.02	0.00%	0.00
Class 6–13 Interstate Commercial Vehicles	5.74	49.4% to 79.2%	2.84 to 4.55
Class 6–13 All	5.76	49.2% to 78.9%	2.84 to 4.55
Total	7.78	38.6% to 60.4%	3.03 to 4.75

($0.16/mile), and MPG is the average fuel efficiency for diesel commercial vehicles (6.1 mpg).

In fiscal year 2013, the total MCFT receipts totaled $488,510 (ILSA, 2013); using a fuel efficiency of 6.1 mpg, this corresponds to a total VMT_{MCFT} of 18.6 million miles.

The motor carrier surcharge tax (MCST) is collected from commercial vehicles based in Indiana or elsewhere, paid to Indiana on the basis of VMT in the state. The formula to determine the VMT from the MCST is:

$$VMT_{MCST} = (MCST/Rate_{MCST})(MPG) \qquad (7.5)$$

where VMT_{MCST} is the VMT on Indiana highways by commercial vehicles based in Indiana and other jurisdictions, $MCST$ is the total motor carrier surcharge tax dispersed to the state, $Rate_{MCST}$ is the per-gallon rate ($0.11/mile) for all motor fuel used by commercial motor carriers operating on Indiana highways, and MPG is the average fuel efficiency for diesel commercial vehicles (6.1 mpg).

In fiscal year 2013, $103,547,462 was collected from the MCST (ILSA, 2013), which yielded a total VMT_{MCST} of 5.74 billion miles. Unfortunately, IFTA data were not available for the study period; therefore subsequent analysis relied on previous research that estimated the percentage of commercial vehicle VMT in Indiana attributable to out-of-state vehicles to be between 49.4% and 72.9% (Fricker & Kumapley, 2002). While this range may seem large, it is important to remember that part of the motivation behind estimating the split of within-state and out-of-state vehicles, was to determine the extent to which out-of-state vehicles are underpaying or overpaying relative to their system usage. The IFTA and IRP systems help ensure that this is not an issue when it comes to interstate commercial vehicle travel.

2.3 Summary of Travel by Out-of-State Diesel Vehicles

The total diesel VMT was calculated to be 7.78 billion vehicle-miles for Indiana in 2012, out of which 0.28 billion vehicle-miles were attributed to passenger vehicles, 0.15 billion vehicle-miles were attributed to buses, 0.02 billion vehicle-miles were attributed to commercial vehicles that are based in and only operate in Indiana, and 5.74 billion vehicle-miles were attributed to commercial vehicles based in Indiana or elsewhere; this leaves a balance of 1.74 billion VMT. The lack of MCFT or MCST records for this amount of travel suggests it may be attributed to class 5 (single-unit, six tires) recreational vehicles (RVs) and pick-up trucks or tax exempt vehicles that include; vehicles operated by government agencies, school buses, casual or charter buses, intercity buses, farm vehicles, and trucks with dealer registration plates. There was inadequate data to calculate a specific percentage of out-of-state vehicles; therefore, it was assumed that the 0.15 billion VMT from city and school buses have an effective in-state vs. out-of-state split of zero. The remaining 1.59 billion VMT was assumed to have the same split as vehicle classes 1–3 due to their travel similarities to these vehicle classes. Table 7.2.2 summarizes the amount of travel by out-of-state diesel vehicles.

3. SUMMARY OF TRAVEL BY OUT-OF-STATE VEHICLES IN INDIANA

3.1 VMT Split Distribution by Vehicle Class

Part 7 of this report detailed the methodology used to determine the percentage of the total state VMT that can be attributed to out-of-state vehicles. This methodology was carried out separately for gasoline and diesel vehicles. The percentage of all gasoline VMT attributed to out-of-state vehicles was determined to be 11.12% using fuel purchase data collected at various locations across Indiana and spatial interpolation techniques. This analysis was then compared with previous research regarding out-of-state commercial VMT in Indiana to provide an assessment of the total VMT attributable to out-of-state vehicles (Table 7.3.1). It was concluded that 10.27–12.13 billion of Indiana's 71.24 billion VMT in 2012 can be attributed to out-of-state vehicles.

3.2 Fuel Consumption and Travel Splits by In-State and Out-of-State Vehicles

Table 7.3.2(a) presents the percentage split of VMT by in-state and out-of-state vehicles. For gasoline vehicles, the percentage split (presented in Table 7.1.5) was determined using stratified sampling of fuel purchases and spatial interpolation, as explained in Chapters 1 and 2 of Part 7 of this report. For diesel

TABLE 7.3.1
Annual VMT by Out-of-State Vehicles.

Vehicle Class	Total VMT (billions)	% Attributable to Out-of-State Vehicles	Out-of-State VMT (billions)
1	0.39	11.12%	0.04
2	44.59	11.12%	4.96
3	17.74	11.12%	1.97
4	0.16	0.00%	0.00
5	2.16	11.12%	0.24
6	0.90	49.2% to 79.2%	0.44 to 0.71
7	0.29	49.2% to 79.2%	0.14 to 0.23
8	0.44	49.2% to 79.2%	0.22 to 0.35
9	4.34	49.2% to 79.2%	2.14 to 3.44
10	0.07	49.2% to 79.2%	0.03 to 0.06
11	0.10	49.2% to 79.2%	0.05 to 0.08
12	0.04	49.2% to 79.2%	0.02 to 0.03
13	0.02	49.2% to 79.2%	0.01 to 0.02
Vehicle Class 1–3 Total	62.71	11.12%	6.97
Vehicle Class 4–13 Total	8.53	38.6% to 60.4%	3.29 to 5.15
All Classes Total	71.24	14.4% to 17.0%	10.27 to 12.13

vehicles, the percentage split was obtained from the IFTA travel data that broke down commercial VMT by state/province of travel and state/province of origin. IFTA data were not available for the study period; therefore analysis relied on IFTA data obtained from the Fricker and Kumapley (2002) report. In that report, the percentage of out-of-state diesel vehicle VMT ranged from 49.4% to 72.9%; the average of this range is 61.15%, which was assumed to be percentage share of VMT by out-of-state diesel vehicles in the present study.

Table 7.3.2(b) presents the percentage split of fuel consumption by in-state and out-of-state vehicles. For gasoline vehicles, the source of the percentages is Table 7.1.4 of this report. For diesel vehicles, the split for diesel consumption is assumed to be the same as the split for VMT (see Table 7.3.2(a)).

Table 7.3.2(c) presents the amount of fuel consumption by in-state and out-of-state vehicles. For gasoline, the average annual consumption is 2.97 billion gallons; of this, 0.322 billion gallons and 2.648 billion gallons are consumed by out-of-state and in-state vehicles respectively (EIA, 2014b). For diesel, the average annual consumption is 1.310 billion gallons; of this, 0.801 billion gallons and 0.508 billion gallons are consumed by out-of-state and in-state vehicles respectively.

TABLE 7.3.2
Distributions of Fuel Consumption and Travel.

(a) Percent of VMT by In-state and Out-of-State Vehicles

	Out of State	In State	Source
Gasoline	11.12%	88.88%	See Table 7.1.5 this report.
Diesel	61.15%	38.85%	Fricker and Kumapley (2002)

(b) Percent of Fuel Consumption by In-state and Out-of-State Vehicles

	Out of State	In State	Source
Gasoline	10.83%	89.17%	Field data. See Table 7.1.4 this report.
Diesel	61.15%	38.85%	Split for diesel consumption is assumed to be the same as the split for VMT (see Table 7.3.2(a) above

(c) Amount of Fuel Consumption by In-state and Out-of-State Vehicles

	Annual Consumption (billions of gallons)[1]					Average Annual Consumptions (gallons)[2]		
	2009	2010	2011	2012	4-year Average	4-year Average	Out-of-state Vehicles	In-state Vehicles
Gasoline	2.99	3.07	2.93	2.89	2.97	2,970,000,000	321,651,000	2,648,349,000
Diesel	1.2	1.33	1.37	1.34	1.31	1,310,000,000	801,065,000	508,935,000

[1]Source of data: EIA (2014b).

[2]Calculated using the % split, Table 7.3.2(b) and the 4-year average annual consumption.

PART 8. REPORT SUMMARY

This study was commissioned to establish and compare the cost responsibility and the revenue contribution of each category of highway users (FHWA vehicle classes) for the construction, preservation, maintenance, and operation of highways in Indiana on the basis of recent expenditure patterns and revenue types. An additional objective was to determine the distribution of fuel purchases and travel by out-of-state vehicles on Indiana's highways.

This report was organized in eight parts. Part 1 discussed the background and the objective for conducting a HCAS in the state of Indiana and the relevance of estimating the extent of out-of-state vehicle travel. Also, Part 1 provided a detailed literature review covering the methodologies for highway cost allocation methodologies at the federal and state levels and for travel estimation.

Part 2 presented the methodological framework that was used to quantify the extent of the highway system usage which was an important input for the subsequent cost allocation and revenue attribution analysis. Traffic volume data collected from temporary count stations were used to calculate the VMT along state routes. It was found that from 2009 to 2012, the annual VMT along state routes fluctuated between 38.1 and 39.2 billion miles. Data collected from the limited number of permanent count stations and Kriging estimation was used to distribute the VMT across the 13 FHWA vehicle classes. Kriging estimation, a spatial analysis process, yielded statewide maps of the traffic stream composition. Thirty-three (33) weigh-in-motion stations provided data for developing vehicle weight distributions for each truck class, for interstate and non-interstate highways. Since the local routes are not covered by count stations, direct calculation of VMT from AADT data was not practical; as such, local route VMT was back-calculated from gasoline and diesel sales data. The annual VMT for local routes was found to vary between 32.1 and 35.61 billion yielding a total (state-local) system usage of 71.24 to 73.75 billion during the study period.

Part 3 presented the methodological framework for cost allocation for state routes. All the highway expenditures were identified by highway functional class (Interstate, Non-Interstate NHS, and Non-NHS), expenditure area (pavement, bridge, safety, mobility and others), project type within each expenditure area (construction, rehabilitation, maintenance, etc.), and expenditure item within each expenditure area (pavement, shoulder, structure, grading, earthwork, signing, ROW, etc.). For new pavement construction, the methodology developed in the 1997 and 2000 FHWA HCAS was adopted and the analysis was conducted on a project-by-project basis. The base facility expenditures was allocated among the vehicle classes on the basis of VMT adjusted for vehicle width while the expenditures of the remaining facility were allocated on the basis of ESAL-miles adjusted for vehicle width. Regarding the allocation of rehabilitation expenditures, a portion of the expenditures, which was related to damage by non-load factors, was attributed based on VMT; and the rest of the expenditures were attributed using the distressed-based FHWA model, NAPCOM. A load and non-load split also was used for the allocation of pavement maintenance expenditures. New bridge construction expenditures were allocated using the incremental factors developed for different AASHTO design loadings. A correlation between AASHTO vehicles and FHWA vehicles was established and thus the allocation results were obtained for FHWA vehicle classes. Bridge replacement expenditures were analyzed in a similar manner except that the bridge sufficiency rating formula was taken into account in the procedure. For bridge rehabilitation, the estimated load-related share of the expenditures was allocated using the incremental methods, while the estimated non-load-related share was analyzed as common costs based on VMT. Bridge in-house maintenance expenditures were also allocated as common costs. The final products of this Part of the report were the total cost responsibilities and average unit costs ($/VMT) for each expenditure type and functional class for the analysis period 2009–2012.

Part 4 discussed the study methodology for cost allocation as well as the data collection, analysis, and results for local routes. For the allocation of road expenditures, the methodology used for the state route pavement cost allocation was adopted with some modifications due to differences in the road geometry and data limitations. Similarly, the allocation of local bridge expenditures also used the methodology for state route bridge cost allocation with some assumptions and simplifications due to data availability issues. For the local route cost allocation, the main sources of data related to road and bridge expenditures were County Operational Reports, City Operational Reports, and the INDOT Site Manager database.

Table 8.1 and Figure 8.1 present key findings from Parts 3 and 4. Table 8.1 summarizes the combined cost responsibility of each FHWA vehicle class by project type for all state routes and local routes in Indiana from 2009 to 2012. Overall, it was determined that as a group, vehicle class 2 had the highest cost responsibility with respect to all project types because of their higher volume on state and local routes compared to the remaining vehicle classes. Of the truck classes, vehicle class 9 was observed to have the highest cost responsibility due to the combined effect of their high loading intensity and low road usage levels compared to the remaining truck classes. Figure 8.1 presents the analysis results of the average unit cost ($/VMT) of each vehicle class by expenditure type for all state and local routes in Indiana over the study period. It can be observed that vehicle classes 1–3 had the lowest unit cost (approximately 2.5 cents/VMT), while vehicle class 7 had the highest unit cost (40 cents/VMT).

Part 5 presented the general overview of highway revenue sources from the state, federal and local levels.

TABLE 8.1
Summary of Cost Responsibility by Vehicle Class and Project Type for State and Local Routes, 2009–2012.

Vehicle Class	New Pavement & Bridge Construction and Reconstruction	Pavement & Bridge Rehabilitation and Repair	Road & Bridge In-House Maintenance	Safety, Mobility & Other Expenditures[a]	Total
1	$11,570,275	$4,846,329	$1,630,317	$18,710,693	$36,757,615
2	$1,321,817,139	$535,034,184	$178,860,856	$2,154,544,360	$4,190,256,539
3	$560,487,453	$228,979,669	$79,346,065	$857,758,918	$1,726,572,105
4	$12,158,459	$5,660,201	$5,996,215	$11,319,226	$35,134,102
5	$102,255,990	$32,807,655	$30,394,517	$154,270,354	$319,728,515
6	$73,060,029	$91,614,837	$92,082,380	$64,603,307	$321,360,553
7	$94,209,299	$108,347,489	$120,745,341	$20,747,856	$344,049,985
8	$39,369,861	$32,037,212	$40,020,068	$53,784,846	$165,211,987
9	$556,237,488	$744,505,884	$694,865,805	$432,543,528	$2,428,152,705
10	$16,511,331	$12,172,705	$10,870,822	$7,896,706	$47,451,563
11	$9,803,477	$6,844,243	$6,188,377	$9,098,335	$31,934,431
12	$7,016,575	$1,929,641	$1,325,001	$3,114,128	$13,385,345
13	$13,632,630	$6,360,977	$5,658,756	$2,501,299	$28,153,663
Total	$2,818,130,006	$1,811,141,026	$1,267,984,520	$3,790,893,556	$9,688,149,107

[a] Other expenditures include: safety, mobility, drainage and erosion control, miscellaneous, preliminary engineering, ROW, utility and railway, other in-house maintenance and other projects.

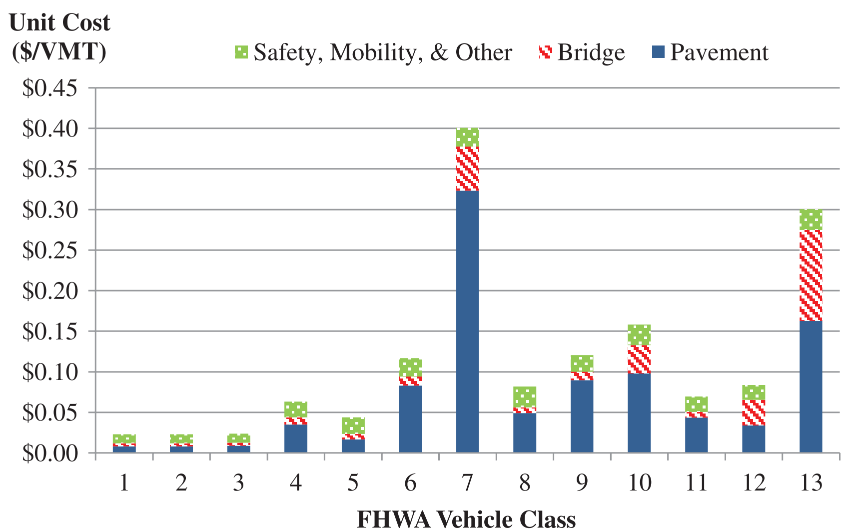


Figure 8.1 Average unit cost ($/VMT) of all expenditures for state and local routes combined, 2009–2012.

Revenues used for highway construction, reconstruction, rehabilitation, and maintenance activities were analyzed. Other revenue sources for highway-related projects considered as non-user (e.g., toll road lease money (Major Moves), federal stimulus (American Recovery and Reinvestment Act)) were also examined. The analysis period was from 2009 to 2012, using the state's fiscal year (July to June). The 4-year average highway user revenues were attributed to each vehicle class on the basis of a number of factors including VMTs, fleet fuel efficiencies, and number of registered vehicles. On average, user revenue sources contributed to about 63.5% (Table 8.2) of the total funding for highway construction and maintenance activities, while the remaining funds came from non-user revenue sources.

Part 6 conducted equity analysis and established which vehicle classes were underpaying or overpaying their cost responsibilities. Of the 13 vehicle classes, only classes 1–4 were found to be overpaying their cost responsibilities while classes 5–13 were underpaying

TABLE 8.2
Summary of Revenue Analysis.

Revenue Source	Level				%
	Federal	State	Local	Total	
User	905.95	1,192.01	69.47	2,167.42	63.5
Non-User	154.31	644.70	446.90	1,245.91	36.5
Total	1,060.26	1,836.71	516.37	3,413.33	100
%	31.1	53.8	15.1	100	

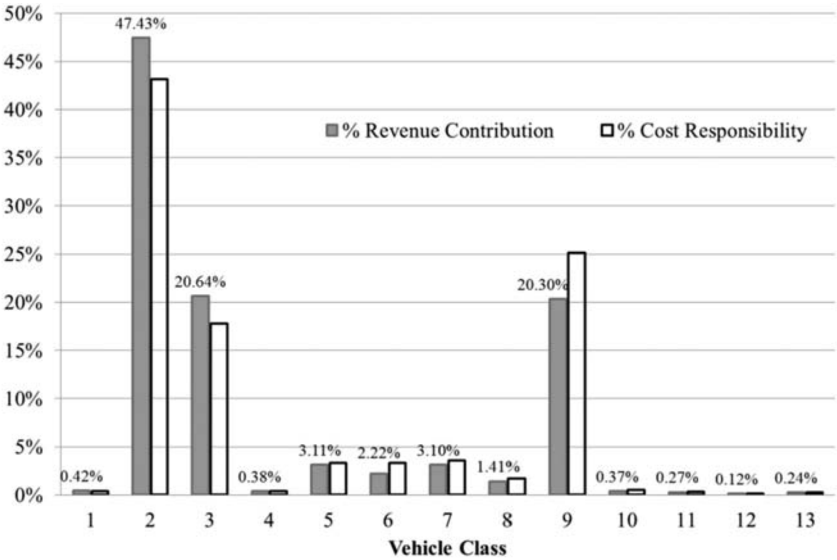


Figure 8.2 Summary of equity analysis.

(Figure 8.2). In order to increase the equity values for single-unit and combination trucks, two scenarios were considered. The first scenario is an increase in diesel tax rate for vehicle classes 5 to 13. The sub-scenarios under the first scenario include an increase in diesel tax rate by 5 cents, 10 cents, 15 cents, and 20 cents. For example, a 20-cent increase in diesel tax rate would bring vehicle class 9 to an equity ratio of 0.93 and vehicle class 2 to an equity ratio of 1.03. The second scenario, which was mileage-based, considered three sub-scenarios. For the three sub-scenarios, vehicle class 9 increases its equity ratio from 0.81 to 0.90 (sub-scenario 1), 1.10 (sub-scenario 2) and 1.37 (sub-scenario 3). The two scenarios analyzed are for illustrative purposes only. Also, a comparison of equity ratios from other states was conducted to assess the consistency of the results with past research.

Part 7 presented an analysis of the extent of travel by out-of-state vehicles on Indiana highways. Two methodologies were developed; the first used gasoline transaction data to estimate the extent of travel by out-of-state passenger vehicles; the second used Department of Revenue data on diesel sales to estimate the travel by out-of-state heavy vehicles. In order to account for variation in gasoline purchasing characteristics, data collection was stratified across rural and urban locations as well as interstate and non-interstate locations. The number of transactions and the amount of fuel purchased per transaction was used to determine the volume percentage of gasoline sales, by out-of-state vehicles. The vehicle stream composition for in-state and out-of-state vehicles was nearly identical. Therefore, it was appropriate to use the split of fuel sales as a measure of the split of vehicle travel. In order to account for variability in fuel purchasing characteristics across the state, spatial analysis of the in-state out-of-state split was carried out using Kriging estimation. It was determined that the percent of passenger vehicle VMT that can be attributed to out of state vehicles was 21.1%, 9.9%, 8.6%, and 7.2% for interstates, NHS non-interstates, non-NHS and local routes respectively.

This report yielded a detailed methodological framework for allocating highway expenditures and attributing revenues to each of the FHWA vehicle classes. The analysis results provided a clear quantitative understanding of the extent of costs incurred by various vehicle classes and the revenues they contribute. This research product is intended to provide a data-based decision support system in the development of strategies regarding highway financing in Indiana. Specifically, the study product facilitates an assessment of the appropriateness of the types and rates of current taxes and fees, and provides a data-based and objective platform to devise future funding types and user rates to meet the financing needs of coming years. Possible options involving highway user taxes and fees can be evaluated in terms of resulting user equity and system financial efficiency. The companion study of the extent of travel attributable to out-of-state vehicles on Indiana highways provided updated information that would be useful in making decisions associated with additional or alternative sources of additional highway revenue, such as the VMT fee for in-state vehicles.

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ADDENDA

ADDENDUM A: TRAFFIC AND FUEL DATA ANALYSIS

Item Type	Item Number	Data Item	Extent	
Traffic	21	Annual Average Daily Traffic	FE + R	
	22	Single-Unit Truck & Bus AADT	FE*	SP*
	23	Percent Peak Single-Unit Trucks & Buses		SP
	24	Combination Truck AADT	FE*	SP*
	25	Percent Peak Combination Trucks		SP
	26	K-factor		SP
	27	Directional Factor		SP
	28	Future AADT		SP
	29	Signal Type		SP
	30	Percent Green Time		SP
	31	No. of Signalized Intersections		SP
	32	No. of Stop Sign Intersections		SP
	33	No. of Intersections, Type—Other		SP

Item Number is the number assigned to each data item
Data Item identifies the type of attribute data to be reported
Extent indicates if the data item is required for the Full Extent (FE), Sample Panel (SP) sections, or the Full Extent and Ramp sections (FE+R)
Adapted from the *Highway Performance Monitoring System Field Manual* Table 2.1 Data Items to be Reported

Figure A.1 Traffic data items reported to the HPMS.

No	Name	Description
1	Motorcycles	All two or three-wheeled motorized vehicles. Typical vehicles in this category have saddle type seats and are steered by handlebars rather than steering wheels. This category includes motorcycles, motor scooters, mopeds, motor-powered bicycles, and three-wheel motorcycles.
2	Passenger Cars	All sedans, coupes, and station wagons manufactured primarily for the purpose of carrying passengers and including those passenger cars pulling recreational or other light trailers.
3	Other Two-Axle, Four-Tire Single Unit Vehicles	All two-axle, four-tire, vehicles, other than passenger cars. Included in this classification are pickups, panels, vans, and other vehicles such as campers, motor homes, ambulances, hearses, carryalls, and minibuses. Other two-axle, four-tire single-unit vehicles pulling recreational or other light trailers are included in this classification. Because automatic vehicle classifiers have difficulty distinguishing class 3 from class 2, these two classes may be combined into class 2.
4	Buses	All vehicles manufactured as traditional passenger-carrying buses with two axles and six tires or three or more axles. This category includes only traditional buses (including school buses) functioning as passenger-carrying vehicles. Modified buses should be considered to be a truck and should be appropriately classified.
5	Two-Axle, Six-Tire, Single-Unit Trucks	All vehicles on a single frame including trucks, camping and recreational vehicles, motor homes, etc., with two axles and dual rear wheels.
6	Three-Axle Single-Unit Trucks	All vehicles on a single frame including trucks, camping and recreational vehicles, motor homes, etc., with three axles.
7	Four or More Axle Single-Unit Trucks	All trucks on a single frame with four or more axles.
8	Four or Fewer Axle Single-Trailer Trucks	All vehicles with four or fewer axles consisting of two units, one of which is a tractor or straight truck power unit.
9	Five-Axle Single-Trailer Trucks	All five-axle vehicles consisting of two units, one of which is a tractor or straight truck power unit.
10	Six or More Axle Single-Trailer Trucks	All vehicles with six or more axles consisting of two units, one of which is a tractor or straight truck power unit.
11	Five or fewer Axle Multi-Trailer Trucks	All vehicles with five or fewer axles consisting of three or more units, one of which is a tractor or straight truck power unit.
12	Six-Axle Multi-Trailer Trucks	All six-axle vehicles consisting of three or more units, one of which is a tractor or straight truck power unit.
13	Seven or More Axle Multi-Trailer Trucks	All vehicles with seven or more axles consisting of three or more units, one of which is a tractor or straight truck power unit.

Figure A.2 FHWA vehicle classification (EPA, 1999; OHPI, 2011b).

Interstate													
	FHWA Vehicle Class												
	1	2	3	4	5	6	7	8	9	10	11	12	13
Mean	0.00	68.0%	12.9%	0.2%	0.9%	0.6%	0.1%	1.0%	13.9%	0.2%	0.5%	0.2%	0.1%
St. Dev.	0.3%	7.8%	2.1%	0.2%	0.4%	0.1%	0.1%	0.7%	7.4%	0.2%	0.3%	0.1%	0.2%
Maximum	1.1%	78.6%	16.2%	0.8%	2.4%	0.8%	0.3%	2.9%	28.0%	0.8%	1.4%	0.5%	0.7%
3rd Quartile	0.2%	73.5%	14.5%	0.2%	0.9%	0.7%	0.1%	1.1%	17.8%	0.2%	0.7%	0.3%	0.0%
Median	0.2%	68.6%	13.0%	0.1%	0.8%	0.6%	0.1%	0.8%	12.4%	0.1%	0.5%	0.2%	0.0%
1st Quartile	0.1%	65.4%	11.7%	0.1%	0.7%	0.5%	0.1%	0.6%	8.5%	0.1%	0.2%	0.1%	0.0%
Minimum	0.0%	51.0%	9.1%	0.0%	0.5%	0.4%	0.0%	0.4%	3.0%	0.0%	0.1%	0.0%	0.0%

Other Principal Arterials													
	FHWA Vehicle Class												
	1	2	3	4	5	6	7	8	9	10	11	12	13
Mean	0.4%	72.8%	19.1%	0.1%	0.8%	0.5%	0.1%	0.5%	4.4%	0.1%	0.1%	0.0%	0.1%
St. Dev.	0.2%	7.1%	3.6%	0.1%	0.3%	0.2%	0.1%	0.3%	4.8%	0.1%	0.1%	0.0%	0.1%
Maximum	0.8%	83.3%	24.4%	0.3%	1.3%	0.8%	0.3%	1.1%	18.2%	0.4%	0.4%	0.1%	0.2%
3rd Quartile	0.5%	78.4%	22.1%	0.1%	1.0%	0.6%	0.1%	0.6%	6.6%	0.1%	0.2%	0.0%	0.1%
Median	0.4%	71.9%	19.4%	0.1%	0.8%	0.5%	0.1%	0.5%	2.5%	0.1%	0.0%	0.0%	0.0%
1st Quartile	0.2%	67.5%	16.7%	0.0%	0.6%	0.3%	0.1%	0.2%	1.0%	0.0%	0.0%	0.0%	0.0%
Minimum	0.1%	60.9%	12.5%	0.0%	0.4%	0.1%	0.0%	0.1%	0.4%	0.0%	0.0%	0.0%	0.0%

Minor Arterials													
	FHWA Vehicle Class												
	1	2	3	4	5	6	7	8	9	10	11	12	13
Mean	0.5%	66.8%	23.4%	0.1%	1.3%	1.0%	0.4%	0.8%	5.1%	0.1%	0.0%	0.0%	0.0%
St. Dev.	0.2%	4.6%	1.3%	0.1%	0.7%	0.4%	0.3%	0.4%	3.0%	0.1%	0.0%	0.0%	0.0%
Maximum	0.9%	71.1%	24.9%	0.3%	2.4%	1.4%	0.7%	1.5%	9.1%	0.2%	0.1%	0.0%	0.1%
3rd Quartile	0.6%	70.7%	24.6%	0.0%	1.1%	1.4%	0.6%	1.1%	6.8%	0.1%	0.0%	0.0%	0.0%
Median	0.4%	67.7%	22.7%	0.0%	1.0%	0.7%	0.2%	0.5%	5.3%	0.0%	0.0%	0.0%	0.0%
1st Quartile	0.4%	64.2%	22.7%	0.0%	0.9%	0.6%	0.2%	0.5%	3.2%	0.0%	0.0%	0.0%	0.0%
Minimum	0.4%	60.1%	22.2%	0.0%	0.8%	0.6%	0.1%	0.4%	1.4%	0.0%	0.0%	0.0%	0.0%

Major Collectors													
	FHWA Vehicle Class												
	1	2	3	4	5	6	7	8	9	10	11	12	13
Mean	0.6%	61.1%	26.0%	0.0%	1.1%	1.3%	0.4%	0.6%	6.0%	0.1%	0.0%	0.0%	0.0%
St. Dev.	0.2%	9.3%	3.9%	0.1%	0.6%	1.1%	0.5%	0.4%	6.2%	0.1%	0.0%	0.0%	0.0%
Maximum	0.9%	72.7%	30.5%	0.3%	2.7%	3.5%	1.7%	1.6%	19.7%	0.4%	0.1%	0.0%	0.1%
3rd Quartile	0.7%	66.9%	29.0%	0.0%	1.2%	1.5%	0.4%	0.7%	9.4%	0.1%	0.0%	0.0%	0.0%
Median	0.6%	64.8%	26.8%	0.0%	1.0%	1.2%	0.2%	0.6%	3.9%	0.1%	0.0%	0.0%	0.0%
1st Quartile	0.4%	53.7%	23.6%	0.0%	0.8%	0.5%	0.1%	0.4%	0.8%	0.0%	0.0%	0.0%	0.0%
Minimum	0.0%	43.6%	16.4%	0.0%	0.5%	0.2%	0.1%	0.1%	0.2%	0.0%	0.0%	0.0%	0.0%

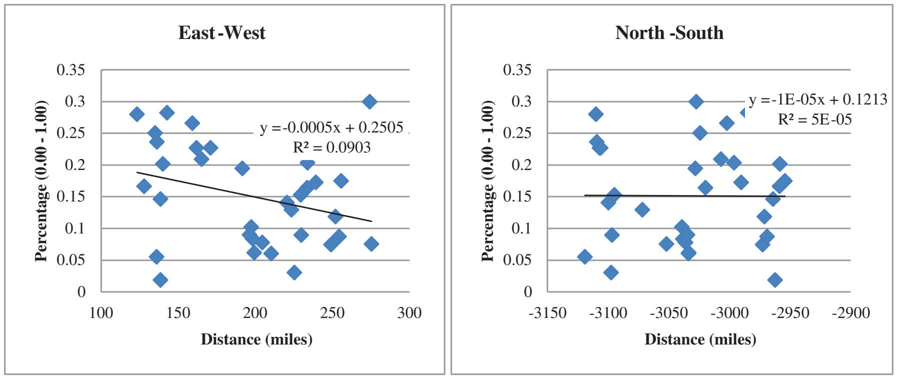
Figure A.3 ATR data descriptive statistics: FHWA vehicle class distribution.

Interstate													
	FHWA Vehicle Class												
	1	2	3	4	5	6	7	8	9	10	11	12	13
Mean	0.5%	46.4%	24.6%	0.5%	5.9%	0.6%	0.1%	1.2%	16.2%	0.2%	0.5%	0.2%	0.0%
St. Dev.	0.3%	10.3%	7.0%	0.2%	4.0%	0.2%	0.1%	0.6%	8.1%	0.2%	0.4%	0.2%	0.0%
Maximum	1.4%	70.3%	37.4%	0.8%	17.9%	1.3%	0.2%	2.4%	29.9%	0.7%	1.5%	0.6%	0.1%
3rd Quartile	0.7%	50.4%	28.7%	0.5%	5.5%	0.7%	0.1%	1.5%	22.2%	0.2%	0.6%	0.3%	0.0%
Median	0.4%	46.2%	26.6%	0.5%	4.4%	0.6%	0.1%	1.0%	17.1%	0.1%	0.5%	0.2%	0.0%
1st Quartile	0.3%	40.4%	19.3%	0.4%	3.4%	0.5%	0.0%	0.7%	8.5%	0.1%	0.3%	0.0%	0.0%
Minimum	0.1%	28.1%	12.6%	0.1%	2.8%	0.1%	0.0%	0.2%	1.9%	0.0%	0.0%	0.0%	0.0%

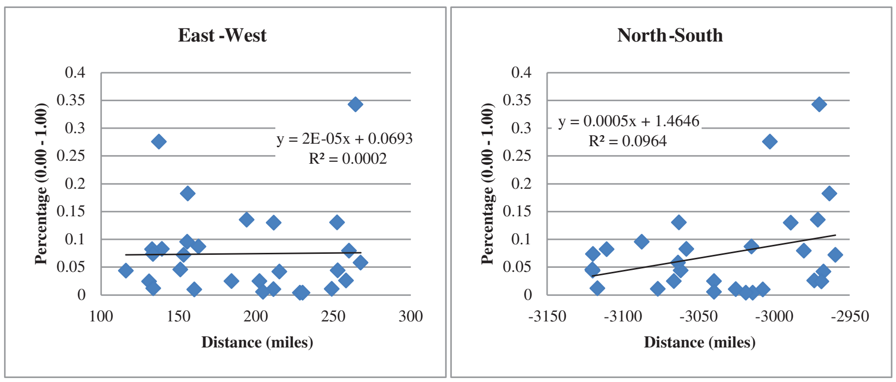
Other Principal Arterials													
	FHWA Vehicle Class												
	1	2	3	4	5	6	7	8	9	10	11	12	13
Mean	0.8%	48.6%	29.9%	0.4%	5.2%	0.6%	0.2%	1.2%	11.3%	0.2%	0.1%	0.0%	0.0%
St. Dev.	0.4%	7.6%	7.6%	0.2%	1.7%	0.3%	0.3%	0.5%	9.3%	0.2%	0.2%	0.1%	0.0%
Maximum	2.0%	62.4%	39.9%	0.9%	9.5%	1.2%	1.2%	1.9%	34.2%	0.8%	0.8%	0.2%	0.0%
3rd Quartile	1.0%	50.5%	34.9%	0.5%	6.5%	0.6%	0.2%	1.7%	13.0%	0.2%	0.1%	0.0%	0.0%
Median	0.7%	47.4%	30.1%	0.3%	4.3%	0.6%	0.1%	1.2%	8.7%	0.1%	0.1%	0.0%	0.0%
1st Quartile	0.5%	45.2%	27.9%	0.3%	3.8%	0.5%	0.1%	0.7%	4.5%	0.0%	0.0%	0.0%	0.0%
Minimum	0.4%	33.2%	9.2%	0.2%	3.5%	0.2%	0.1%	0.4%	1.0%	0.0%	0.0%	0.0%	0.0%

Figure A.4 WIM data descriptive statistics: FHWA vehicle class distribution.

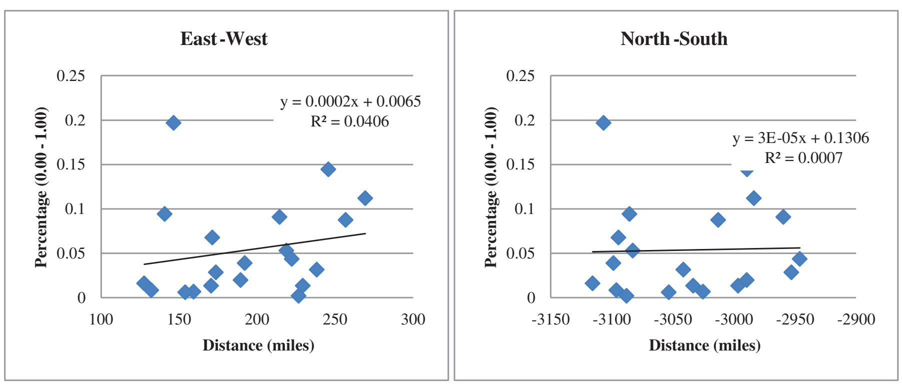
Interstate with Trends



Principal Arterials with Trends



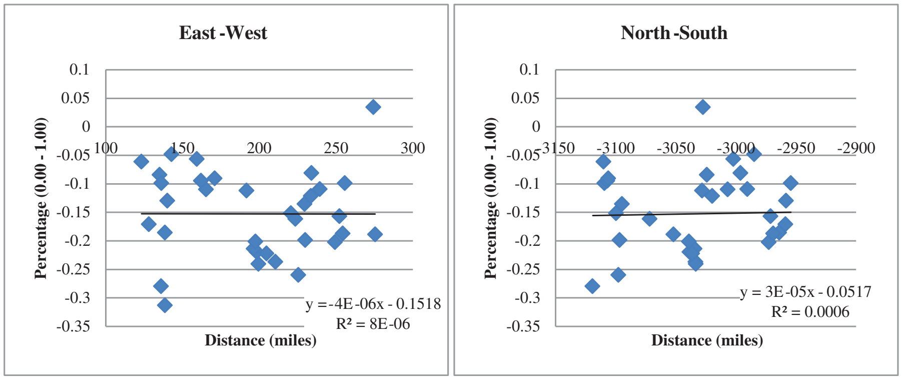
Minor Arterial and Major Collector with Trends



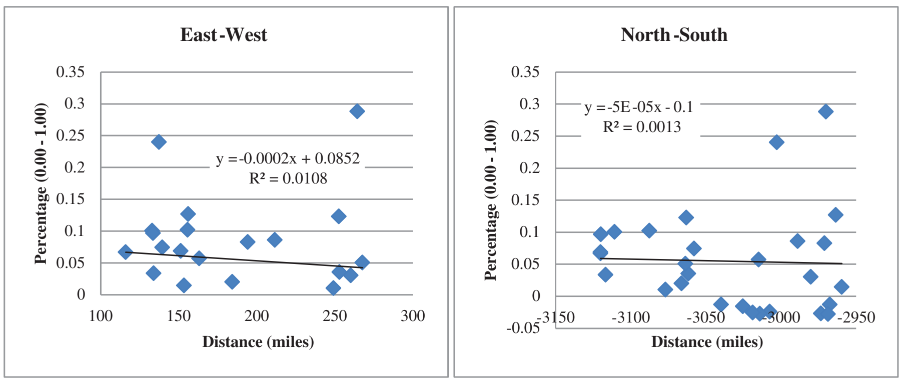
Note: Latitude and Longitude have been converted to Cartesian coordinates for a truer representation of the distances

Figure A.5 Vehicle class 9 Kriging estimation directional trend analysis.

Interstate with Trends Removed



Principal Arterials with Trends Removed



Minor Arterial and Major Collector with Trends Removed

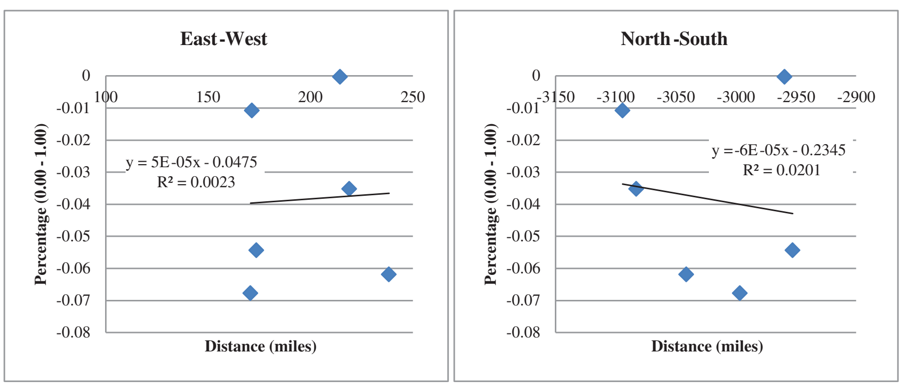


Figure A.6 Vehicle class 9 Kriging estimation directional trend analysis.

Interstates

Reference	Estimation Methodology	Covariance Model	Kappa	Nugget	Range (miles)	Partial Sill	MSPE
———	WLS	Exponential	0.5	0.0046	59.91	0.0068	0.012
———	WLS	Matérn	1	0.0069	400.1	0.010	0.014
– – –	ML	Exponential	0.5	0.000	20.49	0.010	0.011
– – –	ML	Matérn	1	0.000	20.49	0.010	0.011

Semi-Variogram Comparison: Principal Arterials

Reference	Estimation Methodology	Covariance Model	Kappa	Nugget	Range (miles)	Partial Sill	MSPE
———	WLS	Exponential	0.5	0.019	59.91	0.017	3.96e-4
———	WLS	Matérn	1	0.015	27.99	0.019	3.85e-4
– – –	ML	Exponential	0.5	0.000	2.60	0.032	4.11e-4
– – –	ML	Matérn	1	0.021	84.49	0.011	3.73e-4

Semi-Variogram Comparison: Interstates

Reference	Estimation Methodology	Covariance Model	Kappa	Nugget	Range (miles)	Partial Sill	MSPE
———	WLS	Exponential	0.5	0.025	149.8	0.012	0.026
———	WLS	Matérn	1	0.025	400.7	0.025	0.034
– – –	ML	Exponential	0.5	0.000	43.80	0.031	0.033
– – –	ML	Matérn	1	0.017	88.30	0.013	0.051

Figure A.7 Semi-variogram comparison.

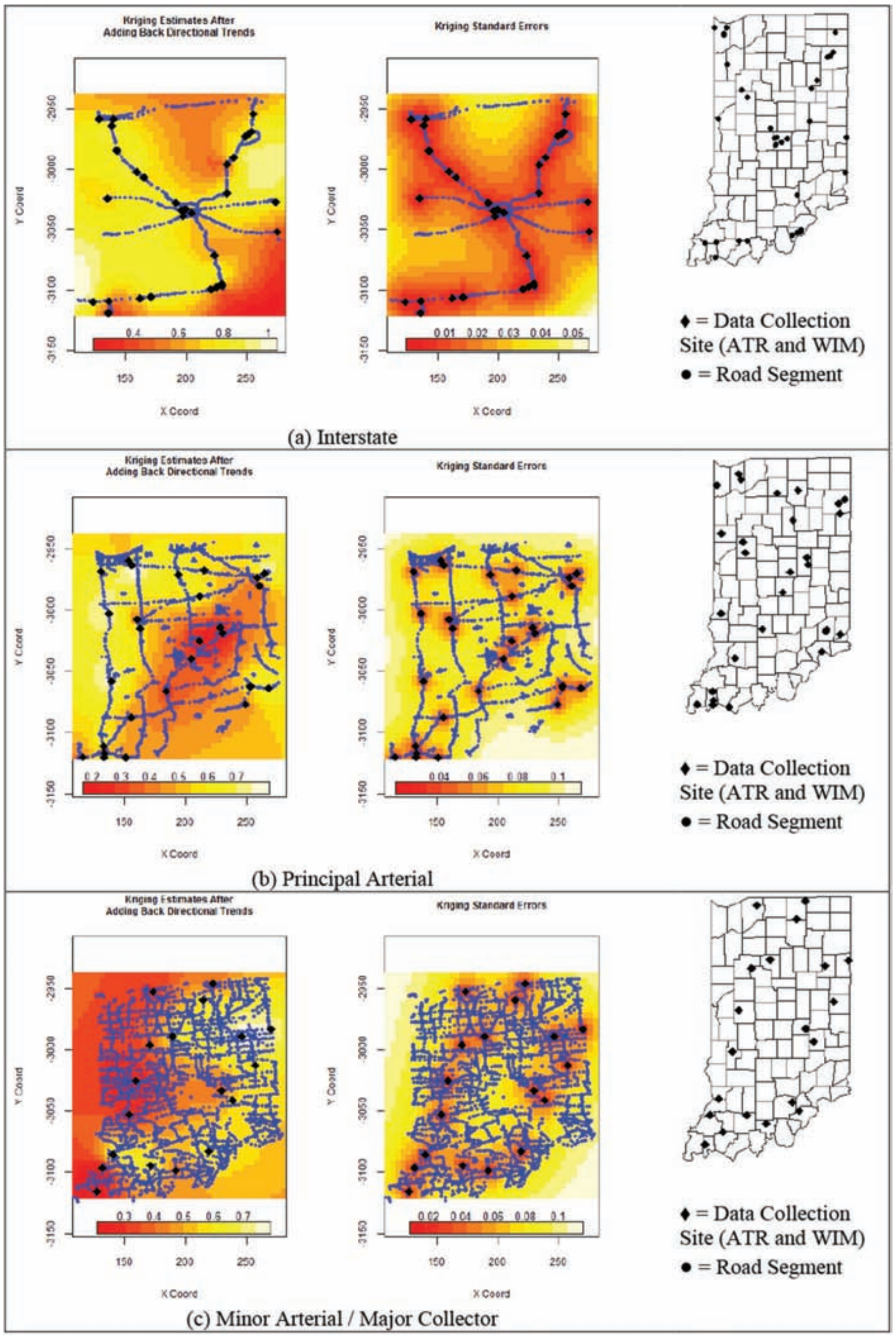


Figure A.8 Estimates and standard errors for (a) interstate, (b) principal arterials, and (c) minor arterial/major collector (coordinates are in miles).

GVW Bins (kips)	NHS Interstate (19 Locations)									
	Class 4 (Bus)	Class 5 (2 Axle Single Unit)	Class 6 (3 Axle Single Unit)	Class 7 (>3 Axle Single Unit)	Class 8 (<5 Axle 2 Unit)	Class 9 (5 Axle 2 Unit)	Class 10 (>5 Axle 2 Unit)	Class 11 (<6 Axle >2 Unit)	Class 12 (6 Axle >2 Unit)	Class 13 (>6 Axle >2 Unit)
0 to 4	0.00%	2.55%	0.23%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
4 to 8	0.00%	34.97%	0.45%	0.12%	0.04%	0.00%	0.00%	0.00%	0.00%	0.00%
8 to 12	0.34%	40.45%	2.51%	0.91%	4.23%	0.01%	0.00%	0.00%	0.00%	0.00%
12 to 16	2.75%	9.42%	7.35%	1.41%	13.71%	0.08%	0.11%	0.00%	0.00%	0.00%
16 to 20	23.56%	5.83%	23.70%	4.15%	13.81%	0.29%	0.07%	0.00%	0.00%	0.00%
20 to 24	26.98%	3.51%	20.13%	4.45%	10.79%	0.99%	0.66%	0.29%	0.00%	0.00%
24 to 28	16.06%	1.89%	10.25%	2.72%	10.01%	2.66%	1.99%	0.99%	0.06%	0.00%
28 to 32	9.54%	0.86%	7.22%	3.29%	10.96%	5.35%	3.52%	2.18%	0.27%	0.00%
32 to 36	6.33%	0.34%	5.80%	3.23%	9.18%	7.60%	5.67%	2.50%	1.42%	0.12%
36 to 40	5.26%	0.12%	6.17%	4.11%	7.65%	7.23%	5.37%	3.31%	2.27%	0.31%
40 to 44	3.56%	0.03%	5.80%	3.66%	5.84%	6.65%	5.93%	4.49%	5.10%	0.72%
44 to 48	2.40%	0.01%	5.08%	4.66%	4.46%	6.44%	5.64%	7.25%	6.11%	2.40%
48 to 52	1.48%	0.01%	2.78%	4.52%	3.51%	6.21%	5.61%	9.43%	7.80%	5.09%
52 to 56	0.90%	0.00%	1.21%	9.68%	2.58%	6.05%	4.62%	11.44%	10.45%	6.40%
56 to 60	0.39%	0.00%	0.55%	6.77%	1.57%	6.01%	4.50%	13.36%	11.06%	3.16%
60 to 64	0.25%	0.00%	0.33%	7.38%	0.83%	6.30%	5.22%	12.08%	11.31%	4.86%
64 to 68	0.12%	0.00%	0.23%	10.16%	0.41%	6.45%	4.92%	10.96%	11.39%	4.47%
68 to 72	0.05%	0.00%	0.10%	9.48%	0.21%	6.67%	5.99%	8.54%	10.35%	2.87%
72 to 76	0.02%	0.00%	0.05%	7.99%	0.10%	7.85%	8.90%	6.02%	8.46%	4.17%
76 to 80	0.02%	0.00%	0.03%	4.79%	0.05%	7.75%	7.96%	3.55%	5.67%	3.60%
80+	0.01%	0.00%	0.03%	6.54%	0.06%	9.40%	23.29%	3.60%	8.28%	61.85%
Total	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

Figure A.9 Average GVW distributions for NHS Interstates.

GVW Bins (kips)	NHS Non-Interstate (12 Locations)									
	Class 4 (Bus)	Class 5 (2 Axle Single Unit)	Class 6 (3 Axle Single Unit)	Class 7 (>3 Axle Single Unit)	Class 8 (<5 Axle 2 Unit)	Class 9 (5 Axle 2 Unit)	Class 10 (>5 Axle 2 Unit)	Class 11 (<6 Axle >2 Unit)	Class 12 (6 Axle >2 Unit)	Class 13 (>6 Axle >2 Unit)
0 to 4	0.00%	7.04%	0.29%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
4 to 8	0.00%	29.33%	0.65%	0.00%	0.05%	0.00%	0.00%	0.00%	0.00%	0.00%
8 to 12	0.02%	40.95%	1.07%	0.21%	5.33%	0.06%	0.00%	0.00%	0.00%	0.00%
12 to 16	1.50%	9.56%	4.71%	1.63%	18.38%	0.24%	0.17%	0.00%	0.00%	0.00%
16 to 20	27.52%	6.36%	18.82%	0.69%	14.02%	0.45%	0.00%	0.00%	0.00%	0.00%
20 to 24	29.04%	3.49%	18.48%	0.65%	9.22%	1.00%	0.64%	0.45%	0.00%	0.00%
24 to 28	14.00%	1.73%	10.72%	2.17%	8.99%	3.96%	1.48%	1.84%	0.00%	0.00%
28 to 32	7.87%	0.93%	9.48%	0.97%	11.59%	9.10%	3.09%	3.85%	10.00%	0.00%
32 to 36	6.36%	0.33%	7.70%	3.87%	10.21%	11.69%	6.29%	6.05%	0.33%	0.00%
36 to 40	5.98%	0.14%	7.23%	1.81%	7.07%	8.98%	7.75%	4.86%	3.02%	0.00%
40 to 44	3.48%	0.05%	6.94%	3.80%	5.10%	6.47%	8.33%	5.34%	19.84%	1.01%
44 to 48	1.30%	0.03%	5.70%	5.67%	3.51%	5.59%	10.18%	6.80%	2.87%	15.40%
48 to 52	1.53%	0.03%	3.60%	8.89%	1.99%	5.00%	5.70%	8.81%	4.45%	5.61%
52 to 56	0.61%	0.01%	1.99%	10.57%	1.63%	4.42%	4.55%	10.46%	5.84%	6.97%
56 to 60	0.36%	0.00%	1.49%	9.88%	0.99%	4.43%	3.70%	13.58%	5.05%	3.91%
60 to 64	0.18%	0.01%	0.37%	11.76%	0.56%	4.90%	3.44%	10.34%	8.52%	1.14%
64 to 68	0.09%	0.00%	0.45%	10.15%	0.33%	5.80%	4.76%	10.86%	11.34%	0.00%
68 to 72	0.13%	0.00%	0.17%	13.04%	0.19%	7.11%	4.67%	7.60%	8.54%	0.00%
72 to 76	0.02%	0.00%	0.09%	8.47%	0.23%	8.05%	7.30%	5.25%	6.98%	3.45%
76 to 80	0.00%	0.00%	0.02%	3.03%	0.18%	7.12%	8.92%	2.01%	8.36%	13.89%
80+	0.02%	0.01%	0.04%	2.74%	0.43%	5.63%	19.01%	1.90%	4.85%	48.62%
Total	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

Figure A.10 Average GVW distributions for NHS non-Interstates.

GVW Bins (kips)	Non-NHS (2 Locations)									
	Class 4 (Bus)	Class 5 (2 Axle Single Unit)	Class 6 (3 Axle Single Unit)	Class 7 (>3 Axle Single Unit)	Class 8 (<5 Axle 2 Unit)	Class 9 (5 Axle 2 Unit)	Class 10 (>5 Axle 2 Unit)	Class 11 (<6 Axle >2 Unit)	Class 12 (6 Axle >2 Unit)	Class 13 (>6 Axle >2 Unit)
0 to 4	0.00%	0.87%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
4 to 8	0.00%	47.85%	0.21%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
8 to 12	0.00%	34.35%	0.49%	0.00%	9.48%	0.00%	0.00%	0.00%	0.00%	0.00%
12 to 16	1.23%	7.64%	5.45%	0.00%	9.79%	0.52%	0.00%	0.00%	0.00%	0.00%
16 to 20	19.72%	4.12%	15.92%	0.00%	9.07%	0.29%	0.00%	0.00%	0.00%	0.00%
20 to 24	23.52%	2.41%	21.53%	0.83%	11.99%	3.70%	0.00%	0.00%	0.00%	0.00%
24 to 28	18.43%	1.40%	11.02%	0.00%	8.34%	10.18%	8.42%	3.13%	0.00%	0.00%
28 to 32	15.54%	0.93%	4.62%	11.67%	9.69%	11.40%	3.91%	2.08%	0.00%	0.00%
32 to 36	11.28%	0.24%	10.13%	0.00%	11.44%	10.51%	6.55%	0.00%	0.00%	0.00%
36 to 40	5.07%	0.08%	11.28%	0.29%	8.63%	8.88%	11.37%	52.08%	0.00%	0.00%
40 to 44	3.11%	0.01%	7.06%	3.54%	7.54%	8.01%	17.40%	17.71%	0.00%	0.00%
44 to 48	0.30%	0.06%	8.74%	11.50%	5.52%	6.92%	9.28%	6.25%	0.00%	0.00%
48 to 52	1.01%	0.02%	1.79%	2.30%	3.54%	5.33%	3.69%	6.25%	0.00%	0.00%
52 to 56	0.40%	0.02%	0.58%	4.51%	1.75%	3.50%	0.74%	3.13%	0.00%	0.00%
56 to 60	0.13%	0.00%	0.42%	20.62%	1.44%	3.41%	3.91%	0.00%	0.00%	0.00%
60 to 64	0.13%	0.00%	0.35%	18.50%	0.87%	4.48%	4.51%	0.00%	0.00%	6.25%
64 to 68	0.00%	0.00%	0.13%	7.22%	0.15%	4.83%	13.24%	3.13%	0.00%	6.25%
68 to 72	0.13%	0.00%	0.30%	3.96%	0.00%	4.57%	3.13%	0.00%	0.00%	0.00%
72 to 76	0.00%	0.00%	0.00%	3.67%	0.00%	3.96%	0.78%	0.00%	25.00%	25.00%
76 to 80	0.00%	0.00%	0.00%	6.05%	0.76%	3.32%	2.91%	2.08%	0.00%	0.00%
80+	0.00%	0.00%	0.00%	5.33%	0.00%	6.21%	10.19%	4.17%	75.00%	62.50%
Total	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

Figure A.11 Average GVW distributions for non-NHS.

State/ Local	NHS Class	2009 Vehicle Class Distribution (%)													
		Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	Class 8	Class 9	Class 10	Class 11	Class 12	Class 13	Total
State	NHS-Interstate	0.37	53.20	18.03	0.37	4.10	0.68	0.11	1.26	20.76	0.20	0.62	0.24	0.06	100.00
State	NHS-Non-Int.	0.58	61.70	23.82	0.29	3.48	0.71	0.22	1.00	7.81	0.15	0.15	0.04	0.04	100.00
State	Non-NHS	0.56	61.98	26.68	0.12	2.09	1.56	0.54	0.96	5.29	0.14	0.03	0.01	0.05	100.00
	Total	***0.49***	***58.31***	***22.07***	***0.29***	***3.44***	***0.88***	***0.24***	***1.10***	***12.54***	***0.17***	***0.32***	***0.11***	***0.05***	***100.00***
Local	Non-NHS	0.60	65.73	27.73	0.08	1.22	0.63	0.21	0.47	3.19	0.07	0.03	0.01	0.02	100.00

State/ Local	NHS Class	2010 Vehicle Class Distribution (%)													
		Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	Class 8	Class 9	Class 10	Class 11	Class 12	Class 13	Total
State	NHS-Interstate	0.37	53.91	18.27	0.36	3.96	0.66	0.11	1.22	20.07	0.19	0.60	0.23	0.06	100.00
State	NHS-Non-Int.	0.58	61.42	23.71	0.29	3.55	0.73	0.22	1.02	8.09	0.15	0.16	0.04	0.04	100.00
State	Non-NHS	0.56	61.93	26.66	0.12	2.11	1.58	0.54	0.97	5.31	0.14	0.03	0.01	0.05	100.00
	Total	***0.49***	***0.49***	***0.49***	***58.43***	***22.10***	***0.28***	***3.41***	***0.88***	***0.24***	***1.09***	***12.43***	***0.16***	***0.31***	***0.11***
Local	Non-NHS	0.60	65.73	27.73	0.08	1.22	0.63	0.21	0.47	3.19	0.07	0.03	0.01	0.02	100.00

State/ Local	NHS Class	2011 Vehicle Class Distribution (%)													
		Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	Class 8	Class 9	Class 10	Class 11	Class 12	Class 13	Total
State	NHS-Interstate	0.42	60.96	20.66	0.29	3.18	0.53	0.08	0.76	12.45	0.12	0.37	0.14	0.04	100.00
State	NHS-Non-Int.	0.61	64.57	24.93	0.22	2.70	0.55	0.17	1.03	4.81	0.15	0.16	0.04	0.05	100.00
State	Non-NHS	0.58	63.66	27.41	0.10	1.79	1.34	0.46	0.95	3.50	0.13	0.03	0.01	0.04	100.00
	Total	***0.49***	***0.49***	***0.52***	***62.80***	***23.63***	***0.22***	***2.70***	***0.72***	***0.20***	***0.89***	***7.83***	***0.13***	***0.22***	***0.08***
Local	Non-NHS	0.59	64.75	27.88	0.10	1.79	1.34	0.46	0.19	2.85	0.03	0.01	0.00	0.01	100.00

State/ Local	NHS Class	2012 Vehicle Class Distribution (%)													
		Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	Class 8	Class 9	Class 10	Class 11	Class 12	Class 13	Total
State	NHS-Interstate	0.41	59.57	20.19	0.26	2.91	0.48	0.08	0.96	14.29	0.15	0.48	0.18	0.05	100.00
State	NHS-Non-Int.	0.58	62.32	24.06	0.36	4.32	0.88	0.27	0.99	5.82	0.15	0.15	0.04	0.04	100.00
State	Non-NHS	0.55	60.64	26.11	0.17	3.07	2.29	0.79	1.00	5.15	0.14	0.03	0.01	0.05	100.00
	Total	***0.49***	***0.49***	***0.50***	***60.72***	***22.92***	***0.27***	***3.40***	***1.07***	***0.32***	***0.98***	***9.26***	***0.15***	***0.26***	***0.09***
Local	Non-NHS	0.59	64.87	27.31	0.16	2.59	1.52	0.52	0.17	2.22	0.02	0.01	0.00	0.01	100.00

Figure A.12 Average vehicle class distributions by year and NHS road functional class.

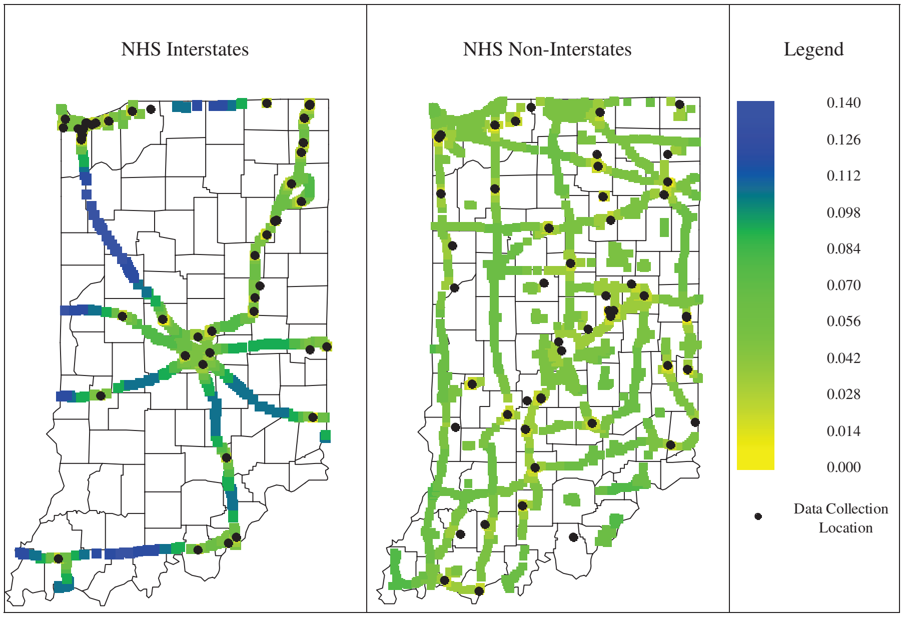


Figure A.13 Standard errors: Percent of VMT by out-of-state drivers on NHS (for gasoline).

		2009 Vehicle Class Distribution (%)													
State/ Local	NHS Class	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	Class 8	Class 9	Class 10	Class 11	Class 12	Class 13	Total
State	NHS-Interstate	0.37	53.20	18.03	0.37	4.10	0.68	0.11	1.26	20.76	0.20	0.62	0.24	0.06	100.00
State	NHS-Non-Int.	0.58	61.70	23.82	0.29	3.48	0.71	0.22	1.00	7.81	0.15	0.15	0.04	0.04	100.00
State	Non-NHS	0.56	61.98	26.68	0.12	2.09	1.56	0.54	0.96	5.29	0.14	0.03	0.01	0.05	100.00
	Total	***0.49***	***58.31***	***22.07***	***0.29***	***3.44***	***0.88***	***0.24***	***1.10***	***12.54***	***0.17***	***0.32***	***0.11***	***0.05***	***100.00***
Local	Non-NHS	0.60	65.73	27.73	0.08	1.22	0.63	0.21	0.47	3.19	0.07	0.03	0.01	0.02	100.00

		2010 Vehicle Class Distribution (%)													
State/ Local	NHS Class	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	Class 8	Class 9	Class 10	Class 11	Class 12	Class 13	Total
State	NHS-Interstate	0.37	53.91	18.27	0.36	3.96	0.66	0.11	1.22	20.07	0.19	0.60	0.23	0.06	100.00
State	NHS-Non-Int.	0.58	61.42	23.71	0.29	3.55	0.73	0.22	1.02	8.09	0.15	0.16	0.04	0.04	100.00
State	Non-NHS	0.56	61.93	26.66	0.12	2.11	1.58	0.54	0.97	5.31	0.14	0.03	0.01	0.05	100.00
	Total	***0.49***	***0.49***	***0.49***	***58.43***	***22.10***	***0.28***	***3.41***	***0.88***	***0.24***	***1.09***	***12.43***	***0.16***	***0.31***	***0.11***
Local	Non-NHS	0.60	65.73	27.73	0.08	1.22	0.63	0.21	0.47	3.19	0.07	0.03	0.01	0.02	100.00

		2011 Vehicle Class Distribution (%)													
State/ Local	NHS Class	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	Class 8	Class 9	Class 10	Class 11	Class 12	Class 13	Total
State	NHS-Interstate	0.42	60.96	20.66	0.29	3.18	0.53	0.08	0.76	12.45	0.12	0.37	0.14	0.04	100.00
State	NHS-Non-Int.	0.61	64.57	24.93	0.22	2.70	0.55	0.17	1.03	4.81	0.15	0.16	0.04	0.05	100.00
State	Non-NHS	0.58	63.66	27.41	0.10	1.79	1.34	0.46	0.95	3.50	0.13	0.03	0.01	0.04	100.00
	Total	***0.49***	***0.49***	***0.52***	***62.80***	***23.63***	***0.22***	***2.70***	***0.72***	***0.20***	***0.89***	***7.83***	***0.13***	***0.22***	***0.08***
Local	Non-NHS	0.59	64.75	27.88	0.10	1.79	1.34	0.46	0.19	2.85	0.03	0.01	0.00	0.01	100.00

		2012 Vehicle Class Distribution (%)													
State/ Local	NHS Class	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	Class 8	Class 9	Class 10	Class 11	Class 12	Class 13	Total
State	NHS-Interstate	0.41	59.57	20.19	0.26	2.91	0.48	0.08	0.96	14.29	0.15	0.48	0.18	0.05	100.00
State	NHS-Non-Int.	0.58	62.32	24.06	0.36	4.32	0.88	0.27	0.99	5.82	0.15	0.15	0.04	0.04	100.00
State	Non-NHS	0.55	60.64	26.11	0.17	3.07	2.29	0.79	1.00	5.15	0.14	0.03	0.01	0.05	100.00
	Total	***0.49***	***0.49***	***0.50***	***60.72***	***22.92***	***0.27***	***3.40***	***1.07***	***0.32***	***0.98***	***9.26***	***0.15***	***0.26***	***0.09***
Local	Non-NHS	0.59	64.87	27.31	0.16	2.59	1.52	0.52	0.17	2.22	0.02	0.01	0.00	0.01	100.00

Figure A.14 Percent of VMT by out-of-state drivers along non-NHS roadways (for gasoline).

ADDENDUM B: STATE ROUTE COST ALLOCATION RESULTS

B.1. PAVEMENT COST ALLOCATION RESULTS FOR STATE HIGHWAYS

B.1.1 New Pavement Construction—Cost Allocation Results

B.1.1.1 New Pavement Construction Cost Allocation Results per Year for Interstates

TABLE B.1.1
Cost Responsibility for Flexible Pavement Construction on Interstates, 2009.

	Base Facility			Remaining Facility	
Vehicle Class	**Earthworks**	**Shoulder**	**Pavement**	**Pavement**	**Total**
1	$12,217	$0	$7,762	$0	$19,980
2	$1,767,441	$0	$1,122,972	$5,442	$2,895,854
3	$599,145	$0	$380,676	$42,883	$1,022,705
4	$14,241	$0	$3,919	$15,605	$33,765
5	$158,003	$0	$43,480	$73,156	$274,640
6	$26,245	$0	$7,222	$27,576	$61,044
7	$4,196	$0	$1,155	$17,547	$22,898
8	$48,536	$0	$13,357	$51,847	$113,740
9	$800,183	$0	$224,601	$1,461,853	$2,486,637
10	$7,665	$0	$2,109	$13,818	$23,593
11	$24,086	$0	$6,628	$55,647	$86,361
12	$9,098	$0	$2,504	$19,877	$31,479
13	$2,373	$0	$653	$7,976	$11,002
Total	$3,473,431	$0	$1,817,038	$1,793,229	$7,083,698

TABLE B.1.2
Cost Responsibility for Rigid Pavement Construction on Interstates, 2009.

	Base Facility			Remaining Facility	
Vehicle Class	**Earthworks**	**Shoulder**	**Pavement**	**Pavement**	**Total**
1	$101,051	$0	$55,604	$0	$156,655
2	$14,618,599	$0	$8,044,091	$163,169	$22,825,859
3	$4,955,563	$0	$2,726,868	$330,475	$8,012,905
4	$117,789	$0	$32,435	$144,475	$294,699
5	$1,306,853	$0	$359,857	$583,782	$2,250,492
6	$217,078	$0	$59,775	$311,592	$588,445
7	$34,706	$0	$9,557	$211,041	$255,305
8	$401,446	$0	$110,543	$462,464	$974,453
9	$6,618,355	$0	$2,004,084	$17,753,323	$26,375,762
10	$63,400	$0	$17,458	$183,094	$263,951
11	$199,218	$0	$54,857	$482,292	$736,367
12	$75,253	$0	$20,722	$209,668	$305,643
13	$19,626	$0	$5,404	$107,277	$132,308
Total	$28,728,936	$0	$13,501,255	$20,942,652	$63,172,843

TABLE B.1.3
Total Cost Responsibility and Unit Cost for New Pavement Construction on Interstates, 2009.

	Base Facility			Remaining Facility		
Vehicle Class	Earthworks	Shoulder	Pavement	Pavement	Total	Unit Cost [$/VMT]
1	$113,268	$0	$63,367	$0	$176,635	$0.0031
2	$16,386,040	$0	$9,167,062	$168,611	$25,721,713	$0.0031
3	$5,554,708	$0	$3,107,545	$373,358	$9,035,610	$0.0032
4	$132,030	$0	$36,353	$160,081	$328,464	$0.0057
5	$1,464,856	$0	$403,337	$656,939	$2,525,132	$0.0039
6	$243,323	$0	$66,997	$339,168	$649,489	$0.0061
7	$38,903	$0	$10,712	$228,589	$278,203	$0.0163
8	$449,982	$0	$123,899	$514,312	$1,088,193	$0.0055
9	$7,418,537	$0	$2,228,685	$19,215,177	$28,862,398	$0.0089
10	$71,065	$0	$19,567	$196,912	$287,544	$0.0092
11	$223,304	$0	$61,485	$537,939	$822,729	$0.0084
12	$84,352	$0	$23,226	$229,545	$337,122	$0.0091
13	$21,999	$0	$6,057	$115,253	$143,310	$0.0148
Total	$32,202,367	$0	$15,318,293	$22,735,882	$70,256,541	

TABLE B.1.4
Cost Responsibility for Flexible Pavement Construction on Interstates, 2010.

	Base Facility			Remaining Facility	
Vehicle Class	Earthworks	Shoulder	Pavement	Pavement	Total
1	$36,382	$70	$5,350	$0	$41,802
2	$5,263,216	$10,171	$773,930	$7,017	$6,054,333
3	$1,784,179	$3,448	$262,355	$34,504	$2,084,486
4	$40,423	$101	$3,587	$15,408	$59,520
5	$448,491	$1,121	$39,799	$70,668	$560,079
6	$74,498	$186	$6,611	$27,770	$109,064
7	$11,911	$30	$1,057	$17,821	$30,819
8	$137,770	$344	$10,788	$45,257	$194,159
9	$2,272,624	$5,679	$131,849	$985,415	$3,395,567
10	$21,758	$54	$1,704	$12,209	$35,725
11	$68,368	$171	$5,353	$48,547	$122,439
12	$25,826	$65	$2,022	$17,423	$45,335
13	$6,735	$17	$527	$7,039	$14,319
Total	$10,192,180	$21,456	$1,244,932	$1,289,078	$12,747,645

TABLE B.1.5
Cost Responsibility for Rigid Pavement Construction on Interstates, 2010.

	Base Facility			Remaining Facility	
Vehicle Class	Earthworks	Shoulder	Pavement	Pavement	Total
1	$191,105	$337	$80,705	$0	$272,146
2	$27,646,420	$48,712	$11,675,225	$89,647	$39,460,005
3	$9,371,866	$16,513	$3,957,787	$328,683	$13,674,850
4	$212,334	$484	$80,582	$294,632	$588,031
5	$2,355,815	$5,368	$894,048	$1,186,388	$4,441,620
6	$391,318	$892	$148,508	$593,944	$1,134,662
7	$62,564	$143	$23,743	$398,280	$484,730
8	$723,672	$1,649	$131,503	$382,004	$1,238,828
9	$11,937,551	$27,199	$3,189,194	$22,108,838	$37,262,782
10	$114,288	$260	$20,768	$137,418	$272,734
11	$359,123	$818	$65,259	$404,282	$829,483
12	$135,656	$309	$24,651	$165,532	$326,148
13	$35,379	$81	$6,429	$79,249	$121,138
Total	$53,537,092	$102,763	$20,298,403	$26,168,898	$100,107,156

TABLE B.1.6
Total Cost Responsibility and Unit Cost for New Pavement Construction on Interstates, 2010.

Vehicle Class	Base Facility: Earthworks	Base Facility: Shoulder	Base Facility: Pavement	Remaining Facility: Pavement	Total	Unit Cost [$/VMT]
1	$227,487	$407	$86,054	$0	$313,948	$0.0054
2	$32,909,636	$58,883	$12,449,155	$96,664	$45,514,337	$0.0054
3	$11,156,045	$19,961	$4,220,142	$363,187	$15,759,335	$0.0055
4	$252,757	$585	$84,169	$310,040	$647,551	$0.0116
5	$2,804,306	$6,488	$933,848	$1,257,057	$5,001,699	$0.0080
6	$465,815	$1,078	$155,119	$621,714	$1,243,726	$0.0120
7	$74,475	$172	$24,800	$416,101	$515,549	$0.0312
8	$861,441	$1,993	$142,291	$427,262	$1,432,987	$0.0075
9	$14,210,175	$32,877	$3,321,043	$23,094,253	$40,658,348	$0.0129
10	$136,046	$315	$22,472	$149,627	$308,459	$0.0102
11	$427,492	$989	$70,612	$452,829	$951,922	$0.0100
12	$161,482	$374	$26,673	$182,954	$371,483	$0.0104
13	$42,115	$97	$6,956	$86,288	$135,457	$0.0145
Total	$63,729,272	$124,219	$21,543,335	$27,457,976	$112,854,801	

TABLE B.1.7
Cost Responsibility for Flexible Pavement Construction on Interstates, 2011.

Vehicle Class	Base Facility: Earthworks	Base Facility: Shoulder	Base Facility: Pavement	Remaining Facility: Pavement	Total
1	$35,220	$68	$20,438	$0	$55,725
2	$5,095,154	$9,782	$2,956,630	$10,614	$8,072,180
3	$1,727,208	$3,316	$1,002,269	$49,434	$2,782,227
4	$27,774	$46	$21,763	$51,101	$100,684
5	$308,147	$765	$241,457	$230,289	$780,658
6	$51,185	$127	$40,108	$93,895	$185,315
7	$8,184	$20	$6,412	$61,142	$75,758
8	$73,240	$182	$54,737	$135,160	$263,318
9	$1,207,475	$2,998	$924,502	$3,916,768	$6,051,742
10	$11,567	$29	$8,644	$39,847	$60,086
11	$36,345	$90	$27,163	$145,168	$208,767
12	$13,729	$34	$10,261	$53,764	$77,788
13	$3,581	$9	$2,676	$23,023	$29,288
Total	$8,598,808	$17,466	$5,317,059	$4,810,203	$18,743,536

TABLE B.1.8
Cost Responsibility for Rigid Pavement Construction on Interstates, 2011.

Vehicle Class	Base Facility: Earthworks	Base Facility: Shoulder	Base Facility: Pavement	Remaining Facility: Pavement	Total
1	$44,222	$641	$50,966	$0	$95,829
2	$6,397,417	$92,771	$7,373,081	$13,901	$13,877,171
3	$2,168,662	$31,448	$2,499,402	$113,119	$4,812,632
4	$34,873	$436	$54,440	$132,053	$221,801
5	$386,906	$7,255	$604,001	$553,774	$1,551,936
6	$64,268	$1,205	$100,329	$250,509	$416,311
7	$10,275	$193	$16,041	$165,255	$191,764
8	$91,959	$1,724	$145,634	$346,846	$586,163
9	$1,516,092	$28,429	$2,247,904	$10,584,414	$14,376,839
10	$14,523	$272	$23,000	$116,995	$154,789
11	$45,635	$856	$72,271	$372,190	$490,952
12	$17,238	$323	$27,300	$146,532	$191,394
13	$4,496	$84	$7,120	$66,524	$78,224
Total	$10,796,565	$165,639	$13,221,488	$12,862,113	$37,045,805

TABLE B.1.9
Total Cost Responsibility and Unit Cost for New Pavement Construction on Interstates, 2011.

Vehicle Class	Base Facility Earthworks	Base Facility Shoulder	Base Facility Pavement	Remaining Facility Pavement	Total	Unit Cost [$/VMT]
1	$79,442	$709	$71,404	$0	$151,555	$0.0022
2	$11,492,571	$102,553	$10,329,710	$24,515	$21,949,350	$0.0022
3	$3,895,869	$34,765	$3,501,671	$162,553	$7,594,858	$0.0022
4	$62,646	$482	$76,203	$183,154	$322,485	$0.0068
5	$695,053	$8,020	$845,458	$784,062	$2,332,594	$0.0044
6	$115,453	$1,332	$140,437	$344,404	$601,626	$0.0069
7	$18,459	$213	$22,453	$226,397	$267,522	$0.0191
8	$165,198	$1,906	$200,371	$482,006	$849,481	$0.0068
9	$2,723,566	$31,427	$3,172,405	$14,501,182	$20,428,580	$0.0099
10	$26,089	$301	$31,644	$156,841	$214,876	$0.0108
11	$81,980	$946	$99,434	$517,358	$699,718	$0.0112
12	$30,967	$357	$37,561	$200,296	$269,182	$0.0114
13	$8,076	$93	$9,796	$89,547	$107,512	$0.0175
Total	$19,395,373	$183,105	$18,538,546	$17,672,317	$55,789,341	

TABLE B.1.10
Cost Responsibility for Flexible Pavement Construction on Interstates, 2012.

Vehicle Class	Base Facility Earthworks	Base Facility Shoulder	Base Facility Pavement	Remaining Facility Pavement	Total
1	$36,865	$47	$19,491	$0	$56,403
2	$5,333,097	$6,837	$2,819,637	$25,853	$8,185,424
3	$1,807,868	$2,318	$955,830	$67,615	$2,833,630
4	$27,209	$30	$24,427	$59,416	$111,082
5	$301,876	$500	$271,019	$282,347	$855,741
6	$50,144	$83	$45,018	$107,781	$203,026
7	$8,017	$13	$7,198	$69,826	$85,054
8	$99,591	$165	$79,978	$183,272	$363,005
9	$1,483,861	$2,460	$1,405,112	$5,608,520	$8,499,953
10	$15,728	$26	$12,631	$48,781	$77,166
11	$49,422	$82	$39,689	$196,704	$285,897
12	$18,669	$31	$14,992	$69,624	$103,316
13	$4,869	$8	$3,910	$28,819	$37,606
Total	$9,237,215	$12,600	$5,698,931	$6,748,558	$21,697,304

TABLE B.1.11
Cost Responsibility for Rigid Pavement Construction on Interstates, 2012.

Vehicle Class	Base Facility Earthworks	Base Facility Shoulder	Base Facility Pavement	Remaining Facility Pavement	Total
1	$29,210	$42	$13,016	$0	$42,268
2	$4,225,715	$6,143	$1,882,943	$11,966	$6,126,766
3	$1,432,476	$2,082	$638,299	$37,020	$2,109,877
4	$21,559	$27	$14,033	$40,494	$76,113
5	$239,193	$450	$155,693	$164,056	$559,392
6	$39,732	$75	$25,862	$86,988	$152,656
7	$6,352	$12	$4,135	$58,826	$69,325
8	$78,912	$148	$50,305	$136,710	$266,075
9	$1,175,747	$2,210	$809,928	$4,923,733	$6,911,619
10	$12,462	$23	$7,945	$53,697	$74,127
11	$39,160	$74	$24,964	$143,049	$207,247
12	$14,792	$28	$9,430	$61,858	$86,108
13	$3,858	$7	$2,459	$31,398	$37,722
Total	$7,319,168	$11,322	$3,639,012	$5,749,794	$16,719,296

TABLE B.1.12
Total Cost Responsibility and Unit Cost for New Pavement Construction on Interstates, 2012.

Vehicle Class	Base Facility			Remaining Facility	Total	Unit Cost [$/VMT]
	Earthworks	Shoulder	Pavement	Pavement		
1	$66,075	$90	$32,506	$0	$98,671	$0.0014
2	$9,558,812	$12,980	$4,702,580	$37,819	$14,312,191	$0.0014
3	$3,240,344	$4,400	$1,594,129	$104,635	$4,943,508	$0.0015
4	$48,767	$57	$38,460	$99,910	$187,195	$0.0043
5	$541,069	$950	$426,712	$446,403	$1,415,134	$0.0029
6	$89,875	$158	$70,880	$194,769	$355,682	$0.0044
7	$14,369	$25	$11,332	$128,652	$154,379	$0.0120
8	$178,502	$313	$130,283	$319,982	$629,080	$0.0039
9	$2,659,609	$4,670	$2,215,040	$10,532,253	$15,411,572	$0.0065
10	$28,191	$49	$20,575	$102,478	$151,294	$0.0060
11	$88,582	$156	$64,653	$339,753	$493,144	$0.0062
12	$33,461	$59	$24,422	$131,482	$189,425	$0.0063
13	$8,727	$15	$6,369	$60,216	$75,328	$0.0096
Total	$16,556,383	$23,922	$9,337,942	$12,498,352	$38,416,600	

TABLE B.1.13
Cost Responsibility for Flexible Pavement Construction on Interstates, 2009–2012.

Vehicle Class	Base Facility			Remaining Facility	Total
	Earthworks	Shoulder	Pavement	Pavement	
1	$120,684	$185	$53,040	$0	$173,910
2	$17,458,908	$26,789	$7,673,168	$48,926	$25,207,792
3	$5,918,399	$9,081	$2,601,129	$194,437	$8,723,047
4	$109,647	$177	$53,696	$141,531	$305,051
5	$1,216,517	$2,386	$595,755	$656,460	$2,471,118
6	$202,072	$396	$98,959	$257,022	$558,449
7	$32,307	$63	$15,822	$166,337	$214,529
8	$359,136	$691	$158,859	$415,536	$934,223
9	$5,764,143	$11,136	$2,686,063	$11,972,556	$20,433,898
10	$56,718	$109	$25,088	$114,655	$196,570
11	$178,222	$343	$78,834	$446,065	$703,464
12	$67,322	$130	$29,779	$160,687	$257,918
13	$17,558	$34	$7,766	$66,857	$92,215
Total	$31,501,633	$51,522	$14,077,959	$14,641,069	$60,272,184

TABLE B.1.14
Cost Responsibility for Rigid Pavement Construction on Interstates, 2009–2012.

	Base Facility			Remaining Facility	
Vehicle Class	Earthworks	Shoulder	Pavement	Pavement	Total
1	$365,587	$1,020	$200,291	$0	$566,899
2	$52,888,151	$147,626	$28,975,339	$278,683	$82,289,800
3	$17,928,567	$50,044	$9,822,357	$809,296	$28,610,264
4	$386,554	$947	$181,489	$611,654	$1,180,644
5	$4,288,767	$13,072	$2,013,600	$2,488,001	$8,803,441
6	$712,395	$2,171	$334,473	$1,243,033	$2,292,073
7	$113,898	$347	$53,476	$833,402	$1,001,123
8	$1,295,988	$3,522	$437,985	$1,328,024	$3,065,519
9	$21,247,745	$57,838	$8,251,110	$55,370,308	$84,927,001
10	$204,673	$556	$69,170	$491,203	$765,602
11	$643,136	$1,748	$217,351	$1,401,813	$2,264,048
12	$242,940	$660	$82,103	$583,591	$909,294
13	$63,359	$172	$21,413	$284,448	$369,392
Total	$100,381,761	$279,724	$50,660,157	$65,723,458	$217,045,100

TABLE B.1.15
Total Cost Responsibility and Unit Cost for New Pavement Construction on Interstates, 2009–2012.

	Base Facility			Remaining Facility		
Vehicle Class	Earthworks	Shoulder	Pavement	Pavement	Total	Unit Cost [$/VMT]
1	$486,271	$1,206	$253,331	$0	$740,808	$0.0029
2	$70,347,059	$174,416	$36,648,507	$327,610	$107,497,592	$0.0029
3	$23,846,966	$59,125	$12,423,486	$1,003,733	$37,333,311	$0.0030
4	$496,201	$1,124	$235,186	$753,185	$1,485,695	$0.0072
5	$5,505,284	$15,458	$2,609,355	$3,144,461	$11,274,558	$0.0049
6	$914,467	$2,568	$433,433	$1,500,055	$2,850,523	$0.0075
7	$146,205	$411	$69,297	$999,739	$1,215,652	$0.0201
8	$1,655,124	$4,213	$596,844	$1,743,561	$3,999,741	$0.0059
9	$27,011,887	$68,974	$10,937,173	$67,342,864	$105,360,899	$0.0097
10	$261,390	$665	$94,258	$605,858	$962,172	$0.0090
11	$821,359	$2,091	$296,185	$1,847,879	$2,967,513	$0.0089
12	$310,263	$790	$111,882	$744,278	$1,167,212	$0.0092
13	$80,917	$206	$29,179	$351,305	$461,607	$0.0140
Total	$131,883,394	$331,246	$64,738,116	$80,364,527	$277,317,283	

B.1.1.2 New Pavement Construction Cost Allocation Results per Year for Non-Interstate NHS

TABLE B.1.16
Cost Responsibility for Flexible Pavement Construction on Non-Interstate NHS, 2009.

	Base Facility			Remaining Facility	
Vehicle Class	Earthworks	Shoulder	Pavement	Pavement	Total
1	$212,534	$210	$97,483	$0	$310,227
2	$22,645,742	$22,420	$10,392,941	$982,090	$34,043,193
3	$8,743,212	$8,656	$4,020,020	$2,122,074	$14,893,963
4	$114,501	$231	$30,097	$297,081	$441,910
5	$1,379,428	$2,782	$364,252	$1,538,311	$3,284,773
6	$282,204	$569	$77,244	$721,245	$1,081,262
7	$87,280	$176	$24,021	$895,126	$1,006,602
8	$395,740	$798	$105,372	$1,017,023	$1,518,932
9	$3,096,082	$6,244	$589,982	$8,662,492	$12,354,799
10	$58,516	$118	$15,566	$249,524	$323,724
11	$61,430	$124	$16,078	$338,488	$416,120
12	$15,369	$31	$4,032	$79,242	$98,673
13	$17,366	$35	$4,631	$139,871	$161,903
Total	$37,109,402	$42,395	$15,741,718	$17,042,566	$69,936,082

TABLE B.1.17
Cost Responsibility for Rigid Pavement Construction on Non-Interstate NHS, 2009.

	Base Facility			Remaining Facility	
Vehicle Class	Earthworks	Shoulder	Pavement	Pavement	Total
1	$141,958	$64	$53,309	$0	$195,331
2	$15,125,765	$6,844	$5,783,242	$197,393	$21,113,243
3	$5,839,852	$2,642	$2,216,121	$485,556	$8,544,171
4	$76,478	$70	$36,245	$138,639	$251,433
5	$921,361	$849	$435,839	$641,061	$1,999,109
6	$188,492	$174	$89,197	$348,670	$626,532
7	$58,297	$54	$27,281	$439,262	$524,894
8	$264,327	$244	$125,484	$452,213	$842,267
9	$2,067,965	$1,906	$1,102,536	$7,000,708	$10,173,115
10	$39,085	$36	$18,593	$137,982	$195,696
11	$41,031	$38	$20,825	$157,893	$219,786
12	$10,265	$9	$5,472	$42,033	$57,780
13	$11,599	$11	$5,528	$75,351	$92,489
Total	$24,786,474	$12,941	$9,919,671	$10,116,761	$44,835,847

TABLE B.1.18
Total Cost Responsibility and Unit Cost for New Pavement Construction on Non-Interstate NHS, 2009.

	Base Facility			Remaining Facility		
Vehicle Class	Earthworks	Shoulder	Pavement	Pavement	Total	Unit Cost [$/VMT]
1	$354,492	$275	$150,792	$0	$505,559	$0.0058
2	$37,771,506	$29,264	$16,176,182	$1,179,483	$55,156,436	$0.0060
3	$14,583,064	$11,299	$6,236,141	$2,607,630	$23,438,133	$0.0066
4	$190,979	$301	$66,342	$435,720	$693,342	$0.0160
5	$2,300,789	$3,631	$800,091	$2,179,372	$5,283,882	$0.0102
6	$470,696	$743	$166,441	$1,069,914	$1,707,794	$0.0160
7	$145,576	$230	$51,302	$1,334,388	$1,531,496	$0.0465
8	$660,067	$1,042	$230,855	$1,469,236	$2,361,199	$0.0158
9	$5,164,047	$8,150	$1,692,518	$15,663,199	$22,527,914	$0.0193
10	$97,601	$154	$34,159	$387,506	$519,419	$0.0235
11	$102,460	$162	$36,903	$496,381	$635,906	$0.0274
12	$25,634	$40	$9,504	$121,275	$156,453	$0.0270
13	$28,965	$46	$10,160	$215,223	$254,393	$0.0388
Total	$61,895,876	$55,337	$25,661,389	$27,159,327	$114,771,928	

TABLE B.1.19
Cost Responsibility for Flexible Pavement Construction on Non-Interstate NHS, 2010.

	Base Facility			Remaining Facility	
Vehicle Class	Earthworks	Shoulder	Pavement	Pavement	Total
1	$134,071	$933	$65,913	$0	$200,917
2	$14,285,428	$99,389	$7,023,098	$425,992	$21,833,907
3	$5,515,409	$38,373	$2,711,523	$943,812	$9,209,116
4	$74,000	$1,049	$26,900	$270,004	$371,952
5	$891,500	$12,635	$324,073	$1,390,143	$2,618,351
6	$182,383	$2,585	$66,299	$651,125	$902,392
7	$56,407	$799	$20,505	$812,138	$889,850
8	$255,760	$3,625	$92,972	$920,315	$1,272,672
9	$2,032,673	$28,808	$568,874	$8,854,904	$11,485,259
10	$37,818	$536	$13,747	$229,610	$281,711
11	$39,701	$563	$14,432	$308,770	$363,465
12	$9,932	$141	$3,611	$72,514	$86,197
13	$11,223	$159	$4,080	$129,185	$144,647
Total	$23,526,306	$189,593	$10,936,027	$15,008,511	$49,660,437

TABLE B.1.20
Cost Responsibility for Rigid Pavement Construction on Non-Interstate NHS, 2010.

	Base Facility			Remaining Facility	
Vehicle Class	Earthworks	Shoulder	Pavement	Pavement	Total
1	$91,543	$309	$64,815	$0	$156,667
2	$9,753,955	$32,920	$6,906,157	$193,521	$16,886,553
3	$3,765,869	$12,710	$2,666,373	$519,694	$6,964,646
4	$50,526	$347	$31,807	$187,038	$269,718
5	$608,708	$4,185	$383,185	$856,634	$1,852,712
6	$124,530	$856	$78,392	$473,730	$677,508
7	$38,514	$265	$24,245	$602,765	$665,789
8	$174,630	$1,201	$109,931	$606,130	$891,892
9	$1,387,890	$9,542	$859,064	$8,382,145	$10,638,641
10	$25,822	$178	$16,255	$189,636	$231,890
11	$27,107	$186	$17,064	$203,228	$247,586
12	$6,782	$47	$4,269	$52,762	$63,860
13	$7,663	$53	$4,824	$103,267	$115,807
Total	$16,063,539	$62,798	$11,166,381	$12,370,550	$39,663,268

TABLE B.1.21
Total Cost Responsibility and Unit Cost for New Pavement Construction on Non-Interstate NHS, 2010.

	Base Facility			Remaining Facility		
Vehicle Class	Earthworks	Shoulder	Pavement	Pavement	Total	Unit Cost [$/VMT]
1	$225,614	$1,242	$130,728	$0	$357,584	$0.0043
2	$24,039,383	$132,309	$13,929,255	$619,513	$38,720,460	$0.0044
3	$9,281,279	$51,083	$5,377,896	$1,463,506	$16,173,762	$0.0047
4	$124,526	$1,396	$58,707	$457,041	$641,670	$0.0151
5	$1,500,208	$16,820	$707,258	$2,246,777	$4,471,063	$0.0088
6	$306,913	$3,441	$144,691	$1,124,855	$1,579,900	$0.0151
7	$94,922	$1,064	$44,750	$1,414,903	$1,555,639	$0.0482
8	$430,390	$4,825	$202,903	$1,526,445	$2,164,564	$0.0148
9	$3,420,563	$38,350	$1,427,938	$17,237,049	$22,123,899	$0.0190
10	$63,640	$713	$30,002	$419,246	$513,601	$0.0237
11	$66,808	$749	$31,496	$511,998	$611,052	$0.0269
12	$16,714	$187	$7,880	$125,276	$150,057	$0.0264
13	$18,886	$212	$8,904	$232,452	$260,454	$0.0405
Total	$39,589,845	$252,391	$22,102,408	$27,379,061	$89,323,705	

TABLE B.1.22
Cost Responsibility for Flexible Pavement Construction on Non-Interstate NHS, 2011.

Vehicle Class	Base Facility			Remaining Facility	Total
	Earthworks	Shoulder	Pavement	Pavement	
1	$251,606	$774	$90,136	$0	$342,517
2	$26,808,942	$82,491	$9,607,108	$312,414	$36,810,955
3	$10,350,567	$31,849	$3,713,761	$872,690	$14,968,867
4	$100,555	$630	$47,436	$346,210	$494,831
5	$1,211,421	$7,593	$572,221	$1,782,943	$3,574,179
6	$247,833	$1,553	$118,285	$834,044	$1,201,715
7	$76,649	$480	$36,643	$1,032,433	$1,146,206
8	$461,491	$2,893	$65,803	$534,050	$1,064,237
9	$2,157,540	$13,523	$898,595	$9,741,676	$12,811,334
10	$68,238	$428	$9,710	$133,006	$211,382
11	$71,636	$449	$9,840	$173,105	$255,030
12	$17,922	$112	$2,471	$40,800	$61,305
13	$20,251	$127	$2,897	$74,237	$97,512
Total	$41,844,653	$142,903	$15,174,907	$15,877,608	$73,040,071

TABLE B.1.23
Cost Responsibility for Rigid Pavement Construction on Non-Interstate NHS, 2011.

Vehicle Class	Base Facility			Remaining Facility	Total
	Earthworks	Shoulder	Pavement	Pavement	
1	$22,539	$0	$18,117	$0	$40,656
2	$2,401,587	$0	$1,944,146	$20,966	$4,366,699
3	$927,220	$0	$771,558	$100,335	$1,799,113
4	$9,008	$0	$9,514	$46,231	$64,753
5	$108,521	$0	$118,035	$217,236	$443,792
6	$22,201	$0	$29,720	$169,181	$221,103
7	$6,866	$0	$9,466	$223,916	$240,248
8	$41,341	$0	$19,607	$133,033	$193,982
9	$193,276	$0	$205,463	$1,902,062	$2,300,801
10	$6,113	$0	$2,809	$42,970	$51,891
11	$6,417	$0	$1,335	$17,165	$24,918
12	$1,605	$0	$375	$5,163	$7,143
13	$1,814	$0	$902	$25,258	$27,974
Total	$3,748,509	$0	$3,131,047	$2,903,516	$9,783,073

TABLE B.1.24
Total Cost Responsibility and Unit Cost for New Pavement Construction on Non-Interstate NHS, 2011.

Vehicle Class	Base Facility			Remaining Facility	Total	Unit Cost [$/VMT]
	Earthworks	Shoulder	Pavement	Pavement		
1	$274,146	$774	$108,253	$0	$383,173	$0.0048
2	$29,210,529	$82,491	$11,551,254	$333,379	$41,177,654	$0.0048
3	$11,277,787	$31,849	$4,485,319	$973,025	$16,767,980	$0.0051
4	$109,563	$630	$56,950	$392,441	$559,584	$0.0190
5	$1,319,942	$7,593	$690,257	$2,000,179	$4,017,971	$0.0113
6	$270,034	$1,553	$148,005	$1,003,225	$1,422,818	$0.0196
7	$83,516	$480	$46,109	$1,256,350	$1,386,455	$0.0617
8	$502,832	$2,893	$85,411	$667,083	$1,258,219	$0.0093
9	$2,350,816	$13,523	$1,104,058	$11,643,738	$15,112,135	$0.0239
10	$74,351	$428	$12,519	$175,976	$263,274	$0.0132
11	$78,053	$449	$11,176	$190,270	$279,948	$0.0133
12	$19,527	$112	$2,845	$45,963	$68,448	$0.0130
13	$22,065	$127	$3,799	$99,495	$125,486	$0.0211
Total	$45,593,162	$142,903	$18,305,954	$18,781,124	$82,823,144	

TABLE B.1.25
Cost Responsibility for Flexible Pavement Construction on Non-Interstate NHS, 2012.

	Base Facility			Remaining Facility	
Vehicle Class	Earthworks	Shoulder	Pavement	Pavement	Total
1	$62,512	$0	$10,184	$0	$72,696
2	$6,660,710	$0	$1,099,870	$8,522	$7,769,102
3	$2,571,610	$0	$422,097	$64,647	$3,058,353
4	$41,400	$0	$5,587	$24,683	$71,669
5	$498,756	$0	$66,805	$125,261	$690,821
6	$102,036	$0	$13,473	$58,366	$173,874
7	$31,557	$0	$4,017	$71,288	$106,863
8	$114,652	$0	$26,965	$96,950	$238,567
9	$671,921	$0	$148,284	$878,118	$1,698,322
10	$16,953	$0	$4,006	$23,971	$44,930
11	$17,797	$0	$4,824	$33,403	$56,025
12	$4,452	$0	$1,326	$8,017	$13,796
13	$5,031	$0	$1,193	$13,242	$19,466
Total	$10,799,386	$0	$1,808,629	$1,406,468	$14,014,483

TABLE B.1.26
Cost Responsibility for Rigid Pavement Construction on Non-Interstate NHS, 2012.

	Base Facility			Remaining Facility	
Vehicle Class	Earthworks	Shoulder	Pavement	Pavement	Total
1	$146,151	$0	$40,453	$0	$186,604
2	$15,572,595	$0	$4,325,055	$32,349	$19,929,999
3	$6,012,367	$0	$1,674,148	$192,949	$7,879,463
4	$96,791	$0	$29,778	$137,468	$264,037
5	$1,166,079	$0	$360,205	$602,927	$2,129,211
6	$238,557	$0	$76,526	$375,948	$691,031
7	$73,781	$0	$23,706	$482,061	$579,547
8	$268,053	$0	$64,859	$228,586	$561,498
9	$1,570,936	$0	$572,675	$4,588,510	$6,732,121
10	$39,636	$0	$9,602	$72,370	$121,607
11	$41,609	$0	$10,484	$76,767	$128,861
12	$10,410	$0	$2,710	$20,247	$33,367
13	$11,763	$0	$2,854	$38,992	$53,608
Total	$25,248,729	$0	$7,193,054	$6,849,173	$39,290,955

TABLE B.1.27
Total Cost Responsibility and Unit Cost for New Pavement Construction on Non-Interstate NHS, 2012.

	Base Facility			Remaining Facility		
Vehicle Class	Earthworks	Shoulder	Pavement	Pavement	Total	Unit Cost [$/VMT]
1	$208,663	$0	$50,636	$0	$259,300	$0.0035
2	$22,233,306	$0	$5,424,925	$40,871	$27,699,102	$0.0035
3	$8,583,976	$0	$2,096,244	$257,595	$10,937,816	$0.0036
4	$138,191	$0	$35,365	$162,151	$335,707	$0.0074
5	$1,664,835	$0	$427,009	$728,187	$2,820,032	$0.0052
6	$340,592	$0	$89,999	$434,313	$864,905	$0.0077
7	$105,338	$0	$27,723	$553,349	$686,410	$0.0198
8	$382,705	$0	$91,823	$325,536	$800,065	$0.0064
9	$2,242,856	$0	$720,959	$5,466,629	$8,430,444	$0.0114
10	$56,589	$0	$13,607	$96,341	$166,537	$0.0090
11	$59,406	$0	$15,309	$110,171	$184,886	$0.0095
12	$14,862	$0	$4,036	$28,264	$47,163	$0.0097
13	$16,794	$0	$4,047	$52,234	$73,074	$0.0132
Total	$36,048,115	$0	$9,001,683	$8,255,640	$53,305,438	

TABLE B.1.28
Cost Responsibility for Flexible Pavement Construction on Non-Interstate NHS, 2009–2012.

	Base Facility			Remaining Facility	
Vehicle Class	Earthworks	Shoulder	Pavement	Pavement	Total
1	$660,724	$1,917	$263,715	$0	$926,356
2	$70,400,823	$204,300	$28,123,017	$1,729,017	$100,457,158
3	$27,180,799	$78,878	$10,867,400	$4,003,223	$42,130,299
4	$330,455	$1,910	$110,020	$937,977	$1,380,362
5	$3,981,104	$23,010	$1,327,352	$4,836,658	$10,168,123
6	$814,455	$4,707	$275,302	$2,264,779	$3,359,243
7	$251,894	$1,456	$85,186	$2,810,985	$3,149,521
8	$1,227,643	$7,315	$291,112	$2,568,338	$4,094,408
9	$7,958,215	$48,575	$2,205,735	$28,137,189	$38,349,715
10	$181,525	$1,082	$43,029	$636,111	$861,747
11	$190,564	$1,136	$45,175	$853,766	$1,090,640
12	$47,675	$284	$11,439	$200,573	$259,972
13	$53,871	$321	$12,800	$356,536	$423,528
Total	$113,279,747	$374,892	$43,661,282	$49,335,152	$206,651,073

TABLE B.1.29
Cost Responsibility for Rigid Pavement Construction on Non-Interstate NHS, 2009–2012.

	Base Facility			Remaining Facility	
Vehicle Class	Earthworks	Shoulder	Pavement	Pavement	Total
1	$402,191	$373	$176,694	$0	$579,258
2	$42,853,902	$39,764	$18,958,600	$444,228	$62,296,494
3	$16,545,308	$15,352	$7,328,200	$1,298,533	$25,187,393
4	$232,804	$418	$107,344	$509,375	$849,941
5	$2,804,669	$5,034	$1,297,264	$2,317,857	$6,424,824
6	$573,780	$1,030	$273,835	$1,367,529	$2,216,174
7	$177,458	$319	$84,697	$1,748,005	$2,010,479
8	$748,351	$1,444	$319,881	$1,419,962	$2,489,638
9	$5,220,066	$11,448	$2,739,738	$21,873,426	$29,844,678
10	$110,655	$214	$47,258	$442,957	$601,084
11	$116,165	$224	$49,708	$455,054	$621,151
12	$29,062	$56	$12,826	$120,205	$162,150
13	$32,839	$63	$14,108	$242,868	$289,878
Total	$69,847,251	$75,739	$31,410,153	$32,240,000	$133,573,143

TABLE B.1.30
Total Cost Responsibility and Unit Cost for New Pavement Construction on Non-Interstate NHS, 2009–2012.

	Base Facility			Remaining Facility		
Vehicle Class	Earthworks	Shoulder	Pavement	Pavement	Total	Unit Cost [$/VMT]
1	$1,062,915	$2,291	$440,410	$0	$1,505,615	$0.0047
2	$113,254,725	$244,064	$47,081,617	$2,173,246	$162,753,652	$0.0047
3	$43,726,107	$94,230	$18,195,599	$5,301,756	$67,317,692	$0.0051
4	$563,259	$2,328	$217,363	$1,447,353	$2,230,303	$0.0139
5	$6,785,773	$28,044	$2,624,615	$7,154,515	$16,592,947	$0.0086
6	$1,388,235	$5,737	$549,136	$3,632,308	$5,575,417	$0.0141
7	$429,352	$1,774	$169,883	$4,558,990	$5,160,000	$0.0422
8	$1,975,994	$8,760	$610,992	$3,988,300	$6,584,047	$0.0118
9	$13,178,281	$60,023	$4,945,473	$50,010,615	$68,194,393	$0.0184
10	$292,180	$1,295	$90,287	$1,079,068	$1,462,831	$0.0178
11	$306,729	$1,360	$94,883	$1,308,820	$1,711,791	$0.0198
12	$76,738	$340	$24,265	$320,778	$422,122	$0.0195
13	$86,710	$384	$26,909	$599,404	$713,407	$0.0292
Total	$183,126,998	$450,630	$75,071,435	$81,575,152	$340,224,215	

B.1.1.3 New Pavement Construction Cost Allocation Results per Year for Non-NHS

TABLE B.1.31
Cost Responsibility for Flexible Pavement Construction on Non-NHS, 2009.

	Base Facility			Remaining Facility	
Vehicle Class	Earthworks	Shoulder	Pavement	Pavement	Total
1	$157,624	$1,662	$99,133	$0	$258,419
2	$17,301,220	$182,408	$11,507,778	$431,560	$29,422,967
3	$7,448,894	$78,534	$4,668,136	$1,215,459	$13,411,023
4	$34,874	$749	$23,914	$200,325	$259,862
5	$629,308	$13,515	$352,332	$1,277,719	$2,272,875
6	$470,382	$10,102	$186,528	$1,531,874	$2,198,886
7	$162,269	$3,485	$61,166	$2,037,826	$2,264,745
8	$289,347	$6,214	$140,580	$1,162,989	$1,599,130
9	$1,595,613	$34,268	$945,633	$10,874,344	$13,449,858
10	$40,847	$877	$20,407	$279,437	$341,569
11	$8,341	$179	$19,000	$269,515	$297,035
12	$2,955	$63	$6,875	$86,176	$96,070
13	$13,586	$292	$6,620	$170,461	$190,959
Total	$28,155,260	$332,350	$18,038,101	$19,537,686	$66,063,398

TABLE B.1.32
Cost Responsibility for Rigid Pavement Construction on Non-NHS, 2009.

	Base Facility			Remaining Facility	
Vehicle Class	Earthworks	Shoulder	Pavement	Pavement	Total
1	$116,124	$206	$66,811	$0	$183,141
2	$12,745,998	$22,624	$7,364,043	$224,170	$20,356,834
3	$5,487,681	$9,740	$3,013,512	$630,829	$9,141,762
4	$25,692	$93	$16,713	$148,643	$191,141
5	$463,618	$1,676	$256,646	$810,658	$1,532,598
6	$346,535	$1,253	$144,413	$1,157,172	$1,649,373
7	$119,546	$432	$48,822	$1,624,281	$1,793,081
8	$213,165	$771	$103,409	$775,124	$1,092,469
9	$1,175,506	$4,250	$512,121	$7,288,839	$8,980,715
10	$30,093	$109	$14,814	$250,635	$295,651
11	$6,145	$22	$7,789	$138,054	$152,010
12	$2,177	$8	$2,488	$42,908	$47,581
13	$10,009	$36	$4,803	$148,019	$162,867
Total	$20,742,288	$41,221	$11,556,383	$13,239,332	$45,579,223

TABLE B.1.33
Total Cost Responsibility and Unit Cost for New Pavement Construction on Non-NHS, 2009.

	Base Facility			Remaining Facility		
Vehicle Class	Earthworks	Shoulder	Pavement	Pavement	Total	Unit Cost [$/VMT]
1	$273,748	$1,868	$165,944	$0	$441,560	$0.0097
2	$30,047,218	$205,032	$18,871,822	$655,730	$49,779,802	$0.0100
3	$12,936,575	$88,275	$7,681,647	$1,846,288	$22,552,786	$0.0105
4	$60,565	$842	$40,627	$348,968	$451,002	$0.0484
5	$1,092,926	$15,192	$608,978	$2,088,377	$3,805,473	$0.0226
6	$816,917	$11,355	$330,941	$2,689,046	$3,848,259	$0.0306
7	$281,815	$3,917	$109,987	$3,662,107	$4,057,826	$0.0936
8	$502,512	$6,985	$243,989	$1,938,112	$2,691,599	$0.0348
9	$2,771,118	$38,519	$1,457,753	$18,163,183	$22,430,573	$0.0526
10	$70,940	$986	$35,222	$530,072	$637,219	$0.0584
11	$14,487	$201	$26,789	$407,569	$449,046	$0.2014
12	$5,132	$71	$9,363	$129,084	$143,650	$0.1819
13	$23,595	$328	$11,423	$318,480	$353,826	$0.0975
Total	$48,897,548	$373,571	$29,594,484	$32,777,017	$111,642,621	

TABLE B.1.34
Cost Responsibility for Flexible Pavement Construction on Non-NHS, 2010.

Vehicle Class	Base Facility			Remaining Facility	Total
	Earthworks	Shoulder	Pavement	Pavement	
1	$69,471	$167	$29,131	$0	$98,769
2	$7,625,253	$18,369	$3,263,296	$206,637	$11,113,555
3	$3,282,988	$7,908	$1,374,858	$490,897	$5,156,652
4	$15,547	$76	$5,499	$56,642	$77,765
5	$280,558	$1,377	$90,340	$416,767	$789,042
6	$209,705	$1,029	$58,836	$660,438	$930,008
7	$72,343	$355	$19,954	$912,202	$1,004,854
8	$128,997	$633	$39,090	$427,288	$596,007
9	$705,725	$3,463	$219,681	$3,831,787	$4,760,657
10	$18,210	$89	$5,580	$101,396	$125,275
11	$3,719	$18	$2,739	$47,252	$53,728
12	$1,317	$6	$980	$15,774	$18,078
13	$6,057	$30	$1,836	$63,861	$71,784
Total	$12,419,891	$33,521	$5,111,820	$7,230,940	$24,796,173

TABLE B.1.35
Cost Responsibility for Rigid Pavement Construction on Non-NHS, 2010.

Vehicle Class	Base Facility			Remaining Facility	Total
	Earthworks	Shoulder	Pavement	Pavement	
1	$53,787	$175	$39,310	$0	$93,272
2	$5,903,789	$19,174	$4,338,009	$208,547	$10,469,518
3	$2,541,826	$8,255	$1,857,054	$565,781	$4,972,917
4	$12,037	$80	$5,544	$66,092	$83,754
5	$217,220	$1,437	$96,914	$441,911	$757,481
6	$162,363	$1,074	$69,370	$886,492	$1,119,299
7	$56,011	$371	$23,810	$1,254,849	$1,335,040
8	$99,875	$661	$43,695	$498,140	$642,371
9	$546,402	$3,615	$146,627	$3,160,878	$3,857,521
10	$14,099	$93	$6,190	$152,146	$172,529
11	$2,879	$19	$1,829	$38,286	$43,014
12	$1,020	$7	$651	$13,975	$15,653
13	$4,689	$31	$2,052	$92,311	$99,084
Total	$9,615,997	$34,990	$6,631,055	$7,379,408	$23,661,451

TABLE B.1.36
Total Cost Responsibility and Unit Cost for New Pavement Construction on Non-NHS, 2010.

Vehicle Class	Base Facility			Remaining Facility	Total	Unit Cost [$/VMT]
	Earthworks	Shoulder	Pavement	Pavement		
1	$123,258	$342	$68,441	$0	$192,040	$0.0042
2	$13,529,043	$37,542	$7,601,304	$415,184	$21,583,073	$0.0043
3	$5,824,815	$16,163	$3,231,912	$1,056,679	$10,129,569	$0.0047
4	$27,585	$156	$11,043	$122,735	$161,518	$0.0171
5	$497,778	$2,814	$187,254	$858,678	$1,546,523	$0.0091
6	$372,068	$2,103	$128,206	$1,546,929	$2,049,307	$0.0161
7	$128,354	$726	$43,764	$2,167,050	$2,339,894	$0.0534
8	$228,871	$1,294	$82,785	$925,428	$1,238,378	$0.0158
9	$1,252,127	$7,078	$366,308	$6,992,665	$8,618,178	$0.0202
10	$32,310	$183	$11,770	$253,542	$297,804	$0.0270
11	$6,598	$37	$4,568	$85,539	$96,741	$0.0429
12	$2,337	$13	$1,631	$29,750	$33,731	$0.0423
13	$10,746	$61	$3,888	$156,172	$170,867	$0.0466
Total	$22,035,889	$68,511	$11,742,875	$14,610,348	$48,457,624	

TABLE B.1.37
Cost Responsibility for Flexible Pavement Construction on Non-NHS, 2011.

	Base Facility			Remaining Facility	
Vehicle Class	Earthworks	Shoulder	Pavement	Pavement	Total
1	$113,203	$0	$18,682	$0	$131,885
2	$12,425,425	$0	$2,091,770	$166,665	$14,683,861
3	$5,349,661	$0	$884,978	$387,277	$6,621,916
4	$20,877	$0	$3,816	$36,897	$61,590
5	$376,729	$0	$57,197	$271,152	$705,077
6	$281,590	$0	$31,925	$432,506	$746,021
7	$97,141	$0	$10,441	$596,440	$704,022
8	$199,918	$0	$23,217	$275,817	$498,952
9	$737,470	$0	$172,159	$2,131,029	$3,040,658
10	$28,222	$0	$3,373	$65,469	$97,065
11	$5,763	$0	$3,343	$33,941	$43,047
12	$2,042	$0	$1,251	$11,601	$14,893
13	$9,387	$0	$1,101	$41,305	$51,793
Total	$19,647,428	$0	$3,303,255	$4,450,098	$27,400,781

TABLE B.1.38
Cost Responsibility for Rigid Pavement Construction on Non-NHS, 2011.

	Base Facility			Remaining Facility	
Vehicle Class	Earthworks	Shoulder	Pavement	Pavement	Total
1	$52,906	$0	$40,187	$0	$93,093
2	$5,807,050	$0	$4,427,992	$279,155	$10,514,197
3	$2,500,176	$0	$1,899,994	$693,359	$5,093,528
4	$9,757	$0	$5,193	$72,044	$86,995
5	$176,065	$0	$88,905	$476,645	$741,615
6	$131,602	$0	$61,987	$1,000,685	$1,194,274
7	$45,399	$0	$21,148	$1,430,709	$1,497,256
8	$93,432	$0	$23,261	$310,182	$426,875
9	$344,658	$0	$143,945	$3,278,420	$3,767,023
10	$13,190	$0	$3,323	$93,848	$110,361
11	$2,693	$0	$1,774	$26,153	$30,620
12	$954	$0	$656	$9,548	$11,158
13	$4,387	$0	$1,097	$57,443	$62,927
Total	$9,182,270	$0	$6,719,462	$7,728,191	$23,629,923

TABLE B.1.39
Total Cost Responsibility and Unit Cost for New Pavement Construction on Non-NHS, 2011.

	Base Facility			Remaining Facility		
Vehicle Class	Earthworks	Shoulder	Pavement	Pavement	Total	Unit Cost [$/VMT]
1	$166,109	$0	$58,869	$0	$224,978	$0.0045
2	$18,232,476	$0	$6,519,762	$445,820	$25,198,058	$0.0046
3	$7,849,838	$0	$2,784,971	$1,080,635	$11,715,445	$0.0050
4	$30,633	$0	$9,010	$108,941	$148,585	$0.0176
5	$552,794	$0	$146,102	$747,796	$1,446,693	$0.0095
6	$413,191	$0	$93,913	$1,433,192	$1,940,296	$0.0170
7	$142,540	$0	$31,589	$2,027,149	$2,201,278	$0.0559
8	$293,350	$0	$46,478	$585,998	$925,827	$0.0114
9	$1,082,128	$0	$316,105	$5,409,449	$6,807,682	$0.0228
10	$41,412	$0	$6,697	$159,317	$207,426	$0.0181
11	$8,457	$0	$5,117	$60,094	$73,668	$0.0315
12	$2,996	$0	$1,907	$21,149	$26,052	$0.0315
13	$13,774	$0	$2,198	$98,748	$114,720	$0.0301
Total	$28,829,698	$0	$10,022,717	$12,178,290	$51,030,705	

TABLE B.1.40
Cost Responsibility for Flexible Pavement Construction on Non-NHS, 2012.

Vehicle Class	Base Facility			Remaining Facility	Total
	Earthworks	Shoulder	Pavement	Pavement	
1	$176,573	$154	$15,463	$0	$192,190
2	$19,381,101	$16,849	$1,671,629	$79,074	$21,148,653
3	$8,344,369	$7,254	$678,497	$200,107	$9,230,227
4	$58,723	$104	$4,775	$55,452	$119,054
5	$1,059,674	$1,877	$61,697	$300,673	$1,423,921
6	$792,063	$1,403	$19,453	$196,847	$1,009,766
7	$273,241	$484	$6,346	$255,127	$535,198
8	$346,492	$614	$19,884	$217,419	$584,409
9	$1,777,413	$3,148	$101,588	$1,585,756	$3,467,905
10	$48,914	$87	$2,902	$53,554	$105,457
11	$9,989	$18	$2,382	$59,879	$72,268
12	$3,538	$6	$618	$14,405	$18,568
13	$16,269	$29	$891	$30,837	$48,025
Total	$32,288,358	$32,025	$2,586,126	$3,049,131	$37,955,640

TABLE B.1.41
Cost Responsibility for Rigid Pavement Construction on Non-NHS, 2012.

Vehicle Class	Base Facility			Remaining Facility	Total
	Earthworks	Shoulder	Pavement	Pavement	
1	$0	$0	$2,048	$0	$2,048
2	$0	$0	$218,739	$1,783	$220,522
3	$0	$0	$85,199	$12,770	$97,968
4	$0	$0	$753	$4,954	$5,707
5	$0	$0	$9,167	$22,429	$31,596
6	$0	$0	$2,029	$13,714	$15,743
7	$0	$0	$635	$17,394	$18,029
8	$0	$0	$2,679	$16,387	$19,066
9	$0	$0	$15,677	$188,542	$204,219
10	$0	$0	$395	$5,114	$5,509
11	$0	$0	$400	$5,227	$5,627
12	$0	$0	$101	$1,382	$1,483
13	$0	$0	$118	$2,761	$2,879
Total	$0	$0	$337,939	$292,456	$630,396

TABLE B.1.42
Total Cost Responsibility and Unit Cost for New Pavement Construction on Non-NHS, 2012.

Vehicle Class	Base Facility			Remaining Facility	Total	Unit Cost [$/VMT]
	Earthworks	Shoulder	Pavement	Pavement		
1	$176,573	$154	$17,511	$0	$194,238	$0.0036
2	$19,381,101	$16,849	$1,890,367	$80,857	$21,369,174	$0.0036
3	$8,344,369	$7,254	$763,695	$212,877	$9,328,195	$0.0036
4	$58,723	$104	$5,529	$60,407	$124,762	$0.0075
5	$1,059,674	$1,877	$70,864	$323,102	$1,455,517	$0.0048
6	$792,063	$1,403	$21,483	$210,561	$1,025,509	$0.0046
7	$273,241	$484	$6,981	$272,521	$553,227	$0.0071
8	$346,492	$614	$22,564	$233,806	$603,475	$0.0061
9	$1,777,413	$3,148	$117,265	$1,774,298	$3,672,124	$0.0073
10	$48,914	$87	$3,298	$58,667	$110,966	$0.0080
11	$9,989	$18	$2,782	$65,106	$77,895	$0.0274
12	$3,538	$6	$719	$15,787	$20,051	$0.0199
13	$16,269	$29	$1,009	$33,598	$50,904	$0.0110
Total	$32,288,358	$32,025	$2,924,066	$3,341,587	$38,586,036	

TABLE B.1.43
Cost Responsibility for Flexible Pavement Construction on Non-NHS, 2009–2012.

	Base Facility			Remaining Facility	
Vehicle Class	Earthworks	Shoulder	Pavement	Pavement	Total
1	$516,871	$1,983	$162,409	$0	$681,263
2	$56,733,000	$217,626	$18,534,473	$883,937	$76,369,035
3	$24,425,912	$93,697	$7,606,469	$2,293,740	$34,419,818
4	$130,020	$929	$38,004	$349,317	$518,270
5	$2,346,269	$16,769	$561,566	$2,266,311	$5,190,914
6	$1,753,739	$12,534	$296,743	$2,821,665	$4,884,681
7	$604,994	$4,324	$97,907	$3,801,595	$4,508,820
8	$964,754	$7,461	$222,771	$2,083,512	$3,278,498
9	$4,816,221	$40,879	$1,439,062	$18,422,916	$24,719,078
10	$136,194	$1,053	$32,262	$499,855	$669,365
11	$27,812	$215	$27,464	$410,587	$466,078
12	$9,852	$76	$9,725	$127,956	$147,610
13	$45,299	$350	$10,449	$306,463	$362,561
Total	$92,510,937	$397,897	$29,039,303	$34,267,855	$156,215,992

TABLE B.1.44
Cost Responsibility for Rigid Pavement Construction on Non-NHS, 2009–2012.

	Base Facility			Remaining Facility	
Vehicle Class	Earthworks	Shoulder	Pavement	Pavement	Total
1	$222,816	$381	$148,356	$0	$371,553
2	$24,456,837	$41,797	$16,348,783	$713,654	$41,561,071
3	$10,529,684	$17,995	$6,855,758	$1,902,739	$19,306,176
4	$47,486	$173	$28,204	$291,734	$367,596
5	$856,903	$3,113	$451,631	$1,751,643	$3,063,291
6	$640,500	$2,327	$277,800	$3,058,062	$3,978,689
7	$220,955	$803	$94,415	$4,327,232	$4,643,405
8	$406,472	$1,431	$173,045	$1,599,832	$2,180,780
9	$2,066,566	$7,865	$818,369	$13,916,679	$16,809,479
10	$57,382	$202	$24,723	$501,743	$584,050
11	$11,718	$41	$11,791	$207,721	$231,271
12	$4,151	$15	$3,896	$67,814	$75,875
13	$19,085	$67	$8,069	$300,534	$327,756
Total	$39,540,555	$76,211	$25,244,840	$28,639,387	$93,500,993

TABLE B.1.45
Total Cost Responsibility and Unit Cost for New Pavement Construction on Non-NHS, 2009–2012.

	Base Facility			Remaining Facility		
Vehicle Class	Earthworks	Shoulder	Pavement	Pavement	Total	Unit Cost [$/VMT]
1	$739,688	$2,364	$310,765	$0	$1,052,816	$0.0054
2	$81,189,837	$259,423	$34,883,255	$1,597,591	$117,930,106	$0.0055
3	$34,955,596	$111,693	$14,462,226	$4,196,479	$53,725,994	$0.0058
4	$177,506	$1,102	$66,208	$641,051	$885,867	$0.0202
5	$3,203,172	$19,882	$1,013,198	$4,017,954	$8,254,205	$0.0104
6	$2,394,239	$14,861	$574,543	$5,879,727	$8,863,370	$0.0150
7	$825,949	$5,127	$192,322	$8,128,827	$9,152,225	$0.0448
8	$1,371,226	$8,892	$395,816	$3,683,344	$5,459,279	$0.0163
9	$6,882,787	$48,744	$2,257,431	$32,339,595	$41,528,557	$0.0250
10	$193,576	$1,255	$56,985	$1,001,599	$1,253,415	$0.0265
11	$39,530	$256	$39,255	$618,308	$697,349	$0.0722
12	$14,003	$91	$13,621	$195,770	$223,484	$0.0653
13	$64,384	$418	$18,518	$606,998	$690,317	$0.0439
Total	$132,051,493	$474,108	$54,284,142	$62,907,243	$249,716,985	

B.1.2 Pavement Rehabilitation—Cost Allocation Results

B.1.2.1 Pavement Rehabilitation Cost Allocation Results per Year and Total for Interstates

TABLE B.1.46
Cost Responsibility for Flexible Rehabilitation on Interstate Pavements, 2009.

Vehicle Class	Pavement Expenditures		Grading & Earthworks	Shoulder	Total
	Load-Related Expenditures	Non-Load-Related Expenditures			
1	$6,530	$7,649	$337	$699	$15,215
2	$944,671	$1,106,501	$48,807	$101,181	$2,201,160
3	$345,334	$375,093	$16,545	$34,299	$771,271
4	$62,284	$7,686	$339	$1,054	$71,363
5	$235,601	$85,274	$3,761	$11,696	$336,332
6	$224,058	$14,165	$625	$1,943	$240,790
7	$123,658	$2,265	$100	$311	$126,333
8	$354,055	$26,195	$1,155	$3,593	$384,998
9	$14,834,595	$431,855	$19,049	$59,235	$15,344,734
10	$133,937	$4,137	$182	$567	$138,824
11	$371,077	$12,999	$573	$1,783	$386,433
12	$116,122	$4,910	$217	$674	$121,923
13	$67,098	$1,281	$56	$176	$68,610
Total	$17,819,019	$2,080,009	$91,748	$217,211	$20,207,986

TABLE B.1.47
Cost Responsibility for Rigid Rehabilitation on Interstate Pavements, 2009.

Vehicle Class	Pavement Expenditures		Grading & Earthworks	Shoulder	Total
	Load-Related Expenditures	Non-Load-Related Expenditures			
1	$100	$86	$38	$26	$250
2	$14,511	$12,389	$5,469	$3,727	$36,095
3	$5,272	$4,200	$1,854	$1,263	$12,589
4	$1,023	$86	$38	$39	$1,186
5	$3,584	$955	$421	$431	$5,391
6	$2,753	$159	$70	$72	$3,053
7	$1,477	$25	$11	$11	$1,525
8	$5,318	$293	$129	$132	$5,873
9	$207,347	$4,835	$2,135	$2,182	$216,499
10	$1,949	$46	$20	$21	$2,037
11	$6,185	$146	$64	$66	$6,460
12	$1,944	$55	$24	$25	$2,048
13	$902	$14	$6	$6	$929
Total	$252,364	$23,289	$10,281	$8,000	$293,934

TABLE B.1.48
Total Cost Responsibility and Unit Cost for Pavement Rehabilitation on Interstates, 2009.

Vehicle Class	Pavement Expenditures		Grading & Earthworks	Shoulder	Total	Unit Cost [$/VMT]
	Load-Related Expenditures	Non-Load-Related Expenditures				
1	$6,630	$7,734	$375	$725	$15,465	$0.0003
2	$959,181	$1,118,890	$54,276	$104,907	$2,237,256	$0.0003
3	$350,606	$379,293	$18,399	$35,563	$783,860	$0.0003
4	$63,307	$7,772	$377	$1,093	$72,549	$0.0013
5	$239,185	$86,228	$4,183	$12,127	$341,723	$0.0005
6	$226,811	$14,323	$695	$2,014	$243,843	$0.0023
7	$125,135	$2,290	$111	$322	$127,858	$0.0075
8	$359,372	$26,488	$1,285	$3,725	$390,870	$0.0020
9	$15,041,942	$436,691	$21,183	$61,416	$15,561,232	$0.0048
10	$135,886	$4,183	$203	$588	$140,861	$0.0045
11	$377,262	$13,145	$638	$1,849	$392,893	$0.0040
12	$118,066	$4,965	$241	$698	$123,970	$0.0033
13	$68,000	$1,295	$63	$182	$69,540	$0.0072
Total	$18,071,382	$2,103,298	$102,029	$225,211	$20,501,920	

TABLE B.1.49
Cost Responsibility for Flexible Rehabilitation on Interstate Pavements, 2010.

Vehicle Class	Pavement Expenditures: Load-Related Expenditures	Pavement Expenditures: Non-Load-Related Expenditures	Grading & Earthworks	Shoulder	Total
1	$8,929	$10,599	$743	$188	$20,459
2	$1,291,774	$1,533,274	$107,473	$27,265	$2,959,787
3	$472,221	$519,765	$36,432	$9,243	$1,037,661
4	$85,169	$10,152	$712	$271	$96,303
5	$322,168	$112,633	$7,895	$3,004	$445,700
6	$306,384	$18,709	$1,311	$499	$326,903
7	$169,094	$2,991	$210	$80	$172,375
8	$484,146	$34,599	$2,425	$923	$522,093
9	$20,285,321	$570,740	$40,005	$15,224	$20,911,290
10	$183,150	$5,464	$383	$146	$189,143
11	$507,424	$17,170	$1,203	$458	$526,255
12	$158,789	$6,486	$455	$173	$165,903
13	$91,752	$1,692	$119	$45	$93,607
Total	$24,366,322	$2,844,273	$199,366	$57,518	$27,467,479

TABLE B.1.50
Cost Responsibility for Rigid Rehabilitation on Interstate Pavements, 2010.

Vehicle Class	Pavement Expenditures: Load-Related Expenditures	Pavement Expenditures: Non-Load-Related Expenditures	Grading & Earthworks	Shoulder	Total
1	$1,497	$1,296	$1,002	$57	$3,852
2	$216,626	$187,429	$145,024	$8,222	$557,301
3	$78,707	$63,536	$49,162	$2,787	$194,192
4	$15,267	$1,241	$960	$82	$17,550
5	$53,505	$13,768	$10,653	$906	$78,833
6	$41,099	$2,287	$1,770	$150	$45,307
7	$22,045	$366	$283	$24	$22,717
8	$79,386	$4,229	$3,273	$278	$87,166
9	$3,095,465	$69,768	$53,983	$4,591	$3,223,807
10	$29,100	$668	$517	$44	$30,329
11	$92,332	$2,099	$1,624	$138	$96,193
12	$29,018	$793	$613	$52	$30,477
13	$13,468	$207	$160	$14	$13,848
Total	$3,767,516	$347,686	$269,025	$17,345	$4,401,572

TABLE B.1.51
Total Cost Responsibility and Unit Cost for Pavement Rehabilitation on Interstates, 2010.

Vehicle Class	Pavement Expenditures: Load-Related Expenditures	Pavement Expenditures: Non-Load-Related Expenditures	Grading & Earthworks	Shoulder	Total	Unit Cost [$/VMT]
1	$10,427	$11,894	$1,745	$245	$24,312	$0.0004
2	$1,508,401	$1,720,703	$252,497	$35,487	$3,517,088	$0.0004
3	$550,928	$583,302	$85,594	$12,030	$1,231,853	$0.0004
4	$100,437	$11,393	$1,672	$352	$113,854	$0.0020
5	$375,673	$126,401	$18,548	$3,910	$524,533	$0.0008
6	$347,483	$20,996	$3,081	$650	$372,210	$0.0036
7	$191,139	$3,357	$493	$104	$195,092	$0.0118
8	$563,532	$38,828	$5,698	$1,201	$609,259	$0.0032
9	$23,380,786	$640,508	$93,989	$19,814	$24,135,097	$0.0077
10	$212,250	$6,132	$900	$190	$219,472	$0.0073
11	$599,755	$19,269	$2,828	$596	$622,448	$0.0066
12	$187,807	$7,279	$1,068	$225	$196,379	$0.0055
13	$105,220	$1,898	$279	$59	$107,455	$0.0115
Total	$28,133,838	$3,191,959	$468,390	$74,863	$31,869,051	

TABLE B.1.52
Cost Responsibility for Flexible Rehabilitation on Interstate Pavements, 2011.

Vehicle Class	Pavement Expenditures: Load-Related Expenditures	Pavement Expenditures: Non-Load-Related Expenditures	Grading & Earthworks	Shoulder	Total
1	$13,391	$17,974	$1,767	$436	$33,568
2	$1,937,287	$2,600,161	$255,559	$63,102	$4,856,109
3	$708,194	$881,429	$86,632	$21,391	$1,697,647
4	$127,729	$12,219	$1,201	$297	$141,445
5	$483,159	$135,564	$13,324	$4,935	$636,981
6	$459,487	$22,518	$2,213	$820	$485,038
7	$253,592	$3,600	$354	$131	$257,678
8	$726,079	$32,220	$3,167	$1,173	$762,639
9	$30,422,093	$531,206	$52,210	$19,337	$31,024,847
10	$274,672	$5,089	$500	$185	$280,446
11	$760,988	$15,989	$1,572	$582	$779,131
12	$238,138	$6,040	$594	$220	$244,991
13	$137,601	$1,575	$155	$57	$139,388
Total	$36,542,409	$4,265,584	$419,246	$112,667	$41,339,906

TABLE B.1.53
Cost Responsibility for Rigid Rehabilitation on Interstate Pavements, 2011.

Vehicle Class	Pavement Expenditures: Load-Related Expenditures	Pavement Expenditures: Non-Load-Related Expenditures	Grading & Earthworks	Shoulder	Total
1	$1,665	$1,629	$1,327	$85	$4,706
2	$240,865	$235,652	$191,954	$12,358	$680,829
3	$87,514	$79,884	$65,070	$4,189	$236,657
4	$16,976	$1,107	$902	$58	$19,043
5	$59,492	$12,286	$10,008	$966	$82,752
6	$45,698	$2,041	$1,662	$161	$49,562
7	$24,511	$326	$266	$26	$25,129
8	$88,269	$2,920	$2,379	$230	$93,797
9	$3,441,822	$48,143	$39,216	$3,787	$3,532,968
10	$32,356	$461	$376	$36	$33,229
11	$102,663	$1,449	$1,180	$114	$105,406
12	$32,265	$547	$446	$43	$33,301
13	$14,975	$143	$116	$11	$15,245
Total	$4,189,070	$386,589	$314,902	$22,065	$4,912,626

TABLE B.1.54
Total Cost Responsibility and Unit Cost for Pavement Rehabilitation on Interstates, 2011.

Vehicle Class	Pavement Expenditures: Load-Related Expenditures	Pavement Expenditures: Non-Load-Related Expenditures	Grading & Earthworks	Shoulder	Total	Unit Cost [$/VMT]
1	$15,056	$19,602	$3,093	$522	$38,274	$0.0005
2	$2,178,152	$2,835,814	$447,513	$75,460	$5,536,938	$0.0005
3	$795,708	$961,313	$151,702	$25,580	$1,934,304	$0.0006
4	$144,705	$13,326	$2,103	$355	$160,488	$0.0034
5	$542,651	$147,850	$23,332	$5,901	$719,733	$0.0014
6	$505,185	$24,559	$3,876	$980	$534,600	$0.0061
7	$278,104	$3,926	$620	$157	$282,807	$0.0202
8	$814,347	$35,141	$5,545	$1,403	$856,436	$0.0068
9	$33,863,915	$579,349	$91,426	$23,125	$34,557,815	$0.0167
10	$307,028	$5,550	$876	$222	$313,675	$0.0158
11	$863,651	$17,439	$2,752	$696	$884,538	$0.0142
12	$270,403	$6,587	$1,040	$263	$278,293	$0.0118
13	$152,576	$1,718	$271	$69	$154,633	$0.0252
Total	$40,731,480	$4,652,174	$734,148	$134,731	$46,252,532	

TABLE B.1.55
Cost Responsibility for Flexible Rehabilitation on Interstate Pavements, 2012.

Vehicle Class	Pavement Expenditures: Load-Related Expenditures	Pavement Expenditures: Non-Load-Related Expenditures	Grading & Earthworks	Shoulder	Total
1	$9,953	$13,054	$698	$318	$24,023
2	$1,439,825	$1,888,414	$100,965	$46,069	$3,475,273
3	$526,342	$640,154	$34,226	$15,617	$1,216,339
4	$94,930	$8,305	$444	$203	$103,883
5	$359,092	$92,148	$4,927	$3,372	$459,539
6	$341,498	$15,307	$818	$560	$358,183
7	$188,474	$2,447	$131	$90	$191,142
8	$539,634	$30,400	$1,625	$1,112	$572,772
9	$22,610,222	$452,953	$24,217	$16,575	$23,103,968
10	$204,141	$4,801	$257	$176	$209,374
11	$565,579	$15,086	$807	$552	$582,024
12	$176,988	$5,699	$305	$209	$183,200
13	$102,267	$1,486	$79	$54	$103,887
Total	$27,158,946	$3,170,255	$169,499	$84,906	$30,583,607

TABLE B.1.56
Cost Responsibility for Rigid Rehabilitation on Interstate Pavements, 2012.

Vehicle Class	Pavement Expenditures: Load-Related Expenditures	Pavement Expenditures: Non-Load-Related Expenditures	Grading & Earthworks	Shoulder	Total
1	$1,363	$1,303	$482	$102	$3,251
2	$197,184	$188,518	$69,773	$14,810	$470,285
3	$71,643	$63,906	$23,652	$5,021	$164,222
4	$13,897	$829	$307	$65	$15,098
5	$48,703	$9,199	$3,405	$1,084	$62,391
6	$37,411	$1,528	$566	$180	$39,684
7	$20,066	$244	$90	$29	$20,430
8	$72,261	$3,035	$1,123	$358	$76,777
9	$2,817,652	$45,218	$16,736	$5,329	$2,884,934
10	$26,488	$479	$177	$56	$27,201
11	$84,045	$1,506	$557	$177	$86,286
12	$26,414	$569	$211	$67	$27,260
13	$12,259	$148	$55	$17	$12,480
Total	$3,429,388	$316,482	$117,134	$27,296	$3,890,300

TABLE B.1.57
Total Cost Responsibility and Unit Cost for Pavement Rehabilitation on Interstates, 2012.

Vehicle Class	Pavement Expenditures: Load-Related Expenditures	Pavement Expenditures: Non-Load-Related Expenditures	Grading & Earthworks	Shoulder	Total	Unit Cost [$/VMT]
1	$11,316	$14,357	$1,180	$421	$27,274	$0.0004
2	$1,637,009	$2,076,932	$170,738	$60,879	$3,945,558	$0.0004
3	$597,985	$704,060	$57,878	$20,637	$1,380,561	$0.0004
4	$108,828	$9,135	$751	$268	$118,981	$0.0027
5	$407,795	$101,347	$8,331	$4,456	$521,930	$0.0011
6	$378,909	$16,835	$1,384	$740	$397,868	$0.0049
7	$208,540	$2,692	$221	$118	$211,572	$0.0164
8	$611,895	$33,435	$2,749	$1,470	$649,549	$0.0041
9	$25,427,874	$498,171	$40,953	$21,904	$25,988,901	$0.0109
10	$230,629	$5,280	$434	$232	$236,576	$0.0094
11	$649,625	$16,592	$1,364	$730	$668,310	$0.0084
12	$203,402	$6,268	$515	$276	$210,460	$0.0070
13	$114,526	$1,635	$134	$72	$116,367	$0.0149
Total	$30,588,334	$3,486,737	$286,633	$112,202	$34,473,907	

TABLE B.1.58
Cost Responsibility for Flexible Rehabilitation on Interstate Pavements, 2009–2012.

Vehicle Class	Pavement Expenditures: Load-Related Expenditures	Pavement Expenditures: Non-Load-Related Expenditures	Grading & Earthworks	Shoulder	Total
1	$38,803	$49,274	$3,545	$1,643	$93,265
2	$5,613,557	$7,128,351	$512,804	$237,617	$13,492,329
3	$2,052,091	$2,416,441	$173,836	$80,550	$4,722,918
4	$370,112	$38,362	$2,696	$1,824	$412,994
5	$1,400,019	$425,618	$29,907	$23,008	$1,878,552
6	$1,331,427	$70,698	$4,968	$3,822	$1,410,914
7	$734,819	$11,303	$794	$611	$747,528
8	$2,103,913	$123,415	$8,373	$6,801	$2,242,502
9	$88,152,232	$1,986,754	$135,482	$110,371	$90,384,838
10	$795,900	$19,491	$1,322	$1,074	$817,787
11	$2,205,068	$61,245	$4,155	$3,375	$2,273,843
12	$690,037	$23,135	$1,570	$1,275	$716,017
13	$398,717	$6,034	$409	$333	$405,493
Total	$105,886,696	$12,360,121	$879,859	$472,303	$119,598,979

TABLE B.1.59
Cost Responsibility for Rigid Rehabilitation on Interstate Pavements, 2009–2012.

Vehicle Class	Pavement Expenditures: Load-Related Expenditures	Pavement Expenditures: Non-Load-Related Expenditures	Grading & Earthworks	Shoulder	Total
1	$4,626	$4,313	$2,849	$270	$12,059
2	$669,186	$623,988	$412,220	$39,117	$1,744,511
3	$243,136	$211,526	$139,739	$13,260	$607,660
4	$47,163	$3,264	$2,207	$244	$52,877
5	$165,284	$36,208	$24,487	$3,387	$229,367
6	$126,961	$6,014	$4,068	$563	$137,606
7	$68,099	$962	$650	$90	$69,801
8	$245,233	$10,478	$6,904	$998	$263,613
9	$9,562,286	$167,964	$112,069	$15,888	$9,858,207
10	$89,893	$1,655	$1,090	$158	$92,796
11	$285,225	$5,200	$3,426	$495	$294,346
12	$89,641	$1,964	$1,294	$187	$93,086
13	$41,604	$512	$338	$49	$42,503
Total	$11,638,338	$1,074,047	$711,341	$74,705	$13,498,431

TABLE B.1.60
Total Cost Responsibility and Unit Cost for Pavement Rehabilitation on Interstates, 2009–2012.

Vehicle Class	Pavement Expenditures: Load-Related Expenditures	Pavement Expenditures: Non-Load-Related Expenditures	Grading & Earthworks	Shoulder	Total	Unit Cost [$/VMT]
1	$43,429	$53,588	$6,394	$1,913	$105,324	$0.0004
2	$6,282,743	$7,752,339	$925,024	$276,734	$15,236,840	$0.0004
3	$2,295,226	$2,627,967	$313,574	$93,810	$5,330,578	$0.0004
4	$417,275	$41,625	$4,903	$2,068	$465,871	$0.0023
5	$1,565,303	$461,827	$54,394	$26,395	$2,107,919	$0.0009
6	$1,458,388	$76,713	$9,035	$4,384	$1,548,520	$0.0041
7	$802,918	$12,265	$1,445	$701	$817,329	$0.0135
8	$2,349,147	$133,892	$15,277	$7,799	$2,506,115	$0.0037
9	$97,714,518	$2,154,718	$247,551	$126,259	$100,243,045	$0.0092
10	$885,793	$21,145	$2,413	$1,232	$910,583	$0.0086
11	$2,490,293	$66,444	$7,581	$3,870	$2,568,189	$0.0077
12	$779,678	$25,099	$2,864	$1,462	$809,103	$0.0064
13	$440,321	$6,546	$747	$381	$447,995	$0.0136
Total	$117,525,034	$13,434,168	$1,591,201	$547,008	$133,097,410	

B.1.2.2 Pavement Rehabilitation Cost Allocation Results per Year and Total for Non-Interstate NHS

TABLE B.1.61
Cost Responsibility for Flexible Rehabilitation on Non-Interstate NHS Pavements, 2009.

	Pavement Expenditures				
Vehicle Class	Load-Related Expenditures	Non-Load-Related Expenditures	Grading & Earthworks	Shoulder	Total
1	$39,126	$25,122	$8,373	$97	$72,718
2	$4,168,877	$2,676,757	$892,193	$10,310	$7,748,137
3	$1,721,874	$1,033,459	$344,464	$3,981	$3,103,778
4	$192,802	$12,532	$4,177	$106	$209,617
5	$729,914	$150,972	$50,321	$1,279	$932,486
6	$1,037,525	$30,886	$10,295	$262	$1,078,967
7	$1,137,409	$9,552	$3,184	$81	$1,150,227
8	$1,022,943	$43,312	$14,436	$367	$1,081,058
9	$21,887,635	$338,853	$112,943	$2,871	$22,342,303
10	$440,769	$6,404	$2,135	$54	$449,362
11	$334,807	$6,723	$2,241	$57	$343,828
12	$71,068	$1,682	$561	$14	$73,325
13	$211,545	$1,901	$633	$16	$214,095
Total	$32,996,293	$4,338,155	$1,445,956	$19,496	$38,799,901

TABLE B.1.62
Cost Responsibility for Rigid Rehabilitation on Non-Interstate NHS Pavements, 2009.

	Pavement Expenditures				
Vehicle Class	Load-Related Expenditures	Non-Load-Related Expenditures	Grading & Earthworks	Shoulder	Total
1	$5,124	$3,020	$1,363	$13	$9,520
2	$545,982	$321,734	$145,241	$1,406	$1,014,362
3	$225,443	$124,217	$56,075	$543	$406,278
4	$24,050	$1,506	$680	$14	$26,251
5	$92,951	$18,146	$8,192	$174	$119,464
6	$84,694	$3,712	$1,676	$36	$90,118
7	$85,087	$1,148	$518	$11	$86,764
8	$119,099	$5,206	$2,350	$50	$126,705
9	$2,012,410	$40,729	$18,386	$392	$2,071,916
10	$42,244	$770	$347	$7	$43,369
11	$45,079	$808	$365	$8	$46,259
12	$9,474	$202	$91	$2	$9,769
13	$18,679	$228	$103	$2	$19,013
Total	$3,310,316	$521,426	$235,388	$2,659	$4,069,789

TABLE B.1.63
Total Cost Responsibility and Unit Cost for Pavement Rehabilitation on Non-Interstate NHS, 2009.

	Pavement Expenditures					
Vehicle Class	Load-Related Expenditures	Non-Load-Related Expenditures	Grading & Earthworks	Shoulder	Total	Unit Cost [$/VMT]
1	$44,250	$28,141	$9,736	$110	$82,238	$0.0009
2	$4,714,859	$2,998,491	$1,037,434	$11,716	$8,762,500	$0.0009
3	$1,947,317	$1,157,676	$400,539	$4,524	$3,510,056	$0.0010
4	$216,852	$14,038	$4,857	$121	$235,868	$0.0055
5	$822,865	$169,119	$58,513	$1,454	$1,051,950	$0.0020
6	$1,122,218	$34,598	$11,971	$297	$1,169,084	$0.0110
7	$1,222,496	$10,701	$3,702	$92	$1,236,991	$0.0376
8	$1,142,042	$48,518	$16,787	$417	$1,207,763	$0.0081
9	$23,900,045	$379,581	$131,330	$3,263	$24,414,219	$0.0209
10	$483,013	$7,174	$2,482	$62	$492,731	$0.0223
11	$379,886	$7,531	$2,606	$65	$390,087	$0.0168
12	$80,542	$1,884	$652	$16	$83,094	$0.0143
13	$230,224	$2,129	$737	$18	$233,108	$0.0356
Total	$36,306,609	$4,859,582	$1,681,344	$22,155	$42,869,690	

TABLE B.1.64
Cost Responsibility for Flexible Rehabilitation on Non-Interstate NHS Pavements, 2010.

	Pavement Expenditures				
Vehicle Class	Load-Related Expenditures	Non-Load-Related Expenditures	Grading & Earthworks	Shoulder	Total
1	$49,718	$31,775	$15,541	$468	$97,503
2	$5,297,557	$3,385,634	$1,655,944	$49,912	$10,389,048
3	$2,188,053	$1,307,147	$639,337	$19,270	$4,153,808
4	$245,002	$16,239	$7,943	$527	$269,710
5	$927,530	$195,634	$95,686	$6,345	$1,225,196
6	$1,318,424	$40,023	$19,576	$1,298	$1,379,320
7	$1,445,351	$12,378	$6,054	$401	$1,464,185
8	$1,299,894	$56,125	$27,451	$1,820	$1,385,290
9	$27,813,485	$446,057	$218,171	$14,467	$28,492,180
10	$560,103	$8,299	$4,059	$269	$572,730
11	$425,452	$8,712	$4,261	$283	$438,708
12	$90,309	$2,180	$1,066	$71	$93,625
13	$268,819	$2,463	$1,205	$80	$272,566
Total	$41,929,697	$5,512,666	$2,696,294	$95,212	$50,233,868

TABLE B.1.65
Cost Responsibility for Rigid Rehabilitation on Non-Interstate NHS Pavements, 2010.

	Pavement Expenditures				
Vehicle Class	Load-Related Expenditures	Non-Load-Related Expenditures	Grading & Earthworks	Shoulder	Total
1	$4,237	$2,485	$2,530	$64	$9,316
2	$451,437	$264,783	$269,572	$6,806	$992,598
3	$186,404	$102,229	$104,078	$2,628	$395,339
4	$19,885	$1,270	$1,293	$72	$22,520
5	$76,855	$15,300	$15,577	$865	$108,598
6	$70,028	$3,130	$3,187	$177	$76,521
7	$70,353	$968	$986	$55	$72,361
8	$98,475	$4,389	$4,469	$248	$107,582
9	$1,663,930	$34,885	$35,516	$1,973	$1,736,304
10	$34,929	$649	$661	$37	$36,275
11	$37,273	$681	$694	$39	$38,686
12	$7,833	$170	$174	$10	$8,187
13	$15,445	$193	$196	$11	$15,844
Total	$2,737,083	$431,133	$438,932	$12,983	$3,620,132

TABLE B.1.66
Total Cost Responsibility and Unit Cost for Pavement Rehabilitation on Non-Interstate NHS, 2010.

	Pavement Expenditures					
Vehicle Class	Load-Related Expenditures	Non-Load-Related Expenditures	Grading & Earthworks	Shoulder	Total	Unit Cost [$/VMT]
1	$53,955	$34,260	$18,071	$532	$106,819	$0.0013
2	$5,748,994	$3,650,417	$1,925,516	$56,718	$11,381,646	$0.0013
3	$2,374,457	$1,409,376	$743,416	$21,898	$4,549,147	$0.0013
4	$264,887	$17,509	$9,235	$598	$292,230	$0.0069
5	$1,004,386	$210,934	$111,263	$7,210	$1,333,793	$0.0026
6	$1,388,451	$43,153	$22,762	$1,475	$1,455,841	$0.0139
7	$1,515,704	$13,346	$7,040	$456	$1,536,546	$0.0476
8	$1,398,369	$60,514	$31,920	$2,069	$1,492,872	$0.0102
9	$29,477,415	$480,942	$253,687	$16,440	$30,228,484	$0.0260
10	$595,031	$8,948	$4,720	$306	$609,005	$0.0281
11	$462,725	$9,393	$4,955	$321	$477,394	$0.0210
12	$98,142	$2,350	$1,240	$80	$101,812	$0.0179
13	$284,263	$2,655	$1,401	$91	$288,410	$0.0449
Total	$44,666,780	$5,943,799	$3,135,226	$108,195	$53,854,000	

TABLE B.1.67
Cost Responsibility for Flexible Rehabilitation on Non-Interstate NHS Pavements, 2011.

	Pavement Expenditures				
Vehicle Class	Load-Related Expenditures	Non-Load-Related Expenditures	Grading & Earthworks	Shoulder	Total
1	$31,239	$20,991	$25,433	$517	$78,181
2	$3,328,535	$2,236,664	$2,709,965	$55,113	$8,330,277
3	$1,374,787	$863,545	$1,046,281	$21,279	$3,305,891
4	$153,938	$7,768	$9,412	$421	$171,539
5	$582,781	$93,582	$113,385	$5,073	$794,821
6	$828,385	$19,145	$23,196	$1,038	$871,765
7	$908,136	$5,921	$7,174	$321	$921,552
8	$816,743	$35,650	$43,194	$1,933	$897,519
9	$17,475,630	$166,669	$201,938	$9,035	$17,853,273
10	$351,921	$5,271	$6,387	$286	$363,865
11	$267,318	$5,534	$6,705	$300	$279,857
12	$56,742	$1,384	$1,677	$75	$59,879
13	$168,903	$1,564	$1,895	$85	$172,447
Total	$26,345,058	$3,463,691	$4,196,643	$95,476	$34,100,867

TABLE B.1.68
Cost Responsibility for Rigid Rehabilitation on Non-Interstate NHS Pavements, 2011.

	Pavement Expenditures				
Vehicle Class	Load-Related Expenditures	Non-Load-Related Expenditures	Grading & Earthworks	Shoulder	Total
1	$10,217	$6,301	$4,140	$71	$20,729
2	$1,088,662	$671,382	$441,157	$7,515	$2,208,717
3	$449,523	$259,212	$170,325	$2,902	$881,960
4	$47,955	$2,332	$1,532	$57	$51,876
5	$185,341	$28,091	$18,458	$692	$232,581
6	$168,875	$5,747	$3,776	$142	$178,540
7	$169,660	$1,777	$1,168	$44	$172,649
8	$237,479	$10,701	$7,032	$264	$255,475
9	$4,012,653	$50,029	$32,874	$1,232	$4,096,788
10	$84,233	$1,582	$1,040	$39	$86,894
11	$89,885	$1,661	$1,091	$41	$92,678
12	$18,891	$416	$273	$10	$19,590
13	$37,246	$470	$309	$12	$38,035
Total	$6,600,618	$1,039,700	$683,174	$13,019	$8,336,512

TABLE B.1.69
Total Cost Responsibility and Unit Cost for Pavement Rehabilitation on Non-Interstate NHS, 2011.

	Pavement Expenditures					
Vehicle Class	Load-Related Expenditures	Non-Load-Related Expenditures	Grading & Earthworks	Shoulder	Total	Unit Cost [$/VMT]
1	$41,456	$27,292	$29,574	$588	$98,910	$0.0012
2	$4,417,197	$2,908,046	$3,151,122	$62,629	$10,538,994	$0.0012
3	$1,824,309	$1,122,757	$1,216,605	$24,180	$4,187,852	$0.0013
4	$201,893	$10,100	$10,944	$479	$223,415	$0.0076
5	$768,122	$121,673	$131,843	$5,765	$1,027,402	$0.0029
6	$997,261	$24,892	$26,972	$1,179	$1,050,304	$0.0145
7	$1,077,795	$7,699	$8,342	$365	$1,094,201	$0.0487
8	$1,054,221	$46,351	$50,226	$2,196	$1,152,994	$0.0085
9	$21,488,283	$216,699	$234,812	$10,267	$21,950,061	$0.0347
10	$436,154	$6,854	$7,427	$325	$450,759	$0.0225
11	$357,203	$7,195	$7,796	$341	$372,535	$0.0177
12	$75,633	$1,800	$1,951	$85	$79,469	$0.0151
13	$206,148	$2,034	$2,204	$96	$210,483	$0.0354
Total	$32,945,676	$4,503,391	$4,879,817	$108,495	$42,437,379	

TABLE B.1.70
Cost Responsibility for Flexible Rehabilitation on Non-Interstate NHS Pavements, 2012.

	Pavement Expenditures				
Vehicle Class	Load-Related Expenditures	Non-Load-Related Expenditures	Grading & Earthworks	Shoulder	Total
1	$24,959	$16,186	$23,880	$177	$65,202
2	$2,659,366	$1,724,610	$2,544,458	$18,900	$6,947,334
3	$1,098,400	$665,848	$982,381	$7,297	$2,753,925
4	$122,991	$9,925	$14,644	$239	$147,799
5	$465,619	$119,573	$176,416	$2,883	$764,491
6	$661,847	$24,462	$36,091	$590	$722,990
7	$725,564	$7,566	$11,162	$182	$744,475
8	$652,545	$27,487	$40,554	$663	$721,248
9	$13,962,331	$161,088	$237,667	$3,884	$14,364,970
10	$281,171	$4,064	$5,996	$98	$291,330
11	$213,577	$4,267	$6,295	$103	$224,241
12	$45,335	$1,067	$1,575	$26	$48,003
13	$134,947	$1,206	$1,780	$29	$137,961
Total	$21,048,649	$2,767,350	$4,082,899	$35,071	$27,933,969

TABLE B.1.71
Cost Responsibility for Rigid Rehabilitation on Non-Interstate NHS Pavements, 2012.

	Pavement Expenditures				
Vehicle Class	Load-Related Expenditures	Non-Load-Related Expenditures	Grading & Earthworks	Shoulder	Total
1	$5,539	$3,297	$3,887	$24	$12,747
2	$590,190	$351,264	$414,214	$2,577	$1,358,245
3	$243,697	$135,618	$159,922	$995	$540,233
4	$25,997	$2,022	$2,384	$33	$30,435
5	$100,478	$24,354	$28,719	$393	$153,944
6	$91,551	$4,982	$5,875	$80	$102,490
7	$91,977	$1,541	$1,817	$25	$95,359
8	$128,743	$5,598	$6,602	$90	$141,033
9	$2,175,356	$32,810	$38,690	$530	$2,247,385
10	$45,665	$828	$976	$13	$47,482
11	$48,729	$869	$1,025	$14	$50,637
12	$10,241	$217	$256	$4	$10,718
13	$20,192	$246	$290	$4	$20,731
Total	$3,578,354	$563,647	$664,658	$4,782	$4,811,441

TABLE B.1.72
Total Cost Responsibility and Unit Cost for Pavement Rehabilitation on Non-Interstate NHS, 2012.

	Pavement Expenditures					
Vehicle Class	Load-Related Expenditures	Non-Load-Related Expenditures	Grading & Earthworks	Shoulder	Total	Unit Cost [$/VMT]
1	$30,498	$19,482	$27,768	$202	$77,949	$0.0011
2	$3,249,556	$2,075,873	$2,958,672	$21,477	$8,305,579	$0.0011
3	$1,342,097	$801,466	$1,142,303	$8,292	$3,294,158	$0.0011
4	$148,988	$11,947	$17,027	$272	$178,234	$0.0039
5	$566,097	$143,928	$205,135	$3,276	$918,436	$0.0017
6	$753,398	$29,445	$41,967	$670	$825,480	$0.0074
7	$817,541	$9,107	$12,979	$207	$839,834	$0.0243
8	$781,288	$33,085	$47,156	$753	$862,282	$0.0069
9	$16,137,686	$193,899	$276,357	$4,413	$16,612,355	$0.0225
10	$326,835	$4,892	$6,973	$111	$338,811	$0.0182
11	$262,305	$5,136	$7,320	$117	$274,878	$0.0141
12	$55,576	$1,285	$1,831	$29	$58,721	$0.0120
13	$155,138	$1,452	$2,069	$33	$158,693	$0.0287
Total	$24,627,003	$3,330,997	$4,747,557	$39,853	$32,745,410	

TABLE B.1.73
Cost Responsibility for Flexible Rehabilitation on Non-Interstate NHS Pavements, 2009–2012.

	Pavement Expenditures				
Vehicle Class	Load-Related Expenditures	Non-Load-Related Expenditures	Grading & Earthworks	Shoulder	Total
1	$145,042	$94,074	$73,228	$1,260	$313,603
2	$15,454,335	$10,023,664	$7,802,560	$134,236	$33,414,795
3	$6,383,114	$3,870,000	$3,012,462	$51,827	$13,317,403
4	$714,733	$46,464	$36,175	$1,293	$798,664
5	$2,705,845	$559,762	$435,808	$15,580	$3,716,995
6	$3,846,180	$114,516	$89,158	$3,187	$4,053,042
7	$4,216,461	$35,417	$27,575	$986	$4,280,439
8	$3,792,124	$162,574	$125,635	$4,783	$4,085,116
9	$81,139,081	$1,112,668	$770,720	$30,257	$83,052,726
10	$1,633,963	$24,039	$18,577	$707	$1,677,286
11	$1,241,154	$25,236	$19,502	$742	$1,286,634
12	$263,454	$6,314	$4,879	$186	$274,833
13	$784,213	$7,134	$5,513	$210	$797,070
Total	$122,319,697	$16,081,862	$12,421,793	$245,254	$151,068,606

TABLE B.1.74
Cost Responsibility for Rigid Rehabilitation on Non-Interstate NHS Pavements, 2009–2012.

	Pavement Expenditures				
Vehicle Class	Load-Related Expenditures	Non-Load-Related Expenditures	Grading & Earthworks	Shoulder	Total
1	$25,117	$15,102	$11,921	$172	$52,312
2	$2,676,271	$1,609,163	$1,270,184	$18,305	$5,573,923
3	$1,105,066	$621,276	$490,401	$7,067	$2,223,810
4	$117,887	$7,129	$5,889	$176	$131,082
5	$455,625	$85,891	$70,946	$2,125	$614,587
6	$415,148	$17,572	$14,514	$435	$447,668
7	$417,076	$5,435	$4,489	$134	$427,134
8	$583,796	$25,895	$20,452	$652	$630,796
9	$9,864,349	$158,453	$125,466	$4,126	$10,152,394
10	$207,070	$3,829	$3,024	$96	$214,020
11	$220,965	$4,020	$3,175	$101	$228,261
12	$46,439	$1,006	$794	$25	$48,264
13	$91,562	$1,136	$897	$29	$93,624
Total	$16,226,371	$2,555,907	$2,022,152	$33,444	$20,837,874

TABLE B.1.75
Total Cost Responsibility and Unit Cost for Pavement Rehabilitation on Non-Interstate NHS, 2009–2012.

	Pavement Expenditures					
Vehicle Class	Load-Related Expenditures	Non-Load-Related Expenditures	Grading & Earthworks	Shoulder	Total	Unit Cost [$/VMT]
1	$170,159	$109,176	$85,149	$1,432	$365,916	$0.0011
2	$18,130,606	$11,632,827	$9,072,744	$152,541	$38,988,718	$0.0011
3	$7,488,180	$4,491,276	$3,502,863	$58,894	$15,541,213	$0.0012
4	$832,620	$53,593	$42,064	$1,470	$929,746	$0.0058
5	$3,161,470	$645,653	$506,754	$17,705	$4,331,582	$0.0022
6	$4,261,328	$132,088	$103,672	$3,622	$4,500,710	$0.0114
7	$4,633,537	$40,852	$32,064	$1,120	$4,707,572	$0.0385
8	$4,375,920	$188,469	$146,088	$5,435	$4,715,911	$0.0085
9	$91,003,429	$1,271,121	$896,185	$34,383	$93,205,119	$0.0252
10	$1,841,033	$27,868	$21,601	$804	$1,891,306	$0.0230
11	$1,462,119	$29,256	$22,677	$844	$1,514,895	$0.0175
12	$309,894	$7,319	$5,673	$211	$323,097	$0.0149
13	$875,774	$8,270	$6,411	$238	$890,694	$0.0364
Total	$138,546,068	$18,637,768	$14,443,945	$278,698	$171,906,480	

B.1.2.3 Pavement Rehabilitation Cost Allocation Results per Year and Total for Non-NHS

TABLE B.1.76
Cost Responsibility for Flexible Rehabilitation on Non-NHS Pavements, 2009.

	Pavement Expenditures				
Vehicle Class	Load-Related Expenditures	Non-Load-Related Expenditures	Grading & Earthworks	Shoulder	Total
1	$101,999	$51,111	$5,032	$111	$158,253
2	$11,195,606	$5,610,072	$552,375	$12,202	$17,370,255
3	$4,996,215	$2,415,369	$237,820	$5,253	$7,654,658
4	$127,988	$10,470	$1,031	$50	$139,539
5	$766,560	$188,943	$18,604	$904	$975,010
6	$3,964,041	$141,227	$13,905	$676	$4,119,849
7	$4,881,522	$48,720	$4,797	$233	$4,935,272
8	$1,867,486	$86,873	$8,554	$416	$1,963,329
9	$29,353,534	$479,066	$47,169	$2,292	$29,882,062
10	$694,106	$12,264	$1,208	$59	$707,636
11	$94,375	$2,504	$247	$12	$97,138
12	$28,170	$887	$87	$4	$29,149
13	$377,171	$4,079	$402	$20	$381,672
Total	$58,448,771	$9,051,587	$891,231	$22,232	$68,413,821

TABLE B.1.77
Cost Responsibility for Rigid Rehabilitation on Non-NHS Pavements, 2009.

	Pavement Expenditures				
Vehicle Class	Load-Related Expenditures	Non-Load-Related Expenditures	Grading & Earthworks	Shoulder	Total
1	$3,996	$1,852	$210	$5	$6,063
2	$438,590	$203,326	$23,016	$508	$665,440
3	$202,035	$87,540	$9,909	$219	$299,703
4	$6,269	$379	$43	$2	$6,694
5	$37,791	$6,848	$775	$38	$45,451
6	$109,669	$5,118	$579	$28	$115,395
7	$111,972	$1,766	$200	$10	$113,947
8	$76,333	$3,149	$356	$17	$79,855
9	$912,266	$17,363	$1,965	$96	$931,689
10	$22,884	$444	$50	$2	$23,381
11	$5,024	$91	$10	$0	$5,125
12	$1,527	$32	$4	$0	$1,563
13	$11,248	$148	$17	$1	$11,414
Total	$1,939,603	$328,057	$37,135	$926	$2,305,721

TABLE B.1.78
Total Cost Responsibility and Unit Cost for Pavement Rehabilitation on Non-NHS, 2009.

	Pavement Expenditures					
Vehicle Class	Load-Related Expenditures	Non-Load-Related Expenditures	Grading & Earthworks	Shoulder	Total	Unit Cost [$/VMT]
1	$105,994	$52,964	$5,242	$116	$164,316	$0.0036
2	$11,634,196	$5,813,398	$575,390	$12,710	$18,035,695	$0.0036
3	$5,198,250	$2,502,909	$247,729	$5,472	$7,954,361	$0.0037
4	$134,257	$10,850	$1,074	$52	$146,233	$0.0157
5	$804,350	$195,791	$19,379	$942	$1,020,462	$0.0061
6	$4,073,710	$146,346	$14,485	$704	$4,235,244	$0.0337
7	$4,993,493	$50,485	$4,997	$243	$5,049,218	$0.1164
8	$1,943,819	$90,022	$8,910	$433	$2,043,184	$0.0264
9	$30,265,799	$496,429	$49,135	$2,388	$30,813,751	$0.0723
10	$716,990	$12,708	$1,258	$61	$731,017	$0.0670
11	$99,399	$2,595	$257	$12	$102,263	$0.0459
12	$29,697	$919	$91	$4	$30,712	$0.0389
13	$388,420	$4,227	$418	$20	$393,085	$0.1083
Total	$60,388,374	$9,379,643	$928,365	$23,158	$70,719,541	

TABLE B.1.79
Cost Responsibility for Flexible Rehabilitation on Non-NHS Pavements, 2010.

Vehicle Class	Pavement Expenditures: Load-Related Expenditures	Pavement Expenditures: Non-Load-Related Expenditures	Grading & Earthworks	Shoulder	Total
1	$81,457	$40,673	$6,633	$166	$128,928
2	$8,940,911	$4,464,334	$728,036	$18,180	$14,151,461
3	$3,994,724	$1,922,081	$313,450	$7,827	$6,238,082
4	$103,148	$8,428	$1,374	$76	$113,026
5	$617,967	$152,090	$24,803	$1,363	$796,222
6	$3,131,706	$113,681	$18,539	$1,018	$3,264,944
7	$3,839,336	$39,217	$6,395	$351	$3,885,299
8	$1,493,757	$69,929	$11,404	$626	$1,575,717
9	$23,264,813	$382,573	$62,389	$3,427	$23,713,203
10	$551,108	$9,872	$1,610	$88	$562,678
11	$76,358	$2,016	$329	$18	$78,720
12	$22,812	$714	$116	$6	$23,649
13	$298,583	$3,283	$535	$29	$302,431
Total	$46,416,680	$7,208,892	$1,175,614	$33,176	$54,834,361

TABLE B.1.80
Cost Responsibility for Rigid Rehabilitation on Non-NHS Pavements, 2010.

Vehicle Class	Pavement Expenditures: Load-Related Expenditures	Pavement Expenditures: Non-Load-Related Expenditures	Grading & Earthworks	Shoulder	Total
1	$2,979	$1,380	$265	$7	$4,631
2	$326,973	$151,457	$29,121	$727	$508,279
3	$150,619	$65,209	$12,538	$313	$228,679
4	$4,674	$286	$55	$3	$5,018
5	$28,173	$5,160	$992	$55	$34,380
6	$81,759	$3,857	$742	$41	$86,398
7	$83,476	$1,330	$256	$14	$85,076
8	$56,907	$2,372	$456	$25	$59,761
9	$680,103	$12,979	$2,496	$137	$695,715
10	$17,060	$335	$64	$4	$17,463
11	$3,745	$68	$13	$1	$3,828
12	$1,138	$24	$5	$0	$1,168
13	$8,386	$111	$21	$1	$8,520
Total	$1,445,993	$244,569	$47,025	$1,327	$1,738,914

TABLE B.1.81
Total Cost Responsibility and Unit Cost for Pavement Rehabilitation on Non-NHS, 2010.

Vehicle Class	Pavement Expenditures: Load-Related Expenditures	Pavement Expenditures: Non-Load-Related Expenditures	Grading & Earthworks	Shoulder	Total	Unit Cost [$/VMT]
1	$81,457	$40,673	$6,633	$166	$128,928	$0.0028
2	$8,940,911	$4,464,334	$728,036	$18,180	$14,151,461	$0.0028
3	$3,994,724	$1,922,081	$313,450	$7,827	$6,238,082	$0.0029
4	$103,148	$8,428	$1,374	$76	$113,026	$0.0120
5	$617,967	$152,090	$24,803	$1,363	$796,222	$0.0047
6	$3,131,706	$113,681	$18,539	$1,018	$3,264,944	$0.0257
7	$3,839,336	$39,217	$6,395	$351	$3,885,299	$0.0886
8	$1,493,757	$69,929	$11,404	$626	$1,575,717	$0.0202
9	$23,264,813	$382,573	$62,389	$3,427	$23,713,203	$0.0555
10	$551,108	$9,872	$1,610	$88	$562,678	$0.0510
11	$76,358	$2,016	$329	$18	$78,720	$0.0349
12	$22,812	$714	$116	$6	$23,649	$0.0296
13	$298,583	$3,283	$535	$29	$302,431	$0.0824
Total	$46,416,680	$7,208,892	$1,175,614	$33,176	$54,834,361	

TABLE B.1.82
Cost Responsibility for Flexible Rehabilitation on Non-NHS Pavements, 2011.

	Pavement Expenditures				
Vehicle Class	Load-Related Expenditures	Non-Load-Related Expenditures	Grading & Earthworks	Shoulder	Total
1	$32,852	$16,910	$11,604	$111	$61,477
2	$3,605,923	$1,856,047	$1,273,647	$12,204	$6,747,821
3	$1,609,200	$799,105	$548,358	$5,254	$2,961,918
4	$41,223	$2,887	$1,981	$42	$46,133
5	$246,896	$52,105	$35,756	$754	$335,511
6	$1,276,753	$38,947	$26,726	$563	$1,342,989
7	$1,572,259	$13,436	$9,220	$194	$1,595,109
8	$601,487	$27,651	$18,974	$400	$648,512
9	$9,454,297	$102,000	$69,994	$1,475	$9,627,765
10	$223,560	$3,903	$2,679	$56	$230,199
11	$30,397	$797	$547	$12	$31,752
12	$9,073	$282	$194	$4	$9,553
13	$121,481	$1,298	$891	$19	$123,689
Total	$18,825,400	$2,915,369	$2,000,569	$21,089	$23,762,428

TABLE B.1.83
Cost Responsibility for Rigid Rehabilitation on Non-NHS Pavements, 2011.

	Pavement Expenditures				
Vehicle Class	Load-Related Expenditures	Non-Load-Related Expenditures	Grading & Earthworks	Shoulder	Total
1	$2,582	$1,229	$483	$5	$4,299
2	$283,372	$134,941	$53,069	$509	$471,890
3	$130,534	$58,098	$22,848	$219	$211,699
4	$4,051	$210	$83	$2	$4,345
5	$24,416	$3,788	$1,490	$31	$29,726
6	$70,857	$2,832	$1,114	$23	$74,825
7	$72,345	$977	$384	$8	$73,714
8	$49,318	$2,010	$791	$17	$52,136
9	$589,413	$7,416	$2,916	$61	$599,806
10	$14,785	$284	$112	$2	$15,183
11	$3,246	$58	$23	$0	$3,327
12	$987	$21	$8	$0	$1,015
13	$7,267	$94	$37	$1	$7,400
Total	$1,253,173	$211,957	$83,357	$879	$1,549,365

TABLE B.1.84
Total Cost Responsibility and Unit Cost for Pavement Rehabilitation on Non-NHS, 2011.

	Pavement Expenditures					
Vehicle Class	Load-Related Expenditures	Non-Load-Related Expenditures	Grading & Earthworks	Shoulder	Total	Unit Cost [$/VMT]
1	$35,434	$18,139	$12,087	$116	$65,776	$0.0013
2	$3,889,295	$1,990,988	$1,326,716	$12,713	$7,219,711	$0.0013
3	$1,739,734	$857,203	$571,206	$5,473	$3,173,617	$0.0014
4	$45,273	$3,097	$2,064	$44	$50,478	$0.0060
5	$271,313	$55,894	$37,245	$785	$365,237	$0.0024
6	$1,347,610	$41,778	$27,839	$587	$1,417,814	$0.0124
7	$1,644,603	$14,412	$9,604	$202	$1,668,822	$0.0424
8	$650,805	$29,661	$19,765	$417	$700,648	$0.0086
9	$10,043,709	$109,415	$72,910	$1,537	$10,227,572	$0.0342
10	$238,346	$4,187	$2,790	$59	$245,382	$0.0214
11	$33,643	$855	$570	$12	$35,079	$0.0150
12	$10,060	$303	$202	$4	$10,569	$0.0128
13	$128,748	$1,393	$928	$20	$131,088	$0.0344
Total	$20,078,573	$3,127,326	$2,083,926	$21,968	$25,311,794	

TABLE B.1.85
Cost Responsibility for Flexible Rehabilitation on Non-NHS Pavements, 2012.

Vehicle Class	Pavement Expenditures: Load-Related Expenditures	Pavement Expenditures: Non-Load-Related Expenditures	Grading & Earthworks	Shoulder	Total
1	$38,633	$18,939	$6,419	$39	$64,030
2	$4,240,479	$2,078,820	$704,543	$4,234	$7,028,076
3	$1,892,380	$895,018	$303,335	$1,823	$3,092,557
4	$48,477	$5,832	$1,977	$26	$56,312
5	$290,344	$105,241	$35,668	$472	$431,725
6	$1,501,431	$78,664	$26,660	$352	$1,607,108
7	$1,848,939	$27,137	$9,197	$122	$1,885,394
8	$707,334	$34,412	$11,663	$154	$753,563
9	$11,118,026	$176,524	$59,826	$791	$11,355,168
10	$262,901	$4,858	$1,646	$22	$269,428
11	$35,746	$992	$336	$4	$37,078
12	$10,670	$351	$119	$2	$11,142
13	$142,859	$1,616	$548	$7	$145,029
Total	$22,138,220	$3,428,404	$1,161,936	$8,048	$26,736,609

TABLE B.1.86
Cost Responsibility for Rigid Rehabilitation on Non-NHS Pavements, 2012.

Vehicle Class	Pavement Expenditures: Load-Related Expenditures	Pavement Expenditures: Non-Load-Related Expenditures	Grading & Earthworks	Shoulder	Total
1	$1,274	$578	$267	$2	$2,121
2	$139,812	$63,410	$29,356	$176	$232,755
3	$64,404	$27,301	$12,639	$76	$104,420
4	$1,999	$178	$82	$1	$2,260
5	$12,047	$3,210	$1,486	$20	$16,763
6	$34,960	$2,399	$1,111	$15	$38,485
7	$35,694	$828	$383	$5	$36,910
8	$24,333	$1,050	$486	$6	$25,875
9	$290,808	$5,385	$2,493	$33	$298,719
10	$7,295	$148	$69	$1	$7,513
11	$1,602	$30	$14	$0	$1,646
12	$487	$11	$5	$0	$503
13	$3,586	$49	$23	$0	$3,658
Total	$618,299	$104,577	$48,414	$335	$771,625

TABLE B.1.87
Total Cost Responsibility and Unit Cost for Pavement Rehabilitation on Non-NHS, 2012.

Vehicle Class	Pavement Expenditures: Load-Related Expenditures	Pavement Expenditures: Non-Load-Related Expenditures	Grading & Earthworks	Shoulder	Total	Unit Cost [$/VMT]
1	$39,907	$19,517	$6,686	$40	$66,150	$0.0012
2	$4,380,291	$2,142,230	$733,899	$4,411	$7,260,830	$0.0012
3	$1,956,784	$922,319	$315,974	$1,899	$3,196,976	$0.0012
4	$50,475	$6,010	$2,059	$27	$58,572	$0.0035
5	$302,391	$108,452	$37,154	$491	$448,488	$0.0015
6	$1,536,391	$81,063	$27,771	$367	$1,645,592	$0.0073
7	$1,884,633	$27,965	$9,580	$127	$1,922,304	$0.0248
8	$731,667	$35,462	$12,149	$161	$779,438	$0.0079
9	$11,408,835	$181,908	$62,319	$824	$11,653,886	$0.0231
10	$270,196	$5,006	$1,715	$23	$276,940	$0.0199
11	$37,347	$1,022	$350	$5	$38,724	$0.0136
12	$11,156	$362	$124	$2	$11,644	$0.0116
13	$146,444	$1,665	$570	$8	$148,687	$0.0322
Total	$22,756,519	$3,532,981	$1,210,351	$8,383	$27,508,233	

TABLE B.1.88
Cost Responsibility for Flexible Rehabilitation on Non-NHS Pavements, 2009–2012.

Vehicle Class	Pavement Expenditures: Load-Related Expenditures	Pavement Expenditures: Non-Load-Related Expenditures	Grading & Earthworks	Shoulder	Total
1	$251,962	$126,253	$29,422	$420	$408,058
2	$27,655,946	$13,857,816	$3,229,479	$46,093	$44,789,333
3	$12,341,900	$5,966,365	$1,390,425	$19,845	$19,718,535
4	$316,162	$27,332	$6,308	$190	$349,993
5	$1,893,594	$493,220	$113,837	$3,437	$2,504,089
6	$9,792,172	$368,662	$85,089	$2,569	$10,248,493
7	$12,058,579	$127,179	$29,353	$886	$12,215,998
8	$4,613,158	$216,493	$50,138	$1,571	$4,881,360
9	$72,510,567	$1,127,183	$236,883	$7,849	$73,882,483
10	$1,714,615	$30,562	$7,078	$222	$1,752,477
11	$233,129	$6,241	$1,445	$45	$240,861
12	$69,586	$2,211	$512	$16	$72,325
13	$931,708	$10,165	$2,354	$74	$944,301
Total	$144,383,079	$22,359,683	$5,182,325	$83,219	$172,008,305

TABLE B.1.89
Cost Responsibility for Rigid Rehabilitation on Non-NHS Pavements, 2009–2012.

Vehicle Class	Pavement Expenditures: Load-Related Expenditures	Pavement Expenditures: Non-Load-Related Expenditures	Grading & Earthworks	Shoulder	Total
1	$10,830	$5,039	$1,226	$17	$17,113
2	$1,188,748	$553,134	$134,562	$1,921	$1,878,364
3	$547,593	$238,147	$57,934	$827	$844,501
4	$16,992	$1,053	$263	$8	$18,316
5	$102,427	$19,006	$4,743	$143	$126,320
6	$297,244	$14,206	$3,545	$107	$315,103
7	$303,486	$4,901	$1,223	$37	$309,646
8	$206,891	$8,581	$2,089	$65	$217,627
9	$2,472,589	$43,142	$9,870	$327	$2,525,929
10	$62,025	$1,211	$295	$9	$63,540
11	$13,617	$247	$60	$2	$13,926
12	$4,139	$88	$21	$1	$4,249
13	$30,487	$403	$98	$3	$30,991
Total	$5,257,068	$889,159	$215,930	$3,467	$6,365,625

TABLE B.1.90
Total Cost Responsibility and Unit Cost for Pavement Rehabilitation on Non-NHS, 2009–2012.

Vehicle Class	Pavement Expenditures: Load-Related Expenditures	Pavement Expenditures: Non-Load-Related Expenditures	Grading & Earthworks	Shoulder	Total	Unit Cost [$/VMT]
1	$262,792	$131,292	$30,648	$437	$425,171	$0.0022
2	$28,844,694	$14,410,950	$3,364,040	$48,013	$46,667,697	$0.0022
3	$12,889,493	$6,204,512	$1,448,359	$20,672	$20,563,036	$0.0022
4	$333,154	$28,385	$6,571	$198	$368,309	$0.0084
5	$1,996,021	$512,227	$118,581	$3,581	$2,630,409	$0.0033
6	$10,089,417	$382,868	$88,634	$2,676	$10,563,596	$0.0178
7	$12,362,065	$132,079	$30,576	$923	$12,525,644	$0.0613
8	$4,820,049	$225,074	$52,228	$1,637	$5,098,987	$0.0152
9	$74,983,157	$1,170,325	$246,753	$8,176	$76,408,412	$0.0461
10	$1,776,640	$31,774	$7,373	$231	$1,816,017	$0.0384
11	$246,746	$6,488	$1,506	$47	$254,787	$0.0264
12	$73,725	$2,298	$533	$17	$76,574	$0.0224
13	$962,195	$10,568	$2,452	$77	$975,292	$0.0620
Total	$149,640,146	$23,248,842	$5,398,256	$86,686	$178,373,930	

B.1.3 Pavement In-House Maintenance—Cost Allocation Results

B.1.3.1 Pavement In-House Maintenance Cost Allocation Results per Year and Total for Interstates

TABLE B.1.91
Cost Responsibility and Unit Cost for Pavement In-House Maintenance on Interstates, 2009.

		Pavement			
Vehicle Class	**Shoulder**	**Non-Load-Related Expenditures**	**Load-Related Expenditures**	**Total**	**Unit Cost [$/VMT]**
1	$815	$1,559	$51	$2,425	$0.0000
2	$117,901	$225,595	$7,349	$350,844	$0.0000
3	$39,967	$76,474	$4,105	$120,546	$0.0000
4	$1,228	$1,567	$12,572	$15,367	$0.0003
5	$13,629	$17,386	$36,564	$67,578	$0.0001
6	$2,264	$2,888	$40,989	$46,141	$0.0004
7	$362	$462	$26,893	$27,717	$0.0016
8	$4,187	$5,341	$91,508	$101,035	$0.0005
9	$69,023	$88,047	$3,237,784	$3,394,854	$0.0010
10	$661	$843	$28,125	$29,630	$0.0009
11	$2,078	$2,650	$110,076	$114,804	$0.0012
12	$785	$1,001	$29,954	$31,740	$0.0009
13	$205	$261	$14,297	$14,762	$0.0015
Total	$253,104	$424,074	$3,640,265	$4,317,444	

TABLE B.1.92
Cost Responsibility and Unit Cost for Pavement In-House Maintenance on Interstates, 2010.

		Pavement			
Vehicle Class	**Shoulder**	**Non-Load-Related Expenditures**	**Load-Related Expenditures**	**Total**	**Unit Cost [$/VMT]**
1	$524	$1,033	$33	$1,590	$0.0000
2	$75,814	$149,406	$4,803	$230,024	$0.0000
3	$25,700	$50,647	$2,683	$79,031	$0.0000
4	$753	$989	$8,217	$9,959	$0.0002
5	$8,354	$10,975	$23,896	$43,225	$0.0001
6	$1,388	$1,823	$26,788	$29,998	$0.0003
7	$222	$291	$17,575	$18,088	$0.0011
8	$2,566	$3,371	$59,800	$65,738	$0.0003
9	$42,331	$55,614	$2,116,053	$2,213,999	$0.0007
10	$405	$532	$18,381	$19,319	$0.0006
11	$1,273	$1,673	$71,940	$74,887	$0.0008
12	$481	$632	$19,576	$20,689	$0.0006
13	$125	$165	$9,343	$9,634	$0.0010
Total	$159,938	$277,153	$2,379,089	$2,816,180	

TABLE B.1.93
Cost Responsibility and Unit Cost for Pavement In-House Maintenance on Interstates, 2011.

		Pavement			
Vehicle Class	**Shoulder**	**Non-Load-Related Expenditures**	**Load-Related Expenditures**	**Total**	**Unit Cost [$/VMT]**
1	$1,023	$1,256	$36	$2,315	$0.0000
2	$148,026	$181,657	$5,163	$334,845	$0.0000
3	$50,179	$61,580	$2,884	$114,643	$0.0000
4	$696	$854	$8,834	$10,383	$0.0002
5	$11,576	$9,471	$25,695	$46,743	$0.0001
6	$1,923	$1,573	$28,806	$32,302	$0.0004
7	$307	$252	$18,900	$19,459	$0.0014
8	$2,751	$2,251	$64,317	$69,319	$0.0006
9	$45,362	$37,112	$2,275,269	$2,357,743	$0.0011
10	$435	$356	$19,764	$20,554	$0.0010
11	$1,365	$1,117	$77,354	$79,836	$0.0013
12	$516	$422	$21,049	$21,987	$0.0009
13	$135	$110	$10,047	$10,292	$0.0017
Total	$264,294	$298,009	$2,558,117	$3,120,420	

TABLE B.1.94
Cost Responsibility and Unit Cost for Pavement In-House Maintenance on Interstates, 2012.

Vehicle Class	Shoulder	Pavement		Total	Unit Cost [$/VMT]
		Non-Load-Related Expenditures	Load-Related Expenditures		
1	$1,496	$1,034	$30	$2,560	$0.0000
2	$216,416	$149,633	$4,353	$370,402	$0.0000
3	$73,363	$50,724	$2,432	$126,519	$0.0000
4	$952	$658	$7,447	$9,057	$0.0002
5	$15,841	$7,302	$21,658	$44,801	$0.0001
6	$2,631	$1,213	$24,280	$28,124	$0.0003
7	$421	$194	$15,930	$16,544	$0.0013
8	$5,226	$2,409	$54,202	$61,837	$0.0004
9	$77,864	$35,891	$1,917,918	$2,031,673	$0.0009
10	$825	$380	$16,660	$17,866	$0.0007
11	$2,593	$1,195	$65,204	$68,993	$0.0009
12	$980	$452	$17,743	$19,175	$0.0006
13	$255	$118	$8,469	$8,842	$0.0011
Total	$398,863	$251,202	$2,156,327	$2,806,392	

TABLE B.1.95
Cost Responsibility and Unit Cost for Pavement In-House Maintenance on Interstates, 2009–2012.

Vehicle Class	Shoulder	Pavement		Total	Unit Cost [$/VMT]
		Non-Load-Related Expenditures	Load-Related Expenditures		
1	$3,858	$4,882	$150	$8,890	$0.0000
2	$558,157	$706,290	$21,668	$1,286,114	$0.0000
3	$189,210	$239,425	$12,103	$440,738	$0.0000
4	$3,629	$4,068	$37,069	$44,766	$0.0002
5	$49,400	$45,133	$107,813	$202,346	$0.0001
6	$8,206	$7,497	$120,862	$136,565	$0.0004
7	$1,312	$1,199	$79,298	$81,809	$0.0014
8	$14,730	$13,372	$269,827	$297,929	$0.0004
9	$234,580	$216,664	$9,547,025	$9,998,269	$0.0009
10	$2,326	$2,112	$82,931	$87,369	$0.0008
11	$7,310	$6,636	$324,574	$338,520	$0.0010
12	$2,761	$2,507	$88,323	$93,590	$0.0007
13	$720	$654	$42,156	$43,530	$0.0013
Total	$1,076,199	$1,250,438	$10,733,798	$13,060,436	

B.1.3.2 Pavement In-House Maintenance Cost Allocation Results per Year and Total for Non-Interstate NHS

TABLE B.1.96
Cost Responsibility and Unit Cost for Pavement In-House Maintenance on Non-Interstate NHS, 2009.

Vehicle Class	Shoulder	Pavement		Total	Unit Cost [$/VMT]
		Non-Load-Related Expenditures	Load-Related Expenditures		
1	$3,889	$3,966	$339	$8,195	$0.0001
2	$414,425	$422,607	$36,130	$873,161	$0.0001
3	$160,004	$163,163	$23,003	$346,170	$0.0001
4	$4,268	$1,978	$41,450	$47,697	$0.0011
5	$51,423	$23,836	$129,693	$204,951	$0.0004
6	$10,520	$4,876	$180,832	$196,229	$0.0018
7	$3,254	$1,508	$228,819	$233,581	$0.0071
8	$14,753	$6,838	$282,442	$304,032	$0.0020
9	$115,417	$53,498	$4,486,029	$4,654,944	$0.0040
10	$2,181	$1,011	$88,121	$91,313	$0.0041
11	$2,290	$1,061	$113,858	$117,210	$0.0051
12	$573	$266	$20,580	$21,418	$0.0037
13	$647	$300	$42,544	$43,491	$0.0066
Total	$783,645	$684,908	$5,673,840	$7,142,393	

TABLE B.1.97
Cost Responsibility and Unit Cost for Pavement In-House Maintenance on Non-Interstate NHS, 2010.

		Pavement			
Vehicle Class	Shoulder	Non-Load-Related Expenditures	Load-Related Expenditures	Total	Unit Cost [$/VMT]
1	$2,969	$3,263	$280	$6,512	$0.0001
2	$316,325	$347,677	$29,878	$693,881	$0.0001
3	$122,129	$134,234	$19,023	$275,385	$0.0001
4	$3,338	$1,668	$34,267	$39,272	$0.0009
5	$40,212	$20,090	$107,199	$167,501	$0.0003
6	$8,227	$4,110	$149,453	$161,790	$0.0015
7	$2,544	$1,271	$189,092	$192,907	$0.0060
8	$11,536	$5,764	$233,414	$250,714	$0.0017
9	$91,687	$45,806	$3,707,947	$3,845,440	$0.0033
10	$1,706	$852	$72,836	$75,394	$0.0035
11	$1,791	$895	$94,112	$96,797	$0.0043
12	$448	$224	$17,011	$17,683	$0.0031
13	$506	$253	$35,162	$35,922	$0.0056
Total	$603,418	$566,106	$4,689,674	$5,859,199	

TABLE B.1.98
Cost Responsibility and Unit Cost for Pavement In-House Maintenance on Non-Interstate NHS, 2011.

		Pavement			
Vehicle Class	Shoulder	Non-Load-Related Expenditures	Load-Related Expenditures	Total	Unit Cost [$/VMT]
1	$3,300	$3,150	$258	$6,707	$0.0001
2	$351,575	$335,596	$27,474	$714,645	$0.0001
3	$135,738	$129,569	$17,493	$282,800	$0.0001
4	$2,686	$1,166	$31,477	$35,328	$0.0012
5	$32,362	$14,041	$98,418	$144,821	$0.0004
6	$6,621	$2,873	$137,165	$146,659	$0.0020
7	$2,048	$888	$173,480	$176,416	$0.0078
8	$12,328	$5,349	$214,176	$231,853	$0.0017
9	$57,636	$25,008	$3,404,151	$3,486,795	$0.0055
10	$1,823	$791	$66,868	$69,482	$0.0035
11	$1,914	$830	$86,407	$89,151	$0.0042
12	$479	$208	$15,621	$16,307	$0.0031
13	$541	$235	$32,275	$33,051	$0.0056
Total	$609,050	$519,703	$4,305,262	$5,434,014	

TABLE B.1.99
Cost Responsibility and Unit Cost for Pavement In-House Maintenance on Non-Interstate NHS, 2012.

		Pavement			
Vehicle Class	Shoulder	Non-Load-Related Expenditures	Load-Related Expenditures	Total	Unit Cost [$/VMT]
1	$7,635	$4,322	$367	$12,323	$0.0002
2	$813,465	$460,508	$39,060	$1,313,033	$0.0002
3	$314,068	$177,796	$24,869	$516,733	$0.0002
4	$10,299	$2,650	$44,753	$57,703	$0.0013
5	$124,081	$31,929	$139,935	$295,945	$0.0005
6	$25,385	$6,532	$195,033	$226,950	$0.0020
7	$7,851	$2,020	$246,674	$256,546	$0.0074
8	$28,523	$7,340	$304,538	$340,401	$0.0027
9	$167,161	$43,014	$4,840,202	$5,050,377	$0.0068
10	$4,218	$1,085	$95,077	$100,380	$0.0054
11	$4,428	$1,139	$122,857	$128,424	$0.0066
12	$1,108	$285	$22,210	$23,603	$0.0048
13	$1,252	$322	$45,891	$47,465	$0.0086
Total	$1,509,472	$738,943	$6,121,466	$8,369,881	

TABLE B.1.100
Cost Responsibility and Unit Cost for Pavement In-House Maintenance on Non-Interstate NHS, 2009–2012.

Vehicle Class	Shoulder	Pavement		Total	Unit Cost [$/VMT]
		Non-Load-Related Expenditures	Load-Related Expenditures		
1	$17,792	$14,701	$1,244	$33,737	$0.0001
2	$1,895,790	$1,566,388	$132,542	$3,594,720	$0.0001
3	$731,939	$604,761	$84,388	$1,421,088	$0.0001
4	$20,592	$7,462	$151,946	$180,000	$0.0011
5	$248,078	$89,896	$475,244	$813,218	$0.0004
6	$50,752	$18,391	$662,484	$731,627	$0.0018
7	$15,696	$5,688	$838,065	$859,450	$0.0070
8	$67,140	$25,290	$1,034,569	$1,127,000	$0.0020
9	$431,901	$167,326	$16,438,328	$17,037,556	$0.0046
10	$9,928	$3,740	$322,902	$336,569	$0.0041
11	$10,422	$3,926	$417,234	$431,582	$0.0050
12	$2,607	$982	$75,421	$79,011	$0.0037
13	$2,946	$1,110	$155,873	$159,929	$0.0065
Total	$3,505,584	$2,509,660	$20,790,242	$26,805,487	

B.1.3.3 Pavement In-House Maintenance Cost Allocation Results per Year and Total for Non-NHS

TABLE B.1.101
Cost Responsibility and Unit Cost for Pavement In-House Maintenance on Non- NHS, 2009.

Vehicle Class	Shoulder	Pavement		Total	Unit Cost [$/VMT]
		Non-Load-Related Expenditures	Load-Related Expenditures		
1	$14,510	$7,052	$985	$22,547	$0.0005
2	$1,592,602	$774,021	$108,162	$2,474,784	$0.0005
3	$685,681	$333,248	$76,661	$1,095,591	$0.0005
4	$6,539	$1,445	$42,895	$50,879	$0.0055
5	$118,003	$26,068	$199,377	$343,448	$0.0020
6	$88,202	$19,485	$983,018	$1,090,706	$0.0087
7	$30,427	$6,722	$1,368,128	$1,405,277	$0.0324
8	$54,256	$11,986	$826,362	$892,604	$0.0115
9	$299,197	$66,097	$8,910,398	$9,275,691	$0.0218
10	$7,659	$1,692	$203,407	$212,758	$0.0195
11	$1,564	$346	$53,084	$54,994	$0.0247
12	$554	$122	$13,508	$14,184	$0.0180
13	$2,548	$563	$110,102	$113,213	$0.0312
Total	$2,901,742	$1,248,846	$12,896,087	$17,046,675	

TABLE B.1.102
Cost Responsibility and Unit Cost for Pavement In-House Maintenance on Non- NHS, 2010.

Vehicle Class	Shoulder	Pavement		Total	Unit Cost [$/VMT]
		Non-Load-Related Expenditures	Load-Related Expenditures		
1	$12,309	$7,950	$1,112	$21,371	$0.0005
2	$1,351,086	$872,594	$122,048	$2,345,728	$0.0005
3	$581,699	$375,688	$86,503	$1,043,890	$0.0005
4	$5,612	$1,647	$48,399	$55,658	$0.0059
5	$101,263	$29,727	$224,957	$355,948	$0.0021
6	$75,690	$22,220	$1,109,113	$1,207,022	$0.0095
7	$26,111	$7,665	$1,543,586	$1,577,362	$0.0360
8	$46,559	$13,668	$932,364	$992,591	$0.0127
9	$254,720	$74,777	$10,053,407	$10,382,904	$0.0243
10	$6,573	$1,930	$229,499	$238,002	$0.0216
11	$1,342	$394	$59,895	$61,631	$0.0274
12	$475	$140	$15,241	$15,856	$0.0199
13	$2,186	$642	$124,226	$127,054	$0.0346
Total	$2,465,625	$1,409,043	$14,550,349	$18,425,017	

TABLE B.1.103
Cost Responsibility and Unit Cost for Pavement In-House Maintenance on Non- NHS, 2011.

Vehicle Class	Shoulder	Pavement		Total	Unit Cost [$/VMT]
		Non-Load-Related Expenditures	Load-Related Expenditures		
1	$12,999	$7,613	$1,034	$21,646	$0.0004
2	$1,426,827	$835,592	$113,466	$2,375,885	$0.0004
3	$614,308	$359,757	$80,423	$1,054,489	$0.0005
4	$4,883	$1,300	$45,053	$51,237	$0.0061
5	$88,123	$23,458	$209,445	$321,025	$0.0021
6	$65,868	$17,534	$1,033,188	$1,116,590	$0.0098
7	$22,723	$6,049	$1,438,614	$1,467,385	$0.0373
8	$46,764	$12,448	$868,489	$927,702	$0.0114
9	$172,506	$45,920	$9,364,233	$9,582,659	$0.0320
10	$6,602	$1,757	$213,770	$222,129	$0.0194
11	$1,348	$359	$55,773	$57,480	$0.0246
12	$478	$127	$14,190	$14,795	$0.0179
13	$2,196	$584	$115,716	$118,496	$0.0311
Total	$2,465,625	$1,312,499	$13,553,393	$17,331,517	

TABLE B.1.104
Cost Responsibility and Unit Cost for Pavement In-House Maintenance on Non-NHS, 2012.

Vehicle Class	Shoulder	Pavement		Total	Unit Cost [$/VMT]
		Non-Load-Related Expenditures	Load-Related Expenditures		
1	$15,699	$9,651	$1,370	$26,720	$0.0005
2	$1,723,199	$1,059,267	$150,360	$2,932,825	$0.0005
3	$741,909	$456,058	$106,580	$1,304,547	$0.0005
4	$10,636	$2,972	$59,878	$73,485	$0.0044
5	$191,924	$53,626	$278,478	$524,027	$0.0017
6	$143,455	$40,083	$1,375,425	$1,558,963	$0.0069
7	$49,488	$13,828	$1,917,288	$1,980,604	$0.0255
8	$62,755	$17,535	$1,156,041	$1,236,331	$0.0126
9	$321,917	$89,948	$12,462,706	$12,874,571	$0.0255
10	$8,859	$2,475	$284,514	$295,848	$0.0213
11	$1,809	$505	$74,179	$76,494	$0.0269
12	$641	$179	$18,867	$19,687	$0.0196
13	$2,947	$823	$154,026	$157,796	$0.0341
Total	$3,275,237	$1,746,950	$18,039,712	$23,061,899	

TABLE B.1.105
Cost Responsibility and Unit Cost for Pavement In-House Maintenance on Non-NHS, 2009–2012.

Vehicle Class	Shoulder	Pavement		Total	Unit Cost [$/VMT]
		Non-Load-Related Expenditures	Load-Related Expenditures		
1	$55,517	$32,265	$4,501	$92,283	$0.0005
2	$6,093,714	$3,541,474	$494,035	$10,129,223	$0.0005
3	$2,623,597	$1,524,752	$350,168	$4,498,516	$0.0005
4	$27,670	$7,364	$196,225	$231,258	$0.0053
5	$499,312	$132,880	$912,257	$1,544,449	$0.0019
6	$373,215	$99,322	$4,500,744	$4,973,281	$0.0084
7	$128,749	$34,264	$6,267,616	$6,430,628	$0.0315
8	$210,334	$55,637	$3,783,256	$4,049,227	$0.0121
9	$1,048,340	$276,742	$40,790,744	$42,115,826	$0.0254
10	$29,693	$7,854	$931,190	$968,737	$0.0205
11	$6,064	$1,604	$242,931	$250,598	$0.0259
12	$2,148	$568	$61,806	$64,522	$0.0189
13	$9,876	$2,612	$504,070	$516,558	$0.0328
Total	$11,108,230	$5,717,338	$59,039,541	$75,865,108	

B.1.4 Other Pavement Projects—Cost Allocation Results

B.1.4.1 Other Pavement Projects Cost Allocation Results for Interstates

TABLE B.1.106
Cost Responsibility per Year for Other Pavement Projects on Interstates.

Vehicle Class	Cost Responsibility				
	2009	2010	2011	2012	Total
1	$64,189	$102,580	$87,201	$14,625	$268,595
2	$9,285,988	$14,839,918	$12,615,002	$2,115,732	$38,856,640
3	$3,147,859	$5,030,587	$4,276,363	$717,213	$13,172,022
4	$64,501	$98,255	$59,280	$9,305	$231,341
5	$715,634	$1,090,124	$657,704	$103,241	$2,566,703
6	$118,872	$181,077	$109,249	$17,149	$426,348
7	$19,005	$28,951	$17,467	$2,742	$68,164
8	$219,832	$334,870	$156,321	$34,060	$745,083
9	$3,624,219	$5,523,952	$2,577,212	$507,477	$12,232,859
10	$34,718	$52,885	$24,687	$5,379	$117,669
11	$109,092	$166,180	$77,575	$16,902	$369,749
12	$41,209	$62,773	$29,303	$6,385	$139,670
13	$10,747	$16,371	$7,642	$1,665	$36,426
Total	$17,455,865	$27,528,524	$20,695,006	$3,551,875	$69,231,270

TABLE B.1.107
Unit Cost for per Year Other Pavement Projects on Interstates.

Vehicle Class	Unit Cost [$/VMT]				
	2009	2010	2011	2012	Average
1	$0.0011	$0.0018	$0.0012	$0.0002	$0.0011
2	$0.0011	$0.0018	$0.0012	$0.0002	$0.0011
3	$0.0011	$0.0018	$0.0012	$0.0002	$0.0011
4	$0.0011	$0.0018	$0.0012	$0.0002	$0.0011
5	$0.0011	$0.0018	$0.0012	$0.0002	$0.0011
6	$0.0011	$0.0018	$0.0012	$0.0002	$0.0011
7	$0.0011	$0.0018	$0.0012	$0.0002	$0.0011
8	$0.0011	$0.0018	$0.0012	$0.0002	$0.0011
9	$0.0011	$0.0018	$0.0012	$0.0002	$0.0011
10	$0.0011	$0.0018	$0.0012	$0.0002	$0.0011
11	$0.0011	$0.0018	$0.0012	$0.0002	$0.0011
12	$0.0011	$0.0018	$0.0012	$0.0002	$0.0011
13	$0.0011	$0.0018	$0.0012	$0.0002	$0.0011

B.1.4.2 Other Pavement Projects Cost Allocation Results for Non-Interstate NHS

TABLE B.1.108
Cost Responsibility per Year for Other Pavement Projects on Non-Interstate NHS.

Vehicle Class	Cost Responsibility				
	2009	2010	2011	2012	Total
1	$45,965	$19,009	$45,686	$44,251	$154,911
2	$4,897,616	$2,025,418	$4,867,857	$4,715,046	$16,505,937
3	$1,890,903	$781,986	$1,879,413	$1,820,415	$6,372,717
4	$22,929	$9,715	$16,906	$27,136	$76,685
5	$276,232	$117,036	$203,671	$326,911	$923,849
6	$56,512	$23,943	$41,667	$66,880	$189,001
7	$17,478	$7,405	$12,887	$20,684	$58,454
8	$79,247	$33,576	$77,589	$75,149	$265,561
9	$619,993	$266,849	$362,738	$440,412	$1,689,992
10	$11,718	$4,965	$11,473	$11,112	$39,267
11	$12,301	$5,212	$12,044	$11,665	$41,222
12	$3,078	$1,304	$3,013	$2,918	$10,313
13	$3,477	$1,473	$3,405	$3,298	$11,653
Total	$7,937,449	$3,297,891	$7,538,348	$7,565,877	$26,339,564

TABLE B.1.109
Unit Cost per Year for Other Pavement Projects on Non-Interstate NHS.

Vehicle Class	Unit Cost [$/VMT]				
	2009	2010	2011	2012	Average
1	$0.0005	$0.0002	$0.0006	$0.0006	$0.0005
2	$0.0005	$0.0002	$0.0006	$0.0006	$0.0005
3	$0.0005	$0.0002	$0.0006	$0.0006	$0.0005
4	$0.0005	$0.0002	$0.0006	$0.0006	$0.0005
5	$0.0005	$0.0002	$0.0006	$0.0006	$0.0005
6	$0.0005	$0.0002	$0.0006	$0.0006	$0.0005
7	$0.0005	$0.0002	$0.0006	$0.0006	$0.0005
8	$0.0005	$0.0002	$0.0006	$0.0006	$0.0005
9	$0.0005	$0.0002	$0.0006	$0.0006	$0.0005
10	$0.0005	$0.0002	$0.0006	$0.0006	$0.0005
11	$0.0005	$0.0002	$0.0006	$0.0006	$0.0005
12	$0.0005	$0.0002	$0.0006	$0.0006	$0.0005
13	$0.0005	$0.0002	$0.0006	$0.0006	$0.0005

B.1.4.3 Other Pavement Projects Cost Allocation Results for Non-NHS

TABLE B.1.110
Cost Responsibility per Year for Other Pavement Projects on Non-NHS.

	Cost Responsibility				
Vehicle Class	**2009**	**2010**	**2011**	**2012**	**Total**
1	$38,271	$39,965	$125,710	$63,587	$267,533
2	$4,200,710	$4,386,621	$13,798,265	$6,979,438	$29,365,035
3	$1,808,580	$1,888,623	$5,940,726	$3,004,938	$12,642,867
4	$7,840	$8,281	$21,466	$19,580	$57,168
5	$141,477	$149,443	$387,364	$353,338	$1,031,621
6	$105,748	$111,702	$289,538	$264,106	$771,094
7	$36,480	$38,534	$99,883	$91,109	$266,007
8	$65,049	$68,712	$205,561	$115,534	$454,857
9	$358,715	$375,913	$758,287	$592,661	$2,085,577
10	$9,183	$9,700	$29,019	$16,310	$64,212
11	$1,875	$1,981	$5,926	$3,331	$13,113
12	$664	$702	$2,099	$1,180	$4,645
13	$3,054	$3,226	$9,652	$5,425	$21,357
Total	$6,777,647	$7,083,404	$21,673,498	$11,510,538	$47,045,086

TABLE B.1.111
Unit Cost per Year for Other Pavement Projects on Non-NHS.

	Unit Cost [$/VMT]				
Vehicle Class	**2009**	**2010**	**2011**	**2012**	**Average**
1	$0.0008	$0.0009	$0.0025	$0.0012	$0.0014
2	$0.0008	$0.0009	$0.0025	$0.0012	$0.0014
3	$0.0008	$0.0009	$0.0025	$0.0012	$0.0014
4	$0.0008	$0.0009	$0.0025	$0.0012	$0.0013
5	$0.0008	$0.0009	$0.0025	$0.0012	$0.0013
6	$0.0008	$0.0009	$0.0025	$0.0012	$0.0013
7	$0.0008	$0.0009	$0.0025	$0.0012	$0.0013
8	$0.0008	$0.0009	$0.0025	$0.0012	$0.0014
9	$0.0008	$0.0009	$0.0025	$0.0012	$0.0013
10	$0.0008	$0.0009	$0.0025	$0.0012	$0.0014
11	$0.0008	$0.0009	$0.0025	$0.0012	$0.0014
12	$0.0008	$0.0009	$0.0025	$0.0012	$0.0014
13	$0.0008	$0.0009	$0.0025	$0.0012	$0.0014

B.1.5 Total Pavement Cost Allocation Results

B.1.5.1 Total Pavement Cost Allocation Results per Year for Interstates

TABLE B.1.112
Cost Responsibility and Unit Cost of Pavement Expenditures on Interstates, 2009.

	Cost Responsibility					
Vehicle Class	New Pavement Construction	Pavement Rehabilitation	Pavement Maintenance	Other Pavement Projects	Total	Unit Cost [$/VMT]
1	$176,635	$15,465	$2,425	$64,189	$258,714	$0.0045
2	$25,721,713	$2,237,256	$350,844	$9,285,988	$37,595,800	$0.0045
3	$9,035,610	$783,860	$120,546	$3,147,859	$13,087,876	$0.0046
4	$328,464	$72,549	$15,367	$64,501	$480,881	$0.0083
5	$2,525,132	$341,723	$67,578	$715,634	$3,650,068	$0.0057
6	$649,489	$243,843	$46,141	$118,872	$1,058,344	$0.0099
7	$278,203	$127,858	$27,717	$19,005	$452,783	$0.0265
8	$1,088,193	$390,870	$101,035	$219,832	$1,799,931	$0.0091
9	$28,862,398	$15,561,232	$3,394,854	$3,624,219	$51,442,703	$0.0158
10	$287,544	$140,861	$29,630	$34,718	$492,752	$0.0158
11	$822,729	$392,893	$114,804	$109,092	$1,439,518	$0.0147
12	$337,122	$123,970	$31,740	$41,209	$534,041	$0.0144
13	$143,310	$69,540	$14,762	$10,747	$238,359	$0.0247
Total	$70,256,541	$20,501,920	$4,317,444	$17,455,865	$112,531,771	

TABLE B.1.113
Cost Responsibility and Unit Cost of Pavement Expenditures on Interstates, 2010.

	Cost Responsibility					
Vehicle Class	New Pavement Construction	Pavement Rehabilitation	Pavement Maintenance	Other Pavement Projects	Total	Unit Cost [$/VMT]
1	$313,948	$24,312	$1,590	$102,580	$442,430	$0.0076
2	$45,514,337	$3,517,088	$230,024	$14,839,918	$64,101,367	$0.0076
3	$15,759,335	$1,231,853	$79,031	$5,030,587	$22,100,806	$0.0077
4	$647,551	$113,854	$9,959	$98,255	$869,618	$0.0155
5	$5,001,699	$524,533	$43,225	$1,090,124	$6,659,580	$0.0107
6	$1,243,726	$372,210	$29,998	$181,077	$1,827,011	$0.0177
7	$515,549	$195,092	$18,088	$28,951	$757,680	$0.0459
8	$1,432,987	$609,259	$65,738	$334,870	$2,442,854	$0.0128
9	$40,658,348	$24,135,097	$2,213,999	$5,523,952	$72,531,396	$0.0230
10	$308,459	$219,472	$19,319	$52,885	$600,135	$0.0199
11	$951,922	$622,448	$74,887	$166,180	$1,815,436	$0.0192
12	$371,483	$196,379	$20,689	$62,773	$651,325	$0.0182
13	$135,457	$107,455	$9,634	$16,371	$268,917	$0.0288
Total	$112,854,801	$31,869,051	$2,816,180	$27,528,524	$175,068,557	

TABLE B.1.114
Cost Responsibility and Unit Cost of Pavement Expenditures on Interstates, 2011.

Vehicle Class	Cost Responsibility: New Pavement Construction	Pavement Rehabilitation	Pavement Maintenance	Other Pavement Projects	Total	Unit Cost [$/VMT]
1	$151,555	$38,274	$2,315	$87,201	$279,344	$0.0040
2	$21,949,350	$5,536,938	$334,845	$12,615,002	$40,436,136	$0.0040
3	$7,594,858	$1,934,304	$114,643	$4,276,363	$13,920,167	$0.0041
4	$322,485	$160,488	$10,383	$59,280	$552,636	$0.0116
5	$2,332,594	$719,733	$46,743	$657,704	$3,756,774	$0.0071
6	$601,626	$534,600	$32,302	$109,249	$1,277,777	$0.0146
7	$267,522	$282,807	$19,459	$17,467	$587,255	$0.0419
8	$849,481	$856,436	$69,319	$156,321	$1,931,557	$0.0154
9	$20,428,580	$34,557,815	$2,357,743	$2,577,212	$59,921,350	$0.0290
10	$214,876	$313,675	$20,554	$24,687	$573,793	$0.0289
11	$699,718	$884,538	$79,836	$77,575	$1,741,667	$0.0280
12	$269,182	$278,293	$21,987	$29,303	$598,764	$0.0254
13	$107,512	$154,633	$10,292	$7,642	$280,080	$0.0456
Total	$55,789,341	$46,252,532	$3,120,420	$20,695,006	$125,857,299	

TABLE B.1.115
Cost Responsibility and Unit Cost of Pavement Expenditures on Interstates, 2012.

Vehicle Class	Cost Responsibility: New Pavement Construction	Pavement Rehabilitation	Pavement Maintenance	Other Pavement Projects	Total	Unit Cost [$/VMT]
1	$98,671	$27,274	$2,560	$14,625	$143,130	$0.0021
2	$14,312,191	$3,945,558	$370,402	$2,115,732	$20,743,883	$0.0021
3	$4,943,508	$1,380,561	$126,519	$717,213	$7,167,799	$0.0021
4	$187,195	$118,981	$9,057	$9,305	$324,538	$0.0074
5	$1,415,134	$521,930	$44,801	$103,241	$2,085,105	$0.0043
6	$355,682	$397,868	$28,124	$17,149	$798,823	$0.0099
7	$154,379	$211,572	$16,544	$2,742	$385,236	$0.0299
8	$629,080	$649,549	$61,837	$34,060	$1,374,526	$0.0086
9	$15,411,572	$25,988,901	$2,031,673	$507,477	$43,939,623	$0.0184
10	$151,294	$236,576	$17,866	$5,379	$411,114	$0.0163
11	$493,144	$668,310	$68,993	$16,902	$1,247,349	$0.0157
12	$189,425	$210,460	$19,175	$6,385	$425,444	$0.0142
13	$75,328	$116,367	$8,842	$1,665	$202,202	$0.0258
Total	$38,416,600	$34,473,907	$2,806,392	$3,551,875	$79,248,773	

TABLE B.1.116
Cost Responsibility and Unit Cost of Pavement Expenditures on Interstates, 2009–2012.

Vehicle Class	Cost Responsibility: New Pavement Construction	Pavement Rehabilitation	Pavement Maintenance	Other Pavement Projects	Total	Unit Cost [$/VMT]
1	$740,808	$105,324	$8,890	$268,595	$1,123,618	$0.0044
2	$107,497,592	$15,236,840	$1,286,114	$38,856,640	$162,877,186	$0.0044
3	$37,333,311	$5,330,578	$440,738	$13,172,022	$56,276,649	$0.0045
4	$1,485,695	$465,871	$44,766	$231,341	$2,227,674	$0.0108
5	$11,274,558	$2,107,919	$202,346	$2,566,703	$16,151,526	$0.0071
6	$2,850,523	$1,548,520	$136,565	$426,348	$4,961,955	$0.0131
7	$1,215,652	$817,329	$81,809	$68,164	$2,182,954	$0.0361
8	$3,999,741	$2,506,115	$297,929	$745,083	$7,548,869	$0.0112
9	$105,360,899	$100,243,045	$9,998,269	$12,232,859	$227,835,072	$0.0210
10	$962,172	$910,583	$87,369	$117,669	$2,077,794	$0.0195
11	$2,967,513	$2,568,189	$338,520	$369,749	$6,243,971	$0.0187
12	$1,167,212	$809,103	$93,590	$139,670	$2,209,575	$0.0175
13	$461,607	$447,995	$43,530	$36,426	$989,558	$0.0300
Total	$277,317,283	$133,097,410	$13,060,436	$69,231,270	$492,706,399	

B.1.5.2 Total Pavement Cost Allocation Results per Year for Non-Interstate NHS

TABLE B.1.117
Cost Responsibility and Unit Cost of Pavement Expenditures on Non-Interstate NHS, 2009.

	Cost Responsibility					
Vehicle Class	**New Pavement Construction**	**Pavement Rehabilitation**	**Pavement Maintenance**	**Other Pavement Projects**	**Total**	**Unit Cost [$/VMT]**
1	$505,559	$82,238	$8,195	$45,965	$641,956	$0.0074
2	$55,156,436	$8,762,500	$873,161	$4,897,616	$69,689,714	$0.0076
3	$23,438,133	$3,510,056	$346,170	$1,890,903	$29,185,262	$0.0082
4	$693,342	$235,868	$47,697	$22,929	$999,836	$0.0231
5	$5,283,882	$1,051,950	$204,951	$276,232	$6,817,016	$0.0131
6	$1,707,794	$1,169,084	$196,229	$56,512	$3,129,619	$0.0294
7	$1,531,496	$1,236,991	$233,581	$17,478	$3,019,546	$0.0917
8	$2,361,199	$1,207,763	$304,032	$79,247	$3,952,242	$0.0265
9	$22,527,914	$24,414,219	$4,654,944	$619,993	$52,217,071	$0.0447
10	$519,419	$492,731	$91,313	$11,718	$1,115,181	$0.0505
11	$635,906	$390,087	$117,210	$12,301	$1,155,505	$0.0498
12	$156,453	$83,094	$21,418	$3,078	$264,043	$0.0455
13	$254,393	$233,108	$43,491	$3,477	$534,470	$0.0816
Total	$114,771,928	$42,869,690	$7,142,393	$7,937,449	$172,721,461	

TABLE B.1.118
Cost Responsibility and Unit Cost of Pavement Expenditures on Non-Interstate NHS, 2010.

	Cost Responsibility					
Vehicle Class	**New Pavement Construction**	**Pavement Rehabilitation**	**Pavement Maintenance**	**Other Pavement Projects**	**Total**	**Unit Cost [$/VMT]**
1	$357,584	$106,819	$6,512	$19,009	$489,924	$0.0059
2	$38,720,460	$11,381,646	$693,881	$2,025,418	$52,821,404	$0.0060
3	$16,173,762	$4,549,147	$275,385	$781,986	$21,780,281	$0.0064
4	$641,670	$292,230	$39,272	$9,715	$982,887	$0.0232
5	$4,471,063	$1,333,793	$167,501	$117,036	$6,089,393	$0.0119
6	$1,579,900	$1,455,841	$161,790	$23,943	$3,221,475	$0.0309
7	$1,555,639	$1,536,546	$192,907	$7,405	$3,292,498	$0.1019
8	$2,164,564	$1,492,872	$250,714	$33,576	$3,941,726	$0.0269
9	$22,123,899	$30,228,484	$3,845,440	$266,849	$56,464,672	$0.0485
10	$513,601	$609,005	$75,394	$4,965	$1,202,965	$0.0556
11	$611,052	$477,394	$96,797	$5,212	$1,190,455	$0.0524
12	$150,057	$101,812	$17,683	$1,304	$270,857	$0.0476
13	$260,454	$288,410	$35,922	$1,473	$586,259	$0.0912
Total	$89,323,705	$53,854,000	$5,859,199	$3,297,891	$152,334,795	

TABLE B.1.119
Cost Responsibility and Unit Cost of Pavement Expenditures on Non-Interstate NHS, 2011.

Vehicle Class	Cost Responsibility					Unit Cost [$/VMT]
	New Pavement Construction	Pavement Rehabilitation	Pavement Maintenance	Other Pavement Projects	Total	
1	$383,173	$98,910	$6,707	$45,686	$534,476	$0.0067
2	$41,177,654	$10,538,994	$714,645	$4,867,857	$57,299,150	$0.0067
3	$16,767,980	$4,187,852	$282,800	$1,879,413	$23,118,045	$0.0071
4	$559,584	$223,415	$35,328	$16,906	$835,233	$0.0283
5	$4,017,971	$1,027,402	$144,821	$203,671	$5,393,865	$0.0152
6	$1,422,818	$1,050,304	$146,659	$41,667	$2,661,448	$0.0366
7	$1,386,455	$1,094,201	$176,416	$12,887	$2,669,958	$0.1188
8	$1,258,219	$1,152,994	$231,853	$77,589	$2,720,655	$0.0201
9	$15,112,135	$21,950,061	$3,486,795	$362,738	$40,911,729	$0.0647
10	$263,274	$450,759	$69,482	$11,473	$794,987	$0.0397
11	$279,948	$372,535	$89,151	$12,044	$753,678	$0.0359
12	$68,448	$79,469	$16,307	$3,013	$167,238	$0.0318
13	$125,486	$210,483	$33,051	$3,405	$372,424	$0.0627
Total	$82,823,144	$42,437,379	$5,434,014	$7,538,348	$138,232,885	

TABLE B.1.120
Cost Responsibility and Unit Cost of Pavement Expenditures on Non-Interstate NHS, 2012.

Vehicle Class	Cost Responsibility					Unit Cost [$/VMT]
	New Pavement Construction	Pavement Rehabilitation	Pavement Maintenance	Other Pavement Projects	Total	
1	$259,300	$77,949	$12,323	$44,251	$393,823	$0.0053
2	$27,699,102	$8,305,579	$1,313,033	$4,715,046	$42,032,760	$0.0053
3	$10,937,816	$3,294,158	$516,733	$1,820,415	$16,569,122	$0.0054
4	$335,707	$178,234	$57,703	$27,136	$598,779	$0.0132
5	$2,820,032	$918,436	$295,945	$326,911	$4,361,323	$0.0080
6	$864,905	$825,480	$226,950	$66,880	$1,984,214	$0.0177
7	$686,410	$839,834	$256,546	$20,684	$1,803,474	$0.0521
8	$800,065	$862,282	$340,401	$75,149	$2,077,896	$0.0165
9	$8,430,444	$16,612,355	$5,050,377	$440,412	$30,533,588	$0.0414
10	$166,537	$338,811	$100,380	$11,112	$616,840	$0.0332
11	$184,886	$274,878	$128,424	$11,665	$599,852	$0.0307
12	$47,163	$58,721	$23,603	$2,918	$132,405	$0.0271
13	$73,074	$158,693	$47,465	$3,298	$282,529	$0.0512
Total	$53,305,438	$32,745,410	$8,369,881	$7,565,877	$101,986,606	

TABLE B.1.121
Cost Responsibility and Unit Cost of Pavement Expenditures on Non-Interstate NHS, 2009–2012.

Vehicle Class	Cost Responsibility					Unit Cost [$/VMT]
	New Pavement Construction	Pavement Rehabilitation	Pavement Maintenance	Other Pavement Projects	Total	
1	$1,505,615	$365,916	$33,737	$154,911	$2,060,178	$0.0064
2	$162,753,652	$38,988,718	$3,594,720	$16,505,937	$221,843,027	$0.0064
3	$67,317,692	$15,541,213	$1,421,088	$6,372,717	$90,652,710	$0.0068
4	$2,230,303	$929,746	$180,000	$76,685	$3,416,734	$0.0213
5	$16,592,947	$4,331,582	$813,218	$923,849	$22,661,596	$0.0117
6	$5,575,417	$4,500,710	$731,627	$189,001	$10,996,755	$0.0278
7	$5,160,000	$4,707,572	$859,450	$58,454	$10,785,476	$0.0882
8	$6,584,047	$4,715,911	$1,127,000	$265,561	$12,692,519	$0.0228
9	$68,194,393	$93,205,119	$17,037,556	$1,689,992	$180,127,060	$0.0487
10	$1,462,831	$1,891,306	$336,569	$39,267	$3,729,973	$0.0453
11	$1,711,791	$1,514,895	$431,582	$41,222	$3,699,490	$0.0428
12	$422,122	$323,097	$79,011	$10,313	$834,542	$0.0386
13	$713,407	$890,694	$159,929	$11,653	$1,775,682	$0.0727
Total	$340,224,215	$171,906,480	$26,805,487	$26,339,564	$565,275,746	

B.1.5.3 Total Pavement Cost Allocation Results per Year for Non-NHS

TABLE B.1.122
Cost Responsibility and Unit Cost of Pavement Expenditures on Non-NHS, 2009

Vehicle Class	Cost Responsibility					Unit Cost [$/VMT]
	New Pavement Construction	Pavement Rehabilitation	Pavement Maintenance	Other Pavement Projects	Total	
1	$441,560	$164,316	$22,547	$38,271	$666,693	$0.0147
2	$49,779,802	$18,035,695	$2,474,784	$4,200,710	$74,490,990	$0.0149
3	$22,552,786	$7,954,361	$1,095,591	$1,808,580	$33,411,317	$0.0155
4	$451,002	$146,233	$50,879	$7,840	$655,954	$0.0704
5	$3,805,473	$1,020,462	$343,448	$141,477	$5,310,860	$0.0316
6	$3,848,259	$4,235,244	$1,090,706	$105,748	$9,279,957	$0.0738
7	$4,057,826	$5,049,218	$1,405,277	$36,480	$10,548,802	$0.2433
8	$2,691,599	$2,043,184	$892,604	$65,049	$5,692,436	$0.0736
9	$22,430,573	$30,813,751	$9,275,691	$358,715	$62,878,731	$0.1475
10	$637,219	$731,017	$212,758	$9,183	$1,590,178	$0.1457
11	$449,046	$102,263	$54,994	$1,875	$608,178	$0.2728
12	$143,650	$30,712	$14,184	$664	$189,211	$0.2396
13	$353,826	$393,085	$113,213	$3,054	$863,178	$0.2378
Total	$111,642,621	$70,719,541	$17,046,675	$6,777,647	$206,186,485	

TABLE B.1.123
Cost Responsibility and Unit Cost of Pavement Expenditures on Non-NHS, 2010.

Vehicle Class	Cost Responsibility					Unit Cost [$/VMT]
	New Pavement Construction	Pavement Rehabilitation	Pavement Maintenance	Other Pavement Projects	Total	
1	$192,040	$128,928	$21,371	$39,965	$382,304	$0.0084
2	$21,583,073	$14,151,461	$2,345,728	$4,386,621	$42,466,883	$0.0085
3	$10,129,569	$6,238,082	$1,043,890	$1,888,623	$19,300,164	$0.0090
4	$161,518	$113,026	$55,658	$8,281	$338,484	$0.0359
5	$1,546,523	$796,222	$355,948	$149,443	$2,848,135	$0.0168
6	$2,049,307	$3,264,944	$1,207,022	$111,702	$6,632,976	$0.0522
7	$2,339,894	$3,885,299	$1,577,362	$38,534	$7,841,089	$0.1789
8	$1,238,378	$1,575,717	$992,591	$68,712	$3,875,398	$0.0496
9	$8,618,178	$23,713,203	$10,382,904	$375,913	$43,090,199	$0.1008
10	$297,804	$562,678	$238,002	$9,700	$1,108,183	$0.1004
11	$96,741	$78,720	$61,631	$1,981	$239,074	$0.1061
12	$33,731	$23,649	$15,856	$702	$73,938	$0.0926
13	$170,867	$302,431	$127,054	$3,226	$603,578	$0.1645
Total	$48,457,624	$54,834,361	$18,425,017	$7,083,404	$128,800,405	

TABLE B.1.124
Cost Responsibility and Unit Cost of Pavement Expenditures on Non-NHS, 2011.

Vehicle Class	Cost Responsibility					Unit Cost [$/VMT]
	New Pavement Construction	Pavement Rehabilitation	Pavement Maintenance	Other Pavement Projects	Total	
1	$224,978	$65,776	$21,646	$125,710	$438,110	$0.0088
2	$25,198,058	$7,219,711	$2,375,885	$13,798,265	$48,591,920	$0.0089
3	$11,715,445	$3,173,617	$1,054,489	$5,940,726	$21,884,276	$0.0093
4	$148,585	$50,478	$51,237	$21,466	$271,766	$0.0321
5	$1,446,693	$365,237	$321,025	$387,364	$2,520,319	$0.0165
6	$1,940,296	$1,417,814	$1,116,590	$289,538	$4,764,238	$0.0417
7	$2,201,278	$1,668,822	$1,467,385	$99,883	$5,437,368	$0.1380
8	$925,827	$700,648	$927,702	$205,561	$2,759,738	$0.0340
9	$6,807,682	$10,227,572	$9,582,659	$758,287	$27,376,200	$0.0916
10	$207,426	$245,382	$222,129	$29,019	$703,956	$0.0615
11	$73,668	$35,079	$57,480	$5,926	$172,152	$0.0737
12	$26,052	$10,569	$14,795	$2,099	$53,514	$0.0646
13	$114,720	$131,088	$118,496	$9,652	$373,956	$0.0983
Total	$51,030,705	$25,311,794	$17,331,517	$21,673,498	$115,347,513	

TABLE B.1.125
Cost Responsibility and Unit Cost of Pavement Expenditures on Non-NHS, 2012.

Vehicle Class	Cost Responsibility					Unit Cost [$/VMT]
	New Pavement Construction	Pavement Rehabilitation	Pavement Maintenance	Other Pavement Projects	Total	
1	$194,238	$66,150	$26,720	$63,587	$350,695	$0.0065
2	$21,369,174	$7,260,830	$2,932,825	$6,979,438	$38,542,268	$0.0065
3	$9,328,195	$3,196,976	$1,304,547	$3,004,938	$16,834,656	$0.0066
4	$124,762	$58,572	$73,485	$19,580	$276,399	$0.0166
5	$1,455,517	$448,488	$524,027	$353,338	$2,781,370	$0.0092
6	$1,025,509	$1,645,592	$1,558,963	$264,106	$4,494,171	$0.0200
7	$553,227	$1,922,304	$1,980,604	$91,109	$4,547,245	$0.0586
8	$603,475	$779,438	$1,236,331	$115,534	$2,734,779	$0.0278
9	$3,672,124	$11,653,886	$12,874,571	$592,661	$28,793,242	$0.0570
10	$110,966	$276,940	$295,848	$16,310	$700,064	$0.0504
11	$77,895	$38,724	$76,494	$3,331	$196,443	$0.0692
12	$20,051	$11,644	$19,687	$1,180	$52,562	$0.0523
13	$50,904	$148,687	$157,796	$5,425	$362,812	$0.0785
Total	$38,586,036	$27,508,233	$23,061,899	$11,510,538	$100,666,706	

TABLE B.1.126
Cost Responsibility and Unit Cost of Pavement Expenditures on Non-NHS, 2009–2012.

Vehicle Class	Cost Responsibility					Unit Cost [$/VMT]
	New Pavement Construction	Pavement Rehabilitation	Pavement Maintenance	Other Pavement Projects	Total	
1	$1,052,816	$425,171	$92,283	$267,533	$1,837,803	$0.0094
2	$117,930,106	$46,667,697	$10,129,223	$29,365,035	$204,092,062	$0.0095
3	$53,725,994	$20,563,036	$4,498,516	$12,642,867	$91,430,413	$0.0099
4	$885,867	$368,309	$231,258	$57,168	$1,542,602	$0.0351
5	$8,254,205	$2,630,409	$1,544,449	$1,031,621	$13,460,684	$0.0170
6	$8,863,370	$10,563,596	$4,973,281	$771,094	$25,171,341	$0.0425
7	$9,152,225	$12,525,644	$6,430,628	$266,007	$28,374,504	$0.1389
8	$5,459,279	$5,098,987	$4,049,227	$454,857	$15,062,350	$0.0450
9	$41,528,557	$76,408,412	$42,115,826	$2,085,577	$162,138,371	$0.0978
10	$1,253,415	$1,816,017	$968,737	$64,212	$4,102,381	$0.0867
11	$697,349	$254,787	$250,598	$13,113	$1,215,847	$0.1259
12	$223,484	$76,574	$64,522	$4,645	$369,226	$0.1079
13	$690,317	$975,292	$516,558	$21,357	$2,203,524	$0.1401
Total	$249,716,985	$178,373,930	$75,865,108	$47,045,086	$551,001,109	

B.2. BRIDGE COST ALLOCATION RESULTS FOR STATE ROUTES

B.2.1 2009 Bridge Cost Allocation Results for State Routes

TABLE B.2.1.1
2009 Bridge Cost Allocation Results for Interstates.

2009	New Bridge Construction		Bridge Replacement		Bridge Rehab/Repair		In-House Maintenance		Bridge Total	
Vehicle Class	Cost Responsibility	Unit Cost ($/VMT)	Cost Responsibility	Unit Cost ($/VMT)	Cost Responsibility	Unit Cost ($/VMT)	Cost Responsibility	Unit Cost ($/VMT)	Cost Responsibility	Unit Cost ($/VMT)
1	$53,906	$0.0009	$118,094	$0.0020	$16,844	$0.0003	$3,052	$0.00005	$191,896	$0.0033
2	$7,800,395	$0.0009	$17,090,877	$0.0020	$2,436,768	$0.0003	$441,559	$0.00005	$27,769,598	$0.0033
3	$2,649,661	$0.0009	$5,811,654	$0.0021	$826,899	$0.0003	$149,684	$0.00005	$9,437,898	$0.0033
4	$65,269	$0.0011	$140,582	$0.0024	$24,981	$0.0004	$4,141	$0.00007	$234,973	$0.0041
5	$643,373	$0.0010	$1,323,122	$0.0021	$257,652	$0.0004	$45,939	$0.00007	$2,270,087	$0.0035
6	$118,136	$0.0011	$253,206	$0.0024	$48,123	$0.0005	$7,631	$0.00007	$427,096	$0.0040
7	$38,388	$0.0022	$98,288	$0.0058	$10,439	$0.0006	$1,220	$0.00007	$148,335	$0.0087
8	$213,028	$0.0011	$463,258	$0.0023	$103,198	$0.0005	$16,725	$0.00008	$796,210	$0.0040
9	$5,392,193	$0.0017	$10,371,788	$0.0032	$2,001,003	$0.0006	$275,737	$0.00008	$18,040,720	$0.0055
10	$118,102	$0.0038	$293,506	$0.0094	$20,038	$0.0006	$2,641	$0.00008	$434,286	$0.0139
11	$139,851	$0.0014	$334,634	$0.0034	$60,179	$0.0006	$8,300	$0.00008	$542,964	$0.0055
12	$98,454	$0.0027	$247,651	$0.0067	$22,368	$0.0006	$3,135	$0.00008	$371,608	$0.0100
13	$69,088	$0.0072	$172,189	$0.0178	$7,325	$0.0008	$818	$0.00008	$249,419	$0.0258
Total	$17,399,844		$36,718,848		$5,835,817		$960,582		$60,915,091	

TABLE B.2.1.2
2009 Bridge Cost Allocation Results for Non-Interstate NHS.

2009	New Bridge Construction		Bridge Replacement		Bridge Rehab/Repair		In-House Maintenance		Bridge Total	
Vehicle Class	Cost Responsibility	Unit Cost ($/VMT)	Cost Responsibility	Unit Cost ($/VMT)	Cost Responsibility	Unit Cost ($/VMT)	Cost Responsibility	Unit Cost ($/VMT)	Cost Responsibility	Unit Cost ($/VMT)
1	$69,345	$0.0008	$76,289	$0.0009	$4,001	$0.0000	$2,341	$0.00003	$151,976	$0.0018
2	$7,435,518	$0.0008	$8,260,184	$0.0009	$426,302	$0.0000	$249,459	$0.00003	$16,371,463	$0.0018
3	$2,955,560	$0.0008	$3,368,715	$0.0009	$167,290	$0.0000	$96,313	$0.00003	$6,587,878	$0.0018
4	$90,069	$0.0021	$103,336	$0.0024	$7,436	$0.0002	$2,569	$0.00006	$203,410	$0.0047
5	$931,623	$0.0018	$816,466	$0.0016	$52,108	$0.0001	$30,953	$0.00006	$1,831,151	$0.0035
6	$221,623	$0.0021	$249,112	$0.0023	$23,008	$0.0002	$6,332	$0.00006	$500,076	$0.0047
7	$144,049	$0.0044	$290,375	$0.0088	$19,258	$0.0006	$1,959	$0.00006	$455,641	$0.0138
8	$303,917	$0.0020	$321,943	$0.0022	$32,131	$0.0002	$8,880	$0.00006	$666,871	$0.0045
9	$2,877,861	$0.0025	$3,331,301	$0.0029	$455,753	$0.0004	$69,474	$0.00006	$6,734,389	$0.0058
10	$90,540	$0.0041	$182,842	$0.0083	$10,560	$0.0005	$1,313	$0.00006	$285,254	$0.0129
11	$63,336	$0.0027	$100,320	$0.0043	$10,094	$0.0004	$1,378	$0.00006	$175,128	$0.0076
12	$20,412	$0.0035	$48,063	$0.0083	$2,350	$0.0004	$345	$0.00006	$71,170	$0.0123
13	$42,381	$0.0065	$104,916	$0.0160	$4,630	$0.0007	$390	$0.00006	$152,317	$0.0232
Total	$15,246,234		$17,253,863		$1,214,920		$471,706		$34,186,723	

TABLE B.2.1.3
2009 Bridge Cost Allocation Results for Non-NHS

2009	New Bridge Construction		Bridge Replacement		Bridge Rehab/Repair		In-House Maintenance		Bridge Total	
Vehicle Class	Cost Responsibility	Unit Cost ($/VMT)	Cost Responsibility	Unit Cost ($/VMT)	Cost Responsibility	Unit Cost ($/VMT)	Cost Responsibility	Unit Cost ($/VMT)	Cost Responsibility	Unit Cost ($/VMT)
1	$85,609	$0.0019	$101,704	$0.0022	$3,162	$0.0001	$5,019	$0.00011	$195,494	$0.0043
2	$9,399,425	$0.0019	$11,230,327	$0.0022	$347,028	$0.0001	$550,917	$0.00011	$21,527,697	$0.0043
3	$4,062,548	$0.0019	$4,995,160	$0.0023	$152,421	$0.0001	$237,193	$0.00011	$9,447,321	$0.0044
4	$58,648	$0.0063	$68,030	$0.0073	$2,327	$0.0002	$2,262	$0.00024	$131,267	$0.0141
5	$733,563	$0.0044	$687,630	$0.0041	$24,547	$0.0001	$40,820	$0.00024	$1,486,560	$0.0088
6	$712,258	$0.0057	$702,661	$0.0056	$37,081	$0.0003	$30,511	$0.00024	$1,482,512	$0.0118
7	$643,956	$0.0149	$862,953	$0.0199	$30,358	$0.0007	$10,526	$0.00024	$1,547,793	$0.0357
8	$406,364	$0.0053	$437,399	$0.0057	$24,786	$0.0003	$18,768	$0.00024	$887,317	$0.0115
9	$1,854,905	$0.0044	$3,776,231	$0.0089	$250,457	$0.0006	$103,499	$0.00024	$5,985,091	$0.0140
10	$144,990	$0.0133	$182,154	$0.0167	$6,453	$0.0006	$2,650	$0.00024	$336,246	$0.0308
11	$24,063	$0.0108	$51,973	$0.0233	$1,365	$0.0006	$541	$0.00024	$77,942	$0.0350
12	$27,267	$0.0345	$46,536	$0.0589	$486	$0.0006	$192	$0.00024	$74,481	$0.0943
13	$106,431	$0.0293	$166,031	$0.0457	$3,163	$0.0009	$881	$0.00024	$276,506	$0.0762
Total	$18,260,027		$23,308,787		$883,633		$1,003,779		$43,456,226	

B.2.2 2010 Bridge Cost Allocation Results for State Routes

TABLE B.2.2.1
2010 Bridge Cost Allocation Results for Interstates

2010	New Bridge Construction		Bridge Replacement		Bridge Rehab/Repair		In-House Maintenance		Bridge Total	
Vehicle Class	Cost Responsibility	Unit Cost ($/VMT)	Cost Responsibility	Unit Cost ($/VMT)	Cost Responsibility	Unit Cost ($/VMT)	Cost Responsibility	Unit Cost ($/VMT)	Cost Responsibility	Unit Cost ($/VMT)
1	$101,343	$0.0017	$88,762	$0.0015	$9,671	$0.0002	$3,514	$0.00006	$203,291	$0.0035
2	$14,666,148	$0.0017	$12,847,354	$0.0015	$1,399,024	$0.0002	$508,408	$0.00006	$29,420,933	$0.0035
3	$4,994,534	$0.0017	$4,383,151	$0.0015	$474,281	$0.0002	$172,345	$0.00006	$10,024,312	$0.0035
4	$134,529	$0.0024	$102,520	$0.0018	$12,525	$0.0002	$4,544	$0.00008	$254,118	$0.0045
5	$1,313,176	$0.0021	$976,273	$0.0016	$138,331	$0.0002	$50,419	$0.00008	$2,478,199	$0.0040
6	$244,264	$0.0024	$186,707	$0.0018	$23,143	$0.0002	$8,375	$0.00008	$462,489	$0.0045
7	$72,805	$0.0044	$62,355	$0.0038	$3,800	$0.0002	$1,339	$0.00008	$140,299	$0.0085
8	$453,109	$0.0024	$334,826	$0.0018	$50,647	$0.0003	$18,356	$0.00010	$856,939	$0.0045
9	$10,366,254	$0.0033	$7,275,738	$0.0023	$845,251	$0.0003	$302,796	$0.00010	$18,790,039	$0.0060
10	$187,400	$0.0062	$148,003	$0.0049	$8,195	$0.0003	$2,899	$0.00010	$346,496	$0.0115
11	$285,018	$0.0030	$218,323	$0.0023	$25,429	$0.0003	$9,109	$0.00010	$537,879	$0.0057
12	$167,441	$0.0047	$132,728	$0.0037	$9,642	$0.0003	$3,441	$0.00010	$313,252	$0.0087
13	$103,396	$0.0111	$83,210	$0.0089	$2,602	$0.0003	$897	$0.00010	$190,106	$0.0204
Total	$33,089,417		$26,839,950		$3,002,543		$1,086,442		$64,018,352	

TABLE B.2.2.2
2010 Bridge Cost Allocation Results for Non-Interstate NHS

2010	New Bridge Construction		Bridge Replacement		Bridge Rehab/Repair		In-House Maintenance		Bridge Total	
Vehicle Class	Cost Responsibility	Unit Cost ($/VMT)	Cost Responsibility	Unit Cost ($/VMT)	Cost Responsibility	Unit Cost ($/VMT)	Cost Responsibility	Unit Cost ($/VMT)	Cost Responsibility	Unit Cost ($/VMT)
1	$154,832	$0.0019	$151,362	$0.0018	$7,306	$0.0001	$2,400	$0.00003	$315,900	$0.0038
2	$16,514,617	$0.0019	$16,191,191	$0.0018	$778,442	$0.0001	$255,768	$0.00003	$33,740,018	$0.0038
3	$6,409,218	$0.0019	$6,393,363	$0.0019	$300,758	$0.0001	$98,749	$0.00003	$13,202,087	$0.0039
4	$175,461	$0.0041	$190,414	$0.0045	$8,404	$0.0002	$2,699	$0.00006	$376,979	$0.0089
5	$1,852,483	$0.0036	$1,654,621	$0.0032	$98,189	$0.0002	$32,514	$0.00006	$3,637,807	$0.0071
6	$431,506	$0.0041	$467,681	$0.0045	$21,081	$0.0002	$6,652	$0.00006	$926,919	$0.0089
7	$276,265	$0.0086	$959,412	$0.0297	$7,595	$0.0002	$2,057	$0.00006	$1,245,330	$0.0386
8	$576,773	$0.0039	$607,279	$0.0041	$29,532	$0.0002	$9,328	$0.00006	$1,222,912	$0.0084
9	$5,798,729	$0.0050	$7,290,314	$0.0063	$250,711	$0.0002	$74,134	$0.00006	$13,413,889	$0.0115
10	$204,165	$0.0094	$716,586	$0.0331	$4,931	$0.0002	$1,379	$0.00006	$927,060	$0.0428
11	$119,925	$0.0053	$214,947	$0.0095	$5,006	$0.0002	$1,448	$0.00006	$341,326	$0.0150
12	$43,222	$0.0076	$138,573	$0.0244	$1,252	$0.0002	$362	$0.00006	$183,410	$0.0323
13	$95,110	$0.0148	$384,804	$0.0599	$1,609	$0.0003	$409	$0.00006	$481,932	$0.0750
Total	$32,652,304		$35,360,549		$1,514,815		$487,900		$70,015,569	

TABLE B.2.2.3
2010 Bridge Cost Allocation Results for Non-NHS

2010	New Bridge Construction		Bridge Replacement		Bridge Rehab/Repair		In-House Maintenance		Bridge Total	
Vehicle Class	Cost Responsibility	Unit Cost ($/VMT)	Cost Responsibility	Unit Cost ($/VMT)	Cost Responsibility	Unit Cost ($/VMT)	Cost Responsibility	Unit Cost ($/VMT)	Cost Responsibility	Unit Cost ($/VMT)
1	$7,001	$0.0002	$62,726	$0.0014	$5,515	$0.0001	$4,453	$0.00010	$79,694	$0.0018
2	$771,374	$0.0002	$6,954,809	$0.0014	$605,349	$0.0001	$488,734	$0.00010	$8,820,266	$0.0018
3	$337,993	$0.0002	$3,108,879	$0.0014	$260,721	$0.0001	$210,420	$0.00010	$3,918,014	$0.0018
4	$4,584	$0.0005	$60,741	$0.0064	$2,249	$0.0002	$2,030	$0.00022	$69,605	$0.0074
5	$49,508	$0.0003	$496,180	$0.0029	$36,920	$0.0002	$36,630	$0.00022	$619,238	$0.0036
6	$57,651	$0.0005	$522,497	$0.0041	$31,189	$0.0002	$27,380	$0.00022	$638,716	$0.0050
7	$97,488	$0.0022	$606,716	$0.0138	$20,508	$0.0005	$9,445	$0.00022	$734,157	$0.0167
8	$31,280	$0.0004	$312,491	$0.0040	$18,373	$0.0002	$16,842	$0.00022	$378,986	$0.0048
9	$324,203	$0.0008	$2,497,086	$0.0058	$128,012	$0.0003	$92,141	$0.00022	$3,041,442	$0.0071
10	$23,960	$0.0022	$163,161	$0.0148	$5,056	$0.0005	$2,378	$0.00022	$194,555	$0.0176
11	$1,988	$0.0009	$48,166	$0.0214	$623	$0.0003	$486	$0.00022	$51,263	$0.0228
12	$6,529	$0.0082	$161,866	$0.2028	$914	$0.0011	$172	$0.00022	$169,481	$0.2123
13	$26,457	$0.0072	$212,278	$0.0578	$3,913	$0.0011	$791	$0.00022	$243,440	$0.0663
Total	$1,740,017		$15,207,594		$1,119,344		$891,901		$18,958,856	

B.2.3 2011 Bridge Cost Allocation Results for State Routes

TABLE B.2.3.1
2011 Bridge Cost Allocation Results for Interstates

2011	New Bridge Construction		Bridge Replacement		Bridge Rehab/Repair		In-House Maintenance		Bridge Total	
Vehicle Class	Cost Responsibility	Unit Cost ($/VMT)	Cost Responsibility	Unit Cost ($/VMT)	Cost Responsibility	Unit Cost ($/VMT)	Cost Responsibility	Unit Cost ($/VMT)	Cost Responsibility	Unit Cost ($/VMT)
1	$261,899	$0.0037	$36,687	$0.0005	$49,430	$0.0007	$3,063	$0.00004	$351,078	$0.0050
2	$37,889,083	$0.0037	$5,309,163	$0.0005	$7,150,816	$0.0007	$443,052	$0.00004	$50,792,114	$0.0050
3	$12,849,114	$0.0037	$1,807,198	$0.0005	$2,424,213	$0.0007	$150,190	$0.00004	$17,230,716	$0.0050
4	$308,190	$0.0065	$53,533	$0.0011	$46,825	$0.0010	$2,811	$0.00006	$411,358	$0.0086
5	$3,215,293	$0.0061	$460,829	$0.0009	$487,318	$0.0009	$31,184	$0.00006	$4,194,624	$0.0079
6	$561,406	$0.0064	$95,408	$0.0011	$85,501	$0.0010	$5,180	$0.00006	$747,495	$0.0085
7	$134,050	$0.0096	$48,914	$0.0035	$24,292	$0.0017	$828	$0.00006	$208,084	$0.0148
8	$507,059	$0.0040	$134,806	$0.0011	$129,161	$0.0010	$8,784	$0.00007	$779,811	$0.0062
9	$14,212,320	$0.0069	$3,152,021	$0.0015	$2,356,614	$0.0011	$144,823	$0.00007	$19,865,778	$0.0096
10	$147,902	$0.0075	$94,814	$0.0048	$48,130	$0.0024	$1,387	$0.00007	$292,233	$0.0147
11	$267,695	$0.0043	$101,388	$0.0016	$75,347	$0.0012	$4,359	$0.00007	$448,789	$0.0072
12	$130,858	$0.0056	$77,165	$0.0033	$43,899	$0.0019	$1,647	$0.00007	$253,568	$0.0108
13	$78,229	$0.0127	$58,557	$0.0095	$25,149	$0.0041	$429	$0.00007	$162,364	$0.0265
Total	$70,563,096		$11,430,485		$12,946,695		$797,737		$95,738,012	

TABLE B.2.3.2
2011 Bridge Cost Allocation Results for Non-Interstate NHS

2011	New Bridge Construction		Bridge Replacement		Bridge Rehab/Repair		In-House Maintenance		Bridge Total	
Vehicle Class	Cost Responsibility	Unit Cost ($/VMT)	Cost Responsibility	Unit Cost ($/VMT)	Cost Responsibility	Unit Cost ($/VMT)	Cost Responsibility	Unit Cost ($/VMT)	Cost Responsibility	Unit Cost ($/VMT)
1	$78,988	$0.0010	$56,455	$0.0007	$965	$0.00001	$2,180	$0.00003	$138,587	$0.0017
2	$8,425,064	$0.0010	$6,041,970	$0.0007	$102,795	$0.00001	$232,285	$0.00003	$14,802,114	$0.0017
3	$3,270,742	$0.0010	$2,400,395	$0.0007	$39,702	$0.00001	$89,682	$0.00003	$5,800,522	$0.0018
4	$97,667	$0.0033	$83,829	$0.0028	$784	$0.00003	$1,775	$0.00006	$184,055	$0.0062
5	$883,012	$0.0025	$649,171	$0.0018	$9,441	$0.00003	$21,381	$0.00006	$1,563,006	$0.0044
6	$249,994	$0.0034	$209,241	$0.0029	$1,942	$0.00003	$4,374	$0.00006	$465,551	$0.0064
7	$304,535	$0.0135	$263,310	$0.0117	$623	$0.00003	$1,353	$0.00006	$569,822	$0.0254
8	$219,360	$0.0016	$273,244	$0.0020	$3,597	$0.00003	$8,145	$0.00006	$504,346	$0.0037
9	$2,500,902	$0.0040	$2,406,826	$0.0038	$16,835	$0.00003	$38,080	$0.00006	$4,962,644	$0.0078
10	$180,065	$0.0090	$188,929	$0.0094	$539	$0.00003	$1,204	$0.00006	$370,737	$0.0185
11	$61,856	$0.0029	$78,321	$0.0037	$558	$0.00003	$1,264	$0.00006	$142,000	$0.0068
12	$31,686	$0.0060	$39,465	$0.0075	$140	$0.00003	$316	$0.00006	$71,608	$0.0136
13	$97,768	$0.0165	$93,359	$0.0157	$162	$0.00003	$357	$0.00006	$191,647	$0.0323
Total	$16,401,640		$12,784,516		$178,082		$402,399		$29,766,638	

TABLE B.2.3.3
2011 Bridge Cost Allocation Results for Non-NHS

2011	New Bridge Construction		Bridge Replacement		Bridge Rehab/Repair		In-House Maintenance		Bridge Total	
Vehicle Class	Cost Responsibility	Unit Cost ($/VMT)	Cost Responsibility	Unit Cost ($/VMT)	Cost Responsibility	Unit Cost ($/VMT)	Cost Responsibility	Unit Cost ($/VMT)	Cost Responsibility	Unit Cost ($/VMT)
1	$51,704	$0.0010	$86,221	$0.0017	$1,427	$0.00003	$4,333	$0.00009	$143,684	$0.0029
2	$5,652,050	$0.0010	$9,518,534	$0.0017	$156,580	$0.00003	$475,592	$0.00009	$15,802,755	$0.0029
3	$2,402,905	$0.0010	$4,215,082	$0.0018	$67,549	$0.00003	$204,762	$0.00009	$6,890,298	$0.0029
4	$27,274	$0.0032	$52,400	$0.0062	$600	$0.00007	$1,628	$0.00019	$81,902	$0.0097
5	$308,023	$0.0020	$610,322	$0.0040	$9,438	$0.00006	$29,373	$0.00019	$957,156	$0.0063
6	$277,225	$0.0024	$618,049	$0.0054	$9,766	$0.00009	$21,955	$0.00019	$926,995	$0.0081
7	$342,936	$0.0087	$1,057,542	$0.0268	$6,599	$0.00017	$7,574	$0.00019	$1,414,651	$0.0359
8	$207,144	$0.0026	$327,006	$0.0040	$6,491	$0.00008	$15,587	$0.00019	$556,228	$0.0069
9	$769,920	$0.0026	$2,490,878	$0.0083	$40,577	$0.00014	$57,500	$0.00019	$3,358,874	$0.0112
10	$83,377	$0.0073	$149,075	$0.0130	$1,553	$0.00014	$2,200	$0.00019	$236,206	$0.0206
11	$13,715	$0.0059	$26,975	$0.0115	$233	$0.00010	$449	$0.00019	$41,372	$0.0177
12	$19,736	$0.0238	$43,247	$0.0522	$146	$0.00018	$159	$0.00019	$63,288	$0.0765
13	$69,290	$0.0182	$155,780	$0.0409	$828	$0.00022	$732	$0.00019	$226,629	$0.0595
Total	$10,225,299		$19,351,110		$301,785		$821,845		$30,700,039	

B.2.4 2012 Bridge Cost Allocation Results for State Routes

TABLE B.2.4.1
2012 Bridge Cost Allocation Results for Interstates

2012	New Bridge Construction		Bridge Replacement		Bridge Rehab/Repair		In-House Maintenance		Bridge Total	
Vehicle Class	Cost Responsibility	Unit Cost ($/VMT)	Cost Responsibility	Unit Cost ($/VMT)	Cost Responsibility	Unit Cost ($/VMT)	Cost Responsibility	Unit Cost ($/VMT)	Cost Responsibility	Unit Cost ($/VMT)
1	$32,726	$0.0005	$5,510	$0.0001	$362	$0.00001	$4,313	$0.00006	$42,911	$0.0006
2	$4,734,425	$0.0005	$798,519	$0.0001	$52,375	$0.00001	$624,011	$0.00006	$6,209,329	$0.0006
3	$1,605,288	$0.0005	$274,130	$0.0001	$17,757	$0.00001	$211,533	$0.00006	$2,108,709	$0.0006
4	$19,839	$0.0005	$9,134	$0.0002	$318	$0.00001	$3,705	$0.00008	$32,997	$0.0008
5	$204,983	$0.0004	$68,900	$0.0001	$3,418	$0.00001	$41,107	$0.00008	$318,407	$0.0007
6	$36,126	$0.0004	$17,083	$0.0002	$591	$0.00001	$6,828	$0.00008	$60,628	$0.0008
7	$9,587	$0.0007	$8,941	$0.0007	$119	$0.00001	$1,092	$0.00008	$19,739	$0.0015
8	$50,214	$0.0003	$40,092	$0.0003	$1,371	$0.00001	$16,073	$0.00010	$107,750	$0.0007
9	$1,231,309	$0.0005	$793,728	$0.0003	$21,323	$0.00001	$239,479	$0.00010	$2,285,839	$0.0010
10	$20,111	$0.0008	$22,043	$0.0009	$292	$0.00001	$2,538	$0.00010	$44,984	$0.0018
11	$30,013	$0.0004	$32,940	$0.0004	$739	$0.00001	$7,976	$0.00010	$71,669	$0.0009
12	$17,545	$0.0006	$20,918	$0.0007	$317	$0.00001	$3,013	$0.00010	$41,793	$0.0014
13	$11,075	$0.0014	$12,514	$0.0016	$115	$0.00001	$786	$0.00010	$24,489	$0.0031
Total	$8,003,241		$2,104,451		$99,097		$1,162,455		$11,369,244	

TABLE B.2.4.2
2012 Bridge Cost Allocation Results for Non-Interstate NHS

2012	New Bridge Construction		Bridge Replacement		Bridge Rehab/Repair		In-House Maintenance		Bridge Total	
Vehicle Class	Cost Responsibility	Unit Cost ($/VMT)	Cost Responsibility	Unit Cost ($/VMT)	Cost Responsibility	Unit Cost ($/VMT)	Cost Responsibility	Unit Cost ($/VMT)	Cost Responsibility	Unit Cost ($/VMT)
1	$134,989	$0.0018	$74,107	$0.0010	$3,758	$0.0001	$2,614	$0.00004	$215,467	$0.0029
2	$14,384,234	$0.0018	$7,899,687	$0.0010	$400,389	$0.0001	$278,517	$0.00004	$22,962,826	$0.0029
3	$5,560,459	$0.0018	$3,073,682	$0.0010	$157,331	$0.0001	$107,532	$0.00004	$8,899,004	$0.0029
4	$161,011	$0.0035	$92,892	$0.0020	$7,807	$0.0002	$3,526	$0.00008	$265,236	$0.0058
5	$1,607,956	$0.0029	$850,123	$0.0016	$55,941	$0.0001	$42,483	$0.00008	$2,556,503	$0.0047
6	$395,685	$0.0035	$228,826	$0.0020	$24,004	$0.0002	$8,691	$0.00008	$657,206	$0.0059
7	$301,987	$0.0087	$576,626	$0.0167	$19,717	$0.0006	$2,688	$0.00008	$901,018	$0.0260
8	$189,616	$0.0015	$165,226	$0.0013	$30,793	$0.0002	$9,766	$0.00008	$395,400	$0.0031
9	$3,130,338	$0.0042	$2,191,953	$0.0030	$431,004	$0.0006	$57,233	$0.00008	$5,810,528	$0.0079
10	$90,589	$0.0049	$179,900	$0.0097	$9,583	$0.0005	$1,444	$0.00008	$281,515	$0.0151
11	$38,885	$0.0020	$39,587	$0.0020	$9,797	$0.0005	$1,516	$0.00008	$89,784	$0.0046
12	$15,325	$0.0031	$25,216	$0.0052	$2,150	$0.0004	$379	$0.00008	$43,070	$0.0088
13	$49,698	$0.0090	$113,073	$0.0205	$4,154	$0.0008	$429	$0.00008	$167,354	$0.0303
Total	$26,060,771		$15,510,895		$1,156,428		$516,819		$43,244,912	

TABLE B.2.4.3
2012 Bridge Cost Allocation Results for Non-NHS

2012	New Bridge Construction		Bridge Replacement		Bridge Rehab/Repair		In-House Maintenance		Bridge Total	
Vehicle Class	Cost Responsibility	Unit Cost ($/VMT)	Cost Responsibility	Unit Cost ($/VMT)	Cost Responsibility	Unit Cost ($/VMT)	Cost Responsibility	Unit Cost ($/VMT)	Cost Responsibility	Unit Cost ($/VMT)
1	$74,462	$0.0014	$49,090	$0.0009	$4,033	$0.0001	$4,421	$0.00008	$132,006	$0.0024
2	$8,005,404	$0.0013	$5,415,705	$0.0009	$442,664	$0.0001	$485,219	$0.00008	$14,348,992	$0.0024
3	$3,206,296	$0.0013	$2,405,630	$0.0009	$192,596	$0.0001	$208,907	$0.00008	$6,013,429	$0.0023
4	$79,565	$0.0048	$60,295	$0.0036	$3,803	$0.0002	$2,995	$0.00018	$146,657	$0.0088
5	$680,866	$0.0023	$550,341	$0.0018	$45,338	$0.0002	$54,042	$0.00018	$1,330,586	$0.0044
6	$327,892	$0.0015	$516,389	$0.0023	$53,783	$0.0002	$40,394	$0.00018	$938,458	$0.0042
7	$430,285	$0.0055	$618,180	$0.0080	$47,379	$0.0006	$13,935	$0.00018	$1,109,780	$0.0143
8	$101,566	$0.0010	$224,527	$0.0023	$21,169	$0.0002	$17,671	$0.00018	$364,932	$0.0037
9	$2,209,040	$0.0044	$2,108,035	$0.0042	$219,730	$0.0004	$90,646	$0.00018	$4,627,450	$0.0092
10	$72,052	$0.0052	$97,769	$0.0070	$6,916	$0.0005	$2,495	$0.00018	$179,232	$0.0129
11	$15,639	$0.0055	$33,614	$0.0118	$1,117	$0.0004	$509	$0.00018	$50,879	$0.0179
12	$77,735	$0.0773	$27,828	$0.0277	$1,054	$0.0010	$180	$0.00018	$106,797	$0.1062
13	$88,174	$0.0191	$97,660	$0.0211	$5,031	$0.0011	$830	$0.00018	$191,695	$0.0415
Total	$15,368,976		$12,205,063		$1,044,613		$922,243		$29,540,894	

B.3. SAFETY, MOBILITY, AND OTHER COST ALLOCATION RESULTS FOR STATE ROUTES

B.3.1 2009 Safety, Mobility, and Other Cost Allocation Results for State Routes

TABLE B.3.1.1
2009 Safety, Mobility and Other Cost Allocation Results for Interstates.

Vehicle Class	Safety	Mobility	Drainage and Erosion Control	Miscellaneous	Other Projects
1	$132,765	$6,271	$76,920	$254,914	$11,228
2	$19,206,662	$907,241	$11,127,770	$36,877,423	$1,624,382
3	$6,510,871	$307,546	$3,772,205	$12,501,086	$550,650
4	$180,105	$8,507	$104,348	$256,154	$15,232
5	$1,998,244	$94,389	$1,157,723	$2,841,996	$168,999
6	$331,923	$15,679	$192,306	$472,076	$28,072
7	$53,068	$2,507	$30,746	$75,476	$4,488
8	$727,504	$34,364	$421,494	$873,019	$61,528
9	$11,993,837	$566,538	$6,948,873	$14,392,851	$1,014,365
10	$114,893	$5,427	$66,566	$137,874	$9,717
11	$361,025	$17,053	$209,167	$433,237	$30,533
12	$136,375	$6,442	$79,011	$163,652	$11,534
13	$35,567	$1,680	$20,606	$42,681	$3,008

Vehicle Class	In-House Maintenance	Preliminary Engineering	Right-of-Way	Utility and Railway
1	$18,952	$131,938	$63,571	$25,507
2	$2,741,669	$19,086,918	$9,196,619	$3,690,054
3	$929,399	$6,470,279	$3,117,564	$1,250,892
4	$25,709	$178,982	$86,239	$34,602
5	$285,241	$1,985,786	$956,808	$383,910
6	$47,381	$329,853	$158,933	$63,770
7	$7,575	$52,737	$25,410	$10,196
8	$103,848	$722,968	$348,346	$139,771
9	$1,712,069	$11,919,061	$5,742,942	$2,304,300
10	$16,401	$114,177	$55,014	$22,074
11	$51,535	$358,774	$172,868	$69,361
12	$19,467	$135,524	$65,300	$26,201
13	$5,077	$35,345	$17,030	$6,833

TABLE B.3.1.2
2009 Total Others Cost Responsibility and Unit Cost Results for Interstates.

Vehicle Class	Cost Responsibility	Cost Responsibility Share	Unit Cost ($/VMT)
1	$722,067	0.33%	$0.0125
2	$104,458,737	48.28%	$0.0125
3	$35,410,492	16.37%	$0.0125
4	$889,879	0.41%	$0.0154
5	$9,873,097	4.56%	$0.0154
6	$1,639,992	0.76%	$0.0154
7	$262,202	0.12%	$0.0154
8	$3,432,841	1.59%	$0.0174
9	$56,594,837	26.16%	$0.0174
10	$542,142	0.25%	$0.0174
11	$1,703,554	0.79%	$0.0174
12	$643,506	0.30%	$0.0174
13	$167,828	0.08%	$0.0174

TABLE B.3.1.3
2009 Safety, Mobility and Other Cost Allocation Results for Non-Interstate NHS.

Vehicle Class	Safety	Mobility	Drainage and Erosion Control	Miscellaneous	Other Projects
1	$135,395	$-	$180,337	$277,336	$2,248
2	$14,426,461	$-	$19,215,058	$29,550,470	$239,561
3	$5,569,860	$-	$7,418,672	$11,409,034	$92,491
4	$148,587	$-	$197,907	$138,345	$2,467
5	$1,790,075	$-	$2,384,257	$1,666,683	$29,725
6	$366,214	$-	$487,772	$340,970	$6,081
7	$113,262	$-	$150,858	$105,455	$1,881
8	$513,549	$-	$684,013	$478,150	$8,528
9	$4,017,766	$-	$5,351,388	$3,740,817	$66,718
10	$75,936	$-	$101,141	$70,702	$1,261
11	$79,717	$-	$106,178	$74,222	$1,324
12	$19,944	$-	$26,564	$18,569	$331
13	$22,535	$-	$30,016	$20,982	$374

Vehicle Class	In-House Maintenance	Preliminary Engineering	Right-of-Way	Utility and Railway
1	$49,545	$197,323	$111,850	$96,791
2	$5,279,038	$21,025,035	$11,917,746	$10,313,199
3	$2,038,165	$8,117,479	$4,601,279	$3,981,786
4	$54,372	$216,549	$122,748	$106,222
5	$655,037	$2,608,844	$1,478,786	$1,279,690
6	$134,008	$533,718	$302,531	$261,799
7	$41,446	$165,068	$93,566	$80,969
8	$187,922	$748,444	$424,245	$367,127
9	$1,470,211	$5,855,466	$3,319,089	$2,872,223
10	$27,787	$110,669	$62,731	$54,285
11	$29,171	$116,179	$65,854	$56,988
12	$7,298	$29,066	$16,476	$14,257
13	$8,246	$32,843	$18,617	$16,110

TABLE B.3.1.4
2009 Total Others Cost Responsibility and Unit Cost Results for Non-Interstate NHS.

Vehicle Class	Cost Responsibility	Cost Responsibility Share	Unit Cost ($/VMT)
1	$1,050,825	0.52%	$0.0121
2	$111,966,567	54.96%	$0.0121
3	$43,228,767	21.22%	$0.0121
4	$987,197	0.48%	$0.0228
5	$11,893,098	5.84%	$0.0228
6	$2,433,093	1.19%	$0.0228
7	$752,505	0.37%	$0.0228
8	$3,411,976	1.67%	$0.0228
9	$26,693,678	13.10%	$0.0228
10	$504,512	0.25%	$0.0228
11	$529,633	0.26%	$0.0228
12	$132,504	0.07%	$0.0228
13	$149,723	0.07%	$0.0228

TABLE B.3.1.5
2009 Safety, Mobility and Other Cost Allocation Results for Non-NHS.

Vehicle Class	Safety	Mobility	Drainage and Erosion Control	Miscellaneous	Other Projects
1	$407,860	$20,060	$408,846	$686,004	$66,672
2	$44,767,692	$2,201,799	$44,875,845	$75,297,388	$7,318,082
3	$19,274,350	$947,966	$19,320,914	$32,418,652	$3,150,738
4	$183,816	$9,041	$184,260	$140,532	$30,048
5	$3,317,036	$163,141	$3,325,049	$2,535,962	$542,229
6	$2,479,348	$121,941	$2,485,337	$1,895,527	$405,294
7	$855,309	$42,066	$857,376	$653,907	$139,816
8	$1,525,128	$75,010	$1,528,812	$1,166,000	$249,309
9	$8,410,358	$413,645	$8,430,676	$6,429,941	$1,374,824
10	$215,302	$10,589	$215,822	$164,604	$35,195
11	$43,967	$2,162	$44,073	$33,614	$7,187
12	$15,575	$766	$15,612	$11,907	$2,546
13	$71,610	$3,522	$71,783	$54,748	$11,706

Vehicle Class	In-House Maintenance	Preliminary Engineering	Right-of-Way	Utility and Railway
1	$83,456	$21,384	$173,583	$78,480
2	$9,160,373	$2,347,153	$19,052,867	$8,614,153
3	$3,943,921	$1,010,547	$8,203,050	$3,708,751
4	$37,612	$9,637	$78,231	$35,370
5	$678,732	$173,911	$1,411,711	$638,261
6	$507,325	$129,991	$1,055,196	$477,074
7	$175,014	$44,844	$364,015	$164,578
8	$312,072	$79,962	$649,085	$293,463
9	$1,720,929	$440,952	$3,579,399	$1,618,312
10	$44,055	$11,288	$91,631	$41,428
11	$8,997	$2,305	$18,712	$8,460
12	$3,187	$817	$6,628	$2,997
13	$14,653	$3,755	$30,477	$13,779

TABLE B.3.1.6
2009 Total Others Cost Responsibility and Unit Cost Results for Non-NHS.

Vehicle Class	Cost Responsibility	Cost Responsibility Share	Unit Cost ($/VMT)
1	$1,946,345	0.52%	$0.0428
2	$213,635,353	57.19%	$0.0428
3	$91,978,890	24.62%	$0.0428
4	$708,547	0.19%	$0.0760
5	$12,786,031	3.42%	$0.0760
6	$9,557,032	2.56%	$0.0760
7	$3,296,923	0.88%	$0.0760
8	$5,878,842	1.57%	$0.0760
9	$32,419,035	8.68%	$0.0760
10	$829,915	0.22%	$0.0760
11	$169,477	0.05%	$0.0760
12	$60,035	0.02%	$0.0760
13	$276,033	0.07%	$0.0760

B.3.2 2010 Safety, Mobility, and Other Cost Allocation Results for State Routes

TABLE B.3.2.1
2010 Safety, Mobility and Other Cost Allocation Results for Interstates.

Vehicle Class	Safety	Mobility	Drainage and Erosion Control	Miscellaneous	Other Projects
1	$123,225	$13,210	$105,474	$1,025,297	$2,130
2	$17,826,456	$1,910,984	$15,258,474	$148,325,909	$308,111
3	$6,042,994	$647,805	$5,172,474	$50,281,035	$104,447
4	$159,339	$17,081	$136,385	$982,062	$2,754
5	$1,767,841	$189,511	$1,513,175	$10,895,857	$30,555
6	$293,651	$31,479	$251,349	$1,809,880	$5,075
7	$46,949	$5,033	$40,186	$289,364	$811
8	$643,620	$68,996	$550,904	$3,347,046	$11,124
9	$10,617,037	$1,138,139	$9,087,605	$55,212,241	$183,504
10	$101,646	$10,896	$87,003	$528,592	$1,757
11	$319,398	$34,239	$273,387	$1,660,978	$5,520
12	$120,650	$12,934	$103,270	$627,423	$2,085
13	$31,466	$3,373	$26,933	$163,633	$544

Vehicle Class	In-House Maintenance	Preliminary Engineering	Right-of-Way	Utility and Railway
1	$23,605	$33,646	$51,235	$22,936
2	$3,414,813	$4,867,452	$7,411,982	$3,318,023
3	$1,157,588	$1,650,019	$2,512,590	$1,124,777
4	$30,523	$43,507	$66,251	$29,658
5	$338,645	$482,703	$735,043	$329,047
6	$56,251	$80,180	$122,096	$54,657
7	$8,993	$12,819	$19,521	$8,739
8	$123,291	$175,738	$267,608	$119,796
9	$2,033,786	$2,898,945	$4,414,410	$1,976,140
10	$19,471	$27,754	$42,263	$18,919
11	$61,183	$87,210	$132,801	$59,449
12	$23,112	$32,943	$50,165	$22,457
13	$6,028	$8,592	$13,083	$5,857

TABLE B.3.2.2
2010 Total Others Cost Responsibility and Unit Cost Results for Interstates.

Vehicle Class	Cost Responsibility	Cost Responsibility Share	Unit Cost ($/VMT)
1	$1,400,756	0.36%	$0.0239
2	$202,642,203	51.80%	$0.0239
3	$68,693,729	17.56%	$0.0239
4	$1,467,558	0.38%	$0.0262
5	$16,282,377	4.16%	$0.0262
6	$2,704,620	0.69%	$0.0262
7	$432,415	0.11%	$0.0262
8	$5,308,123	1.36%	$0.0278
9	$87,561,809	22.38%	$0.0278
10	$838,301	0.21%	$0.0278
11	$2,634,166	0.67%	$0.0278
12	$995,038	0.25%	$0.0278
13	$259,508	0.07%	$0.0278

TABLE B.3.2.3
2010 Safety, Mobility and Other Cost Allocation Results for Non-Interstate NHS.

Vehicle Class	Safety	Mobility	Drainage & Erosion Control	Miscellaneous	Other Projects
1	$106,504	$-	$137,350	$867,576	$1,815
2	$11,348,127	$-	$14,634,814	$92,441,193	$193,346
3	$4,381,357	$-	$5,650,302	$35,690,285	$74,648
4	$119,746	$-	$154,427	$443,383	$2,040
5	$1,442,617	$-	$1,860,434	$5,341,581	$24,579
6	$295,131	$-	$380,608	$1,092,782	$5,028
7	$91,278	$-	$117,714	$337,975	$1,555
8	$413,868	$-	$533,734	$1,532,431	$7,051
9	$3,289,253	$-	$4,241,899	$12,179,123	$56,041
10	$61,197	$-	$78,921	$226,593	$1,043
11	$64,244	$-	$82,850	$237,875	$1,095
12	$16,073	$-	$20,728	$59,512	$274
13	$18,161	$-	$23,421	$67,246	$309

Vehicle Class	In-House Maintenance	Preliminary Engineering	Right-of-Way	Utility and Railway
1	$48,179	$190,407	$101,363	$59,545
2	$5,133,560	$20,288,088	$10,800,305	$6,344,590
3	$1,981,998	$7,832,954	$4,169,851	$2,449,560
4	$54,169	$214,080	$113,965	$66,948
5	$652,598	$2,579,099	$1,372,976	$806,549
6	$133,509	$527,633	$280,884	$165,004
7	$41,291	$163,186	$86,871	$51,032
8	$187,222	$739,910	$393,889	$231,388
9	$1,487,962	$5,880,500	$3,130,467	$1,838,979
10	$27,684	$109,407	$58,242	$34,214
11	$29,062	$114,854	$61,142	$35,918
12	$7,271	$28,734	$15,297	$8,986
13	$8,216	$32,468	$17,284	$10,154

TABLE B.3.2.4
2010 Total Others Cost Responsibility and Unit Cost Results for Non-Interstate NHS.

Vehicle Class	Cost Responsibility	Cost Responsibility Share	Unit Cost ($/VMT)
1	$1,512,739	0.54%	$0.0182
2	$161,184,022	57.23%	$0.0182
3	$62,230,956	22.10%	$0.0182
4	$1,168,759	0.41%	$0.0276
5	$14,080,433	5.00%	$0.0276
6	$2,880,579	1.02%	$0.0276
7	$890,903	0.32%	$0.0276
8	$4,039,495	1.43%	$0.0276
9	$32,104,225	11.40%	$0.0276
10	$597,300	0.21%	$0.0276
11	$627,041	0.22%	$0.0276
12	$156,874	0.06%	$0.0276
13	$177,260	0.06%	$0.0276

TABLE B.3.2.5
2010 Safety, Mobility and Other Cost Allocation Results for Non-NHS.

Vehicle Class	Safety	Mobility	Drainage and Erosion Control	Miscellaneous	Other Projects
1	$291,649	$-	$294,061	$926,819	$83,121
2	$32,012,120	$-	$32,276,850	$101,729,826	$9,123,508
3	$13,782,547	$-	$13,896,524	$43,798,914	$3,928,049
4	$132,958	$-	$134,058	$192,055	$37,893
5	$2,399,284	$-	$2,419,125	$3,465,714	$683,800
6	$1,793,366	$-	$1,808,196	$2,590,479	$511,112
7	$618,664	$-	$623,780	$893,647	$176,320
8	$1,103,158	$-	$1,112,280	$1,593,488	$314,402
9	$6,035,243	$-	$6,085,153	$8,717,781	$1,720,055
10	$155,733	$-	$157,020	$224,952	$44,384
11	$31,802	$-	$32,065	$45,938	$9,064
12	$11,265	$-	$11,359	$16,273	$3,211
13	$51,797	$-	$52,226	$74,820	$14,762

Vehicle Class	In-House Maintenance	Preliminary Engineering	Right-of-Way	Utility and Railway
1	$74,687	$42,978	$421,898	$207,012
2	$8,197,808	$4,717,408	$46,308,526	$22,722,150
3	$3,529,497	$2,031,040	$19,937,743	$9,782,829
4	$34,048	$19,593	$192,336	$94,373
5	$614,419	$353,566	$3,470,788	$1,703,007
6	$459,253	$264,276	$2,594,271	$1,272,928
7	$158,430	$91,168	$894,955	$439,126
8	$282,502	$162,565	$1,595,821	$783,020
9	$1,545,532	$889,373	$8,730,544	$4,283,806
10	$39,881	$22,949	$225,282	$110,539
11	$8,144	$4,686	$46,005	$22,573
12	$2,885	$1,660	$16,296	$7,996
13	$13,264	$7,633	$74,930	$36,766

TABLE B.3.2.6
2010 Total Others Cost Responsibility and Unit Cost Results for Non-NHS.

Vehicle Class	Cost Responsibility	Cost Responsibility Share	Unit Cost ($/VMT)
1	$2,342,227	0.52%	$0.0515
2	$257,088,196	57.41%	$0.0515
3	$110,687,143	24.72%	$0.0515
4	$837,315	0.19%	$0.0889
5	$15,109,703	3.37%	$0.0889
6	$11,293,881	2.52%	$0.0889
7	$3,896,090	0.87%	$0.0889
8	$6,947,235	1.55%	$0.0889
9	$38,007,487	8.49%	$0.0889
10	$980,740	0.22%	$0.0889
11	$200,277	0.04%	$0.0889
12	$70,945	0.02%	$0.0889
13	$326,198	0.07%	$0.0889

B.3.3 2011 Safety, Mobility and Other Cost Allocation Results for State Routes

TABLE B.3.3.1
2011 Safety, Mobility and Other Cost Allocation Results for Interstates.

Vehicle Class	Safety	Mobility	Drainage and Erosion Control	Miscellaneous	Other Projects
1	$125,247	$-	$139,823	$383,843	$23,761
2	$18,119,010	$-	$20,227,736	$55,529,152	$3,437,373
3	$6,142,167	$-	$6,857,005	$18,823,840	$1,165,236
4	$114,945	$-	$128,322	$260,941	$21,806
5	$1,275,297	$-	$1,423,718	$2,895,103	$241,938
6	$211,836	$-	$236,490	$480,897	$40,188
7	$33,868	$-	$37,810	$76,886	$6,425
8	$359,240	$-	$401,049	$688,100	$68,152
9	$5,922,665	$-	$6,611,957	$11,344,459	$1,123,594
10	$56,734	$-	$63,337	$108,670	$10,763
11	$178,274	$-	$199,022	$341,471	$33,820
12	$67,342	$-	$75,179	$128,988	$12,775
13	$17,563	$-	$19,607	$33,640	$3,332

Vehicle Class	In-House Maintenance	Preliminary Engineering	Right-of-Way	Utility and Railway
1	$22,493	$21,409	$3,378	$19,715
2	$3,253,971	$3,097,114	$488,662	$2,852,124
3	$1,103,064	$1,049,891	$165,652	$966,842
4	$20,643	$19,648	$3,100	$18,094
5	$229,029	$217,989	$34,394	$200,745
6	$38,043	$36,209	$5,713	$33,345
7	$6,082	$5,789	$913	$5,331
8	$64,516	$61,406	$9,689	$56,548
9	$1,063,644	$1,012,372	$159,732	$932,290
10	$10,189	$9,698	$1,530	$8,931
11	$32,016	$30,473	$4,808	$28,062
12	$12,094	$11,511	$1,816	$10,600
13	$3,154	$3,002	$474	$2,765

TABLE B.3.3.2
2011 Total Others Cost Responsibility and Unit Cost Results for Interstates.

Vehicle Class	Cost Responsibility	Cost Responsibility Share	Unit Cost ($/VMT)
1	$739,669	0.40%	$0.0106
2	$107,005,141	58.22%	$0.0106
3	$36,273,698	19.74%	$0.0106
4	$587,498	0.32%	$0.0123
5	$6,518,212	3.55%	$0.0123
6	$1,082,722	0.59%	$0.0123
7	$173,106	0.09%	$0.0123
8	$1,708,700	0.93%	$0.0136
9	$28,170,713	15.33%	$0.0136
10	$269,851	0.15%	$0.0136
11	$847,946	0.46%	$0.0136
12	$320,306	0.17%	$0.0136
13	$83,536	0.05%	$0.0136

TABLE B.3.3.3
2011 Safety, Mobility and Other Cost Allocation Results for Non-Interstate NHS.

Vehicle Class	Safety	Mobility	Drainage and Erosion Control	Miscellaneous	Other Projects
1	$158,511	$-	$189,624	$331,798	$10,621
2	$16,889,574	$-	$20,204,645	$35,353,401	$1,131,680
3	$6,520,834	$-	$7,800,738	$13,649,467	$436,926
4	$129,045	$-	$154,374	$122,781	$8,647
5	$1,554,651	$-	$1,859,797	$1,479,186	$104,169
6	$318,051	$-	$380,478	$302,612	$21,311
7	$98,367	$-	$117,674	$93,592	$6,591
8	$592,245	$-	$708,490	$563,497	$39,683
9	$2,768,833	$-	$3,312,297	$2,634,430	$185,525
10	$87,572	$-	$104,761	$83,321	$5,868
11	$91,933	$-	$109,977	$87,470	$6,160
12	$23,000	$-	$27,514	$21,883	$1,541
13	$25,989	$-	$31,090	$24,727	$1,741

Vehicle Class	In-House Maintenance	Preliminary Engineering	Right-of-Way	Utility and Railway
1	$53,357	$153,520	$218,678	$167,944
2	$5,685,260	$16,357,749	$23,300,398	$17,894,616
3	$2,195,001	$6,315,504	$8,995,966	$6,908,868
4	$43,438	$124,982	$178,027	$136,724
5	$523,317	$1,505,698	$2,144,755	$1,647,163
6	$107,060	$308,036	$438,775	$336,977
7	$33,111	$95,269	$135,704	$104,220
8	$199,358	$573,596	$817,045	$627,488
9	$932,027	$2,681,647	$3,819,807	$2,933,597
10	$29,478	$84,815	$120,812	$92,783
11	$30,946	$89,038	$126,828	$97,403
12	$7,742	$22,276	$31,730	$24,368
13	$8,748	$25,170	$35,853	$27,535

TABLE B.3.3.4
2011 Total Others Cost Responsibility and Unit Cost Results for Non-Interstate NHS.

Vehicle Class	Cost Responsibility	Cost Responsibility Share	Unit Cost ($/VMT)
1	$1,284,054	0.56%	$0.0161
2	$136,817,324	59.35%	$0.0161
3	$52,823,305	22.91%	$0.0161
4	$898,019	0.39%	$0.0305
5	$10,818,736	4.69%	$0.0305
6	$2,213,300	0.96%	$0.0305
7	$684,527	0.30%	$0.0305
8	$4,121,402	1.79%	$0.0305
9	$19,268,163	8.36%	$0.0305
10	$609,411	0.26%	$0.0305
11	$639,755	0.28%	$0.0305
12	$160,054	0.07%	$0.0305
13	$180,854	0.08%	$0.0305

TABLE B.3.3.5
2011 Safety, Mobility and Other Cost Allocation Results for Non-NHS.

Vehicle Class	Safety	Mobility	Drainage and Erosion Control	Miscellaneous	Other Projects
1	$250,541	$4,472	$292,566	$489,160	$94,003
2	$27,499,940	$490,889	$32,112,674	$53,691,315	$10,317,975
3	$11,839,866	$211,348	$13,825,839	$23,116,340	$4,442,316
4	$94,120	$1,680	$109,907	$83,528	$35,314
5	$1,698,434	$30,318	$1,983,323	$1,507,295	$637,252
6	$1,269,509	$22,661	$1,482,452	$1,126,641	$476,320
7	$437,947	$7,818	$511,407	$388,661	$164,318
8	$901,305	$16,089	$1,052,486	$799,873	$338,169
9	$3,324,786	$59,349	$3,882,473	$2,950,620	$1,247,459
10	$127,237	$2,271	$148,579	$112,918	$47,739
11	$25,983	$464	$30,341	$23,059	$9,749
12	$9,204	$164	$10,748	$8,168	$3,453
13	$42,320	$755	$49,418	$37,557	$15,878

Vehicle Class	In-House Maintenance	Preliminary Engineering	Right-of-Way	Utility and Railway
1	$75,930	$75,385	$431,482	$295,563
2	$8,334,245	$8,274,475	$47,360,454	$32,441,711
3	$3,588,238	$3,562,505	$20,390,642	$13,967,503
4	$28,524	$28,320	$162,094	$111,033
5	$514,734	$511,043	$2,925,047	$2,003,645
6	$384,743	$381,984	$2,186,352	$1,497,642
7	$132,726	$131,774	$754,233	$516,647
8	$273,153	$271,194	$1,552,229	$1,063,270
9	$1,007,623	$1,000,397	$5,725,954	$3,922,254
10	$38,561	$38,284	$219,128	$150,102
11	$7,875	$7,818	$44,748	$30,652
12	$2,789	$2,769	$15,851	$10,858
13	$12,826	$12,734	$72,883	$49,924

TABLE B.3.3.6
2011 Total Others Cost Responsibility and Unit Cost Results for Non-NHS.

Vehicle Class	Cost Responsibility	Cost Responsibility Share	Unit Cost ($/VMT)
1	$2,009,102	0.54%	$0.0405
2	$220,523,677	59.18%	$0.0405
3	$94,944,599	25.48%	$0.0405
4	$654,520	0.18%	$0.0773
5	$11,811,090	3.17%	$0.0773
6	$8,828,304	2.37%	$0.0773
7	$3,045,531	0.82%	$0.0773
8	$6,267,768	1.68%	$0.0773
9	$23,120,917	6.20%	$0.0773
10	$884,820	0.24%	$0.0773
11	$180,689	0.05%	$0.0773
12	$64,006	0.02%	$0.0773
13	$294,295	0.08%	$0.0773

B.3.4 2012 Safety, Mobility, and Other Cost Allocation Results for State Routes

TABLE B.3.4.1
2012 Safety, Mobility and Other Cost Allocation Results for Interstates.

Vehicle Class	Safety	Mobility	Drainage and Erosion Control	Miscellaneous	Other Projects
1	$43,828	$-	$36,933	$89,296	$3,922
2	$6,340,429	$-	$5,343,024	$12,918,109	$567,399
3	$2,149,344	$-	$1,811,233	$4,379,113	$192,343
4	$37,646	$-	$31,724	$56,816	$3,369
5	$417,679	$-	$351,975	$630,361	$37,378
6	$69,380	$-	$58,466	$104,708	$6,209
7	$11,092	$-	$9,347	$16,741	$993
8	$163,313	$-	$137,622	$207,961	$14,615
9	$2,433,293	$-	$2,050,515	$3,098,523	$217,753
10	$25,792	$-	$21,734	$32,843	$2,308
11	$81,044	$-	$68,295	$103,201	$7,253
12	$30,614	$-	$25,798	$38,983	$2,740
13	$7,984	$-	$6,728	$10,167	$714
Vehicle Class	**In-House Maintenance**	**Preliminary Engineering**	**Right-of-Way**	**Utility and Railway**	
1	$27,141	$28,401	$12,058	$3,994	
2	$3,926,325	$4,108,609	$1,744,365	$577,839	
3	$1,330,986	$1,392,778	$591,323	$195,882	
4	$23,312	$24,395	$10,357	$3,431	
5	$258,649	$270,657	$114,911	$38,065	
6	$42,963	$44,958	$19,088	$6,323	
7	$6,869	$7,188	$3,052	$1,011	
8	$101,132	$105,827	$44,930	$14,884	
9	$1,506,822	$1,576,778	$669,442	$221,760	
10	$15,972	$16,713	$7,096	$2,351	
11	$50,187	$52,517	$22,297	$7,386	
12	$18,958	$19,838	$8,422	$2,790	
13	$4,944	$5,174	$2,197	$728	

TABLE B.3.4.2
2012 Total Others Cost Responsibility and Unit Cost Results for Interstates.

Vehicle Class	Cost Responsibility	Cost Responsibility Share	Unit Cost ($/VMT)
1	$245,573	0.38%	$0.0036
2	$35,526,099	55.68%	$0.0036
3	$12,043,001	18.88%	$0.0036
4	$191,050	0.30%	$0.0044
5	$2,119,675	3.32%	$0.0044
6	$352,093	0.55%	$0.0044
7	$56,293	0.09%	$0.0044
8	$790,284	1.24%	$0.0049
9	$11,774,888	18.46%	$0.0049
10	$124,808	0.20%	$0.0049
11	$392,180	0.61%	$0.0049
12	$148,143	0.23%	$0.0049
13	$38,636	0.06%	$0.0049

TABLE B.3.4.3
2012 Safety, Mobility and Other Cost Allocation Results for Non-Interstate NHS.

Vehicle Class	Safety	Mobility	Drainage and Erosion Control	Miscellaneous	Other Projects
1	$97,400	$-	$105,862	$212,998	$16,606
2	$10,378,099	$-	$11,279,702	$22,695,167	$1,769,407
3	$4,006,843	$-	$4,354,939	$8,762,295	$683,144
4	$131,399	$-	$142,815	$130,613	$22,403
5	$1,583,011	$-	$1,720,536	$1,573,536	$269,894
6	$323,853	$-	$351,988	$321,914	$55,215
7	$100,161	$-	$108,862	$99,561	$17,077
8	$363,896	$-	$395,509	$361,718	$62,042
9	$2,132,623	$-	$2,317,896	$2,119,859	$363,600
10	$53,807	$-	$58,482	$53,485	$9,174
11	$56,487	$-	$61,394	$56,149	$9,631
12	$14,132	$-	$15,360	$14,047	$2,409
13	$15,968	$-	$17,356	$15,873	$2,723

Vehicle Class	In-House Maintenance	Preliminary Engineering	Right-of-Way	Utility and Railway
1	$54,454	$211,726	$84,480	$172,169
2	$5,802,108	$22,559,588	$9,001,395	$18,344,769
3	$2,240,115	$8,709,950	$3,475,316	$7,082,666
4	$73,462	$285,632	$113,968	$232,267
5	$885,018	$3,441,100	$1,373,017	$2,798,197
6	$181,057	$703,981	$280,892	$572,456
7	$55,997	$217,727	$86,874	$177,049
8	$203,444	$791,025	$315,623	$643,238
9	$1,192,291	$4,635,830	$1,849,721	$3,769,716
10	$30,082	$116,965	$46,670	$95,112
11	$31,580	$122,789	$48,993	$99,848
12	$7,901	$30,719	$12,257	$24,980
13	$8,927	$34,711	$13,850	$28,226

TABLE B.3.4.4
2012 Total Others Cost Responsibility and Unit Cost Results for Non-Interstate NHS.

Vehicle Class	Cost Responsibility	Cost Responsibility Share	Unit Cost ($/VMT)
1	$955,694	0.52%	$0.0129
2	$101,830,236	55.57%	$0.0129
3	$39,315,267	21.45%	$0.0129
4	$1,132,558	0.62%	$0.0249
5	$13,644,309	7.45%	$0.0249
6	$2,791,356	1.52%	$0.0249
7	$863,308	0.47%	$0.0249
8	$3,136,496	1.71%	$0.0249
9	$18,381,536	10.03%	$0.0249
10	$463,778	0.25%	$0.0249
11	$486,870	0.27%	$0.0249
12	$121,806	0.07%	$0.0249
13	$137,635	0.08%	$0.0249

TABLE B.3.4.5
2012 Safety, Mobility and Other Cost Allocation Results for Non-NHS.

Vehicle Class	Safety	Mobility	Drainage and Erosion Control	Miscellaneous	Other Projects
1	$161,547	$-	$199,188	$322,137	$65,915
2	$17,731,805	$-	$21,863,337	$35,358,522	$7,234,991
3	$7,634,278	$-	$9,413,075	$15,223,312	$3,114,964
4	$109,441	$-	$134,940	$99,197	$44,654
5	$1,974,903	$-	$2,435,057	$1,790,046	$805,806
6	$1,476,158	$-	$1,820,105	$1,337,986	$602,307
7	$509,236	$-	$627,888	$461,570	$207,780
8	$645,753	$-	$796,215	$585,309	$263,482
9	$3,312,544	$-	$4,084,371	$3,002,480	$1,351,595
10	$91,161	$-	$112,402	$82,628	$37,196
11	$18,616	$-	$22,954	$16,873	$7,596
12	$6,594	$-	$8,131	$5,977	$2,691
13	$30,320	$-	$37,385	$27,482	$12,371

Vehicle Class	In-House Maintenance	Preliminary Engineering	Right-of-Way	Utility and Railway
1	$77,060	$63,095	$510,772	$202,496
2	$8,458,234	$6,925,470	$56,063,487	$22,226,447
3	$3,641,621	$2,981,702	$24,137,659	$9,569,408
4	$52,204	$42,744	$346,024	$137,182
5	$942,047	$771,333	$6,244,143	$2,475,499
6	$704,141	$576,540	$4,667,240	$1,850,334
7	$242,910	$198,891	$1,610,074	$638,316
8	$308,030	$252,210	$2,041,709	$809,438
9	$1,580,114	$1,293,773	$10,473,428	$4,152,205
10	$43,485	$35,605	$288,228	$114,268
11	$8,880	$7,271	$58,859	$23,335
12	$3,146	$2,576	$20,850	$8,266
13	$14,463	$11,842	$95,866	$38,006

TABLE B.3.4.6
2012 Total Others Cost Responsibility and Unit Cost Results for Non-NHS.

Vehicle Class	Cost Responsibility	Cost Responsibility Share	Unit Cost ($/VMT)
1	$1,602,210	0.49%	$0.0296
2	$175,862,292	54.05%	$0.0296
3	$75,716,018	23.27%	$0.0296
4	$966,385	0.30%	$0.0579
5	$17,438,835	5.36%	$0.0579
6	$13,034,811	4.01%	$0.0579
7	$4,496,665	1.38%	$0.0579
8	$5,702,148	1.75%	$0.0579
9	$29,250,512	8.99%	$0.0579
10	$804,971	0.25%	$0.0579
11	$164,383	0.05%	$0.0579
12	$58,230	0.02%	$0.0579
13	$267,737	0.08%	$0.0579

ADDENDUM C: LOCAL ROUTE COST ALLOCATION RESULTS

C.1. ROAD COST ALLOCATION RESULTS FOR LOCAL ROUTES

C.1.1 New Road Construction Cost Allocation Results per Year for Local Routes

TABLE C.1.1
Cost Responsibility for New Road Construction on Local Routes, 2009.

Vehicle Class	Flexible Road Construction		Rigid Road Construction		Total
	Base Facility	Remaining Facility	Base Facility	Remaining Facility	
1	$727,565	$0	$265,333	$0	$992,898
2	$79,392,310	$1,340,874	$28,953,322	$327,455	$110,013,960
3	$33,492,988	$4,229,109	$12,214,448	$971,069	$50,907,614
4	$99,119	$451,214	$36,147	$127,607	$714,088
5	$1,475,946	$2,872,996	$538,258	$700,313	$5,587,513
6	$762,252	$3,374,646	$277,983	$1,042,596	$5,457,477
7	$258,370	$4,581,946	$94,224	$1,467,778	$6,402,318
8	$570,030	$2,552,158	$207,882	$680,910	$4,010,980
9	$3,849,221	$29,111,926	$1,403,760	$10,016,424	$44,381,330
10	$81,677	$614,714	$29,787	$222,781	$948,959
11	$39,208	$378,588	$14,299	$100,470	$532,564
12	$10,978	$99,789	$4,004	$30,365	$145,137
13	$26,211	$372,036	$9,559	$131,038	$538,844
Total	$120,785,874	$49,979,995	$44,049,005	$15,818,807	$230,633,682

TABLE C.1.2
Cost Responsibility for New Road Construction on Local Routes, 2010.

Vehicle Class	Flexible Road Construction		Rigid Road Construction		Total
	Base Facility	Remaining Facility	Base Facility	Remaining Facility	
1	$742,268	$0	$270,695	$0	$1,012,964
2	$80,996,746	$1,399,177	$29,538,439	$322,974	$112,257,336
3	$34,169,846	$4,220,672	$12,461,289	$1,064,226	$51,916,035
4	$101,122	$455,426	$36,878	$133,970	$727,396
5	$1,505,773	$2,846,761	$549,136	$747,640	$5,649,310
6	$777,656	$3,410,071	$283,601	$1,057,550	$5,528,878
7	$263,592	$4,633,786	$96,128	$1,470,087	$6,463,593
8	$581,549	$2,551,345	$212,083	$715,663	$4,060,641
9	$3,927,009	$29,977,010	$1,432,128	$10,137,461	$45,473,608
10	$83,328	$634,806	$30,389	$221,801	$970,323
11	$40,000	$378,945	$14,587	$106,263	$539,795
12	$11,200	$101,259	$4,085	$31,264	$147,807
13	$26,741	$380,782	$9,752	$129,589	$546,864
Total	$123,226,832	$50,990,039	$44,939,190	$16,138,488	$235,294,550

TABLE C.1.3
Cost Responsibility for New Road Construction on Local Routes, 2011.

Vehicle Class	Flexible Road Construction		Rigid Road Construction		Total
	Base Facility	Remaining Facility	Base Facility	Remaining Facility	
1	$720,655	$0	$262,813	$0	$983,468
2	$79,100,726	$1,481,313	$28,846,985	$323,260	$109,752,283
3	$34,056,147	$3,636,485	$12,419,825	$934,463	$51,046,920
4	$121,378	$496,430	$44,265	$128,673	$790,746
5	$2,190,319	$3,839,398	$798,780	$708,394	$7,536,892
6	$1,637,174	$6,514,890	$597,055	$1,116,476	$9,865,596
7	$564,782	$9,073,798	$205,968	$1,577,683	$11,422,231
8	$237,144	$1,004,920	$86,483	$640,063	$1,968,610
9	$3,480,945	$24,015,898	$1,269,455	$10,102,003	$38,868,301
10	$33,478	$243,037	$12,209	$218,812	$507,535
11	$6,836	$68,183	$2,493	$92,710	$170,223
12	$2,422	$22,333	$883	$28,749	$54,387
13	$11,135	$153,209	$4,061	$127,895	$296,299
Total	$122,163,140	$50,549,894	$44,551,276	$15,999,181	$233,263,491

TABLE C.1.4
Cost Responsibility for New Road Construction on Local Routes, 2012.

Vehicle Class	Flexible Road Construction		Rigid Road Construction		Total
	Base Facility	Remaining Facility	Base Facility	Remaining Facility	
1	$665,134	$0	$242,565	$0	$907,699
2	$72,536,223	$1,228,789	$26,452,998	$279,270	$100,497,280
3	$30,536,012	$3,879,259	$11,136,078	$863,004	$46,414,354
4	$183,841	$739,527	$67,044	$123,684	$1,114,097
5	$2,892,153	$4,913,312	$1,054,730	$676,291	$9,536,487
6	$1,697,983	$6,473,068	$619,232	$1,034,771	$9,825,054
7	$579,521	$8,758,058	$211,344	$1,457,150	$11,006,072
8	$194,229	$937,411	$70,833	$589,173	$1,791,646
9	$2,484,206	$18,794,881	$905,957	$9,186,963	$31,372,007
10	$27,705	$245,073	$10,104	$202,482	$485,364
11	$11,001	$120,110	$4,012	$86,420	$221,542
12	$3,207	$34,047	$1,169	$26,823	$65,245
13	$8,988	$146,556	$3,278	$118,580	$277,402
Total	$111,820,204	$46,270,090	$40,779,344	$14,644,611	$213,514,250

TABLE C.1.5
Cost Responsibility for New Road Construction on Local Routes, 2009–2012.

Vehicle Class	Flexible Road Construction		Rigid Road Construction		Total
	Base Facility	Remaining Facility	Base Facility	Remaining Facility	
1	$2,855,622	$0	$1,041,407	$0	$3,897,029
2	$312,026,006	$5,450,152	$113,791,743	$1,252,959	$432,520,860
3	$132,254,993	$15,965,526	$48,231,641	$3,832,763	$200,284,923
4	$505,460	$2,142,598	$184,334	$513,934	$3,346,326
5	$8,064,192	$14,472,466	$2,940,904	$2,832,639	$28,310,201
6	$4,875,064	$19,772,676	$1,777,871	$4,251,394	$30,677,005
7	$1,666,264	$27,047,587	$607,664	$5,972,698	$35,294,214
8	$1,582,952	$7,045,834	$577,282	$2,625,809	$11,831,877
9	$13,741,382	$101,899,715	$5,011,300	$39,442,850	$160,095,246
10	$226,188	$1,737,629	$82,488	$865,876	$2,912,181
11	$97,045	$945,825	$35,391	$385,864	$1,464,125
12	$27,807	$257,428	$10,141	$117,200	$412,576
13	$73,076	$1,052,583	$26,650	$507,102	$1,659,410
Total	$477,996,050	$197,790,019	$174,318,816	$62,601,088	$912,705,973

TABLE C.1.6
Unit Cost per Year for New Road Construction on Local Routes.

Vehicle Class	Unit Cost [$/VMT]				
	2009	2010	2011	2012	Average
1	$0.0050	$0.0047	$0.0048	$0.0048	$0.0048
2	$0.0051	$0.0048	$0.0049	$0.0048	$0.0049
3	$0.0056	$0.0053	$0.0053	$0.0053	$0.0054
4	$0.0266	$0.0249	$0.0231	$0.0211	$0.0234
5	$0.0140	$0.0130	$0.0122	$0.0115	$0.0124
6	$0.0265	$0.0246	$0.0214	$0.0202	$0.0223
7	$0.0916	$0.0849	$0.0718	$0.0662	$0.0749
8	$0.0260	$0.0242	$0.0295	$0.0322	$0.0266
9	$0.0426	$0.0401	$0.0397	$0.0440	$0.0414
10	$0.0430	$0.0403	$0.0539	$0.0611	$0.0458
11	$0.0502	$0.0467	$0.0885	$0.0702	$0.0537
12	$0.0489	$0.0457	$0.0798	$0.0709	$0.0529
13	$0.0760	$0.0708	$0.0945	$0.1076	$0.0808

C.1.2 Road Rehabilitation Cost Allocation Results per Year for Local Routes

TABLE C.1.7
Cost Responsibility for Road Rehabilitation on Local Routes, 2009.

Vehicle Class	Flexible Rehabilitation		Rigid Rehabilitation		Total
	Non-Load-Related Expenses	Load-Related Expenses	Non-Load-Related Expenses	Load-Related Expenses	
1	$282,575	$685,449	$7,765	$14,705	$990,494
2	$30,834,751	$74,796,583	$847,307	$1,604,642	$108,083,283
3	$13,008,161	$32,772,828	$357,451	$742,779	$46,881,219
4	$38,496	$709,078	$1,058	$18,028	$766,661
5	$573,235	$3,428,883	$15,752	$92,597	$4,110,466
6	$296,047	$12,265,496	$8,135	$167,141	$12,736,819
7	$100,347	$15,063,625	$2,757	$149,036	$15,315,766
8	$221,391	$6,882,776	$6,084	$138,377	$7,248,627
9	$1,494,978	$138,710,804	$41,080	$1,981,084	$142,227,947
10	$31,722	$2,714,338	$872	$42,214	$2,789,146
11	$15,228	$923,501	$418	$22,827	$961,975
12	$4,264	$213,667	$117	$5,689	$223,737
13	$10,180	$1,413,501	$280	$19,981	$1,443,942
Total	$46,911,375	$290,580,530	$1,289,076	$4,999,101	$343,780,082

TABLE C.1.8
Cost Responsibility for Road Rehabilitation on Local Routes, 2010.

Vehicle Class	Flexible Rehabilitation		Rigid Rehabilitation		Total
	Non-Load-Related Expenses	Load-Related Expenses	Non-Load-Related Expenses	Load-Related Expenses	
1	$267,830	$651,456	$7,360	$14,023	$940,668
2	$29,225,754	$71,087,307	$803,094	$1,530,145	$102,646,300
3	$12,329,378	$31,155,469	$338,799	$708,603	$44,532,249
4	$36,487	$673,952	$1,003	$17,093	$728,534
5	$543,323	$3,267,564	$14,930	$88,119	$3,913,935
6	$280,599	$11,587,855	$7,711	$157,802	$12,033,966
7	$95,111	$14,224,654	$2,614	$139,700	$14,462,079
8	$209,838	$6,553,144	$5,766	$130,932	$6,899,680
9	$1,416,968	$131,225,460	$38,937	$1,866,211	$134,547,575
10	$30,067	$2,568,878	$826	$39,800	$2,639,571
11	$14,433	$881,571	$397	$21,593	$917,994
12	$4,041	$203,731	$111	$5,390	$213,273
13	$9,649	$1,336,615	$265	$18,833	$1,365,362
Total	$44,463,478	$275,417,657	$1,221,811	$4,738,242	$325,841,187

TABLE C.1.9
Cost Responsibility for Road Rehabilitation on Local Routes, 2011.

Vehicle Class	Flexible Rehabilitation		Rigid Rehabilitation		Total
	Non-Load-Related Expenses	Load-Related Expenses	Non-Load-Related Expenses	Load-Related Expenses	
1	$209,875	$501,696	$5,767	$10,889	$728,227
2	$23,036,357	$55,067,322	$633,015	$1,195,216	$79,931,910
3	$9,918,108	$24,602,256	$272,539	$564,641	$35,357,545
4	$35,349	$626,157	$971	$16,424	$678,902
5	$637,883	$3,703,284	$17,528	$102,468	$4,461,163
6	$476,791	$18,895,194	$13,102	$266,505	$19,651,592
7	$164,480	$23,582,188	$4,520	$240,968	$23,992,157
8	$69,063	$2,063,615	$1,898	$42,782	$2,177,358
9	$1,013,749	$89,954,566	$27,857	$1,328,378	$92,324,549
10	$9,750	$798,043	$268	$12,835	$820,895
11	$1,991	$116,091	$55	$2,957	$121,094
12	$705	$33,966	$19	$933	$35,624
13	$3,243	$430,387	$89	$6,295	$440,014
Total	$35,577,343	$220,374,766	$977,629	$3,791,292	$260,721,031

TABLE C.1.10
Cost Responsibility for Road Rehabilitation on Local Routes, 2012.

Vehicle Class	Flexible Rehabilitation		Rigid Rehabilitation		Total
	Non-Load-Related Expenses	Load-Related Expenses	Non-Load-Related Expenses	Load-Related Expenses	
1	$255,957	$633,675	$7,033	$13,988	$910,654
2	$27,913,435	$69,105,530	$767,033	$1,525,502	$99,311,500
3	$11,750,887	$30,258,909	$322,902	$706,046	$43,038,745
4	$70,746	$1,357,464	$1,944	$34,764	$1,464,918
5	$1,112,960	$6,930,543	$30,583	$189,583	$8,263,669
6	$653,419	$27,880,631	$17,955	$383,858	$28,935,863
7	$223,012	$34,477,143	$6,128	$339,843	$35,046,126
8	$74,743	$2,432,760	$2,054	$48,834	$2,558,391
9	$955,974	$91,690,744	$26,269	$1,313,005	$93,985,992
10	$10,662	$943,799	$293	$14,730	$969,484
11	$4,233	$270,548	$116	$6,634	$281,532
12	$1,234	$64,988	$34	$1,726	$67,982
13	$3,459	$496,076	$95	$7,046	$506,676
Total	$43,030,721	$266,542,811	$1,182,440	$4,585,560	$315,341,532

TABLE C.1.11
Cost Responsibility for Road Rehabilitation on Local Routes, 2009–2012.

Vehicle Class	Flexible Rehabilitation		Rigid Rehabilitation		Total
	Non-Load-Related Expenses	Load-Related Expenses	Non-Load-Related Expenses	Load-Related Expenses	
1	$1,016,237	$2,472,277	$27,925	$53,605	$3,570,044
2	$111,010,297	$270,056,742	$3,050,449	$5,855,505	$389,972,993
3	$47,006,534	$118,789,462	$1,291,691	$2,722,070	$169,809,757
4	$181,078	$3,366,651	$4,976	$86,310	$3,639,015
5	$2,867,400	$17,330,274	$78,793	$472,766	$20,749,234
6	$1,706,855	$70,629,176	$46,903	$975,306	$73,358,241
7	$582,950	$87,347,611	$16,019	$869,548	$88,816,127
8	$575,035	$17,932,294	$15,801	$360,925	$18,884,057
9	$4,881,669	$451,581,573	$134,143	$6,488,678	$463,086,063
10	$82,200	$7,025,058	$2,259	$109,579	$7,219,096
11	$35,885	$2,191,712	$986	$54,011	$2,282,594
12	$10,244	$516,353	$282	$13,738	$540,617
13	$26,531	$3,676,580	$729	$52,154	$3,755,994
Total	$169,982,917	$1,052,915,764	$4,670,956	$18,114,195	$1,245,683,832

TABLE C.1.12
Unit Cost per Year for Road Rehabilitation on Local Routes.

Vehicle Class	Unit Cost [$/VMT]				
	2009	2010	2011	2012	Average
1	$0.0050	$0.0044	$0.0036	$0.0048	$0.0044
2	$0.0050	$0.0044	$0.0036	$0.0048	$0.0044
3	$0.0052	$0.0045	$0.0037	$0.0049	$0.0046
4	$0.0286	$0.0249	$0.0199	$0.0278	$0.0255
5	$0.0103	$0.0090	$0.0072	$0.0100	$0.0091
6	$0.0618	$0.0536	$0.0426	$0.0594	$0.0532
7	$0.2192	$0.1899	$0.1509	$0.2108	$0.1885
8	$0.0470	$0.0411	$0.0326	$0.0459	$0.0425
9	$0.1367	$0.1186	$0.0942	$0.1319	$0.1197
10	$0.1263	$0.1096	$0.0871	$0.1220	$0.1136
11	$0.0907	$0.0794	$0.0629	$0.0892	$0.0838
12	$0.0754	$0.0659	$0.0523	$0.0739	$0.0693
13	$0.2037	$0.1767	$0.1404	$0.1965	$0.1830

C.1.3 Road Maintenance Cost Allocation Results per Year for Local Routes

TABLE C.1.13
Cost Responsibility and Unit Cost for Road Maintenance on Local Routes, 2009.

Vehicle Class	Cost Responsibility			Unit Cost [$/VMT]
	Non-Load-Related Expenses	Load-Related Expenses	Total	
1	$137,762	$34,572	$172,334	$0.0009
2	$15,032,713	$3,772,526	$18,805,239	$0.0009
3	$6,341,804	$2,615,565	$8,957,369	$0.0010
4	$18,768	$1,072,240	$1,091,007	$0.0407
5	$279,466	$4,121,725	$4,401,191	$0.0110
6	$144,330	$13,897,763	$14,042,093	$0.0681
7	$48,922	$18,773,526	$18,822,448	$0.2694
8	$107,934	$12,576,801	$12,684,734	$0.0823
9	$728,839	$183,321,095	$184,049,934	$0.1768
10	$15,465	$3,532,623	$3,548,088	$0.1607
11	$7,424	$2,138,912	$2,146,336	$0.2025
12	$2,079	$435,959	$438,037	$0.1476
13	$4,963	$1,845,762	$1,850,725	$0.2611
Total	$22,870,470	$248,139,066	$271,009,536	

TABLE C.1.14
Cost Responsibility and Unit Cost for Road Maintenance on Local Routes, 2010.

Vehicle Class	Cost Responsibility			Unit Cost [$/VMT]
	Non-Load-Related Expenses	Load-Related Expenses	Total	
1	$130,123	$32,388	$162,511	$0.0008
2	$14,199,107	$3,534,145	$17,733,252	$0.0008
3	$5,990,133	$2,451,107	$8,441,240	$0.0009
4	$17,727	$1,010,811	$1,028,539	$0.0352
5	$263,969	$3,885,274	$4,149,243	$0.0095
6	$136,327	$13,117,986	$13,254,313	$0.0590
7	$46,209	$17,735,642	$17,781,851	$0.2334
8	$101,948	$11,869,920	$11,971,868	$0.0712
9	$688,423	$173,232,102	$173,920,525	$0.1533
10	$14,608	$3,337,163	$3,351,771	$0.1392
11	$7,012	$2,018,500	$2,025,512	$0.1752
12	$1,963	$411,178	$413,142	$0.1276
13	$4,688	$1,742,835	$1,747,523	$0.2261
Total	$21,602,237	$234,379,051	$255,981,288	

TABLE C.1.15
Cost Responsibility and Unit Cost for Road Maintenance on Local Routes, 2011.

Vehicle Class	Cost Responsibility: Non-Load-Related Expenses	Load-Related Expenses	Total	Unit Cost [$/VMT]
1	$123,123	$29,785	$152,908	$0.0008
2	$13,514,279	$3,269,272	$16,783,551	$0.0008
3	$5,818,458	$2,313,929	$8,132,388	$0.0008
4	$20,737	$1,148,364	$1,169,101	$0.0342
5	$374,214	$5,349,237	$5,723,451	$0.0093
6	$279,709	$26,135,224	$26,414,934	$0.0573
7	$96,492	$35,958,388	$36,054,880	$0.2268
8	$40,516	$4,580,725	$4,621,241	$0.0692
9	$594,716	$145,299,199	$145,893,915	$0.1489
10	$5,720	$1,268,691	$1,274,410	$0.1352
11	$1,168	$326,483	$327,651	$0.1703
12	$414	$84,142	$84,556	$0.1240
13	$1,902	$686,742	$688,645	$0.2197
Total	$20,871,449	$226,450,182	$247,321,631	

TABLE C.1.16
Cost Responsibility and Unit Cost for Road Maintenance on Local Routes, 2012.

Vehicle Class	Cost Responsibility: Non-Load-Related Expenses	Load-Related Expenses	Total	Unit Cost [$/VMT]
1	$110,262	$29,748	$140,010	$0.0007
2	$12,024,613	$3,244,164	$15,268,778	$0.0007
3	$5,062,074	$2,244,236	$7,306,310	$0.0008
4	$30,476	$1,868,315	$1,898,791	$0.0360
5	$479,444	$7,587,913	$8,067,356	$0.0097
6	$281,481	$29,076,098	$29,357,579	$0.0603
7	$96,069	$39,540,384	$39,636,453	$0.2385
8	$32,198	$4,025,492	$4,057,690	$0.0728
9	$411,817	$111,101,324	$111,513,140	$0.1565
10	$4,593	$1,125,301	$1,129,894	$0.1422
11	$1,824	$563,621	$565,444	$0.1792
12	$532	$119,610	$120,141	$0.1306
13	$1,490	$594,377	$595,867	$0.2311
Total	$18,536,872	$201,120,582	$219,657,454	

TABLE C.1.17
Cost Responsibility and Unit Cost for Road Maintenance on Local Routes, 2009–2012.

Vehicle Class	Cost Responsibility: Non-Load-Related Expenses	Load-Related Expenses	Total	Unit Cost [$/VMT]
1	$501,270	$126,493	$627,763	$0.0008
2	$54,770,712	$13,820,107	$68,590,820	$0.0008
3	$23,212,470	$9,624,836	$32,837,306	$0.0009
4	$87,708	$5,099,730	$5,187,438	$0.0363
5	$1,397,093	$20,944,149	$22,341,242	$0.0098
6	$841,848	$82,227,071	$83,068,918	$0.0603
7	$287,692	$112,007,940	$112,295,632	$0.2383
8	$282,596	$33,052,937	$33,335,533	$0.0750
9	$2,423,795	$612,953,720	$615,377,515	$0.1591
10	$40,386	$9,263,778	$9,304,164	$0.1464
11	$17,428	$5,047,516	$5,064,943	$0.1859
12	$4,988	$1,050,888	$1,055,876	$0.1353
13	$13,043	$4,869,716	$4,882,760	$0.2379
Total	$83,881,028	$910,088,881	$993,969,910	

C.1.4 Traffic & Safety Projects Cost Allocation Results for Local Routes

TABLE C.1.18
Cost Responsibility per Year for Traffic & Safety Projects on Local Routes.

Vehicle Class	Cost Responsibility				
	2009	**2010**	**2011**	**2012**	**Total**
1	$418,109	$466,011	$429,490	$480,022	$1,793,631
2	$45,624,279	$50,851,355	$47,141,760	$52,348,822	$195,966,216
3	$19,247,373	$21,452,503	$20,296,485	$22,037,600	$83,033,961
4	$56,960	$63,486	$72,338	$132,677	$325,461
5	$848,180	$945,354	$1,305,367	$2,087,244	$5,186,146
6	$438,042	$488,228	$975,708	$1,225,421	$3,127,399
7	$148,477	$165,488	$336,594	$418,236	$1,068,795
8	$327,578	$365,108	$141,331	$140,174	$974,191
9	$2,212,027	$2,465,454	$2,074,543	$1,792,832	$8,544,856
10	$46,937	$52,315	$19,952	$19,995	$139,199
11	$22,531	$25,113	$4,074	$7,939	$59,658
12	$6,309	$7,032	$1,443	$2,314	$17,098
13	$15,063	$16,789	$6,636	$6,487	$44,974
Total	$69,411,867	$77,364,235	$72,805,722	$80,699,762	$300,281,586

TABLE C.1.19
Unit Cost per Year for Traffic & Safety Projects on Local Routes.

Vehicle Class	Unit Cost [$/VMT]				
	2009	**2010**	**2011**	**2012**	**Average**
1	$0.0021	$0.0022	$0.0021	$0.0025	$0.0022
2	$0.0021	$0.0022	$0.0021	$0.0025	$0.0022
3	$0.0021	$0.0022	$0.0021	$0.0025	$0.0022
4	$0.0021	$0.0022	$0.0021	$0.0025	$0.0023
5	$0.0021	$0.0022	$0.0021	$0.0025	$0.0023
6	$0.0021	$0.0022	$0.0021	$0.0025	$0.0023
7	$0.0021	$0.0022	$0.0021	$0.0025	$0.0023
8	$0.0021	$0.0022	$0.0021	$0.0025	$0.0022
9	$0.0021	$0.0022	$0.0021	$0.0025	$0.0022
10	$0.0021	$0.0022	$0.0021	$0.0025	$0.0022
11	$0.0021	$0.0022	$0.0021	$0.0025	$0.0022
12	$0.0021	$0.0022	$0.0021	$0.0025	$0.0022
13	$0.0021	$0.0022	$0.0021	$0.0025	$0.0022

C.1.5 Total Road Cost Allocation Results per Year for Local Routes

TABLE C.1.20
Cost Responsibility and Unit Cost of Road Expenditures on Local Routes, 2009.

Vehicle Class	Cost Responsibility					Unit Cost [$/VMT]
	New Road Construction	Road Rehabilitation	Road Maintenance	Traffic & Safety Projects	Total	
1	$992,898	$990,494	$172,334	$418,109	$2,573,835	$0.0131
2	$110,013,960	$108,083,283	$18,805,239	$45,624,279	$282,526,762	$0.0132
3	$50,907,614	$46,881,219	$8,957,369	$19,247,373	$125,993,575	$0.0139
4	$714,088	$766,661	$1,091,007	$56,960	$2,628,716	$0.0981
5	$5,587,513	$4,110,466	$4,401,191	$848,180	$14,947,350	$0.0375
6	$5,457,477	$12,736,819	$14,042,093	$438,042	$32,674,431	$0.1585
7	$6,402,318	$15,315,766	$18,822,448	$148,477	$40,689,010	$0.5824
8	$4,010,980	$7,248,627	$12,684,734	$327,578	$24,271,919	$0.1575
9	$44,381,330	$142,227,947	$184,049,934	$2,212,027	$372,871,237	$0.3583
10	$948,959	$2,789,146	$3,548,088	$46,937	$7,333,131	$0.3321
11	$532,564	$961,975	$2,146,336	$22,531	$3,663,406	$0.3456
12	$145,137	$223,737	$438,037	$6,309	$813,220	$0.2740
13	$538,844	$1,443,942	$1,850,725	$15,063	$3,848,574	$0.5430
Total	$230,633,682	$343,780,082	$271,009,536	$69,411,867	$914,835,167	

TABLE C.1.21
Cost Responsibility and Unit Cost of Road Expenditures on Local Routes, 2010.

Vehicle Class	Cost Responsibility					Unit Cost [$/VMT]
	New Road Construction	Road Rehabilitation	Road Maintenance	Traffic & Safety Projects	Total	
1	$1,012,964	$940,668	$162,511	$466,011	$2,582,153	$0.0120
2	$112,257,336	$102,646,300	$17,733,252	$50,851,355	$283,488,242	$0.0121
3	$51,916,035	$44,532,249	$8,441,240	$21,452,503	$126,342,027	$0.0128
4	$727,396	$728,534	$1,028,539	$63,486	$2,547,955	$0.0872
5	$5,649,310	$3,913,935	$4,149,243	$945,354	$14,657,843	$0.0337
6	$5,528,878	$12,033,966	$13,254,313	$488,228	$31,305,384	$0.1393
7	$6,463,593	$14,462,079	$17,781,851	$165,488	$38,873,011	$0.5103
8	$4,060,641	$6,899,680	$11,971,868	$365,108	$23,297,297	$0.1386
9	$45,473,608	$134,547,575	$173,920,525	$2,465,454	$356,407,162	$0.3141
10	$970,323	$2,639,571	$3,351,771	$52,315	$7,013,980	$0.2913
11	$539,795	$917,994	$2,025,512	$25,113	$3,508,414	$0.3035
12	$147,807	$213,273	$413,142	$7,032	$781,254	$0.2414
13	$546,864	$1,365,362	$1,747,523	$16,789	$3,676,538	$0.4758
Total	$235,294,550	$325,841,187	$255,981,288	$77,364,235	$894,481,261	

TABLE C.1.22
Cost Responsibility and Unit Cost of Road Expenditures on Local Routes, 2011.

Vehicle Class	Cost Responsibility					Unit Cost [$/VMT]
	New Road Construction	Road Rehabilitation	Road Maintenance	Traffic & Safety Projects	Total	
1	$983,468	$728,227	$152,908	$429,490	$2,294,093	$0.0113
2	$109,752,283	$79,931,910	$16,783,551	$47,141,760	$253,609,505	$0.0114
3	$51,046,920	$35,357,545	$8,132,388	$20,296,485	$114,833,337	$0.0120
4	$790,746	$678,902	$1,169,101	$72,338	$2,711,086	$0.0793
5	$7,536,892	$4,461,163	$5,723,451	$1,305,367	$19,026,874	$0.0309
6	$9,865,596	$19,651,592	$26,414,934	$975,708	$56,907,830	$0.1235
7	$11,422,231	$23,992,157	$36,054,880	$336,594	$71,805,861	$0.4517
8	$1,968,610	$2,177,358	$4,621,241	$141,331	$8,908,540	$0.1335
9	$38,868,301	$92,324,549	$145,893,915	$2,074,543	$279,161,309	$0.2849
10	$507,535	$820,895	$1,274,410	$19,952	$2,622,792	$0.2783
11	$170,223	$121,094	$327,651	$4,074	$623,043	$0.3238
12	$54,387	$35,624	$84,556	$1,443	$176,010	$0.2582
13	$296,299	$440,014	$688,645	$6,636	$1,431,594	$0.4567
Total	$233,263,491	$260,721,031	$247,321,631	$72,805,722	$814,111,874	

TABLE C.1.23
Cost Responsibility and Unit Cost of Road Expenditures on Local Routes, 2012.

Vehicle Class	Cost Responsibility					Unit Cost [$/VMT]
	New Road Construction	Road Rehabilitation	Road Maintenance	Traffic & Safety Projects	Total	
1	$907,699	$910,654	$140,010	$480,022	$2,438,385	$0.0128
2	$100,497,280	$99,311,500	$15,268,778	$52,348,822	$267,426,379	$0.0129
3	$46,414,354	$43,038,745	$7,306,310	$22,037,600	$118,797,008	$0.0136
4	$1,114,097	$1,464,918	$1,898,791	$132,677	$4,610,483	$0.0874
5	$9,536,487	$8,263,669	$8,067,356	$2,087,244	$27,954,756	$0.0337
6	$9,825,054	$28,935,863	$29,357,579	$1,225,421	$69,343,918	$0.1424
7	$11,006,072	$35,046,126	$39,636,453	$418,236	$86,106,886	$0.5180
8	$1,791,646	$2,558,391	$4,057,690	$140,174	$8,547,901	$0.1534
9	$31,372,007	$93,985,992	$111,513,140	$1,792,832	$238,663,972	$0.3350
10	$485,364	$969,484	$1,129,894	$19,995	$2,604,737	$0.3278
11	$221,542	$281,532	$565,444	$7,939	$1,076,457	$0.3412
12	$65,245	$67,982	$120,141	$2,314	$255,684	$0.2780
13	$277,402	$506,676	$595,867	$6,487	$1,386,433	$0.5378
Total	$213,514,250	$315,341,532	$219,657,454	$80,699,762	$829,212,998	

TABLE C.1.24
Cost Responsibility and Unit Cost of Road Expenditures on Local Routes, 2009–2012.

Vehicle Class	Cost Responsibility					Unit Cost [$/VMT]
	New Road Construction	Road Rehabilitation	Road Maintenance	Traffic & Safety Projects	Total	
1	$3,897,029	$3,570,044	$627,763	$1,793,631	$9,888,466	$0.0123
2	$432,520,860	$389,972,993	$68,590,820	$195,966,216	$1,087,050,889	$0.0124
3	$200,284,923	$169,809,757	$32,837,306	$83,033,961	$485,965,947	$0.0130
4	$3,346,326	$3,639,015	$5,187,438	$325,461	$12,498,240	$0.0875
5	$28,310,201	$20,749,234	$22,341,242	$5,186,146	$76,586,823	$0.0336
6	$30,677,005	$73,358,241	$83,068,918	$3,127,399	$190,231,563	$0.1380
7	$35,294,214	$88,816,127	$112,295,632	$1,068,795	$237,474,768	$0.5039
8	$11,831,877	$18,884,057	$33,335,533	$974,191	$65,025,657	$0.1462
9	$160,095,246	$463,086,063	$615,377,515	$8,544,856	$1,247,103,680	$0.3224
10	$2,912,181	$7,219,096	$9,304,164	$139,199	$19,574,640	$0.3081
11	$1,464,125	$2,282,594	$5,064,943	$59,658	$8,871,320	$0.3257
12	$412,576	$540,617	$1,055,876	$17,098	$2,026,167	$0.2596
13	$1,659,410	$3,755,994	$4,882,760	$44,974	$10,343,139	$0.5039
Total	$912,705,973	$1,245,683,832	$993,969,910	$300,281,586	$3,452,641,300	

C.2. BRIDGE COST ALLOCATION RESULTS FOR LOCAL ROUTES

TABLE C.2.1
2009 Bridge Cost Allocation Results for Local Routes by Project Type.

2009	Bridge Construction or Reconstruction		Bridge Rehabilitation		Bridge Maintenance or Repair		Others		Bridge Total	
Vehicle Class	Cost Responsibility	Unit Cost ($/VMT)	Cost Responsibility	Unit Cost ($/VMT)	Cost Responsibility	Unit Cost ($/VMT)	Cost Responsibility	Unit Cost ($/VMT)	Cost Responsibility	Unit Cost ($/VMT)
1	$575,946	$0.0029	$52,767	$0.0003	$224,991	$0.0011	$123,028	$0.0006	$976,734	$0.0050
2	$62,847,600	$0.0029	$5,758,013	$0.0003	$24,551,198	$0.0011	$13,424,926	$0.0006	$106,581,737	$0.0050
3	$26,513,322	$0.0029	$2,429,115	$0.0003	$10,357,338	$0.0011	$5,663,532	$0.0006	$44,963,307	$0.0050
4	$383,293	$0.0143	$20,635	$0.0008	$67,433	$0.0025	$36,873	$0.0014	$508,234	$0.0190
5	$2,984,360	$0.0075	$244,967	$0.0006	$1,004,124	$0.0025	$549,069	$0.0014	$4,782,521	$0.0120
6	$2,725,023	$0.0132	$153,593	$0.0007	$518,579	$0.0025	$283,566	$0.0014	$3,680,762	$0.0179
7	$5,872,941	$0.0841	$165,281	$0.0024	$175,776	$0.0025	$96,117	$0.0014	$6,310,115	$0.0903
8	$1,632,121	$0.0106	$105,579	$0.0007	$387,806	$0.0025	$212,057	$0.0014	$2,337,563	$0.0152
9	$23,322,570	$0.0224	$994,349	$0.0010	$2,618,724	$0.0025	$1,431,954	$0.0014	$28,367,596	$0.0273
10	$1,854,112	$0.0840	$52,193	$0.0024	$55,567	$0.0025	$30,385	$0.0014	$1,992,257	$0.0902
11	$244,756	$0.0231	$10,293	$0.0010	$26,674	$0.0025	$14,586	$0.0014	$296,308	$0.0280
12	$951,849	$0.3207	$23,089	$0.0078	$7,469	$0.0025	$4,084	$0.0014	$986,491	$0.3323
13	$2,005,947	$0.2830	$49,026	$0.0069	$17,832	$0.0025	$9,751	$0.0014	$2,082,557	$0.2939
Total	$131,913,843		$10,058,901		$40,013,513		$21,879,927		$203,866,183	

TABLE C.2.2
2010 Bridge Cost Allocation Results for Local Routes by Project Type.

2010	Bridge Construction or Reconstruction		Bridge Rehabilitation		Bridge Maintenance or Repair		Others		Bridge Total	
Vehicle Class	Cost Responsibility	Unit Cost ($/VMT)	Cost Responsibility	Unit Cost ($/VMT)	Cost Responsibility	Unit Cost ($/VMT)	Cost Responsibility	Unit Cost ($/VMT)	Cost Responsibility	Unit Cost ($/VMT)
1	$617,479	$0.0029	$85,708	$0.0004	$238,043	$0.0011	$179,039	$0.0008	$1,120,269	$0.0052
2	$67,379,633	$0.0029	$9,352,505	$0.0004	$25,975,421	$0.0011	$19,536,834	$0.0008	$122,244,393	$0.0052
3	$28,425,237	$0.0029	$3,945,512	$0.0004	$10,958,170	$0.0011	$8,241,944	$0.0008	$51,570,863	$0.0052
4	$410,933	$0.0141	$33,516	$0.0011	$71,345	$0.0024	$53,660	$0.0018	$569,454	$0.0195
5	$3,199,567	$0.0074	$397,891	$0.0009	$1,062,374	$0.0024	$799,041	$0.0018	$5,458,872	$0.0125
6	$2,921,529	$0.0130	$249,475	$0.0011	$548,662	$0.0024	$412,664	$0.0018	$4,132,330	$0.0184
7	$6,296,448	$0.0827	$268,460	$0.0035	$185,973	$0.0024	$139,875	$0.0018	$6,890,756	$0.0905
8	$1,749,815	$0.0104	$171,488	$0.0010	$410,303	$0.0024	$308,600	$0.0018	$2,640,206	$0.0157
9	$25,004,394	$0.0220	$1,615,081	$0.0014	$2,770,637	$0.0024	$2,083,873	$0.0018	$31,473,985	$0.0277
10	$1,987,815	$0.0826	$84,775	$0.0035	$58,791	$0.0024	$44,218	$0.0018	$2,175,599	$0.0904
11	$262,405	$0.0227	$16,718	$0.0014	$28,221	$0.0024	$21,226	$0.0018	$328,571	$0.0284
12	$1,020,489	$0.3153	$37,502	$0.0116	$7,902	$0.0024	$5,943	$0.0018	$1,071,837	$0.3312
13	$2,150,599	$0.2783	$79,631	$0.0103	$18,867	$0.0024	$14,190	$0.0018	$2,263,287	$0.2929
Total	$141,426,343		$16,338,261		$42,334,709		$31,841,108		$231,940,421	

TABLE C.2.3
2011 Bridge Cost Allocation Results for Local Routes by Project Type.

2010	Bridge Construction or Reconstruction		Bridge Rehabilitation		Bridge Maintenance or Repair		Others		Bridge Total	
Vehicle Class	Cost Responsibility	Unit Cost ($/VMT)	Cost Responsibility	Unit Cost ($/VMT)	Cost Responsibility	Unit Cost ($/VMT)	Cost Responsibility	Unit Cost ($/VMT)	Cost Responsibility	Unit Cost ($/VMT)
1	$578,452	$0.0029	$62,672	$0.0003	$174,218	$0.0009	$83,253	$0.0004	$898,595	$0.0044
2	$63,492,176	$0.0029	$6,879,000	$0.0003	$19,122,600	$0.0009	$9,138,038	$0.0004	$98,631,814	$0.0044
3	$27,336,018	$0.0029	$2,961,695	$0.0003	$8,233,073	$0.0009	$3,934,305	$0.0004	$42,465,091	$0.0044
4	$437,128	$0.0128	$29,292	$0.0009	$64,555	$0.0019	$30,849	$0.0009	$561,824	$0.0164
5	$4,167,590	$0.0068	$427,225	$0.0007	$1,164,921	$0.0019	$556,676	$0.0009	$6,316,412	$0.0102
6	$5,454,318	$0.0118	$383,062	$0.0008	$870,731	$0.0019	$416,093	$0.0009	$7,124,203	$0.0155
7	$10,652,079	$0.0670	$371,086	$0.0023	$300,379	$0.0019	$143,541	$0.0009	$11,467,085	$0.0721
8	$637,082	$0.0095	$51,319	$0.0008	$126,125	$0.0019	$60,271	$0.0009	$874,796	$0.0131
9	$19,035,257	$0.0194	$1,017,109	$0.0010	$1,851,341	$0.0019	$884,693	$0.0009	$22,788,400	$0.0233
10	$1,184,812	$0.1257	$37,073	$0.0039	$17,805	$0.0019	$8,508	$0.0009	$1,248,199	$0.1325
11	$39,575	$0.0206	$2,057	$0.0011	$3,636	$0.0019	$1,738	$0.0009	$47,006	$0.0244
12	$461,366	$0.6768	$12,916	$0.0189	$1,288	$0.0019	$615	$0.0009	$476,185	$0.6985
13	$1,807,355	$0.5766	$50,834	$0.0162	$5,922	$0.0019	$2,830	$0.0009	$1,866,940	$0.5956
Total	$135,283,206		$12,285,339		$31,936,594		$15,261,409		$194,766,549	

TABLE C.2.4
2012 Bridge Cost Allocation Results for Local Routes by Project Type.

2010	Bridge Construction or Reconstruction		Bridge Rehabilitation		Bridge Maintenance or Repair		Others		Bridge Total	
Vehicle Class	Cost Responsibility	Unit Cost ($/VMT)	Cost Responsibility	Unit Cost ($/VMT)	Cost Responsibility	Unit Cost ($/VMT)	Cost Responsibility	Unit Cost ($/VMT)	Cost Responsibility	Unit Cost ($/VMT)
1	$588,321	$0.0031	$72,256	$0.0004	$188,687	$0.0010	$29,443	$0.0002	$588,321	$0.0031
2	$64,159,463	$0.0031	$7,879,887	$0.0004	$20,577,240	$0.0010	$3,210,887	$0.0002	$64,159,463	$0.0031
3	$27,009,597	$0.0031	$3,317,244	$0.0004	$8,662,525	$0.0010	$1,351,707	$0.0002	$27,009,597	$0.0031
4	$739,100	$0.0140	$55,758	$0.0011	$114,735	$0.0022	$17,903	$0.0003	$739,100	$0.0140
5	$5,904,725	$0.0071	$699,788	$0.0008	$1,804,996	$0.0022	$281,653	$0.0003	$5,904,725	$0.0071
6	$6,292,219	$0.0129	$498,430	$0.0010	$1,059,713	$0.0022	$165,358	$0.0003	$6,292,219	$0.0129
7	$12,315,796	$0.0741	$485,302	$0.0029	$361,679	$0.0022	$56,437	$0.0003	$12,315,796	$0.0741
8	$574,374	$0.0103	$52,508	$0.0009	$121,218	$0.0022	$18,915	$0.0003	$574,374	$0.0103
9	$15,342,301	$0.0215	$919,436	$0.0013	$1,550,396	$0.0022	$241,925	$0.0003	$15,342,301	$0.0215
10	$1,111,960	$0.1399	$39,418	$0.0050	$17,291	$0.0022	$2,698	$0.0003	$1,111,960	$0.1399
11	$72,791	$0.0231	$4,222	$0.0013	$6,866	$0.0022	$1,071	$0.0003	$72,791	$0.0231
12	$692,011	$0.7524	$22,023	$0.0239	$2,001	$0.0022	$312	$0.0003	$692,011	$0.7524
13	$1,652,520	$0.6410	$52,830	$0.0205	$5,610	$0.0022	$875	$0.0003	$1,652,520	$0.6410
Total	$136,455,179		$14,099,101		$34,472,957		$5,379,185		$136,455,179	

About the Joint Transportation Research Program (JTRP)

On March 11, 1937, the Indiana Legislature passed an act which authorized the Indiana State Highway Commission to cooperate with and assist Purdue University in developing the best methods of improving and maintaining the highways of the state and the respective counties thereof. That collaborative effort was called the Joint Highway Research Project (JHRP). In 1997 the collaborative venture was renamed as the Joint Transportation Research Program (JTRP) to reflect the state and national efforts to integrate the management and operation of various transportation modes.

The first studies of JHRP were concerned with Test Road No. 1—evaluation of the weathering characteristics of stabilized materials. After World War II, the JHRP program grew substantially and was regularly producing technical reports. Over 1,500 technical reports are now available, published as part of the JHRP and subsequently JTRP collaborative venture between Purdue University and what is now the Indiana Department of Transportation.

Free online access to all reports is provided through a unique collaboration between JTRP and Purdue Libraries. These are available at: http://docs.lib.purdue.edu/jtrp

Further information about JTRP and its current research program is available at: http://www.purdue.edu/jtrp

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