Environmental Costs of Commercial Motor Vehicle (CMV) Crashes

Phase II – Part 2: Estimation Report

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1. INTRODUCTION

The Federal Motor Carrier Safety Administration (FMCSA) is generally charged with preparing economic and environmental impact analyses to support proposed amendments and additions to the Federal Motor Carrier Safety Regulations (FMCSRs).

Economic analyses are performed in support of amendments and additions to the FMCSRs as a consequence of Executive Order 12866 and Department of Transportation (DOT) Policies and Procedures. For those economic analyses, FMCSA currently uses "Revised Costs of Large Truck- and Bus-Involved Crashes" (2002) by Eduard Zaloshnja and Ted Miller of the Pacific Institute.[1] That report, commissioned by FMCSA, provides regulators and analysts at the agency (and elsewhere) with estimates of the economic costs associated with commercial motor vehicle (CMV) crashes.

Environmental compliance analyses are performed in support of amendments and additions to the FMCSRs as a consequence of the National Environmental Policy Act (NEPA) and FMCSA's Order 5610.1. Up to now, FMCSA has not had a source comparable to Zaloshnja and Miller that could be used when evaluating the environmental impacts of proposed regulations. As a consequence, generalizations and qualitative statements have been generally used when evaluating the potential environmental impacts of FMCSRs, their effect on changing the frequency and severity of CMV crashes and other safety related incidents, and their associated environmental impacts and costs.

1.1 PURPOSE

The purpose of this report is to provide FMCSA with estimates for its environmental analyses comparable to those currently being used by the agency for its economic analyses. These environmental estimates, along with the included descriptions of the methodologies upon which they are based, will enable FMCSA to describe the inherent links between CMV safety and environmental protection. The estimates presented in this report are meant to be used primarily in the preparation of Environmental Assessments (EAs) and related documents. For Environmental Impact Statements (EISs), which look at potentially significant impacts on the environment, the estimates and methodologies presented in this report represent a starting point for analysts, who will probably want to develop their own more detailed estimates.

1.2 FOCUS

Consistent with the primary safety focus of FMCSA, the focus of this report is on environmental estimates for commercial trucks with a gross weight rating of over 10,000 pounds and buses. In an effort to promote consistency, to the extent practicable, the methodologies and estimates presented in this report are for the same general vehicle categories used by Zaloshnja and Miller for economic analyses:

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[1] This report was updated in 2006, and it is expected that this update will replace the 2002 version in FMCSA economic analyses in the very near future.

- Straight Trucks
- Truck Tractors
- Medium/Heavy Trucks
- Buses

1.3 WHAT IS A CMV CRASH?

For the purposes of this analysis, a CMV involved in a crash is defined as follows:

- Any truck having a gross vehicle weight rating (GVWR) of more than 10,000 pounds or a gross combination weight rating (GCWR) over 10,000 pounds used on public highways,
  OR
- Any motor vehicle designed to transport more than eight people, including the driver,
  OR
- Any vehicle displaying a hazardous materials placard (regardless of weight) [NOTE: This criterion assumes that an officer at a crash site may not be familiar with the Federal Hazardous Materials Regulations (Specifically, 49 CFR Part 172). If an officer or associate is knowledgeable in those, any vehicle discovered to be transporting hazardous materials without a required placard should also be included.]
  AND
- That vehicle is involved in a crash while operating on a roadway customarily open to the public, which results in:
    - A fatality: any person(s) killed in or outside of any vehicle (truck, bus, car, etc.) involved in the crash or who dies within 30 days of the crash as a result of an injury sustained in the crash, OR
    - An injury: any person(s) injured as a result of the crash who immediately receives medical treatment away from the crash scene, OR
    - A tow-away: any motor vehicle (truck, bus, car, etc.) disabled as a result of the crash and transported away from the scene by a tow truck or other vehicle.

  EXCEPT

  Crashes that involve:
- A personally-owned truck or passenger vehicle meant for personal use only as the sole vehicle meeting the criteria above, OR
- A driver with a disease condition (stroke, heart attack, diabetic coma or epileptic seizure) and no other injury or damage occurs,[2] OR
    - Deliberate intent (suicide, self-inflicted injury, homicide, etc.), with no unintentional injury or damage.[3]

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[2] Defined in the American National Standard Institute – "Manual on Classification of Motor Vehicle Traffic Accidents" (ANSI D1.6, Section 2.4.1).

[3] Defined in the American National Standard Institute – "Manual on Classification of Motor Vehicle Traffic Accidents" (ANSI D16.1, Section 2.4.2).

The foregoing description matches the conditions for reporting crashes to FMCSA via Safetynet. The description differs slightly from the definition of an “accident” found at 49 CFR 390.5, it should be noted.

1.4 RESOURCE CATEGORIES

Consistent with the requirements of NEPA and FMCSA implementing regulations, estimates are presented in this report for the following four resource categories:

- Congestion
- Air Quality and Greenhouse Gases
- Hazardous Materials
- Solid Waste

Other resource categories, such as noise, ecological resources, and water quality, which would appear to require significantly more elaborate and involved analyses, may be addressed in future updates of this report.

1.5 LIMITATIONS

To properly use the environmental estimates presented in this report, analysts and policy-makers using this report must be aware of their limitations. A summary of some of the more significant limitations by resource category is presented below.

1.5.1 Congestion

- Crashes affect traffic flow beyond the vehicles delayed at the crash site. This report does not include CMV crash impacts attributable to re-scheduling, re-routing, reduced mobility, and reliability.
- No estimate of the delay associated with evacuations due to hazardous materials spills from CMVs is included in this report.
- The congestion impact of severe crashes (i.e., those involving the closure of major highway arteries for extended (crash related delay lasting more than 9 hours) periods) was not calculated. In the case of extended road closures, traffic will be diverted to alternative routes and the associate delays will be dispersed over multiple roadways.
- Only limited real-world delay data could be obtained for the congestion analysis.
- Breakdowns and other non-crash related delay is not considered in the report

1.5.2 Air Quality and Greenhouse Gases

- The air quality and greenhouse gases analysis does not consider idling time and instantaneous speed and acceleration throughout the duration of the congestion associated with the slow stop-and-go driving characteristics. This is a significant limitation, since fuel consumption and emissions are highly dependent on acceleration and are significantly higher during idle and stop-and-go driving (especially at very slow speeds) than those resulting from unrestricted free-flow driving conditions. Using average steady state speeds, as was done in this analysis, is expected to largely underestimate emissions and fuel consumption.

- The air quality and greenhouse gases analysis uses time of delay rather than the total time in congestion. Time of delay is a portion of the total time in congestion. The accuracy of the estimates is limited by not estimating the difference betweeen the emissions and fuel consumption associated with the total time in congestion (at the congested driving conditions) and the emissions and fuel consumption associated with the time it would take to travel the distance affected by the CMV crash (at an average free-flow speed associated with the specific facility type affected in the incident).
- The air quality analysis does not address impacts of air pollutants on visibility and the associated social costs. Air pollutant impacts on health and greenhouse gases and impacts on climate change are addressed in this document.

1.5.3 Hazardous Materials

- FMCSA data inexplicably reports more crashes involving hazardous materials releases than PHMSA data.
- There was a possibility of double counting of certain non-crash incidents when quantities were categorized by hazardous materials class.
- No information was readily available on spills from bus fuel tanks.

1.5.4 Solid Waste

- Only rough approximations are readily available for the solid waste generated by automobiles, truck tractors, and buses involved in CMV crashes.
- No information is readily available for the solid waste generated by other types of CMVs involved in CMV crashes.
- No information is readily available for the solid waste generated by truck trailers that are involved in CMV crashes.
- No information is readily available for the solid waste generated by cargoes being carried by CMVs involved in crashes (or for cargoes being carried by other conveyances that might be involved in CMV crashes). This would appear to be counterintuitive, since the insurance industry is generally paying for cargoes lost due to CMV crashes. The insurance industry should have the desired information. The insurance industry, however, lumps cargoes for which they paid because of vehicular accidents with cargoes for which they paid because of cargo theft, which is a significantly bigger problem for insurers than cargo damage/loss due to vehicular accidents.

Because of the limitations to the environmental estimates presented in this report, in some cases, analysts developing EAs may need to develop their own estimates of the environmental impact of certain actions. For instance, analysts working on a new safety rule for intermodal containers might need to develop ad hoc estimates of the solid waste typically generated in a CMV crash.

1.6 OVERVIEW OF THE REPORT

The remainder of this report is organized as follows. Chapter 2 looks at congestion. Congestion relief is one of the top U.S. DOT priorities. Thus, having estimates of congestion impacts (traffic delay and associated economic and environmental costs) from changes in the frequency and severity of CMV crashes will allow FMCSA to support DOT in this strategic goal. Additionally, congestion serves an important input for the environmental impact of CMV crashes on air quality and greenhouse gases.

Chapter 3 discusses air quality and greenhouse gases. With respect to air quality, Section 2a of the Clean Air Act charges the U.S. DOT with monitoring, evaluating, and controlling transportation activities (such as motor vehicle operation) in order to protect and enhance the quality of the environment. Thus, estimates of the air quality impacts of CMV crashes will enable FMCSA to consider emissions impacts associated with evaluating safety regulations and programs by capturing their associated environmental and health costs. Given the relevance and increased focus on the potential impacts of greenhouse gases (GHG) on global climate change, the air quality chapter also addresses GHG estimates.

Chapter 4 addresses hazardous materials (HM) incidents. FMCSA seeks accurate information on HM releases into the environment. The hazardous materials chapter presents estimates of releases from CMV crashes on a per unit basis, and also estimates of releases from transportation incidents involving CMVs but not resulting from a CMV crash.

Chapter 5 considers the solid waste generated by CMV crashes.

Chapter 6 presents a bibliography containing all of references for the report.

2. CONGESTION

2.1 INTRODUCTION

Congestion from CMV crashes reduces U.S. productive efficiency by delaying shipments of goods. Extra time spent stopped or traveling at slower speeds could be spent in more economically productive and enjoyable activities. Recurring congestion can eventually cause urban development to spread out as businesses attempt to decentralize jobs and housing to reduce travel time (Downs 2004). The longer distances between workplaces and home in turn produce more demand for fossil fuels. For CMVs, this means more deliveries of petroleum and more time on the road transporting household goods, which in turn results in higher consumption of fuel.

2.1.1 Congestion and Delay

Traffic congestion is a daily visible challenge to economic efficiency and quality of life. The National League of Cities (NLC) has found that city officials believe alleviating traffic conditions is their one of their most important goals (NLC 2006). In addition, traffic delay is at the top of NLC's list (34 percent of respondents) of conditions that have most deteriorated over the past five years. The Texas Transportation Institute (TTI) estimates that the 85 largest metropolitan areas experienced 3.7 billion vehicle hours of delay (TTI 2004). Traffic volumes are rising every year, so congestion is expected to increase. More CMV's will have to travel on roadways to move a volume of freight that is expected to nearly double by 2020 (FHWA 2006). American businesses have realized huge productivity gains in part from reducing inventory requirements and use of "just in time delivery." Growing congestion threatens to reverse some of these efficiencies and require businesses to carry larger inventories (US DOT 2006a). In 2006, the U.S. DOT created an executive Congestion Working Group to prioritize solutions to our nation's growing problems with traffic delay. Collision related delays constitute a sizeable portion of total congestion in the U.S. In 1999, as many as 1.7 billion vehicle hours were lost to delay due to collisions (Chin et al. 2004). Vehicles involved in crashes often block traffic, need emergency response, and cause curious drivers to slow down to "rubberneck." Cambridge Systematics estimates that traffic incidents (including crashes) constitute approximately 25 percent of traffic congestion (Cambridge Systematics 2005). CMV crashes represent a sizable number of the overall number of crashes, and, due to the large size of trucks and buses, often result in longer delays than crashes where just cars are involved (Ullman and Ogden 1995, Glickman et al. 1991).

CMV crash linked congestion also effects air quality and fuel use. Increased idling, accelerating and decelerating, and longer engine run times all result in increased emissions above steady road speeds. The congestion delay estimation will assist the evaluation of the air quality effects of CMV crashes, which is discussed in the next chapter of the report. FMCSA regulations can have an indirect effect on congestion related to CMV collisions. If regulations effectively reduce the number of large truck and bus crashes, associated delay will also decrease. This chapter proposes a method to quantify the congestion impacts associated with CMV crashes.

For this report, economically productive and leisure activities are valued equally. Both types of activities have an “opportunity cost.” An individual makes a decision, based partly on economics, that they will forgo some action and its payoff in order to pursue a certain activity. Congestion delay impedes both the selected action and the forgone alternative.

2.1.2 Chapter Overview

This chapter helps fulfill the U.S. DOT Congestion Working Group’s seven-point strategy for reducing congestion. The chapter provides background information about congestion and how it occurs. Following that background discussion, two possible methodologies are outlined for calculating both congestion delay and its associated costs. The first method builds on Zaloshnja and Miller’s work using updated data. The second method is an alternative slightly modifying a Battelle approach previously developed for FMCSA. The preferred method is identified, including the reasons for the choice. An approach to validate the results of the methodology is proposed. The chapter then discusses accounting for significant regional incidents – large crashes that can skew results due to the scale of their impact.

2.2 BACKGROUND

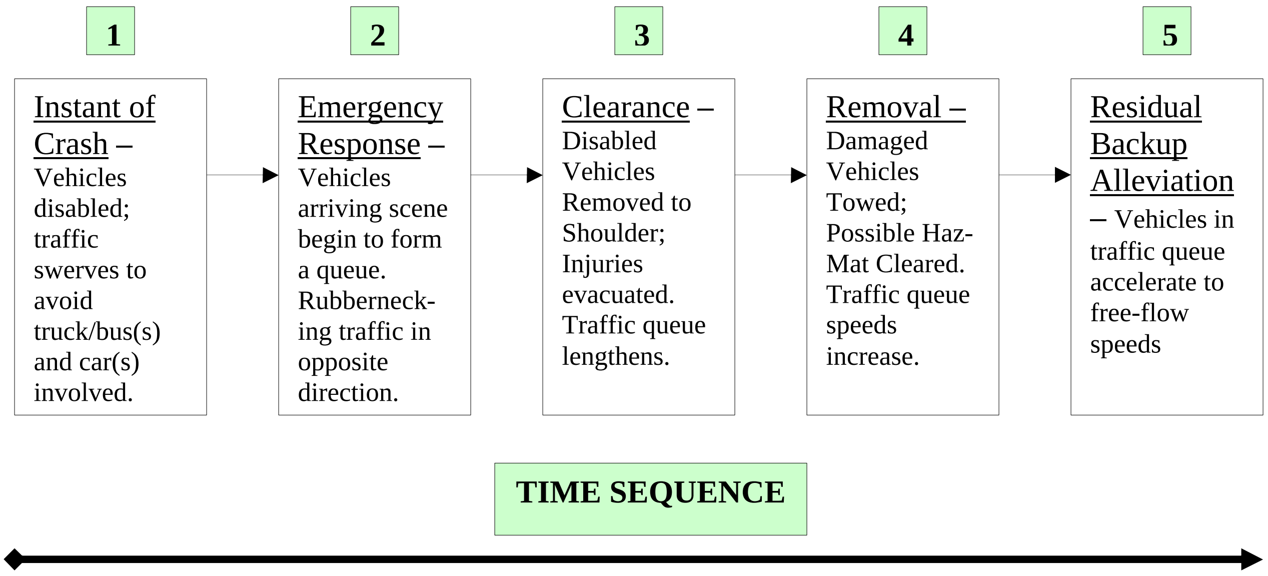
CMV crashes cause traffic delay in a number of ways. Crashes can cause damage to the driver’s own vehicle, other trucks, buses, or cars, requiring removal of some or all of the vehicles involved from the roadway. The damaged vehicles may block roadway lanes, necessitating tow removal. The tow vehicles themselves may impede traffic flow as other vehicles in the traffic bottleneck will stop and allow access. Drivers and passengers may be injured or killed, requiring emergency medical vehicles to respond, rescue, and evacuate. Cargo spills, especially hazardous materials, may require specialized clean up procedures. Fires from vehicles or cargo may have to be extinguished. In some cases, bridges and other road infrastructure could be damaged, requiring extended closure to assess and repair. In all cases, curious drivers will likely slow down to view the incident causing even more congestion, which is referred to as *rubbernecking* or *gaper’s block*.

Any safety regulation that effectively reduces the number of CMV crashes has the potential to reduce congestion impacts. Delay estimates can be derived through studying a number of metropolitan regions that represent large, medium, and small cities. Police departments record crash delay times. That information can be used to estimate the total number of hours of delay. Economic costs can be calculated by multiplying the total delay by the value of time for all the individuals caught in the traffic (Miller 2006). With this data, FMCSA can make a forecast of the monetary impact of the crash and combine it with the medical, air quality, and hazardous waste analyses to obtain a total social cost for each crash, and thus quantify the monetary benefit of regulations that reduce the number of incidents by a known or projected quantity.

One well-regarded study of U.S. congestion from the Texas Transportation Institute estimates 3.7 billion hours of annual congestion delay valued at $63 billion in economic cost (Schrank and Lomax 2005). The Texas Transportation Institute calculates congestion costs with productivity losses due to time spent in delay and extra fuel expended from longer travel times.

Compared to other social costs (not covered by the price of vehicle operation and user fees), congestion may be the highest (Gomez-Ibanez 1997, K.T. Analytics 1997). The Texas Transportation Institute found that incidents, including collisions, cause 52 percent of congestion in 85 urban areas it studied in 2003. Studies have found that trucks are involved with 17 percent of crashes in the Washington D.C. capital beltway area (Glickman et al. 1991) and approximately 11 percent of incidents in the Houston area (Ullman and Ogden 1996). The percentage of congestion caused by incidents varies greatly from region to region. Ranges in one 1984 study found a low of 37 percent (San Diego) and a high of 100 percent (Indianapolis) (Downs 2004). This impact is greater when major incidents are analyzed. Ullman and Ogden found trucks were involved in 90 percent of major incidents (major was defined as having a median delay time of 2.5 hours).

FIGURE 2-1. TIME FLOWCHART OF A CMV CRASH



Note: Traffic diversions and repairs to roadway infrastructure are not represented in this flowchart.

Congestion delays also affect air quality. Vehicles idling, decelerating and accelerating, and traveling over longer periods of time due to traffic slow downs will produce more emissions. Congestion delay data can be used along with other information to determine the how much vehicle emissions increase when there is congestion, as compared to the emissions when there is an unimpeded traffic flow.

2.3 CONGESTION DELAY IMPACT METHODOLOGY

The highest accuracy could be obtained by studying crashes immediately after they occur and measuring the time traffic behavior and delay time at the scene. Unfortunately, due to the stochastic nature of truck crashes and the difficulty of obtaining field data. Crash delay models are linked either to capacity reductions (estimates in traffic flow on roadways with blocked lanes) or to broad estimates using traffic flow calculations based on speed estimates and the length of traffic queues. Zaloshnja and Miller addressed this lack of data by collecting CMV crash delay duration information from local police departments (Zaloshnja and Miller 2000). The same method was selected for use here.

All 68 cities in the Texas Transportation Institute's Urban Mobility Report (Schrank and Lomax 2005) were contacted for data relating to CMV crash delay. Both state departments of transportation and police departments were contacted for each of the urban areas.

Only three states: Pennsylvania, Kentucky, and Washington were able to provide relevant delay data to the Volpe research team. Each of these states provided CMV crash vehicle delays for 2003-2005. Kentucky provided the total duration of delay for each level of CMV crash severity. The CMV delay data from Pennsylvania and Washington was provided in time ranges with crashes placed in the following time categories:

- 0-30 minutes
- 30-60 minutes
- 1-3 hours
- 3-6 hours
- 6-9 hours
- 9+ hours
- Unknown duration

The ranges were converted into values for use in this study by assigning an average, maximum, and minimum time for each time period. For example, 0-30 minutes was calculated as 15, 30, and 1 minute, respectively; 9+ hours was calculated as 9.5, 12, and 9 hours, respectively. Crash delay lasting more than 12 hours was not accounted for in the Pennsylvania and Washington data. The unknown duration crashes were excluded from the estimate.

All the CMV crash delay times were summed and then divided by the number of crashes to yield the following ratios:

- **Low:** 56 minutes- Property Damage Only (PDO): 64 minutes- Injury: 192 minutes- Fatality
- **Mid:** 72 minutes- PDO: 91 minutes- Injury: 261 minutes- Fatality

- **High:** 89 minutes- PDO: 120 minutes- Injury: 336 minutes- Fatality

The mid-level calculation was selected, as the average duration is most likely the most accurate conservative approximation of the delay times.

TABLE 2-1. COMPARISON OF CMV CRASH ROAD DELAY BY SEVERITY LEVEL

Type of Crash	Volpe 2007 (mid-level)	Zaloshnja and Miller 2006
Fatality	261 minutes	385 minutes
Injury	91 minutes	130 minutes
Property Damage Only	72 minutes	40 minutes

The mid-level figures developed for this study can be compared to the figures developed by Zaloshnja and Miller for comparable crashes: 40 minutes – PDO; 130 minutes – Injury; 385 minutes – Fatality (Zaloshnja and Miller 2000). Zaloshnja and Miller collected their police reported crash delay information from police departments in the early and mid 1990s.

It is interesting to note that, based on the updated information, property damage crashes create more congestion, while both injury and fatal crashes create less delay than Zaloshnja and Miller found. Property damage only crashes may create more congestion due to the increased volume of traffic on U.S. roadways. More severe crashes may cause less traffic due to dramatic improvements in emergency response. A recent National Cooperative Highway Research Program Report indicates that states are adopting a growing number of quick clearance procedures (TRB 2003). Traffic fatality certification laws allow responders to remove the deceased from the roadway before medical examiners arrive to facilitate traffic flow. Even though injuries and fatalities may create less delay following CMV crashes than they did in Zaloshnja and Miller's original findings, overall delay is greater, since the vast majority of CMV crashes are limited to property damage only.

The National Highway Transportation Safety Administration (NHTSA) Fatal Analysis Reporting System (FARS) database was utilized for CMV crash information. NHTSA's General Estimates System (GES) was used as a supplement for injury and PDO crashes.

The steps below were followed to calculate the vehicle delay in hours discussed above:

- **Step 1**: CMV crash delay: Determine crash delay times associated with each type of crash based on field-collected data. Bus data was taken from MCMIS state reporting and normalized using 2004 truck ratios. Crash delay time is in vehicle minutes. Note actual hours for bus delay are likely greater as they are more likely to occur on urban roadways.

- **Step 2**: Highway Lane Miles: Use FHWA 2004 Highway Statistics to determine the Lanes per Facility Type. Assumption 1 – Delay only occurs to the traffic traveling in the same direction as the CMV crash.

- **Step 3**: Combine roadway lane miles with facility type traffic flow to determine traffic volume. Lane volume was calculated based on traffic demand found in FHWA Highway Statistics. Traffic flow, traveling in the opposite direction to the crash, was assumed to move at unrestricted speeds or at the highest Level of Service (LOS) – LOS A. See below for a more detailed explanation of LOS.

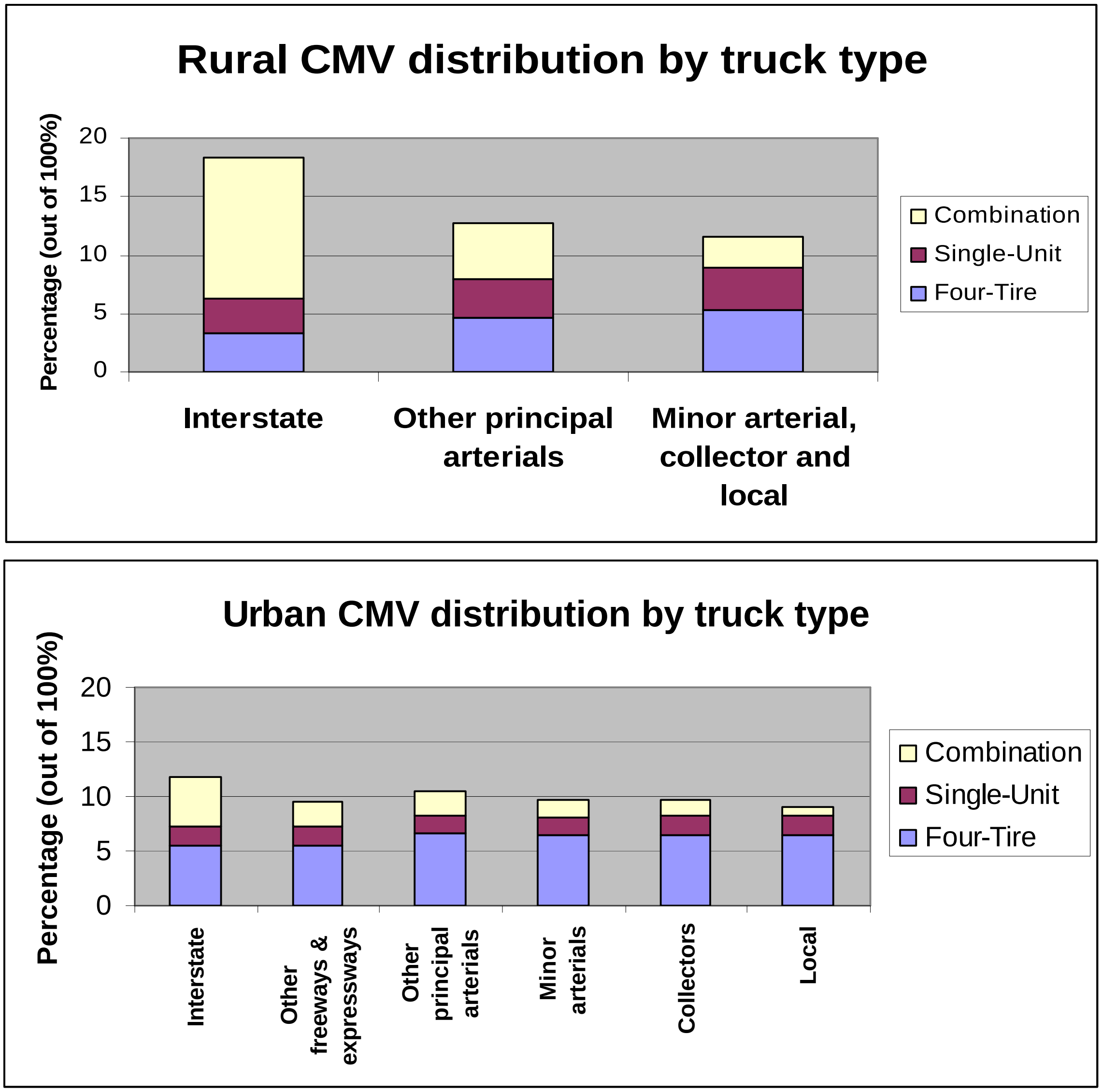
- **Step 4**: Weight time of day according to peak travel times. Use FARS and GES data for crash times for CMVs. Assumption 2 – 50 percent of traffic flow occurs between 6-9am and 3-6pm (Schrank and Lomax 2005).

- **Step 5**: Use CMV crash data with facility type location information and assign the crash numbers to the traffic volume calculations from previous steps. Assumption 3 – Unknown roadway types for CMV crashes have been assigned to roadway types in the same proportion as the known location data.

- **Step 6**: Traffic Volume has been multiplied by the delay ratios from Step 1 and summed to obtain total delay results. The minutes from the police department data were converted back into hours.

- **Step 7**: Cost Calculation: Multiply total hours of delay by vehicle occupants using 1.25 per vehicle. The fleet mix (private vs. Commercial Motor Vehicle) is calculated according to the 2000 Highway Capacity Manual. The hourly productivity delay cost was $13.45 (cars) and $71.05 (commercial vehicles) originally calculated in 1999 dollars (Zaloshnja and Miller 2002) multiplied by the 2005 US DOT guidance to obtain 2004 dollars (US DOT 2006b).

FIGURE 2-2. CMV TYPE BY ROADWAY FACILITY (RURAL AND URBAN)



CMV crash delay data is limited. Ideally, actual field data could be collected at the exact time of a collision. Each vehicle's classification and additional time spent idling or at reduced speeds could be recorded. Lack of predictability and technical recording, however, makes such field data only a theoretical possibility.

Crash delay measurement is complex and the related challenges are listed in the methodology. Ideally, complete information on the congestion delay from each large truck and bus crash could be assessed. Point detection systems, with surveillance equipment spaced in short intervals, could record data on vehicle volume and lane occupancy following a crash (Cambridge Systematics, 2005). As a proxy for recording every CMV crash event, at least one congestion delay event could be recorded for each level of crash severity on each roadway facility type. Video recorders could record vehicle fleet composition and physical extent of the queue backup. Ideally, a responding police officer could verify the accuracy of the electronically gathered information.

2.4 RESULTS

2.4.1 Overall CMV Crash Related Delay

The report determined that there was an estimated 159,177,000 total vehicle hours of delay from CMV collisions in 2004.[4] The average vehicle delay associated with a CMV crash was 386 hours. Table 2-1 provides the total rural and urban crashes for each roadway facility:

TABLE 2-2. TOTAL NUMBER OF RURAL AND URBAN CRASHES BY ROADWAY TYPE

Severity Level	CMV crashes in 2004			
	Trucks		Buses	
	Rural	Urban	Rural	Urban
Fatality	2,929	1,511	184	95
Injury	54,750	28,250	3,427	1,769
Property Damage Only*	205,806	106,194	2,404	1,241

Sources: FAR, MCMIS, and GES, National Highway Traffic Safety Administration
*Note: Adjusted for Unknown Crashes. *MCMIS supplied information for bus crashes and non fatality/injury crashes are limited to "Towaway" only (i.e. they are a smaller subset of all Property Damage Only crashes).*

Associated costs for the delay are estimated to be approximately $3.7 billion (thousand million) in 2004 dollars. The average vehicle delay for CMV crashes resulting in a fatality was 1,780 hours for urban roadways and 870 hours for rural roadways. Crashes that caused injuries resulted in an average of 698 vehicles hours on urban roadways and 341 on rural roadways. Property damage only CMV crashes resulted in an average of 539 vehicle hours of congestion delay on urban roads and 234 hours of delay on rural roads. In the next table, this delay is broken down by crash severity (fatality, injury, or property damage only) and roadway type:

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[4] It should be recognized that there is considerable uncertainty in the data used to generate this estimate.

TABLE 2-3. CMV CRASH CONGESTION DELAY AND COSTS BY CRASH SEVERITY AND ROADWAY TYPE

Congestion Delay from CMV crashes involving Fatalities in 2004(Vehicle Hours in bold, Cost in smaller font)

Roadway Type *(Urban Facility type in Italics)*	**Rural**		**Urban**	
	Facility Total	**Per Crash**	**Facility Total**	**Per Crash**
Interstate/ *Interstate*	1,356,100 $38,045,721	1,914 $53,698	1,534,128 $37,289,770	3,107 $75,521
Other Principal/ *Freeway Expressway*	867,710 $21,584,080	878 $21,840	433,023 $9,959,766	2,434 $55,983
Minor Arterial/ *Other Principal Arterial*	372,759 $8,997,073	543 $13,106	613,592 $14,461,438	1,368 $32,242
Major Collector/ *Minor Arterial*	96,842 $2,337,421	203 $4,900	226,271 $5,217,208	898 $20,706
Minor Collector/ *Collector*	9,880 $238,468	102 $2,462	33,555 $775,595	480 $11,095
Local Road/ *Local Road*	4,556 $109,966	29 $700	18,197 $413,374	111 $2,522
Unknown*	*Numbers divided proportionally to known crash occurrence by facility type.*			
Total or *Average*	2,707,848 $71,313,000	870 *average* $42,406	2,858,766 $68,117,000	1780 *average* $16,632

Congestion Delay from CMV crashes involving Injuries in 2004(Vehicle Hours in bold, Cost in smaller font)

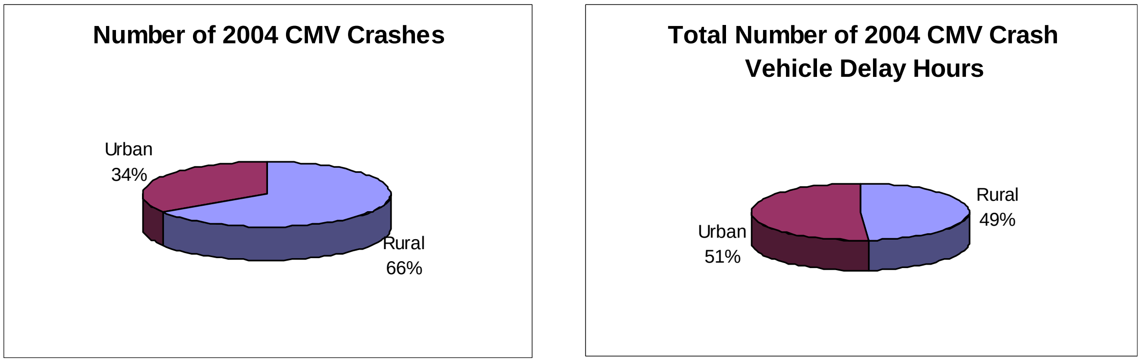
Facility Type *(Urban Facility type in Italics)*	**Rural**		**Urban**	
	Facility Total	**Per Crash**	**Facility Total**	**Per Crash**
Interstate/ *Interstate*	9,939,145 $278,845,170	751 $21,069	11,244,111 $27,330,853	1,219 $29,630
Other Principal/ *Freeway Expressway*	6,359,691 $158,195,799	344 $8,557	3,173,632 $72,995,272	955 $21,966
Minor Arterial/ *Other Principal Arterial*	2,732,057 $65,942,116	213 $5,141	4,497,130 $105,990,568	536 $12,633
Major Collector/ *Minor Arterial*	709,777 $17,131,486	80 $1,931	1,658,354 $38,237,235	352 $8,116
Minor Collector/ *Collector*	72,409 $1,747,695	40 $965	245,925 $5,684,344	188 $4,345
Local Road/ *Local Road*	33,393 $805,988	11 $266	133,366 $3,029,618	43 $977
Unknown*	*Numbers divided proportionally to known crash occurrence by facility type.*			
Total or *Average*	19,846,472 $522,668,000	341 *average* $8986	20,952,518 $253,268,000	698 *average* $16,632

Congestion Delay from CMV crashes involving Property Damage Only in 2004(Vehicle Hours in bold, Cost in smaller font)				
Facility Type ***(Urban Facility type in Italics)***	**Rural**		**Urban**	
	Facility Total	**Per Crash**	**Facility Total**	**Per Crash**
Interstate/ *Interstate*	27,482,375 $771,024,825	580 $16,272	31,090,689 $755,715,717	942 $22,897
Other Principal/ *Freeway Expressway*	17,584,953 $435,421,517	266 $6,617	8,775,297 $201,836,632	738 $16,974
Minor Arterial/ *Other Principal Arterial*	7,554,313 $182,334,183	165 $3,983	12,434,852 $293,070,697	414 $9,757
Major Collector/ *Minor Arterial*	1,962,578 $47,490,318	61 $1,472	4,585,456 $105,728,425	272 $6,271
Minor Collector/ *Collector*	200,215 $4,832,476	31 $748	679,999 $15,717,589	145 $3,351
Local Road/ *Local Road*	92,334 $2,228,614	9 $217	368,764 $8,775,297	34 $772
Unknown*	*Numbers divided proportionally to known crash occurrence by facility type.*			
Total or *Average*	54,876,769 $1,445,332,000	264 *average* $6,942	57,935,057 1,380,446,000	539 *average* $12,850

** Adjusted for Unknown Crashes*

Nearly twice as many CMV crashes occurred on rural roadways; however, the total delay for urban verses rural is roughly similar: 52.4 percent for urban vs. 48.6 percent for rural. Higher traffic density in urban areas causes greater delay per crash incident than for rural areas.

FIGURE 2-3. COMPARING RURAL AND URBAN CMV CRASHES AND DELAY



2.4.2 Hazardous Materials (HM) CMV Crash Delay

CMV crashes that involve HM are assumed to cause greater delay than collisions without the presence of HM. No reliable information is available detailing the recorded times for HM crashes vs. trucks carrying non-hazardous cargo. For this report, the HM crash delay was calculated strictly on a proportional basis of HM vs. non-HM crashes. The data was obtained from the MCMIS and HMIS databases which provide the number of crashes. Please note that the information likely underestimates the delay associated with Hazardous Material CMV crashes as the clean-up and added safety protocols most likely increases congestion delay.

TABLE 2-4. HM AND NON-HM CRASH VEHICLE DAY HOURS

Roadway Type	HM Adjusted*	Non-HM Adjusted*
Interstate	111,874,000	4,617,805,000
freeway/expressway	50,337,000	2,090,154,000
Other Principal Arterial	38,169,000	1,571,151,000
Minor Arterial	12,510,000	513,748,000
Collector	1,684,000	68,996,000
Local Road	1,675,000	69,939,000
*Unknown**	N/A	N/A
Grand Total Min.	216,249,000	8,931,794,000
Grand Total Hours	3,604,000	148,863,000

**Unknown Crashes were assigned to both HM and non-HM according to the proportion of known crashes.*

The average duration for all crashes is less than the 2 hours for common HM incidents and less than the 12 hours for the 5 percent of incidents that could be classified as major (Battelle 2003). This report estimates that 84 minutes is the average delay for all types of CMV crashes. One study cites that evacuations were needed in 15 percent of hazardous waste incidents (TRB 1993). No estimate of delay from HM evacuations is included , since there are no readily available models or tools to calculate the additional delays attributable to evacuations.

2.4.3 Significant Regional Incidents

Severe crashes involving closure of major highway arteries can have a large effect on overall delay, even if they are few in number. For example, on April 13, 2006, a truck crash in Washington DC caused traffic delays on Interstate 95 for over 5 hours and 10 miles of backup during the Thursday evening commute home (Washington Post 2006). To keep consistency with the rest of the congestion methodology, CMV “mega-crashes” were analyzed for 2004. The HMIS database was searched but proved to be of limited value for calculating delay beyond providing the hours of road closure. There is no accurate method to calculate delay associated with extended road closures. Traffic will be diverted to alternative routes and the associate delays will be dispersed over multiple roadways.

Although it is difficult to ascertain the frequency and total impact of significant regional incidents, one example is provided to highlight the possibilities. On March 27, 2004, a truck carrying 12,000 gallons of heating oil skidded into an overpass on Interstate 95 near Bridgeport, Connecticut. The truck and its cargo burst into flames and burned for over 2 hours at 2000 degree Fahrenheit (NYT 2004). The fire caused extensive damage to a bridge-span and necessitated closing a 2-mile section of the interstate for over one week. An estimated 120,000 vehicles pass over the affected span on a daily basis. Fortunately, no vehicle drivers or passengers were injured in the crash.

Using this report's methodology, a crash involving property damage, on an urban interstate, results in an average of 942 hours of delay. The Bridgeport I-95 crash caused at least 138,000 hours delay based on conservative estimates from news reports.

The foregoing Bridgeport I-95 estimate is based on the following assumptions:

- Lane closures: 5 days for southbound, 7 days for northbound
- Vehicle Fleet Composition: 95 percent passenger automobiles and 5 percent commercial trucks, which aligns with general congestion methodology.
- Lane closures: 5 days for southbound, 7 days for northbound
- Diversion: 10 miles of extra mileage = 10 minutes delay for automobiles, and 40 miles of extra mileage = 40 minutes delay for trucks
- Actual Crash Event On Site Delay: Not included in the calculations due to lack of measurement of delay.

The delay from the Bridgeport I-95 CMV crash compares to an average of 942 hours predicted for an urban interstate PDO truck crash. The I-95 crash is over two orders of magnitude greater in severity and cost at least $2,800,000 in lost productivity.

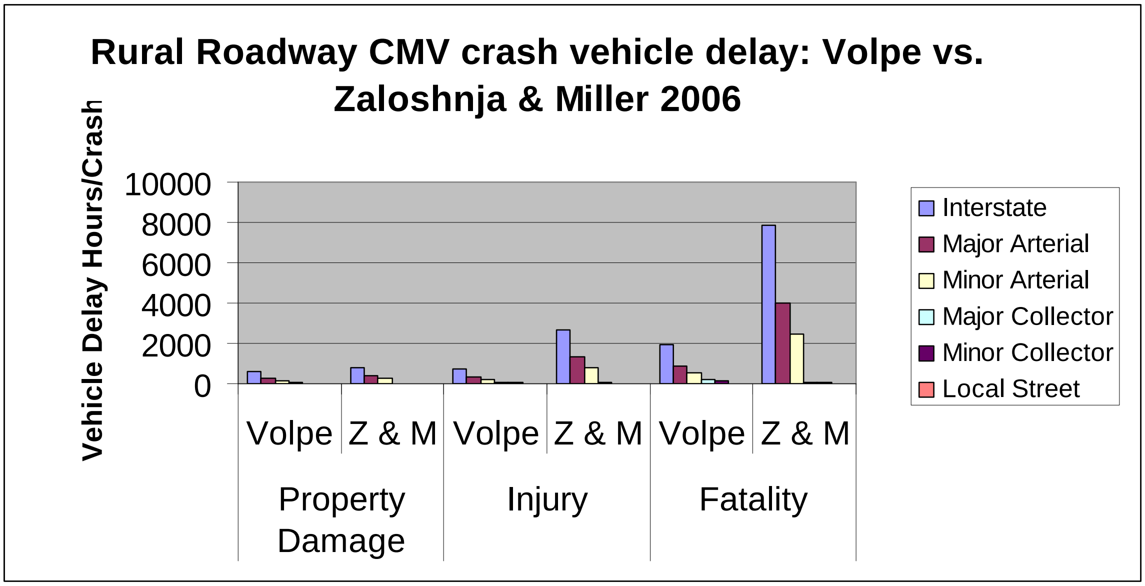
Unfortunately, there is no standardized data collection for these huge crashes. The delay resulting from the I-95 Bridgeport crash likely exceeded 138,000 hours estimate. The delay from just this single mega-crash was equal to 0.4 percent of the total delay calculated for Urban Interstate Roadway. In addition, road diversions likely caused additional delays due to extra travel time and traffic bottlenecks created on smaller alternative facilities during interstate repairs. Significant regional incidents have the potential to cause delays exceeding the average CMV crashes and thus altering the overall estimates.

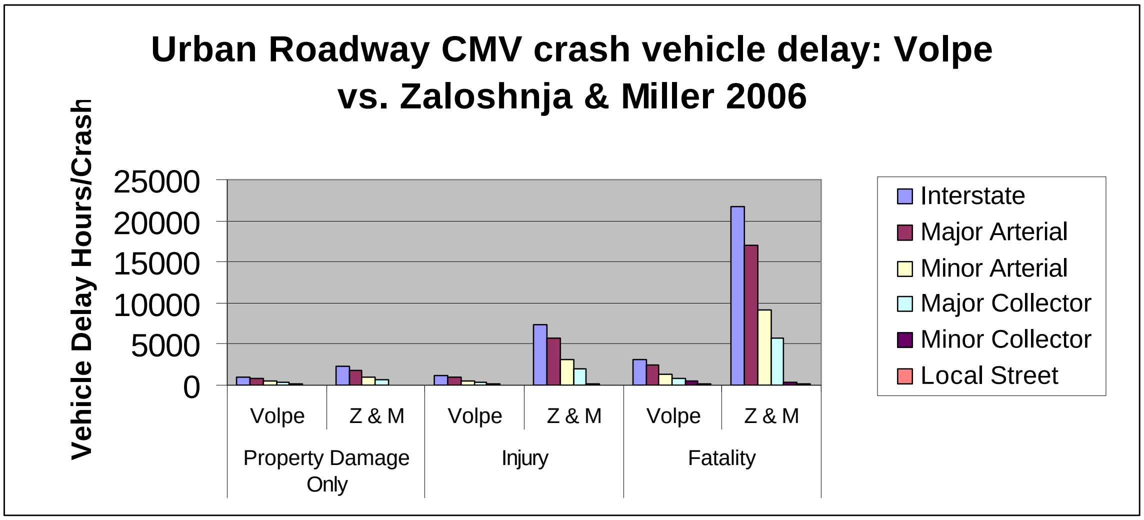
2.5 CONGESTION DELAY VALIDATION

The total delay and associated productivity costs are a conservative estimate based on comparisons to other national estimates. The Urban Mobility Report estimates that non-recurring events, such as collisions, create half of all congestion related delays. The 2005 Urban Mobility Report estimates a total of 3.7 billion hours of vehicle delay in urban areas (Shrank and Lomack 2005). Oak Ridge National Laboratories' (ORNL) comprehensive estimate of national vehicle delay estimated a total of 2.3 billion hours of vehicle delay on U.S. freeways and principal arterials for 1999 (Chin et al 2002). ORNL also estimated 772.6 million hours of vehicle delay from all crashes. The ORNL report includes all roadways and both rural and urban areas.

This chapter's delay estimate, approximately 159 million delay vehicle hours from CMV collisions, almost 4.3 percent of the Urban Mobility report total delay and about 20 percent of ORNL's 1999 total crash (automobile and CMV) delay estimate.

FIGURES 2-4. VOLPE VS. ZALOSHNJA AND MILLER 2006 (RURAL AND URBAN)





One potential factor causing the smaller Volpe estimates is that Zaloshnja and Miller used another report to scale up their urban delay numbers (Lan and Hu, 1999). Lan and Hu found in Minneapolis, Minnesota, that crashes with heavy trucks involved caused an average of 5,057 hours of delay. They also found that non-truck crashes caused 2,405 hours of vehicle delay. This non-truck estimate is approximately 5 times greater than ORNL found in their most recent report (ORNL 2004). Based on the estimates of the Minneapolis study, Zaloshnja and Miller increased their delay numbers. ORNL estimates that an average crash (truck and non-truck) results in 506 hours of delay.

Regional variations may account for a larger or smaller impact in specific locations. Actual CMV crashes in different cities will likely result in varying hours of vehicle delay. For example, the interstate roadways in the Los Angeles, California metropolitan region have many more lanes and traffic volume than those in Beaumont, Texas. However, both locations are designated as urban areas.

Crashes affect traffic flow beyond the vehicles delayed at the crash site. This report does not include CMV crash impacts arising from re-scheduling, re-routing, reduced mobility, or reduced reliability. No reliable method was found for estimating these associated delay impacts.

2.6 RECOMMENDATIONS FOR FUTURE STUDY

The delay calculations provided in this report are conservative and are lower than noted by ORNL and Zaloshnja and Miller. Estimates could be improved by accounting for traffic delay in the opposite direction of the crash (rubbernecking/gaper’s block). In addition, using the location in the roadway for each of the crashes can yield more precise results. With a specific crash location, highway capacity can be estimated using past research models. For example, a crash that occurs on the left shoulder of the highway has an accepted value of 0.840 capacity for a three lane highway (Giuliano 1989). That means that all three lanes would only be able to accommodate 84 percent of the maximum traffic volume while the crash is being cleared away. The FARS and GES databases have recorded roadway locations for CMV crashes. Also, using queuing theory from the TRB Highway Capacity Manual can provide a more precise estimate of delay, driver behavior, and associated speeds. The speeds in turn can create more accurate estimates for associated emissions. Lastly, a validation of the calculations can be made for a few specific cities using traffic volumes and crash data from that location. The results can be compared with the TTI report.

In summary, the current recommendations with respect to congestion for future drafts of this report include:

- Account for Rubbernecking in non-crash lanes.
- Account for Capacity Reductions depending on location of crash
- Account for LOS adjustments for traffic flow using ORNL’s approach
- Make assumptions on length of the queue and traffic behavior to yield more precise delay results

- Provide additional data on a truck type/configuration for fleet mix
- Validation for specific cities

3. AIR QUALITY AND GREENHOUSE GASES

3.1 INTRODUCTION

Commercial motor vehicle (CMV) crashes cause air quality impacts. Congestion resulting from the crashes results in higher motor vehicle emissions than those associated with travel in free flowing conditions (FHWA 2002, Daniel and Bekka 2000). In addition, motor vehicles delayed in traffic will consume more fuel due to longer engine run times and higher rates of fuel consumption in idling, stop-and-go traffic, and low speed conditions (Schrank and Lomax 2005). This increase in vehicle emissions can contribute to local and regional air pollution problems. The emissions can damage human and ecological health and can also harm agricultural crops and forests, damage buildings and cultural resources, and impair visibility. In addition, some types of cargo released in crashes, such as volatile materials, can impact air quality.

This chapter describes the methodology and analysis used to quantify the criteria pollutant and greenhouse gas (GHG) emissions resulting from the congestion associated with CMV crashes. This chapter also presents the main results of the analysis. Air quality impacts carry a cost that is not contained within private transportation prices and thus are born by the general public, known as social costs. This chapter also presents the methodology and estimation results for the social costs associated with air pollutant impacts on health and climate change (but not air pollutant impacts on visibility, it should be noted). The methodology for estimating air quality impacts will provide estimates of the criteria pollutant and GHG emissions per CMV crash, and their associated damage costs.

The methodology presented allows for the estimation of the fuel consumption, emissions, and damage costs associated with congestion resulting from CMV crashes. The estimates can be calculated on an aggregate level for all CMV crashes and on a per crash basis. The estimates can also be calculated by facility type and accident severity, and the relevant combinations thereof. This allows FMCSA to estimate the changes in emissions and damage costs resulting from regulations and rulemakings that affect CMV accident rates as a whole or a subset of accidents by severity or on particular facility types.

The ideal approach would use idling time and instantaneous speed and acceleration throughout the duration of the congestion associated with a CMV crash to simulate the real world driving conditions associated with the slow stop-and-go driving characteristics. Fuel consumption and emissions during idle and stop-and-go driving (especially at very slow speeds) are significantly higher than those resulting from unrestricted flow conditions. In addition, fuel consumption and emissions are highly dependent on acceleration. Therefore, using average steady-state speeds, as was done in this analysis, is expected to largely underestimate emissions and fuel consumption and provide only a general approximation to what actually would occur. However, there is extremely limited information on the traffic conditions, idling time, travel speeds, and acceleration after an incident.

In the absence of this data, work developed by Oak Ridge National Laboratory (ORNL) analyzing fuel economy and emissions as functions of speed and acceleration could be used. ORNL developed a model to simulate emissions and fuel consumption for different driving schedules. Driving schedules and drive cycles are synonymous terms for describing an identified range of vehicle velocities and their resulting tailpipe emissions. Thus, as an extension of the current analysis, a collection of driving schedules considered representative of driving conditions under congestion resulting from a CMV crash could be selected and used in the model to estimate emissions and fuel consumption and their associated damage costs. Since the model data has acceleration and deceleration, once a cycle to be simulated is selected, the appropriate values from the model lookup tables could be used to estimate emissions and fuel consumption over the cycle. An even better approximation of emissions and fuel consumption could be developed by selecting the section of the driving schedule that more closely resembles driving conditions under the congestion associated with a CMV crash. A confidence interval based on the range of fuel consumption and emissions calculated using the different driving schedules could be developed to derive more accurate conclusions.

The main shortcoming of this approach is that the data collected by ORNL is not a perfect representation of the vehicle fleet composition. Additionally, there is no data that allows for accurately determining the driving conditions (and hence which schedule to select) after an incident. Therefore, a decision regarding the conditions representative of driving after an incident needs to be made. This last shortcoming also applies to the current analysis. However, it can certainly provide a proper indication of changes among different congestion scenarios (defined by driving schedules). Alternatively, assumptions regarding driving conditions after an incident could be developed and used in the ORNL model.

Another potential approach is to study the applicability of the EPA’s Motor Vehicle Emission Simulator (MOVES) model (US EPA 2007a). This model estimates emissions for on-road and non-road sources, covers a broad range of pollutants, and can provide both fine-scale analysis and national inventory estimation. The main advantage is that the model will estimate emissions for real world driving conditions. In addition, when fully implemented, MOVES will serve as the replacement for MOBILE6. Thus, studying how to use it for the current analysis would be helpful for future FMCSA environmental compliance activities. The main shortcoming is that data is very limited (only a small set of vehicles have been tested for emissions and have not been selected to represent fleet composition).

The analysis could also be extended by calculating the total time in congestion instead of only using the time of delay, which is the unit of delay used in this analysis. The time of delay is a portion of the total time in congestion. The analysis would be more accurate by estimating the difference between the emissions and fuel consumption associated with the total time in congestion (at the congested driving conditions) and the emissions and fuel consumption associated with the time it would take to travel the distance affected by the CMV crash (at an average free flow speed associated with the specific facility type affected by the incident). This would provide an estimate of the delay emissions and fuel consumption, which given the non-linearity of emissions and fuel consumption, is not the same as calculating the emissions and fuel consumption for the delay time, which is what was done in this analysis. Free-flow speeds by facility type are available from the FHWA Highway Performance Monitoring System. However, in order to accurately perform the analysis in this proposed way, data on the queue length associated with a CMV accident would be needed; this data is not available. If free-flow emissions and fuel consumption are subtracted from the delay emissions and fuel consumption, we would be systematically underestimating things since we would be subtracting from the delay portion and not the total congestion emissions and fuel consumption. In the absence of data on queue length associated with a CMV accident, the current analysis based on delay provides the most accurate representation of congestion emissions and fuel consumption.

However, estimates of the distance traveled under congested conditions following an incident could be developed. Queuing theory modeling could be used to develop confidence intervals of the distance traveled under congested conditions to determine the "real additional" emissions and fuel consumption associated with a CMV crash. Data on arrival rates by facility type (number of vehicles per unit of time) would be needed to be collected. The service rate (smaller after an incident) by facility type for different scenarios would then be estimated for different scenarios: (1) no accident: service rate = capacity; (2) one lane closure; (3) two lane closure; etc. Time of day flow and resulting congestion delay could be included in the analysis. The main objective of this approach would be to develop a confidence interval by facility type of the queue length (number of vehicles), to then translate queue length information into confidence intervals for distance by considering fleet composition (car lengths) by facility type and car-following assumptions (based on speed).

As explained, using steady-state speed does not provide very accurate estimates of emissions and fuel consumption associated with congested conditions. However, given the lack of data and in the absence of a much more complex and time intensive approach, the three scenarios of travel characterized by different average (steady-state) speeds selected for the analysis provide useful information to quantify the emissions and costs associated with congestion resulting from CMV crashes. Further refinements to the analysis and the accuracy of the estimates could be obtained with the use of the above-mentioned recommendations.

3.2 BACKGROUND

The United States Environmental Protection Agency (EPA) sets standards for the maximum concentration of known harmful air pollutants defined as "criteria pollutants" (US EPA 1998). The 1990 Clean Air Act Amendment provides authority for the EPA to set limits on these pollutants to protect the public and the environment. The EPA monitors emission that impact air quality and helps to track emissions trends for each pollutant. The agency also sets limits on quantity of allowable pollution.

Air quality is measured by determining the concentration of air pollutants present within the air mass of a region, in parts per million (ppm) or micrograms per cubic meter (pg/m3). Air pollutants are a significant cause of concern for both public health and welfare. In response to both of these concerns, Federal regulations have been developed for six criteria pollutants, under the National Ambient Air Quality Standards (NAAQS), that are considered harmful to public health and the environment. The six criteria pollutants are carbon monoxide (CO), lead (Pb), nitrogen dioxide (NO_2), ozone (O_3), sulfur dioxide (SO_2), and particulate matter (PM). Nitrogen dioxide reacts in the atmosphere over the course of several hours and is often referred to simply as nitrogen oxides (NO_X). Similarly, sulfur dioxide is often referred to simply as sulfur oxides (SO_X).

The ambient concentration of pollutants is compared with the EPA's NAAQS in order to measure air quality. There are two types of standards – primary and secondary. Primary standards protect against adverse health effects; secondary standards protect against adverse welfare effects, such as damage to farm crops and vegetation and damage to buildings. Because different pollutants have different effects, the NAAQS for each pollutant is different. Some pollutants have standards for both long-term and short-term averaging times. The short-term standards were designed to protect against acute, or short-term, health effects, while the long-term standards were established to protect against chronic health effects.

When a geographic area falls within the NAAQS established by the Clean Air Act, it is called an attainment area; when concentrations of criteria pollutants in the region exceed the standards, it is called a non-attainment area. The EPA continuously monitors ambient air quality within counties and air basins in the U.S. A description of the relevant criteria pollutants is presented below (US EPA 2006a):

- Carbon Monoxide (CO): colorless, odorless, and poisonous gas produced by the incomplete combustion of carbon in fuels. CO reduces the delivery of oxygen to the body's organs and tissues when it enters the bloodstream and is a serious health risk for people with cardiovascular disease.

- Nitrogen Dioxide (NO_2) and NO_X: brownish highly reactive gases that can irritate lungs, cause bronchitis and pneumonia, as well as lower resistance to respiratory infections. Nitrogen oxides are precursors to ozone (O_3) and acid rain, which negatively impact aquatic and terrestrial ecosystems.

- Sulfur Dioxide (SO_2) and SO_X: high concentrations of these gases can affect breathing and aggravate existing respiratory and cardiac disease. People with asthma, bronchitis or emphysema, or children and elderly are sensitive to elevated SO_2 levels. SO_2 is a primary component of acid rain, and SO_X compounds reduce visibility.

- Particulate Matter (PM): particulate matter pollutants include dust, dirt, soot, smoke, and liquid droplets emitted by sources such as automobiles. PM is a major concern for human health and possible effects are breathing and respiratory symptoms, aggravation of existing respiratory and cardiovascular disease, alterations to immunological response, lung tissue damage, carcinogenesis, and premature death. In addition, PM damages soils and crops, and impairs visibility.

- Hydrocarbon (HC): Hydrocarbons are a precursor to ground-level ozone - a key component of smog. Ground-level ozone causes health problems such as difficulty breathing, lung damage, and reduced cardiovascular functioning. A number of hydrocarbons can cause cancer or other health issues.

- Volatile Organic Compounds (VOC): A notable subset of hydrocarbons, volatile organic compounds includes benzene, toluene, ethylbenzene, m-/p-/o-xylene, and formaldehyde (Chan et al. 1991). VOCs can cause eye, nose, and throat irritation; headaches, loss of coordination, nausea; damage to liver, kidney, and central nervous system. Some VOCs can cause cancer in animals; some are suspected or known to cause cancer in humans. Note: benzene may be independently analyzed, as the EPA is strengthening its hazardous air emissions control largely due to increased concern over the effects of this pollutant (EPA 2006b).

- Greenhouse gases (GHG): Recent government and scientific studies strongly suggest that anthropogenic GHG emissions are contributing to a rise in surface and lower atmosphere temperatures beyond the naturally occurring greenhouse "effect" (CCSP 2006). Carbon dioxide (CO_2) is the most prevalent GHG emission from vehicles. Methane (CH_4) and nitrous oxide (N_2O) are also formed from vehicle emissions and cause GHG impacts.

Transportation sources in the U.S. account for the highest or second highest levels of emissions for several pollutants of concern for environmental and public health reasons. The transportation sector continues to be a substantial source of air pollutants at the national level, and is responsible for most of the total carbon monoxide (CO) and nitrogen oxide (NO_X) emissions, close to half of the total volatile organic compounds (VOC), and a quarter of total particulate matter (PM) emissions. The contributions to lead (Pb) and sulfur oxide (SO_X) emissions from vehicles are relatively less, partly due to their reduced presence in transportation fuels (lead has essentially been eliminated from gasoline). However, SO_X is formed when fuel that contains sulfur, such as coal and oil, is burned, and when gasoline is extracted from oil in petroleum refineries. Thus, the analysis of criteria pollutant emissions from CMV crashes will focus on the effects of on CO, NO_X, VOC, PM, and SO_X emissions.

The transportation sector – specifically, motor-vehicle operation – is also a substantial contributor to GHG emissions, accounting for approximately one third of all GHG emissions in the U.S. The operation of motor vehicles accounts for the majority of these emissions. Thus, this chapter examines the effects of CMV collision related congestion on GHG emissions. GHG occur naturally, but also result from human activities, such as fossil fuel combustion, industrial processes, agricultural activities, deforestation, and waste treatment activities. CO_2 is one of the main products of motor vehicle exhaust and, although it does not directly impair human health and is not regulated, in recent years it has started to be viewed as an issue of concern for its global climate change potential.

Vehicles stopped or running at slow speeds, as those associated with congestion, can create more ambient air emissions than drivers traveling without delays at higher speeds (Daniel and Bekka 2000). CMV crashes and the related congestion delay induced emissions contribute more greenhouse gases than free flowing traffic. Emissions carry a number of social costs that are not directly paid for in either vehicle operation or related transportation taxation and tolls. Our methodology includes analysis of carbon monoxide, nitrogen dioxide, sulfur dioxide, particulate matter, hydrocarbons, and greenhouse emission from current CMV crashes.

Emissions from motor vehicles occur from either fuel that is either not fully combusted, or formed by chemical processes during combustion, and others occur through chemical reactions in the atmosphere. The processes are complex and are influenced by fuel and engine type, ambient temperature, and natural background concentrations of the chemical compounds (Harrington and McConnell 2003). Emissions profiles of gasoline and diesel engines are different. Gasoline engines produce high levels of carbon monoxide, volatile organic compounds, and N_2O. Diesel engines produce high levels of NO_X and particulate matter in comparison to gasoline engines (Harrington and McConnell 2003). Both engine types produce CO_2 in fairly direct proportion to fuel consumption.

Diesel exhaust is a complex mixture containing hundreds of organic and inorganic materials, in gaseous and particulate forms, from diesel engine combustion processes. Diesel engines include light- and heavy-duty engines in trucks, buses, and some automobiles. Diesel emissions include 40 hazardous air pollutants listed under the Clean Air Act, 15 of which are known or probable carcinogens (U.S. EPA 2007). Diesel exhaust includes both gases and particles (PM). The gaseous fraction contains nitrogen, oxygen, carbon dioxide, water vapor, and many toxic substances including aldehydes. The particles consist of an elemental carbon core with volatile organic compounds, sulfates, nitrogen oxides, heavy metals, trace elements, and irritants (such as acrolein, ammonia and acids) adsorbed to the surface. Specific toxic chemicals of concern include polycyclic aromatic hydrocarbons (PAHs) and nitroarenes which are concentrated in the particle phase. The particle size distribution and chemical composition of diesel exhaust emissions can vary greatly depending on the engine type (light vs. heavy duty), the speed and load at which it is run, the fuel composition, the lubricating oil, and the emission control technology. The mass, composition, and particle size distribution of diesel exhaust have also changed over time as fuel and engine technology have improved (U.S. EPA 2007).

3.3 AIR QUALITY EMISSIONS METHODOLOGY

Ideally, any analysis of total pollutant emissions would be based on accurate knowledge of factors that determine emissions while vehicles are slowed after a large truck and bus crash. For the purposes of this paper, we propose analyzing CMV crash related health impacts in total and on a per unit basis so that FMCSA can have a general assessment of how regulatory changes may benefit air quality and health. The per unit analysis will use the emissions estimates for and the damage cost figures to calculate total air quality damages for an average large truck and bus crash.

Based on a review of scientific literature, vehicle speeds and vehicle fleet composition information are critical variables to estimate emissions. One study found that congestion can increase fuel consumption by 40 percent and emissions by 800 percent (De Vlieger et al. 2000). The three groups of factors that influence air quality emissions are

- Vehicle Speeds: acceleration, idling, and total times for each vehicle caught in the crash congestion influence emissions (Kulkarni et al. 1996).

- Vehicle Fleet Composition: precise numbers of the vehicles involved in every traffic delay created from large truck and bus crashes along with each type of engine, fuel, and emissions profile (Romilly 1999).

- Vehicle Age and Maintenance: the age and maintenance history of vehicles are also factors that influence emissions (Romilly 1999).

Comprehensive and precise data sources for congestion conditions in general, and specifically for those associated with CMV crashes, are extremely limited. Therefore, an analytical methodology that allows for the estimation of air quality impacts resulting from the delay associated with CMV crashes was developed. The first step in the process was the calculation of the total vehicle miles traveled (VMT) under the congested conditions generated by CMV crashes in the United States (see Chapter 2, which addresses congestion, for an explanation of the delay estimation process). VMT under congested conditions is calculated by multiplying the total hours of delay for each facility type and accident severity type by the average speed during the congestion resulting from CMV crashes.

Data on speed and acceleration under congested conditions is very scarce. The Texas Transportation Institute (TTI) estimated average speeds of approximately 36 mph for congested conditions (Schrank and Lomax 2005). DeLucci (1998) estimated average speeds under congested conditions at between 27.5 and 37 mph. Both estimates were developed for congested conditions at full capacity for a variety of facility types. Therefore, these estimates are high for the kind of driving conditions that can be expected following a CMV crash. Even though drive cycles used for estimating fuel economy and emissions are not designed to represent driving conditions following a CMV crash, they are representative of real world conditions associated with different driving situations. Therefore, drive cycles were studied to determine which ones could be more representative of conditions following a CMV crash. Examining the drive schedules used by EPA and state agencies, the EPA urban drive cycle and New York City driving schedule were selected as the two that most closely represent conditions similar to the ones experienced following a CMV crash. The EPA urban drive cycle is designed to represent the slow speed and stop-and-go traffic conditions associated with rush hour driving in urban areas. The average speed for the urban drive cycle is 19.59 mph. The New York City driving schedule is designed to represent very low speed stop-and-go traffic conditions. The average speed for this schedule is 7.1 mph. Based on this information, three scenarios of congestion represented by different average speeds were selected: high-level congestion (5 mph), mid-level congestion (10 mph), and low-level congestion (20 mph). These three values were used to estimate the corresponding total VMT under congested conditions for each facility, accident severity, and congestion scenario.

The second step was the estimation of emission rates for criteria pollutants. Emissions of the speed sensitive criteria pollutants (carbon monoxide, volatile organic compounds, and nitrogen oxides) were estimated by using the EPA Mobile 6.2 model (MOBILE6) to calculate emission rates by speed and facility type. The Highway Vehicle Particulate Emission Modeling Software - PART5 was used to estimate the emission rates of PM2.5, PM10 and SOx. Calculations were made for 2008, since the Low Sulfur Fuel Rule is being phased-in over 2006-07 and affects some emission rates significantly, and combining the 2006 values for the speed sensitive criteria pollutants with the 2008 values for particulate emissions was considered inappropriate. It is important to note that emission rates of the speed sensitive criteria pollutants decline significantly between 2006 and 2008. Thus, using 2008 values will understate today's (i.e., 2006-07) emissions. However, since the analysis presented in this document is intended for future use, the use of 2008 values was considered more appropriate and useful for FMCSA. In summary, MOBILE6 and the PART5 model, along with a typical vehicle fleet composition for each facility type, were used to estimate composite emission rates for criteria pollutants. The criteria pollutant emission rates used (for the roadway types and speeds, in miles per hour – mph –, of interest) in the analysis are presented in Table 3-1.

The vehicle fleet composition for each facility type is needed to estimate the emission rates for criteria pollutants. The vehicle fleet composition was derived using the Federal Highway Administration Highway Economic Requirements System (HERS) computer model (FHWA 2002). The HERS-ST model is a highway investment/performance model that considers engineering and economic concepts and principles in reviewing the impact of alternative highway investment levels and program structures on highway condition, performance, and user impacts. Specifically, the HERS-ST model simulates highway condition and performance levels and identifies deficiencies through the use of engineering principles. As stated above, it is important to consider the changes in CMV emission rates associated with EPA diesel engine regulations being phased in over the following years.

Volpe estimated the mix of MOBILE6 vehicle classes (MOBILE6 uses 28 of them) typically operating on each type of roadway, using extremely detailed data on vehicle classes and roadway types obtained from a special 1999 FHWA study, which were supplied by the FHWA Office of Policy. The same data was used to estimate the mix of PART5 vehicle classes operating on each type of roadway. Then, MOBILE6 and PART5 were used to estimate the emission rates for the characteristic mix of vehicles operating on each roadway type defined by HERS at different speeds. These results are stored in the HERS model, and HERS uses the rate appropriate to the roadway type and estimated speed before and after improvements are made to the roadway.

TABLE 3-1. EMISSION RATES (GRAMS/MILE) BY ROADWAY TYPE

ROADWAY TYPE	CO Speed (mph)			VOC Speed (mph)			NO_X Speed (mph)			PM10	PM2.5	SO_2
	5	10	20	5	10	20	5	10	20			
Rural												
Interstate	28.030	19.292	15.517	2.685	1.518	1.008	4.057	3.347	2.734	0.160	0.123	0.162
Other Principal	30.931	21.733	17.097	2.999	1.665	1.074	2.569	2.127	1.677	0.098	0.080	0.126
Minor Arterial	31.493	22.139	17.467	3.047	1.681	1.084	2.214	1.829	1.445	0.075	0.067	0.115
Major Collector	31.942	22.445	17.734	3.079	1.694	1.093	1.988	1.640	1.300	0.078	0.062	0.110
Minor Collector	31.942	22.445	17.734	3.079	1.694	1.093	1.988	1.640	1.300	0.078	0.062	0.110
Local Road	31.942	22.445	17.734	3.079	1.694	1.093	1.988	1.640	1.300	0.078	0.062	0.110
Urban												
Interstate	25.061	17.609	14.707	1.861	1.060	0.744	2.327	1.847	1.510	0.077	0.060	0.068
freeway/expressway	25.410	17.868	15.061	1.866	1.049	0.739	1.806	1.392	1.137	0.062	0.045	0.054
Other Principal Arterial	26.300	18.793	15.178	1.992	1.133	0.744	1.791	1.471	1.158	0.059	0.043	0.053
Minor Arterial	27.282	19.450	15.489	2.080	1.184	0.801	1.785	1.471	1.168	0.053	0.041	0.048
Collector	26.470	18.932	15.365	1.995	1.128	0.771	1.530	1.249	0.983	0.051	0.035	0.045
Local Road	26.470	18.932	15.365	1.995	1.128	0.771	1.530	1.249	0.983	0.051	0.035	0.045

Source: Calculated using MOBILE6 and PART5 vehicle emission factor models.

Figures 3-1 and 3-2 present the composite emission rates (for CO, VOC and NO_X) by speed for an urban interstate roadway as an example of the highly speed sensitive (and distinct) nature of CO, VOC and NO_X emissions. For scaling purposes, CO data is presented in a separate figure, while VOC and NO_X are presented together. Figures 3-3 and 3-4 present the relationship between speed and carbon dioxide emissions for two roadway types.

Criteria pollutant tailpipe emissions associated with the congestion conditions for each roadway type, accident severity, and congestion scenario were calculated as the product of the total incident-delayed VMT and the emission rates. Since emissions are estimated for each accident severity and roadway type, depending on the projected results of the rulemaking or regulatory action, the emissions associated with the respective delay can easily be determined. The total tailpipe emissions for each congestion scenario were calculated as the sum of the tailpipe emissions for each facility and accident severity type. Table 3-2 presents the total tailpipe emissions for each criteria pollutant and congestion scenario. Figure 3-5 presents the tailpipe emissions per crash for each criteria pollutant by accident severity and congestion scenario.

FIGURE 3-1. CARBON MONOXIDE EMISSIONS VS. VELOCITY

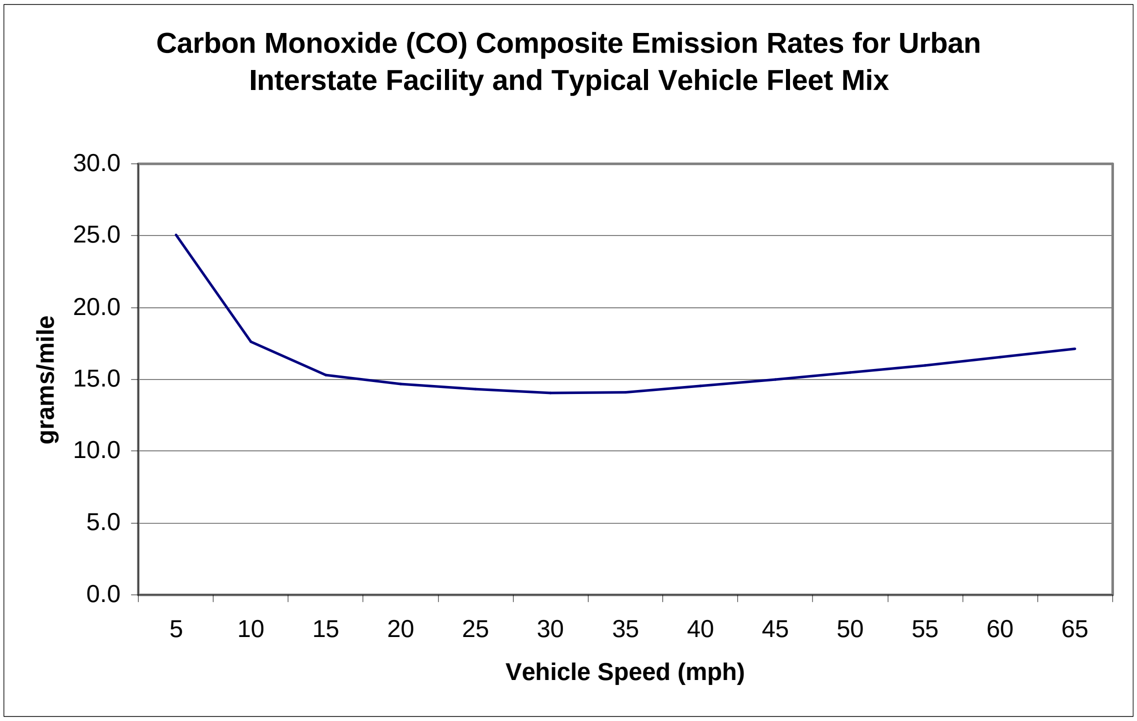


FIGURE 3-2. VOC AND NOx EMISSIONS VS. VELOCITY

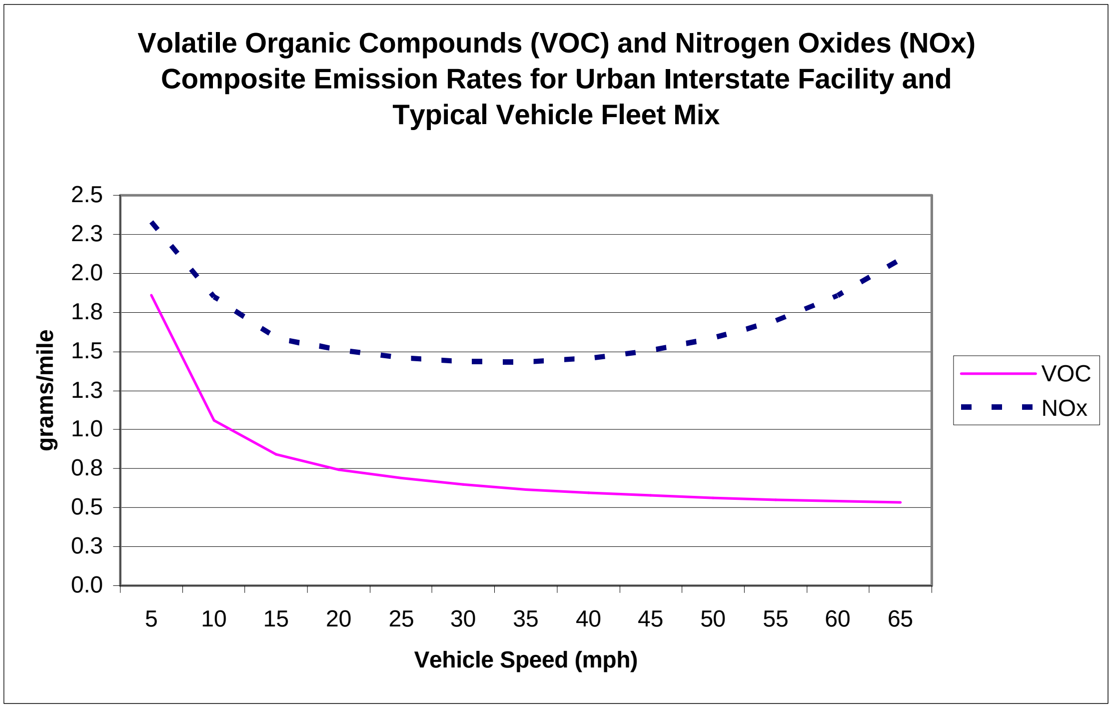


FIGURE 3-3. CARBON DIOXIDE EMISSIONS VS. VELOCITY

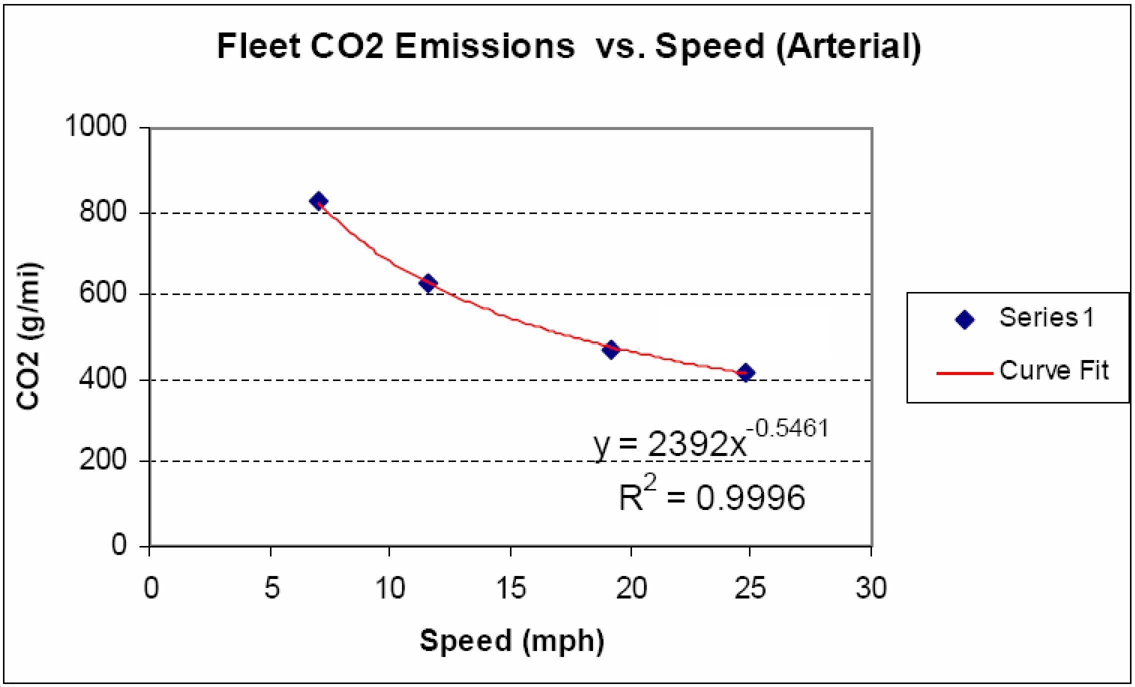
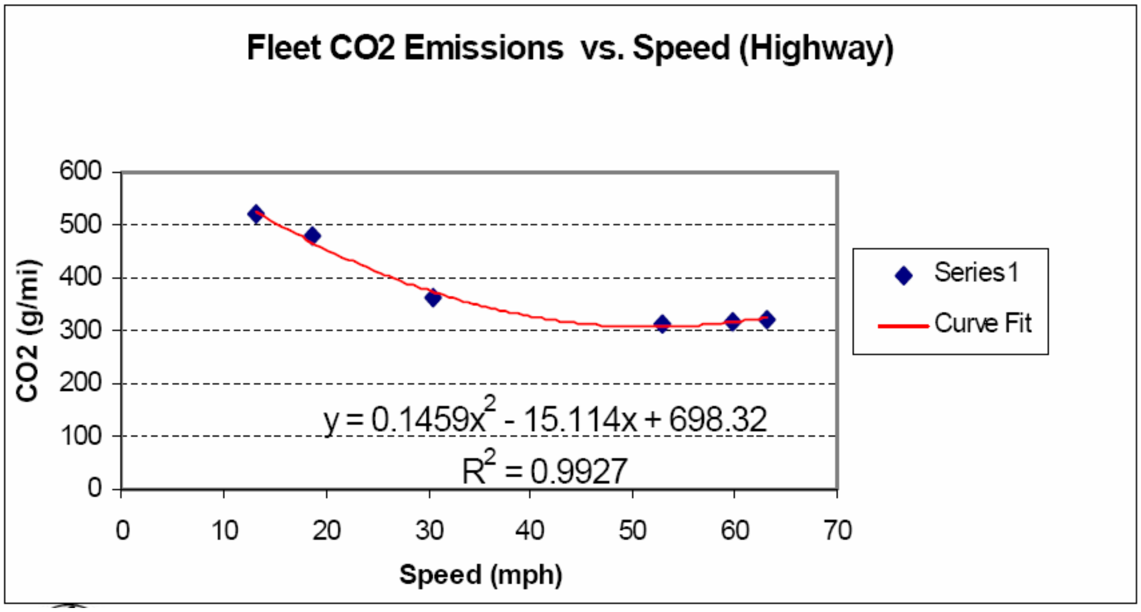


FIGURE 3-4. CARBON DIOXIDE VS. SPEED

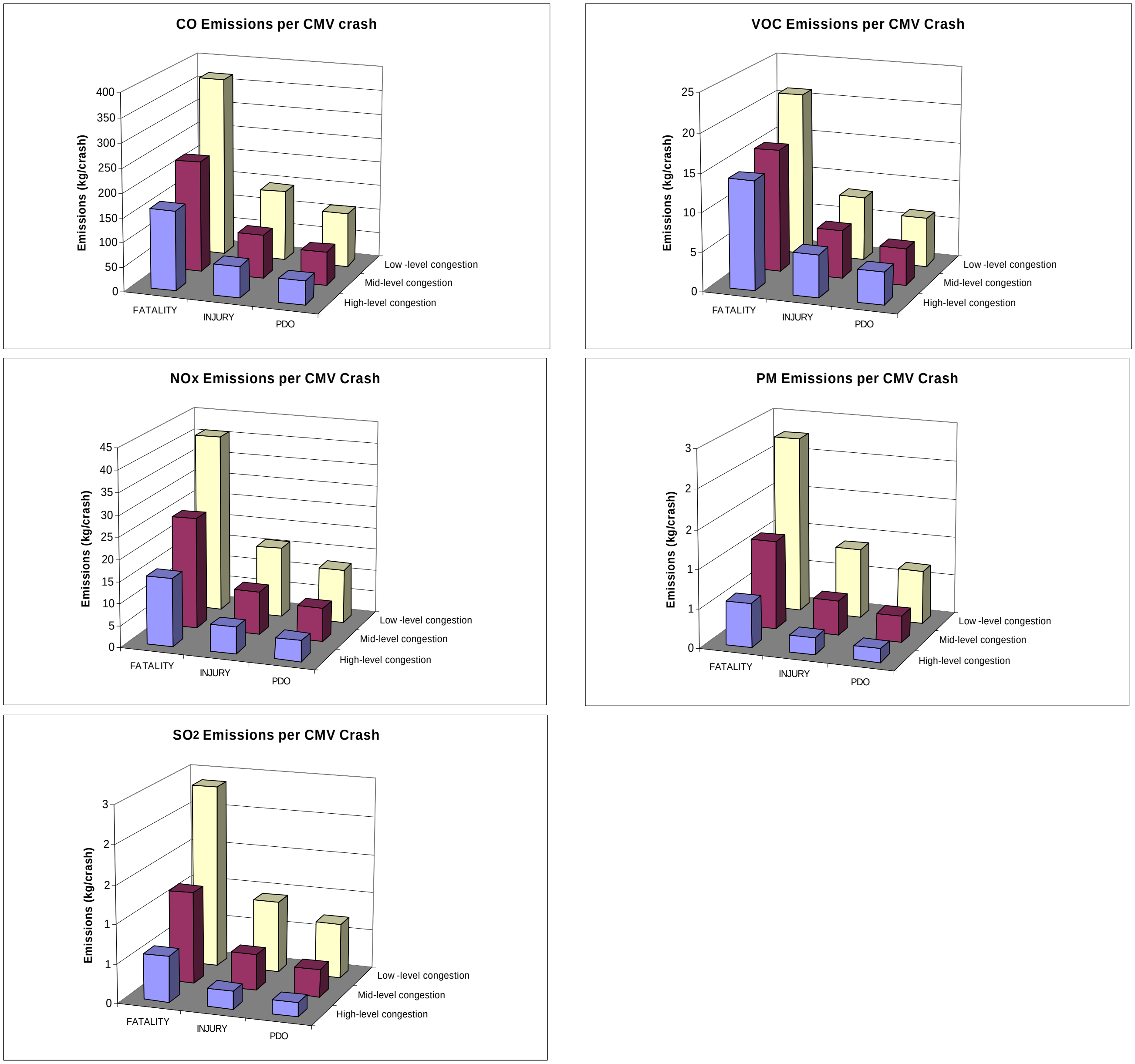


<u>Source</u>: Dr. Lawrence Frank, Center for Clean Air Policy, January 2004 TRB Presentation

TABLE 3-2. TOTAL TAILPIPE EMISSIONS

	Emissions (tons)		
Pollutant	**High-level congestion**	**Mid-level congestion**	**Low-level congestion**
CO	23399	32801	53162
VOC	2012	2266	3031
NO_X	2246	3659	5911
PM10	82	163	326
PM2.5	64	127	255
SO_2	85	170	340

FIGURE 3-5. TAILPIPE CRITERIA POLLUTANT EMISSIONS PER CRASH



In addition to the criteria pollutant emissions associated with the fuel wasted in incident-related delays caused by CMV crashes, there are emissions associated with the refining and distribution of that wasted fuel. To calculate those emissions, it is necessary to determine the fuel consumption for the incident-delayed VMT. The fuel consumption is calculated simply by dividing the incident-delayed VMT for each accident severity, roadway type, and congestion scenario by the fuel economy associated with the average speed for each congestion scenario. However, there is very little information available with respect to the relationship between speed and fuel economy.

For the low-level congestion scenario (representative of the urban drive cycle), the estimated fuel economy determined by EPA for 1975-2006 vehicles for the adjusted city driving schedule can be used (EPA 2006). The report has values for the combined average fuel economy of new cars and light trucks on the urban test cycle that range between approximately 18-19 miles per gallon (mpg) for approximately the last 20 model years. It can be assumed that the fleet average in urban driving is within this range, since the fleet is composed primarily of vehicles from these model years. The value for the 2006 vehicle models (18.6 mpg), roughly the midpoint of this range, was selected for this analysis. The test value has already been adjusted downward (by 10 percent) to reflect differences between laboratory test conditions and real-world driving conditions.

For the mid-level and high-level congestion scenarios, the fuel economy associated with the respective average speeds was estimated using the results of a methodology developed by ORNL for FHWA to determine modal vehicle emissions and fuel consumption models (SAE 1997 and FHWA 1999). The models, in the form of look-up tables of fuel economy and emission rates as a function of speed and acceleration, are designed to simulate fuel consumption and emissions for different driving schedules. Differences in emission rates as a result of more stringent EPA regulations would have to be considered. The authors derived their results from tests with a limited number of vehicles from different model years, selected to be representative of the overall vehicle fleet. Even though the number of vehicles tested and used in the model is small, the weighted averages (based on their selected vehicle fleet composition as represented by the tested vehicles) for curb weight, engine displacement, and number of cylinders closely resembles the real world vehicle fleet composition. In addition, the authors compared their results to those of a test in Detroit with 30 vehicles, and obtained very similar results.

The average speed for the mid-level and high-level congestion scenario (10 and 5 miles per hour – mph –, respectively) was matched with the corresponding fuel economy figures from the ORNL study. The resulting values are 15 and 9.5 mpg, respectively. These numbers seem somewhat high for the driving conditions expected after a CMV crash. Overestimation of fuel economy is expected since the fuel economy values are for the respective average speeds and do not consider acceleration and stop-and-go conditions. However, the values are reasonable in the context of the fuel economy figure for the urban drive cycle. When comparing the fuel economy values from the ORNL study (22.6 mpg) to the urban drive cycle figure (18.6 mpg), it is seen that using the ORNL steady-state speed of approximately overestimates fuel economy by 20 percent.

However, in the absence of more detailed information, the ORNL fuel economy figures (for the vehicle fleet) for steady-state 10 and 5 mph are used in the current analysis.

Since the high-level congestion (5 mph) scenario is representative of conditions with significant idling, considering idling fuel consumption will result in more realistic estimates of congestion related fuel consumption. Information on idling fuel consumption is very limited. However, a recent study motivated by the concern over idling emissions from CMVs was prepared by ORNL (SAE 2003). The results can be used to account for CMV idling emissions during congestion. Even though there is no information on the idling time during congestion associated with crashes, it was considered useful to include them in the analysis. A TTI study estimates the fleet composition at 95 percent vehicles and light trucks and 5 percent CMV. However, as this estimate seems very low, data from the 2000 Transportation Research Board Highway Capacity Manual was selected as a better representation of the relative fleet composition by facility type (TRB 2000). The actual values for the percentage of CMVs by facility type are presented in the Congestion section. Thus, for this scenario, it was assumed that the CMVs (represented by the corresponding fleet contribution by facility type) were idling during the congestion incident and the rest of the vehicles were traveling at a steady-state speed of 5 mph. Using CMV idling emissions somewhat offsets the underestimation of fuel consumption that results from using steady-state conditions instead of acceleration and stop-and-go. The results show that the high-level congestion scenario results in higher fuel consumption and CO_2 emissions than the mid-level congestion scenario.

The estimates of fuel consumption for each scenario were then used to calculate the upstream emissions associated with the refining and distribution of this wasted fuel. The energy content of gasoline and emission rates for criteria pollutants associated with refining and distribution were calculated from the GREET model (Argonne National Laboratory 2006). The upstream emissions are calculated as the product of the fuel consumption (gallons of wasted fuel) and the emission rates (grams per gallon). These estimates are then added to the total tailpipe emissions for the respective pollutants, to calculate the total criteria pollutant emissions associated with congestion generated by CMV crashes. The total emissions per crash are estimated by dividing the total emissions by the number of CMV crashes. Figure 3-6 presents the carbon (carbon dioxide) emissions per crash and by accident severity and congestion scenario. Table 3-3 presents the total criteria pollutant emissions (tailpipe and upstream) for each congestion scenario. Table 3-4 and Figure 3-7 present the total criteria pollutant emissions per crash for each congestion scenario.

FIGURE 3-6. FUEL CONSUMPTION PER CMV CRASH

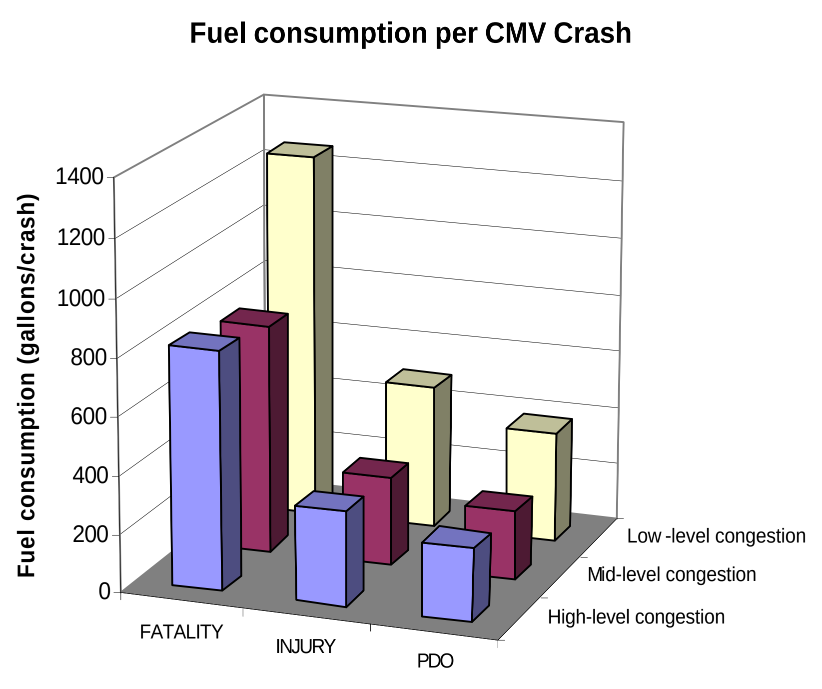


FIGURE 3-7. CO_2 EMISSIONS PER CMV CRASH

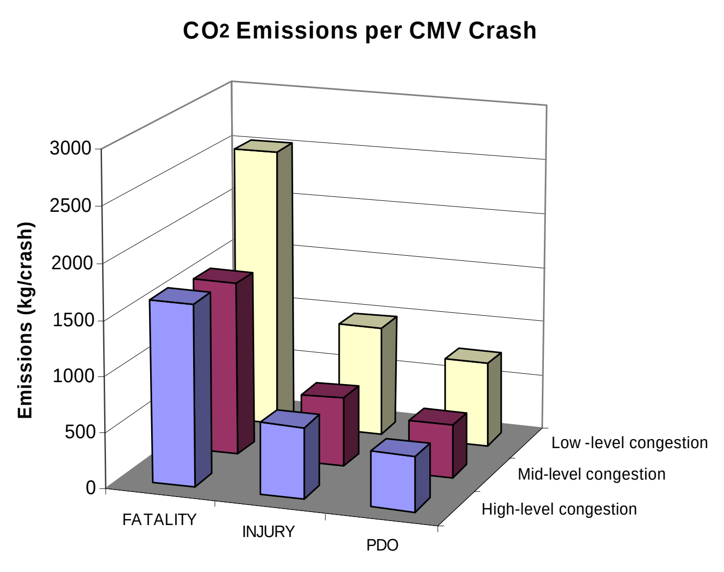


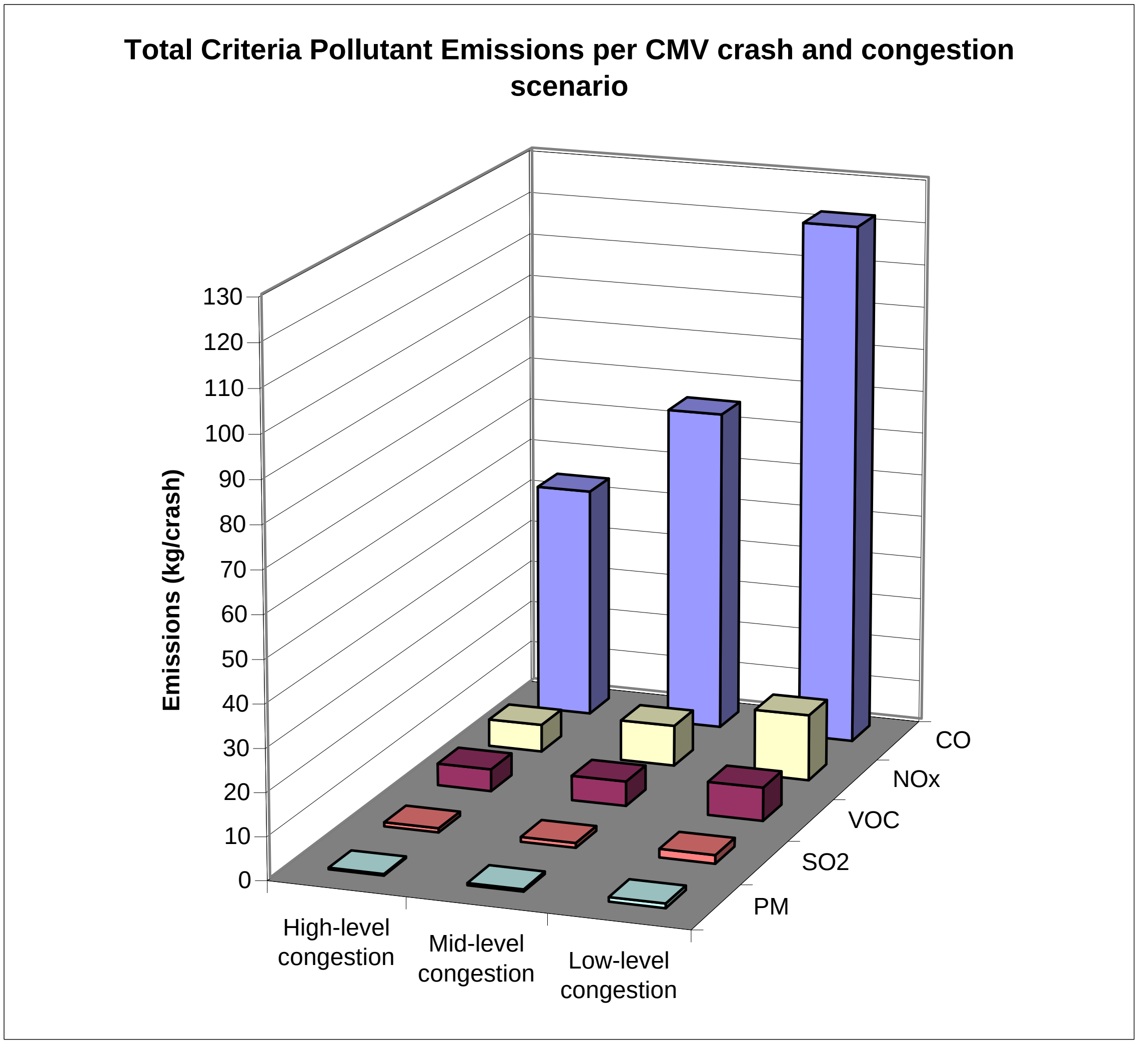
TABLE 3-3. TOTAL EMISSIONS

	Emissions (tons)		
Pollutant	**High-level congestion**	**Mid-level congestion**	**Low-level congestion**
CO	23767	33155	53732
VOC	2267	2510	3426
NO_X	2800	4192	6770
PM10	161	239	449
PM2.5	120	181	341
SO_2	418	490	856

TABLE 3-4. TOTAL PER CRASH EMISSIONS

	Emissions (kilogram/crash)		
Pollutant	**High-level congestion**	**Mid-level congestion**	**Low-level congestion**
CO	54.06	75.41	122.22
VOC	5.16	5.71	7.79
NO_X	6.37	9.53	15.40
PM10	0.37	0.54	1.02
PM2.5	0.27	0.41	0.78
SO_2	0.95	1.11	1.95

FIGURE 3-8. CRITERIA POLUTANT EMISSIONS PER CRASH



The estimation of GHG focused on carbon dioxide (CO_2), as it represents 97-98 percent of total GHG from producing, distributing, and consuming motor fuel. Carbon (C) emissions associated with the wasted fuel resulting from CMV crash-induced congestion are estimated as the product of the total fuel consumption, the mass density of fuel (averages 2,364 grams per gallon for the current U.S. gasoline mix), and the percentage of fuel mass represented by carbon (averages 84.7 percent for current U.S. gasoline mix). CO_2 emissions are estimated as the product of the carbon emissions and the ratio of molecular weight of CO_2 to that of its carbon component. Since the atomic mass of carbon is 12 g/mol and the atomic mass of oxygen is 16 g/mol, the ratio is 44:12.

In addition, as in the case of criteria pollutants, there are upstream emissions associated with the refining and distribution of the wasted fuel. From GREET, upstream emissions per gallon of fuel refined and distributed average (for the current U.S. gasoline mix) 557 grams per gallon for carbon, and 2,043 grams per gallon for CO_2. The upstream emissions are estimated as the product of fuel consumption and the average upstream emissions per gallon of fuel refined and distributed. GREET can also be used to determine the non-carbon dioxide GHG emissions (CH_4 and N_2O) from refining and burning fuel, but they are much smaller in magnitude and thus not considered here. Table 3-5 presents carbon and CO_2 emissions per CMV crash from wasted fuel and upstream emissions from its refining and distribution.

TABLE 3-5. CARBON AND CARBON DIOXIDE EMISSIONS PER CMV CRASH FROM WASTED FUEL AND UPSTREAM EMISSIONS FROM FUEL REFINING AND DISTRIBUTION BY CONGESTION SCENARIO

	Emissions (kilogram/crash)		
Pollutant	**High-level congestion**	**Mid-level congestion**	**Low-level congestion**
Carbon	686.92	659.61	1063.88
Carbon dioxide	2518.70	2418.56	3900.90

3.4 HUMAN HEALTH DAMAGES

Human exposure to the vehicle emissions from CMV crashes has health impacts. Direct emissions from ozone and other emissions result in a number of pathologies including impaired breathing, cardiac conditions, and can be fatal (US EPA 2006d). If FMCSA regulations reduce emissions from CMV crashes, they will also be reducing overall concentrations of harmful air pollution.

The formation of ambient pollution from emissions is a non-linear process and to some extent the effect of ambient pollution on people's health is not linear (McCubbin and Delucchi 1996). A marginal and discreet reduction of air emissions will not necessarily reduce air pollution or health impacts on a corresponding per unit basis. Despite these complexities, the Office of Management and Budget has accepted damage cost values for each of the criteria pollutants (OMB draft 2006) and based their numbers on two Regulatory Impact Analysis Reports from the EPA (US EPA 2005a, US EPA 2005b). The OMB's estimates have been thoroughly reviewed by analysts, and the executive branch recommends policy-makers use them in benefit-cost analyses (OMB draft 2006, OMB 1992).

OMB's estimates are derived from the EPA's 2005 Regulatory Impact Analysis for Final Clean Air Act Interstate Rule. The report analyzes the economic impact of Clean Air Act regulations including only estimates for values that can be monetized (US EPA 2005a). The EPA developed the estimates based on detailed analysis of the health costs associated with air pollution and includes both on-road and off-road emissions. Damage cost values were obtained from the OMB Draft 2006 Report to Congress on the Costs and Benefits of Federal Regulations (OMB 2006). OMB does not provide a value for carbon monoxide since it estimates that damage costs associated with this pollutant are very low. Damage cost values are:

- Hydrocarbon: $600 to $2,700 per ton
- Nitrogen Oxide (mobile): $1,100 to $11,600 per ton
- Particulate Matter: $10,000 to $100,000 per ton
- Sulfur Dioxide: $1,700 to $18,000 per ton

A value for carbon monoxide was taken from the research literature. In addition, a value for carbon (representative of carbon dioxide emissions) was estimated by Volpe in a previous study and is used in this analysis. Adjusting all values to 2008 dollars, the damage costs are

- Carbon Monoxide A value of $20 is used (McCubbin and DeLucci)
- Hydrocarbon: $691 to $3,110 per ton
- Nitrogen Oxide (mobile): $1,267 to $13,359 per ton
- Particulate Matter: $11,517 to $115,167 per ton
- Sulfur Dioxide: $1,958 to $20,730 per ton
- Carbon (carbon dioxide): $20 (Volpe 2006)

Note that OMB damage estimates for particulate matter don't necessarily break out PM10 and PM2.5, although MOBILE6 does have the capability to measure each pollutant independently. There is near consensus among researchers that PM2.5 is more dangerous than coarser particles, since it can penetrate deeper in the lung (Dockery et al 1995, Marrack 1995, Pope et al.1995). The OMB damage cost for particulate matter does not currently differentiate between PM10 and PM2.5 for total emissions. There may be future OMB guidance on the different impact costs of each of these two particle sizes. For the purposes of this analysis, the estimation of damage costs is done accounting only for the PM2.5 emissions. For the other criteria pollutants, the cost figure used is the midpoint of the range provided.

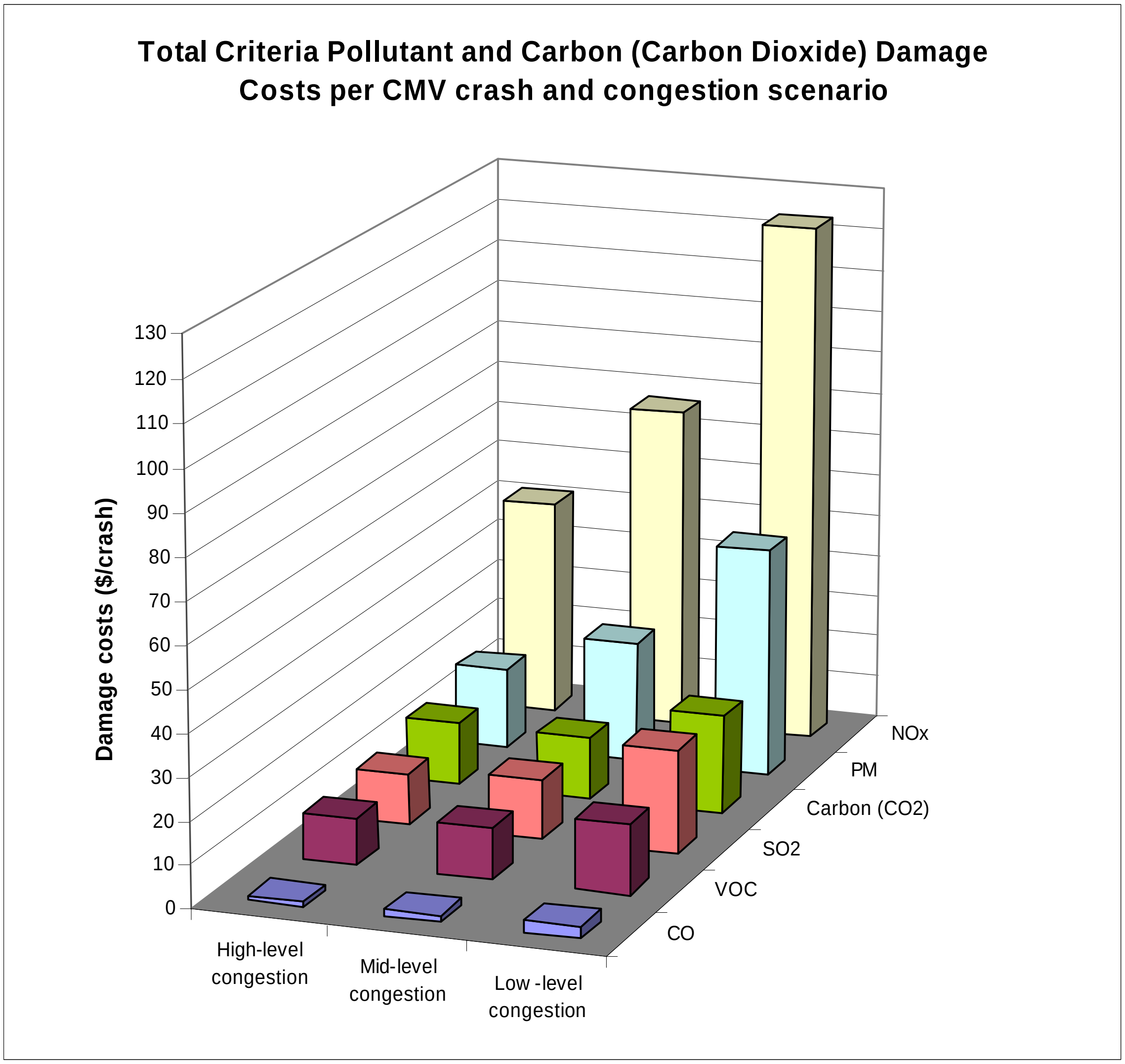
The damage costs are estimated as the product of the total emissions and the damage cost values. This estimation includes air quality impacts, which are compared with human exposure, physical damage, and assesses the cost associated with the health damage. OMB does not consider the economic impact costs to ecological and agricultural resources, since consensus has not been reached on methods to estimate those (US EPA 2005).

Table 3-6 presents the total damage costs and damage costs per CMV crash for criteria pollutants and carbon (carbon dioxide). Figure 3-8 presents the damage costs per crash for criteria pollutants and carbon (carbon dioxide) for each congestion scenario.

TABLE 3-6. TOTAL DAMAGE COSTS AND DAMAGE COSTS PER CMV CRASH FOR ALL POLLUTANTS

	Total Damage Costs (2008 $)			Per Crash Damage Costs (2008 $)		
Pollutant	**High-level congestion**	**Mid-level congestion**	**Low-level congestion**	**High-level congestion**	**Mid-level congestion**	**Low-level congestion**
CO	$475,336	$663,096	$1,074,633	$1.2	$1.7	$2.7
VOC	$4,307,816	$4,770,002	$6,509,438	$10.8	$12.0	$16.3
NO_X	$20,477,503	$30,653,222	$49,508,481	$51.3	$76.9	$124.1
PM	$7,578,042	$11,470,325	$21,623,018	$19.0	$28.8	$54.2
SO_2	$4,740,264	$5,555,693	$9,708,288	$11.9	$13.9	$24.3
Carbon (CO_2)	$6,039,883	$5,799,740	$9,354,420	$15.1	$14.5	$23.5
Total Damage Costs	**$ 43,618,845**	**$ 58,912,078**	**$ 97,778,279**	**$109**	**$148**	**$245**

FIGURE 3-9. TOTAL CRITERIA POLLUTANT AND CARBON DAMAGE PER CMV CRASH AND CONGESTION SCENARIO



Contrary to what would be expected, emissions, fuel consumption, and costs for the low-level congestion scenario are the highest and those for the high-level congestion scenario are the lowest. Given that a high-level congestion scenario is intended to represent a situation with very slow speeds and stop-and-go driving, the opposite results might be expected. However, the results can be easily explained by the fact that the ratio of average speeds for each congestion scenario (and thus the estimated VMT under congested conditions) is much higher than the corresponding ratios of emissions and fuel economy. For example, the same vehicle delayed for one hour in congestion will create more emissions traveling at 10 mph than it would at 5 mph because it travels twice the distance. Longer distances result in more fuel consumption along with all the related emissions. This result is driven by the fact that the analysis uses average speeds verses actual time in congestion and does not consider idling and stop-and-go acceleration.

To correct this, one alternative would be to consider a fourth scenario (or change the high-level congestion scenario to a lower average speed). MOBILE6 uses 2.5 mph as the speed representative of idling conditions. In reality, what this means, is that 2.5 mph is the slowest speed at which the model can reliably estimate emission rates (in grams/mile, which is the unit used by the model). Idling emissions should be estimated in emissions per unit of time. However, there is very little data on idling emissions. Since the emission rates (for the speed sensitive pollutants) at 2.5 mph are significantly higher than those at 5 mph, this alternative scenario might provide a more realistic representation of emissions. As an extension of the current analysis, a scenario considering emissions and fuel consumption at 2.5 mph could be developed to provide a “conservative” scenario.

4. HAZARDOUS MATERIALS

4.1 INTRODUCTION

CMV crashes can result in the release of hazardous materials (HM) into the environment. Crashes occur in varying locations and with varying amounts and types of HM being released from the CMV cargo. Environmental impacts are dependent on these variables. In addition, HM from the CMV cargo is also released into the environment from non-crash related incidents that occur during in-transit movements, loading, unloading and in-transit temporary storage. Similar to CMV crashes, the environmental impacts are dependent on the location, quantity and type of HM being released.

In general, HM are substances that may pose a threat to public safety or the environment during transportation, because of their physical, chemical, or radioactive properties. The potential for environmental damage or contamination exists when packages of HM are involved in crashes or en route incidents resulting from cargo shifts, valve failures, package failures, or loading, unloading, or handling problems. Accidental releases of HM can result in explosions or fires. Radioactive, toxic, infectious, or corrosive HM can have short- or long-term exposure effects on humans or the environment. Diesel fuel released during a CMV crash from a fuel tank rupture, although not classified as a HM under federal HM transportation law (see Section 4.2) can also adversely impact the environment.

This chapter contains 1) a brief overview of HM transportation law, 2) a description of the different classes of HM, 3) quantification tables for use by the FMCSA responsible federal official to estimate the releases of HM per commercial CMV crash (or non-crash related incident), 4) general narrative summaries of environmental impacts by HM class, 5) specific narrative summaries of HM releases into the environment based on database research conducted for 2003, 2004 and 2005, and 5) quantification and environmental impact summaries of diesel fuel releases that occur during a CMV crash from a fuel tank rupture.

This chapter can be used as an informational tool for FMCSA's responsible federal official when preparing a NEPA document and/or it can be inserted in whole or in part as an appendix to a NEPA document when a FMCSA action may affect the release of HM into the environment. For example, the narrative portion of the report (see Section 4.5) can be inserted as an appendix into certain NEPA documents to provide context and background information on HM in transportation; however, not all quantification tables may be applicable. Quantification tables can be used to estimate the reduction in the amount of HM released into the environment if the number of avoided CMV crashes or non-crash related incidents is known, but not necessarily included in the appendix of a NEPA document.

Note that this chapter focuses on the HM transportation law. There are numerous other federal and state laws and regulations that apply to HM and can also be referenced for use in FMCSA's HM analyses.

4.2 BACKGROUND

The federal hazardous materials transportation law, 49 U.S.C. § 5101 et seq., (formally the Hazardous Materials Transportation Act, 49 App. U.S.C. § 1801 et seq.) is the basic statute regulating hazardous materials transportation in the U.S. The purpose of the law is to provide adequate protection against the risks to life and property inherent in transporting HM in commerce by improving the regulatory and enforcement authority of the Secretary of Transportation (Secretary).

The Secretary has the authority to designate a material or a group or class of materials as hazardous when the Secretary decides that transporting the material in commerce in a particular amount and form may pose an unreasonable risk to health and safety or property. The HM regulations (HMR) can be found at Title 49 CFR Parts 171-180. The HMR cover five areas as follows:

- Hazardous materials definition/classification (Part 172, Subparts A-B, and Part 173);
- Hazard communication (Part 172, Subparts C-G);
- Packaging requirements (Parts 173, 178, 179 and 180);
- Operational rules (Parts 171, 173, 174, 175, 176 and 177); and
- Training (Part 172, Subpart H).

The U.S. DOT, Pipeline and Hazardous Materials Safety Administration (PHMSA), has public responsibilities for the safe and secure movement of HM to industry and consumers by all transportation modes, including the nation's pipelines. PHMSA's Office of Hazardous Materials Safety (OHMS) is the federal safety authority for the transportation of HM by air, rail, highway and water.

The HMR (49 CFR Section 171.16) require that certain type of HM incidents be reported to PHMSA on US DOT Form F 5800.1, Hazardous Material Incident Report (HMIR). The information in the report is fundamental to HM transportation risk analysis and risk management by government and industry. Additional information on transportation and HM can be found on the PHMSA website at (www.phmsa.dot.gov).

Classes of Federal Hazardous Materials

The DOT divides regulated HM into nine classes, some of which are further divided into divisions (see also HMR at 49 CFR Part 173). HM in transportation must be placarded. Some materials must always be placarded; others may only require placarding in certain circumstances. A listing of all HM classes and divisions is given below. Some examples of the various classes and divisions are also given. Section 4.5 of this chapter includes a general description of the potential environmental impacts that can occur by HM class. In addition, specific quantities of actual releases from 2003, 2004 and 2005 are given.

Class 1: Explosives — Six subclasses.

1.1 — Explosives with a mass explosion hazard. (*nitroglycerin/dynamite*)
1.2 — Explosives with a blast/projection hazard.
1.3 — Explosives with a minor blast hazard. (*rocket propellant, display fireworks*)
1.4 — Explosives with a major fire hazard. (*consumer fireworks, ammunition*)
1.5 — Blasting agents.
1.6 — Extremely insensitive explosives.

Class 2: Compressed Gases — Three subclasses.

2.1 — Flammable gases. (*propane, hydrogen*)
2.2 — Non-flammable gases. (*helium, nitrogen*)
2.3 — Poison gases. (*chlorine, phosgene*)

Class 3: Flammable Liquids — Liquids with a flash point at or below 140 °F (*gasoline, some alcoholic beverages*)

Combustible Liquids — Liquids with a flash point between 140 and 200 °F

Class 4: Flammables — Three subclasses.

4.1 — Flammable solids. (*magnesium powder, red phosphorus, etc.*)
4.2 — Spontaneously combustible materials. (*white phosphorus*)
4.3 — Water reactive materials. (*sodium, potassium*)

Class 5: Oxidizing Materials — Two subclasses.

5.1 — Oxidizers. (*ammonium nitrate, hydrogen peroxide*)
5.2 — Organic peroxides. (*benzoyl peroxide*)

Class 6: Toxic Materials — Three subclasses.

6.1 — Poisonous liquids or solids. (*potassium cyanide, mercuric chloride*)
6.2 — Infectious/biohazardous substances. (*anthrax, HIV*)
6.3 — Liquids and solids with a lower toxicity than those in group 6.1.

Class 7: Radioactive Materials — Three subclasses.

7.1-7.3 — Radioactive I, II, III. (*uranium, plutonium, radioactive waste*)

Class 8: Corrosive Materials — acids and bases (*sodium hydroxide, sulfuric acid*)

Class 9: Miscellaneous Dangerous Goods — materials that are hazardous during transportation but do not meet the definition of any of the other hazard classes, for example *dry ice* in an airplane or *hot asphalt*).

4.3 METHODOLOGIES

4.3.1 Data Sources

Three databases were used to estimate the release of HM from cargo and diesel fuel from a CMV fuel tank: 1) the Hazardous Material Information System (HMIS), 2) the Motor Carrier Management Information System (MCMIS), and 3) The Spill Center, Acton, MA, Spill Database. Details about these sources are presented below.

Hazardous Material Information System (HMIS)

The federal hazardous materials transportation law (49 U.S.C. Sec. 5101 et seq.) and implementing regulations (HMR 49 CFR Parts 171-180) apply to persons who transport hazardous materials in commerce, which includes intrastate motor carriers.

Carriers from any mode of transportation are required to complete a HMIR when there is an unintentional release of a HM during transportation (including loading, unloading, and temporary storage related to transportation). The most current form used is Form DOT F 5800.1 (01-2004). The form is submitted to the US DOT, PHMSA, OHMS for database entry.

The form contains key entries for use in the HM analysis, including but not limited to 1) mode of transportation (e.g. highway, rail, etc.), 2) transportation phase (in-transit, loading, unloading, etc.), 3) hazardous class/division and quantity of the HM released, and 4) if the HM vehicle was involved in a crash. The HM form does not contain a field for fuel spills from fuel tanks, only a field for cargo spills.

Motor Carrier Management Information System (MCMIS)

MCMIS is a system managed by FMCSA. MCMIS contains CMV crash data submitted by the states. The states collect state crash data from police accident reports (PAR) for large trucks and buses (including HM placarded vehicles) using the Safetynet system. Safetynet information is subsequently forwarded to FMCSA’s MCMIS. Each state has adopted the National Governors’ Association’s (NGA) uniform accident data elements for their PAR.

Reportable crashes include those that involve 1) any truck weighing more than 10,000 pounds, 2) any motor vehicle designed to transport more than eight people (including driver), or 3) any vehicle displaying a hazardous material placard (regardless of weight). In addition, the vehicle involved in the crash must be operating on a public road. Finally, to be reportable, the crash must result in 1) a person being killed or receiving bodily injury requiring immediate medical treatment away from the scene of the accident, or 2) the vehicle being disabled as a result of the crash and transported from the scene by a tow truck or other vehicle. (Note: in theory, this would capture less info for HM spills than the HMIS; however, it is assumed that most spills - including those from fuel tanks - would result in a tow-away.) Reports are not required for crashes caused by a driver with a disease condition. Additionally, they are not required for crashes caused as part of a suicide attempt.

It should be understood that MCMIS is not a complete collection of crashes, and the quality of the reporting varies by state. The FMCSA's Analysis and Information (A&I) Online (http://ai.fmcsa.dot.gov) presents State Safety Data Quality (SSDQ) reports that rate each state on a quarterly basis on the completeness, timeliness and accuracy of state reported crash data in MCMIS.

The Spill Center, Acton, MA, Spill Database

Neither the HMIS nor MCMIS include information specific to CMV crashes and fuel spills from the CMV fuel tanks of trucks or buses. The Acton Spill Center (ASC) tracks HM spill data at the national level. They are able to query the data for CMV gas tank spill releases separate from HM cargo releases.

Their database contains information on approximately 900 fleets nationally and goes back 16 years. The Acton Spill Center Database has information allowing the identification of spills from large trucks (> 10,000 pounds) and small trucks (= 10,000 pounds). The Acton Spill Center was not able to identify any bus data for this analysis.

4.3.2 Data Query Descriptions

The following queries were run to estimate the releases of HM and diesel fuel spills from the CMV fuel tank:

For CMV Crashes

HMIS Query 1 Crashes - This query was run for years 2003, 2004 and 2005. Its purpose was to identify all CMV crashes that resulted in a release of HM. Applicable query fields included the city, state and date where the HM release from the CMV crash occurred, as well as the land use type where the HM was released.

HMIS Query 1 was used to obtain data that could be used to estimate the following:

- The total number of unique CMV crashes with a HM release per year.

- The percentages of HM releases in certain land use areas such as agricultural, commercial, industrial, residential and undeveloped.

The following were the primary HMIS Query 1 limitations and assumptions:

- Since PHMSA does not have a minimum reportable HM spill quantity for crashes, all HM spills from CMV crashes (in theory) should be reported and captured in the HMIS database. MCMIS also contains a field for crashes that result in a release of HM. There are some discrepancies between the HMIS and MCMIS databases however. MCMIS includes a slightly higher number of CMV crashes with an HM release than HMIS as follows: 1) 2003 – 263 for HMIS vs. 282 for MCMIS, 2) 2004 – 205 for HMIS vs. 325 for MCMIS, and 3) 2005 - 233 for HMIS vs. 300 for MCMIS. Although MCMIS includes information indicating that a HM spill occurred, the HM Class is sometimes missing (between 22 and 27 percent of the time) and there is no information on the spill quantity. The accuracy of this data with respect to HM releases from CMV crashes is questionable, consequently.

- Approximately 2 percent of the reported incidents did not include information on land use types. In addition, the land use fields were only available for the years 2003 and 2004, due to the changes in the HMIR form that occurred in January 2005. The land use percentages calculated from the HMIS were based on those reported. It is assumed that those reported are representative of the entire population.

<u>HMIS Query 2 Crashes</u> - This query was run for years 2003, 2004 and 2005. It lists the CMV crashes by city, state and date and also lists the HM Class, quantity and units of the HM released into the environment. Land use type and CMV type (truck type or other vehicle type) is also listed for 2003 and 2004.

HMIS Query 2 was used to obtain data that could be used to estimate the following:

- HM quantities overall and by HM Class per CMV type per year
- Percentages of HM spills by HM Class in certain land use areas such as: agricultural, commercial, industrial, residential and undeveloped

The following were the primary HMIS Query 2 limitations and assumptions:

- Since the release of more than one HM Class may result from a CMV crash, Query 2 may list some crashes more than once. As a result, the number of crashes identified in Query 2 is greater than Query 1 as follows: 1) 2003 – 263 for Query 1 vs.294 for Query 2, 2) 2004 - 205 for Query 1 vs. 230 for Query 2, and 3) 2005 – 233 for Query 1 vs. 270 for Query 2. In order to keep the HM Class estimates consistent with each unique crash, a manual search was performed of the Query 2 data to identify the crashes listed more than once as a consequence of there being more than one HM Class released. The crash incident was then assigned to the

HM Class that resulted in the largest release. Although not as accurate as the quantities per crash that can be calculated using the data from Query 1, this constitutes a reasonable approximation of the amount of HM released by Class based on the best available information.

- Approximately 2 percent of the reported incidents did not include information on land use types. In addition, the land use fields were only available for the years 2003 and 2004, due to the changes in the HMIR form that occurred in January 2005. The land use percentages calculated from the HMIS were based on those reported. It is assumed that those reported are representative of the entire population.

- The “other vehicle” category was relied on to determine the HM Class released per vehicle type. This field was only available for 2003, and 2004 due to changes in the HMIR form that occurred in January 2005. If the vehicle type did not match one of the CMV descriptions listed on the form, those submitting reports were required to list identify the “other vehicle type”. There were only a few “other vehicle” types listed, including an auto, pickup truck and passenger vehicle. Assuming those submitting reports were accurate in identifying their vehicle type, it was concluded that the vast majority of HM releases are from large trucks (> 10,000 pounds), not buses or other CMVs.

<u>MCMIS Query Crashes</u> - This query was run for years 2003, 2004 and 2005. It identified crashes by the following CMV types: 1) trucks less than or equal to 10,000 pounds, 2) trucks between 10,001-26,000 pounds, 3) trucks more than 26,000 pounds, 4) buses with seats for 9-15 people, and 5) buses with seats for > 15 people.

The MCMIS Query was used to obtain data that could be used to estimate the following:

- The number of crashes by CMV type including; 1) trucks > 10,000 pounds, 2) trucks < 10,000 pounds and 3) buses (seats for greater than 15 people including the driver).
- The number of crashes with HM placards by CMV type.

The following were the primary MCMIS Query limitations and assumptions:

- In order to obtain the desired estimates, certain MCMIS database fields needed to be combined. This was a basic addition exercise. Also, some of the MCMIS crash reports did not have information on the type of CMV. For this analysis, the unidentified CMVs were proportionately assigned to a CMV type based on the percentages of the known vehicle types. This was done for each year as follows 1) 2003 - 32,553 of 127,725 (CMV type not reported for 25 percent of crashes); 2) 2004 - 39,486 of 84,593 (CMV type not reported for 25 percent of crashes), and 3) 2005 - 38,019 of 145,259 (CMV type not reported for 26 percent of crashes). This exercise was also performed for the CMVs with HM placards for which the CMV type was not reported at the following percentages: 2003 - 17 percent, 2004 – 20 percent, 2005 - 21 percent.

Acton Spill Center Query Crashes - This query was run for years 2002 through 2006. The Acton Spill Center provided the estimates for the percentage of CMV crashes based on a single 5,000 tractor fleet group.

The Acton Spill Center Query was used to obtain data that could be used to estimate the following:

- The percentage of truck crashes that result in release of diesel fuel from the fuel tank and the average amount of fuel per CMV truck type (e.g. trucks > 10,000 pounds and trucks < 10,000 pounds).

The following were the primary Acton Spill Center Query limitations and assumptions:

- The Acton Spill Center database included spills from one CMV truck fleet group, not the entire Nation's CMV truck fleet. It should be noted that this particular fleet group reports all fuel spills, no matter the quantity. In addition, the group should be highly representative of the U.S. trucking industry, because the Spill Center subscribers include all segments of the trucking industry such as LTL (less than truck load, TL (truck load), private fleets, tank and straight trucks. Based on five years of data from this group, the Acton Spill Center estimated that 12 percent of all CMV trucks experienced a crash that resulted in a release of diesel fuel from the vehicle's fuel tank. Quantities could also be estimated for trucks > 10,000 pounds - 72 gallons per crash - and trucks < 10,000 pounds - 40 gallons per crash. The percentage and quantity per crash figures developed using the Acton Spill Center data were applied to the total number of truck crashes estimated using the MCMIS database. It was not possible to estimate diesel fuel releases for buses, it must be noted.

For CMV Incidents

HMIS Query 1 Non-crash Incidents - This query was run for years 2003, 2004 and 2005. It identifies the CMV non-crash incidents by transportation phase (e.g. In-Transit, Loading, Unloading and In-Transit Temporary Storage) during which the HM release occurred. Applicable query fields used included the city, state and date for the HM release, as well as the land use type where the HM was released.

HMIS Query 1 was used to obtain data that could be used to estimate the following:

- Total number of unique CMV non-crash incidents with a HM release per year
- Total number of unique CMV non-crash incidents per year by transportation phase with a HM release
- Percentages of HM releases in certain land use areas such as: agricultural, commercial, industrial, residential and undeveloped

The following were the primary HMIS Query 1 limitations and assumptions:

- PHMSA does not require reporting for minimal amounts of HM released during loading or unloading incidents, so long as no property damage is caused. In addition, since MCMIS does not capture HM non-crash related incidents, it cannot be used to cross check the HMIS incident data.

- Approximately 2 percent of the reported non-crash incidents did not include information on land use types. In addition, the land use fields were only available for the years 2003 and 2004, due to the changes in the HMIR form that occurred in January 2005. The land use percentages calculated from the HMIS were based on those reported. It is assumed that those reported are representative of the entire population.

<u>HMIS Query 2 Non-Crash Incidents</u> - This query was run for years 2003, 2004 and 2005. It identifies the CMV non-crash incidents by city, state and date and also identifies the HM Class, quantity and units of the HM released into the environment.

HMIS Query 2 was used to obtain data that could be used to estimate the following:

- HM quantities overall by transportation phase and by HM Class per CMV type per year

The following were the primary HMIS Query 2 limitations and assumptions:

- Since the release of more than one HM Class may occur from each unique CMV non-crash incident, Query 2 may identify the same incident more than once. As a result, the number of non-crash incidents in Query 2 is greater than (approximately 1-2%) the unique non-crash incidents listed in Query 1, due to multiple incident counts when more than one type of HM Class is released. Unlike Query 2 for crashes, the number of non-crash incidents was too large to manually identify those incidents listed multiple times. As a result, the number of non-crash incidents assigned to each HM Class within each transportation phase was based solely on the Query 2 results. Although the HM Class estimates are not as accurate as the per incident quantity by transportation phase (e.g., total HM quantities/Query 1 unique incidents), it is believed that the HM quantities by HM Class in Query 2 is a reasonable representation for general NEPA analyses purposes as it represents the best available information at this time.

- Since there were a statistically insignificant number of “other vehicle types” in the HMIS incident data, it was assumed that all releases occurred from large trucks.

4.4 RESULTS

The following tables summarize the information related to HM releases for CMV crashes and non-crash incidents for all HM classes (1-9) and fuel spills to be used by FMCSA in NEPA documents. Note that in the following tables, the units of measurement are defined as follows: “gal” = gallons, “lbs” = pounds, “cf” = cubic feet, and “ci” = curies.

4.4.1 Table 4-1 – CMV Crashes and HM

Table 4-1 includes the following information:

- The total number of CMV crashes per year (based on a 3-year average using 2003, 2004 and 2005 data) categorized by large trucks buses and other CMVs.
  Source: MCMIS data.
  Purpose: Background information and for use in other tables

- The total number crashes per year (based on a 3-year average using 2003, 2004 and 2005 data) involving either an HM vehicle (includes HM crashes with no release of material per FMCSA Order 5610.1 or any CMV crash with a release of HM cargo categorized by large trucks and buses).
  Source: Primarily MCMIS cross-checked using HMIS data
  Purpose: Background information and for use in other tables

- Total number of CMV crashes per year (based on a 3-year average) that resulted in a release of hazardous materials as cargo with a subset of HM Class type (1-9) with corresponding quantities broken out by trucks, with references to buses and other CMVs.
  Source: Primarily MCMIS cross-checked using HMIS data
  Purpose: Background information and for use in other tables

- Number of CMV truck crashes (based on that resulted in a fuel tank spill and the average number of gallons released per year (based on a 5-year average).
  Source: Acton Spill Center database
  Purpose: Background information and for use in other tables

TABLE 4-1. CMV CRASHES AND HM

Categories of CMV Crashes	**Annual Averages**	
By CMV Type	**Total Number**	
Large Trucks *(> 10,000 pounds)*	**136,395**	
Buses *(seats for > 15 people including driver)*	**9,332**	
Other CMVs (*Trucks < 10,000 pounds & Other vehicles w/HM Placards Required)*	**2,117**	
All CMVs Combined	**147,844**	
Involving a Hazardous Materials Vehicle (with and without a Hazardous Material cargo release)	**Total Number**	
Large Trucks *(> 10,000 pounds)*	**1,998**	
Buses *(includes > 15 passengers)*	**2.0**	
Other CMV's (*Trucks < 10,000 pounds & Other vehicles w/HM Placards Required)*	**37**	
All HM Vehicle Crashes Combined	**2,037**	
Involving a Cargo Release by CMV Type and Hazardous Materials Class	**Total Number**	**Total Quantity Released**
Large Trucks *(> 10,000 pounds)*	*(# HMIS database w/ MCMIS cross check)*	*(HMIS database)*
Hazard Class 1 *Explosives*	**3**	**437.50 gal** **27,017 lbs**
Hazard Class 2 *Gases (flammable, nonflammable, toxic/non-toxic)*	**30**	**57,852.30 gal** **58.71 cf**
Hazard Class 3 *Flammable and Combustible Liquids Hazard*	**136**	**391,117.69 gal**
Hazard Class 4 *Flammable solids*	**3**	**1,829.21 gal** **8,971.75 lbs**
Hazard Class 5 *Oxidizing Substances and Organic Peroxides*	**10**	**4,860.27 gal** **47,270.63 lbs**
Hazard Class 6 *Toxic Substances and Infectious Substances*	**4**	**1,443.88 gal** **15,351.67 lbs**
Hazard Class 7 *Radioactive Materials*	**2**	**18.88 gal** **200.09 ci**
Hazard Class 8 *Corrosive Substances*	**33**	**20,794.37 gal** **2,791.33 lbs**
Hazard Class 9 *Miscellaneous Hazardous Materials*	**12**	**14,291.07 gal** **57,628.73 lbs**

TABLE 4-1. CMV CRASHES AND HM

<table>
<tr><th>Categories of CMV Crashes</th><th colspan="3">Annual Averages</th></tr>
<tr><td>Involving a Cargo Release by CMV Type and Hazardous Materials Class</td><td colspan="2">Total Number (#)
(# HMIS database w/ MCMIS cross check)</td><td>Total Quantity Released
(HMIS database)</td></tr>
<tr><td colspan="4">Buses (seats for > 15 people including driver)

Note, based on 2003 and 2004 HMIS data and using the “other vehicle” category, there were no HM releases from buses. Data was not available for 2005, as the new HMIS database does not include categories for vehicle type.</td></tr>
<tr><td></td><td colspan="2">Total Number (#)</td><td>Total Quantity Released</td></tr>
<tr><td>Other CMVs (Trucks < 10,000 pounds and other vehicles w/HM Placards)</td><td colspan="2">(# HMIS database w/ MCMIS cross check)</td><td>(HMIS database)</td></tr>
<tr><td colspan="4">Note, based on 2003 and 2004 HMIS data and using the “other vehicle” category the following releases occurred:
Pickup Truck - 113.63 cf release of Class 2 HM (based on one event only)
Passenger Vehicles – 4,020 gal release of Class 3 HM (based on two events only)

HM data from 2005 was not available by vehicle type. In summary, HM releases by “Other CMVs” is statistically insignificant (with only three individual events) and a separate table is not warranted.</td></tr>
<tr><td>CMVs (Trucks) Involving Fuel Tank Spills from Fuel Tanks
(Information from the Acton Spill Center was extrapolated and applied to MCMIS data for all truck crashes)</td><td># of Crashes Per Year with Fuel Tank Spills
(12% of Truck Crashes’)</td><td>Avg. Release per Crash</td><td>Est. Total amount of fuel released annually</td></tr>
<tr><td>Large Trucks (> 10,000 pounds)</td><td>16,367</td><td>72 gal</td><td>1,178,424 gal</td></tr>
<tr><td>Non-Large Trucks (< 10,000 pounds)</td><td>254</td><td>40 gal</td><td>10,160 gal</td></tr>
<tr><td>Total Large and Non-Large Trucks</td><td>16,621</td><td></td><td>1,188,584 gal</td></tr>
</table>

4.4.2 Table 4-2 – Releases of HM per Crash by CMV Category

Table 4-2 presents information for four FMCSA regulatory options and includes the following information:

- "Option I" - The amount overall of HM released and the average release of HM per CMV crash (including HM classes 1-9). All quantities of HM releases were added by class and divided by the total number of CMV crashes.
  Source: HMIS and MCMIS database
  Purpose: For use when FMCSA regulations apply to all CMVs

- "Option II" – The amount overall of HM released and the average release of HM per large truck crash (including HM classes 1-9). All quantities of large truck releases were added by class and divided by the total number of large truck crashes.
  Source: HMIS and MCMIS database.
  Purpose: For use when FMCSA regulations apply to all large trucks.

- "Option III" - The amount overall of HM released and the average release of HM per HM carrier type. All quantities of HM carrier releases were added by class and divided by the total number of HM carrier crashes.
  Source: MCMIS and HMIS database.
  Purpose: For use when FMCSA regulations apply to all HM carriers only.

- "Option IV" - The average release per HM carrier by HM carrier class. Quantities of each HM class are divided by the total number HM carriers for that particular class
  Source: HMIS only database.
  Purpose: For use when FMCSA regulations apply to a particular HM class only.

TABLE 4-2. RELEASES OF HM PER CRASH BY CMV CATEGORY

Note: Table 4-2 contains four NEPA analysis options

Option I. - All CMVs

Use the below information when FMCSA proposes new or modified regulations that apply to all CMVs

Instructions for NEPA Analysis: Multiply the number of avoided CMV crashes by the average release per crash overall or by each HM class. ***For example, if FMCSA regulations would result in 100 fewer CMV crashes per year, the reduction in the overall HM quantities released would be (100 x 3.3322 gallons, 1.0757 pounds, 0.0004 cubic feet and 0.0014 curries) = 333.22 gallons, 107.57 pounds, 0.04 cubic feet and 0.14 curries respectively, and the reduction for HM Class 2 would be (100 x 0.3913 gallons and .0004 cubic feet) = 39.13 gallons and 0.04 cubic feet, respectively.***

Total HM Quantities	**Average # CMV Crashes**	**HM Quantity per CMV Crash**
492,645.17 gal	147,844	**3.3322 gal**
159,031 lbs	147,844	**1.0757 lbs**
58.71 cf	147,844	**0.0004 cf**
200.09 ci	147,844	**0.0014 ci**

Hazardous Material Class	**Quantities of Average Annual HM Releases** *(average annual release HM class/average annual # CMV crashes)*	
Hazard Class 1 *Explosives*	437.50 gal/147,844 27,017 lbs/147,844	**0.0030 gal** **0.1827 lbs**
Hazard Class 2 *Gases (flammable, nonflammable, toxic/non-toxic)*	57,852.30 gal/147,844 58.71 cf/147,844	**0.3913 gal** **0.0004 cf**
Hazard Class 3 *Flammable and Combustible Liquids Hazard*	391,117.69 gal/147,844	**2.6455 gal**
Hazard Class 4 *Flammable solids*	1,829.21 gal/147,844 8,971.75 lbs/147,844	**0.0124 gal** **0.0607 lbs**
Hazard Class 5 *Oxidizing Substances and Organic Peroxides*	4,860.27 gal/147,844 47,270.63 lbs/147,844	**0.0329 gal** **0.3197 lbs**
Hazard Class 6 *Toxic Substances and Infectious Substances*	1,443.88 gal/147,844 15,351.67 lbs/147,844	**0.0098 gal** **0.1038 lbs**
Hazard Class 7 *Radioactive Materials*	18.88 gal/147,844 200.09 ci/147,844	**0.0001 gal** **0.0014 ci**
Hazard Class 8 *Corrosive Substances*	20,794.37 gal/147,844 2791.33 lbs/147,844	**0.1407 gal** **0.0189 lbs**
Hazard Class 9 *Miscellaneous Hazardous Materials*	14,291.07 gal/147,844 57,628.73 lbs/147,844	**0.0967 gal** **0.3898 lbs**

TABLE 4-2. RELEASES OF HM PER CRASH BY CMV CATEGORY

Note: Table 4-2 contains four NEPA analysis options

Option II.- All Large Trucks

Use the below information when FMCSA proposes new or modified regulations that apply to Large Trucks

Instructions for NEPA Analysis: Multiply the number of avoided large truck crashes by the average release per crash overall or by each HM class. ***For example, if FMCSA regulations result in 50 fewer large truck crashes per year, the reduction in the overall HM quantities released would be (50 x 3.6120 gallons, 1.1660 pounds, 0.0004 cubic feet and 0.0015 curries) = 180.6 gallons, 58.3 pounds, 0.02 cubic feet and 0.75 curries respectively, and the reduction for HM Class 3 would be (50 x 2.865 gallons) = 143.25 gallons.***

Total HM Quantities	Average # Lg. Truck Crashes	HM Quantity per Large Truck Crash
492,645.17 gal	136,395	**3.6120 gal**
159,031 lbs	136,395	**1.1660 lbs**
58.71 cf	136,395	**0.0004 cf**
200.09 ci	136,395	**0.0015 ci**

Hazardous Material Class	**Quantities of Average Annual HM Releases** *(average annual release HM class/average annual # large truck crashes)*	
Hazard Class 1 *Explosives*	437.50 gal/136,395 27017 lbs/136,395	**0.0032 gal** **0.1981 lbs**
Hazard Class 2 *Gases (flammable, nonflammable, toxic/non-toxic)*	57,852.30 gal/136,395 58.71 cf/136,395	**0.4242 gal** **0.0004 cf**
Hazard Class 3 *Flammable and Combustible Liquids Hazard*	391,117.69 gal/136,395	**2.865 gal**
Hazard Class 4 *Flammable solids*	1,829.21 gal/136,395 8,971.75 lbs/136,395	**0.0134 gal** **0.0658 lbs**
Hazard Class 5 *Oxidizing Substances and Organic Peroxides*	4,860.27 gal/136,395 47,270.63 lbs/136,395	**0.0356 gal** **0.3446 lbs**
Hazard Class 6 *Toxic Substances and Infectious Substances*	1,443.88 gal/136,395 15,351.67 lbs/136,395	**0.0106 gal** **0.1126 lbs**
Hazard Class 7 *Radioactive Materials*	18.88 gal/136,395 200.09 ci/136,395	**0.0001 gal** **0.0015 ci**
Hazard Class 8 *Corrosive Substances*	20,794.37 gal/136,395 2,791.33 lbs/136,395	**0.1525 gal** **0.0205 lbs**
Hazard Class 9 *Miscellaneous Hazardous Materials*	14,291.07 gal/136,395 57,628.73 lbs/136,395	**0.1048 gal** **0.4225 lbs**

TABLE 4-2. RELEASES OF HM PER CRASH BY CMV CATEGORY

Note: Table 4-2 contains four NEPA analysis options

Option III.- All HM Carriers

Use the below information when FMCSA proposes new or modified regulations that apply to all HM carriers.

Instructions for NEPA Analysis: Multiply the number of avoided HM carrier crashes by the average release per crash overall or by each HM class. ***For example, if FMCSA regulations would result in 10 fewer HM carrier crashes per year, the reduction in the overall HM quantities released would be (10 x 241.8484 gallons, 78.0712 pounds, 0.0288 cubic feet and 0.0982 curries) = 2418 .48 gallons, 7807.12 pounds, 2.88 cubic feet and 9.82 curries respectively, and the reduction for HM Class 4 would be (10 x 0.8980 gallons and 4.4043 pounds) = 8.980 gallons and 44.043 pounds, respectively.***

Total HM Quantities	**Average # HM Carrier Crashes**	**HM Quantity per HM Carrier Crash**
492,645.17 gal	2,037	**241.8484 gal**
159,031 lbs	2,037	**78.0712 lbs**
58.71 cf	2,037	**0.0288 cf**
200.09 ci	2,037	**0.0982 ci**

Hazardous Material Class	**Quantities of Average Annual HM Releases** *(average annual release HM class/average annual # HM placarded crashes)*	
Hazard Class 1 *Explosives*	437.50 gal/2,037 27,017 lbs/2,037	**0.2147 gal** **13.2631 lbs**
Hazard Class 2 *Gases (flammable, nonflammable, toxic/non-toxic)*	57,852.30 gal/2,037 58.71 cf/2,037	**28.4007 gal** **0.0288 cf**
Hazard Class 3 *Flammable and Combustible Liquids Hazard*	391,117.69 gal/2,037	**192.0067 gal**
Hazard Class 4 *Flammable solids*	1,829.21 gal/2,037 8,971.75 lbs/2,037	**0.8980 gal** **4.4043 lbs**
Hazard Class 5 *Oxidizing Substances and Organic Peroxides*	4,860.27 gal/2,037 47,270.63 lbs/2,037	**2.3860 gal** **23.2060 lbs**
Hazard Class 6 *Toxic Substances and Infectious Substances*	1,443.88 gal/2,037 15,351.67 lbs/2,037	**0.7088 gal** **7.5336 lbs**
Hazard Class 7 *Radioactive Materials*	18.88 gal/2,037 200.09 ci/2,037	**0.0093 gal** **0.0982 ci**
Hazard Class 8 *Corrosive Substances*	20,794.37 gal/2,037 2,791.33 lbs/2,037	**10.2083 gal** **1.3703 lbs**
Hazard Class 9 *Miscellaneous Hazardous Materials*	14,291.07 gal/2,037 57,628.73 lbs/2,037	**7.0157 gal** **28.2910 lbs**

TABLE 4-2. RELEASES OF HM PER CRASH BY CMV CATEGORY

Note: Table 4-2 contains four NEPA analysis options.

Option IV. – HM Carriers by HM Class

Use the information below when FMCSA proposes new or modified regulations that apply to HM carriers of a specific HM Class.

Instructions for NEPA Analysis: Multiply the number of avoided crashes by the average per crash release of the applicable HM Class. ***For example, if FMCSA regulations would result in 5 fewer Class 7 crashes per year, the reduction in the quantity of Class 7 released into the environment each year would be as follows: (5 x 9.44 gallons and 100.5 curies) or 47.2 gallons and 502.5 curies, respectively.***

Hazardous Material Class	**Quantities of Average Annual HM Releases** *(average annual release HM class/average annual # HM Class crashes)*	
Hazard Class 1 *Explosives*	437.50 gal/3 27,017 lbs/3	**145.83 gal** **9005.67 lbs**
Hazard Class 2 *Gases (flammable, nonflammable, toxic/non-toxic)*	57,852.30 gal/30 58.71 cf/30	**1928.41 gal** **1.96 cf**
Hazard Class 3 *Flammable and Combustible Liquids Hazard*	391,117.69 gal/136	**2875.87 gal**
Hazard Class 4 *Flammable solids*	1,829.21 gal/3 8,971.75 lbs/3	**609.74 gal** **2,990.58 lbs**
Hazard Class 5 *Oxidizing Substances and Organic Peroxides*	4,860.27 gal/10 47,270.63 lbs/10	**486.83 gal** **4,727.06 lbs**
Hazard Class 6 *Toxic Substances and Infectious Substances*	1,443.88 gal/4 15,351.67 lbs/4	**360.97 gal** **3,837.92 lbs**
Hazard Class 7 *Radioactive Materials*	18.88 gal/2 200.09 ci/2	**9.44 gal** **100.05 ci**
Hazard Class 8 *Corrosive Substances*	20,794.37 gal/33 2,791.33 lbs/33	**630.13 gal** **84.59 lbs**
Hazard Class 9 *Miscellaneous Hazardous Materials*	14,291.07 gal/12 57,628.73 lbs/12	**1,190.92 gal** **4,802.39 lbs**

4.4.3 Table 4-3 – CMV HM Incidents and Releases of HM

Table 4-3 presents information for four regulatory options and includes the following information:

- "Option I" - The amount overall of HM released per in-transit incident and also by each HM class. Quantities of each HM class were divided by the total number of in transit incidents for that HM Class.
  Source: HMIS
  Purpose: For use when FMCSA regulations apply to all CMVs In-transit.

- "Option II" - The amount overall of HM released per loading incident and also by each HM class. Quantities of each HM Class were divided by the total number of loading incidents for that HM Class.
  Source: HMIS
  Purpose: For use when FMCSA regulations apply to all CMV loading incidents

- "Option III" - The amount overall of HM released per unloading incident and also by each HM class. Quantities of each HM Class were divided by the total number of unloading incidents for that HM Class.
  Source: HMIS
  Purpose: For use when FMCSA regulations apply to all CMV unloading incidents.

- "Option IV" - The amount overall of HM released per in transit storage incident and also by each HM Class. Quantities of each HM Class were divided by the total number of in transit storage incidents for that HM Class.
  Source: HMIS
  Purpose: For use when FMCSA regulations apply to all CMV in transit storage incidents.

This table is for use as an informational resource for NEPA documents if FMCSA regulations are modified and that modification is expected to result in a decrease of HM releases due to both CMV crashes and incidents.

TABLE 4-3. CMV HM INCIDENTS AND RELEASES OF HM

Note: Table 4-3 contains four NEPA analysis options.

Option 1 – In-Transit HM Incidents

Use the below information when FMCSA proposes new or modified regulations that apply only to CMVs In-Transit

Instructions for NEPA Analysis: Multiply the number of avoided CMV in-transit incidents by the average release per incident overall or by each HM class. ***For example, if FMCSA regulations would result in 50 fewer in-transit incidents, the reduction in overall HM quantities would be (50 x 36.39 gallons, 11.76 pounds and 39.75 cubic feet) = 1,819.5 gallons, 588 pounds and 1,987.5 cubic feet, respectively, and the reduction for HM Class 3 would be (50 x 50.93 gallons) = 2,546.5 gallons.***

Total In-Transit HM Quantities	**In-Transit Average # Incidents**	**Per Incident Quantity**
48,832.31 gal	1,342	**36.39 gal**
15,778.82 lbs	1,342	**11.76 lbs**
53,348.86 cf	1,342	**39.75 cf**

Incident Type	**Annual Averages**		
In Transit (non crash related)	**# of In-Transit Incidents**	**Total Units Released**	**Release HM Class per In Transit Incident**
Hazard Class 1 *Explosives*	3	8.05 gal 400.06 lbs	**2.68 gal** **133.35 lbs**
Hazard Class 2 *Gases (flammable, nonflammable, toxic/non-toxic)*	53	4,309.87 gal 59.5 lbs 53,348.86 cf	**81.32 gal** **1.12 lbs** **1,006.58 cf**
Hazard Class 3 *Flammable and Combustible Liquids Hazard*	625	31,828.35 gal	**50.93 gal**
Hazard Class 4 *Flammable solids*	6	33.68 gal 678.48 lbs	**5.61 gal** **113.08 lbs**
Hazard Class 5 *Oxidizing Substances and Organic Peroxides*	42	424.47 gal 1,051.73 lbs	**10.11 gal** **25.04 lbs**
Hazard Class 6 *Toxic Substances and Infectious Substances*	210	379.95 gal 75.33 lbs	**1.81.gal** **0.36 lbs**
Hazard Class 7 *Radioactive Materials*	1	0 ci	**0**
Hazard Class 8 *Corrosive Substances*	470	10,533.77 gal 1,706.84 lbs	**22.41 gal** **3.63 lbs**
Hazard Class 9 ***Miscellaneous Hazardous Materials***	48	1,314.17 gal 11,806.88 lbs	**27.38 gal** **245.98 lbs**

TABLE 4-3. CMV HM INCIDENTS AND RELEASES OF HM

Note: Table 4-3 contains four NEPA analysis options.

Option II – Loading HM Incidents

Use the below information when FMCSA proposes new or modified regulations that apply only to CMV Loading HM incidents

Instructions for NEPA Analysis: Multiply the number of avoided CMV loading incidents by the average release per incident overall or by each HM class. ***For example, if FMCSA regulations would result in 200 fewer loading incidents the reduction in the overall HM quantity released would be (200 x 13.30 gallons, 8.97 pounds and 0.08 cubic feet) = 2,660 gallons, 1,794 pounds and 16 cubic feet, and the reduction for HM Class 4 would be (200 x 2.67 gallons and 22.16 cubic feet) = 534 gallons and 4,432 pounds.***

Total Loading HM Quantities	Loading Average # Incidents	Per Incident Quantity
21,328.03 gal	1,604	**13.30 gal**
14,384.28 lbs	1,604	**8.97 lbs**
128.44 cf	1,604	**0.08 cf**

Incident Type	**Annual Averages**		
Loading	**# of Loading Incidents**	**Total Units Released**	**Release per Loading Incident**
Hazard Class 1 *Explosives*	1	0.02 gal 2.20 lbs	**0.02 gal** **2.20 lbs**
Hazard Class 2 *Gases (flammable, nonflammable, toxic/non-toxic)*	68	3,771.08 gal 180.47 lbs 128.44 cf	**55.46 gal** **2.65 lbs** **1.89 cf**
Hazard Class 3 *Flammable and Combustible Liquids Hazard*	748	10,782.21 gal	**14.41 gal**
Hazard Class 4 *Flammable solids*	10	26.7 gal 221.60 lbs	**2.67 gal** **22.16 lbs**
Hazard Class 5 *Oxidizing Substances and Organic Peroxides*	50	418.44 gal 107.49 lbs	**8.37 gal** **2.15 lbs**
Hazard Class 6 *Toxic Substances and Infectious Substances*	66	334.38 gal 115.14 lbs	**5.06.gal** **1.74 lbs**
Hazard Class 7 *Radioactive Materials*	0	0	**0**
Hazard Class 8 *Corrosive Substances*	614	4,298.79 gal 145.77 lbs	**7.00 gal** **0.24 lbs**
Hazard Class 9 *Miscellaneous Hazardous Materials*	44	1,696.41 gal 13,611.61 lbs	**38.55 gal** **309.35 lbs**

TABLE 4-3. CMV HM INCIDENTS AND RELEASES OF HM

Note: Table 4-3 contains four NEPA analysis options.

Option III – Unloading HM Incidents

Use the below information when FMCSA proposes new or modified regulations that apply only to CMV Unloading HM incidents

Instructions for NEPA Analysis: Multiply the number of avoided CMV unloading incidents by the average release per incident overall or by each HM class. ***For example, if FMCSA regulations would result in 50 fewer unloading incidents, the overall reduction of the HM quantity released would be (50 x 12.82 gallons, 1.315 pounds and 0.18 cubic feet) = 641 gallons, 65.75 pounds and 9 cubic feet and the reduction for HM Class 5 would be (50 x 3.41 gallons and 9.38 pounds) = 170.5 gallons and 469 pounds.***

Total Unloading HM Quantities	Unloading Total #	Per Incident Quantity
117,062.81 gal	9,129	**12.82 gal**
12,012.14 lbs	9,129	**1.315 lbs**
1,633.56 cf	9,129	**0.18 cf**

Incident Type	**Annual Averages**		
Unloading	**# Unloading Incidents**	**Total Unit Released**	**Release per Unloading Incident**
Hazard Class 1 *Explosives*	1	0.01 gal 0.79 lbs	**0.01 gal** **0.79 lbs**
Hazard Class 2 *Gases (flammable, nonflammable, toxic/non-toxic)*	387	6,645.70 gal 1,109.26 lbs 1,633.56 cf	**17.17 gal** **2.87 lbs** **4.22 cf**
Hazard Class 3 *Flammable and Combustible Liquids Hazard*	4433	50,755.92 gal 0.17 lbs	**11.45 gal**
Hazard Class 4 *Flammable solids*	64	9.76 gal 726.49 lbs	**0.15 gal** **11.35 lbs**
Hazard Class 5 *Oxidizing Substances and Organic Peroxides*	396	1,351.52 gal 3,715.98 lbs	**3.41 gal** **9.38 lbs**
Hazard Class 6 *Toxic Substances and Infectious Substances*	438	2,568.51 gal 1,478.56 lbs	**5.86 gal** **3.38 lbs**
Hazard Class 7 *Radioactive Materials*	0	0	**0**
Hazard Class 8 *Corrosive Substances*	3218	40,614.68 gal 3,441.50 lbs	**12.62 gal** **1.07 lbs**
Hazard Class 9 *Miscellaneous Hazardous Materials*	230	6,050.47 gal 1,539.39 lbs	**26.31 gal** **6.70 lbs**

TABLE 4-3. CMV HM INCIDENTS AND RELEASES OF HM

Note: Table 4-3 contains four NEPA analysis options.

Option IV – In-Transit Storage

Use the below information when FMCSA proposes new or modified regulations that apply only to CMV In-Transit Storage incidents

Instructions for NEPA Analysis: Multiply the number of avoided CMV in-transit storage incidents by the average release per incident overall or by each HM class. *For example, if FMCSA regulations would result in 20 fewer in-transit storage incidents, the reduction in the overall HM quantity release would be (20 x 31.14 gallons, 16.58 pounds and 0.39 cubic feet) = 622.8 gallons, 331.6 pounds and 7.8 cubic feet, and the reduction for HM Class 8 would be (20 x 51.30 gallons and 1.72 pounds) = 1,026 gallons and 34.4 pounds.*

Total In-Transit Storage HM Quantities	**Unloading Total #**	**Per Incident Quantity**
18,183.78 gal	584	**31.14 gal**
9,680.04 lbs	584	**16.58 lbs**
225.25 cf	584	**0.39 cf**

Incident Type	**Annual Averages**		
In Transit Storage	**# In-Transit Storage Incidents**	**Total Unit Released**	**Average Release Per Incident** *(Quantity/#HM Incidents)*
Hazard Class 1 *Explosives*	0	0.13 gal	**0 gal**
Hazard Class 2 *Gases (flammable, nonflammable, toxic/non-toxic)*	30	2,306.38 gal 13.01 lbs 225.25 cf	**76.88 gal** **0.43 lbs** **7.51 cf**
Hazard Class 3 *Flammable and Combustible Liquids Hazard*	233	5,264.69 gal	**22.60 gal**
Hazard Class 4 *Flammable solids*	3	0.01 gal 5.54 lbs	**0.003 gal** **1.85 lbs**
Hazard Class 5 *Oxidizing Substances and Organic Peroxides*	20	78.92 gal 9,062.66 lbs	**3.95 gal** **453.13 lbs**
Hazard Class 6 *Toxic Substances and Infectious Substances*	59	103.87 gal 143.74 lbs	**1.76 gal** **2.44 lbs**
Hazard Class 7 *Radioactive Materials*	0	0	**0**
Hazard Class 8 *Corrosive Substances*	202	10,363.50 gal 347.0 lbs	**51.30 gal** **1.72 lbs**
Hazard Class 9 *Miscellaneous Hazardous Materials*	34	66.29 gal 251.83 lbs	**1.95 gal** **7.41 lbs** **6.70 lbs**

4.5 ENVIRONMENTAL IMPACT SUMMARIES FOR HAZARDOUS MATERIALS

The adverse environmental impacts associated with releases of most HM in highway transportation are usually short-term impacts that can be greatly reduced or eliminated through prompt clean up of the accident scene. Most HM transported by CMVs is not in quantities sufficient to cause significant, large scale, long-term environmental damage if they are released; however, environmental damage can occur depending on the amount and location of the spill/release.

The natural resources that could be adversely affected by a HM release include air, surface and ground water, soil, wetlands, and ecological resources (for example, wildlife habitats or endangered species). Historic properties protected under Section 106 of the National Historic Preservation Act and parklands or wildlife refuges protected under Section 4(f) of the DOT Act can also be adversely impacted.

Impacts vary depending on the class and amount of the HM and the location where it is released. Below is a general description of the environmental impacts that can be expected from a release as well as a more specific description of the quantities, types and locations where the releases for each HM class have occurred. Specific information is based on a three year analysis (2003, 2004 and 2005) of PHMSA's HMIS database, which relies on the submission the HMIRs.

In addition, information on fuel released from fuel tanks was obtained from the Acton Spill Center.

4.5.1 Hazardous Materials Overall

There are 688,986 gallons, 211,030 pounds, 53, 925 cubic feet and 201 curies released into the environment on an average annual basis from both CMV crashes and CMV non-crash related incidents combined.

CMV Crashes - On average, there are 234 CMV crashes a year that result in the release of a hazardous material from the cargo. For all hazardous material classes combined, there is an average of 492,645 gallons, 159,031 pounds, 59 cubic feet and 201 curies released into the environment annually. Most hazardous material releases from CMV crashes occur in undeveloped (38 percent) and commercial (32 percent) areas, followed by agricultural (12 percent), residential (10 percent) and industrial (8 percent) areas.

CMV Non-Crash Incidents **-** On average, there are 12,659 CMV non-crash related incidents a year that result in the release of a hazardous material. Most of these incidents occur during unloading (9,129) followed by loading (1,604), in-transit (1,342) and in-transit temporary storage (584). For all HM combined, there is an average of 196,341 gallons, 51,999 pounds, and 53, 866 cubic feet released into the environment annually. Most HM releases from CMV non-crash related incidents occur in commercial (53 percent) and industrial (44 percent) areas, followed by residential (2 percent) and undeveloped (1 percent) areas.

4.5.2 Hazardous Materials by Class

Class 1 - Explosives

General - The potential environmental impacts from a release of a Class 1 material depend on the nature of the explosive. Spills or fires related to explosive materials can cause destruction of the immediate area and may require local evacuations up to a mile away. Explosives have the potential to throw fragments over a mile. Besides their immediate threat to public health (human injuries and fatalities), fires related to an incident may produce irritating, corrosive, or toxic gases and harm plants and wildlife as well. Additionally, fire control methods may produce runoff pollutants into wetlands, waterways and contaminate ground water.

In total, there are 445.71 gallons and 27,420.05 pounds of Class 1 HM released into the environment on an average annual basis from both CMV crashes and CMV non-crash related incidents combined.

CMV Crashes – On average, there are approximately three (3) CMV crashes a year that result in the average release of 437.50 gallons and 27,017 pounds of Class 1 HM into the environment. Most Class 1 releases occurred in undeveloped (57 percent) and commercial (29 percent) areas.

CMV Non-crash Incidents – On average, there is approximately one (1) non-crash related incident a year that results in the release of 8.21 gallons and 403.05 pounds of Class 1 HM into the environment. The release usually occur in-transit.

Class 2 - Compressed Gases

General – Releases of Class 2 materials can lead to injuries and fatalities, as well as carrier damage and incident delay costs. Depending on the actual material, there could be catastrophic impacts and extensive cleanup costs. Flammable gases are extremely flammable and can easily ignite by heat, sparks, or flames. They can also form explosive mixtures with air and have environmental impacts similar to Class 1 explosives. Containers may explode when heated and ruptured cylinders may rocket. Vapors may travel to a source of ignition and flash back; some vapors also are heavier than air and may spread along the ground. Some corrosive gases may react violently with water. Oxidizing gasses do not burn, but still support combustion, and may react explosively with fuels. In incidents with compressed gases, vapors may also travel to a source of ignition and flash back. Runoff from fire control could subsequently cause pollution.

Potential health effects of compressed gases include asphyxiation, dizziness, and irritation when inhaled. Contact with liquefied gas may cause burns. Some flammable gases may also be fatal if inhaled or also through absorption of the skin. Potential spills or leaks would need to be isolated. Large spills require evacuations downwind up to a ½ mile, while fires may require evacuations up to a mile radius from the incident.

In total, there are 74,885.33 gallons, 1,362.24 pounds and 53,924.82 cubic feet of Class 2 HM released into the environment on an average annual basis from both CMV crashes and CMV incidents combined.

CMV Crashes – On average, there are approximately 30 CMV crashes a year that result in the release of 57,852.30 gallons and 58.71 cubic feet of Class 2 HM into the environment. Most Class 2 releases occurred in commercial (42 percent) and undeveloped (27 percent) areas.

CMV Non-crash Incidents – On average, there are approximately 135 non-crash related incidents a year that result in the release of 17,033.03 gallons 1,362.24 pounds and 53,866.11 cubic feet of Class 2 HM into the environment. Releases are most likely to occur during unloading.

Class 3 - Flammable Liquids

General - Flammable liquids are extremely flammable and can easily ignite by heat, sparks, or flames. Their vapors can also form explosive mixtures with air. Containers containing flammable liquids can explode when heated and ruptured cylinders can rocket. Vapors may travel to a source of ignition and flash back; some vapors also are heavier than air and may spread along the ground. Many liquids in this category are lighter than water. Vapors may also travel to a source of ignition and flash back. Runoff from fire control could subsequently cause pollution.

Public health and safety concerns include irritation or burns of the skin and eyes via inhalation or contact with the material. Dizziness and suffocation from vapors are more serious effects. Spills should be isolated and larger spills may necessitate downwind evacuations up to 1000 feet. Fires may produce irritating, corrosive, or toxic gases, and runoff from fire control also may cause pollution. Fires also necessitate isolation and evacuation measures up to a ½ mile radius from the incident.

In total, there are 489,748.86 gallons and 0.17 pounds of Class 3 HM released into the environment on an average annual basis from both CMV crashes and CMV non-crash related incidents combined.

CMV Crashes – On average, there are approximately three 137 CMV crashes a year that result in the average release of 391,117.69 gallons of Class 3 HM into the environment. Most class 3 releases occurred in undeveloped (42 percent) and commercial (30 percent) areas.

CMV Non-crash Incidents – On average, there is approximately 1,510 of non-crash related incidents a year that result in the release of 98,631.17 gallons and 0.17 pounds of Class 3 HM into the environment. The release is most likely to occur during unloading.

Class 4 - Flammables

General - Flammables are considered hazardous because they are easily ignited and many burn rapidly if ignited. Flammables may be ignited by friction, heat, sparks, or flames. Flammable powders, dusts, shavings, borings, turnings, or cuttings can explode or burn with explosive violence. Vapors from toxic or corrosive substances may form explosive mixtures with air when heated. Toxic and corrosive flammable solids may also produce flammable hydrogen gas when in contact with metals. Some spontaneously combustibles react explosively on contact with water. Containers carrying these substances can explode if heated. Additionally, these substances have the capability to re-ignite after a fire is extinguished. In the case of spontaneously combustible materials, runoff may also create a fire or explosion hazard.

Impacts to human health can occur if fires produce irritating or toxic gases. Additionally, contact with these materials or associated molten substances may cause burns to the skin and eyes. Ingestion or inhalation of a spontaneously combustible substance or its decomposition products is toxic and can cause severe injuries and death. Fires can produce toxic gases, and water-reactive substances may generate heat reacting with water, which can also increase the concentration of fumes in the air.

Spills should be isolated immediately at a radius of at least 75 feet. Large spills may also required downwind evacuations up to 330 feet. Fires associated with these materials may necessitate isolation and evacuation up to a ½ mile in all directions. Fire control may also subsequently cause runoff pollution.

In total, there are 1,899.36 gallons and 10,603.86 pounds of Class 4 hazardous materials released into the environment on an average annual basis from both CMV crashes and CMV non-crash related incidents combined.

CMV Crashes – On average, there are approximately three (3) CMV crashes a year that result in the average release of 1,829.21 gallons and 8,971.75 pounds of Class 4 HM into the environment. Most class 4 releases occurred in commercial (71 percent) and undeveloped (29 percent) areas.

CMV Non-crash Incidents – On average, there are approximately 21 non-crash related incidents a year that result in the release of 70.15 gallons and 1,632.11 pounds of Class 4 HM into the environment. The release is most likely to occur during unloading.

Class 5 - Oxidizing Materials

General - Oxidizing materials accelerate burning if they are involved in a fire. They can explode from friction, heat, or contamination. Some oxidizers can react explosively with fuels, water, or ignite other combustibles. Some water-reactive oxidizers can produce flammable hydrogen gas upon contact with metals. Containers holding organic peroxides can explode if heated. Some organic peroxides can be particularly sensitive to temperature rises, and can decompose violently and catch fire if a give control temperature for a substance is exceeded. Runoff from incidents with oxidizing materials can also pose a fire or explosion hazard.

Oxidizing materials are toxic if ingested or if associated dusts are inhaled. Contact with oxidizing substances can cause severe burns to the skin or eyes. Toxic/flammable fumes may accumulate in confined areas. Fires involving these materials can produce irritating, corrosive, and toxic gases. Ingestion or inhalation of oxidizing materials or their decomposition products is toxic and can cause severe injuries and death.

Spills of these materials may require isolation and evacuations from 75 to 800 feet. Fires involving these materials should be isolated up to a half mile radius surrounding the incident. Fire control may also subsequently cause runoff pollution.

In total, there are 7,133.62 gallons and 61,208.49 pounds of Class 5 HM released into the environment on an average annual basis from both CMV crashes and CMV non-crash related incidents combined.

CMV Crashes – On average, there are approximately 10 CMV crashes a year that result in the average release of 4,860.27 gallons and 47,270.63 pounds of Class 51 HM into the environment. Most Class 5 releases occurred in undeveloped (58 percent) and commercial (17 percent) areas.

CMV Non-crash Incidents – On average, there are approximately 127 non-crash related incidents a year that result in the release of 2,273.35 gallons and 13,937.86 pounds of Class 5 HM into the environment. The release is most likely to occur during unloading.
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Class 6 - Toxic Materials

General - Toxic substances may or may not be combustible. In the case of non-combustible toxic substances, the substance itself does not burn but may decompose upon heating to produce corrosive and toxic fumes. Combustible toxic materials may burn but do not ignite readily. Containers carrying toxic materials can explode if heated. Infectious materials do not ignite readily but are sometimes transported in flammable liquids. Runoff from an incident could also pollute waterways.

Toxic materials are by nature highly toxic, and can be fatal if inhaled, swallowed, or absorbed through the skin. Contact with molten substances may cause severe burns. Health effects from these substances may be delayed. Contact with or inhalation of infectious substances may cause infection, disease, or death. Fires involving these substances may also produce corrosive and toxic gases. Runoff from fire control methods could also cause pollution. Spills should be isolated up to 150 feet. Fires should be isolated up to a ½ mile in all directions.

In total, there are 4,830.59 gallons and 17,164.44 pounds of Class 6 HM released into the environment on an average annual basis from both CMV crashes and CMV non-crash related incidents combined.

CMV Crashes – On average, there are approximately four CMV crashes a year that result in the average release of 1,443.88 gallons and 15,351.67 pounds of Class 6 HM into the environment. Most Class 6 releases occurred in undeveloped (36 percent) and commercial (36 percent) areas.

CMV Non-crash Incidents – On average, there is approximately 193 non-crash related incidents a year that result in the release of 3,386.71 gallons and 1,812.77 pounds of Class 6 HM into the environment. The release is most likely to during unloading.

Class 7 - Radioactive Materials

General - Radioactive materials do not typically ignite readily but may burn. Additionally, radioactivity does not change the flammability or other properties of materials.

Radioactive material presents minimal risk to transport workers, emergency response personnel, and the public during transportation accidents. Packaging durability increases as the potential hazard of radioactive content increases. Radioactive materials that are packaged as Type A contain non-life endangering amounts. Type B and C packages contain the most hazardous amounts of radioactive material. Life threatening conditions may exist only if the contents are released or the package shielding fails. Because of the design, evaluation, and testing of the packages, these conditions would only be expected for accidents of utmost severity. For spills and fires involving these materials, isolation and evacuations may be necessary from 330-1000 feet.

In total, there are 18.88 gallons and 200.09 curies of Class 7 HM released into the environment on an average annual basis.

CMV Crashes – On average, there are approximately two CMV crashes a year that result in the average release of 18.88 gallons and 200.09 curies of Class 7 HM into the environment. Most class 1 releases occurred in undeveloped (50 percent) and commercial (20 percent) areas.

CMV Non-crash Incidents – On average, no Class 7 releases occurred from CMV non-crash related incidents.

Class 8 - Corrosive Materials

General - Corrosive materials may or may not be combustible; some do not ignite readily while others are highly flammable. When heated, corrosive materials can release vapors with the potential to explode upon contact with air. Corrosive materials may produce flammable hydrogen gas upon contact with metals. Some substances react violently with water, releasing flammable, toxic, or corrosive gases and runoff. Runoff from incidents with corrosive materials may pollute waterways.

Corrosive materials are highly toxic. Inhalation, ingestion, or skin contact with corrosive materials may cause severe burns, injuries, or death. Effects of these materials may also be delayed. Reaction with water or moist air can release toxic, corrosive, or flammable gases, and can generate heat, which will increase the concentration of fumes in the air. Most vapors are heavier than air and will collect in low or confined areas. Fires involving these substances may also produce corrosive and toxic gases. Runoff from fire control methods could also cause pollution. Spills should be isolated up to 75-150 feet. Fires should be isolated up to a ½ mile in all directions.

In total, there are 86,605.11 gallons and 8,432.44 pounds of Class 8 HM released into the environment on an average annual basis from both CMV crashes and CMV non-crash related incidents combined.

CMV Crashes – On average, there are approximately 33 CMV crashes a year that result in the average release of 20,794.37 gallons and 2,791.33 pounds of Class 8 HM into the environment. Most Class 8 releases occurred in undeveloped (43 percent) and commercial (41 percent) areas.

CMV Non-crash Incidents – On average, there are approximately 1,126 non-crash related incidents a year that result in the release of 65,810.74 gallons and 5,641.11 pounds of Class 8 HM into the environment. The release is most likely to occur during unloading.

Class 9 - Miscellaneous Dangerous Goods

General - Mixed goods could contain any or many types of HM. As such, the potential hazards and health impacts could be similar to any of the categories listed above. Mixed goods could explode from heat, sparks, shock, friction, or contamination. Mixed goods could react explosively with air, water, or foam. Vapors may travel to the source of ignition and flash back. Containers may explode if heated and ruptured cylinders may rocket.

Health risks include severe injury, infection, disease, or death from inhalation, ingestion, or contact with substances. Contact with mixed materials may cause burns to the skin and eyes. High concentrations of gas may cause asphyxiation without warning. Fire or contact with water may produce irritation, toxic, and corrosive gases. Fire control methods may subsequently produce polluted runoff.

In total, there are 23,418.41 gallons and 84,838.44 pounds of Class 9 HM released into the environment on an average annual basis from both CMV crashes and CMV non-crash related incidents combined.

CMV Crashes – On average, there are approximately 12 CMV crashes a year that result in the average release of 14,291.07 gallons and 57,628.73 pounds of Class 9 HM into the environment. Most Class 9 releases occurred in commercial (41 percent) and undeveloped (35 percent) areas.

CMV Non-crash Incidents – On average, there are approximately 89 non-crash related incidents a year that result in the release of 9,127.34 gallons and 27,209.71 pounds of Class 9 HM into the environment. The release is most likely to occur during unloading.

Potential Environmental Impacts of Fuel Tank Spills

General – Petroleum is a mix of many chemicals, many of which (especially in gasoline) evaporate quickly, which is why it is flammable and why it evaporates quickly from warm pavement. If a petroleum spill is not recovered, it can pose health threats in drinking water wells if it percolates into the ground water. Petroleum can kill aquatic life and wildlife if it reaches surface water directly or through a storm sewer.

CMV Crashes – On average, each year approximately 1,188,584 gallons of diesel fuel (petroleum) are released into the environment as a result of CMV crashes. The majority of the fuel is released from large trucks (> 10,000 pounds) (see Table 4-4).

TABLE 4-4. SUMMARY: FUEL TANK SPILLS DUE TO CMV CRASHES

CMVs (Trucks) Involving Fuel Tank Spills from Fuel Tanks (Information from the Acton Spill Center was extrapolated and applied to MCMIS data for all truck crashes)	# of Crashes Per Year with Fuel Tank Spills (12% of Truck Crashes’)	Avg. Release per Crash	Est. Total amount of fuel released annually
Large Trucks *(> 10,000 pounds)*	**16,367**	**72 gal**	**1,178,424 gal**
Non-Large Trucks *(< 10,000 pounds)*	**254**	**40 gal**	**10,160 gal**
Total Large and Non-Large Trucks	**16,621**		**1,188,584 gal**

4.6 CONCLUSION

The estimates outlined in Tables 4-1 to 4-3 can be used to quantify the environmental benefits from FMCSA regulatory changes reducing crashes and/or non-crash related incidents. Estimates for crashes can be used in concert with Zaloshnja’s and Miller’s report for FMCSA on the Revised Cost of Large Truck – and Bus Involved Crashes. Non-crash incidents will be used independently, since Zaloshnja’s and Miller’s report only considers CMV crashes. In addition, FMCSA Order 5610.1, Appendix 18, 3. Hazardous Materials, requires FMCSA to document how a proposed action will impact the use, transportation, and storage of HM or the number or severity of HM crashes or non-crash related incidents. The above methods and estimates address all of these regulatory requirements.

Order 5610.1 further states that the NEPA analysis must identify any moderate to significant adverse impacts to public safety and health, transportation, property damage, water resources, and biological resources from releases of hazardous materials associated with safety-related crashes and incidents. The above methods and estimates can be used to assess the potential adverse or beneficial impacts. Most of the anticipated impacts will be beneficial. In cases where there are adverse impacts, Tables 4-1 to 4-3 can be used to calculate the increases in HM releases. Quantification of the HM releases avoided can also be tracked and used by FMCSA as an optional “mitigation banking” measure.

The HM environmental impact summary narrative contained in Section 4.5 describes (in general) the types of impacts that can occur to various natural resources and public health as required in FMCSA Order 5610.1. Section 4.5 also summarizes the quantities of HM released into the environment by HM Class and in aggregate. The data is comprehensive for the years 2003, 2004 and 2005. This narrative can be used in NEPA analyses to supplement the HM quantities derived from Tables 4-1 to 4-3.

5. SOLID WASTES

5.1 INTRODUCTION

CMV crashes can generate solid wastes. The Resource Conservation and Recovery Act (RCRA) and related regulations establish the waste management requirements that apply to CMV crash generated waste. The chassis and engines, as well as associated fluids and components of trucks, buses, and automobiles and the contents of the vehicle can all be deemed waste. The waste can also include damage to the roadway infrastructure including road surface, barriers, bridges, and signage. The purpose of this report section is to quantify solid waste generated from CMV crashes.

Waste material has one of three fates. First, the material can be returned to the originally intended use: vehicles can be repaired, cargo can be still be utilized. Second, damaged vehicles parts or cargo may be recycled, depending on market demand and availability of recycling technology and facilities. Third, material that cannot be repaired or recycled must be abandoned. The term abandoned refers to material that is either disposed in a landfill or burned in an incinerator (US EPA).

According to RCRA regulations the definition of a solid waste encompasses the following materials: (1) materials that are abandoned; (2) materials that are recycled, (3) materials that are inherently waste-like, and (4) waste military munitions (40 CFR 261.2). Recycled materials still fall under regulatory classification of solid waste depending on the type of material and recycling method. For example, for CMV crashes, scrap metal from automobiles is regulated as a solid waste (40 CFR 261.1(c)(6)). All materials that are permanently disposed of due to CMV crashes are technically solid waste (including liquids). These materials can include components of vehicles that are discarded during repair.

FMCSA's actions and proposed regulations to reduce the number and severity of CMV crashes may impact the quantity and number of occurrences of collisions producing solid waste generated in the U.S. Less solid waste translates into cost savings from reductions in the following areas: (1) transport of waste material, (2) energy required for recycling efforts, and (3) landfill or incinerator fees.

The goal of this report is to provide data on both solid waste mass and volume generated from CMV collisions. Unfortunately, accurate data on waste from CMV crashes is extremely limited. Due to limitations of available information, the report is only able to make estimations of vehicle based solid waste with a known percentage of the car/truck/bus impacted. No aggregated national level or average CMV crash solid waste mass or volume is provided.

5.2 BACKGROUND

CMV crashes involve at least one CMV and may also involve

- Other CMVs,
- Non-CMV vehicles (e.g., one or more automobiles)
- Roadway infrastructure (e.g., bridge abutments)
- Roadside objects and structures (e.g., trees, boulders, telephone poles, or buildings),
- Animals (wildlife, livestock, or pets), and
- People.

A crash can also involve only a single CMV without damage to any other vehicle, structure, or individual (e.g., if an axle breaks). Any CMV involved in a crash may be carrying cargo or traveling empty. Some non-CMV vehicles involved in CMV crashes may be carrying cargo, as well.

CMV crashes can generate solid waste in several ways. Debris dislodged from vehicles as the result of crashes is solid waste. Likewise, any cargo that is not removed from the crash site can be solid waste. Even when removed from the crash site, some portion of a damaged CMV and/or cargo may end up as solid waste. Damaged roadway infrastructure and roadside objects and structures, as well as other vehicles damaged in a CMV crash, are also solid waste. There are items carried by individuals struck by CMVs, such as groceries, strollers, bicycles, walkers which may end up as solid wastes. Pets, livestock, and wildlife killed in crashes are also considered solid waste.

At the ends of their useful life, most CMVs and many of the products that move by truck are "junked," meaning that they are removed from operation. Some portion of CMVs and their cargoes eventually enter the solid waste stream (or end up as roadside and similar trash). As a consequence, FMCSA's regulations impacting CMV crashes affect the timing of when solid waste is generated and not the ultimate generation of solid waste. FMCSA's rules do not prevent trucks and cargoes from becoming solid waste. The rules affect the circumstances and the rate at which trucks and cargoes (as well as any other materials damaged in a CMV crash) may become solid waste. The functional use and lifespan of CMVs and their constituent materials is extended by a reduction in CMV collisions.

5.3 SOLID WASTE IMPACT METHODOLOGY AND RESULTS

Currently in the U.S., between 10 and 11 million vehicles of all types reach the end of their useful lives each year. An estimated 94 percent of those vehicles are reprocessed by the Nation's vehicle recycling industry (Environmental Defense). Most of the remaining 6% is either stored or abandoned (Staudinger and Keoleian; Gesing).

The Nation's vehicle recycling industry consists of the following:

- Vehicle dismantlers (also known as salvage yards or salvagers), where useful parts are stripped from the vehicles,

- Vehicle shredders, where vehicles obtained from dismantlers are shredded into fist-sized pieces and receive their initial sorting with steel being the primary material recovered at this stage of the process,
- Sink-float plants, where more comprehensive metal separation is performed, and finally
- Metal sorters, where final metal sorting can be performed (Staudinger and Keoleian; Gesing; “Auto Recycling Demonstration Project”).

In total in North America, there are less than 6 thousand salvage yards, approximately 200 vehicle shredders, approximately 10 sink-float plants, and 1 metal sorter (Gesing).

Generally, the useful materials from vehicle recycling are usable parts and bulk metals. Vehicle tires and batteries have their own recycling networks and are generally removed from scrapped vehicles. All other materials accumulated during the vehicle recycling process are considered “auto shredder residue” (ASR or “fluff”), which is separated from the useful materials and sent to landfills for disposal.

The focus of this chapter is on the CMV crash generated solid wastes that are abandoned otherwise referred to as the ASR. The generation of ASR diminishes available landfill capacity. Furthermore, unlike recycling, the disposal of ASR in landfills results in potentially useful materials being thrown away. The ASR generated by CMV crashes is derived primarily from the automobiles, CMV power units, CMV trailers, and CMV cargoes involved in those crashes. In the remainder of this chapter, the ASR generated by CMV crashes from automobiles, CMV power units, CMV trailers, and CMV cargoes are considered.

5.3.1 Automobiles

Automobiles are frequently involved in CMV crashes. Damage to automobiles in CMV crashes can run the gambit from minor dents to complete destruction. It is not possible, a priori, to predict the amount of damage that each automobile involved in a CMV crash will receive. Assuming that (1) a typical automobile contains 1,050 kg of metals and 350 kg of ASR (Environmental Defense--Auto Shredder Residue), (2) any metal scrap resulting from a CMV crash will be recycled and any other scrap will be ASR that is sent to a landfill, and (3) as mentioned above, 94% of all automobiles at the end of their lives are recycled, it is possible to develop estimates for the amount of ASR going to landfills as a result of an automobile being involved in a CMV crash. These estimates are presented in Table 5-1.

TABLE 5-1. QUANTITY OF ASR SENT TO LANDFILL FOR EACH AUTOMOBILE INVOLVED IN A CMV CRASH

Percent of vehicle needing to be replaced	Kilograms of ASR sent to landfill
10	33
20	66
30	99
40	132
50	165
60	197
70	230
80	263
90	296
100	329

To simplify the estimation, the calculations performed for Table 5-1 assume that metal and other material are uniformly distributed throughout a vehicle. Furthermore, the estimates in Table 5-1 assume that only metal parts are salvaged from automobiles prior to shredding. A weighted average for damaged parts could potentially be determined from insurance damage payments, provided that insurance companies were willing to supply the data.

Table 5-2 presents estimates of the U.S. percentage of automobiles that were “totaled” for all crashes (CMV and non-CMV) during the years 2003 through 2005. Definitive data is available quantifying just CMV totaled vehicles. “Totaled,” means that the cost of repairing a vehicle is greater than the market value of that vehicle. It roughly corresponds to the 100 percent row in Table 5-1 (“totaled” vehicles may still be drivable, and some may continue to be used, with or without repairs).

TABLE 5-2. PERCENTAGE OF ALL U.S. AUTOMOBILES “TOTALED,” 2003-2005

Year	Percentage of Automobiles “Totaled”
2003	12.1
2004	13.4
2005	13.0

Note: The estimates in this table include only appraisals and do not include “…vehicles that were obvious totals where no appraisal was generated….”
Source: Susanna Gotsch, “Crash Course,” CCCUpFront, Vol. III, Issue 2, http://www.cccis.com/static/upfront/issue08/feature_01.htm.

There are no public accident databases that include damage severity. An analyst might use the information in Table 5-2 to develop a rough estimate for the percentage of automobiles needing to be 100 percent replaced; however, information that could be used for other levels of replacement is not readily available. The well-known Principle (or Criterion) of Insufficient Reason could be used by analysts to develop a full set of estimates. The Principle of Insufficient Reason states that, if there is no reason to believe that one alternative is more likely than any other, then all can be assumed to have the same probability. For this to be true, the set of alternatives under consideration must be mutually exclusive and exhaustive. According to the Principle of Insufficient Reason, the ten categories presented in Table 5-1 could each be assumed to have a likelihood of 10%. Using this estimate, a weighted average for the percentage of automobiles needing to be replaced could be developed.

5.3.2 CMV Power Units

The CMV power units that might be involved in a CMV crash include truck tractors, straight trucks, medium/heavy trucks, and buses. Damage to any of power units in a CMV crash is likely to result in the creation of solid wastes. Conversely, if such damage can be prevented through regulations or other actions, material will be delay from entering the Nation’s solid waste stream.

Truck Tractors

Truck tractors are frequently involved in CMV crashes. Damage impact to truck tractors in those crashes can range from minor dents to complete destruction. It is not possible to predict the amount of damage that each truck tractor involved in a CMV crash will receive.

The average or typical amount of scrap metal and ASR that could be obtained from a typical truck tractor as a result of a CMV crash is unknown. Some crashes may destroy potentially reusable or recyclable components due to fire or compression. As a consequence, a hypothetical truck tractor is used for this analysis. This hypothetical truck tractor is based on information available from Volvo on certain of its FM12 and FH12 truck tractor models. Table 5-3 contains information on the materials in the hypothetical truck tractor.

TABLE 5-3. LIST OF MATERIALS FOR A HYPOTHETICAL CMV TRUCK TRACTOR

Material	Weight (Kg)	Potential End-of-Life Destination
Iron		
-Wrought, tempered	1,196	Recycled
-Cast	1,478	Recycled
Steel		
-Rod	198	Recycled
-Hot-rolled	1,645	Recycled
-Cold-rolled	925	Recycled
Other metals		
-Aluminum	201	Recycled
-Lead (battery)	95	Recycled
-Copper	14	Recycled
-Brass, bronze	9	Recycled
-Stainless steel	15	Recycled
Plastics		
-Thermoplastics	339	Solid waste stream
-Reinforced thermoplastics	74	Solid waste stream
-Thermosetting plastics	6	Solid waste stream
Other materials		
Rubber	459	Recycled
Glass	60	Solid waste stream
Textile, other fibers	57	Solid waste stream
Paint	13	Solid waste stream
Brake pads	22	Solid waste stream
Oil, grease	62	Solid waste stream
Electronics	56	Solid waste stream
Sulfuric acid (battery)	36	Recycled
Bitumen	6	Solid waste stream
Wood	11	Solid waste stream
Cooling agent (R134a)	1	Solid waste stream
Glycol	17	Solid waste stream
Ethanol	4	Solid waste stream
TOTAL	7,000	

Source for columns 1 and 2: Volvo, "Environmental Product Declaration, Volvo FH12 and Volvo FM12, Euro 3," p.5; source for column 3: various.

In total, the hypothetical truck tractor weighs 15,432.2 pounds (7,000 kilograms). Of this, metals, tires, and the battery accounts for 13,827.3 pounds (6,272 kilograms). If the truck tractor were to be totaled in a CMV crash, this material would likely be recycled. The remaining 1604.9 pounds (728 kilograms) would be ASR.

Assuming that (1) a truck tractor contains 13,827.3 pounds (6,272 kilograms) of recyclable material and 1604.9 pounds (728 kilograms) of non-recyclable material, (2) any metal scrap resulting from a CMV crash will be recycled and any other scrap will be ASR that is sent to a landfill, and (3) 94 percent of all vehicles at the end of their lives are recycled, it is possible to develop estimates for the amount of ASR going to landfills as a result of a truck tractor being involved in a CMV crash. These estimates are presented in Table 5-4.

TABLE 5-4. QUANTITY OF ASR SENT TO LANDFILL FOR EACH TRUCK TRACTOR INVOLVED IN A CMV CRASH

Percent of vehicle needing to be replaced	Kilograms of ASR sent to landfill
10	68
20	137
30	205
40	274
50	342
60	411
70	479
80	547
90	616
100	684

To simplify the estimation, the calculations performed for Table 5-4 assume that metal and other material are uniformly distributed throughout a vehicle. The estimates in Table 5-4 assume that only metal parts are salvaged from truck tractors prior to shredding.

Straight Trucks

Information on straight trucks that could be used to estimate the amount ASR that would be sent to a landfill as a result of a CMV crash is not readily available. No estimate of the ASR can be made at this time.

Medium/Heavy Trucks

Information on medium/heavy trucks that could be used to estimate the amount ASR that would be sent to a landfill as a result of a CMV crash is not readily available. No estimate of the ASR can be made at this time.

5.3.3 Buses

There are a variety of CMV buses that might be involved in a CMV crash, including intercity buses, suburban commuter buses, transit buses, school buses, tour buses, and entertainer buses.

Intercity Buses

Intercity buses, which tend to be 40-45 feet in length, carry 46-55 passengers, and have restrooms and underfloor baggage compartments, are sometimes involved in CMV crashes. The damage to these buses resulting from those crashes can run the gambit from minor dents to complete destruction. It is not possible to predict the amount of damage that each bus involved in a crash will receive.

The amount of scrap metal and ASR that could be generated by a typical or average intercity bus involved in a CMV crash is unknown. As a consequence, a hypothetical intercity bus is used for this analysis. This hypothetical bus is based on information available from Volvo on one of its bus models. Table 5-5 contains information the materials in the hypothetical bus.

TABLE 5-5. LIST OF MATERIALS FOR A HYPOTHETICAL INTERCITY BUS

Material	Weight (Kg)	Potential End-of-Life Destination
Iron		
-Wrought	502	Recycled
-Cast	1,029	Recycled
Steel		
-Rod	2,408	Recycled
-Hot-rolled	1,590	Recycled
-Cold-rolled	568	Recycled
Other metals		
-Aluminum	1,666	Recycled
-Lead (battery)	90	Recycled
-Copper	109	Recycled
-Brass, bronze	3	Recycled
-Stainless steel	690	Recycled
Plastics		
-Thermoplastics	295	Solid waste stream
-Reinforced thermoplastics	132	Solid waste stream
-Thermosetting plastics	126	Solid waste stream
Other materials		
Rubber	405	Recycled
Glass	490	Solid waste stream
Textile, other fibers	23	Solid waste stream

Material	Weight (Kg)	Potential End-of-Life Destination
Paint	30	Solid waste stream
Oil, grease	78	Solid waste stream
Electronics	56	Solid waste stream
Sulfuric acid (battery)	34	Recycled
Bitumen	54	Solid waste stream
Wood	396	Solid waste stream
Glycol	26	Solid waste stream
Other	182	Solid waste stream
TOTAL	10,900	

Source for columns 1 and 2: Volvo, "Environmental Product Declaration, Volvo 8500 Low Entry," p.5; source for column 3: various.

In total, the hypothetical bus weighs 24,030.1 pounds (10,900 kilograms). The bus identified for the calculations can also be referred to as a "10+ metric ton bus." Of the total mass, metals, tires, and the battery account for 20,048.6 pounds (9,094 kilograms). If the bus were to be totaled in a CMV crash, this material would likely be recycled. The remaining 4,157.9 pounds (1,886 kilograms) would be ASR.

The report makes the following assumptions: (1) a CMV bus contains kilograms of recyclable material and kilograms of non-recyclable material, (2) any metal scrap resulting from a CMV crash will be recycled and any other scrap will be ASR that is sent to a landfill, and (3) 94 percent of all vehicles at the end of their lives are recycled. The amount of ASR going to landfills as a result of a CMV bus involved in a crash can be calculated using these assumptions. These estimates are presented in Table 5-6.

TABLE 5-6. QUANTITY OF ASR SENT TO LANDFILL FOR EACH INTERCITY BUS INVOLVED IN A CMV CRASH

Percent of vehicle needing to be replaced	Kilograms of ASR sent to landfill
10	177
20	355
30	532
40	709
50	886
60	1,064
70	1,241
80	1,418
90	1,596
100	1,773

To simplify the estimation, the calculations performed for Table 5-6 assume that metal and other material are uniformly distributed throughout a vehicle. The estimates in Table 5-6 assume that only metal parts are salvaged from intercity buses prior to shredding.

It should be noted that suburban commuter, long-distance airport, and top-end tour and entertainer buses are all generally similar to intercity buses.

Other Buses

Solid waster information on other types of bus including transit and school buses, as well as on mid-size buses (20-35 feet in length, 16-35 passengers, some with restrooms) is not readily available. The ASR estimate is limited to the intercity 10+ metric ton bus.

5.4 CMV TRAILERS

When a CMV crash occurs, sometimes at least one of the CMVs involved is a tractor-trailer in combination. If the trailer is damaged, some part of it may end up in a landfill. It should be noted that a CMV crash will not necessarily involve a CMV trailer. CMV crashes may involve bobtails, tractors without trailers, or buses.

The trailers variations include

- Box semi-trailers,
- Liquid tank trailers,
- Gas tank trailers,
- Dry bulk trailers,
- Flatbed trailers,
- Automobile trailers,
- Special trailers, and
- Intermodal chassis.

Information on trailer material composition is not readily available. Consequently, estimates of the amount of material from a trailer that might be sent to a landfill after a CMV crash cannot be estimated. Analysts interesting in pursuing this further might want to start their effort by contacting the Truck Trailer Manufacturers' Association (TTMA).[5]

5.5 CMV CARGOES

Cargo is another key source of potential solid waste from CMV crashes. Cargo damaged in a CMV incident may be sent to a landfill or be burned in an incinerator. It should be noted that a CMV crash will not necessarily involve a CMV carrying a cargo. The CMV crash may involve a tractor without a trailer, a bus, or a CMV making an empty backhaul.

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[5] The website for TTMA can be found at http://www.ttmanet.org/.

Thousands of different types of cargoes are carried by CMVs. Those cargoes are so varied and diverse that it is not possible to empirically determine the fate of the goods after a crash impact. Consider the following possible CMV crash examples: a CMV crash involving a full garbage truck, a truck hauling a full load of watermelons, and a truck hauling a full load of anvils. The cargo of the garbage truck, already destined for a landfill, will not be impacted by the crash. Some or all of the watermelons will likely be too damaged to consume and will be diverted from their original destination to a landfill. The anvils, on the other hand, are likely to survive the crash unscathed. If some do not, the metal that they contain can be recycled. For another example, consider a tanker load of gasoline involved in a CMV crash with an automobile. If no gasoline leaks from the tanker, the gasoline can be transferred to another vehicle and sent on to a gasoline station. Additionally, a portion of any gasoline that does leak from the tanker may be retrieved during site cleanup, reprocessed, and sold.

5.6 CONCLUSIONS

The usefulness of the information on the solid wastes resulting from CMV crashes is severely limited. Estimates can be derived for additions to the solid waste stream due to automobiles involved in CMV crashes. Rough estimates can be derived for solid waste stream additions due to truck tractors and intercity buses involved in CMV crashes. Estimates are not readily available for any other additions to the solid waste stream.

At least in theory, the manufacturers of straight trucks, medium/heavy trucks, transit buses, and various types of truck trailers should be able to provide information on the composition of their conveyances. This information could be used to develop estimates of the additions to the solid waste stream that would result when the conveyances are involved in a CMV crash. Rough estimates could be developed using cargo composition straight averages conveyance composition if it was available. More truly representative estimates could be developed with information on the nature and composition of the national fleet. Better estimates of the additions to the solid waste stream could be developed if additional truck and bus manufacturers provided vehicle composition information.

It is likely that cargoes damaged in CMV crashes contribute more to the solid waste stream than anything else. Unfortunately, information on the damages sustained by cargoes in crashes is not readily available, and it may not exist. The insurance industry is generally paying for cargoes lost due to CMV crashes and should have information on those losses. Unfortunately, the information must be derived from insurers' general category of losses, which includes theft. Cargo theft is reportedly a significantly bigger problem for insurers than cargo damage/loss due to vehicular accidents. Potentially, data on cargo losses due to accidents could be purchased from the insurance industry. Alternatively, the insurance industry might be able to provide a percentage breakdown between theft and accident losses. With that information and the total cost of both theft and accidents, a rough estimate of the dollar value of losses due to accidents could be developed. This introduces another problem: there is not necessarily a predictable correlation between the value of a cargo and its pollution potential. Furthermore, there is not necessarily a one-to-one correspondence between the value of a cargo and its volume. Small cargoes may have a large cash value and other larger cargoes may have nominal market value. Conversely, both loads would contribute differing amounts of solid waste. Consequently, the insured value of cargoes would not necessarily be representative of their impact on the solid waste stream or on the Nation's landfills.

5.7 RECOMMENDATIONS FOR FURTHER STUDY

There are many missing data elements that would be needed in order to reliably estimate solid waste generated from CMV crashes. The missing data includes the following:

- Vehicles Involved - Number and type of vehicle involved in each type of CMV collision.
- Totaled Vehicles – Number of vehicles that have to be completed scrapped or significantly repaired to resume function
- Type of Truck – The type of truck influences the potential solid waste generated. For example concrete mixer will have different
- Cargo loss – Mass and volume of cargo loss. Mass and Volume could potentially be determined by studying average freight cargos and making assumptions that crashes involve average freight.

Additional research could potentially establish values for many of these missing items. The insurance industry might prove to be an excellent source of information to address these gaps. The insurance industry, however, is likely to require payment for developing, estimating, or locating any of the missing data relating to solid wastes.

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