Appendix A – Analysis of Air Quality Impacts

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Appendix A. Analysis of Air Quality Impacts

A.1. INTRODUCTION

This section provides an analysis of the potential air quality impacts of the four alternatives, including changes in emissions of criteria air pollutants, air toxics, and greenhouse gases (GHGs). These impacts could result from changes in the number of vehicle-miles traveled (VMT) and in vehicle hours idling (VHI) and changes resulting from transportation mode shifts[1] for each alternative.

This air quality analysis is based on total national emissions (in units of metric tons per year) of mobile source emissions of criteria air pollutants, emissions of air toxics, and GHG emissions (carbon dioxide equivalent [CO_2e])[2] for each alternative. This analysis also compares potential emissions for Alternatives 2, 3, and 4 to potential emissions for the No Action Alternative (Alternative 1). Changes in VMT, VHI, and transportation mode shifts will affect overall emissions from commercial motor vehicles (CMVs). Air emissions for the No Action Alternative and the action alternatives (Alternatives 2 through 4) are estimated using emission factors (pollutant emission rates per unit of activity) and projected vehicle activity levels (i.e., VMT and VHI) for each transportation mode the rule would affect. Considering the broad distribution of truck and rail transportation routes throughout the United States, this analysis of air quality impacts is limited to estimating the total nationwide changes in criteria pollutant air emissions, air toxics emissions, and GHG emissions resulting from expected vehicle activity under each alternative.

FMCSA cannot predict the specific locations of any changes in truck and rail routes and operations that would result from the alternatives. The local air quality effects of air pollutant emissions cannot be predicted accurately on a national scale because the effects depend on local conditions. Without knowing the location, topography, time of day, ambient pollutant concentrations, and meteorological conditions (e.g., temperature, sunlight, wind conditions) under which these emissions occur, their potential impacts on air quality are speculative. Therefore, FMCSA used the total nationwide CMV emissions of each pollutant as an indicator of its relative impact.

A.2. AIR QUALITY IMPACT ANALYSIS METHODOLOGY

The methodology FMCSA used consists of estimating total criteria pollutant, air toxics, and GHG emissions for each alternative for three analysis years (2012, 2015, and 2020) related to the following three factors:

[1] The term "mode shift" refers to a change in transportation modes used to move goods, for example, by rail instead of by truck.

[2] CO_2 emissions represent approximately 96.9 percent of GHG emissions from the vehicles affected under the 2010 HOS rule, and other GHG emissions are effectively proportional to CO_2 emissions within the vehicle classes and age (model year) distributions examined here. Thus, CO_2 is a good indicator of overall GHG emissions from trucks and can be used to approximate CO_2e. In this environmental assessment, where estimation of CO_2e emissions is not possible, CO_2 is used.

- Transportation mode shift of freight from long-haul truck to intermodal rail with associated drayage[3] truck operations;
- Change in aggregate annual CMV activity (i.e., VMT and VHI); and
- Change in number of CMV crashes.

Analysis year 2012 represents the first complete calendar year following implementation of the final HOS rules. Average emission rates for trucks and locomotives are declining over time due to increasingly restrictive EPA emissions standards. As older, higher emitting vehicles are gradually retired and replaced with newer, lower-emitting ones the average emission rates of the fleet decrease on a per-vehicle basis. Analysis years 2015 and 2020 were included to indicate the effects of these trends in emissions on the alternatives over a short term and a somewhat longer term.

CMV activity for the three analysis years was calculated based on historic VMT and VHI estimated and projected using growth factors. Vehicle travel was estimated at 147.2 billion VMT in 2007, and vehicle idling was estimated at 2,415.36 million VHI in 2006. These data and the methodology for developing the VMT estimates are described in the *2011 Hours-of-Service Rules Regulatory Impact Analysis* (FMCSA 2011). The vehicle idling estimate was derived using the 2002 vehicle idling value of 2,220 million hours and scaling this value by the Bureau of Labor Statistics-reported growth of 8.8 percent of the population of production workers in the long-distance trucking industry (BLS 2008).

Vehicle activity was projected to 2012, to represent the first year of complete implementation of the final HOS rules. To generate estimates for 2012 vehicle activity for conditions under the No Action Alternative, an annual growth factor of 2.9 percent was applied to baseline data (described above) until 2010, after which the factor was reduced to 2.0 percent. These factors were derived using Federal Highway Administration (FHWA) projections (FHWA 2002b). Exhibit A-1 summarizes relevant projected operating data for CMV operations for all analysis years.

A.2.1. Transportation Mode Shift Emissions

Under Alternatives 2, 3, and 4 compared to the No Action Alternative, truck driver productivity is projected to decrease due to the requirements for longer or additional rest breaks. As a result, the trucking industry would need to hire more drivers to move the same amount of freight, which is projected to lead to an increase in truck shipping prices (freight rates). For the segment of long-haul trucking that competes with rail, the percentage increase in truck freight rates is determined as a function of increases in total driver compensation caused by in the increase in the number of drivers required. The mode shift from long-haul truck for each alternative is discussed in FMCSA (2011). The potential rate of mode shift from long-haul truck to rail, expressed as the elasticity of the truck mode share of freight with respect to shipping rates, is assumed to remain constant over time at a value of 1.4 (i.e., a 1-percent increase in truck shipping rates results in a 1.4-percent shift of freight to rail). The amount of mode shift from truck to rail is calculated from the change in total long-haul VMT for each alternative compared

[3] Drayage is the transport of shipments between rail yards or other freight terminals and final delivery locations, for either pickup or delivery purposes. This type of truck service is necessary to support intermodal operations.

to the No Action Alternative (Alternative 1). The VMT change is then multiplied by an assumed average payload of 16 tons (DOT 2008) to calculate the total ton-miles shifted to rail.

Exhibit A-1 shows total truck VMT, total change in VMT, and percentage change in VMT for each alternative based on a long-haul operation with an average length of haul of at least 100 miles. Projected values are presented for 2012, 2015, and 2020.

Exhibit A-1. Hours-of-Service Truck Vehicle-miles Traveled Mode-shift Analysis

Scenario	Alternative 1: No Action	Alternative 2	Alternative 3: Agency-Preferred Alternative	Alternative 4
2012				
Total truck VMT (millions)	167,030	166,232	166,680	165,245
VMT change compared to No Action Alternative (millions)	–	−798	−350	−1,785
Percent change in VMT	–	−0.48%	−0.21%	−1.07%
Change in rail ton-miles (millions)	–	12,767	5,600	28,554
2015				
Total truck VMT (millions)	177,330	176,483	176,959	175,436
VMT change compared to No Action Alternative (millions)	–	−847	−372	−1,895
Percent change in VMT	–	-0.48%	-0.21%	−1.07%
Change in rail ton-miles (millions)	–	13,554	5,946	30,315
2020				
Total truck VMT (millions)	195,928	194,992	195,518	193,835
VMT change compared to No Action and Alternative 1 (millions)	–	−936	−411	−2,093
Percent change in VMT	–	−0.48%	−0.21%	−1.07%
Change in rail ton-miles (millions)	–	14,975	6,569	33,495

Notes: VMT = vehicle-miles traveled

Emission factors for truck (long-haul and drayage) VMT and VHI will vary over time, as will those for rail locomotives, as emission standards and the vehicle fleet age distribution change. The emissions changes due to transportation mode shifts consist of decreased long-haul trucking emissions (accounted for in the VMT values shown in Exhibit A-1) and increases in two other types of emissions:

- Railroad locomotive emissions; and
- Drayage truck emissions.

The emissions for the mode shift to rail are calculated based on the increase in rail ton-miles of travel (assumed equal to the decrease in truck ton-miles of travel) estimated for each action alternative compared to the No Action Alternative. This value is then divided by an intermodal rail locomotive efficiency of 400 ton-miles per gallon of diesel fuel to determine total fuel consumption (EPA 2009a). Exhibit A-2 shows the rail locomotive emission factors, in grams of pollutant emitted per gallon of diesel fuel consumed, used to calculate rail emissions.

The changes in direct emissions from rail operations for each action alternative compared to the No Action Alternative as a result of mode shift are calculated by multiplying the change in gallons of diesel fuel consumption by the locomotive emission factors shown in Exhibit A-2.

Emission factors for 2012, 2015, and 2020 were developed for drayage trucks and long-haul trucks using the U.S. Environmental Protection Agency's (EPA) Motor Vehicle Emission Simulator (MOVES2010; EPA 2010a). Long-haul CMV emissions were estimated using both

Exhibit A-2. Emission Factors for Rail Locomotives

Pollutant	Grams of Pollutant per Gallon of Fuel		
	2012	**2015**	**2020**
CO[a]	26.6	26.6	26.6
NO_x	144	129	99
$PM_{2.5}$[b]	3.98	3.30	2.23
PM_{10}	4.10	3.40	2.30
SO_2[c,d]	0.094	0.094	0.094
VOC[e]	7.5	6.0	3.8
Acetaldehyde	0.188	0.188	0.188
Acrolein	0.026	0.026	0.026
Benzene	0.026	0.026	0.026
1,3-butadiene	0.032	0.032	0.032
Formaldehyde	0.433	0.433	0.433
CO_2[d]	10,084	10,084	10,084

Source: EPA (2009a) for criteria pollutants and carbon dioxide (CO_2); Pechan & Associates (2005) for air toxics.
Notes: Average U.S. factors used for air toxics emission factors. Values not projected for future years. Diesel particulate matter (DPM) emissions assumed equal to PM_{10}.
[a] Carbon monoxide (CO) factors could overestimate emissions because the U.S. Environmental Protection Agency does not project reductions in CO emission standards, despite expected CO emission reductions from particulate matter (PM) and hydrocarbon controls.
[b] $PM_{2.5}$ is assumed to be 97 percent of PM_{10}.
[c] Emission factor for sulfur dioxide (SO_2) assumes ultralow fuel sulfur content of 15 parts per million.
[d] Emission factors of SO_2 and CO_2 are assumed to largely depend on fuel properties rather than engine parameters.
[e] Volatile organic compound (VOC) emissions are assumed equal to 1.053 times hydrocarbon emissions (EPA 2009a).

the combination and single-unit long-haul truck categories. Drayage trucks are necessary to support intermodal operations and are used to transport shipments between rail yards and final delivery or pick-up locations. Drayage truck emissions were estimated using both the combination and single-unit short-haul truck categories. Exhibit A-3 presents that proportion of each vehicle category that was used to estimate emissions from long-haul and drayage trucks. Default national average vehicle fleet characteristics (e.g., age of fleet, distribution of vehicle types) from MOVES were used to develop emission factors for long-haul and drayage truck travel. Drayage truck curb idling rates were derived using vehicle fleet characteristics based on selected counties that contain large ports where large drayage fleets operate. Only combination long-haul trucks are expected to experience extended idle (hoteling).

Exhibits A-4 and A-5 show the mileage and idle emission factors for long-haul and drayage trucks in terms of grams of pollutant per vehicle-mile and grams of pollutant per vehicle idling hour. PM_{10} emission factors reflect exhaust emissions and exclude re-entrained road dust.

Exhibit A-3. Vehicle Category Contribution to Long-haul and Drayage Truck Categories

Category	2012		2015		2020	
	Long-haul	Drayage	Long-haul	Drayage	Long-haul	Drayage
Travel[a]						
Combination	93.6%	58.9%	93.4%	58.5%	93.2%	57.9%
Single-unit	6.4%	41.1%	6.6%	41.5%	6.8%	42.1%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Idle[b]						
Combination	100.0%	54.3%	100.0%	53.9%	100.0%	53.3%
Single-unit	–	45.7%	–	46.1%	–	46.7%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Source: MOVES2010 (EPA 2010a)
[a] Values calculated as a percentage of total truck vehicle-miles traveled (VMT) within each truck category.
[b] Values calculated as a percentage of total truck vehicle hours idling (VHI) within each truck category.

To calculate the number of trips for drayage trucks, FMCSA assumed that the truck trips that shift from truck to rail have an average length of haul of 1,000 miles (FMCSA 2011). The ton-miles carried by rail, as calculated above, are thus divided by 1,000 miles to determine the tons carried, divided by 16 tons to determine the number of truckload shipments, and multiplied by 2 to represent one drayage move at both the origin and destination. The average trip for a drayage truck is assumed to be 40 miles, and 1 hour of loading or unloading (truck curb idle time) is assumed at each trip end (i.e., from origin or destination to a rail yard). Total drayage emissions are calculated by multiplying total drayage mileage and idling hours by appropriate drayage emission factors in grams per mile and grams per hour of pollutant, respectively, as shown in Exhibits A-4 and A-5. Finally, the total emission increases caused by transportation mode shifts are obtained by summing emissions from rail operations and drayage truck operations.

A.2.2. Long-Haul Truck Travel Emissions

The VMT for the No Action Alternative and each action alternative (Alternatives 2 through 4) is multiplied by the long-haul emission factors expressed in grams of pollutant per vehicle-mile to calculate truck mileage-based emissions. Emission factors for VMT are shown in Exhibit A-4.

Exhibit A-4. Long-haul and Drayage Truck Travel Emission Factors

Pollutant	Emission Factor (Grams of Pollutant per Vehicle-mile)					
	2012		2015		2020	
	Long-haul	Drayage	Long-haul	Drayage	Long-haul	Drayage
CO	0.83	0.77	0.57	0.51	0.31	0.27
NO_x	3.48	3.40	2.37	2.21	1.31	1.15
$PM_{2.5}$	0.16	0.15	0.10	0.09	0.05	0.04
PM_{10}	0.16	0.15	0.10	0.09	0.05	0.04
SO_2	0.0057	0.0056	0.0055	0.0054	0.0053	0.0053
VOC	0.15	0.15	0.11	0.10	0.06	0.06
Acetaldehyde	0.0046	0.0044	0.0032	0.0030	0.0019	0.0017
Acrolein	0.0006	0.0005	0.0004	0.0004	0.0002	0.0002

Exhibit A-4. Long-haul and Drayage Truck Travel Emission Factors

Pollutant	Emission Factor (Grams of Pollutant per Vehicle-mile)					
	2012		2015		2020	
	Long-haul	Drayage	Long-haul	Drayage	Long-haul	Drayage
Benzene	0.0017	0.0016	0.0012	0.0011	0.0007	0.0006
1,3-butadiene	0.0010	0.0009	0.0007	0.0006	0.0004	0.0004
Formaldehyde	0.0124	0.0119	0.0088	0.0082	0.0051	0.0045
CO_2e	752.44	748.00	751.78	748.00	750.92	748.00

Source: MOVES2010 (EPA 2010a)
Notes: Diesel particulate matter (DPM) emissions are assumed equal to PM_{10}.

Exhibit A-5. Long-haul and Drayage Truck Idle Emission Factors

Pollutant	Emission Factor (Grams of Pollutant per Vehicle Idling Hour)					
	2012		2015		2020	
	Long-haul	Drayage	Long-haul	Drayage	Long-haul	Drayage
CO	88.68	0.88	88.73	0.59	88.77	0.31
NO_x	236.21	2.44	232.03	1.62	227.92	0.89
$PM_{2.5}$	1.71	0.12	1.20	0.08	0.71	0.03
PM_{10}	1.76	0.13	1.24	0.08	0.73	0.03
SO_2	0.061	0.004	0.061	0.004	0.061	0.003
VOC	55.09	0.007	54.51	0.005	53.94	0.003
Acetaldehyde	1.63	3.42E-05	1.61	2.43E-05	1.59	1.42E-05
Acrolein	0.20	4.16E-06	0.20	2.95E-06	0.19	1.72E-06
Benzene	0.59	1.25E-05	0.59	8.86E-06	0.58	5.17E-06
1,3-butadiene	0.34	7.24E-06	0.34	5.15E-06	0.34	3.01E-06
Formaldehyde	4.42	9.29E-05	4.37	6.60E-05	4.33	3.85E-05
CO_2e	8,977.93	165.46	8,959.96	165.47	8,943.90	165.48

Source: MOVES2010 (EPA 2010a)
Notes: Diesel particulate matter (DPM) emissions are assumed equal to PM_{10}.

A.2.3. Long-Haul Truck Idle Emissions

The annual average number of idling hours for each alternative is calculated by multiplying the number of idling hours under the No Action Alternative by the relative percentage change in idling hours for each action alternative as compared to the No Action Alternative.

The idling hours for the No Action Alternative and for Alternatives 2 through 4 and for the percentage changes compared to the No Action Alternative were estimated by constructing typical weekly schedules for drivers working at maximum capacity, estimating the ratio of idling time to driving time, and then adjusting for the percentage of operations that are not at maximum capacity. In these schedules, hours were categorized into time for loading and unloading, driving, layovers on the road, and other breaks. The Regulatory Impact Analysis (FMCSA 2011) contains further detail on these schedules. From these schedules, FMCSA computed the ratio of idling hours to driving hours under the assumption, based on data from Argonne National Laboratory, that tractors idle 70 percent of non-driving hours when they are being loaded or unloaded and during breaks and layovers during the week (ANL 2000). (Weekend layovers were excluded, assuming that the trucks would not be left idling for the days when drivers were not in them.) Using this approach, the ratio of idling hours to driving hours can increase if drivers are required to take longer layovers or more layovers during which they might leave their trucks idling.

Exhibit A-6 shows a summary of the idling hours for the four alternatives. The total idling hours given in Exhibit A-6 are multiplied by the emission factors in grams of pollutant per vehicle-hour as shown in Exhibit A-5 to calculate the total idling emissions.

Exhibit A-6. Total Potential Vehicle-hours Idling in Millions for Alternatives 1 through 4

Year	Alternative 1: No Action	Alternative 2	Alternative 3: Agency-Preferred Alternative	Alternative 4
2012	3,069	3,132	3,079	3,240
2015	3,258	3,325	3,269	3,440
2020	3,600	3,674	3,612	3,801

A.2.4. Emissions Resulting from Crashes

To assess the potential emission impacts associated with CMV crashes under each alternative, FMCSA estimated the cost of all CMV crashes, and then divided that cost by the cost per crash to obtain the expected number of crashes. The percent reduction in long-haul crashes was assumed equal to the percent reduction in damages under each alternative. See FMCSA (2011) for further details on this methodology. The total number and relative change in crashes for each alternative for all analysis years are presented in Exhibit A-7. The total number of crashes under each alternative is not projected for future years because, based on FMCSA analysis of recent crash data trends, the total number of crashes for combination trucks is expected to remain generally unchanged from year to year despite expected increases in long-haul truck VMT over time.

Alternatives 2 through 4 show an anticipated decrease in CMV crashes. Emissions are expected to change based on changes in traffic congestion resulting, in turn, from changes in crash frequency. The mid-level congestion-per-crash emission estimates provided in *Environmental Costs of Commercial Motor Vehicle (CMV) Crashes* (Volpe Center 2007) were used to estimate the changes in criteria air pollutant emissions resulting from these congestion changes. The Volpe Center (2007) methodology was used to produce similar emission factors and estimates for air toxics.[4]

Exhibit A-7. Projected Annual Long-haul Crashes

Category	Alternative 1: No Action	Alternative 2	Alternative 3: Agency-Preferred Alternative	Alternative 4
Total Number of Crashes Per Year	251,553	247,916	249,649	243,864
Change in Crashes from No Action Alternative	–	−3,637	−1,904	−7,689

[4] The Volpe Center used EPA's MOBILE6 model (EPA 2004) to produce emission factors for criteria air pollutants in units of grams per crash resulting from increased congestion due to CMV crashes (DOT Volpe Center 2007). FMCSA applied this methodology using MOBILE6 to produce similar emission factors for air toxics.

Exhibit A-7. Projected Annual Long-haul Crashes

Category	Alternative 1: No Action	Alternative 2	Alternative 3: Agency-Preferred Alternative	Alternative 4
% Change in Crashes	–	−1.45%	−0.76%	−3.06%

Source: ICF International estimate

Exhibit A-8 presents the emission factors associated with changes in CMV crashes. The same emission factors were applied to each alternative for each analysis year.

Exhibit A-8. Emission Factors per Long-haul CMV Crash

Pollutant	Grams of Pollutant Per Crash
CO	75,410
NO_x	9,530
$PM_{2.5}$	410
PM_{10}	540
SO_2	1,110
VOC	5,710
Acetaldehyde[a]	0.090
Acrolein[a]	0.008
Benzene[a]	0.536
1,3-butadiene[a]	0.058
DPM[a]	0.136
Formaldehyde[a]	0.187
CO_2	2,418,560

Source: Volpe Center (2007)

[a] Developed by FMCSA with EPA MOBILE6 model using Volpe Center (2007) methodology.

A.3. RESULTS

A.3.1. Transportation Mode Shift Emissions

This section summarizes the changes in emissions for each action alternative that could result from transportation mode shifts and changes in VMT from the No Action Alternative (Alternative 1). Total potential emissions and changes in emissions as compared to the No Action Alternative are included for each alternative in Exhibits A-9 through A-11.

The potential emissions resulting from transportation mode shifts (i.e., increase in emissions from drayage trucks and rail) for each alternative (in metric tons per year) as compared to the No Action Alternative are shown in Exhibit A-9 for 2012, Exhibit A-10 for 2015, and Exhibit A-11 for 2020.

Exhibit A-9. Total Potential Change in Emissions (in metric tons per year) from Mode Shift, 2012

Pollutant	Alternative 1: No Action	Alternative 2	Alternative 3: Agency-Preferred Alternative	Alternative 4
CO	–	900	395	2,013
NO_x	–	4,817	2,113	10,774
$PM_{2.5}$	–	136	60	305
PM_{10}	–	141	62	315
SO_2	–	3	1	8
VOC	–	248	109	555
Acetaldehyde	–	6	3	14
Acrolein	–	1	0	2
Benzene	–	1	0	2
1,3-butadiene	–	1	0	2
DPM	–	141	62	315
Formaldehyde	–	15	6	33
CO_2e[a]	–	369,862	162,251	827,250

Note: Values less than 0.5 are rounded to zero.
[a] CO_2-only emissions for rail were summed with CO_2e for drayage truck GHG emissions.

Exhibit A-10. Total Potential Change in Emissions (in metric tons per year) from Mode Shift, 2015

Pollutant	Alternative 1: No Action	Alternative 2	Alternative 3: Agency-Preferred Alternative	Alternative 4
CO	–	938	411	2,098
NO_x	–	4,524	1,985	10,118
$PM_{2.5}$	–	118	52	264
PM_{10}	–	122	53	272
SO_2	–	4	2	8
VOC	–	210	92	470
Acetaldehyde	–	7	3	15
Acrolein	–	1	0	2
Benzene	–	1	0	2
1,3-butadiene	–	1	1	3
DPM	–	122	53	272
Formaldehyde	–	15	7	34
CO_2e[a]	–	392,671	172,256	878,265

Note: Values less than 0.5 are rounded to zero.
[a] CO_2-only emissions for rail were summed with CO_2e for drayage truck GHG emissions.

Exhibit A-11. Total Potential Change in Emissions (in metric tons per year) from Mode Shift, 2020

Pollutant	Alternative 1: No Action	Alternative 2	Alternative 3: Agency-Preferred Alternative	Alternative 4
CO	–	1,017	446	2,275
NO_x	–	3,794	1,665	8,487
$PM_{2.5}$	–	86	38	193
PM_{10}	–	89	39	199
SO_2	–	4	2	9
VOC	–	146	64	327
Acetaldehyde	–	7	3	16
Acrolein	–	1	0	2
Benzene	–	1	0	2
1,3-butadiene	–	1	1	3
DPM	–	89	39	199
Formaldehyde	–	17	7	37
CO_2e[a]	–	433,853	190,322	970,375

Note: Values less than 0.5 are rounded to zero.

[a] CO_2-only emissions for rail were summed with CO_2e for drayage truck GHG emissions.

A.3.2. Long-Haul Truck Travel Emissions

The changes in potential emissions from long-haul VMT for each alternative (in metric tons per year) are shown in Exhibits A-12, A-13, and A-14 for years 2012, 2015, and 2020, respectively.

Exhibit A-12. Total Potential Change in Emissions (in metric tons per year) from Long-haul Vehicle Miles Traveled, 2012

Pollutant	Alternative 1: No Action	Alternative 2	Alternative 3: Agency-Preferred Alternative	Alternative 4
CO	–	−660	−289	−1,476
NO_x	–	−2,780	−1,219	−6,217
$PM_{2.5}$	–	−125	−55	−279
PM_{10}	–	−129	−56	−288
SO_2	–	−5	−2	−10
VOC	–	−123	−54	−276
Acetaldehyde	–	−4	−2	−8
Acrolein	–	0	0	−1
Benzene	–	−1	−1	−3
1,3-butadiene	–	−1	0	−2
DPM	–	−129	−56	−288
Formaldehyde	–	−10	−4	−22

Exhibit A-12. Total Potential Change in Emissions (in metric tons per year) from Long-haul Vehicle Miles Traveled, 2012

Pollutant	Alternative 1: No Action	Alternative 2	Alternative 3: Agency-Preferred Alternative	Alternative 4
CO_2e	–	−600,383	−263,375	−1,342,843

Note: Values less than 0.5 are rounded to zero.

Exhibit A-13. Total Potential Change in Emissions (in metric tons per year) from Long-haul Vehicle Miles Traveled, 2015

Pollutant	Alternative 1: No Action	Alternative 2	Alternative 3: Agency-Preferred Alternative	Alternative 4
	11 hr/No[a]	10 hr/Yes	11 hr/Yes	9 hr/Yes
CO	–	−481	−211	−1,075
NO_x	–	−2,007	−880	−4,489
$PM_{2.5}$	–	−86	−38	−192
PM_{10}	–	−89	−39	−198
SO_2	–	−5	−2	−10
VOC	–	−93	−41	−208
Acetaldehyde	–	−3	−1	−6
Acrolein	–	0	0	−1
Benzene	–	−1	0	−2
1,3-butadiene	–	−1	0	−1
DPM	–	−89	−39	−198
Formaldehyde	–	−7	−3	−17
CO_2e	–	−636,844	−279,370	−1,424,393

Note: Values less than 0.5 are rounded to zero.

Exhibit A-14. Total Potential Change in Emissions (in metric tons per year) from Long-haul Vehicle Miles Traveled, 2020

Pollutant	Alternative 1: No Action	Alternative 2	Alternative 3: Agency-Preferred Alternative	Alternative 4
CO	–	−288	−126	−644
NO_x	–	−1,225	−537	−2,740
$PM_{2.5}$	–	−45	−20	−101
PM_{10}	–	−47	−20	−104
SO_2	–	−5	−2	−11
VOC	–	−59	−26	−133
Acetaldehyde	–	−2	−1	−4
Acrolein	–	0	0	0
Benzene	–	−1	0	−1

Exhibit A-14. Total Potential Change in Emissions (in metric tons per year) from Long-haul Vehicle Miles Traveled, 2020

Pollutant	Alternative 1: No Action	Alternative 2	Alternative 3: Agency-Preferred Alternative	Alternative 4
1,3-butadiene	–	0	0	−1
DPM	–	−47	−20	−104
Formaldehyde	–	−5	−2	−11
CO_2e	–	−702,833	−308,318	−1,571,988

Note: Values less than 0.5 are rounded to zero.

A.3.3. Long-Haul Truck Idle Emissions

The potential changes in emissions from long-haul truck idling based on VHI for each alternative (in metric tons per year) are presented in Exhibits A-15 for 2012, A-16 for 2015, and A-17 for 2020.

Exhibit A-15. Potential Emissions (in metric tons per year)from Long-haul Vehicle-hours Idling, 2012

Pollutant	Alternative 1: No Action	Alternative 2	Alternative 3: Agency-Preferred Alternative	Alternative 4
CO	–	5,578	868	15,167
NO_x	–	14,857	2,311	40,399
$PM_{2.5}$	–	108	17	292
PM_{10}	–	111	17	301
SO_2	–	4	1	10
VOC	–	3,465	539	9,423
Acetaldehyde	–	102	16	279
Acrolein	–	12	2	34
Benzene	–	37	6	102
1,3-butadiene	–	22	3	59
DPM	–	111	17	301
Formaldehyde	–	278	43	756
CO_2e	–	564,700	87,842	1,535,528

Exhibit A-16. Potential Emissions (in metric tons per year) from Long-haul Vehicle-hours Idling, 2015

Pollutant	Alternative 1: No Action	Alternative 2	Alternative 3: Agency-Preferred Alternative	Alternative 4
CO	–	5,925	922	16,112
NO_x	–	15,494	2,410	42,132
$PM_{2.5}$	–	80	12	218

Exhibit A-16. Potential Emissions (in metric tons per year) from Long-haul Vehicle-hours Idling, 2015

Pollutant	Alternative 1: No Action	Alternative 2	Alternative 3: Agency-Preferred Alternative	Alternative 4
PM_{10}	–	83	13	225
SO_2	–	4	1	11
VOC	–	3,640	566	9,898
Acetaldehyde	–	108	17	293
Acrolein	–	13	2	36
Benzene	–	39	6	107
1,3-butadiene	–	23	4	62
DPM	–	83	13	225
Formaldehyde	–	292	45	794
CO_2e	–	598,324	93,073	1,626,957

Exhibit A-17. Potential Emissions (in metric tons per year) from Long-haul Vehicle-hours Idling, 2020

Pollutant	Alternative 1: No Action	Alternative 2	Alternative 3: Agency-Preferred Alternative	Alternative 4
CO	–	6,549	1,019	17,809
NO_x	–	16,816	2,616	45,726
$PM_{2.5}$	–	52	8	142
PM_{10}	–	54	8	147
SO_2	–	5	1	12
VOC	–	3,980	619	10,821
Acetaldehyde	–	118	18	320
Acrolein	–	14	2	39
Benzene	–	43	7	117
1,3-butadiene	–	25	4	68
DPM	–	54	8	147
Formaldehyde	–	319	50	869
CO_2e	–	659,889	102,649	1,794,365

A.3.4. Emissions Resulting from Crashes

Exhibit A-18 presents potential total emissions associated with projected changes in the number of crashes for all alternatives, based on the number of crashes (see Exhibit A-7) and emission factors per crash (see Exhibit A-8).

Exhibit A-18. Potential Emission Changes (in metric tons per year) Resulting from Changes in Long-haul Crash Incidence, 2012 through 2020

Pollutant	Alternative 1: No Action	Alternative 2	Alternative 3: Agency-Preferred Alternative	Alternative 4
CO	–	−274.27	−143.58	−579.83
NO_x	–	−34.66	−18.15	−73.28
$PM_{2.5}$	–	−1.49	−0.78	−3.15
PM_{10}	–	−1.96	−1.03	−4.15
SO_2	–	−4.04	−2.11	−8.53
VOC	–	−20.77	−10.87	−43.90
Acetaldehyde	–	0.000	0.000	−0.001
Acrolein	–	0.000	0.000	0.000
Benzene	–	−0.002	−0.001	−0.004
1,3-butadiene	–	0.000	0.000	0.000
DPM	–	0.000	0.000	−0.001
Formaldehyde	–	−0.001	0.000	−0.001
CO_2e[a]	–	−8796	−4605	−18596

Note: Differences less than 0.0005 are rounded to zero.
[a] CO_2-only emissions for crash incidence are assumed to approximate CO_2e.

A.3.5. Total Emissions

The total potential emission change relative to the No Action Alternative as a result of mode shift, VMT, VHI, and CMV crashes for each alternative (in metric tons per year) for the three action alternatives are presented in Exhibits A-19, A-20, and A-21 for 2012, 2015, and 2020 respectively.

Exhibit A-19. Total Potential Emission Changes (in metric tons per year) Relative to the No Action Alternative, 2012

Pollutant	Alternative 1: No Action	Alternative 2	Alternative 3: Agency-Preferred Alternative	Alternative 4
CO	–	5,544	830	15,125
NO_x	–	16,860	3,187	44,882
$PM_{2.5}$	–	118	21	315
PM_{10}	–	121	21	324
SO_2	–	−1	−2	−1
VOC	–	3,569	583	9,658
Acetaldehyde	–	105	17	284
Acrolein	–	13	2	35
Benzene	–	37	6	101
1,3-butadiene	–	22	4	60
DPM	–	123	22	328
Formaldehyde	–	283	45	767
CO_2e[a]	–	325,383	−17,887	1,001,338

Exhibit A-19. Total Potential Emission Changes (in metric tons per year) Relative to the No Action Alternative, 2012

Pollutant	Alternative 1: No Action	Alternative 2	Alternative 3: Agency-Preferred Alternative	Alternative 4

[a] CO_2-only emissions for rail and crashes are summed with CO_2e emissions from long-haul and drayage truck VMT and VHI emissions to approximate CO_2e.

Exhibit A-20. Total Potential Emission Changes (in metric tons per year) Relative to the No Action Alternative, 2015

Pollutant	Alternative 1: No Action	Alternative 2	Alternative 3: Agency-Preferred Alternative	Alternative 4
CO	–	6,108	979	16,554
NO_x	–	17,977	3,496	47,689
$PM_{2.5}$	–	111	26	287
PM_{10}	–	114	26	295
SO_2	–	−1	−2	0
VOC	–	3,736	607	10,116
Acetaldehyde	–	111	18	301
Acrolein	–	14	2	37
Benzene	–	39	6	107
1,3-butadiene	–	23	4	63
DPM	–	116	27	299
Formaldehyde	–	300	49	812
CO_2e[a]	–	345,354	−18,646	1,062,232

[a] CO_2-only emissions for rail and crashes are summed with CO_2e emissions from long-haul and drayage truck VMT and VHI emissions to approximate CO_2e.

Exhibit A-21. Total Potential Emission Changes (in metric tons per year) Relative to the No Action Alternative, 2020

Pollutant	Alternative 1: No Action	Alternative 2	Alternative 3: Agency-Preferred Alternative	Alternative 4
CO	–	7,004	1,195	18,860
NO_x	–	19,351	3,725	51,400
$PM_{2.5}$	–	92	25	231
PM_{10}	–	94	26	238
SO_2	–	−1	−2	1
VOC	–	4,046	646	10,971
Acetaldehyde	–	123	21	332
Acrolein	–	15	3	41
Benzene	–	43	7	117
1,3-butadiene	–	26	4	70
DPM	–	96	27	242
Formaldehyde	–	331	55	895
CO_2e[a]	–	382,113	−19,951	1,174,156

[a] CO_2-only emissions for rail and crashes are summed with CO_2e emissions from long-haul and drayage truck VMT and VHI emissions to approximate CO_2e.

Exhibits A-19 through A-21 show that emissions of all pollutants (criteria and air toxics) would increase under the action alternatives (Alternative 2 through 4) compared to the No Action Alternative with the exception of SO_2 for Alternatives 2 and 3, which would have very small reductions, and CO_2e for Alternative 3, which would have relatively small reductions. The potential increases in all pollutants are due to the expected increase in activity of drayage trucks, rail locomotives, and idling for long-haul trucks associated with Alternatives 2 through 4 compared to the No Action Alternative. Increases in long-haul idling under each action alternative are primarily responsible for potential emission increases of all pollutants. For DPM, $PM_{2.5}$, PM_{10}, and SO_2, increases in locomotive emissions are also a key driver. For SO_2, emission increases from long-haul truck idling and rail transport would approximately balance with emission reductions from long-haul truck VMT and crashes. Because total freight activity is expected to increase between 2010 and 2020, the magnitude of the HOS-related emission changes also would increase between analysis years (i.e., from 2012 to 2015 and from 2015 to 2020). This increase would occur for all pollutants except for PM_{10}, $PM_{2.5}$, and DPM. Emission factors for PM_{10}, $PM_{2.5}$, and DPM are expected to decrease more rapidly than freight activity is expected to increase between 2010 and 2020.

A.3.6. Emissions in National Context

Exhibits A-22 through A-24 show the potential emission change for all alternatives compared to the No Action Alternative (Alternative 1) as a percentage of total highway emission sources nationwide. Exhibits A-25 through A-27 show the potential emission change for all alternatives compared to the No Action Alternative as a percentage of total national emissions from all sources.

Exhibit A-22. Potential Emission Changes Relative to the No Action Alternative, as a Percentage of Total National Emissions from Highway Sources, 2012

Pollutant	Highway Sources[a] (Metric Tons per Year)	Alternative 1: No Action	Alternative 2	Alternative 3: Agency-Preferred Alternative	Alternative 4
CO	35,258,642	–	0.02%	0.00%	0.04%
NO_x	4,722,804	–	0.36%	0.07%	0.95%
$PM_{2.5}$	99,790	–	0.12%	0.02%	0.32%
PM_{10}	155,129	–	0.08%	0.01%	0.21%
SO_2	58,060	–	0.00%	0.00%	0.00%
VOC	3,100,757	–	0.12%	0.02%	0.31%
Acetaldehyde	21,563	–	0.49%	0.08%	1.32%
Acrolein	2,278	–	0.56%	0.09%	1.53%
Benzene	129,610	–	0.03%	0.00%	0.08%
1,3-butadiene	15,484	–	0.14%	0.02%	0.39%
DPM	175,232	–	0.07%	0.01%	0.19%
Formaldehyde	48,191	–	0.59%	0.09%	1.59%
CO_2e[b]	1,580,600,000	–	0.02%	0.00%	0.06%

Sources: EPA (2009b) for all criteria air pollutants; EIA (2009) for CO_2e based on total transportation sources; EPA (2008) for air toxics.

Exhibit A-22. Potential Emission Changes Relative to the No Action Alternative, as a Percentage of Total National Emissions from Highway Sources, 2012

Pollutant	Highway Sources[a] (Metric Tons per Year)	Alternative 1: No Action	Alternative 2	Alternative 3: Agency-Preferred Alternative	Alternative 4

Note: Values less than 0.005% are rounded to zero.
[a] Based on 2008 emissions for criteria air pollutants and CO_2, 2005 emissions for air toxics.
[b] CO_2 only.

Exhibit A-23. Potential Emission Changes Relative to the No Action Alternative, as a Percentage of Total National Emissions from Highway Sources, 2015

Pollutant	Highway Sources[a] (Metric Tons Per Year)	Alternative 1: No Action	Alternative 2	Alternative 3: Agency-Preferred Alternative	Alternative 4
CO	35,258,642	–	0.02%	0.00%	0.05%
NO_x	4,722,804	–	0.38%	0.07%	1.01%
$PM_{2.5}$	99,790	–	0.11%	0.03%	0.29%
PM_{10}	155,129	–	0.07%	0.02%	0.19%
SO_2	58,060	–	0.00%	0.00%	0.00%
VOC	3,100,757	–	0.12%	0.02%	0.33%
Acetaldehyde	21,563	–	0.52%	0.09%	1.40%
Acrolein	2,278	–	0.60%	0.10%	1.62%
Benzene	129,610	–	0.03%	0.00%	0.08%
1,3-butadiene	15,484	–	0.15%	0.02%	0.41%
DPM	175,232	–	0.07%	0.02%	0.17%
Formaldehyde	48,191	–	0.62%	0.10%	1.68%
CO_2e[b]	1,580,600,000	–	0.02%	0.00%	0.07%

Sources: EPA (2009b) for all criteria air pollutants; EIA (2009) for CO_2e based on total transportation sources; EPA (2008) for air toxics.
Note: Values less than 0.005% are rounded to zero.
[a] Based on 2008 emissions for criteria air pollutants and CO_2, 2005 emissions for air toxics.
[b] CO_2 only.

Exhibit A-24. Potential Emission Changes Relative to the No Action Alternative as a Percentage of Total National Emissions from Highway Sources, 2020

Pollutant	Highway Sources[a] (Metric Tons Per Year)	Alternative 1: No Action	Alternative 2	Alternative 3: Agency-Preferred Alternative	Alternative 4
CO	35,258,642	–	0.02%	0.00%	0.05%
NO_x	4,722,804	–	0.41%	0.08%	1.09%
$PM_{2.5}$	99,790	–	0.09%	0.03%	0.23%
PM_{10}	155,129	–	0.06%	0.02%	0.15%
SO_2	58,060	–	0.00%	0.00%	0.00%
VOC	3,100,757	–	0.13%	0.02%	0.35%

Exhibit A-24. Potential Emission Changes Relative to the No Action Alternative as a Percentage of Total National Emissions from Highway Sources, 2020

Pollutant	Highway Sources[a] (Metric Tons Per Year)	Alternative 1: No Action	Alternative 2	Alternative 3: Agency-Preferred Alternative	Alternative 4
Acetaldehyde	21,563	–	0.57%	0.10%	1.54%
Acrolein	2,278	–	0.66%	0.11%	1.78%
Benzene	129,610	–	0.03%	0.01%	0.09%
1,3-butadiene	15,484	–	0.17%	0.03%	0.45%
DPM	175,232	–	0.06%	0.02%	0.14%
Formaldehyde	48,191	–	0.69%	0.11%	1.86%
CO_2e[b]	1,580,600,000	–	0.02%	0.00%	0.07%

Sources: EPA (2009b) for all criteria air pollutants; EIA (2009) for CO_2e based on total transportation sources; EPA (2008) for air toxics.
Note: Values less than 0.005% are rounded to zero.
[a] Based on 2008 emissions for criteria air pollutants and CO_2, 2005 emissions for air toxics
[b] CO_2 only.

Exhibit A-25. Potential Emission Changes Relative to the No Action Alternative as a Percentage of Total National Emissions From All Sources, 2012

Pollutant	All Sources[a] (Metric Tons Per Year)	Alternative 1: No Action	Alternative 2	Alternative 3: Agency-Preferred Alternative	Alternative 4
CO	70,474,647	–	0.01%	0.00%	0.02%
NO_x	14,822,491	–	0.11%	0.02%	0.30%
$PM_{2.5}$	4,436,133	–	0.00%	0.00%	0.01%
PM_{10}	13,431,777	–	0.00%	0.00%	0.00%
SO_2	10,368,214	–	0.00%	0.00%	0.00%
VOC	14,448,731	–	0.02%	0.00%	0.07%
Acetaldehyde	65,895	–	0.16%	0.03%	0.43%
Acrolein	27,488	–	0.05%	0.01%	0.13%
Benzene	317,956	–	0.01%	0.00%	0.03%
1,3-butadiene	43,375	–	0.05%	0.01%	0.14%
DPM	19,006,694	–	0.00%	0.00%	0.00%
Formaldehyde	223,260	–	0.13%	0.02%	0.34%
CO_2e[b]	5,814,400,000	–	0.01%	0.00%	0.02%

Sources: EPA (2009b) for all criteria air pollutants; EIA (2009) for CO_2e based on total transportation sources; EPA (2008) for air toxics.
Note: Values less than 0.005% are rounded to zero.
[a] Based on 2008 emissions for criteria air pollutants and CO_2, 2005 emissions for air toxics.
[b] CO_2 only.

Exhibit A-26. Potential Emission Changes Relative to the No Action Alternative, 2015, as a Percentage of Total National Emissions From All Sources

Pollutant	All Sources[a] (Metric Tons Per Year)	Alternative 1: No Action	Alternative 2	Alternative 3: Agency-Preferred Alternative	Alternative 4
CO	70,474,647	–	0.01%	0.00%	0.02%
NO_x	14,822,491	–	0.12%	0.02%	0.32%
$PM_{2.5}$	4,436,133	–	0.00%	0.00%	0.01%
PM_{10}	13,431,777	–	0.00%	0.00%	0.00%
SO_2	10,368,214	–	0.00%	0.00%	0.00%
VOC	14,448,731	–	0.03%	0.00%	0.07%
Acetaldehyde	65,895	–	0.17%	0.03%	0.46%
Acrolein	27,488	–	0.05%	0.01%	0.13%
Benzene	317,956	–	0.01%	0.00%	0.03%
1,3-butadiene	43,375	–	0.05%	0.01%	0.15%
DPM	19,006,694	–	0.00%	0.00%	0.00%
Formaldehyde	223,260	–	0.13%	0.02%	0.36%
CO_2e[b]	5,814,400,000	–	0.01%	0.00%	0.02%

Sources: EPA (2009b) for all criteria air pollutants; EIA (2009) for CO_2e based on total transportation sources; EPA (2008) for air toxics.
Note: Values less than 0.005% are rounded to zero.
[a] Based on 2008 emissions for criteria air pollutants and CO_2, 2005 emissions for air toxics.
[b] CO_2 only.

Exhibit A-27. Potential Emission Changes Relative to the No Action Alternative, as a Percentage of Total National Emissions From All Sources, 2020

Pollutant	All Sources[a] (Metric Tons Per Year)	Alternative 1: No Action	Alternative 2	Alternative 3: Agency-Preferred Alternative	Alternative 4
CO	70,474,647	–	0.01%	0.00%	0.03%
NO_x	14,822,491	–	0.13%	0.03%	0.35%
$PM_{2.5}$	4,436,133	–	0.00%	0.00%	0.01%
PM_{10}	13,431,777	–	0.00%	0.00%	0.00%
SO_2	10,368,214	–	0.00%	0.00%	0.00%
VOC	14,448,731	–	0.03%	0.00%	0.08%
Acetaldehyde	65,895	–	0.19%	0.03%	0.50%
Acrolein	27,488	–	0.05%	0.01%	0.15%
Benzene	317,956	–	0.01%	0.00%	0.04%
1,3-butadiene	43,375	–	0.06%	0.01%	0.16%
DPM	19,006,694	–	0.00%	0.00%	0.00%
Formaldehyde	223,260	–	0.15%	0.02%	0.40%
CO_2e[b]	5,814,400,000	–	0.01%	0.00%	0.02%

Sources: EPA (2009b) for all criteria air pollutants; EIA (2009) for CO_2e based on total transportation sources; EPA (2008) for air toxics.
Note: Values less than 0.005% are rounded to zero.
[a] Based on 2008 emissions for criteria air pollutants and CO_2, 2005 emissions for air toxics.

Exhibit A-27. Potential Emission Changes Relative to the No Action Alternative, as a Percentage of Total National Emissions From All Sources, 2020

Pollutant	All Sources[a] (Metric Tons Per Year)	Alternative 1: No Action	Alternative 2	Alternative 3: Agency-Preferred Alternative	Alternative 4

[c] CO_2 only.

CO_2 is a GHG that causes climate effects due to its overall concentration in the atmosphere, rather than local conditions near the CO_2 emission sources. Consequently, its impacts are most appropriately evaluated on a national rather than local scale. An appropriate context for evaluating CO_2 emissions associated with the HOS rules is the national GHG emissions inventory. The emission inventory for calendar year 2009, published April 15, 2011 (EPA 2011b), is the latest available. The amount of CO_2 emitted from fossil-fueled transportation sources in the United States in 2009 was 1,719.7 million metric tons. For all fossil-fuel (e.g., coal, petroleum, natural gas) combustion sources, including transportation, the 2009 nationwide emissions were 5,505.2 million metric tons of CO_2. In all, the change in CMV-related GHG emissions represents approximately one-hundredth to one-tenth of one percent of annual total U.S. net GHG emissions, depending on the HOS alternative.

A.4. References

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