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CONTROL OF OZONE PRECURSOR EMISSIONS IN THE LAKE MICHIGAN AIR DIRECTORS CONSORTIUM REGION

Task 3 Draft Final Report Chapter: Identify NO_x and VOC Emission Control Options for Non-NEI Sources in the LADCO Region

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3.0 EMISSIONS FROM NON-NEI SOURCES

3.1 Existing Conditions and Background

In Task 3, Ramboll reviewed the National Emission Inventory (NEI) to determine whether there are sources for which emissions may be underrepresented and, for which, control strategies have not yet been identified. Under consultation with LADCO, we revised LADCO's emission inventory for heavy-duty diesel vehicles (HDDV) and volatile chemical products (VCP) source categories and identified potential emission control options for these categories. This section describes the steps taken:

1) Reviewed available documentation for the NEI and the MOtor Vehicle Emission Simulator (MOVES) to identify emission processes that may not be accurately represented in the NEI such as low-load/speed and tampering and mal-maintenance effects on HDDV exhaust emissions. Similarly, available literature and NEI documentation on VCPs was reviewed to evaluate potentially underestimated emissions for this sector in LADCO states.
2) Developed emission inventory adjustments that can be applied to LADCO emission inventories or future bottom-up inventories developed by LADCO (e.g. onroad inventories).
3) Investigated and quantified reductions from control strategies that address the estimated excess emissions for heavy-duty vehicles and nonpoint VCP sources.

The emission estimates developed in this chapter are for LADCO and member states' consideration. Use of these inventories for air quality planning is at the discretion of LADCO and member states.

3.1.1 Heavy-Duty Vehicles

Heavy-duty vehicles are certified under emission standards which necessitate application of aftertreatment devices such as diesel particulate filters (DPF) and selective catalytic reduction (SCR) for particulate matter and nitrogen oxides (NOx) emission control, respectively. The latest PM standard has been required for 2007 model year and later engines. The latest NOx standard was phased-in from 2007 to 2010 model year engines. EPA[1] is considering further emission controls for new engines with as yet unspecified controls, levels, and implementation schedules.

EPA[2] is currently evaluating 2010+ model year heavy-duty vehicle emissions rates and expects to update the MOVES model to better characterize emission profiles.

> "*We're updating MOVES to incorporate new data on HDVs. We're aiming to release the model later this year* [2020]. *The updates will include op-mode* [operating modes defined by speed/power bins] *specific changes to better account for real-world performance of SCR and other aftertreatment, updates to better account for idling (extended idle and "off-network"*[3] *idling) and updates to account for gliders, etc. Most of this work has been discussed at the MOVES Review Workgroup* https://www.epa.gov/moves/moves-model-review-work-group *and summarized in the EPA presentation* [at the 2019 International Emissions Inventory Conference, July 31, 2019, Dallas, TX.]" **EPA Group Mobile, June 16, 2020**

Many of the emission inventory updates have already been considered and implemented in California's EMission FACtors (EMFAC) model[4], which is used to estimate onroad emissions in California. The

[1] Cleaner Truck Initiative, https://www.epa.gov/regulations-emissions-vehicles-and-engines/cleaner-trucks-initiative

[2] Personal communication with EPA Group Mobile, June 16, 2020.

[3] Off-network idling, also know as short-term idling, refers to any idling activity of less than 1-hour per event at off-network locations (parking lots, driveways, warehouses, etc.). Extended idling refers to idling activity of more than 1-hour per event, typically observed in sleeper/long haul combination trucks hoteling by the road or at rest stops.

[4] EMFAC2017 is the model referenced in this report

EMFAC model has different activity and emissions binning but, compared to MOVES, incorporates more recent information on low load emissions characteristics and emission control device deterioration to estimate emissions from modern HDDVs. The MOVES2014[5] model relied on the numerical emission standards limits and engineering judgement instead of actual emissions data such as was used by ARB in the development of EMFAC2017.[6] EPA is quoted in the MOVES documentation to have not used emissions data for modern (2010+) diesel on-road engine and vehicle emissions:

> *"In this section we discuss the "hole-filling" methodology used to fill missing operating mode bins, and missing vehicle-type and model year combinations. To do so, we rely on the heavy-duty diesel emission standards, as well as engineering knowledge and test data of emission control technologies that were forecasted to be implemented to meet more stringent standards in 2007 and 2010." EPA 2015.*[5]

3.1.2 Volatile Chemical Products

A recent study[7] by McDonald et al. estimated that VOC emissions from VCPs (i.e., pesticides, coatings, printing inks, adhesives, cleaning agents, and personal care products) are potentially substantially underestimated in current emission inventories by a factor of about three, nationwide. We used this reference and developed a methodology to make emission adjustments for applicable categories. In collaboration with LADCO staff and members, we revised the LADCO VOC emissions for these source categories. McDonald et al. (2018) did not indicate how the underreported emissions occur, such as whether current sources are underestimated or whether additional sources and categories have been ignored. The conditions when or how the additional emissions are occurring is important to understand when crafting control programs to address these sources.

3.1.3 Regulatory Setting

In order to develop the LADCO ozone precursor emissions control strategies analysis, potential emission reductions must be informed by an understanding of on-the-books (OTB) and on-the-way (OTW) regulations. Ultimately, control strategies must result in emission reductions based on control of emissions and/or activity reductions on top of requirements under federal, state, and/or local regulations.

In Task 1, Ramboll compiled, and LADCO member states reviewed and commented on, local and state regulations applicable to anthropogenic sources responsible for a vast majority of nitrogen oxides (NOx) and volatile organic compound (VOC) emissions in the LADCO region (table included as Attachment 1 for the HDDV and VCP emissions)[8]. State/local regulations which incorporated Federal regulations by reference, and that do not require emissions control beyond Federal requirements were not included (e.g. Minnesota Rules Chapter 7011.0830 incorporates 40 CFR Subpart F: New Source Performance Standards for Portland Cement Plants). While it is not comprehensive, the regulation list includes a vast majority of anthropogenic source category NOx and VOC emissions in the LADCO region.

State regulations listed in Attachment 1 are indicative of control requirements that are more stringent than Federal requirements. However, in many cases, it may be feasible to increase control stringency further. During control option screening, the presence of an existing state regulation will not preclude

[5] EPA 2015. "Exhaust Emission Rates for Heavy-Duty On-road Vehicles in MOVES2014," EPA-420-R-15-015a, November 2015. https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100NO46.pdf

[6] https://ww3.arb.ca.gov/msei/downloads/emfac2017_workshop_11_09_2017_final.pdf HDDV emission rates begin on slide 45.

[7] McDonald, B. C. et al. Volatile chemical products emerging as largest petrochemical source of urban organic emissions. Science 359, 760–764 (2018). https://science.sciencemag.org/content/359/6377/760

[8] Emission category groupings that represent >0.5% of total NOx+VOC inventory are included in the state regulations compilation.

selection of a control option for more detailed analysis if additional control would result in substantial emission reductions. For example, Ohio adopted the 2006 Ozone Transport Commission (OTC) model rule for Consumer Products, but there are several more recent 2014/2019 OTC model rules for Consumer Products that could result in greater emission reductions.

Control measures listed in resources such as EPA's Menu of Control Measures and other state implementation planning references take as the minimum starting point existing Federal regulations. In addition, potential measures compiled for the screening analysis are based on more stringent regulatory and/or voluntary programs proposed by EPA or in other non-LADCO regions which go beyond the established Federal regulations. Therefore, to perform a screening analysis of potential control measures, a listing of Federal regulations is not required.

As part of Task 2, Ramboll summarized OTB regulations and screened potential emission reduction strategies that could apply to a range of emission sources. In Task 3, we focus on the emission reduction strategies that specifically address emission increases described herein for HDDVs and VCPs.

3.2 Heavy-Duty Vehicle Emissions

3.2.1 Emissions Inventory Adjustments Methodology

Excess emissions were estimated by applying the California EMFAC model assumptions to a LADCO emissions inventory. The EMFAC model estimates additional tampering, mal-maintenance, and malfunction (TM&M) emissions. EMFAC also addresses low speed and low load operations efficiency of new (2010 model year and later) technology vehicles with more updated data than was incorporated in the MOVES2014 emission estimates.

EMFAC emission factors were applied to the LADCO emissions inventory to estimation emissions from TM&M using the age and model year associations shown in Table 3-1. The EMFAC model assumes that engine model year lags truck model year by one year owing to the estimate that trucks take time to build, sell, and be introduced into the market. The EMFAC emissions rates were only used to adjust emissions for 2010+ model year trucks that use SCR devices. Adjustments were made to account for low load and low speed conditions and the deterioration rate effects built into EMFAC that are possibly less well characterized by MOVES2014b.

Table 3-1. Age and model year vehicle model comparisons.

Calendar Year	EMFAC Output		EMFAC* (Emissions Factors basis)	MOVES Output	
	Truck Chassis		Engine**	Truck Chassis/ Engine**	
	Age	Model Year	Model Year	Age	Model Year
2026	-1	2027	2026	0	2026
2026	0	2026	2025	1	2025
2026	1	2025	2024	2	2024
2026	2	2024	2023	3	2023
2026	3	2023	2022	4	2022
2026	4	2022	2021	5	2021
2026	5	2021	2020	6	2020
2026	6	2020	2019	7	2019
	…	…	…	…	…

* EMFAC assumes that the engine model year lags the truck model year by one year.

** Engine model year determines emission standard applicability

MOVES only exports speed-specific emissions rates (g/mile) under its Rate-Per-Distance (RPD) export when run in Rate Mode. These lookup tables are typically used to develop regional onroad emission inventories using SMOKE-MOVES. Ramboll developed adjustment factors that may be applied to SMOKE-MOVES by-speed emission rates tables during inventory development as described below. The resulting adjustment factors are included in Attachment 2.

The approach uses EMFAC2017-based NOx emission factors for 2010+ model years, which include EMFAC assumptions on failure rates and speed correction factors. The model-output EMFAC rates were adjusted to account for MOVES-based relative mileage accumulation of HHDVs. These EMFAC-adjusted emissions factors by model year were aggregated to a fleet-wide average based on the MOVES national age distribution for HHDVs. The HHDVs categories covered for these adjustments were combination unit trucks (short and long haul) and refuse trucks because these vehicle types account for a vast majority of emissions from Class 8 trucks (33,000 GVWR+).

Developing Adjustments for MOVES Rate Tables

Emission factors by model year (MY) and by speed for HHDVs can be extracted from EMFAC2017 which include effects of speed corrections at low loads and EMFAC deterioration and failure rates. However, these emission factors are based on CA-vehicles typical mileage accumulation rates and odometer readings. Ramboll adjusted the EMFAC emission factors by updating the deterioration using EMFAC methodology and MOVES mileage accumulation rates as indicated in Equations 1-3 shown below.

$$Default\ Emission\ Rate_{MY} = [\ ZMR_{MY} + DR * Odometer|_{EMFAC}/10{,}000] \quad \text{(eq. 1)}$$

$$MOVESadj\ Emission\ Rate_{MY} = [ZMR_{MY} + DR * Odometer|_{MOVES}/10{,}000] \quad \text{(eq. 2)}$$

$$\%\ Base\ Rate\ Change_{MY} = \frac{MOVESadj\ Emission\ Rate_{MY}}{Default\ Base\ Rate_{MY}} \quad \text{(eq. 3)}$$

where:

ZMR_{MY} is the zero-mile base rate for a specific MY (g/mile)

DR is the deterioration rate for a specific MY (g/mile/10k miles)

Odometer is the average accumulated mileage by vehicle age and type

% Base Rate Change is the percent change in emissions based on MOVES default mileage accumulation rate for HHDVs

The *% Base Rate Change* ratios were applied to by model year and by speed California-wide emission rate outputs from EMFAC2017 for model year 2010+. MOVES emission rates by model year and by speed for HHDVs of model 2009 and older were obtained from a MOVES National default run under rate mode. Both the EMFAC adjusted emission factors (MY2010 and newer) and MOVES "raw" emission factors (MY2009 and older) were then combined into an aggregated fleet-wide rate using vehicle miles traveled (VMT) fractions that are based on MOVES default 2026 national age distribution and relative mileage accumulation rates for HHDVs, as shown in Equation 4. These rates were combined into a fleet-wide composite given that, typical SMOKE-MOVES RPD tables do not include model-year detail.

$$Composite.EMFAC.Adj.EF_{\substack{|by\\speed}} = \sum_{1996}^{2009} EF_{MOVESraw} \times \frac{VMT_{|byMY}}{VMT_{fleet}} + \sum_{2010}^{2026} EF_{EMFACadjusted} \times \frac{VMT_{|byMY}}{VMT_{fleet}} \quad \text{(eq. 4)}$$

where:

$EF_{MOVESraw}$ is an MOVES emission factor from default rate run by MY, by speed (g/mile)

$EF_{EMFACadjusted}$ is an EMFAC emission factor by MY by speed, multiplied by $\%\,Base\ Rate\ Change_{MY}$

$\frac{VMT_{|byMY}}{VMT_{fleet}}$ is the VMT fraction, resulting from the ratio of VMT by MY over fleet-wide VMT

$Composite.EMFAC.Adj.EF_{\substack{|by\\speed}}$ is the EMFAC adjusted emission factor by speed

These rates ($Composite.EMFAC.Adj.EF$) have the following level of detail:

- Calendar Year: 2026
- Fuel type: Diesel
- Source types: Combination Long-haul Truck, Combination Short-haul Truck, Refuse Truck
- Average Speed: 5 mph increments
- Road type: all four MOVES road types. Emission factors do not vary by road type as they are speed dependent

The adjustment factors are based on the ratio of Composite EMFAC adjusted emission rates (from eq. 4) and MOVES "raw" RDP rates, based on national defaults.

$$AdjustmentFactor_{|speed} = \frac{Composite.EMFAC.Adj.EF_{|speed}}{MOVES_{default}.RPD.EF_{|speed}} \quad \text{(eq. 5)}$$

The adjustment factor table can be used by LADCO to adjust lookup rate RPD tables developed through SMOKE-MOVES process, to capture increased TM&M and speed effects in the EMFAC2017 model. Below we note caveats for applying these adjustment factors to estimate revised MOVES inventories for the LADCO region for 2026.

- Effects that are considered and factored in the methodology
  - Age distribution: Based on MOVES2014b National 2026 default for each source type. SMOKE-MOVES "lookup rate tables" includes speed detail but not model year detail
  - Speed distribution: Based on MOVES2014b National default
  - Difference in Relative MAR between EMFAC and MOVES: Captures MOVES national default assumptions
- Effects that are not considered
  - Fuel adjustments: Based on MOVES2014b National 2026 defaults. Fuel adjustment variations by state not captured. Likely not an issue for diesel-based NOx.
  - Meteorology: Methodology does not consider geographical variations in temperature and humidity (the basis of the estimates is a summer meteorology sample for Cook County, IL). Because these are modern diesel engine emissions and not gasoline, meteorological effects are not expected to be significant.

Estimating Adjustment Effect on Emissions Inventory Sample

For the LADCO geographic region, we exported 2026 VMT by source classification code (SCC) for a summer month (July) from MOVES2014 default database and allocated VMT to speed bins using the MOVES average speed distribution table.

With the VMT by speed bin and SCC, the running exhaust (RPD) SCC emissions by speed were calculated using two sets of emission factors:

1) MOVES Base Case = sum of (MOVES default output RPD table * VMT) by speed bin, SCC
2) EMFAC Adjusted Case = sum of ($Composite.EMFAC.Adj.EF_{|by\ speed}$ * VMT) by speed bin, SCC

The emissions by speed are aggregated to calculate MOVES Base Case and EMFAC Adjusted Case Inventories.

3.2.2 Adjustment Emissions Results

As explained in the previous section, Ramboll used the MOVES default activity rates by speed bin to estimate the overall emissions inventory using the comparable EMFAC emission rates (Eq. 4). Figure 3-1 shows NOx emission factors (EFs) by speed bin for the 2026 national average fleet. Overall, EMFAC adjusted emission factors are generally higher, especially at lower speeds. The average speed emission rates from MOVES or EMFAC models are based on driving cycles that reflect stops and idling which raise emission rates at slower speeds. At high speeds, the aerodynamic drag raises emissions rates.

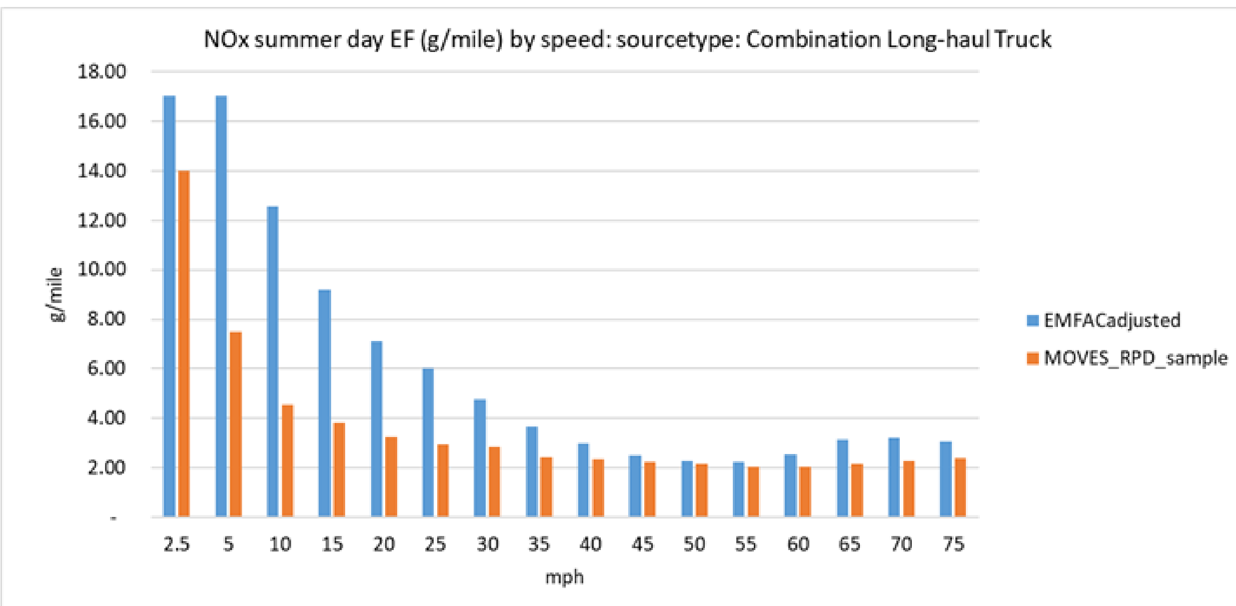

Figure 3-1. HHDV emission rate estimates by speed bin.

The overall adjusted LADCO emission inventory reflects the impact of added deterioration (including deliberate or unintentional failures) and the by-speed-bin adjustments. In Table 3-2, the emission inventory using EMFAC adjusted emission rates is compared with an emissions inventory developed using the MOVES rate per distance estimates.

Table 3-2. HDDV emissions for the base case and adjusted inventory by source type and state (lbs/day).

Source Type	State	EMFAC adjusted	MOVES Base Case	EMFAC Adjustment Increase
Combination Long-haul Truck	IL	198,417	134,193	48%
Combination Long-haul Truck	IN	175,747	122,731	43%
Combination Long-haul Truck	MI	228,545	161,030	42%
Combination Long-haul Truck	MN	129,845	92,420	40%
Combination Long-haul Truck	OH	274,351	191,297	43%
Combination Long-haul Truck	WI	140,509	100,617	40%
Combination Long-haul Truck Subtotal		**1,147,413**	**802,288**	**43%**
Combination Short-haul Truck	IL	47,225	34,601	36%
Combination Short-haul Truck	IN	40,907	31,364	30%
Combination Short-haul Truck	MI	52,874	41,049	29%
Combination Short-haul Truck	MN	30,030	23,612	27%
Combination Short-haul Truck	OH	64,077	48,985	31%
Combination Short-haul Truck	WI	32,243	25,602	26%
Combination Short-haul Truck Subtotal		**267,355**	**205,212**	**30%**
Refuse Truck	IL	3,971	3,432	16%
Refuse Truck	IN	3,419	3,104	10%
Refuse Truck	MI	4,441	4,076	9%
Refuse Truck	MN	2,513	2,333	8%
Refuse Truck	OH	5,365	4,848	11%
Refuse Truck	WI	2,701	2,536	7%
Refuse Truck Subtotal		**22,410**	**20,328**	**10%**
All States and Sources Total		**1,437,178**	**1,027,827**	**40%**
LADCO Average Emission Factors				
Combination Long-haul Truck (g/mile)		**3.45**	**2.40**	**43%**
Combination Short-haul Truck (g/mile)		**2.22**	**1.69**	**31%**
Refuse Truck (g/mile)		**1.81**	**1.64**	**11%**

3.2.3 EMFAC Tampering, Mal-maintenance, and Malfunction (TM&M) Impact

California Air Resources Board (CARB) estimated the failure rates at full useful life (1,000,000 miles) and NOx emissions impact of those failures (see Table 3-3). EMFAC uses these effects and apportions the failures to linearly increase with vehicle age. In Selective Catalytic Reduction (SCR) Systems, NOx sensors are used to improve the metering of diesel exhaust fluid (usually a urea/water mixture) prior to the SCR catalysts that reduces NOx emissions. Exhaust gas recirculation (EGR) is used often with a cooler to reduce engine-out NOx emissions prior to the SCR systems. Diesel particulate filters (DPF) are used to reduce PM and have little effect on NOx emissions.

Table 3-3. EMFAC NOx emission failure increases at useful life[9] (except as noted).

Failure Category	MY2010-2012		MY2013+	
	Fail Rate	Fail Effect	Fail Rate	Fail Effect
NOx Sensor	36%	200%	24%	200%
Replacement NOx Sensor	1.8%	200%	1.2%	200%
SCR System	40%	300%	27%	300%
EGR	16%	150%	11%	150%
DPF[1]	10%	5200%	6.7%	5200%

[1] PM Effect only.

To evaluate the effect of TM&M emissions adjustments separate from the low-load effects, Ramboll used the EMFAC base emission factors combined with the 2010+ national average fleet to estimate the relative emissions with deterioration (reflecting mal-maintenance and defeat device identification and repairs) and without deterioration. The emissions results and comparisons are shown in Table 3-4. The fleet of long-haul combination trucks tend to be younger than short-haul truck fleets, and therefore, short-haul accrues a larger repair benefit. The older vehicles are more likely to have malfunctioning vehicles and benefit more from repairs. Table 3-4 also reflects 100% control, i.e., all vehicles are perfectly maintained with no deterioration implying that failures are identified, and repairs are made, immediately.

Table 3-4. Estimated effect of TM&M (Maximum Repair Benefit) on NOx emissions.

Source Type	TM&M Effect on NOx Emissions (Maximum Repair Benefit)
Combination Long-haul Truck	27%
Combination Short-haul Truck	33%
Refuse Truck	34%
Total	**29%**

3.2.4 Heavy-Duty Control Program Options

For heavy-duty vehicles, emission control programs need to address the two main updates (TM&M and low speed conditions). Programs or projects to address these issues will affect the fleet in different ways and could be implemented as intrusive mandatory or smaller scale voluntary programs.

Heavy-Duty Failure Identification and Repair

Programs to address TM&M emission failures seek to encourage owner/operators to promptly repair their vehicles by identifying faults or malfunctions quickly. The identification program could be designed as a responsibility of larger fleet managers or all vehicle owners with few small business exemptions. Centralized inspection stations are not typically considered to be a viable strategy for

[9] Source: CARB, 2018. EMFAC2017 Volume III – Technical Documentation. Available at https://ww3.arb.ca.gov/msei/downloads/emfac2017-volume-iii-technical-documentation.pdf

heavy-duty vehicles, but remote sensing and other in-use verification methods (such as remote diagnostics[10]) could be considered.

ARB[11] estimated the cost of the emission control system warranty at $2,289 for 316,000 miles for heavy heavy-duty vehicles (HHDV) averaging $0.0072/mile across the fleet. After the end of the warranty, there may be more failures through the useful life compared with newer vehicles. In addition to the raw repair costs, the indirect opportunity costs due to the lost revenue from downtime per vehicle would be incurred. ARB[12] estimated that lost revenue cost could be equivalent or higher than the cost of the repair. Lastly, in order to reduce the expected failure rates, the State needs to develop and administer an effective enforcement strategy. The elements of the enforcement strategy may be enhanced regulations for fleet owners to manage their fleets or more intensive inspection and remote sensing identification. The cost of these enhanced enforcement should be included in the cost of any approach. The overall cost then would be higher than the repair cost itself probably ranging from $0.01 to $0.02 per mile. For comparison, one estimate[13] of the operating cost of heavy-duty trucks is about $1.38 per mile including about $0.50 per mile from fuel alone.

The benefit of repair will not be realized to the full extent estimated in Table 3-4 because all failing vehicles are typically not quickly identified and repaired. Likewise, all vehicles may not be covered by an identification program with much of the long-haul truck fleet engaged in interstate commerce. Thus, benefit estimates presented in Table 3-4 would overestimate the benefit and underestimate the cost effectiveness. Assuming perfectly complete repair control, the cost effectiveness of repair at $0.02 per mile would range from $19,500/ton for long-haul combination trucks to $29,500/ton for refuse vehicles with an average of $20,250/ton for all source types considered. If the repair effectiveness is only 50%, these cost effectiveness estimates would double.

Heavy-Duty Freight Route Planning

To reduce low speed and low load activity, there are a few options to streamline operations. For example, limits on long- and short-term idling have been implemented in various metropolitan areas[14]. Short-term idling emission control measures are evaluated in Chapter 2. Secondly, traffic streamlining could take the form of infrastructure (e.g. dedicated freight movement lanes or routing), non-peak travel (afterhours deliveries), or improved signal timing. Probably the least expensive approach is improved signal timing for large trucking facilities.

Signalization improvements have historical costs (purchase cost for 10-year life, retiming, and maintenance) for timed traffic signals to improve traffic flows at about $3,600 per signal[15] per year in 2005 dollars or about $4,800 in 2020 dollars. As examples, three large urban rail intermodal facilities (BNSF Corwith, Norfolk Southern 47th St., and Union Pacific Global I) in the Chicago metropolitan area use surface streets as access to these facilities from nearby freeways. These facilities transfer containers (each container moved in or out of the facility is called a lift) to and from trains and trucks creating between one or two truck trips per lift each way to the local interstate. Table 3-5 shows the

[10] https://www.geotab.com/blog/remote-diagnostics/

[11] ARB 2018. "Public Hearing To Consider Proposed Amendments To California Emission Control System Warranty Regulations And Maintenance Provisions For 2022 And Subsequent Model Year On-Road Heavy-Duty Diesel Vehicles And Heavy-Duty Engines With Gross Vehicle Weight Ratings Greater Than 14,000 Pounds And Heavy-Duty Diesel Engines In Such Vehicles Staff Report: Initial Statement Of Reasons, Date Of Release: May 8, 2018, Scheduled For Consideration: June 28, 2018.

[12] Ibid.

[13] https://www.thetruckersreport.com/infographics/cost-of-trucking/

[14] https://cdllife.com/2014/idling-laws-state/

[15] https://www.itscosts.its.dot.gov/its/benecost.nsf/0/215F723DB93D293C8525725F00786FD8

intermodal activity and surface street route characteristics to each facility and the associated cost to install and maintain an improved traffic signal corridor.

Table 3-5. Rail intermodal example traffic routes.

Railroad	Yard	Annual Lifts[16]	Route from Interstate Each Way			Annualized Cost ($)
		2018	Number of Traffic Lights [a]	Road Miles	Lights per mile	
BNSF	Corwith	850,686	3.5	0.60	5.8	17,000
NS	47th St.	630,513	2.5	0.25	10	12,100
UP	Global I	336,729	9	1.75	5.1	43,600

[a] Depending on which entrance/exit of interstate is used. The assumption is the IN and OUT are different routes, so if the same route is used IN and OUT, then the project can effectuate 2x the emissions reductions and cost effectiveness is halved.

Depending on the local traffic conditions, the traffic lights could result in trucks braking, idling, and accelerating from the traffic lights. Traffic light timing could be maintained to result in a smooth flow of truck traffic and higher average trip speeds along the surface streets to and from the intermodal facility.

To analyze what benefit traffic signal improvements could realize, Ramboll assumed that untimed lights result in a delay (idling plus braking, acceleration, and added congestion) of about 20 seconds per light compared with timed lights. Assuming 25 mph with timed lights, for 5 lights per mile, the untimed average speed is about 15 mph, and 10 lights per mile results in 10 mph average speeds. The average speed incorporates the braking, idling, and accelerating inherent in stop and go driving that is reflected in the emission rates by speed bin shown in Figure 3-1. Using these average emission rates with the intermodal truck activity, we estimated the annual emissions for each case, determined the benefit of the project, and divided it into the annual costs to estimate project cost effectiveness shown in Table 3-6.

Table 3-6. Rail intermodal example project benefits and cost effectiveness.

Railroad	Yard	Annual Lifts[17]	Route to Interstate Each Way			Annual NOx Tons Reduced	Cost Effectiveness ($/ton)
		CY 2018	Road Miles	Timed lights NOx EF [25 mph] (g/mi)	Untimed lights NOx EF [Speed] (g/mi)		
BNSF	Corwith	850,686	0.60	6	9 [15 mph]	1.69	$10,000
NS	47th St.	630,513	0.25	6	12.5 [10 mph]	1.13	$11,000
UP	Global I	336,729	1.75	6	9 [15 mph]	1.95	$22,000

Assumptions in the above analysis may be refined with site-specific data to generate more accurate estimates, or this methodology could be applied to other areas for which benefits are available from such a project. These sample projects are likely to be among the most cost-effective examples

[16] Each lift is a container arriving or departing and moved through the facility. https://www.cmap.illinois.gov/mobility/freight/freight-data-resources

[17] https://www.cmap.illinois.gov/mobility/freight/freight-data-resources

because these facilities demand many truck trips and use relatively easy to define surface street routes that could benefit from traffic signalization improvements. Each program or project to address local truck traffic should be evaluated on its own merits based on local conditions and activity. Other similar programs (e.g. afterhours deliveries) or projects near these facilities could have a similar or better impact on emissions and program costs.

A more aggressive program to address local facilities is the California Drayage Truck regulation[18] that mandated that all trucks to major ports and rail intermodal yards use diesel particulate filters (DPF) or be compliant with at least the 2007 and later engine emissions rule by 2014. CARB estimated a cost effectiveness of $12,000-$16,000 per ton of NOx reduced for the drayage truck rule.[19] California[20] extended this program to fleets across the state such that by 2023, all vehicles must use 2010 and later engines.

3.3 Volatile Chemical Products (VCP)

3.3.1 Emission Inventory Adjustments

The primary evidence for an underestimate of emissions from volatile chemical products (VCP) comes from a study by McDonald et al. (2018)[21] which used chemical analysis of ambient samples, product use, and modeling to estimate a revised emission inventory. McDonald et al. investigated the production and use of various products releasing VOCs to identify chemical signatures related to each product type. McDonald et al. estimated the emission inventory that would result in the chemical species concentrations measured by air monitoring stations through modeling. The study then compared the revised and published emission inventories, which Ramboll used to develop emission inventory adjustment factors. Table 3-7 shows the McDonald et al. (2018) emission inventory comparison and the adjustment ratios that Ramboll used to adjust the emission inventory.

Table 3-7. VCP emission inventory adjustments.

VCP Category	McDonald et al. (2018)		Adjustment Ratio
	Total VOC [a] Study Estimate (Tg)	EPA NEI 2011 (Tg)	
Pesticides	1.1	0.65	1.69
Coatings	2.4	0.89	2.70
Printing Inks [b]	0.24	0.05	4.80
Adhesives	1.8	0.1	18.00
Cleaning Agents	0.66	0.59	1.12
Personal Care	1.4	0.27	5.19
All	**7.6**	**2.6**	**2.92**

[a] McDonald includes semi-, intermediate, and normal volatile organic compounds into total VOC
[b] includes graphic arts

[18] https://ww2.arb.ca.gov/our-work/programs/drayage-trucks-seaports-railyards
[19] CARB, 2007. Staff Report: Initial Statement of Reasons: Proposed Regulation for Drayage Trucks. https://ww3.arb.ca.gov/regact/2007/drayage07/drayisor.pdf
[20] https://ww2.arb.ca.gov/our-work/programs/truck-bus-regulation/truck-and-bus-regulation-regulation-advisories
[21] "Volatile Chemical Products Emerging As Largest Petrochemical Source Of Urban Organic Emissions," Brian C. McDonald,* Joost A. de Gouw, Jessica B. Gilman, Shantanu H. Jathar, Ali Akherati, Christopher D. Cappa, Jose L. Jimenez, Julia Lee-Taylor, Patrick L. Hayes, Stuart A. McKeen, Yu Yan Cui, Si Wan Kim, Drew R. Gentner, Gabriel Isaacman-VanWertz, Allen H. Goldstein, Robert A. Harley, Gregory J. Frost, James M. Roberts, Thomas B. Ryerson, Michael Trainer, Published 16 February 2018, Science 359, 760 (2018).

It is important to understand that the emission increase adjustments are due to unidentified or under reported sources. This unknown nature of the emissions leads to uncertainty how or which programs would most effectively address the emissions increases estimated.

3.3.2 Emission Inventory Results

Each VCP category was associated with the 2016v1 modeling platform emissions for point and nonpoint source category using the category description. To obtain a 2026 base inventory for LADCO states, the 2028 (2028fh) and 2023 (2023fh) inventories from the modeling platform were interpolated. For point sources, the industrial categories include Organic Solvent Evaporation with subcategories of Cleaning/Stripping, Printing/Publishing, and Surface Coating. The nonpoint source categories are listed under the main Solvent Utilization categorization. Ramboll cross referenced the categories with the adjustment factors in Table 3-7 and summarized the unadjusted and adjustment emissions in Table 3-8 and Table 3-9. The overall estimated emission inventory for these categories is 3.2x the baseline NEI and the adjusted inventory is shown by State in Figure 3-2 and Table 3-10.

Table 3-8. Baseline National Emission Inventory (NEI) for 2026.

VCP Category	Inventoried Emissions (short tons/year)						LADCO-wide
	Illinois	Indiana	Michigan	Minnesota	Ohio	Wisconsin	
Pesticides	34,389	10,845	12,438	10,551	13,963	8,303	**90,489**
Coatings	44,277	40,843	57,802	27,367	60,828	30,383	**261,501**
Printing Inks [a]	4,975	20,594	13,766	5,888	33,719	3,034	**81,976**
Adhesives	3,995	2,328	3,601	1,977	3,640	2,171	**17,713**
Cleaning Agents	21,886	12,873	18,935	11,117	22,083	11,904	**98,799**
Personal Care	12,734	6,977	10,207	5,970	12,066	6,133	**54,087**
Others	246	87	85	54	74	462	**1,008**
LADCO Total	**122,503**	**94,547**	**116,836**	**62,924**	**146,373**	**62,392**	**605,573**

[a] includes graphic arts

Table 3-9. Adjusted National Emission Inventory for 2026.

VCP Category	Adjusted Emissions (short tons/year)						LADCO-wide
	Illinois	Indiana	Michigan	Minnesota	Ohio	Wisconsin	
Pesticides	58,197	18,353	21,049	17,855	23,629	14,051	**153,135**
Coatings	119,399	110,137	155,871	73,800	164,030	81,933	**705,171**
Printing Inks [a]	23,880	98,851	66,079	28,263	161,850	14,564	**393,487**
Adhesives	71,918	41,911	64,824	35,578	65,525	39,084	**318,839**
Cleaning Agents	24,483	14,401	21,182	12,436	24,703	13,317	**110,521**
Personal Care	66,027	36,175	52,923	30,957	62,565	31,803	**280,451**
Others	246	87	85	54	74	462	**1,008**
LADCO Total	**364,150**	**319,915**	**382,014**	**198,942**	**502,376**	**195,213**	**1,962,611**

[a] includes graphic arts

Table 3-10. Percent increase in VCP 2026 inventory due to adjustments.

VCP Category	Emissions Increase Difference (short tons/year)						LADCO-wide
	Illinois	Indiana	Michigan	Minnesota	Ohio	Wisconsin	
Pesticides	69%	69%	69%	69%	69%	69%	**69%**
Coatings	170%	170%	170%	170%	170%	170%	**170%**
Printing Inks [a]	380%	380%	380%	380%	380%	380%	**380%**
Adhesives	1700%	1700%	1700%	1700%	1700%	1700%	**1700%**
Cleaning Agents	12%	12%	12%	12%	12%	12%	**12%**
Personal Care	419%	419%	419%	419%	419%	419%	**419%**
Others	0%	0%	0%	0%	0%	0%	**0%**
Total	**197%**	**238%**	**227%**	**216%**	**243%**	**213%**	**224%**

[a] includes graphic arts

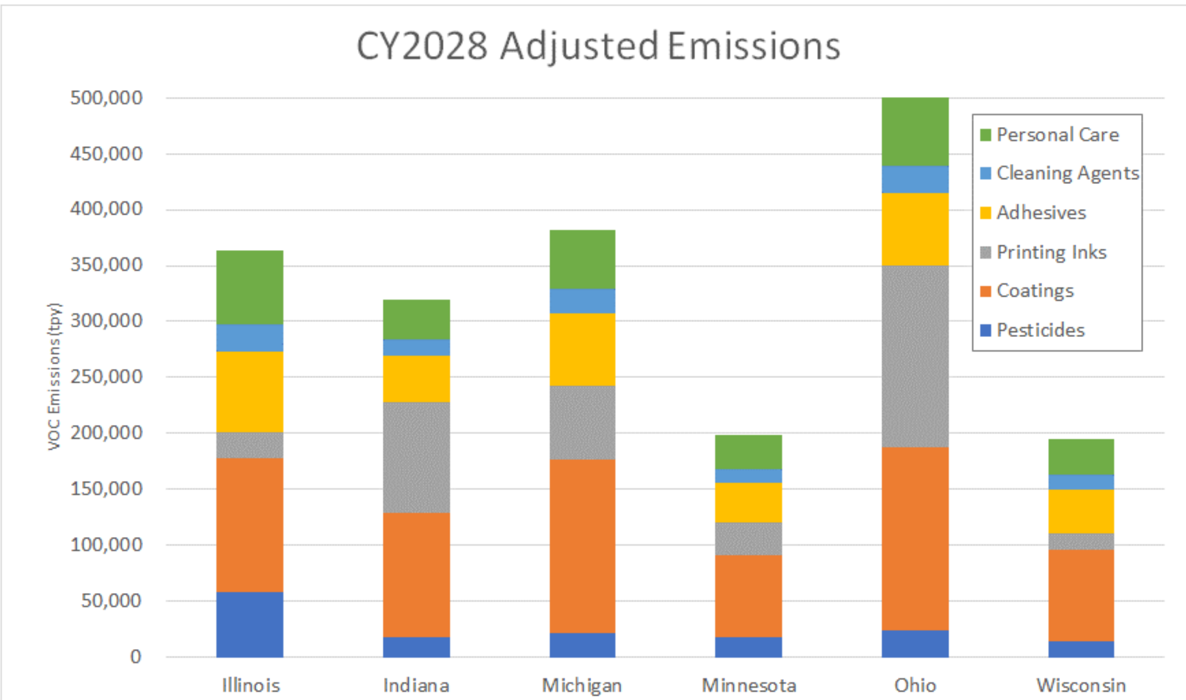

Figure 3-2. Adjustment VCP Emissions Inventory.

Use of VCPs encompasses a wide range of industrial, commercial, and consumer products and applications. The industrial uses could be incorporated and controlled within facilities through facility-based activities such as product coating, degreasing, and other operations. Commercial uses of products could be wide and varied with application usually outside of a controlled manufacturing setting. Consumer products are general use products that can only be controlled through product reformulation.

3.3.3 Volatile Chemical Products (VCP) Control Programs

The control programs for VCPs include facility and product specific VOC limits. Facility VOC limits could apply to VCP sources such as printing and graphic arts, coatings, and cleaning sources, and would not generally limit the VOC in the products used, and instead would rely on VOC control systems. The VOC control systems include aftertreatment devices to capture and control the VOC emissions within the facility. Product VOC limits are used for products for which fugitive VOC emissions capture is infeasible.

Facility-based control programs seek to limit VOC emissions, usually by capture and control. There are usually small volume exemptions for facilities that have a lower 'potential to emit'[22], which do not need to comply with the rules. For those that exceed de minimis criteria, the VOC limits are set according to the local permitting rules. The facility-based rules are most likely to affect the printing/graphic arts, coatings, and adhesives VCP source categories. EPA[23] had reviewed RACT emissions controls for flexible package printing specifically and noted capture efficiency of 67 – 95%, and included backstop VOC content limits for inks for facilities not using capture and control. The San Joaquin Valley Air Pollution Control District (similar to other California districts) Rule 4607[24] outlined the rules for printing inks, coatings, and adhesives that include product specification if capture and control are not employed at capture efficiencies of 75 – 90% (increased from as low as 67% in previous rules). Rule 4607 also lowered the facility VOC control exemption limits to 200 pounds per year (less than 1 pound per day on average) from 400 pounds per month to increase the rule effectiveness. For example, Indiana Title 326, Article 8-16, exempts facilities below 15 pounds VOC per day.

For the major source categories of adhesives, coatings, and personal care products representing 66% of the post-adjusted VCP inventory in Table 3-9, the Ozone Transport Commission (OTC)[25] has developed model rules for various products within these source categories and compared these with earlier versions of the model rules. Our review of the existing LADCO states regulations in Task 2 revealed that the on-the-books regulations largely represents the OTC 2005/2009 model rules. The updated OTC rules for 2014/2019 represents emission reduction that could be realized with regulation updates. Table 3-11 outlines the change in rules for these three main categories; additional controls programs for cleaning and other products are available. Each product represents an unknown portion of the emissions under each VCP subcategory listed in Table 3-9 and only some products are forecasted to be reduced under the updated OTC model rules. California's[26] approach is to apply specific VOC limits that may exceed the OTC model rules each product category; some of the most recent proposed changes are shown in Table 3-11.

Table 3-11. OTC model rule summary of selected products.

Category	VOC % by Weight		Proposed California [a]
	OTC Earlier	OTC Phase V	
	2005/2009	2014/2019	2020
Adhesives and Sealants			
Adhesive Remover	various	same as earlier	
Aerosol Mist Spray	65	30	
Aerosol Web Spray	55	40	
Special Purpose: (Automotive, other polymers)	60 - 70	same as earlier	

[22] For example, https://www.epa.gov/sites/production/files/2015-08/documents/lowmarch.pdf

[23] EPA 2006. "Control Techniques Guidelines for Flexible Package Printing," EPA 453/R-06-003, September 2006

[24] SJVUAPCD 2008. "RULE 4607 GRAPHIC ARTS AND PAPER, FILM, FOIL AND FABRIC COATINGS, " https://www.valleyair.org/rules/currntrules/r4607.pdf

[25] OTC Model Rule for Consumer Products - Phase V, Developed by the OTC Consumer Products Workgroup within the Stationary and Area Sources Committee' DRAFT, 4/17/2018

[26] https://ww2.arb.ca.gov/our-work/programs/consumer-products-program/consumer-products-regulatory-activity-workshops

Category	VOC % by Weight		Proposed California [a]
	OTC Earlier	OTC Phase V	
	2005/2009	2014/2019	2020
Screen Printed	no standard	55	
Chemically Curing, Non-aerosol	4	3	
Nonchemically Curing, Non-Aerosol	4	1.5	
Construction, Panel, and Floor Covering	15	7	
Contact Adhesive: General and Special	55/80	same as earlier	
General Purpose	10	same as earlier	
Structural Waterproofing	15	same as earlier	
Personal Care			
Air Freshener:			
Single-Phase Aerosol	30	same as earlier	5
Double-Phase	25	20	5
Dual Purpose Air Freshener/Disinfectant	no standard	60	
Liquids/Pump Sprays	18	same as earlier	
Solids/semisolids	3	same as earlier	
Antiperspirants:			
Aerosol	40 HVOC; 10 HVOC		
Non-Aerosol	0		
Anti-Static Product:			
Aerosol	no standard	80	
Non-Aerosol	11	same as earlier	
Astringent/Toner	no standard	35	
Deodorants	various	same as earlier	
Disinfectants	no standard	70 aerosols, 1 non-aerosol	
Fabric Protectants:			
Aerosol	60	60	
Non-Aerosol	60	1	
Fabric Refresher	6-15 Aerosol	same as earlier	
Fragrance (<20%) [>20%]	no standard	(75) [65]	(50)
Hair Products	all types	same as earlier	
Hair Finishing Spray\Shine		55	50
Heavy-duty hand cleaner or soap	8	1	
Nail polish	75	1	
Shaving cream	5	same as earlier	
Shaving gel	7	4	
Coatings			
Automotive Wax, Polish, Sealant or Glaze:			
Hard Paste Waxes	45	same as earlier	
Instant Detailers	3	same as earlier	
All Other Forms	15	same as earlier	

Category	VOC % by Weight		Proposed California [a]
	OTC Earlier	OTC Phase V	
	2005/2009	2014/2019	2020
Floor Polishes or Waxes:			
Resilient Flooring Materials	7	1	
Nonresilient Flooring Materials	10	1	
Wood Floor Wax	90	70	
Floor Wax Strippers, Non-Aerosol	no standard	3 - 12 as used	
Metal polishes and cleaners	30	15 (3 non-aerosol)	
Paint removers or strippers	50	same as earlier	
Paint Thinner aerosol		10	
Paint Thinner nonaerosol		3	

[a] California measures that exceeded the stringency of the most recent OTC proposals are listed. Blank cells indicate that California VOC limits are consistent with OTC Phase V.

ATTACHMENT 1: EXISTING STATE REGULATIONS

State and Local Regulations by LADCO-wide emissions inventory groupings, organized from largest to smallest NOx+VOC contribution[27]

Category	Percent of 2016 Emissions LADCO-wide			On-the-Books /On-the-Way Regulations					
	NOx+VOC[28]	NOx	VOC	Michigan	Illinois	Indiana	Minnesota	Ohio[29]	Wisconsin
Mobile Sources									
Heavy Duty Haul Trucks	6.4%	12.1%	1.0%					Chapter 3745-80, Statewide Motor Vehicle Anti-Tampering Program [30]	Chapter NR 485 Control of Emissions from Motor Vehicles, Internal Combustion Engines and Mobile Sources; Tampering Prohibition[31]
Stationary Sources (Point and Non-Point Sources)									
Solvents: Consumer, Commercial, Household, Personal Care Products	7.4%		14.5%	Part 6. Emission Limitation and Prohibitions – Existing and New Sources of Volatile Organic Compounds Emissions (336.1660, 336.1661)[32]	Title 35, Part 223: Subpart B: Consumer and Commercial Products[33]	Title 326, Article 8-15 (Standards for Consumer and Commercial Products)[34]		Chapter 3745-112, Consumer Products[35] based on 2006 OTC model rule Phase II (statewide)	
Surface Coating	2.9%		5.7%	Part 6 and7. Emission Limitation and Prohibitions – Existing and New Sources of Volatile Organic Compounds Emissions (336.1610, 336.1620, 336.1621, 336.1632)[36]	Title 35, Parts 218 and 219: Subpart F: Coating Operations[37, 38]	Title 326, Article 8-14 Volatile Organic Compound Rules (Standards for Architectural and Industrial Maintenance (AIM) Coatings) [39]		Chapter 3745-21, Carbon Monoxide, Photochemically Reactive Materials, Hydrocarbons, and Related Materials Standards[40] (geographic applicability varies by control technique guideline "CTG")	Chapter NR 421 Control of Organic Compound Emissions from Chemical, Coatings And Rubber Products Manufacturing[41] Chapter NR 422 Control of Organic Compound Emissions from Surface Coating, Printing And Asphalt Surfacing Operations[42]
Agriculture - Pesticides Application & Livestock	2.2%		4.2%						
Graphic Arts	2.1%		4.1%	Part 6 and 7. Emission Limitation and Prohibitions – Existing and New Sources of Volatile Organic Compounds Emissions (336.1624)[43]	Title 35, Parts 218 and 219, Subpart H: Printing and Publishing: Printing and Publishing [44, 45]	Title 326, Article 8-16 (Offset Lithographic Printing and Letterpress Printing)[46]		Chapter 3745-21, Carbon Monoxide, Photochemically Reactive Materials, Hydrocarbons, and Related Materials Standards[47] (geographic applicability varies by CTG)	Chapter NR 422.14(422.145) Control of Organic Compound Emissions From Surface Coating, Printing And Asphalt Surfacing Operations[48]
Architectural Coatings	1.8%		3.5%		Title 35, Part 223, Subpart C, Architectural and Industrial Maintenance Coatings[49] Title 35, Parts 218 and 219, Subpart X: Construction[50, 51]	Title 326, Article 8-14 Volatile Organic Compound Rules (Standards for Architectural and Industrial Maintenance (AIM) Coatings)[52]		Chapter 3745-113, Architectural and Industrial Maintenance (AIM) Coatings[53] based on 2001 OTC model rule (statewide)	Chapter 422.15 Control of Organic Compound Emissions From Surface Coating, Printing And Asphalt Surfacing Operations[54]

27 2016v1 modeling platform for calendar year 2016 (v2016fh)
28 NOx+VOC values represent the ratio of NOx and VOC emissions by category to total NOx and VOC emissions in the 2016 LADCO inventory. The sum of individual NOx and VOC percentages does not equal the NOx+VOC value.
29 Ohio EPA has provided information on the geographical scope of Ohio regulations.
30 https://www.epa.ohio.gov/dapc/regs/3745_80
31 http://docs.legis.wisconsin.gov/code/admin_code/nr/400/485.pdf
32 https://dtmb.state.mi.us/ARS_Public/AdminCode/DownloadAdminCodeFile?FileName=1608_2016-003EQ_AdminCode.pdf
33 http://www.ilga.gov/commission/jcar/admincode/035/03500223sections.html
34 http://www.in.gov/legislative/iac/T03260/A00080.PDF
35 https://www.epa.ohio.gov/dapc/regs/3745_112
36 https://dtmb.state.mi.us/ARS_Public/AdminCode/DownloadAdminCodeFile?FileName=1608_2016-003EQ_AdminCode.pdf
37 https://pcb.illinois.gov/documents/dsweb/Get/Document-11930/
38 https://pcb.illinois.gov/documents/dsweb/Get/Document-11932/
39 http://www.in.gov/legislative/iac/T03260/A00080.PDF
40 https://www.epa.ohio.gov/dapc/regs/3745_21
41 https://docs.legis.wisconsin.gov/code/admin_code/nr/400/421
42 https://docs.legis.wisconsin.gov/code/admin_code/nr/400/422
43 https://dtmb.state.mi.us/ARS_Public/AdminCode/DownloadAdminCodeFile?FileName=1608_2016-003EQ_AdminCode.pdf
44 https://pcb.illinois.gov/documents/dsweb/Get/Document-11930/
45 https://pcb.illinois.gov/documents/dsweb/Get/Document-11932/
46 http://www.in.gov/legislative/iac/T03260/A00080.PDF
47 https://www.epa.ohio.gov/dapc/regs/3745_21
48 https://docs.legis.wisconsin.gov/code/admin_code/nr/400/422
49 https://casetext.com/regulation/illinois-administrative-code/title-35-environmental-protection/part-223-standards-and-limitations-for-organic-material-emissions-for-area-sources/subpart-c-architectural-and-industrial-maintenance-coatings
50 https://pcb.illinois.gov/documents/dsweb/Get/Document-11930/
51 https://pcb.illinois.gov/documents/dsweb/Get/Document-11932/
52 http://www.in.gov/legislative/iac/T03260/A00080.PDF
53 https://www.epa.ohio.gov/dapc/regs/3745_113
54 https://docs.legis.wisconsin.gov/code/admin_code/nr/400/422

ATTACHMENT 2: HHDV RATES EMFAC ADJUSTMENT FACTORS

SCC	avgSpeedBinID	AvgSpeed (mph)	Pollutant	EMFAC_toMOVES_adjFactor
2202510272	1	2.5	NOX	0.963606782
2202510272	2	5	NOX	1.792782273
2202510272	3	10	NOX	2.23428226
2202510272	4	15	NOX	1.953205493
2202510272	5	20	NOX	1.746376774
2202510272	6	25	NOX	1.616856167
2202510272	7	30	NOX	1.317279656
2202510272	8	35	NOX	1.156854887
2202510272	9	40	NOX	0.945959007
2202510272	10	45	NOX	0.799024998
2202510272	11	50	NOX	0.736938263
2202510272	12	55	NOX	0.765324146
2202510272	13	60	NOX	0.866887398
2202510272	14	65	NOX	1.06102694
2202510272	15	70	NOX	1.042471636
2202510272	16	75	NOX	0.946747639
2202510372	1	2.5	NOX	1.299050161
2202510372	2	5	NOX	2.086737539
2202510372	3	10	NOX	2.266359085
2202510372	4	15	NOX	1.934661885
2202510372	5	20	NOX	1.737099537
2202510372	6	25	NOX	1.616372294
2202510372	7	30	NOX	1.323962222
2202510372	8	35	NOX	1.176748886
2202510372	9	40	NOX	0.966972274
2202510372	10	45	NOX	0.81914334
2202510372	11	50	NOX	0.757651003
2202510372	12	55	NOX	0.79053071
2202510372	13	60	NOX	0.894694163
2202510372	14	65	NOX	1.0915587
2202510372	15	70	NOX	1.06626818
2202510372	16	75	NOX	0.962474113
2202510472	1	2.5	NOX	0.963606782
2202510472	2	5	NOX	1.792782273
2202510472	3	10	NOX	2.234282261
2202510472	4	15	NOX	1.953205493
2202510472	5	20	NOX	1.746376775
2202510472	6	25	NOX	1.616856167
2202510472	7	30	NOX	1.317279657
2202510472	8	35	NOX	1.156854888
2202510472	9	40	NOX	0.945959007
2202510472	10	45	NOX	0.799024998
2202510472	11	50	NOX	0.736938263
2202510472	12	55	NOX	0.765324146
2202510472	13	60	NOX	0.866887398
2202510472	14	65	NOX	1.06102694
2202510472	15	70	NOX	1.042471637
2202510472	16	75	NOX	0.946747639
2202510572	1	2.5	NOX	1.299050161
2202510572	2	5	NOX	2.086737539
2202510572	3	10	NOX	2.266359084
2202510572	4	15	NOX	1.934661885
2202510572	5	20	NOX	1.737099536
2202510572	6	25	NOX	1.616372294
2202510572	7	30	NOX	1.323962222
2202510572	8	35	NOX	1.176748886
2202510572	9	40	NOX	0.966972274
2202510572	10	45	NOX	0.81914334
2202510572	11	50	NOX	0.757651003
2202510572	12	55	NOX	0.79053071
2202510572	13	60	NOX	0.894694163
2202510572	14	65	NOX	1.0915587
2202510572	15	70	NOX	1.06626818
2202510572	16	75	NOX	0.962474113
2202610272	1	2.5	NOX	1.218126431
2202610272	2	5	NOX	2.249430345
2202610272	3	10	NOX	2.819766262
2202610272	4	15	NOX	2.457787812

SCC	avgSpeedBinID	AvgSpeed (mph)	Pollutant	EMFAC_toMOVES_adjFactor
2202610272	5	20	NOX	2.188628062
2202610272	6	25	NOX	2.018815016
2202610272	7	30	NOX	1.631670643
2202610272	8	35	NOX	1.419598104
2202610272	9	40	NOX	1.146989656
2202610272	10	45	NOX	0.957744927
2202610272	11	50	NOX	0.874337393
2202610272	12	55	NOX	0.90600933
2202610272	13	60	NOX	1.035273918
2202610272	14	65	NOX	1.267776376
2202610272	15	70	NOX	1.236649333
2202610272	16	75	NOX	1.116495113
2202610372	1	2.5	NOX	1.210965843
2202610372	2	5	NOX	2.266959677
2202610372	3	10	NOX	2.808119628
2202610372	4	15	NOX	2.427179791
2202610372	5	20	NOX	2.166119203
2202610372	6	25	NOX	2.005061313
2202610372	7	30	NOX	1.623807385
2202610372	8	35	NOX	1.427139373
2202610372	9	40	NOX	1.157311773
2202610372	10	45	NOX	0.969233629
2202610372	11	50	NOX	0.887966391
2202610372	12	55	NOX	0.922980645
2202610372	13	60	NOX	1.053436766
2202610372	14	65	NOX	1.285039565
2202610372	15	70	NOX	1.248819759
2202610372	16	75	NOX	1.122475125
2202610472	1	2.5	NOX	1.218126432
2202610472	2	5	NOX	2.249430345
2202610472	3	10	NOX	2.819766262
2202610472	4	15	NOX	2.457787812
2202610472	5	20	NOX	2.188628063
2202610472	6	25	NOX	2.018815017
2202610472	7	30	NOX	1.631670643
2202610472	8	35	NOX	1.419598104
2202610472	9	40	NOX	1.146989656
2202610472	10	45	NOX	0.957744928
2202610472	11	50	NOX	0.874337393
2202610472	12	55	NOX	0.906009331
2202610472	13	60	NOX	1.035273918
2202610472	14	65	NOX	1.267776376
2202610472	15	70	NOX	1.236649333
2202610472	16	75	NOX	1.116495113
2202610572	1	2.5	NOX	1.210965843
2202610572	2	5	NOX	2.266959677
2202610572	3	10	NOX	2.808119628
2202610572	4	15	NOX	2.427179791
2202610572	5	20	NOX	2.166119203
2202610572	6	25	NOX	2.005061312
2202610572	7	30	NOX	1.623807385
2202610572	8	35	NOX	1.427139373
2202610572	9	40	NOX	1.157311773
2202610572	10	45	NOX	0.969233629
2202610572	11	50	NOX	0.887966391
2202610572	12	55	NOX	0.922980645
2202610572	13	60	NOX	1.053436766
2202610572	14	65	NOX	1.285039565
2202610572	15	70	NOX	1.248819759
2202610572	16	75	NOX	1.122475124
2202620272	1	2.5	NOX	1.226161167
2202620272	2	5	NOX	2.266228868
2202620272	3	10	NOX	2.772673461
2202620272	4	15	NOX	2.45059298
2202620272	5	20	NOX	2.198478106
2202620272	6	25	NOX	2.056004798
2202620272	7	30	NOX	1.704298074
2202620272	8	35	NOX	1.514841127
2202620272	9	40	NOX	1.272320173
2202620272	10	45	NOX	1.106075827

SCC	avgSpeedBinID	AvgSpeed (mph)	Pollutant	EMFAC_toMOVES_adjFactor
2202620272	11	50	NOX	1.037806604
2202620272	12	55	NOX	1.077757027
2202620272	13	60	NOX	1.211991107
2202620272	14	65	NOX	1.438424361
2202620272	15	70	NOX	1.412568667
2202620272	16	75	NOX	1.292493923
2202620372	1	2.5	NOX	1.218182958
2202620372	2	5	NOX	2.28031921
2202620372	3	10	NOX	2.758472358
2202620372	4	15	NOX	2.419412695
2202620372	5	20	NOX	2.174471233
2202620372	6	25	NOX	2.039888941
2202620372	7	30	NOX	1.694148763
2202620372	8	35	NOX	1.518643747
2202620372	9	40	NOX	1.27914731
2202620372	10	45	NOX	1.114716516
2202620372	11	50	NOX	1.048762901
2202620372	12	55	NOX	1.091972319
2202620372	13	60	NOX	1.227724179
2202620372	14	65	NOX	1.452602492
2202620372	15	70	NOX	1.42208161
2202620372	16	75	NOX	1.296543554
2202620472	1	2.5	NOX	1.226161167
2202620472	2	5	NOX	2.266228868
2202620472	3	10	NOX	2.772673461
2202620472	4	15	NOX	2.45059298
2202620472	5	20	NOX	2.198478106
2202620472	6	25	NOX	2.056004798
2202620472	7	30	NOX	1.704298074
2202620472	8	35	NOX	1.514841128
2202620472	9	40	NOX	1.272320174
2202620472	10	45	NOX	1.106075827
2202620472	11	50	NOX	1.037806604
2202620472	12	55	NOX	1.077757027
2202620472	13	60	NOX	1.211991107
2202620472	14	65	NOX	1.438424361
2202620472	15	70	NOX	1.412568674
2202620472	16	75	NOX	1.292493923
2202620572	1	2.5	NOX	1.22
2202620572	2	5	NOX	2.28
2202620572	3	10	NOX	2.76
2202620572	4	15	NOX	2.42
2202620572	5	20	NOX	2.17
2202620572	6	25	NOX	2.04
2202620572	7	30	NOX	1.69
2202620572	8	35	NOX	1.52
2202620572	9	40	NOX	1.28
2202620572	10	45	NOX	1.11
2202620572	11	50	NOX	1.05
2202620572	12	55	NOX	1.09
2202620572	13	60	NOX	1.23
2202620572	14	65	NOX	1.45
2202620572	15	70	NOX	1.42
2202620572	16	75	NOX	1.30