

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT

Draft Proposed Rule 2306 Calculation Methodology

Proposed Rule 2306 – Freight Rail Yards Proposed Rule 316.2 – Fees for Rule 2306

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This document provides the methodology for calculating: 1) Actual Annual NOx Emissions for the Freight Rail Yard; 2) Annual Reference NOx Emissions for the Freight Rail Yard; and 3) Aggregate Emission Factor for the Freight Rail Yard, as required under Proposed Rule 2306 – Freight Rail Yards (PR 2306).

The data tables for input parameters referenced in emissions calculation equations in this methodology document are provided in the Data Appendix to Draft Proposed Rule 2306 Calculation Methodology (herein “Data Appendix”).

For all emission calculations described below, supporting documentation must be provided if actual operating parameters are used in lieu of default parameters (if provided in equations) for applicable mobile sources operating at and travelling through the freight rail yards.

1. Actual Annual NOx Emissions for a Freight Rail Yard

This section outlines the methodologies to calculate the actual NOx emissions for a freight rail yard for each milestone year from the applicable mobile sources, including locomotives, drayage trucks, CHE, TRU, and OSE, to be used in PR 2306 Equation 1, Equation 2, and Equation 3, as applicable.

A. Locomotives

This section provides the detailed methodology to calculate the actual annual NOx emissions for each milestone year from all locomotives operating at the freight rail yard(s), which are operated by the same freight rail yard operator, within the State of California or within South Coast AQMD.

The statewide actual annual NOx emissions from all locomotives operated by the same freight rail yard within the State of California are calculated based on the annual usage in megawatt-hours (MWhr) in non-zero-emissions (ZE) configuration for all locomotives operating at all freight rail yards in California operated by the same freight rail yard operator in conjunction with the corresponding average NOx emission factors by locomotive Tier level using the following equation:

$$CAEL_i = \left\{ \sum_l \left[(CAMWhr_{l,i} - CAMWhr_{l,i}^{ze}) \times CF \times EF_l \right] \right\} \times U \quad (\text{Equation 1.A.1})$$

Where:

$CAEL_i$ = Actual NOx emissions (in tons) from all Locomotives operated by the same Freight Rail Yard Operator within the State of California in year i

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$CAMW hr_{l,i}$ = Annual usage (in megawatt-hours) of Locomotive l operated by the same Freight Rail Yard Operator within the State of California in year i

$CAMW hr_{l,i}^{ze}$ = Annual usage (in megawatt-hours) in ZE Configuration of Locomotive l operated by the same Freight Rail Yard Operator within the State of California in year i

CF = Conversion factor for megawatt to horsepower (1341.02)

EF_l = Average NOx emission factor for Locomotive l (in grams per brake horsepower-hour), as specified in Data Appendix, Table A-1

U = Unit conversion factor for grams to tons (1/907,180¹)

The average NOx emission factors for locomotives are based on EPA's average emission factors for line-haul and switcher locomotives by locomotive Tier level² and are provided in Data Appendix, Table A-1.

The actual annual NOx emissions for all locomotives operating at and travelling to and from a freight rail yard within South Coast AQMD is calculated based on the total annual usage in MWhr in non-ZE configuration for locomotives operating within South Coast AQMD, NOx emission factors for locomotives, and the number of days locomotives operated at and travelling to and from this freight rail yard compared to the total number of days that locomotives operated at and travelling to and from all freight rail yards by the same freight rail yard operator within South Coast AQMD using the following equation:

$$EL_i = \left\{ \sum_l \left[(MWhr_{l,i} - MWhr_{l,i}^{ze}) \times CF \times EF_l \times \frac{DaysFRY_{l,i}}{\sum_y DaysALLFRY_{l,i,y}} \right] \right\} \times U \quad (\text{Equation 1.A.2})$$

Where:

EL_i = Actual NOx emissions (in tons) from all Locomotives operating at and travelling to and from the Freight Rail Yard in year i

$MWhr_{l,i}$ = Annual usage (in megawatt-hours) by Locomotive l operating within the South Coast AQMD jurisdiction in year i

$MWhr_{l,i}^{ze}$ = Annual usage (in megawatt-hours) in ZE Configuration by Locomotive l operating within the South Coast AQMD jurisdiction in year i

CF = Conversion factor for megawatt to horsepower (1341.02)

¹ Tons to grams conversion: 453.59 grams/pound X 2000 pounds/ton = 907,180 grams/ton

² EPA's Emission Factors for Locomotives (Tables 1 and 2), EPA-420-F-09-025, April 2009

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EF_l = NOx emission rate based on the duty cycle weighted emission test results as provided in Locomotive l 's Locomotive Engine Certification Data, or the average NOx emission factor for

Locomotive l (in grams per brake horsepower-hour) as specified in Data Appendix, Table A-1

$DaysFRY_{l,i}$ = Total number of days Locomotive l operating at and travelling to and from the Freight Rail Yard in year i

$DaysALLFRY_{l,i,y}$ = Total number of days Locomotive l operating at and travelling to and from any Freight Rail Yard y within the South Coast AQMD jurisdiction in year i

U = Unit conversion factor for grams to tons (1/907,180)

The NOx emission factors for locomotives in this equation can be based on the locomotive engine certification data (i.e., duty cycle weighted emission test result), if available, or based on the EPA's average emission factors by locomotive Tier level provided in Data Appendix, Table A-1. The locomotive engine certification data must be provided as supporting documentation if used in emission calculation for any locomotive in this equation.

The total annual MWhr usage of locomotives may be directly obtained from locomotives megawatt-hour meters or calculated based on the locomotives fuel consumption in gallons using the following equation and conversion factors for line-haul and switcher locomotives provided in Data Appendix Table A-2.

$$MWhr_{l,i} = Fuel\ Consumption_{l,i} \times Conversion\ Factor_l \quad (Equation\ 1.A.2.a)$$

The conversion factors for line-haul and switcher locomotives in MWhr/gal are extracted from CARB's In-Use Locomotive Regulation.³

³ CARB's In-Use Locomotive Regulation, Table 1; <https://ww2.arb.ca.gov/rulemaking/2022/locomotive>

B. Drayage Trucks

This section provides the detailed methodology to calculate the actual annual NOx emissions for each milestone year from all drayage trucks operating at and travelling to and from the freight rail yard(s) within the State of California or within South Coast AQMD based on the number of individual truck trips to the freight rail yard(s) within the applicable jurisdiction, miles traveled to and from the freight rail yard(s) using the actual mileage or a default mileage (39.9 miles per trip), and the corresponding composite NOx emission factors by truck model year provided in Data Appendix, Tables B-1 through B-4 using the following equation:

$$EDT_i = \sum_d [NT_{d,i} \times VMT_{d,i} \times EF_{d,i}] \times U \quad (\text{Equation 1.B.1})$$

Where:

EDT_i = Actual NOx emissions (in tons) from all Drayage Truck operating at and travelling to and from the Freight Rail Yard within the applicable jurisdiction in year i

$NT_{d,i}$ = Number of Truck Trips by Drayage Truck d in year i to and from the Freight Rail Yard, calculated as total number of unique entry date(s) multiplied by 2

$VMT_{d,i}$ = Actual vehicle miles traveled by Drayage Truck d in year i to and from the Freight Rail Yard, or use default factor of 39.9 miles/trip

$EF_{d,i}$ = Composite emission factor for Drayage Truck d (in grams per mile by model year) in year i , as specified in Data Appendix, Tables B-1 through B-4, or 0 if Drayage Truck d operates in ZE Configuration

U = Unit conversion factor for grams to tons (1/907,180)

The composite NOx emission factors for drayage trucks by truck model year are derived from CARB's EMFAC2021 Model⁴ for T7 Tractor Class 8 category by calendar year (EMFAC2021 Emissions Run for statewide or South Coast regions at aggregate speed), and they also reflect the impact of CARB's Heavy-Duty Inspection and Maintenance Regulation⁵. The default mileage of 39.9 miles per round trip for drayage trucks visiting a freight rail yard is derived from 2016 Regional Transportation Plan documents.⁶

⁴ EMFAC2021: <https://arb.ca.gov/emfac/>

⁵ CARB's Heavy-Duty Inspection and Maintenance Program: <https://ww2.arb.ca.gov/our-work/programs/CTC>

⁶ 2016-2040 Regional Transportation Plan/Sustainable Communities Strategy <https://scag.ca.gov/2016-rtpscs>

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The model year and fuel type of the drayage trucks operating at and travelling to and from the freight rail yard can be directly tracked by the freight rail yard operator or obtained from the truck's vehicle identification number (VIN) tracked by the freight rail yard operator using publicly available tools such as from the National Highway Traffic Safety Administration (NHTSA) at: <https://vpic.nhtsa.dot.gov/api/>.

C. TRU

This section provides the detailed methodology to calculate the actual annual NO_x emissions for each milestone year from all TRU operating at and travelling to and from a freight rail yard within South Coast AQMD. The actual annual NO_x emissions for TRU operating at and travelling to and from the freight rail yard are calculated based on the maximum rated horsepower (hp), load factor, annual operating hours, fuel correction factor, and emission factor for each TRU using the following equation:

$$ETRU_i = \sum_r [HP_{r,i} \times LF_{r,i} \times (HR_{r,i} - HR_{r,i}^{ZE}) \times EF_{r,i} \times FCF_{r,i}] \times U \quad (\text{Equation 1.C.1})$$

Where:

$ETRU_i$ = Actual NO_x emissions (in tons) from all TRUs operating at and travelling to and from the Freight Rail Yard in year i

$HP_{r,i}$ = Maximum rated horsepower for TRU r operating at and travelling to and from the Freight Rail Yard in year i

$LF_{r,i}$ = Load factor for TRU r operating at and travelling to and from the Freight Rail Yard in year i , as specified in Data Appendix, Table C-1

$HR_{r,i}$ = Annual operating hours for TRU r operating at and travelling to and from the Freight Rail Yard in year i

$HR_{r,i}^{ZE}$ = Annual operating hours in ZE Configuration for TRU r operating at and travelling to and from the Freight Rail Yard in year i

$EF_{r,i}$ = Emission factor (in grams per brake horsepower-hour) for TRU r operating at and travelling to and from the Freight Rail Yard in year i , using Equation 1.C.1.a

$FCF_{r,i}$ = Fuel Correction Factor for TRU r operating at and travelling to and from the Freight Rail Yard in year i , as specified in Data Appendix, Table F-1

U = Unit conversion factor for grams to tons (1/907,180)

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Load factors for various TRU types and horsepower categories are provided in Data Appendix, Table C-1 and are based on CARB's TRU documentation⁷. The fuel correction factors for TRU by fuel type are provided in Data Appendix, Table F-1 and are based on CARB's Offroad documentation⁸.

If hp data for TRU is not available, the default hp values provided in Data Appendix, Table C-4 may be used in Equation 1.C.1. The default hp values are based on CARB's TRU documentation⁹.

The emission factor for each TRU is calculated based on the zero-hour emission factor, deterioration rate, and accumulated operating hours (reflecting equipment age and capped at 12,000 hours) for each TRU operating at the freight rail yard using the following equation:

$$EF_{r,i} = [EFzh_{r,i} + (DR_{r,i} \times AccumulatedHours_{r,i})] \quad (Equation 1.C.1.a)$$

Where:

$EFzh_{r,i}$ = Zero-hour emission factor (in gram per brake horsepower-hour) for TRU r operating at and traveling to and from the Freight Rail Yard in year i , pursuant to Data Appendix, Tables F-2 through F-10

$DR_{r,i}$ = Deterioration rate (in grams per brake horsepower per squared-hour) for TRU r operating at and traveling to and from the Freight Rail Yard in year i , pursuant to Data Appendix, Tables F-2 through F-10

$AccumulatedHours_{r,i}$ = Total hours from the unit's non-resettable hour-meter, if available; otherwise, the average annual operating hours times the age of TRU r (capped at 12,000 hours) in year i

The zero-hour emission factors and deterioration rates for each TRU type, fuel type, hp bin, and model year are provided in Data Appendix, Tables F-2 to F-10 and are based on CARB's OffRoad

⁷ CARB's TRU documentation (Table 10 in Appendix H);

<https://ww2.arb.ca.gov/sites/default/files/barcu/board/rulemaking/tru2021/apph.pdf>

⁸ 2017 OffRoad Diesel, Propane and Gasoline Emission Factors; <https://ww2.arb.ca.gov/our-work/programs/msei/road-categories/road-diesel-models-and-documentation>

⁹ CARB's TRU documentation (Table 3 in Appendix H);

<https://ww2.arb.ca.gov/sites/default/files/barcu/board/rulemaking/tru2021/apph.pdf>

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documentation¹⁰. The accumulated hours for each OSE can be determined based on the total hours from the unit's non-resettable hour-meter or calculated based on the average annual operating hours times the age of the unit. The accumulated hours are capped at 12,000 hours based on CARB's documentation¹¹. If model year data is not available for each TRU, then a default age of 7 years can be used for all TRUs.¹²

The annual operating hours for each TRU must be based on the following order of hierarchy pending availability of operational data: 1) non-resettable hour-meters, 2) maintenance records, 3) fuel consumption data, or 4) default average operating hours for each TRU type provided in Data Appendix, Table C-2. adjusted for the TRU operating at and traveling to and from the freight rail yard. For each TRU, only one method for annual operating hours can be used for all milestone years to prevent potential variations between these methods affecting the actual annual emissions.

If the fuel consumption data for TRU operating at and traveling to and from the rail yard is available, the annual operating hours can be estimated using the following equation and fuel consumption conversion factors conversion factors in Data Appendix, Table F-11.

$$HR_{r,i} = Fuel\ Consumption_{r,i} \times Conversion\ Factor_{A2} \div (HP_{r,i} \times LF_{r,i})$$

(Equation 1.C.1.b)

The fuel consumption conversion factors in Data Appendix, Table F-11 are derived from brake-specific fuel consumption rates from CARB's Offroad documentation¹³ and density for each fuel type.

The total annual operating hours for TRU r operating and travelling to and from the rail yard can also be proportioned from the total operating hours for TRU r within the South Coast AQMD jurisdiction and the number of days TRU r operated at and travelled to and from this freight rail

¹⁰ 2017 OffRoad Diesel, Propane and Gasoline Emission Factors; <https://ww2.arb.ca.gov/our-work/programs/msei/road-categories/road-diesel-models-and-documentation>

¹¹ CARB 2011 CHE Documentation
<https://ww2.arb.ca.gov/our-work/programs/mobile-source-emissions-inventory/road-documentation/msei-documentation-road>

¹² Figure 6 from CARB's TRU Emissions Inventory shows that 7 years is a conservative default age assumption based on actual data. <https://ww2.arb.ca.gov/sites/default/files/barcu/board/rulemaking/tru2021/apph.pdf>

¹³ 2017 OffRoad Diesel, Propane and Gasoline Emission Factors; <https://ww2.arb.ca.gov/our-work/programs/msei/road-categories/road-diesel-models-and-documentation>

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yard compared to the total number of days that TRU r operated at South Coast AQMD jurisdiction using Equation 1.C.1.c below.

$$HR_{r,i} = HrSC_{r,i} \times \frac{DaysFRY_{r,i}}{DaysALLSC_{r,i}} \quad (\text{Equation 1.C.1.c})$$

Where:

$HrSC_{r,i}$ = Total number of hours TRU r operating within the South Coast AQMD jurisdiction in year i

$DaysFRY_{r,i}$ = Total number of days TRU r operating at and travelling to and from the Freight Rail Yard in year i

$DaysALLSC_{r,i}$ = Total number of days TRU r operating within the South Coast AQMD jurisdiction in year i

For TRU, the annual operating hours can also be calculated using Equation 1.C.1.d below.

$$HR_{r,i} = Time_{Onroad,r} + Time_{Onrail,r} + Time_{Onyard,r} \quad (\text{Equation 1.C.1.d})$$

Where:

$Time_{Onroad,r}$ = 39.9 miles per trip \div 47 miles per hour (using default values from the Regional Transportation Plan)¹⁴. This parameter is 0 for railcar TRUs.

$Time_{Onrail,r}$ = Distance via rail from rail yard to South Coast AQMD boundary (miles) \div annual average intermodal velocity (miles per hour)¹⁵

$Time_{Onyard,r}$ = Annual average terminal dwell time¹⁶

D. CHE

This section provides the detailed methodology to calculate the actual annual NOx emissions for each milestone year from all CHE operating at and travelling to and from a freight rail yard within South Coast AQMD. The actual annual NOx emissions for CHE operating at and travelling to and

¹⁴ SCAG 2016 RTP and [Regional Travel Demand Model Validation](#)

¹⁵ Available in reports to Surface Transportation Board here: <https://www.stb.gov/reports-data/rail-service-data/>

¹⁶ Ibid

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from the freight rail yard are calculated based on the maximum rated horsepower (hp), load factor, annual operating hours, fuel correction factor, and emission factors for each CHE using the following equation:

$$ECHE_i = \sum_c [HP_{c,i} \times LF_{c,i} \times (HR_{c,i} - HR_{c,i}^{ZE}) \times EF_{c,i} \times FCF_{c,i}] \times U \quad (\text{Equation 1.D.1})$$

Where:

$ECHE_i$ = Actual NO_x emissions (in tons) from all CHE operating at and traveling to and from the Freight Rail Yard in year i

$HP_{c,i}$ = Maximum rated horsepower for CHE c operating at and traveling to and from the Freight Rail Yard in year i

$LF_{c,i}$ = Load factor for CHE c operating at and traveling to and from the Freight Rail Yard in year i , as specified in Data Appendix, Table D-1

$HR_{c,i}$ = Annual operating hours for CHE c operating at and traveling to and from the Freight Rail Yard in year i

$HR_{c,i}^{ZE}$ = Annual operating hours in ZE Configuration for CHE c operating at and traveling to and from the Freight Rail Yard in year i

$EF_{c,i}$ = Emission factor (in grams per brake horsepower-hour) for CHE c operating at and traveling to and from the Freight Rail Yard in year i , using Equation 1.D.1.a

$FCF_{c,i}$ = Fuel Correction Factor for CHE c operating at and traveling to and from Freight Rail Yard y in year i , as specified in Data Appendix, Table F-1

U = Unit conversion factor for grams to tons (1/907,180)

Load factors for various CHE types and horsepower categories and the fuel correction factors are provided in Data Appendix, Table D-1 and Table F-1, respectively and are based on CARB's OffRoad documentation¹⁷.

The emission factor for each CHE is calculated based on the zero-hour emission factor, deterioration rate, and accumulated operating hours (reflecting equipment age and capped at 12,000 hours) for each CHE operating at the freight rail yard using the following equation:

¹⁷ 2017 OffRoad Diesel, Propane and Gasoline Emission Factors; <https://ww2.arb.ca.gov/our-work/programs/msei/road-categories/road-diesel-models-and-documentation>

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$$EF_{c,i} = [EFzh_{c,i} + (DR_{c,i} \times AccumulatedHours_{c,i})] \quad (Equation 1.D.1.a)$$

Where:

$EFzh_{c,i}$ = Zero-hour emission factor (in gram per brake horsepower-hour) for CHE c operating at and traveling to and from the Freight Rail Yard in year i , pursuant to Data Appendix, Tables F-2 through F-10

$DR_{c,i}$ = Deterioration rate (in grams per break horsepower per squared-hour) for CHE c operating at and traveling to and from the Freight Rail Yard in year i , pursuant to Data Appendix, Tables F-2 through F-10

$AccumulatedHours_{c,i}$ = Total hours from the unit's non-resettable hour-meter, if available; otherwise, the average annual operating hours times the age of CHE c (capped at 12,000 hours) in year i

The zero-hour emission factors and deterioration rates for each CHE type, fuel type, hp bin, and model year are provided in Data Appendix, Tables F-2 to F-10 are based on CARB's OffRoad documentation¹⁸. The accumulated hours for each CHE can be determined based on the total hours from the unit's non-resettable hour-meter or calculated based on the average annual operating hours times the age of the unit. The accumulated hours are capped at 12,000 hours based on CARB's documentation¹⁹.

The annual operating hours for each CHE must be based on the following order of hierarchy pending availability of operational data: 1) non-resettable hour-meters, 2) maintenance records, or 3) fuel consumption data. If the fuel consumption data for CHE operating at and traveling to and from the rail yard is available, the annual operating hours can be estimated using the Equation 1.C.1.b and the fuel consumption conversion factors in Data Appendix, Table F-11. For each CHE, only one method for annual operating hours can be used for all milestone years to prevent potential variations between these methods affecting the actual annual emissions.

¹⁸ 2017 OffRoad Diesel, Propane and Gasoline Emission Factors; <https://ww2.arb.ca.gov/our-work/programs/msei/road-categories/road-diesel-models-and-documentation>

¹⁹ CARB 2011 CHE Documentation
<https://ww2.arb.ca.gov/our-work/programs/mobile-source-emissions-inventory/road-documentation/msei-documentation-road>

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The fuel consumption conversion factors in Data Appendix, Table F-11 are derived from brake-specific fuel consumption rates from CARB's Offroad documentation²⁰ and density for each fuel type.

E. OSE

This section provides the detailed methodology to calculate the actual annual NOx emissions for each milestone year from all OSE operating at and travelling to and from a freight rail yard within South Coast AQMD. The actual annual NOx emissions for OSE operating at and travelling to and from the freight rail yard are calculated based on the maximum rated horsepower (hp), load factor, annual operating hours, fuel correction factor, and emission factor for each OSE using the following equation:

$$EOSE_i = \sum_o [HP_{o,i} \times LF_{o,i} \times (HR_{o,i} - HR_{o,i}^{ZE}) \times EF_{o,i} \times FCF_{o,i}] \times U \quad (\text{Equation 1.E.1})$$

Where:

$EOSE_i$ = Actual NOx emissions (in tons) for all OSE operating at and traveling to and from the Freight Rail Yard in year i

$HP_{o,i}$ = Maximum rated horsepower for OSE o operating at and traveling to and from the Freight Rail Yard in year i

$LF_{o,i}$ = Load factor for OSE o operating at and traveling to and from the Freight Rail Yard in year i , as specified in Data Appendix, Table E-1

$HR_{o,i}$ = Annual operating hours for OSE o operating at and traveling to and from the Freight Rail Yard in year i

$HR_{o,i}^{ZE}$ = Annual operating hours in ZE Configuration for OSE o operating at and traveling to and from the Freight Rail Yard in year i

$EF_{o,i}$ = Emission factor (in grams per brake horsepower-hour) for OSE o operating at and traveling to and from the Freight Rail Yard in year i , using Equation 1.E.1.a

$FCF_{o,i}$ = Fuel Correction Factor for OSE o operating at and traveling to and from the Freight Rail Yard in year i , as specified in Data Appendix, Table F-1

U = Unit conversion factor for grams to tons (1/907,180)

²⁰ 2017 OffRoad Diesel, Propane and Gasoline Emission Factors; <https://ww2.arb.ca.gov/our-work/programs/msei/road-categories/road-diesel-models-and-documentation>

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Load factors for various OSE types and horsepower categories and the fuel correction factors are provided in Data Appendix, Table E-1 and Table F-1, respectively, and are based on CARB's OffRoad documentation²¹.

The emission factor for each OSE is calculated based on the zero-hour emission factor, deterioration rate, and accumulated operating hours (reflecting equipment age and capped at 12,000 hours) for each OSE operating at the freight rail yard using the following equation:

$$EF_{o,i} = [EFzh_{o,i} + (DR_{o,i} \times AccumulatedHours_{o,i})] \quad (Equation 1.E.1.a)$$

Where:

$EFzh_{o,i}$ = Zero-hour emission factor (in gram per brake horsepower-hour) for OSE o operating at and traveling to and from the Freight Rail Yard in year i , pursuant to Data Appendix, Tables F-2 through F-10

$DR_{o,i}$ = Deterioration rate (in grams per break horsepower per squared-hour) for OSE o operating at and traveling to and from the Freight Rail Yard in year i , pursuant to Data Appendix Tables F-2 through F-10

$AccumulatedHours_{o,i}$ = Total hours from the unit's non-resettable hour-meter, if available; otherwise, the average annual operating hours times the age of OSE o (capped at 12,000 hours) in year i

The zero-hour emission factors and deterioration rates for each OSE type, fuel type, hp bin, and model year are provided in Data Appendix, Tables F-2 through F-10 are based on CARB's OffRoad documentation²². The accumulated hours for each OSE can be determined based on the total hours from the unit's non-resettable hour-meter or calculated based on the average annual operating hours times the age of the unit. The accumulated hours are capped at 12,000 hours based on CARB's documentation²³.

²¹ 2017 OffRoad Diesel, Propane and Gasoline Emission Factors; <https://ww2.arb.ca.gov/our-work/programs/msei/road-categories/road-diesel-models-and-documentation>

²² 2017 OffRoad Diesel, Propane and Gasoline Emission Factors; <https://ww2.arb.ca.gov/our-work/programs/msei/road-categories/road-diesel-models-and-documentation>

²³ CARB 2011 CHE Documentation

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The annual operating hours for each OSE must be based on the following order of hierarchy pending availability of operational data: 1) non-resettable hour-meters, 2) maintenance records, or 3) fuel consumption data. If the fuel consumption data for OSE operating at and traveling to and from the rail yard is available, the annual operating hours can be estimated using the Equation 1.C.1.b and the fuel consumption conversion factors in Data Appendix, Table F-11. For each OSE, only one method for annual operating hours can be used for all milestone years to prevent potential variations between these methods affecting the actual annual emissions.

The fuel consumption conversion factors in Data Appendix, Table F-11 are derived from brake-specific fuel consumption rates from CARB's Offroad documentation²⁴ and density for each fuel type.

2. Annual Reference NOx Emissions for a Freight Rail Yard

This section outlines the methodologies to calculate the annual reference scenario NOx emissions for each milestone year from applicable mobile sources including locomotives, drayage trucks, CHE, TRU, and OSE, to be used in PR 2306 Equation 1 and Equation 2, as applicable.

A. Locomotives

This section provides the detailed methodology to calculate the annual reference NOx emissions for each milestone year from locomotives operating at the freight rail yard(s) by the same freight rail yard operator within the State of California or within South Coast AQMD.

The statewide annual reference NOx emissions are calculated based on the annual usage in megawatt-hours (MWhr) in non-zero-emissions (ZE) configuration for all locomotives operating at all freight rail yards in California operated by the same freight rail yard operator in conjunction with the composite emission factors by locomotive type (line-haul or switcher) and by calendar year in Data Appendix, Table A-3 using the following equation:

$$CAEL_{i,RS} = \left[\sum_i (CAMW hr_{l,i} \times CF \times EF_{l,RS}) \right] \times U \quad (\text{Equation 2.A.1})$$

Where:

<https://ww2.arb.ca.gov/our-work/programs/mobile-source-emissions-inventory/road-documentation/msei-documentation-road>

²⁴ 2017 OffRoad Diesel, Propane and Gasoline Emission Factors; <https://ww2.arb.ca.gov/our-work/programs/msei/road-categories/road-diesel-models-and-documentation>

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$CAEL_{i,RS}$ = Reference Scenario (RS) NOx emissions (in tons) from all Locomotives operated by the same Freight Rail Yard Operator within the State of California in year i

$CAMW hr_{l,i}$ = Annual usage (in megawatt-hours) of Locomotive l operated by the same Freight Rail Yard Operator within the State of California in year i

CF = Conversion factor for megawatt to horsepower (1341.02)

$EF_{l,RS}$ = Composite NOx emission factor for Locomotive l (in grams per brake horsepower-hour) under Reference Scenario (RS), as specified in Data Appendix, Table A-3

U = Unit conversion factor for grams to tons (1/907,180)

The annual reference NOx emissions for all locomotives operating at and travelling to and from a freight rail yard within South Coast AQMD is calculated based on the annual usage in MWhr in non-ZE configuration for these locomotives in conjunction with the composite emission factors by locomotive type (line-haul or switcher) and by calendar year, and the number of days locomotives operated at this freight rail yard compared to the total number of days that locomotives operated at all freight rail yards operated by the same operator within South Coast AQMD using the following equation:

$$EL_{i,RS} = \left[\sum_l \left(MW hr_{l,i} \times CF \times \frac{DaysFRY_{l,i}}{\sum_y DaysALLFRY_{l,i,y}} \right) \right] \times EF_{i,RS} \times U \quad (Equation 2.A.2)$$

Where:

$EL_{i,RS}$ = Reference Scenario (RS) NOx emissions (in tons) from all Locomotives operating at and travelling to and from the Freight Rail Yard in year i

$MW hr_{l,i}$ = Annual usage (in megawatt-hours) by Locomotive l operating within the South Coast AQMD jurisdiction in year i

CF = Conversion factor for megawatt to horsepower (1341.02)

$EF_{l,RS}$ = Composite NOx emission factor (in grams per brake horsepower-hour) under Reference Scenario (RS) in year i , as specified in Data Appendix, Table A-3

$DaysFRY_{l,i}$ = Total number of days Locomotive l operating at and travelling to and from the Freight Rail Yard in year i

$DaysALLFRY_{l,i,y}$ = Total number of days Locomotive l operating at and travelling to and from any Freight Rail Yard y within the South Coast AQMD jurisdiction in year I

U = Unit conversion factor for grams to tons (1/907,180)

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The composite NOx emission factors by locomotive type (line-haul and switcher) and by calendar year are provided in Data Appendix, Table A-3 and are based on CARB's In-Use Locomotive Regulation.²⁵

The total annual MWhr usage of locomotives may be directly obtained from locomotives megawatt-hour meters or calculated based on the locomotives fuel consumption in gallons using Equation 1.A.2.a. and conversion factors provided in Data Appendix, Table A-2 for line-haul and switcher locomotives.

B. Drayage Trucks

This section provides the detailed methodology to calculate the annual reference NOx emissions for each milestone year from all drayage trucks visiting freight rail yards within the State of California or within South Coast AQMD.

The annual reference NOx emissions from drayage trucks are calculated based on the number of individual truck trips to the freight rail yard(s) within the applicable jurisdiction, miles traveled to and from the freight rail yard(s) using the actual mileage or a default mileage and the corresponding composite NOx emission factors by calendar year using the following equation:

$$EDT_{i,RS} = \sum_d (NT_{d,i} \times VMT_{d,i}) \times EF_{i,RS} \times U \quad (\text{Equation 2.B.1})$$

Where:

$EDT_{i,RS}$ = Reference Scenario NOx emissions (in tons) from all Drayage Truck operating at and travelling to and from the Freight Rail Yard within the applicable jurisdiction in year i

$NT_{d,i}$ = Number of Truck Trips by Drayage Truck d in year i to and from the Freight Rail Yard, calculated as total number of unique entry date(s) multiplied by 2

$VMT_{d,i}$ = Actual vehicle miles traveled by Drayage Truck d in year i to and from the Freight Rail Yard, or use default factor of 39.9 miles/trip

$EF_{i,RS}$ = Composite emission factor (in grams per mile by calendar year) in year i under Reference Scenario (RS), as specified in Data Appendix, Table B-5

U = Unit conversion factor for grams to tons (1/907,180)

²⁵ CARB's In-Use Locomotive Regulation; <https://ww2.arb.ca.gov/rulemaking/2022/locomotive>

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The composite NOx emission factors for drayage trucks by calendar year are derived from CARB's EMFAC2021 Model²⁶ for T7 Tractor Class 8 category by calendar year (EMFAC2021 Emissions Run for statewide or South Coast region at aggregate model year and aggregate speed), and they also reflect the impact of CARB's Heavy-Duty Inspection and Maintenance Regulation²⁷.

C. TRU

This section provides the detailed methodology to calculate the annual reference NOx emissions for each milestone year from all TRU operating at and travelling to and from a freight rail yard within South Coast AQMD. The annual reference NOx emissions for TRU operating at and travelling to and from the freight rail yard are calculated based on the annual operating hours for each TRU type (i.e., same equipment type, fuel, hp bin, model year) and the average emission factor for each TRU type using the following equation:

$$ETRU_i^{RS} = \sum_t \left[\left(\sum_{r \in t} HR_{r,i} \right) \times ER_{t,i}^{RS} \right] \quad (\text{Equation 2.C.1})$$

Where:

$ETRU_i^{RS}$ = Reference Scenario NOx emissions (in tons) from all TRUs operating at and travelling to and from the Freight Rail Yard in year i

$HR_{r,i}$ = Annual operating hours for TRU r associated with TRU type t operating at and travelling to and from the Freight Rail Yard in year i

$ER_{t,i}^{RS}$ = NOx emissions rate of TRU type t (in grams per hour) in year i under Reference Scenario (RS), as specified in Data Appendix, Tables C-3

The annual operating hours and emission rates in the above equation are for each TRU type which is defined as TRU with the same equipment type, fuel type, hp, and model year (referred to TRU r type t in above equation).

The annual operating hours for each TRU must be based on the following order of hierarchy pending availability of operational data: 1) non-resettable hour-meters, 2) maintenance records, 3) fuel consumption data, or 4) default average operating hours for each TRU type from Data Appendix, Table C-2. If the fuel consumption data is available, the annual operating hours can be

²⁶ EMFAC2021: <https://arb.ca.gov/emfac/>

²⁷ CARB's Heavy-Duty Inspection and Maintenance Program: <https://ww2.arb.ca.gov/our-work/programs/CTC>

estimated using Equation 1.C.1.b, and the fuel consumption conversion factors in Data Appendix, Table F-11. Annual operating hours may also be calculated using Equation 1.C.1.c. or 1.C.1.d. If model year data is not available for each TRU, then a default age of 7 years can be used for all TRUs.²⁸

For each TRU, the same method for annual operating hours used for calculating the actual annual NOx emissions should also be used for calculating the annual reference NOx emissions to prevent potential variations between these methods affecting annual reference emissions as well as for consistent comparison between the actual and reference emissions for the same milestone year.

D. CHE

This section provides the detailed methodology to calculate the annual reference NOx emissions for each milestone year from all CHE operating at and travelling to and from a freight rail yard within South Coast AQMD. The annual reference NOx emissions for CHE operating at and travelling to and from the freight rail yard are calculated based on the annual operating hours for each CHE type (i.e., same equipment type, fuel, hp bin, model year) and the average emission factors for each CHE type using the following equation:

$$ECHE_i^{RS} = \sum_t [(\sum_{c \in t} HR_{c,i}) \times ER_{t,i}^{RS}] \quad (\text{Equation 2.D.1})$$

Where:

$ECHE_i^{RS}$ = Reference Scenario NOx emissions (in tons) from all CHE operating at and travelling to and from the Freight Rail Yard in year i

$HR_{c,i}$ = Annual operating hours for CHE c associated with CHE type t operating at and travelling to and from the Freight Rail Yard in year i

$ER_{t,i}^{RS}$ = NOx emissions rate of CHE type t (in grams per hour) in year i under Reference Scenario (RS), as specified in Data Appendix, Tables D-2 through D-4

The annual operating hours and emission rates in the above equation are for each CHE type which is defined as CHE with the same equipment type, fuel type, hp, and model year (referred to CHE c type t in above equation).

²⁸ Figure 6 from CARB's TRU Emissions Inventory shows that 7 years is a conservative default age assumption based on actual data. <https://ww2.arb.ca.gov/sites/default/files/barcu/board/rulemaking/tru2021/apph.pdf>

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The annual operating hours for each CHE must be based on the following order of hierarchy pending availability of operational data: 1) non-resettable hour-meters, 2) maintenance records, or 3) fuel consumption data. If the fuel consumption data is available, the annual operating hours can be estimated using Equation 1.C.1.b, and the fuel consumption conversion factors in Data Appendix, Table F-11. For each CHE, the same method for annual operating hours used for calculating the actual annual NOx emissions should also be used for calculating the annual reference NOx emissions to prevent potential variations between these methods affecting annual reference emissions as well as for consistent comparison between the actual and reference emissions for the same milestone year.

E. OSE

This section provides the detailed methodology to calculate the annual reference NOx emissions for each milestone year from all OSE operating at and travelling to and from a freight rail yard within South Coast AQMD. The annual reference NOx emissions for OSE at and travelling to and from the freight rail yard are calculated based on the annual operating hours for each OSE type (i.e., same equipment type, fuel, hp bin, model year) and the average emission factor for each OSE type using the following equation:

$$EOSE_i^{RS} = \sum_t [(\sum_{o \in t} HR_{o,i}) \times ER_{t,i}^{RS}] \quad (\text{Equation 2.E.1})$$

Where:

$EOSE_{i,RS}$ = Reference Scenario NOx emissions (in tons) from all OSE operating on the Freight Rail Yard in year i

$HR_{o,i}$ = Annual operating hours for OSE o associated with OSE type t operating at and travelling to and from the Freight Rail Yard in year i

$ER_{t,i}^{RS}$ = NOx emissions rate of OSE type t (in gram per hour) in year i , as specified in Data Appendix Tables E-2 and E-3

The annual operating hours and emission rates in the above equation are for each OSE type which is defined as OSE with the same equipment type, fuel type, hp, and model year (referred to OSE o type t in above equation).

The annual operating hours for each OSE must be based on the following order of hierarchy pending availability of operational data: 1) non-resettable hour-meters, 2) maintenance records, or 3) fuel consumption data. If the fuel consumption data is available, the annual operating hours can

be estimated using Equation 1.C.1.b, and the fuel consumption conversion factors in Data Appendix, Table F-11. For each OSE, the same method for annual operating hours used for calculating the actual annual NOx emissions should also be used for calculating the annual reference NOx emissions to prevent potential variations between these methods affecting annual reference emissions as well as for consistent comparison between the actual and reference emissions for the same milestone year.

3. Aggregate Emission Factor a Freight Rail Yard

This section outlines the methodology for the owner or operator of a freight rail yard within the South Coast AQMD jurisdiction to calculate the annual aggregate NOx emission factor (AEF) for the freight rail yard for the milestone year and the base period encompassing all applicable mobile sources including locomotives, drayage trucks, CHE, TRU, and OSE as part of the Initial Facility Information Report pursuant to subparagraph (e)(1)(E) and the Milestone Compliance Report pursuant to subparagraph (f)(1)(E) of this rule.

The annual AEF for each freight rail yard is expressed in grams per brake-horsepower-hour (g/hp-hr) for NOx emissions and is calculated based on the actual annual NOx emissions in tons and the energy consumed in hp-hr for the applicable mobile sources using the following equation:

$$AEF_i = \frac{(EL_i + EDT_i + ETRU_i + ECHE_i + EOSE_i) \times V}{L_i + DT_i + TRU_i + CHE_i + OSE_i} \quad (\text{Equation 3})$$

Where:

AEF_i = Aggregate Emission Factor in g/hp-hr in year i

EL_i = Actual NOx emissions (in tons) from all Locomotives operating at and travelling to and from the Freight Rail Yard in year i , as calculated by Equation 1.A.1

EDT_i = Actual NOx emissions (in tons) from all Drayage Trucks operating at and travelling to and from the Freight Rail Yard in year i , as calculated by Equation 1.B.1

$ETRU_i$ = Actual NOx emissions (in tons) for all TRUs operating at and travelling to and from the Freight Rail Yard in year i , as calculated by Equation 1.C.1

$ECHE_i$ = Actual NOx emissions (in tons) for all CHE operating at and travelling to and from the Freight Rail Yard in year i , as calculated by Equation 1.D.1

$EOSE_i$ = Actual NOx emissions (in tons) for all OSE operating at and travelling to and from the Freight Rail Yard in year i , as calculated by Equation 1.E.1

V = Unit conversion factor for tons to grams (907,180)

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L_i = Total energy consumed (in hp-hr) by all Locomotives operating at and travelling to and from the Freight Rail Yard in year i

DT_i = Total energy consumed (in hp-hr) by all Drayage Trucks operating at and travelling to and from the Freight Rail Yard in year i

TRU_i = Total energy consumed (in hp-hr) by all TRU operating at and travelling to and from the Freight Rail Yard in year i

CHE_i = Total energy consumed (in hp-hr) by all CHE operating at and travelling to and from the Freight Rail Yard in year i

OSE_i = Total energy consumed (in hp-hr) by all OSE operating at and travelling to and from the Freight Rail Yard in year i

The actual NO_x emissions in tons for each milestone year for the freight rail yard from the applicable mobile sources are calculated based on the detailed methodologies provided in Section 1 of this document and converted to grams using the unit conversion factor (907,180 grams per ton²⁹).

A. Locomotives

The total annual energy consumed for locomotives at each freight rail yard is calculated based on the annual usage in MWhr for all locomotives operating at and travelling to and from the freight rail yard and the number of days locomotives operated at the freight rail yard compared to the total number of days that locomotives operated at all freight rail yards by the same freight rail yard operator within South Coast AQMD using the following equation:

$$L_i = \sum_l \left(MWhr_{l,i} \times \frac{DaysFRY_{l,i}}{\sum_y DaysALLFRY_{l,i,y}} \right) \times CF \quad (\text{Equation 3.A.1})$$

Where:

$MWhr_{l,i}$ = Annual usage (in megawatt-hours) by Locomotive l operating within the South Coast AQMD jurisdiction in year i

$DaysFRY_{l,i}$ = Total number of days Locomotive l operating at and travelling to and from the Freight Rail Yard in year i

$DaysALLFRY_{l,i,y}$ = Total number of days Locomotive l operating at and travelling to and from any Freight Rail Yard y within the South Coast AQMD jurisdiction in year i

²⁹ Grams to tons conversion: 453.59 grams/pound X 2000 pounds/ton = 907,180 grams/ton

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CF = Conversion factor for megawatt to horsepower (1341.02)

B. Drayage Trucks

The total annual energy consumed for drayage trucks visiting each freight rail yard is calculated based on the total number of individual truck trips to and from the freight rail yard, miles traveled to and from the freight rail yard using the actual mileage or default mileage, and a conversion factor (to convert miles to hp-hr) using the following equation:

$$DT_i = \sum_d (NT_{d,i} \times VMT_{d,i} \times CF) \quad (\text{Equation 3.B.1})$$

Where:

$NT_{d,i}$ = Number of Truck Trips by Drayage Truck d in year i to and from the Freight Rail Yard, calculated as total number of unique entry date(s) multiplied by 2

$VMT_{d,i}$ = Actual vehicle miles traveled by Drayage Truck d in year i to and from the Freight Rail Yard, or use default factor of 39.9 miles/trip

CF = Conversion factor (2.9 hp-hr/mile for diesel trucks and 3.65 hp-hr/mile for CNG trucks)³⁰

C. TRU

The total annual energy consumed for TRU for each freight rail yard is calculated based on the maximum rated horsepower (hp), load factor, and annual operating hours for TRUs operating at and travelling to and from the freight rail yard using the following equation:

$$TRU_i = \sum_r (HP_{r,i} \times LF_{r,i} \times HR_{r,i}) \quad (\text{Equation 3.C.1})$$

Where:

³⁰ Methods to Find the Cost-Effectiveness of Funding Air Quality Projects (for diesel trucks): https://ww2.arb.ca.gov/sites/default/files/2023-01/Cost%20Effectiveness%20Tables%202022_final.pdf, and In-Use Emissions Testing and Activity Profiles for On-Road Heavy-Duty Vehicles (for CNG trucks): <https://www.energy.ca.gov/sites/default/files/2023-03/CEC-500-2023-002.pdf>.

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$HP_{r,i}$ = Maximum rated horsepower for TRU r operating at and travelling to and from the Freight Rail Yard in year i

$LF_{r,i}$ = Load factor for TRU r operating at and travelling to and from the Freight Rail Yard in year i , as specified in Data Appendix, Table C-1

$HR_{r,i}$ = Annual operating hours for TRU r operating at and travelling to and from the Freight Rail Yard in year i

D. CHE

The hp, load factor and the annual operating hours for each TRU used in this equation must be the same as the ones used for calculating the actual NOx emissions based on the detailed methodologies specified in Section 1 of this document.

The total annual energy consumed for CHE for each freight rail yard is calculated based on the maximum rated horsepower (hp), load factor, and annual operating hours for CHE operating at the freight rail yard using the following equation:

$$CHE_i = \sum_c (HP_{c,i} \times LF_{c,i} \times HR_{c,i}) \quad (\text{Equation 3.D.1})$$

Where:

$HP_{c,i}$ = Maximum rated horsepower for CHE c operating at and travelling to and from the Freight Rail Yard in year i

$LF_{c,i}$ = Load factor for CHE c operating at and travelling to and from the Freight Rail Yard in year i , as specified in Data Appendix, Table D-1

$HR_{c,i}$ = Annual operating hours for CHE c operating at and travelling to and from the Freight Rail Yard in year i

E. OSE

The hp, load factor and the annual operating hours for each CHE used in this equation must be the same as the ones used for calculating the actual NOx emissions based on the detailed methodologies specified in Section 1 of this document.

The total annual energy consumed for OSE for each freight rail yard is calculated based on the maximum rated horsepower (hp), load factor, and annual operating hours for OSE operating at the freight rail yard using the following equation:

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$$OSE_i = \sum_o (HP_{o,i} \times LF_{o,i} \times HR_{o,i}) \quad (\text{Equation 3.E.1})$$

Where:

$HP_{o,i}$ = Maximum rated horsepower for OSE o operating at and travelling to and from the Freight Rail Yard in year i

$LF_{o,i}$ = Load factor for OSE o operating at and travelling to and from the Freight Rail Yard in year i , as specified in Data Appendix, Table E-1

$HR_{o,i}$ = Annual operating hours for OSE o operating at and travelling to and from the Freight Rail Yard in year i

The hp, load factor and the annual operating hours for each OSE used in this equation must be the same as the ones used calculating the actual NO_x emissions based on the detailed methodologies specified in Section 1 of this document.