CHAPTER 3: Emissions Inventory

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This chapter presents our analysis of the emission impact of the proposed rule for the four categories of nonroad diesel engines affected: land-based diesel engines, commercial marine diesel vessels, locomotives, and recreational marine diesel engines. New engine controls are being proposed for the land-based diesel engine category. For the other three nonroad diesel categories, no new engine controls are being proposed; however, the diesel fuel sulfur requirements are expected to decrease particulate matter less than 2.5 microns ($PM_{2.5}$) and sulfur dioxide (SO_2) emissions for these categories.

Section 3.1 presents an overview of the methodology used to generate the baseline inventories. The baseline inventories represent current and future emissions with only the existing standards. Sections 3.2 and 3.3 then describe the contribution of nonroad diesel engines to national and selected local baseline inventories, respectively. Section 3.4 describes the development of the controlled inventories, specifically the changes made to the baseline inputs to incorporate the proposed standards and fuel sulfur requirements. Section 3.5 follows with the expected emission reductions associated with the proposed rule. Section 3.6 concludes the chapter by describing the changes in the inputs and resulting emissions inventories between the preliminary baseline and control scenarios used for the air quality modeling and the updated baseline and control scenarios in this proposal.

The estimates of baseline emissions and emission reductions from the proposed rule for nonroad land-based, recreational marine, locomotive, and commercial marine vessel diesel engines are reported for both 48-state and 50-state inventories. The 48-state inventories are used for the air quality modeling that EPA uses to analyze regional ozone and PM air quality, of which Alaska and Hawaii are not a part. In addition, 50-state emission estimates for other sources (such as stationary and area sources) are not available. As a result, in cases where nonroad diesel sources are compared with other emission sources, the 48-state emission inventory estimates are used.

Inventories are presented for the following pollutants: $PM_{2.5}$, PM_{10}, oxides of nitrogen (NO_x), SO_2, volatile organic compounds (VOC), carbon monoxide (CO), and air toxics. The specific air toxics are benzene, formaldeyde, acetaldehyde, 1,3-butadiene, and acrolein. The PM inventories include directly emitted PM only, although secondary sulfates are taken into account in the air quality modeling.

3.1 Nonroad Diesel Baseline Emissions Inventory Development

This section describes how the baseline emissions inventories were developed for the four categories of nonroad diesel engines affected by this proposal: land-based diesel engines, commercial marine diesel vessels, locomotives, and recreational marine diesel engines. For land-based diesel engines, there is a section that discusses inventory development for $PM_{2.5}$, NO_x, SO_2, VOC, and CO, followed by a section for air toxics.

3.1.1 Land-Based Nonroad Diesel Engines—$PM_{2.5}$, NO_x, SO_2, VOC, and CO Emissions

The baseline emissions inventories for land-based diesel engines were generated using the draft NONROAD2002 model. The baseline inventories account for the effect of existing federal emission standards that establish three tiers of emission standards (Tier 1 through Tier 3). Section 3.1.1.1 provides an overview of the draft NONROAD2002 model and a description of the methodology used in the model to estimate emissions. Details of the baseline modeling inputs (e.g., populations, activity, and emission factors) for land-based diesel engines can be found in the technical reports documenting the draft NONROAD2002 model. The single scenario option variable that affects diesel emissions is the in-use fuel sulfur level. The in-use diesel fuel sulfur level inputs used for the baseline scenarios are given in Section 3.1.1.2.3.

3.1.1.1 Overview

The draft NONROAD2002 model estimates emissions inventories of important air emissions from diverse nonroad equipment. The model's scope includes all nonroad sources with the exception of locomotives, aircraft and commercial marine vessels. Users can construct inventories for criteria pollutants including carbon monoxide (CO), oxides of nitrogen (NO_x), oxides of sulfur (SO_2), and particulate matter (PM), as well as other emissions including total hydrocarbon (THC) and carbon dioxide (CO_2). As a related feature, the model estimates fuel consumption. The model can distinguish emissions on the basis of equipment type, size and technology group. A central feature of the model is projection of future or past emissions between the years 1970 and 2050.

The draft NONROAD2002 model contains three major components: (1) the core model, a FORTRAN program that performs model calculations, (2) the reporting utility, a Microsoft Access application that compiles and presents results, and (3) the graphic user interface (GUI), a Visual-Basic application that allows users to easily construct scenarios for submission to the core model. The following discussion will describe processes performed by the core model in the calculation of emissions inventories.

This section describes how the draft NONROAD2002 model estimates emissions particularly relevant to this analysis, including particulate matter (PM), oxides of nitrogen (NO_x), oxides of sulfur (SO_2), carbon monoxide (CO) and volatile organic compounds (VOC). As appropriate, we will focus on estimation of emissions of these pollutants by diesel engines. The model estimates emissions from approximately 80 types of diesel equipment. As with other engine classes, the model defines engine or equipment "size" in terms of the rated power (horsepower) of the engine. For diesel engines, the proposed regulations also classify engines on the basis of rated power.

The first four chemical species are exhaust emissions, i.e., pollutants emitted directly as exhaust from combustion of diesel fuel in the engine. However, the last emission, VOC, includes both exhaust and evaporative components. The exhaust component represents hydrocarbons emitted as products of combustion; the evaporative component includes compounds emitted from unburned fuel during operation, i.e., “crankcase emissions.” For VOC, we will first describe estimation of total hydrocarbon exhaust emissions, in conjunction with the description for the other exhaust emissions. We discuss subsequent estimation of associated VOC emissions in subsection 3.1.1.4.

3.1.1.2 NONROAD’s Major Inputs

The draft NONROAD2002 model uses three major sets of inputs in estimation of exhaust emission inventories: (1) emissions calculation variables, (2) projection variables, and (3) scenario option variables.

3.1.1.2.1 Emissions Calculation Variables

The draft NONROAD2002 model estimates exhaust emissions using the equation

$$I_{exh} = E_{exh} \cdot A \cdot L \cdot P \cdot N$$

where each term is defined as follows:

I_{exh} = the exhaust emission inventory (gram/year, gram/day),
E_{exh} = exhaust emission factor (gram/hp-hr),
A = equipment activity (operating hours/year),
L = Load factor (average proportion of rated power used during operation (%)),
P = average rated power (hp)
N = Equipment population (units).

Emissions are then converted and reported as tons/year or tons/day.

For diesel engines, each of the inputs applies to sub-populations of equipment, as classified by type (dozer, tractor, backhoe, etc.), rated power class (50-100 hp, 100-300 hp, etc.) and regulatory tier (tier 1, tier 2, etc.).

Exhaust Emission Factor. The emission factor in a given simulation year consists of three components, a “zero-hour” emission level (ZHL) , a transient adjustment factor (TAF) and a deterioration factor (DF). The ZHL represents the emission rate for recently manufactured engines, i.e., engines with few operating hours, and is typically derived directly from laboratory measurements on new or nearly new engines on several commonly used duty cycles, hence the term “zero-hour.”

Because most emissions data has been collected under steady-state conditions (constant engine speed and load), and because most real-world operation involves transient conditions (variable speed and load), we attempt to adjust for the difference between laboratory measurements and real-world operation through the use of transient adjustment factors (TAFs). The TAF is a ratio representing the difference in the emission rate between transient and steady-state operation. The TAFs are estimated by collecting emissions measurements on specific engines using both transient and steady-state cycles, and calculating the ratio

$$TAF = \frac{EF_{transient}}{EF_{steady-state}}$$

where $EF_{transient}$ is the measurement for a given engine on a specific transient cycle, and $EF_{steady\text{-}state}$ is the corresponding measurement for the same engine on a selected steady-state cycle. Data from seven transient cycles were used to develop seven TAFs for each of the four pollutants. The seven cycle TAFs were then binned into two categories, based on the cycle load factors. TAFs were then assigned to each equipment type represented in the model on the basis of engineering judgment. If steady-state operation was typical of an equipment type, no adjustment was made (i.e., TAF = 1.0).

Emission factors in the model input file represent the product (ZHL·TAF) for each combination of equipment type, size class and regulatory tier represented by the model. We refer to this product as the "baseline emission factor." For more detail on the derivation and application of EFs and TAFs, refer to the model documentation on diesel emission factors[1].

During a model run, the model applies emissions deterioration to the baseline emission factor, based on the age distribution of the equipment type in the year simulated. Deterioration expresses an assumption that emissions increase with equipment age and is expressed as a multiplicative deterioration factor (DF). Thus, the final emission factor applied in the simulation year is the product ZHL·TAF·DF. Deterioration factors vary from year to year; we describe their calculation in more detail in subsection 3.1.1.2.2 below.

The model estimates fuel consumption by substituting brake-specific fuel consumption (BSFC, lb/hp-hr) for the emission factor in the equation above. We apply a TAF to the BSFC but assume that BSFC does not deteriorate with equipment age.

In estimation of PM emissions, we apply an additional adjustment to the emission factor to account for the in-use sulfur level of diesel fuel.[1] Based on user-specified diesel sulfur levels for a given scenario, NONROAD adjusts the PM emission factor by the margin S_{PMadj} (g/hp-hr) calculated as

$$S_{PMadj} = BSFC \cdot m_{SO4,S} \cdot m_{PM,S} \cdot 0.01 \cdot (S_{base} - S_{in-use})$$

where: BSFC = brake-specific fuel consumption (g fuel/hp-hr),

$m_{SO4,S}$ = a constant, representing the sulfate fraction of total particulate sulfur, equal to 7.0 g PM SO_4/g PM S,

$m_{PM,S}$ = a constant, representing the fraction of fuel sulfur converted to particulate sulfur, equal to 0.02247 g PM S/g fuel S,

0.01 = conversion factor from wt% to wt fraction

S_{base} = base sulfur level in NONROAD (0.33 wt%, 3300 ppm for pre-control and Tier 1 engines; 0.20 wt%, 2000 ppm for Tier 2-3 engines),

S_{in-use} = in-use diesel sulfur level as specified by user (wt%).

Equipment Activity. Activity represents the usage of equipment, expressed in operating hours per year. Activity estimates are specific to equipment types and remain constant in any given simulation year. Activity estimates for diesel equipment have been adopted from the *Partslink* model, a commercial source developed and maintained by Power Systems Research/Compass International, Inc. For discussion of activity estimates for specific equipment types, refer to the technical documentation for the model.[2]

Load Factor. This parameter represents the average fraction of rated power that equipment uses during operation. Load factors are assigned by equipment type, and remain constant in any simulation year. For use in draft NONROAD2002, we derived load factors from the results of a project designed to develop transient engine test cycles. During the course of the project, seven cycles were developed, designed to represent the operation of specific common equipment types.

Specific load factors for the cycles fell into two broad groups, which we designated as “high” and “low.” We calculated an average for each group, with the high group containing four cycles and the low group three; resulting load factors were 0.59 for the high group and 0.21 for the low group. Then, we assigned one of these two factors to each equipment type for which we believed engineering judgment was sufficient to make an assignment. For remaining equipment types, for which we considered engineering judgment insufficient to make an assignment, we assigned a ‘steady-state’ load factor, calculated as the average of load factors for all seven transient cycles (0.43). Of NONROAD’s 90 diesel applications, half were assigned ‘high’ or ‘low’ load factors, with the remainder assigned ‘steady-state’ load factors. For more detail on the derivation of load factors and assignment to specific equipment types, refer to the appropriate technical report[2].

Rated Power. This parameter represents the average rated power for equipment, as assigned to each combination of equipment type and rated-power class represented by the model. Values assigned to a given type/power combination represents the sales-weighted average of engines for that equipment type in that rated-power class.[3] Rated-power assignments remain constant in any given simulation year. For use in draft NONROAD2002, we obtained estimates from the *Partslink* database, maintained by Power Systems Research/Compass International, Inc. The product of load factor and rated power (*LP*) represents actual power output during equipment operation.

Equipment Population. As the name implies, this model input represents populations of equipment pieces. For diesel engines, the model generates separate sub-populations for individual combinations of equipment type and rated-power class. However, unlike activity and load factor, populations do not remain constant from year to year. Projection of future or past populations is the means through which the draft NONROAD2002 model projects future or past emissions. As a reference point, the input file contains populations in the model’s base year 1998. We generated populations in the base year using a simple attrition model that calculated base-year populations as a function of equipment sales, scrappage, activity and load factor. Equipment sales by model year were obtained from the commercially available *Partslink* database, developed and maintained by Power Systems Research/Compass International, Inc.

(PSR). This database contains sales estimates for nonroad equipment for model years 1973 through 1999. Base-year population development is discussed in the technical documentation.[3]

3.1.1.2.2 Projection Variables

The model uses three variables to project emissions over time: the annual population growth rate, the equipment median life, and the relative deterioration rate. Collectively, these variables represent population growth, changes in the equipment age distribution, and emissions deterioration.

Annual Population Growth Rate (%/year). The population growth rate represents the percentage increase in the equipment population for a given equipment type over successive years. The growth rate is linear for diesel equipment, and is applied to the entire population, including all rated-power classes and tiers[4]. Diesel growth rates vary by sector (e.g., agricultural, construction).

Equipment Median Life (hours @ full load). This variable represents the period of time over which 50% of the engines in a given "model-year cohort" are scrapped. A "model-year cohort" represents a sub-population of engines represented as entering the population in a given year. The input value assumes that (1) engines are run at full load until failure, and (2) equipment scrappage follows the model's scrappage curve. During a simulation, the model uses the "annualized median life," which represents the actual service life of equipment in years, depending on how much and how hard the equipment is used. Annualized median life is calculated as median life in hours (l_h), divided by the product of activity and load factor ($l_y = l_h/AL$). Engines persist in the equipment population over two median lives ($2l_y$); during the first median life, 50% of the engines are scrapped, and over the second, the remaining 50% are scrapped. For a more detailed description of median life, see the model documentation.[2]

Relative Deterioration Rate (% increase in emission factor/% median life expended). This variable plays a key role in calculation of the deterioration factor. Values of the relative deterioration rate are assigned based on pollutant, rated-power class, and tier. Using the relative deterioration rate (d), the annualized median life (l_y) and the equipment age, draft NONROAD2002 calculates the deterioration factor as

$$DF_{\text{pollutant,tier,year}} = 1 + d_{\text{pollutant,tier}} \left(\frac{\text{age}_{\text{year}}}{l_y} \right)$$

where:

$DF_{\text{pollutant,year}}$ = the deterioration factor for a given pollutant for a model-year cohort in the simulation year,

d = the relative deterioration rate for a given pollutant (% increase in emission factor / % useful life expended) and regulatory tier,

age = the age of a specific model-year group of engines in the simulation year,

l_y = the annualized median life of the given model-year cohort (years).

The deterioration factor adjusts the exhaust emission factor for engines in a given model-year cohort in relation to the proportion of median life expended. The model calculates the deterioration linearly over one median life for a given model-year cohort (represented as a fraction of the entire population). Following the first median life, the deteriorated emission factor is held constant over the remaining life for engines in the cohort. The model's deterioration calculations are discussed in greater detail in the technical documentation.[1]

3.1.1.2.3 Scenario Option Variables

These inputs apply to entire model runs or scenarios, rather than to equipment. Scenario options describe fuel characteristics and ambient weather conditions. The option that applies to inventories for diesel equipment is the in-use diesel sulfur level (wt%).

The in-use diesel fuel sulfur level inputs used for land-based diesel engines for the baseline scenarios are provided in Table 3.1-1. The fuel sulfur levels account for spillover use of highway fuel and are discussed in more detail in Chapter 7.

Table 3.1-1
Modeled Baseline In-Use Diesel Fuel Sulfur Content
for Land-Based Nonroad Diesel Engines

Fuel Sulfur (ppm)	Calendar Year
2318	through 2005
2271	2006
2237	2007-2009
2217	2010+

3.1.1.3 Emissions Estimation Process

To project emissions in a given year, the draft NONROAD2002 model performs a series of steps (not necessarily in the order described).

Equipment Population. The model projects the equipment population for the user-specified simulation year. The current year's population (N_{year}) is projected as a function of the base-year population (N_{base}) as

$$N_{year} = N_{base}(1 + ng)$$

where g is the annual growth rate and n is the number of years between the simulation year and the base year. For diesel equipment, population projection follows a linear trend as in the equation above. Diesel growth rates in the model vary only by sector (e.g., agricultural, construction). The sector-specific growth rates are applied to all equipment types and hp categories within each sector.

Equipment Age Distribution. The model assigns an age distribution for each sub-population calculated in the previous step. This calculation divides the total population into a series of model-year cohorts of decreasing size, with the number of cohorts equal to twice the annualized median life for the rated-power class under consideration ($2l_y$). Each model-year cohort is estimated as a fraction of the total population, using fractions derived from NONROAD's scrappage curve, scaled to the useful life of the given rated-power class, also equal to $2l_y$.[5]

Emission and Deterioration Factors. Because the previous steps were performed for engines of a given rated-power class, the model assigns emission factors to different model year cohorts simply by relating equipment age to regulatory tier. Similarly, the model calculates deterioration factors for each cohort. The algorithm identifies the appropriate relative deterioration rate in relation to tier and rated-power class, calculates the age of the cohort, and supplies these inputs to the deterioration factor equation.

Activity and Load Factor. The model obtains the appropriate activity, load factor and rated power estimates. Activity and load factor are defined on the basis of equipment type alone; they are constant for all model-year cohorts, and rated power is determined on the basis of equipment type and rated power class.

Emissions Calculation. For a given pollutant, the calculations described above are performed and the resulting inputs multiplied in the exhaust emissions equation. The steps are repeated for each rated-power class within an equipment type to obtain total emissions for that type. The resulting subtotals for equipment types are then summed to obtain total emissions from all equipment types included in the simulation. These processes are repeated for each pollutant requested for the simulation. Using summation notation, the process may be summarized as

$$I_{\text{exh,poll}} = \overbrace{\sum \left[\overbrace{\sum \left(\overbrace{\sum \left(E_{\text{exh,poll}} \cdot A \cdot L \cdot P \cdot N \right)}^{\substack{\text{sum over all model-year cohorts} \\ \text{within a rated-power class}}} \right)}^{\substack{\text{sum over all rated-power classes} \\ \text{within an equipment type}}} \right]}^{\text{sum over all equipment types}}$$

3.1.1.4 Estimation of VOC Emissions

Volatile organic compounds are a class of hydrocarbons considered to be of regulatory interest. For purposes of inventory modeling, we define VOC as total hydrocarbon (THC) plus reactive oxygenated species, represented by aldehydes (RCHO) and alcohols (RCOH), less non-reactive species represented by methane and ethane (CH_4 and CH_3CH_3), as follows:

$$VOC = THC + (RCHO + RCOH) - (CH_4 + CH_3CH_3)$$

The NONROAD model estimates VOC in relation to THC, where THC is defined as those hydrocarbons measured by a flame ionization detector (FID) calibrated to propane. Total hydrocarbon has exhaust and evaporative components, where the evaporative THC represents 'crankcase emissions.' Crankcase emissions are hydrocarbons that escape from the cylinder through the piston rings into the crankcase. The draft NONROAD2002 model assumes that all diesel engines have open crankcases, allowing that gases in the crankcase to escape to the atmosphere.

For diesel engines, the emission factor for crankcase emissions (EF_{crank}) is estimated as a fraction of the exhaust emission factor (EF_{exh}), as

$$EF_{crank,HC,year} = 0.02 \cdot EF_{exh,HC,year}$$

Note that the model adjusts crankcase emissions for deterioration. In a given simulation year, the crankcase emission factor is calculated from the deteriorated exhaust emission factor for that year, i.e., $EF_{exh,year} = ZHL \cdot TAF \cdot DF_{year}$.

The model estimates exhaust and crankcase VOC as a fraction of exhaust and crankcase THC, respectively.

$$VOC_{exh} = 1.053 \cdot THC_{exh}, \quad VOC_{crank} = 1.053 \cdot THC_{crank}$$

Note the fraction is greater than one, reflecting the addition of oxygenated species to THC. For additional discussion of the model's estimation of crankcase and VOC emissions, refer to the model documentation.[1,6]

3.1.1.5 Estimation of SO_2 Emissions

To estimate SO_2 emissions, the draft NONROAD2002 model does not use an explicit emission factor. Rather, the model estimates a SO_2 emission factor EF_{SO2} on the basis of brake-specific fuel consumption, the user-defined diesel sulfur level, and the emission factor for THC.

$$EF_{SO_2} = \left[BSFC \cdot (1 - m_{PM,S}) - EF_{THC}\right] \cdot S_{in-use} \cdot m_{SO_2,S}$$

where:

BSFC = brake-specific fuel consumption (g/hp-hr),

$m_{PM,S}$ = a constant, representing the fraction of fuel sulfur converted to particulate sulfur, equal to 0.02247 g PM S/g fuel S,

EF_{THC} = the in-use adjusted THC emission factor (g/hp-hr),
$S_{in\text{-}use}$ = the user-specified scenario-specific sulfur content of diesel fuel (weight fraction), and
$m_{SO2,S}$ = a constant, representing fraction of fuel sulfur converted to SO_2, equal to 2.0 g SO_2/g S.

This equation includes corrections for the fraction of sulfur that is converted to PM ($m_{PM,S}$) and for the sulfur remaining in the unburned fuel (EF_{THC}). The correction for unburned fuel, as indicated by THC emissions, is more significant for gasoline emissions, but insubstantial for diesel emissions.

Having estimated EF_{SO2}, the model estimates SO_2 emissions as it does other exhaust emissions.

3.1.1.6 Estimation of $PM_{2.5}$ Emissions

The model estimates emissions of diesel $PM_{2.5}$ as a multiple of PM_{10} emissions. $PM_{2.5}$ is estimated to compose 92% of PM_{10} emissions. This is based on an analysis of size distribution data for diesel vehicles.[7]

3.1.1.7 Estimation of Fuel Consumption

The draft NONROAD2002 model estimates fuel consumption using the equation

$$F = \frac{BSFC \cdot A \cdot L \cdot P \cdot N}{D}$$

where:
F = fuel consumption (gallons/year)
BSFC = brake-specific fuel consumption (lb/hp-hr)
A = equipment activity (operating hours/year)
L = load factor (average proportion of rated power used during operation (%))
P = average rated power (hp)
N = equipment population (units)
D = fuel density (lb/gal); diesel fuel density = 7.1 lb/gal

The fuel consumption estimates for land-based diesel and recreational marine diesel engines are given in Section 3.1.5.

3.1.1.8 Baseline Inventory

Tables 3.1-2a and 3.1-2b present the PM_{10}, $PM_{2.5}$, NO_x, SO_2, VOC, and CO baseline emissions for land-based nonroad engines in 1996 and 2000-2040, for the 48-state and 50-state inventories, respectively.

Table 3.1-2a
Baseline (48-State) Emissions for Land-Based Nonroad Diesel Engines (short tons)

Year	PM_{10}	$PM_{2.5}$	NO_x	SO_2	VOC	CO
1996	191,858	176,510	1,583,664	147,926	221,403	1,010,518
2000	175,155	161,143	1,569,902	167,094	200,366	923,886
2001	169,360	155,811	1,556,973	171,957	191,785	886,722
2002	163,684	150,589	1,544,395	176,819	183,584	850,751
2003	157,726	145,108	1,522,881	181,677	176,201	817,858
2004	152,310	140,125	1,503,228	186,532	169,541	790,468
2005	147,050	135,286	1,483,942	191,385	163,193	764,918
2006	142,043	130,680	1,450,762	192,228	156,295	742,184
2007	138,140	127,089	1,414,673	194,003	149,518	724,213
2008	135,640	124,789	1,374,171	198,657	142,310	709,119
2009	133,495	122,815	1,331,986	203,311	135,259	695,970
2010	131,530	121,007	1,291,533	206,104	128,391	684,552
2011	130,288	119,865	1,255,472	210,737	122,161	675,805
2012	129,691	119,316	1,225,493	215,366	116,940	671,268
2013	129,674	119,300	1,202,185	219,992	112,619	670,147
2014	129,932	119,537	1,183,043	224,615	108,942	670,842
2015	130,388	119,957	1,167,635	229,235	105,800	672,944
2016	130,986	120,507	1,156,099	233,809	103,210	676,412
2017	131,765	121,224	1,147,635	238,381	101,137	681,217
2018	132,672	122,059	1,142,299	242,952	99,415	686,723
2019	133,767	123,065	1,140,236	247,521	97,952	692,845
2020	135,146	124,334	1,140,727	252,089	96,855	700,017
2021	136,655	125,723	1,143,660	256,656	96,055	707,986
2022	138,195	127,140	1,148,710	261,222	95,488	716,295
2023	139,797	128,613	1,155,440	265,786	95,170	724,914
2024	141,410	130,097	1,163,558	270,350	95,066	733,953
2025	143,091	131,644	1,172,971	274,913	95,144	743,434
2026	144,798	133,214	1,183,408	279,446	95,373	753,165
2027	146,471	134,753	1,194,643	283,978	95,729	763,023
2028	148,187	136,332	1,206,483	288,510	96,186	773,136
2029	149,915	137,922	1,218,884	293,042	96,724	783,449
2030	151,660	139,527	1,231,995	297,573	97,348	793,923
2031	153,451	141,175	1,245,794	302,104	98,059	804,566
2032	155,260	142,839	1,259,909	306,635	98,822	815,321
2033	157,088	144,521	1,274,280	311,165	99,628	826,151
2034	158,922	146,208	1,288,943	315,695	100,482	837,047
2035	160,748	147,888	1,303,901	320,226	101,380	847,953
2036	162,618	149,609	1,319,167	324,755	102,336	858,992
2037	164,511	151,350	1,334,609	329,285	103,325	870,072
2038	166,681	153,346	1,350,619	333,814	104,415	881,159
2039	168,853	155,345	1,366,795	338,344	105,529	892,281
2040	171,019	157,337	1,383,101	342,873	106,664	903,406

Table 3.1-2b
Baseline (50-State) Emissions for Land-Based Nonroad Diesel Engines (short tons)

Year	PM_{10}	$PM_{2.5}$	NO_x	SO_2	VOC	CO
1996	192,750	177,330	1,592,025	148,729	222,517	1,015,773
2000	175,981	161,903	1,578,148	167,999	201,386	928,674
2001	170,165	156,552	1,565,144	172,889	192,765	891,304
2002	164,467	151,310	1,552,490	177,777	184,524	855,132
2003	158,487	145,808	1,530,854	182,662	177,107	822,062
2004	153,045	140,802	1,511,087	187,544	170,414	794,522
2005	147,761	135,940	1,491,692	192,424	164,035	768,838
2006	142,732	131,314	1,458,315	193,272	157,104	745,994
2007	138,814	127,708	1,422,017	195,057	150,293	727,946
2008	136,306	125,401	1,381,288	199,736	143,050	712,797
2009	134,154	123,422	1,338,867	204,416	135,965	699,604
2010	132,184	121,609	1,298,193	207,225	129,063	688,153
2011	130,942	120,466	1,261,939	211,884	122,803	679,389
2012	130,347	119,919	1,231,796	216,538	117,555	674,849
2013	130,335	119,908	1,208,367	221,189	113,212	673,736
2014	130,598	120,150	1,189,132	225,837	109,517	674,446
2015	131,060	120,575	1,173,656	230,483	106,359	676,570
2016	131,665	121,132	1,162,082	235,083	103,757	680,068
2017	132,452	121,856	1,153,602	239,680	101,676	684,911
2018	133,368	122,698	1,148,271	244,276	99,946	690,458
2019	134,470	123,713	1,146,227	248,870	98,478	696,625
2020	135,858	124,990	1,146,750	253,464	97,378	703,845
2021	137,377	126,387	1,149,727	258,056	96,575	711,863
2022	138,926	127,812	1,154,830	262,647	96,006	720,223
2023	140,537	129,294	1,161,619	267,237	95,688	728,896
2024	142,161	130,788	1,169,801	271,826	95,584	737,990
2025	143,853	132,345	1,179,283	276,414	95,663	747,528
2026	145,570	133,925	1,189,792	280,972	95,894	757,318
2027	147,254	135,474	1,201,104	285,529	96,253	767,234
2028	148,981	137,062	1,213,023	290,086	96,713	777,407
2029	150,719	138,662	1,225,506	294,643	97,255	787,780
2030	152,475	140,277	1,238,701	299,199	97,882	798,316
2031	154,278	141,936	1,252,586	303,755	98,598	809,021
2032	156,098	143,610	1,266,789	308,311	99,367	819,838
2033	157,937	145,302	1,281,249	312,867	100,178	830,731
2034	159,783	147,001	1,296,002	317,422	101,037	841,690
2035	161,621	148,691	1,311,051	321,977	101,940	852,660
2036	163,503	150,423	1,326,409	326,532	102,902	863,763
2037	165,407	152,174	1,341,945	331,087	103,898	874,908
2038	167,589	154,182	1,358,049	335,642	104,994	886,060
2039	169,774	156,192	1,374,321	340,196	106,114	897,248
2040	171,952	158,195	1,390,723	344,750	107,257	908,439

3.1.2 Land-Based Nonroad Diesel Engines—Air Toxics Emissions

EPA focused on 5 major air toxics pollutants for the proposed rule: benzene, formaldehyde, acetaldehyde, 1,3-butadiene, and acrolein. These pollutants are VOCs and are included in the total land-based nonroad diesel VOC emissions estimate. EPA developed the baseline inventory estimates for these pollutants by multiplying the baseline VOC emissions from the draft NONROAD2002 model for a given year by the constant fractional amount that each air toxic pollutant contributes to VOC emissions. Table 3.1-3 shows the fractions that EPA used for each air toxics pollutant. EPA developed these nonroad air toxics pollutant fractions for the National Emissions Inventory.[8]

Table 3.1-3
Air Toxics Fractions of VOC

Benzene	Formaldehyde	Acetaldehyde	1,3-butadiene	Acrolein
0.020	0.118	0.053	0.002	0.003

Tables 3.1-4a and 3.1-4b show our 48-state and 50-state estimates of national baseline emissions for five selected major air toxic pollutants (benzene, formaldehyde, acetaldehyde, 1,3-butadiene, and acrolein) for 1996, as well as for selected years from 2005 to 2030, modeled with the existing Tier 1-3 standards. Toxics emissions decrease over time until 2025 as engines meeting the Tier 1-3 standards are introduced into the fleet. Beyond 2025, the growth in population overtakes the effect of the existing emission standards. Chapter 2 discusses the health effects of these pollutants.

Table 3.1-4a
Baseline (48-State) Air Toxics Emissions
for Land-Based Nonroad Diesel Engines (short tons)

Year	Benzene	Formaldehyde	Acetaldehyde	1,3-Butadiene	Acrolein
1996	4,428	26,126	11,734	443	664
2000	4,007	23,643	10,619	401	601
2005	3,264	19,257	8,649	326	490
2007	2,990	17,643	7,924	299	449
2010	2,568	15,150	6,805	257	385
2015	2,116	12,484	5,607	212	317
2020	1,937	11,429	5,133	194	291
2025	1,903	11,227	5,043	190	285
2030	1,947	11,487	5,159	195	292

Table 3.1-4b
Baseline (50-State) Air Toxics Emissions
for Land-Based Nonroad Diesel Engines (short tons)

Year	Benzene	Formaldehyde	Acetaldehyde	1,3-Butadiene	Acrolein
1996	4,450	26,257	11,793	445	668
2000	4,028	23,764	10,673	403	604
2005	3,281	19,356	8,694	328	492
2007	3,006	17,735	7,966	301	451
2010	2,581	15,229	6,840	258	387
2015	2,127	12,550	5,637	213	319
2020	1,948	11,491	5,161	195	292
2025	1,913	11,288	5,070	191	287
2030	1,958	11,550	5,188	196	294

3.1.3 Commercial Marine Vessels and Locomotives

Although no new engine controls are being proposed for diesel commercial marine and locomotive engines, these engines do use diesel fuel and the effects of the proposed fuel changes need to be modeled. This section addresses the modeling of the baseline case for these engines, which includes effects of certain other rules such as (a) the April 1998 locomotive emissions final rule, (b) the December 1999 final rule for commercial marine diesel engines, and (c) the January 2001 heavy duty highway diesel fuel rule that takes effect in June 2006.

Since the draft NONROAD2002 model does not generate emission estimates for these applications, the emission inventories were calculated using the following methodology. VOC, CO, and NO_x emissions for 1996, 2020, and 2030 (the years chosen for air quality modeling) were taken from the existing HDDV inventory. These are presented in Table 3.1-5. Only 48-state emission estimates are available for these pollutants. VOC emissions in this inventory were calculated by multiplying THC emissions by a factor of 1.053, which is also the factor used for land-based diesel engines.

Table 3.1-5
Baseline (48-State) NO_x, VOC, and CO Emissions
for Locomotives and Commercial Marine Vessels (short tons)

Year	NO_x		VOC		CO	
	Locomotives	CMV	Locomotives	CMV	Locomotives	CMV
1996	921,556	959,704	48,381	31,545	112,171	126,382
2020	612,722	819,201	36,546	37,290	119,302	159,900
2030	534,520	814,827	31,644	41,354	119,302	176,533

The baseline SO_2 and PM emission inventory estimates were revised to reflect changes to the base sulfur levels. Tables 3.1-6a and 3.1-6b provide the 48-state and 50-state baseline fuel sulfur levels, $PM_{2.5}$, and SO_2 emissions. The fuel sulfur levels were calculated as weighted average in-use levels of (a) uncontrolled nonroad diesel fuel at 3400 ppm sulfur, (b) "spillover" of low sulfur highway diesel fuel into use by nonroad applications outside of California, and (c) full use of low sulfur California fuel in all nonroad applications in California. The slight decrease in average sulfur level in 2006 is due to the introduction of highway diesel fuel meeting the 2007 15 ppm standard, and the "spillover" of this highway fuel into the nonroad fuel pool. The derivation of the fuel sulfur levels is discussed in more detail in Chapter 7.

Locomotive diesel fuel volumes were calculated by the following methodology. Calendar year 2000 distillate fuel consumption for railroads was taken from the US Energy Information Administration (EIA) Fuel Oil & Kerosene Supply (FOKS) 2000 report. The volume of diesel fuel consumed by railroad was assumed to represent 95 percent of the reported distillate value. Also, the fuel volumes reported in FOKS appear to represent fuel usage by locomotives as well as by rail maintenance equipment, so the fuel consumption specific to locomotives was calculated by subtracting one percent, which is our estimate of rail maintenance fuel consumption, from the railroad diesel volume estimate. Calendar year 2001-2020 locomotive fuel consumption values were computed by multiplying the year 2000 fuel volume by a growth factor computed as the ratio of projected calendar year railroad sector energy consumption to year 2000 energy consumption from the EIA Annual Energy Outlook (AEO) 2002, Table 7, Transportation Sector, Key Indicators and Delivered Energy Consumption, Energy Use by Mode, Railroad. Calendar year 2021-2040 locomotive gallons were computed by growing the year 2000 locomotive fuel volume using the EIA/AEO 2000-2020 average annual compound growth of 0.892% (e.g., 2030CY growth factor = $1.00892^{30} = 1.305$). The methodology for determining the locomotive diesel fuel consumption is further documented in Chapter 7. The locomotive diesel fuel consumption for 1996 was estimated by multiplying the calendar year 2000 locomotive fuel volume by the ratio of the FOKS railroad distillate fuel volumes for 1996 and 2000.

Table 3.1-6a
Baseline (48-State) Fuel Sulfur Levels, SO_2,
Sulfate PM, and $PM_{2.5}$ Emissions for Locomotives and Commercial Marine Vessels

Year	Locomotive Usage (10^9 gal/yr)	Commercial Marine Usage (10^9 gal/yr)	Base Sulfur Level (ppm)	Base						
				SO_2		Sulfate PM		PM_{10} EF Loco (g/gallon)	Total $PM_{2.5}$	
				Loco	CMV	Loco	CMV		Loco	CMV
1996	3.039	1.560	2396	50,534	25,948	4,066	2,088	6.8	20,937	36,366
2000	2.821	1.611	2396	46,911	26,791	3,774	2,155	6.8	19,436	37,186
2001	2.966	1.629	2396	49,328	27,083	3,969	2,179	6.8	20,438	37,397
2002	2.918	1.646	2396	48,521	27,379	3,904	2,203	6.8	20,103	37,608
2003	2.969	1.664	2396	49,366	27,679	3,972	2,227	6.8	20,453	37,819
2004	3.010	1.683	2396	50,047	27,983	4,026	2,251	6.8	20,735	38,031
2005	3.051	1.701	2396	50,738	28,291	4,082	2,276	6.6	20,403	38,243
2006	3.081	1.720	2352	50,288	28,078	4,046	2,259	6.4	19,977	38,416
2007	3.111	1.739	2321	50,109	28,015	4,031	2,254	6.2	19,541	38,601
2008	3.124	1.758	2321	50,331	28,326	4,049	2,279	6.0	18,994	38,813
2009	3.146	1.778	2321	50,679	28,638	4,077	2,304	5.9	18,807	39,026
2010	3.169	1.797	2302	50,625	28,718	4,073	2,310	5.7	18,300	39,221
2011	3.223	1.817	2302	51,487	29,036	4,142	2,336	5.7	18,612	39,434
2012	3.237	1.838	2302	51,720	29,359	4,161	2,362	5.6	18,368	39,647
2013	3.246	1.858	2302	51,861	29,686	4,172	2,388	5.5	18,089	39,860
2014	3.255	1.879	2302	52,006	30,019	4,184	2,415	5.4	17,809	40,074
2015	3.270	1.900	2302	52,240	30,356	4,203	2,442	5.3	17,559	40,288
2016	3.303	1.921	2302	52,776	30,698	4,246	2,470	5.2	17,404	40,503
2017	3.322	1.943	2302	53,079	31,045	4,270	2,498	5.1	17,167	40,718
2018	3.340	1.965	2302	53,355	31,397	4,293	2,526	5.1	17,257	40,933
2019	3.358	1.988	2302	53,655	31,754	4,317	2,555	5.0	17,013	41,149
2020	3.369	2.010	2302	53,832	32,117	4,331	2,584	4.9	16,728	41,365
2021	3.399	2.033	2302	54,312	32,485	4,370	2,614	4.8	16,533	41,767
2022	3.430	2.057	2302	54,796	32,859	4,409	2,644	4.7	16,333	42,171
2023	3.460	2.080	2302	55,285	33,239	4,448	2,674	4.7	16,478	42,574
2024	3.491	2.105	2302	55,778	33,624	4,488	2,705	4.6	16,272	42,978
2025	3.522	2.129	2302	56,276	34,016	4,528	2,737	4.5	16,060	43,382
2026	3.554	2.154	2302	56,778	34,413	4,568	2,769	4.4	15,843	43,787
2027	3.585	2.179	2302	57,285	34,817	4,609	2,801	4.4	15,985	44,192
2028	3.617	2.205	2302	57,796	35,227	4,650	2,834	4.3	15,761	44,598
2029	3.650	2.231	2302	58,311	35,644	4,691	2,868	4.2	15,531	45,004
2030	3.682	2.257	2302	58,832	36,068	4,733	2,902	4.2	15,670	45,411
2031	3.715	2.284	2302	59,356	36,498	4,775	2,936	4.1	15,433	45,818
2032	3.748	2.312	2302	59,886	36,936	4,818	2,972	4.0	15,191	46,226
2033	3.782	2.340	2302	60,420	37,380	4,861	3,007	4.0	15,327	46,634
2034	3.815	2.368	2302	60,959	37,832	4,904	3,044	3.9	15,077	47,043
2035	3.849	2.397	2302	61,503	38,292	4,948	3,081	3.9	15,211	47,453
2036	3.884	2.426	2302	62,052	38,759	4,992	3,118	3.9	15,347	47,863
2037	3.918	2.456	2302	62,605	39,235	5,037	3,157	3.8	15,087	48,273
2038	3.953	2.486	2302	63,164	39,718	5,082	3,195	3.8	15,222	48,684
2039	3.989	2.517	2302	63,727	40,210	5,127	3,235	3.7	14,953	49,096

2040	4.024	2.548	2302	64,296	40,710	5,173	3,275	3.7	15,087	49,509

Table 3.1-6b
Baseline (50-State) Fuel Sulfur Levels, SO_2,
Sulfate PM, and $PM_{2.5}$ Emissions for Locomotives and Commercial Marine Vessels

Year	Locomotive Usage (10^9 gal/yr)	Commercial Marine Usage (10^9 gal/yr)	Base Sulfur Level (ppm)	Base						
				SO_2		Sulfate PM		PM_{10} EF Loco (g/gallon)	Total $PM_{2.5}$	
				Loco	CMV	Loco	CMV		Loco	CMV
1996	3.043	1.642	2396	50,604	27,297	4,071	2,196	6.8	20,966	38,257
2000	2.825	1.695	2396	46,976	28,184	3,779	2,267	6.8	19,463	39,119
2001	2.970	1.713	2396	49,396	28,491	3,974	2,292	6.8	20,466	39,340
2002	2.922	1.732	2396	48,589	28,802	3,909	2,317	6.8	20,131	39,563
2003	2.973	1.751	2396	49,434	29,118	3,977	2,343	6.8	20,482	39,785
2004	3.014	1.770	2396	50,116	29,437	4,032	2,368	6.8	20,764	40,008
2005	3.055	1.790	2396	50,808	29,762	4,088	2,394	6.6	20,432	40,231
2006	3.085	1.809	2352	50,358	29,538	4,051	2,376	6.4	20,004	40,413
2007	3.115	1.830	2321	50,178	29,471	4,037	2,371	6.2	19,568	40,608
2008	3.129	1.850	2321	50,401	29,798	4,055	2,397	6.0	19,021	40,831
2009	3.150	1.870	2321	50,749	30,127	4,083	2,424	5.9	18,833	41,054
2010	3.173	1.891	2302	50,695	30,210	4,079	2,431	5.7	18,325	41,259
2011	3.227	1.912	2302	51,559	30,545	4,148	2,457	5.7	18,637	41,483
2012	3.242	1.933	2302	51,792	30,885	4,167	2,485	5.6	18,393	41,708
2013	3.251	1.955	2302	51,933	31,229	4,178	2,512	5.5	18,114	41,932
2014	3.260	1.977	2302	52,078	31,579	4,190	2,541	5.4	17,834	42,157
2015	3.274	1.999	2302	52,313	31,934	4,209	2,569	5.3	17,583	42,382
2016	3.308	2.021	2302	52,849	32,293	4,252	2,598	5.2	17,428	42,608
2017	3.327	2.044	2302	53,153	32,658	4,276	2,627	5.1	17,191	42,834
2018	3.344	2.067	2302	53,429	33,029	4,299	2,657	5.1	17,281	43,061
2019	3.363	2.091	2302	53,729	33,405	4,323	2,688	5.0	17,037	43,288
2020	3.374	2.115	2302	53,906	33,787	4,337	2,718	4.9	16,751	43,515
2021	3.404	2.139	2302	54,387	34,174	4,376	2,749	4.8	16,556	43,939
2022	3.434	2.164	2302	54,872	34,567	4,415	2,781	4.7	16,355	44,363
2023	3.465	2.189	2302	55,362	34,967	4,454	2,813	4.7	16,501	44,787
2024	3.496	2.214	2302	55,856	35,372	4,494	2,846	4.6	16,294	45,212
2025	3.527	2.240	2302	56,354	35,784	4,534	2,879	4.5	16,082	45,637
2026	3.559	2.266	2302	56,857	36,202	4,574	2,913	4.4	15,865	46,063
2027	3.590	2.292	2302	57,364	36,627	4,615	2,947	4.4	16,007	46,490
2028	3.622	2.320	2302	57,876	37,059	4,656	2,981	4.3	15,782	46,916
2029	3.655	2.347	2302	58,392	37,497	4,698	3,017	4.2	15,553	47,344
2030	3.687	2.375	2302	58,913	37,943	4,740	3,053	4.2	15,692	47,772
2031	3.720	2.403	2302	59,439	38,396	4,782	3,089	4.1	15,455	48,200
2032	3.753	2.432	2302	59,969	38,856	4,825	3,126	4.0	15,212	48,629
2033	3.787	2.461	2302	60,504	39,323	4,868	3,164	4.0	15,348	49,059
2034	3.821	2.491	2302	61,044	39,799	4,911	3,202	3.9	15,098	49,489
2035	3.855	2.521	2302	61,588	40,282	4,955	3,241	3.9	15,233	49,919
2036	3.889	2.552	2302	62,138	40,774	4,999	3,280	3.9	15,368	50,351
2037	3.924	2.583	2302	62,692	41,274	5,044	3,321	3.8	15,108	50,783

2038	3.959	2.615	2302	63,252	41,783	5,089	3,362	3.8	15,243	51,215
2039	3.994	2.648	2302	63,816	42,300	5,134	3,403	3.7	14,974	51,648
2040	4.030	2.680	2302	64,385	42,826	5,180	3,445	3.7	15,108	52,082

Vessel bunkering (commercial and recreational marine) distillate fuel consumption for calendar year 2000 was also taken from the EIA FOKS 2000 report. The volume of diesel fuel consumed by vessel bunkering was assumed to represent 90 percent of the reported distillate value. The fuel consumption specific to commercial marine was then calculated by subtracting the recreational marine fuel consumption as generated by the draft NONROAD2002 model. Calendar year 2001-2040 commercial marine diesel fuel consumption values were computed by multiplying the year 2000 volume by the growth factor of CO emission projections for the combination of Category 1 and 2 vessels in the 2002 diesel marine engine final rule. CO emission projections were used due to availability and applicability as an appropriate surrogate for fuel consumption. The commercial marine diesel fuel consumption for 1996 was estimated by multiplying the calendar year 2000 commercial marine fuel volume by the ratio of the CO emission projections for 1996 and 2000.

Annual SO_2 emission estimates for locomotives and commercial marine vessels were calculated by multiplying the gallons of fuel use by the fuel density, the fuel sulfur content, and the molecular weight ratio of SO_2 to sulfur. This is then reduced by the fraction of fuel sulfur that is converted to sulfate PM (2.247% on average for engines without aftertreatment).[1] Following is an example of the calculation for the case when fuel sulfur content is 2300 ppm.

SO_2 tons = gallons × 7.1 lb/gallon × 0.0023 S wt. Fraction × (1-0.02247 S fraction converted to SO_2) × 64/32 SO_2 to S M.W. ratio / 2000 lb/ton

Unlike the equation used in the draft NONROAD2002 model for land-based diesel and recreational marine diesel engines (described in Section 3.1.1.5), this equation does not include a correction for the sulfur remaining in the unburned fuel. The correction for unburned fuel, as indicated by THC emissions, is not used for two reasons: 1) THC emission factors were not available for years other than 1996, 2020, and 2030, and 2) this correction factor is insubstantial for diesel emissions.

Annual sulfate PM emission estimates for locomotives and commercial marine vessels were calculated by multiplying the gallons of fuel use by the fuel density, the fuel sulfur content, the molecular weight ratio of hydrated sulfate to sulfur, and the fraction of fuel sulfur converted to sulfate on average. Following is an example of the calculation for the case when fuel sulfur content is 2300 ppm.

Sulfate tons = gallons × 7.1 lb/gallon × 0.0023 S wt. Fraction × 0.02247 fraction of S converted to sulfate × 224/32 sulfate to S M.W. ratio / 2000 lb/ton

Annual total PM_{10} emission estimates for locomotives were calculated by multiplying the gallons of fuel use by the gram per gallon PM emission factor from the 1998 locomotive final rule Regulatory Support Document. Following is an example calculation:

PM_{10} tons = gallons × g/gal EF / 454g/lb / 2000 lbs/ton

PM_{10} is assumed to be equivalent to total PM, and $PM_{2.5}$ is estimated by multiplying PM_{10} emissions by a factor of 0.92. This is the factor used for all nonroad diesel engines; the basis is described in Section 3.1.1.6.

Annual PM_{10} emission estimates for commercial marine vessels in calendar years 1996 and 2000 were taken from the inventory done for the HD07 rule. For years 2001 - 2030, the year 2000 inventory was adjusted according to the commercial marine growth factor mentioned above from the 2002 diesel marine engine final rule. The fuel sulfate portion was then adjusted to account for the revised sulfur levels.

3.1.4 Recreational Marine Engines

Diesel recreational marine engines consist mainly of inboard engines used in larger power boats and sailboats, but there are also a small number of outboard diesel engines in use. Emission estimates for this category were generated using the draft NONROAD2002 model. Details of the modeling inputs (e.g., populations, activity, and emission factors) for these engines can be found in the technical reports documenting the draft NONROAD2002 model. The emission inventory numbers presented here assume that recreational marine applications would use diesel fuel with the same sulfur content and sulfur-to-sulfate conversion rate as locomotives and commercial marine vessels.

It should be noted that these inventory values do not account for the newest standards promulgated in September 2002, which take effect in 2006-2009, for diesel recreational marine engines greater than 37 kw (50 hp). Although those standards provide substantial benefits for the affected engines (e.g., 25% - 37% reductions of PM, NO_x, and HC in 2030), the impact of this on the total nonroad diesel inventory is quite small, representing less than 1% of the baseline nonroad diesel inventory (without locomotives or commercial marine) for PM, NO_x, and HC in 2030.

Tables 3.1-7a and 3.1-7b present the PM_{10}, $PM_{2.5}$, NO_x, SO_2, VOC, and CO emissions for recreational marine engines in 1996 and 2000-2040 for the 48-state and 50-state inventories, respectively.

Table 3.1-7a
Baseline (48-State) Emissions for Recreational Marine Diesel Engines (short tons)

Year	PM_{10}	$PM_{2.5}$	NO_x	SO_2	VOC	CO
1996	529	487	19,440	2,251	803	3,215
2000	594	547	21,899	2,537	900	3,613
2001	611	562	22,548	2,613	923	3,713
2002	627	577	23,196	2,689	947	3,814
2003	643	592	23,844	2,765	970	3,913
2004	660	607	24,492	2,841	992	4,013
2005	676	622	25,139	2,917	1,015	4,112
2006	688	633	25,790	2,939	1,037	4,211
2007	700	644	26,439	2,974	1,059	4,309
2008	716	659	27,088	3,049	1,081	4,406
2009	732	673	27,736	3,123	1,102	4,503
2010	745	686	28,384	3,171	1,124	4,599
2011	760	700	29,028	3,244	1,145	4,695
2012	776	714	29,671	3,317	1,166	4,790
2013	791	728	30,314	3,390	1,186	4,884
2014	806	741	30,957	3,463	1,207	4,979
2015	821	755	31,600	3,536	1,227	5,072
2016	836	769	32,244	3,610	1,247	5,166
2017	851	783	32,888	3,683	1,268	5,260
2018	865	796	33,531	3,756	1,288	5,353
2019	880	810	34,174	3,830	1,308	5,445
2020	895	823	34,817	3,903	1,328	5,538
2021	909	837	35,460	3,976	1,347	5,630
2022	924	850	36,103	4,050	1,367	5,722
2023	938	863	36,746	4,123	1,387	5,814
2024	953	877	37,388	4,196	1,406	5,906
2025	967	890	38,031	4,270	1,426	5,997
2026	982	903	38,673	4,343	1,446	6,089
2027	996	917	39,316	4,416	1,465	6,181
2028	1,011	930	39,959	4,489	1,486	6,275
2029	1,026	944	40,604	4,563	1,507	6,370
2030	1,042	958	41,250	4,636	1,528	6,465
2031	1,057	973	41,896	4,709	1,550	6,561
2032	1,072	987	42,543	4,782	1,571	6,656
2033	1,088	1,001	43,189	4,856	1,592	6,752
2034	1,103	1,015	43,836	4,929	1,614	6,848
2035	1,119	1,029	44,483	5,002	1,636	6,945
2036	1,134	1,044	45,131	5,075	1,658	7,041
2037	1,150	1,058	45,779	5,149	1,680	7,139
2038	1,166	1,073	46,428	5,222	1,703	7,238
2039	1,182	1,087	47,076	5,295	1,725	7,336
2040	1,198	1,102	47,725	5,368	1,748	7,435

Table 3.1-7b
Baseline (50-State) Emissions for Recreational Marine Diesel Engines (short tons)

Year	PM_{10}	$PM_{2.5}$	NO_x	SO_2	VOC	CO
1996	532	490	19,562	2,265	808	3,236
2000	598	550	22,036	2,553	906	3,635
2001	615	566	22,689	2,629	929	3,737
2002	631	581	23,342	2,706	953	3,838
2003	648	596	23,994	2,783	976	3,938
2004	664	611	24,646	2,859	999	4,038
2005	680	626	25,297	2,936	1,021	4,138
2006	692	637	25,952	2,957	1,044	4,237
2007	705	648	26,605	2,993	1,066	4,336
2008	721	663	27,258	3,068	1,088	4,434
2009	736	677	27,911	3,142	1,109	4,531
2010	750	690	28,563	3,191	1,131	4,628
2011	765	704	29,210	3,264	1,152	4,724
2012	781	718	29,858	3,338	1,173	4,820
2013	796	732	30,505	3,411	1,194	4,915
2014	811	746	31,152	3,485	1,214	5,010
2015	826	760	31,798	3,559	1,235	5,104
2016	841	774	32,446	3,632	1,255	5,199
2017	856	787	33,094	3,706	1,276	5,293
2018	871	801	33,742	3,780	1,296	5,386
2019	886	815	34,389	3,854	1,316	5,480
2020	900	828	35,036	3,928	1,336	5,573
2021	915	842	35,683	4,001	1,356	5,665
2022	930	855	36,330	4,075	1,376	5,758
2023	944	869	36,977	4,149	1,395	5,850
2024	959	882	37,623	4,223	1,415	5,943
2025	973	895	38,270	4,297	1,435	6,035
2026	988	909	38,916	4,370	1,455	6,127
2027	1,003	922	39,563	4,444	1,475	6,220
2028	1,018	936	40,210	4,518	1,495	6,314
2029	1,033	950	40,860	4,591	1,516	6,410
2030	1,048	964	41,510	4,665	1,538	6,506
2031	1,064	979	42,160	4,739	1,559	6,602
2032	1,079	993	42,810	4,812	1,581	6,698
2033	1,095	1,007	43,461	4,886	1,602	6,795
2034	1,110	1,021	44,112	4,960	1,624	6,891
2035	1,126	1,036	44,763	5,034	1,646	6,988
2036	1,141	1,050	45,414	5,107	1,668	7,086
2037	1,157	1,065	46,067	5,181	1,691	7,184
2038	1,173	1,079	46,719	5,255	1,713	7,283
2039	1,189	1,094	47,372	5,328	1,736	7,382
2040	1,205	1,109	48,025	5,402	1,759	7,482

3.1.5 Fuel Consumption for Nonroad Diesel Engines

Table 3.1-8 presents the fuel consumption estimates for the land-based, recreational marine, locomotive, and commercial marine nonroad diesel categories. Fuel consumption estimates are provided for 1996 and 2000-2040 for the 48-state and 50-state inventories.

The fuel consumption estimates for land-based diesel and recreational marine diesel engines were obtained using the draft NONROAD2002 model. The methodology is described in Section 3.1.1.7. The derivation of the fuel consumption estimates for locomotives and commercial marine vessels is described in Section 3.1.3.

Some of the estimates in Table 3.1-8 are different than those presented in Chapter 7, which are ultimately used in estimating the cost of the proposed fuel regulations. As described above, the diesel fuel consumption volumes for land-based nonroad engines in this chapter were obtained from the draft NONROAD2002 model. In Chapter 7, land-based diesel fuel consumption demand was developed from an independent source of fuel consumption information. Specifically, those estimates are based primarily on data contained in the EIA FOKS 2000 report. That document broadly reports fuel sales for all uses, including stationary sources. Therefore, a number of assumptions must be applied to the information contained in FOKS 2000 to obtain an estimate of diesel fuel for nonroad engines.

When comparing the two methods of developing fuel consumption estimates, there is some difference in the results. Rather than adopt one of the two for all uses, we have decided to maintain the NONROAD2002 based estimates for inventory generation and the land-based diesel fuel estimates of Chapter 7 for the cost analyses. Use of the nonroad estimates for cost or the Chapter 7 estimates for emissions would introduce internal inconsistencies in the resulting cost or inventory results. These two estimates differ by a relatively small amount, approximately 15 percent in 2030, so we decided that maintaining consistency within the emissions modeling and within the cost estimation was preferable to enforcing consistency between these two areas. The Agency will continue to investigate how to resolve the differences between the two approaches for the final rule, if appropriate.

Although the locomotive diesel demand volumes in this chapter are identical to those described in Chapter 7, the marine diesel volumes are slightly different. In Chapter 7, the marine end-use category is a combination of both commercial and recreational marine end uses. In this chapter, recreational marine demand is estimated separately with the draft NONROAD2002 model for each calendar year, and subtracted from the respective combined marine end use volume to produce the commercial marine estimate. Also, the combined marine volume estimates in the two chapters differ by about one percentage for years prior to 2008 due to the use of a slightly different computational methodology for that period.

Table 3.1-8
Fuel Consumption for Nonroad Diesel Engines

Year	Fuel Consumption (10^6 gal/year)							
	Land-Based Diesel		Recreational Marine		Locomotives		Commercial Marine	
	48-State	50-State	48-State	50-State	48-State	50-State	48-State	50-State
1996	9,254	9,304	136	136	3,039	3,043	1,560	1,642
2000	10,440	10,496	153	154	2,821	2,825	1,611	1,695
2001	10,740	10,798	157	158	2,966	2,970	1,629	1,713
2002	11,040	11,100	162	163	2,918	2,922	1,646	1,732
2003	11,340	11,401	167	168	2,969	2,973	1,664	1,751
2004	11,640	11,703	171	172	3,010	3,014	1,683	1,770
2005	11,940	12,005	176	177	3,051	3,055	1,701	1,790
2006	12,238	12,304	180	181	3,081	3,085	1,720	1,809
2007	12,535	12,603	185	186	3,111	3,115	1,739	1,830
2008	12,833	12,903	190	191	3,124	3,129	1,758	1,850
2009	13,131	13,202	194	195	3,146	3,150	1,778	1,870
2010	13,429	13,502	199	200	3,169	3,173	1,797	1,891
2011	13,728	13,803	203	205	3,223	3,227	1,817	1,912
2012	14,028	14,104	208	209	3,237	3,242	1,838	1,933
2013	14,327	14,405	212	214	3,246	3,251	1,858	1,955
2014	14,627	14,706	217	218	3,255	3,260	1,879	1,977
2015	14,926	15,007	222	223	3,270	3,274	1,900	1,999
2016	15,223	15,306	226	228	3,303	3,308	1,921	2,021
2017	15,519	15,604	231	232	3,322	3,327	1,943	2,044
2018	15,816	15,902	235	237	3,340	3,344	1,965	2,067
2019	16,112	16,200	240	242	3,358	3,363	1,988	2,091
2020	16,409	16,498	245	246	3,369	3,374	2,010	2,115
2021	16,706	16,797	249	251	3,399	3,404	2,033	2,139
2022	17,002	17,095	254	255	3,430	3,434	2,057	2,164
2023	17,299	17,393	258	260	3,460	3,465	2,080	2,189
2024	17,595	17,691	263	265	3,491	3,496	2,105	2,214
2025	17,892	17,989	268	269	3,522	3,527	2,129	2,240
2026	18,186	18,286	272	274	3,554	3,559	2,154	2,266
2027	18,481	18,582	277	279	3,585	3,590	2,179	2,292
2028	18,776	18,878	281	283	3,617	3,622	2,205	2,320
2029	19,070	19,175	286	288	3,650	3,655	2,231	2,347
2030	19,365	19,471	291	292	3,682	3,687	2,257	2,375
2031	19,660	19,767	295	297	3,715	3,720	2,284	2,403
2032	19,954	20,063	300	302	3,748	3,753	2,312	2,432
2033	20,249	20,358	304	306	3,782	3,787	2,340	2,461
2034	20,544	20,656	309	311	3,815	3,821	2,368	2,491
2035	20,838	20,952	314	315	3,849	3,855	2,397	2,521
2036	21,133	21,249	318	320	3,884	3,889	2,426	2,552
2037	21,428	21,545	323	325	3,918	3,924	2,456	2,583
2038	21,722	21,841	327	329	3,953	3,959	2,486	2,615
2039	22,017	22,137	332	334	3,989	3,994	2,517	2,648
2040	22,312	22,434	336	339	4,024	4,030	2,548	2,680

3.2 Contribution of Nonroad Diesel Engines to National Emission Inventories

This section provides the contribution of nonroad diesel engines to national baseline emission inventories in 1996, 2020, and 2030. The emission inventories are based on 48-state inventories that exclude Alaska and Hawaii in order to be consistent with the air quality modeling region. The baseline cases represent current and future emissions with only the existing standards. For nonroad engines, the baseline inventories were developed prior to promulgation of standards that cover large spark-ignition engines (>25 hp), recreational equipment, and recreational marine diesel engines (>50 hp).[9] Although the future inventories presented here do not account for the impact of the standards for those nonroad categories, qualitative impacts of those standards on the inventories will be discussed. We intend to account for the impact of these standards in the final rule analysis.

The calendar years correspond to those chosen for the air quality modeling. Pollutants discussed include $PM_{2.5}$, NO_x, SO_2, VOC, and CO. VOC includes both exhaust and evaporative emissions.

Of interest are the contributions of emissions from nonroad diesel sources affected by the proposed rule. For $PM_{2.5}$ and SO_2, this includes emissions from all nonroad diesel sources. For NO_x, VOC, and CO, this includes emissions from land-based nonroad diesel engines. Contributions to both total mobile source emissions and total emissions from all sources are presented. For $PM_{2.5}$, contributions of nonroad diesel engines to both total diesel $PM_{2.5}$ and total manmade $PM_{2.5}$ are also presented.

The development of the 1996, 2020, and 2030 baseline emissions inventories for the nonroad sector and for the sectors not affected by this proposed rule will be briefly described, followed by discussions for each pollutant of the contribution of nonroad diesel engines to national baseline inventories.

3.2.1 Baseline Emissions Inventory Development

For 1996, 2020, and 2030, county-level emission estimates were developed by Pechan under contract to EPA. These were used as input for the air quality modeling. These inventories account for county-level differences in parameters such as fuel characteristics and temperature. The draft NONROAD2002 model was used to generate the county-level emissions estimates for all nonroad sources, with the exception of commercial marine engines, locomotives, and aircraft. The methodology has been documented elsewhere.[10]

The on-highway estimates are based on the MOBILE5b model, but with some further adjustments to reflect MOBILE6 emission factors. The on-highway inventories are similar to those prepared for the Heavy-Duty Diesel (HDD) rulemaking [11], with the exception of adjustments to NO_x and VOC for California counties, based on county-level estimates from the California Air Resources Board.

The stationary point and area source estimates are also based on the HDD rulemaking, with the exception of adjustments to NO_x and VOC for California counties, based on county-level estimates from the California Air Resources Board. There were also some stack parameter corrections made to the point source estimates.

The model inputs for the diesel nonroad sources have been described in detail in Section 3.1. Although county-level-based inventories were developed by Pechan for the land-based diesel and recreational marine diesel categories, these were not used in this section. Instead, the emission estimates for these categories were based on national level runs. This was done for two reasons. First, the baseline inventories for 2020 and 2030 were revised since the county-level estimates were developed (specifically, $PM_{2.5}$ and SO_2 emissions were changed to reflect revised diesel fuel sulfur inputs). It was not possible to develop revised county-level estimates for these categories due to resource and time constraints. Second, county-level estimates were only developed for 2020 and 2030. Estimates for interim years are also needed to fully evaluate the anticipated emission benefits of the proposed rule. Interim year estimates are generated using national level model runs. In order to be consistent with other sections of the RIA in which interim year estimates from 1996 to 2030 are presented, the inventory estimates presented here for the land-based diesel and recreational marine diesel categories are based on national level model runs. Model results for national level runs are similar to those based on an aggregation of county-level runs. For a more detailed comparison of national level and county level results, see Section 3.6.

3.2.2 $PM_{2.5}$ Emissions

Table 3.2-1 provides the contribution of land-based diesel engines and other source categories to total diesel $PM_{2.5}$ emissions.

$PM_{2.5}$ emissions from land-based nonroad diesels are 43% of the total diesel $PM_{2.5}$ emissions in 1996, and this percentage increases to 64% by 2030. Emissions from land-based nonroad diesels actually decrease from 176,510 tons in 1996 to 124,334 tons in 2020 due to the existing emission standards. From 2020 to 2030, however, emissions increase to 139,527 tons, as growth in this sector offsets the effect of the existing emission standards.

$PM_{2.5}$ emissions from recreational marine diesel engines, commercial marine diesel engines, and locomotives will also be affected by this proposal due to the fuel sulfur requirements. For all nonroad diesel sources affected by this proposal, the contribution to total diesel $PM_{2.5}$ emissions increases from 57% in 1996 to 92% in 2030.

Table 3.2-2 provides the contribution of land-based diesel engines and other source categories to total manmade $PM_{2.5}$ emissions. $PM_{2.5}$ emissions from land-based nonroad diesels are 8% of the total manmade $PM_{2.5}$ emissions in 1996, and this percentage drops slightly to 6% in 2020 and 2030. The contribution of land-based diesels to total mobile source $PM_{2.5}$ emissions is 32% in 1996, rising to 37% by 2030. For all nonroad diesel sources, the contribution to total manmade $PM_{2.5}$ emissions is 11% in 1996, and this percentage drops slightly to 9% in 2020 and 2030.

The recently promulgated standards for large spark-ignition engines, recreational equipment, and recreational marine diesel engines (>50 hp) include PM standards for the recreational equipment and recreational marine diesel categories. $PM_{2.5}$ emissions from recreational equipment would be reduced roughly 50% by 2030, whereas $PM_{2.5}$ emissions from recreational marine diesel engines over 50 hp would be reduced roughly 25% by 2030 with these standards. Since $PM_{2.5}$ emissions from recreational equipment and recreational marine diesel engines constitute less than 1% of the total emissions, the impact of these PM standards will have a negligible effect on the inventories provided in Tables 3.2-1 and 3.2-2.

3.2.3 NO_x Emissions

Table 3.2-3 provides the contribution of land-based diesel engines and other source categories to total NO_x emissions.

NO_x emissions from land-based nonroad diesels are 6% of the total emissions in 1996, and this percentage increases to 8% by 2030. The contribution of land-based diesels to total mobile source NO_x emissions is 12% in 1996, rising to 24% by 2030. Emissions from land-based nonroad diesels actually decrease from 1,583,664 tons in 1996 to 1,140,727 tons in 2020 due to the existing emission standards. From 2020 to 2030, however, emissions increase to 1,231,995 tons, as growth in this sector offsets the effect of the existing emission standards.

NO_x emissions from recreational marine diesel engines, commercial marine diesel engines, and locomotives will not be affected by this proposal. For these categories combined, the contribution to total NO_x emissions remains stable at 9% from 1996 to 2030.

The recently promulgated standards for large spark-ignition engines, recreational equipment, and recreational marine diesel engines (>50 hp) include NO_x standards for the recreational marine diesel and large spark-ignition categories. NO_x emissions from recreational marine diesel engines over 50 hp would be reduced roughly 25% by 2030, whereas NO_x emissions from large spark-ignition engines would be reduced roughly 90% by 2030 with these standards. Although the contribution from these categories will decrease due to the standards, the contribution of land-based diesel engines to the total NO_x inventory remains stable at 8% in 2030.

3.2.4 SO_2 Emissions

Table 3.2-4 provides the contribution of land-based diesel engines and other source categories to total SO_2 emissions.

SO_2 emissions from land-based nonroad diesels are 1% of the total emissions in 1996, and this percentage increases to 2% by 2030. The contribution of land-based diesels to total mobile source SO_2 emissions is 20% in 1996, rising to 44% by 2030, due to continued growth in this sector.

SO_2 emissions from recreational marine diesel engines, commercial marine diesel engines, and locomotives will also be affected by this proposal due to the fuel sulfur requirements. For all nonroad diesel sources affected by this proposal, the contribution to total SO_2 emissions increases from 1% in 1996 to 3% in 2030.

The recently promulgated standards for large spark-ignition engines, recreational equipment, and recreational marine diesel engines (>50 hp) do not impact SO_2 emissions; therefore, the SO_2 emissions inventories presented in Table 3.2-4 are not affected by these standards.

3.2.5 VOC Emissions

Table 3.2-5 provides the contribution of land-based diesel engines and other source categories to total VOC emissions. VOC includes both exhaust and evaporative emissions. VOC is an ozone precursor; therefore, VOC inventories are required for air quality modeling.

VOC emissions from land-based nonroad diesels are 1% of the total emissions in 1996, and this percentage remains stable at 1% by 2030. The contribution of land-based diesels to total mobile source VOC emissions is 3% in 1996, decreasing slightly to 2% by 2030. Emissions from land-based nonroad diesels actually decrease from 221,403 tons in 1996 to 96,855 tons in 2020 due to the existing emission standards. From 2020 to 2030, however, emissions increase to 97,348 tons, as growth in this sector offsets the effect of the existing emission standards.

VOC emissions from recreational marine diesel engines, commercial marine diesel engines, and locomotives will not be affected by this proposal. For these categories combined, the contribution to total VOC emissions increases slightly from 1% from 1996 to 2% in 2030.

The recently promulgated standards for large spark-ignition engines, recreational equipment, and recreational marine diesel engines (>50 hp) include VOC standards for each category. VOC emissions from large spark-ignition engines would be reduced roughly 65% by 2030 with these standards. VOC emissions from recreational equipment would be reduced roughly 70%, whereas VOC emissions from recreational marine diesel engines over 50 hp would be reduced roughly 35% by 2030. Although the contribution from these categories will decrease due to the standards, the contribution of land-based diesel engines to the total VOC inventory remains stable at 1% in 2030.

3.2.6 CO Emissions

Table 3.2-6 provides the contribution of land-based diesel engines and other source categories to total CO emissions.

CO emissions from land-based nonroad diesels are 1% of the total emissions in 1996, and this percentage remains stable at 1% by 2030. The contribution of land-based diesels to total mobile source CO emissions is also 1% in 1996, remaining at 1% by 2030. Emissions from land-based nonroad diesels actually decrease from 1,010,518 tons in 1996 to 700,017 tons in 2020 due to the existing emission standards. From 2020 to 2030, however, emissions increase to 793,923 tons, as growth in this sector offsets the effect of the existing emission standards.

CO emissions from recreational marine diesel engines, commercial marine diesel engines, and locomotives will not be affected by this proposal. For these categories combined, the contribution to total CO emissions is less than 1% in 1996 and 2030.

The recently promulgated standards for large spark-ignition engines, recreational equipment, and recreational marine diesel engines (>50 hp) include CO standards for the large spark-ignition and recreational equipment categories. CO emissions from large spark-ignition engines would be reduced roughly 90% by 2030 with these standards, whereas CO emissions from recreational equipment would be reduced roughly 20% by 2030. Although the contribution from these categories will decrease due to the standards, the contribution of land-based diesel engines to the total CO inventory remains stable at 1% in 2030.

Table 3.2-1
Annual Diesel $PM_{2.5}$ Baseline Emission Levels for Mobile and Other Source Categories[a]

Category	1996			2020			2030		
	short tons	% of mobile source	% of total	short tons	% of mobile source	% of total	short tons	% of mobile source	% of total
Land-Based Nonroad Diesel	176,510	43.9%	42.6%	124,334	61.7%	60.4%	139,527	64.7%	63.5%
Recreational Marine Diesel ≤50 hp	62	0.0%	0.0%	70	0.0%	0.0%	64	0.0%	0.0%
Recreational Marine Diesel >50 hp [b]	425	0.1%	0.1%	753	0.4%	0.4%	894	0.4%	0.4%
Commercial Marine Diesel	36,367	9.1%	8.8%	41,365	20.5%	20.1%	45,411	21.1%	20.7%
Locomotive	20,937	5.2%	5.1%	16,727	8.3%	8.1%	15,670	7.3%	7.1%
Total Nonroad Diesel	234,301	58%	57%	183,249	91%	89%	201,566	94%	92%
Total Highway Diesel	167,384	42%	40%	18,426	9%	9%	13,948	6%	6%
Total Mobile Source Diesel	401,685	100%	97%	201,675	100%	98%	215,514	100%	98%
Stationary Point and Area Source Diesel [c]	12,199	—	3%	4,010	—	2%	4,231	—	2%
Total Man-Made Diesel Sources	413,884	—		205,685	—		219,745	—	
Mobile Source Percent of Total	97%	—		98%	—		98%	—	

[a] These are 48-state inventories. They do not include Alaska and Hawaii.
[b] These inventories do not account for the final rule to control emissions from nonroad large spark-ignition engines, recreational marine diesel engines >50 hp, and recreational vehicles, published November 8, 2002.
[c] This category includes point sources burning either diesel, distillate oil (diesel), or diesel/kerosene fuel.

Table 3.2-2
Annual $PM_{2.5}$ Baseline Emission Levels for Mobile and Other Source Categories [a,b]

Category	1996			2020			2030		
	short tons	% of mobile source	% of total	short tons	% of mobile source	% of total	short tons	% of mobile source	% of total
Land-Based Nonroad Diesel	176,510	31.5%	8.0%	124,334	35.4%	6.0%	139,527	36.7%	6.3%
Recreational Marine Diesel ≤50 hp	62	0.0%	0.0%	70	0.0%	0.0%	64	0.0%	0.0%
Recreational Marine Diesel >50 hp [c]	425	0.1%	0.0%	753	0.2%	0.0%	894	0.2%	0.0%
Recreational Marine SI	35,147	6.3%	1.6%	26,110	7.4%	1.3%	27,223	7.2%	1.2%
Nonroad SI ≤25 hp	24,130	4.3%	1.1%	29,998	8.5%	1.5%	34,435	9.1%	1.6%
Nonroad SI >25hp [c]	1,370	0.2%	0.1%	2,297	0.6%	0.1%	2,687	0.7%	0.1%
Recreational SI [c]	4,632	0.8%	0.2%	5,557	1.6%	0.3%	5,912	1.6%	0.3%
Commercial Marine Diesel	36,367	6.5%	1.6%	41,365	11.8%	2.0%	45,411	12.0%	2.1%
Commercial Marine SI	1,370	0.2%	0.1%	1,326	0.4%	0.1%	1,427	0.4%	0.1%
Locomotive	20,937	3.7%	1.0%	16,727	4.8%	0.8%	15,670	4.1%	0.7%
Aircraft	27,891	5.0%	1.3%	30,024	8.6%	1.5%	30,606	8.1%	1.4%
Total Nonroad	328,841	59%	15%	278,561	79%	14%	303,856	80%	14%
Total Highway	230,684	41%	10%	72,377	21%	4%	75,825	20%	3%
Total Mobile Sources	559,525	100%	25%	350,938	100%	17%	379,681	100%	17%
Stationary Point and Area Sources	1,653,392	—	75%	1,712,004	—	83%	1,824,609	—	83%
Total Man-Made Sources	2,212,917	—		2,062,942	—		2,204,290	—	
Mobile Source Percent of Total	25%	—		17%	—		17%	—	25%

[a] These are 48-state inventories. They do not include Alaska and Hawaii.
[b] Excludes natural and miscellaneous sources.
[c] These inventories do not account for the final rule to control emissions from nonroad large spark-ignition engines, recreational marine diesel engines >50 hp, and recreational vehicles, published November 8, 2002.

Table 3.2-3
Annual NO_x Baseline Emission Levels for Mobile and Other Source Categories [a]

Category	1996			2020			2030		
	short tons	% of mobile source	% of total	short tons	% of mobile source	% of total	short tons	% of mobile source	% of total
Land-Based Nonroad Diesel	1,583,664	12.1%	6.4%	1,140,727	20.8%	7.3%	1,231,995	23.6%	7.9%
Recreational Marine Diesel ≤50 hp	523	0.0%	0.0%	682	0.0%	0.0%	706	0.0%	0.0%
Recreational Marine Diesel >50 hp [b]	18,917	0.1%	0.1%	34,136	0.6%	0.2%	40,544	0.8%	0.3%
Recreational Marine SI	33,304	0.3%	0.1%	61,749	1.1%	0.4%	67,893	1.3%	0.4%
Nonroad SI ≤25 hp	63,584	0.5%	0.3%	100,119	1.8%	0.6%	116,514	2.2%	0.7%
Nonroad SI >25hp [b]	281,068	2.1%	1.1%	484,504	8.8%	3.1%	567,696	10.9%	3.7%
Recreational SI [b]	8,606	0.1%	0.0%	13,065	0.2%	0.1%	13,539	0.3%	0.1%
Commercial Marine Diesel	959,704	7.3%	3.9%	819,201	14.9%	5.3%	814,827	15.6%	5.2%
Commercial Marine SI	6,428	0.0%	0.0%	4,551	0.1%	0.0%	4,355	0.1%	0.0%
Locomotive	921,556	7.0%	3.8%	612,722	11.2%	3.9%	534,520	10.2%	3.4%
Aircraft	165,018	1.3%	0.7%	228,851	4.2%	1.5%	258,102	4.9%	1.7%
Total Nonroad	4,042,371	31%	17%	3,500,307	64%	22%	3,650,691	70%	24%
Total Highway	9,066,489	69%	37%	1,984,611	36%	13%	1,577,788	30%	10%
Total Mobile Sources	13,108,860	100%	53%	5,484,917	100%	35%	5,228,479	100%	34%
Stationary Point and Area Sources	11,449,752	—	47%	10,050,213	—	65%	10,320,361	—	66%
Total Man-Made Sources	24,558,612	—		15,535,130	—		15,548,840	—	
Mobile Source Percent of Total	53%	—		35%	—		34%	—	

[a] These are 48-state inventories. They do not include Alaska and Hawaii.
[b] These inventories do not account for the final rule to control emissions from nonroad large spark-ignition engines, recreational marine diesel engines >50 hp, and recreational vehicles, published November 8, 2002.

Table 3.2-4
Annual SO_2 Baseline Emission Levels for Mobile and Other Source Categories [a]

Category	1996			2020			2030		
	short tons	% of mobile source	% of total	short tons	% of mobile source	% of total	short tons	% of mobile source	% of total
Land-Based Nonroad Diesel	147,926	19.9%	0.8%	252,089	41.7%	1.7%	297,573	43.7%	1.9%
Recreational Marine Diesel ≤50 hp	57	0.0%	0.0%	100	0.0%	0.0%	119	0.0%	0.0%
Recreational Marine Diesel >50 hp	2,194	0.3%	0.0%	3,803	0.6%	0.0%	4,517	0.7%	0.0%
Recreational Marine SI	2,170	0.3%	0.0%	2,522	0.4%	0.0%	2,698	0.4%	0.0%
Nonroad SI ≤25 hp	6,530	0.9%	0.0%	8,347	1.4%	0.1%	9,714	1.4%	0.1%
Nonroad SI >25hp	882	0.1%	0.0%	1,060	0.2%	0.0%	1,211	0.2%	0.0%
Recreational SI	1,673	0.2%	0.0%	2,679	0.4%	0.0%	2,774	0.4%	0.0%
Commercial Marine Diesel	25,948	3.5%	0.1%	32,117	5.3%	0.2%	36,068	5.3%	0.2%
Commercial Marine SI	191,813	25.8%	1.0%	196,918	32.6%	1.3%	210,060	30.8%	1.4%
Locomotive	50,534	6.8%	0.3%	53,832	8.9%	0.4%	58,832	8.6%	0.4%
Aircraft	11,305	1.5%	0.1%	15,267	2.5%	0.1%	16,813	2.5%	0.1%
Total Nonroad	441,032	59%	2%	568,734	94%	4%	640,379	94%	4%
Total Highway	302,938	41%	2%	35,311	6%	0%	40,788	6%	0%
Total Mobile Sources	743,970	100%	4%	604,045	100%	4%	681,167	100%	4%
Stationary Point and Area Sources	17,636,602	—	96%	14,510,426	—	96%	14,782,220	—	96%
Total Man-Made Sources	18,380,572	—		15,114,471	—		15,463,387	—	
Mobile Source Percent of Total	4%	—		4%	—		4%	—	

[a] These are 48-state inventories. They do not include Alaska and Hawaii.

Table 3.2-5
Annual VOC Baseline Emission Levels for Mobile and Other Source Categories [a]

Category	1996			2020			2030		
	short tons	% of mobile source	% of total	short tons	% of mobile source	% of total	short tons	% of mobile source	% of total
Land-Based Nonroad Diesel	221,403	2.7%	1.2%	96,855	2.3%	0.7%	97,348	2.1%	0.6%
Recreational Marine Diesel ≤50 hp	128	0.0%	0.0%	108	0.0%	0.0%	80	0.0%	0.0%
Recreational Marine Diesel >50 hp [b]	676	0.0%	0.0%	1,219	0.0%	0.0%	1,448	0.0%	0.0%
Recreational Marine SI	804,488	9.6%	4.3%	380,891	8.9%	2.7%	372,970	8.0%	2.4%
Nonroad SI ≤25 hp	1,330,229	15.9%	7.2%	650,158	15.3%	4.7%	751,883	16.1%	4.9%
Nonroad SI >25hp [b]	44,926	0.5%	0.2%	42,504	1.0%	0.3%	47,411	1.0%	0.3%
Recreational SI [b]	403,984	4.8%	2.2%	719,031	16.9%	5.2%	749,134	16.1%	4.9%
Commercial Marine Diesel	31,545	0.4%	0.2%	37,290	0.9%	0.3%	41,354	0.9%	0.3%
Commercial Marine SI	960	0.0%	0.0%	998	0.0%	0.0%	1,079	0.0%	0.0%
Locomotive	48,381	0.6%	0.3%	36,546	0.9%	0.3%	31,644	0.7%	0.2%
Aircraft	176,394	2.1%	0.9%	239,654	5.6%	1.7%	265,561	5.7%	1.7%
Total Nonroad	3,063,114	37%	17%	2,205,255	52%	16%	2,359,912	51%	15%
Total Highway	5,286,948	63%	28%	2,055,843	48%	15%	2,296,972	49%	15%
Total Mobile Sources	8,350,062	100%	45%	4,261,098	100%	31%	4,656,884	100%	30%
Stationary Point and Area Sources	10,249,136	—	55%	9,648,376	—	69%	10,751,134	—	70%
Total Man-Made Sources	18,599,198	—		13,909,474	—		15,408,018	—	
Mobile Source Percent of Total	45%	—		31%	—		30%	—	

[a] These are 48-state inventories. They do not include Alaska and Hawaii.
[b] These inventories do not account for the final rule to control emissions from nonroad large spark-ignition engines, recreational marine diesel engines >50 hp, and recreational vehicles, published November 8, 2002.

Table 3.2-6
Annual CO Baseline Emission Levels for Mobile and Other Source Categories [a]

Category	1996			2020			2030		
	short tons	% of mobile source	% of total	short tons	% of mobile sources	% of total	short tons	% of mobile source	% of total
Land-Based Nonroad Diesel	1,010,518	1.3%	1.1%	700,017	0.8%	0.7%	793,923	0.8%	0.7%
Recreational Marine Diesel ≤50 hp	365	0.0%	0.0%	395	0.0%	0.0%	356	0.0%	0.0%
Recreational Marine Diesel >50 hp [b]	2,850	0.0%	0.0%	5,143	0.0%	0.0%	6,109	0.0%	0.0%
Recreational Marine SI	1,995,907	2.5%	2.1%	1,977,403	2.4%	2.0%	2,075,666	2.2%	1.9%
Nonroad SI ≤25 hp	16,735,812	21.3%	17.7 %	24,675,763	29.8%	25.0%	28,728,492	30.2%	25.8 %
Nonroad SI >25hp [b]	2,144,654	2.7%	2.3%	2,785,383	3.4%	2.8%	3,198,141	3.4%	2.9%
Recreational SI [b]	1,824,753	2.3%	1.9%	2,765,874	3.3%	2.8%	2,891,759	3.0%	2.6%
Commercial Marine Diesel	126,382	0.2%	0.1%	159,900	0.2%	0.2%	176,533	0.2%	0.2%
Commercial Marine SI	6,010	0.0%	0.0%	6,702	0.0%	0.0%	7,233	0.0%	0.0%
Locomotive	112,171	0.1%	0.1%	119,302	0.1%	0.1%	119,302	0.1%	0.1%
Aircraft	949,313	1.2%	1.0%	1,387,178	1.7%	1.4%	1,502,265	1.6%	1.3%
Total Nonroad	24,908,737	32%	26%	34,583,061	42%	35%	39,499,779	42%	35%
Total Highway	53,585,364	68%	56%	48,333,986	58%	49%	55,609,767	58%	50%
Total Mobile Sources	78,494,101	100%	83%	82,917,047	100%	84%	95,109,546	100%	85%
Stationary Point and Area Sources	16,318,451	—	17%	15,648,555	—	16%	16,325,306	—	15%
Total Man-Made Sources	94,812,552	—		98,565,602	—		111,434,852	—	
Mobile Source Percent of Total	83%	—		84%	—		85%	—	

[a] These are 48-state inventories. They do not include Alaska and Hawaii.
[b] These inventories do not account for the final rule to control emissions from nonroad large spark-ignition engines, recreational marine diesel engines >50 hp, and recreational vehicles, published November 8, 2002.

3.3 Contribution of Nonroad Diesel Engines to Selected Local Emission Inventories

The contribution of land-based nonroad compression-ignition (CI) engines to $PM_{2.5}$ and NO_x emission inventories in many U.S. cities can be significantly greater than that reflected by national average values.[A] This is not surprising given the high density of these engines one would expect to be operating in urban areas. The EPA selected a collection of typical cities spread across the United States in order to compare projected urban inventories with national average ones for 1996, 2020, and 2030. The results of this analysis are shown below.

3.3.1 $PM_{2.5}$ Emissions

As illustrated in Tables 3.3-1, 3.3-2, and 3.3-3, EPA's city-specific analysis of selected metropolitan areas for 1996, 2020, and 2030 show that land-based nonroad diesel engine engines are a significant contributor to total $PM_{2.5}$ emissions from all man-made sources.

[A] Construction, industrial, and commercial nonroad diesel equipment comprise most of the land-based nonroad emissions inventory. These types of equipment are more concentrated in urban areas where construction projects, manufacturing, and commercial operations are prevalent.

Table 3.3-1
Land-Based Nonroad Percent Contribution
to $PM_{2.5}$ Inventories in Selected Urban Areas in 1996[a]

MSA, CMSA / State	Land-Based Diesel (short tons)	Mobile Sources (short tons)	Total Man-Made Sources (short tons)	Land-Based Diesel as % of Total	Land-Based Diesel as % of Mobile Sources
Atlanta, GA	1,650	7,308	22,190	7%	23%
Boston, MA	4,265	9,539	23,254	18%	45%
Chicago, IL	3,374	10,106	40,339	8%	33%
Dallas-Fort Worth, TX	1,826	5,606	13,667	13%	33%
Indianapolis, IN	1,040	3,126	7,083	15%	33%
Minneapolis, MN	1,484	4,238	15,499	10%	35%
New York, NY	2,991	6,757	23,380	13%	44%
Orlando, FL	764	2,559	5,436	14%	30%
Sacramento, CA	529	2,140	7,103	7%	25%
San Diego, CA	879	3,715	9,631	9%	24%
Denver, CO	1,125	3,199	10,107	11%	35%
El Paso, TX	252	822	1,637	15%	31%
Las Vegas, NV-AZ	1,155	2,700	7,511	15%	43%
Phoenix-Mesa, AZ	1,549	4,994	10,100	15%	31%
Seattle, WA	1,119	4,259	15,187	7%	26%

[a] Includes only direct exhaust emissions; see Chapter 2 for a discussion of secondary fine PM levels.

Table 3.3-2
Annual Land-Based Nonroad Diesel Contributions
to $PM_{2.5}$ Inventories in Selected Urban Areas in 2020[a]

MSA, CMSA / State	Land-Based Diesel (short tons)	Mobile Sources (short tons)	Total Man-Made Sources (short tons)	Land-Based Diesel as % of Total	Land-Based Diesel as % of Mobile Sources
Atlanta, GA	1,429	4,506	22,846	6%	32%
Boston, MA	3,580	6,720	20,365	18%	53%
Chicago, IL	2,824	6,984	42,211	7%	40%
Dallas-Fort Worth, TX	1,499	3,544	15,202	10%	42%
Indianapolis, IN	794	1,779	6,238	13%	45%
Minneapolis, MN	1,188	2,509	15,096	8%	47%
New York, NY	2,573	4,549	21,566	12%	57%
Orlando, FL	652	1,743	5,627	12%	37%
Sacramento, CA	391	1,301	5,505	7%	30%
San Diego, CA	678	2,478	9,135	7%	27%
Denver, CO	923	2,149	10,954	8%	43%
El Paso, TX	212	478	1,140	19%	44%
Las Vegas, NV-AZ	961	2,080	7,804	12%	46%
Phoenix-Mesa, AZ	1,299	3,512	10,768	12%	37%
Seattle, WA	946	3,043	13,094	7%	31%

[a] Includes only direct exhaust emissions; see Chapter 2 for a discussion of secondary fine PM levels.

Table 3.3-3
Land-Based Nonroad Percent Contribution
to $PM_{2.5}$ Inventories in Selected Urban Areas in 2030[a]

MSA, CMSA / State	Land-Based Diesel (short tons)	Mobile Sources (short tons)	Total Man-Made Sources (short tons)	Land-Based Diesel as % of Total	Land-Based Diesel as % of Mobile Sources
Atlanta, GA	1,647	4,937	24,880	7%	33%
Boston, MA	4,132	7,529	21,846	19%	55%
Chicago, IL	3,236	7,735	45,975	7%	42%
Dallas-Fort Worth, TX	1,721	3,919	16,622	10%	44%
Indianapolis, IN	902	1,934	6,753	13%	47%
Minneapolis, MN	1,354	2,769	16,586	8%	49%
New York, NY	2,953	5,064	22,891	13%	58%
Orlando, FL	752	1,957	6,084	12%	38%
Sacramento, CA	447	1,445	5,890	8%	31%
San Diego, CA	777	2,770	10,096	8%	28%
Denver, CO	1,060	2,379	12,117	9%	45%
El Paso, TX	244	524	1,243	20%	47%
Las Vegas, NV-AZ	1,113	2,307	8,512	13%	48%
Phoenix-Mesa, AZ	1,499	3,870	11,989	13%	39%
Seattle, WA	1,084	3,357	14,148	8%	32%

[a] Includes only direct exhaust emissions; see Chapter 2 for a discussion of secondary fine PM levels.

3.3.2 NO_x Emissions

As presented in Tables 3.3-4, 3.3-5, and 3.3-6, EPA's city-specific analysis of selected metropolitan areas for 1996, 2020, and 2030 show that land-based nonroad diesel engine engines are a significant contributor to total NO_x emissions from all man-made sources.

Table 3.3-4
Land-Based Nonroad Percent Contribution
to NO_x Inventories in Selected Urban Areas in 1996

MSA, CMSA / State	Land-Based Diesel (short tons)	Mobile Sources (short tons)	Total Man-Made Sources (short tons)	Land-Based Diesel as % of Total	Land-Based Diesel as % of Mobile Sources
Atlanta, GA	16,238	205,465	298,361	5%	8%
Boston, MA	43,362	232,444	311,045	14%	19%
Chicago, IL	32,276	296,710	509,853	6%	11%
Dallas-Fort Worth, TX	17,852	152,878	186.824	10%	12%
Indianapolis, IN	9,487	89,291	113,300	8%	11%
Minneapolis, MN	13,843	124,437	224,817	6%	11%
New York, NY	29,543	184,384	262,021	11%	16%
Orlando, FL	7,493	61,667	75,714	10%	12%
Sacramento, CA	5,666	55,144	58,757	10%	10%
San Diego, CA	9,460	99,325	107,024	9%	10%
Denver, CO	11,080	86,329	146,807	8%	13%
El Paso, TX	2,498	24,382	30,160	8%	10%
Las Vegas, NV-AZ	11,788	50,724	108,875	11%	23%
Phoenix-Mesa, AZ	15,145	115,544	161,606	9%	13%
Seattle, WA	11,227	115,264	133,840	8%	10%

Table 3.3-5
Annual Land-Based Nonroad Diesel Contributions
to NO_x Inventories in Selected Urban Areas in 2020

MSA, CMSA / State	Land-Based Diesel (short tons)	Mobile Sources (short tons)	Total Man-Made Sources (short tons)	Land-Based Diesel as % of Total	Land-Based Diesel as % of Mobile Sources
Atlanta, GA	12,650	69,816	193,456	7%	18%
Boston, MA	31,282	93,308	167,572	19%	34%
Chicago, IL	24,732	123,823	333,945	7%	20%
Dallas-Fort Worth, TX	13,334	60,745	101,453	13%	22%
Indianapolis, IN	6,982	36,283	60,059	12%	19%
Minneapolis, MN	10,376	47,375	165,775	6%	22%
New York, NY	22,456	67,083	112,960	20%	33%
Orlando, FL	5,837	28,653	45,362	13%	20%
Sacramento, CA	4,297	18,870	23,111	19%	23%
San Diego, CA	7,464	46,005	51,909	14%	16%
Denver, CO	8,251	38,435	103,533	8%	21%
El Paso, TX	1,847	10,105	12,452	15%	18%
Las Vegas, NV-AZ	8,501	26,840	72,829	12%	32%
Phoenix-Mesa, AZ	11,560	48,348	105,185	11%	24%
Seattle, WA	8,283	51,252	76,161	11%	16%

Table 3.3-6
Land-Based Nonroad Percent Contribution
to NO_x Inventories in Selected Urban Areas in 2030

MSA, CMSA / State	Land-Based Diesel (short tons)	Mobile Sources (short tons)	Total Man-Made Sources (short tons)	Land-Based Diesel as % of Total	Land-Based Diesel as % of Mobile Sources
Atlanta, GA	14,190	65,746	191,932	7%	22%
Boston, MA	35,039	92,537	168,422	21%	38%
Chicago, IL	27,525	120,694	334,334	8%	23%
Dallas-Fort Worth, TX	14,839	56,907	100,721	15%	26%
Indianapolis, IN	7,641	34,442	58,793	13%	22%
Minneapolis, MN	11,444	45,326	167,154	7%	25%
New York, NY	25,064	67,163	108,215	23%	37%
Orlando, FL	6,551	28,365	45,267	14%	23%
Sacramento, CA	4,806	17,498	21,952	22%	27%
San Diego, CA	8,401	43,930	50,296	17%	19%
Denver, CO	9,185	37,105	104,217	9%	25%
El Paso, TX	2,062	9,422	11,905	17%	22%
Las Vegas, NV-AZ	9,544	26,349	72,926	13%	36%
Phoenix-Mesa, AZ	12,952	46,280	106,061	12%	28%
Seattle, WA	9,247	49,258	77,133	12%	19%

3.4 Nonroad Diesel Controlled Emissions Inventory Development

This section describes how the controlled emissions inventories were developed for the four categories of nonroad diesel engines affected by this proposal: land-based diesel engines, commercial marine diesel vessels, locomotives, and recreational marine diesel engines. For land-based diesel engines, there are separate sections for criteria (i.e., $PM_{2.5}$, NO_x, SO_2, VOC, and CO) and air toxics emissions development.

3.4.1 Land-Based Diesel Engines—$PM_{2.5}$, NO_x, SO_2, VOC, and CO Emissions

The emission inventory estimates used in this proposed rule were generated using the draft NONROAD2002 model with certain input modifications to account for the in-use diesel fuel sulfur reductions and the additional controls being proposed for the Tier 4 engines. This section will only describe these modifications to the model inputs, since the other aspects of the model, including inputs for earlier engines, are covered in detail in the technical reports that document the draft NONROAD2002 model.

3.4.1.1 Standards and Zero-Hour Emission Factors

The proposed standards that are presented in Section 3 of the preamble are shown in Table 3.4-1. The modeled emission factors corresponding to the proposed standards are shown in Table 3.4-2. These emission factors are derived from the standards by applying an assumed 8% compliance margin to the standard. This compliance margin was derived from data for highway diesel vehicles and used in the HD07 rule. Additionally, a transient adjustment factor is applied, as described below, if the engine power and model year place it in a category subject to a steady-state certification test cycle instead of a transient test.

Besides exhaust emissions, the proposed rule includes changes in crankcase hydrocarbon emissions. Crankcase losses prior to Tier 4 have been modeled as 2.0 percent of exhaust HC, and any crankcase emissions of other pollutants have been considered negligible. For all Tier 4 engines, including those using transitional controls without particulate traps, our modeling now assumes zero crankcase emissions.

3.4.1.2 Transient Adjustment Factors

As shown in Table 3.4-2, the proposed new standards for engines over 75 hp beginning in 2011 or 2012, and for those under 75 hp beginning in 2008, call for use of a transient certification test cycle. Thus, there was no Transient Adjustment Factor (TAF) applied to the emission factors for these engines (i.e., the model applies a TAF of 1.0); the zero-hour emission factor was modeled simply as the value of the standard minus an assumed 8% compliance margin.

Table 3.4-1
Proposed Tier 4 Exhaust Emissions Certification Standards

Engine Power	Emissions Standard (g/bhp-hr)[a]					Model Year
	transitional or final	PM	NO_x	NMHC	CO	
kW < 19 (hp <25)	final	0.30	5.6[b,c]		4.9	2008
19 ≤ kW < 56 (25 ≤ hp < 75)	transitional[d]	0.22	5.6/3.5[b,c]		3.7	2008
	final	0.02	3.5[b]		3.7 [c]	2013
56 ≤ kW < 130 (75 ≤ hp < 175)	transitional	0.01 (100%)	0.30 (50%)	0.14 (50%)	3.7 [c]	2012-2013
	final	0.01 (100%)	0.30 (100%)	0.14 (100%)	3.7 [c]	2014
130 ≤ kW < 560 (175 ≤ hp < 750)	transitional	0.01 (100%)	0.30 (50%)	0.14 (50%)	2.6 [c]	2011-2013
	final	0.01 (100%)	0.30 (100%)	0.14 (100%)	2.6 [c]	2014
kW ≥ 560 (hp ≥ 750)	transitional	0.01 (50%)	0.30 (50%)	0.14 (50%)	2.6 [c]	2011-2013
	final	0.01 (100%)	0.30 (100%)	0.14 (100%)	2.6 [c]	2014

[a] Percentages are model year sales fractions required to comply with the indicated standard.
[b] This is a combined NMHC + NO_x standard.
[c] This emissions standard level is unchanged from the level that applies in the previous model year. For 25-75 hp engines, the transitional NMHC + NO_x standard is 5.6 g/bhp-hr for engines below 50 hp and 3.5 g/bhp-hr for engines at or above 50 hp.
[d] Manufacturers may optionally skip the transitional standards for 25-75 hp engines; the final standards would then take effect for these engines in the 2012 model year.

Table 3.4-2
NONROAD Model EF Inputs for Proposed Tier 4 Exhaust Emissions Standards

Engine Power	Emission Factor Modeling Inputs g/bhp-hr							Model Year
	Type of standard		PM	NO_x [a b]		THC [b,c]	CO [d]	
hp ≤ 11	final [e]		0.28	4.30		0.55	4.11	2008
11 < hp ≤ 25	final [e]		0.28	4.44		0.44	2.16	2008
25 < hp ≤ 50	transitional [f]		0.20	4.73		0.28	1.53	2008
	final		0.018	3.0		0.13	0.15	2013
50 < hp ≤ 75	transitional [f]		0.20	3.0		0.18	2.4	2008
	final		0.018	3.0		0.13	0.24	2013
75 < hp ≤ 100	transitional		0.01	3.0 (50%)	0.28 (50%)	0.13	0.24	2012-2013
	final		0.01	0.28		0.13	0.24	2014
100 < hp ≤ 175	transitional		0.01	2.5 (50%)	0.28 (50%)	0.13	0.87	2012-2013
	final		0.01	0.28		0.13	0.087	2014
175 < hp ≤ 300	transitional		0.01	2.5 (50%)	0.28 (50%)	0.13	7.5	2011-2013
	final		0.01	0.28		0.13	0.075	2014
300 < hp ≤ 600	transitional		0.01	2.5 (50%)	0.28 (50%)	0.13	8.4	2011-2013
	final		0.01	0.28		0.13	0.084	2014
600 < hp ≤ 750	transitional		0.01	2.5 (50%)	0.28 (50%)	0.13	1.3	2011-2013
	final		0.01	0.28		0.13	0.13	2014
hp > 750	trans-itional[g]	50%	0.13	4.1		0.17	0.76	2011-2013
		50%	0.01	0.28		0.13	0.076	
	final		0.01	0.30		0.13	0.076	2014

[a] Percentages are model-year sales fractions required to comply with the indicated standard.
[b] NMHC + NO_x is a combined standard, so for modeling purposes the NO_x and HC are separated using a NO_x/HC ratio that approximates the results found in prior test programs, as described in technical report NR-009b.
[c] HC Standards are in terms of NMHC, but the model expects inputs as THC, so a conversion factor of 1.02 is applied to the NMHC value to get the THC model input.
[d] Tier 4 CO is assumed to decrease by 90% from its prior levels in any cases where particulate traps are expected for PM control.
[e] Final standards and emission factor inputs for engines under 25 hp take effect in 2008, starting in 2008 the modeling of these inputs changes to reflect the start of a transient certification test requirement at which time Transient Adjustment Factors are no longer applied to the emission factors.
[f] Transitional standards and emission factor inputs for 25-75 hp engines are based on transient use, so Transient Adjustment Factors will not be applied to the emission factors shown here.
[g] The transitional standards for engines >750 hp consist of 50% engines meeting Tier 2 standards with the 8-mode test and 50% meeting the final Tier 4 standards with transient test. TAFs will only get applied to the emissions of the engines meeting the Tier 2 standards. Application of TAF's is described in technical report NR-009b.[1]

3.4.1.3 Deterioration Rates

The deterioration rates (*d*) used for the modeling of Tier 4 engines are the same as used for Tier 3 engines for all affected pollutants (PM, NO_x, HC, and CO). These are listed in Table 3.4-3 below and are fully documented in technical report NR-009b.[1]

Table 3.4-3
Deterioration Rates for Nonroad Diesel Engines

Pollutant	Relative Deterioration Rate (% increase per %useful life expended)[a]				
	Base/Tier 0	Tier 1	Tier 2	Tier 3	Tier 4
HC	0.047	0.036	0.034	0.027	0.027
CO	0.185	0.101	0.101	0.151	0.151
NO_x	0.024	0.024	0.009	0.008	0.008
PM	0.473	0.473	0.473	0.473	0.473

[a] At the median life point, the Deterioration Factor = 1 + relative deterioration rate.

3.4.1.4 In-Use Sulfur Levels, Certification Sulfur Levels, and Sulfur Conversion Factors

Tables 3.4-4 and 3.4-5 show the certification and in-use fuel sulfur levels by calendar year and engine power range that was assumed for modeling the engines that would be regulated under this rule. The certification sulfur levels are the default fuel sulfur levels used to calculate the zero mile PM and SO_2 emission factors in the model (referred to as S_{base} in Section 3.1.1.2.1). The in-use fuel sulfur level is the episodic fuel sulfur level (referred to as $S_{in\text{-}use}$ in Section 3.1.1.2.1). Adjustments to PM and SO_2 for in-use fuel sulfur levels are made relative to the certification sulfur levels in the model. As described above for the baseline inventory development, the in-use fuel sulfur content, fuel consumption, sulfate conversion factor, and exhaust HC emission factor (unburned fuel) determine the SO_2 emissions, and a fraction of the fuel sulfur is also converted to sulfate PM. The changes for modeling of the control case are (a) lower sulfur content for in-use and certification fuel per this proposed rule, and (b) the use of a higher sulfur-to-sulfate conversion factor for engines that are expected to use a particulate trap/filter to achieve the PM standards of 0.01 or 0.02 g/bhp-hr (30% conversion instead of 2.247% that is used for all earlier non-trap equipped engines).

Table 3.4-4
Modeled Certification Diesel Fuel Sulfur Content

Engine Power	Standards	Modeled Certification Fuel Sulfur Content, PPM	Model Year
kW < 56 (hp <75)	Tier 2	2000	through 2007
	transitional	500	2008
	final	15	2013
56 ≤ kW < 75 (75 ≤ hp < 100)	Tier 3 transitional [a]	500	2008-2011
	final	15	2012
75 ≤ kW < 130 (100 ≤ hp < 175)	Tier 3	2000	2007-2011
	final	15	2012
130 ≤ kW < 560 (175 ≤ hp < 750)	Tier 3	2000	2006-2010
	final	15	2011
kW ≥ 560 (hp ≥ 750)	Tier 2	2000	2006-2010
	transitional [b]	50% 2000 50% 15	2011-2013
	final	15	2014

[a] The emission standard here is still Tier 3 as in the Baseline case, but since the Tier 3 standard begins in 2008 for 50-100 hp engines it is assumed that this new technology introduction would allow manufacturers to take advantage of the availability of 500 ppm fuel that year.

[b] The engines remaining at the Tier 2 level would be allowed to continue certifying on the same fuel as earlier Tier 2 engines, but those meeting the Tier 4 0.01 PM standard are assumed to certify on 15 ppm fuel.

Table 3.4-5
Modeled 48-State & 50-State In-Use Diesel Fuel Sulfur Content for Controlled Inventories

Applications	Standards	Modeled In-Use Fuel Sulfur Content, ppm	Calendar Year
Land-based, all power ranges	Baseline	2318	through 2005
		2271	2006
	June intro of 500 ppm	1075	2007
	500 ppm standard	245	2008-2009
	June intro of 15 ppm	100	2010
	Final 15 ppm standard	11	2011+
Recreational Marine, Commercial Marine, and Locomotives	Baseline	2396	through 2005
		2352	2006
	June intro of 500 ppm	1114	2007
	Final 500 ppm standard	252	2008-2009
		233	2010+

3.4.1.5 Modeling 50-75 hp and 75-100 hp Within the NONROAD 50-100 hp Bin

The proposed standards call for different treatment of diesel engines above and below 75 hp (56 kW), but the NONROAD model is not currently designed to handle a 75 hp cutpoint within its 50-100 hp bin. Thus, a modeling method was used in which the NONROAD model was run twice for each scenario -- one time applying the 50-75 hp standards to the 50-100 hp bin, and one time applying the 75-100 hp standards to that bin. Then a weighted average of the two sets of emission inventory outputs was calculated, with the weighting based on overall diesel population and horsepower within the 50-100 hp range. The population weighting was essentially 50/50 (half 50-75 hp and half 75-100 hp), but when the average hp of these two power sub-ranges is taken into account, the resulting inventory weighting was 57% for the 75-100 hp outputs and 43% for the 50-75 hp outputs.

The engine population and power data that was used to calculate this weighting was based on detailed sales data from PSR[12] as described in technical report NR-006b, "Nonroad Engine Population Estimates."

3.4.1.6 Controlled Inventory

Tables 3.4-6a and 3.4-6b present the PM_{10}, $PM_{2.5}$, NO_x, SO_2, VOC, and CO controlled emissions for land-based nonroad diesel engines in 1996 and 2000-2040, for the 48-state and 50-state inventories, respectively.

Table 3.4-6a
Controlled (48-State) Emissions for Land-Based Nonroad Diesel Engines (short tons)

Year	PM_{10}	$PM_{2.5}$	NO_x	SO_2	VOC	CO
1996	191,858	176,510	1,583,664	147,926	221,403	1,010,518
2000	175,155	161,143	1,569,903	167,094	200,366	923,887
2001	169,360	155,811	1,556,973	171,957	191,785	886,723
2002	163,684	150,589	1,544,395	176,819	183,584	850,751
2003	157,726	145,108	1,522,881	181,677	176,201	817,858
2004	152,310	140,125	1,503,228	186,532	169,541	790,468
2005	147,050	135,286	1,483,942	191,385	163,193	764,918
2006	142,043	130,680	1,450,762	192,228	156,295	742,184
2007	130,006	119,606	1,414,673	93,229	149,518	724,213
2008	120,783	111,120	1,373,870	21,757	142,282	709,158
2009	117,672	108,258	1,331,368	22,267	135,201	696,085
2010	113,732	104,633	1,290,526	9,297	128,301	684,775
2011	108,633	99,943	1,234,897	1,032	121,298	661,317
2012	101,846	93,698	1,173,275	1,032	114,587	625,141
2013	94,540	86,976	1,114,569	1,027	108,169	580,076
2014	87,051	80,086	1,030,363	1,021	102,315	534,590
2015	79,578	73,211	950,060	1,014	97,013	490,424
2016	72,412	66,619	874,829	1,009	92,325	449,037
2017	65,636	60,385	804,895	1,005	88,273	411,280
2018	59,412	54,659	742,607	1,003	84,706	377,046
2019	53,834	49,527	686,592	1,003	81,526	345,972
2020	48,976	45,057	637,025	1,005	78,822	318,530
2021	44,686	41,111	595,511	1,009	76,555	294,889
2022	40,803	37,539	560,026	1,015	74,606	273,610
2023	37,312	34,327	529,072	1,022	72,984	254,823
2024	34,073	31,347	502,436	1,029	71,635	237,880
2025	31,098	28,610	479,114	1,038	70,520	222,570
2026	28,431	26,156	459,646	1,047	69,626	209,119
2027	26,095	24,008	443,460	1,058	68,961	197,634
2028	24,198	22,262	429,909	1,070	68,470	188,366
2029	22,486	20,687	418,492	1,083	68,103	180,519
2030	20,912	19,239	410,084	1,096	67,861	173,579
2031	19,617	18,048	403,630	1,109	67,795	168,098
2032	18,444	16,968	398,093	1,123	67,826	163,618
2033	17,347	15,959	393,543	1,137	67,919	159,577
2034	16,334	15,027	389,845	1,151	68,080	156,020
2035	15,427	14,193	387,098	1,166	68,309	153,038
2036	14,653	13,481	385,165	1,180	68,617	150,653
2037	13,942	12,827	383,784	1,195	68,967	148,547
2038	13,548	12,464	383,422	1,210	69,432	146,684
2039	13,236	12,177	383,769	1,226	69,944	145,351
2040	12,957	11,921	384,422	1,241	70,495	144,359

Table 3.4-6b
Controlled (50-State) Emissions for Land-Based Nonroad Diesel Engines (short tons)

Year	PM_{10}	$PM_{2.5}$	NO_x	SO_2	VOC	CO
1996	192,750	177,330	1,592,025	148,729	222,517	1,015,773
2000	175,981	161,903	1,578,148	167,999	201,386	928,674
2001	170,165	156,552	1,565,144	172,889	192,765	891,304
2002	164,467	151,310	1,552,490	177,777	184,524	855,132
2003	158,487	145,808	1,530,854	182,662	177,107	822,062
2004	153,045	140,802	1,511,087	187,544	170,414	794,522
2005	147,761	135,940	1,491,692	192,424	164,035	768,838
2006	142,732	131,314	1,458,315	193,272	157,104	745,994
2007	130,636	120,185	1,422,017	93,735	150,293	727,946
2008	121,368	111,658	1,380,984	21,875	143,022	712,836
2009	118,245	108,786	1,338,243	22,388	135,906	699,719
2010	114,290	105,147	1,297,178	9,347	128,973	688,377
2011	109,168	100,435	1,241,223	1,038	121,935	664,805
2012	102,347	94,159	1,179,237	1,038	115,188	628,436
2013	95,004	87,403	1,120,193	1,033	108,735	583,127
2014	87,475	80,477	1,035,489	1,026	102,849	537,388
2015	79,963	73,566	954,717	1,020	97,519	492,974
2016	72,758	66,937	879,052	1,014	92,806	451,351
2017	65,944	60,669	808,721	1,010	88,733	413,376
2018	59,687	54,912	746,089	1,009	85,149	378,949
2019	54,078	49,752	689,768	1,009	81,954	347,705
2020	49,194	45,258	639,935	1,011	79,238	320,115
2021	44,881	41,290	598,209	1,015	76,959	296,347
2022	40,979	37,701	562,551	1,020	75,001	274,958
2023	37,472	34,474	531,454	1,027	73,371	256,081
2024	34,220	31,482	504,702	1,035	72,015	239,060
2025	31,232	28,734	481,283	1,044	70,894	223,684
2026	28,555	26,270	461,742	1,053	69,996	210,176
2027	26,210	24,113	445,499	1,064	69,328	198,641
2028	24,304	22,360	431,900	1,076	68,834	189,329
2029	22,585	20,778	420,447	1,089	68,466	181,441
2030	21,004	19,323	412,011	1,102	68,223	174,465
2031	19,704	18,128	405,538	1,115	68,157	168,958
2032	18,526	17,044	399,987	1,129	68,189	164,459
2033	17,426	16,032	395,428	1,143	68,282	160,400
2034	16,409	15,096	391,724	1,157	68,444	156,827
2035	15,500	14,260	388,976	1,172	68,676	153,833
2036	14,722	13,544	387,045	1,187	68,985	151,436
2037	14,009	12,888	385,668	1,202	69,338	149,320
2038	13,613	12,524	385,312	1,217	69,805	147,450
2039	13,300	12,236	385,667	1,232	70,321	146,113
2040	13,020	11,979	386,330	1,248	70,875	145,119

3.4.2 Land-Based Diesel Engines—Air Toxics Emissions

Since air toxics emissions are part of the VOC emissions inventory, NMHC standards being proposed in this rule would also affect air toxics emissions. Tables 3.4-7a and 3.4-7b show 48-state and 50-state estimated emissions for five major air toxics, benzene, formaldehyde, acetaldehyde, 1,3-butadiene, and acrolein, resulting from the proposed rule. The EPA uses the same fractions used to calculate the base air toxic emissions without the proposed rule (see section 3.1.2), along with the estimated VOC emissions resulting from the proposed rule, to calculate the air toxics emissions resulting from the proposed rule.

Table 3.4-7a
Controlled (48-State) Air Toxic Emissions for Land-Based Nonroad Diesel Engines (short tons)

Year	Benzene	Formaldehyde	Acetaldehyde	1,3-Butadiene	Acrolein
2000	4,007	23,643	10,619	401	601
2005	3,264	19,257	8,649	326	490
2007	2,990	17,643	7,924	299	449
2010	2,556	15,140	6,800	257	385
2015	1,940	11,448	5,142	194	291
2020	1,576	9,301	4,178	158	236
2025	1,410	8,321	3,738	141	212
2030	1,357	8,008	3,597	136	204

Table 3.4-7b
Controlled (50-State) Air Toxic Emissions for Land-Based Nonroad Diesel Engines (short tons)

Year	Benzene	Formaldehyde	Acetaldehyde	1,3-Butadiene	Acrolein
2000	4,028	23,764	10,673	403	604
2005	3,281	19,356	8,694	328	492
2007	3,006	17,735	7,966	301	451
2010	2,579	15,219	6,836	258	387
2015	1,950	11,507	5,168	195	293
2020	1,585	9,350	4,200	158	238
2025	1,418	8,366	3,757	142	213
2030	1,364	8,050	3,616	136	205

3.4.3 Commercial Marine Vessels and Locomotives

The control case locomotive and commercial marine inventories for VOC, CO, and NO_x are identical to the base case inventories, since no new controls are being proposed for these engines. However, due to the diesel fuel sulfur changes that are being proposed, decreases are expected in PM and SO_2 inventories for these engines.

The method used for estimating PM and SO_2 emissions in the control case is essentially the same as described in Section 3.1.3 for the base case, but the fuel sulfur levels in the equations are changed to reflect the control case sulfur. The control case PM and SO_2 emission inventory estimates presented here assume that locomotive and commercial marine applications would use diesel fuel meeting a 500 ppm sulfur standard beginning in June 2007. This was modeled as 340 ppm sulfur outside of California and 120 ppm in California, based on available fuel survey data for in-use highway fuel relative to the existing 500 ppm highway diesel fuel sulfur standards. Additional sulfur adjustments were made to account for the "spillover" of low sulfur highway fuel meeting a 15 ppm standard in the applicable years prior to the start of the proposed 15 ppm nonroad fuel standard.

As in the base case, the same sulfur-to-sulfate conversion rate was used as for land-based diesel applications prior to their use of aftertreatment (2.247%). The fuel sulfur levels were calculated as weighted average in-use levels of (a) uncontrolled nonroad diesel fuel at 3400 ppm sulfur, (b) controlled locomotive and marine diesel fuel at 340 ppm, (c) "spillover" of low sulfur highway diesel fuel into use by nonroad applications outside of California, and (d) full use of low sulfur California fuel in all nonroad applications in California. The slight decrease in average sulfur level in 2006 is due to the introduction of highway diesel fuel meeting the 2007 15 ppm standard, and the "spillover" of this highway fuel into the nonroad fuel pool. Note that there are transition years in which the control sulfur level begins in June, in which case the annual average sulfur level shown reflects an interpolation of 5 months at the higher sulfur level of the prior year plus 7 months at the new lower sulfur level. The derivation of these sulfur levels are described in more detail in Chapter 7.

The control case locomotive and commercial marine PM inventories were calculated by subtracting the sulfate PM benefits (from decreased fuel sulfur content) described above from the base case locomotive and commercial marine PM inventories. The 48-state and 50-state control case locomotive and commercial marine $PM_{2.5}$ and SO_2 inventories are given in Tables 3.4-8a and 3.4-8b, respectively.

Table 3.4-8a
Controlled (48-State) Fuel Sulfur Levels, SO_2,
Sulfate PM, and $PM_{2.5}$ Emissions for Locomotives and Commercial Marine Vessels

Year	Control Sulfur Level (ppm)	Control					
		SO_2		Sulfate PM		Total $PM_{2.5}$	
		Loco (tons/yr)	CMV (tons/yr)	Loco (tons/yr)	CMV (tons/yr)	Loco (tons/yr)	CMV (tons/yr)
2007	1114	24,051	13,446	1,935	1,082	17,612	37,523
2008	252	5,457	3,071	439	247	15,673	36,944
2009	252	5,495	3,105	442	250	15,462	37,136
2010	233	5,119	2,904	412	234	14,932	37,310
2011	233	5,205	2,936	419	236	15,186	37,502
2012	233	5,230	2,969	421	239	14,927	37,693
2013	233	5,245	3,002	422	242	14,639	37,885
2014	233	5,260	3,036	423	244	14,350	38,077
2015	233	5,285	3,071	425	247	14,083	38,269
2016	233	5,339	3,106	430	250	13,893	38,460
2017	233	5,370	3,141	432	253	13,636	38,652
2018	233	5,399	3,177	434	256	13,707	38,844
2019	233	5,430	3,214	437	259	13,444	39,036
2020	233	5,449	3,251	438	262	13,147	39,228
2021	233	5,498	3,288	442	265	12,920	39,606
2022	233	5,547	3,326	446	268	12,687	39,985
2023	233	5,597	3,365	450	271	12,801	40,363
2024	233	5,647	3,404	454	274	12,561	40,741
2025	233	5,698	3,444	458	277	12,316	41,119
2026	233	5,749	3,485	463	280	12,066	41,498
2027	233	5,801	3,526	467	284	12,174	41,876
2028	233	5,853	3,567	471	287	11,916	42,255
2029	233	5,905	3,610	475	290	11,652	42,633
2030	233	5,959	3,653	479	294	11,756	43,012
2031	233	6,012	3,697	484	297	11,485	43,390
2032	233	6,065	3,741	488	301	11,208	43,769
2033	233	6,119	3,786	492	305	11,308	44,148
2034	233	6,174	3,832	497	308	11,022	44,527
2035	233	6,229	3,878	501	312	11,120	44,905
2036	233	6,285	3,926	506	316	11,219	45,284
2037	233	6,341	3,974	510	320	10,923	45,663
2038	233	6,397	4,023	515	324	11,020	46,042
2039	233	6,454	4,072	519	328	10,714	46,421
2040	233	6,512	4,123	524	332	10,810	46,801

Table 3.4-8b
Controlled (50-State) Fuel Sulfur Levels, SO_2,
Sulfate PM, and $PM_{2.5}$ Emissions for Locomotives and Commercial Marine Vessels

Year	Control Sulfur Level (ppm)	Control					
		SO_2		Sulfate PM		Total $PM_{2.5}$	
		Loco (tons/yr)	CMV (tons/yr)	Loco (tons/yr)	CMV (tons/yr)	Loco (tons/yr)	CMV (tons/yr)
2007	1114	24,084	14,145	1,938	1,138	17,637	39,473
2008	252	5,465	3,231	440	260	15,695	38,864
2009	252	5,503	3,267	443	263	15,484	39,066
2010	233	5,126	3,055	412	246	14,952	39,249
2011	233	5,213	3,088	419	248	15,207	39,451
2012	233	5,237	3,123	421	251	14,947	39,653
2013	233	5,252	3,158	423	254	14,659	39,854
2014	233	5,268	3,194	424	257	14,369	40,056
2015	233	5,292	3,231	426	260	14,103	40,258
2016	233	5,347	3,267	430	263	13,912	40,460
2017	233	5,378	3,304	433	266	13,655	40,662
2018	233	5,407	3,342	435	269	13,726	40,863
2019	233	5,438	3,381	437	272	13,462	41,065
2020	233	5,456	3,420	439	275	13,165	41,267
2021	233	5,505	3,459	443	278	12,938	41,665
2022	233	5,555	3,499	447	282	12,705	42,063
2023	233	5,605	3,540	451	285	12,818	42,461
2024	233	5,655	3,581	455	288	12,579	42,859
2025	233	5,706	3,623	459	291	12,333	43,257
2026	233	5,757	3,666	463	295	12,083	43,655
2027	233	5,809	3,709	467	298	12,191	44,053
2028	233	5,861	3,753	472	302	11,932	44,451
2029	233	5,914	3,798	476	306	11,669	44,849
2030	233	5,967	3,843	480	309	11,773	45,248
2031	233	6,020	3,889	484	313	11,501	45,646
2032	233	6,074	3,935	489	317	11,223	46,044
2033	233	6,128	3,983	493	320	11,323	46,443
2034	233	6,183	4,031	497	324	11,037	46,841
2035	233	6,238	4,080	502	328	11,136	47,240
2036	233	6,293	4,130	506	332	11,235	47,638
2037	233	6,350	4,180	511	336	10,938	48,037
2038	233	6,406	4,232	515	340	11,035	48,436
2039	233	6,463	4,284	520	345	10,729	48,834
2040	233	6,521	4,337	525	349	10,825	49,233

3.4.4 Recreational Marine Engines

Even though this proposed rule does not include any emission standards for marine engines, there are PM and SO_2 benefits associated with these engines due to the proposed fuel sulfur standards. The emission inventory estimates presented in Tables 3.4-9a and 3.4-9b assume that recreational marine applications would use diesel fuel meeting the same standards as locomotive and commercial marine diesel fuel, which means an in-use sulfur content of 1114 ppm in the 2007 transition year and 232 ppm in 2010 and later as shown in Table 3.4-5. Consistent with the baseline inventory described above, these inventory values do not include the benefits associated with the standards promulgated in September 2002 for diesel recreational marine engines.

Table 3.4-9a
Controlled (48-State) Emissions for Recreational Marine Diesel Engines (short tons)

Year	PM_{10}	$PM_{2.5}$	NO_x	SO_2	VOC	CO
1996	529	487	19,440	2,251	803	3,215
2000	594	547	21,899	2,537	900	3,613
2001	611	562	22,548	2,613	923	3,713
2002	627	577	23,196	2,689	947	3,814
2003	643	592	23,844	2,765	970	3,913
2004	660	607	24,492	2,841	992	4,013
2005	676	622	25,139	2,917	1,015	4,112
2006	688	633	25,790	2,939	1,037	4,211
2007	576	530	26,439	1,428	1,059	4,309
2008	497	457	27,088	331	1,081	4,406
2009	507	467	27,736	339	1,102	4,503
2010	516	474	28,384	321	1,124	4,599
2011	526	484	29,028	328	1,145	4,695
2012	535	493	29,671	336	1,166	4,790
2013	545	502	30,314	343	1,186	4,884
2014	555	511	30,957	351	1,207	4,979
2015	565	520	31,600	358	1,227	5,072
2016	574	528	32,244	365	1,247	5,166
2017	584	537	32,888	373	1,268	5,260
2018	593	546	33,531	380	1,288	5,353
2019	603	555	34,174	388	1,308	5,445
2020	612	563	34,817	395	1,328	5,538
2021	621	572	35,460	402	1,347	5,630
2022	631	580	36,103	410	1,367	5,722
2023	640	589	36,746	417	1,387	5,814
2024	649	597	37,388	425	1,406	5,906
2025	658	605	38,031	432	1,426	5,997
2026	667	614	38,673	440	1,446	6,089
2027	677	622	39,316	447	1,465	6,181
2028	686	631	39,959	454	1,486	6,275
2029	696	640	40,604	462	1,507	6,370
2030	706	650	41,250	469	1,528	6,465
2031	716	659	41,896	477	1,550	6,561
2032	726	668	42,543	484	1,571	6,656
2033	736	677	43,189	491	1,592	6,752
2034	746	687	43,836	499	1,614	6,848
2035	757	696	44,483	506	1,636	6,945
2036	767	705	45,131	514	1,658	7,041
2037	777	715	45,779	521	1,680	7,139
2038	788	725	46,428	529	1,703	7,238
2039	798	734	47,076	536	1,725	7,336
2040	809	744	47,725	543	1,748	7,435

Table 3.4-9b
Controlled (50-State) Emissions for Recreational Marine Diesel Engines (short tons)

Year	PM_{10}	$PM_{2.5}$	NO_x	SO_2	VOC	CO
1996	532	490	19,562	2,265	808	3,236
2000	598	550	22,036	2,553	906	3,635
2001	615	566	22,689	2,629	929	3,737
2002	631	581	23,342	2,706	953	3,838
2003	648	596	23,994	2,783	976	3,938
2004	664	611	24,646	2,859	999	4,038
2005	680	626	25,297	2,936	1,021	4,138
2006	692	637	25,952	2,957	1,044	4,237
2007	579	533	26,605	1,437	1,066	4,336
2008	500	460	27,258	333	1,088	4,434
2009	511	470	27,911	341	1,109	4,531
2010	519	477	28,563	323	1,131	4,628
2011	529	487	29,210	330	1,152	4,724
2012	539	496	29,858	338	1,173	4,820
2013	549	505	30,505	345	1,194	4,915
2014	559	514	31,152	353	1,214	5,010
2015	568	523	31,798	360	1,235	5,104
2016	578	532	32,446	368	1,255	5,199
2017	588	541	33,094	375	1,276	5,293
2018	597	549	33,742	383	1,296	5,386
2019	607	558	34,389	390	1,316	5,480
2020	616	567	35,036	398	1,336	5,573
2021	625	575	35,683	405	1,356	5,665
2022	635	584	36,330	412	1,376	5,758
2023	644	592	36,977	420	1,395	5,850
2024	653	601	37,623	427	1,415	5,943
2025	662	609	38,270	435	1,435	6,035
2026	671	618	38,916	442	1,455	6,127
2027	681	626	39,563	450	1,475	6,220
2028	690	635	40,210	457	1,495	6,314
2029	700	644	40,860	465	1,516	6,410
2030	710	654	41,510	472	1,538	6,506
2031	721	663	42,160	480	1,559	6,602
2032	731	672	42,810	487	1,581	6,698
2033	741	682	43,461	495	1,602	6,795
2034	751	691	44,112	502	1,624	6,891
2035	761	700	44,763	509	1,646	6,988
2036	772	710	45,414	517	1,668	7,086
2037	782	720	46,067	524	1,691	7,184
2038	793	729	46,719	532	1,713	7,283
2039	803	739	47,372	539	1,736	7,382
2040	814	749	48,025	547	1,759	7,482

3.5 Anticipated Emission Reductions With the Proposed Rule

Emissions from nonroad diesel engines will continue to be a significant part of the emissions inventory in the coming years. In the absence of new emission standards, we expect overall emissions from nonroad diesel engines to generally decline across the nation for the next

10 to 15 years, depending on the pollutant. Although nonroad diesel engine emissions decline during this period, this trend will not be enough to adequately reduce the large amount of emissions that these engines contribute. In addition, after the 2010 to 2015 time period we project that this trend reverses and emissions rise into the future in the absence of additional regulation of these engines. The initial downward trend occurs as the nonroad fleet becomes increasingly dominated over time by engines that comply with existing emission regulations. The upturn in emissions beginning around 2015 results as growth in the nonroad sector overtakes the effect of the existing emission standards.

The engine and fuel standards in this proposal will affect fine particulate matter ($PM_{2.5}$), oxides of nitrogen (NO_x), sulfur oxides (SO_2), volatile organic hydrocarbons (VOC), air toxics, and carbon monoxide (CO). For engines used in locomotives, commercial marine vessels, and recreational marine vessels, the proposed fuel standards will affect $PM_{2.5}$ and SO_2.

This section discusses the expected emission reductions associated with this proposal. The baseline case represents future emissions with current standards. The controlled case estimates the future emissions of these engines based on the proposed standards and fuel requirements in this notice. Both 48-state and 50-state results are presented. Tables 3.5-1a and 3.5-1b present a summary of the total 48-state and 50-state emission reductions for each pollutant.

3.5.1 $PM_{2.5}$ Reductions

48-State and 50-state emissions of $PM_{2.5}$ from land-based nonroad diesel engines are shown in Tables 3.5-2a and 3.5-2b, respectively, along with estimates of the reductions from this proposal. $PM_{2.5}$ will be reduced due to the proposed PM exhaust emission standards and changes in the sulfur level in nonroad diesel fuel. The exhaust emission standards begin in 2008 for engines less than 75 hp, and are completely phased in for all hp categories by 2014. Nonroad diesel fuel sulfur is reduced to a 500 ppm standard in June of 2007, and further reduced for land-based nonroad diesel engines to a 15 ppm standard (11 ppm in-use) in June of 2010. The 15 ppm standard is fully phased in starting in 2011.

Tables 3.5-2a and 3.5-2b present results for five year increments from 2000 to 2030. Individual years from 2007 to 2011 are also included, since fuel sulfur levels are changing during this period. Emissions are projected to 2030 in order to reflect close to complete turnover of the fleet to engines meeting the proposed standards. For comparison purposes, emissions reductions are also shown from reducing the diesel fuel sulfur level to 500 ppm beginning in June of 2007, without any new emission standards or any additional sulfur level reductions.

Table 3.5-1a
Total Emission Reductions (48-State) from Proposed Rule

Year	$PM_{2.5}$	NO_x	SO_2	VOC	CO	Benzene	Formaldehyde	Acetaldehyde	1,3-Butadiene	Acrolein
2000	0	0	0	0	0	0	0	0	0	0
2005	0	0	0	0	0	0	0	0	0	0
2007	10,605	0	142,948	0	0	0	0	0	0	0
2008	19,061	301	249,746	29	0	1	3	2	0	0
2009	19,998	619	254,544	59	0	1	7	3	0	0
2010	21,864	1,007	270,977	90	0	2	11	5	0	0
2011	25,496	20,574	285,003	862	14,487	17	102	46	2	3
2015	52,476	217,575	305,639	8,788	182,520	176	1,037	466	18	26
2020	85,254	503,701	331,840	18,033	381,487	361	2,128	956	36	54
2025	109,325	693,857	358,863	24,624	520,864	492	2,906	1,305	49	74
2030	126,910	821,911	385,932	29,487	620,345	590	3,479	1,563	59	88

Table 3.5-1b
Total Emission Reductions (50-State) from Proposed Rule

Year	$PM_{2.5}$	NO_x	SO_2	VOC	CO	Benzene	Formaldehyde	Acetaldehyde	1,3-Butadiene	Acrolein
2000	0	0	0	0	0	0	0	0	0	0
2005	0	0	0	0	0	0	0	0	0	0
2007	10,705	0	144,298	0	0	0	0	0	0	0
2008	19,238	304	252,100	29	0	1	3	2	0	0
2009	20,181	624	256,935	59	0	1	7	3	0	0
2010	22,058	1,015	273,470	91	0	2	11	5	0	0
2011	25,712	20,717	287,583	868	14,585	17	102	46	2	3
2015	52,851	218,939	308,386	8,841	183,596	177	1,043	469	18	27
2020	85,827	506,815	334,799	18,141	383,730	363	2,141	961	36	54
2025	110,026	698,000	362,041	24,769	523,844	495	2,923	1,313	50	74
2030	127,708	826,690	389,337	29,660	623,851	593	3,500	1,572	59	89

Table 3.5-2a
Estimated National (48-State) $PM_{2.5}$
Emissions and Reductions From Nonroad Land-Based Diesel Engines[a]

Year	$PM_{2.5}$ Emissions [short tons]			$PM_{2.5}$ Reductions [short tons]	
	Without Rule	With fuel sulfur reduced to 500 ppm in 2007; No Tier 4 standards	With Rule (Fuel sulfur reduced to 15 ppm in 2010; Tier 4 standards)	With fuel sulfur reduced to 500 ppm in 2007; No Tier 4 standards	With Rule
2000	161,143	161,143	161,143	0	0
2005	135,286	135,286	135,286	0	0
2007	127,089	119,606	119,606	7,483	7,483
2008	124,789	111,657	111,120	13,132	13,669
2009	122,815	109,378	108,258	13,437	14,557
2010	121,007	107,265	104,633	13,742	16,374
2011	119,865	105,816	99,943	14,049	19,922
2015	119,957	104,682	73,211	15,275	46,745
2020	124,344	107,543	45,057	16,801	79,277
2025	131,644	113,335	28,610	18,309	103,034
2030	139,527	119,710	19,239	19,817	120,288

[a] $PM_{2.5}$ represents 92% of PM10 emissions.

Table 3.5-2b
Estimated National (50-State) $PM_{2.5}$
Emissions and Reductions From Nonroad Land-Based Diesel Engines[a]

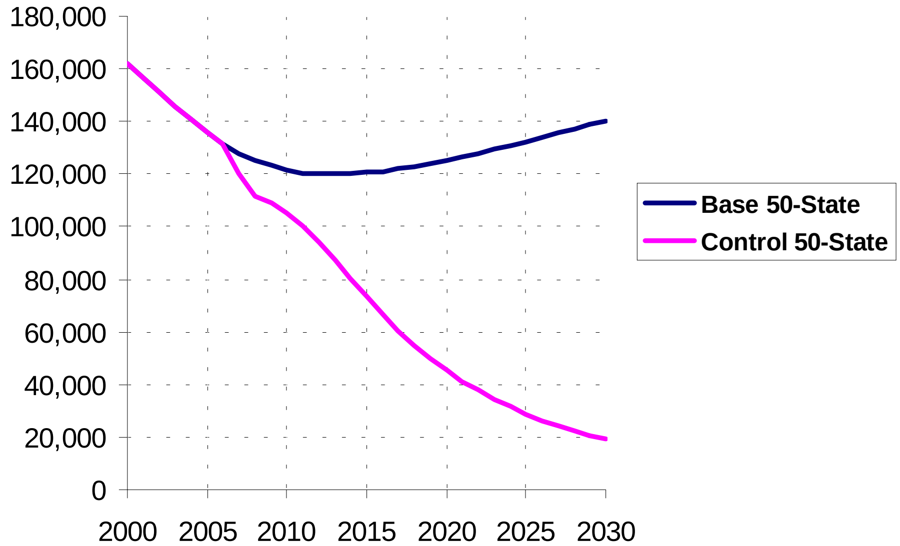
Year	$PM_{2.5}$ Emissions [short tons]			$PM_{2.5}$ Reductions [short tons]	
	Without Rule	With fuel sulfur reduced to 500 ppm in 2007; No Tier 4 standards	With Rule (Fuel sulfur reduced to 15 ppm in 2010; Tier 4 standards)	With fuel sulfur reduced to 500 ppm in 2007; No Tier 4 standards	With Rule
2000	161,903	161,903	161,903	0	0
2005	135,940	135,940	135,940	0	0
2007	127,708	120,185	120,185	7,524	7,524
2008	125,401	112,197	111,658	13,204	13,743
2009	123,422	109,911	108,786	13,510	14,636
2010	121,609	107,792	105,147	13,817	16,462
2011	120,466	106,341	100,435	14,125	20,032
2015	120,575	105,218	73,566	15,357	47,010
2020	124,990	108,106	45,258	16,883	79,732
2025	132,345	113,936	28,734	18,409	103,611
2030	140,277	120,352	19,323	19,925	120,954

[a] $PM_{2.5}$ represents 92% of PM10 emissions.

The benefits in the early years of the program (i.e., pre-2010) are primarily from reducing the diesel fuel sulfur level to 500 ppm. As the standards phase in and fleet turnover occurs, $PM_{2.5}$ emissions are impacted more significantly from the proposed rule requirements. $PM_{2.5}$ emissions are reduced roughly 120,000 tons with the proposed rule by 2030.

Figure 3.5-1 shows EPA's estimate of 50-state $PM_{2.5}$ emissions from land-based diesel engines for 2000 to 2030 with and without the proposed $PM_{2.5}$ rule. By 2030, we estimate that $PM_{2.5}$ emissions from this source would be reduced by 86 percent in that year.

Figure 3.5-1: Estimated Reductions in $PM_{2.5}$ Emissions From Land-Based Nonroad Engines (tons/year)



Nonroad diesel engines used in locomotives, commercial marine vessels, and recreational marine vessels are not affected by the emission standards of this proposal. $PM_{2.5}$ emissions from these engines would be reduced by the reductions in diesel fuel sulfur for these types of engines from an in-use average of 2400 ppm today to an in-use average of about 240 ppm in 2010. The estimated 48-state and 50-state reductions in $PM_{2.5}$ emissions from these engines based on the proposed change in diesel fuel sulfur are given in Tables 3.5-3a and 3.5-3b, respectively. Total $PM_{2.5}$ reductions reach roughly 6,700 tons in 2030 for these diesel nonroad engine categories.

Tables 3.5-4a and 3.5-4b present the $PM_{2.5}$ emissions and reductions for all nonroad diesel categories combined. The 50-state results are also presented graphically in Figure 3.5-2. For all nonroad diesel categories combined, the estimated reductions in $PM_{2.5}$ emissions are 85,000 tons in 2020, increasing to 127,000 tons in 2030. Simply reducing the fuel sulfur level to 500 ppm in 2007 would result in $PM_{2.5}$ reductions of 23,000 tons in 2020 and 26,000 tons in 2030.

Table 3.5-3a
Estimated National (48-State) $PM_{2.5}$ Reductions
From Locomotives, Commercial Marine, and Recreational Marine Diesel Engines

Year	$PM_{2.5}$ Reductions with Rule [short tons]			
	Locomotives	Commerical Marine Diesel	Recreational Marine Diesel	Total $PM_{2.5}$ Reductions
2000	0	0	0	0
2005	0	0	0	0
2007	1,929	1,078	114	3,121
2008	3,321	1,869	202	5,392
2009	3,345	1,890	206	5,441
2010	3,368	1,911	212	5,491
2011	3,426	1,932	216	5,574
2015	3,476	2,019	235	5,730
2020	3,581	2,137	260	5,978
2025	3,744	2,263	285	6,292
2030	3,914	2,399	308	6,621

Table 3.5-3b
Estimated National (50-State) $PM_{2.5}$ Reductions
From Locomotives, Commercial Marine, and Recreational Marine Diesel Engines

Year	$PM_{2.5}$ Reductions with Rule [short tons]			
	Locomotives	Commerical Marine Diesel	Recreational Marine Diesel	Total $PM_{2.5}$ Reductions
2000	0	0	0	0
2005	0	0	0	0
2007	1,931	1,134	115	3,181
2008	3,326	1,966	203	5,495
2009	3,349	1,988	208	5,545
2010	3,373	2,010	213	5,595
2011	3,430	2,032	217	5,680
2015	3,480	2,124	237	5,842
2020	3,586	2,248	262	6,095
2025	3,749	2,380	286	6,415
2030	3,919	2,524	311	6,754

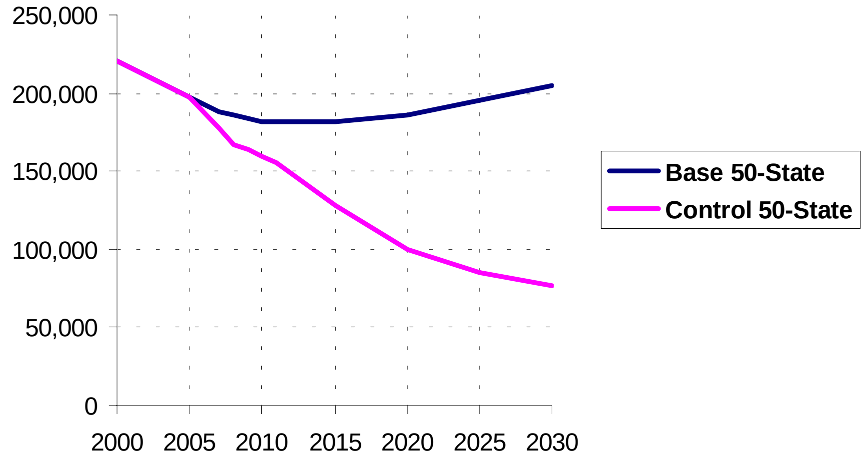
Table 3.5-4a
Estimated National (48-State) $PM_{2.5}$ Emissions and Reductions from
Land-Based Nonroad, Locomotive, Commercial Marine, and Recreational Marine Vessels

Year	$PM_{2.5}$ Emissions [short tons]			$PM_{2.5}$ Reductions [short tons]	
	Without Rule	With fuel sulfur reduced to 500 ppm in 2007	With fuel sulfur further reduced to 15 ppm in 2010 for land-based diesels	With fuel sulfur reduced to 500 ppm in 2007	With fuel sulfur further reduced to 15 ppm in 2010 for land-based diesels
2000	218,311	218,311	218,311	0	0
2005	194,554	194,554	194,554	0	0
2007	185,875	175,270	175,270	10,605	10,605
2008	183,256	164,731	164,195	18,525	19,061
2009	181,321	162,443	161,323	18,878	19,998
2010	179,213	159,981	157,349	19,232	21,864
2011	178,610	158,987	153,114	19,622	25,496
2015	178,559	157,554	126,083	21,005	52,476
2020	183,250	160,481	97,996	22,769	85,254
2025	191,976	167,376	82,651	24,600	109,325
2030	201,567	175,128	74,657	26,438	126,910

Table 3.5-4b
Estimated National (50-State) $PM_{2.5}$ Emissions and Reductions from
Land-Based Nonroad, Locomotive, Commercial Marine, and Recreational Marine Vessels

Year	$PM_{2.5}$ Emissions [short tons]			$PM_{2.5}$ Reductions [short tons]	
	Without Rule	With fuel sulfur reduced to 500 ppm in 2007	With fuel sulfur further reduced to 15 ppm in 2010 for land-based diesels	With fuel sulfur reduced to 500 ppm in 2007	With fuel sulfur further reduced to 15 ppm in 2010 for land-based diesels
2000	221,035	221,035	221,035	0	0
2005	197,228	197,228	197,228	0	0
2007	188,532	177,828	177,828	10,705	10,705
2008	185,916	167,217	166,678	18,699	19,238
2009	183,986	164,931	163,805	19,055	20,181
2010	181,883	162,471	159,826	19,412	22,058
2011	181,291	161,486	155,579	19,805	25,712
2015	181,301	160,101	128,449	21,199	52,851
2020	186,084	163,105	100,257	22,979	85,827
2025	194,960	170,135	84,933	24,825	110,026
2030	204,705	178,026	76,997	26,679	127,708

Figure 3.5-2: Estimated Reductions in $PM_{2.5}$ Emissions From Land-Based Nonroad Engines, CMVs, RMVs, and Locomotives (tons/year)



3.5.2 NO_x Reductions

Tables 3.5-5a and 3.5-5b show the estimated 48-state and 50-state NO_x emissions in five year increments from 2000 to 2030 with and without the proposed rule and the estimated emissions reductions. The 50-state results are shown graphically in Figure 3.5-3. By 2030, we estimate that NO_x emissions from these engines will be reduced by 67 percent in that year.

NO_x emissions from locomotives, commercial marine diesel vessels, and recreational marine diesel vessels are not affected by this proposal.

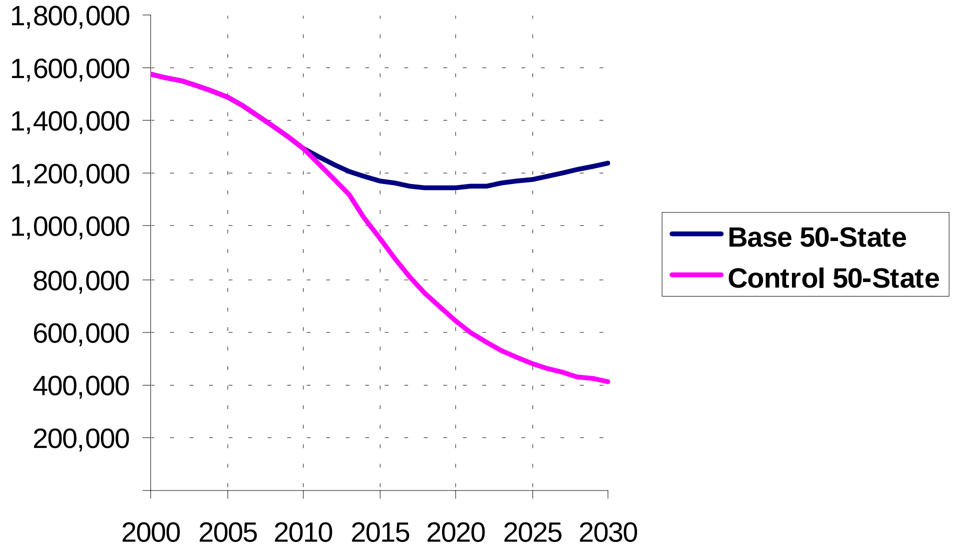
Table 3.5-5a
Estimated National (48-State) NO_x Emissions
and Reductions From Nonroad Land-Based Diesel Engines

Year	NO_x Emissions Without Rule [short tons]	NO_x Emissions With Rule	NO_x Reductions With Rule
2000	1,569,903	1,569,903	0
2005	1,483,942	1,483,942	0
2010	1,291,533	1,290,526	1,007
2015	1,167,635	950,060	217,575
2020	1,140,727	637,025	503,701
2030	1,231,995	410,084	821,911

Table 3.5-5b
Estimated National (50-State) NO_x Emissions
and Reductions From Nonroad Land-Based Diesel Engines

Year	NO_x Emissions Without Rule [short tons]	NO_x Emissions With Rule	NO_x Reductions With Rule
2000	1,578,148	1,578,148	0
2005	1,491,692	1,491,692	0
2010	1,298,193	1,297,178	1,015
2015	1,173,656	954,717	218,939
2020	1,146,750	639,935	506,815
2030	1,238,701	412,011	826,690

Figure 3.5-3: Estimated Reductions in NOx Emissions From Land-Based Nonroad Engines (tons/year)



3.5.3 SO_2 Reductions

As part of this proposal, sulfur levels in fuel would be significantly reduced, leading to large reductions in nonroad diesel SO_2 emissions. By 2007, the sulfur in diesel fuel used by all nonroad diesel engines would be reduced from the current average in-use level of roughly 2300 ppm to an average in-use level of about 1100 ppm. By 2010, the sulfur in diesel fuel used by land-based nonroad engines would be reduced to an average in-use level of 11 ppm with a maximum level of 15 ppm. The sulfur in diesel fuel used by locomotives, commercial marine, and recreational marine engines would remain at an average in-use level of about 230 ppm.

48-State and 50-state emissions of SO_2 from land-based nonroad diesel engines are shown in Tables 3.5-6a and 3.5-6b, respectively, along with estimates of the reductions from this proposal. Results are presented for five year increments from 2000 to 2030. Individual years from 2007 to 2011 are also included, since fuel sulfur levels are changing during this period. SO_2 will be reduced due to the changes in the sulfur level in nonroad diesel fuel. For comparison purposes, emissions reductions are also shown from reducing the diesel fuel sulfur level to 500 ppm beginning in June of 2007, without any new emission standards or any additional sulfur level reductions.

Table 3.5-6a
Estimated National (48-State) SO_2
Emissions and Reductions From Nonroad Land-Based Diesel Engines

Year	SO_2 Emissions [short tons]			SO_2 Reductions [short tons]	
	Without Rule	With fuel sulfur reduced to 500 ppm in 2007	With Rule (Fuel sulfur reduced to 15 ppm in 2010)	With fuel sulfur reduced to 500 ppm in 2007	With Rule
2000	167,094	167,094	167,094	0	0
2005	191,385	191,385	191,385	0	0
2007	194,003	93,229	93,229	100,774	100,774
2008	198,657	21,757	21,757	176,900	176,900
2009	203,311	22,267	22,267	181,044	181,044
2010	206,104	20,917	9,297	185,187	196,807
2011	210,737	21,387	1,032	189,350	209,705
2015	229,235	23,265	1,014	205,970	228,221
2020	252,089	25,584	1,005	226,505	251,084
2025	274,913	27,901	1,038	247,012	273,875
2030	297,573	30,200	1,096	267,373	296,477

Table 3.5-6b
Estimated National (50-State) SO_2
Emissions and Reductions From Nonroad Land-Based Diesel Engines

Year	SO_2 Emissions [short tons]			SO_2 Reductions [short tons]	
	Without Rule	With fuel sulfur reduced to 500 ppm in 2007	With Rule (Fuel sulfur reduced to 15 ppm in 2010)	With fuel sulfur reduced to 500 ppm in 2007	With Rule
2000	167,999	167,999	167,999	0	0
2005	192,424	192,424	192,424	0	0
2007	195,057	93,735	93,735	101,321	101,321
2008	199,736	21,875	21,875	177,861	177,861
2009	204,416	22,388	22,388	182,028	182,028
2010	207,225	21,031	9,347	186,194	197,878
2011	211,884	21,504	1,038	190,380	210,846
2015	230,483	23,391	1,020	207,092	229,464
2020	253,464	25,724	1,011	227,740	252,453
2025	276,414	28,053	1,044	248,361	275,370
2030	299,199	30,365	1,102	268,834	298,098

The benefits in the early years of the program (i.e., pre-2010) are from reducing the diesel fuel sulfur level to 500 ppm. Reducing the diesel fuel sulfur level to 15 ppm in June of 2010 proportionately reduces SO_2 further. Total 50-state SO_2 emissions are reduced 298,000 tons with the proposed rule by 2030. Note that SO_2 emissions continue to increase over time due to the growth in the nonroad sector.

Nonroad diesel engines used in locomotives, commercial marine vessels, and recreational marine vessels are not affected by the emission standards of this proposal. SO_2 emissions from these engines would be reduced by the reductions in diesel fuel sulfur for these types of engines from an in-use average of 2400 ppm today to an in-use average of about 230 ppm in 2010. The estimated 48-state and 50-state reductions in SO_2 emissions from these engines based on the proposed change in diesel fuel sulfur are given in Tables 3.5-7a and 3.5-7b, respectively. Total 50-state SO_2 reductions reach 91,000 tons in 2030 for these diesel nonroad engine categories.

Tables 3.5-8a and 3.5-8b present the SO_2 emissions and reductions for all nonroad diesel categories combined. The 50-state results are also presented graphically in Figure 3.5-4. For all nonroad diesel categories combined, the estimated 50-state reductions in SO_2 emissions with the proposed rule are 334,000 tons in 2020, increasing to 389,000 tons in 2030. Simply reducing the fuel sulfur level to 500 ppm in 2007 would result in SO_2 reductions of 310,000 tons in 2020 and 360,000 tons in 2030.

Table 3.5-7a
Estimated National (48-State) SO_2 Reductions
From Locomotives, Commercial Marine, and Recreational Marine Diesel Engines

Year	SO_2 Reductions with Rule [short tons]			
	Locomotives	Commerical Marine Diesel Vessels	Recreational Marine Diesel Vessels	Total SO_2 Reductions
2000	0	0	0	0
2005	0	0	0	0
2007	26,058	14,569	1,546	42,173
2008	44,874	25,255	2,718	72,847
2009	45,184	25,533	2,784	73,501
2010	45,506	25,814	2,850	74,170
2011	46,282	26,100	2,916	75,298
2015	46,955	27,285	3,178	77,418
2020	48,383	28,866	3,508	80,757
2025	50,578	30,572	3,838	84,988
2030	52,873	32,415	4,167	89,455

Table 3.5-7b
Estimated National (50-State) SO_2 Reductions
From Locomotives, Commercial Marine, and Recreational Marine Diesel Engines

Year	SO_2 Reductions with Rule [short tons]			
	Locomotives	Commerical Marine Diesel Vessels	Recreational Marine Diesel Vessels	Total SO_2 Reductions
2000	0	0	0	0
2005	0	0	0	0
2007	26,094	15,326	1,556	42,977
2008	44,936	26,568	2,735	74,239
2009	45,246	26,860	2,801	74,907
2010	45,569	27,156	2,868	75,592
2011	46,346	27,457	2,934	76,737
2015	47,021	28,703	3,198	78,922
2020	48,450	30,367	3,530	82,346
2025	50,648	32,161	3,862	86,671
2030	52,946	34,100	4,193	91,239

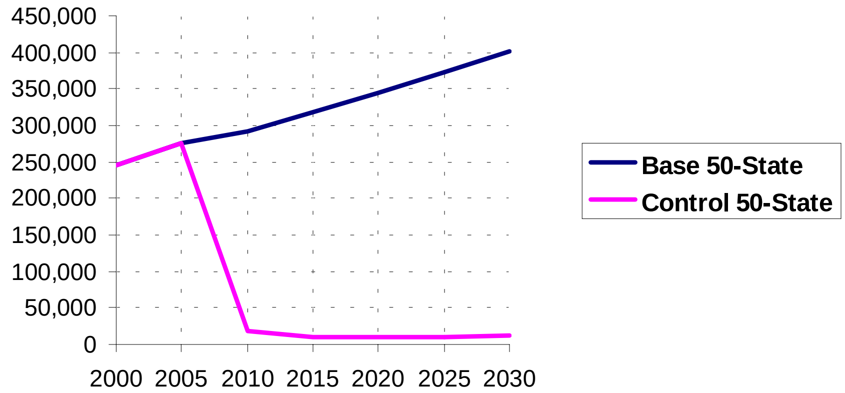
Table 3.5-8a
Estimated National (48-State) SO_2 Emissions and Reductions from
Land-Based Nonroad, Locomotive, Commercial Marine, and Recreational Marine Vessels

Year	SO_2 Emissions [short tons]			SO_2 Reductions [short tons]	
	Without Rule	With fuel sulfur reduced to 500 ppm in 2007	With fuel sulfur further reduced to 15 ppm in 2010 for land-based diesels	With fuel sulfur reduced to 500 ppm in 2007	With fuel sulfur further reduced to 15 ppm in 2010 for land-based diesels
2000	243,333	243,333	243,333	0	0
2005	273,331	273,331	273,331	0	0
2007	275,101	132,153	132,153	142,948	142,948
2008	280,363	30,617	30,617	249,746	249,746
2009	285,750	31,206	31,206	254,543	254,543
2010	288,617	29,261	17,640	259,356	270,977
2011	294,504	29,857	9,502	264,648	285,003
2015	315,367	31,978	9,728	283,389	305,639
2020	341,941	34,679	10,100	307,262	331,840
2025	369,475	37,475	10,612	332,000	358,863
2030	397,109	40,281	11,176	356,828	385,932

Table 3.5-8b
Estimated National (50-State) SO_2 Emissions and Reductions from
Land-Based Nonroad, Locomotive, Commercial Marine, and Recreational Marine Vessels

Year	SO_2 Emissions [short tons]			SO_2 Reductions [short tons]	
	Without Rule	With fuel sulfur reduced to 500 ppm in 2007	With fuel sulfur further reduced to 15 ppm in 2010 for land-based diesels	With fuel sulfur reduced to 500 ppm in 2007	With fuel sulfur further reduced to 15 ppm in 2010 for land-based diesels
2000	245,712	245,712	245,712	0	0
2005	275,929	275,929	275,929	0	0
2007	277,699	133,401	133,401	144,298	144,298
2008	283,004	30,904	30,904	252,100	252,100
2009	288,434	31,499	31,499	256,935	256,935
2010	291,320	29,534	17,851	261,786	273,470
2011	297,252	30,135	9,669	267,117	287,583
2015	318,288	32,274	9,903	286,014	308,386
2020	345,084	34,998	10,285	310,086	334,799
2025	372,849	37,817	10,807	335,032	362,041
2030	400,720	40,647	11,383	360,073	389,337

Figure 3.5-4: Estimated SOx Benefits from Reducing Sulfur for Land-Based Nonroad Engines, CMVs, RMVs, and Locomotives



3.5.4 VOC and Air Toxics Reductions

Tables 3.5-9a and 3.5-9b show our projection of the 48-state and 50-state reductions in VOC emissions that EPA expects from implementing the proposed NMHC standards.

Although this proposal does not include specific standards for air toxics, these pollutants would be reduced through the implementation of the proposed NMHC standards. Tables 3.5-10a and 3.5-10b show our estimate of the proposed rule's beneficial impact on the key air toxics emissions of benzene, formaldehyde, acetaldehyde, 1,3-butadiene, and acrolein. We base these numbers on the assumption that air toxic emissions are a constant fraction of hydrocarbon exhaust emissions.

Table 3.5-9a
VOC Reductions (48-State) from Land-Based Nonroad Diesel Engines

Calendar Year	VOC Without Rule [short tons]	VOC With Rule [short tons]	VOC Reductions With Rule [short tons]
2000	200,366	200,366	0
2005	163,193	163,193	0
2010	128,391	128,301	90
2015	105,800	97,013	8,788
2020	96,855	78,822	18,033
2025	95,144	70,520	24,624
2030	97,348	67,861	29,487

Table 3.5-9b
VOC Reductions (50-State) from Land-Based Nonroad Diesel Engines

Calendar Year	VOC Without Rule [short tons]	VOC With Rule [short tons]	VOC Reductions With Rule [short tons]
2000	201,386	201,386	0
2005	164,035	164,035	0
2010	129,063	128,973	91
2015	106,359	97,519	8,841
2020	97,378	79,238	18,141
2025	95,663	70,894	24,769
2030	97,882	68,223	29,660

Table 3.5-10a
Air Toxic Reductions (48-State) (tons/year)

Year		Benzene	Formaldehyde	Acetaldehyde	1,3-Butadiene	Acrolein
2000	Base	4,007	23,643	10,619	401	601
	Control	4,007	23,643	10,619	401	601
	Reduction	0	0	0	0	0
2005	Base	3,264	19,257	8,649	326	490
	Control	3,264	19,257	8,649	326	490
	Reduction	0	0	0	0	0
2007	Base	2,990	17,643	7,924	299	449
	Control	2,990	17,643	7,924	299	449
	Reduction	0	0	0	0	0
2010	Base	2,568	15,150	6,805	257	385
	Control	2,566	15,140	6,800	257	385
	Reduction	2	11	5	0	0
2015	Base	2,116	12,484	5,607	212	317
	Control	1,940	11,448	5,142	194	291
	Reduction	176	1,037	466	18	26
2020	Base	1,937	11,429	5,133	194	291
	Control	1,576	9,301	4,178	158	236
	Reduction	361	2,128	956	36	55
2025	Base	1,903	11,227	5,043	190	285
	Control	1,410	8,321	3,738	141	212
	Reduction	492	2,906	1,305	49	73
2030	Base	1,947	11,487	5,159	195	292
	Control	1,357	8,008	3,597	136	204
	Reduction	590	3,479	1,563	59	88

Table 3.5-10b
Air Toxic Reductions (50-State) (tons/year)

Year		Benzene	Formaldehyde	Acetaldehyde	1,3-Butadiene	Acrolein
2000	Base	4,028	23,764	10,673	403	604
	Control	4,028	23,764	10,673	403	604
	Reduction	0	0	0	0	0
2005	Base	3,281	19,356	8,694	328	492
	Control	3,281	19,356	8,694	328	492
	Reduction	0	0	0	0	0
2007	Base	3,006	17,735	7,966	301	451
	Control	3,006	17,735	7,966	301	451
	Reduction	0	0	0	0	0
2010	Base	2,581	15,229	6,840	258	387
	Control	2,579	15,219	6,836	258	387
	Reduction	2	11	5	0	0
2015	Base	2,127	12,550	5,637	213	319
	Control	1,950	11,507	5,168	195	293
	Reduction	177	1,043	469	18	27
2020	Base	1,948	11,491	5,161	195	292
	Control	1,585	9,350	4,200	158	238
	Reduction	363	2,141	961	36	54
2025	Base	1,913	11,288	5,070	191	287
	Control	1,418	8,366	3,757	142	213
	Reduction	495	2,923	1,313	50	74
2030	Base	1,958	11,550	5,188	196	294
	Control	1,364	8,050	3,616	136	205
	Reduction	593	3,500	1,572	59	89

3.5.5 CO Reductions

Tables 3.5-11a and 3.5-11b show the estimated 48-state and 50-state emissions of CO from land-based diesel engines in five year increments from 2000 to 2030 with and without the proposed rule and the estimated emissions reductions. Although for most engines, Tier 4 does not revise the existing CO standards, CO is estimated to be reduced 90% with the advent of trap-equipped engines (corresponding to the start of 0.02 or 0.01 g/bhp-hr PM standards). By 2030, we estimate that 50-state CO emissions from these engines will be reduced 623,000 tons in that year.

CO emissions from locomotives, commercial marine diesel vessels, and recreational marine diesel vessels are not affected by this proposal.

Table 3.5-11a
Estimated National (48-State) CO
Emissions and Reductions From Nonroad Land-Based Diesel Engines

Year	CO Emissions Without Rule [short tons]	CO Emissions With Rule [short tons]	CO Reductions With Rule [short tons]
2000	923,886	923,886	0
2005	764,918	764,918	0
2010	684,552	684,552	0
2015	672,944	490,424	182,520
2020	700,017	318,530	381,487
2030	793,923	173,579	620,345

Table 3.5-11b
Estimated National (50-State) CO
Emissions and Reductions From Nonroad Land-Based Diesel Engines

Year	CO Emissions Without Rule [short tons]	CO Emissions With Rule [short tons]	CO Reductions With Rule [short tons]
2000	923,674	928,674	0
2005	768,838	768,838	0
2010	688,153	688,377	0
2015	676,570	492,974	183,596
2020	703,845	320,115	383,730
2030	798,316	174,465	623,851

3.6 Emission Inventories Used for Air Quality Modeling

The emissions inputs for the air quality modeling are required early in the analytical process, in order to be able to conduct the air quality modeling and present the results in this proposal. The air quality modeling was based on a preliminary control scenario. Since the preliminary control scenario was developed, we have gathered more information regarding the technical feasibility of the standards (see Section 3 of the preamble for this proposal and Chapter 4 of this document). As a result, we have revised the control scenario. We have also made minor changes to the baseline fuel sulfur levels. This section describes the changes in the inputs and resulting emissions inventories between the preliminary baseline and control scenarios used for the air quality modeling and the updated baseline and control scenarios in this proposal. This section will focus on the four nonroad diesel categories that are affected by the proposed standards and/or the fuel sulfur requirements: land-based diesel engines, recreational marine diesel engines, commercial marine diesel engines, and locomotives. There have been no changes to any other source categories (e.g., highway, stationary point and area sources). While these other source categories are not affected by the proposed rule, revisions to the inventories for these other source categories can impact air quality results.

The methodology used to develop the emissions inventories for the air quality modeling is first briefly described, followed by comparisons of the preliminary and proposed baseline and control inventories.

3.6.1 Methodology for Emission Inventory Preparation

Air quality modeling was performed for calendar years 1996, 2020, and 2030. For these years, county-level emission estimates were developed by Pechan under contract to EPA. These inventories account for county-level differences in fuel characteristics and temperature. The NONROAD model was used to generate the county-level emissions estimates for all nonroad sources, with the exception of commercial marine engines, locomotives, and aircraft. The methodology has been documented in detail.[10]

For the diesel nonroad categories affected by the proposed rule, the only fuel characteristic that affects emissions is the fuel sulfur level. The specific pollutants affected by fuel sulfur level are PM and SO_2. To develop the county-level emission estimates for each baseline and control inventory, one diesel fuel sulfur level was used to characterize all counties outside California. A separate diesel fuel sulfur level was used to characterize all counties within California. Diesel emissions as modeled are not affected by ambient temperature.

3.6.2 Baseline Inventories

Table 3.6-1 presents the preliminary 48-state baseline inventories used for the air quality modeling. These are an aggregation of the county-level results. Results expressed as short tons are presented for 1996, 2020, and 2030 for the land-based diesel, recreational marine diesel, commercial marine diesel, and locomotive categories. The pollutants include $PM_{2.5}$, NO_x, SO_2, VOC, and CO. VOC includes both exhaust and crankcase emissions.

Table 3.6-1
Modeled 48-State Baseline Emissions
Preliminary Baseline Used for Air Quality Modeling

Applications	Year	NO_x [short tons]	$PM_{2.5}$ [short tons]	SO_2 [short tons]	VOC [short tons]	CO [short tons]
Land-Based Diesel Engines	1996	1,583,641	178,500	172,175	221,398	1,010,501
	2020	1,144,686	127,755	308,075	97,113	702,145
	2030	1,231,981	143,185	360,933	97,345	793,899
Recreational Marine Diesel Engines	1996	19,438	511	2,535	803	3,215
	2020	34,814	876	4,562	1,327	5,537
	2030	41,246	1,021	5,418	1,528	6,464
Commercial Marine Diesel Engines	1996	959,704	37,203	37,252	31,545	126,382
	2020	819,201	42,054	43,028	37,290	159,900
	2030	814,827	46,185	48,308	41,354	176,533
Locomotives	1996	921,556	22,396	57,979	48,381	112,171
	2020	612,722	17,683	62,843	36,546	119,302
	2030	534,520	16,988	70,436	31,644	119,302

For the proposed baseline inventories, we have made minor changes to the diesel fuel sulfur levels. The diesel fuel sulfur inputs used for the preliminary and proposed baseline inventories are provided in Table 3.6-2. The diesel fuel sulfur level is now reduced from 2500ppm to roughly 2300ppm, beginning in 2006. Both the preliminary and proposed sulfur levels account for spillover of highway fuel, but the preliminary sulfur levels did not properly account for the 15ppm highway fuel sulfur content control phase-in beginning in 2006.

There have also been reductions to the fuel volumes assigned to locomotives and commercial marine vessels. For the preliminary inventory development, railroad distillate and vessel bunkering distillate values were taken from the EIA Fuel and Kerosene Supply 2000 report. Fuel consumption specific to locomotives was calculated by subtracting the rail maintenance fuel consumption as generated by the draft NONROAD2002 model from the EIA railroad distillate estimates. Similarly, fuel consumption specific to commercial marine vessels was calculated by subtracting the recreational marine fuel consumption as generated by the draft NONROAD2002 model from the EIA vessel bunkering estimates.

For the proposed inventory, the EIA railroad distillate and vessel bunkering distillate estimates were first adjusted to estimate the fraction of distillate that is diesel fuel. The diesel fractions used are 0.95 for railroad distillate and 0.90 for vessel bunkering distillate. Fuel consumption estimates from rail maintenance and recreational marine engines were then subtracted. The estimate of rail maintenance fuel consumption was also revised by assuming these engines consume one percent of the total railroad diesel fuel estimate, rather than using the estimate derived from draft NONROAD2002. The revised estimate of rail maintenance fuel consumption is roughly half of the NONROAD-derived estimate; however, the rail maintenance portion of the total railroad diesel fuel consumption is small, so this change alone does not significantly affect the resulting locomotive estimate. The estimate of recreational marine fuel consumption continues to be that generated from the draft NONROAD2002 model. The derivation of diesel fractions and the revised estimate of rail maintenance fuel consumption is documented in Chapter 7.

As a result, the corrections to fuel sulfur levels and locomotive and commercial marine fuel volumes will reduce the PM and SO_2 baseline inventories in 2020 and 2030.

Table 3.6-2
Modeled Baseline In-Use Diesel Fuel Sulfur Content
Proposed Baseline vs Preliminary Baseline Used for Air Quality Modeling

Applications	Proposed Baseline		Preliminary Baseline	
	Fuel Sulfur ppm	Calendar Year	Fuel Sulfur ppm	Calendar Year
Land-Based Diesel Engines	2318	through 2005	2500[a]	all years
	2271	2006		
	2237	2007-2009		
	2217	2010+		
Commercial and Recreational Marine Engines and Locomotives	2396	through 2005	2500[a]	all years
	2352	2006		
	2321	2007-2009		
	2302	2010+		

[a] 2500ppm is the 48-state average diesel fuel sulfur level, based on 2700ppm in 47 states and 120ppm in California.

For the commercial marine diesel and locomotive categories, revised PM and SO_2 inventories were generated for the proposed baseline scenarios. For the land-based diesel and recreational marine diesel categories, it was not possible to generate revised county-level baseline inventories due to time and resource constraints. Instead, for the land-based diesel and recreational marine diesel categories, national level NONROAD model runs were used as the basis for comparison of the preliminary and proposed baseline scenarios. National level model runs were done using the 48-state average fuel sulfur levels for both the preliminary and proposed baseline scenarios in 1996, 2020 and 2030.

To examine the feasibility of using national level model results, Table 3.6-3 first provides a comparison of the 48-state emissions derived from national level model runs to those derived from a sum of county level runs for the same preliminary baseline scenario. The county-level results were taken from Table 3.6-1. The national level and sum of county level results are quite similar for NO_x, VOC, and CO. Use of the national level model runs lowers the emissions baseline slightly for SO_2, and less so for PM. This is expected, since diesel NO_x, VOC, and CO emissions are insensitive to county-level differences in fuel characteristics and temperature. PM and SO_2 are sensitive to fuel sulfur levels, with SO_2 exhibiting the most sensitivity.

Table 3.6-4 compares the proposed and preliminary 48-state baseline scenario inventories for land-based diesel engines, recreational marine diesel engines, commercial marine diesel engines, and locomotives. The national level model run results are used as the basis for comparison for the land-based diesel and recreational marine diesel categories. Results are only presented for $PM_{2.5}$ and SO_2 emissions, since these are the only pollutants affected by the changes.

$PM_{2.5}$ emissions are reduced roughly 2% with the proposed baseline scenario in 2020 and 2030, while SO_2 is reduced 13%. These reductions to the baseline will serve to decrease the emission reductions of the rule for $PM_{2.5}$ and SO_2.

Table 3.6-3
Modeled 48-State Emissions for Preliminary Baseline Scenario Used for Air Quality Modeling
Comparison of Results Derived from National Level Model Runs vs. Sum of County Level Model Runs

Applications	Year	NO_x [short tons]			$PM_{2.5}$ [short tons]			SO_2 [short tons]		
		National Level	County Level	% Difference	National Level	County Level	% Difference	National Level	County Level	% Difference
Land-Based Diesel Engines	1996	1,583,664	1,583,641	0.0%	177,375	178,500	-0.6%	159,540	172,175	-7.3%
	2020	1,140,727	1,144,686	-0.3%	126,720	127,755	-0.8%	284,268	308,075	-7.7%
	2030	1,231,995	1,231,981	0.0%	142,342	143,185	-0.6%	335,558	360,933	-7.0%
Recreational Marine Diesel Engines	1996	19,440	19,438	0.0%	494	511	-3.3%	2,349	2,535	-7.4%
	2020	34,817	34,814	0.0%	848	876	-3.2%	4,239	4,562	-7.1%
	2030	41,250	41,246	0.0%	988	1,021	-3.2%	5,035	5,418	-7.1%

Table 3.6-3, continued

Applications	Year	VOC [short tons]			CO [short tons]		
		National Level	County Level	% Difference	National Level	County Level	% Difference
Land-Based Diesel Engines	1996	221,403	221,398	0.0%	1,010,501	1,010,501	0.0%
	2020	96,855	97,113	-0.3%	700,017	702,145	-0.3%
	2030	97,348	97,345	0.0%	793,923	793,899	0.0%
Recreational Marine Diesel Engines	1996	803	803	0.0%	3,215	3,215	0.0%
	2020	1,328	1,327	0.0%	5,538	5,537	0.0%
	2030	1,528	1,528	0.0%	6,465	6,464	0.0%

Table 3.6-4
Modeled 48-State Baseline $PM_{2.5}$ and SO_2 Emission Reductions Due to Changes in Baseline

Applications	Year	$PM_{2.5}$ Emissions [short tons]			SO_2 [short tons]		
		Proposed	Preliminary	Reduction	Proposed	Preliminary	Reduction
Land-Based Diesel Engines	1996	176,510	177,375	865 (0.5%)	147,926	159,540	11,614 (7.3%)
	2020	124,334	126,720	2,386 (1.9%)	252,089	284,268	32,179 (11.3%)
	2030	139,527	142,342	2,815 (2.0%)	297,573	335,558	37,985 (11.3%)
Recreational Marine Diesel Engines	1996	487	494	7 (1.4%)	2,251	2,349	98 (4.2%)
	2020	823	848	25 (2.9%)	3,903	4,239	336 (7.9%)
	2030	958	988	30 (3.0%)	4,636	5,035	399 (7.9%)
Commercial Marine Diesel Engines	1996	36,367	37,203	836 (2.2%)	25,948	37,252	11,304 (30.3%)
	2020	41,365	42,054	689 (1.6%)	32,117	43,028	10,911 (25.4%)
	2030	45,411	46,185	774 (1.7%)	36,068	48,308	12,240 (25.3%)
Locomotives	1996	20,937	22,396	1,459 (6.5%)	50,534	57,979	7,445 (12.8%)
	2020	16,727	17,683	956 (5.4%)	53,832	62,843	9,011 (14.3%)
	2030	15,670	16,988	1,318 (7.8%)	58,832	70,436	11,604 (16.5%)
Total	1996	234,301	237,468	3,167 (1.3%)	226,659	257,120	30,461 (11.8%)
	2020	183,249	187,305	4,056 (2.2%)	341,941	394,378	52,437 (13.3%)
	2030	201,566	206,503	4,937 (2.4%)	397,109	459,337	62,228 (13.5%)

[a] Based on 48-state national runs for land-based and recreational marine categories. Based on 48-state sum of county level runs for commercial marine and locomotive engines.

3.6.3 Control Inventories

Table 3.6-5 presents the preliminary 48-state control inventories used for the air quality modeling. These are an aggregation of the county-level results. Results expressed as short tons are presented for 2020 and 2030 for the land-based diesel, recreational marine diesel, commercial marine diesel, and locomotive categories. Results are not presented for 1996, since controls will only affect future year emission estimates.

Table 3.6-5
Modeled 48-State Controlled Emissions
Preliminary Control Scenario Used for Air Quality Modeling

Applications	Year	NO_x [short tons]	$PM_{2.5}$ [short tons]	SO_2 [short tons]	VOC [short tons]	CO [short tons]
Land-Based Diesel Engines	2020	481,068	36,477	3,340	73,941	249,734
	2030	222,237	14,112	1,159	63,285	133,604
Recreational Marine Diesel Engines	2020	34,814	552	20	1,327	5,537
	2030	41,246	636	24	1,528	6,464
Commercial Marine Diesel Engines	2020	819,201	38,882	184	37,290	159,900
	2030	814,827	42,625	206	41,354	176,533
Locomotives	2020	612,722	13,051	272	36,546	119,302
	2030	534,520	11,798	305	31,644	119,302

The certification standards used for the preliminary and proposed control scenarios are provided in Tables 3.6-6 and 3.6-7, respectively. In general, the preliminary control scenario is more stringent in terms of levels and effective model years for PM and NO_x than the proposed control scenario for all horsepower categories. The NMHC standard is 0.14 g/bhp-hr with both scenarios, although the phase-in of this standard is later in the proposed control scenario. The CO standards are unchanged in both control scenarios, although CO is assumed to be reduced 90% in both scenarios with the advent of trap-equipped engines (corresponding to the start of 0.02 or 0.01 g/bhp-hr PM standards). As a result, the proposed standards will increase the emissions of PM, NO_x, NMHC, and CO in 2020 and 2030 relative to the preliminary standards.

Table 3.6-6
Preliminary Tier 4 Exhaust Emissions Certification Standards Used for Air Quality Modeling

Engine Power	Emission Standards g/bhp-hr					Model Year
	transitional or final	PM	NO_x	NMHC	CO	
hp <25	transitional	0.01	5.6 [a,b]		6.0/4.9 [b]	2010
	final	0.01	0.30	0.14	6.0/4.9 [b]	2012
25 ≤ hp < 50	transitional	0.01	5.6 [a,b]		4.1 [b]	2010
	final	0.01	0.30	0.14	4.1 [b]	2012
50 ≤ hp < 100	transitional	0.01	3.5 [a,b]		3.7 [b]	2010
	final	0.01	0.30	0.14	3.7 [b]	2012
100 ≤ hp < 175	transitional	0.01	3.0 [a,b]		3.7 [b]	2010
	final	0.01	0.30	0.14	3.7 [b]	2012
175 ≤ hp < 750	transitional	0.01	3.0 [a,b]		2.6 [b]	2009
	final	0.01	0.30	0.14	2.6 [b]	2011
hp ≥ 750	transitional	0.01	4.8 [a,b]		2.6 [b]	2009
	final	0.01	0.30	0.14	2.6 [b]	2011

[a] This is a combined NMHC + NO_x standard.
[b] This emission standard is unchanged from the level that applies in the previous model year. For engines below 25 hp, the CO standard is 6.0 g/bhp-hr for engines below 11 hp and 4.9 g/bhp-hr for engines at or above 11 hp.

Table 3.6-7
Proposed Tier 4 Exhaust Emissions Certification Standards

Engine Power	Emissions Standard (g/bhp-hr)[a]					Model Year
	transitional or final	PM	NO_x	NMHC	CO	
hp <25	final	0.30	5.6 [b,c]		4.9	2008
25 ≤ hp < 75	transitional[d]	0.22	5.6/3.5 [b,c]		3.7	2008
	final	0.02	3.5 [b]		3.7 [c]	2013
75 ≤ hp < 175	transitional	0.01 (100%)	0.30 (50%)	0.14 (50%)	3.7 [c]	2012-2013
	final	0.01 (100%)	0.30 (100%)	0.14 (100%)	3.7 [c]	2014
175 ≤ hp < 750	transitional	0.01 (100%)	0.30 (50%)	0.14 (50%)	2.6 [c]	2011-2013
	final	0.01 (100%)	0.30 (100%)	0.14 (100%)	2.6 [c]	2014
hp ≥ 750	transitional	0.01 (50%)	0.30 (50%)	0.14 (50%)	2.6 [c]	2011-2013
	final	0.01 (100%)	0.30 (100%)	0.14 (100%)	2.6 [c]	2014

[a] Percentages are model year sales fractions required to comply with the indicated standard.
[b] This is a combined NMHC + NO_x standard.
[c] This emissions standard level is unchanged from the level that applies in the previous model year. For 25-75 hp engines, the transitional NMHC + NO_x standard is 5.6 g/bhp-hr for engines below 50 hp and 3.5 g/bhp-hr for engines at or above 50 hp.
[d] Manufacturers may optionally skip the transitional standards for 25-75 hp engines; the final standards would then take effect for these engines in the 2012 model year.

The diesel fuel sulfur inputs used for the preliminary and proposed control scenarios are provided in Tables 3.6-8 and 3.6-9, respectively. For land-based diesel engines, the modeled in-use diesel fuel sulfur content is 11ppm in 2020 and 2030 for both scenarios. For recreational marine engines, commercial marine engines and locomotives, the modeled in-use diesel fuel sulfur content is 11ppm in 2020 and 2030 for the preliminary control scenario, but 233 ppm in 2020 and 2030 for the proposed control scenario. As a result, the proposed fuel sulfur levels will serve to increase the PM and SO_2 control inventories for the recreational marine, commercial marine, and locomotive categories in 2020 and 2030. This will be offset slightly by the reduced fuel volumes assigned to the commercial marine and locomotive categories.

Table 3.6-8
Modeled 48-State & 50-State In-Use
Diesel Fuel Sulfur Content Used for Air Quality Modeling

Applications	Standards	Modeled In-Use Fuel Sulfur Content, ppm	Calendar Year
All Diesel Categories	Baseline + hwy 500 ppm "spillover"	2500	through 2005
	Baseline + hwy 15 ppm "spillover"	2400	2006-2007
	June intro of 15 ppm	1006	2008
	Final 15 ppm standard	11	2009

Table 3.6-9
Modeled 48-State & 50-State In-Use Diesel Fuel Sulfur Content for Proposed Standards

Applications	Standards	Modeled In-Use Fuel Sulfur Content, ppm	Calendar Year
Land-based, all power ranges	Baseline	2318	through 2005
		2271	2006
	June intro of 500 ppm	1075	2007
	500 ppm standard	245	2008-2009
	June intro of 15 ppm	100	2010
	Final 15 ppm standard	11	2011+
Recreational and Commercial Marine Diesel Engines and Locomotives	Baseline	2396	through 2005
		2352	2006
	June intro of 500 ppm	1114	2007
	Final 500 ppm standard	252	2008-2009
		233	2010+

To adjust PM emissions for these in-use fuel sulfur levels, the adjustment is made relative to the certification diesel fuel sulfur levels in the model. The modeled certification diesel fuel sulfur inputs used for the preliminary and proposed control scenarios are provided in Tables 3.6-10 and 3.6-11, respectively. For 2020 and 2030, the certification diesel fuel sulfur levels are the same for both the preliminary and proposed control scenarios.

For the commercial marine diesel and locomotive categories, inventories were generated for the proposed control scenarios, using the fuel volume and fuel sulfur level estimates. For the land-based diesel and recreational marine diesel categories, it was not possible to generate revised county-level control inventories. Instead, for the land-based diesel and recreational marine diesel categories, national level NONROAD model runs were used as the basis for comparison of the preliminary and proposed control scenarios. National level model runs were done using the 48-state average fuel sulfur levels for both the preliminary and proposed control scenarios in 2020 and 2030.

To examine the feasibility of using national level model results, Table 3.6-12 first provides a comparison of the 48-state emissions derived from national level model runs to those derived from a sum of county level runs for the same preliminary control scenario. The county-level results were taken from Table 3.6-5. The national level and sum of county level results are quite similar. This is expected, since diesel NO_x, VOC, and CO emissions are insensitive to county-level differences in fuel characteristics and temperature. PM and SO_2 are sensitive to fuel sulfur levels, with SO_2 exhibiting the most sensitivity.

Table 3.6-13 compares the proposed and preliminary 48-state control scenario inventories for land-based diesel engines, recreational marine diesel engines, commercial marine diesel engines, and locomotives. The national level model run results are used as the basis for comparison for the land-based diesel and recreational marine diesel categories. Results are presented for $PM_{2.5}$, NO_x, SO_2, VOC, and CO emissions.

For land-based diesel engines, emissions of $PM_{2.5}$, NO_x, VOC, and CO emissions are higher for the proposed control scenario. This is due to the less stringent emission standards. There were no differences in either the in-use or certification diesel fuel sulfur levels in 2020 and 2030 for this category. The minor difference in SO_2 emissions between the proposed and preliminary scenarios is attributed to differences in aggregation of county-level runs compared to using one national level run.

The recreational marine, commercial marine, and locomotive categories are not controlled in either scenario; however, the in-use fuel sulfur level is 11ppm for the preliminary control scenario and 233 ppm for the proposed control scenario. This affects the PM and SO_2 emissions. Accordingly, the PM and SO_2 emissions for these categories are higher for the proposed control scenario.

Table 3.6-10
Modeled Certification Diesel Fuel Sulfur Content Used for Air Quality Modeling

Engine Power	Standards	Modeled Certification Fuel Sulfur Content, PPM	Model Year
hp <50	Tier 2	2000	through 2009
	Tier 4[a]	15	2010
50 ≤ hp < 175	Tier 3	2000	through 2009
	Tier 4[a]	15	2010
175 ≤ hp < 750	Tier 3	2000	through 2008
	Tier 4[a]	15	2009
hp ≥ 750	Tier 2	2000	through 2008
	Tier 4[a]	15	2009

[a] Tier 4 refers to both transitional and final standards.

Table 3.6-11
Modeled Certification Diesel Fuel Sulfur Content for Proposed Standards

Engine Power	Standards	Modeled Certification Fuel Sulfur Content, PPM	Model Year
hp <75	Tier 2	2000	through 2007
	transitional	500	2008
	final	15	2013
75 ≤ hp < 100	Tier 3 transitional[a]	500	2008-2011
	final	15	2012
100 ≤ hp < 175	Tier 3	2000	2007-2011
	final	15	2012
175 ≤ hp < 750	Tier 3	2000	2006-2010
	final	15	2011
hp ≥ 750	Tier 2	2000	2006-2010
	transitional[b]	50% 2000 50% 15	2011-2013
	final	15	2014

[a] The emission standard here is still Tier 3 as in the Baseline case, but since the Tier 3 standard begins in 2008 for 50-100 hp engines it is assumed that this new technology introduction would allow manufacturers to take advantage of the availability of 500 ppm fuel that year.

[b] The engines remaining at the Tier 2 level would be allowed to continue certifying on the same fuel as earlier Tier 2 engines, but those meeting the Tier 4 0.01 PM standard are assumed to certify on 15 ppm fuel.

Table 3.6-12
Modeled 48-State Emissions for Preliminary Control Scenario Used for Air Quality Modeling
Comparison of Results Derived from National Level Model Runs vs. Sum of County Level Model Runs

Applications	Year	NO_x [short tons]			$PM_{2.5}$ [short tons]			SO_2 [short tons]		
		National Level	County Level	% Difference	National Level	County Level	% Difference	National Level	County Level	% Difference
Land-Based Diesel Engines	2020	477,100	481,068	-0.8%	35,991	36,477	-1.3%	968	1,040	-6.9%
	2030	222,238	222,237	0.0%	14,031	14,112	-0.6%	1,078	1,159	-7.0%
Recreational Marine Diesel Engines	2020	34,817	34,814	0.0%	535	552	-3.1%	19	20	-5.0%
	2030	41,250	41,246	0.0%	616	636	-3.1%	22	24	-8.3%

Applications	Year	VOC [short tons]			CO [short tons]		
		National Level	County Level	% Difference	National Level	County Level	% Difference
Land-Based Diesel Engines	2020	74,423	73,941	0.7%	247,593	249,734	-0.9%
	2030	64,329	63,285	1.6%	133,606	133,604	0.0%
Recreational Marine Diesel Engines	2020	1,328	1,327	0.1%	5,538	5,537	0.0%
	2030	1,528	1,528	0.0%	6,465	6,464	0.0%

Table 3.6-13
Modeled 48-State Controlled Emissions
Emissions Impact Due to Changes in Control Scenario

Applications	Year	NO_x [short tons]			$PM_{2.5}$ [short tons]			SO_2 [short tons]		
		Proposed	Preliminary	Difference	Proposed	Preliminary	Difference	Proposed	Preliminary	Difference
Land-Based Diesel Engines	2020	637,025	477,100	159,925 (+33.5%)	45,057	35,991	9,066 (+25.2%)	1,005	968	37 (+3.8%)
	2030	410,084	222,238	188,264 (+84.7%)	19,239	14,031	5,208 (+37.1%)	1,096	1,078	18 (+1.7%)
Recreational Marine Diesel Engines	2020	34,817	34,817	0 (0.0%)	563	535	28 (+5.2%)	395	19	376 (+1979%)
	2030	41,250	41,250	0 (0.0%)	650	616	34 (+5.5%)	469	22	447 (+2032%)
Commercial Marine Diesel Engines	2020	819,201	819,201	0 (0.0%)	39,228	38,882	346 (+0.9%)	3,251	184	3,067 (+1667%)
	2030	814,827	814,827	0 (0.0%)	43,012	42,625	387 (+0.9%)	3,653	206	3,447 (+1673%)
Locomotives	2020	612,722	612,722	0 (0.0%)	13,147	13,051	96 (+0.7%)	5,449	272	5,177 (+1903%)
	2030	534,520	534,520	0 (0.0%)	11,756	11,798	42 (-0.4%)	5,959	305	5,654 (+1854%)

Table 3.6-13 (cont.)
Modeled 48-State Controlled Emissions Impact Due to Changes in Control Scenario

Applications	Year	VOC [short tons]			CO [short tons]		
		Proposed	Preliminary	Difference	Proposed	Preliminary	Difference
Land-Based Diesel Engines	2020	78,822	74,423	4,399 (+5.9%)	318,530	247,593	70,937 (+28.7%)
	2030	67,861	64,329	3,532 (+5.5%)	173,579	133,606	39,973 (+29.9%)
Recreational Marine Diesel Engines	2020	1,328	1,328	0 (0.0%)	5,538	5,538	0 (0.0%)
	2030	1,528	1,528	0 (0.0%)	6,465	6,465	0 (0.0%)
Commercial Marine Diesel Engines	2020	37,290	37,290	0 (0.0%)	159,900	159,900	0 (0.0%)
	2030	41,354	41,354	0 (0.0%)	176,533	176,533	0 (0.0%)
Locomotives	2020	36,546	36,546	0 (0.0%)	119,302	119,302	0 (0.0%)
	2030	31,644	31,644	0 (0.0%)	119,312	119,312	0 (0.0%)

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