Appendix 4-7:
Nonroad 2017 and 2023 Emission Inventories

1.0 Nonroad Sources

Nonroad mobile sources include internal combustion engines used to propel marine vessels, airplanes, and locomotives, or to operate equipment such as forklifts, lawn and garden equipment, portable generators, etc. For sources other than marine vessels, airplanes, and locomotives, the inventories were developed using USEPA's nonroad model, NONROAD2008a (NONROAD), which is incorporated in USEPA's Motor Vehicle Emission Simulator model, MOVES3. This was the latest version of the model when New Jersey started its runs. This update does not change the Volatile Organic Compound (VOC) and Nitrogen Oxide (NOx) emissions from nonroad model equipment. Therefore, New Jersey did not have to redo its runs with the updated model. This conforms with USEPA instructions included in MOVES3 Update Log.

Since the NONROAD model does not include emissions from commercial marine vessels, airplanes, and locomotives, these emissions were estimated by New Jersey using the latest USEPA guidance or by groups such as the Eastern Regional Technical Advisory Committee (ERTAC). This group represents a collaborative effort among the Northeastern, Mid-Atlantic, Southeastern, and Lake Michigan area states, industry representatives and multi-jurisdictional planning organizations (MJO) to improve emission inventories.

The following sections describe the inventory methodologies and results for the: NONROAD model sources, commercial marine vessels, aircraft and locomotives.

1.1 NONROAD Model

NONROAD estimates emissions from nonroad mobile sources such as: recreational marine vessels, recreational land-based vehicles, farm and construction machinery, lawn and garden equipment, aircraft ground support equipment (GSE) and rail maintenance equipment. This equipment is powered by diesel, gasoline, compressed natural gas or liquefied petroleum gas engines.

New Jersey ran the NONROAD model for each county included in the New Jersey portions of the New York-Northern New Jersey-Long Island Nonattainment Area (hereafter referred to as the Northern New Jersey-New York-Connecticut or Northern NJ-NY-CT Nonattainment Area), as well as the Philadelphia-Wilmington-Atlantic City nonattainment area (hereafter referred to as the Southern New Jersey-Pennsylvania-Delaware-Maryland or Southern NJ-PA-DE-MD Nonattainment Area.)

. The NONROAD model utilizes USEPA nonroad defaults for equipment populations and growth factors. It also interfaces with the USEPA MOVES highway defaults for fuel specific parameters and climatological data. New Jersey made only one change to these defaults. The pleasure craft equipment populations were updated based on registration data for recreational marine vessels from the New Jersey Motor Vehicle Commission (NJMVC). Also, New Jersey replaced the airport ground support equipment inventory estimated by the MOVES NONROAD model as discussed below.

1.1.1 Recreational Marine Vessel Population Revision

New Jersey updated default populations for each of the four major recreational marine vessel categories contained in the NONROAD model (Outboard, Personal Watercraft, Inboard/Sterndrive, Inboard). The NJMVC registration database was accessed to obtain total statewide populations of all recreational marine vessels in New Jersey based on the total number registered in 2007 of 186,084 and in 2019 of 150,948. For the base year 2017 inventory, New Jersey interpolated this data to obtain a value of 156,804 for this year. For the projection year 2023 inventory, no growth was assumed after 2019 and so the 2019 NJMVC population of 150,948 was applied for the projection year 2023. This is because there is no reason to indicate that recreational marine vessel population will continue to decrease after 2019 and not otherwise stabilize at this population amount.

The estimated population of registered users in 2017 of 156,804 and in 2023 of 150,948 was divided by the total NONROAD model default recreational marine vessel population in 2017 of 301,439 and in 2023 of 318,359 to develop for 2017, a ratio of 0.520, and for 2023, a ratio of 0.474. These ratios were applied to the recreational marine vessel category emissions for their respective emission inventory years of 2017 and 2023. The calculations of recreational marine vessel populations and updated emissions are provided in Attachments 1A and B. These attachments are only available electronically.

1.1.2 Airport Ground Support Equipment Replacement

USEPA's NONROAD model estimates emissions from airport GSE. Airport GSE emissions are also included in the USEPA's aircraft inventory that was calculated using the Federal Aviation Administration's (FAA) Aviation Environmental Design Tool (AEDT). Correspondence with the USEPA indicated that they consider the emissions calculated by AEDT to be more accurate than those calculated by the NONROAD model. For this reason, all emissions calculated by the NONROAD model for airport GSE were removed from the inventory to avoid double counting. More information on airport GSE and the FAA AEDT is included in Section 1.3.

1.1.3 NONROAD Model Growth Information

In estimating future year emissions, the NONROAD model includes growth and scrappage rates for equipment in addition to a variety of control programs. Before running the core model, you must define the scenario you are interested in modeling by indicating the year that you want to run. The year selected will include all growth and controls applied up until the end of that year. It is not possible to separate out the portion of the future year emissions due to "growth only" and "control only" in a single run. That is, the model run can only provide a single future year estimate that is a "growth and control" scenario.

All model input files, and scenario specific parameters are specified in the input option file. The information contained in each option file is separated into "packets" based on common information. For example, all data items related to the period for which you are interested in estimating emissions is grouped into a single packet, as are the data files related to the population of equipment for a modeling region.

The growth packet of the NONROAD model cross-references each source classification code (SCC) to a growth indicator code. The indicator code is an arbitrary code that identifies an actual predicted value such as human population or employment that is used to estimate the future year source population. The growth packet also defines the scrappage curves used to estimate the future year model year distribution.

The scrappage curve is the percentage of equipment scrapped as a function of the fraction of useful life consumed. For example, the default scrappage curve may have 9 percent of equipment scrapped when the equipment has reached 45 percent of its median life. More information concerning model-based engine population growth packets and methodology for progjeccting growth and scrappage is provided in the USEPA document “Nonroad Engine Population Growth Estimates in MOVES2014b, EPA-420-R-18-010, July 2018.

1.1.4 NONROAD Model Control Information

The NONROAD model also accounts for all USEPA emission standards for nonroad equipment. There are multiple standards that vary by equipment type, rated power, model year, and pollutant. Table 1.1.4 is a summary of the emission control programs accounted for in the NONROAD model.

Table 1.1.4: Control Programs Included in USEPA’s NONROAD Model

Regulation/ (USEPA’s emission standard reference guide)	Description
Control of Air Pollution; Determination of Significance for Nonroad Sources and Emission Standards for New Nonroad Compression Ignition Engines at or Above 37 Kilowatts 59 FR 31036 June 17, 1994 (USEPA-420-B-16-022, March 2016)	This rule establishes Tier 1 exhaust emission standards for HC, NO_x, CO, and PM for nonroad compression-ignition (CI) engines ≥37kW (≥50hp). Marine engines are not included in this rule. The start dates and pollutants affected vary by hp category as follows: 50-100 hp: Tier 1,1998; NO_x only 100-175 hp: Tier 1, 1998; NO_x only 175-750 hp: Tier 1, 1996; HC, CO, NO_x, PM >750 hp: Tier 1, 2000; HC, CO, NO_x, PM
Emissions for New Nonroad Spark-Ignition Engines at or Below 19 Kilowatts; Final Rule 60 FR 34581 July 3, 1995 (USEPA-420-B-16-028, March 2016)	This rule establishes Phase 1 exhaust emission standards for HC, NO_x, and CO for nonroad spark-ignition engines ≤19kW (≤25hp). This rule includes both handheld (HH) and non-handheld (NHH) engines. The Phase 1 standards become effective in 1997 for: Class I NHH engines (<225cc), Class II NHH engines (≥225cc), Class III HH engines (<20cc), and Class IV HH engines (≥20cc and <50cc). The Phase 1 standards become effective in 1998 for: Class V HH engines (≥50cc)
Final Rule for New Gasoline Spark-Ignition Marine Engines; Exemptions for New Nonroad Compression-Ignition Engines at or Above 37 Kilowatts and New Nonroad Spark-Ignition Engines at or Below 19 Kilowatts 61 FR 52088 October 4, 1996 (USEPA-420-B-16-026, March 2016)	This rule establishes exhaust emission standards for HC+ NO_x for personal watercraft and outboard (PWC/OB) and Stern Inboard (SI) marine engines. The standards are phased in from 1998-2010 for PWC/OB and from 2010-2012 for SI engines.
Control of Emissions of Air Pollution from Nonroad Diesel Engines 63 FR 56967 October 23, 1998 (USEPA-420-B-16-22, March 2016)	This final rule sets Tier 1 standards for engines under 50 hp, phasing in from 1999 to 2004. It also phases in more stringent Tier 2 standards for all engine sizes from 2001 to 2006, and yet more stringent Tier 3 standards for engines rated over 50 hp from 2006 to 2008. The Tier 2 standards apply to NMHC+ NO_x, CO, and PM, whereas the Tier 3 standards apply to NMHC+ NO_x and CO. The start dates by hp category and tier are as follows:

Regulation/ (USEPA's emission standard reference guide)	Description
	hp<25: Tier 1, 2000; Tier 2, 2005; No Tier 3 25-50 hp: Tier 1, 1999; Tier 2, 2004; No Tier 3 50-100 hp: Tier 1, 1998: Tier 2, 2004; Tier 3, 2008 100-175 hp: Tier 1, 1997: Tier 2, 2003; Tier 3, 2007 175-300 hp: Tier 1, 1996: Tier 2, 2003; Tier 3, 2006 300-600 hp: Tier 1, 1996; Tier 2, 2001; Tier 3, 2006 600-750 hp: Tier 1, 1996; Tier 2, 2002; Tier 3, 2006 >750 hp: Tier 1, 2000; Tier 2, 2006, No Tier 3 This rule does not apply to marine diesel engines > 50 hp.
Phase 2: Emission Standards for New Nonroad Nonhandheld Spark Ignition Engines at or Below 19 Kilowatts 64 FR 15207 March 30, 1999 (USEPA-420-b-16-028, March 2016)	This rule establishes Phase 2 exhaust emission standards for HC+ NO_x for nonroad nonhandheld (NHH) spark-ignition engines ≤19kW (≤25hp). The Phase 2 standards for Class I NHH engines (<225cc) become effective on August 1, 2001 or August 1, 2003 for any engine initially produced on or after that date. The Phase 2 standards for Class II NHH engines (≥225cc) are phased in from 2001-2005.
Phase 2: Emission Standards for New Nonroad Spark-Ignition Handheld Engines at or Below 19 Kilowatts and Minor Amendments to Emission Requirements Applicable to Small Spark-Ignition Engines and Marine Spark-Ignition Engines; Final Rule 65 FR 24268 April 25, 2000 (USEPA-420-B-16-028, March 2016)	This rule establishes Phase 2 exhaust emission standards for HC+ NO_x for nonroad handheld (HH) spark-ignition engines ≤19kW (≤25hp). The Phase 2 standards are phased in from 2002-2005 for Class III and Class IV engines and are phased in from 2004-2007 for Class V engines. The Phase 3 standards are phased in from 2011-2012 for Class I, II and III-V.
Control of Emissions from Nonroad Large Spark-Ignition Engines and Recreational Engines (Marine and Land-Based); Final Rule 67 FR 68241 November 8, 2002 (USEPA-420-B-16-023, March 2016) (USEPA-420-B-16-027, March 2016) (USEPA-420-B-16-029, March 2016) (USEPA-420-B-16-025, March 2016)	This rule establishes exhaust and evaporative standards for several nonroad categories: 1) Two tiers of emission standards are established for large spark-ignition engines over 19 kW. Tier 1 includes exhaust standards for HC+ NO_x and CO and is phased in from 2004-2006. Tier 2 becomes effective in 2007 and includes exhaust standards for HC+ NO_x and CO, as along with evaporative controls affecting fuel line permeation, diurnal emissions and running loss emissions. 2) Exhaust and evaporative emission standards are established for recreational vehicles, which include snowmobiles, off-highway motorcycles, and all-terrain vehicles (ATVs). For snowmobiles, HC and CO exhaust standards are phased-in from 2006-2012. For off-highway motorcycles, HC+ NO_x and CO exhaust emission standards are phased in from 2006-2007. For ATVs, HC+NO_x and CO exhaust emission standards are phased in from 2006-2007. Evaporative emission standards for fuel tank and hose permeation apply to all recreational vehicles beginning in 2008 and for Stern Inboard (SI) marine engines beginning in 2009. 3) Exhaust emission standards for recreational marine diesel engines over 50 hp for NOx becomes effective in 2004. This is a "Tier 1" standard. While the "Tier 2" standard for HC+ NO_x, CO, and PM begins in 2006-2009,

Regulation/ (USEPA's emission standard reference guide)	Description
	depending on the engine displacement. "Tier 3" standards begin in 2009-2014.
Control of Emissions of Air Pollution from Nonroad Diesel Engines and Fuel; Final Rule (Clean Air Nonroad Diesel Rule – Tier 4) 69 FR 38958 June 29, 2004 (USEPA-420-B-16-022, March 2016)	This final rule sets Tier 4 exhaust standards for CI engines covering all hp categories (except marine and locomotives) and regulates nonroad diesel fuel sulfur content. 1) The Tier 4 start dates and pollutants affected vary by hp and tier as follows: hp<25: 2008, PM only 25-50 hp: Tier 4 transitional, 2008, PM only; Tier 4 final, 2013, NMHC+ NO_x and PM 50-75 hp: Tier 4 transitional, 2008; PM only; Tier 4 final, 2013, NMHC+ NO_x and PM 75-175 hp: Tier 4 transitional, 2012, HC, NO_x, and PM; Tier 4 final, 2014, HC, NO_x,, PM 175-750 hp:Tier 4 transitional, 2011, HC, NO_x, and PM; Tier 4 final, 2014, HC, NO_x,, PM >750 hp: Tier 4 transitional, 2011, HC, NO_x, and PM; Tier 4 final, 2015, HC, NO_x,, PM 2) This rule will reduce nonroad diesel fuel sulfur levels in two steps. First, starting in 2007, fuel sulfur levels in nonroad diesel fuel will be limited to a maximum of 500 ppm, the same as for current highway diesel fuel. Second, starting in 2010, fuel sulfur levels in most nonroad diesel fuel will be reduced to 15 ppm.
Control of Emissions from Nonroad Spark-Ignition Engines and Equipment; Final Rule (Bond Rule) 73 FR 59034 October 8, 2008 (USEPA-420-B-16-026, March 2016)	This rule establishes exhaust and evaporative standards for small SI engines and marine SI engines: 1) Phase 3 HC+ NO_x exhaust emission standards are established for Class I NHH engines starting in 2012 and for Class II NHH engines starting in 2011. There are no new exhaust emission standards for handheld engines. New evaporative standards are adopted for both handheld and non-handheld equipment. The new evaporative standards control fuel tank permeation, fuel hose permeation, and diffusion losses. The evaporative standards begin in 2012 for Class I NHH engines and 2011 for Class II NHH engines. For handheld engines, the evaporative standards are phased-in from 2012-2016. 2) More stringent HC+ NO_x and CO standards are established for Pleasure craft/Outboard (PWC/OB) and stern inboard (SI) marine engines beginning in 2010. In addition, new exhaust HC+ NO_x and CO standards are established for SI marine engines beginning in 2010. High performance SI marine engines are subject to separate HC+ NO_x and CO exhaust standards that are phased-in from 2010-2011. New evaporative standards were also adopted for all SI marine engines that control fuel hose permeation, diurnal emissions, and fuel tank permeation emissions. The hose permeation, diurnal, and tank permeation standards take effect in 2009, 2010, and 2011, respectively.

1.1.5 NONROAD Model Equipment Emissions Inventories

Tables 1.1.5.1, 2 and 3 summarize the emissions for sources in the NONROAD model for a typical summer work weekday by county and nonattainment area (NAA) for VOC, NO_x and CO for 2017 and 2023 and annual emissions by county for VOC, NOx, CO, PM_{10}, $PM_{2.5}$, SO_2 and NH_3 for 2017. Attachments 1A and 1B contain the detailed NONROAD Model source emission inventories. Thes attachments are only available electronically.

Table 1.1.5.1:
2017 NONROAD Model Equipment Emission Inventory by NAA, County and Pollutant
Summer Work Weekday Tons Per Day (TPD)

County	VOC	NO_x	CO
NJ Portion of Northern NJ-NY-Ct NAA			
Bergen	7.145	6.714	142.411
Essex	2.852	3.975	54.697
Hudson	2.094	3.833	32.296
Hunterdon	1.708	1.692	27.986
Middlesex	5.320	6.562	100.537
Monmouth	5.306	5.455	87.919
Morris	4.937	3.999	89.412
Passaic	2.585	2.630	44.804
Somerset	3.695	3.039	70.204
Sussex	1.459	1.298	18.295
Union	3.054	2.692	59.157
Warren	0.929	0.758	12.453
Total NJ Portion of NAA	**41.084**	**42.645**	**740.073**
NJ Portion of Southern NJ-PA-DE-MD NAA			
Atlantic	3.358	2.539	32.874
Burlington	3.344	3.354	54.907
Camden	2.484	2.462	44.096
Cape May	3.779	2.323	28.515
Cumberland	1.322	1.383	13.658
Gloucester	2.343	1.972	37.888
Mercer	2.545	3.599	44.506
Ocean	6.725	4.669	61.714
Salem	0.751	0.578	7.641
Total NJ Portion of NAA	**26.651**	**22.880**	**325.800**
Total NJ	**67.735**	**65.526**	**1,065.873**

Table 1.1.5.2:
2023 NONROAD Model Equipment Emission Inventory by NAA, County and Pollutant
Summer Work Weekday Tons Per Day (TPD)

County	VOC	NO_x	CO
NJ Portion of Northern NJ-NY-Ct NAA			
Bergen	6.824	5.036	144.982

Essex	2.629	2.868	55.392
Hudson	1.716	2.654	32.424
Hunterdon	1.538	1.198	28.010
Middlesex	4.989	4.715	101.640
Monmouth	4.694	3.908	87.919
Morris	4.599	3.010	90.307
Passaic	2.300	1.958	45.217
Somerset	3.580	2.255	70.876
Sussex	1.291	0.922	18.394
Union	2.901	2.056	59.884
Warren	0.783	0.547	12.336
Total NJ Portion of NAA	**37.843**	**31.128**	**747.380**
NJ Portion of Southern NJ-PA-DE-MD NAA			
Atlantic	2.411	1.826	31.929
Burlington	3.067	2.425	55.123
Camden	2.270	1.814	44.552
Cape May	3.608	2.280	32.877
Cumberland	0.902	0.998	12.923
Gloucester	2.082	1.444	37.991
Mercer	2.370	2.500	44.705
Ocean	4.595	3.422	59.384
Salem	0.538	0.417	7.371
Total NJ Portion of NAA	**21.842**	**17.126**	**326.855**
Total NJ	**59.685**	**48.254**	**1,074.235**

Table 1.1.5.3
2017 Annual NONROAD Model Equipment Emission Inventory
Tons Per Year (TPY) by County and Pollutant

County	VOC	NOx	CO	PM_{10}	$PM_{2.5}$	SO_2	NH_3
Atlantic	996.10	774.84	8,949.27	71.53	67.74	1.35	1.64
Bergen	2,108.59	**1,946.22**	37,476.44	229.86	217.18	4.39	4.64
Burlington	989.72	938.66	14,288.14	107.00	101.30	1.85	2.18
Camden	739.36	**708.37**	11,797.29	79.01	74.80	1.46	1.67
Cape May	1,128.85	718.30	8,264.02	63.50	59.99	1.32	1.51
Cumberland	399.45	417.46	3,942.96	31.53	30.04	0.70	0.79
Essex	861.86	1,148.87	15,162.39	113.14	107.70	2.07	2.57
Gloucester	682.73	546.88	9,557.72	68.07	64.22	1.16	1.32
Hudson	654.06	1,099.39	9,585.21	95.89	91.79	1.58	2.34
Hunterdon	488.99	453.51	6,871.79	56.15	53.06	0.86	1.07
Mercer	730.32	985.97	11,203.08	107.76	102.37	1.60	2.25
Middlesex	1,546.12	1,847.74	25,945.53	202.52	192.11	3.45	4.22
Monmouth	1,557.60	1,545.01	22,727.35	170.75	161.56	2.92	3.57
Morris	1,424.78	1,131.01	22,556.19	145.65	137.23	2.66	2.77
Ocean	2,107.90	1,420.07	17,847.59	129.71	122.62	2.67	3.08
Passaic	772.85	767.83	12,063.38	81.62	77.35	1.58	1.75
Salem	229.42	159.75	2,147.09	15.49	14.68	0.30	0.32
Somerset	2,068.00	1,656.38	33,928.42	231.77	218.10	3.88	4.21
Sussex	455.60	365.14	4,983.83	39.63	37.53	0.67	0.84
Union	893.31	779.32	15,337.21	94.11	88.83	1.84	1.86
Warren	297.71	216.39	3,414.45	24.62	23.28	0.44	0.49
Total NJ	**21,133.35**	**19,597.12**	**298,049.34**	**2,159.32**	**2,043.49**	**38.73**	**45.10**

1.1.6 NONROAD Model Equipment Emission Reductions

Control measure emission reductions are normally calculated by the difference between the 2023 projection year emissions without post-2017 controls applied (growth only scenario) and the 2023 projection year emissions with all controls applied (controlled scenario). However, the NONROAD model does not allow for control technology adjustments to a year different from the designated model run year. Therefore, 2017 year emissions were used for the 2023 projection year growth only scenario.   This generally realizes less emission reductions because the 2023 growth only scenario generates greater emissions from three years of growth without application of new control measures after 2017.

Emission reductions accrue from rules establishing lower emission standards for nonroad spark and compression ignition engines as described above in Section 1.1.4. Table 1.1.6 summarizes the 2023 projection year NONROAD Model equipment emission benefits by NAA and county for average summer work week day for VOC and NOx. CO emisson reductions are not included in this table since there are none..   This is because nonroad CO emission control measures are not as significant as those estimated for NOx and VOC and the increases due to growth are greater than the reductions due to control.

Attachment 5 contains the detailed non-road source emission reductions. This attachment is only available electronically.

Table 1.1.6:
2023 NONROAD Model Equipment Emission Reductions by NAA, County and Pollutant Summer Work Weekday Tons Per Day (TPD)

County	VOC Tons per Day	NO_x Tons per Day
NJ Portion of Northern NJ-NY-Ct NAA		
Bergen	0.297	1.678
Essex	0.214	1.107
Hudson	0.371	1.179
Hunterdon	0.161	0.493
Middlesex	0.324	1.846
Monmouth	0.592	1.547
Morris	0.307	0.988
Passaic	0.268	0.671
Somerset	0.101	0.783
Sussex	0.143	0.375
Union	0.140	0.635
Warren	0.120	0.210
Total NJ Portion of NAA	**3.037**	**11.513**
NJ Portion of Southern NJ-PA-DE-MD NAA		
Atlantic	0.895	0.711
Burlington	0.229	0.928
Camden	0.192	0.648
Cape May	0.038	0.041
Cumberland	0.418	0.385
Gloucester	0.243	0.528
Mercer	0.164	1.100
Ocean	2.077	1.246
Salem	0.201	0.161
Total NJ Portion of NAA	**4.457**	**5.747**
Total NJ	**7.494**	**17.261**

1.2 Commercial Marine Vessels (CMV)

CMV engines are divided into three categories based on displacement (swept volume) per cylinder. Category 2 (C2) and Category 1 (C1), (C21 includes both C1 and C2), marine diesel engines typically range in size from about 500 to 8,000 kW (700 to 11,000 hp) with engines having displacements below 7 liters per cylinder for C1 and greater than or equal to 7 liter per cylinder and below 30 liters per cylinder for C2. These engines are used to provide propulsion power on many kinds of vessels including towboats, assist tugs, push boats, supply vessels, fishing vessels, and other commercial vessels in and around ports. They are also used as stand-alone generators for auxiliary electrical power on vessels. Category 3 (C3) marine diesel engines typically range in size from 2,500 to 70,000 kW (3,000 to 100,000 hp) with engines having displacements equal to or above 30 liters per cylinder. These are very large marine diesel engines used for propulsion power on ocean-going vessels such as: container ships, oil tankers, bulk carriers, and cruise ships.

All marine vessels are powered by diesel engines that are fueled with distillate fuel oil blends. USEPA has assumed that C3 vessels primarily use distillate blends with sulfur content of 1,000 parts per million (ppm) while C21 vessels use distillate fuels with 15 ppm in accordance with USEPA and International Marine Organization (IMO) regulations (Annex VI of the 1997 International Convention for the Prevention of Pollution from Ships (a treaty called MARPOL)) within the North American Emission Control Area (ECA). These control measures are more completely discussed in Section 1.2.3.

CMV emission inventories for C3 and C21 vessels were available from the USEPA 2017 National Emission Inventory (NEI).[1] This NEI database included diesel fueled CMV emissions for both the port and underway operation modes for main propulsion and auxiliary engines. The annual 2017 NEI emissions were converted to summer day emissions by dividing by 365.

The Portway operation mode includes operations which occur at the docking facilities or close by. These include “hoteling operations”, meaning CMVs that remained in a single location for more than one hour operating only their auxiliary engines and boilers usually because they have docked in their dockyard berth. Also, any maneuvering that occurs near the dockyard is usually considered part of the Portway operations. The underway operation includes almost all the waterborne area outside of the docking facilities and may constitute maneuvering, reduced speed zone or cruise operation modes. USEPA used GIS Arc Info to map shape files to present exactly what constituted the port and underway areas.

The CMV C3 and C21 sources are categorized as operating either in-port or underway and encoded using the source classification codes (SCCs) listed in Table 1.2 below which distinguishes between port areas versus underway, and main versus auxiliary engines.

Table 1.2: CMV SCCs

SCC	Tier 1 Description	Tier 2 Description	Tier 3 Description	Tier 4 Description
2280002101	C21	Diesel	Portway	Main
2280002102	C21	Diesel	Portway	Auxiliary
2280002103	C3	Diesel	Portway	Main

[1] U.S. Environmental Protection Agency. 2014 National Emissions Inventory, version 1, Technical Support Documentation, December 2016.

2280002104	C3	Diesel	Portway	Auxiliary
2280002201	C21	Diesel	Underway	Main
2280002202	C21	Diesel	Underway	Auxiliary
2280002203	C3	Diesel	Underway	Main
2280002204	C3	Diesel	Underway	Auxiliary

The 2017 NEI emissions were developed based on signals from Automated Identification System (AIS) transmitters. AIS is a tracking system used by vessels to enhance navigation and avoid collision with other AIS transmitting vessels. The USEPA received AIS data from the U.S. Coast Guard (USCG) to quantify all ship activity which occurred between January 1 and December 31, 2017. The provided AIS data extends beyond 200 nautical miles from the U.S coast. This boundary is roughly equivalent to the border of the North American ECA.

The AIS data were compiled into five-minutes intervals by the USCG, providing a reasonably refined assessment of a vessel's movement. For example, using a five-minute average, a vessel traveling at 25 knots would be captured every two nautical miles that the vessel travels. For slower moving vessels, the distance between transmissions would be less. The ability to track vessel movements through AIS data and link them to attribute data, has allowed for the development of an inventory of very accurate emission estimates. These AIS data were used to define the locations of individual vessel movements, estimate hours of operation, and quantify propulsion engine loads.

At specific hours in certain locations, particularly around ports, exceptionally high emissions values were identified from the compilation of AIS data. These high emissions values were found to be caused by vessel hoteling. Hoteling is the time at a pier/wharf/dock or anchorage when the vessel is operating at some load conditions the entire time the vessel is docked. Peak loads will occur after the propulsion engines are shut down. The auxiliary engines are responsible for all onboard power or are used to power off-loading equipment or both when the vessel is hoteling. All hoteling emissions longer than one hour were equally apportioned across all the hours during which the ship was stationary up until a maximum of 400 hours.

The compiled AIS data also included the vessel's IMO's number and Maritime Mobile Service Identifier (MMSI); which allowed each vessel to be matched to their characteristics obtained from the Clarkson's ship registry. This registry data contained engine parameters, vessel power parameters and service speeds; and other factors such as year of manufacture and tonnage which helped separate the C3 vessels from the C21 vessels and to differentiate the various types of C3 and C21.

Next, vessels were identified in order to determine their vessel type, and thus their vessel group, power rating, and engine tier information which are required for the emissions calculations. The emissions were calculated for each time interval between consecutive AIS messages for each vessel and allocated to the location of the message corresponding to the interval. Emissions were calculated according to the following equation:

$$\text{Emissions}_{\text{interval}} = \text{Time (hr)}_{\text{interval}} \times \text{Power (kW)} \times \text{EF (g/kWh)} \times \text{LLAF}$$

Power is calculated for the propulsion (main), auxiliary, and auxiliary boiler engines for each interval based on actual speed and the power ratings and service speeds pulled from the above referenced Clarkson registry data or default surrogate values developed for each vessel group if

Clarkson has not specifically recorded a power rating for that specific vessel. LLAF represents the low load adjustment factor; a unitless factor which reflects increasing propulsive emissions during low load operations. Time indicates the activity duration time between consecutive intervals.

Emission factor (EF) reflects the assigned emission factors for each engine. The emission factors used in this inventory take into consideration the USEPA's marine vessel fuel regulations as well as exhaust standards that are based on the year that the vessel was manufactured to determine the appropriate regulatory tier. Emission factors in g/kW-hr by tier for NOx, PM_{10}, $PM_{2.5}$, CO, CO_2, SO_2 and VOC were developed using Tables 3-7 through 3-10 in USEPA's 2008 Regulatory Impact Analysis (RIA) for C21 CMV (RIA 2008)[2] and the current USEPA Port Guidance Methodologies[3] for C3 CMV. Also, IMO requirements establish specific EFs for C3 CMVs.

The resulting emissions were available at 5-minute intervals. Code was developed to aggregate these emissions to modeling grid cells and up to hourly levels so that the emissions data could be inputted for emissions modeling. These emissions were also made available in NEI input format (NIF) at the county/SCC summary level and ArcGIS shape files.

In addition, the 2017 NEI does not utilize shape files in the same manner as earlier NEIs. Although the detailed 2017 files used for air quality modeling have 1-hour emissions in detailed spatial grids, the NEI estimate is annual and in over-water-only shape file codes for port estimates and in county FIP codes for underway emissions. The port shapefiles do not cross countries and can be readily summed to individual port or to county. Shape files are posted on the 2017 NEI page under the link Commercial Marine Vessel GIS Shape Files (port and underway, current and retired).

1.2.1 CMV Growth Factors

USEPA developed projections for CMV emissions that included both growth and control factors for C12 and C3 CMV based on the RIA 2008 and 2009 and additional updated information such as fuel use for C3 marine vessels to project future year CMV emissions. New Jersey could not use these factors for calculation of growth-only emissions because USEPA did not provide separate growth-only factors or the new fuel use report that they developed. Therefore, New Jersey estimated its own growth-only factors.

New Jersey developed C12 CMV growth-only emissions from 2017 to 2023 using the fuel use consumption increase from 2017 to 2023 included in the RIA 2008. Similarly, C3 growth-only emissions from 2017 to 2023 were developed from the fuel use included in the USEPA RIA for C3 CMV engines (RIA 2009)[4]. These growth factors are included below in Table 1.2.1 and a complete listing of the grown 2023 inventories developed for these engines is included in Attachment 2B.

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[2] Regulatory Impact Analysis: Control of Emissions of Air Pollution from Locomotive Engines and Marine Compression Ignition Engines Less than 30 Liters Per Cylinder, USEPA, USEPA420-R-08-001, March 2008.
[3] Methodologies for Estimating Port-Related and Goods Movement Mobile Source Emission Inventories, USUSEPA, Office of Transportation Air Quality, USEPA-420-D-20-001, February 2020.
[4] Regulatory Impact Analysis: Control of Emissions from New Marine Compression-Ignition Engines at or Above 30 Liters per Cylinder, USEPA, USEPA-420-F-09-068, December 2009.

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Table 1.2.1: CMV Growth Only Factors from 2017 to 2023

Category	C21	C3
Growth Factor 2017 to 2023	1.055	1.302

1.2.2 CMV Category 1 & 2 Engine Control Factors

A combined growth and control factor for each pollutant was developed based on methodologies documented in the USEPA RIA 2008 for C21 CMV. USEPA considered the following scenarios that accounted for both the 2004 Nonroad diesel rule and the 2008 diesel marine vessel rule in developing their grown and controlled emission projections:

1. The impact of existing tier 1 and 2 engine regulations that took effect in 2004 and 2007,
2. The 2004 Clean Air Nonroad Diesel Rule that will decrease the allowable levels of sulfur in fuel beginning in 2007,
3. Fleet turnover,
4. The reductions from USEPA's 2008 rule Final Locomotive-Marine rule for tier 3 and 4 engines,
5. The 2008 final rule that includes the first-ever national emission standards for existing marine diesel engines, applying to engines larger than 600kW when they are remanufactured. The rule also sets tier 3 emissions standards for newly built engines that are phasing in from 2009,
6. Finally, the rule establishes tier 4 standards for newly built commercial marine diesel engines above 600kW, phasing in beginning in 2014.

In the RIA 2008, the USEPA applied the above control measures to develop control factors for C21 CMV propulsion and auxiliary engines. USEPA applied these control measures to the growth factors discussed in Section 1.2.1 above to develop a single growth and control factor for C21 CMVs.

The 2017 to 2023 growth and control factors obtained for VOC, NOx and CO for the four C21 SCC` categories are shown below in Table 1.2.2 and a complete listing of the controlled emission factors developed for these engines is included in Attachment 2B.

Table 1.2.2:
CMV Category 1 & 2 Engine Growth and Control Factors from 2017 to 2023

CMV	VOC	NOx	CO
2280002103	0.789	1.058	1.439
2280002104	0.878	1.321	1.777
2280002203	0.894	1.304	
2280002204	1.061	1.085	0.8586

1.2.3 CMV Category 3 Engine Control Factors

A combined growth and control factor for each pollutant was developed based on methodologies documented in the RIA 2009 for C3 CMV and from projected bunker fuel demand that projects marine bunker fuel demand to the year 2030. Marine bunker fuel usage was used as a surrogate for CMV C3 vessel activity. The bunker fuel growth rate from 2016 to

2023 in addition to control factors derived from the RIA 2009 was directly applied to the 2017 emissions to develop the 2023 projected emissions inventory. The USEPA report on bunker fuel is not referenced because it was not provided by the USEPA.

USEPA considered the following scenarios that accounted for both the 2004 Nonroad diesel rule and the 2008 diesel marine vessel rule in developing their grown and controlled emission projections:

In February 2003, the USEPA established standards for C3 CMV engines manufactured on January 1,2004 or later.

On March 26, 2010, the IMO officially designated waters off North American coasts as an ECA with stringent international emission standards that apply to ships as first explained in Section 1.2. In practice, implementation of the ECA means that ships entering the designated area need to use compliant fuel for the duration of their voyage that is within that area, including time in port and voyages whose routes pass through the area without calling on a port. The North American ECA includes waters of the Atlantic Ocean extending up to 200 nautical miles from the east coast of the US. The quality of fuel that complies with the ECA standard will change over time. From the effective date in 2012 until 2015, fuel used by vessels operating in designated areas cannot exceed 1.0 percent sulfur (10,000 ppm). Beginning in 2015, fuel used by vessels operating in these areas cannot exceed 0.1 percent sulfur (1000 ppm). Beginning in 2016, NO_x after treatment requirements become applicable.

On April 30, 2010, USEPA adopted final emission standards under the Clean Air Act for new marine diesel engines with per-cylinder displacement at or above 30 liters (called Category 3 CMV engines) installed on U.S.-flagged vessels. The final engine standards are equivalent to those adopted in the amendments to MARPOL. The emission standards applied in two stages: near-term standards for newly built engines applied beginning in 2011, and long-term standards requiring an 80 percent reduction in NO_x began in 2016. USEPA also adopted changes to the diesel fuel program to allow for the production and sale of diesel fuel with no more than 1,000 ppm sulfur for use in C3 CMVs. The regulations generally forbid production and sale of fuels with more than 1,000 ppm sulfur for use in the North American ECA unless operators achieve equivalent emission reductions in other ways.

In the RIA 2009, the USEPA applied the above control measures to develop controlled emission factors for C3 CMV propulsion and auxiliary engines. USEPA applied these control measures to the growth factors developed from their bunker fuel projections discussed in Section 1.2.1 above to develop combined growth and control factors for C3 CMVs.

These 2017 to 2023 factors for NOx, VOC and CO are shown in Table 1.2.3 below and a complete listing of the controlled and uncontrolled inventories developed for these engines is included in Attachment 2B.

Table 1.2.3:
CMV Category 3 Engine Growth and Control Factors from 2017 to 2023

SCC	NOx	VOC	CO
2280002103	1.058	1.438	1.439
2280002104	1.321	1.770	1.777
2280002203	1.304	1.566	1.647
2280002204	1.085	1.466	1.471

1.2.4 Commercial Marine Vessel Emission Inventory

Tables 1.2.4.1, 2 and 3 summarize the actual 2017 and the projection 2023 CMV emissions summer work weekday by county, and NAA for VOC, NO_x and CO for 2017 and 2023; and annual by county for VOC, NOx, CO, PM_{10}, $PM_{2.5}$, SO_2 and NH_3 for 2017. Attachments 2A and B contains the detailed CMV emission inventories. These attachments are only available electronically.

Table 1.2.4.1:
2017 Commercial Marine Vessel Emission Inventory by NAA, County and Pollutant
Summer Work Weekday Tons Per Day (TPD)

County	VOC Tons per Day	NO_x Tons per Day	CO Tons per Day
NJ Portion of Northern NJ-NY-CT NAA			
Bergen	0.009	0.256	0.039
Essex	0.214	2.489	0.351
Hudson	0.520	11.263	1.635
Hunterdon	0	0	0
Middlesex	0.059	1.125	0.154
Monmouth	0.157	3.526	0.505
Morris	0	0	0
Passaic	0	0	0
Somerset	0	0	0
Sussex	0	0	0
Union	0.159	2.023	0.293
Warren	0	0	0
Total NJ Portion of NAA	**1.118**	**20.682**	**2.977**
Atlantic	0.035	0.947	0.138
Burlington	0.004	0.102	0.014
Camden	0.053	0.798	0.103
Cape May	0.067	1.951	0.294
Cumberland	0.056	1.299	0.143
Gloucester	0.097	1.314	0.192
Mercer	0	0.005	0.001
Ocean	0.048	1.361	0.203
Salem	0.035	0.805	0.089
Total NJ Portion of NAA	**0.396**	**8.582**	**1.178**
Total NJ	**1.514**	**29.264**	**4.155**

Table 1.2.4.2:
2023 Commercial Marine Vessel Emission Inventory by NAA, County and Pollutant
Summer Work Weekday Tons Per Day (TPD)

County	VOC Tons per Day	NO_x Tons per Day	CO Tons per Day
NJ Portion of Northern NJ-NY-CT Nonattainment Area			
Bergen	0.009	0.256	0.054
Essex	0.316	2.889	0.539
Hudson	0.612	11.277	2.233
Hunterdon	0	0	0
Middlesex	0.077	1.191	0.222
Monmouth	0.197	3.756	0.724
Morris	0	0	0
Passaic	0	0	0
Somerset	0	0	0
Sussex	0	0	0
Union	0.226	2.249	0.438
Warren	0	0	0
Total NJ Portion of NAA	**1.438**	**21.617**	**4.210**
NJ Portion of Southern NJ-PA-DE-MD NAA			
Atlantic	0.033	0.878	0.177
Burlington	0.006	0.113	0.021
Camden	0.077	0.892	0.155
Cape May	0.062	1.789	0.374
Cumberland	0.081	1.591	0.226
Gloucester	0.142	1.526	0.298
Mercer	0	0.004	0.001
Ocean	0.048	1.324	0.271
Salem	0.051	0.988	0.140
Total NJ Portion of NAA	**0.500**	**9.104**	**1.664**
Total NJ	**1.938**	**30.722**	**5.875**

Table 1.2.4.3
2017 Annual Commercial Marine Vessels Emission Inventory
Tons Per Year (TPY) by County and Pollutant

County	VOC	NOx	CO	$PM_{2.5}$	PM_{10}	SO_2	NH_3
Atlantic	12.95	345.66	50.46	9.12	9.41	1.69	0.18
Bergen	3.25	93.43	14.11	2.33	2.40	0.21	0.04
Burlington	1.61	37.32	5.20	0.79	0.82	0.53	0.02
Camden	19.40	291.22	37.59	6.35	6.81	11.00	0.12
Cape May	24.40	712.05	107.48	18.06	18.64	2.16	0.35
Cumberland	20.39	473.96	52.33	7.27	7.74	9.67	0.14
Essex	77.97	908.36	128.12	20.21	21.74	36.01	0.39
Gloucester	35.49	479.62	70.18	11.02	11.74	15.28	0.21
Hudson	189.88	4,110.99	596.74	97.77	101.68	46.28	1.88
Hunterdon	0	0	0	0	0	0	0
Mercer	0.05	1.72	0.27	0.04	0.04	0	0
Middlesex	21,68	410.71	56.31	9.57	10.09	9.78	0.18
Monmouth	57.22	1,286.97	184.38	27.90	29.12	15.53	0.54
Morris	0	0	0	0	0	0	0
Ocean	17.39	496.75	73.95	12.10	12.51	1.88	0.23
Passaic	0	0	0	0	0	0	0
Salem	12.74	293.96	32.54	4.39	4.69	6.41	0.08
Somerset	0	0	0	0	0	0	0
Sussex	0	0	0	0	0	0	0
Union	58.11	738.48	107.07	17.73	18.88	25.78	0.34
Warren	0	0	0	0	0	0	0
Total NJ	**552.48**	**10,681.20**	**1,516.73**	**244.65**	**256.32**	**182.24**	**4.71**

1.2.5 CMV Control Measure Emission Reductions

CMV control measure emission reductions were calculated by the difference between the 2023 projection year emissions without post 2017 controlspost 2017 controls (growth only scenario) and the 2023 projection year emissions with all controls applied (controlled scenario).

Emissions are only reduced for NOx emissions. These NOx reductions accrue from: existing tier 1 to 2 standards that took effect in 2004 and 2007 for category 1, 2 and 3 engines, the long term effects of the May 2008 Final Locomotive-Marine rule tier 3 and 4 standards for category 2 engines, the April 2010 rule on the new tier standards for new category 3 diesel engines, and the implementation of ECA as referenced above in Section 1.2.3.

Emissions increased for VOC and CO from CMV growth and also because the standards are not as stringent for VOC and CO as they are for NOx emissions.

Emission reductions are summarized below in Table 1.2.5 by county for NOx. Attachment 5 contains the detailed CMV emission benefits. This attachment is only available electronically.

Table 1.2.5:
2023 CMV Emission Reductions by NAA, County and Pollutant
Summer Work Weekday Tons Per Day (TPD)

County	NOx Tons per Day
NJ Portion of Northern NJ-NY-CT Nonattainment Area	
Bergen	0.016
Essex	0.248
Hudson	1.200
Hunterdon	0
Middlesex	0.129
Monmouth	0.256
Morris	0
Passaic	0
Somerset	0
Sussex	0
Union	0.207
Warren	0
Total NJ Portion of NAA	**2.055**
NJ Portion of Southern NJ-PA-DE-MD NAA	
Atlantic	0.150
Burlington	0.016
Camden	0.122
Cape May	0.309
Cumberland	0.199
Gloucester	0.203
Mercer	0.001
Ocean	0.215
Salem	0.123
Total NJ Portion of NAA	**0.761**
Total NJ	**2.817**

1.3 Aircraft

Aircraft emissions are associated with an aircraft's landing and takeoff (LTO) cycle. The cycle begins when the aircraft approaches the airport on its descent from cruising altitude, then lands and taxis to the gate, where it idles during passenger deplaning. The cycle continues as the aircraft idles during passenger boarding, taxis back onto the runway, takes off, and ascends (or climbs out) to cruising altitude. Therefore, the six specific operating modes are: Approach, Taxi/idle-in, Taxi/idle-out, Idling, Takeoff and Climb out.

The LTO cycle provides a basis for calculating aircraft emissions associated with airports. During each mode of operation, an aircraft engine operates at a specific power setting and fuel consumption rate for a given aircraft make and model. Emissions for one complete cycle are calculated by directly multiplying emission factors for each operating mode for each specific aircraft engine for the number of LTOs conducted for that engine at a specific airport. This is accomplished by LTO count inputs into a Federal Aviation Agency (FAA)'s Aviation Environmental Design tool (AEDT) for those airports that have submitted specific counts for each specific aircraft engine operation as discussed below in Section 1.3.1. Otherwise, a USEPA default emission factor is applied to those counts based on the six aircraft category operation types in addition to associated ground support equipment (GSE) and auxiliary power unit (APU) operations that service the aircraft as presented below including the associated SCC:

- Air carrier operations represent LTOs of commercial aircraft with seating capacity of more than 60 seats (SCC 22-75-020-000);
- Commuter/air taxi operations are one category. Commuter operations include LTOs by aircraft with 60 or fewer seats that transport regional passengers on scheduled commercial flights. Air taxi operations include LTOs by aircraft with 60 or fewer seats conducted on non-scheduled or for-hire flights (SCC 22-75-060-011 (Piston) or 012 (Turbine));
- General aviation represents all civil aviation LTOs not classified as commercial (SCC 22-75-050-011 (Piston) or 012 (Turbine));
- Military operations represent LTOs by military aircraft (SCC 22-75-001-000);
- Ground Support Equipment (GSE) typically includes aircraft refueling and baggage handling vehicles and equipment, aircraft towing vehicles, and passenger buses (SCC 22-65-008-005 (4-Stroke Gasoline), 22-67-008-005 (LPG), 22-68-008-005 (CNG), 22-70-008-005 (Diesel)); and
- Auxiliary power units (APUs) provide power to start the main engines and run the heating, cooling, and ventilation systems prior to starting the main engines. (SCC 22-75-070-000).

1.3.1 Aircraft Emissions Estimation Methodology

NJDEP 2017 Aircraft Emission inventory is based on 2017 aircraft emissions calculated by the USEPA as presented in the 2017 NEI. The annual 2017 NEI emissions were converted to summer day emissions by dividing by 365. As discussed in Section 1.3 above aircraft exhaust, GSE and APU emissions estimates are associated with aircrafts' LTO cycle. LTO data was obtained from the Federal Aviation Agency (FAA) databases by the USEPA consultant, Eastern Research Group (ERG). These databases include the 2017 T-100 dataset, which provides activity for large commercial aircraft and represents most emissions. To ensure completeness, the FAA's 2014 Terminal Area Forecast (TAF) data, 2014 Air Traffic Activity Data Systems

(ATADS) data, and 2014 Airport Master Record (form 5010) data are also used to capture the smaller general aviation (GA), air taxis (AT) and military operations.

The T-100 data is derived from commercial aviation operations, reported directly by the airlines, and specifically includes very detailed information about large commercial air carriers and air taxis. Because the T-100 aircraft data are provided for individual aircraft (specifying manufacturer and aircraft model), they can be matched to specific aircraft in the FAA's new Aviation Environmental Design Tool (AEDT) which is a SQL based software tool used to estimate emissions. Because of the details provided in T-100, it is also possible to identify which aircraft are typically used for air taxi services based on typical passenger capacity. All non-air taxi data in the T-100 data are assumed to be larger commercial aircraft.

The FAA's TAF and ATADS datasets do not provide operational data counts at the aircraft manufacturer and model level of detail that the T-100 data does; instead, operational counts are provided for general aircraft types (i.e., AC, AT, GA and MIL). ATADS includes actual operational data counts for AC, AT, GA and MIL aircraft at FAA controlled facilities, while TAF includes the ATADS data and modeled operations for other non-FAA control facilities. Note that the TAF and ATADS data are provided as operations (separate operation counts for each landing and takeoff leg), such that the TAF and ATADS operations need to be divided by two to get LTOs. A USEPA default emission factor is then applied to each of these category LTO counts based on established percentages of turbine, piston or jet engines.

The national AT and GA aircraft fleet includes both jet and propeller-driven aircraft, though these aircraft types also include smaller business jets and turboprops and helicopters equipped with piston or turboshaft engines. The piston-driven aircraft tend to have higher VOC emissions and lower NOx emissions than turbine-powered aircraft. Therefore, a different default emission factor is utilized based on the percentages of these aircrafts. They account for 72.1 % and 27.9 %, respectively, of all GA emissions. Propeller-driven aircraft and turbine-driven aircraft account for 21.8 % and 78.2 %, respectively, of all AT emissions.[5] Both Military and CA aircraft are assumed to be jet-powered.

The USEPA aircraft LTO data are compiled and provided for review and revision by state agencies in order to accurately estimate activity data for all aircraft types. NJDEP reviewed the USEPA LTO data and determined that it needed to include updated LTO for two military airport facilities which were McGuire Air Force Base (WRI) and Lakehurst Maxfield Station (NEL), formerly known as Naval Air Engineering Station Lakehurst (NEL) Naval Air Station. New Jersey submitted specific aircraft LTO data for these two facilities to USEPA based on a 2016 LTO count provided to us by the joint military command of these bases in January 2017. New Jersey assumed that these counts were representative of 2017 activity at these two facilities and so submitted them to the USEPA without any changes.

The emission factors used, as well as the complete methodology for estimating aircraft inventories from LTOs can be found in the USEPA 2017 NEI documentation: "2017Aircraft_main_19aug2019.pdf" and the LTO listing is available in the 2017 LTO for Agencies Form database, both provided on the USEPA Supplemental data FTP site.:.

1.3.2 Aircraft Emissions Growth Factors

Aircraft operations were projected from the inventory year 2017 to the projection year 2023 by applying activity growth using data on itinerant (ITN) operations at every airport in New Jersey

[5] USEPA, Calculating Piston-Engine Aircraft Activity for the Draft 2011 National Emissions Inventory. June 2012.

as reported in the Federal Aviation Administration's (FAA) Terminal Area Forecast (TAF) System for 1990-2045.[6] The ITN operations are defined as aircraft LTOs.

The data were aggregated and applied at the county level for the four operation types: commercial, general, air taxi and military. A growth factor was computed for each operation type by dividing projection year 2023 ITN by inventory year 2017 ITN. Inventory SCCs were assigned growth factors based on the operation type, as shown in Table 1.3.2 below.

Table 1.3.2: Crosswalk between SCC and FAA Operations Type

SCC	SCC Description	FAA Operation Type Used for Growth Factor
2265008005	Airport Ground Support Equipment, 4-Stroke Gas	Total Itinerant Operations
2267008005	Airport Ground Support Equipment, LPG	Total Itinerant Operations
2268008005	Airport Ground Support Equipment, CNG	Total Itinerant Operations
2270008005	Airport Ground Support Equipment, Diesel	Total Itinerant Operations
2275001000	Aircraft /Military Aircraft /Total	Itinerant Military Operations
2275020000	Aircraft /Commercial Aircraft /Total: All Types	Itinerant Air Commercial Operations
2275050011	Aircraft /General Aviation /Piston	Itinerant General Aviation Operations
2275050012	Aircraft /General Aviation /Turbine	Itinerant General Aviation Operations
2275060011	Aircraft /Air Taxi /Piston	Itinerant Air Taxi Operations
2275060012	Aircraft /Air Taxi /Turbine	Itinerant Air Taxi Operations
2275070000	Aircraft /Aircraft Auxiliary Power Units /Total	Total Itinerant Operations

The growth factors for each aircraft SCC type are included in Attachments 3A and B.

1.3.3 Aircraft Control Factors

The NO_x aircraft engine emissions standards adopted by USEPA in November 2005 were reviewed.[7] The standards are equivalent to the NO_x emission standards (adopted in 1999 for implementation beginning in 2004) of the United Nations International Civil Aviation Organization (ICAO). They bring the US aircraft standards into alignment with the international standards. The standards apply to new aircraft engines used on commercial aircraft including small regional jets, single-aisle, and twin-aisle aircraft, and 747s and larger aircraft. The standards also apply to general aviation and military aircraft, which sometimes use commercial engines. For example, small regional jet engines are used in executive general aviation aircraft, and larger commercial aircraft engines may be used in military transport aircraft.

Nearly all previously certified or in-production engine models currently meet or perform better than the standards USEPA adopted in the November 2005 rule. In addition, manufacturers have already been developing improved technology in response to the ICAO standards. According to USEPA's recent analysis for the proposed transport rule, this rule is expected to

[6] Federal Aviation Administration, Terminal Area Forecast 2009-2030 Database File
[7] U.S. Environmental Protection Agency. Control of Air Pollution from Aircraft and Aircraft Engines, Emission Standards and Test Procedures: Final Rule. November 17, 2005.

reduce NO_x emissions by approximately two percent in 2015 and three percent in 2020.[8] Because of the relatively small amount of NO_x reductions, our aircraft emission projections assume a control factor of one between 2017 and 2023.

1.3.4 Aircraft Emission Inventory

Tables 1.3.4.1, 2 and 3 summarizes the aircraft emissions by summer work weekday by county, and NAA for VOC, NO_x and CO for 2017 and 2023 and annual emissions by county for VOC, NOx, CO, PM_{10}, $PM_{2.5}$, SO_2 and NH_3. Attachments 3A and B contains the detailed aircraft emission inventories. These attachments are only available electronically.

Table 1.3.4.1:
2017 Aircraft Emission Inventory by Emission Inventory by NAA, County and Pollutant Summer Work Weekday Tons Per Day (TPD)

County	VOC Tons per Day	NOx Tons per Day	CO Tons per Day
NJ Portion of Northern NJ-NY-CT NAA			
Bergen	0.073	0.058	1.279
Essex	1.635	6.219	13.978
Hudson	0	0	0.008
Hunterdon	0.013	0.006	0.498
Middlesex	0.004	0.002	0.126
Monmouth	0.016	0.009	0.452
Morris	0.027	0.017	0.749
Passaic	0.004	0.002	0.149
Somerset	0.022	0.011	0.738
Sussex	0.012	0.005	0.437
Union	0.013	0.012	0.342
Warren	0.008	0.004	0.317
Total NJ Portion of NAA	**1.826**	**6.345**	**19.072**
NJ Portion of Southern NJ-PA-DE-MD NAA			
Atlantic	0.348	0.720	1.290
Burlington	0.830	1.676	2.729
Camden	0.002	0.001	0.050
Cape May	0.015	0.009	0.495
Cumberland	0.035	0.051	0.516
Gloucester	0.007	0.003	0.284
Mercer	0.055	0.100	0.849
Ocean	0.088	0.302	0.813
Salem	0.003	0.001	0.104
Total NJ Portion of NAA	**1.382**	**2.863**	**7.131**
Total NJ	**3.208**	**9.208**	**26.204**

Table 1.3.4.2:
2023 Aircraft Emission Inventory by Emission Inventory by NAA, County and Pollutant Summer Work Weekday Tons Per Day (TPD)

County			

[8] U.S. Environmental Protection Agency. Transport Rule Emission Inventories Notice of Data Availability (NODA). Docket ID No. USEPA-HQ-QAR-2009-0491. October 27, 2010.

	VOC Tons per Day	NOx Tons per Day	CO Tons per Day
NJ Portion of Northern NJ-NY-CT NAA			
Bergen	0.046	0.036	0.922
Essex	1.462	6.602	14.317
Hudson	0	0	0.006
Hunterdon	0.010	0.005	0.396
Middlesex	0.003	0.001	0.100
Monmouth	0.011	0.005	0.346
Morris	0.019	0.011	0.576
Passaic	0.003	0.001	0.118
Somerset	0.016	0.008	0.580
Sussex	0.009	0.004	0.348
Union	0.011	0.011	0.274
Warren	0.007	0.003	0.252
Total NJ Portion of NAA	**1.597**	**6.688**	**18.236**
NJ Portion of Southern NJ-PA-DE-MD NAA			
Atlantic	0.357	0.752	1.266
Burlington	0.815	1.785	2.754
Camden	0.001	0.001	0.040
Cape May	0.012	0.008	0.395
Cumberland	0.033	0.052	0.425
Gloucester	0.006	0.003	0.226
Mercer	0.049	0.104	0.713
Ocean	0.089	0.312	0.747
Salem	0.002	0.001	0.083
Total NJ Portion of NAA	**1.363**	**3.018**	**6.648**
Total NJ	**2.961**	**9.706**	**24.883**

Table 1.1.4.2:
2017 Annual Aircraft Emission Inventory Tons Per Year (TPY) by County and Pollutant

County	VOC	NOx	CO	$PM_{2.5}$	PM_{10}	SO_2	NH_3
Atlantic	130.17	274.37	462.11	17.38	18.27	27.82	NA
Bergen	16.80	13.10	336.48	10.86	12.57	2.33	NA
Burlington	297.38	651.69	1,005.11	13.34	14.60	49.73	NA
Camden	0.44	0.21	14.57	0.24	0.31	0.04	NA
Cape May	4.34	2.89	144.04	2.36	3.05	0.46	NA
Cumberland	12.06	19.04	154.95	3.25	3.93	1.97	NA
Essex	533.65	2,409.76	5,225.53	41.25	43.23	327.31	NA
Gloucester	2.16	0.99	82.42	1.32	1.72	0.20	NA
Hudson	0.11	0.05	2.31	0.05	0.05	0.01	NA
Hunterdon	3.80	1.74	144.60	2.32	3.02	0.35	NA
Mercer	17.95	37.98	260.31	4.50	5.52	4.76	NA
Middlesex	1.05	0.48	36.52	0.60	0.77	0.10	NA
Monmouth	3.94	1.97	126.14	2.82	3.45	0.40	NA
Morris	6.78	3.93	210.36	4.32	5.36	0.74	NA
Ocean	32.40	111.93	272.52	3.88	4.48	12.15	NA
Passaic	1.15	0.53	43.17	0.69	0.90	0.11	NA
Salem	0.77	0.35	30.31	0.48	0.63	0.07	NA
Somerset	5.97	2.82	211.61	3.82	4.85	0.57	NA
Sussex	3.39	1.55	127.05	2.04	2.65	0.31	NA
Union	3.99	4.08	100.15	1.74	2.21	0.51	NA
Warren	2.42	1.11	92.10	1.47	1.92	0.22	NA
Total NJ	1,080.73	3,542.56	9,082.38	118.75	133.48	430.17	NA

1.3.5 Aircraft Control Measure Emission Reductions

Aircraft emission reductions were zero because of the de minimis NO_x emission reductions expected from controls between 2017 and 2023 as explained above in Section 1.3.3.

1.4 Railroad Diesel Locomotives

The locomotive sector includes railroad locomotives powered by diesel-electric engines. A diesel-electric locomotive uses 2-stroke or 4-stroke diesel engines and an alternator or a generator to produce the electricity required to power its traction motors. The locomotive source category is further divided up into categories: Class I line-haul, Class II/III line-haul, Passenger, Commuter, and Yard. Following are descriptions of the various categories including the corresponding SCCs:

- Class I line-haul locomotives are operated by large freight railroad companies and are used to power freight train operations over long distances (SCC 22-85-002-006);
- Class II/III line-haul locomotives are operated by smaller freight railroad companies and are used to power freight train operations over long distances (SCC 22-85-002-007);
- Inter-city passenger train locomotives are operated primarily by Amtrak to provide inter-city passenger transport (SCC 22-85-002-008);
- Independent commuter rail systems operate locomotives provide passenger transport within a metropolitan area (SCC 22-85-002-009); and
- Yard/switch locomotives are used in freight yards to assemble and disassemble trains, for short hauls of trains that are made up of only a few cars (SCC 22-85-002-01).

All the above source sector categories are included in the nonpoint sector except the yard locomotives which are now included in the point sector. Previously, rail yard locomotive emissions were present in both the nonpoint and point sector inventories. Therefore, nonpoint source sector yard locomotives (SCC 22850020100) are not present in the 2017 NEI.

In general, New Jersey used the USEPA 2017 NEI emission inventory for its 2017 locomotives emissions inventories. The annual 2017 NEI emissions were converted to summer day emissions by dividing by 365.

1.4.1 Line-Haul Class I Locomotive Emission Calculation Methodology

USEPA's 2017 rail emissions were developed by LADCO (Lake Michigan Air Directors Consortium and the State of Illinois, with support from various other states in a collaborative team called Eastern Regional Technical Advisory Committee (ERTAC). ERTAC used confidential line-haul activity GIS data, in millions of gross ton (MGT) route miles per link, from the Federal Railroad Administration (FRA) for 2016.

In addition, the Association of American Railroads (AAR) provided national emission tier fleet mix information. This allowed ERTAC to calculate weighted emission factors (EFs) for each pollutant based on the percentage of the Class I line-haul locomotives in each USEPA tier level category (See Table 1.4.1.1 below). These two datasets, along with 2016 Class 1 line-haul fuel use data reported to the Surface Transportation Board (STB).(See Table 1.4.2 for fuel use statistics for Class I Railroads that operate in New Jersey), were used to create a link-level

Class I emissions inventory, based on a methodology recommended by Sierra Research[9,10]. This link-level inventory is nationwide in extent but can be aggregated at either the state or county level.

ERTAC calculated class I specific emission factors from USEPA annual default emission factors for locomotives based on operating patterns ("duty cycles") and the estimated nationwide fleet mixes for both switcher and line-haul locomotives[11]. However, tier level fleet mixes vary significantly between the Class I and Class II/III railroads. Class I railroad activity is highly regionalized in nature and is subject to variations in terrain across the country, which can have a significant impact on fuel efficiency and overall fuel consumption.

For the 2016 inventory, the AAR provided a national line-haul tier fleet mix profile representing the entire Class I locomotive fleet. A locomotive's tier level determines its emission rates based on the year when it was built and/or re-manufactured. The national fleet mix data for each tier level is shown Table 1.4.1.1 below.

Table 1.4.1.1: 2016 Line-haul Locomotive EFs by Tier, AAR Fleet Mix (grams/gal)[28]

Tier Level	AAR Fleet Mix Ratio	PM10	HC	NOx	CO
Uncontrolled per 1973	0.047494	6.656	9.984	270.40	26.624
Tier 0 (1973-2001)	0.188077	6.656	9.984	178.88	26.624
Tier 0+ (Tier 0 rebuilds)	0.141662	4.160	6.240	149.76	26.624
Tier 1 (2002-2004)	0.029376	6.656	9.776	139.36	26.624
Tier 1+ (Tier 1 rebuilds)	0.223147	4.160	6.032	139.36	26.624
Tier 2 (2005-2011)	0.124536	3.744	5.408	102.96	26.624
Tier 2+ (Tier 2 rebuilds)	0.093607	1.664	2.704	102.96	26.624
Tier 3 (2012-2014)	0.123113	1.644	2.704	102.96	26.624
Tier 4 (2015 and later)	0.028988	0.312	0.832	20.80	26.624
2016 Weighted EF's	1.000000	4.117	6.153	138.631	26.624

Weighted EFs per pollutant for each gallon of fuel used (grams/gal) were calculated for the US Class I locomotive fleet based on the percentage of line-haul locomotives certified at each regulated tier level from Table 1.4.1.1 above based on the following equation:

$EF_i = \sum (EF_{iT} * f_T)$

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[9] "Revised Inventory Guidance for Locomotive Emissions"; Report No. SR2004-06-01. Prepared for Southeastern States Air Resource Managers (SESARM) by Sierra Research Inc. June 2004.
[10] "Research Project: Development of Railroad Emission Inventory Methodologies"; Report No. SR2004-06-02. Prepared for Southeastern States Air Resource Manager (SESARM) by Sierra Research Inc. June 2004
[11] "USEPA Technical Highlights: Emission Factors for Locomotives", USEPA Office of Transportation and Air Quality, USEPA-420-F-09-025, April 2009.

Where:

EF_i = Weighted EF for pollutant i for Class I locomotive fleet (g/gal)
EF_{iT} = EF for pollutant i for Class I locomotive of Tier T (g/gal)
f_T = Percentage of the Class I locomotive fleet in Tier T expressed as a ratio

EFs for other pollutants are not tier level specific because these pollutants are not directly regulated by USEPA's locomotive emission standards. PM2.5 was assumed to be 97 % of PM10[28], the ratio of VOC to HC was assumed to be 1.053[28], and the emission factors used for SO_2 and NH_3 were 0.93888 g/gal[28] and 83.3 mg/gal[12]; respectively. The 2016 SO_2 emission factor is based on the nationwide adoption of 15 ppm diesel fuel by the rail industry.

These EFs were applied to the Railroad Fuel Consumption Index (RFCI) for each Class I railroad using the system-wide line-haul fuel consumption (FC) and gross ton-mile (GTM) data reported in their annual R-1 reports submitted to the Surface Transportation Board[13] (see equation below). These values represent the average number of GTM produced per gallon of diesel fuel burned by each Class I railroad for a given year. RFCI values vary between Class I railroads depending on factors such as average locomotive fuel efficiency, severity of grades, and differences in operational practices related to train speed, train tonnage, and train type mix (e.g., intermodal, unit, and manifest).

Adjusted RFCI values were used to allocate each Class I railroad's fuel use to links based on MGT route miles. Adjustments were made to account for discrepancies between the R-1 report GTM route miles totals and the GTM totals obtained from the FRA's GIS data layer for each Class I railroad. This change ensured that each Class I railroad's line-haul use total matched what was recorded in their R-1 reports, regardless of any problems with the FRA MGT data.

Adjusted RFCI values were calculated for each Class I railroad using the system-wide line-haul FC and GTM route miles data reported in their annual R-1 reports submitted to the STB as shown in the following equation:

$$RFCI_{RRA} = GTM_{RR\text{-}FRA}/FC_{RR}$$

Where:

$RFCI_{RRA}$ = Adjusted Railroad Fuel Consumption Index (gross ton-miles/gal) per Class I railroad.

$GTM_{RR\text{-}RA}$ = Gross Ton-Miles (GTM), annual system-wide gross ton-miles of freight transported per railroad. (FRA 2016 GIS network)

$FC_{RR\,=}$ Annual system-wide fuel consumption by line-haul and work trains per railroad (gal). (R-1 Report Schedule 750, Lines 1 and 6).

The Adjusted RFCI values calculated for Class I railroads operating in New Jersey are presented in the table 1.4.1.2 below:

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[12] "Estimating Ammonia Emissions from Anthropogenic Nonagricultural Sources", Draft Final Report. Prepared for USEPA/STAPPA-ALAPCO Emission Inventory Improvement Program by E.H. Pechan & Assoc. April 2004. Supported by personal communication (5/6/2010) with Craig Harvey, USEPA, OTAG, and Robert Wooten, NC DENR.
[13] STB R-1 reports.

<u>Table 1.4.1.2</u>: Class 1 Railroad R-1 Reported Locomotive Fuel Use Statistics for 2016

Class 1 Railroads	Line-Haul Fuel Use (gal/year)	Switcher Fuel Use (gal/year)	Rail Fuel Consumption Index (RFCI) (ton-miles/gal)	Adjusted RFCI (ton-miles/gal)
CSX Transportation	404,147,932	39,364,896	1,072.31	1,043.74
Norfolk Southern (NS)	437,110,632	28,595,955	919.90	905.51

The next step in the methodology to create a Class I link-level Class I emissions inventory from the application of the weighted EFs with apportioned MGT traffic density values between multiple railroads operating on the same link and the $RFCI_{RRA}$. This is presented in the equation below:

$$E_{IL} = \sum (MGT_L * 10^6/N) * I_L/RFCI_{RRA} * EF_{iRR}$$

E_{IL} = Emissions of pollutant i per link L (tons/year)

N = Number of Class I railroads operating on link L.

MGT_L = Millions of Gross Tons hauled per link per year from the FRA database (10^6 tons/yr)[9].

I_L = Link length from the FRA database (miles).

EFi_{RR} = Weighted Emission Factor for pollutant i per railroad RR (Equation 1; tons/gal).

$RFCI_{RRA}$ = Adjusted Railroad Fuel Consumption Index per railroad RR (Equation 2a; gross ton-miles/gal).

The final step is to aggregate emissions for inclusion into the 2017 NEI. The final link-level emissions for each pollutant were aggregated by state/county FIPS.

Regarding passenger locomotive emissions (AMTRAK), AMTRAK only used electric powered locomotives on the Northeast corridor line in New Jersey. These electric engines do not generate any emissions.

1.4.2 Class II/III Line Haul, Commuter and Yard Diesel Locomotives Emission Calculation Methodology

The ERTAC rail Class II/III inventory uses a comprehensive nationwide GIS database of locations where short line and regional railroads operate. It also provides a comprehensive spatial allocation of Class II/III locomotive emissions based on the nationwide Class II/III railroads and commuter railroads. The data sources, calculations, and assumptions used to develop the Class II/III inventory are described below.

The first step is the identification and correct placement of Class II/III railroad in a comprehensive electronic dataset. The FRA GIS data layer used for the Class I inventories also identifies links owned or operated by specific short line or regional railroads using reporting mark identification codes. The locations of these links along with related data including: reporting mark, railroad name, number of links, route miles owned or operated, and total route miles of links, were extracted by ERTAC. While the FRA GIS data layer contains confidential data for the Class I railroads, the spatial location of Class II and III links and related attribute data are public information. This data are available online as part of the Bureau of Transportation Statistics National Transportation Atlas database (NTAD)[14].

The next step is to calculate the EFs for the Class II/III railroads. Most of the locomotives in this sector served for decades in Class I fleets before being sold to the Class II/III railroads. As a result, a large portion of the Class II/III locomotive fleet consists of uncontrolled locomotives built before 1973. To better characterize this rail sector, ERTAC requested that the AAR, through its Railinc subsidiary, provide a national line-haul tier fleet mix profile for 2016. The national fleet mix data was then used to calculate weighted average in-use emission factors for the locomotives operated by the Class II/III and Commuter railroads as shown in Table 1.4.2.1 and those operated by the Yard railroads as shown in Table 1.4.2.2 below.

Table 1.4.2.1: 2016 Class II/III Line-haul and Commuter Locomotive EFs by Tier, AAR Fleet Mix (grams/gal)[28]

Tier Level	AAR Fleet Mix Ratio	PM_{10}	HC	NOx	CO
Uncontrolled pre 1973	0.484296	6.656	9.984	270.40	26.624
Tier 0 (1973-2001)	0.432286	6.656	9.984	178.88	26.624
Tier 0+ (Tier 0 rebuilds)	0.000000	4.160	6.240	149.76	26.624
Tier 1 (2002-2004)	0.002364	6.656	9.776	139.36	26.624
Tier 1+ (Tier 1 rebuilds)	0.000000	4.160	6.032	139.36	26.624
Tier 2 (2005-2011)	0.034786	3.744	5.408	102.96	26.624
Tier 2+ (Tier 2 rebuilds)	0.000000	1.664	2.704	102.96	26.624
Tier 3 (2012-2014)	0.039514	1.644	2.704	102.96	26.624
Tier 4 (2015 and later)	0.006754	0.312	0.832	20.80	26.624
2016 Weighted EF's	1.000000	6.314	9.475	216.401	26.624

Table 1.4.2.2: 2016 Yard Locomotive EFs by Tier, AAR Fleet Mix (grams/gal)[28]

Tier Level	AAR Fleet Mix Ratio	PM_{10}	HC	NOx	CO
Uncontrolled pre 1973	0.2601	6.656	9.984	264.48	27.816

[14] US DOT, Bureau of Transportation Statistics, National Transportation Atlas Database Available at: https://www.bts.gov/geospatial/national-transportation-atlas-database

Tier 0 (1973-2001)	0.2361	6.656	9.984	191.52	27.816
Tier 0+ (Tier 0 rebuilds)	0.2599	4.160	6.240	161.12	27.816
Tier 1 (2002-2004)	0.0000	6.656	9.776	150.48	27.816
Tier 1+ (Tier 1 rebuilds)	0.0476	4.160	6.032	150.48	27.816
Tier 2 (2005-2011)	0.0233	3.744	5.408	110.96	27.816
Tier 2+ (Tier 2 rebuilds)	0.0464	1.664	2.704	110.96	27.816
Tier 3 (2012-2014)	0.1018	1.644	2.704	68.4	27.816
Tier 4 (2015 and later)	0.0247	0.312	0.832	15.2	27.816
2016 Weighted EF's	0.9999	6.314	9.475	178.12	27.813

EFs for PM2.5, SO2, NH3, VOC, and GHGs were calculated in the same manner as those used for Class I line-haul inventory described above.

New Jersey developed fuel usage data for all its Class II/III, Commuter and Yard railroads. New Jersey received updated fuel use data from Conrail Consolidated Railroad (CCR) for its Class II/III short line and yard operations in New Jersey for 2017. We received similar information from NJTRANSIT commuter railroad operations conducted in 2007. Additionally, New Jersey conducted a survey of all other Non-CCR short line operations from 2007 until 2017. New Jersey assumed that the fuel use provided for any of these years for any of these short line and commuter railroads would be the same as for 2017 because their current operations are usually consistent with prior operations.

Mark Janssen of LADCO submitted a spreadsheet with default fuel use data with a column for states to include their own surveyed fuel use for each Class II/III short line and Commuter railroad linkage. New Jersey made their submission for their Class II/III and Commuter (NJTRANSIT) railroads on September 5, 2018.

Mark Janssen of LADCO submitted a spreadsheet with default fuel use data with a column for states to include their own surveyed fuel use for each yard locomotive at a specific longitude and latitude. New Jersey made their submission on November 26, 2018 and this was finalized by LADCO on November 28, 2018. New Jersey did not include any yard operations from line haul Class I CSX railroad because this railroad already provided this information to LADCO.

Regarding passenger locomotive emissions (AMTRAK), AMTRAK only used electric powered locomotives on the Northeast corridor line in New Jersey. These electric engines do not generate any emissions.

These fuel use estimates by railroad were then multiplied by the pollutant emission factors. These railroad/county-specific emissions data were then aggregated to produce county level emissions.

1.4.3 Railroad Diesel Locomotive Growth Factors

Future year national fuel use values for 2020, 2023 and 2028 were based on the Energy Information Administration's 2018 Annual Energy Outlook (AEO) freight rail energy use growth rate projections for 2016 thru 2028 (see Table 1.4.3,1). A correction factor was added to adjust the AEO projected fuel use for 2017 to match the actual 2017 R-1 national fuel use data. The additive effect of this correction factor was carried forward for each subsequent year from 2018 thru 2028. The modified AEO growth rates were used to calculate future year Class I national line-haul fuel use totals for the projection years 2020, 2023 and 2028. The future year national fuel use values ranged between 3.2 and 3.4 billion gallons, which matched up well with the long-term line-haul fuel use trend between 2005 and 2018.

<u>Table 1.4.3.1</u>: ERTAC Class I Line-Haul National Fuel Use Projections 2016-2028, based on 2018 AEO Data

YEAR	AEO FREIGHT FACTOR	FACTOR ERTAC	CORRECTED AEO FUEL	RAW AEO FUEL
2016	1.0000	1.0000	3,203,595,133	3,203,595,133
2017	1.0212	1.0346	3,314,384,605	3,271,393,249
2018	1.0177	1.0311	3,303,251,591	3,260,224,235
2019	1.0092	1.0226	3,275,939,538	3,232,948,182
2020	1.0128	1.0262	3,287,479,935	3,244,488,580
2023	0.9969	1.0103	3,236,531,624	3,193,540,268
2028	1.0356	1.0490	3,360,491,175	3,317,499,820

ERTAC used the 2018 AEO fuel use national projections to calculate Adjusted RFCI values for each Class I railroad for 2020, 2023, and 2028 (see Table 1.4.3.2). New Jersey used the ratio of the 2023 national projected fuel use of the only line-haul railroads that operate in New Jersey, CSXT and NS, divided by the 2016 fuel use that was first adjusted to the base year 2017. This determined a growth only factor of 0.9765 to be applied to the NJDEP Class I 2017 base year inventory to grow without control to the projection year 2023. The AEO national fuel use is applicable to growth only because it does not consider control.

<u>Table 1.4.3.2</u>: ERTAC Projected National Fuel Use Data by Class I Railroad for 2020, 2023 and 2028

Rail	2016 Fuel Use	2016 Adj-RFCI	2020 Fuel Adj	2020 Adj-RFCI	2023 Fuel Adj	2023 Adj-RFCI	2028 Fuel Adj	2028 Adj-RFCI
CSX	404,147,932	1,081.5	414,730,377	1,017.1	408,303,018	1,033.1	423,941,073	995.0
NS	437,110,632	994.5	448,556,192	882.4	441,604,611	896.3	458,518,121	863.2

New Jersey applied this growth only factor to both yard and Class II/III railroads because these railroads activity depends on class line-haul I activity. For commuter rail a growth factor of 1.0753 was applied. This was based on AEO fuel use projections for commuter railroads from 2016 (adjusted to 2017) to the projection year 2023.

1.4.4 Railroad Diesel Locomotive Control Factors

ERTAC has collected historical line-haul fleet mix data for the Class I railroads via the AAR for 2007, 2014, 2016, and 2017. Comparison of the actual NOx, PM10, and hydrocarbon emission factors developed by ERTAC for 2007, 2014, 2016, and 2017 with USEPA Office of Transportation and Air Quality (OTAQ) EF projections[26] shows that OTAQ's 2009 fleet turnover forecast is more aggressive (See Tables 5, 6 and 7 in Attachment 4B). To correct for this, the workgroup used the historical data provided by the AAR to ERTAC to develop its own future year emission factor projections using Excel's trendline function. All trendlines generated from the AAR data have R2 values greater than 0.99. The workgroup's future year projections better represent what is known about current and near-future industry trends – namely, reduced purchases of new Tier 4 locomotives and large rebuilding programs for 1990's-era locomotives.

New Jersey used the ratio of above referenced ERTAC line-haul Class I EFs for 2023 divided by their line-haul Class II EFs for 2017 to establish a growth with control factor to project all railroad emissions from 2017 to the projection year 2023. These control factors are applied directly to uncontrolled emissions. New Jersey assumed that this factor applied to all railroad categories because it was assumed that the reduced purchases of higher tier level locomotives in Class I railroads would also apply to Class II/III, yard and commuter railroad. These control factors are presented below in Table 1.4.4.

Table 1.4.4: Locomotive Control Factors from 2017 to 2023 from ERTAC

Category	VOC	NOx	PM10 & PM2.5
All Locomotives	0.7863	0.8409	0.7860

The projected fuel use data from Table 1.4.3 was combined with ERTAC's EF estimates from Table 1.4.4 to create future year link-level emission inventories based on the MGT traffic density values contained in the FRA's 2016 shapefile. The link-level data created for 2017, 2020, 2023 and 2028 was aggregated to create state/county emissions estimates. The state/county-level data was provided to USEPA in FF10 format to be loaded into the 2016v1 emissions platform and the 2017 NEI.

1.4.5 Railroad Diesel Locomotives Control Measures

USEPA specific year diesel locomotive emission factors referenced in Section 1.4.4 above decreased from 2017 to the projection year 2023 because of the following :

1. The impact of existing regulations for Tier 0, 1, and 2 locomotive engines that took effect in 2008,

2. The 2004 Clean Air Nonroad Diesel Rule that decreased allowable levels of sulfur in locomotives fuel beginning in 2007,

3. Fleet turnover.

4. Reductions from USEPA's 2008 Final Locomotive-Marine rule for Tier 3 and 4 engines. This rule lowered diesel sulfur content and tightened emission standards for existing and new locomotives.
5. Voluntary retrofits under the National Clean Diesel Campaign are not included in these projections.

1.4.6 Railroad Diesel Locomotive Emission Inventory

Tables 1.4.6.1 and 2 summarize the railroad emissions for a summer work weekday by county, and NAA for VOC, NO_x and CO for 2017 and 2023, and annual emissions by county for VOC, NOx, CO, PM_{10}, $PM_{2.5}$, SO_2 and NH_3 for 2017. Attachments 4A and B contain the detailed railroad source emission inventories. These attachments are only available electronically.

Table 1.4.6.1:
2017 Railroad Diesel Locomotive Emission Inventory for by County and Pollutant
New Jersey Portion of Northern NJ-NY-CT Nonattainment Area

County	VOC Tons per Day	NO_x Tons per Day	CO Tons per Day
NJ Portion of Northern NJ-NY-CT NAA			
Bergen	0.140	3.006	0.403
Essex	0.072	1.304	0.193
Hudson	0.096	1.899	0.275
Hunterdon	0.045	0.964	0.145
Middlesex	0.060	1.233	0.180
Monmouth	0.072	1.562	0.194
Morris	0.040	0.869	0.108
Passaic	0.040	0.856	0.106
Somerset	0.055	1.132	0.172
Sussex	0.003	0.071	0.009
Union	0.075	1.528	0.217
Warren	0.007	0.153	0.027
Total NJ Portion of NAA	**0.707**	**14.577**	**2.028**
NJ Portion of Southern NJ-PA-DE-MD NAA			
Atlantic	0.017	0.364	0.045
Burlington	0.002	0.039	0.005
Camden	0.033	0.622	0.084
Cape May	0	0.010	0.001
Cumberland	0.007	0.143	0.018
Gloucester	0.009	0.194	0.026
Mercer	0.014	0.309	0.049
Ocean	0.003	0.064	0.008
Salem	0.005	0.118	0.015
Total NJ Portion of NAA	**0.091**	**1.862**	**0.253**
Total NJ	**0.798**	**16.439**	**2.281**

Table 1.4.6.2:
2023 Railroad Diesel Locomotive Emission Inventory by County and Pollutant
New Jersey Portion of Northern NJ-NY-CT Nonattainment Area

County	VOC Tons per Day	NO_x Tons per Day	CO Tons per Day
NJ Portion of Northern NJ-NY-CT NAA			

Bergen	0.117	2.677	0.424
Essex	0.057	1.111	0.194
Hudson	0.078	1.645	0.281
Hunterdon	0.036	0.843	0.149
Middlesex	0.049	1.063	0.183
Monmouth	0.061	1.411	0.208
Morris	0.034	0.782	0.116
Passaic	0.033	0.771	0.114
Somerset	0.044	0.981	0.175
Sussex	0.003	0.059	0.009
Union	0.061	1.333	0.223
Warren	0.006	0.129	0.027
Total NJ Portion of NAA	**0.579**	**12.805**	**2.104**
NJ Portion of Southern NJ-PA-DE-MD NAA			
Atlantic	0.014	0.328	0.049
Burlington	0.002	0.032	0.005
Camden	0.026	0.539	0.087
Cape May	0	0.008	0.001
Cumberland	0.005	0.117	0.018
Gloucester	0.007	0.159	0.025
Mercer	0.012	0.267	0.050
Ocean	0.003	0.058	0.009
Salem	0.004	0.097	0.014
Total NJ Portion of NAA	**0.073**	**1.605**	**0.258**
Total NJ	**0.652**	**14.410**	**2.362**

Table 1.4.6.3
2017 Annual Railroad Diesel Locomotive Emission Inventory
Tons Per Year (TPY) by County and Pollutant

County	VOC	NOx	CO	$PM_{2.5}$	PM_{10}	SO_2	NH_3
Atlantic	6.18	132.89	16.59	3.77	3.89	0.06	0.05
Bergen	51.16	1097.17	147.01	31.08	32.04	0.52	0.46
Burlington	0.74	14.28	1.99	1.39	0.41	0.01	0.01
Camden	11.9	226.91	30.79	6.23	6.42	0.11	0.09
Cape May	0.17	3.73	0.48	0.11	0.11	0.0	0
Cumberland	2.53	52.01	6.73	1.46	1.50	0.02	0.02
Essex	26.44	475.98	70.42	12.83	13.23	0.24	0.22
Gloucester	3.40	70.64	9.40	1.99	2.05	0.03	0.03
Hudson	35.19	693.29	100.36	19.20	19.79	0.35	0.31
Hunterdon	16.26	351.97	52.99	9.99	10.30	0.19	0.17
Mercer	5.21	112.76	17.93	3.20	3.30	0.06	0.06
Middlesex	22.04	449.91	65.62	12.59	12.98	0.23	0.20
Monmouth	26.38	570.21	70.79	16.19	16.69	0.25	0.22
Morris	14.76	317.06	39.50	8.99	9.26	0.14	0.12
Ocean	1.08	23.36	2.90	0.66	0.68	0.01	0.01
Passaic	14.46	312.58	38.79	8.87	9.15	0.14	0.12
Salem	1.99	43.03	5.38	1.22	1.26	0.02	0.02
Somerset	20.02	413.01	62.70	11.58	11.94	0.22	0.20
Sussex	1.2	26.04	3.23	0.74	0. 76	0.01	0.01
Union	27.46	557.81	79.19	15.58	16.06	0.28	0.25
Warren	2.57	55.70	9.79	1.58	1.63	0.03	0.03
Total NJ	**291.15**	**6000.34**	**832.60**	**168.26**	**173.46**	**2.92**	**2.59**

1.4.7 Railroad Diesel Locomotives Control Measure Emission Reductions

Railroad diesel locomotive control measure emission reductions were calculated by the difference between the 2023 projection year emissions without post 2017 controls applied (growth only scenario) and the 2023 projection year emissions with all controls applied (controlled scenario). Multiplication of the 2017 locomotive emissions referenced above in

Table 1.4.6.1 with specific locomotive growth only factors referenced above in Section 1.4.3.2 for all line-haul and commuter rail determined the 2023 growth only scenario

Emission reductions accrue from existing Tier 0 to 2 engine standards that took effect in 2008 and the long-term effects of the May 2008 Final Locomotive-Marine rule for Tier 3 and 4 engines. Emission benefits are summarized below in Table 1.4.7 for summer work week day by county for VOC and NO_x.

Attachment 5 contains the detailed railroad emission benefits. This attachment is only available electronically.

Table 1.4.7:
2023 Railroad Diesel Locomotive Emission Reductions by County and Pollutant
New Jersey Portion of Northern NJ-NY-CT NAA

County	VOC Tons per Day	NO_x Tons per Day
NJ Portion of Northern NJ-NY-CT NAA		
Bergen	0.032	0.506
Essex	0.016	0.210
Hudson	0.021	0.311
Hunterdon	0.010	0.159
Middlesex	0.013	0.201
Monmouth	0.017	0.267
Morris	0.009	0.148
Passaic	0.009	0.146
Somerset	0.012	0.186
Sussex	0.001	0.011
Union	0.017	0.252
Warren	0.002	0.024
Total NJ Portion of NAA	**0.157**	**2.423**
NJ Portion of Southern NJ-PA-DE-MD NAA		
Atlantic	0.004	0.062
Burlington	0	0.006
Camden	0.007	0.102
Cape May	0	0.002
Cumberland	0.001	0.022
Gloucester	0.002	0.030
Mercer	0.003	0.051
Ocean	0.001	0.011
Salem	0.001	0.018
Total NJ Portion of NAA	**0.020**	**0.304**
Total NJ	**0.177**	**2.726**

1.5.1 Total Nonroad Emission Inventory

Table 1.5.1.1, 2 and 3 summarizes the total actual 2017 and the projection 2023 Non-road Sources (NONROAD model equipment, CMV, Aircraft and Locomotive) emissions by summer work weekday by county, and NAA for VOC, NO_x and CO; and annual by county for VOC, NOx, CO, PM_{10}, $PM_{2.5}$, SO_2 and NH_3 for 2017. Attachment 5 contains the detailed nonroad source emission inventories. This attachment is only available electronically.

Table 1.5.1.1:
Total 2017 Non-road Sources Emission Inventory by County and Pollutant
New Jersey Portion of Northern NJ-NY-CT Nonattainment Area

County	VOC Tons per Day	NO_x Tons per Day	CO Tons per Day
NJ Portion of NJ-NY-CT NAA			
Bergen	7.367	10.034	144.131
Essex	4.773	13.987	69.219
Hudson	2.711	16.996	34.214
Hunterdon	1.766	2.662	28.629
Middlesex	5.443	8.921	100.997
Monmouth	5.551	10.552	88.970
Morris	5.004	4.884	90.270
Passaic	2.629	3.488	45.059
Somerset	3.771	4.181	71.114
Sussex	1.474	1.375	18.741
Union	3.301	6.255	60.009
Warren	0.944	0.914	12.797
Total NJ Portion of NAA	**44.735**	**84.250**	**764.1510**
NJ Portion of Southern NJ-PA-DE-MD NAA			
Atlantic	3.759	4.570	34.348
Burlington	4.181	5.171	57.656
Camden	2.572	3.883	44.334
Cape May	3.861	4.293	29.305
Cumberland	1.419	2.876	14.337
Gloucester	2.457	3.483	38.390
Mercer	2.614	4.013	45.405
Ocean	6.863	6.396	62.738
Salem	0.794	1.503	7.849
Total NJ Portion of NAA	**28.519**	**36.187**	**334.361**
Total NJ	**73.254**	**120.437**	**1,098.513**

Table 1.5.1.2:
Total 2023 Non-road Sources Emission Inventory by County and Pollutant
New Jersey Portion of Northern NJ-NY-CT Nonattainment Area

County	**VOC Tons per Day**	**NO_x Tons per Day**	**CO Tons per Day**
NJ Portion of NJ-NY-CT NAA			
Bergen	6.996	8.005	146.382
Essex	4.464	13.470	70.442
Hudson	2.407	15.575	34.945
Hunterdon	1.585	2.046	28.556
Middlesex	5.118	6.970	102.145
Monmouth	4.963	9.081	89.197
Morris	4.652	3.803	90.999
Passaic	2.336	2.731	45.449
Somerset	3.640	3.244	71.631
Sussex	1.302	0.985	18.751
Union	3.199	5.649	60.820
Warren	0.796	0.679	12.615
Total NJ Portion of NAA	**41.457**	**72.238**	**771.931**
NJ Portion of Southern NJ-PA-DE-MD NAA			
Atlantic	2.815	3.783	33.421
Burlington	3.889	4.356	57.903
Camden	2.375	3.245	44.834
Cape May	3.683	4.084	33.647
Cumberland	1.021	2.759	13.591
Gloucester	2.237	3.131	38.540
Mercer	2.431	2.875	45.469
Ocean	4.734	5.116	60.411
Salem	0.595	1.503	7.609
Total NJ Portion of NAA	**23.779**	**30.852**	**335.424**
Total NJ	**65.236**	**103.091**	**1,107.355**

Table 1.5.1.3
2017 Annual Non-road Sources Emission Inventory
Tons Per Year (TPY) by County and Pollutant

County	VOC	NOx	CO	$PM_{2.5}$	PM_{10}	SO_2	NH_3
Atlantic	1,142.33	1,486.20	9,487.16	97.57	102.77	29.43	1.87
Bergen	2,189.65	3,157.93	38,104.48	264.70	280.68	9.10	5.14
Burlington	1,294.96	1,601.84	15,291.54	116.32	123.62	47.76	2.20
Camden	771.22	1,226.76	11,884.00	87.69	92.62	12.62	1.89
Cape May	1,158.70	1,437.37	8,552.48	81.11	86.07	4.03	1.86
Cumberland	434.99	962.22	4,190.52	42.50	45.35	12.39	0.95
Essex	1,562.99	4,803.30	20,462.90	182.86	192.86	332.53	3.17
Gloucester	724.36	1,098.40	9,740.82	78.89	84.02	16.73	1.56
Hudson	879.26	5,903.73	10,285.23	208.81	217.43	48.22	4.54
Hunterdon	510.07	807.68	7,106.45	65.97	70.25	1.49	1.23
Mercer	755.60	1,136.85	11,531.25	111.02	117.78	6.12	2.31
Middlesex	1,591.17	2,708.96	26,113.38	215.03	226.55	13.59	4.60
Monmouth	1,647.03	3,405.49	23,147.57	209.27	220.99	19.37	4.33
Morris	1,449.26	1,454.25	22,869.12	151.74	161.74	3.97	2.90
Ocean	2,158.48	2,050.54	18,221.36	139.66	147.90	16.32	3.32
Passaic	788.77	1,081.07	12,156.40	87.10	91.90	1.85	1.87
Salem	245.12	497.17	2,223.05	20.90	22.23	6.82	0.42
Somerset	2,096.01	2,073.37	34,260.42	234.54	249.86	4.90	4.41
Sussex	461.09	393.14	5,146.66	40.85	43.73	1.08	0.85
Union	983.49	2,079.87	15,648.25	124.28	131.77	28.46	2.45
Warren	303.34	273.49	3,539.90	26.72	28.67	0.76	0.52
Total NJ	**23,147.90**	**39,639.64**	**309,962.96**	**2,587.52**	**2,738.82**	**617.55**	**52.40**

1.5.2 Total Nonroad Sources Emission Inventory Benefits

Table 1.5.2 summarizes NONROAD model equipment, CMV, Aircraft and Locomotive emissions sources benefits accrued in the projection year 2023 emission inventory for summer work weekday by county for VOC and NO_x. Attachment 5 contains the detailed nonroad source emission benefits inventory. This attachment is only available electronically.

Table 1.5.2:
Total 2023 Nonroad Sources Emission Reductions by County and Pollutant
New Jersey Portion of Northern NJ-NY-CT Nonattainment Area

County	VOC Tons per Day	NO_x Tons per Day
NJ Portion of NJ-NY-CT NAA		
Bergen	0.353	2.200
Essex	0.197	1.565
Hudson	0.387	2.691
Hunterdon	0.180	0.653
Middlesex	0.338	2.177
Monmouth	0.617	2.070
Morris	0.348	1.137
Passaic	0.295	0.818
Somerset	0.127	0.969
Sussex	0.169	0.387
Union	0.144	1.095
Warren	0.147	0.235
Total NJ Portion of NAA	**3.302**	**15.996**
NJ Portion of Southern NJ-PA-DE-MD NAA		
Atlantic	0.955	0.898
Burlington	0.278	0.940
Camden	0.212	0.854
Cape May	0.180	0.323
Cumberland	0.410	0.430
Gloucester	0.243	0.629
Mercer	0.178	1.151
Ocean	2.134	1.394
Salem	0.208	0.199
Total NJ Portion of NAA	**4.798**	**6.819**
Total NJ	**8.100**	**22.815**