

**NJDEP Bureau of Air Permits  
Nonroad Diesel Engine Cancer Risk Screening July 2, 2015**

This document describes the basis for the development of the risk screening worksheet for nonroad diesel engines. The purpose of the risk screening worksheet is to provide a tool for quick estimation of a diesel engine’s cancer risk impact on and outside the facility boundary. It divides diesel engines into two categories: engines rated at less than or equal to 600 hp, and engines over 600 hp. It involves two steps and the use of two tables. For engines up to 600 hp, use Table 1 and Table 3. For engines over 600 hp, use Table 2 and Table 4.

**Step 1. Determine Annual Potential DPM Emission Rate**

Table 1 (for engines up to 600 hp) and Table 2 (for engines over 600 hp) are used to calculate each engine’s Diesel Particulate Matter (DPM) annual potential to emit. Based on the engine power, Tier, DPM emission factor (from Table 1 or Table 2), and the maximum projected annual operating hour, the following equation is used to calculate its potential to emit:

$$\text{PTE (lbs/yr)} = \text{DPM Emission Factor (g/bhp-hr)} \times \text{Engine Power (bhp)} \\ \times \text{Operating Hour (hr/yr)} \div 454 \text{ (g/lb)}$$

**Table 1. Nonroad Diesel Engine Particulate Emissions Calculation  
(For Engines Rated at 600 HP or Less)**

Range of Engine Power	Tier	Year that Engine was Manufactured	DPM Emission Factor (g/bhp-hr)	Engine Power (bhp)	Annual Operating Hour (hrs/yr)	Annual DPM Emission	
						(lbs/yr)	(ton/yr)
50 ≤ hp < 100	Tier 1	1998-2003	1	A*	B*	C*	D*
	Tier 2	2004-2007	0.3	A*	B*	C*	D*
	Tier 3	After 2008	0.3	A*	B*	C*	D*
100 ≤ hp < 175	Tier 1	1997-2002	1	A*	B*	C*	D*
	Tier 2	2003-2006	0.22	A*	B*	C*	D*
	Tier 3	After 2007	0.22	A*	B*	C*	D*
175 ≤ hp < 300	Tier 1	1996-2002	0.4	A*	B*	C*	D*
	Tier 2	2003-2005	0.15	A*	B*	C*	D*
	Tier 3	After 2006	0.15	A*	B*	C*	D*
300 ≤ hp < 600	Tier 1	1996-2000	0.4	A*	B*	C*	D*
	Tier 2	2001-2005	0.15	A*	B*	C*	D*
	Tier 3	After 2006	0.15	A*	B*	C*	D*

- A\* : Enter engine power in bhp
- B\* : Enter engine maximum potential annual operating hours
- C\* : Table entries are used to calculate engine annual DPM emissions in lbs/yr as follows: DPM Emission Factor x Column A x Column B ÷ 454 (g/lb)

D\* : Table entries are used to calculate engine annual DPM emission in ton/yr as follows: Column C ÷ 2000 (lb/ton)

**Table 2. Nonroad Diesel Engine Particulate Emissions Calculation  
(For Engines Rated Larger than 600 HP)**

Type of Engine Power	Tier	Year that Engine was Manufactured	DPM Emission Factor (g/bhp-hr)	Engine Power (bhp)	Annual Operating Hour (hrs/yr)	Annual DPM Emission	
						(lbs/yr)	(ton/yr)
600 ≤ hp < 750	Tier 1	1996-2001	0.4	A*	B*	C*	D*
	Tier 2	2002-2005	0.15	A*	B*	C*	D*
	Tier 3	After 2006	0.15	A*	B*	C*	D*
750 ≤ hp	Tier 1	2000-2005	0.4	A*	B*	C*	D*
	Tier 2	After 2006	0.15	A*	B*	C*	D*

A\* : Engine power in bhp

B\* : Engine maximum potential annual operating hours

C\* : Table entries are used to calculate engine annual DPM emissions in lbs/yr as follows: DPM Emission Factor x Column A x Column B ÷ 454 (g/lb)

D\* : Table entries are used to calculate engine annual DPM emission in ton/yr as follows: Column C ÷ 2000 (lb/ton)

**Step 2. Assess Cancer Risk Impact**

Table 3 and Table 4 list the calculated DPM incremental cancer risks at different distances from property line and emission rates. Based on the DPM emission rate calculated in Step 1, the effective stack height, and distance from the stack to property line, the magnitude of the engine’s cancer impact can be estimated.

For engines rated at 600 hp or less, a stack height of 15 feet and a plume rise of 25 ft are used. The Effective Stack Height used in the risk assessment and the creation of Table 3 is therefore 40 ft.

For engines rated over 600 hp, a stack height of 25 feet and a plume rise of 50 ft are used. The Effective Stack Height used in the risk assessment and the creation of Table 4 is therefore 75 ft.

**NOTE:**

1. When the cancer risk level is determined, Annual DPM emissions, in pounds per year is rounded up, and Distance to the Property, in feet, is rounded down to the nearest value in Table 3, “DPM Incremental Cancer Risk at Different Emission Rates and Distances (For Engines Rated at 600 HP or Less)” or Table 4 “DPM Incremental Cancer Risk at Different Emission Rates and Distances (For

Engines Rated over 600 HP),” as applicable. For example, an engine with an annual DPM of 210 lb/yr will be evaluated at 250 lb/yr. Similarly, an engine located at a distance of 165 feet to the property line will be evaluated at 150 feet.

2. Color key for Tables 3 and 4:
  - A. **Green** (risk of less than or equal to 1 in a million) should be approvable. This risk level is generally acceptable as long as there are no unique circumstances, such as an engine being located very close to a sensitive receptor, such as a day care center and the less costly risk minimization options (see Number 3 below), such as the use of ultra-low sulfur diesel, are adopted.
  - B. **Yellow** (risk of greater than 1 in a million and less than 10 in a million) risk should be approvable if the best Air Pollution Control technology is employed (see Item 3 below).
  - C. **Orange** (risk of greater than 10 in a million and less than 100 in a million) a refined air quality modeling analysis must be conducted.
  - D. **Red** (risk of 100 in a million or greater)
3. Risk minimization must be considered for incremental cancer risks over ten in a million. Risk minimization options include: 1) use of ultra-low sulfur fuel (less than 15 ppmw); 2) relocation of engine away from property line or off-site receptors; 3) installation of a diesel particulate filter; and 4) reduction in annual operating hours.

**Table 3. DPM Incremental Cancer Risk at Different Emission Rates and Distances  
(For Engines Rated at 600 HP or Less) -\***  
**(Stack Discharge must be at least 15 feet above the ground and have a vertical discharge direction)**

Distance (ft)	DPM Emission Rate (lbs/yr)														
	1	5	10	50	100	150	200	250	300	350	400	450	500	1000	5000
<50	1.2E-6	5.8E-6	1.2E-5	5.8E-5	1.2E-4	1.7E-4	2.3E-4	2.9E-4	3.5E-4	4.0E-4	4.6E-4	5.2E-4	5.8E-4	1.2E-3	5.8E-3
100	3.4E-7	1.7E-6	3.4E-6	1.7E-5	3.4E-5	5.1E-5	6.8E-5	8.6E-5	1.0E-4	1.2E-4	1.4E-4	1.5E-4	1.7E-4	3.4E-4	1.7E-3
150	2.6E-7	1.3E-6	2.6E-6	1.3E-5	2.6E-5	3.9E-5	5.2E-5	6.5E-5	7.7E-5	9.0E-5	1.0E-4	1.2E-4	1.3E-4	2.6E-4	1.3E-3
200	2.2E-7	1.1E-6	2.2E-6	1.1E-5	2.2E-5	3.3E-5	4.4E-5	5.6E-5	6.7E-5	7.8E-5	8.9E-5	1.0E-4	1.1E-4	2.2E-4	1.1E-3
250	1.9E-7	9.7E-7	1.9E-6	9.7E-6	1.9E-5	2.9E-5	3.9E-5	4.8E-5	5.8E-5	6.8E-5	7.7E-5	8.7E-5	9.7E-5	1.9E-4	9.7E-4
300	1.7E-7	8.3E-7	1.7E-6	8.3E-6	1.7E-5	2.5E-5	3.3E-5	4.1E-5	5.0E-5	5.8E-5	6.6E-5	7.4E-5	8.3E-5	1.7E-4	8.3E-4
350	1.4E-7	7.1E-7	1.4E-6	7.1E-6	1.4E-5	2.1E-5	2.9E-5	3.6E-5	4.3E-5	5.0E-5	5.7E-5	6.4E-5	7.1E-5	1.4E-4	7.1E-4
400	1.2E-7	6.0E-7	1.2E-6	6.0E-6	1.2E-5	1.8E-5	2.4E-5	3.0E-5	3.6E-5	4.2E-5	4.8E-5	5.4E-5	6.0E-5	1.2E-4	6.0E-4
450	1.1E-7	5.3E-7	1.1E-6	5.3E-6	1.1E-5	1.6E-5	2.1E-5	2.6E-5	3.2E-5	3.7E-5	4.2E-5	4.8E-5	5.3E-5	1.1E-4	5.3E-4
500	9.2E-8	4.6E-7	9.2E-7	4.6E-6	9.2E-6	1.4E-5	1.8E-5	2.3E-5	2.7E-5	3.2E-5	3.7E-5	4.1E-5	4.6E-5	9.2E-5	4.6E-4
550	8.3E-8	4.2E-7	8.3E-7	4.2E-6	8.3E-6	1.2E-5	1.7E-5	2.1E-5	2.5E-5	2.9E-5	3.3E-5	3.7E-5	4.2E-5	8.3E-5	4.2E-4
600	7.5E-8	3.7E-7	7.5E-7	3.7E-6	7.5E-6	1.1E-5	1.5E-5	1.9E-5	2.2E-5	2.6E-5	3.0E-5	3.4E-5	3.7E-5	7.5E-5	3.7E-4
650	6.6E-8	3.3E-7	6.6E-7	3.3E-6	6.6E-6	9.9E-6	1.3E-5	1.7E-5	2.0E-5	2.3E-5	2.7E-5	3.0E-5	3.3E-5	6.6E-5	3.3E-4
700	5.8E-8	2.9E-7	5.8E-7	2.9E-6	5.8E-6	8.7E-6	1.2E-5	1.4E-5	1.7E-5	2.0E-5	2.3E-5	2.6E-5	2.9E-5	5.8E-5	2.9E-4
750	5.0E-8	2.5E-7	5.0E-7	2.5E-6	5.0E-6	7.4E-6	9.9E-6	1.2E-5	1.5E-5	1.7E-5	2.0E-5	2.2E-5	2.5E-5	5.0E-5	2.5E-4
800	4.6E-8	2.3E-7	4.6E-7	2.3E-6	4.6E-6	6.8E-6	9.1E-6	1.1E-5	1.4E-5	1.6E-5	1.8E-5	2.1E-5	2.3E-5	4.6E-5	2.3E-4
900	3.8E-8	1.9E-7	3.8E-7	1.9E-6	3.8E-6	5.7E-6	7.6E-6	9.5E-6	1.1E-5	1.3E-5	1.5E-5	1.7E-5	1.9E-5	3.8E-5	1.9E-4
1000	3.0E-8	1.5E-7	3.0E-7	1.5E-6	3.0E-6	4.5E-6	6.0E-6	7.5E-6	9.0E-6	1.1E-5	1.2E-5	1.4E-5	1.5E-5	3.0E-5	1.5E-4

**NOTE:** Risk minimization must be considered for incremental cancer risks over 10 in a million. Risk minimization options include: 1) use of ultra-low sulfur fuel (less than 15 ppmw); 2) relocation of engine away from property line or off-site receptors; 3) installation of a diesel particulate filter; or 4) reduction in annual operating hours.

**COLOR KEY FOR RISK LEVELS**

**GREEN** (risk of less than or equal to 1 in a million) should be approvable

**YELLOW** (risk of greater than 1 in a million and less than 10 in a million) risk may be approvable if the best Air Pollution Control technology is employed

Orange (risk of greater than or equal to 10 in a million and less than 100 in a million) a refined modeling analysis must be conducted

**RED** (risk greater than 100 in a million) not approvable

**Table 4. DPM Incremental Cancer Risk at Different Emission Rates and Distances**

**(For Engines Rated over 600 HP)**

**(Stack Discharge must be at least 25 feet above the ground and have a vertical discharge direction.)**

Distance (ft)	DPM Emission Rate (lbs/yr)														
	1	5	10	50	100	150	200	250	300	350	400	450	500	1000	5000
<50	3.8E-7	1.9E-6	3.8E-6	1.9E-5	3.8E-5	5.7E-5	7.7E-5	9.6E-5	1.1E-4	1.3E-4	1.5E-4	1.7E-4	1.9E-4	3.8E-4	1.9E-3
100	2.7E-7	1.3E-6	2.7E-6	1.3E-5	2.7E-5	4.0E-5	5.3E-5	6.6E-5	8.0E-5	9.3E-5	1.1E-4	1.2E-4	1.3E-4	2.7E-4	1.3E-3
150	1.8E-7	8.9E-7	1.8E-6	8.9E-6	1.8E-5	2.7E-5	3.6E-5	4.5E-5	5.4E-5	6.2E-5	7.1E-5	8.0E-5	8.9E-5	1.8E-4	8.9E-4
200	8.4E-8	4.2E-7	8.4E-7	4.2E-6	8.4E-6	1.3E-5	1.7E-5	2.1E-5	2.5E-5	2.9E-5	3.4E-5	3.8E-5	4.2E-5	8.4E-5	4.2E-4
250	7.4E-8	3.7E-7	7.4E-7	3.7E-6	7.4E-6	1.1E-5	1.5E-5	1.9E-5	2.2E-5	2.6E-5	3.0E-5	3.3E-5	3.7E-5	7.4E-5	3.7E-4
300	6.5E-8	3.2E-7	6.5E-7	3.2E-6	6.5E-6	9.7E-6	1.3E-5	1.6E-5	1.9E-5	2.3E-5	2.6E-5	2.9E-5	3.2E-5	6.5E-5	3.2E-4
350	5.9E-8	2.9E-7	5.9E-7	2.9E-6	5.9E-6	8.8E-6	1.2E-5	1.5E-5	1.8E-5	2.0E-5	2.3E-5	2.6E-5	2.9E-5	5.9E-5	2.9E-4
400	5.3E-8	2.6E-7	5.3E-7	2.6E-6	5.3E-6	7.9E-6	1.1E-5	1.3E-5	1.6E-5	1.8E-5	2.1E-5	2.4E-5	2.6E-5	5.3E-5	2.6E-4
450	4.8E-8	2.4E-7	4.8E-7	2.4E-6	4.8E-6	7.2E-6	9.6E-6	1.2E-5	1.4E-5	1.7E-5	1.9E-5	2.2E-5	2.4E-5	4.8E-5	2.4E-4
500	4.4E-8	2.2E-7	4.4E-7	2.2E-6	4.4E-6	6.5E-6	8.7E-6	1.1E-5	1.3E-5	1.5E-5	1.7E-5	2.0E-5	2.2E-5	4.4E-5	2.2E-4
550	4.1E-8	2.0E-7	4.1E-7	2.0E-6	4.1E-6	6.1E-6	8.1E-6	1.0E-5	1.2E-5	1.4E-5	1.6E-5	1.8E-5	2.0E-5	4.1E-5	2.0E-4
600	3.8E-8	1.9E-7	3.8E-7	1.9E-6	3.8E-6	5.6E-6	7.5E-6	9.4E-6	1.1E-5	1.3E-5	1.5E-5	1.7E-5	1.9E-5	3.8E-5	1.9E-4
650	3.5E-8	1.7E-7	3.5E-7	1.7E-6	3.5E-6	5.2E-6	6.9E-6	8.6E-6	1.0E-5	1.2E-5	1.4E-5	1.6E-5	1.7E-5	3.5E-5	1.7E-4
700	3.2E-8	1.6E-7	3.2E-7	1.6E-6	3.2E-6	4.7E-6	6.3E-6	7.9E-6	9.5E-6	1.1E-5	1.3E-5	1.4E-5	1.6E-5	3.2E-5	1.6E-4
750	2.9E-8	1.4E-7	2.9E-7	1.4E-6	2.9E-6	4.3E-6	5.7E-6	7.1E-6	8.6E-6	1.0E-5	1.1E-5	1.3E-5	1.4E-5	2.9E-5	1.4E-4
800	2.7E-8	1.3E-7	2.7E-7	1.3E-6	2.7E-6	4.1E-6	5.4E-6	6.8E-6	8.1E-6	9.5E-6	1.1E-5	1.2E-5	1.3E-5	2.7E-5	1.3E-4
900	2.4E-8	1.2E-7	2.4E-7	1.2E-6	2.4E-6	3.6E-6	4.8E-6	6.0E-6	7.2E-6	8.4E-6	9.6E-6	1.1E-5	1.2E-5	2.4E-5	1.2E-4
1000	2.1E-8	1.1E-7	2.1E-7	1.1E-6	2.1E-6	3.2E-6	4.2E-6	5.3E-6	6.3E-6	7.4E-6	8.4E-6	9.5E-6	1.1E-5	2.1E-5	1.1E-4

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