

Appendix E

Construction Emissions Estimates

National Grid Renewables Development, LLC
 Plum Creek Wind Farm Project
 HVTL Route Permit Amendment Request
 Construction Emission Calculations

Summary of Potential Construction Emissions (tons)										
Description	NOx	CO	VOC	SO ₂	PM ₁₀	PM _{2.5}	CO ₂	CH ₄	N ₂ O	CO ₂ e ^a
Off-Road Engine Emissions	24.41	5.37	1.73	0.01	0.94	0.93	1,008.62	0.04	0.01	1,011.94
Unpaved Roads	--	--	--	--	2.55	0.25	--	--	--	--
Commuters and Delivery Vehicles	--	--	--	--	--	--	206.12	0.00	0.00	206.12
Earthmoving	--	--	--	--	6.51	0.69	--	--	--	--
TOTAL	24.41	5.37	1.73	0.01	10.00	1.88	1,214.75	0.04	0.01	1,218.06

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Emission Factors for Construction Engines													
Equipment	Quantity ^a	Hours per Day	Number of Days	Total Hours Used ^b	Max Power (HP)	Load Factor ^c	Loaded Power (HP)	NOx	CO	Emission Factors ^d (g/hp-hr)			
										VOC	SO ₂	PM ₁₀	PM _{2.5}
Air Compressor	2	2	180	720	80	1	80	4.700	2.366	0.367	0.002	0.240	0.240
ATV	2	8	150	2,400	20	0.5	10	4.440	2.161	0.438	0.002	0.267	0.267
Backhoe	1	10	90	900	75	0.8	60	4.700	2.366	0.367	0.002	0.240	0.240
Bulldozer	1	10	90	900	250	1	250	4.000	0.748	0.309	0.002	0.132	0.132
Compactor	1	10	90	900	300	1	300	4.335	0.843	0.167	0.002	0.132	0.132
Compactor, Vibratory	1	10	90	900	100	1	100	4.100	0.867	0.338	0.002	0.180	0.180
Fork Lift	1	10	150	1,500	120	1	120	4.335	0.843	0.167	0.002	0.132	0.132
Concrete Mixer Truck	10	10	60	6,000	325	1	325	4.100	0.867	0.338	0.002	0.180	0.180
Concrete Pump	1	10	45	450	300	1	300	4.100	0.867	0.338	0.002	0.180	0.180
Dump Truck	1	10	45	450	325	0.8	260	4.100	0.867	0.338	0.002	0.180	0.180
Excavator	1	10	90	900	138	1	138	4.000	0.748	0.309	0.002	0.132	0.132
Front End Loader	1	10	150	1,500	196	1	196	4.000	0.748	0.309	0.002	0.132	0.132
Generator	1	10	90	900	250	0.5	125	4.335	0.843	0.167	0.002	0.132	0.132
Light Tower	2	10	60	1,200	50	1	50	4.000	0.748	0.309	0.002	0.132	0.132
Manlift	2	10	90	1,800	50	1	50	4.100	0.867	0.338	0.002	0.180	0.180
Pickup Truck	4	10	150	6,000	150	0.25	38	4.335	0.843	0.167	0.002	0.132	0.132
Pickup Truck (on road travel only)	1	10	150	1,500	150	0.25	38	4.335	0.843	0.167	0.002	0.132	0.132
Skid steer loader	1	10	150	1,500	50	1	50	4.000	0.748	0.309	0.002	0.132	0.132
Water truck	1	10	150	1,500	100	0.5	50	4.700	2.366	0.637	0.002	0.240	0.240
Welding machine	1	10	200	2,000	35	0.8	28	4.700	2.366	0.367	0.002	0.240	0.240
Grader	1	10	150	1,500	35	0.8	28	4.44	2.161	0.438	0.002	0.267	0.259
Medium Crane	1	10	90	900	450	0.7	315	4.0	0.7475	0.3085	0.002	0.132	0.128
Fuel Truck	1	10	200	2,000	200	0.59	118	4.0	0.7475	0.3085	0.002	0.132	0.128
Hydrovac Truck	1	10	30	300	200	0.59	118	4.0	0.7475	0.3085	0.002	0.132	0.128
Semitruck/Trailer	1	10	90	900	500	0.59	500	4.335	0.843	0.167	0.002	0.132	0.132

^a Equipment counts for the HVTL Project only.

^b Generally assumes work will occur 7 am - 7 pm, Monday through Saturday.

^c Load Factors from Appendix A of EPA 420_P-04-005, Median Life, Annual Activity, and Load Factor Values for Nonroad Engine Emissions Modeling, USEPA, April 2004.

^d EPA 420-P-04-009, Exhaust and Crankcase Emission Factors for Nonroad Engine Modeling - Compression Ignition, USEPA, April 2004 - Tier 2 Engines.

Assumption:

393.5 hp-hr/MMBtu

453.6 g/lb

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Emission Estimates from Construction Engines						
Equipment	Potential Emissions (tons)					
	NOx	CO	VOC	SO ₂	PM ₁₀	PM _{2.5}
Air Compressor	0.298	0.150	2.33E-02	0.000	0.015	0.015
ATV	0.117	0.057	1.16E-02	0.000	0.007	0.007
Backhoe	0.280	0.141	2.19E-02	0.000	0.014	0.014
Bulldozer	0.992	0.185	7.65E-02	0.000	0.033	0.033
Compactor	1.290	0.251	4.97E-02	0.001	0.039	0.039
Compactor, Vibratory	0.407	0.086	3.36E-02	0.000	0.018	0.018
Fork Lift	0.860	0.167	3.31E-02	0.000	0.026	0.026
Concrete Mixer Truck	8.813	1.863	7.27E-01	0.004	0.387	0.387
Concrete Pump	0.610	0.129	5.04E-02	0.000	0.027	0.027
Dump Truck	0.529	0.112	4.36E-02	0.000	0.023	0.023
Excavator	0.548	0.102	4.22E-02	0.000	0.018	0.018
Front End Loader	1.296	0.242	1.00E-01	0.001	0.043	0.043
Generator	0.538	0.104	2.07E-02	0.000	0.016	0.016
Light Tower	0.265	0.049	2.04E-02	0.000	0.009	0.009
Manlift	0.407	0.086	3.36E-02	0.000	0.018	0.018
Pickup Truck	1.075	0.209	4.14E-02	0.000	0.033	0.033
Pickup Truck (on road travel only)	0.269	0.052	1.03E-02	0.000	0.008	0.008
Skid steer loader	0.331	0.062	2.55E-02	0.000	0.011	0.011
Water truck	0.389	0.196	5.27E-02	0.000	0.020	0.020
Welding machine	0.290	0.146	2.27E-02	0.000	0.015	0.015
Grader	0.206	0.100	2.03E-02	0.000	0.012	0.012
Medium Crane	1.250	0.234	9.64E-02	0.001	0.041	0.040
Fuel Truck	1.041	0.194	8.03E-02	0.001	0.034	0.033
Hydrovac Truck	0.156	0.029	1.20E-02	0.000	0.005	0.005
Semitruck/Trailer	2.150	0.418	8.28E-02	0.001	0.065	0.065
TOTAL	24.41	5.37	1.73	0.01	0.94	0.93

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Fugitive Dust Emissions from Unpaved Roads								
Equipment	Quantity ^a	Total Days Used	VMT ^b	W	Emission Factor (lb/VMT) ^c		Emissions (tons)	
					PM ₁₀	PM _{2.5}	PM ₁₀	PM _{2.5}
ATV	2	150	300	20	1.73	0.17	0.26	0.03
Backhoe	1	90	90	50	2.62	0.26	0.12	0.01
Bulldozer	1	90	90	20	1.73	0.17	0.08	0.01
Fork Lift	1	150	150	20	1.73	0.17	0.13	0.01
Concrete Mixer Truck	10	60	600	20	1.73	0.17	0.52	0.05
Dump Truck	1	45	45	21	1.77	0.18	0.04	0.00
Excavator	1	90	90	22	1.81	0.18	0.08	0.01
Front End Loader	1	150	150	23	1.85	0.18	0.14	0.01
Manlift	2	90	180	24	1.88	0.19	0.17	0.02
Pickup Truck	4	150	600	24	1.88	0.19	0.56	0.06
Piping Truck	0	0	0	25	1.92	0.19	0.00	0.00
Skid steer loader	1	150	150	26	1.95	0.20	0.15	0.01
Water truck	1	150	150	20	1.73	0.17	0.13	0.01
Welding Machine	1	200	200	20	1.73	0.17	0.17	0.02
Grader	1	150	150	20	1.73	0.17	0.13	0.01
Large Crane	0	90	0	50	2.62	0.26	0.00	0.00
Medium Crane	1	90	90	25	1.92	0.19	0.09	0.01
Semitruck/Trailer	1	90	90	25	1.92	0.19	0.09	0.01
TOTAL	--	--	--	--	--	--	2.55	0.25

^a Equipment counts are estimated based current construction plan.

^b Each vehicle is assumed to travel 1.0 mile per day on site.

^c AP-42 Section 13.2.2 Unpaved Roads, dated November 2006, Equations 1a and 2 TOTALS 11.19 1.12 Surface Silt content based on Table 13.2.2-1 - construction sites.

Eq 1a: $E = k * (s/12)^a * (W/3)^b$

Eq 2: $E_{ext} = E * [(365-P)/365]$

where:

VMT = Vehicle Miles Traveled

W = Mean Vehicle Weight, tons

S = Mean Vehicle Speed, mph

P = 120 days with at least 0.01 inches rain, EPA's AP-42 Figure 13.2.2-1

s = 8.5 surface material silt content (%) for construction sites, EPA's AP-42 Table 13.2.2-1

E = size-specific emission factor, lb/ VMT

E_{ext} = annual size-specific emission factor extrapolated for natural migration, lb/VMT

Constants	PM	PM ₁₀	PM _{2.5}
k (lb/VMT)	4.9	1.5	0.15
a	0.7	0.9	0.9
b	0.45	0.45	0.45

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Fugitive Dust Emissions From Earthmoving Activities							
Construction Activity	Material Handling	Material	Average	Emission Factors ^{b - d}		Emissions	
	Rate ^a (ton/day)	Handling Time (days)	Exposed Area (acres)	PM ₁₀	PM _{2.5}	PM ₁₀	PM _{2.5}
OPTIMIZED ROUTE SEGMENT							
Topsoil removed by scraper ^e	1,664.9	90	---	0.058	0.0061	4.35	0.46
Topsoil replacement	1,664.9	90	---	0.012	0.0013	0.90	0.10
Wind erosion of exposed areas	---	90	74.30	0.38	0.03999	1.27	0.13
TOTAL - OPTIMIZED ROUTE SEGMENT	---	---	---	---	---	6.51	0.69
Notes and Assumptions:							
^a Soil density: 1.25 tons per yard.							
^b As worst case, PM ₁₀ is set equal to Total Particulate Matter. PM _{2.5} is set to 0.105 times PM ₁₀ per AP-42 Section 11.9 Table 11.9-1.							
^c Wind Erosion Exposed Areas emission factor: AP-42 Section 11.9 Western Surface Coal Mining, Table 11.9-4, July 1998, wind erosion of exposed areas							
^d Emission factor: AP-42 Section 11.9 Western Surface Coal Mining, Table 11.9-4, July 1998, topsoil removal by scraper.							
^e Assumes the entire workspace is cleared to 1 foot deep, 1.25 tons per cubic yard.							

Topsoil Removed by Scraper					
County/Facility	Construction Schedule (days)	Total (Acres)	Soil Volume (yd ³)	Soil Weight (ton)	Handling Rate (ton/day)
HVTL Project - Optimized Route Segment	90	74.30	119,871	149,838	1,665

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Construction Greenhouse Gas Emission Calculations

Summary of Potential Greenhouse Gas Emissions From Construction Engines (tons)				
Description	CO ₂	CH ₄	N ₂ O	CO ₂ e ^a
Off-Road Engine Emissions	1,008.62	0.04	0.01	1,011.94
Commuters and Delivery Vehicles	206.12	0.00	0.00	206.12
TOTAL	1,214.75	0.04	0.01	1,218.06
^a CO ₂ e = carbon dioxide equivalent. Includes global warming potentials from US EPA's 2024 GHG Emission Factors Hub.				

Global Warming Potentials		
CO ₂	CH ₄	N ₂ O
1	25	298
Source: US EPA's 2024 GHG Emission Factors Hub.		

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Emission Estimates from Construction Engines														
Equipment	Quantity ^a	Hours per Day	Days Used	Total Hours Used ^b	Max Power (HP)	Load Factor ^c	Loaded Power (HP)	Emission Factors ^{d,e} (g/hp-hr)			Potential Emissions ^f (tons)			
								CO ₂	CH ₄	N ₂ O	CO ₂	CH ₄	N ₂ O	CO ₂ e
Air Compressor	2	2	180	720	80	1	80	188.262	0.008	0.002	11.95	0.00	0.00	11.99
ATV	2	8	150	2,400	20	0.5	10	188.262	0.008	0.002	4.98	0.00	0.00	5.00
Backhoe	1	10	90	900	75	0.8	60	188.262	0.008	0.002	11.21	0.00	0.00	11.24
Bulldozer	1	10	90	900	250	1	250	188.262	0.008	0.002	46.69	0.00	0.00	46.85
Compactor	1	10	90	900	300	1	300	188.262	0.008	0.002	56.03	0.00	0.00	56.22
Compactor, Vibratory	1	10	90	900	100	1	100	188.262	0.008	0.002	18.68	0.00	0.00	18.74
Fork Lift	1	10	150	1,500	120	1	120	188.262	0.008	0.002	37.35	0.00	0.00	37.48
Concrete Mixer Truck	10	10	60	6,000	325	1	325	188.262	0.008	0.002	404.67	0.02	0.00	406.00
Concrete Pump	1	10	45	450	300	1	300	188.262	0.008	0.002	28.02	0.00	0.00	28.11
Dump Truck	1	10	45	450	325	0.8	260	188.262	0.008	0.002	24.28	0.00	0.00	24.36
Excavator	1	10	90	900	138	1	138	188.262	0.008	0.002	25.77	0.00	0.00	25.86
Front End Loader	1	10	150	1,500	196	1	196	188.262	0.008	0.002	61.01	0.00	0.00	61.21
Generator	1	10	90	900	250	0.5	125	188.262	0.008	0.002	23.35	0.00	0.00	23.42
Light Tower	2	10	60	1,200	50	1	50	188.262	0.008	0.002	12.45	0.00	0.00	12.49
Manlift	2	10	90	1,800	50	1	50	188.262	0.008	0.002	18.68	0.00	0.00	18.74
Pickup Truck	4	10	150	6,000	150	0.25	38	188.262	0.008	0.002	46.69	0.00	0.00	46.85
Skid steer loader	1	10	150	1,500	50	1	50	188.262	0.008	0.002	15.56	0.00	0.00	15.62
Water truck	1	10	150	1,500	100	0.5	50	188.262	0.008	0.002	15.56	0.00	0.00	15.62
Welding machine	1	10	200	2,000	35	0.8	28	188.262	0.008	0.002	11.62	0.00	0.00	11.66
Grader	1	10	150	1,500	35	0.8	28	188.262	0.008	0.002	8.72	0.00	0.00	8.74
Medium Crane	1	10	90	900	450	0.7	315	188.262	0.008	0.002	58.83	0.00	0.00	59.03
Fuel Truck	1	10	200	2,000	200	0.59	118	188.262	0.008	0.002	48.98	0.00	0.00	49.14
Hydrovac Truck	1	10	30	300	200	0.59	118	188.262	0.008	0.002	7.35	0.00	0.00	7.37
Semitruck/Trailer	1	10	90	900	50	1	50	188.262	0.008	0.002	9.34	0.00	0.00	9.37
TOTAL	--	--	--	--	--	--	--				1,008.62	0.04	0.008	1,011.94
^a Equipment counts based on experience with construction of a similar projects. ^b Generally assumes work will occur 7 am - 7 pm, Monday through Saturday. ^c Load Factors from Appendix A of EPA 420_P-04-005, Median Life, Annual Activity, and Load Factor Values for Nonroad Engine Emissions Modeling , USEPA, April 2004. ^d EPA 420-P-04-009, Exhaust and Crankcase Emission Factors for Nonroad Engine Modeling - Compression Ignition, USEPA, April 2004 - Tier 2 Engines. ^e GHG emission factors from Title 40 Subchapter C Part 98 Subpart C Table C-1 and C-2 to Subpart C. ^f CO ₂ e is carbon dioxide equivalent and includes global warming potentials from 40 CRF Part 98 Table A-1.														

Global Warming Potentials		
CO ₂	CH ₄	N ₂ O
1	28	265

Source: US EPA's 2024 GHG Emission Factors Hub.

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Construction Greenhouse Gas Emission Calculations

Greenhouse Gas Emissions from On Road Construction Traffic						
	Vehicles	Miles	Number	Fuel Used	CO ₂ Emission Factor ^b	CO ₂ Emissions
	per day	per vehicle ^a	of Days	(gallons)	(g/gal)	(tons)
Commuter Vehicles - Gasoline ^c	20	60	150	7,500	8,780	72.59
Pickup Truck - Gasoline ^d	4	60	200	2,526	8,780	24.45
Concrete Mix Truck - Diesel ^e	10	60	90	8,308	10,210	93.50
Semitruck/Trailer - Diesel ^e	1	60	150	1,385	10,210	15.58
TOTAL						206.12

^a Assumes commuters travel 30 miles each way (60 miles round trip) per day.

^b Emission factors from US EPA's 2024 GHG Emission Factors Hub.

^c Assumes a commuter vehicle a fuel economy of 24 miles per gallon, per US EPA and US Department of Energy Fuel Economy data for combined city and highway driving in 2023, available online at: <https://www.fueleconomy.gov/feg/download.shtml>.

^d Assumes a pickup truck vehicle a fuel economy of 19 miles per gallon, per US EPA and US Department of Energy Fuel Economy data for combined city and highway driving in 2023, available online at: <https://www.fueleconomy.gov/feg/download.shtml>.

^e Assumes a delivery trucks fuel economy of 6.5 miles per gallon, industry average.