Appendix Y:
Emission Inventories for Alternatives

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Y. Emission Inventories for Alternatives

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Alternative A Summary

BiFO Future Year Emission Estimate Summary

Ownership	Emissions (tpy)										
	CO	NO_x	VOC	SO_2	PM_{10}	$PM_{2.5}$	HAPs	CO_2	CH_4	N_2O	CO_{2eq}
Federal / BLM											
Oil and Gas Development and Production											
Oil	67.4	30.6	241.1	0.5	28.8	4.1	15.2	6,290.4	38.6	0.0	7,112.9
Natural Gas	10.8	4.6	3.1	0.1	4.9	0.7	0.3	1,044.4	13.9	0.0	1,333.4
BLM Travel	1.3	0.5	0.6	0.0	54.9	5.5	0.1	85.6	0.0	0.0	89.0
BLM Road Maintenance	0.2	0.5	0.0	0.0	1.7	0.2	0.0	60.4	0.0	0.0	60.6
Coal Mining [1]	11.3	23.7	1.2	0.0	29.9	3.0	---	274.4	0.0	0.0	274.4
Fire Management [2]	433.2	19.4	23.2	3.9	55.7	38.0	13.3	309,072.5	154.6	31.3	322,494.4
Forestry Management	0.6	0.8	0.1	0.0	2.9	0.3	0.0	94.1	0.0	0.0	94.5
Livestock Grazing	0.4	0.4	0.1	0.0	88.7	8.9	0.0	73.5	272.8	0.0	5,803.8
Recreation and Visitor Services	8.6	0.2	0.9	0.0	226.9	22.8	0.1	106.4	0.0	0.0	118.5
Vegetation Management	2.9	0.0	0.7	0.0	13.7	1.4	0.1	10.2	0.0	0.0	10.5
Federal Emission Total	**536.7**	**80.7**	**271.1**	**4.6**	**507.9**	**85.0**	**29.1**	**317,111.8**	**479.9**	**31.4**	**337,392.1**
Non-Federal											
Oil and Gas Development and Production											
Oil	250.9	207.5	968.8	1.9	119.7	21.0	61.4	25,161.5	154.2	0.1	28,431.4
Natural Gas	42.5	28.8	13.1	0.4	20.0	3.3	1.3	4,176.2	55.6	0.0	5,328.7
Non-Federal Emission Total	**293.4**	**236.3**	**981.9**	**2.3**	**139.7**	**24.3**	**62.7**	**29,337.7**	**209.8**	**0.1**	**33,760.2**

tpy = short tons per year

[1] To be conservative, coal mining emissions are assumed to result from coal mined from BLM mineral estate. Coal mine emissions reflect ongoing operations at the Signal Peak Energy, LLC coal mine located in Musselshell County. Only PM10 emissions are included in the mine's state-issued permit. $PM_{2.5}$ emissions are assumed to be 10 percent of PM_{10} emissions. Criteria air pollutants and greenhouse gases are estimated by scaling emissions from coal mines in the MCFO based on production.

[2] Excludes emissions from wildfires.

Comparison to Current Total County Emissions

Emissions	Emissions (tpy)					
	CO	NO_x	VOC	SO_2	PM_{10}	$PM_{2.5}$
2008 NEI Emissions	54,931	16,068	8,949	8,147	32,692	4,533
Alt. A (%) of NEI Emissions	1.0%	0.5%	3.0%	0.1%	1.6%	1.9%

County Emissions (Big Horn, Carbon, Golden Valley, Musselshell, Stillwater, Sweet Grass, Wheatland, Yellowstone)

Source: USEPA 2011e.

Alt. A (%) without Mine Emissions	1.0%	0.4%	3.0%	0.1%	1.5%	1.8%

Alternative B Summary

BiFO Future Year Emission Estimate Summary

Ownership	Emissions (tpy)										
	CO	NO_x	VOC	SO_2	PM_{10}	$PM_{2.5}$	HAPs	CO_2	CH_4	N_2O	CO_{2eq}
Federal / BLM											
Oil and Gas Development and Production											
Oil	67.4	30.6	241.1	0.5	28.8	4.1	15.2	6,290.4	38.6	0.0	7,112.9
Natural Gas	10.8	4.6	3.1	0.1	4.9	0.7	0.3	1,044.4	13.9	0.0	1,333.4
BLM Travel	1.3	0.5	0.6	0.0	54.9	5.5	0.1	85.6	0.0	0.0	89.0
BLM Road Maintenance	0.2	0.5	0.0	0.0	1.7	0.2	0.0	60.4	0.0	0.0	60.6
Coal Mining 1	11.3	23.7	1.2	0.0	29.9	3.0	---	274.4	0.0	0.0	274.4
Fire Management 2	1,475.6	48.5	76.5	11.9	172.7	129.0	18.7	309,076.8	209.8	39.3	326,137.0
Forestry Management	0.9	1.2	0.1	0.0	6.3	0.7	0.0	148.9	0.0	0.0	149.7
Livestock Grazing	0.4	0.4	0.1	0.0	88.7	8.9	0.0	73.5	272.8	0.0	5,803.8
Recreation and Visitor Services	8.6	0.2	0.9	0.0	226.9	22.8	0.1	106.4	0.0	0.0	118.5
Vegetation Management	0.5	0.0	0.1	0.0	2.3	0.2	0.0	1.7	0.0	0.0	1.8
Federal Emission Total	**1,577.0**	**110.2**	**323.8**	**12.5**	**617.0**	**175.1**	**34.4**	**317,162.5**	**535.1**	**39.4**	**341,081.1**
Non-Federal											
Oil and Gas Development and Production											
Oil	250.9	207.5	968.8	1.9	119.7	21.0	61.4	25,161.5	154.2	0.1	28,431.4
Natural Gas	42.5	28.8	13.1	0.4	20.0	3.3	1.3	4,176.2	55.6	0.0	5,328.7
Non-Federal Emission Total	**293.4**	**236.3**	**981.9**	**2.3**	**139.7**	**24.3**	**62.7**	**29,337.7**	**209.8**	**0.1**	**33,760.2**

tpy = short tons per year

1 To be conservative, coal mining emissions are assumed to result from coal mined from BLM mineral estate. Coal mine emissions reflect ongoing operations at the Signal Peak Energy, LLC coal mine located in Musselshell County. Only PM10 emissions are included in the mine's state-issued permit. PM2.5 emissions are assumed to be 10 percent of PM10 emissions. Criteria air pollutants and greenhouse gases are estimated by scaling emissions from coal mines in the MCFO based on production.

2 Excludes emissions from wildfires.

Comparison to Current Total County Emissions

Emissions	Emissions (tpy)					
	CO	NO_x	VOC	SO_2	PM_{10}	$PM_{2.5}$
2008 NEI Emissions	54931	16068	8949	8147	32692	4533
Alt. B (%) of NEI Emissions	2.9%	0.7%	3.6%	0.2%	1.9%	3.9%

County Emissions (Big Horn, Carbon, Golden Valley, Musselshell, Stillwater, Sweet Grass, Wheatland, Yellowstone)

Source: USEPA 2011e.

Alt. B (%) without Mine Emissions	2.9%	0.5%	3.6%	0.2%	1.8%	3.8%

Alternative C Summary

BiFO Future Year Emission Estimate Summary

Ownership	Emissions (tpy)										
	CO	NO_x	VOC	SO_2	PM_{10}	$PM_{2.5}$	HAPs	CO_2	CH_4	N_2O	CO_{2eq}
Federal / BLM											
Oil and Gas Development and Production											
Oil	67.4	30.6	241.1	0.5	28.8	4.1	15.2	6,290.4	38.6	0.0	7,112.9
Natural Gas	10.8	4.6	3.1	0.1	4.9	0.7	0.3	1,044.4	13.9	0.0	1,333.4
BLM Travel	1.3	0.5	0.6	0.0	54.9	5.5	0.1	85.6	0.0	0.0	89.0
BLM Road Maintenance	0.2	0.5	0.0	0.0	1.7	0.2	0.0	60.4	0.0	0.0	60.6
Coal Mining 1	11.3	23.7	1.2	0.0	29.9	3.0	---	274.4	0.0	0.0	274.4
Fire Management 2	1,477.8	48.5	76.9	11.9	164.0	128.0	18.7	309,080.4	209.8	39.3	326,140.6
Forestry Management	1.4	1.9	0.2	0.0	15.4	1.7	0.0	243.0	0.0	0.0	244.2
Livestock Grazing	0.4	0.4	0.1	0.0	88.7	8.9	0.0	73.5	272.8	0.0	5,803.8
Recreation and Visitor Services	8.6	0.2	0.9	0.0	226.9	22.8	0.1	106.4	0.0	0.0	118.5
Vegetation Management	2.2	0.0	0.5	0.0	10.4	1.1	0.1	7.8	0.0	0.0	8.0
Federal Emission Total	**1,581.5**	**111.0**	**324.7**	**12.6**	**625.5**	**175.9**	**34.5**	**317,266.2**	**535.1**	**39.4**	**341,185.4**
Non-Federal											
Oil and Gas Development and Production											
Oil	250.9	207.5	968.8	1.9	119.7	21.0	61.4	25,161.5	154.2	0.1	28,431.4
Natural Gas	42.5	28.8	13.1	0.4	20.0	3.3	1.3	4,176.2	55.6	0.0	5,328.7
Non-Federal Emission Total	**293.4**	**236.3**	**981.9**	**2.3**	**139.7**	**24.3**	**62.7**	**29,337.7**	**209.8**	**0.1**	**33,760.2**

tpy = short tons per year

1 To be conservative, coal mining emissions are assumed to result from coal mined from BLM mineral estate. Coal mine emissions reflect ongoing operations at the Signal Peak Energy, LLC coal mine located in Musselshell County. Only PM10 emissions are included in the mine's state-issued permit. PM2.5 emissions are assumed to be 10 percent of PM10 emissions. Criteria air pollutants and greenhouse gases are estimated by scaling emissions from coal mines in the MCFO based on production.

2 Excludes emissions from wildfires.

Comparison to Current Total County Emissions

Emissions	Emissions (tpy)					
	CO	NO_x	VOC	SO_2	PM_{10}	$PM_{2.5}$
2008 NEI Emissions	54931	16068	8949	8147	32692	4533
Alt. C (%) of NEI Emissions	2.9%	0.7%	3.6%	0.2%	1.9%	3.9%

County Emissions (Big Horn, Carbon, Golden Valley, Musselshell, Stillwater, Sweet Grass, Wheatland, Yellowstone)

Source: USEPA 2011e.

Alt. C (%) without Mine Emissions	2.9%	0.5%	3.6%	0.2%	1.8%	3.8%

Alternative D Summary

BiFO Future Year Emission Estimate Summary

Ownership	Emissions (tpy)										
	CO	NO_x	VOC	SO_2	PM_{10}	$PM_{2.5}$	HAPs	CO_2	CH_4	N_2O	CO_{2eq}
Federal / BLM											
Oil and Gas Development and Production											
Oil	67.4	30.6	241.1	0.5	28.8	4.1	15.2	6,290.4	38.6	0.0	7,112.9
Natural Gas	10.8	4.6	3.1	0.1	4.9	0.7	0.3	1,044.4	13.9	0.0	1,333.4
BLM Travel	1.3	0.5	0.6	0.0	54.9	5.5	0.1	85.6	0.0	0.0	89.0
BLM Road Maintenance	0.2	0.5	0.0	0.0	1.7	0.2	0.0	60.4	0.0	0.0	60.6
Coal Mining 1	11.3	23.7	1.2	0.0	29.9	3.0	---	274.4	0.0	0.0	274.4
Fire Management 2	1,475.7	48.4	76.5	11.9	171.2	128.9	18.7	309,060.3	209.8	39.3	326,120.3
Forestry Management	1.2	1.5	0.2	0.0	10.3	1.1	0.0	196.0	0.0	0.0	197.0
Livestock Grazing	0.4	0.4	0.1	0.0	88.7	8.9	0.0	73.5	272.8	0.0	5,803.8
Recreation and Visitor Services	8.6	0.2	0.9	0.0	226.9	22.8	0.1	106.4	0.0	0.0	118.5
Vegetation Management	1.2	0.0	0.3	0.0	5.6	0.6	0.0	4.2	0.0	0.0	4.3
Federal Emission Total	**1,578.1**	**110.5**	**324.0**	**12.5**	**622.8**	**175.8**	**34.4**	**317,195.5**	**535.1**	**39.4**	**341,114.1**
Non-Federal											
Oil and Gas Development and Production											
Oil	250.9	207.5	968.8	1.9	119.7	21.0	61.4	25,161.5	154.2	0.1	28,431.4
Natural Gas	42.5	28.8	13.1	0.4	20.0	3.3	1.3	4,176.2	55.6	0.0	5,328.7
Non-Federal Emission Total	**293.4**	**236.3**	**981.9**	**2.3**	**139.7**	**24.3**	**62.7**	**29,337.7**	**209.8**	**0.1**	**33,760.2**

tpy = short tons per year

1 To be conservative, coal mining emissions are assumed to result from coal mined from BLM mineral estate. Coal mine emissions reflect ongoing operations at the Signal Peak Energy, LLC coal mine located in Musselshell County. Only PM10 emissions are included in the mine's state-issued permit. PM2.5 emissions are assumed to be 10 percent of PM10 emissions. Criteria air pollutants and greenhouse gases are estimated by scaling emissions from coal mines in the MCFO based on production.

2 Excludes emissions from wildfires.

Comparison to Current Total County Emissions

Emissions	Emissions (tpy)					
	CO	NO_x	VOC	SO_2	PM_{10}	$PM_{2.5}$
2008 NEI Emissions	54931	16068	8949	8147	32692	4533
Alt. D (%) of NEI Emissions	2.9%	0.7%	3.6%	0.2%	1.9%	3.9%

County Emissions (Big Horn, Carbon, Golden Valley, Musselshell, Stillwater, Sweet Grass, Wheatland, Yellowstone)

Source: USEPA 2011e.

Alt. D (%) without Mine Emissions	2.9%	0.5%	3.6%	0.2%	1.8%	3.8%

Oil Wells - Alternatives A, B, C, and D

Alternatives A, B, C, and D input parameters for calculating oil wells emissions:

Maximum Annual Wells Drilled - Federal (RMP estimate)	3	Maximum Annual Wells Drilled - Non-Federal (RMP estimate)	12
Federal Producing Wells - RMP Year 20	60	Non-Federal Producing Wells - RMP Year 20	240
Average Well Barrel Oil Per Day (BOPD)	20	Average Well Barrel Oil Per Day (BOPD)	20

* 100% full RMP estimates for Federal, full RMP estimates (100%) for non-Federal

Federal Oil Wells Summaries

Total Annual Emissions from Federal Oil Wells - RMP Year - Alternatives A, B, C, and D

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs	CO_2	CH_4	N_2O	CO_{2eq}	CO2eq metric tons
Well Pad Construction - Fugitive Dust	0.15	0.01	---	---	---	---	---	---	---	---	---	---
Heavy Equipment Combustive Emissions	0.08	0.08	1.63	0.32	8.27	0.45	0.04	1650.30	0.02	0.02	1656.49	1503.17
Commuting Vehicles - Construction	15.90	1.60	0.15	0.00	0.18	0.06	0.01	40.04	0.00	0.00	40.93	37.14
Wind Erosion	0.04	0.01	---	---	---	---	---	---	---	---	---	---
Sub-total: Construction	**16.17**	**1.70**	**1.78**	**0.32**	**8.45**	**0.51**	**0.05**	**1,690.34**	**0.02**	**0.02**	**1,697.42**	**1,540.31**
Well Workover Operations - Fugitive Dust	0.85	0.09	---	---	---	---	---	---	---	---	---	---
Well Workover Operations - On-site Exhaust	0.02	0.02	0.36	0.14	3.10	0.17	0.02	630.45	0.01	0.01	632.87	574.29
Well Workover Operations - On-road Exhaust	0.00	0.00	0.03	0.00	0.06	0.02	0.002	7.44	0.00	0.00	7.65	6.94
Well Visits for Inspection & Repair - Operations	2.09	0.21	0.01	0.00	0.21	0.01	0.001	4.10	0.00	0.00	4.59	4.16
Recompletion Traffic	1.47	0.15	0.06	0.00	0.10	0.04	0.00	15.10	0.00	0.00	15.49	14.05
Water Tanks & Traffic	4.72	0.50	0.40	0.00	0.26	0.05	0.01	117.63	6.86	0.00	262.01	237.76
Oil Tanks & Traffic	0.98	0.12	0.26	0.00	0.17	212.18	12.23	87.42	24.18	0.00	595.45	540.34
Venting	---	---	---	---	---	2.34	0.19	0.08	2.93	0.00	61.53	55.83
Compression and Well Pumps	1.22	1.22	27.52	0.02	55.04	19.26	1.93	3,713.41	0.07	0.01	3717.06	3373.01
Dehydrators	0.00	0.00	0.00	0.00	0.00	6.31	0.78	4.08	4.22	0.00	92.80	84.21
Compression Station Fugitives	---	---	---	---	---	0.21	0.02	0.01	0.26	0.00	5.55	5.04
Sub-total: Operations	**11.35**	**2.30**	**28.65**	**0.16**	**58.92**	**240.59**	**15.18**	**4,579.70**	**38.54**	**0.02**	**5,394.99**	**4,895.64**
Road Maintenance	1.02	0.11	0.13	0.003	0.06	0.02	0.002	16.39	0.00	0.00	16.49	14.96
Sub-total: Maintenance	**1.02**	**0.11**	**0.13**	**0.003**	**0.06**	**0.02**	**0.002**	**16.391**	**0.000**	**0.00**	**16.49**	**14.96**
Road Reclamation	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.00	0.00	0.13	0.12
Well Reclamation	0.21	0.02	0.02	0.00	0.02	0.00	0.00	3.82	0.00	0.00	3.84	3.48
Sub-total: Reclamation	**0.21**	**0.02**	**0.02**	**0.0007**	**0.02**	**0.003**	**0.0003**	**3.9514**	**0.0001**	**0.0001**	**3.9715**	**3.6039**
Total Emissions	**28.75**	**4.14**	**30.58**	**0.49**	**67.45**	**241.12**	**15.23**	**6,290.38**	**38.56**	**0.04**	**7,112.88**	**6,454.52**

Oil Wells - Alternatives A, B, C, and D

Non-Federal Oil Wells Summaries

Total Annual Emissions from Non-Federal Oil Wells - RMP Year - Alternatives A, B, C, and D

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs	CO_2	CH_4	N_2O	CO_{2eq}	CO2eq metric tons
Well Pad Construction - Fugitive Dust	0.59	0.06	---	---	---	---	---	---	---	---	---	---
Heavy Equipment Combustive Emissions	3.22	3.14	61.28	1.27	15.85	4.48	0.45	6601.19	0.07	0.02	6608.46	5996.79
Commuting Vehicles - Construction	63.59	6.40	0.61	0.00	0.73	0.25	0.03	160.16	0.01	0.00	161.15	146.24
Wind Erosion	0.18	0.03	---	---	---	---	---	---	---	---	---	---
Sub-total: Construction	**67.58**	**9.62**	**61.90**	**1.28**	**16.58**	**4.74**	**0.47**	**6,761.35**	**0.07**	**0.02**	**6,769.61**	**6,143.03**
Well Workover Operations - Fugitive Dust	3.41	0.34	---	---	---	---	---			---	---	---
Well Workover Operations - On-site Exhaust	1.81	1.76	31.87	0.54	10.71	2.31	0.23	2521.79	0.04	0.03	2531.46	2297.15
Well Workover Operations - On-road Exhaust	0.01	0.01	0.13	0.00	0.23	0.09	0.009	29.76	0.00	0.00	30.59	27.76
Well Visits for Inspection & Repair - Operations	8.35	0.83	0.04	0.00	0.82	0.04	0.004	16.40	0.00	0.01	18.35	16.65
Recompletion Traffic	5.87	0.60	0.25	0.00	0.40	0.16	0.02	60.38	0.00	0.00	61.94	56.21
Water Tanks & Traffic	18.89	2.01	1.61	0.01	1.02	0.21	0.02	470.50	27.45	0.00	1048.06	951.05
Oil Tanks & Traffic	3.93	0.47	1.05	0.01	0.66	848.73	48.92	349.66	96.73	0.00	2381.81	2161.35
Venting	---	---	---	---	---	9.35	0.76	0.30	11.71	0.00	246.12	223.34
Compression and Well Pumps	4.88	4.88	110.08	0.07	220.16	77.06	7.71	14,853.66	0.28	0.03	14868.23	13492.04
Dehydrators	0.00	0.00	0.01	0.00	0.01	25.23	3.13	16.30	16.90	0.00	371.19	336.84
Compression Station Fugitives	---	---	---	---	---	0.84	0.08	0.03	1.06	0.00	22.21	20.16
Sub-total: Operations	**47.15**	**10.90**	**145.05**	**0.63**	**234.02**	**964.01**	**60.87**	**18,318.79**	**154.16**	**0.08**	**21,579.96**	**19,582.54**
Road Maintenance	4.08	0.43	0.52	0.014	0.24	0.07	0.007	65.56	0.00	0.00	65.97	59.86
Sub-total: Maintenance	**4.08**	**0.43**	**0.52**	**0.014**	**0.24**	**0.07**	**0.007**	**65.564**	**0.001**	**0.00**	**65.97**	**59.86**
Road Reclamation	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.53	0.00	0.00	0.53	0.48
Well Reclamation	0.83	0.09	0.06	0.00	0.07	0.01	0.00	15.28	0.00	0.00	15.36	13.94
Sub-total: Reclamation	**0.85**	**0.10**	**0.06**	**0.0028**	**0.07**	**0.014**	**0.0014**	**15.8057**	**0.0003**	**0.0002**	**15.8859**	**14.4155**
Total Emissions	**119.66**	**21.04**	**207.53**	**1.93**	**250.91**	**968.83**	**61.36**	**25,161.51**	**154.24**	**0.10**	**28,431.42**	**25,799.84**

Oil Wells - Alternatives A, B, C, and D

Fugitive Dust Emissions From Well Pad Construction

Fugitive Dust from Heavy Construction Operations			
INPUTS & ASSUMPTIONS			
Description	**Value**	**Source**	**Notes**
Control Efficiency (C) of watering[a]	0	a	
PM_{10} Emission Factor	0.11	b	Tons PM_{10}/acre-month
Conversion factor for PM_{10} to $PM_{2.5}$	0.1	c	Percentage of PM_{10}

[a] The PM_{10} emission factor shown below includes 50% control based on watering.

[b] WRAP Fugitive Dust Handbook, September 2006.

[c] Midwest Research Institute. 2006. *Background Document for Revisions to Fine Fraction Ratios Used for AP-42 Fugitive Dust Emission Factors* , Report prepared for the Western Governors' Association, Western Regional Air Partnership (WRAP), MRI Project No. 110397, November 1, 2006.

Emissions Estimation for Construction Activities

Area Disturbed for Oil Wells	Avg. Disturbed Acres per well	Construction Days	Total # of Wells	Total Disturbed Acres	Emissions			
					(lbs/well)		(tpy/well)	
					PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$
Improved Road	1.5	3	1	1.5	3.30E+01	3.30E+00	1.65E-02	1.65E-03
Well Pad and other structures	3.0	3	1	3.0	6.60E+01	6.60E+00	3.30E-02	3.30E-03
			Total		**9.90E+01**	**9.90E+00**	**4.95E-02**	**4.95E-03**

Number of acres per well pad provided by data in Billings Field Office Resource Management Plan.

Oil Wells - Alternatives A, B, C, and D

Exhaust Emissions from Well Pad Construction Heavy Equipment and Drilling Equipment (Federal)

Emission Factors for Construction Equipment

Equipment	Emission Factors (g/hp-hr)									Equipment Category
	NO_x	PM_{10}	SO_2	CO	VOCs	$PM_{2.5}$	CO_2	CH_4	N_2O[a]	
Dozer - 175 Hp	4.37	0.34	0.12	1.52	0.35	0.33	535.76	0.005	0.006	Track-Type Tractor
Blade - 150 Hp	4.85	0.57	0.13	3.94	0.50	0.55	594.65	0.008	0.006	Motor Grader

Source: EPA NONROADS 2008a

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

NOTE: Use emission factors for 2008 for all project years = conservative estimate of fleet turnover

Emission Estimations for Construction Equipment (using 2008 emission factors)

Construction Site	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Operating Hours/Day	# of Operating Days/Well	# of Operating Hours/Well	# of Wells	Max. Annual Emissions (lbs/equipment type/well)					Max. Annual Emissions (tons/equipment type/well)								
									NO_x	PM_{10}	SO_2	CO	VOC	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Improved & Two-Track Road	Blade	150	1	75	10	2	20	1	24.06	2.83	0.64	19.54	2.48	0.01	0.00	0.00	0.01	0.00	0.00	1.47	0.000	0.000
Well Pad	Blade	175	1	75	10	3	30	1	42.10	4.95	1.13	34.20	4.34	0.02	0.00	0.00	0.02	0.00	0.00	2.58	0.000	0.000
	Dozer	175	1	80	10	3	30	1	40.46	3.15	1.11	14.07	3.24	0.02	0.00	0.00	0.01	0.00	0.00	2.75	0.000	0.000
													Subtotal	5.33E-02	5.46E-03	1.44E-03	3.39E-02	5.03E-03	6.30E-03	6.81E+00	8.64E-05	6.93E-05

Exhaust Emission Factors for Diesel Powered Bore/Drill Rig Engines

Project Year/Hp Category	Emission Factors (g/hp-hr)								
	NO_x	PM_{10}	SO_2	CO	VOCs	$PM_{2.5}$	CO_2	CH_4	N_2O[a]
Year 2018									
50 to 75	3.50	0.022	0.12	3.70	0.14	0.02	589.10	0.006	0.006
75 to 100	0.30	0.015	0.11	3.70	0.14	0.02	589.10	0.006	0.006
100 to 175	0.30	0.015	0.11	3.70	0.14	0.02	530.10	0.005	0.006
175 to 300	0.30	0.015	0.11	2.60	0.14	0.02	530.18	0.004	0.006
300 to 600	0.30	0.015	0.11	2.60	0.14	0.02	530.25	0.004	0.006
600 to 750	0.30	0.015	0.11	2.60	0.14	0.02	530.28	0.004	0.006
>750	0.50	0.022	0.10	2.60	0.14	0.02	529.92	0.006	0.006

Sources: Tier 4 non-road diesel emission factors for non-SO2, non-GHG pollutants. EPA NONROADS 2008a (Year 2008) for CO2 and CH4.

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emissions Estimation for Industrial Engines

Construction Site	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Operating Hours/Day	# of Operating Days/Well	# of Operating Hours/Well	# of Wells	Max. Annual Emissions (lbs/equipment type/well)					Max. Annual Emissions (tons/equipment type/well)								
									NO_x	PM_{10}	SO_2	CO	VOC	NO_x	PM_{10}	SO_x	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Main Deck	1,000	3	70	24	16	384	1	889	39	182	4,622	249	0.44	0.02	0.09	2.31	0.12	0.02	471.0	0.005	0.005
	Auxiliary Pump	600	1	80	8	15	120	1	38	2	15	330	18	0.02	0.00	0.01	0.17	0.01	0.00	33.7	0.000	0.000
	Generators	150	2	75	24	8	192	1	29	1	11	352	13	0.01	0.00	0.01	0.18	0.01	0.00	25.2	0.000	0.000
Well Completion & Testing	Main Deck	600	1	50	11	5	55	1	11	1	4	95	5	0.01	0.00	0.00	0.05	0.00	0.00	9.6	0.000	0.000
	Auxiliary Pump	225	1	80	8	2	16	1	2	0	1	17	1	0.00	0.00	0.00	0.01	0.00	0.00	1.7	0.000	0.000
	Power Swivel	150	1	75	8	2	16	1	1	0	0	15	1	0.00	0.00	0.00	0.01	0.00	0.00	1.1	0.000	0.000
	Equipment Type	**Capacity (hp)**	**# of Units**	**Avg. Load Factor (%)[b]**	**# of Operating Hours/ Day**	**# of Operating Days/ Well**	**# of Operating Hours/ Well**	**# of Wells**														
	Field Generators for Pumps & Lighting	55	1	75	12	3	36	1	11.46	0.07	0.38	12.11	0.46	0.01	0.00	0.00	0.01	0.00	0.00	1.0	0.000	0.000
													Subtotal	4.91E-01	2.16E-02	1.06E-01	2.72E+00	1.43E-01	2.16E-02	5.43E+02	5.60E-03	6.20E-03
													Total	5.44E-01	2.71E-02	1.08E-01	2.76E+00	1.49E-01	2.79E-02	5.50E+02	5.69E-03	6.27E-03

Oil Wells - Alternatives A, B, C, and D

Exhaust Emissions from Well Pad Construction Heavy Equipment and Drilling Equipment (Non-Federal)

Emission Factors for Construction Equipment

Equipment	Emission Factors (g/hp-hr)									Equipment Category
	NO_x	PM_{10}	SO_2	CO	VOCs	$PM_{2.5}$	CO_2	CH_4	N_2O[a]	
Dozer - 175 Hp	4.37	0.34	0.12	1.52	0.35	0.33	535.76	0.005	0.006	Track-Type Tractor
Blade - 150 Hp	4.85	0.57	0.13	3.94	0.50	0.55	594.65	0.008	0.006	Motor Grader

Source: EPA NONROADS 2008a

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

NOTE: Use emission factors for 2008 for all project years = conservative estimate of fleet turnover

Emission Estimations for Construction Equipment (using 2008 emission factors)

Construction Site	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Operating Hours/Day	# of Operating Days/Well	# of Operating Hours/Well	# of Wells	Max. Annual Emissions (lbs/equipment type/well)					Max. Annual Emissions (tons/equipment type/well)								
									NO_x	PM_{10}	SO_2	CO	VOC	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Improved & Two-Track Road	Blade	150	1	75	10	2	20	1	24.06	2.83	0.64	19.54	2.48	0.01	0.00	0.00	0.01	0.00	0.00	1.47	0.000	0.000
Well Pad	Blade	175	1	75	10	3	30	1	42.10	4.95	1.13	34.20	4.34	0.02	0.00	0.00	0.02	0.00	0.00	2.58	0.000	0.000
	Dozer	175	1	80	10	3	30	1	40.46	3.15	1.11	14.07	3.24	0.02	0.00	0.00	0.01	0.00	0.00	2.75	0.000	0.000
													Subtotal	5.33E-02	5.46E-03	1.44E-03	3.39E-02	5.03E-03	6.30E-03	6.81E+00	8.64E-05	6.93E-05

Exhaust Emission Factors for Diesel Powered Bore/Drill Rig Engines

Project Year/Hp Category	Emission Factors (g/hp-hr)								
	NO_x	PM_{10}	SO_2	CO	VOCs	$PM_{2.5}$	CO_2	CH_4	N_2O[a]
Year 2018									
50 to 75	4.55	0.41	0.12	2.13	0.42	0.40	589.10	0.006	0.006
75 to 100	3.75	0.42	0.11	2.03	0.42	0.41	589.10	0.006	0.006
100 to 175	3.57	0.27	0.10	1.00	0.31	0.26	530.10	0.005	0.006
175 to 300	3.37	0.23	0.10	0.83	0.28	0.22	530.18	0.004	0.006
300 to 600	3.61	0.21	0.10	1.06	0.26	0.21	530.25	0.004	0.006
600 to 750	3.61	0.22	0.10	1.25	0.25	0.21	530.28	0.004	0.006
>750	5.13	0.26	0.10	1.29	0.37	0.25	529.92	0.006	0.006

Source: EPA NONROADS 2008a - Year 2018 accounts for mixture of Tier 1-3 engines

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emissions Estimation for Industrial Engines

Construction Site	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Operating Hours/Day	# of Operating Days/Well	# of Operating Hours/Well	# of Wells	Max. Annual Emissions (lbs/equipment type/well)					Max. Annual Emissions (tons/equipment type/well)								
									NO_x	PM_{10}	SO_2	CO	VOC	NO_x	PM_{10}	SO_x	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Main Deck	1,000	3	70	24	16	384	1	9,126	462	182	2,291	661	4.56	0.23	0.09	1.15	0.33	0.22	471.0	0.005	0.005
	Auxiliary Pump	600	1	80	8	15	120	1	459	27	13	134	33	0.23	0.01	0.01	0.07	0.02	0.01	33.7	0.000	0.000
	Generators	150	2	75	24	8	192	1	340	25	10	95	30	0.17	0.01	0.00	0.05	0.01	0.01	25.2	0.000	0.000
Well Completion & Testing	Main Deck	600	1	50	11	5	55	1	131	8	4	38	9	0.07	0.00	0.00	0.02	0.00	0.00	9.6	0.000	0.000
	Auxiliary Pump	225	1	80	8	2	16	1	21	1	1	5	2	0.01	0.00	0.00	0.00	0.00	0.00	1.7	0.000	0.000
	Power Swivel	150	1	75	8	2	16	1	14	1	0	4	1	0.01	0.00	0.00	0.00	0.00	0.00	1.1	0.000	0.000
	Equipment Type	**Capacity (hp)**	**# of Units**	**Avg. Load Factor (%)[b]**	**# of Operating Hours/ Day**	**# of Operating Days/ Well**	**# of Operating Hours/ Well**	**# of Wells**														
	Field Generators for Pumps & Lighting	55	1	75	12	3	36	1	14.90	1.33	0.38	6.98	1.38	0.01	0.00	0.00	0.00	0.00	0.00	1.0	0.000	0.000
													Subtotal	5.05E+00	2.63E-01	1.05E-01	1.29E+00	3.69E-01	2.55E-01	5.43E+02	5.60E-03	6.20E-03
													Total	5.11E+00	2.69E-01	1.06E-01	1.32E+00	3.74E-01	2.62E-01	5.50E+02	5.69E-03	6.27E-03

Oil Wells - Alternatives A, B, C, and D

Fugitive Dust Emissions from Construction and Drilling Support Vehicles

Emission Factors for Industrial Unpaved Roads [a]

		Parameter	PM_{10}	$PM_{2.5}$
E (lb/VMT) =	$k (s/12)^a (W/3)^b$	k	1.5	0.15
		a	0.9	0.9
		b	0.45	0.45
E_{ext} = E (1 - P/365)				

Function/Variable Description	Assumed Value	Reference
E = size-specific emission factor (lb/VMT)		
E_{ext} = size-specific emission factor extrapolated for natural		
s = surface material silt content (%)	34.6	Billings Field Office, Dustin Crowe email dated August 16, 2010.
W = mean vehicle weight (tons)	Listed in the table below	
M = surface material moisture content (%)	2.0	EPA AP-42 Section 13.2.2
P = Number of days precip per year	96.3	Billings, MT Climate Summary from 1961-1990, Western Regional Climate Center.
CE = control efficiency of gravel or scoria surfacing	84%	WRAP Fugitive Dust Handbook, September 2006.

[a] *Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2, Nov. 2006*

Fugitive Dust Emission Estimations for Road Traffic - All Project Years

Construction Site Destination	Vehicle Type	Avg. Vehicle Weight (tons)	Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells	PM_{10} Controlled Em. Factor (lb/VMT)	PM_{10} Emissions (lbs/vehicle/well)	PM_{10} Emissions (tons/ vehicle type/well)	PM_{10} Emissions (tons/well)	$PM_{2.5}$ Controlled Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions (lbs/vehicle/well)	$PM_{2.5}$ Emissions (tons/ vehicle type/well)	$PM_{2.5}$ Emissions (tons/well)
Improved & Two-Track Road	Semi Trucks	42	6	47	282	1	1.50	423.74	0.21	0.22	0.15	42.37	0.02	0.02
	Pickup Trucks	5	6	3	18	1	0.58	10.38	0.01		0.06	1.04	0.00	
Well Pad	Semi Trucks	42	6	5	30	1	1.50	45.08	0.02	0.03	0.15	4.51	0.00	0.00
	Pickup Trucks	5	6	4	24	1	0.58	13.84	0.01		0.06	1.38	0.00	
Other Construction Activities	Semi Trucks	42	6	2	12	1	1.50	18.03	0.01	0.02	0.15	1.80	0.00	0.00
	Haul Trucks	25	6	2	12	1	1.19	14.28	0.01		0.12	1.43	0.00	
	Pickup Trucks	5	6	1	6	1	0.58	3.46	0.00		0.06	0.35	0.00	
Rig-up, Drilling, and Rig-down	Semi Rig Transport, Drill Rig	42	6	44	264	1	1.50	396.69	0.20	0.47	0.15	39.67	0.02	0.05
	Fuel Haul Truck	25	6	6	36	1	1.19	42.83	0.02		0.12	4.28	0.00	
	Mud Haul Truck, Water Hauling	25	6	4	24	1	1.19	28.55	0.01		0.12	2.86	0.00	
	Rig Crew	5	6	51	306	1	0.58	176.46	0.09		0.06	17.65	0.01	
	Rig Mechanics	5	6	2	12	1	0.58	6.92	0.00		0.06	0.69	0.00	
	Co. Supervisor	5	6	20	120	1	0.58	69.20	0.03		0.06	6.92	0.00	
	Tool Pusher	25	6	8	48	1	1.19	57.11	0.03		0.12	5.71	0.00	
	Mud Logger	25	6	6	36	1	1.19	42.83	0.02		0.12	4.28	0.00	
	Mud Engineer	25	6	15	90	1	1.19	107.08	0.05		0.12	10.71	0.01	
	Logger, Engr Truck	25	6	1	6	1	1.19	7.14	0.00		0.12	0.71	0.00	
	Drill Bit Delivery	25	6	2	12	1	1.19	14.28	0.01		0.12	1.43	0.00	
Well Completion & Testing (continued below)	Semi Casing Haulers	42	6	6	36	1	1.50	54.09	0.03	0.07	0.15	5.41	0.00	0.01
	Semi Completion, Unit Rig	42	6	1	6	1	1.50	9.02	0.00		0.15	0.90	0.00	
	Semi Fracing, Blender	25	6	1	6	1	1.19	7.14	0.00		0.12	0.71	0.00	
	Semi Pumping/Tank Battery	25	6	6	36	1	1.19	42.83	0.02		0.12	4.28	0.00	
	Tubing Truck	25	6	2	12	1	1.19	14.28	0.01		0.12	1.43	0.00	
	Haul Cementer, Pump Truck	25	6	2	12	1	1.19	14.28	0.01		0.12	1.43	0.00	
									Subtotal	**8.10E-01**				**8.10E-02**

Oil Wells - Alternatives A, B, C, and D

Emission Estimations for Road Traffic - All Project Years (continued)

Construction Site Destination	Vehicle Type	Avg. Vehicle Weight (tons)	Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells	PM_{10}				$PM_{2.5}$			
							Controlled Em. Factor (lb/VMT)	Emissions (lbs/vehicle type)	Emissions (tons/ vehicle type/well)	Emissions (tons/well)	Controlled Em. Factor (lb/VMT)	Emissions (lbs/vehicle type)	Emissions (tons/ vehicle type/well)	Emissions (tons/well)
Well Completion & Testing (continued from above)	Haul Cementer, Cement Truck	25	40	3	120	1	1.19	142.77	0.07	4.48	0.12	14.28	0.01	0.45
	Haul Completion,	25	40	3	120	1	1.19	142.77	0.07		0.12	14.28	0.01	
	Haul Service Tools	25	40	2	80	1	1.19	95.18	0.05		0.12	9.52	0.00	
	Haul Perforators Logging Truck	25	40	1	40	1	1.19	47.59	0.02		0.12	4.76	0.00	
	Haul Anchor, Installation	25	40	1	40	1	1.19	47.59	0.02		0.12	4.76	0.00	
	Haul Anchor, Testing	25	40	1	40	1	1.19	47.59	0.02		0.12	4.76	0.00	
	Haul Fracing, Tank	25	40	1	40	1	1.19	47.59	0.02		0.12	4.76	0.00	
	Haul Fracing, Pump	25	40	1	40	1	1.19	47.59	0.02		0.12	4.76	0.00	
	Haul Fracing, Chemical	25	40	1	40	1	1.19	47.59	0.02		0.12	4.76	0.00	
	Haul Fracing, Sand	25	40	1	40	1	1.19	47.59	0.02		0.12	4.76	0.00	
	Haul Fracing, Other	25	40	1	40	1	1.19	47.59	0.02		0.12	4.76	0.00	
	Haul Welders	25	40	6	240	1	1.19	285.54	0.14		0.12	28.55	0.01	
	Haul Water Truck	25	40	150	6000	1	1.19	7,138.57	3.57		0.12	713.86	0.36	
	Pickup Cementer, Engineer	5	40	2	80	1	0.58	46.13	0.02		0.06	4.61	0.00	
	Pickup Casing Crew	5	40	2	80	1	0.58	46.13	0.02		0.06	4.61	0.00	
	Pickup Completion Crew	5	40	5	200	1	0.58	115.33	0.06		0.06	11.53	0.01	
	Pickup Completion, Pusher	5	40	5	200	1	0.58	115.33	0.06		0.06	11.53	0.01	
	Pickup Perforators, Engineer	5	40	2	80	1	0.58	46.13	0.02		0.06	4.61	0.00	
	Pickup Fracing, Engineer	5	40	1	40	1	0.58	23.07	0.01		0.06	2.31	0.00	
	Pickup Co. Supervisor	5	40	10	400	1	0.58	230.67	0.12		0.06	23.07	0.01	
	Pickup Miscellaneous Supplies	5	40	3	120	1	0.58	69.20	0.03		0.06	6.92	0.00	
	Pickup Roustabout Crew	5	40	4	160	1	0.58	92.27	0.05		0.06	9.23	0.00	
									Subtotal	4.48E+00				4.48E-01
									Total	5.29E+00				5.29E-01

Oil Wells - Alternatives A, B, C, and D

Exhaust Emissions from Construction and Drilling Support Vehicles

Emission Factors for Commuting Vehicles

Vehicle		Emission Factors (g/mi)								
Type	Class	NO_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
Heavy-Duty Diesel Truck	HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.044

Source: MOBILE6.2.03

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emissions Estimation Road Traffic

Construction Site Destination	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells	Emissions																					
							(lbs/vehicle type/well)						(tons/vehicle type/well)						(tons/well)									
	Type	Class					NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	CO_2	CH_4	N_2O
Improved & Two-Track Road	Semi Trucks	HDDV	40	47	1880	1	11.2568	1.1406	0.9520	0.0547	7.1329	1.4672	0.0056	0.0006	0.0005	0.0000	0.0036	0.0007	0.006	0.001	0.000	0.000	0.004	0.001	1.6	0.0001	0.0001
	Pickup Trucks	LDDT	40	3	120	1	0.6116	0.0288	0.0234	0.0015	1.6526	0.7267	0.0003	0.0000	0.0000	0.0000	0.0008	0.0004							0.1	0.0000	0.0000
Well Pad	Semi Trucks	HDDV	40	5	200	1	1.1975	0.1213	0.1013	0.0058	0.7588	0.1561	0.0006	0.0001	0.0001	0.0000	0.0004	0.0001	0.001	0.000	0.000	0.000	0.001	0.001	0.2	0.0000	0.0000
	Pickup Trucks	LDDT	40	4	160	1	0.8155	0.0383	0.0312	0.0020	2.2035	0.9690	0.0004	0.0000	0.0000	0.0000	0.0011	0.0005							0.1	0.0000	0.0000
Other Construction Activities	Semi Trucks	HDDV	40	2	80	1	0.4790	0.0485	0.0405	0.0023	0.3035	0.0624	0.0002	0.0000	0.0000	0.0000	0.0002	0.0000	0.001	0.000	0.000	0.000	0.001	0.000	0.1	0.0000	0.0000
	Haul Trucks	HDDV	40	2	80	1	0.4790	0.0485	0.0405	0.0023	0.3035	0.0624	0.0002	0.0000	0.0000	0.0000	0.0002	0.0000							0.1	0.0000	0.0000
	Pickup Trucks	LDDT	40	1	40	1	0.2039	0.0096	0.0078	0.0005	0.5509	0.2422	0.0001	0.0000	0.0000	0.0000	0.0003	0.0001							0.0	0.0000	0.0000
																		Subtotal	7.52E-03	7.18E-04	5.98E-04	3.46E-05	6.45E-03	1.84E-03	2.10E+00	9.21E-05	1.28E-04

Oil Wells - Alternatives A, B, C, and D

Combustive Emissions Estimation Road Traffic

Construction Site Destination	Vehicle Type	Vehicle Class	Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells	Emissions (lbs/vehicle type/well) NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	(tons/vehicle type/well) NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	(tons/well) NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	CO_2	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Semi Rig Transport, Drill Rig	HDDV	40	44	1760	1	10.5383	1.0678	0.8913	0.0512	6.6776	1.3735	0.0053	0.0005	0.0004	0.0000	0.0033	0.0007							1.5	0.0001	0.0001
	Fuel Haul Truck	HDDV	40	6	240	1	1.4370	0.1456	0.1215	0.0070	0.9106	0.1873	0.0007	0.0001	0.0001	0.0000	0.0005	0.0001							0.2	0.0000	0.0000
	Mud Haul Truck, Water Hauling	HDDV	40	4	160	1	0.9580	0.0971	0.0810	0.0047	0.6071	0.1249	0.0005	0.0000	0.0000	0.0000	0.0003	0.0001							0.1	0.0000	0.0000
	Rig Crew	LDDT	40	51	2040	1	10.3979	0.4989	0.3980	0.0252	28.0950	12.3542	0.0052	0.0002	0.0002	0.0000	0.0140	0.0062							0.9	0.0000	0.0001
	Rig Mechanics	HDDV	40	2	80	1	0.4790	0.0485	0.0405	0.0023	0.3035	0.0624	0.0002	0.0000	0.0000	0.0000	0.0002	0.0000	0.02	0.00	0.00	0.00	0.03	0.01	0.1	0.0000	0.0000
	Co. Supervisor	LDDT	40	20	800	1	4.0776	0.1917	0.1561	0.0099	11.0176	4.8448	0.0020	0.0001	0.0001	0.0000	0.0055	0.0024							0.4	0.0000	0.0000
	Tool Pusher	LDDT	40	8	320	1	1.6310	0.0767	0.0624	0.0040	4.4071	1.9379	0.0008	0.0000	0.0000	0.0000	0.0022	0.0010							0.1	0.0000	0.0000
	Mud Logger	LDDT	40	6	240	1	1.2233	0.0575	0.0468	0.0030	3.3053	1.4534	0.0006	0.0000	0.0000	0.0000	0.0017	0.0007							0.1	0.0000	0.0000
	Mud Engineer	LDDT	40	15	600	1	3.0582	0.1438	0.1171	0.0074	8.2632	3.6336	0.0015	0.0001	0.0001	0.0000	0.0041	0.0018							0.3	0.0000	0.0000
	Logger, Engr Truck	HDDV	40	1	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Drill Bit Delivery	LDDT	40	2	80	1	0.4078	0.0192	0.0156	0.0010	1.1018	0.4845	0.0002	0.0000	0.0000	0.0000	0.0006	0.0002							0.0	0.0000	0.0000
Well Completion & Testing	Semi Casing Haulers	HDDV	40	6	240	1	1.4370	0.1456	0.1215	0.0070	0.9106	0.1873	0.0007	0.0001	0.0001	0.0000	0.0005	0.0001							0.2	0.0000	0.0000
	Semi Completion, Unit Rig	HDDV	40	1	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Semi Fracing, Blender	HDDV	40	1	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Semi Pumping/Tank Battery	HDDV	40	6	240	1	1.4370	0.1456	0.1215	0.0070	0.9106	0.1873	0.0007	0.0001	0.0001	0.0000	0.0005	0.0001							0.2	0.0000	0.0000
	Tubing Truck	HDDV	40	2	80	1	0.4790	0.0485	0.0405	0.0023	0.3035	0.0624	0.0002	0.0000	0.0000	0.0000	0.0002	0.0000							0.1	0.0000	0.0000
	Haul Cementer, Pump Truck	HDDV	40	2	80	1	0.4790	0.0485	0.0405	0.0023	0.3035	0.0624	0.0002	0.0000	0.0000	0.0000	0.0002	0.0000							0.1	0.0000	0.0000
	Haul Cementer, Cement Truck	HDDV	40	3	120	1	0.7185	0.0728	0.0608	0.0035	0.4553	0.0937	0.0004	0.0000	0.0000	0.0000	0.0002	0.0000							0.1	0.0000	0.0000
	Haul Completion, Equip Truck	HDDV	40	3	120	1	0.7185	0.0728	0.0608	0.0035	0.4553	0.0937	0.0004	0.0000	0.0000	0.0000	0.0002	0.0000							0.1	0.0000	0.0000
	Haul Service Tools	LDDT	40	2	80	1	0.4078	0.0192	0.0156	0.0010	1.1018	0.4845	0.0002	0.0000	0.0000	0.0000	0.0006	0.0002							0.0	0.0000	0.0000
	Haul Perforators Logging Truck	HDDV	40	1	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Haul Anchor, Installation	HDDV	40	1	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Haul Anchor, Testing	HDDV	40	1	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Haul Fracing, Tank	HDDV	40	1	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Haul Fracing, Pump	HDDV	40	1	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Haul Fracing, Chemical	HDDV	40	1	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000	0.03	0.00	0.00	0.00	0.02	0.01	0.0	0.0000	0.0000
	Haul Fracing, Sand	HDDV	40	1	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Haul Fracing, Other	HDDV	40	1	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Haul Welders	HDDV	40	6	240	1	1.4370	0.1456	0.1215	0.0070	0.9106	0.1873	0.0007	0.0001	0.0001	0.0000	0.0005	0.0001							0.2	0.0000	0.0000
	Haul Water Truck	HDDV	40	150	6000	1	35.9259	3.6402	3.0384	0.1746	22.7646	4.6825	0.0180	0.0018	0.0015	0.0001	0.0114	0.0023							5.2	0.0002	0.0003
	Pickup Cementer, Engineer	LDDT	40	2	80	1	0.4078	0.0192	0.0156	0.0010	1.1018	0.4845	0.0002	0.0000	0.0000	0.0000	0.0006	0.0002							0.0	0.0000	0.0000
	Pickup Casing Crew	HDDV	40	2	80	1	0.4790	0.0485	0.0405	0.0023	0.3035	0.0624	0.0002	0.0000	0.0000	0.0000	0.0002	0.0000							0.1	0.0000	0.0000
	Pickup Completion Crew	HDDV	40	5	200	1	1.1975	0.1213	0.1013	0.0058	0.7588	0.1561	0.0006	0.0001	0.0001	0.0000	0.0004	0.0001							0.2	0.0000	0.0000
	Pickup Completion, Pusher	LDDT	40	5	200	1	1.0194	0.0479	0.0390	0.0025	2.7544	1.2112	0.0005	0.0000	0.0000	0.0000	0.0014	0.0006							0.1	0.0000	0.0000
	Pickup Perforators, Engineer	LDDT	40	2	80	1	0.4078	0.0192	0.0156	0.0010	1.1018	0.4845	0.0002	0.0000	0.0000	0.0000	0.0006	0.0002							0.0	0.0000	0.0000
	Pickup Fracing, Engineer	HDDV	40	1	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Pickup Co. Supervisor	LDDT	40	10	400	1	2.0388	0.0959	0.0780	0.0049	5.5088	2.4224	0.0010	0.0000	0.0000	0.0000	0.0028	0.0012							0.2	0.0000	0.0000
	Pickup Miscellaneous Supplies	LDDT	40	3	120	1	0.6116	0.0288	0.0234	0.0015	1.6526	0.7267	0.0003	0.0000	0.0000	0.0000	0.0008	0.0004							0.1	0.0000	0.0000
	Pickup Roustabout Crew	HDDV	40	4	160	1	0.9580	0.0971	0.0810	0.0047	0.6071	0.1249	0.0005	0.0000	0.0000	0.0000	0.0003	0.0001							0.1	0.0000	0.0000
																	Subtotal		**4.36E-02**	**3.72E-03**	**3.09E-03**	**1.81E-04**	**5.42E-02**	**1.93E-02**	**1.12E+01**	**4.30E-04**	**7.97E-04**
																	Total		**5.11E-02**	**4.44E-03**	**3.69E-03**	**2.15E-04**	**6.07E-02**	**2.11E-02**	**1.33E+01**	**5.22E-04**	**9.25E-04**

Oil Wells - Alternatives A, B, C, and D

Exhaust and Fugitive Dust Emissions from Well Work Overs (Federal)

Fugitive Dust from Heavy Equipment on Industrial Unpaved Roads

Emission Factors for Industrial Unpaved Roads [a]

E (lb/VMT) =	k (s/12)[a] (W/3)[b]
E_{ext} = E (1 - P/365)	

Parameter	PM_{10}	$PM_{2.5}$
k	1.5	0.15
a	0.9	0.9
b	0.45	0.45

Function/Variable Description	Assumed Value	Reference
E = size-specific emission factor (lb/VMT)		
E_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)		
s = surface material silt content (%)	34.6	Billings Field Office, Dustin Crowe email dated August 16, 2010.
W = mean vehicle weight (tons)	Listed in the table below	
M = surface material moisture content (%)	2.0	EPA AP-42 Section 13.2.2
P = Number of days precip per year	96.3	Billings, MT Climate Summary from 1961-1990, Western Regional Climate Center.
CE = control efficiency of gravel or scoria surfacing	84%	WRAP Fugitive Dust Handbook, September 2006.

[a] *Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2, Nov. 2006*

Assumption: Avg. Frequency & Duration: three days, once in the first year;
Equipment: Truck-mounted Unit: capacity **600 hp**, fuel **60 gpd**, hours/day **10**
Truck: Type **WO rig**, Round trip mileage: **6** miles on unpaved road
Max. number of crews in the field on a given day considering weekends and inclement weather: **15**

Fugitive Dust Estimations for Road Traffic

Activity	Vehicle Type	Avg. Vehicle Weight (tons)	Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells Drilled	PM_{10} Emission Factor (lb/VMT)	PM_{10} Emissions (lbs/well)	PM_{10} Emissions (tpy/ well)	$PM_{2.5}$ Emission Factor (lb/VMT)	$PM_{2.5}$ Emissions (lbs/ well)	$PM_{2.5}$ Emissions (tpy/ well)
Well Workover	WO Rig	42	6	1	6	1	1.50	9.02	0.00	0.15	0.90	0.00
	Haul Truck	42	6	1	6	1	1.50	9.02	0.00	0.15	0.90	0.00
	Pickup Truck	5	6	3	18	1	0.58	10.38	0.01	0.06	1.04	0.00
								Total	1.42E-02			1.42E-03

Number of wells is based on peak year applied to all project years (provides for a conservative estimate).

Exhaust Emissions from Well Work Overs

Emission Factors Bore/Drill Rig Engines 300-600 Hp

Fuel Type	Emission Factors (gm/hp-hr)								
	NO_x	PM_{10}	SO_x	CO	VOC	PM2.5	CO_2	CH_4	N_2O[a]
Diesel	0.30	0.02	0.11	2.60	0.14	0.02	529.58	0.007	0.006

Source: Tier 4 non-road diesel emission factors for non-SO2, non-GHG pollutants. EPA NONROADS 2008a (Year 2008) for CO2 and CH4.
[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Emission Estimations for Engines

Activity	Equipment Type	Capacity (hp)	# of Operating Hours/Day	# of Operating Days/Well	# of Operating Hours/Well	Total # of Wells Drilled	Max. Annual Emissions (lbs/well) NO_x	PM_{10}	SO_x	CO	VOC	Max. Annual Emissions (tpy/well) NO_x	PM_{10}	SO_x	CO	VOC	PM2.5	CO_2	CH_4	N_2O
Well Workover	Truck-Mounted Unit	600	10	3	30	1	12	1	5	103	6	5.95E-03	2.98E-04	2.26E-03	5.16E-02	2.78E-03	2.98E-04	1.05E+01	1.46E-04	1.20E-04

Exhaust emission factors for commuting vehicles

Vehicle Type	Vehicle Class	Emission Factors (g/mi) NO_x	PM_{10}[a,b]	$PM_{2.5}$[a,b]	SO_x[a]	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
Heavy-Duty Diesel Truck	HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.044

Source: MOBILE 6.2.03
Emission factors for 2008 used for all project years = conservative estimate of vehicle fleet turnover
[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Emission Estimations for Road Traffic

Activity	Vehicle Type	Vehicle Class	Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells Drilled	Max. Annual Emissions (lbs/well) NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	Max. Annual Emissions (tpy/well) NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Well Workover	WO Rig	HDDV	40	1	40	1	0.240	0.024	0.020	0.001	0.152	0.031	0.000	0.000	0.000	0.000	0.000	0.000	0.0349	0.0000	0.0000
	Haul Truck	HDDV	40	1	40	1	0.240	0.024	0.020	0.001	0.152	0.031	0.000	0.000	0.000	0.000	0.000	0.000	0.0349	0.0000	0.0000
	Pickup Truck	LDDT	40	3	120	1	0.612	0.029	0.023	0.001	1.653	0.727	0.000	0.000	0.000	0.000	0.001	0.000	0.0542	0.0000	0.0000
												Total	5.45E-04	3.86E-05	3.20E-05	1.90E-06	9.78E-04	3.95E-04	1.24E-01	3.53E-06	1.09E-05

Performed once in the first year of well operation
Number of wells is based on peak year applied to all project years (provides for a conservative estimate).

Oil Wells - Alternatives A, B, C, and D

Exhaust and Fugitive Dust Emissions from Well Work Overs (Non-Federal)

Fugitive Dust from Heavy Equipment on Industrial Unpaved Roads

Emission Factors for Industrial Unpaved Roads [a]

E (lb/VMT) =	k (s/12)^a (W/3)^b
E_{ext} = E (1 - P/365)	

Parameter	PM_{10}	$PM_{2.5}$
k	1.5	0.15
a	0.9	0.9
b	0.45	0.45

Function/Variable Description	Assumed Value	Reference
E = size-specific emission factor (lb/VMT)		
E_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)		
s = surface material silt content (%)	34.6	Billings Field Office, Dustin Crowe email dated August 16, 2010.
W = mean vehicle weight (tons)	Listed in the table below	
M = surface material moisture content (%)	2.0	EPA AP-42 Section 13.2.2
P = Number of days precip per year	96.3	Billings, MT Climate Summary from 1951-1990, Western Regional Climate Center.
CE = control efficiency of gravel or scoria surfacing	84%	WRAP Fugitive Dust Handbook, September 2006.

[a] *Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2, Nov. 2006*

Assumption: Avg. Frequency & Duration: three days, once in the first year;
Equipment: Truck-mounted Unit: capacity **600 hp**, fuel **60 gpd**, hours/day **10**
Truck: Type **WO rig**, Round trip mileage: **6** miles on unpaved road
Max. number of crews in the field on a given day
considering weekends and inclement weather: **15**

Fugitive Dust Estimations for Road Traffic

Activity	Vehicle Type	Avg. Vehicle Weight (tons)	Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells Drilled	PM_{10} Emission Factor (lb/VMT)	PM_{10} Emissions (lbs/well)	PM_{10} Emissions (tpy/well)	$PM_{2.5}$ Emission Factor (lb/VMT)	$PM_{2.5}$ Emissions (lbs/ well)	$PM_{2.5}$ Emissions (tpy/well)
Well Workover	WO Rig	42	6	1	6	1	1.50	9.02	0.00	0.15	0.90	0.00
	Haul Truck	42	6	1	6	1	1.50	9.02	0.00	0.15	0.90	0.00
	Pickup Truck	5	6	3	18	1	0.58	10.38	0.01	0.06	1.04	0.00
								Total	1.42E-02			1.42E-03

Number of wells is based on peak year applied to all project years (provides for a conservative estimate).

Exhaust Emissions from Well Work Overs

Emission Factors Bore/Drill Rig Engines 300-600 Hp

Fuel Type	Emission Factors (gm/hp-hr)								
	NO_x	PM_{10}	SO_x	CO	VOC	PM2.5	CO_2	CH_4	N_2O [a]
Diesel	6.69	0.38	0.11	2.25	0.48	0.37	529.58	0.007	0.006

Source: EPA NONROADS 2008a. Year 2008.

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Emission Estimations for Engines

Activity	Equipment Type	Capacity (hp)	# of Operating Hours/Day	# of Operating Days/Well	# of Operating Hours/Well	Total # of Wells Drilled	Max. Annual Emissions (lbs/well) NO_x	PM_{10}	SO_x	CO	VOC	(tpy/well) NO_x	PM_{10}	SO_x	CO	VOC	PM2.5	CO_2	CH_4	N_2O
Well Workover	Truck-Mounted Unit	600	10	3	30	1	266	15	5	89	19	1.33E-01	7.55E-03	2.26E-03	4.46E-02	9.61E-03	7.32E-03	1.05E+01	1.46E-04	1.20E-04

Exhaust emission factors for commuting vehicles

Vehicle Type	Class	Emission Factors (g/mi) NO_x	PM_{10} [a,b]	$PM_{2.5}$ [a,b]	SO_x [a]	CO	VOC	CO_2	CH_4	N_2O [a]
Light-Duty Diesel Truck	LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
Heavy-Duty Diesel Truck	HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.044

Source: MOBILE 6.2.03
Emission factors for 2008 used for all project years = conservative estimate of vehicle fleet turnover
[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Emission Estimations for Road Traffic

Activity	Vehicle Type	Class	Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells Drilled	Max. Annual Emissions (lbs/well) NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	(tpy/well) NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Well Workover	WO Rig	HDDV	40	1	40	1	0.240	0.024	0.020	0.001	0.152	0.031	0.000	0.000	0.000	0.000	0.000	0.000	0.0349	0.0000	0.0000
	Haul Truck	HDDV	40	1	40	1	0.240	0.024	0.020	0.001	0.152	0.031	0.000	0.000	0.000	0.000	0.000	0.000	0.0349	0.0000	0.0000
	Pickup Truck	LDDT	40	3	120	1	0.612	0.029	0.023	0.001	1.653	0.727	0.000	0.000	0.000	0.000	0.001	0.000	0.0542	0.0000	0.0000
												Total	5.45E-04	3.86E-05	3.20E-05	1.90E-06	9.78E-04	3.95E-04	1.24E-01	3.53E-06	1.09E-05

Performed once in the first year of well operation
Number of wells is based on peak year applied to all project years (provides for a conservative estimate).

Oil Wells - Alternatives A, B, C, and D

Fugitive Dust and Exhaust Emissions from Site Visits and Inspections

Fugitive Dust from Commuting Vehicles on Unpaved Roads

Emission Factors for Publicly Accessible Unpaved Roads[a]

$$E\ (lb/VMT) = \frac{k\ (s/12)^a\ (S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\ (1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
k	1.8	0.18
a	1	1
d	0.5	0.5
c	0.2	0.2

Function/Variable Description		Assumed Value	Reference
E = size-specific emission factor (lb/VMT)			
E_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)			
s = surface material silt content (%)		34.6	Billings Field Office, Dustin Crowe email dated August 13, 2010.
S = mean vehicle speed (mph)		Listed in the table below	
C = emission factor for 1980's vehicle fleet exhaust, brake wear, and tire wear (lb/VMT)	$PM_{2.5}$	0.00036	EPA AP-42 Section 13.2.2, Table 13.2.2-4
	PM_{10}	0.00047	EPA AP-42 Section 13.2.2, Table 13.2.2-4
M = surface material moisture content (%)		2.0	EPA AP-42 Section 13.2.2
P = Number of days precip per year		96.3	Billings, MT Climate Summary from 1961-1990, Western Regional Climate Center.
CE = control efficiency of gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

[a] *Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2, Nov. 2006*

Assumption:
Frequency of visit: once/week/well
Crew: **1** person and **1** light-duty truck
Av. number of wells served by a pumper per day **25**
Round trip mileage per day: 50 total/20 wells = **2.5** miles/well on unpaved road

Emission Estimations for Road Traffic - RMP Year 20

Activity	Vehicle Type[a]	Avg. Vehicle Speed (mph)	Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Federal Wells Producing	PM_{10}			$PM_{2.5}$		
							Emission Factor (lb/VMT)	Emissions (lbs/ well/ yr)	Emissions (tpy/ well)	Emission Factor (lb/VMT)	Emissions (lbs/ well/yr)	Emissions (tpy/ well)
Inspection Visits for Wells	Pickup Truck	40	2.5	52	130	1	0.53	69.54	**3.48E-02**	0.05	6.95	**3.47E-03**

Exhaust Emissions from Site Visits and Inspections

Emission factors for Commuting Vehicles Exhaust

Vehicle Class	Emission Factors (g/mi)								
	NO_x	PM_{10}[a,b]	$PM_{2.5}$[a,b]	SO_x[a]	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Gasoline Truck	1.13	0.03	0.01	0.01	23.97	1.07	476.9	0.07	0.18

Source: MOBILE 6.2.03

Emission factors for 2008 used for all years = conservative estimate for fleet vehicle turnover

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Emission Estimations for Road Traffic - RMP Year 20

Activity	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Federal Wells Producing	Emissions (lbs/well/yr)						Emissions (tpy/well)								
	Type	Class					NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Inspection Visits for Wells	Pickup Truck	LDGT2	2.5	52	130	1	0.32	0.01	0.00	0.00	6.87	0.31	**1.61E-04**	**3.63E-06**	**1.68E-06**	**1.26E-06**	**3.43E-03**	**1.53E-04**	**6.83E-02**	**9.74E-06**	**2.56E-05**

Oil Wells - Alternatives A, B, C, and D

Fugitive Dust and Exhaust Emissions from Heavy Equipment and Support Vehicles for Road Maintenance
Exhaust Emissions from Heavy Equipment and Support Vehicles for Road Maintenance

Given Data

Maintenance*	Equipment/Vehicle			Road Length Worked on/Day (miles)	# of Operating Hours/Day
	Type	Fuel	Capacity (hp)		
Summer	Heavy Equipment*	Diesel-30 gpd	135	6	10
	Commuting Vehicle	Gas-6 gpd	225	6	1*
Winter	Heavy Equipment*	Diesel-30 gpd	135	6	10
	Commuting Vehicle	Gas-6 gpd	225	6	1.5*

* Road maintenance would be made twice in summer and once in winter every year
* Assume a motor grader 135 hp.
* Assume three round trips per two days.

Estimation of Total and Cumulative Length of Roads for the Project - RMP Year 20

Length of Improved Roads per Well (miles)*	1.00
Number of Wells	1.00
Cumulative Length of Roads* (miles/operation)	1.00

* Source: SRES
* miles of road built per well * No. of operating wells/year

Estimation of Total Operation Days and Hours - RMP Year 20

Season	# of Operations per Season	Cumulative Length of Roads (miles/operation)	Road Length Worked On (mi/day)	# of Operating Hours per Day	Total # of Operating Days	Total # of Operating Hours
Summer	2	1	6	10	0.3	3
Winter	1	1	6	10	0.2	2
				Total	0.5	5

Emission Factors for Grading - Fugitive Dust

Pollutant	Emission Factor Equation (lb/VMT)	S* (mph)	Em. Factors (lb/VMT)
PM_{10}	$E = (0.6)(0.051)\ S^2$	5	0.766
$PM_{2.5}$	$E = (0.031)(0.04)\ S^{2.5}$	5	0.069

* S = mean vehicle speed (S), assume 5 mph for grading
Source: EPA AP-42, Section 11.9, Table 11.9-1, Oct 1998

Fugitive Dust Emission Estimations for Grader : RMP Year 20

Activity	Equipment	Total # of Operating Hours *	Mean Vehicle Speed (mph)	Total Miles Traveled	PM_{10}		$PM_{2.5}$	
					Emissions (lb/year)	Emissions (tpy)	Emissions (lb/year)	Emissions (tpy)
Road Maintenance	Grader	3	5	16	12.24	6.12E-03	1.11	5.55E-04

* Assume grader operates at 60% of the time (idling, loading, dumping, breaks, etc)

Emission Factors for Construction Equipment Exhaust

Equipment	Emission Factors (g/hp-hr)								
	NO_x	PM_{10}	SO_2	CO	VOC	PM2.5	CO_2	CH_4	N_2O*
Grader 100-175 Hp	4.34	0.34	0.12	1.51	0.35	0.33	535.77	0.0053	0.005

Source: EPA NONROADS 2008a
Use emission factors for 2008 for all project years - conservative estimate of vehicle turnover
* N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,800 Btu/gal(b), 2545 Btu/hp-hr.

Emission Estimations for Grader : RMP Year 20

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours*	Emissions													
				(lbs/activity/hr)					(tons/well)								
				NO_x	PM_{10}	SO_2	CO	VOC	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Road Maintenance	Grader	135	3	1.29	0.10	0.04	0.46	0.10	2.07E-03	1.62E-04	5.71E-05	7.19E-04	1.67E-04	1.57E-04	2.55E-01	2.52E-06	2.88E-06

* Assume grader operates at 60% of the time (idling, loading, dumping, breaks, etc)

Fugitive Dust from Commuting Vehicles on Unpaved Roads

Emission Factors for Publicly Accessible Unpaved Roads*

$$E\ (lb/VMT) = \frac{k(s/12)^a(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
k	1.8	0.18
a	1	1
d	0.5	0.5
c	0.2	0.2

Function/Variable Description		Assumed Value	Reference
E = size-specific emission factor (lb/VMT)			
E_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)			
s = surface material silt content (%)		34.6	Billings Field Office, Bus in Crowe email dated August 16, 2010.
S = mean vehicle speed (mph)		Listed in the table below	
C = emission factor for 1980's vehicle fleet exhaust, brake wear, and tire wear (lb/VMT)	$PM_{2.5}$	0.00036	EPA AP-42 Section 13.2.2, Table 13.2.2-4
	PM_{10}	0.00047	EPA AP-42 Section 13.2.2, Table 13.2.2-4
M = surface material moisture content (%)		2.0	EPA AP-42 Section 13.2.2
P = Number of days precip per year		96.3	Billings, MT Climate Summary from 1961-1990, Western Regional climate center.
CE = control efficiency of gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

* Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2, Nov. 2006

Emission Estimations for Road Traffic - RMP Year 20

Activity	Vehicle Type	Avg. Vehicle Speed (mph)	Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled (VMT/yr)	PM_{10}			$PM_{2.5}$		
						Emission Factor (lb/VMT)	Emissions		Emission Factor (lb/VMT)	Emissions	
							(lbs/yr)	(tpy)		(lbs/yr)	(tpy)
Road Maintenance	Pickup Truck	40	40	1.0	40	0.53	21.40	1.07E-02	0.05	2.14	1.07E-03

Emission Factors for Commuting Vehicles Exhaust

Vehicle Class	Emission Factors (g/mi)								
	NO_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O*
Light-Duty Diesel Truck	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053

Source: MOBILE 6.2.03

* Compendium of Greenhouse Gas Emission Methodologies for the Oil and Gas Industry, Table 4-17 for N2O (HDDV moderate control, LDGT oxidation catalyst, LDDT moderate control) ,Mobile Source Combustion Factors, American Petroleum Institute (2009).

Emission Estimations for Road Traffic - RMP Year 20

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled (VMT/yr)	Emissions (tpy)									
	Type	Class				NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	CO_2	CH_4	N_2O
Road Maintenance	Pickup Truck	LDDT	40	1.0	40	1.02E-04	4.79E-06	3.90E-06	2.47E-07	2.75E-04	1.21E-04	1.81E-02	8.82E-08	2.34E-06

Oil Wells - Alternatives A, B, C, and D

Water Tank and Hauling Emissions

Oil Well Water Tank Flashing Emissions

Project Year	Flashing Loss Emission Factor (lbs CH_4 / 1000 bbl of water) [a]	Water Production (bbl/year/well)	CH4 Emissions (tpy/well)
All	31.31	7300	**1.14E-01**

[a] Average Conditions for Table 5-10 of the API Compedium of GHG Emissions Methodologies for the Oil and Gas Industry, August 2009.

Emission Factors for Road Traffic

$$E\ (lb/VMT) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
k	1.8	0.18
a	1	1
d	0.5	0.5
c	0.2	0.2

Function/Variable Description		Assumed Value	Reference
E = size-specific emission factor (lb/VMT)			
E_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)			
s = surface material silt content (%)		34.6	Billings Field Office, Dustin Crowe email dated August 16, 2010.
S = mean vehicle speed (mph)		Listed in the table below	
C = emission factor for 1980's vehicle fleet exhaust, brake wear, and tire wear (lb/VMT)	$PM_{2.5}$	0.00036	EPA AP-42 Section 13.2.2, Table 13.2.2-4
	PM_{10}	0.00047	EPA AP-42 Section 13.2.2, Table 13.2.2-4
M = surface material moisture content (%)		2.0	EPA AP-42 Section 13.2.2
P = Number of days precip per year		96.3	Billings, MT Climate Summary from 1961-1990, Western Regional Climate Center.
CE = control efficiency of gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

[a] *Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2, Nov. 2006*

Fugitive Dust Emission Estimations for Road Traffic - Based on Water Produced Per Barrel of Oil

Activity	Vehicle Type	Avg. Vehicle Speed (mph)	Round Trip Distance (miles)	Annual # of Round Trips/Well	Miles Traveled/Well	Total # of Wells	PM_{10}			$PM_{2.5}$		
							Emission Factor (lb/VMT)	Emissions (lb/year/well)	Emissions (tpy/well)	Emission Factor (lb/VMT)	Emissions (lb/year/well)	Emissions (tpy/well)
Produced Water Hauling	Haul Truck (130 bbl)	30	6	56	337	1	0.46	156.07	**7.80E-02**	0.05	15.59	**7.80E-03**

Assume no dust control measures (watering) would be used

Emission Factors for Water Transport Vehicles - Road Traffic

Vehicle Class	Emission Factors (g/mi)								
	NO_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O[a]
Heavy-Duty Diesel Truck (HDDV)	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.006

Source: MOBILE6.2.03

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

On-Road Exhaust Emission Estimations for Road Traffic - Based on Water Produced Per Barrel of Oil

Activity	Vehicle		Round Trip Distance (miles)	Annual # of Round Trips/Well	Miles Traveled/Well	Total # of Wells	Emissions (lbs/well/yr)						Emissions (tpy/well)								
	Type	Class					NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Produced Water Hauling	Haul Truck (130 bbl)	HDDV	40	56	2246	1	13.449	1.363	1.137	0.065	8.522	1.753	**6.72E-03**	**6.81E-04**	**5.69E-04**	**3.27E-05**	**4.26E-03**	**8.76E-04**	**1.96E+00**	**9.16E-05**	**1.50E-05**

Oil Wells - Alternatives A, B, C, and D

Oil Tank, Loadout and Hauling Emissions

Oil Well Oil Seperator Flashing and Tank Emissions [a]

Project Year	Emissions[b]			
	HAPs Emissions (tpy/well)	VOC Emissions (tpy/well)	CO2 Emissions (tpy/well)	CH4 Emissions (tpy/well)
All	1.77E-01	3.18E+00	1.82E-01	4.03E-01

[a] Based on average of data from Montana BLM (Laakso, 2010) and calculations using E&P Tanks, July, 2010. Assumes 20 BOPD per well.
[b] Assumes submerged filling with no other emissions control.

Oil Well Oil Truck Loadout VOC Emissions

Emissions were estimated based on EPA, AP-42 Section 5.2.2.1.1 Equation 1

$$L_L = 12.46 \frac{SPM}{T}$$

L_L = Loading Loss pounds per 1000 gallons (lb/10^3gal) of liquid loaded
S = a saturation factor
P = true vapor pressure of liquid loaded, pounds per square inch absolute (psia)
M = molecular weight of vapors, pounds per pounds-mole (lb/lb-mole)
T = temperature of bulk liquid loaded (F+460)

S =	0.6	from EPA, AP-42 Section Table 5.2-1
P =	3.4	from EPA, AP-42 Section Table 7.2-1
M =	50	from EPA, AP-42 Section Table 7.2-1
T =	540	ave. temp.
L_L =	2.35	

Oil Well Oil Truck Loadout Emissions - All Project Years [a]

Project Year	Emission Factor (lbs/1,000 gallons)	Annual Oil Volume (bbl) - per well	Oil (1,000 gallons)	VOC Emissions (tpy/well)	CO_2 Emissions (tpy/well)	CH_4 Emissions (tpy/well)	HAPs Emissions (tpy/well)
All	2.35	7,300	307	3.61E-01	6.47E-04	1.05E-07	2.68E-02

[a] Uses E&P Tanks Stream Data for W&S Gas mol % (shown below). E&P Tanks input data from Montana BLM (Laakso, 2010)

Emission Factors for Work Over Vehicles - Road Traffic

Vehicle Class	Emission Factors (g/mi)								
	NO_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O[a]
Heavy-Duty Diesel Truck (HDDV)	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.006

Source: MOBILE6.2.03
[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

On-Road Exhaust Emission Estimations for Road Traffic - Based on Produced Per Barrel of Oil

Activity	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well	Miles Traveled/Well	Total # of Wells	Emissions														
							(lb/well)						(tpy/well)								
	Type	Class					NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Produced Oil Hauling	Haul Truck (200 bbl)	HDDV	40	37	1460	1	8.742	0.886	0.739	0.042	5.539	1.139	0.0044	0.0004	0.0004	0.0000	0.0028	0.0006	1.274	0.000	0.000
						TOTAL							4.37E-03	4.43E-04	3.70E-04	2.12E-05	2.77E-03	5.70E-04	1.27E+00	5.95E-05	9.74E-06

W&S Composition for Truck Load Out Emissions

W&S Gas Component	Mole Fraction[a] (%)	Molecular Weight (lb/lb-mole)	Gas Weight (lb/lb-mole)	Weight Percent (wt%)
Methane	0.000	16.040	0.000	0.000
Ethane	4.732	30.070	1.423	2.476
Nitrogen	0.000	28.020	0.000	0.000
Water	0.000	18.015	0.000	0.000
Carbon Dioxide	0.224	43.990	0.098	0.171
Nitrous Oxide	0.000	44.020	0.000	0.000
Hydrogen Sulfide	1.018	34.060	0.347	0.603
Non-reactive, non-HA	5.974	---	1.868	3.250
Propane	27.635	44.100	12.187	21.203
Iso-butane	10.353	58.120	6.017	10.468
n-butane	25.191	58.120	14.641	25.473
i-pentane	8.741	72.150	6.307	10.972
n-pentane	9.278	72.150	6.694	11.647
Hexanes	3.874	100.210	3.882	6.754
Heptanes	2.680	100.200	2.685	4.671
Octanes	1.820	114.230	2.079	3.616
Nonanes	0.302	128.258	0.388	0.675
Decanes+	0.000	142.29	0.000	0.000
Reactive VOC	89.873	---	54.879	95.481
Benzene	0.325	78.110	0.254	0.441
Ethylbenzene	0.011	106.160	0.012	0.021
n-Hexane	3.334	100.210	3.341	5.813
Toluene	0.350	92.130	0.322	0.560
Xylenes	0.133	106.160	0.141	0.246
HAPs	4.153	---	4.070	7.082
Totals	**100.000**	---	**57.476**	**100.000**

[a] E&P Tanks Stream Data for W&S Gas mol %. E&P Tanks input data from Montana BLM (Laakso, 2010)

Oil Wells - Alternatives A, B, C, and D

Fugitive Dust Emissions from Recompletion Support Vehicles

Emission Factors for Industrial Unpaved Roads [a]

		Parameter	PM_{10}	$PM_{2.5}$
E (lb/VMT) =	$k (s/12)^a (W/3)^b$	k	1.5	0.15
		a	0.9	0.9
		b	0.45	0.45
E_{ext} = E (1 - P/365)				

Function/Variable Description	Assumed Value	Reference
E = size-specific emission factor (lb/VMT)		
E_{ext} = size-specific emission factor extrapolated for natural		
s = surface material silt content (%)	34.6	Billings Field Office, Dustin Crowe email dated August 16, 2010.
W = mean vehicle weight (tons)	Listed in the table below	
M = surface material moisture content (%)	2.0	EPA AP-42 Section 13.2.2
P = Number of days precip per year	96.3	Billings, MT Climate Summary from 1961-1990, Western Regional Climate Center.
CE = control efficiency of gravel or scoria surfacing	84%	WRAP Fugitive Dust Handbook, September 2006.

[a] *Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2, Nov. 2006*

Fugitive Dust Emission Estimations for Road Traffic

Construction Site Destination	Vehicle Type	Avg. Vehicle Weight (tons)	Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells	PM_{10} Controlled Em. Factor (lb/VMT)	PM_{10} Emissions (lbs/vehicle/well)	PM_{10} Emissions (tpy/well)	PM_{10} Emissions (tons/well)	$PM_{2.5}$ Controlled Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions (lbs/vehicle/well)	$PM_{2.5}$ Emissions (tons/year/well)	$PM_{2.5}$ Emissions (tons/well)
Well Recompletion	Fuel Haul Truck	25	6	6	36	1	1.19	42.83	0.02	0.49	0.12	4.28	0.00	0.05
	Mud Haul Truck, Water Hauling	25	6	4	24	1	1.19	28.55	0.01		0.12	2.86	0.00	
	Rig Crew	5	6	51	306	1	0.58	176.46	0.09		0.06	17.65	0.01	
	Rig Mechanics	5	6	1	6	1	0.58	3.46	0.00		0.06	0.35	0.00	
	Co. Supervisor	5	6	20	120	1	0.58	69.20	0.03		0.06	6.92	0.00	
	Semi Completion, Unit Rig	42	6	1	6	1	1.50	9.02	0.00		0.15	0.90	0.00	
	Semi Fracing, Blender	25	6	1	6	1	1.19	7.14	0.00		0.12	0.71	0.00	
	Semi Pumping/Tank Battery	25	6	6	36	1	1.19	42.83	0.02		0.12	4.28	0.00	
	Tubing Truck	25	6	2	12	1	1.19	14.28	0.01		0.12	1.43	0.00	
	Haul Cementer, Pump Truck	25	6	2	12	1	1.19	14.28	0.01		0.12	1.43	0.00	
	Haul Cementer, Cement Truck	25	6	3	18	1	1.19	21.42	0.01		0.12	2.14	0.00	
	Haul Completion,	25	6	3	18	1	1.19	21.42	0.01		0.12	2.14	0.00	
	Haul Service Tools	25	6	2	12	1	1.19	14.28	0.01		0.12	1.43	0.00	
	Haul Perforators Logging Truck	25	6	1	6	1	1.19	7.14	0.00		0.12	0.71	0.00	
	Haul Fracing, Tank	25	6	1	6	1	1.19	7.14	0.00		0.12	0.71	0.00	
	Haul Fracing, Pump	25	6	1	6	1	1.19	7.14	0.00		0.12	0.71	0.00	
	Haul Fracing, Chemical	25	6	1	6	1	1.19	7.14	0.00		0.12	0.71	0.00	
	Haul Fracing, Sand	25	6	1	6	1	1.19	7.14	0.00		0.12	0.71	0.00	
	Haul Fracing, Other	25	6	1	6	1	1.19	7.14	0.00		0.12	0.71	0.00	
	Haul Water Truck	25	6	50	300	1	1.19	356.93	0.18		0.12	35.69	0.02	
	Pickup Cementer, Engineer	5	6	2	12	1	0.58	6.92	0.00		0.06	0.69	0.00	
	Pickup Casing Crew	5	6	5	30	1	0.58	17.30	0.01		0.06	1.73	0.00	
	Pickup Completion, Pusher	5	6	5	30	1	0.58	17.30	0.01		0.06	1.73	0.00	
	Pickup Perforators, Engineer	5	6	2	12	1	0.58	6.92	0.00		0.06	0.69	0.00	
	Pickup Fracing, Engineer	5	6	1	6	1	0.58	3.46	0.00		0.06	0.35	0.00	
	Pickup Co. Supervisor	5	6	10	60	1	0.58	34.60	0.02		0.06	3.46	0.00	
	Pickup Miscellaneous Supplies	5	6	3	18	1	0.58	10.38	0.01		0.06	1.04	0.00	
	Pickup Roustabout Crew	5	6	4	24	1	0.58	13.84	0.01		0.06	1.38	0.00	
									Subtotal	**4.88E-01**				**4.88E-02**
									Total	**4.88E-01**				**4.88E-02**

Number of wells is based on peak year applied to all project years (provides for a conservative estimate).

Oil Wells - Alternatives A, B, C, and D

Exhaust Emissions from Recompletion Support Vehicles

Emission Factors for Commuting Vehicles

Vehicle		Emission Factors (g/mi)								
Type	Class	NO_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
Heavy-Duty Diesel Truck	HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.044

Source: MOBILE6.2.03

[a]N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emissions Estimation Road Traffic

Construction Site Destination	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells	Emissions																				
							(lbs/vehicle type/well)						(tons/vehicle type/well)						(tons/well)								
	Type	Class					NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	CO_2	CH_4	N_2O
Well Recompletion	Fuel Haul Truck	HDDV	40	6	240	1	1.4370	0.1456	0.1215	0.0070	0.9106	0.1873	0.0007	0.0001	0.0001	0.0000	0.0005	0.0001							0.2	0.0000	0.0000
	Mud Haul Truck, Water Hauling	HDDV	40	4	160	1	0.9580	0.0971	0.0810	0.0047	0.6071	0.1249	0.0005	0.0000	0.0000	0.0000	0.0003	0.0001							0.1	0.0000	0.0000
	Rig Crew	LDDT	40	51	2040	1	10.3979	0.4889	0.3980	0.0252	29.0950	12.3542	0.0052	0.0002	0.0002	0.0000	0.0140	0.0062							0.9	0.0000	0.0001
	Rig Mechanics	HDDV	40	1	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Co. Supervisor	LDDT	40	20	800	1	4.0776	0.1917	0.1561	0.0099	11.0176	4.8448	0.0020	0.0001	0.0001	0.0000	0.0055	0.0024							0.4	0.0000	0.0000
	Semi Completion, Unit Rig	HDDV	40	1	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Semi Fracing, Blender	HDDV	40	1	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Semi Pumping/Tank Battery	HDDV	40	6	240	1	1.4370	0.1456	0.1215	0.0070	0.9106	0.1873	0.0007	0.0001	0.0001	0.0000	0.0005	0.0001							0.2	0.0000	0.0000
	Tubing Truck	HDDV	40	2	80	1	0.4790	0.0485	0.0405	0.0023	0.3035	0.0624	0.0002	0.0000	0.0000	0.0000	0.0002	0.0000							0.1	0.0000	0.0000
	Haul Cementer, Pump Truck	HDDV	40	2	80	1	0.4790	0.0485	0.0405	0.0023	0.3035	0.0624	0.0002	0.0000	0.0000	0.0000	0.0002	0.0000							0.1	0.0000	0.0000
	Haul Cementer, Cement Truck	HDDV	40	3	120	1	0.7185	0.0728	0.0608	0.0035	0.4553	0.0937	0.0004	0.0000	0.0000	0.0000	0.0002	0.0000							0.1	0.0000	0.0000
	Haul Completion, Equip Truck	HDDV	40	3	120	1	0.7185	0.0728	0.0608	0.0035	0.4553	0.0937	0.0004	0.0000	0.0000	0.0000	0.0002	0.0000							0.1	0.0000	0.0000
	Haul Service Tools	LDDT	40	2	80	1	0.4078	0.0192	0.0156	0.0010	1.1018	0.4845	0.0002	0.0000	0.0000	0.0000	0.0006	0.0002							0.0	0.0000	0.0000
	Haul Perforators Logging Truck	HDDV	40	1	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Haul Fracing, Tank	HDDV	40	1	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000	0.02	0.00	0.00	0.00	0.03	0.01	0.0	0.0000	0.0000
	Haul Fracing, Pump	HDDV	40	1	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Haul Fracing, Chemical	HDDV	40	1	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Haul Fracing, Sand	HDDV	40	1	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Haul Fracing, Other	HDDV	40	1	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Haul Water Truck	HDDV	40	50	2000	1	11.9753	1.2134	1.0128	0.0582	7.5882	1.5608	0.0060	0.0006	0.0005	0.0000	0.0038	0.0008							1.7	0.0001	0.0001
	Pickup Cementer, Engineer	LDDT	40	2	80	1	0.4078	0.0192	0.0156	0.0010	1.1018	0.4845	0.0002	0.0000	0.0000	0.0000	0.0006	0.0002							0.0	0.0000	0.0000
	Pickup Completion Crew	HDDV	40	5	200	1	1.1975	0.1213	0.1013	0.0058	0.7588	0.1561	0.0006	0.0001	0.0001	0.0000	0.0004	0.0001							0.2	0.0000	0.0000
	Pickup Completion, Pusher	LDDT	40	5	200	1	1.0194	0.0479	0.0390	0.0025	2.7544	1.2112	0.0005	0.0000	0.0000	0.0000	0.0014	0.0006							0.1	0.0000	0.0000
	Pickup Perforators, Engineer	LDDT	40	2	80	1	0.4078	0.0192	0.0156	0.0010	1.1018	0.4845	0.0002	0.0000	0.0000	0.0000	0.0006	0.0002							0.0	0.0000	0.0000
	Pickup Fracing, Engineer	HDDV	40	1	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Pickup Co. Supervisor	LDDT	40	10	400	1	2.0388	0.0959	0.0780	0.0049	5.5088	2.4224	0.0010	0.0000	0.0000	0.0000	0.0028	0.0012							0.2	0.0000	0.0000
	Pickup Miscellaneous Supplies	LDDT	40	3	120	1	0.6116	0.0288	0.0234	0.0015	1.6526	0.7267	0.0003	0.0000	0.0000	0.0000	0.0008	0.0004							0.1	0.0000	0.0000
	Pickup Roustabout Crew	HDDV	40	4	160	1	0.9580	0.0971	0.0810	0.0047	0.6071	0.1249	0.0005	0.0000	0.0000	0.0000	0.0003	0.0001							0.1	0.0000	0.0000
																	Subtotal		2.11E-02	1.61E-03	1.33E-03	7.87E-05	3.34E-02	1.30E-02	5.03E+00	1.63E-04	4.08E-04
																	Total		2.11E-02	1.61E-03	1.33E-03	7.87E-05	3.34E-02	1.30E-02	5.03E+00	1.63E-04	4.08E-04

Oil Wells - Alternatives A, B, C, and D

Venting Emissions from Well Completion Activities (applied to all wells drilled)

Gas Component	Mole Fraction	Molecular Weight	Gas Weight	Weight Percent	Weight	Emissions Mass Flow
	(%)	(lb/lb-mol)	(lb/lb-mol)	(wt%)	(lb/MMscf))	(ton/well)
Methane	65.450	16.040	10.498	42.544	18064.029	0.488
Ethane	15.330	30.070	4.610	18.681	7931.881	0.214
Nitrogen	3.260	28.020	0.913	3.702	1571.760	0.042
Water	0.000	18.015	0.000	0.000	0.000	0.000
Carbon Dioxide	0.620	43.990	0.273	1.105	469.295	0.013
Nitrous Oxide	0.000	44.020	0.000	0.000	0.000	0.000
Hydrogen Sulfide	0.000	34.060	0.000	0.000	0.000	0.000
Non-reactive, non-HAP	84.660	---	16.294	66.031		0.757
Propane	7.890	44.100	3.479	14.101	5987.096	0.162
Iso-butane	1.370	58.120	0.796	3.227	1370.083	0.037
n-butane	3.360	58.120	1.953	7.914	3360.203	0.091
i-pentane	1.000	72.150	0.722	2.924	1241.472	0.034
n-pentane	1.040	72.150	0.750	3.041	1291.131	0.035
Hexanes	0.680	100.210	0.681	2.761	1172.521	0.032
Heptanes	0.000	100.200	0.000	0.001	0.529	0.000
Octanes	0.000	114.230	0.000	0.000	0.000	0.000
Nonanes	0.000	128.258	0.000	0.000	0.000	0.000
Decanes+	0.000	142.29	0.000	0.000	0.000	0.000
Reactive VOC	15.340	---	8.382	33.969		0.389
Benzene	0.000	78.110	0.000	0.000	0.000	0.000
Ethylbenzene	0.000	106.160	0.000	0.000	0.000	0.000
n-Hexane [3]	*0.680*	*100.210*	*0.681*	*2.761*	*1172.521*	*0.032*
Toluene	0.000	92.130	0.000	0.000	0.000	0.000
Xylenes	0.000	106.160	0.000	0.000	0.000	0.000
HAPs	0.680	---	0.681	2.761		0.032
Totals	**100.000**	**---**	**24.676**	**100.000**		**1.146**

Oil well natural gas analysis for Formation: Madison, Lease: Berry 11-4

Volume Flow:	900 SCF / bbl oil
BBL oil / day:	20 bbl oil / day
Completion activity duration:	3 days
Total Completion/Recompletion Volume Flow per Well	0.054 MMSCF/well

Assume: Gas density is 0.04246 lb/scf (19.26 g/scf).

Venting Emissions from Well Re-Completion Activities (applied to 5% of operating wells)

Gas Component	Mole Fraction	Molecular Weight	Gas Weight	Weight Percent	Weight	Emissions Mass Flow
	(%)	(lb/lb-mol)	(lb/lb-mol)	(wt%)	(lb/MMscf))	(ton/well)
Methane	65.450	16.040	10.498	42.544	18064.029	0.488
Ethane	15.330	30.070	4.610	18.681	7931.881	0.214
Nitrogen	3.260	28.020	0.913	3.702	1571.760	0.042
Water	0.000	18.015	0.000	0.000	0.000	0.000
Carbon Dioxide	0.620	43.990	0.273	1.105	469.295	0.013
Nitrous Oxide	0.000	44.020	0.000	0.000	0.000	0.000
Hydrogen Sulfide	0.000	34.060	0.000	0.000	0.000	0.000
Non-reactive, non-HAP	84.660	---	16.294	66.031		0.757
Propane	7.890	44.100	3.479	14.101	5987.096	0.162
Iso-butane	1.370	58.120	0.796	3.227	1370.083	0.037
n-butane	3.360	58.120	1.953	7.914	3360.203	0.091
i-pentane	1.000	72.150	0.722	2.924	1241.472	0.034
n-pentane	1.040	72.150	0.750	3.041	1291.131	0.035
Hexanes	0.680	100.210	0.681	2.761	1172.521	0.032
Heptanes	0.000	100.200	0.000	0.001	0.529	0.000
Octanes	0.000	114.230	0.000	0.000	0.000	0.000
Nonanes	0.000	128.258	0.000	0.000	0.000	0.000
Decanes+	0.000	142.29	0.000	0.000	0.000	0.000
Reactive VOC	15.340	---	8.382	33.969		0.389
Benzene	0.000	78.110	0.000	0.000	0.000	0.000
Ethylbenzene	0.000	106.160	0.000	0.000	0.000	0.000
n-Hexane [3]	*0.680*	*100.210*	*0.681*	*2.761*	*1172.521*	*0.032*
Toluene	0.000	92.130	0.000	0.000	0.000	0.000
Xylenes	0.000	106.160	0.000	0.000	0.000	0.000
HAPs	0.680	---	0.681	2.761		0.032
Totals	**100.000**	**---**	**24.676**	**100.000**		**1.146**

Oil Wells - Alternatives A, B, C, and D

Compressor Stations Emissions

Emission Factors for Natural Gas-Fired Compressors and Pumps

Compressor / Pump		Horse-Power Rating	Units	Emission Factors									
				NO_x[a]	PM_{10}[b]	SO_2[b]	CO[a]	VOC[a]	$PM_{2.5}$[b]	CO_2[c]	CH_4[c]	HCHO[b]	N_2O[c]
Compression Station	Lean Burn	300	gm/bhp-hr	1.00	0.044	0.001	2.00	0.70	0.044	134.9	2.5E-03	0.064	2.55E-04
			lb/MMBTU		3.84E-02	5.88E-04			3.84E-02	116.9	2.2E-03	5.52E-02	2.20E-04
Oil Pump at Well Head	Lean Burn	40	gm/bhp-hr	1.00	0.044	0.001	2.00	0.70	0.044	134.9	0.003	0.064	2.55E-04
			lb/MMBTU		3.84E-02	5.88E-04			3.84E-02	116.9	2.20E-03	5.52E-02	2.20E-04

[a] Source: assume compressors will comply with NSPS 40 CFR part 60 subpart JJJJ
[b] Source: EPA, AP-42 Section 3.2 Natural Gas Fired Reciprocating Engines
Note: Compressors assumed to be equipped with nonselective catalytic reduction (NSCR) catalyst.
[c] EPA Mandatory GHG Reporting, Part 98, Subpart C, Tables C-1 and C-2.

Emission Estimations for Compressors and Pumps - All Years

Type of Compressors / Pumps	Rate (Hp/well)	Annual # of Wells in Production	Annual Compression (Hp)	Operating Hours/Year	Emissions (tpy/well)									
					NOx	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	HCHO	N_2O
Compression Station	7.5	1.00	7.5	8,760	0.07	0.00	0.00	0.14	0.05	0.00	9.8	0.00	0.00	0.00
Oil Pump at Well Head	40	1.00	40	8,760	0.39	0.02	0.00	0.77	0.27	0.02	52.1	0.00	0.02	0.00
				Total	**4.59E-01**	**2.03E-02**	**3.11E-04**	**9.17E-01**	**3.21E-01**	**2.03E-02**	**6.19E+01**	**1.17E-03**	**2.92E-02**	**1.17E-04**

HCHO = Formaldehyde
Compression rate of 5 compressors (300 hp each) per 200 wells based on BLM survey (Laakso, 2010)
Typical oil well head pump of 40 hp per BLM survey (Laakso, 2010)

Compressor Station Fugitives

Fugitive Emissions from Equipment Leaks

Well Equipment Component	TOC Emission Factor							
	Gas		Light Oil >20º API		Heavy Oil <20º API		Water/Oil	
	(kg/hr)	(lb/hr)	(kg/hr)	(lb/hr)	(kg/hr)	(lb/hr)	(kg/hr)	(lb/hr)
valves	4.50E-03	9.92E-03	2.50E-03	5.51E-03	8.40E-06	1.85E-05	9.80E-05	2.16E-04
pump seals	2.40E-03	5.29E-03	1.30E-02	2.87E-02	3.20E-05	7.05E-05	2.40E-05	5.29E-05
others	8.80E-03	1.94E-02	7.50E-03	1.65E-02	3.20E-05	7.05E-05	1.40E-02	3.09E-02
connectors	2.00E-04	4.41E-04	2.10E-04	4.63E-04	7.50E-06	1.65E-05	1.10E-04	2.43E-04
flanges	3.90E-04	8.60E-04	1.10E-04	2.43E-04	3.90E-07	8.60E-07	2.90E-06	6.39E-06
open-ended lines	2.00E-03	4.41E-03	1.40E-03	3.09E-03	1.40E-04	3.09E-04	2.50E-04	5.51E-04

Source: EPA-453/R-95-017 Protocol for Equipment Leak Emission Estimates, November 1995
Table 2-4 , Oil and Gas Production Operations Average Estimation Factors
"Other" category includes compressor seals, pressure relief valves, diaphragms, drains, dump arms, hatches, instruments, meters, polished rods and vents

From Montana BLM provided NG analysis

VOC Wt% =	33.97
CO2 Wt% =	1.11
CH4 Wt% =	42.54
N2O Wt% =	0.00

Oil Wells - Alternatives A, B, C, and D

Emissions from Equipment Leaks at Compressor Station per Well

component	Ave. # in Gas Service	Emission factor (lb/hr)	Ave. # in Liquid service	Emission factor (lb/hr)	Ave. # in Water/Oil Service	Emission factor (lb/hr)	TOC emissions per well (lb/hr)	VOC emissions per well (lb/hr)	CO_2 emissions per well (lb/hr)	CH_4 emissions per well (lb/hr)
valves	0.175	0.0099	0	0.0055	0	0.0002	0.002	0.001	0.000	0.001
pump seals	0.000	0.0053	0	0.0287	0	0.0001	0.000	0.000	0.000	0.000
others	0.000	0.0194	0	0.0165	0	0.0309	0.000	0.000	0.000	0.000
connectors	0.250	0.0004	0	0.0005	0	0.0002	0.000	0.000	0.000	0.000
flanges	0.600	0.0009	0	0.0002	0	0.0000	0.001	0.000	0.000	0.000
open-ended lines	0.000	0.0044	0	0.0031	0	0.0006	0.000	0.000	0.000	0.000
						TOTAL emissions/well/hr =	0.002	0.001	0.000	0.001

Number of components provided by Montana BLM FO personnel (Laakso, 2010)

Annual Emissions from Equipment Leaks Per Well								
Year	**Number of Producing Wells**	**Operating Hours**	**VOC emissions (lb/yr)**	**VOC emissions (tpy)**	**CO_2 emissions (lb/yr)**	**CO2 emissions (tpy)**	**CH_4 emissions (lb/yr)**	**CH4 emissions (tpy)**
Year 20	1	8760	7.03	**3.51E-03**	0.23	**1.14E-04**	8.80	**4.40E-03**

Oil Wells - Alternatives A, B, C, and D

Emission Factors for Industrial Wind Erosion

E (tpy) = $k * \frac{P * M * N}{453.6 * 2000}$ AP-42 Section 13.2.5.3 Equation 2

Erosion Potential P (g/m2/year) = $58(U^*-Ut^*)^2 + 25(U^*-Ut^*)$ for U*>Ut*; F AP-42 Section 13.2.5.3 Equation 3

Friction Velocity U* (m/s) = $0.053\ U_{10}^*$ AP-42 Section 13.2.5.3 Equation 4

P = Erosion Potential ($gm/m^2/yr$) M = Disturbed area (m^2)
U* = Friction velocity (m/s) N = # of disturbances
U_t = threshold velocity (m/s) k = 0.5 for PM_{10}
U10 = fastest wind speed (m/s) k = 0.075 for $PM_{2.5}$

U_{10} = 26.08 58.33 average fastest (mph) for Billings, Montana (1939-1987) from http://www.itl.nist.gov/div898/winds/nondirectional.htm
U_t well pads = 1.33 AP-42 Industrial Wind Erosion Table 13.2.5-2, Scoria
U_t roads/pipelines = 1.33 AP-42 Industrial Wind Erosion Table 13.2.5-2, Roadbed material

Construction Wind Erosion Emissions - Based on Peak Wells Drilled each Alternative

	Fastest Mile (U_{10}) (m/s)	Max. Friction Velocity (U*) (m/s)	Well Erosion Potential (P) ($g/m^2/yr$)	Road Erosion Potential (P) ($g/m^2/yr$)	Peak # of Wells Drilled per year	Average Disturbed acres per well [a]	Disturbed Area (M) (m^2)	Number of Disturbances (N)	PM10 Emissions (tpy/well)	PM2.5 Emissions (tpy/well)
Well pad construction	26.08	1.38	1.46		1.00	3.00	12144.98	1.00	9.76E-03	1.46E-03
Road and Pipeline Construction	26.08	1.38		1.46	1.00	1.50	6072.49	1.00	4.88E-03	7.32E-04
								TOTAL	**1.46E-02**	**2.20E-03**

[a] Number of acres per well pad provided by data in Billings Field Office Resource Management Plan.

Oil Wells - Alternatives A, B, C, and D

Emissions for Road and Well Pad Reclamation

Type	Equipment/Vehicle			Total Miles Worked on/Day	# of Operating Hours/Day
	Type	Fuel	Capacity (hp)		
Roads	Heavy Equipment	Diesel	80	6	10
	Commuting Vehicle	Gasoline	225	6	1.5
Wells[a]	Heavy Equipment	Diesel	100	N/A	10
	Commuting Vehicle	Gasoline	225	6	2

[a] Assume 0.5 day with a blade and tractor each for reseeding per well at time of abandonment.
Source: values from SEIS

Estimation of Total Miles of Roads

Length of Roads Built per Well	0.250
Number of Roads Reclaimed Annually Per Well	0.153
Annual Miles of Roads Reclaimed Per Well	0.038
Number of wells reclaimed (per well)	0.153

Reclamation rates derived from RMP (total Federal and non-Federal)

Estimation of Total Operation Days and Hours

Annual Miles of Roads Reclaimed	Daily Miles of Road Work	Total # of Operating Days	Annual Operating Hours
0.038	6	0.0064	0.0639
		Total	**0.0639**

Assume average miles/day = 6

Emission Factors for Grader

Pollutant	Emission Factor Equation (lb/VMT)	S[a] (mph)	Emission Factor (lb/VMT)
PM_{10}	$E = (0.6)(0.051)\ S^2$	5	0.765
$PM_{2.5}$	$E = (0.031)(0.04)\ S^{2.5}$	5	0.069

[a] Assumed a mean vehicle speed (S) of 5 mph.
Source: EPA AP-42, Section 11.9, Table 11.9-1

Fugitive Dust Emissions Estimation for Grader - Road Reclamation

Activity	Equipment	Total # of Operating Hours[a]	Mean Vehicle Speed (mph)	Total Miles Maintained	PM_{10}		$PM_{2.5}$	
					Em. Factor (lb/VMT)	(tpy/well)	Em. Factor (lb/VMT)	(tpy/well)
Road Reclamation	Grader	0.038	5	0.192	0.765	**7.33E-05**	0.069	**6.64E-06**

[a] Assumed a grader operates 60% of the time, considering hours for preparation and closing of the shift, lunch break, and other extra activities.

Emission Factors for 75-100 hp Off-Road Engines

Year	Emission Factors (g/hp-hr)								
	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O[a]
2008	5.36	0.65	0.13	4.15	0.66	0.63	600.5	0.010	0.006
2018	2.40	0.41	0.11	2.33	0.36	0.40	613.9	0.006	0.006
2027	0.64	0.19	0.10	0.75	0.18	0.19	608.6	0.003	0.006

[a] Emissions of $PM_{2.5}$ were assumed to be the same as those for PM_{10}.
[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Exhaust Emissions Estimation for Grader Road Reclamation

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours	Emissions													
				(lbs/hour)					(tpy/well)								
				NO_x	PM_{10}	SO_x	CO	VOC	NO_x	PM_{10}	SO_x	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Road Reclamation	Grader	80	0.038	0.4238	0.0720	0.0197	0.4106	0.0629	**8.12E-06**	**1.38E-06**	**3.77E-07**	**7.87E-06**	**1.20E-06**	**1.34E-06**	**2.08E-03**	**1.87E-08**	**2.05E-08**

Oil Wells - Alternatives A, B, C, and D

Emission Factors for Road Traffic

$$E\ (lb/VMT) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
k	1.8	0.18
a	1	1
d	0.5	0.5
c	0.2	0.2

Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2

Function/Variable Description		Assumed Value	Reference
E = size-specific emission factor (lb/VMT)			
E_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)			
s = surface material silt content (%)		34.6	Billings Field Office, Dustin Crowe email dated August 16, 2010.
S = mean vehicle speed (mph)		Listed in the table below	
C = emission factor for 1980's vehicle fleet exhaust, brake wear, and tire wear (lb/VMT)	$PM_{2.5}$	0.00036	EPA AP-42 Section 13.2.2, Table 13.2.2-4
	PM_{10}	0.00047	EPA AP-42 Section 13.2.2, Table 13.2.2-4
M = surface material moisture content (%)		2.0	EPA AP-42 Section 13.2.2
P = Number of days precip per year		96.3	Billings, MT Climate Summary from 1961-1990, Western Regional Climate Center.
CE = control efficiency of gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

[a] *Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2, Nov. 2006*

Emissions Estimation for Commuting Vehicles: Road Reclamation

Activity	Vehicle Type	Avg. Vehicle Speed (mph)	Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	PM_{10}		$PM_{2.5}$	
						Em. Factor (lb/VMT)[a]	(tpy/well)	Em. Factor (lb/VMT)[a]	(tpy/well)
Road Reclamation	Pickup Truck	40	6	0.0064	0.0383	0.535	**1.03E-05**	0.053	**1.02E-06**

[a] No dust control measures would be applied.

Exhaust Emission Factors for Commuting Reclamation Vehicles Road Traffic

Vehicle Class	Emission Factors (g/mi)								
	NO_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053

Source: MOBILE6.2.03

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Exhaust Emissions Estimation for Commuting Reclamation Vehicles: Road Traffic

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tpy/well)								
	Type	Class				NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Road Reclamation	Pickup Truck	LDDV	40	0.0064	0.2556	**6.51E-07**	**3.06E-08**	**2.49E-08**	**1.58E-09**	**1.76E-06**	**7.74E-07**	**1.15E-04**	**5.63E-10**	**1.49E-08**

Estimation of Annual Days and Hours for Well Reclamation

Equipment	# of Wells Reclaimed/Year	# of Hours/Day	Annual # of Days	Annual Hours of Operation
Grader	0.153	10	0.153	1.53

Assume grader works 0.5 day as a blade and tractor each per well.

Oil Wells - Alternatives A, B, C, and D

Fugitive Dust Emissions Estimation for Grader: Well Reclamation

Activity	Equipment	Total # of Operating Hours[a]	Mean Vehicle Speed (mph)	Total Miles Reclaimed	PM_{10}		$PM_{2.5}$	
					Em. Factor (lb/VMT)	(tpy/well)	Em. Factor (lb/VMT)	(tpy/well)
Well Reclamation	Grader	0.9200	5	4.600	0.765	**1.76E-03**	0.069	**1.59E-04**

[a] Assumed a grader operates 60% of the time, considering hours for preparation and closing of the shift, lunch break, and other extra activities.

Exhaust Emissions Estimation for Grader: Well Reclamation

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours	Emissions													
				(lbs/hour)					(tpy/well)								
				NO_x	PM_{10}	SO_x	CO	VOC	NO_x	PM_{10}	SO_x	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Well Reclamation	Grader	100	0.9200	0.5297	0.0900	0.0246	0.5132	0.0786	**2.44E-04**	**4.14E-05**	**1.13E-05**	**2.36E-04**	**3.61E-05**	**6.43E-05**	**6.09E-02**	**1.01E-06**	**6.14E-07**

Emissions Estimation for Commuting Vehicles: Well Reclamation

Activity	Vehicle Type	Class	Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	PM_{10}		$PM_{2.5}$	
						Em. Factor (lb/VMT)[a]	(tpy/well)	Em. Factor (lb/VMT)[a]	(tpy/well)
Well Reclamation	Pickup Truck	LDDV	40	0.1533	6.1333	0.535	**1.64E-03**	0.053	**1.64E-04**

[a] No dust control measures would be applied.

Exhaust Emissions Estimation for Commuting Vehicles: Well Reclamation

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions								
						(tpy/well)								
	Type	Class				NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Well Reclamation	Pickup Truck	LDDV	40	0.1533	6.1333	**1.56E-05**	**7.35E-07**	**5.98E-07**	**3.79E-08**	**4.22E-05**	**1.86E-05**	**2.77E-03**	**1.35E-08**	**3.58E-07**

Oil Wells - Alternatives A, B, C, and D

Emissions for Gas Dehydration

Emission Factors for Dehydrator Heaters

Unit	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	HCHO	N_2O
lb/MMSCF	100	7.60	0.60	84	5.50	5.7	120000	2.3	0.075	2.2
lb/MMBTU	0.098	0.007	0.001	0.082	0.005	0.006	117.647	0.002	0.000	0.002

Source: EPA, AP-42 Section 1.4 Natural Gas Combustion

Emission Estimate for Dehydrator Heaters

Operating Hours per Year[a]	Dehydrator Heater Size MMBtu/Hour	Fuel Usage MMCF/Year	Number of Dehydrator Stations / Well	Emissions (tpy/well)									
				NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	HCHO	N_2O
2,190	1	2.20	0.001	**5.66E-05**	**4.30E-06**	**3.40E-07**	**4.75E-05**	**3.11E-06**	**3.23E-06**	**6.79E-02**	**1.30E-06**	**4.24E-08**	**1.25E-06**

Values from Montana BLM (Laakso, 2010)

Annual Dehydrator Venting and Tank Flashing Emissions

Annual Well Gas Production MMscf	CH_4 Emission Factor (ton/MMscf)	CH_4 Emissions (tpy/well)	VOC Emission Factor (ton/MMscf)	VOC Emissions (tpy/well)	HAPs Emission Factor (ton per MMscf)	HAPs Emissions (tpy/well)
6.57	0.011	**7.04E-02**	0.016	**1.05E-01**	0.002	**1.30E-02**

Gas analysis and dehydration process information provided by Montana BLM (Laakso, 2010)
Emission factor include emissions from dehy/regenerator still vents (no control) and flash tank emissions (no control).
Assumed 100% of gas production flows through dehydrators at sales compressor station (Laakso, 2010)

The following Compressor Station assumptions were used with oil Well specific gas composition analysis to derive dehydrator emissions: per dehydrator:

wet gas temperature:		108	degrees F	Laakso, 2010 - South Baker Compressor Station
wet gas pressure:		450	psi	Laakso, 2010 - South Baker Compres ---
gas is saturated	---		---	Laakso, 2010 - South Baker Compressor Station
dry gas flow rate:		35	MMCFD	Laakso, 2010 - South Baker Compressor Station
dry gas water content:		3.2	lbs/MMscf	Laakso, 2010 - South Baker Compressor Station
lean glycol water content:		0.2	wt%	Laakso, 2010 - South Baker Compressor Station
lean glycol circulation rate:		5	gpm	Laakso, 2010 - South Baker Compressor Station
flash tank temperature:		108	degrees F	Laakso, 2010 - South Baker Compressor Station
flash tank pressure:		60	psi	Laakso, 2010 - South Baker Compressor Station
stripping gas source:	dry gas		---	Laakso, 2010 - South Baker Compressor Station
stripping gas flow rate:		17	scfm	Laakso, 2010 - South Baker Compressor Station

Natural Gas Wells - Alternatives A, B, C, and D

Alternatives A, B, C, and D, B, C, and D input parameters for calculating Natural Gas wells emissions

Maximum Annual Wells Drilled - Federal (RMP estimate)	1	Maximum Annual Wells Drilled - Non-Federal (RMP estimate)	4
Federal Producing Wells - RMP Year 20	20	Non-Federal Producing Wells - RMP Year 20	80
Average Gas Production Per Well (MCFD)	40	Average Gas Production Per Well (MCFD)	40

* 100% full RMP estimates for Federal, full RMP estimates (100%) for non-Federal

Federal NG Wells Summaries

Total Annual Emissions from Federal NG Wells - RMP Year - Alternatives A, B, C, and D

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs	CO_2	CH_4	N_2O	CO_{2eq}	CO2eq metric tons
Well Pad Construction - Fugitive Dust	0.06	0.01	---	---	---	---	---	---	---	---	---	---
Heavy Equipment Combustive Emissions	0.01	0.01	0.19	0.05	1.24	0.07	0.01	241.19	0.00	0.00	242.08	219.67
Commuting Vehicles - Construction	2.48	0.25	0.05	0.00	0.06	0.02	0.00	13.35	0.00	0.00	13.64	12.38
Wind Erosion	0.02	0.00	---	---	---	---	---	---	---	---	---	---
Completion Venting	---	---	---	---	---	0.02	0.00	0.01	2.27	0.00	47.62	43.21
Sub-total: Construction	**2.57**	**0.27**	**0.24**	**0.05**	**1.30**	**0.11**	**0.01**	**254.54**	**2.27**	**0.00**	**303.34**	**275.27**
Well Workover Operations - Fugitive Dust	0.47	0.05	---	---	---	---	---	---	---	---	---	---
Well Workover Operations - On-site Exhaust	0.01	0.01	0.12	0.05	1.03	0.06	0.01	210.43	0.00	0.00	211.20	191.65
Well Workover Operations - On-road Exhaust	0.00	0.00	0.01	0.00	0.02	0.01	0.001	2.48	0.00	0.00	2.55	2.31
Well Visits for Inspection & Repair - Operations	0.70	0.07	0.00	0.00	0.07	0.00	0.000	1.37	0.00	0.00	1.53	1.39
Wellhead and Compressor Station Fugitives	---	---	---	---	---	0.05	0.01	0.02	7.07	0.00	148.59	134.84
Compression	0.18	0.18	4.13	0.00	8.27	2.89	0.29	557.85	0.01	0.00	558.40	506.71
Station Visits - Operations	0.08	0.01	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.00	0.14	0.13
Dehydrators	0.00	0.00	0.00	0.00	0.00	0.01	0.00	3.02	4.54	0.00	98.27	89.18
Sub-total: Operations	**1.44**	**0.32**	**4.27**	**0.05**	**9.39**	**3.02**	**0.30**	**775.31**	**11.62**	**0.00**	**1,020.68**	**926.21**
Road Maintenance	0.24	0.03	0.04	0.001	0.02	0.00	0.000	5.30	0.00	0.00	5.32	4.83
Sub-total: Maintenance	**0.24**	**0.03**	**0.04**	**0.001**	**0.02**	**0.00**	**0.000**	**5.295**	**0.000**	**0.00**		**4.83**
Road Reclamation	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.31	0.00	0.00	0.31	0.28
Well Reclamation	0.59	0.07	0.04	0.00	0.04	0.01	0.00	8.99	0.00	0.00	9.05	8.21
Sub-total: Reclamation	**0.61**	**0.07**	**0.04**	**0.0016**	**0.04**	**0.009**	**0.0009**	**9.3048**	**0.0001**	**0.0002**	**9.3591**	**8.4928**
Total Emissions	**4.86**	**0.68**	**4.59**	**0.10**	**10.75**	**3.14**	**0.31**	**1,044.45**	**13.89**	**0.01**	**1,333.39**	**1,214.80**

Natural Gas Wells - Alternatives A, B, C, and D

Non-Federal NG Wells Summaries

Total Annual Emissions from Non-Federal NG Wells - RMP Year - Alternatives A, B, C, and D

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs	CO_2	CH_4	N_2O	CO_{2eq}	CO2eq metric tons
Well Pad Construction - Fugitive Dust	0.25	0.02	—	—	—	—	—	—	—	—	—	—
Heavy Equipment Combustive Emissions	0.06	0.06	1.05	0.19	4.96	0.27	0.03	964.28	0.01	0.00	965.34	875.99
Commuting Vehicles - Construction	9.90	1.00	0.20	0.00	0.24	0.08	0.01	53.39	0.00	0.00	53.72	48.75
Wind Erosion	0.07	0.01	—	—	—	—	—	—	—	—	—	—
Completion Venting	—	—	—	—	—	0.07	0.00	0.03	9.07	0.00	190.49	172.85
Sub-total: Construction	**10.28**	**1.10**	**1.25**	**0.19**	**5.20**	**0.42**	**0.04**	**1,017.70**	**9.08**	**0.00**	**1,209.54**	**1,097.59**
Well Workover Operations - Fugitive Dust	1.89	0.19	—	—	—	—	—			—	—	—
Well Workover Operations - On-site Exhaust	0.60	0.59	10.62	0.18	3.57	0.77	0.08	840.60	0.01	0.01	843.82	765.72
Well Workover Operations - On-road Exhaust	0.00	0.00	0.04	0.00	0.08	0.03	0.003	9.92	0.00	0.00	10.20	9.25
Well Visits for Inspection & Repair - Operations	2.78	0.28	0.01	0.00	0.27	0.01	0.001	5.47	0.00	0.00	6.12	5.55
Wellhead and Compressor Station Fugitives	—	—	—	—	—	0.22	0.02	0.10	28.30	0.00	594.37	539.36
Compression	0.73	0.73	16.54	0.01	33.07	11.58	1.16	2,231.40	0.04	0.00	2233.59	2026.85
Station Visits - Operations	0.33	0.03	0.00	0.00	0.01	0.00	0.00	0.55	0.00	0.00	0.57	0.52
Dehydrators	0.00	0.00	0.01	0.00	0.01	0.03	0.01	12.07	18.14	0.00	393.09	356.71
Sub-total: Operations	**6.34**	**1.82**	**27.23**	**0.19**	**37.01**	**12.63**	**1.27**	**3,100.10**	**46.49**	**0.02**	**4,081.76**	**3,703.96**
Road Maintenance	0.96	0.10	0.17	0.005	0.07	0.02	0.002	21.18	0.00	0.00	21.29	19.32
Sub-total: Maintenance	**0.96**	**0.10**	**0.17**	**0.005**	**0.07**	**0.02**	**0.002**	**21.181**	**0.000**	**0.00**		**19.32**
Road Reclamation	0.10	0.01	0.01	0.00	0.01	0.00	0.00	1.24	0.00	0.00	1.25	1.14
Well Reclamation	2.36	0.26	0.15	0.01	0.17	0.04	0.00	35.98	0.00	0.00	36.19	32.84
Sub-total: Reclamation	**2.46**	**0.27**	**0.15**	**0.0065**	**0.17**	**0.037**	**0.0037**	**37.2192**	**0.0006**	**0.0007**	**37.4362**	**33.9712**
Total Emissions	**20.04**	**3.30**	**28.81**	**0.39**	**42.45**	**13.11**	**1.31**	**4,176.20**	**55.58**	**0.02**	**5,328.74**	**4,854.83**

Natural Gas Wells - Alternatives A, B, C, and D

Fugitive Dust Emissions From Well Pad Construction

Fugitive Dust from Heavy Construction Operations			
INPUTS & ASSUMPTIONS			
Description	**Value**	**Source**	**Notes**
Control Efficiency (C) of watering[a]	0	a	
PM_{10} Emission Factor	0.11	b	Tons PM_{10}/acre-month
Conversion factor for PM_{10} to $PM_{2.5}$	0.1	c	Percentage of PM_{10}

[a] The PM_{10} emission factor shown below includes 50% control based on watering.
[b] WRAP Fugitive Dust Handbook, September 2006.
[c] Midwest Research Institute. 2006. *Background Document for Revisions to Fine Fraction Ratios Used for AP-42 Fugitive Dust Emission Factors*, Report prepared for the Western Governors' Association, Western Regional Air Partnership (WRAP), MRI Project No. 110397, November 1, 2006.

Emissions Estimation for Construction Activities

Area Disturbed for Oil Wells	Avg. Disturbed Acres per well[a]	Construction Days	Total # of Wells	Total Disturbed Acres	(lbs/well)		(tpy/well)	
					PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$
Improved Road	1.5	3	1	1.5	3.30E+01	3.30E+00	1.65E-02	1.65E-03
Well Pad and other structures	4.0	3	1	4.0	8.80E+01	8.80E+00	4.40E-02	4.40E-03
Field Compressor Station	0.04	6	1	0.04	1.83E+00	1.83E-01	9.13E-04	9.13E-05
Sales Compressor Station	0.01	6	1	0.01	3.04E-01	3.04E-02	1.52E-04	1.52E-05
			Total		**123**	**12.31**	**6.16E-02**	**6.16E-03**

[a] Road and well pad disturbance provided by data in Billings Field Office RMP; average disturbed area data for new NG wells shown in SEIS and for Compressor Stations provided by Montana BLM (Laakso, 2010)

Natural Gas Wells - Alternatives A, B, C, and D

Exhaust Emissions from Well Pad Construction Heavy Equipment and Drilling Equipment (Federal)

Emission Factors for Construction Equipment

Equipment	Emission Factors (g/hp-hr)									Equipment Category
	NO_x	PM_{10}	SO_2	CO	VOCs	$PM_{2.5}$	CO_2	CH_4	N_2O[a]	
Dozer - 175 Hp	4.37	0.34	0.12	1.52	0.35	0.33	535.76	0.005	0.006	Track-Type Tractor
Blade - 150 Hp	4.85	0.57	0.13	3.94	0.50	0.55	594.65	0.008	0.006	Motor Grader

Source: EPA NONROADS 2008a

NOTE: Use emission factors for 2008 for all project years = conservative estimate of fleet turnover

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Emission Estimations for Construction Equipment (using 2008 emission factors)

Construction Site	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Operating Hours/Day	# of Operating Days/Well	# of Operating Hours/Well	# of Wells	Max. Annual Emissions (lbs/equipment type/well)					Max. Annual Emissions (tons/equipment type/well)								
									NO_x	PM_{10}	SO_2	CO	VOC	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Improved & Two-Track Road	Blade	150	1	75	10	2	20	1	24.06	2.83	0.64	19.54	2.48	0.01	0.00	0.00	0.01	0.00	0.00	1.4748	0.0000	0.0000
Well Pad	Blade	175	1	75	10	3	30	1	42.10	4.95	1.13	34.20	4.34	0.02	0.00	0.00	0.02	0.00	0.00	2.5809	0.0000	0.0000
	Dozer	175	1	80	10	3	30	1	40.46	3.15	1.11	14.07	3.24	0.02	0.00	0.00	0.01	0.00	0.00	2.7530	0.0000	0.0000
													Subtotal	5.33E-02	5.46E-03	1.44E-03	3.39E-02	5.03E-03	6.30E-03	6.81E+00	8.64E-05	6.93E-05

Exhaust Emission Factors for Diesel Powered Bore/Drill Rig Engines

Project Year/Hp Category	Emission Factors (g/hp-hr)								
	NO_x	PM_{10}	SO_2	CO	VOCs	$PM_{2.5}$	CO_2	CH_4	N_2O[a]
Year 2018									
50 to 75	3.50	0.022	0.12	3.70	0.14	0.02	589.10	0.006	0.006
75 to 100	0.30	0.015	0.11	3.70	0.14	0.02	589.10	0.006	0.006
100 to 175	0.30	0.015	0.11	3.70	0.14	0.02	530.10	0.005	0.006
175 to 300	0.30	0.015	0.11	2.60	0.14	0.02	530.18	0.004	0.006
300 to 600	0.30	0.015	0.11	2.60	0.14	0.02	530.25	0.004	0.006
600 to 750	0.30	0.015	0.11	2.60	0.14	0.02	530.28	0.004	0.006
>750	0.50	0.022	0.10	2.60	0.14	0.02	529.92	0.006	0.006

Sources: Tier 4 non-road diesel emission factors for non-SO2, non-GHG pollutants. EPA NONROADS 2008a (Year 2008) for CO2 and CH4.

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emissions Estimation for Industrial Engines

Construction Site	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Operating Hours/ Day	# of Operating Days/ Well	# of Operating Hours/ Well	# of Wells	Max. Annual Emissions (lbs/equipment type/well)					Max. Annual Emissions (tons/equipment type/well)								
									NO_x	PM_{10}	SO_2	CO	VOC	NO_x	PM_{10}	SO_x	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Main Deck	400	3	70	24	16	384	1	213	11	81	1,849	100	0.11	0.01	0.04	0.92	0.05	0.01	188.53	0.00	0.00
	Auxiliary Pump	200	1	80	8	15	120	1	13	1	5	110	6	0.01	0.00	0.00	0.06	0.00	0.00	11.22	0.00	0.00
	Generators	150	2	75	24	8	192	1	29	1	11	352	13	0.01	0.00	0.01	0.18	0.01	0.00	25.24	0.00	0.00
Well Completion & Testing	Main Deck	400	1	50	11	5	55	1	7	0	3	63	3	0.00	0.00	0.00	0.03	0.00	0.00	6.43	0.00	0.00
	Auxiliary Pump	125	1	80	8	2	16	1	1	0	0	13	0	0.00	0.00	0.00	0.01	0.00	0.00	0.93	0.00	0.00
	Power Swivel	150	1	75	8	2	16	1	1	0	0	15	1	0.00	0.00	0.00	0.01	0.00	0.00	1.05	0.00	0.00
	Equipment Type	**Capacity (hp)**	**# of Units**	**Avg. Load Factor (%)[b]**	**# of Operating Hours/ Day**	**# of Operating Days/ Well**	**# of Operating Hours/ Well**	**# of Wells**														
	Field Generators for Pumps & Lighting	55	1	75	12	3	36	1	11.46	0.07	0.38	12.11	0.46	5.73E-03	3.60E-05	1.90E-04	6.06E-03	2.29E-04	3.60E-05	9.64E-01	1.05E-05	9.91E-06
													Subtotal	1.38E-01	6.64E-03	5.06E-02	1.21E+00	6.19E-02	6.64E-03	2.34E+02	1.80E-03	2.67E-03
												Total		1.91E-01	1.21E-02	5.20E-02	1.24E+00	6.69E-02	1.29E-02	2.41E+02	1.89E-03	2.74E-03

Natural Gas Wells - Alternatives A, B, C, and D

Exhaust Emissions from Well Pad Construction Heavy Equipment and Drilling Equipment (Non-Federal)

Emission Factors for Construction Equipment

Equipment	Emission Factors (g/hp-hr)									Equipment Category
	NO_x	PM_{10}	SO_2	CO	VOCs	$PM_{2.5}$	CO_2	CH_4	N_2O[a]	
Dozer - 175 Hp	4.37	0.34	0.12	1.52	0.35	0.33	535.76	0.005	0.006	Track-Type Tractor
Blade - 150 Hp	4.85	0.57	0.13	3.94	0.50	0.55	594.65	0.008	0.006	Motor Grader

Source: EPA NONROADS 2008a
NOTE: Use emission factors for 2008 for all project years = conservative estimate of fleet turnover
[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Emission Estimations for Construction Equipment (using 2008 emission factors)

Construction Site	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Operating Hours/Day	# of Operating Days/Well	# of Operating Hours/Well	# of Wells	Max. Annual Emissions (lbs/equipment type/well)					Max. Annual Emissions (tons/equipment type/well)								
									NO_x	PM_{10}	SO_2	CO	VOC	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Improved & Two-Track Road	Blade	150	1	75	10	2	20	1	24.06	2.83	0.64	19.54	2.48	0.01	0.00	0.00	0.01	0.00	0.00	1.4748	0.0000	0.0000
Well Pad	Blade	175	1	75	10	3	30	1	42.10	4.95	1.13	34.20	4.34	0.02	0.00	0.00	0.02	0.00	0.00	2.5809	0.0000	0.0000
	Dozer	175	1	80	10	3	30	1	40.46	3.15	1.11	14.07	3.24	0.02	0.00	0.00	0.01	0.00	0.00	2.7530	0.0000	0.0000
													Subtotal	**5.33E-02**	**5.46E-03**	**1.44E-03**	**3.39E-02**	**5.03E-03**	**6.30E-03**	**6.81E+00**	**8.64E-05**	**6.93E-05**

Exhaust Emission Factors for Diesel Powered Bore/Drill Rig Engines

Project Year/Hp Category	Emission Factors (g/hp-hr)								
	NO_x	PM_{10}	SO_2	CO	VOCs	$PM_{2.5}$	CO_2	CH_4	N_2O[a]
Year 2018									
50 to 75	4.55	0.41	0.12	2.13	0.42	0.40	589.10	0.006	0.006
75 to 100	3.75	0.42	0.11	2.03	0.42	0.41	589.10	0.006	0.006
100 to 175	3.57	0.27	0.10	1.00	0.31	0.26	530.10	0.005	0.006
175 to 300	3.37	0.23	0.10	0.83	0.28	0.22	530.18	0.004	0.006
300 to 600	3.61	0.21	0.10	1.06	0.26	0.21	530.25	0.004	0.006
600 to 750	3.61	0.22	0.10	1.25	0.25	0.21	530.28	0.004	0.006
>750	5.13	0.26	0.10	1.29	0.37	0.25	529.92	0.006	0.006

Source: EPA NONROADS 2008a - Year 2018 accounts for mixture of Tier 1-3 engines
[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emissions Estimation for Industrial Engines

Construction Site	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Operating Hours/Day	# of Operating Days/Well	# of Operating Hours/Well	# of Wells	Max. Annual Emissions (lbs/equipment type/well)					Max. Annual Emissions (tons/equipment type/well)								
									NO_x	PM_{10}	SO_2	CO	VOC	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Main Deck	400	3	70	24	16	384	1	356	16	73	1,849	100	0.18	0.01	0.04	0.92	0.05	0.01	188.4150	0.0020	0.0022
	Auxiliary Pump	200	1	80	8	15	120	1	13	1	5	110	6	0.01	0.00	0.00	0.06	0.00	0.00	11.2223	0.0001	0.0001
	Generators	150	2	75	24	8	192	1	29	1	11	352	13	0.01	0.00	0.01	0.18	0.01	0.00	25.2427	0.0002	0.0003
Well Completion & Testing	Main Deck	400	1	50	11	5	55	1	7	0	3	63	3	0.00	0.00	0.00	0.03	0.00	0.00	6.4295	0.0000	0.0001
	Auxiliary Pump	125	1	80	8	2	16	1	1	0	0	9	0	0.00	0.00	0.00	0.00	0.00	0.00	0.9351	0.0000	0.0000
	Power Swivel	150	1	75	8	2	16	1	1	0	0	15	1	0.00	0.00	0.00	0.01	0.00	0.00	1.0518	0.0000	0.0000
	Equipment Type	**Capacity (hp)**	**# of Units**	**Avg. Load Factor (%)[b]**	**# of Operating Hours/ Day**	**# of Operating Days/ Well**	**# of Operating Hours/ Well**	**# of Wells**														
	Field Generators for Pumps & Lighting	55	1	75	12	3	36	1	11.46	0.07	0.38	12.11	0.46	0.01	0.00	0.00	0.01	0.00	0.00	0.9643	0.0000	0.0000
													Subtotal	**2.09E-01**	**9.13E-03**	**4.62E-02**	**1.21E+00**	**6.19E-02**	**9.13E-03**	**2.34E+02**	**2.39E-03**	**2.67E-03**
													Total	**2.62E-01**	**1.46E-02**	**4.76E-02**	**1.24E+00**	**6.69E-02**	**1.54E-02**	**2.41E+02**	**2.48E-03**	**2.74E-03**

Natural Gas Wells - Alternatives A, B, C, and D

Fugitive Dust Emissions from Construction and Drilling Support Vehicles

Emission Factors for Industrial Unpaved Roads [a]

E (lb/VMT) =	k (s/12)^a (W/3)^b
E_{ext} = E (1 - P/365)	

Parameter	PM_{10}	$PM_{2.5}$
k	1.5	0.15
a	0.9	0.9
b	0.45	0.45

Function/Variable Description	Assumed Value	Reference
E = size-specific emission factor (lb/VMT)		
E_{ext} = size-specific emission factor extrapolated for natural		
s = surface material silt content (%)	34.6	Billings Field Office, Dustin Crowe email dated August 16, 2010.
W = mean vehicle weight (tons)	Listed in the table below	
M = surface material moisture content (%)	2.0	EPA AP-42 Section 13.2.2
P = Number of days precip per year	96.3	Billings, MT Climate Summary from 1961-1990, Western Regional Climate Center.
CE = control efficiency of gravel or scoria surfacing	84%	WRAP Fugitive Dust Handbook, September 2006

[a] *Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2, Nov. 2006*

Fugitive Dust Emission Estimations for Road Traffic - All Project Years

Construction Site Destination	Vehicle Type	Avg. Vehicle Weight (tons)	Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells	PM_{10} Controlled Em. Factor (lb/VMT)	PM_{10} Emissions (lbs/vehicle/ well)	PM_{10} Emissions (tons/ vehicle type/well)	PM_{10} Emissions (tons/well)	$PM_{2.5}$ Controlled Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions (lbs/vehicle/ well)	$PM_{2.5}$ Emissions (tons/ vehicle type/well)	$PM_{2.5}$ Emissions (tons/well)
Improved & Two-Track Road	Semi Trucks	42	10	47	470	1	1.50	706.23	0.35	0.362	0.15	70.62	0.04	0.036
	Pickup Trucks	5	10	3	30	1	0.58	17.30	0.01		0.06	1.73	0.00	
Well Pad	Semi Trucks	42	10	5	50	1	1.50	75.13	0.04	0.049	0.15	7.51	0.00	0.005
	Pickup Trucks	5	10	4	40	1	0.58	23.07	0.01		0.06	2.31	0.00	
Other Construction Activities	Semi Trucks	42	10	2	20	1	1.50	30.05	0.02	0.030	0.15	3.01	0.00	0.003
	Haul Trucks	25	10	2	20	1	1.19	23.80	0.01		0.12	2.38	0.00	
	Pickup Trucks	5	10	1	10	1	0.58	5.77	0.00		0.06	0.58	0.00	
Rig-up, Drilling, and Rig-down	Semi Rig Transport, Drill Rig	42	10	44	440	1	1.50	661.15	0.33	0.791	0.15	66.12	0.03	0.079
	Fuel Haul Truck	25	10	6	60	1	1.19	71.39	0.04		0.12	7.14	0.00	
	Mud Haul Truck, Water Hauling	25	10	4	40	1	1.19	47.59	0.02		0.12	4.76	0.00	
	Rig Crew	5	10	51	510	1	0.58	294.10	0.15		0.06	29.41	0.01	
	Rig Mechanics	5	10	2	20	1	0.58	11.53	0.01		0.06	1.15	0.00	
	Co. Supervisor	5	10	20	200	1	0.58	115.33	0.06		0.06	11.53	0.01	
	Tool Pusher	25	10	8	80	1	1.19	95.18	0.05		0.12	9.52	0.00	
	Mud Logger	25	10	6	60	1	1.19	71.39	0.04		0.12	7.14	0.00	
	Mud Engineer	25	10	15	150	1	1.19	178.46	0.09		0.12	17.85	0.01	
	Logger, Engr Truck	25	10	1	10	1	1.19	11.90	0.01		0.12	1.19	0.00	
	Drill Bit Delivery	25	10	2	20	1	1.19	23.80	0.01		0.12	2.38	0.00	
Well Completion & Testing (continued below)	Semi Casing Haulers	42	10	6	60	1	1.50	90.16	0.05	0.118	0.15	9.02	0.00	0.012
	Semi Completion, Unit Rig	42	10	1	10	1	1.50	15.03	0.01		0.15	1.50	0.00	
	Semi Fracing, Blender	25	10	1	10	1	1.19	11.90	0.01		0.12	1.19	0.00	
	Semi Pumping/Tank Battery	25	10	6	60	1	1.19	71.39	0.04		0.12	7.14	0.00	
	Tubing Truck	25	10	2	20	1	1.19	23.80	0.01		0.12	2.38	0.00	
	Haul Cementer, Pump Truck	25	10	2	20	1	1.19	23.80	0.01		0.12	2.38	0.00	
									Subtotal	**1.35E+00**				**1.35E-01**

Natural Gas Wells - Alternatives A, B, C, and D

Emission Estimations for Road Traffic - All Project Years (continued)

Construction Site Destination	Vehicle Type	Avg. Vehicle Weight (tons)	Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells	PM_{10}				$PM_{2.5}$			
							Controlled Em. Factor (lb/VMT)	Emissions			Controlled Em. Factor (lb/VMT)	Emissions		
								(lbs/vehicle type)	(tons/ vehicle type/well)	(tons/well)		(lbs/vehicle type)	(tons/ vehicle type/well)	(tons/well)
Well Completion & Testing (continued from above)	Haul Cementer, Cement Truck	25	10	3	30	1	1.19	35.69	0.02	1.121	0.12	3.57	0.00	0.112
	Haul Completion,	25	10	3	30	1	1.19	35.69	0.02		0.12	3.57	0.00	
	Haul Service Tools	25	10	2	20	1	1.19	23.80	0.01		0.12	2.38	0.00	
	Haul Perforators Logging Truck	25	10	1	10	1	1.19	11.90	0.01		0.12	1.19	0.00	
	Haul Anchor, Installation	25	10	1	10	1	1.19	11.90	0.01		0.12	1.19	0.00	
	Haul Anchor, Testing	25	10	1	10	1	1.19	11.90	0.01		0.12	1.19	0.00	
	Haul Fracing, Tank	25	10	1	10	1	1.19	11.90	0.01		0.12	1.19	0.00	
	Haul Fracing, Pump	25	10	1	10	1	1.19	11.90	0.01		0.12	1.19	0.00	
	Haul Fracing, Chemical	25	10	1	10	1	1.19	11.90	0.01		0.12	1.19	0.00	
	Haul Fracing, Sand	25	10	1	10	1	1.19	11.90	0.01		0.12	1.19	0.00	
	Haul Fracing, Other	25	10	1	10	1	1.19	11.90	0.01		0.12	1.19	0.00	
	Haul Welders	25	10	6	60	1	1.19	71.39	0.04		0.12	7.14	0.00	
	Haul Water Truck	25	10	150	1500	1	1.19	1,784.64	0.89		0.12	178.46	0.09	
	Pickup Cementer, Engineer	5	10	2	20	1	0.58	11.53	0.01		0.06	1.15	0.00	
	Pickup Casing Crew	5	10	2	20	1	0.58	11.53	0.01		0.06	1.15	0.00	
	Pickup Completion Crew	5	10	5	50	1	0.58	28.83	0.01		0.06	2.88	0.00	
	Pickup Completion, Pusher	5	10	5	50	1	0.58	28.83	0.01		0.06	2.88	0.00	
	Pickup Perforators, Engineer	5	10	2	20	1	0.58	11.53	0.01		0.06	1.15	0.00	
	Pickup Fracing, Engineer	5	10	1	10	1	0.58	5.77	0.00		0.06	0.58	0.00	
	Pickup Co. Supervisor	5	10	10	100	1	0.58	57.67	0.03		0.06	5.77	0.00	
	Pickup Miscellaneous Supplies	5	10	3	30	1	0.58	17.30	0.01		0.06	1.73	0.00	
	Pickup Roustabout Crew	5	10	4	40	1	0.58	23.07	0.01		0.06	2.31	0.00	
									Subtotal	1.12E+00				1.12E-01
									Total	2.47E+00				2.47E-01

Natural Gas Wells - Alternatives A, B, C, and D

Exhaust Emissions from Construction and Drilling Support Vehicles

Emission Factors for Commuting Vehicles

Vehicle		Emission Factors (g/mi)								
Type	Class	NO_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
Heavy-Duty Diesel Truck	HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.044

Source: MOBILE6.2.03

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emissions Estimation Road Traffic

Construction Site Destination	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells	Emissions																				
							(lbs/vehicle type/well)						(tons/vehicle type/well)						(tons/well)								
	Type	Class					NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	CO_2	CH_4	N_2O
Improved & Two-Track Road	Semi Trucks	HDDV	40	47	1880	1	11.2568	1.1406	0.9520	0.0547	7.1329	1.4672	0.0056	0.0006	0.0005	0.0000	0.0036	0.0007	0.006	0.001	0.000	0.000	0.004	0.001	1.6409	0.000077	0.000092
	Pickup Trucks	LDDT	40	3	120	1	0.6116	0.0288	0.0234	0.0015	1.6526	0.7267	0.0003	0.0000	0.0000	0.0000	0.0008	0.0004							0.0542	0.000000	0.000007
Well Pad	Semi Trucks	HDDV	40	5	200	1	1.1975	0.1213	0.1013	0.0058	0.7588	0.1561	0.0006	0.0001	0.0001	0.0000	0.0004	0.0001	0.001	0.000	0.000	0.000	0.001	0.001	0.1746	0.000008	0.000010
	Pickup Trucks	LDDT	40	4	160	1	0.8155	0.0383	0.0312	0.0020	2.2035	0.9690	0.0004	0.0000	0.0000	0.0000	0.0011	0.0005							0.0722	0.000000	0.000009
Other Construction Activities	Semi Trucks	HDDV	40	2	80	1	0.4790	0.0485	0.0405	0.0023	0.3035	0.0624	0.0002	0.0000	0.0000	0.0000	0.0002	0.0000	0.001	0.000	0.000	0.000	0.001	0.000	0.0698	0.000003	0.000004
	Haul Trucks	HDDV	40	2	80	1	0.4790	0.0485	0.0405	0.0023	0.3035	0.0624	0.0002	0.0000	0.0000	0.0000	0.0002	0.0000							0.0698	0.000003	0.000004
	Pickup Trucks	LDDT	40	1	40	1	0.2039	0.0096	0.0078	0.0005	0.5509	0.2422	0.0001	0.0000	0.0000	0.0000	0.0003	0.0001							0.0181	0.000000	0.000002
																		Subtotal	7.52E-03	7.18E-04	5.98E-04	3.46E-05	6.45E-03	1.84E-03	2.10E+00	9.21E-05	1.28E-04

Natural Gas Wells - Alternatives A, B, C, and D

Combustive Emissions Estimation Road Traffic

Construction Site Destination	Vehicle Type	Vehicle Class	Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells	Emissions (lbs/vehicle type/well) NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	(tons/vehicle type/well) NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	(tons/well) NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	CO_2	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Semi Rig Transport, Drill Rig	HDDV	40	44	1760	1	10.5383	1.0678	0.8913	0.0512	6.6776	1.3735	0.0053	0.0005	0.0004	0.0000	0.0033	0.0007	0.02	0.00	0.00	0.00	0.03	0.01	1.5	0.000072	0.000086
	Fuel Haul Truck	HDDV	40	6	240	1	1.4370	0.1456	0.1215	0.0070	0.9106	0.1873	0.0007	0.0001	0.0001	0.0000	0.0005	0.0001							0.2	0.000010	0.000012
	Mud Haul Truck, Water Hauling	HDDV	40	4	160	1	0.9580	0.0971	0.0810	0.0047	0.6071	0.1249	0.0005	0.0000	0.0000	0.0000	0.0003	0.0001							0.1	0.000007	0.000008
	Rig Crew	LDDT	40	51	2040	1	10.3979	0.4889	0.3960	0.0252	28.0950	12.3542	0.0052	0.0002	0.0002	0.0000	0.0140	0.0062							0.9	0.000004	0.000119
	Rig Mechanics	HDDV	40	2	80	1	0.4790	0.0485	0.0405	0.0023	0.3035	0.0624	0.0002	0.0000	0.0000	0.0000	0.0002	0.0000							0.1	0.000003	0.000004
	Co. Supervisor	LDDT	40	20	800	1	4.0776	0.1917	0.1561	0.0099	11.0176	4.8448	0.0020	0.0001	0.0001	0.0000	0.0055	0.0024							0.4	0.000002	0.000047
	Tool Pusher	LDDT	40	8	320	1	1.6318	0.0767	0.0624	0.0040	4.4071	1.9379	0.0008	0.0000	0.0000	0.0000	0.0022	0.0010							0.1	0.000001	0.000019
	Mud Logger	LDDT	40	6	240	1	1.2233	0.0575	0.0468	0.0030	3.3053	1.4534	0.0006	0.0000	0.0000	0.0000	0.0017	0.0007							0.1	0.000001	0.000014
	Mud Engineer	LDDT	40	15	600	1	3.0583	0.1438	0.1171	0.0074	8.2632	3.6336	0.0015	0.0001	0.0001	0.0000	0.0041	0.0018							0.3	0.000001	0.000035
	Logger, Engr Truck	HDDV	40	1	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.000002	0.000002
	Drill Bit Delivery	LDDT	40	2	80	1	0.4078	0.0192	0.0156	0.0010	1.1018	0.4845	0.0002	0.0000	0.0000	0.0000	0.0006	0.0002							0.0	0.000000	0.000005
Well Completion & Testing	Semi Casing Haulers	HDDV	40	6	240	1	1.4370	0.1456	0.1215	0.0070	0.9106	0.1873	0.0007	0.0001	0.0001	0.0000	0.0005	0.0001	0.03	0.00	0.00	0.00	0.02	0.01	0.2	0.000010	0.000012
	Semi Completion, Unit Rig	HDDV	40	1	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.000002	0.000002
	Semi Fracing, Blender	HDDV	40	1	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.000002	0.000002
	Semi Pumping/Tank Battery	HDDV	40	6	240	1	1.4370	0.1456	0.1215	0.0070	0.9106	0.1873	0.0007	0.0001	0.0001	0.0000	0.0005	0.0001							0.2	0.000010	0.000012
	Tubing Truck	HDDV	40	2	80	1	0.4790	0.0485	0.0405	0.0023	0.3035	0.0624	0.0002	0.0000	0.0000	0.0000	0.0002	0.0000							0.1	0.000003	0.000004
	Haul Cementer, Pump Truck	HDDV	40	2	80	1	0.4790	0.0485	0.0405	0.0023	0.3035	0.0624	0.0002	0.0000	0.0000	0.0000	0.0002	0.0000							0.1	0.000003	0.000004
	Haul Cementer, Cement Truck	HDDV	40	3	120	1	0.7185	0.0728	0.0608	0.0035	0.4553	0.0937	0.0004	0.0000	0.0000	0.0000	0.0002	0.0000							0.1	0.000005	0.000006
	Haul Completion, Equip Truck	HDDV	40	3	120	1	0.7185	0.0728	0.0608	0.0035	0.4553	0.0937	0.0004	0.0000	0.0000	0.0000	0.0002	0.0000							0.1	0.000005	0.000006
	Haul Service Tools	LDDT	40	2	80	1	0.4078	0.0192	0.0156	0.0010	1.1018	0.4845	0.0002	0.0000	0.0000	0.0000	0.0006	0.0002							0.0	0.000000	0.000005
	Haul Perforators Logging Truck	HDDV	40	1	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.000002	0.000002
	Haul Anchor, Installation	HDDV	40	1	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.000002	0.000002
	Haul Anchor, Testing	HDDV	40	1	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.000002	0.000002
	Haul Fracing, Tank	HDDV	40	1	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.000002	0.000002
	Haul Fracing, Pump	HDDV	40	1	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.000002	0.000002
	Haul Fracing, Chemical	HDDV	40	1	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.000002	0.000002
	Haul Fracing, Sand	HDDV	40	1	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.000002	0.000002
	Haul Fracing, Other	HDDV	40	1	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.000002	0.000002
	Haul Welders	HDDV	40	6	240	1	1.4370	0.1456	0.1215	0.0070	0.9106	0.1873	0.0007	0.0001	0.0001	0.0000	0.0005	0.0001							0.2	0.000010	0.000012
	Haul Water Truck	HDDV	40	150	6000	1	35.9259	3.6402	3.0384	0.1746	22.7646	4.6825	0.0188	0.0018	0.0015	0.0001	0.0114	0.0023							5.2	0.000245	0.000293
	Pickup Cementer, Engineer	LDDT	40	2	80	1	0.4078	0.0192	0.0156	0.0010	1.1018	0.4845	0.0002	0.0000	0.0000	0.0000	0.0006	0.0002							0.0	0.000000	0.000005
	Pickup Casing Crew	HDDV	40	2	80	1	0.4790	0.0485	0.0405	0.0023	0.3035	0.0624	0.0002	0.0000	0.0000	0.0000	0.0002	0.0000							0.1	0.000003	0.000004
	Pickup Completion Crew	HDDV	40	5	200	1	1.1975	0.1213	0.1013	0.0058	0.7588	0.1561	0.0006	0.0001	0.0001	0.0000	0.0004	0.0001							0.2	0.000008	0.000010
	Pickup Completion, Pusher	LDDT	40	5	200	1	1.0194	0.0479	0.0390	0.0025	2.7544	1.2112	0.0005	0.0000	0.0000	0.0000	0.0014	0.0006							0.1	0.000000	0.000012
	Pickup Perforators, Engineer	LDDT	40	2	80	1	0.4078	0.0192	0.0156	0.0010	1.1018	0.4845	0.0002	0.0000	0.0000	0.0000	0.0006	0.0002							0.0	0.000000	0.000005
	Pickup Fracing, Engineer	HDDV	40	1	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.000002	0.000002
	Pickup Co. Supervisor	LDDT	40	10	400	1	2.0388	0.0959	0.0780	0.0049	5.5088	2.4224	0.0010	0.0000	0.0000	0.0000	0.0028	0.0012							0.2	0.000001	0.000023
	Pickup Miscellaneous Supplies	LDDT	40	3	120	1	0.6116	0.0288	0.0234	0.0015	1.6526	0.7267	0.0003	0.0000	0.0000	0.0000	0.0008	0.0004							0.1	0.000000	0.000007
	Pickup Roustabout Crew	HDDV	40	4	160	1	0.9580	0.0971	0.0810	0.0047	0.6071	0.1249	0.0005	0.0000	0.0000	0.0000	0.0003	0.0001							0.1	0.000007	0.000008
																		Subtotal	**4.36E-02**	**3.72E-03**	**3.09E-03**	**1.81E-04**	**5.42E-02**	**1.93E-02**	**1.12E+01**	**4.30E-04**	**7.97E-04**
																		Total	**5.11E-02**	**4.44E-03**	**3.69E-03**	**2.15E-04**	**6.07E-02**	**2.11E-02**	**1.33E+01**	**5.22E-04**	**9.25E-04**

Natural Gas Wells - Alternatives A, B, C, and D

Exhaust and Fugitive Dust Emissions from Well Work Overs (Federal)

Fugitive Dust from Heavy Equipment on Industrial Unpaved Roads
Emission Factors for Industrial Unpaved Roads [a]

E (lb/VMT) =	$k (s/12)^a (W/3)^b$
E_{ext} = E (1 - P/365)	

Parameter	PM_{10}	$PM_{2.5}$
k	1.5	0.15
a	0.9	0.9
b	0.45	0.45

Function/Variable Description	Assumed Value	Reference
E = size-specific emission factor (lb/VMT)		
E_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)		
s = surface material silt content (%)	34.6	Billings Field Office, Dustin Crowe email dated August 16, 2010.
W = mean vehicle weight (tons)	Listed in the table below	
M = surface material moisture content (%)	2.0	EPA AP-42 Section 13.2.2
P = Number of days precip per year	96.3	Billings, MT Climate Summary from 1961-1990, Western Regional Climate Center.
CE = control efficiency of gravel or scoria surfacing	84%	WRAP Fugitive Dust Handbook, September 2006.

[a] *Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2, Nov. 2006*

Assumption:	Avg. Frequency & Duration: three days, once in the first year; Equipment: Truck-mounted Unit: capacity **600 hp**, fuel **60 gpd**, hours/day **10** Truck: Type **WO rig**, Round trip mileage: **10** miles on unpaved road Max. number of crews in the field on a given day considering weekends and inclement weather: **15**

Fugitive Dust Estimations for Road Traffic

Activity	Vehicle Type	Avg. Vehicle Weight (tons)	Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells Drilled	PM_{10} Emission Factor (lb/VMT)	PM_{10} Emissions (lbs/well)	PM_{10} Emissions (tpy/well)	$PM_{2.5}$ Emission Factor (lb/VMT)	$PM_{2.5}$ Emissions (lbs/ well)	$PM_{2.5}$ Emissions (tpy/well)
Well Workover	WO Rig	42	10	1	10	1	1.50	15.03	0.01	0.15	1.50	0.00
	Haul Truck	42	10	1	10	1	1.50	15.03	0.01	0.15	1.50	0.00
	Pickup Truck	5	10	3	30	1	0.58	17.30	0.01	0.06	1.73	0.00
								Total	**2.37E-02**			**2.37E-03**

Number of wells is based on peak year applied to all project years (provides for a conservative estimate).

Natural Gas Wells - Alternatives A, B, C, and D

Exhaust Emissions from Well Work Overs

Emission Factors Bore/Drill Rig Engines 300-600 Hp

Fuel Type	Emission Factors (gm/hp-hr)								
	NO_x	PM_{10}	SO_x	CO	VOC	PM2.5	CO_2	CH_4	N_2O[a]
Diesel	0.30	0.015	0.11	2.60	0.14	0.02	530.28	0.004	0.006

Sources: Tier 4 non-road diesel emission factors for non-SO2, non-GHG pollutants. EPA NONROADS 2008a (Year 2008) for CO2 and CH4.

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Emission Estimations for Engines

Activity	Equipment Type	Capacity (hp)	# of Operating Hours/Day	# of Operating Days/Well	# of Operating Hours/Well	Total # of Wells Drilled	Max. Annual Emissions (lbs/well)					Max. Annual Emissions (tpy/well)								
							NO_x	PM_{10}	SO_x	CO	VOC	NO_x	PM_{10}	SO_x	CO	VOC	PM2.5	CO_2	CH_4	N_2O
Well Workover	Truck-Mounted Unit	600	10	3	30	1	12	1	5	103	6	5.95E-03	2.98E-04	2.27E-03	5.16E-02	2.78E-03	2.98E-04	1.05E+01	7.56E-05	1.19E-04

Exhaust emission factors for commuting vehicles

Vehicle		Emission Factors (g/mi)								
Type	Class	NO_x	PM_{10}[a,b]	$PM_{2.5}$[a,b]	SO_x[a]	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
Heavy-Duty Diesel Truck	HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.044

Source: MOBILE 6.2.03

Emission factors for 2008 used for all project years = conservative estimate of vehicle fleet turnover

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Emission Estimations for Road Traffic

Activity	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells Drilled	Max. Annual Emissions (lbs/well)						Max. Annual Emissions (tpy/well)								
	Type	Class					NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Well Workover	WO Rig	HDDV	40	1	40	1	0.240	0.024	0.020	0.001	0.152	0.031	0.000	0.000	0.000	0.000	0.000	0.000	0.03	0.000	0.000
	Haul Truck	HDDV	40	1	40	1	0.240	0.024	0.020	0.001	0.152	0.031	0.000	0.000	0.000	0.000	0.000	0.000	0.03	0.000	0.000
	Pickup Truck	LDDT	40	3	120	1	0.612	0.029	0.023	0.001	1.653	0.727	0.000	0.000	0.000	0.000	0.001	0.000	0.05	0.000	0.000
												Total	**5.45E-04**	**3.86E-05**	**3.20E-05**	**1.90E-06**	**9.78E-04**	**3.95E-04**	**1.24E-01**	**3.53E-06**	**1.09E-05**

Performed once in the first year of well operation

Number of wells is based on peak year applied to all project years (provides for a conservative estimate).

Natural Gas Wells - Alternatives A, B, C, and D

Exhaust and Fugitive Dust Emissions from Well Work Overs (Non-Federal)

Fugitive Dust from Heavy Equipment on Industrial Unpaved Roads

Emission Factors for Industrial Unpaved Roads[a]

E (lb/VMT) =	$k (s/12)^a (W/3)^b$
E_{ext} = E (1 - P/365)	

Parameter	PM_{10}	$PM_{2.5}$
k	1.5	0.15
a	0.9	0.9
b	0.45	0.45

Function/Variable Description	Assumed Value	Reference
E = size-specific emission factor (lb/VMT)		
E_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)		
s = surface material silt content (%)	34.6	Billings Field Office, Dustin Crowe email dated August 16, 2010.
W = mean vehicle weight (tons)	Listed in the table below	
M = surface material moisture content (%)	2.0	EPA AP-42 Section 13.2.2
P = Number of days precip per year	96.3	Billings, MT Climate Summary from 1961-1990, Western Regional Climate Center.
CE = control efficiency of or scoria gravel surfacing	84%	WRAP Fugitive Dust Handbook, September 2006.

[a] *Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2, Nov. 2006*

Assumption:	Avg. Frequency & Duration: three days, once in the first year; Equipment: Truck-mounted Unit: capacity **600 hp**, fuel **60 gpd**, hours/day **10** Truck: Type **WO rig**, Round trip mileage: **10** miles on unpaved road Max. number of crews in the field on a given day considering weekends and inclement weather: **15**

Fugitive Dust Estimations for Road Traffic

Activity	Vehicle Type	Avg. Vehicle Weight (tons)	Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells Drilled	PM_{10} Emission Factor (lb/VMT)	PM_{10} Emissions (lbs/well)	PM_{10} Emissions (tpy/well)	$PM_{2.5}$ Emission Factor (lb/VMT)	$PM_{2.5}$ Emissions (lbs/ well)	$PM_{2.5}$ Emissions (tpy/well)
Well Workover	WO Rig	42	10	1	10	1	1.50	15.03	0.01	0.15	1.50	0.00
	Haul Truck	42	10	1	10	1	1.50	15.03	0.01	0.15	1.50	0.00
	Pickup Truck	5	10	3	30	1	0.58	17.30	0.01	0.06	1.73	0.00
								Total	**2.37E-02**			**2.37E-03**

Number of wells is based on peak year applied to all project years (provides for a conservative estimate).

Exhaust Emissions from Well Work Overs

Emission Factors Bore/Drill Rig Engines 300-600 Hp

Fuel Type	Emission Factors (gm/hp-hr)								
	NO_x	PM_{10}	SO_x	CO	VOC	PM2.5	CO_2	CH_4	N_2O[a]
Diesel	6.69	0.38	0.11	2.25	0.48	0.37	529.58	0.007	0.006

Source: EPA NONROADS 2008a. Year 2008.

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Emission Estimations for Engines

Activity	Equipment Type	Capacity (hp)	# of Operating Hours/Day	# of Operating Days/Well	# of Operating Hours/Well	Total # of Wells Drilled	Max. Annual Emissions (lbs/well) NO_x	PM_{10}	SO_x	CO	VOC	(tpy/well) NO_x	PM_{10}	SO_x	CO	VOC	PM2.5	CO_2	CH_4	N_2O
Well Workover	Truck-Mounted Unit	600	10	3	30	1	266	15	5	89	19	**1.33E-01**	**7.55E-03**	**2.26E-03**	**4.46E-02**	**9.61E-03**	**7.32E-03**	**1.05E+01**	**1.46E-04**	**1.20E-04**

Natural Gas Wells - Alternatives A, B, C, and D

Exhaust emission factors for commuting vehicles

Vehicle		Emission Factors (g/mi)								
Type	Class	NO_x	PM_{10}[a,b]	$PM_{2.5}$[a,b]	SO_x[a]	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
Heavy-Duty Diesel Truck	HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.044

Source: MOBILE 6.2.03

Emission factors for 2008 used for all project years = conservative estimate of vehicle fleet turnover

[a] N2O factor source: 2008 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Emission Estimations for Road Traffic

Activity	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells Drilled	Max. Annual Emissions (lbs/well)						Max. Annual Emissions (tpy/well)								
	Type	Class					NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Well Workover	WO Rig	HDDV	40	1	40	1	0.240	0.024	0.020	0.001	0.152	0.031	0.000	0.000	0.000	0.000	0.000	0.000	0.03	0.000	0.000
	Haul Truck	HDDV	40	1	40	1	0.240	0.024	0.020	0.001	0.152	0.031	0.000	0.000	0.000	0.000	0.000	0.000	0.03	0.000	0.000
	Pickup Truck	LDDT	40	3	120	1	0.612	0.029	0.023	0.001	1.653	0.727	0.000	0.000	0.000	0.000	0.001	0.000	0.05	0.000	0.000
												Total	**5.45E-04**	**3.86E-05**	**3.20E-05**	**1.90E-06**	**9.78E-04**	**3.95E-04**	**1.24E-01**	**3.53E-06**	**1.09E-05**

Performed once in the first year of well operation

Number of wells is based on peak year applied to all project years (provides for a conservative estimate).

Natural Gas Wells - Alternatives A, B, C, and D

Fugitive Dust and Exhaust Emissions from Site Visits and Inspections

Fugitive Dust from Commuting Vehicles on Unpaved Roads

Emission Factors for Publicly Accessible Unpaved Roads[a]

$$E\ (lb/VMT) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
k	1.8	0.18
a	1	1
d	0.5	0.5
c	0.2	0.2

Function/Variable Description		Assumed Value	Reference
E = size-specific emission factor (lb/VMT)			
E_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)			
s = surface material silt content (%)		34.6	Billings Field Office, Dustin Crowe email dated August 16, 2010.
S = mean vehicle speed (mph)		Listed in the table below	
C = emission factor for 1980's vehicle fleet exhaust, brake wear, and tire wear (lb/VMT)	$PM_{2.5}$	0.00036	EPA AP-42 Section 13.2.2, Table 13.2.2-4
	PM_{10}	0.00047	EPA AP-42 Section 13.2.2, Table 13.2.2-4
M = surface material moisture content (%)		2.0	EPA AP-42 Section 13.2.2
P = Number of days precip per year		96.3	Billings, MT Climate Summary from 1961-1990, Western Regional Climate Center.
CE = control efficiency of gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

[a] *Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2, Nov. 2006*

Assumption:	Frequency of visit: once/week/well
	Crew: **1** person and **1** light-duty truck
	Av. number of wells served by a pumper per day **20**
	Round trip mileage per day: 50 total/20 wells = 2.**5** miles/well on unpaved road

Emission Estimations for Road Traffic - RMP Year 20

Activity	Vehicle Type[a]	Avg. Vehicle Speed (mph)	Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Federal Wells Producing	PM_{10}			$PM_{2.5}$		
							Emission Factor (lb/VMT)	Emissions (lbs/well/ yr)	Emissions (tpy/well)	Emission Factor (lb/VMT)	Emissions (lbs/ well/yr)	Emissions (tpy/ well)
Inspection Visits for Wells	Pickup Truck	40	2.5	52	130	1	0.53	69.54	**3.48E-02**	0.05	6.95	**3.47E-03**

Exhaust Emissions from Site Visits and Inspections

Emission factors for Commuting Vehicles Exhaust

Vehicle Class	Emission Factors (g/mi)								
	NO_x	PM_{10}[a,b]	$PM_{2.5}$[a,b]	SO_x[a]	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Gasoline Truck	1.13	0.03	0.01	0.01	23.97	1.07	476.9	0.07	0.18

Source: MOBILE 6.2.03

Emission factors for 2008 used for all years = conservative estimate for fleet vehicle turnover

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Emission Estimations for Road Traffic - RMP Year 20

Activity	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Federal Wells Producing	Emissions (lbs/well/yr)						Emissions (tpy/well)								
	Type	Class					NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Inspection Visits for Wells	Pickup Truck	LDGT2	2.5	52	130	1	0.32	0.01	0.00	0.00	6.87	0.31	**1.61E-04**	**3.63E-06**	**1.68E-06**	**1.26E-06**	**3.43E-03**	**1.53E-04**	**6.83E-02**	**9.74E-06**	**2.56E-05**

Natural Gas Wells - Alternatives A, B, C, and D

Exhaust Emissions from Heavy Equipment and Support Vehicles for Road Maintenance

Given Data

Maintenance[a]	Equipment/Vehicle			Road Length Worked on/Day (miles)	# of Operating Hours/Day
	Type	Fuel	Capacity (hp)		
Summer	Heavy Equipment[b]	Diesel-30 gpd	135	6	10
	Commuting Vehicle	Gas-5 gpd	225	6	1[c]
Winter	Heavy Equipment[b]	Diesel-30 gpd	135	5	10
	Commuting Vehicle	Gas-5 gpd	225	6	1.5[c]

[a] Road maintenance would be made twice in summer and once in winter every yea
[b] Assume a motor grader 135 Hp.
[c] Assume three round trips per two days.

Estimation of Total and Cumulative Length of Roads for the Project - RMP Year 20

Length of Improved Roads per Well (miles) [a]	1.00
Number of Wells	1.00
Cumulative Length of Roads [b] (miles/operation)	1.00

[a] Source: SEIS
[b] miles of road built per well * No. of operating wells/year

Estimation of Total Operation Days and Hours - RMP Year 20

Season	# of Operations per Season	Cumulative Length of Roads (miles/operation)	Road Length Worked On (mi/day)	# of Operating Hours per Day	Total # of Operating Days	Total # of Operating Hours
Summer	2	1	6	10	0.3	3
Winter	1	1	5	10	0.2	2
				Total	0.5	5

Emission Factors for Grading - Fugitive Dust

Pollutant	Emission Factor Equation (lb/VMT)	S[a] (mph)	Em. Factors (lb/VMT)
PM_{10}	$E = (0.6)(0.051)\ S^2$	5	0.765
$PM_{2.5}$	$E = (0.031)(0.04)\ S^{2.5}$	5	0.069

[a] S = mean vehicle speed (S), assume 5 mph for grading
Source: EPA AP-42, Section 11.9, Table 11.9-1, Oct. 1998

Fugitive Dust Emission Estimations for Grader: RMP Year 20

Activity	Equipment	Total # of Operating Hours [a]	Mean Vehicle Speed (mph)	Total Miles Traveled	PM_{10}		$PM_{2.5}$	
					Emissions (lb/year)	Emissions (tpy)	Emissions (lb/year)	Emissions (tpy)
Road Maintenance	Grader	3	5	16	12.24	**6.12E-03**	1.11	**5.55E-04**

[a] Assume grader operates at 60% of the time (minus hours for clothing change, breaks, etc.)

Emission Factors for Construction Equipment Exhaust

Equipment	Emission Factors (g/hp-hr)								
	NO_x	PM_{10}	SO_2	CO	VOC	PM2.5	CO_2	CH_4	N_2O[a]
Grader 100-175 Hp	4.34	0.34	0.12	1.51	0.35	0.33	535.77	0.0053	0.006

Source: EPA NONROADS 2008a
Use emission factors for 2008 for all project years - conservative estimate of vehicle turnover
[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Natural Gas Wells - Alternatives A, B, C, and D

Emission Estimations for Grader: RMP Year 20

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours[a]	Emissions (lbs/activity/hr)					Emissions (tons/well)								
				NO_x	PM_{10}	SO_x	CO	VOC	NO_x	PM_{10}	SO_x	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Road Maintenance	Grader	135	3	1.29	0.10	0.04	0.45	0.10	2.07E-03	1.62E-04	5.71E-05	7.19E-04	1.67E-04	1.57E-04	2.55E-01	2.52E-06	2.88E-06

[a] Assume grader operates at 60% of the time (minus hours for clothing change, breaks, etc.)

Fugitive Dust from Commuting Vehicles on Unpaved Roads

Emission Factors for Publicly Accessible Unpaved Roads[a]

$$E\ (lb/VMT) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
k	1.8	0.18
a	1	1
d	0.5	0.5
c	0.2	0.2

Function/Variable Description		Assumed Value	Reference
E = size-specific emission factor (lb/VMT)			
E_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)			
s = surface material silt content (%)		34.6	Billings Field Office, Dustin Crowe email dated August 16, 2010.
S = mean vehicle speed (mph)		Listed in the table below	
C = emission factor for 1980's vehicle fleet exhaust, brake wear, and tire wear (lb/VMT)	$PM_{2.5}$	0.00036	EPA AP-42 Section 13.2.2, Table 13.2.2-4
	PM_{10}	0.00047	EPA AP-42 Section 13.2.2, Table 13.2.2-4
M = surface material moisture content (%)		2.0	EPA AP-42 Section 13.2.2
P = Number of days precip per year		96.3	Billings, MT Climate Summary from 1961-1990, Western Regional Climate Center.
CE = control efficiency of gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

[a] *Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2, Nov. 2006*

Emission Estimations for Road Traffic - RMP Year 20

Activity	Vehicle Type	Avg. Vehicle Speed (mph)	Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled (VMT/yr)	PM_{10} Emission Factor (lb/VMT)	PM_{10} Emissions (lbs/yr)	PM_{10} Emissions (tpy)	$PM_{2.5}$ Emission Factor (lb/VMT)	$PM_{2.5}$ Emissions (lbs/yr)	$PM_{2.5}$ Emissions (tpy)
Road Maintenance	Pickup Truck	40	40	0.5	21	0.53	11.41	5.71E-03	0.05	1.14	5.70E-04

Emission Factors for Commuting Vehicles Exhaust

Vehicle Class	Emission Factors (g/mi)								
	NO_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053

Source: MOBILE 6.2.03

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Emission Estimations for Road Traffic - RMP Year 20

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled (VMT/yr)	Emissions (tpy/well)								
	Type	Class				NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Road Maintenance	Pickup Truck	LDDT	40	0.5	21	5.44E-05	2.56E-06	2.08E-06	1.32E-07	1.47E-04	6.46E-05	9.63E-03	4.70E-08	1.25E-06

Natural Gas Wells - Alternatives A, B, C, and D

Emission Factors for Industrial Wind Erosion

E (tpy) =	$k * \frac{P * M * N}{453.6 * 2000}$		AP-42 Section 13.2.5.3 Equation 2
Erosion Potential P (g/m2/year) =	$58(U^*-Ut^*)^2 + 25(U^*-Ut^*)$	for U*>Ut*; P=0 otherwise	AP-42 Section 13.2.5.3 Equation 3
Friction Velocity U* (m/s) =	$0.053\ U_{10}^*$		AP-42 Section 13.2.5.3 Equation 4

P = Erosion Potential ($gm/m^2/yr$)	M = Disturbed area (m^2)
U* = Friction velocity (m/s)	N = # of disturbances
U_t = threshold velocity (m/s)	k = 0.5 for PM_{10}
U10 = fastest wind speed (m/s)	k = 0.075 for $PM_{2.5}$

U_{10} =	26.08	58.33	average fastest (mph) for Billings, Montana (1939-1987) from http://www.itl.nist.gov/div898/winds/nondirectional.htm
U_t well pads =	1.33	AP-42 Industrial Wind Erosion Table 13.2.5-2, Roadbed material	
U_t roads/pipelines =	1.33	AP-42 Industrial Wind Erosion Table 13.2.5-2, Roadbed material	

Construction Wind Erosion Emissions - Based on Peak Wells Drilled each Alternative

	Fastest Mile (U_{10}) (m/s)	Max. Friction Velocity (U*) (m/s)	Well Erosion Potential (P) ($g/m^2/yr$)	Road Erosion Potential (P) ($g/m^2/yr$)	Peak # of Wells Drilled per year	Average Disturbed acres per well [a]	Disturbed Area (M) (m^2)	Number of Disturbances (N)	PM10 Emissions (tpy/well)	PM2.5 Emissions (tpy/well)
Well pad construction	26.08	1.38	1.46		1.00	4.00	16193.31	1.00	0.01	0.00
Road and Pipeline Construction	26.08	1.38		1.46	1.00	1.50	6072.49	1.00	0.00	0.00
								TOTAL	**1.79E-02**	**2.68E-03**

[a] Average disturbed area shown in SEIS

Natural Gas Wells - Alternatives A, B, C, and D

Emissions for Road and Well Pad Reclamation

Type	Equipment/Vehicle			Total Miles Worked on/Day	# of Operating Hours/Day
	Type	Fuel	Capacity (hp)		
Roads	Heavy Equipment	Diesel	80	6	10
	Commuting Vehicle	Gasoline	225	6	1.5
Wells[a]	Heavy Equipment	Diesel	100	N/A	10
	Commuting Vehicle	Gasoline	225	6	2

[a] Assume 0.5 day with a blade and tractor each for reseeding per well at time of abandonment.
Source: values from SEIS

Estimation of Total Miles of Roads

Length of Roads Built per Well	0.25
Number of Roads Reclaimed Annually Per Well	1.060
Annual Miles of Roads Reclaimed Per Well	0.265
Number of wells reclaimed (per well)	1.060

Reclamation rates derived from RMP (total Federal and non-Federal)

Estimation of Total Operation Days and Hours

Annual Miles of Roads Reclaimed	Daily Miles of Road Work	Total # of Operating Days	Annual Operating Hours
0.2650	6	0.04417	0.4417
		Total	**0.442**

Assume average miles/day = 6

Emission Factors for Grader

Pollutant	Emission Factor Equation (lb/VMT)	S[a] (mph)	Emission Factor (lb/VMT)
PM_{10}	$E = (0.6)(0.051)\ S^2$	5	0.765
$PM_{2.5}$	$E = (0.031)(0.04)\ S^{2.5}$	5	0.069

[a] Assumed a mean vehicle speed (S) of 5 mph.
Source: EPA AP-42, Section 11.9, Table 11.9-1

Fugitive Dust Emissions Estimation for Grader - Road Reclamation

Activity	Equipment	Total # of Operating Hours[a]	Mean Vehicle Speed (mph)	Total Miles Maintained	PM_{10}		$PM_{2.5}$	
					Em. Factor (lb/VMT)	(tpy/well)	Em. Factor (lb/VMT)	(tpy/well)
Road Reclamation	Grader	0.265	5	1.325	0.765	**5.07E-04**	0.069	**4.59E-05**

[a] Assumed a grader operates 60% of the time, considering hours for preparation and closing of the shift, lunch break, and other extra activities.

Emission Factors for 75-100 hp Off-Road Engines

Year	Emission Factors (g/hp-hr)								
	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O[a]
2008	5.36	0.65	0.13	4.15	0.66	0.63	600.5	0.010	0.006
2018	2.40	0.41	0.11	2.33	0.36	0.40	613.9	0.006	0.006
2027	0.64	0.19	0.10	0.75	0.18	0.19	608.6	0.003	0.006

Source: EPA NONROADS 2008a
[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Exhaust Emissions Estimation for Grader Road Reclamation

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours	Emissions													
				(lbs/hour)					(tpy/well)								
				NO_x	PM_{10}	SO_x	CO	VOC	NO_x	PM_{10}	SO_x	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Road Reclamation	Grader	80	0.265	0.4238	0.0720	0.0197	0.4106	0.0629	**5.62E-05**	**9.54E-06**	**2.61E-06**	**5.44E-05**	**8.33E-06**	**9.25E-06**	**1.43E-02**	**1.29E-07**	**1.41E-07**

Natural Gas Wells - Alternatives A, B, C, and D

Emission Factors for Road Traffic

$$E\ (lb/VMT) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^f} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
k	1.8	0.18
a	1	1
d	0.5	0.5
c	0.2	0.2

Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2

Function/Variable Description		Assumed Value	Reference
E = size-specific emission factor (lb/VMT)			
E_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)			
s = surface material silt content (%)		34.6	Billings Field Office, Dustin Crowe email dated August 16, 2010.
S = mean vehicle speed (mph)		Listed in the table below	
C = emission factor for 1980's vehicle fleet exhaust, brake wear, and tire wear (lb/VMT)	$PM_{2.5}$	0.00036	EPA AP-42 Section 13.2.2, Table 13.2.2-4
	PM_{10}	0.00047	EPA AP-42 Section 13.2.2, Table 13.2.2-4
M = surface material moisture content (%)		2.0	EPA AP-42 Section 13.2.2
P = Number of days precip per year		96.3	Billings, MT Climate Summary from 1961-1990, Western Regional Climate Center.
CE = control efficiency of gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

[a] *Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2, Nov. 2006*

Emissions Estimation for Commuting Vehicles: Road Reclamation

Activity	Vehicle Type	Avg. Vehicle Speed (mph)	Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	PM_{10}		$PM_{2.5}$	
						Em. Factor (lb/VMT)[a]	(tpy/well)	Em. Factor (lb/VMT)[a]	(tpy/well)
Road Reclamation	Pickup Truck	40	60	0.0442	2.650	0.53	**7.09E-04**	0.05	**7.08E-05**

[a] No dust control measures would be applied.

Exhaust Emission Factors for Commuting Reclamation Vehicles Road Traffic

Vehicle Class	Emission Factors (g/mi)								
	NO_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053

Source: MOBILE6.2.03

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Exhaust Emissions Estimation for Commuting Reclamation Vehicles: Road Traffic

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tpy/well)								
	Type	Class				NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Road Reclamation	Pickup Truck	LDDV	60	0.0442	2.6500	**6.75E-06**	**3.18E-07**	**2.59E-07**	**1.64E-08**	**1.82E-05**	**8.02E-06**	**1.20E-03**	**5.84E-09**	**1.55E-07**

Estimation of Annual Days and Hours for Well Reclamation

Equipment	# of Wells Reclaimed/Year	# of Hours/Day	Annual # of Days	Annual Hours of Operation
Grader	1.060	10	1.060	10.60

Assume grader works 0.5 day as a blade and tractor each per well.

Natural Gas Wells - Alternatives A, B, C, and D

Fugitive Dust Emissions Estimation for Grader: Well Reclamation

Activity	Equipment	Total # of Operating Hours[a]	Mean Vehicle Speed (mph)	Total Miles Reclaimed	PM_{10}		$PM_{2.5}$	
					Em. Factor (lb/VMT)	(tpy/well)	Em. Factor (lb/VMT)	(tpy/well)
Well Reclamation	Grader	6.36	5	31.80	0.765	1.22E-02	0.069	1.10E-03

[a] Assumed a grader operates 60% of the time, considering hours for preparation and closing of the shift, lunch break, and other extra activities.

Exhaust Emissions Estimation for Grader: Well Reclamation

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours	Emissions (lbs/hour)					Emissions (tpy/well)								
				NO_x	PM_{10}	SO_x	CO	VOC	NO_x	PM_{10}	SO_x	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Well Reclamation	Grader	100	6.36	0.5297	0.0900	0.0246	0.5132	0.0786	1.68E-03	2.86E-04	7.82E-05	1.63E-03	2.50E-04	4.44E-04	4.21E-01	7.01E-06	4.24E-06

Emissions Estimation for Commuting Vehicles: Well Reclamation

Activity	Vehicle Type	Class	Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	PM_{10}		$PM_{2.5}$	
						Em. Factor (lb/VMT)[a]	(tpy/well)	Em. Factor (lb/VMT)[a]	(tpy/well)
Well Reclamation	Pickup Truck	LDDV	60	1.06	63.60	0.535	1.70E-02	0.053	1.70E-03

[a] No dust control measures would be applied.

Exhaust Emissions Estimation for Commuting Vehicles: Well Reclamation

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tpy/well)								
	Type	Class				NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Well Reclamation	Pickup Truck	LDDV	60	1.06	63.60	1.62E-04	7.62E-06	6.20E-06	3.93E-07	4.38E-04	1.93E-04	2.87E-02	1.40E-07	3.72E-06

Natural Gas Wells - Alternatives A, B, C, and D

Emission Factors for Dehydrator Heaters

Unit	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	HCHO	N_2O
lb/MMSCF	100	7.60	0.60	84	5.50	5.7	120000	2.3	0.075	2.2
lb/MMBTU	0.098	0.007	0.001	0.082	0.005	0.006	117.647	0.002	0.000	0.002

Source: EPA, AP-42 Section 1.4 Natural Gas Combustion

Emission Estimate for Dehydrator Heaters

Operating Hours per Year[a]	Dehydrator Heater Size MMBtu/Hour	Fuel Usage MMCF/Year	Number of Dehydrator Stations / Well	Emissions (tpy/well)									
				NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	HCHO	N_2O
2,190	1	2.20	0.001	**1.26E-04**	**9.56E-06**	**7.55E-07**	**1.06E-04**	**6.92E-06**	**7.17E-06**	**1.51E-01**	**2.89E-06**	**9.43E-08**	**2.77E-06**

Values from Montana BLM (Laakso, 2010)

Annual Dehydrator Venting and Tank Flashing Emissions

Annual Well Gas Production MMscf	CH_4 Emission Factor (ton per MMscf)	CH_4 Emissions (TPY/well)	VOC Emission Factor (ton per MMscf)	VOC Emissions (TPY/well)	HAPs Emission Factor (ton per MMscf)	HAPs Emissions (TPY/well)
14.60	0.016	**2.27E-01**	0.00002	**3.11E-04**	0.00001	**1.51E-04**

Gas analysis and dehydration process information provided by Montana BLM (Laakso, 2010) and emissions estimated with GLYCalc Program.
Emission factor include emissions from dehy/regenerator still vents (no control) and flash tank emissions (no control).
Assumed 100% of gas production flows through dehydrators at sales compressor station (Laakso, 2010)

The following Compressor Station assumptions were used with natural gas Well specific gas composition analysis to derive dehydrator emissions: per dehydrator:

wet gas temperature:		108	degrees F	Laakso, 2010 - South Baker Compressor Station
wet gas pressure:		450	psi	Laakso, 2010 - South Baker Compressor Station
gas is saturated	---		---	Laakso, 2010 - South Baker Compressor Station
dry gas flow rate:		35	MMCFD	Laakso, 2010 - South Baker Compressor Station
dry gas water content:		3.2	lbs/MMscf	Laakso, 2010 - South Baker Compressor Station
lean glycol water content:		0.2	wt%	Laakso, 2010 - South Baker Compressor Station
lean glycol circulation rate:		5	gpm	Laakso, 2010 - South Baker Compressor Station
flash tank temperature:		108	degrees F	Laakso, 2010 - South Baker Compressor Station
flash tank pressure:		60	psi	Laakso, 2010 - South Baker Compressor Station
stripping gas source:	dry gas		---	Laakso, 2010 - South Baker Compressor Station
stripping gas flow rate:		17	scfm	Laakso, 2010 - South Baker Compressor Station

Natural Gas Wells - Alternatives A, B, C, and D

Wellhead Fugitives
Fugitive Emissions from Equipment Leaks

TOC Emission Factor								
Well Equipment	Gas		Light Oil >20° API		Heavy Oil <20° API		Water/Oil	
Component	(kg/hr)	(lb/hr)	(kg/hr)	(lb/hr)	(kg/hr)	(lb/hr)	(kg/hr)	(lb/hr)
valves	4.50E-03	9.92E-03	2.50E-03	5.51E-03	8.40E-06	1.85E-05	9.80E-05	2.16E-04
pump seals	2.40E-03	5.29E-03	1.30E-02	2.87E-02	3.20E-05	7.05E-05	2.40E-05	5.29E-05
others	8.80E-03	1.94E-02	7.50E-03	1.65E-02	3.20E-05	7.05E-05	1.40E-02	3.09E-02
connectors	2.00E-04	4.41E-04	2.10E-04	4.63E-04	7.50E-06	1.65E-05	1.10E-04	2.43E-04
flanges	3.90E-04	8.60E-04	1.10E-04	2.43E-04	3.90E-07	8.60E-07	2.90E-06	6.39E-06
open-ended lines	2.00E-03	4.41E-03	1.40E-03	3.09E-03	1.40E-04	3.09E-04	2.50E-04	5.51E-04

Source: EPA-453/R-95-017 Protocol for Equipment Leak Emission Estimates, November 1995
Table 2-4 , Oil and Gas Production Operations Average Estimation Factors
"Other" category includes compressor seals, pressure relief valves, diaphragms, drains, dump arms, hatches, instruments, meters, polished rods and vents

From Montana BLM provided NG analysis

VOC Wt% =	0.68
CO2 Wt% =	0.30
CH4 Wt% =	89.00
N2O Wt% =	0.00

Emissions from Equipment Leaks at Wellhead per Well

component	Ave. # in Gas Service	Emission factor (lb/hr)	Ave. # in Liquid service	Emission factor (lb/hr)	Ave. # in Water/Oil Service	Emission factor (lb/hr)	TOC emissions per well (lb/hr)	VOC emissions per well (lb/hr)	CO_2 emissions per well (lb/hr)	CH_4 emissions per well (lb/hr)
valves	7	0.0099	1	0.0055	0	0.0002	0.07496	0.00051	0.00022	0.06671
pump seals	0	0.0053	0	0.0287	0	0.0001	0.00000	0.00000	0.00000	0.00000
others	0	0.0194	0	0.0165	0	0.0309	0.00000	0.00000	0.00000	0.00000
connectors	24	0.0004	0	0.0005	0	0.0002	0.01058	0.00007	0.00003	0.00942
flanges	2	0.0009	0	0.0002	0	0.0000	0.00172	0.00001	0.00001	0.00153
open-ended lines	0	0.0044	0	0.0031	0	0.0006	0.00000	0.00000	0.00000	0.00000
TOTAL emissions/well/hr =							0.08726	0.00060	0.00026	0.07766

Number of components provided by Montana BLM FO personnel (Laakso, 2010)

Annual Emissions from Equipment Leaks Per Well								
Year	**Number of Producing Wells**	**Operating Hours**	**VOC emissions (lb/yr)**	**VOC emissions (tpy)**	**CO_2 emissions (lb/yr)**	**CO2 emissions (tpy)**	**CH_4 emissions (lb/yr)**	**CH4 emissions (tpy)**
RMP Year	1	8760	5.22	**2.61E-03**	2.29	**1.14E-03**	680.28	**3.40E-01**

Natural Gas Wells - Alternatives A, B, C, and D

Speciated Analysis - NG & Venting Emissions from Well Completion Activities (applied to all wells drilled)

Gas Component	Mole Fraction	Molecular Weight	Gas Weight	Weight Percent	Weight	Emissions Mass Flow
	(%)	(lb/lb-mol)	(lb/lb-mol)	(wt%)	(lb/MMscf))	(ton/well)
Methane	93.716	16.040	15.032	88.998	37788.643	2.267319
Ethane	1.624	30.070	0.488	2.891	1227.616	0.073657
Nitrogen	4.297	28.020	1.204	7.128	3026.751	0.181605
Water	0.000	18.015	0.000	0.000	0.000	0.000000
Carbon Dioxide	0.115	43.990	0.051	0.300	127.173	0.007630
Nitrous Oxide	0.000	44.020	0.000	0.000	0.000	0.000000
Hydrogen Sulfide	0.000	34.060	0.000	0.000	0.000	0.000000
Non-reactive, non-HAP	99.752	---	16.775	99.317		2.530211
Propane	0.211	44.100	0.093	0.551	233.918	0.014035
Iso-butane	0.019	58.120	0.011	0.065	27.760	0.001666
n-butane	0.015	58.120	0.009	0.052	21.916	0.001315
i-pentane	0.002	72.150	0.001	0.009	3.628	0.000218
n-pentane	0.001	72.150	0.001	0.004	1.814	0.000109
Hexanes	0.000	100.210	0.000	0.000	0.000	0.000000
Heptanes	0.000	100.200	0.000	0.002	0.781	0.000047
Octanes	0.000	114.230	0.000	0.000	0.000	0.000000
Nonanes	0.000	128.258	0.000	0.000	0.000	0.000000
Decanes+	0.000	142.29	0.000	0.000	0.000	0.000000
Reactive VOC	0.248	---	0.115	0.683		0.017389
Benzene	0.000	78.110	0.000	0.000	0.000	0.000000
Ethylbenzene	0.000	106.160	0.000	0.000	0.000	0.000000
n-Hexane [3]	*0.000*	*100.210*	*0.000*	*0.000*	*0.000*	*0.000000*
Toluene	0.000	92.130	0.000	0.000	0.000	0.000000
Xylenes	0.000	106.160	0.000	0.000	0.000	0.000000
HAPs	0.000	---	0.000	0.000		0.000000
Totals	**100.000**	**---**	**16.890**	**100.000**		**2.547600**

Sample taken 03-09-2010 at Baker South 7 W 0429.

Volume Flow:	40 MSCF/day/well
Completion activity duration:	3 days
Total Volume Flow per Well	0.12 MMSCF/well

Assume: Gas density is 0.04246 lb/scf (19.26 g/scf).

BTU value = 994 BTU/scf

Natural Gas Wells - Alternatives A, B, C, and D

Compressor Station Emissions

Emission Factors for Natural Gas-Fired Compressors

Compressor		Horse-Power Rating	Units	Emission Factors									
				NO_x[a]	PM_{10}[b]	SO_2[b]	CO[a]	VOC[a]	$PM_{2.5}$[b]	CO_2[c]	CH_4[c]	HCHO[b]	N_2O[c]
Field Compression Station	Rich Burn	300	gm/bhp-hr	1.00	0.044	0.001	2.00	0.70	0.044	134.9	2.5E-03	0.064	2.55E-04
			lb/MMBTU		3.84E-02	5.88E-04			3.84E-02	116.9	2.2E-03	5.52E-02	2.20E-04
Sales Compression Station	Rich Burn	1,680	gm/bhp-hr	1.00	0.044	0.001	2.00	0.70	0.044	134.9	0.003	0.064	2.55E-04
			lb/MMBTU		3.84E-02	5.88E-04			3.84E-02	116.9	2.20E-03	5.52E-02	2.20E-04

[a] Source: assume compressors will comply with NSPS 40 CFR part 60 subpart JJJJ
[b] Source: EPA, AP-42 Section 3.2 Natural Gas Fired Reciprocating Engines
Note: Compressors assumed to be equipped with nonselective catalytic reduction (NSCR) catalyst.
[c] EPA Mandatory GHG Reporting, Part 98, Subpart C, Tables C-1 and C-2.

Emission Estimations for Compressors

Type of Compressors	Compression Rate (Hp/well)	Annual # of Wells in Production	Total Compression (Hp)	Operating Hours/Year	Emissions (tpy/well)									
					NOx	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	HCHO	N_2O
Field Compression Station	11	1	11	8,760	0.11	0.00	0.00	0.21	0.07	0.00	14.427	0.0003	0.01	0.00003
Sales Compression Station	10	1	10	8,760	0.10	0.00	0.00	0.20	0.07	0.00	13.465	0.0003	0.01	0.00003
				Total	**2.07E-01**	**9.16E-03**	**1.40E-04**	**4.13E-01**	**1.45E-01**	**9.16E-03**	**2.79E+01**	**5.26E-04**	**1.32E-02**	**5.26E-05**

HCHO = Formaldehyde

Compression rate of 36 - 300 hp field compressors, and 6 - 1680 hp sales compressors per 867 CBNG wells based on BLM survey (Laakso, 2010). Values were scaled based on per well NG production.

Compressor Station Fugitives

Fugitive Emissions from Equipment Leaks

Well Equipment Component	TOC Emission Factor							
	Gas		Light Oil >20° API		Heavy Oil <20° API		Water/Oil	
	(kg/hr)	(lb/hr)	(kg/hr)	(lb/hr)	(kg/hr)	(lb/hr)	(kg/hr)	(lb/hr)
valves	4.50E-03	9.92E-03	2.50E-03	5.51E-03	8.40E-06	1.85E-05	9.80E-05	2.16E-04
pump seals	2.40E-03	5.29E-03	1.30E-02	2.87E-02	3.20E-05	7.05E-05	2.40E-05	5.29E-05
others	8.80E-03	1.94E-02	7.50E-03	1.65E-02	3.20E-05	7.05E-05	1.40E-02	3.09E-02
connectors	2.00E-04	4.41E-04	2.10E-04	4.63E-04	7.50E-06	1.65E-05	1.10E-04	2.43E-04
flanges	3.90E-04	8.60E-04	1.10E-04	2.43E-04	3.90E-07	8.60E-07	2.90E-06	6.39E-06
open-ended lines	2.00E-03	4.41E-03	1.40E-03	3.09E-03	1.40E-04	3.09E-04	2.50E-04	5.51E-04

Source: EPA-453/R-95-017 Protocol for Equipment Leak Emission Estimates, November 1995
Table 2-4 , Oil and Gas Production Operations Average Estimation Factors
"Other" category includes compressor seals, pressure relief valves, diaphragms, drains, dump arms, hatches, instruments, meters, polished rods and vents

From Montana BLM provided NG analysis

VOC Wt% =	0.68
CO2 Wt% =	0.30
CH4 Wt% =	89.00
N2O Wt% =	0.00

Natural Gas Wells - Alternatives A, B, C, and D

Emissions from Equipment Leaks at Compressor Station per Well

component	Ave. # in Gas Service / Well	Emission factor (lb/hr)	Ave. # in Liquid service	Emission factor (lb/hr)	Ave. # in Water/Oil Service	Emission factor (lb/hr)	TOC emissions per well (lb/hr)	VOC emissions per well (lb/hr)	CO_2 emissions per well (lb/hr)	CH_4 emissions per well (lb/hr)
valves	0.258	0.0099	0	0.0055	0	0.0002	0.003	0.000	0.000	0.002
pump seals	0.000	0.0053	0	0.0287	0	0.0001	0.000	0.000	0.000	0.000
others	0.000	0.0194	0	0.0165	0	0.0309	0.000	0.000	0.000	0.000
connectors	0.369	0.0004	0	0.0005	0	0.0002	0.000	0.000	0.000	0.000
flanges	0.886	0.0009	0	0.0002	0	0.0000	0.001	0.000	0.000	0.001
open-ended lines	0.000	0.0044	0	0.0031	0	0.0006	0.000	0.000	0.000	0.000
						TOTAL emissions/well/hr =	0.00349	0.00002	0.00001	0.00310

Number of components provided by Montana BLM FO personnel (Laakso, 2010)

Annual Emissions from Equipment Leaks Per Well								
Year	**Number of Producing Wells**	**Operating Hours**	**VOC (lb/yr)**	**VOC (tpy)**	**CO_2 (lb/yr)**	**CO_2 (tpy)**	**CH_4 (lb/yr)**	**CH4 (tpy)**
RMP Year	1	8760	0.21	**1.04E-04**	0.0915	**4.58E-05**	27.1891	**1.36E-02**

Natural Gas Wells - Alternatives A, B, C, and D

Emission Factors for Publicly Accessible Unpaved Roads[a]

$$E\ (lb/VMT) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
k	1.8	0.18
a	1	1
d	0.5	0.5
c	0.2	0.2

Function/Variable Description		Assumed Value	Reference
E = size-specific emission factor (lb/VMT)			
E_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)			
s = surface material silt content (%)		34.6	Billings Field Office, Dustin Crowe email dated August 16, 2010.
S = mean vehicle speed (mph)		Listed in the table below	
C = emission factor for 1980's vehicle fleet exhaust, brake wear, and tire wear (lb/VMT)	$PM_{2.5}$	0.00036	EPA AP-42 Section 13.2.2, Table 13.2.2-4
	PM_{10}	0.00047	EPA AP-42 Section 13.2.2, Table 13.2.2-4
M = surface material moisture content (%)		2.0	EPA AP-42 Section 13.2.2
P = Number of days precip per year		96.3	Billings, MT Climate Summary from 1961-1990, Western Regional Climate Center.
CE = control efficiency of gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

[a] *Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2, Nov. 2006*

Fugitive Dust Emission Estimations for Road Traffic

Activity	Compressor Station	Vehicle Type	Avg. Vehicle Speed (mph)	# of Compressor Stations / Well	# of Inspection Visits/ Station/ Year	# of Inspection Visits/Well/Year	Total Miles/ Inspection	PM_{10} Em. Factor (lb/VMT)	PM_{10} Emissions (lbs/trip)	PM_{10} Emissions (tpy/well)	$PM_{2.5}$ Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions (lbs/trip)	$PM_{2.5}$ Emissions (tpy/well)
Inspection Visits for Compressor Stations	Field Station	Pickup Truck	40	0.04	12	0.4	20	0.53	10.70	0.00	0.05	1.07	0.00
	Sales Station	Pickup Truck	40	0.01	52	0.3	20	0.53	10.70	0.00	0.05	1.07	0.00
									Total	4.08E-03			4.08E-04

Assume no dust control (watering)

Compressor Station Inspection Traffic Exhaust Emissions
Emission factors for Commuting Vehicles Exhaust

Vehicle Type	Vehicle Class	NO_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O[a]
		Emission Factors (g/mi)								
Light-Duty Diesel Truck	LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053

Source: MOBILE6.2.03

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Exhaust Emissions Estimation for Road Traffic

Activity	Compressor Station	Vehicle Type	Vehicle Class	# of Compressor Stations / Well	# of Inspection Visits/ Station	# of Inspection Visits/Well/Year	Total Miles/ Inspection	Emissions (lbs/trip) NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	Emissions (tpy/well) NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Inspection Visits for Compressor Stations	CPF Compressor Station	Pickup Truck	LDDT	0.04	12	0.4	20	0.102	0.005	0.004	0.000	0.275	0.121	0.00	0.00	0.00	0.00	0.00	0.00	0.00400	0.00000	0.00000
	Primary Compressor Station	Pickup Truck	LDDT	0.01	52	0.3	20	0.102	0.005	0.004	0.000	0.275	0.121	0.00	0.00	0.00	0.00	0.00	0.00	0.00289	0.00000	0.00000
													Total	3.89E-05	1.83E-06	1.49E-06	9.42E-08	1.05E-04	4.62E-05	6.89E-03	3.36E-08	8.91E-07

General Purpose BLM Fleet Travel - Alternatives A, B, C, and D

General Purpose Travel - BLM Fleet **Alternatives A-D**

Total Annual Emissions from General Purpose BLM Travel - Alternatives A-D

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs[a]	CO_2	CH_4	N_2O	$CO2_{eq}$ tons	$CO2_{eq}$ metric tons
Commuting Vehicles - Fugitive Dust	54.91	5.49	---	---	---	---	---	---	---	---	---	---
Commuting Vehicles - Vehicle Exhaust	0.02	0.02	0.48	0.00	1.31	0.57	0.06	85.55	0.00	0.01	88.99	80.76
Total	**54.94**	**5.51**	**0.48**	**0.00**	**1.31**	**0.57**	**0.06**	**85.55**	**0.00**	**0.01**	**88.99**	**80.76**

[a] HAPs = Hazardous Air Pollutants; assumed = VOCs * 0.1

General Purpose BLM Fleet Travel - Alternatives A, B, C, and D

ALTERNATIVE: Alternatives A-D

Emission Factors for Publicly Accessible Unpaved Roads[a]

$$E\ (lb/VMT) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
k	1.8	0.18
a	1	1
d	0.5	0.5
c	0.2	0.2

Function/Variable Description		Assumed Value	Reference
E = size-specific emission factor (lb/VMT)			
E_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)			
s = surface material silt content (%)		34.6	Billings Field Office, Dustin Crowe email dated August 16, 2010.
S = mean vehicle speed (mph)			
C = emission factor for 1980's vehicle fleet exhaust, brake wear, and tire wear (lb/VMT)	$PM_{2.5}$	0.00036	EPA AP-42 Section 13.2.2, Table 13.2.2-4
	PM_{10}	0.00047	EPA AP-42 Section 13.2.2, Table 13.2.2-4
M = surface material moisture content (%)		2.0	EPA AP-42 Section 13.2.2
P = Number of days precip per year		96.3	Billings, MT Climate Summary from 1961-1990, Western Regional Climate Center.
CE = control percent for applying dust suppressant to unpaved roads [b]		0%	No control is assumed.

[a] *Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2, Nov. 2006*

[b] Fitzpatrick, M. 1990. *User's Guide: Emission Control Technologies and Emission Factors for Unpaved Road Fugitive Emissions*, EPA/625/5-87/022. http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=20008SFC.

Fugitive Dust Emission Estimations for Commuting Vehicles on Unpaved Roads - All Project Years

Activity	Fleet Group	Avg. Vehicle Speed (mph)	Total Annual Vehicle Miles	PM_{10}			$PM_{2.5}$		
				Controlled Em. Factor (lb/VMT)	Emissions (tons/fleet group)	Emissions (tpy)	Controlled Em. Factor (lb/VMT)	Emissions (tons/fleet group)	Emissions (tpy)
General Purpose BLM Travel	All Vehicles	25	41,555	2.64	54.91	54.91	0.26	5.49	5.49
		Total	**41,555**	**Total**	**54.91**			**5.487**	

Source of activity data: Billings Field Office (Craig Drake 9/12/2011 spreadsheet).
Assumes no surfacing or water application to control dust from unpaved roads.

General Purpose BLM Fleet Travel - Alternatives A, B, C, and D

ALTERNATIVE: Alternatives A-D

Emission Factors for Commuting Vehicles

	Emission Factors (gm/mile)								
Project Year	NO_x	PM_{10}	$PM_{2.5}$	SO2	CO	VOC	CO_2	CH_4	N_2O[1]
2008									
LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.04

Source: Moblie 6.2.03

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emission Estimations for Commuting Vehicles on Unpaved and Paved Roads - All Project Years

Activity	Fleet Group[a]	Class	Total Annual Vehicle Miles Traveled	Emissions (tons/yr)								
				NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	CO_2	CH_4	N_2O
General Purpose BLM Travel	All Fleets	LDDT	189,531	0.48	0.02	0.02	0.00	1.31	0.57	85.55	0.00	0.01
			Total	**0.4830**	**0.0227**	**0.0185**	**0.00117**	**1.31**	**0.57390**	**8.56E+01**	**4.18E-04**	**1.11E-02**

Source of activity data: Billings Field Office (Craig Drake 9/12/2011 spreadsheet).

[a] All vehicles are considered diesel-powered.

BLM Road Maintenance - Alternatives A, B, C, and D

BLM Road Maintenance **Alternatives A-D**

Total Annual Emissions from Road Maintenance Projects - Alternatives A-D

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs[a]	CO_2	CH_4	N_2O	CO_{2eq}	CO_{2eq} metric Tons
Road Maintenance	1.65	0.19	0.53	0.01	0.20	0.04	0.00	60.42	0.00	0.00	60.64	55.03
Total	**1.65**	**0.19**	**0.53**	**0.01**	**0.20**	**0.04**	**0.00**	**60.42**	**0.0006**	**0.0007**	**60.64**	**55.03**

[a] HAPs = Hazardous Air Pollutants; assumed = VOCs * 0.1

BLM Road Maintenance - Alternatives A, B, C, and D

ALTERNATIVE: Alternatives A-D
Road Maintenance - Independent of Well Road Maintenance

Annual Average Miles of Maintained Road

Cumulative Length of Maintained Roads (miles)	115

Emission Factors for Grader

Pollutant	Emission Factor Equation (lb/VMT)[a]
PM_{10}	$E = (0.6)(0.051)\ S^2$
$PM_{2.5}$	$E = (0.031)(0.04)\ S^{2.5}$

[a] Mean vehicle speed (S)
Source: EPA AP-42, Section 11.9, Table 11.9-1

Emission Factors for Publicly Accessible Unpaved Roads[a]

$$E\ (lb/VMT) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\ (1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
k	1.8	0.18
a	1	1
d	0.5	0.5
c	0.2	0.2

Function/Variable Description		Assumed Value	Reference
E = size-specific emission factor (lb/VMT)			
E_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)			
s = surface material silt content (%)		34.6	Source of activity data: Craig Drake of Billings Field Office, 9-19-2011.
S = mean vehicle speed (mph)			
C = emission factor for 1980's vehicle fleet exhaust, brake wear, and tire wear (lb/VMT)	$PM_{2.5}$	0.00036	EPA AP-42 Section 13.2.2, Table 13.2.2-4
	PM_{10}	0.00047	EPA AP-42 Section 13.2.2, Table 13.2.2-4
M = surface material moisture content (%)		2.0	EPA AP-42 Section 13.2.2
P = Number of days precip per year		80	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = control percent		0%	

[a] *Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2, Nov. 2006*
[b] Fitzpatrick, M. 1990. *User's Guide: Emission Control Technologies and Emission Factors for Unpaved Road Fugitive Emissions* , EPA/625/5-87/022. http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=20008SFC.
* no emissions controls

Estimation of Annual Fugitive Dust Emissions - All Project Years

Activity	Equipment	Total # of Operating Hours	Mean Vehicle Speed (mph)	Total Miles Traveled/ Year	PM_{10}		$PM_{2.5}$	
					Em. Factor (lb/VMT)	Emissions (tons/year)	Em. Factor (lb/VMT)	Emissions (tons/year)
Road Maintenance	Grader	150	5	750	0.765	0.29	0.069	0.03
Road Maintenance	Semi-truck	100	20	200	2.51	0.25	0.25	0.03
Road Maintenance	Lowboy Trailer	100	20	756	2.51	0.95	0.25	0.09
				Total	**1.49**		**0.15**	

BLM Road Maintenance - Alternatives A, B, C, and D

Emission Factors for Off-Road Engines

Horsepower	Emission Factors (g/hp-hr)								
	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O[1]
100 - 175	4.95	0.38	0.12	1.85	0.44	0.37	540.3	0.007	0.0061
~ 300	4.39	0.25	0.12	1.76	0.22	0.24	536.15	0.003	0.0061

Source: EPA NONROADS 2008a
1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.
Source of activity data: MCFO

Combustive Emissions for Grader - Road Maintenance

Equipment	Horsepower	# of Units	Av. Load Factor (%)	Hours/Year	Emissions (tons/year)								
					NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Forklift	100	0	0.10	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Backhoe	87	0	0.80	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Semi-truck	450	1	0.50	100	0.11	0.01	0.00	0.04	0.01	0.01	13.29	0.00	0.00
Lowboy Trailer	450	1	0.50	100	0.11	0.01	0.00	0.04	0.01	0.01	13.29	0.00	0.00
Bobcat	82	1	0.80	500	0.18	0.01	0.00	0.07	0.02	0.01	19.52	0.00	0.00
Grader	165	1	0.90	150	0.12	0.01	0.00	0.05	0.01	0.01	13.26	0.00	0.00
Loader	60	1	0.75	40	0.01	0.00	0.00	0.00	0.00	0.00	1.07	0.00	0.00
Dump Truck	350	0	0.50	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Airport Forklift	100	0	0.10	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Snowplow	350	0	0.25	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total					**5.3E-01**	**3.6E-02**	**1.3E-02**	**2.0E-01**	**3.9E-02**	**3.5E-02**	**6.0E+01**	**5.9E-04**	**6.8E-04**

Wind Erosion Associated with Land Disturbance

Activity	Land Area Disturbed	Silt Content	Days with Wind Speed Greater Than 5.4 m/s	Total Suspended Particulate	Months to Disturb Total Area	Total Suspended Particulate	Emission Control Percent	PM_{10} Emissions	$PM_{2.5}$ Emissions
	(acre/year)	(%)	(%)	(lbs/acre/month)	(months)	(lbs/year)	(%)	(tons/year)	(tons/year)
Total Land Disturbance	258.0	34.6	30	121.812	0.033	1,047.58	0	**0.13**	**0.01**

* account for wind blown dust occuring one time (day) for the disturbed land area (includes disturbed road ways), therefore input one day for calculation purposes.
* assume roadway 12 feet wide for disturbance estimation.
* "Control of Fugitive Dust Sources" EPA-450/3-98-008 (EPA 1998). TSP (lb/acre/month) = 1.7 × (s/1.5) × ([365-p]/235) × (f/15), where:
p = number of days with > 0.001 in precipitation (not used)
f = percent of time wind speed exceeds 5.4 (m/s) [equivalent to 12 mph] = 30% derived from Billings, Montana Airport surface meteorology 1980-1989 dataset.
* AP-42 (EPA 2006), Section 13.2.2 "Unpaved Roads", Background Document. Assuming that PM10 accounts for 25% of TSP. Daily and hourly emissions based on 30.4-day month.
* Assuming that $PM_{2.5}$ accounts for 10% of PM_{10} based on "Analysis of the Fine Fraction of PM in Fugitive Dust," Midwest Research Institute (MRI) Report 110397 (2005).

Coal Mining - Alternatives A, B, C, and D

BiFO Coal Mining Emission Estimates

Mine	Emissions (tpy)						
	CO [1]	NOx [1]	VOC [1]	SO2 [1]	PM10 [2]	PM2.5 [2]	CO2 [3]
Signal Peak Energy LLC (Bull Mountains Mine No. 1)	11.3	23.7	1.2	0.0	29.9	3.0	274.4

1. Non-particulate criteria air pollutants are based on emissions reported in the 2008 NEI.

2. PM10 emissions are based on Montana Department of Environmental Quality Permit Number #3179-04 (February 5, 2009) for the facility. PM2.5 emissions are assumed to be equal to 10 percent of PM10 emissions.

3. CO2 emissions are estimated from fuel use based on information in the Bull Mountains Mine No. 1 Environmental Assessment (DOI-BLM-MT-C010-2009-0010-EA, April, 2011) and information from the air quality permit. See calculations below for GHG emissions.

Non-Boiler Liquid Fuel Combustion GHG Emissions

Fuel Type	Annual Usage (gal/yr)	Emissions (lb/gal)			Emissions (tpy)		
		CO2	CH4	N2O	CO2	CH4	N2O
Gaoline	11,000	19.4	Negl.	Negl.	106.7	Negl.	Negl.
Diesel	181,000	22.2	Negl.	Negl.	122.1	Negl.	Negl.

CO2 emission factors are based on IPCC recommended calculation procedures summarized in "Emission Facts: Average Carbon Dioxide Emissions Resulting from Gasoline and Diesel Fuel", http://www.epa.gov/oms/climate/420f05001.htm, accessed 8/31.2011.

Boiler GHG Emissions

Fuel Type	Annual Usage		Heating Value [2]		CO2 Emission Factors		CO2 Emissions
	Quantity	Usage Units	High Heat Value	High Heat Value Units	(kg CO2/ MMBtu) [2]	(ton CO2/ MMBtu)	(tpy)
Sub-bituminous coal [1]	26	short ton/yr	17.25	MMBtu/short ton	97.02	0.05	21.8
Propane	8517	gal/yr	0.09	MMBtu/gal	61.46	0.03	23.8

[1] The air quality permit allows combustoin of up to 26 tons per year of coal in facility boilers, which include two 35,000 Btu/hr boilers. Propane is used for remaining fuel. Based on 80% boiler efficiency, total fuel needed is estimated to be 767 MMBtu/yr. Based on maximum allowable coal combustion, propane usage would be 8,517 gal/yr.

[2] Source: 40 CFR Part 98, Subpart C. Table C-1.

Fire Management Resource - Alternative A

Fire Management and Ecology **Alternative A**

Total Annual Emissions from Fire Management Projects - Alternative A

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs [a]	CO_2	CH_4	N_2O	$CO2_{eq}$	CO_{2eq} metric Tonnes
Fugitive Dust and Smoke	258.88	222.33	72.09	19.76	2,581.48	131.66	13.17	0.00	136.73	19.81	9,012.40	8,178.22
Heavy Equipment Exhaust	0.18	0.23	7.43	0.65	9.55	1.58	0.16	309,157.85	34.39	11.52	313,452.58	284,439.72
Commuting Vehicles - Fugitive Dust	8.76	0.88	---	---	---	---	---	---	---	---	---	---
Commuting Vehicles - Vehicle Exhaust	0.01	0.01	0.10	0.00	0.11	0.06	0.01	28.91	0.00	0.00	29.45	26.72
Total	**267.8**	**223.4**	**79.6**	**20.4**	**2,591.1**	**133.3**	**13.3**	**309,186.8**	**171.1**	**31.3**	**322,494.4**	**292,644.7**
Emissions Without Wildfire Smoke	**55.7**	**38.0**	**19.4**	**3.9**	**433.2**	**23.2**	**13.3**	**309,072.5**	**154.6**	**31.3**	**322,494.4**	**292,644.7**
% of Emissions From Wildfire Smoke	**79%**	**83%**	**76%**	**81%**	**83%**	**83%**	**0%**	**0%**	**10%**	**0%**	**0%**	**0%**

[a] HAPs = Hazardous Air Pollutants; assumed = VOCs * 0.1

Fire Management Resource - Alternative A

ALTERNATIVE: Alternative A

Fugitive Dust from Heavy Construction Operations

INPUTS & ASSUMPTIONS

Description	Value	Source	Notes
Control Efficiency (C) of watering	0.5	a	
TSP Emission Factor	1.2	b	Tons TSP/acre-month
Conversion factor for TSP to PM_{10}	0.26	c	Percentage of TSP
Conversion factor for PM_{10} to $PM_{2.5}$	0.1	d	Percentage of PM_{10}

[a] Fitzpatrick, M. 1990. *User's Guide: Emission Control Technologies and Emission Factors for Unpaved Road Fugitive Emissions* , EPA/625/5-87/022. http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=20008SFC.
[b] EPA, AP-42, Volume I, Section 13.2.3 Heavy Construction Operations, Jan. 1995 (Errata Feb. 2010)
[c] EPA, AP-42, Volume I, Section 13.2.4 Aggregate Handling and Storage Piles, Nov. 2006
[d] Midwest Research Institute. 2006. *Background Document for Revisions to Fine Fraction Ratios Used for AP-42 Fugitive Dust Emission Factors* , Report prepared for the Western Governors' Association, Western Regional Air Partnership (WRAP), MRI Project No. 110397, November 1, 2006.

Fugitive Dust Emission Estimations for Fire Management - Mechanical Treatment (Hand Work) and Prescribed Fire

Area of Activity & Type of Treatment	Average Annual Disturbed Acreage	# of Days to Complete/Year[b]	Emissions (tons/year)	
			PM_{10} [c]	$PM_{2.5}$ [c]
Mechanical Treatments (Hand Work)	157	1	0.20	0.02
Prescribed Fire	471	1	0.61	0.06
Wild Fire	2,400	1	3.12	0.31
Resource Benefit	0	1	0.00	0.00
Coal Seam Fire	Negl.	1	0.00	0.00
		Total	**3.94**	**0.39**

[a] Source: BIFO
[b] Assume land area disturbed once, therefore input one day to complete for calculation purposes.
[c] Assume only 25% of treated acreage is disturbed by heavy equipment

	Emission Factor[a] (tons/acre burned)								
Activity	**PM_{10}**	**$PM_{2.5}$**	**NO_x**	**SO_2**	**CO**	**VOC**	**CO_2[b]**	**CH_4**	**N_2O**
Prescribed and Wild Fire	0.088	0.077	0.025	0.007	0.899	0.046		0.048	0.0069

[a] Derived from From: Western Governor's Association/Western Regional Air Partnership 2002 Fire Emission Inventory For the WRAP Region - Phase II July 22, 2005
[b] No emission factor for CO_2 as emissions from fire are considered part of the carbon cycle

Smoke Emissions from Fire - All Project Years

Area of Activity & Type of Treatment	Annual Acreage	PM_{10} (tons/year)	$PM_{2.5}$ (tons/year)	NO_x (tons/year)	SO_2 (tons/year)	CO (tons/year)	VOC (tons/year)	CO_2 (tons/year)	CH_4 (tons/year)	N_2O [a] (tons/year)
Prescribed Fire	471	41.64	36.39	11.83	3.24	423.50	21.60	0.00	22.43	3.2499
Wild Fire	2400	212.17	185.43	60.26	16.52	2157.97	110.06	0.00	114.30	16.56
	Total	**253.81**	**221.82**	**72.09**	**19.76**	**2581.48**	**131.66**	**0.00**	**136.73**	**19.81**

[a] Based on average fuel loading for Region 2: Rocky Mountain = 30 tons/acre from AP-42 Table 13.1-1

Wind Erosion Associated with Land Disturbance

Activity	Land Area Disturbed	Silt Content	Days with Wind Speed Greater Than 5.4 m/s	Total Suspended Particulate	Months to Disturb Total Area	Total Suspended Particulate	Emission Control Percent	PM_{10} Emissions	$PM_{2.5}$ Emissions
	(acre/year)	(%)	(%)	(lbs/acre/month)	(months)	(lbs/year)	(%)	(tons/year)	(tons/year)
Total Land Disturbance	3,028	34.6	30	89.673	0.033	9,051.03	0	**1.13**	**0.11**

* Account for wind blown dust occuring one time (day) for the disturbed land area (includes disturbed roadways), therefore input one day for calculation purposes.
* "Control of Fugitive Dust Sources" EPA-450/3-98-008 (EPA 1998). TSP (lb/acre/month) = 1.7 × (s/1.5) × ([365-p]/235) × (f/15), where:
p = number of days with > 0.001 in precipitation
f = percent of time wind speed exceeds 5.4 (m/s) [equivalent to 12 mph] = 30.0% derived from Soda Springs Mountain, Montana surface meteorology 2004-2010 dataset.
* AP-42 (EPA 2006), Section 13.2.2 "Unpaved Roads", Background Document. Assuming that PM10 accounts for 25% of TSP. Daily and hourly emissions based on 30.4-day month.
* Assuming that $PM_{2.5}$ accounts for 10% of PM_{10} based on "Analysis of the Fine Fraction of PM in Fugitive Dust," Midwest Research Institute (MRI) Report 110397 (2006).

Fire Management Resource - Alternative A

ALTERNATIVE: Alternative A

Exhaust Emission Factors for Diesel-Powered Off-Road Construction Equipment

Project Year/Hp Category	Emission Factors (g/hp-hr)								
	NOx	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O[1]
Year 2008									
100 to 175	4.95	0.38	0.12	1.85	0.44	0.37	540.3	0.007	0.0061
175 to 300	4.37	0.29	0.11	1.46	0.36	0.28	506.7	0.006	0.0061

Source: EPA NONROADS 2008a

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr

Emission Factors for Logging Equipment

	Emission Factors (g/hp-hr)								
Year 2008	NOx	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O[1]
Chainsaw 6-11 Hp	1.32	9.75	0.14	293.54	61.89	8.97	686.00	0.54	0.0043
Feller/Bunch/Skidder 75-100 Hp	4.70	0.54	0.13	3.88	0.46	0.52	594.76	0.01	0.0061

Source: EPA NONROADS 2008a

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr

Emission Factors for Additional Equipment

	Emission Factors gm/LTO								
	NOx	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Aircraft Landing/Take-Off Cycle (LTO)	10200.00	0.00	800.00	8100.00	2600.00	0.00	2680000.00	300.00	100.00
	Emission Factors gm/gallon fuel								
	NOx	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Aircraft (cruise)	44.00	0.00	4.00	28.00	2.80	0.00	12600.00	0.00	0.40

Source: IPCC Guidelines on National Greenhouse Gas Inventories. Reference Manual, page 1.98, Table 2, Domestic Average Fleet and Cruise. Jet fuel A density ~ 8lbs/gallon.

Combustive Emission Estimations for Fire Management Activities

Activity	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Hrs/ Day	# of Days/ Project	# of Projects/ Year	Total Hours/ Unit/Year	Emissions (lbs/year)					Emissions (tons/year)								
									NO_x	PM_{10}	SO_2	CO	VOC	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Mechanical Treatments	Skid Steer Loader	75	1	50	6	40	1	240	93.31	10.66	2.54	76.98	9.14	0.05	0.01	0.00	0.04	0.00	0.01	5.90	0.00	0.00
	Chain Saw	5.4	4	80	6	40	1	960	12.10	89.13	1.28	2,683.75	565.84	0.01	0.04	0.00	1.34	0.28	0.05	2.72	0.00	0.00
Prescribed Fire	Skid Steer Loader	75	1	25	5	15	1	75	14.58	1.67	0.40	12.03	1.43	0.01	0.00	0.00	0.01	0.00	0.00	0.92	0.00	0.00
	Chain Saw	5.4	2	40	5	15	1	150	0.94	6.96	0.10	209.67	44.21	0.00	0.00	0.00	0.10	0.02	0.01	0.21	0.00	0.00
	Pumps	25	2	95	5	15	1	150	10.39	76.56	1.10	2,305.38	486.06	0.01	0.04	0.00	1.15	0.24	0.00	2.34	0.00	0.00
Wild Fire	Dozer	100	1	15	6	20	1	120	18.66	2.13	0.51	15.40	1.83	0.01	0.00	0.00	0.01	0.00	0.00	1.18	0.00	0.00
	Chain Saw	5.4	20	50	6	20	1	2400	18.90	139.26	2.00	4,193.36	884.12	0.01	0.07	0.00	2.10	0.44	0.13	4.25	0.00	0.00
	Pumps	25	6	95	10	20	1	1200	295.50	33.77	8.04	243.77	28.94	0.15	0.02	0.00	0.12	0.01	0.02	18.68	0.00	0.00
Underground Coal Seam Fire	Excavator	100	1	80	8	5	1	40	33.18	3.79	0.90	27.37	3.25	0.02	0.00	0.00	0.01	0.00	0.00	2.10	0.00	0.00
	Water Tender	75	1	50	8	5	1	40	15.55	1.78	0.42	12.83	1.52	0.01	0.00	0.00	0.01	0.00	0.00	0.98	0.00	0.00
													Total	**0.26**	**0.18**	**0.01**	**4.89**	**1.01**	**0.23**	**39.28**	**0.00**	**0.00**

Activity data source: BIFO. Year 2008 emissions factors used (conservative).

Combustive Emission Estimations for Fire Management Activities - Additional Equipment

Activity	Equipment Type	# of LTO/year	gallons of fuel used/trip (cruising)	trips/year	gallons (cruising)/ year	Emissions (lbs/year)					Emissions (tons/year)								
						NO_x	PM_{10}	SO_2	CO	VOC	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Prescribed Fire	Aircraft	2	76	2	152	59.72	0.00	4.87	45.10	12.40	0.03	0.00	0.00	0.02	0.01	0.00	11,818.69	1.32	0.44
Wild Fire	Aircraft	50	2715	50	135750	14,292.33	0.00	1,285.27	9,272.49	1,124.56	7.15	0.00	0.64	4.64	0.56	0.00	297,299.88	33.07	11.08
					Total	14,352.05	0.00	1,290.14	9,317.58	1,136.96	**7.18**	**0.00**	**0.65**	**4.66**	**0.57**	**0.00**	**309,118.57**	**34.39**	**11.52**

Activity data source: BIFO, weighted average of Field personnel data survey response.

Fire Management Resource - Alternative A

ALTERNATIVE: Alternative A
Emission Factors for Road Traffic

$$E\ (lb/VMT) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
k	1.8	0.18
a	1	1
d	0.5	0.5
c	0.2	0.2

Function/Variable Description		Assumed Value	Reference
E = size-specific emission factor (lb/VMT)			
E_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)			
s = surface material silt content (%)		34.6	Billings Field Office, Dustin Crowe email dated August 16, 2010.
S = mean vehicle speed (mph)		Listed in the table below	
C = emission factor for 1980's vehicle fleet exhaust, brake wear, and tire wear (lb/VMT)	$PM_{2.5}$	0.00036	EPA AP-42 Section 13.2.2, Table 13.2.2-4
	PM_{10}	0.00047	EPA AP-42 Section 13.2.2, Table 13.2.2-4
M = surface material moisture content (%)		2.0	EPA AP-42 Section 13.2.2
P = Number of days precip per year		96.3	Billings, MT Climate Summary from 1961-1990, Western Regional Climate Center.
CE = emission control percent for watering unpaved roads [b]		50%	Source: Billings Field Office.

[a] *Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2, Nov. 2006*
[b] Fitzpatrick, M. 1990. *User's Guide: Emission Control Technologies and Emission Factors for Unpaved Road Fugitive Emissions*, EPA/625/5-87/022. http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=20008SFC.

Fugitive Dust Emission Estimations for Commuting Vehicles on Unpaved Roads

Activity	Equipment Type	Avg. Vehicle Speed (mph)	Round Trip Distance (miles)	# of Round Trips/ Project	Vehicle Miles Traveled/ Project	# of Projects/ Year	Total Annual Vehicle Miles	PM_{10}			$PM_{2.5}$		
								Controlled Em. Factor (lb/VMT)	Emissions (tons/vehicle type)	Emissions (tons/ activity)	Controlled Em. Factor (lb/VMT)	Emissions (tons/vehicle type)	Emissions (tons/ activity)
Mechanical Treatments (Hand Work)	Support Truck	35	30	40	1,200	1	1200	1.56	0.94	1.17	0.16	0.09	0.12
	ATV	20	20	20	400	1	400	1.18	0.24		0.12	0.02	
Prescribed Fires	Fire Truck	30	70	15	1,050	1	1050	1.45	0.76	3.29	0.14	0.08	0.33
	Fuel Truck	30	70	15	1,050	1	1050	1.45	0.76		0.14	0.08	
	Water Truck	30	70	15	1,050	1	1050	1.45	0.76		0.14	0.08	
	Support Truck	35	70	15	1,050	1	1050	1.56	0.82		0.16	0.08	
	UTV/ATV	20	40	8	320	1	320	1.18	0.19		0.12	0.02	
Wild Fires	Fire Truck	30	70	20	1,400	1	1400	1.45	1.01	4.19	0.14	0.10	0.42
	Fuel Truck	30	70	20	1,400	1	1400	1.45	1.01		0.14	0.10	
	Water Truck	30	70	20	1,400	1	1400	1.45	1.01		0.14	0.10	
	Support Truck	35	70	20	1,400	1	1400	1.56	1.09		0.16	0.11	
	UTV/ATV	20	20	5	100	1	100	1.18	0.06		0.12	0.01	
Coal Seam Fires	Support Truck	30	70	2	140	1	140	1.45	0.10	0.10	0.14	0.01	0.01
								Total	8.76			0.88	

Source of activity data: BiFO. Activities were determined on an annual rather than a project basis.

Fire Management Resource - Alternative A

ALTERNATIVE: Alternative A

Emission Factors for Commuting Vehicles

	Emission Factors (gm/mile)								
Project Year	NO_x	PM_{10}	$PM_{2.5}$	SO2	CO	VOC	CO_2	CH_4	N_2O[1]
2008									
LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.04

Source: MOBILE6.2.03

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Emission Factors for Off-Road ATV

Vehicle	Emission Factors (gm/mile)								
Type	NO_x	PM_{10}	$PM_{2.5}$	SO2	CO	VOC	CO_2	CH_4	N_2O[1]
2-Stroke ATV	0.25	1.86	1.71	0.03	47.81	48.72	140.15	0.42	0.003

Source: EPA NONROADS 2008a

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17.

Combustive Emission Estimations for Commuting Vehicles on Unpaved and Paved Roads

Activity	Equipment Type[a]	Class	Round Trip Distance (miles)	# of Round Trips per Project	Vehicle Miles Traveled /Project	# of Projects/ Year	Total Annual Vehicle Miles Traveled/ Year	Emissions (tons/year)								
								NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	CO_2	CH_4	N_2O
Mechanical Treatments (Hand Work)	Support Truck	HDDV	150	40	6,000	1	6,000	0.02	0.00	0.00	0.00	0.01	0.00	5.24	0.00	0.00
	ATV	R12S	20	20	400	1	400	0.00	0.00	0.00	0.00	0.02	0.02	0.06	0.00	0.00
Prescribed Fires	Fire Truck	HDDV	190	15	2,850	1	2,850	0.01	0.00	0.00	0.00	0.01	0.00	2.49	0.00	0.00
	Fuel Truck	HDDV	190	15	2,850	1	2,850	0.01	0.00	0.00	0.00	0.01	0.00	2.49	0.00	0.00
	Water Truck	HDDV	190	15	2,850	1	2,850	0.01	0.00	0.00	0.00	0.01	0.00	2.49	0.00	0.00
	Support Truck	HDDV	190	15	2,850	1	2,850	0.01	0.00	0.00	0.00	0.01	0.00	2.49	0.00	0.00
	UTV / ATV	R12S	40	8	320	1	320	0.00	0.00	0.00	0.00	0.02	0.02	0.05	0.00	0.00
Wild Fires	Fire Truck	HDDV	190	20	3,800	1	3,800	0.01	0.00	0.00	0.00	0.01	0.00	3.32	0.00	0.00
	Fuel Truck	HDDV	190	20	3,800	1	3,800	0.01	0.00	0.00	0.00	0.01	0.00	3.32	0.00	0.00
	Water Truck	HDDV	190	20	3,800	1	3,800	0.01	0.00	0.00	0.00	0.01	0.00	3.32	0.00	0.00
	Support Truck	HDDV	190	20	3,800	1	3,800	0.01	0.00	0.00	0.00	0.01	0.00	3.32	0.00	0.00
	UTV / ATV	R12S	20	5	100	1	100	0.00	0.00	0.00	0.00	0.01	0.01	0.02	0.00	0.00
Coal Seam Fires	Support Truck	HDDV	190	2	380	1	380	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00
							Total	**0.10**	**0.01**	**0.01**	**0.00**	**0.11**	**0.06**	**28.91**	**0.00**	**0.00**

Activity data source: BiFO. Year 2008 emissions factors used (conservative). Activities were estimated based on an annual, rather than a project, basis.

Fire Management Resource - Alternative B

Fire Management and Ecology **Alternative B**

Total Annual Emissions from Fire Management Projects - Alternative B

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs [a]	CO_2	CH_4	N_2O	$CO2_{eq}$	CO_{2eq} metric Tonnes
Fugitive Dust and Smoke	372.72	313.01	101.19	27.74	3,623.60	184.80	18.48	0.00	191.93	27.81	12,650.64	11,479.71
Heavy Equipment Exhaust	0.20	0.18	7.46	0.65	9.84	1.64	0.16	309,161.89	34.39	11.52	313,456.62	284,443.40
Commuting Vehicles - Fugitive Dust	11.98	1.20	---	---	---	---	---	---	---	---	---	---
Commuting Vehicles - Vehicle Exhaust	0.01	0.01	0.10	0.00	0.14	0.09	0.01	29.22	0.00	0.00	29.76	27.01
Total	**384.9**	**314.4**	**108.8**	**28.4**	**3,633.6**	**186.5**	**18.7**	**309,191.1**	**226.3**	**39.3**	**326,137.0**	**295,950.1**
Emissions Without Wildfire Smoke	**172.7**	**129.0**	**48.5**	**11.9**	**1,475.6**	**76.5**	**18.7**	**309,076.8**	**209.8**	**39.3**	**326,137.0**	**295,950.1**
% of Emissions From Wildfire Smoke	**55%**	**59%**	**55%**	**58%**	**59%**	**59%**	**0%**	**0%**	**7%**	**0%**	**0%**	**0%**

[a] HAPs = Hazardous Air Pollutants; assumed = VOCs * 0.1

Fire Management and Ecology **Alternative B Compared to Alternative A**

Total Annual Emissions from Fire Management Projects - Alternative B

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs [a]	CO_2	CH_4	N_2O	$CO2_{eq}$	CO_{2eq} metric Tonnes
Increase From Alternative A	**68%**	**71%**	**60%**	**67%**	**71%**	**70%**	**29%**	**0%**	**26%**	**20%**	**1%**	**1%**

[a] HAPs = Hazardous Air Pollutants; assumed = VOCs * 0.1

Fire Management Resource - Alternative B

ALTERNATIVE: Alternative B

Fugitive Dust from Heavy Construction Operations

INPUTS & ASSUMPTIONS			
Description	**Value**	**Source**	**Notes**
Control Efficiency (C) of watering	0.5	a	
TSP Emission Factor	1.2	b	Tons TSP/acre-month
Conversion factor for TSP to PM_{10}	0.26	c	Percentage of TSP
Conversion factor for PM_{10} to $PM_{2.5}$	0.1	d	Percentage of PM_{10}

[a] Fitzpatrick, M. 1990. *User's Guide: Emission Control Technologies and Emission Factors for Unpaved Road Fugitive Emissions* , EPA/625/5-87/022. http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=20008SFC.
[b] EPA, AP-42, Volume I, Section 13.2.3 Heavy Construction Operations, Jan. 1995 (Errata Feb. 2010)
[c] EPA, AP-42, Volume I, Section 13.2.4 Aggregate Handling and Storage Piles, Nov. 2006
[d] Midwest Research Institute. 2006. *Background Document for Revisions to Fine Fraction Ratios Used for AP-42 Fugitive Dust Emission Factors* , Report prepared for the Western Governors' Association, Western Regional Air Partnership (WRAP), MRI Project No. 110397, November 1, 2006.

Fugitive Dust Emission Estimations for Fire Management - Mechanical Treatment (Hand Work) and Prescribed Fire

Area of Activity & Type of Treatment	Average Annual Disturbed Acreage	# of Days to Complete/Year[b]	Emissions (tons/year)	
			PM_{10}[c]	$PM_{2.5}$[c]
Mechanical Treatments (Hand Work)	540	1	0.70	0.07
Prescribed Fire	1,630	1	2.12	0.21
Wild Fire	2,400	1	3.12	0.31
Resource Benefit	5,254	1	6.83	0.68
Coal Seam Fire	Negl.	1	0.00	0.00
		Total	**12.77**	**1.28**

[a] Source: BIFO
[b] Assume land area disturbed once, therefore input one day to complete for calculation purposes.
[c] Assume only 25% of treated acreage is disturbed by heavy equipment

	Emission Factor[a] (tons/acre burned)								
Activity	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	CO_2[b]	CH_4	N_2O
Prescribed and Wild Fire	0.088	0.077	0.025	0.007	0.899	0.046		0.048	0.0069

[a] Derived from From: Western Governor's Association/Western Regional Air Partnership 2002 Fire Emission Inventory For the WRAP Region - Phase II July 22, 2005
[b] No emission factor for CO_2 as emissions from fire are considered part of the carbon cycle

Smoke Emissions from Fire - All Project Years

Area of Activity & Type of Treatment	Annual Acreage	PM_{10} (tons/year)	$PM_{2.5}$ (tons/year)	NO_x (tons/year)	SO_2 (tons/year)	CO (tons/year)	VOC (tons/year)	CO_2 (tons/year)	CH_4 (tons/year)	N_2O [a] (tons/year)
Prescribed Fire	1630	144.10	125.94	40.93	11.22	1465.62	74.75	0.00	77.63	11.247
Wild Fire	2400	212.17	185.43	60.26	16.52	2157.97	110.06	0.00	114.30	16.56
	Total	**356.27**	**311.37**	**101.19**	**27.74**	**3623.60**	**184.80**	**0.00**	**191.93**	**27.81**

[a] Based on average fuel loading for Region 2: Rocky Mountain = 30 tons/acre from AP-42 Table 13.1-1

Wind Erosion Associated with Land Disturbance

Activity	Land Area Disturbed	Silt Content	Days with Wind Speed Greater Than 5.4 m/s	Total Suspended Particulate	Months to Disturb Total Area	Total Suspended Particulate	Emission Control Percent	PM_{10} Emissions	$PM_{2.5}$ Emissions
	(acre/year)	(%)	(%)	(lbs/acre/month)	(months)	(lbs/year)	(%)	(tons/year)	(tons/year)
Total Land Disturbance	9,824	34.6	30	89.673	0.033	29,365.04	0	**3.67**	**0.37**

* Account for wind blown dust occuring one time (day) for the disturbed land area (includes disturbed roadways), therefore input one day for calculation purposes.
* "Control of Fugitive Dust Sources" EPA-450/3-98-008 (EPA 1998). TSP (lb/acre/month) = 1.7 × (s/1.5) × ([365-p]/235) × (f/15), where:
p = number of days with > 0.001 in precipitation
f = percent of time wind speed exceeds 5.4 (m/s) [equivalent to 12 mph] = 30.0% derived from Soda Springs Mountain, Montana surface meteorology 2004-2010 dataset.
* AP-42 (EPA 2006), Section 13.2.2 "Unpaved Roads", Background Document. Assuming that PM10 accounts for 25% of TSP. Daily and hourly emissions based on 30.4-day month.
* Assuming that $PM_{2.5}$ accounts for 10% of PM_{10} based on "Analysis of the Fine Fraction of PM in Fugitive Dust," Midwest Research Institute (MRI) Report 110397 (2006).

Fire Management Resource - Alternative B

ALTERNATIVE: Alternative B

Exhaust Emission Factors for Diesel-Powered Off-Road Construction Equipment

Project Year/Hp Category	Emission Factors (g/hp-hr)								
	NOx	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O[1]
Year 2008									
100 to 175	4.95	0.38	0.12	1.85	0.44	0.37	540.3	0.007	0.0061
175 to 300	4.37	0.29	0.11	1.46	0.36	0.28	506.7	0.006	0.0061

Source: EPA NONROADS 2008a

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr

Emission Factors for Logging Equipment

	Emission Factors (g/hp-hr)								
Year 2008	NOx	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O[1]
Chainsaw 6-11 Hp	1.32	9.75	0.14	293.54	61.89	8.97	686.00	0.54	0.0043
Feller/Bunch/Skidder 75-100 Hp	4.70	0.54	0.13	3.88	0.46	0.52	594.76	0.01	0.0061

Source: EPA NONROADS 2008a

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr

Emission Factors for Additional Equipment

	Emission Factors gm/LTO								
	NOx	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Aircraft Landing/Take-Off Cycle (LTO)	10200.00	0.00	800.00	8100.00	2600.00	0.00	2680000.00	300.00	100.00
	Emission Factors gm/gallon fuel								
	NOx	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Aircraft (cruise)	44.00	0.00	4.00	28.00	2.80	0.00	12600.00	0.00	0.40

Source: IPCC Guidelines on National Greenhouse Gas Inventories. Reference Manual, page 1.98, Table 2, Domestic Average Fleet and Cruise. Jet fuel A density ~ 8lbs/gallon.

Combustive Emission Estimations for Fire Management Activities

Activity	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Hrs/ Day	# of Days/ Project	# of Projects/ Year	Total Hours/ Unit/Year	Emissions (lbs/year)					Emissions (tons/year)								
									NO_x	PM_{10}	SO_2	CO	VOC	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Mechanical Treatments	Skid Steer Loader	75	1	50	6	75	1	450	174.96	20.00	4.76	144.34	17.14	0.09	0.01	0.00	0.07	0.01	0.02	11.06	0.00	0.00
	Chain Saw	5.4	4	80	6	75	1	1800	22.68	167.11	2.40	5,032.03	1,060.94	0.01	0.08	0.00	2.52	0.53	0.10	5.10	0.00	0.00
Prescribed Fire	Skid Steer Loader	75	1	25	5	25	1	125	24.30	2.78	0.66	20.05	2.38	0.01	0.00	0.00	0.01	0.00	0.01	1.54	0.00	0.00
	Chain Saw	5.4	2	40	5	25	1	250	1.57	11.60	0.17	349.45	73.68	0.00	0.01	0.00	0.17	0.04	0.01	0.35	0.00	0.00
	Pumps	25	2	95	5	25	1	250	17.32	127.60	1.84	3,842.30	810.10	0.01	0.06	0.00	1.92	0.41	0.00	3.89	0.00	0.00
Wild Fire	Dozer	100	1	15	6	20	1	120	18.66	2.13	0.51	15.40	1.83	0.01	0.00	0.00	0.01	0.00	0.00	1.18	0.00	0.00
	Chain Saw	5.4	2	60	6	20	1	240	2.27	16.71	0.24	503.20	106.09	0.00	0.01	0.00	0.25	0.05	0.01	0.51	0.00	0.00
	Pumps	25	6	95	10	20	1	1200	295.50	33.77	8.04	243.77	28.94	0.15	0.02	0.00	0.12	0.01	0.02	18.68	0.00	0.00
Resource Benefit	Chain Saw	5.4	2	25	6	20	1	240	0.94	6.96	0.10	209.67	44.21	0.00	0.00	0.00	0.10	0.02	0.00	0.21	0.00	0.00
	Pumps	25	2	15	8	20	1	320	12.44	1.42	0.34	10.26	1.22	0.01	0.00	0.00	0.01	0.00	0.00	0.79	0.00	0.00
													Total	**0.29**	**0.20**	**0.01**	**5.19**	**1.07**	**0.18**	**43.32**	**0.00**	**0.00**

Activity data source: BIFO. Year 2008 emissions factors used (conservative).

Combustive Emission Estimations for Fire Management Activities - Additional Equipment

Activity	Equipment Type	# of LTO/year	gallons of fuel used/trip (cruising)	trips/year	gallons (cruising)/ year	Emissions (lbs/year)					Emissions (tons/year)								
						NO_x	PM_{10}	SO_2	CO	VOC	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Prescribed Fire	Aircraft	2	76	2	152	59.72	0.00	4.87	45.10	12.40	0.03	0.00	0.00	0.02	0.01	0.00	11,818.69	1.32	0.44
Wild Fire	Aircraft	50	2715	50	135750	14,292.33	0.00	1,285.27	9,272.49	1,124.56	7.15	0.00	0.64	4.64	0.56	0.00	297,299.88	33.07	11.08
Total						14,352.05	0.00	1,290.14	9,317.58	1,136.96	**7.18**	**0.00**	**0.65**	**4.66**	**0.57**	**0.00**	**309,118.57**	**34.39**	**11.52**

Activity data source: BIFO, weighted average of Field personnel data survey response.

Fire Management Resource - Alternative B

ALTERNATIVE: Alternative B
Emission Factors for Road Traffic

$$E\ (lb/VMT) = \frac{k\ (s/12)^a\ (S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\ (1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
k	1.8	0.18
a	1	1
d	0.5	0.5
c	0.2	0.2

Function/Variable Description		Assumed Value	Reference
E = size-specific emission factor (lb/VMT)			
E_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)			
s = surface material silt content (%)		34.6	Billings Field Office, Dustin Crowe email dated August 16, 2010.
S = mean vehicle speed (mph)		Listed in the table below	
C = emission factor for 1980's vehicle fleet exhaust, brake wear, and tire wear (lb/VMT)	$PM_{2.5}$	0.00036	EPA AP-42 Section 13.2.2, Table 13.2.2-4
	PM_{10}	0.00047	EPA AP-42 Section 13.2.2, Table 13.2.2-4
M = surface material moisture content (%)		2.0	EPA AP-42 Section 13.2.2
P = Number of days precip per year		96.3	Billings, MT Climate Summary from 1961-1990, Western Regional Climate Center.
CE = emission control percent for watering unpaved roads [b]		50%	Source: Billings Field Office.

[a] *Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2, Nov. 2006*
[b] Fitzpatrick, M. 1990. *User's Guide: Emission Control Technologies and Emission Factors for Unpaved Road Fugitive Emissions*, EPA/625/5-87/022. http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=20008SFC.

Fugitive Dust Emission Estimations for Commuting Vehicles on Unpaved Roads

Activity	Equipment Type	Avg. Vehicle Speed (mph)	Round Trip Distance (miles)	# of Round Trips/ Project	Vehicle Miles Traveled/ Project	# of Projects/ Year	Total Annual Vehicle Miles	PM_{10} Controlled Em. Factor (lb/VMT)	PM_{10} Emissions (tons/vehicle type)	PM_{10} Emissions (tons/ activity)	$PM_{2.5}$ Controlled Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions (tons/vehicle type)	$PM_{2.5}$ Emissions (tons/ activity)
Mechanical Treatments (Hand Work)	Support Truck	35	30	75	2,250	1	2250	1.56	1.76	2.21	0.16	0.18	0.22
	ATV	20	20	38	760	1	760	1.18	0.45		0.12	0.04	
Prescribed Fires	Fire Truck	30	70	25	1,750	1	1750	1.45	1.27	5.48	0.14	0.13	0.55
	Fuel Truck	30	70	25	1,750	1	1750	1.45	1.27		0.14	0.13	
	Water Truck	30	70	25	1,750	1	1750	1.45	1.27		0.14	0.13	
	Support Truck	35	70	25	1,750	1	1750	1.56	1.37		0.16	0.14	
	UTV/ATV	20	40	13	520	1	520	1.18	0.31		0.12	0.03	
Wild Fires	Fire Truck	30	70	20	1,400	1	1400	1.45	1.01	4.19	0.14	0.10	0.42
	Fuel Truck	30	70	20	1,400	1	1400	1.45	1.01		0.14	0.10	
	Water Truck	30	70	20	1,400	1	1400	1.45	1.01		0.14	0.10	
	Support Truck	35	70	20	1,400	1	1400	1.56	1.09		0.16	0.11	
	UTV/ATV	20	20	5	100	1	100	1.18	0.06		0.12	0.01	
Coal Seam Fires	Support Truck	30	70	2	140	1	140	1.45	0.10	0.10	0.14	0.01	0.01
								Total	11.98			1.20	

Source of activity data: BIFO. Activities were determined on an annual rather than a project basis.

Fire Management Resource - Alternative B

ALTERNATIVE: Alternative B

Emission Factors for Commuting Vehicles

	Emission Factors (gm/mile)								
Project Year	NO_x	PM_{10}	$PM_{2.5}$	SO2	CO	VOC	CO_2	CH_4	N_2O[1]
2008									
LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.04

Source: MOBILE6.2.03

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Emission Factors for Off-Road ATV

Vehicle	Emission Factors (gm/mile)								
Type	NO_x	PM_{10}	$PM_{2.5}$	SO2	CO	VOC	CO_2	CH_4	N_2O[1]
2-Stroke ATV	0.25	1.86	1.71	0.03	47.81	48.72	140.15	0.42	0.003

Source: EPA NONROADS 2008a

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17.

Combustive Emission Estimations for Commuting Vehicles on Unpaved and Paved Roads

Activity	Equipment Type[a]	Class	Round Trip Distance (miles)	# of Round Trips per Project	Vehicle Miles Traveled /Project	# of Projects/ Year	Total Annual Vehicle Miles Traveled/ Year	Emissions (tons/year)								
								NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	CO_2	CH_4	N_2O
Mechanical Treatments (Hand Work)	Support Truck	HDDV	150	75	11,250	1	11,250	0.03	0.00	0.00	0.00	0.02	0.00	9.82	0.00	0.00
	ATV	R12S	20	38	760	1	760	0.00	0.00	0.00	0.00	0.04	0.04	0.12	0.00	0.00
Prescribed Fires	Fire Truck	HDDV	190	25	4,750	1	4,750	0.01	0.00	0.00	0.00	0.01	0.00	4.15	0.00	0.00
	Fuel Truck	HDDV	190	25	4,750	1	4,750	0.01	0.00	0.00	0.00	0.01	0.00	4.15	0.00	0.00
	Water Truck	HDDV	190	25	4,750	1	4,750	0.01	0.00	0.00	0.00	0.01	0.00	4.15	0.00	0.00
	Support Truck	HDDV	190	25	1750	1	1,750	0.01	0.00	0.00	0.00	0.00	0.00	1.53	0.00	0.00
	UTV / ATV	R12S	40	13	520	1	520	0.00	0.00	0.00	0.00	0.03	0.03	0.08	0.00	0.00
Wild Fires	Fire Truck	HDDV	190	20	1400	1	1,400	0.00	0.00	0.00	0.00	0.00	0.00	1.22	0.00	0.00
	Fuel Truck	HDDV	190	20	1400	1	1,400	0.00	0.00	0.00	0.00	0.00	0.00	1.22	0.00	0.00
	Water Truck	HDDV	190	20	1400	1	1,400	0.00	0.00	0.00	0.00	0.00	0.00	1.22	0.00	0.00
	Support Truck	HDDV	190	20	1400	1	1,400	0.00	0.00	0.00	0.00	0.00	0.00	1.22	0.00	0.00
	UTV / ATV	R12S	20	5	100	1	100	0.00	0.00	0.00	0.00	0.01	0.01	0.02	0.00	0.00
Coal Seam Fires	Support Truck	HDDV	190	2	380	1	380	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00
							Total	**0.10**	**0.01**	**0.01**	**0.00**	**0.14**	**0.09**	**29.22**	**0.00**	**0.00**

Activity data source: BiFO. Year 2008 emissions factors used (conservative). Activities were estimated based on an annual, rather than a project, basis.

Fire Management Resource: Alternative C

Fire Management and Ecology **Alternative C**

Total Annual Emissions from Fire Management Projects - Alternative C

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs [a]	CO_2	CH_4	N_2O	$CO2_{eq}$	CO_{2eq} metric Tonnes
Fugitive Dust and Smoke	363.92	312.13	101.19	27.74	3,623.60	184.80	18.48	0.00	191.93	27.81	12,650.64	11,479.71
Heavy Equipment Exhaust	0.27	0.07	7.46	0.66	12.00	2.10	0.21	309,165.48	34.39	11.52	313,460.22	284,446.67
Commuting Vehicles - Fugitive Dust	11.98	1.20	---	---	---	---	---	---	---	---	---	---
Commuting Vehicles - Vehicle Exhaust	0.01	0.01	0.10	0.00	0.14	0.09	0.01	29.22	0.00	0.00	29.76	27.01
Total	**376.2**	**313.4**	**108.8**	**28.4**	**3,635.7**	**187.0**	**18.7**	**309,194.7**	**226.3**	**39.3**	**326,140.6**	**295,953.4**
Emissions Without Wildfire Smoke	**164.0**	**128.0**	**48.5**	**11.9**	**1,477.8**	**76.9**	**18.7**	**309,080.4**	**209.8**	**39.3**	**326,140.6**	**295,953.4**
% of Emissions From Wildfire Smoke	**56%**	**59%**	**55%**	**58%**	**59%**	**59%**	**0%**	**0%**	**7%**	**0%**	**0%**	**0%**

[a] HAPs = Hazardous Air Pollutants; assumed = VOCs * 0.1

Fire Management Resource: Alternative C

ALTERNATIVE: Alternative C

Fugitive Dust from Heavy Construction Operations

INPUTS & ASSUMPTIONS			
Description	**Value**	**Source**	**Notes**
Control Efficiency (C) of watering	0.5	a	
TSP Emission Factor	1.2	b	Tons TSP/acre-month
Conversion factor for TSP to PM_{10}	0.26	c	Percentage of TSP
Conversion factor for PM_{10} to $PM_{2.5}$	0.1	d	Percentage of PM_{10}

[a] Fitzpatrick, M. 1990. *User's Guide: Emission Control Technologies and Emission Factors for Unpaved Road Fugitive Emissions* , EPA/625/5-87/022. http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=20008SFC.
[b] EPA, AP-42, Volume I, Section 13.2.3 Heavy Construction Operations, Jan. 1995 (Errata Feb. 2010)
[c] EPA, AP-42, Volume I, Section 13.2.4 Aggregate Handling and Storage Piles, Nov. 2006
[d] Midwest Research Institute. 2006. *Background Document for Revisions to Fine Fraction Ratios Used for AP-42 Fugitive Dust Emission Factors* , Report prepared for the Western Governors' Association, Western Regional Air Partnership (WRAP), MRI Project No. 110397, November 1, 2006.

Fugitive Dust Emission Estimations for Fire Management - Mechanical Treatment (Hand Work) and Prescribed Fire

Area of Activity & Type of Treatment	Average Annual Disturbed Acreage	# of Days to Complete/Year[b]	Emissions (tons/year)	
			PM_{10}[c]	$PM_{2.5}$[c]
Mechanical Treatments (Hand Work)	540	1	0.70	0.07
Prescribed Fire	1,630	1	2.12	0.21
Wild Fire	2,400	1	3.12	0.31
Resource Benefit	0	1	0.00	0.00
Coal Seam Fire	Negl.	1	0.00	0.00
		Total	**5.94**	**0.59**

[a] Source: BIFO
[b] Assume land area disturbed once, therefore input one day to complete for calculation purposes.
[c] Assume only 25% of treated acreage is disturbed by heavy equipment

	Emission Factor[a] (tons/acre burned)								
Activity	**PM_{10}**	**$PM_{2.5}$**	**NO_x**	**SO_2**	**CO**	**VOC**	**CO_2[b]**	**CH_4**	**N_2O**
Prescribed and Wild Fire	0.088	0.077	0.025	0.007	0.899	0.046		0.048	0.0069

[a] Derived from From: Western Governor's Association/Western Regional Air Partnership 2002 Fire Emission Inventory For the WRAP Region - Phase II July 22, 2005
[b] No emission factor for CO_2 as emissions from fire are considered part of the carbon cycle

Smoke Emissions from Fire - All Project Years

Area of Activity & Type of Treatment	Annual Acreage	PM_{10} (tons/year)	$PM_{2.5}$ (tons/year)	NO_x (tons/year)	SO_2 (tons/year)	CO (tons/year)	VOC (tons/year)	CO_2 (tons/year)	CH_4 (tons/year)	N_2O [a] (tons/year)
Prescribed Fire	1630	144.10	125.94	40.93	11.22	1465.62	74.75	0.00	77.63	11.247
Wild Fire	2400	212.17	185.43	60.26	16.52	2157.97	110.06	0.00	114.30	16.56
Total		**356.27**	**311.37**	**101.19**	**27.74**	**3623.60**	**184.80**	**0.00**	**191.93**	**27.81**

[a] Based on average fuel loading for Region 2: Rocky Mountain = 30 tons/acre from AP-42 Table 13.1-1

Wind Erosion Associated with Land Disturbance

Activity	Land Area Disturbed	Silt Content	Days with Wind Speed Greater Than 5.4 m/s	Total Suspended Particulate	Months to Disturb Total Area	Total Suspended Particulate	Emission Control Percent	PM_{10} Emissions	$PM_{2.5}$ Emissions
	(acre/year)	(%)	(%)	(lbs/acre/month)	(months)	(lbs/year)	(%)	(tons/year)	(tons/year)
Total Land Disturbance	4,570	34.6	30	89.673	0.033	13,660.25	0	**1.71**	**0.17**

* Account for wind blown dust occuring one time (day) for the disturbed land area (includes disturbed roadways), therefore input one day for calculation purposes.
* "Control of Fugitive Dust Sources" EPA-450/3-98-008 (EPA 1998). TSP (lb/acre/month) = 1.7 × (s/1.5) × ([365-p]/235) × (f/15), where:
p = number of days with > 0.001 in precipitation
f = percent of time wind speed exceeds 5.4 (m/s) [equivalent to 12 mph] = 30.0% derived from Soda Springs Mountain, Montana surface meteorology 2004-2010 dataset.
* AP-42 (EPA 2006), Section 13.2.2 "Unpaved Roads", Background Document. Assuming that PM10 accounts for 25% of TSP. Daily and hourly emissions based on 30.4-day month.
* Assuming that $PM_{2.5}$ accounts for 10% of PM_{10} based on "Analysis of the Fine Fraction of PM in Fugitive Dust," Midwest Research Institute (MRI) Report 110397 (2006)

Fire Management Resource: Alternative C

ALTERNATIVE: Alternative C

Exhaust Emission Factors for Diesel-Powered Off-Road Construction Equipment

Project Year/Hp Category	Emission Factors (g/hp-hr)								
	NOx	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O[1]
Year 2008									
100 to 175	4.95	0.38	0.12	1.85	0.44	0.37	540.3	0.007	0.0061
175 to 300	4.37	0.29	0.11	1.46	0.36	0.28	506.7	0.006	0.0061

Source: EPA NONROADS 2008a

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr

Emission Factors for Logging Equipment

	Emission Factors (g/hp-hr)								
Year 2008	NOx	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O[1]
Chainsaw 6-11 Hp	1.32	9.75	0.14	293.54	61.89	8.97	686.00	0.54	0.0043
Feller/Bunch/Skidder 75-100 Hp	4.70	0.54	0.13	3.88	0.46	0.52	594.76	0.01	0.0061

Source: EPA NONROADS 2008a

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr

Emission Factors for Additional Equipment

	Emission Factors gm/LTO								
	NOx	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Aircraft Landing/Take-Off Cycle (LTO)	10200.00	0.00	800.00	8100.00	2600.00	0.00	2680000.00	300.00	100.00
	Emission Factors gm/gallon fuel								
	NOx	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Aircraft (cruise)	44.00	0.00	4.00	28.00	2.80	0.00	12600.00	0.00	0.40

Source: IPCC Guidelines on National Greenhouse Gas Inventories. Reference Manual, page 1.98, Table 2, Domestic Average Fleet and Cruise. Jet fuel A density ~ 8lbs/gallon.

Combustive Emission Estimations for Fire Management Activities

Activity	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Hrs/ Day	# of Days/ Project	# of Projects/ Year	Total Hours/ Unit/Year	Emissions (lbs/year)					Emissions (tons/year)								
									NO_x	PM_{10}	SO_2	CO	VOC	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Mechanical Treatments	Skid Steer Loader	75	1	50	6	75	1	450	174.96	20.00	4.76	144.34	17.14	0.09	0.01	0.00	0.07	0.01	0.02	11.06	0.00	0.00
	Chain Saw	5.4	4	80	6	75	1	1800	22.68	167.11	2.40	5,032.03	1,060.94	0.01	0.08	0.00	2.52	0.53	0.01	5.10	0.00	0.00
Prescribed Fire	Skid Steer Loader	75	1	25	5	25	1	125	24.30	2.78	0.66	20.05	2.38	0.01	0.00	0.00	0.01	0.00	0.01	1.54	0.00	0.00
	Chain Saw	5.4	2	40	5	25	1	250	1.57	11.60	0.17	349.45	73.68	0.00	0.01	0.00	0.17	0.04	0.00	0.35	0.00	0.00
	Pumps	25	2	95	5	25	1	250	17.32	127.60	1.84	3,842.30	810.10	0.01	0.06	0.00	1.92	0.41	0.00	3.89	0.00	0.00
Wild Fire	Dozer	100	1	15	6	20	1	120	18.66	2.13	0.51	15.40	1.83	0.01	0.00	0.00	0.01	0.00	0.01	1.18	0.00	0.00
	Chain Saw	5.4	20	60	6	20	1	2400	22.68	167.11	2.40	5,032.03	1,060.94	0.01	0.08	0.00	2.52	0.53	0.01	5.10	0.00	0.00
	Pumps	25	6	95	10	20	1	1200	295.50	33.77	8.04	243.77	28.94	0.15	0.02	0.00	0.12	0.01	0.02	18.68	0.00	0.00
Resource Benefit	Chain Saw	5.4	2	25	6	0	1	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Pump	25	2	15	8	0	1	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
													Total	**0.29**	**0.27**	**0.01**	**7.34**	**1.53**	**0.07**	**46.91**	**0.00**	**0.00**

Activity data source: BiFO. Year 2008 emissions factors used (conservative).

Combustive Emission Estimations for Fire Management Activities - Additional Equipment

Activity	Equipment Type	# of LTO/year	gallons of fuel used/trip (cruising)	trips/year	gallons (cruising)/ year	Emissions (lbs/year)					Emissions (tons/year)								
						NO_x	PM_{10}	SO_2	CO	VOC	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Prescribed Fire	Aircraft	2	76	2	152	59.72	0.00	4.87	45.10	12.40	0.03	0.00	0.00	0.02	0.01	0.00	11,818.69	1.32	0.44
Wild Fire	Aircraft	50	2715	50	135750	14,292.33	0.00	1,285.27	9,272.49	1,124.56	7.15	0.00	0.64	4.64	0.56	0.00	297,299.88	33.07	11.08
					Total	14,352.05	0.00	1,290.14	9,317.58	1,136.96	**7.18**	**0.00**	**0.65**	**4.66**	**0.57**	**0.00**	**309,118.57**	**34.39**	**11.52**

Activity data source: BiFO, weighted average of Field personnel data survey response.

Fire Management Resource: Alternative C

ALTERNATIVE: Alternative C
Emission Factors for Road Traffic

$$E\ (lb/VMT) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
k	1.8	0.18
a	1	1
d	0.5	0.5
c	0.2	0.2

Function/Variable Description		Assumed Value	Reference
E = size-specific emission factor (lb/VMT)			
E_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)			
s = surface material silt content (%)		34.6	Billings Field Office, Dustin Crowe email dated August 16, 2010.
S = mean vehicle speed (mph)		Listed in the table below	
C = emission factor for 1980's vehicle fleet exhaust, brake wear, and tire wear (lb/VMT)	$PM_{2.5}$	0.00036	EPA AP-42 Section 13.2.2, Table 13.2.2-4
	PM_{10}	0.00047	EPA AP-42 Section 13.2.2, Table 13.2.2-4
M = surface material moisture content (%)		2.0	EPA AP-42 Section 13.2.2
P = Number of days precip per year		96.3	Billings, MT Climate Summary from 1961-1990, Western Regional Climate Center.
CE = emission control percent for watering unpaved roads [b]		50%	Source: Billings Field Office.

[a] *Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2, Nov. 2006*
[b] Fitzpatrick, M. 1990. *User's Guide: Emission Control Technologies and Emission Factors for Unpaved Road Fugitive Emissions*, EPA/625/5-87/022. http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=20008SFC.

Fugitive Dust Emission Estimations for Commuting Vehicles on Unpaved Roads

Activity	Equipment Type	Avg. Vehicle Speed (mph)	Round Trip Distance (miles)	# of Round Trips/ Project	Vehicle Miles Traveled/ Project	# of Projects/ Year	Total Annual Vehicle Miles	PM_{10} Controlled Em. Factor (lb/VMT)	PM_{10} Emissions (tons/vehicle type)	PM_{10} Emissions (tons/ activity)	$PM_{2.5}$ Controlled Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions (tons/vehicle type)	$PM_{2.5}$ Emissions (tons/ activity)
Mechanical Treatments (Hand Work)	Support Truck	35	30	75	2,250	1	2250	1.56	1.76	2.21	0.16	0.18	0.22
	ATV	20	20	38	760	1	760	1.18	0.45		0.12	0.04	
Prescribed Fires	Fire Truck	30	70	25	1,750	1	1750	1.45	1.27	5.48	0.14	0.13	0.55
	Fuel Truck	30	70	25	1,750	1	1750	1.45	1.27		0.14	0.13	
	Water Truck	30	70	25	1,750	1	1750	1.45	1.27		0.14	0.13	
	Support Truck	35	70	25	1,750	1	1750	1.56	1.37		0.16	0.14	
	UTV/ATV	20	40	13	520	1	520	1.18	0.31		0.12	0.03	
Wild Fires	Fire Truck	30	70	20	1,400	1	1400	1.45	1.01	4.19	0.14	0.10	0.42
	Fuel Truck	30	70	20	1,400	1	1400	1.45	1.01		0.14	0.10	
	Water Truck	30	70	20	1,400	1	1400	1.45	1.01		0.14	0.10	
	Support Truck	35	70	20	1,400	1	1400	1.56	1.09		0.16	0.11	
	UTV/ATV	20	20	5	100	1	100	1.18	0.06		0.12	0.01	
Coal Seam Fires	Support Truck	30	70	2	140	1	140	1.45	0.10	0.10	0.14	0.01	0.01
								Total	11.98			1.20	

Source of activity data: BIFO. Activities were determined on an annual rather than a project basis.

Fire Management Resource - Alternative C

ALTERNATIVE: Alternative C

Emission Factors for Commuting Vehicles

	Emission Factors (gm/mile)								
Project Year	NO_x	PM_{10}	$PM_{2.5}$	SO2	CO	VOC	CO_2	CH_4	N_2O[1]
2008									
LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.04

Source: MOBILE6.2.03

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Emission Factors for Off-Road ATV

Vehicle	Emission Factors (gm/mile)								
Type	NO_x	PM_{10}	$PM_{2.5}$	SO2	CO	VOC	CO_2	CH_4	N_2O[1]
2-Stroke ATV	0.25	1.86	1.71	0.03	47.81	48.72	140.15	0.42	0.003

Source: EPA NONROADS 2008a

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17.

Combustive Emission Estimations for Commuting Vehicles on Unpaved and Paved Roads

Activity	Equipment Type[a]	Class	Round Trip Distance (miles)	# of Round Trips per Project	Vehicle Miles Traveled /Project	# of Projects/ Year	Total Annual Vehicle Miles Traveled/ Year	Emissions (tons/year)								
								NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	CO_2	CH_4	N_2O
Mechanical Treatments (Hand Work)	Support Truck	HDDV	150	75	11,250	1	11,250	0.03	0.00	0.00	0.00	0.02	0.00	9.82	0.00	0.00
	ATV	R12S	20	38	760	1	760	0.00	0.00	0.00	0.00	0.04	0.04	0.12	0.00	0.00
Prescribed Fires	Fire Truck	HDDV	190	25	4,750	1	4,750	0.01	0.00	0.00	0.00	0.01	0.00	4.15	0.00	0.00
	Fuel Truck	HDDV	190	25	4,750	1	4,750	0.01	0.00	0.00	0.00	0.01	0.00	4.15	0.00	0.00
	Water Truck	HDDV	190	25	4,750	1	4,750	0.01	0.00	0.00	0.00	0.01	0.00	4.15	0.00	0.00
	Support Truck	HDDV	190	25	1750	1	1,750	0.01	0.00	0.00	0.00	0.00	0.00	1.53	0.00	0.00
	UTV / ATV	R12S	40	13	520	1	520	0.00	0.00	0.00	0.00	0.03	0.03	0.08	0.00	0.00
Wild Fires	Fire Truck	HDDV	190	20	1400	1	1,400	0.00	0.00	0.00	0.00	0.00	0.00	1.22	0.00	0.00
	Fuel Truck	HDDV	190	20	1400	1	1,400	0.00	0.00	0.00	0.00	0.00	0.00	1.22	0.00	0.00
	Water Truck	HDDV	190	20	1400	1	1,400	0.00	0.00	0.00	0.00	0.00	0.00	1.22	0.00	0.00
	Support Truck	HDDV	190	20	1400	1	1,400	0.00	0.00	0.00	0.00	0.00	0.00	1.22	0.00	0.00
	UTV / ATV	R12S	20	5	100	1	100	0.00	0.00	0.00	0.00	0.01	0.01	0.02	0.00	0.00
Coal Seam Fires	Support Truck	HDDV	190	2	380	1	380	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00
							Total	**0.10**	**0.01**	**0.01**	**0.00**	**0.14**	**0.09**	**29.22**	**0.00**	**0.00**

Activity data source: BiFO. Year 2008 emissions factors used (conservative). Activities were estimated based on an annual, rather than a project, basis.

Fire Management Resource - Alternative D

Fire Management and Ecology **Alternative D**

Total Annual Emissions from Fire Management Projects - Alternative D

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs [a]	CO_2	CH_4	N_2O	$CO2_{eq}$	CO_{2eq} metric Tonnes
Fugitive Dust and Smoke	374.45	313.19	101.19	27.74	3,623.60	184.80	18.48	0.00	191.93	27.81	12,650.64	11,479.71
Heavy Equipment Exhaust	0.19	0.23	7.41	0.65	9.95	1.67	0.17	309,155.62	34.39	11.52	313,450.34	284,437.69
Commuting Vehicles - Fugitive Dust	8.76	0.88	---	---	---	---	---	---	---	---	---	---
Commuting Vehicles - Vehicle Exhaust	0.01	0.01	0.06	0.00	0.08	0.05	0.01	18.96	0.00	0.00	19.32	17.53
Total	**383.4**	**314.3**	**108.7**	**28.4**	**3,633.6**	**186.5**	**18.7**	**309,174.6**	**226.3**	**39.3**	**326,120.3**	**295,934.9**
Emissions Without Wildfire Smoke	**171.2**	**128.9**	**48.4**	**11.9**	**1,475.7**	**76.5**	**18.7**	**309,060.3**	**209.8**	**39.3**	**326,120.3**	**295,934.9**
% of Emissions From Wildfire Smoke	**55%**	**59%**	**55%**	**58%**	**59%**	**59%**	**0%**	**0%**	**7%**	**0%**	**0%**	**0%**

[a] HAPs = Hazardous Air Pollutants; assumed = VOCs * 0.1

Fire Management Resource - Alternative D

ALTERNATIVE: Alternative D

Fugitive Dust from Heavy Construction Operations

INPUTS & ASSUMPTIONS			
Description	**Value**	**Source**	**Notes**
Control Efficiency (C) of watering	0.5	a	
TSP Emission Factor	1.2	b	Tons TSP/acre-month
Conversion factor for TSP to PM_{10}	0.26	c	Percentage of TSP
Conversion factor for PM_{10} to $PM_{2.5}$	0.1	d	Percentage of PM_{10}

[a] Fitzpatrick, M. 1990. *User's Guide: Emission Control Technologies and Emission Factors for Unpaved Road Fugitive Emissions* , EPA/625/5-87/022. http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=20008SFC.
[b] EPA, AP-42, Volume I, Section 13.2.3 Heavy Construction Operations, Jan. 1995 (Errata Feb. 2010)
[c] EPA, AP-42, Volume I, Section 13.2.4 Aggregate Handling and Storage Piles, Nov. 2006
[d] Midwest Research Institute. 2006. *Background Document for Revisions to Fine Fraction Ratios Used for AP-42 Fugitive Dust Emission Factors* , Report prepared for the Western Governors' Association, Western Regional Air Partnership (WRAP), MRI Project No. 110397, November 1, 2006.

Fugitive Dust Emission Estimations for Fire Management - Mechanical Treatment (Hand Work) and Prescribed Fire

Area of Activity & Type of Treatment	Average Annual Disturbed Acreage	# of Days to Complete/Year[b]	Emissions (tons/year)	
			PM_{10}[c]	$PM_{2.5}$[c]
Mechanical Treatments (Hand Work)	540	1	0.70	0.07
Prescribed Fire	1,630	1	2.12	0.21
Wild Fire	2,400	1	3.12	0.31
Resource Benefit	6,293	1	8.18	0.82
Coal Seam Fire	Negl.	1	0.00	0.00
		Total	**14.12**	**1.41**

[a] Source: BIFO
[b] Assume land area disturbed once, therefore input one day to complete for calculation purposes.
[c] Assume only 25% of treated acreage is disturbed by heavy equipment

	Emission Factor[a] (tons/acre burned)								
Activity	**PM_{10}**	**$PM_{2.5}$**	**NO_x**	**SO_2**	**CO**	**VOC**	**CO_2[b]**	**CH_4**	**N_2O**
Prescribed and Wild Fire	0.088	0.077	0.025	0.007	0.899	0.046		0.048	0.0069

[a] Derived from From: Western Governor's Association/Western Regional Air Partnership 2002 Fire Emission Inventory For the WRAP Region - Phase II July 22, 2005
[b] No emission factor for CO_2 as emissions from fire are considered part of the carbon cycle

Smoke Emissions from Fire - All Project Years

Area of Activity & Type of Treatment	Annual Acreage	PM_{10} (tons/year)	$PM_{2.5}$ (tons/year)	NO_x (tons/year)	SO_2 (tons/year)	CO (tons/year)	VOC (tons/year)	CO_2 (tons/year)	CH_4 (tons/year)	N_2O [a] (tons/year)
Prescribed Fire	1630	144.10	125.94	40.93	11.22	1465.62	74.75	0.00	77.63	11.247
Wild Fire	2400	212.17	185.43	60.26	16.52	2157.97	110.06	0.00	114.30	16.56
	Total	**356.27**	**311.37**	**101.19**	**27.74**	**3623.60**	**184.80**	**0.00**	**191.93**	**27.81**

[a] Based on average fuel loading for Region 2: Rocky Mountain = 30 tons/acre from AP-42 Table 13.1-1

Wind Erosion Associated with Land Disturbance

Activity	Land Area Disturbed	Silt Content	Days with Wind Speed Greater Than 5.4 m/s	Total Suspended Particulate	Months to Disturb Total Area	Total Suspended Particulate	Emission Control Percent	PM_{10} Emissions	$PM_{2.5}$ Emissions
	(acre/year)	(%)	(%)	(lbs/acre/month)	(months)	(lbs/year)	(%)	(tons/year)	(tons/year)
Total Land Disturbance	10,863	34.6	30	89.673	0.033	32,470.73	0	**4.06**	**0.41**

* Account for wind blown dust occuring one time (day) for the disturbed land area (includes disturbed roadways), therefore input one day for calculation purposes.
* "Control of Fugitive Dust Sources" EPA-450/3-98-008 (EPA 1998). TSP (lb/acre/month) = 1.7 × (s/1.5) × ([365-p]/235) × (f/15), where:
p = number of days with > 0.001 in precipitation
f = percent of time wind speed exceeds 5.4 (m/s) [equivalent to 12 mph] = 30.0% derived from Soda Springs Mountain, Montana surface meteorology 2004-2010 dataset.
* AP-42 (EPA 2006), Section 13.2.2 "Unpaved Roads", Background Document. Assuming that PM10 accounts for 25% of TSP. Daily and hourly emissions based on 30.4-day month.
* Assuming that $PM_{2.5}$ accounts for 10% of PM_{10} based on "Analysis of the Fine Fraction of PM in Fugitive Dust," Midwest Research Institute (MRI) Report 110397 (2006)

Fire Management Resource - Alternative D

ALTERNATIVE: Alternative D

Exhaust Emission Factors for Diesel-Powered Off-Road Construction Equipment

Project Year/Hp Category	Emission Factors (g/hp-hr)								
	NOx	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O[1]
Year 2008									
100 to 175	4.95	0.38	0.12	1.85	0.44	0.37	540.3	0.007	0.0061
175 to 300	4.37	0.29	0.11	1.46	0.36	0.28	506.7	0.006	0.0061

Source: EPA NONROADS 2008a
1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr

Emission Factors for Logging Equipment

	Emission Factors (g/hp-hr)								
Year 2008	NOx	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O[1]
Chainsaw 6-11 Hp	1.32	9.75	0.14	293.54	61.89	8.97	686.00	0.54	0.0043
Feller/Bunch/Skidder 75-100 Hp	4.70	0.54	0.13	3.88	0.46	0.52	594.76	0.01	0.0061

Source: EPA NONROADS 2008a
1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr

Emission Factors for Additional Equipment

	Emission Factors gm/LTO								
	NOx	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Aircraft Landing/Take-Off Cycle (LTO)	10200.00	0.00	800.00	8100.00	2600.00	0.00	2680000.00	300.00	100.00
	Emission Factors gm/gallon fuel								
	NOx	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Aircraft (cruise)	44.00	0.00	4.00	28.00	2.80	0.00	12600.00	0.00	0.40

Source: IPCC Guidelines on National Greenhouse Gas Inventories. Reference Manual, page 1.98, Table 2, Domestic Average Fleet and Cruise. Jet fuel A density ~ 8lbs/gallon.

Combustive Emission Estimations for Fire Management Activities

Activity	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Hrs/ Day	# of Days/ Project	# of Projects/ Year	Total Hours/ Unit/Year	Emissions (lbs/year)					Emissions (tons/year)								
									NO_x	PM_{10}	SO_2	CO	VOC	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Mechanical Treatments	Skid Steer Loader	75	1	50	6	40	1	240	93.31	10.66	2.54	76.98	9.14	0.05	0.01	0.00	0.04	0.00	0.01	5.90	0.00	0.00
	Chain Saw	5.4	4	80	6	40	1	960	12.10	89.13	1.28	2,683.75	565.84	0.01	0.04	0.00	1.34	0.28	0.05	2.72	0.00	0.00
Prescribed Fire	Skid Steer Loader	75	1	25	5	15	1	75	14.58	1.67	0.40	12.03	1.43	0.01	0.00	0.00	0.01	0.00	0.00	0.92	0.00	0.00
	Chain Saw	5.4	2	40	5	15	1	150	0.94	6.96	0.10	209.67	44.21	0.00	0.00	0.00	0.10	0.02	0.01	0.21	0.00	0.00
	Pumps	25	2	95	5	15	1	150	10.39	76.56	1.10	2,305.38	486.06	0.01	0.04	0.00	1.15	0.24	0.00	2.34	0.00	0.00
Wild Fire	Dozer	100	1	15	6	20	1	120	18.66	2.13	0.51	15.40	1.83	0.01	0.00	0.00	0.01	0.00	0.00	1.18	0.00	0.00
	Chain Saw	5.4	20	60	6	20	1	2400	22.68	167.11	2.40	5,032.03	1,060.94	0.01	0.08	0.00	2.52	0.53	0.13	5.10	0.00	0.00
	Pumps	25	6	95	10	20	1	1200	295.50	33.77	8.04	243.77	28.94	0.15	0.02	0.00	0.12	0.01	0.02	18.68	0.00	0.00
Resource Benefit	Chain Saw	5.4	2	25	6	0	1	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Pumps	25	2	15	8	0	1	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
								Total						**0.23**	**0.19**	**0.01**	**5.29**	**1.10**	**0.23**	**37.05**	**0.00**	**0.00**

Activity data source: BIFO. Year 2008 emissions factors used (conservative).

Combustive Emission Estimations for Fire Management Activities - Additional Equipment

Activity	Equipment Type	# of LTO/year	gallons of fuel used/trip (cruising)	trips/year	gallons (cruising)/ year	Emissions (lbs/year)					Emissions (tons/year)								
						NO_x	PM_{10}	SO_2	CO	VOC	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Prescribed Fire	Aircraft	2	76	2	152	59.72	0.00	4.87	45.10	12.40	0.03	0.00	0.00	0.02	0.01	0.00	11,818.69	1.32	0.44
Wild Fire	Aircraft	50	2715	50	135750	14,292.33	0.00	1,285.27	9,272.49	1,124.56	7.15	0.00	0.64	4.64	0.56	0.00	297,299.88	33.07	11.08
					Total	14,352.05	0.00	1,290.14	9,317.58	1,136.96	**7.18**	**0.00**	**0.65**	**4.66**	**0.57**	**0.00**	**309,118.57**	**34.39**	**11.52**

Activity data source: BIFO, weighted average of Field personnel data survey response.

Fire Management Resource - Alternative D

ALTERNATIVE: Alternative D
Emission Factors for Road Traffic

$$E\ (lb/VMT) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
k	1.8	0.18
a	1	1
d	0.5	0.5
c	0.2	0.2

Function/Variable Description		Assumed Value	Reference
E = size-specific emission factor (lb/VMT)			
E_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)			
s = surface material silt content (%)		34.6	Billings Field Office, Dustin Crowe email dated August 16, 2010.
S = mean vehicle speed (mph)		Listed in the table below	
C = emission factor for 1980's vehicle fleet exhaust, brake wear, and tire wear (lb/VMT)	$PM_{2.5}$	0.00036	EPA AP-42 Section 13.2.2, Table 13.2.2-4
	PM_{10}	0.00047	EPA AP-42 Section 13.2.2, Table 13.2.2-4
M = surface material moisture content (%)		2.0	EPA AP-42 Section 13.2.2
P = Number of days precip per year		96.3	Billings, MT Climate Summary from 1961-1990, Western Regional Climate Center.
CE = emission control percent for watering unpaved roads[b]		50%	Source: Billings Field Office.

[a] *Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2, Nov. 2006*
[b] Fitzpatrick, M. 1990. *User's Guide: Emission Control Technologies and Emission Factors for Unpaved Road Fugitive Emissions*, EPA/625/5-87/022. http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=20008SFC.

Fugitive Dust Emission Estimations for Commuting Vehicles on Unpaved Roads

Activity	Equipment Type	Avg. Vehicle Speed (mph)	Round Trip Distance (miles)	# of Round Trips/ Project	Vehicle Miles Traveled/ Project	# of Projects/ Year	Total Annual Vehicle Miles	PM_{10}			$PM_{2.5}$		
								Controlled Em. Factor (lb/VMT)	Emissions (tons/vehicle type)	Emissions (tons/ activity)	Controlled Em. Factor (lb/VMT)	Emissions (tons/vehicle type)	Emissions (tons/ activity)
Mechanical Treatments (Hand Work)	Support Truck	35	30	40	1,200	1	1200	1.56	0.94	1.17	0.16	0.09	0.12
	ATV	20	20	20	400	1	400	1.18	0.24		0.12	0.02	
Prescribed Fires	Fire Truck	30	70	15	1,050	1	1050	1.45	0.76	3.29	0.14	0.08	0.33
	Fuel Truck	30	70	15	1,050	1	1050	1.45	0.76		0.14	0.08	
	Water Truck	30	70	15	1,050	1	1050	1.45	0.76		0.14	0.08	
	Support Truck	35	70	15	1,050	1	1050	1.56	0.82		0.16	0.08	
	UTV/ATV	20	40	8	320	1	320	1.18	0.19		0.12	0.02	
Wild Fires	Fire Truck	30	70	20	1,400	1	1400	1.45	1.01	4.19	0.14	0.10	0.42
	Fuel Truck	30	70	20	1,400	1	1400	1.45	1.01		0.14	0.10	
	Water Truck	30	70	20	1,400	1	1400	1.45	1.01		0.14	0.10	
	Support Truck	35	70	20	1,400	1	1400	1.56	1.09		0.16	0.11	
	UTV/ATV	20	20	5	100	1	100	1.18	0.06		0.12	0.01	
Coal Seam Fires	Support Truck	30	70	2	140	1	140	1.45	0.10	0.10	0.14	0.01	0.01
								Total	8.76			0.88	

Source of activity data: BIFO. Activities were determined on an annual rather than a project basis.

Fire Management Resource - Alternative D

ALTERNATIVE: Alternative D

Emission Factors for Commuting Vehicles

	Emission Factors (gm/mile)								
Project Year	NO_x	PM_{10}	$PM_{2.5}$	SO2	CO	VOC	CO_2	CH_4	N_2O[1]
2008									
LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.04

Source: MOBILE6.2.03

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Emission Factors for Off-Road ATV

Vehicle	Emission Factors (gm/mile)								
Type	NO_x	PM_{10}	$PM_{2.5}$	SO2	CO	VOC	CO_2	CH_4	N_2O[1]
2-Stroke ATV	0.25	1.86	1.71	0.03	47.81	48.72	140.15	0.42	0.003

Source: EPA NONROADS 2008a

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17.

Combustive Emission Estimations for Commuting Vehicles on Unpaved and Paved Roads

Activity	Equipment Type[a]	Class	Round Trip Distance (miles)	# of Round Trips per Project	Vehicle Miles Traveled /Project	# of Projects/ Year	Total Annual Vehicle Miles Traveled/ Year	Emissions (tons/year)								
								NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	CO_2	CH_4	N_2O
Mechanical Treatments (Hand Work)	Support Truck	HDDV	150	40	6,000	1	6,000	0.02	0.00	0.00	0.00	0.01	0.00	5.24	0.00	0.00
	ATV	R12S	20	20	400	1	400	0.00	0.00	0.00	0.00	0.02	0.02	0.06	0.00	0.00
Prescribed Fires	Fire Truck	HDDV	190	15	2,850	1	2,850	0.01	0.00	0.00	0.00	0.01	0.00	2.49	0.00	0.00
	Fuel Truck	HDDV	190	15	2,850	1	2,850	0.01	0.00	0.00	0.00	0.01	0.00	2.49	0.00	0.00
	Water Truck	HDDV	190	15	2,850	1	2,850	0.01	0.00	0.00	0.00	0.01	0.00	2.49	0.00	0.00
	Support Truck	HDDV	190	15	1050	1	1,050	0.00	0.00	0.00	0.00	0.00	0.00	0.92	0.00	0.00
	UTV / ATV	R12S	40	8	320	1	320	0.00	0.00	0.00	0.00	0.02	0.02	0.05	0.00	0.00
Wild Fires	Fire Truck	HDDV	190	20	1400	1	1,400	0.00	0.00	0.00	0.00	0.00	0.00	1.22	0.00	0.00
	Fuel Truck	HDDV	190	20	1400	1	1,400	0.00	0.00	0.00	0.00	0.00	0.00	1.22	0.00	0.00
	Water Truck	HDDV	190	20	1400	1	1,400	0.00	0.00	0.00	0.00	0.00	0.00	1.22	0.00	0.00
	Support Truck	HDDV	190	20	1400	1	1,400	0.00	0.00	0.00	0.00	0.00	0.00	1.22	0.00	0.00
	UTV / ATV	R12S	20	5	100	1	100	0.00	0.00	0.00	0.00	0.01	0.01	0.02	0.00	0.00
Coal Seam Fires	Support Truck	HDDV	190	2	380	1	380	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00
							Total	**0.06**	**0.01**	**0.01**	**0.00**	**0.08**	**0.05**	**18.96**	**0.00**	**0.00**

Activity data source: BiFO. Year 2008 emissions factors used (conservative). Activities were estimated based on an annual, rather than a project, basis.

Forestry and Woodland Products - Alternative A

Forest Products **Alternative A**

Total Annual Emissions from Forest and Woodlands Projects - Alternative A

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs[a]	CO_2	CH_4	N_2O	$CO2_{eq}$ tons	$CO2_{eq}$ metric tons
Heavy Equipment - Fugitive Dust	1.86	0.19	---	---	---	---	---	---	---	---	---	---
Heavy Equipment - Vehicle Exhaust	0.06	0.06	0.74	0.02	0.52	0.08	0.01	86.70	0.00	0.00	87.01	78.96
Sub-total: Heavy Equipment	**1.92**	**0.24**	**0.74**	**0.02**	**0.52**	**0.08**	**0.01**	**86.70**	**0.00**	**0.00**	**87.01**	**78.96**
Commuting Vehicles - Fugitive Dust	0.95	0.10	---	---	---	---	---	---	---	---	---	---
Commuting Vehicles - Vehicle Exhaust	0.00	0.00	0.03	0.00	0.03	0.01	0.00	7.37	0.00	0.00	7.53	6.83
Sub-total: Commuting Vehicles	**0.95**	**0.10**	**0.03**	**0.00**	**0.03**	**0.01**	**0.00**	**7.37**	**0.00**	**0.00**	**7.53**	**6.83**
Total	**2.87**	**0.34**	**0.76**	**0.02**	**0.55**	**0.09**	**0.01**	**94.07**	**0.001**	**0.001**	**94.54**	**85.79**

[a] HAPs = Hazardous Air Pollutants (HAPs), which are assumed to account for 10 percent of VOC emissions.

Forestry and Woodland Products - Alternative A

ALTERNATIVE: Alternative A

Fugitive Dust from Heavy Construction Operations

INPUTS & ASSUMPTIONS			
Description	**Value**	**Source**	**Notes**
Control Efficiency (C) of watering[a]	0	a	
PM_{10} Emission Factor	0.11	b	Tons PM_{10}/acre-month
Conversion factor for PM_{10} to $PM_{2.5}$	0.1	c	Percentage of PM_{10}

[a] The PM_{10} emission factor shown below includes 50% control based on watering.
[b] WRAP Fugitive Dust Handbook, September 2006.
Regional Air Partnership (WRAP), MRI Project No. 110397, November 1, 2006.

Fugitive Dust Emission Estimations for Forest Products - All Project Years

Forest Harvesting		Total Disturbed Acres/Year	Total Disturbed Acres (20 years)	# of Days to Complete/ Project[1]	Emissions (tons/year)	
					PM_{10}	$PM_{2.5}$
Forest/Woodland Forest Products		42	840	12	1.85	0.18
				Total	**1.85**	**0.18**

1. Land surface disturbed one time, so assume one day of disturbance for each acre.

Wind Erosion Associated with Land Disturbance

Activity	Land Area Disturbed	Silt Content	Days with Wind Speed Greater Than 5.4 m/s	Days with Precipitation >0.001 Inch	Total Suspended Particulate	Months to Disturb Total Area	Total Suspended Particulate	Emission Control Percent	PM_{10} Emissions	$PM_{2.5}$ Emissions
	(acre/year)	(%)	(%)	(number)	(lbs/acre/month)	(months)	(lbs/year)	(%)	(tons/year)	(tons/year)
Total Land Disturbance	42.0	34.6	30	96.3	89.673	0.033	125.54	0	**0.02**	**0.00**

* Account for wind blown dust occuring one time (day) for the disturbed land area (includes disturbed road ways), therefore input one day for calculation purposes.
* "Control of Fugitive Dust Sources" EPA-450/3-98-008 (EPA 1998). TSP (lb/acre/month) = 1.7 × (s/1.5) × ([365-p]/235) × (f/15), where:
p = number of days with > 0.001 in precipitation
f = percent of time wind speed exceeds 5.4 (m/s) [equivalent to 12 mph] = 30.0% derived from Soda Springs Mountain, Montana surface meteorology 2004-2010 dataset.
* AP-42 (EPA 2006), Section 13.2.2 "Unpaved Roads", Background Document. Assuming that PM10 accounts for 25% of TSP. Daily and hourly emissions based on 30.4-day month.
* Assuming that $PM_{2.5}$ accounts for 10% of PM_{10} based on "Analysis of the Fine Fraction of PM in Fugitive Dust," Midwest Research Institute (MRI) Report 110397 (2005).

Forestry and Woodland Products - Alternative A

ALTERNATIVE: Alternative A

Emission Factors for Logging Equipment

	Emission Factors (g/hp-hr)								
Year 2008	NOx	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O[1]
Chainsaw 6-11 Hp	1.32	9.75	0.14	293.54	61.89	8.97	686.00	0.54	0.0043
Feller/Bunch/Skidder 75-100	4.70	0.54	0.13	3.88	0.46	0.52	594.76	0.01	0.0061
Log Equipp 300 Hp	4.39	0.25	0.12	1.76	0.22	0.24	536.15	0.003	0.0061

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emission Estimations for Forest and Woodland Activities - All Years

Activity	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Hours/ Day	# of Days/ Project	Total Hours/ Project/ Year	Emissions (lbs/year/activity)					Emissions (tons/year)								
								NO_x	PM_{10}	SO_2	CO	VOC	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Forest/Woodland Forest Products	Skidder	205	1	70	8	12	96	142.83	16.32	3.89	117.83	13.99	7.1E-02	8.2E-03	1.9E-03	5.9E-02	7.0E-03	7.9E-03	9.0E+00	1.1E-04	9.2E-05
	Log Truck	450	1	60	10	12	120	335.93	17.59	8.24	125.81	15.95	1.7E-01	8.8E-03	4.1E-03	6.3E-02	8.0E-03	8.5E-03	1.9E+01	1.2E-04	2.2E-04
	Chainsaw	6	1	80	8	12	96	4.78	9.90	0.14	298.19	62.87	2.4E-03	5.0E-03	7.1E-05	1.5E-01	3.1E-02	4.6E-03	3.5E-01	2.7E-04	2.2E-06
	Feller Buncher	300	1	100	8	12	96	298.61	34.13	8.12	246.33	29.25	1.5E-01	1.7E-02	4.1E-03	1.2E-01	1.5E-02	1.7E-02	1.9E+01	2.2E-04	1.9E-04
	Loader	200	1	80	10	12	120	199.07	10.42	4.88	74.55	9.45	1.0E-01	5.2E-03	2.4E-03	3.7E-02	4.7E-03	5.1E-03	1.1E+01	7.2E-05	1.3E-04
	Dozer	200	1	90	8	12	96	179.16	9.38	4.39	67.10	8.51	9.0E-02	4.7E-03	2.2E-03	3.4E-02	4.3E-03	4.5E-03	1.0E+01	6.5E-05	1.2E-04
	Delimber	250	1	100	10	12	120	311.05	16.28	7.63	116.49	14.77	1.6E-01	8.1E-03	3.8E-03	5.8E-02	7.4E-03	7.9E-03	1.8E+01	1.1E-04	2.0E-04
												Total	7.4E-01	5.7E-02	1.9E-02	5.2E-01	7.7E-02	5.5E-02	8.7E+01	9.7E-04	9.5E-04

Source of activity data: Billings Field Office.
Assume 2008 emission factors for all years; this is a conservative estimate.

Forestry and Woodland Products - Alternative A

ALTERNATIVE: Alternative A

Emission Factors for Publicly Accessible Unpaved Roads[a]

$$E\ (lb/VMT) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
k	1.8	0.18
a	1	1
d	0.5	0.5
c	0.2	0.2

Function/Variable Description		Assumed Value	Reference
E = size-specific emission factor (lb/VMT)			
E_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)			
s = surface material silt content (%)		34.6	Billings Field Office, Dustin Crowe email dated August 16, 2010.
S = mean vehicle speed (mph)			
C = emission factor for 1980's vehicle fleet exhaust, brake wear, and tire wear (lb/VMT)	$PM_{2.5}$	0.00036	EPA AP-42 Section 13.2.2, Table 13.2.2-4
	PM_{10}	0.00047	EPA AP-42 Section 13.2.2, Table 13.2.2-4
M = surface material moisture content (%)		2.0	EPA AP-42 Section 13.2.2
P = Number of days precip per year		96.3	Billings, MT Climate Summary from 1961-1990, Western Regional Climate Center.
CE = control percent for applying dust suppressant to unpaved ro		50%	

[a] *Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2, Nov. 2006*

[b] Fitzpatrick, M. 1990. *User's Guide: Emission Control Technologies and Emission Factors for Unpaved Road Fugitive Emissions*, EPA/625/5-87/022. http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=20008SFC.

Fugitive Dust Emission Estimations for Commuting Vehicles on Unpaved Roads - All Project Years

Activity	Equipment Type	Avg. Vehicle Speed (mph)	Round Trip Distance (miles)	# of Round Trips/Project	Vehicle Miles Traveled/ Project	# of Projects/Year	Total Annual Vehicle Miles	PM_{10} Controlled Em. Factor (lb/VMT)	PM_{10} Emissions (tons/ vehicle type)	PM_{10} Emissions (tons/ activity)	$PM_{2.5}$ Controlled Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions (tons/ vehicle type)	$PM_{2.5}$ Emissions (tons/ activity)
Forest/Woodland Forest Products	Support Truck	25	30	12	360	1	360	1.32	0.24	0.95	0.13	0.02	0.10
	Log Truck	25	30	24	720	1	720	1.32	0.48		0.13	0.05	
	Pick-up Truck	25	30	12	360	1	360	1.32	0.24		0.13	0.02	
								Total	**0.95**			**0.10**	

Source of activity data: Billings Field Office.
Assume application of water ~ 50% emissions control.

Forestry and Woodland Products - Alternative A

ALTERNATIVE: Alternative A

Emission Factors for Commuting Vehicles

	Emission Factors (gm/mile)								
Project Year	NO_x	PM_{10}	$PM_{2.5}$	SO2	CO	VOC	CO_2	CH_4	N_2O[1]
2008									
LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.04

Source: Moblie 6.2.03

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Emission Factors for Off-Road ATV

Vehicle	Emission Factors (gm/mile)									
Type	Class	NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O[1]
2-Stroke ATV	R12S	0.25	1.86	1.71	0.03	47.81	48.72	140.15	0.42	0.003

Source: EPA NONROADS 2008a

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17.

Combustive Emission Estimations for Commuting Vehicles on Unpaved and Paved Roads - All Project Years

Activity	Equipment Type[a]	Class	Round Trip Distance (miles)	# of Round Trips/ Project	Vehicle Miles Traveled/ Project	# of Projects/ Year	Total Annual Vehicle Miles Traveled/ Activity	Emissions														
								(tons/vehicle type)						(tons/year)								
								NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	CO_2	CH_4	N_2O
Forest/Woodland Forest Products	Support Truck	HDDV	200	12	2,400	1	2,400	0.01	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.03	0.01	2.09	0.00	0.00
	Log Truck	HDDV	200	24	4,800	1	4,800	0.01	0.00	0.00	0.00	0.01	0.00							4.19	0.00	0.00
	Pick-up Truck	LDDT	200	12	2,400	1	2,400	0.01	0.00	0.00	0.00	0.02	0.01							1.08	0.00	0.00
							Total	0.03	0.00	0.00	0.00	0.03	0.01	0.03	0.00	0.00	0.00	0.03	0.01	7.37	0.0003	0.0005

Source of activity data: Billings Field Office.

[a] All vehicles are diesel-powered, except ATVs, which are gasoline-powered.

Forestry and Woodland Products - Alternative B

Forest Products **Alternative B**

Total Annual Emissions from Forest and Woodlands Projects - Alternative B

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs[a]	CO_2	CH_4	N_2O	$CO2_{eq}$ tons	$CO2_{eq}$ metric tons
Heavy Equipment - Fugitive Dust	4.69	0.47	---	---	---	---	---	---	---	---	---	---
Heavy Equipment - Vehicle Exhaust	0.09	0.09	1.11	0.03	0.83	0.12	0.01	137.27	0.00	0.00	137.77	125.02
Sub-total: Heavy Equipment	**4.78**	**0.56**	**1.11**	**0.03**	**0.83**	**0.12**	**0.01**	**137.27**	**0.00**	**0.00**	**137.77**	**125.02**
Commuting Vehicles - Fugitive Dust	1.51	0.15	---	---	---	---	---	---	---	---	---	---
Commuting Vehicles - Vehicle Exhaust	0.00	0.00	0.04	0.00	0.05	0.02	0.00	11.67	0.00	0.00	11.92	10.81
Sub-total: Commuting Vehicles	**1.51**	**0.15**	**0.04**	**0.00**	**0.05**	**0.02**	**0.00**	**11.67**	**0.00**	**0.00**	**11.92**	**10.81**
Total	**6.29**	**0.71**	**1.15**	**0.03**	**0.88**	**0.14**	**0.01**	**148.94**	**0.002**	**0.002**	**149.69**	**135.83**

[a] HAPs = Hazardous Air Pollutants (HAPs), which are assumed to account for 10 percent of VOC emissions.

Forestry and Woodland Products - Alternative B

ALTERNATIVE: Alternative B

Fugitive Dust from Heavy Construction Operations

INPUTS & ASSUMPTIONS			
Description	**Value**	**Source**	**Notes**
Control Efficiency (C) of watering[a]	0	a	
PM_{10} Emission Factor	0.11	b	Tons PM_{10}/acre-month
Conversion factor for PM_{10} to $PM_{2.5}$	0.1	c	Percentage of PM_{10}

[a] The PM_{10} emission factor shown below includes 50% control based on watering.
[b] WRAP Fugitive Dust Handbook, September 2006.
Regional Air Partnership (WRAP), MRI Project No. 110397, November 1, 2006.

Fugitive Dust Emission Estimations for Forest Products - All Project Years

Forest Harvesting		Total Disturbed Acres/Year	Total Disturbed Acres (20 years)	# of Days to Complete/ Project[1]	Emissions (tons/year)	
					PM_{10}	$PM_{2.5}$
Forest/Woodland Forest Products		67	1,340	19	4.67	0.47
				Total	**4.67**	**0.47**

1. Land surface disturbed one time, so assume one day of disturbance for each acre.

Wind Erosion Associated with Land Disturbance

Activity	Land Area Disturbed	Silt Content	Days with Wind Speed Greater Than 5.4 m/s	Days with Precipitation >0.001 Inch	Total Suspended Particulate	Months to Disturb Total Area	Total Suspended Particulate	Emission Control Percent	PM_{10} Emissions	$PM_{2.5}$ Emissions
	(acre/year)	(%)	(%)	(number)	(lbs/acre/month)	(months)	(lbs/year)	(%)	(tons/year)	(tons/year)
Total Land Disturbance	67.0	34.6	30	96.3	89.673	0.033	200.27	0	**0.03**	**0.00**

* Account for wind blown dust occuring one time (day) for the disturbed land area (includes disturbed road ways), therefore input one day for calculation purposes.
* "Control of Fugitive Dust Sources" EPA-450/3-98-008 (EPA 1998). TSP (lb/acre/month) = 1.7 × (s/1.5) × ([365-p]/235) × (f/15), where:
p = number of days with > 0.001 in precipitation
f = percent of time wind speed exceeds 5.4 (m/s) [equivalent to 12 mph] = 30.0% derived from Soda Springs Mountain, Montana surface meteorology 2004-2010 dataset.
* AP-42 (EPA 2006), Section 13.2.2 "Unpaved Roads", Background Document. Assuming that PM10 accounts for 25% of TSP. Daily and hourly emissions based on 30.4-day month.
* Assuming that $PM_{2.5}$ accounts for 10% of PM_{10} based on "Analysis of the Fine Fraction of PM in Fugitive Dust," Midwest Research Institute (MRI) Report 110397 (2005).

Forestry and Woodland Products - Alternative B

ALTERNATIVE: Alternative B

Emission Factors for Logging Equipment

	Emission Factors (g/hp-hr)								
Year 2008	NOx	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O[1]
Chainsaw 6-11 Hp	1.32	9.75	0.14	293.54	61.89	8.97	686.00	0.54	0.0043
Feller/Bunch/Skidder 75-100	4.70	0.54	0.13	3.88	0.46	0.52	594.76	0.01	0.0061
Log Equipp 300 Hp	4.39	0.25	0.12	1.76	0.22	0.24	536.15	0.003	0.0061

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emission Estimations for Forest and Woodland Activities - All Years

Activity	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Hours/ Day	# of Days/ Project	Total Hours/ Project/ Year	Emissions (lbs/year/activity)					Emissions (tons/year)								
								NO_x	PM_{10}	SO_2	CO	VOC	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Forest/Woodland Forest Products	Skidder	205	1	70	8	19	152	226.15	25.85	6.15	186.56	22.15	1.1E-01	1.3E-02	3.1E-03	9.3E-02	1.1E-02	1.3E-02	1.4E+01	1.7E-04	1.5E-04
	Log Truck	450	1	60	10	19	190	496.50	27.84	13.04	199.20	25.26	2.5E-01	1.4E-02	6.5E-03	1.0E-01	1.3E-02	1.4E-02	3.0E+01	1.9E-04	3.4E-04
	Chainsaw	6	1	80	8	19	152	2.13	15.68	0.23	472.14	99.55	1.1E-03	7.8E-03	1.1E-04	2.4E-01	5.0E-02	7.2E-03	5.5E-01	4.3E-04	3.5E-06
	Feller Buncher	300	1	100	8	19	152	472.79	54.04	12.86	390.03	46.31	2.4E-01	2.7E-02	6.4E-03	2.0E-01	2.3E-02	2.6E-02	3.0E+01	3.5E-04	3.0E-04
	Loader	200	1	80	10	19	190	294.23	16.50	7.73	118.04	14.97	1.5E-01	8.2E-03	3.9E-03	5.9E-02	7.5E-03	8.0E-03	1.8E+01	1.1E-04	2.0E-04
	Dozer	200	1	90	8	19	152	264.80	14.85	6.96	106.24	13.47	1.3E-01	7.4E-03	3.5E-03	5.3E-02	6.7E-03	7.2E-03	1.6E+01	1.0E-04	1.8E-04
	Delimber	250	1	100	10	19	190	459.73	25.78	12.08	184.44	23.39	2.3E-01	1.3E-02	6.0E-03	9.2E-02	1.2E-02	1.3E-02	2.8E+01	1.8E-04	3.2E-04
												Total	1.1E+00	9.0E-02	3.0E-02	8.3E-01	1.2E-01	8.7E-02	1.4E+02	1.5E-03	1.5E-03

Source of activity data: Billings Field Office.
Assume 2008 emission factors for all years; this is a conservative estimate.

Forestry and Woodland Products - Alternative B

ALTERNATIVE: Alternative B

Emission Factors for Publicly Accessible Unpaved Roads[a]

$$E\ (lb/VMT) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
k	1.8	0.18
a	1	1
d	0.5	0.5
c	0.2	0.2

Function/Variable Description		Assumed Value	Reference
E = size-specific emission factor (lb/VMT)			
E_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)			
s = surface material silt content (%)		34.6	Billings Field Office, Dustin Crowe email dated August 16, 2010.
S = mean vehicle speed (mph)			
C = emission factor for 1980's vehicle fleet exhaust, brake wear, and tire wear (lb/VMT)	$PM_{2.5}$	0.00036	EPA AP-42 Section 13.2.2, Table 13.2.2-4
	PM_{10}	0.00047	EPA AP-42 Section 13.2.2, Table 13.2.2-4
M = surface material moisture content (%)		2.0	EPA AP-42 Section 13.2.2
P = Number of days precip per year		96.3	Billings, MT Climate Summary from 1961-1990, Western Regional Climate Center.
CE = control percent for applying dust suppressant to unpaved ro		50%	

[a] *Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2, Nov. 2006*

[b] Fitzpatrick, M. 1990. *User's Guide: Emission Control Technologies and Emission Factors for Unpaved Road Fugitive Emissions*, EPA/625/5-87/022. http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=20008SFC.

Fugitive Dust Emission Estimations for Commuting Vehicles on Unpaved Roads - All Project Years

Activity	Equipment Type	Avg. Vehicle Speed (mph)	Round Trip Distance (miles)	# of Round Trips/Project	Vehicle Miles Traveled/ Project	# of Projects/Year	Total Annual Vehicle Miles	PM_{10} Controlled Em. Factor (lb/VMT)	PM_{10} Emissions (tons/ vehicle type)	PM_{10} Emissions (tons/ activity)	$PM_{2.5}$ Controlled Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions (tons/ vehicle type)	$PM_{2.5}$ Emissions (tons/ activity)
Forest/Woodland Forest Products	Support Truck	25	30	19	570	1	570	1.32	0.38	1.51	0.13	0.04	0.15
	Log Truck	25	30	38	1,140	1	1,140	1.32	0.75		0.13	0.08	
	Pick-up Truck	25	30	19	570	1	570	1.32	0.38		0.13	0.04	
								Total	**1.51**			**0.15**	

Source of activity data: Billings Field Office.
Assume application of water ~ 50% emissions control.

Forestry and Woodland Products - Alternative B

ALTERNATIVE: Alternative B

Emission Factors for Commuting Vehicles

	Emission Factors (gm/mile)								
Project Year	NO_x	PM_{10}	$PM_{2.5}$	SO2	CO	VOC	CO_2	CH_4	N_2O[1]
2008									
LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.04

Source: Moblie 6.2.03

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Emission Factors for Off-Road ATV

Vehicle	Emission Factors (gm/mile)									
Type	Class	NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O[1]
2-Stroke ATV	R12S	0.25	1.86	1.71	0.03	47.81	48.72	140.15	0.42	0.003

Source: EPA NONROADS 2008a

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17.

Combustive Emission Estimations for Commuting Vehicles on Unpaved and Paved Roads - All Project Years

Activity	Equipment Type[a]	Class	Round Trip Distance (miles)	# of Round Trips/ Project	Vehicle Miles Traveled/ Project	# of Projects/ Year	Total Annual Vehicle Miles Traveled/ Activity	Emissions (tons/vehicle type)						Emissions (tons/year)								
								NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	CO_2	CH_4	N_2O
Forest/Woodland Forest Products	Support Truck	HDDV	200	19	3,800	1	3,800	0.01	0.00	0.00	0.00	0.01	0.00	0.04	0.00	0.00	0.00	0.05	0.02	3.32	0.00	0.00
	Log Truck	HDDV	200	38	7,600	1	7,600	0.02	0.00	0.00	0.00	0.01	0.00							6.63	0.00	0.00
	Pick-up Truck	LDDT	200	19	3,800	1	3,800	0.01	0.00	0.00	0.00	0.03	0.01							1.72	0.00	0.00
							Total	0.04	0.00	0.00	0.00	0.05	0.02	0.04	0.00	0.00	0.00	0.05	0.02	11.67	0.0005	0.0008

Source of activity data: Billings Field Office.

[a] All vehicles are diesel-powered, except ATVs, which are gasoline-powered.

Forestry and Woodland Products - Alternative C

Forest Products **Alternative C**

Total Annual Emissions from Forest and Woodlands Projects - Alternative C

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs[a]	CO_2	CH_4	N_2O	$CO2_{eq}$ tons	$CO2_{eq}$ metric tons
Heavy Equipment - Fugitive Dust	12.77	1.28	---	---	---	---	---	---	---	---	---	---
Heavy Equipment - Vehicle Exhaust	0.15	0.14	1.81	0.05	1.35	0.20	0.02	223.97	0.00	0.00	224.78	203.98
Sub-total: Heavy Equipment	**12.92**	**1.42**	**1.81**	**0.05**	**1.35**	**0.20**	**0.02**	**223.97**	**0.00**	**0.00**	**224.78**	**203.98**
Commuting Vehicles - Fugitive Dust	2.46	0.25	---	---	---	---	---	---	---	---	---	---
Commuting Vehicles - Vehicle Exhaust	0.01	0.01	0.07	0.00	0.08	0.03	0.00	19.03	0.00	0.00	19.44	17.64
Sub-total: Commuting Vehicles	**2.46**	**0.25**	**0.07**	**0.00**	**0.08**	**0.03**	**0.00**	**19.03**	**0.00**	**0.00**	**19.44**	**17.64**
Total	**15.38**	**1.67**	**1.88**	**0.05**	**1.43**	**0.23**	**0.02**	**243.01**	**0.003**	**0.004**	**244.23**	**221.62**

[a] HAPs = Hazardous Air Pollutants (HAPs), which are assumed to account for 10 percent of VOC emissions.

Forestry and Woodland Products - Alternative C

ALTERNATIVE: Alternative C

Fugitive Dust from Heavy Construction Operations

INPUTS & ASSUMPTIONS			
Description	**Value**	**Source**	**Notes**
Control Efficiency (C) of watering[a]	0	a	
PM_{10} Emission Factor	0.11	b	Tons PM_{10}/acre-month
Conversion factor for PM_{10} to $PM_{2.5}$	0.1	c	Percentage of PM_{10}

[a] The PM_{10} emission factor shown below includes 50% control based on watering.
[b] WRAP Fugitive Dust Handbook, September 2006.
Regional Air Partnership (WRAP), MRI Project No. 110397, November 1, 2006.

Fugitive Dust Emission Estimations for Forest Products - All Project Years

Forest Harvesting		Total Disturbed Acres/Year	Total Disturbed Acres (20 years)	# of Days to Complete/ Project[1]	Emissions (tons/year)	
					PM_{10}	$PM_{2.5}$
Forest/Woodland Forest Products		112	2,240	31	12.73	1.27
				Total	**12.73**	**1.27**

1. Land surface disturbed one time, so assume one day of disturbance for each acre.

Wind Erosion Associated with Land Disturbance

Activity	Land Area Disturbed	Silt Content	Days with Wind Speed Greater Than 5.4 m/s	Days with Precipitation >0.001 Inch	Total Suspended Particulate	Months to Disturb Total Area	Total Suspended Particulate	Emission Control Percent	PM_{10} Emissions	$PM_{2.5}$ Emissions
	(acre/year)	(%)	(%)	(number)	(lbs/acre/month)	(months)	(lbs/year)	(%)	(tons/year)	(tons/year)
Total Land Disturbance	112.0	34.6	30	96.3	89.673	0.033	334.78	0	**0.04**	**0.00**

* Account for wind blown dust occuring one time (day) for the disturbed land area (includes disturbed road ways), therefore input one day for calculation purposes.
* "Control of Fugitive Dust Sources" EPA-450/3-98-008 (EPA 1998). TSP (lb/acre/month) = 1.7 × (s/1.5) × ([365-p]/235) × (f/15), where:
p = number of days with > 0.001 in precipitation
f = percent of time wind speed exceeds 5.4 (m/s) [equivalent to 12 mph] = 30.0% derived from Soda Springs Mountain, Montana surface meteorology 2004-2010 dataset.
* AP-42 (EPA 2006), Section 13.2.2 "Unpaved Roads", Background Document. Assuming that PM10 accounts for 25% of TSP. Daily and hourly emissions based on 30.4-day month.
* Assuming that $PM_{2.5}$ accounts for 10% of PM_{10} based on "Analysis of the Fine Fraction of PM in Fugitive Dust," Midwest Research Institute (MRI) Report 110397 (2005).

Forestry and Woodland Products - Alternative C

ALTERNATIVE: Alternative C

Emission Factors for Logging Equipment

	Emission Factors (g/hp-hr)								
Year 2008	NOx	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O[1]
Chainsaw 6-11 Hp	1.32	9.75	0.14	293.54	61.89	8.97	686.00	0.54	0.0043
Feller/Bunch/Skidder 75-100	4.70	0.54	0.13	3.88	0.46	0.52	594.76	0.01	0.0061
Log Equipp 300 Hp	4.39	0.25	0.12	1.76	0.22	0.24	536.15	0.003	0.0061

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emission Estimations for Forest and Woodland Activities - All Years

Activity	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Hours/ Day	# of Days/ Project	Total Hours/ Project/ Year	Emissions (lbs/year/activity)					Emissions (tons/year)								
								NO_x	PM_{10}	SO_2	CO	VOC	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Forest/Woodland Forest Products	Skidder	205	1	70	8	31	248	368.99	42.17	10.04	304.39	36.14	1.8E-01	2.1E-02	5.0E-03	1.5E-01	1.8E-02	2.0E-02	2.3E+01	2.7E-04	2.4E-04
	Log Truck	450	1	60	10	31	310	810.09	45.43	21.28	325.00	41.21	4.1E-01	2.3E-02	1.1E-02	1.6E-01	2.1E-02	2.2E-02	4.9E+01	3.1E-04	5.6E-04
	Chainsaw	6	1	80	8	31	248	3.47	25.58	0.37	770.34	162.42	1.7E-03	1.3E-02	1.8E-04	3.9E-01	8.1E-02	1.2E-02	9.0E-01	7.1E-04	5.6E-06
	Feller Buncher	300	1	100	8	31	248	771.40	88.16	20.98	636.36	75.56	3.9E-01	4.4E-02	1.0E-02	3.2E-01	3.8E-02	4.3E-02	4.9E+01	5.7E-04	5.0E-04
	Loader	200	1	80	10	31	310	480.05	26.92	12.61	192.59	24.42	2.4E-01	1.3E-02	6.3E-03	9.6E-02	1.2E-02	1.3E-02	2.9E+01	1.9E-04	3.3E-04
	Dozer	200	1	90	8	31	248	432.05	24.23	11.35	173.34	21.98	2.2E-01	1.2E-02	5.7E-03	8.7E-02	1.1E-02	1.2E-02	2.6E+01	1.7E-04	3.0E-04
	Delimber	250	1	100	10	31	310	750.08	42.06	19.71	300.93	38.16	3.8E-01	2.1E-02	9.9E-03	1.5E-01	1.9E-02	2.0E-02	4.6E+01	2.9E-04	5.2E-04
												Total	1.8E+00	1.5E-01	4.8E-02	1.4E+00	2.0E-01	1.4E-01	2.2E+02	2.5E-03	2.4E-03

Source of activity data: Billings Field Office.
Assume 2008 emission factors for all years; this is a conservative estimate.

Forestry and Woodland Products - Alternative C

ALTERNATIVE: Alternative C

Emission Factors for Publicly Accessible Unpaved Roads[a]

$$E\ (lb/VMT) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
k	1.8	0.18
a	1	1
d	0.5	0.5
c	0.2	0.2

Function/Variable Description		Assumed Value	Reference
E = size-specific emission factor (lb/VMT)			
E_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)			
s = surface material silt content (%)		34.6	Billings Field Office, Dustin Crowe email dated August 16, 2010.
S = mean vehicle speed (mph)			
C = emission factor for 1980's vehicle fleet exhaust, brake wear, and tire wear (lb/VMT)	$PM_{2.5}$	0.00036	EPA AP-42 Section 13.2.2, Table 13.2.2-4
	PM_{10}	0.00047	EPA AP-42 Section 13.2.2, Table 13.2.2-4
M = surface material moisture content (%)		2.0	EPA AP-42 Section 13.2.2
P = Number of days precip per year		96.3	Billings, MT Climate Summary from 1961-1990, Western Regional Climate Center.
CE = control percent for applying dust suppressant to unpaved ro		50%	

[a] *Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2, Nov. 2006*

[b] Fitzpatrick, M. 1990. *User's Guide: Emission Control Technologies and Emission Factors for Unpaved Road Fugitive Emissions*, EPA/625/5-87/022. http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=20008SFC.

Fugitive Dust Emission Estimations for Commuting Vehicles on Unpaved Roads - All Project Years

Activity	Equipment Type	Avg. Vehicle Speed (mph)	Round Trip Distance (miles)	# of Round Trips/Project	Vehicle Miles Traveled/ Project	# of Projects/Year	Total Annual Vehicle Miles	PM_{10} Controlled Em. Factor (lb/VMT)	PM_{10} Emissions (tons/ vehicle type)	PM_{10} Emissions (tons/ activity)	$PM_{2.5}$ Controlled Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions (tons/ vehicle type)	$PM_{2.5}$ Emissions (tons/ activity)
Forest/Woodland Forest Products	Support Truck	25	30	31	930	1	930	1.32	0.61	2.46	0.13	0.06	0.25
	Log Truck	25	30	62	1,860	1	1,860	1.32	1.23		0.13	0.12	
	Pick-up Truck	25	30	31	930	1	930	1.32	0.61		0.13	0.06	
								Total	**2.46**			**0.25**	

Source of activity data: Billings Field Office.
Assume application of water ~ 50% emissions control.

Forestry and Woodland Products - Alternative C

ALTERNATIVE: Alternative C

Emission Factors for Commuting Vehicles

	Emission Factors (gm/mile)								
Project Year	NO_x	PM_{10}	$PM_{2.5}$	SO2	CO	VOC	CO_2	CH_4	N_2O[1]
2008									
LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.04

Source: Moblie 6.2.03

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Emission Factors for Off-Road ATV

Vehicle	Emission Factors (gm/mile)									
Type	Class	NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O[1]
2-Stroke ATV	R12S	0.25	1.86	1.71	0.03	47.81	48.72	140.15	0.42	0.003

Source: EPA NONROADS 2008a

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17.

Combustive Emission Estimations for Commuting Vehicles on Unpaved and Paved Roads - All Project Years

Activity	Equipment Type[a]	Class	Round Trip Distance (miles)	# of Round Trips/ Project	Vehicle Miles Traveled/ Project	# of Projects/ Year	Total Annual Vehicle Miles Traveled/ Activity	Emissions (tons/vehicle type)						Emissions (tons/year)								
								NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	CO_2	CH_4	N_2O
Forest/Woodland Forest Products	Support Truck	HDDV	200	31	6,200	1	6,200	0.02	0.00	0.00	0.00	0.01	0.00	0.07	0.01	0.01	0.00	0.08	0.03	5.41	0.00	0.00
	Log Truck	HDDV	200	62	12,400	1	12,400	0.04	0.00	0.00	0.00	0.02	0.00							10.82	0.00	0.00
	Pick-up Truck	LDDT	200	31	6,200	1	6,200	0.02	0.00	0.00	0.00	0.04	0.02							2.80	0.00	0.00
							Total	**0.07**	**0.01**	**0.01**	**0.00**	**0.08**	**0.03**	**0.07**	**0.01**	**0.01**	**0.00**	**0.08**	**0.03**	**19.03**	**0.0008**	**0.0013**

Source of activity data: Billings Field Office.

[a] All vehicles are diesel-powered, except ATVs, which are gasoline-powered.

Forestry and Woodland Products - Alternative D

Forest Products **Alternative D**

Total Annual Emissions from Forest and Woodlands Projects - Alternative D

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs[a]	CO_2	CH_4	N_2O	$CO2_{eq}$ tons	$CO2_{eq}$ metric tons
Heavy Equipment - Fugitive Dust	8.19	0.82	---	---	---	---	---	---	---	---	---	---
Heavy Equipment - Vehicle Exhaust	0.12	0.11	1.46	0.04	1.09	0.16	0.02	180.62	0.00	0.00	181.28	164.50
Sub-total: Heavy Equipment	**8.31**	**0.93**	**1.46**	**0.04**	**1.09**	**0.16**	**0.02**	**180.62**	**0.00**	**0.00**	**181.28**	**164.50**
Commuting Vehicles - Fugitive Dust	1.98	0.20	---	---	---	---	---	---	---	---	---	---
Commuting Vehicles - Vehicle Exhaust	0.01	0.00	0.06	0.00	0.06	0.02	0.00	15.35	0.00	0.00	15.68	14.23
Sub-total: Commuting Vehicles	**1.99**	**0.20**	**0.06**	**0.00**	**0.06**	**0.02**	**0.00**	**15.35**	**0.00**	**0.00**	**15.68**	**14.23**
Total	**10.30**	**1.14**	**1.52**	**0.04**	**1.15**	**0.18**	**0.02**	**195.97**	**0.003**	**0.003**	**196.96**	**178.73**

[a] HAPs = Hazardous Air Pollutants (HAPs), which are assumed to account for 10 percent of VOC emissions.

Forestry and Woodland Products - Alternative D

ALTERNATIVE: Alternative D

Fugitive Dust from Heavy Construction Operations

INPUTS & ASSUMPTIONS			
Description	**Value**	**Source**	**Notes**
Control Efficiency (C) of watering[a]	0	a	
PM_{10} Emission Factor	0.11	b	Tons PM_{10}/acre-month
Conversion factor for PM_{10} to $PM_{2.5}$	0.1	c	Percentage of PM_{10}

[a] The PM_{10} emission factor shown below includes 50% control based on watering.
[b] WRAP Fugitive Dust Handbook, September 2006.
Regional Air Partnership (WRAP), MRI Project No. 110397, November 1, 2006.

Fugitive Dust Emission Estimations for Forest Products - All Project Years

Forest Harvesting		Total Disturbed Acres/Year	Total Disturbed Acres (20 years)	# of Days to Complete/ Project[1]	Emissions (tons/year)	
					PM_{10}	$PM_{2.5}$
Forest/Woodland Forest Products		89	1,780	25	8.16	0.82
				Total	**8.16**	**0.82**

1. Land surface disturbed one time, so assume one day of disturbance for each acre.

Wind Erosion Associated with Land Disturbance

Activity	Land Area Disturbed	Silt Content	Days with Wind Speed Greater Than 5.4 m/s	Days with Precipitation >0.001 Inch	Total Suspended Particulate	Months to Disturb Total Area	Total Suspended Particulate	Emission Control Percent	PM_{10} Emissions	$PM_{2.5}$ Emissions
	(acre/year)	(%)	(%)	(number)	(lbs/acre/month)	(months)	(lbs/year)	(%)	(tons/year)	(tons/year)
Total Land Disturbance	89.0	34.6	30	96.3	89.673	0.033	266.03	0	**0.03**	**0.00**

* Account for wind blown dust occuring one time (day) for the disturbed land area (includes disturbed road ways), therefore input one day for calculation purposes.
* "Control of Fugitive Dust Sources" EPA-450/3-98-008 (EPA 1998). TSP (lb/acre/month) = 1.7 × (s/1.5) × ([365-p]/235) × (f/15), where:
p = number of days with > 0.001 in precipitation
f = percent of time wind speed exceeds 5.4 (m/s) [equivalent to 12 mph] = 30.0% derived from Soda Springs Mountain, Montana surface meteorology 2004-2010 dataset.
* AP-42 (EPA 2006), Section 13.2.2 "Unpaved Roads", Background Document. Assuming that PM10 accounts for 25% of TSP. Daily and hourly emissions based on 30.4-day month.
* Assuming that $PM_{2.5}$ accounts for 10% of PM_{10} based on "Analysis of the Fine Fraction of PM in Fugitive Dust," Midwest Research Institute (MRI) Report 110397 (2005).

Forestry and Woodland Products - Alternative D

ALTERNATIVE: Alternative D

Emission Factors for Logging Equipment

	Emission Factors (g/hp-hr)								
Year 2008	NOx	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O[1]
Chainsaw 6-11 Hp	1.32	9.75	0.14	293.54	61.89	8.97	686.00	0.54	0.0043
Feller/Bunch/Skidder 75-100	4.70	0.54	0.13	3.88	0.46	0.52	594.76	0.01	0.0061
Log Equipp 300 Hp	4.39	0.25	0.12	1.76	0.22	0.24	536.15	0.003	0.0061

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emission Estimations for Forest and Woodland Activities - All Years

Activity	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Hours/ Day	# of Days/ Project	Total Hours/ Project/ Year	Emissions (lbs/year/activity)					Emissions (tons/year)								
								NO_x	PM_{10}	SO_2	CO	VOC	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Forest/Woodland Forest Products	Skidder	205	1	70	8	25	200	297.57	34.01	8.09	245.48	29.15	1.5E-01	1.7E-02	4.0E-03	1.2E-01	1.5E-02	1.6E-02	1.9E+01	2.2E-04	1.9E-04
	Log Truck	450	1	60	10	25	250	653.30	36.64	17.16	262.10	33.23	3.3E-01	1.8E-02	8.6E-03	1.3E-01	1.7E-02	1.8E-02	4.0E+01	2.5E-04	4.5E-04
	Chainsaw	6	1	80	8	25	200	2.80	20.63	0.30	621.24	130.98	1.4E-03	1.0E-02	1.5E-04	3.1E-01	6.5E-02	9.5E-03	7.3E-01	5.7E-04	4.5E-06
	Feller Buncher	300	1	100	8	25	200	622.10	71.10	16.92	513.19	60.93	3.1E-01	3.6E-02	8.5E-03	2.6E-01	3.0E-02	3.4E-02	3.9E+01	4.6E-04	4.0E-04
	Loader	200	1	80	10	25	250	387.14	21.71	10.17	155.32	19.69	1.9E-01	1.1E-02	5.1E-03	7.8E-02	9.8E-03	1.1E-02	2.4E+01	1.5E-04	2.7E-04
	Dozer	200	1	90	8	25	200	348.42	19.54	9.15	139.79	17.72	1.7E-01	9.8E-03	4.6E-03	7.0E-02	8.9E-03	9.5E-03	2.1E+01	1.3E-04	2.4E-04
	Delimber	250	1	100	10	25	250	604.90	33.92	15.89	242.69	30.77	3.0E-01	1.7E-02	7.9E-03	1.2E-01	1.5E-02	1.6E-02	3.7E+01	2.3E-04	4.2E-04
												Total	1.5E+00	1.2E-01	3.9E-02	1.1E+00	1.6E-01	1.1E-01	1.8E+02	2.0E-03	2.0E-03

Source of activity data: Billings Field Office.

Assume 2008 emission factors for all years; this is a conservative estimate.

Forestry and Woodland Products - Alternative D

ALTERNATIVE: Alternative D

Emission Factors for Publicly Accessible Unpaved Roads[a]

$$E\ (lb/VMT) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
k	1.8	0.18
a	1	1
d	0.5	0.5
c	0.2	0.2

Function/Variable Description		Assumed Value	Reference
E = size-specific emission factor (lb/VMT)			
E_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)			
s = surface material silt content (%)		34.6	Billings Field Office, Dustin Crowe email dated August 16, 2010.
S = mean vehicle speed (mph)			
C = emission factor for 1980's vehicle fleet exhaust, brake wear, and tire wear (lb/VMT)	$PM_{2.5}$	0.00036	EPA AP-42 Section 13.2.2, Table 13.2.2-4
	PM_{10}	0.00047	EPA AP-42 Section 13.2.2, Table 13.2.2-4
M = surface material moisture content (%)		2.0	EPA AP-42 Section 13.2.2
P = Number of days precip per year		96.3	Billings, MT Climate Summary from 1961-1990, Western Regional Climate Center.
CE = control percent for applying dust suppressant to unpaved ro		50%	

[a] *Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2, Nov. 2006*

[b] Fitzpatrick, M. 1990. *User's Guide: Emission Control Technologies and Emission Factors for Unpaved Road Fugitive Emissions*, EPA/625/5-87/022. http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=20008SFC.

Fugitive Dust Emission Estimations for Commuting Vehicles on Unpaved Roads - All Project Years

Activity	Equipment Type	Avg. Vehicle Speed (mph)	Round Trip Distance (miles)	# of Round Trips/Project	Vehicle Miles Traveled/ Project	# of Projects/Year	Total Annual Vehicle Miles	PM_{10} Controlled Em. Factor (lb/VMT)	PM_{10} Emissions (tons/ vehicle type)	PM_{10} Emissions (tons/ activity)	$PM_{2.5}$ Controlled Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions (tons/ vehicle type)	$PM_{2.5}$ Emissions (tons/ activity)
Forest/Woodland Forest Products	Support Truck	25	30	25	750	1	750	1.32	0.50	1.98	0.13	0.05	0.20
	Log Truck	25	30	50	1,500	1	1,500	1.32	0.99		0.13	0.10	
	Pick-up Truck	25	30	25	750	1	750	1.32	0.50		0.13	0.05	
								Total	**1.98**			**0.20**	

Source of activity data: Billings Field Office.
Assume application of water ~ 50% emissions control.

Forestry and Woodland Products - Alternative D

ALTERNATIVE: Alternative D

Emission Factors for Commuting Vehicles

	Emission Factors (gm/mile)								
Project Year	NO_x	PM_{10}	$PM_{2.5}$	SO2	CO	VOC	CO_2	CH_4	N_2O[1]
2008									
LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.04

Source: Moblie 6.2.03

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Emission Factors for Off-Road ATV

Vehicle		Emission Factors (gm/mile)								
Type	Class	NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O[1]
2-Stroke ATV	R12S	0.25	1.86	1.71	0.03	47.81	48.72	140.15	0.42	0.003

Source: EPA NONROADS 2008a

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17.

Combustive Emission Estimations for Commuting Vehicles on Unpaved and Paved Roads - All Project Years

Activity	Equipment Type[a]	Class	Round Trip Distance (miles)	# of Round Trips/ Project	Vehicle Miles Traveled/ Project	# of Projects/ Year	Total Annual Vehicle Miles Traveled/ Activity	Emissions														
								(tons/vehicle type)						(tons/year)								
								NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	CO_2	CH_4	N_2O
Forest/Woodland Forest Products	Support Truck	HDDV	200	25	5,000	1	5,000	0.01	0.00	0.00	0.00	0.01	0.00	0.06	0.01	0.00	0.00	0.06	0.02	4.36	0.00	0.00
	Log Truck	HDDV	200	50	10,000	1	10,000	0.03	0.00	0.00	0.00	0.02	0.00							8.73	0.00	0.00
	Pick-up Truck	LDDT	200	25	5,000	1	5,000	0.01	0.00	0.00	0.00	0.03	0.02							2.26	0.00	0.00
							Total	**0.06**	**0.01**	**0.00**	**0.00**	**0.06**	**0.02**	**0.06**	**0.01**	**0.00**	**0.00**	**0.06**	**0.02**	**15.35**	**0.0006**	**0.0010**

Source of activity data: Billings Field Office.

[a] All vehicles are diesel-powered, except ATVs, which are gasoline-powered.

Livestock Grazing - Alternatives A, B, C, and D

Livestock Grazing **Alternatives A-D**

Total Annual Emissions from Livestock Grazing Projects - Alternatives A-D

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs [a]	CO_2	CH_4	N_2O	CO_{2eq}	CO_{2eq} metric Tons
Heavy Equipment - Fugitive Dust	0.39	0.04	---	---	---	---	---	---	---	---	---	---
Heavy Equipment - Vehicle Exhaust	0.02	0.02	0.29	0.01	0.12	0.02	0.00	29.80	0.00	0.00	29.9	27.1
Sub-total: Construction	**0.41**	**0.06**	**0.29**	**0.01**	**0.12**	**0.02**	**0.00**	**29.80**	**0.00**	**0.00**	**29.9**	**27.1**
Commuting Vehicles - Fugitive Dust	88.25	8.82	---	---	---	---	---	---	---	---	---	---
Commuting Vehicles - Vehicle Exhaust	0.02	0.01	0.15	0.00	0.29	0.10	0.01	43.68	0.00	0.00	44.6	40.5
Enteric Fermentation and Manure Management	---	---	---	---	---	---	---	---	272.82	---	5,729.3	5,199.0
Sub-total: Operations and Maintenance	**88.26**	**8.83**	**0.15**	**0.00**	**0.29**	**0.10**	**0.01**	**43.68**	**272.83**	**0.00**	**5,773.9**	**5,239.5**
Total	**88.67**	**8.89**	**0.43**	**0.01**	**0.41**	**0.12**	**0.01**	**73.48**	**272.83**	**0.00**	**5,803.8**	**5,266.6**

[b] HAPs = Hazardous Air Pollutants; assumed = VOCs * 0.1

Livestock Grazing - Alternatives A, B, C, and D

ALTERNATIVE: Alternatives A-D

Fugitive Dust from Heavy Construction Operations

INPUTS & ASSUMPTIONS			
Description	**Value**	**Source**	**Notes**
Control Efficiency (C) of watering[a]	0	a	
PM_{10} Emission Factor	0.11	b	month
Conversion factor for PM_{10} to $PM_{2.5}$	0.1	c	Percentage of PM_{10}

[a] The PM_{10} emission factor shown below includes 50% control based on watering.

[b] WRAP Fugitive Dust Handbook, September 2006.

[c] Midwest Research Institute. 2006. *Background Document for Revisions to Fine Fraction Ratios Used for AP-42 Fugitive Dust Emission Factors*, Report prepared for the Western Governors' Association, Western Regional Air Partnership (WRAP), MRI Project No. 110397, November 1, 2006.

Fugitive Dust Emissions Estimation for Construction Activities - All Project Years

Construction Activity	Total Disturbed Acres/ Year	# of Days to Complete/ Year[1]	Emissions (tons/year)	
			PM_{10}	$PM_{2.5}$
Springs	1.00	1	3.67E-03	3.67E-04
Reservoirs/Pits	10.00	1	3.67E-02	3.67E-03
Wells	5.00	1	1.83E-02	1.83E-03
Pipelines	50.00	1	1.83E-01	1.83E-02
Fences	25.00	1	9.17E-02	9.17E-03
Reservoirs Maintenance	6.00	1	2.20E-02	2.20E-03
		Total	**3.56E-01**	**3.56E-02**

a information from Billings Field Office. Assumes no emissions controls.

1. assumes total acreage is disturbed once annually, so input one day for calculation purposes

Wind Erosion Associated with Land Disturbance

Activity	Land Area Disturbed	Silt Content	Days with Wind Speed Greater Than 5.4 m/s	Total Suspended Particulate	Months to Disturb Total Area	Total Suspended Particulate	Emission Control Percent	PM_{10} Emissions	$PM_{2.5}$ Emissions
	(acre/year)	(%)	(%)	(lbs/acre/month)	(months)	(lbs/year)	(%)	(tons/year)	(tons/year)
Total Land Disturbance	97.0	34.6	30	89.673	0.033	289.94	0	**0.04**	**0.00**

* account for wind blown dust occuring one time (day) for the disturbed land area (includes disturbed road ways), therefore input one day for calculation purposes.

* "Control of Fugitive Dust Sources" EPA-450/3-98-008 (EPA 1998). TSP (lb/acre/month) = 1.7 × (s/1.5) × ([365-p]/235) × (f/15), where:
p = number of days with > 0.001 in precipitation
f = percent of time wind speed exceeds 5.4 (m/s) [equivalent to 12 mph] = 30.0% derived from Soda Springs, Montana surface meteorology 2004-2011 dataset from Western Research Climate Center.

* AP-42 (EPA 2006), Section 13.2.2 "Unpaved Roads", Background Document. Assuming that PM10 accounts for 25% of TSP. Daily and hourly emissions based on 30.4-day month.

* Assuming that $PM_{2.5}$ accounts for 10% of PM_{10} based on "Analysis of the Fine Fraction of PM in Fugitive Dust," Midwest Research Institute (MRI) Report 110397 (2005).

Livestock Grazing - Alternatives A, B, C, and D

ALTERNATIVE: Alternatives A-D

Exhaust Emission Factors for Diesel-Powered Off-Road Construction Equipment

Project Year/Hp Category	Emission Factors (g/hp-hr)								
	NOx	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O[1]
Year 2008									
50 to 75	5.34	0.63	0.13	4.03	0.66	0.61	601.0	0.010	0.0061
75 to 100	5.36	0.65	0.13	4.15	0.66	0.63	600.5	0.010	0.0061
100 to 175	4.95	0.38	0.12	1.85	0.44	0.37	540.3	0.007	0.0061
175 to 300	4.37	0.29	0.11	1.46	0.36	0.28	506.7	0.006	0.0061
300 to 600	5.25	0.32	0.12	2.22	0.33	0.31	534.7	0.005	0.0061
600 to 750	5.24	0.32	0.11	2.54	0.31	0.31	534.6	0.005	0.0061
>750	6.47	0.34	0.11	2.19	0.46	0.33	533.8	0.007	0.0061

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emissions Estimation for Construction Activities

Construction Activity	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Hours/Day	# of Days/ Project	# of Projects/ Year	Total Hours/ Unit/Year	Emissions (lbs/year)					Emissions (tons/year)								
									NO_x	PM_{10}	SO_2	CO	VOC	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O[1]
Springs	Backhoe	80	1	50	8	3	1.00	24.0	11	1	0	9	1	0.01	0.00	0.00	0.00	0.00	0.00	0.64	0.00	0.00
Reservoirs/Pits	Bulldozer	500	1	70	8	3	2.00	48.0	194	12	4	82	12	0.10	0.01	0.00	0.04	0.01	0.01	9.90	0.00	0.00
	Scraper	650	1	70	8	3	2.00	48.0	253	15	6	107	16	0.13	0.01	0.00	0.05	0.01	0.01	12.87	0.00	0.00
Wells	Drill Rig	200	1	100	8	1	1.00	8.0	15	1	0	5	1	0.01	0.00	0.00	0.00	0.00	0.00	0.89	0.00	0.00
	Water Truck	200	1	70	8	1	1.00	8.0	11	1	0	4	1	0.01	0.00	0.00	0.00	0.00	0.00	0.63	0.00	0.00
Pipelines	Dozer	200	1	75	1	1	1.00	1.0	2	0	0	1	0	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.00
	Trencher	80	1	75	8	1	1.00	8.0	6	1	0	4	1	0.00	0.00	0.00	0.00	0.00	0.00	0.32	0.00	0.00
	Backhoe	80	1	75	8	1	1.00	8.0	6	1	0	4	1	0.00	0.00	0.00	0.00	0.00	0.00	0.32	0.00	0.00
Fences (Miles/yr.)	Auger Truck	250	1	75	8	1	2.00	16.0	29	2	1	10	2	0.01	0.00	0.00	0.00	0.00	0.00	1.68	0.00	0.00
Reservoir Maintenance	Bulldozer	500	1	70	2	3	2.00	12.0	49	3	1	21	3	0.02	0.00	0.00	0.01	0.00	0.00	2.48	0.00	0.00
													Total	**2.88E-01**	**1.83E-02**	**6.41E-03**	**1.23E-01**	**1.95E-02**	**1.78E-02**	**2.98E+01**	**2.98E-04**	**3.38E-04**

Source for activity data: Billings Field Office

all emissions calculated with year 2008 factors (conservative)

Livestock Grazing - Alternatives A, B, C, and D

ALTERNATIVE: Alternatives A-D

Fugitive Dust from Commuting Vehicles on Unpaved Roads

Emission Factors for Publicly Accessible Unpaved Roads[a]

$$E\ (lb/VMT) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
k	1.8	0.18
a	1	1
d	0.5	0.5
c	0.2	0.2

Function/Variable Description		Assumed Value	Reference
E = size-specific emission factor (lb/VMT)			
E_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)			
s = surface material silt content (%)		34.6	Billings Field Office, Dustin Crowe email dated August 16, 2010.
S = mean vehicle speed (mph)			
C = emission factor for 1980's vehicle fleet exhaust, brake wear, and tire wear (lb/VMT)	$PM_{2.5}$	0.00036	EPA AP-42 Section 13.2.2, Table 13.2.2-4
	PM_{10}	0.00047	EPA AP-42 Section 13.2.2, Table 13.2.2-4
M = surface material moisture content (%)		2.0	EPA AP-42 Section 13.2.2
P = Number of days precip per year		96.3	Billings, MT Climate Summary from 1961-1990, Western Regional Climate Center.
CE = emission control percent for watering unpaved roads[b]		50%	Billings Field Office.

[a] *Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2, Nov. 2006*

[b] Fitzpatrick, M. 1990. *User's Guide: Emission Control Technologies and Emission Factors for Unpaved Road Fugitive Emissions*, EPA/625/5-87/022. http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=20008SFC.

Fugitive Dust Emission Estimations for Commuting Vehicle on Unpaved Roads - All Project Years

Construction Activity	Equipment Type	Avg. Vehicle Speed (mph)	Round Trip Distance (miles)	# of Round Trips/Project	Total Vehicle Miles/Project	# of Projects/Year	Total Annual Vehicle Miles Traveled	PM_{10} Controlled Em. Factor (lb/VMT)	PM_{10} Emissions[a] (tons/vehicle type)	PM_{10} Emissions[a] (tons/activity)	$PM_{2.5}$ Controlled Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions[a] (tons/vehicle type)	$PM_{2.5}$ Emissions[a] (tons/activity)
Springs	Tractor-Trailer	35	75	2	150	1.00	150	1.56	0.12	0.23	0.16	0.01	0.02
	Pick-up Truck	35	75	2	150	1.00	150	1.56	0.12		0.16	0.01	
Reservoirs/Pits	Tractor-Trailer	35	75	3	225	2.00	450	1.56	0.35	0.70	0.16	0.04	0.07
	Pick-up Truck	35	75	3	225	2.00	450	1.56	0.35		0.16	0.04	
Wells	Drill Truck	35	75	3	225	1.00	225	1.56	0.18	0.70	0.16	0.02	0.07
	Support Truck	35	75	3	225	1.00	225	1.56	0.18		0.16	0.02	
	Water Truck	35	75	3	225	1.00	225	1.56	0.18		0.16	0.02	
	Pick-up Truck	35	75	3	225	1.00	225	1.56	0.18		0.16	0.02	
Pipelines	Tractor-Trailer	35	75	1	75	1.00	75	1.56	0.06	0.35	0.16	0.01	0.04
	Pick-up Truck	35	75	5	375	1.00	375	1.56	0.29		0.16	0.03	
Fences	Support Truck	35	75	1	75	2.00	150	1.56	0.12	1.17	0.16	0.01	0.12
	Pick-up Truck	35	75	4	300	2.00	600	1.56	0.47		0.16	0.05	
	ATV	35	75	5	375	2.00	750	1.56	0.59		0.16	0.06	
Reservoirs Maintenance	Tractor-Trailer	35	75	3	225	2.00	450	1.56	0.35	0.70	0.16	0.04	0.07
	Pick-up Truck	35	75	3	225	2.00	450	1.56	0.35		0.16	0.04	
Livestock Management	Tractor-Trailer (spring turnout, fall gather)	35	75	1087	81525	1.00	81525	1.56	63.74	63.74	0.16	6.37	6.37
	Pick-up-Trailer (spring calves)	35	75	352	26400	1.00	26400	1.56	20.64	20.64	0.16	2.06	2.06
								Total	**88.25**			**8.82**	

Source for activity data: Billings Field Office, Larry Padden, 9-19-2011.

Livestock Grazing - Alternatives A, B, C, and D

ALTERNATIVE: Alternatives A-D

Emission factors for Commuting Vehicles Exhaust

Vehicle		Emission Factors (g/mi)								
Type	Class	NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O[1]
Light-Duty Gasoline Truck	LDGT2	1.13	0.03	0.01	0.01	23.97	1.07	476.9	0.07	0.053
Heavy-Duty Diesel Truck	HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.04

Source: EPA MOBILE 6.2.03 use 2008 emission factors for all years = worst case

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Vehicle		Emission Factors (g/mi)								
Type	Class	NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O[1]
2-Stroke ATV	R12S	0.25	1.86	1.71	0.03	47.81	48.72	140.15	0.42	0.18

Source: EPA NONROADS 2008a

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emission Estimations for Commuting Vehicle on Unpaved and Paved Roads - All Project Years

Construction Activity	Equipment Type	Class	Round Trip Distance (miles)	Round Trips per Project	Total Vehicle Miles per Project	# of Projects/Year	Total Annual Vehicle Miles Traveled	Emissions (tons/vehicle type)						Emissions (tons/year)								
								NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	CO_2	CH_4	N_2O
Springs	Tractor-Trailer	HDDV	150	2	300	1.00	300.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.26	0.00	0.00
	Pick-up Truck	LDGT2	150	2	300	1.00	300.0	0.00	0.00	0.00	0.00	0.01	0.00							0.16	0.00	0.00
Reservoirs/Pits	Tractor-Trailer	HDDV	150	3	450	2.00	900.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.79	0.00	0.00
	Pick-up Truck	LDGT2	150	3	450	2.00	900.0	0.00	0.00	0.00	0.00	0.02	0.00							0.47	0.00	0.00
Wells	Drill Truck	HDDV	150	3	450	1.00	450.0	0.00	0.00	0.00	0.00	0.00	0.00	0.0046	0.0004	0.0003	0.0000	0.0145	0.0011	0.39	0.00	0.00
	Support Truck	HDDV	150	3	450	1.00	450.0	0.00	0.00	0.00	0.00	0.00	0.00							0.39	0.00	0.00
	Water Truck	HDDV	150	3	450	1.00	450.0	0.00	0.00	0.00	0.00	0.00	0.00							0.39	0.00	0.00
	Pick-up Truck	LDGT2	150	3	450	1.00	450.0	0.00	0.00	0.00	0.00	0.01	0.00							0.24	0.00	0.00
Pipelines	Tractor-Trailer	HDDV	150	1	150	1.00	150.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.13	0.00	0.00
	Pick-up Truck	LDGT2	150	5	750	1.00	750.0	0.00	0.00	0.00	0.00	0.02	0.00							0.39	0.00	0.00
Fences	Support Truck	HDDV	150	1	150	2.00	300.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.08	0.26	0.00	0.00
	Pick-up Truck	LDGT2	150	4	600	2.00	1,200.0	0.00	0.00	0.00	0.00	0.03	0.00							0.63	0.00	0.00
	ATV	R12S	150	5	750	2.00	1,500.0	0.00	0.00	0.00	0.00	0.08	0.08							0.23	0.00	0.00
Reservoirs Maintenance	Tractor-Trailer	HDDV	150	3	450	2.00	900.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.79	0.00	0.00
	Pick-up Truck	LDGT2	150	3	450	2.00	900.0	0.00	0.00	0.00	0.00	0.02	0.00							0.47	0.00	0.00
Livestock Management	Tractor-Trailer (spring turnout, fall gather)	HDDV	30	1087	32610	1.00	32,610.0	0.10	0.01	0.01	0.00	0.06	0.01	0.13	0.01	0.01	0.00	0.08	0.02	28.46	0.00	0.00
	Pcik-up-Trailer (spring calves)	HDDV	30	352	10560	1.00	10,560.0	0.03	0.00	0.00	0.00	0.02	0.00							9.22	0.00	0.00
													TOTAL	**0.15**	**0.02**	**0.01**	**0.00**	**0.29**	**0.10**	**43.68**	**0.00**	**0.00**

Source for activity data: Billings Field Office

Livestock Grazing - Alternatives A, B, C, and D

ALTERNATIVE: Alternatives A-D

CH4 Emissions from Enteric Fermentation and Manure Management

Methane Emission Factors					
Livestock		Enteric Fermentation (Kg/head/yr)	Enteric Fermentation (lb/head/yr)	Manure Management (Kg/head/yr)	Manure Management (lb/head/yr)
Cattle	includes bulls, yearlings, and calves	53	116.84	2	4.41
Horse		18	39.68	2.34	5.16
Sheep		8	17.64	0.28	0.62

Source: 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4 Agriculture, Forestry, and Other Land Use, Chapter 10 Emissions From Livestock and Manure Management

Methane Emissions from Livestock - All Project Years

Livestock Category	Animal Unit Months (AUM) per Year	Enteric Fermentation emission factor (lb/head/month)	Annual Methane Emissions from Enteric Fermentation (tons/yr)	Manure Management emission factor (lb/head/month)	Annual Methane Emissions from Manure Management (tons/yr)	Total Methane Emissions (tons/yr)
Cattle	53,776	9.74	261.80	0.37	9.88	271.68
Horse	274	3.31	0.45	0.43	0.06	0.51
Sheep	823	1.47	0.60	0.05	0.02	0.63
					Total Methane emissions	**272.82**

BiFO total AUMs (excluding suspended units) are 54,873 for each Alternative. More than 97% of allocations are for cattle, with the remainder for sheep and horses. Because cattle authorizations are larger than sheep and horse authorizations, cattle/sheep/horse AUMs are estimated to be 99%/0.75%/0.25 respectively. Total AUMs and authorization numbers provided by Larry Padden on 9-19-2011.

Recreation and Visitor Services - Alternatives A, B, C, and D

Trails and Travel Management **Alternatives A-D**

Total Annual Emissions from Trails and Travel Managment - Alternatives A-D

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs[a]	CO_2	CH_4	N_2O	$CO2_{eq}$ tons	$CO2_{eq}$ metric tons
Recreation Vehicles - Fugitive Dust	226.76	22.66	---	---	---	---	---	---	---	---	---	---
Recreation Vehicles - Vehicle Exhaust	0.16	0.14	0.24	0.00	8.64	0.86	0.09	106.41	0.05	0.036	118.51	107.54
Sub-total: Vehicles	**226.92**	**22.80**	**0.24**	**0.00**	**8.64**	**0.86**	**0.09**	**106.41**	**0.05**	**0.04**	**118.51**	**107.54**
Total	**226.92**	**22.80**	**0.24**	**0.00**	**8.64**	**0.86**	**0.09**	**106.41**	**0.048**	**0.036**	**118.51**	**107.54**

[a] HAPs = Hazardous Air Pollutants; assumed = VOCs * 0.1

Recreation and Visitor Services - Alternatives A, B, C, and D

ALTERNATIVE: Alternatives A-D

Emission Factors for Publicly Accessible Unpaved Roads[a]

$$E\ (lb/VMT) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
k	1.8	0.18
a	1	1
d	0.5	0.5
c	0.2	0.2

Function/Variable Description		Assumed Value	Reference
E = size-specific emission factor (lb/VMT)			
E_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)			
s = surface material silt content (%)		34.6	Billings Field Office, Dustin Crowe email dated August 16, 2010.
S = mean vehicle speed (mph)			
C = emission factor for 1980's vehicle fleet exhaust, brake wear, and tire wear (lb/VMT)	$PM_{2.5}$	0.00036	EPA AP-42 Section 13.2.2, Table 13.2.2-4
	PM_{10}	0.00047	EPA AP-42 Section 13.2.2, Table 13.2.2-4
M = surface material moisture content (%)		2.0	EPA AP-42 Section 13.2.2
P = Number of days precip per year		96.3	Billings, MT Climate Summary from 1961-1990, Western Regional Climate Center.
CE = control percent for applying dust suppressant to unpaved roads [b]		0%	No control

[a] *Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2, Nov. 2006*

Fugitive Dust Emission Estimations for Recreation Vehicles on Unpaved Roads - All Project Years

Activity Location	Equipment Type	Avg. Vehicle Speed (mph)	Round Trip Distance (miles)	Number of Trips	Total Annual Vehicle Miles	PM_{10} Controlled Em. Factor (lb/VMT)	PM_{10} Emissions (tons/vehicle type)	PM_{10} Emissions (tons/year)	$PM_{2.5}$ Controlled Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions (tons/vehicle type)	$PM_{2.5}$ Emissions (tons/year)
Shapard Ah-Nei	ATV	15	25	365	9,113	2.05	9.33	45.74	0.20	0.93	4.57
	Off-Road Motorcycles	25	25	365	9,113	2.64	12.04		0.26	1.20	
	Pickup Truck	40	10	1458	14,580	3.34	24.37		0.33	2.44	
South Hills	ATV	15	10	900	9,000	2.05	9.21	27.12	0.20	0.92	2.71
	Off-Road Motorcycles	25	10	900	9,000	2.64	11.89		0.26	1.19	
	Pickup Truck	40	2	1800	3,600	3.34	6.02		0.33	0.60	
Pryor Mountain	ATV	15	30	306	9,180	2.05	9.40	135.96	0.20	0.94	13.59
	Off-Road Motorcycles	25	60	306	18,360	2.64	24.26		0.26	2.42	
	Pickup Truck	40	60	1020	61,200	3.34	102.30		0.33	10.22	
Elk Basin Motorcycle Race	ATV	15	0	0	0	2.05	0.00	17.94	0.20	0.00	1.79
	Off-Road Motorcycles	50	75	125	9,375	3.74	17.52		0.37	1.75	
	Pickup Truck	40	2	125	250	3.34	0.42		0.33	0.04	
							Total	226.76			22.66

Source of activity data: Craid Drake, Miles City Field Office, based on the following: Shepard Ah-Nei 1,358 daily passes and 10 annual passes (10 trips per year); South Hills 10 motorcycles per day for 6 months/yr; Pryor Mountain 1,020 estimated round trips; Elk Bas Motorcycle Race with 125 participants. ATV and motorcycle use are assumed to be evenly split for non-race activities.

Recreation and Visitor Services - Alternatives A, B, C, and D

ALTERNATIVE: Alternatives A-D

Emission Factors for Off-Road Recreation Vehicles

Vehicle	Emission Factors (gm/mile)									
Type	Class	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	CO_2	CH_4	N_2O[1]
2-Stroke ATV	R12S	0.25	1.86	1.71	0.03	47.81	48.72	140.15	0.42	0.003
Gasoline Light-Duty Truck	LDDT	1.13	0.03	0.01	0.01	23.97	1.07	476.9	0.07	0.18

Source: EPA NONROADS 2008a

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17.

Combustive Emission Estimations for Recreation Vehicles on Unpaved and Paved Roads - All Project Years

Activity	Equipment Type[a]	Class	Round Trip Distance (miles)	# of Tripsper Year	Total Annual Vehicle Miles Traveled	Emissions (tons/year)								
						NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	CO_2	CH_4	N_2O
Shapard Ah-Nei	ATV	R12S	25	365	9,113	0.00	0.02	0.02	0.00	0.48	0.49	1.41	0.00	0.00
	Off-Road Motorcyles	R12S	25	365	9,113	0.00	0.02	0.02	0.00	0.48	0.49	1.41	0.00	0.00
	Pickup Truck	LDDT	40	1458	58,320	0.07	0.00	0.00	0.00	1.54	0.07	30.66	0.00	0.01
South Hills	ATV	R12S	10	900	9,000	0.00	0.02	0.02	0.00	0.47	0.48	1.39	0.00	0.00
	Off-Road Motorcyles	R12S	10	900	9,000	0.00	0.02	0.02	0.00	0.47	0.48	1.39	0.00	0.00
	Pickup Truck	LDDT	20	1800	36,000	0.04	0.00	0.00	0.00	0.95	0.04	18.92	0.00	0.01
Pryor Mountain	ATV	R12S	30	306	9,180	0.00	0.02	0.02	0.00	0.48	0.49	1.42	0.00	0.00
	Off-Road Motorcyles	R12S	60	306	18,360	0.01	0.04	0.03	0.00	0.97	0.99	2.84	0.01	0.00
	Pickup Truck	LDDT	80	1020	81,600	0.10	0.00	0.00	0.00	2.16	0.10	42.90	0.01	0.02
Elk Basin Motorcycle Race	ATV	R12S	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Off-Road Motorcyles	R12S	75	125	9,375	0.00	0.02	0.02	0.00	0.49	0.50	1.45	0.00	0.00
	Pickup Truck	LDDT	40	125	5,000	0.01	0.00	0.00	0.00	0.13	0.01	2.63	0.00	0.00
					Total	0.24	0.16	0.14	0.00	8.64	4.14	106.41	0.05	0.04

Source of activity data: Craid Drake, Miles City Field Office, based on the following: Shepard Ah-Nei 1,358 daily passes and 10 annual passes (10 trips per year); South Hills 10 motorcycles per day for 6 months/yr; Pryor Mountain 1,020 estimated round trips; Elk Basin Motorcycle Race with 125 participants. ATV and motorcycle use are assumed to be evenly split for non-race activities.

Vegetation Management Resource - Alternative A

Weed Treatment **Alternative A**

Total Annual Emissions for Weed Treatment - RMP Year - Alternative A

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs[a]	CO_2	CH_4	N_2O	$CO2_{eq}$ tons	$CO2_{eq}$ metric tons
Heavy Equipment - Fugitive Dust	11.09	1.11	---	---	---	---	---	---	---	---	---	---
Heavy Equipment - Vehicle Exhaust	0.09	0.09	0.01	0.00	2.80	0.59	0.06	6.53	0.01	0.00	6.65	6.04
Sub-total: Heavy Equipment	**11.18**	**1.19**	**0.01**	**0.00**	**2.80**	**0.59**	**0.06**	**6.53**	**0.01**	**0.0000**	**6.65**	**6.04**
Commuting Vehicles - Fugitive Dust	2.48	0.25	---	---	---	---	---	---	---	---	---	---
Commuting Vehicles - Vehicle Exhaust	0.00	0.00	0.02	0.00	0.11	0.08	0.01	3.69	0.00	0.00	3.84	3.49
Sub-total: Commuting Vehicles	**2.48**	**0.25**	**0.02**	**0.00**	**0.11**	**0.08**	**0.01**	**3.69**	**0.00**	**0.0005**	**3.84**	**3.49**
Total	**13.66**	**1.44**	**0.03**	**0.00**	**2.91**	**0.67**	**0.07**	**10.22**	**0.01**	**0.000**	**10.49**	**9.52**

[a] HAPs = Hazardous Air Pollutants; assumed = VOCs * 0.1

Vegetation Management Resource - Alternative A

ALTERNATIVE: Alternative A

Fugitive Dust from Heavy Construction Operations

INPUTS & ASSUMPTIONS			
Description	**Value**	**Source**	**Notes**
Control Efficiency (C) of watering[a]	0	a	
PM_{10} Emission Factor	0.11	b	Tons PM_{10}/acre-month
Conversion factor for PM_{10} to $PM_{2.5}$	0.1	c	Percentage of PM_{10}

[a] The PM_{10} emission factor shown below includes 50% control based on watering.

[b] WRAP Fugitive Dust Handbook, September 2006.
[c] Midwest Research Institute. 2006. *Background Document for Revisions to Fine Fraction Ratios Used for AP-42 Fugitive Dust Emission Factors* , Report prepared for the Western Governors' Association, Western Regional Air Partnership (WRAP), MRI Project No. 110397, November 1, 2006.

Fugitive Dust Emission Estimations for Weed Treatment - All Project Years

Construction Activity		Total Disturbed Acres/Year	Total Disturbed Acres (20 years)	# of Days to Complete/ Activity[1]	Emissions (tons/year)	
					PM_{10}	$PM_{2.5}$
Weed Treatment		2744	54,880	1	10.06	1.01
				Total	**10.06**	**1.01**

1. Input for calculation purposes, land disturbed one time per year.

Wind Erosion Associated with Land Disturbance

Activity	Land Area Disturbed	Silt Content	Days with Wind Speed Greater Than 5.4 m/s	Total Suspended Particulate	Months to Disturb Total Area	Total Suspended Particulate	Emission Control Percent	PM_{10} Emissions	$PM_{2.5}$ Emissions
	(acre/year)	(%)	(%)	(lbs/acre/month)	(months)	(lbs/year)	(%)	(tons/year)	(tons/year)
Total Land Disturbance	2744.0	34.6	30	89.673	0.033	8,202.13	0	**1.03**	**0.10**

* account for wind blown dust occuring one time (day) for the disturbed land area (includes disturbed road ways), therefore input one day for calculation purposes.
* "Control of Fugitive Dust Sources" EPA-450/3-98-008 (EPA 1998). TSP (lb/acre/month) = 1.7 × (s/1.5) × ([365-p]/235) × (f/15), where:
p = number of days with > 0.001 in precipitation
f = percent of time wind speed exceeds 5.4 (m/s) [equivalent to 12 mph] = 30.0% derived from Soda Springs Mountain, Montana surface meteorology 2004-2010 dataset.
* AP-42 (EPA 2006), Section 13.2.2 "Unpaved Roads", Background Document. Assuming that PM10 accounts for 25% of TSP. Daily and hourly emissions based on 30.4-day month.
* Assuming that $PM_{2.5}$ accounts for 10% of PM_{10} based on "Analysis of the Fine Fraction of PM in Fugitive Dust," Midwest Research Institute (MRI) Report 110397 (2005).

Vegetation Management Resource - Alternative A

ALTERNATIVE: Alternative A

Emission Factors for Equipment

	Emission Factors (g/hp-hr)								
Year 2008	**NOx**	**PM_{10}**	**SO_2**	**CO**	**VOC**	**$PM_{2.5}$**	**CO_2**	**CH_4**	**N_2O[1]**
Chainsaw 6-11 Hp	1.32	9.75	0.14	293.54	61.89	8.97	686.00	0.54	0.0043
Feller/Bunch/Skidder 75-100	4.70	0.54	0.13	3.88	0.46	0.52	594.76	0.01	0.0061
Heavy Equipp 300 Hp	4.39	0.25	0.12	1.76	0.22	0.24	536.15	0.00	0.0061

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emission Estimations for Weed Management Activities - All Years

Activity	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Hours/ Day	# of Days/ Activity	Total Hours/ Activity/Year	Emissions (lbs/year/activity)					Emissions (tons/year)								
								NO_x	**PM_{10}**	**SO_2**	**CO**	**VOC**	**NO_x**	**PM_{10}**	**SO_2**	**CO**	**VOC**	**$PM_{2.5}$**	**CO_2**	**CH_4**	**N_2O**
Weed Treatment	Spray Vehicle	40	---	100	---	---	216	25.20	185.68	2.67	5,591.15	1,178.83	0.01	0.09	0.00	2.80	0.59	0.09	6.53	0.01	0.00
	Spray Unit	0	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
												Total	**1.26E-02**	**9.28E-02**	**1.34E-03**	**2.80E+00**	**5.89E-01**	**8.54E-02**	**6.53E+00**	**5.13E-03**	**4.09E-05**

Source of activity data: Billings Field Office, Melissa Passes, 9-20-2011. Hours estimated by dividing total vehicle miles traveled by speed.
Assume 2008 emission factors for all years = conservative estimate

Vegetation Management Resource - Alternative A

ALTERNATIVE: Alternative A

Emission Factors for Publicly Accessible Unpaved Roads[a]

$$E\ (lb/VMT) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
k	1.8	0.18
a	1	1
d	0.5	0.5
c	0.2	0.2

Function/Variable Description		Assumed Value	Reference
E = size-specific emission factor (lb/VMT)			
E_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)			
s = surface material silt content (%)		34.6	Source of activity data: Billings Field Office.
S = mean vehicle speed (mph)			
C = emission factor for 1980's vehicle fleet exhaust, brake wear, and tire wear (lb/VMT)	$PM_{2.5}$	0.00036	EPA AP-42 Section 13.2.2, Table 13.2.2-4
	PM_{10}	0.00047	EPA AP-42 Section 13.2.2, Table 13.2.2-4
M = surface material moisture content (%)		2.0	EPA AP-42 Section 13.2.2
P = Number of days precip per year		96.3	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = control efficiency of watering [b]		0%	

[a] *Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2, Nov. 2006*

[b] Fitzpatrick, M. 1990. *User's Guide: Emission Control Technologies and Emission Factors for Unpaved Road Fugitive Emissions* , EPA/625/5-87/022. http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=20008SFC.

Fugitive Dust Emission Estimations for Commuting Vehicles on Unpaved Roads - All Project Years

Activity	Equipment Type[a]	Avg. Vehicle Speed (mph)	Round Trip Distance (miles)	# of Round Trips/ Activity	Vehicle Miles Traveled/ Activity	# of Activities/ Year	Total Annual Vehicle Miles	PM_{10}			$PM_{2.5}$		
								Controlled Em. Factor (lb/VMT)	Emissions (tons/vehicle type)	Emissions (tons/activity)	Controlled Em. Factor (lb/VMT)	Emissions (tons/vehicle type)	Emissions (tons/activity)
Weed Treatment	ATV and Other Equipment	5	---	---	4,200	1	4,200	1.18	2.48	2.48	0.12	0.25	0.25
								Total	**2.48**			**0.25**	

Source of activity data: Billings Field Office, Melissa Passes, 9-20-2011. Data provided in terms of total vehicle miles traveled. VMT is equal to total ATV travel (all on unpaved roads) plus 40% of total truck travel.

Assume no watering

a Accounts for Billings Field Office. "other" equipment associated with this project.

Vegetation Management Resource - Alternative A

ALTERNATIVE: Alternative A

Emission Factors for Commuting Vehicles

	Emission Factors (gm/mile)								
Project Year	NO_x	PM_{10}	$PM_{2.5}$	SO2	CO	VOC	CO_2	CH_4	N_2O[1]
2008									
LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.04

Source: Moblie 6.2.03

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Emission Factors for Off-Road ATV

Vehicle	Emission Factors (gm/mile)									
Type	Class	NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O[1]
2-Stroke ATV	R12S	0.25	1.86	1.71	0.03	47.81	48.72	140.15	0.42	0.003

Source: EPA NONROADS 2008a

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emission Estimations for Commuting Vehicles on Unpaved and Paved Roads - All Project Years

Activity	Equipment Type[a]	Class	Round Trip Distance (miles)	# of Round Trips/Activity	Vehicle Miles Traveled/ Activity	# of Activities/ Year	Total Annual Vehicle Miles Traveled/ Activity	Emissions														
								(tons/vehicle type)						(tons/year)								
								NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	CO_2	CH_4	N_2O
Weed Treatment	ATV	R12S	---	---	---	---	1,080	0.00	0.00	0.00	0.00	0.06	0.06	0.00	0.00	0.00	0.00	0.06	0.06	0.17	0.00	0.00
Weed Treatment	Other Equipment	LDDT	---	---	---	---	7,800	0.02	0.00	0.00	0.00	0.05	0.02	0.02	0.00	0.00	0.00	0.05	0.02	3.52	0.00	0.00
							Total	0.02	0.00	0.00	0.00	0.11	0.08	0.02	0.00	0.00	0.00	0.11	0.08	3.69	0.00	0.000

Source of activity data: Billings Field Office, Melissa Passes, 9-20-2011. Data provided in terms of total vehicle miles traveled.

a All vehicles are diesel-powered, except the ATVs, which are gasoline-powered.

Vegetation Management Resource - Alternative B

Weed Treatment **Alternative B**

Total Annual Emissions for Weed Treatment - RMP Year - Alternative B

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs[a]	CO_2	CH_4	N_2O	$CO2_{eq}$ tons	$CO2_{eq}$ metric tons
Heavy Equipment - Fugitive Dust	1.87	0.19	---	---	---	---	---	---	---	---	---	---
Heavy Equipment - Vehicle Exhaust	0.02	0.01	0.00	0.00	0.48	0.10	0.01	1.11	0.00	0.00	1.13	1.03
Sub-total: Heavy Equipment	**1.89**	**0.20**	**0.00**	**0.00**	**0.48**	**0.10**	**0.01**	**1.11**	**0.00**	**0.0000**	**1.13**	**1.03**
Commuting Vehicles - Fugitive Dust	0.42	0.04	---	---	---	---	---	---	---	---	---	---
Commuting Vehicles - Vehicle Exhaust	0.00	0.00	0.00	0.00	0.02	0.01	0.00	0.63	0.00	0.00	0.65	0.59
Sub-total: Commuting Vehicles	**0.42**	**0.04**	**0.00**	**0.00**	**0.02**	**0.01**	**0.00**	**0.63**	**0.00**	**0.0001**	**0.65**	**0.59**
Total	**2.31**	**0.24**	**0.01**	**0.00**	**0.49**	**0.11**	**0.01**	**1.74**	**0.00**	**0.000**	**1.78**	**1.62**

[a] HAPs = Hazardous Air Pollutants; assumed = VOCs * 0.1

Vegetation Management Resource - Alternative B

ALTERNATIVE: Alternative B

Fugitive Dust from Heavy Construction Operations

INPUTS & ASSUMPTIONS			
Description	**Value**	**Source**	**Notes**
Control Efficiency (C) of watering[a]	0	a	
PM_{10} Emission Factor	0.11	b	Tons PM_{10}/acre-month
Conversion factor for PM_{10} to $PM_{2.5}$	0.1	c	Percentage of PM_{10}

[a] The PM_{10} emission factor shown below includes 50% control based on watering.

[b] WRAP Fugitive Dust Handbook, September 2006.

[c] Midwest Research Institute. 2006. *Background Document for Revisions to Fine Fraction Ratios Used for AP-42 Fugitive Dust Emission Factors* , Report prepared for the Western Governors' Association, Western Regional Air Partnership (WRAP), MRI Project No. 110397, November 1, 2006.

Fugitive Dust Emission Estimations for Weed Treatment - All Project Years

Construction Activity		Total Disturbed Acres/Year	Total Disturbed Acres (20 years)	# of Days to Complete/ Activity[1]	Emissions (tons/year)	
					PM_{10}	$PM_{2.5}$
Weed Treatment		464	9,280	1	1.70	0.17
				Total	**1.70**	**0.17**

1. Input for calculation purposes, land disturbed one time per year.

Wind Erosion Associated with Land Disturbance

Activity	Land Area Disturbed	Silt Content	Days with Wind Speed Greater Than 5.4 m/s	Total Suspended Particulate	Months to Disturb Total Area	Total Suspended Particulate	Emission Control Percent	PM_{10} Emissions	$PM_{2.5}$ Emissions
	(acre/year)	(%)	(%)	(lbs/acre/month)	(months)	(lbs/year)	(%)	(tons/year)	(tons/year)
Total Land Disturbance	464.0	34.6	30	89.673	0.033	1,386.95	0	**0.17**	**0.02**

* account for wind blown dust occuring one time (day) for the disturbed land area (includes disturbed road ways), therefore input one day for calculation purposes.

* "Control of Fugitive Dust Sources" EPA-450/3-98-008 (EPA 1998). TSP (lb/acre/month) = 1.7 × (s/1.5) × ([365-p]/235) × (f/15), where:
p = number of days with > 0.001 in precipitation
f = percent of time wind speed exceeds 5.4 (m/s) [equivalent to 12 mph] = 30.0% derived from Soda Springs Mountain, Montana surface meteorology 2004-2010 dataset.

* AP-42 (EPA 2006), Section 13.2.2 "Unpaved Roads", Background Document. Assuming that PM10 accounts for 25% of TSP. Daily and hourly emissions based on 30.4-day month.

* Assuming that $PM_{2.5}$ accounts for 10% of PM_{10} based on "Analysis of the Fine Fraction of PM in Fugitive Dust," Midwest Research Institute (MRI) Report 110397 (2005).

Vegetation Management Resource - Alternative B

ALTERNATIVE: Alternative B

Emission Factors for Equipment

Year 2008	Emission Factors (g/hp-hr)								
	NOx	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O[1]
Chainsaw 6-11 Hp	1.32	9.75	0.14	293.54	61.89	8.97	686.00	0.54	0.0043
Feller/Bunch/Skidder 75-100	4.70	0.54	0.13	3.88	0.46	0.52	594.76	0.01	0.0061
Heavy Equipp 300 Hp	4.39	0.25	0.12	1.76	0.22	0.24	536.15	0.00	0.0061

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emission Estimations for Weed Management Activities - All Years

Activity	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Hours/ Day	# of Days/ Activity	Total Hours/ Activity/Year	Emissions (lbs/year/activity)					Emissions (tons/year)								
								NO_x	PM_{10}	SO_2	CO	VOC	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Weed Treatment	Spray Vehicle	40	---	100	---	---	37	4.28	31.57	0.45	950.50	200.40	0.00	0.02	0.00	0.48	0.10	0.01	1.11	0.00	0.00
	Spray Unit	0	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
												Total	**2.14E-03**	**1.58E-02**	**2.27E-04**	**4.75E-01**	**1.00E-01**	**1.45E-02**	**1.11E+00**	**8.72E-04**	**6.95E-06**

Source of activity data: Billings Field Office, Melissa Passes, 9-20-2011.. Hours estimated by dividing total vehicle miles traveled by speed.
Assume 2008 emission factors for all years = conservative estimate

Vegetation Management Resource - Alternative B

ALTERNATIVE: Alternative B

Emission Factors for Publicly Accessible Unpaved Roads[a]

$$E\ (lb/VMT) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
k	1.8	0.18
a	1	1
d	0.5	0.5
c	0.2	0.2

Function/Variable Description		Assumed Value	Reference
E = size-specific emission factor (lb/VMT)			
E_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)			
s = surface material silt content (%)		34.6	Source of activity data: Billings Field Office.
S = mean vehicle speed (mph)			
C = emission factor for 1980's vehicle fleet exhaust, brake wear, and tire wear (lb/VMT)	$PM_{2.5}$	0.00036	EPA AP-42 Section 13.2.2, Table 13.2.2-4
	PM_{10}	0.00047	EPA AP-42 Section 13.2.2, Table 13.2.2-4
M = surface material moisture content (%)		2.0	EPA AP-42 Section 13.2.2
P = Number of days precip per year		96.3	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = control efficiency of watering [b]		0%	

[a] *Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2, Nov. 2006*

[b] Fitzpatrick, M. 1990. *User's Guide: Emission Control Technologies and Emission Factors for Unpaved Road Fugitive Emissions* , EPA/625/5-87/022. http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=20008SFC.

Fugitive Dust Emission Estimations for Commuting Vehicles on Unpaved Roads - All Project Years

Activity	Equipment Type[a]	Avg. Vehicle Speed (mph)	Round Trip Distance (miles)	# of Round Trips/ Activity	Vehicle Miles Traveled/ Activity	# of Activities/ Year	Total Annual Vehicle Miles	PM_{10} Controlled Em. Factor (lb/VMT)	PM_{10} Emissions (tons/vehicle type)	PM_{10} Emissions (tons/activity)	$PM_{2.5}$ Controlled Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions (tons/vehicle type)	$PM_{2.5}$ Emissions (tons/activity)
Weed Treatment	ATV and Other Equipment	5	---	---	714	1	714	1.18	0.42	0.42	0.12	0.04	0.04
								Total	**0.42**			**0.04**	

Source of activity data: Billings Field Office, Melissa Passes, 9-20-2011. Data provided in terms of total vehicle miles traveled. VMT is equal to total ATV travel (all on unpaved roads) plus 40% of total truck travel.

Assume no watering

a Accounts for Billings Field Office. "other" equipment associated with this project.

Vegetation Management Resource - Alternative B

ALTERNATIVE: Alternative B

Emission Factors for Commuting Vehicles

	Emission Factors (gm/mile)								
Project Year	NO_x	PM_{10}	$PM_{2.5}$	SO2	CO	VOC	CO_2	CH_4	N_2O[1]
2008									
LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.04

Source: Moblie 6.2.03

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Emission Factors for Off-Road ATV

Vehicle	Emission Factors (gm/mile)									
Type	Class	NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O[1]
2-Stroke ATV	R12S	0.25	1.86	1.71	0.03	47.81	48.72	140.15	0.42	0.003

Source: EPA NONROADS 2008a

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emission Estimations for Commuting Vehicles on Unpaved and Paved Roads - All Project Years

Activity	Equipment Type[a]	Class	Round Trip Distance (miles)	# of Round Trips/Activity	Vehicle Miles Traveled/ Activity	# of Activities/ Year	Total Annual Vehicle Miles Traveled/ Activity	Emissions														
								(tons/vehicle type)						(tons/year)								
								NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	CO_2	CH_4	N_2O
Weed Treatment	ATV	R12S	---	---	---	---	184	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.03	0.00	0.00
Weed Treatment	Other Equipment	LDDT	---	---	---	---	1,326	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.60	0.00	0.00
							Total	**0.00**	**0.00**	**0.00**	**0.00**	**0.02**	**0.01**	**0.00**	**0.00**	**0.00**	**0.00**	**0.02**	**0.01**	**0.63**	**0.00**	**0.000**

Source of activity data: Billings Field Office, Melissa Passes, 9-20-2011. Data provided in terms of total vehicle miles traveled scaled from Alternative A based on the ratio of treated acreage. Alternative B acreage is 17% of Alternative A acreage.

a All vehicles are diesel-powered, except the ATVs, which are gasoline-powered.

Vegetation Management Resource - Alternative C

Weed Treatment **Alternative C**

Total Annual Emissions for Weed Treatment - RMP Year - Alternative C

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs[a]	CO_2	CH_4	N_2O	$CO2_{eq}$ tons	$CO2_{eq}$ metric tons
Heavy Equipment - Fugitive Dust	8.44	0.84	---	---	---	---	---	---	---	---	---	---
Heavy Equipment - Vehicle Exhaust	0.07	0.06	0.01	0.00	2.12	0.45	0.04	4.97	0.00	0.00	5.06	4.59
Sub-total: Heavy Equipment	**8.51**	**0.91**	**0.01**	**0.00**	**2.12**	**0.45**	**0.04**	**4.97**	**0.00**	**0.0000**	**5.06**	**4.59**
Commuting Vehicles - Fugitive Dust	1.89	0.19	---	---	---	---	---	---	---	---	---	---
Commuting Vehicles - Vehicle Exhaust	0.00	0.00	0.02	0.00	0.08	0.06	0.01	2.80	0.00	0.00	2.92	2.65
Sub-total: Commuting Vehicles	**1.89**	**0.19**	**0.02**	**0.00**	**0.08**	**0.06**	**0.01**	**2.80**	**0.00**	**0.0003**	**2.92**	**2.65**
Total	**10.40**	**1.10**	**0.02**	**0.00**	**2.21**	**0.51**	**0.05**	**7.77**	**0.00**	**0.000**	**7.98**	**7.24**

[a] HAPs = Hazardous Air Pollutants; assumed = VOCs * 0.1

Vegetation Management Resource - Alternative C

ALTERNATIVE: Alternative C

Fugitive Dust from Heavy Construction Operations

INPUTS & ASSUMPTIONS			
Description	**Value**	**Source**	**Notes**
Control Efficiency (C) of watering[a]	0	a	
PM_{10} Emission Factor	0.11	b	Tons PM_{10}/acre-month
Conversion factor for PM_{10} to $PM_{2.5}$	0.1	c	Percentage of PM_{10}

[a] The PM_{10} emission factor shown below includes 50% control based on watering.

[b] WRAP Fugitive Dust Handbook, September 2006.

[c] Midwest Research Institute. 2006. *Background Document for Revisions to Fine Fraction Ratios Used for AP-42 Fugitive Dust Emission Factors* , Report prepared for the Western Governors' Association, Western Regional Air Partnership (WRAP), MRI Project No. 110397, November 1, 2006.

Fugitive Dust Emission Estimations for Weed Treatment - All Project Years

Construction Activity		Total Disturbed Acres/Year	Total Disturbed Acres (20 years)	# of Days to Complete/ Activity[1]	Emissions (tons/year)	
					PM_{10}	$PM_{2.5}$
Weed Treatment		2088	41,760	1	7.66	0.77
				Total	**7.66**	**0.77**

1. Input for calculation purposes, land disturbed one time per year.

Wind Erosion Associated with Land Disturbance

Activity	Land Area Disturbed	Silt Content	Days with Wind Speed Greater Than 5.4 m/s	Total Suspended Particulate	Months to Disturb Total Area	Total Suspended Particulate	Emission Control Percent	PM_{10} Emissions	$PM_{2.5}$ Emissions
	(acre/year)	(%)	(%)	(lbs/acre/month)	(months)	(lbs/year)	(%)	(tons/year)	(tons/year)
Total Land Disturbance	2088.0	34.6	30	89.673	0.033	6,241.27	0	**0.78**	**0.08**

* account for wind blown dust occuring one time (day) for the disturbed land area (includes disturbed road ways), therefore input one day for calculation purposes.

* "Control of Fugitive Dust Sources" EPA-450/3-98-008 (EPA 1998). TSP (lb/acre/month) = 1.7 × (s/1.5) × ([365-p]/235) × (f/15), where:
  p = number of days with > 0.001 in precipitation
  f = percent of time wind speed exceeds 5.4 (m/s) [equivalent to 12 mph] = 30.0% derived from Soda Springs Mountain, Montana surface meteorology 2004-2010 dataset.

* AP-42 (EPA 2006), Section 13.2.2 "Unpaved Roads", Background Document. Assuming that PM10 accounts for 25% of TSP. Daily and hourly emissions based on 30.4-day month.

* Assuming that $PM_{2.5}$ accounts for 10% of PM_{10} based on "Analysis of the Fine Fraction of PM in Fugitive Dust," Midwest Research Institute (MRI) Report 110397 (2005).

Vegetation Management Resource - Alternative C

ALTERNATIVE: Alternative C

Emission Factors for Equipment

	Emission Factors (g/hp-hr)								
Year 2008	**NOx**	**PM_{10}**	**SO_2**	**CO**	**VOC**	**$PM_{2.5}$**	**CO_2**	**CH_4**	**N_2O[1]**
Chainsaw 6-11 Hp	1.32	9.75	0.14	293.54	61.89	8.97	686.00	0.54	0.0043
Feller/Bunch/Skidder 75-100	4.70	0.54	0.13	3.88	0.46	0.52	594.76	0.01	0.0061
Heavy Equipp 300 Hp	4.39	0.25	0.12	1.76	0.22	0.24	536.15	0.00	0.0061

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emission Estimations for Weed Management Activities - All Years

Activity	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Hours/ Day	# of Days/ Activity	Total Hours/ Activity/Year	Emissions (lbs/year/activity)					Emissions (tons/year)								
								NO_x	**PM_{10}**	**SO_2**	**CO**	**VOC**	**NO_x**	**PM_{10}**	**SO_2**	**CO**	**VOC**	**$PM_{2.5}$**	**CO_2**	**CH_4**	**N_2O**
Weed Treatment	Spray Vehicle	40	---	100	---	---	164	19.15	141.12	2.03	######	895.91	0.01	0.07	0.00	2.12	0.45	0.06	4.97	0.00	0.00
	Spray Unit	0	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
												Total	**9.58E-03**	**7.06E-02**	**1.01E-03**	**2.12E+00**	**4.48E-01**	**6.49E-02**	**4.97E+00**	**3.90E-03**	**3.11E-05**

Source of activity data: Billings Field Office, Melissa Passes, 9-20-2011. Hours estimated by dividing total vehicle miles traveled by speed.
Assume 2008 emission factors for all years = conservative estimate

Vegetation Management Resource - Alternative C

ALTERNATIVE: Alternative C

Emission Factors for Publicly Accessible Unpaved Roads[a]

$$E\ (lb/VMT) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
k	1.8	0.18
a	1	1
d	0.5	0.5
c	0.2	0.2

Function/Variable Description		Assumed Value	Reference
E = size-specific emission factor (lb/VMT)			
E_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)			
s = surface material silt content (%)		34.6	Source of activity data: Billings Field Office.
S = mean vehicle speed (mph)			
C = emission factor for 1980's vehicle fleet exhaust, brake wear, and tire wear (lb/VMT)	$PM_{2.5}$	0.00036	EPA AP-42 Section 13.2.2, Table 13.2.2-4
	PM_{10}	0.00047	EPA AP-42 Section 13.2.2, Table 13.2.2-4
M = surface material moisture content (%)		2.0	EPA AP-42 Section 13.2.2
P = Number of days precip per year		96.3	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = control efficiency of watering [b]		0%	

[a] *Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2, Nov. 2006*

[b] Fitzpatrick, M. 1990. *User's Guide: Emission Control Technologies and Emission Factors for Unpaved Road Fugitive Emissions* , EPA/625/5-87/022. http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=20008SFC.

Fugitive Dust Emission Estimations for Commuting Vehicles on Unpaved Roads - All Project Years

Activity	Equipment Type[a]	Avg. Vehicle Speed (mph)	Round Trip Distance (miles)	# of Round Trips/ Activity	Vehicle Miles Traveled/ Activity	# of Activities/ Year	Total Annual Vehicle Miles	PM_{10} Controlled Em. Factor (lb/VMT)	PM_{10} Emissions (tons/vehicle type)	PM_{10} Emissions (tons/activity)	$PM_{2.5}$ Controlled Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions (tons/vehicle type)	$PM_{2.5}$ Emissions (tons/activity)
Weed Treatment	ATV and Other Equipment	5	---	---	3,192	1	3,192	1.18	1.89	1.89	0.12	0.19	0.19
								Total	**1.89**			**0.19**	

Source of activity data: Billings Field Office, Melissa Passes, 9-20-2011. Data provided in terms of total vehicle miles traveled. VMT is equal to total ATV travel (all on unpaved roads) plus 40% of total truck travel.

Assume no watering

a Accounts for Billings Field Office. "other" equipment associated with this project.

Vegetation Management Resource - Alternative C

ALTERNATIVE: Alternative C

Emission Factors for Commuting Vehicles

	Emission Factors (gm/mile)								
Project Year	NO_x	PM_{10}	$PM_{2.5}$	SO2	CO	VOC	CO_2	CH_4	N_2O[1]
2008									
LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.04

Source: Moblie 6.2.03

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Emission Factors for Off-Road ATV

Vehicle	Emission Factors (gm/mile)									
Type	Class	NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O[1]
2-Stroke ATV	R12S	0.25	1.86	1.71	0.03	47.81	48.72	140.15	0.42	0.003

Source: EPA NONROADS 2008a

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emission Estimations for Commuting Vehicles on Unpaved and Paved Roads - All Project Years

Activity	Equipment Type[a]	Class	Round Trip Distance (miles)	# of Round Trips/Activity	Vehicle Miles Traveled/ Activity	# of Activities/ Year	Total Annual Vehicle Miles Traveled/ Activity	Emissions														
								(tons/vehicle type)						(tons/year)								
								NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	CO_2	CH_4	N_2O
Weed Treatment	ATV	R12S	---	---	---	---	821	0.00	0.00	0.00	0.00	0.04	0.04	0.00	0.00	0.00	0.00	0.04	0.04	0.13	0.00	0.00
Weed Treatment	Other Equipment	LDDT	---	---	---	---	5,928	0.02	0.00	0.00	0.00	0.04	0.02	0.02	0.00	0.00	0.00	0.04	0.02	2.68	0.00	0.00
							Total	**0.02**	**0.00**	**0.00**	**0.00**	**0.08**	**0.06**	**0.02**	**0.00**	**0.00**	**0.00**	**0.08**	**0.06**	**2.80**	**0.00**	**0.000**

Source of activity data: Billings Field Office, Melissa Passes, 9-20-2011. Data provided in terms of total vehicle miles traveled scaled from Alternative A based on the ratio of treated acreage. Alternative C acreage is 76% of Alternative A acreage.

a All vehicles are diesel-powered, except the ATVs, which are gasoline-powered.

Vegetation Management Resource - Alternative D

Weed Treatment **Alternative D**

Total Annual Emissions for Weed Treatment - RMP Year - Alternative D

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs[a]	CO_2	CH_4	N_2O	$CO2_{eq}$ tons	$CO2_{eq}$ metric tons
Heavy Equipment - Fugitive Dust	4.50	0.45	---	---	---	---	---	---	---	---	---	---
Heavy Equipment - Vehicle Exhaust	0.04	0.04	0.01	0.00	1.15	0.24	0.02	2.68	0.00	0.00	2.73	2.48
Sub-total: Heavy Equipment	**4.54**	**0.49**	**0.01**	**0.00**	**1.15**	**0.24**	**0.02**	**2.68**	**0.00**	**0.0000**	**2.73**	**2.48**
Commuting Vehicles - Fugitive Dust	1.02	0.10	---	---	---	---	---	---	---	---	---	---
Commuting Vehicles - Vehicle Exhaust	0.00	0.00	0.01	0.00	0.05	0.03	0.00	1.51	0.00	0.00	1.57	1.43
Sub-total: Commuting Vehicles	**1.02**	**0.10**	**0.01**	**0.00**	**0.05**	**0.03**	**0.00**	**1.51**	**0.00**	**0.0002**	**1.57**	**1.43**
Total	**5.56**	**0.59**	**0.01**	**0.00**	**1.19**	**0.28**	**0.03**	**4.19**	**0.00**	**0.000**	**4.30**	**3.90**

[a] HAPs = Hazardous Air Pollutants; assumed = VOCs * 0.1

Vegetation Management Resource - Alternative D

ALTERNATIVE: Alternative D

Fugitive Dust from Heavy Construction Operations

INPUTS & ASSUMPTIONS			
Description	**Value**	**Source**	**Notes**
Control Efficiency (C) of watering[a]	0	a	
PM_{10} Emission Factor	0.11	b	Tons PM_{10}/acre-month
Conversion factor for PM_{10} to $PM_{2.5}$	0.1	c	Percentage of PM_{10}

[a] The PM_{10} emission factor shown below includes 50% control based on watering.

[b] WRAP Fugitive Dust Handbook, September 2006.
[c] Midwest Research Institute. 2006. *Background Document for Revisions to Fine Fraction Ratios Used for AP-42 Fugitive Dust Emission Factors* , Report prepared for the Western Governors' Association, Western Regional Air Partnership (WRAP), MRI Project No. 110397, November 1, 2006.

Fugitive Dust Emission Estimations for Weed Treatment - All Project Years

Construction Activity		Total Disturbed Acres/Year	Total Disturbed Acres (20 years)	# of Days to Complete/ Activity[1]	Emissions (tons/year)	
					PM_{10}	$PM_{2.5}$
Weed Treatment		1114	22,280	1	4.08	0.41
				Total	**4.08**	**0.41**

1. Input for calculation purposes, land disturbed one time per year.

Wind Erosion Associated with Land Disturbance

Activity	Land Area Disturbed	Silt Content	Days with Wind Speed Greater Than 5.4 m/s	Total Suspended Particulate	Months to Disturb Total Area	Total Suspended Particulate	Emission Control Percent	PM_{10} Emissions	$PM_{2.5}$ Emissions
	(acre/year)	(%)	(%)	(lbs/acre/month)	(months)	(lbs/year)	(%)	(tons/year)	(tons/year)
Total Land Disturbance	1114.0	34.6	30	89.673	0.033	3,329.87	0	**0.42**	**0.04**

* account for wind blown dust occuring one time (day) for the disturbed land area (includes disturbed road ways), therefore input one day for calculation purposes.
* "Control of Fugitive Dust Sources" EPA-450/3-98-008 (EPA 1998). TSP (lb/acre/month) = 1.7 × (s/1.5) × ([365-p]/235) × (f/15), where:
p = number of days with > 0.001 in precipitation
f = percent of time wind speed exceeds 5.4 (m/s) [equivalent to 12 mph] = 30.0% derived from Soda Springs Mountain, Montana surface meteorology 2004-2010 dataset.
* AP-42 (EPA 2006), Section 13.2.2 "Unpaved Roads", Background Document. Assuming that PM10 accounts for 25% of TSP. Daily and hourly emissions based on 30.4-day month.
* Assuming that $PM_{2.5}$ accounts for 10% of PM_{10} based on "Analysis of the Fine Fraction of PM in Fugitive Dust," Midwest Research Institute (MRI) Report 110397 (2005).

Vegetation Management Resource - Alternative D

ALTERNATIVE: Alternative D

Emission Factors for Equipment

	Emission Factors (g/hp-hr)								
Year 2008	NOx	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O[1]
Chainsaw 6-11 Hp	1.32	9.75	0.14	293.54	61.89	8.97	686.00	0.54	0.0043
Feller/Bunch/Skidder 75-100	4.70	0.54	0.13	3.88	0.46	0.52	594.76	0.01	0.0061
Heavy Equipp 300 Hp	4.39	0.25	0.12	1.76	0.22	0.24	536.15	0.00	0.0061

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emission Estimations for Weed Management Activities - All Years

Activity	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Hours/ Day	# of Days/ Activity	Total Hours/ Activity/Year	Emissions (lbs/year/activity)					Emissions (tons/year)								
								NO_x	PM_{10}	SO_2	CO	VOC	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Weed Treatment	Spray Vehicle	40	---	100	---	---	89	10.33	76.13	1.09	2,292.37	483.32	0.01	0.04	0.00	1.15	0.24	0.04	2.68	0.00	0.00
	Spray Unit	0	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
												Total	5.17E-03	3.81E-02	5.47E-04	1.15E+00	2.42E-01	3.50E-02	2.68E+00	2.10E-03	1.68E-05

Source of activity data: Billings Field Office, Melissa Passes, 9-20-2011. Hours estimated by dividing total vehicle miles traveled by speed.
Assume 2008 emission factors for all years = conservative estimate

Vegetation Management Resource - Alternative D

ALTERNATIVE: Alternative D

Emission Factors for Publicly Accessible Unpaved Roads[a]

$$E\ (lb/VMT) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
k	1.8	0.18
a	1	1
d	0.5	0.5
c	0.2	0.2

Function/Variable Description		Assumed Value	Reference
E = size-specific emission factor (lb/VMT)			
E_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)			
s = surface material silt content (%)		34.6	Source of activity data: Billings Field Office.
S = mean vehicle speed (mph)			
C = emission factor for 1980's vehicle fleet exhaust, brake wear, and tire wear (lb/VMT)	$PM_{2.5}$	0.00036	EPA AP-42 Section 13.2.2, Table 13.2.2-4
	PM_{10}	0.00047	EPA AP-42 Section 13.2.2, Table 13.2.2-4
M = surface material moisture content (%)		2.0	EPA AP-42 Section 13.2.2
P = Number of days precip per year		96.3	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = control efficiency of watering [b]		0%	

[a] *Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2, Nov. 2006*

[b] Fitzpatrick, M. 1990. *User's Guide: Emission Control Technologies and Emission Factors for Unpaved Road Fugitive Emissions* , EPA/625/5-87/022. http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=20008SFC.

Fugitive Dust Emission Estimations for Commuting Vehicles on Unpaved Roads - All Project Years

Activity	Equipment Type[a]	Avg. Vehicle Speed (mph)	Round Trip Distance (miles)	# of Round Trips/ Activity	Vehicle Miles Traveled/ Activity	# of Activities/ Year	Total Annual Vehicle Miles	PM_{10} Controlled Em. Factor (lb/VMT)	PM_{10} Emissions (tons/vehicle type)	PM_{10} Emissions (tons/activity)	$PM_{2.5}$ Controlled Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions (tons/vehicle type)	$PM_{2.5}$ Emissions (tons/activity)
Weed Treatment	ATV and Other Equipment	5	---	---	1,722	1	1,722	1.18	1.02	1.02	0.12	0.10	0.10
							Total		**1.02**			**0.10**	

Source of activity data: Billings Field Office, Melissa Passes, 9-20-2011. Data provided in terms of total vehicle miles traveled. VMT is equal to total ATV travel (all on unpaved roads) plus 40% of total truck travel.

Assume no watering

a Accounts for Billings Field Office. "other" equipment associated with this project.

Vegetation Management Resource - Alternative D

ALTERNATIVE: Alternative D

Emission Factors for Commuting Vehicles

	Emission Factors (gm/mile)								
Project Year	NO_x	PM_{10}	$PM_{2.5}$	SO2	CO	VOC	CO_2	CH_4	N_2O[1]
2008									
LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.04

Source: Moblie 6.2.03

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Emission Factors for Off-Road ATV

Vehicle	Emission Factors (gm/mile)									
Type	Class	NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O[1]
2-Stroke ATV	R12S	0.25	1.86	1.71	0.03	47.81	48.72	140.15	0.42	0.003

Source: EPA NONROADS 2008a

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emission Estimations for Commuting Vehicles on Unpaved and Paved Roads - All Project Years

Activity	Equipment Type[a]	Class	Round Trip Distance (miles)	# of Round Trips/Activity	Vehicle Miles Traveled/ Activity	# of Activities/Year	Total Annual Vehicle Miles Traveled/ Activity	Emissions														
								(tons/vehicle type)						(tons/year)								
								NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	CO_2	CH_4	N_2O
Weed Treatment	ATV	R12S	---	---	---	---	443	0.00	0.00	0.00	0.00	0.02	0.02	0.00	0.00	0.00	0.00	0.02	0.02	0.07	0.00	0.00
Weed Treatment	Other Equipment	LDDT	---	---	---	---	3,198	0.01	0.00	0.00	0.00	0.02	0.01	0.01	0.00	0.00	0.00	0.02	0.01	1.44	0.00	0.00
							Total	**8.27E-03**	**1.29E-03**	**1.15E-03**	**3.34E-05**	**4.54E-02**	**3.35E-02**	**8.27E-03**	**1.29E-03**	**1.15E-03**	**3.34E-05**	**4.54E-02**	**3.35E-02**	**#######**	**2.14E-04**	**1.88E-04**

Source of activity data: Billings Field Office, Melissa Passes, 9-20-2011. Data provided in terms of total vehicle miles traveled scaled from Alternative A based on the ratio of treated acreage. Alternative D treated acreage is 41% of Alternative A treated acreage.

[a] All vehicles are diesel-powered, except the ATVs, which are gasoline-powered.

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