Appendix A

Detailed U.S. Inventory of Methane Emissions from Natural Gas Systems

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U.S. Detailed Inventory of Methane Emissions from Natural Gas Systems

PRODUCTION OFFSHORE	Total Emissions Nationally (MMcf/year)	Tonnes CO2e/ Year	% of Sector Emissions	% of total Inventory Emissions	Activity Factors	Leak Detection	Direct Measurement	Engineering Estimate	Accesible Source
Amine gas sweetening unit	0.2	80	0.01%	0.0001%	NE	c	c	a	n
Boiler/heater/burner	0.8	332	0.05%	0.0002%		c	d	a	n
Diesel or gasoline engine	0.01	6	0.001%	0.000004%		c	d	a	n
Drilling rig	3	1,134	0.17%	0.001%		c	d	a	n
Flare	24	9,583	1.47%	0.01%		c	c	b	n
Centrifugal Seals	358	144,547	22%	0.10%		a	a	a	b
Connectors	0.8	309	0.05%	0.0002%		b	b	b	b
Flanges	2.38	960	0.15%	0.001%		b	b	b	b
OEL	0.1	32	0.005%	0.00002%		b	b	b	b
Other	44	17,576	2.70%	0.01%		b	b	b	b
Pump Fugitive	0.5	191	0.03%	0.0001%		b	b	a	b
Valves	19	7,758	1%	0.01%		b	b	b	b
Glycol dehydrator	25	9,914	2%	0.01%		c	c	b	n
Loading operation	0.1	51	0.01%	0.00004%		c	d	a	n
Separator	796	321,566	49%	0.23%		c	c	b	b
Mud degassing	8	3,071	0.47%	0.002%		c	d	a	n
Natural gas engines	191	77,000	12%	0.05%					
Natural gas turbines	3	1,399	0.22%	0.001%					
Pneumatic pumps	7	2,682	0.41%	0.002%		c	b	a	b
Pressure/level controllers	2	636	0.10%	0.0005%		c	b	a	b
Storage tanks	7	2,933	0.45%	0.002%		c	c	a	n
VEN exhaust gas	121	48,814	8%	0.03%		c	c	b	n

NOTES: Leak Detection: a – Yes and cost effective; b – Yes but cost burden c - No. Cost effectiveness based on expert judgment.
Direct Measurement: a – Accurate and cost effective; b – Accurate but cost burden; c – Questionable; d – No direct measurement.
Engineering Estimate: a – Exists; b – does not exist.
Accessible Source: y – Yes; n – No; b – Both.

Source: *Greenhouse Gas Emissions Reporting from the Petroleum and Natural Gas Industry: Background Technical Support Document*, Appendix A (USEPA, undated).

U.S. Detailed Inventory of Methane Emissions from Natural Gas Systems

PRODUCTION ONSHORE	Total Emissions Nationally (MMcf/year)	Tonnes CO2e/ Year	% of Sector Emissions	% of total Inventory Emissions	Activity Factors	Leak Detection	Direct Measurement	Engineering Estimate	Accesible Source
Normal Fugitives									
Gas Wells									
Non-associated Gas Wells (less Unconventional)	2,682	1,083,539	2%	0.77%	376784	b	b	b	b
Unconventional Gas Wells	69	27,690	0.06%	0.02%	35440	a	b	b	b
Field Separation Equipment					0				
Heaters	1,463	591,023	1%	0.42%	89720	a	b	b	b
Separators	4,718	1,906,206	4%	1%	247919	b	b	b	b
Dehydrators	1,297	524,154	1%	0.37%	37925	a	b	b	b
Meters/Piping	4,556	1,840,683	4%	1%	315487	b	b	b	b
Gathering Compressors					0				
Small Reciprocating Comp.	2,926	1,182,062	2%	1%	28490	a	a	b	b
Large Reciprocating Comp.	664	268,133	0.54%	0.19%	112	a	a	b	b
Large Reciprocating Stations	45	18,178	0.04%	0.01%	14	a	a	b	b
Pipeline Leaks	8,087	3,267,306	7%	2%	392624	b	b	b	n
Vented and Combusted									
Drilling and Well Completion									
Completion Flaring	0	188	0.00%	0.00%	597	c	c	c	n
Well Drilling	96	38,946	0.08%	0.03%	35600	c	c	a	y
Coal Bed Methane									
Powder River	2,924	1,181,246	2%	1%	396920	c	c	a	n
Black Warrior	543	219,249	0.44%	0.16%		c	c	a	n
Normal Operations									
Pneumatic Device Vents	52,421	21,178,268	43%	15%		c	b	a	b
Chemical Injection Pumps	2,814	1,136,867	2%	0.81%		c	b	a	b
Kimray Pumps	11,572	4,674,913	9%	3%		c	b	a	n
Dehydrator Vents	3,608	1,457,684	3%	1%		c	c	a	n
Condensate Tank Vents									
Condensate Tanks without Control Devices	1,225	494,787	1%	0.35%		c	c	a	b
Condensate Tanks with Control Devices	245	98,957	0.20%	0.07%		c	d	a	b
Compressor Exhaust Vented									
Gas Engines	11,680	4,718,728	9%	3%					
Well Workovers									
Gas Wells	47	18,930	0.04%	0.01%		c	d	b	y
Well Clean Ups (LP Gas Wells)	9,008	3,639,271	7%	3%		c	d	a	n
Blowdowns									
Vessel BD	31	12,563	0.03%	0.01%		c	d	a	n
Pipeline BD	129	52,040	0.10%	0.04%		c	d	a	b
Compressor BD	113	45,648	0.09%	0.03%		c	d	a	n
Compressor Starts	253	102,121	0.20%	0.07%		c	d	a	n
Upsets									
Pressure Relief Valves	29	11,566	0.02%	0.01%		c	d	b	n
Mishaps	70	28,168	0.06%	0.02%		c	d	b	n

Notes: Leak Detection: a – Yes and cost effective; b – Yes but cost burden; c - No. Cost effectiveness based on expert judgment.
Direct Measurement: a – Accurate and cost effective; b – Accurate but cost burden; c – Questionable; d – No direct measurement.
Engineering Estimate: a – Exists; b – does not exist.
Accessible Source: y – Yes; n – No; b – Both.

Source: *Greenhouse Gas Emissions Reporting from the Petroleum and Natural Gas Industry: Background Technical Support Document*, Appendix A (USEPA, undated).

U.S. Detailed Inventory of Methane Emissions from Natural Gas Systems

GAS PROCESSING PLANTS	Total Emissions Nationally (MMcf/year)	Tonnes CO2e/ Year	% of Sector Emissions	% of total Inventory Emissions	Activity Factors	Leak Detection	Direct Measurement	Engineering Estimate	Accesible Source
Normal Fugitives									
Plants	1,634	660,226	5%	0.47%		a	a	b	b
Recip. Compressors	17,351	7,009,755	48%	5%		a	a	b	b
Centrifugal Compressors	5,837	2,358,256	16%	2%		a	a	b	b
Vented and Combusted									
Normal Operations									
Compressor Exhaust									
Gas Engines	6,913	2,792,815	19%	2%					
Gas Turbines	195	78,635	1%	0.06%					
AGR Vents	643	259,592	2%	0.18%		c	c	a	n
Kimray Pumps	177	71,374	0.49%	0.05%		c	b	a	b
Dehydrator Vents	1,088	439,721	3%	0.31%		c	c	a	n
Pneumatic Devices	93	37,687	0.3%	0.03%		c	b	a	b
Routine Maintenance									
Blowdowns/Venting	2,299	928,900	6%	1%		c	d	a	n

Notes:
Leak Detection: a – Yes and cost effective; b – Yes but cost burden; c - No. Cost effectiveness based on expert judgment.
Direct Measurement: a – Accurate and cost effective; b – Accurate but cost burden; c – Questionable; d – No direct measurement.
Engineering Estimate: a – Exists; b – does not exist.
Accessible Source: y – Yes; n – No; b – Both.

Source: *Greenhouse Gas Emissions Reporting from the Petroleum and Natural Gas Industry: Background Technical Support Document*, Appendix A (USEPA, undated).

U.S. Detailed Inventory of Methane Emissions from Natural Gas Systems

TRANSMISSION	Total Emissions Nationally (MMcf/year)	Tonnes CO2e/ Year	% of Sector Emissions	% of total Inventory Emissions	Activity Factors	Leak Detection	Direct Measurement	Engineering Estimate	Accesible Source
Fugitives									
Pipeline Leaks	166	67,238	0.17%	0.05%		a	c	a	n
Compressor Stations (Transmission)									
Station	5,619	2,270,177	6%	2%		a	a	b	b
Recip Compressor	38,918	15,722,907	40%	11%		a	a	b	b
Centrifugal Compressor	7,769	3,138,795	8%	2%		a	a	b	b
M&R (Trans. Co. Interconnect)	3,798	1,534,238	4%	1%		a	a	b	b
M&R (Farm Taps + Direct Sales)	853	344,646	1%	0.25%		b	b	b	b
Vented and Combusted									
Normal Operation									
Dehydrator vents (Transmission)	105	42,329	0.11%	0.03%		c	c	a	n
Compressor Exhaust									
Engines (Transmission)	10,820	4,371,314	11%	3%					
Turbines (Transmission)	61	24,772	0.06%	0.02%					
Generators (Engines)	529	213,911	0.55%	0.15%					
Generators (Turbines)	0	60	0.0002%	0.00004%					
Pneumatic Devices Trans + Stor									
Pneumatic Devices Trans	11,393	4,602,742	12%	3%		c	b	a	b
Routine Maintenance/Upsets									
Pipeline venting	9,287	3,752,013	10%	3%		c	d	a	b
Station venting Trans + Storage									
Station Venting Transmission	7,645	3,088,575	8%	2%		c	d	a	n

Notes: Leak Detection: a – Yes and cost effective; b – Yes but cost burden; c - No. Cost effectiveness based on expert judgment.
Direct Measurement: a – Accurate and cost effective; b – Accurate but cost burden; c – Questionable; d – No direct measurement.
Engineering Estimate: a – Exists; b – does not exist.
Accessible Source: y – Yes; n – No; b – Both.

Source: *Greenhouse Gas Emissions Reporting from the Petroleum and Natural Gas Industry: Background Technical Support Document*, Appendix A (USEPA, undated).

U.S. Detailed Inventory of Methane Emissions from Natural Gas Systems

STORAGE	Total Emissions Nationally (MMcf/year)	Tonnes CO2e/ Year	% of Sector Emissions	% of total Inventory Emissions	Activity Factors	Leak Detection	Direct Measurement	Engineering Estimate	Accesible Source
Fugitives									
Compressor Stations (Storage)									
Station	2,801	1,131,492	16%	1%		a	a	b	b
Recip Compressor	8,093	3,269,454	45%	2%		a	a	b	n
Centrifugal Compressor	1,149	464,354	6%	0.33%		a	a	b	n
Wells (Storage)	695	280,891	4%	0.20%		a	a	b	y
Vented and Combusted									
Normal Operation									
Dehydrator vents (Storage)	217	87,514	1%	0.06%		c	c	a	n
Compressor Exhaust									
Engines (Storage)	1,092	441,108	6%	0.31%					
Turbines (Storage)	9	3,680	0.05%	0.003%					
Pneumatic Devices Trans + Stor									
Pneumatic Devices Storage	2,318	936,324	13%	1%		c	b	a	b
Station venting Trans + Storage									
Station Venting Storage	1,555	628,298	9%	0.45%		c	d	a	n

Notes: Leak Detection: a – Yes and cost effective; b – Yes but cost burden; c - No. Cost effectiveness based on expert judgment.
Direct Measurement: a – Accurate and cost effective; b – Accurate but cost burden; c – Questionable; d – No direct measurement.
Engineering Estimate: a – Exists; b – does not exist.
Accessible Source: y – Yes; n – No; b – Both.

Source: *Greenhouse Gas Emissions Reporting from the Petroleum and Natural Gas Industry: Background Technical Support Document*, Appendix A (USEPA, undated).

U.S. Detailed Inventory of Methane Emissions from Natural Gas Systems

LNG STORAGE	Total Emissions Nationally (MMcf/year)	Tonnes CO2e/ Year	% of Sector Emissions	% of total Inventory Emissions	Activity Factors	Leak Detection	Direct Measurement	Engineering Estimate	Accesible Source
LNG Storage									
LNG Stations	552	222,824	14%	0.16%		b	b	b	b
LNG Reciprocating Compressors	2,084	842,118	54%	1%		b	b	b	b
LNG Centrifugal Compressors	715	288,756	19%	0.21%		b	b	b	b
LNG Compressor Exhaust									
LNG Engines	172	69,632	5%	0.05%					
LNG Turbines	1	261	0.02%	0.0002%					
LNG Station venting	306	123,730	8%	0.09%		c	d	a	n

LNG IMPORT AND EXPORT TERMINALS	Total Emissions Nationally (MMcf/year)	Tonnes CO2e/ Year	% of Sector Emissions	% of total Inventory Emissions	Activity Factors	Leak Detection	Direct Measurement	Engineering Estimate	Accesible Source
LNG Import Terminals									
LNG Stations	22	8,880	3%	0.01%		b	b	b	b
LNG Reciprocating Compressors	105	42,347	14%	0.03%		b	b	a	b
LNG Centrifugal Compressors	27	10,820	4%	0.01%		b	b	a	b
LNG Compressor Exhaust									
LNG Engines	586	236,647	78%	0.17%					
LNG Turbines	3	1,370	0.45%	0.001%					
LNG Station venting	12	4,931	2%	0.004%		c	d	a	n

Notes: Leak Detection: a – Yes and cost effective; b – Yes but cost burden; c - No.
Direct Measurement: a – Accurate and cost effective; b – Accurate but cost burden; c – Questionable; d – No direct measurement.
Engineering Estimate: a – Exists; b – does not exist.
Accessible Source: y – Yes; n – No; b – Both.
Export Terminals are not currently included in the U.S. GHG Inventory, therefore they were not included in this analysis. There is currently only one export terminal, located in Alaska.

Source: *Greenhouse Gas Emissions Reporting from the Petroleum and Natural Gas Industry: Background Technical Support Document*, Appendix A (USEPA, undated).

U.S. Detailed Inventory of Methane Emissions from Natural Gas Systems

DISTRIBUTION	Total Emissions Nationally (MMcf/year)	Tonnes CO2e/ Year	% of Sector Emissions	% of total Inventory Emissions	Activity Factors	Leak Detection	Direct Measurement	Engineering Estimate	Accesible Source
Normal Fugitives									
Pipeline Leaks									
Mains - Cast Iron	9,222	3,725,675	14%	3%		a	b	b	n
Mains - Unprotected steel	6,515	2,632,209	10%	2%		a	b	b	n
Mains - Protected steel	1,422	574,529	2%	0.41%		a	b	b	n
Mains - Plastic	6,871	2,775,759	10%	2%		a	b	b	n
Total Pipeline Miles			36%	7%					
Services - Unprotected steel	7,322	2,957,970	11%	2%		a	b	b	n
Services Protected steel	2,863	1,156,473	4%	1%		a	b	b	n
Services - Plastic	315	127,210	0.47%	0.09%		a	b	b	n
Services - Copper	47	19,076	0.07%	0.01%		a	b	a	n
Total Services			16%	3%					
Meter/Regulator (City Gates)			37%	7%					
M&R >300	5,037	2,034,986	7%	1%	3,198	a	a	b	b
M&R 100-300	10,322	4,170,101	15%	3%	12,325	b	b	b	b
M&R <100	249	100,480	0.37%	0.07%	6,587	a	c	b	b
Reg >300	5,237	2,115,726	8%	2%	3,693	a	a	b	b
R-Vault >300	25	9,976	0.04%	0.01%	2,168	a	a	b	b
Reg 100-300	4,025	1,625,929	6%	1%	11,344	b	b	b	b
R-Vault 100-300	8	3,247	0.01%	0.002%	5,097	a	c	b	b
Reg 40-100	306	123,586	0.45%	0.09%	33,578	b	b	b	b
R-Vault 40-100	23	9,115	0.03%	0.01%	29,776	b	b	b	b
Reg <40	17	6,690	0.02%	0.005%	14,213	b	b	b	b
Customer Meters									
Residential	5,304	2,142,615	8%	2%	37017342	b	b	a	y
Commercial/Industry	203	81,880	0.30%	0.06%	4231191	b	b	a	y
Vented									
Rountine Maintenance									
Pressure Relief Valve Releases	63	25,346	0.09%	0.02%		c	d	b	n
Pipeline Blowdown	122	49,422	0.18%	0.04%		c	d	a	n
Upsets									
Mishaps (Dig-ins)	1,907	770,405	3%	1%		c	d	b	n

NOTES: Leak Detection: a – Yes and cost effective; b – Yes but cost burden; c - No. Cost effectiveness based on expert judgment.
Direct Measurement: a – Accurate and cost effective; b – Accurate but cost burden; c – Questionable; d – No direct measurement.
Engineering Estimate: a – Exists; b – does not exist.
Accessible Source: y – Yes; n – No; b – Both.

Source: *Greenhouse Gas Emissions Reporting from the Petroleum and Natural Gas Industry: Background Technical Support Document*, Appendix A (USEPA, undated).

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Appendix B

Billings Planning Area GHG Emission Inventory

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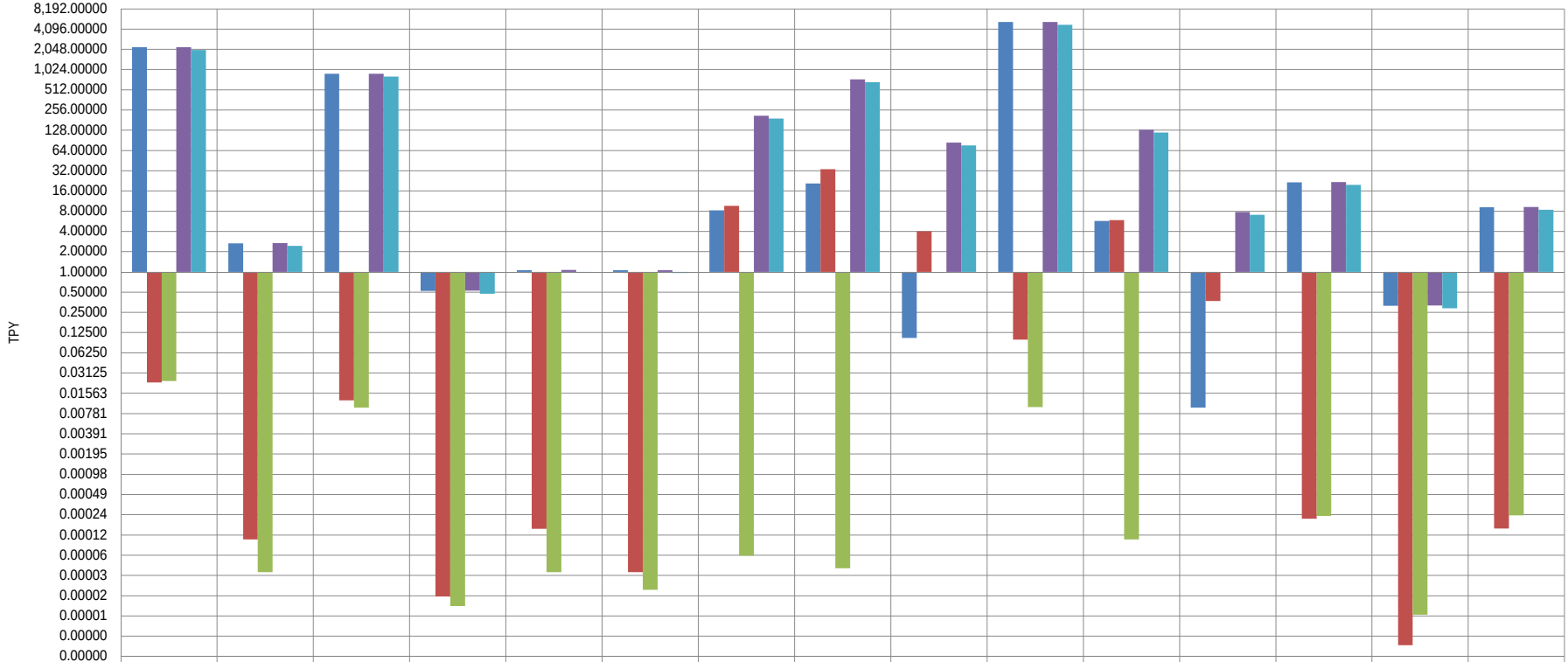
Billings input parameters for calculating oil wells emissions

Maximum Annual Wells Drilled - Federal (RMP estimate)	4	Maximum Annual Wells Drilled - Non-Federal (RMP estimate)	4
Federal Producing Wells - RMP Year 20	84	Non-Federal Producing Wells - RMP Year 20	84
Average Well Barrel Oil Per Day (BOPD)	20	Average Well Barrel Oil Per Day (BOPD)	20

Federal Oil Wells Summaries

Total Annual Emissions from Federal Oil Wells - RMP Year 20

Activity	Annual Emissions (Tons)				
	CO_2	CH_4	N_2O	CO_{2eq}	CO_{2eq} metric tons
Well Pad Construction - Fugitive Dust	---	---	---	---	---
Heavy Equipment Combustive Emissions	2200.40	0.02	0.02	2208.29	2003.89
Commuting Vehicles - Construction	2.67	0.00	0.00	2.68	2.43
Wind Erosion	---	---	---	---	---
Sub-total: Construction	**2,203.07**	**0.02**	**0.02**	**2,210.97**	**2,006.33**
Well Workover Operations - Fugitive Dust	---	---	---	---	---
Well Workover Operations - On-site Exhaust	882.63	0.01	0.01	885.86	803.87
Well Workover Operations - On-road Exhaust	0.52	0.00	0.00	0.52	0.48
Well Visits for Inspection & Repair - Operations	1.06	0.00	0.00	1.07	0.97
Recompletion Traffic	1.06	0.00	0.00	1.06	0.96
Water Tanks & Traffic	8.23	9.60	0.00	209.85	190.43
Oil Tanks & Traffic	20.69	33.85	0.00	731.60	663.89
Venting	0.10	4.00	0.00	84.09	76.31
Compression and Well Pumps	5,198.78	0.10	0.01	5203.88	4722.21
Dehydrators	5.71	5.91	0.00	129.92	117.89
Compression Station Fugitives	0.01	0.37	0.00	7.77	7.05
Sub-total: Operations	**6,118.79**	**53.85**	**0.02**	**7,255.64**	**6,584.07**
Road Maintenance	21.55	0.00	0.00	21.63	19.63
Sub-total: Maintenance	**21.552**	**0.000**	**0.00**	**21.63**	**19.63**
Road Reclamation	0.31	0.00	0.00	0.32	0.29
Well Reclamation	9.20	0.00	0.00	9.27	8.42
Sub-total: Reclamation	**9.5109**	**0.0002**	**0.0002**	**9.5904**	**8.7027**
Total Emissions	**8,352.92**	**53.87**	**0.04**	**9,497.84**	**8,618.73**

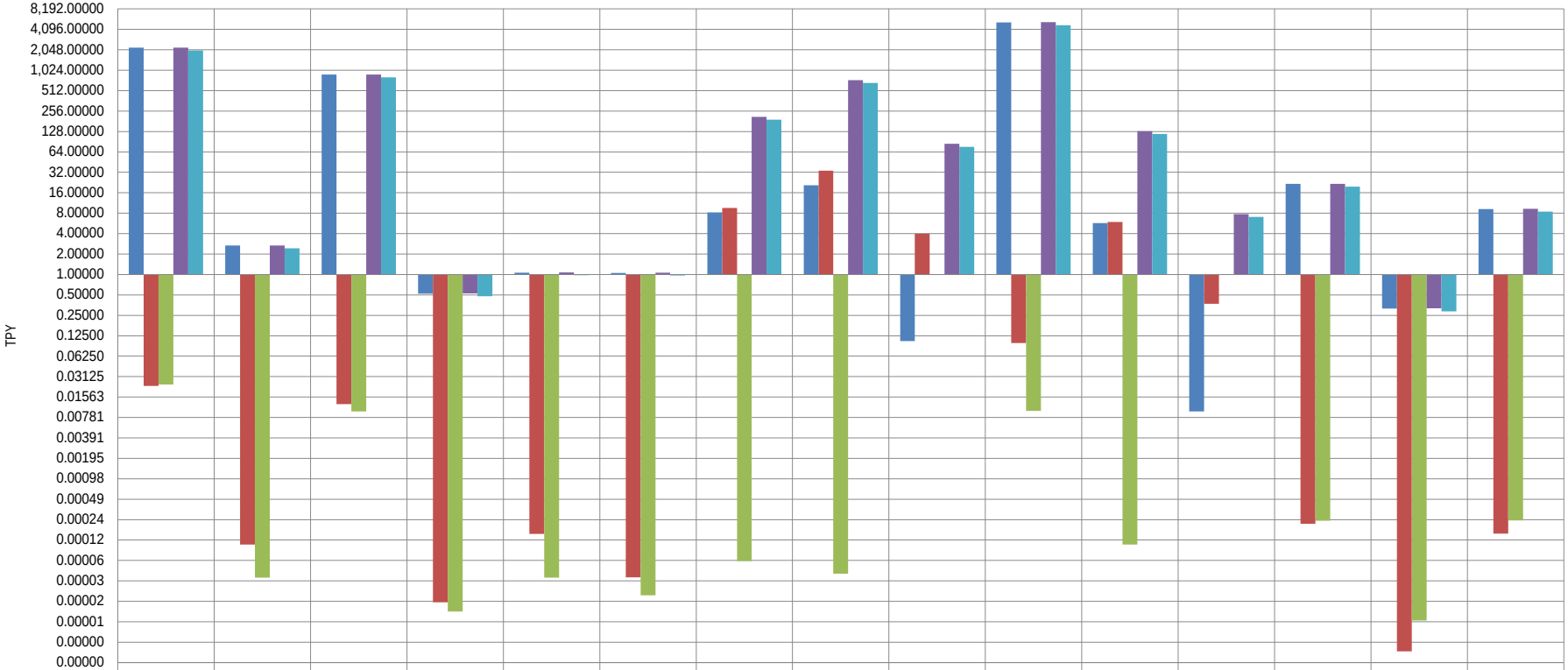


	Heavy Equipment Combustive Emissions	Commuting Vehicles - Construction	Well Workover Operations - On-site Exhaust	Well Workover Operations - On-road Exhaust	Well Visits for Inspection & Repair - Operations	Recompletion Traffic	Water Tanks & Traffic	Oil Tanks & Traffic	Venting	Compression and Well Pumps	Dehydrators	Compression Station Fugitives	Road Maintenance	Road Reclamation	Well Reclamation
CO2	2200.40	2.67	882.63	0.52	1.06	1.06	8.23	20.69	0.10	5,198.78	5.71	0.01	21.55	0.31	9.20
CH4	0.02	0.00	0.01	0.00	0.00	0.00	9.60	33.85	4.00	0.10	5.91	0.37	0.00	0.00	0.00
N2O	0.02	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
CO2eq	2208.29	2.68	885.86	0.52	1.07	1.06	209.85	731.60	84.09	5203.88	129.92	7.77	21.63	0.32	9.27
CO2eq metric tons	2003.89	2.43	803.87	0.48	0.97	0.96	190.43	663.89	76.31	4722.21	117.89	7.05	19.63	0.29	8.42

Non-Federal Oil Wells Summaries

Total Annual Emissions from Non-Federal Oil Wells - RMP Year 20

Activity	Annual Emissions (Tons)				
	CO_2	CH_4	N_2O	CO_{2eq}	CO_{2eq} metric tons
Well Pad Construction - Fugitive Dust	---	---	---	---	---
Heavy Equipment Combustive Emissions	2200.40	0.02	0.02	2208.29	2003.89
Commuting Vehicles - Construction	2.67	0.00	0.00	2.68	2.43
Wind Erosion	---	---	---	---	---
Sub-total: Construction	**2,203.07**	**0.02**	**0.02**	**2,210.97**	**2,006.33**
Well Workover Operations - Fugitive Dust			---	---	---
Well Workover Operations - On-site Exhaust	882.63	0.01	0.01	885.86	803.87
Well Workover Operations - On-road Exhaust	0.52	0.00	0.00	0.52	0.48
Well Visits for Inspection & Repair - Operations	1.06	0.00	0.00	1.07	0.97
Recompletion Traffic	1.06	0.00	0.00	1.06	0.96
Water Tanks & Traffic	8.23	9.60	0.00	209.85	190.43
Oil Tanks & Traffic	20.69	33.85	0.00	731.60	663.89
Venting	0.10	4.00	0.00	84.09	76.31
Compression and Well Pumps	5,198.78	0.10	0.01	5203.88	4722.21
Dehydrators	5.71	5.91	0.00	129.92	117.89
Compression Station Fugitives	0.01	0.37	0.00	7.77	7.05
Sub-total: Operations	**6,118.79**	**53.85**	**0.02**	**7,255.64**	**6,584.07**
Road Maintenance	21.55	0.00	0.00	21.63	19.63
Sub-total: Maintenance	**21.552**	**0.000**	**0.00**	**21.63**	**19.63**
Road Reclamation	0.31	0.00	0.00	0.32	0.29
Well Reclamation	9.20	0.00	0.00	9.27	8.42
Sub-total: Reclamation	**9.5109**	**0.0002**	**0.0002**	**9.5904**	**8.7027**
Total Emissions	**8,352.92**	**53.87**	**0.04**	**9,497.84**	**8,618.73**



	Heavy Equipment Combustive Emissions	Commuting Vehicles - Construction	Well Workover Operations - On-site Exhaust	Well Workover Operations - On-road Exhaust	Well Visits for Inspection & Repair - Operations	Recompletion Traffic	Water Tanks & Traffic	Oil Tanks & Traffic	Venting	Compression and Well Pumps	Dehydrators	Compression Station Fugitives	Road Maintenance	Road Reclamation	Well Reclamation
CO2	2200.40	2.67	882.63	0.52	1.06	1.06	8.23	20.69	0.10	5,198.78	5.71	0.01	21.55	0.31	9.20
CH4	0.02	0.00	0.01	0.00	0.00	0.00	9.60	33.85	4.00	0.10	5.91	0.37	0.00	0.00	0.00
N2O	0.02	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
CO2eq	2208.29	2.68	885.86	0.52	1.07	1.06	209.85	731.60	84.09	5203.88	129.92	7.77	21.63	0.32	9.27
CO2eq metric tons	2003.89	2.43	803.87	0.48	0.97	0.96	190.43	663.89	76.31	4722.21	117.89	7.05	19.63	0.29	8.42

Exhaust Emissions from Well Pad Construction Heavy Equipment and Drilling Equipment

Emission Factors for Construction Equipment

Equipment	Emission Factors (g/hp-hr)			Equipment Category
	CO_2	CH_4	N_2O[a]	
Dozer - 175 Hp	535.76	0.005	0.006	Track-Type Tractor
Blade - 150 Hp	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] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

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 (tons/equipment type/well)		
									CO_2	CH_4	N_2O
Improved & Two-Track Road	Blade	150	1	75	10	2	20	1	1.47E+00	1.87E-05	1.43E-05
Well Pad	Blade	175	1	75	10	3	30	1	2.58E+00	3.28E-05	2.50E-05
	Dozer	175	1	80	10	3	30	1	2.75E+00	3.50E-05	2.67E-05
								Subtotal	**6.81E+00**	**8.64E-05**	**6.61E-05**

Exhaust Emission Factors for Diesel Powered Bore/Drill Rig Engines

Project Year/Hp Category	Emission Factors (g/hp-hr)		
	CO_2	CH_4	N_2O[a]
Year 2018			
50 to 75	589.096	0.006	0.006
75 to 100	589.103	0.006	0.006
100 to 175	530.097	0.005	0.006
175 to 300	530.181	0.004	0.006
300 to 600	530.255	0.004	0.006
600 to 750	530.283	0.004	0.006
>750	529.917	0.006	0.006

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

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

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 (tons/equipment type/well)		
									CO_2	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Main Deck	1,000	3	70	24	16	384	1	4.71E+02	5.02E-03	5.13E-03
	Auxiliary Pump	600	1	80	8	15	120	1	3.37E+01	2.51E-04	3.66E-04
	Generators	150	2	75	24	8	192	1	2.52E+01	2.26E-04	2.75E-04
Well Completion & Testing	Main Deck	600	1	50	11	5	55	1	9.64E+00	7.19E-05	1.05E-04
	Auxiliary Pump	225	1	80	8	2	16	1	1.68E+00	1.37E-05	1.83E-05
	Power Swivel	150	1	75	8	2	16	1	1.05E+00	9.42E-06	1.14E-05
	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	55	1	75	12	3	36	1	9.64E-01	1.05E-05	9.44E-06
								Subtotal	**5.43E+02**	**5.60E-03**	**5.91E-03**
								Total	**5.50E+02**	**5.69E-03**	**5.98E-03**

Exhaust Emissions from Construction and Drilling Support Vehicles

Emission Factors for Commuting Vehicles

Vehicle		Emission Factors (g/mi)		
Type	Class	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	409.5	0.0020	0.0155
Heavy-Duty Diesel Truck	HDDV	791.8	0.0370	0.0058

Source: MOBILE6.2.03

[a] 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).

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 (tons/well)		
	Type	Class					CO_2	CH_4	N_2O
Improved & Two-Track Road	Semi Trucks	HDDV	2	47	94	1	8.20E-02	3.83E-06	5.98E-07
	Pickup Trucks	LDDT	2	3	6	1	2.71E-03	1.32E-08	1.03E-07
Well Pad	Semi Trucks	HDDV	2	5	10	1	8.73E-03	4.08E-07	6.36E-08
	Pickup Trucks	LDDT	2	4	8	1	3.61E-03	1.76E-08	1.37E-07
Other Construction Activities	Semi Trucks	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Haul Trucks	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Pickup Trucks	LDDT	2	1	2	1	9.03E-04	4.41E-09	3.42E-08
						Subtotal	**1.05E-01**	**4.60E-06**	**9.86E-07**

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 (tons/well)		
	Type	Class					CO_2	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Semi Rig Transport, Drill Rig	HDDV	2	44	88	1	7.68E-02	3.59E-06	5.60E-07
	Fuel Haul Truck	HDDV	2	6	12	1	1.05E-02	4.89E-07	7.63E-08
	Mud Haul Truck, Water Hauling	HDDV	2	4	8	1	6.98E-03	3.26E-07	5.09E-08
	Rig Crew	LDDT	2	51	102	1	4.60E-02	2.25E-07	1.74E-06
	Rig Mechanics	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Co. Supervisor	LDDT	2	20	40	1	1.81E-02	8.82E-08	6.83E-07
	Tool Pusher	LDDT	2	8	16	1	7.22E-03	3.53E-08	2.73E-07
	Mud Logger	LDDT	2	6	12	1	5.42E-03	2.65E-08	2.05E-07
	Mud Engineer	LDDT	2	15	30	1	1.35E-02	6.61E-08	5.13E-07
	Logger, Engr Truck	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Drill Bit Delivery	LDDT	2	2	4	1	1.81E-03	8.82E-09	6.83E-08

Combustive Emissions Estimation Road Traffic (cont.)

Construction Site Destination	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells	Emissions (tons/well)		
	Type	Class					CO_2	CH_4	N_2O
Well Completion & Testing	Semi Casing Haulers	HDDV	2	6	12	1	1.05E-02	4.89E-07	7.63E-08
	Semi Completion, Unit Rig	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Semi Fracing, Blender	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Semi Pumping/Tank Battery	HDDV	2	6	12	1	1.05E-02	4.89E-07	7.63E-08
	Tubing Truck	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Haul Cementer, Pump Truck	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Haul Cementer, Cement	HDDV	2	3	6	1	5.24E-03	2.45E-07	3.82E-08
	Haul Completion, Equip	HDDV	2	3	6	1	5.24E-03	2.45E-07	3.82E-08
	Haul Service Tools	LDDT	2	2	4	1	1.81E-03	8.82E-09	6.83E-08
	Haul Perforators Logging Truck	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Anchor, Installation	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Anchor, Testing	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Tank	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Pump	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Chemical	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Sand	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Other	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Welders	HDDV	2	6	12	1	1.05E-02	4.89E-07	7.63E-08
	Haul Water Truck	HDDV	2	150	300	1	2.62E-01	1.22E-05	1.91E-06
	Pickup Cementer, Engineer	LDDT	2	2	4	1	1.81E-03	8.82E-09	6.83E-08
	Pickup Casing Crew	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Pickup Completion Crew	HDDV	2	5	10	1	8.73E-03	4.08E-07	6.36E-08
	Pickup Completion,	LDDT	2	5	10	1	4.51E-03	2.20E-08	1.71E-07
	Pickup Perforators, Engineer	LDDT	2	2	4	1	1.81E-03	8.82E-09	6.83E-08
	Pickup Fracing, Engineer	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Pickup Co. Supervisor	LDDT	2	10	20	1	9.03E-03	4.41E-08	3.42E-07
	Pickup Miscellaneous Supplies	LDDT	2	3	6	1	2.71E-03	1.32E-08	1.03E-07
	Pickup Roustabout Crew	HDDV	2	4	8	1	6.98E-03	3.26E-07	5.09E-08
						Subtotal	**5.62E-01**	**2.15E-05**	**7.57E-06**
					Total		**6.67E-01**	**2.61E-05**	**8.56E-06**

Exhaust Emissions from Well Work Overs

Emission Factors Bore/Drill Rig Engines 300-600 Hp

Fuel Type	Emission Factors (gm/hp-hr)		
	CO_2	CH_4	N_2O[a]
Diesel	529.5755	0.0074	0.0058

Source: EPA NONROADS 2008a. Year 2008.

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

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 (tons/year/well)		
							CO_2	CH_4	N_2O
Well Workover	Truck-Mounted Unit	600	10	3	30	1	1.05E+01	1.46E-04	1.14E-04

Exhaust emission factors for commuting vehicles

Vehicle		Emission Factors (g/mi)		
Type	Class	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	409.5	0.0020	0.0155
Heavy-Duty Diesel Truck	HDDV	791.8	0.0370	0.0058

Source: MOBILE 6.2.03

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

[a] 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

Activity	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells Drilled	Max. Annual Emissions (tons/year/well)		
	Type	Class					CO_2	CH_4	N_2O
Well Workover	WO Rig	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Truck	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Pickup Truck	LDDT	2	3	6	1	2.71E-03	1.32E-08	1.03E-07
						Total	**6.20E-03**	**1.76E-07**	**1.28E-07**

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).

Round trip distance = 2 based on data found in the SEIS

Exhaust Emissions from Site Visits and Inspections

Emission factors for Commuting Vehicles Exhaust

Vehicle Class	Emission Factors (g/mi)		
	CO_2	CH_4	N_2O[a]
Light-Duty Gasoline Truck	476.9	0.0680	0.0154

Source: MOBILE 6.2.03

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

[a] 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)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Federal Wells Producing	Emissions (tons/yr/well)		
	Type	Class					CO_2	CH_4	N_2O
Inspection Visits for Wells	Pickup Truck	LDGT2	2	12	24	1	1.26E-02	1.80E-06	4.07E-07

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 year

[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
Cumulative Length of Roads [b] (miles/operation)	1

[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	**1**	**5**

Emission Factors for Construction Equipment Exhaust

Equipment	Emission Factors (g/hp-hr)		
	CO_2	CH_4	N_2O[a]
Grader 100-175 Hp	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] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

Emission Estimations for Grader: RMP Year 20

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours[a]	Emissions (tons/well)		
				CO_2	CH_4	N_2O
Road Maintenance	Grader	135	3	2.55E-01	2.52E-06	2.75E-06

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

Emission Factors for Commuting Vehicles Exhaust

Vehicle Class	Emission Factors (g/mi)		
	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	409.5	0.002	0.016

Source: MOBILE 6.2.03

[a] 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 (tons/yr)		
	Type	Class				CO_2	CH_4	N_2O
Road Maintenance	Pickup Truck	LDGT2	6	0.5	3	1.44E-03	7.05E-09	5.47E-08

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)	CH_4 Emissions (ton/yr/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 Work Over Vehicles - Road Traffic

Vehicle Class	Emission Factors (g/mi)		
	CO_2	CH_4	N_2O[a]
Heavy-Duty Diesel Truck (HDDV)	791.8	0.037	0.006

Source: MOBILE6.2.03

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

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 (tons/yr/well)		
	Type	Class					CO_2	CH_4	N_2O
Produced Water Hauling	Haul Truck (130 bbl)	HDDV	2	56	112	1	9.80E-02	4.58E-06	7.14E-07

Oil Tank, Loadout and Hauling Emissions

Oil Well Oil Seperator Flashing and Tank Emissions[a]

Project Year	Emissions[b]			
	HAPs Emissions (ton/yr/well)	VOC Emissions (ton/yr/well)	CO_2 Emissions (ton/yr/well)	CH_4 Emissions (ton/yr/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 no 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 ($lb/10^3$ gal) 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)
All	2.35	7,300	307	3.61E-01	6.47E-04	1.05E-07

[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)		
	CO_2	CH_4	N_2O[a]
Heavy-Duty Diesel Truck (HDDV)	791.8	0.037	0.006

Source: MOBILE6.2.03

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

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 (tons/year/well)		
	Type	Class					CO_2	CH_4	N_2O
Produced Oil Hauling	Haul Truck (200 bbl)	HDDV	2	37	73	1	6.37E-02	2.98E-06	4.64E-07
						TOTAL	**6.37E-02**	**2.98E-06**	**4.64E-07**

W&S Composition for Truck Load Out Emissions

W&S Gas Component	Mole Fraction[a] (%)	Molecular Weight (lb/lb-mol)	Gas Weight (lb/lb-mol)	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-HAP	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)

Exhaust Emissions from Recompletion Support Vehicles

Emission Factors for Commuting Vehicles

Vehicle		Emission Factors (g/mi)		
Type	Class	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	409.5	0.002	0.016
Heavy-Duty Diesel Truck	HDDV	791.8	0.04	0.006

Source: MOBILE6.2.03

[a] 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).

Combustive Emissions Estimation Road Traffic - Based on Peak Wells Drilled each Alternative

Construction Site Destination	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well/Year	Miles Traveled/ Well/Year	Total # of Wells	Emissions (tons/well)		
	Type	Class					CO_2	CH_4	N_2O
Well Recompletion	Fuel Haul Truck	HDDV	2	6	12	1	1.05E-02	4.89E-07	7.63E-08
	Mud Haul Truck, Water Hauling	HDDV	2	4	8	1	6.98E-03	3.26E-07	5.09E-08
	Rig Crew	LDDT	2	51	102	1	4.60E-02	2.25E-07	1.74E-06
	Rig Mechanics	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Co. Supervisor	LDDT	2	20	40	1	1.81E-02	8.82E-08	6.83E-07
	Semi Completion, Unit Rig	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Semi Fracing, Blender	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Semi Pumping/Tank Battery	HDDV	2	6	12	1	1.05E-02	4.89E-07	7.63E-08
	Tubing Truck	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Haul Cementer, Pump Truck	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Haul Cementer, Cement Truck	HDDV	2	3	6	1	5.24E-03	2.45E-07	3.82E-08
	Haul Completion, Equip Truck	HDDV	2	3	6	1	5.24E-03	2.45E-07	3.82E-08
	Haul Service Tools	LDDT	2	2	4	1	1.81E-03	8.82E-09	6.83E-08
	Haul Perforators Logging Truck	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Tank	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Pump	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Chemical	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Sand	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Other	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Water Truck	HDDV	2	50	100	1	8.73E-02	4.08E-06	6.36E-07
	Pickup Cementer, Engineer	LDDT	2	2	4	1	1.81E-03	8.82E-09	6.83E-08
	Pickup Completion Crew	HDDV	2	5	10	1	8.73E-03	4.08E-07	6.36E-08
	Pickup Completion, Pusher	LDDT	2	5	10	1	4.51E-03	2.20E-08	1.71E-07
	Pickup Perforators, Engineer	LDDT	2	2	4	1	1.81E-03	8.82E-09	6.83E-08

	Pickup Fracing, Engineer	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Pickup Co. Supervisor	LDDT	2	10	20	1	9.03E-03	4.41E-08	3.42E-07
	Pickup Miscellaneous Supplies	LDDT	2	3	6	1	2.71E-03	1.32E-08	1.03E-07
	Pickup Roustabout Crew	HDDV	2	4	8	1	6.98E-03	3.26E-07	5.09E-08
					Subtotal		**2.52E-01**	**8.17E-06**	**4.45E-06**
					Total		**2.52E-01**	**8.17E-06**	**4.45E-06**

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

Gas Component	Mole Fraction (%)	Molecular Weight (lb/lb-mol)	Gas Weight (lb/lb-mol)	Weight Percent (wt%)	Weight (lb/MMscf))	Emissions Mass Flow (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**

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

Gas Component	Mole Fraction (%)	Molecular Weight (lb/lb-mol)	Gas Weight (lb/lb-mol)	Weight Percent (wt%)	Weight (lb/MMscf))	Emissions Mass Flow (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).

Compressor Stations Emissions

Emission Factors for Natural Gas-Fired Compressors and Pumps

Compressor / Pump		Horse-Power Rating	Units	Emission Factors		
				CO_2[a]	CH_4[a]	N_2O[a]
Compression Station	Lean Burn	300	gm/bhp-hr	134.94	2.55E-03	2.55E-04
			lb/MMBTU	116.89	2.20E-03	2.20E-04
Oil Pump at Well Head	Lean Burn	40	gm/bhp-hr	134.94	2.55E-03	2.55E-04
			lb/MMBTU	116.89	2.20E-03	2.20E-04

Note: Compressors assumed to be equipped with nonselective catalytic reduction (NSCR) catalyst.

[a] 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 (tons/year/well)		
					CO_2	CH_4	N_2O
Compression Station	7.5	1.00	7.5	8,760	9.77E+00	1.84E-04	1.84E-05
Oil Pump at Well Head	40	1.00	40	8,760	5.21E+01	9.83E-04	9.83E-05
				Total	**6.19E+01**	**1.17E-03**	**1.17E-04**

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

TOC Emission Factor								
Well Equipment Component	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

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	1.74E-03	5.90E-04	1.92E-05	7.39E-04
pump seals	0.000	0.0053	0	0.0287	0	0.0001	0.00E+00	0.00E+00	0.00E+00	0.00E+00
others	0.000	0.0194	0	0.0165	0	0.0309	0.00E+00	0.00E+00	0.00E+00	0.00E+00
connectors	0.250	0.0004	0	0.0005	0	0.0002	1.10E-04	3.74E-05	1.22E-06	4.69E-05
flanges	0.600	0.0009	0	0.0002	0	0.0000	5.16E-04	1.75E-04	5.70E-06	2.19E-04
open-ended lines	0.000	0.0044	0	0.0031	0	0.0006	0.00E+00	0.00E+00	0.00E+00	0.00E+00
					TOTAL emissions/well/hr =		2.36E-03	8.02E-04	2.61E-05	1.00E-03

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 (ton/yr)**	**CO_2 emissions (lb/yr)**	**CO_2 emissions (ton/yr)**	**CH_4 emissions (lb/yr)**	**CH_4 emissions (ton/yr)**
Year 20	1	8760	7.03E+00	3.51E-03	2.29E-01	1.14E-04	8.80E+00	4.40E-03

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	0.274
Annual Miles of Roads reclaimed Per Well	0.068
Number of wells reclaimed (per well)	0.274

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
0.07	6	0.0	0
		Total	**0**

Assume average miles/day = 6

Emission Factors for 75-100 hp Off-Road Engines

Year	Emission Factors (g/hp-hr)		
	CO_2	CH_4	N_2O[a]
2008	600.507	0.010	0.016
2018	613.888	0.006	0.016
2027	608.641	0.003	0.016

[a] 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).

Exhaust Emissions Estimation for Grader Road Reclaim

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours[a]	Emissions (tons/year/well)		
				CO_2	CH_4	N_2O
Road Reclamation	Grader	80	0.1	3.71E-03	3.33E-08	9.36E-08

Exhaust Emission Factors for Commuting Reclaim Vehicles Road Traffic

Vehicle Class	Emission Factors (g/mi)		
	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	409.5	0.002	0.016

Source: MOBILE6.2.03

[a] 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).

Exhaust Emissions Estimation for Commuting Reclaim Vehicles: Road Traffic

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tons/year/well)		
	Type	Class				CO_2	CH_4	N_2O
Road Reclamation	Pickup Truck	LDDV	6	0.01	0.07	3.09E-05	1.51E-10	1.17E-09

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	0.274	10	0.274	2.738

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

Exhaust Emissions Estimation for Grader: Well Reclamation

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours [a]	Emissions (tons/year/well)		
				CO_2	CH_4	N_2O
Well Reclamation	Grader	100	1.6	1.09E-01	1.81E-06	2.81E-06

Exhaust Emissions Estimation for Commuting Vehicles: Well Reclamation

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tons/year/well)		
	Type	Class				CO_2	CH_4	N_2O
Well Reclamation	Pickup Truck	LDDV	6	0.3	1.6	7.42E-04	3.62E-09	2.81E-08

Emissions for Gas Dehydration

Emission Factors for Dehydrator Heaters

Unit	CO_2	CH_4	N_2O
lb/MMSCF	120000	2.3	2.2
lb/MMBTU	117.647	0.002	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 (tons/year/well)		
				CO_2	CH_4	N_2O
2,190	1	2.20	0.001	6.79E-02	1.30E-06	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 per MMscf)	CH_4 Emissions (TPY/well)	VOC Emission Factor (ton per MMscf)	VOC Emissions (TPY/well)
6.57	1.07E-02	7.04E-02	1.60E-02	1.05E-01

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 South Baker 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 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	

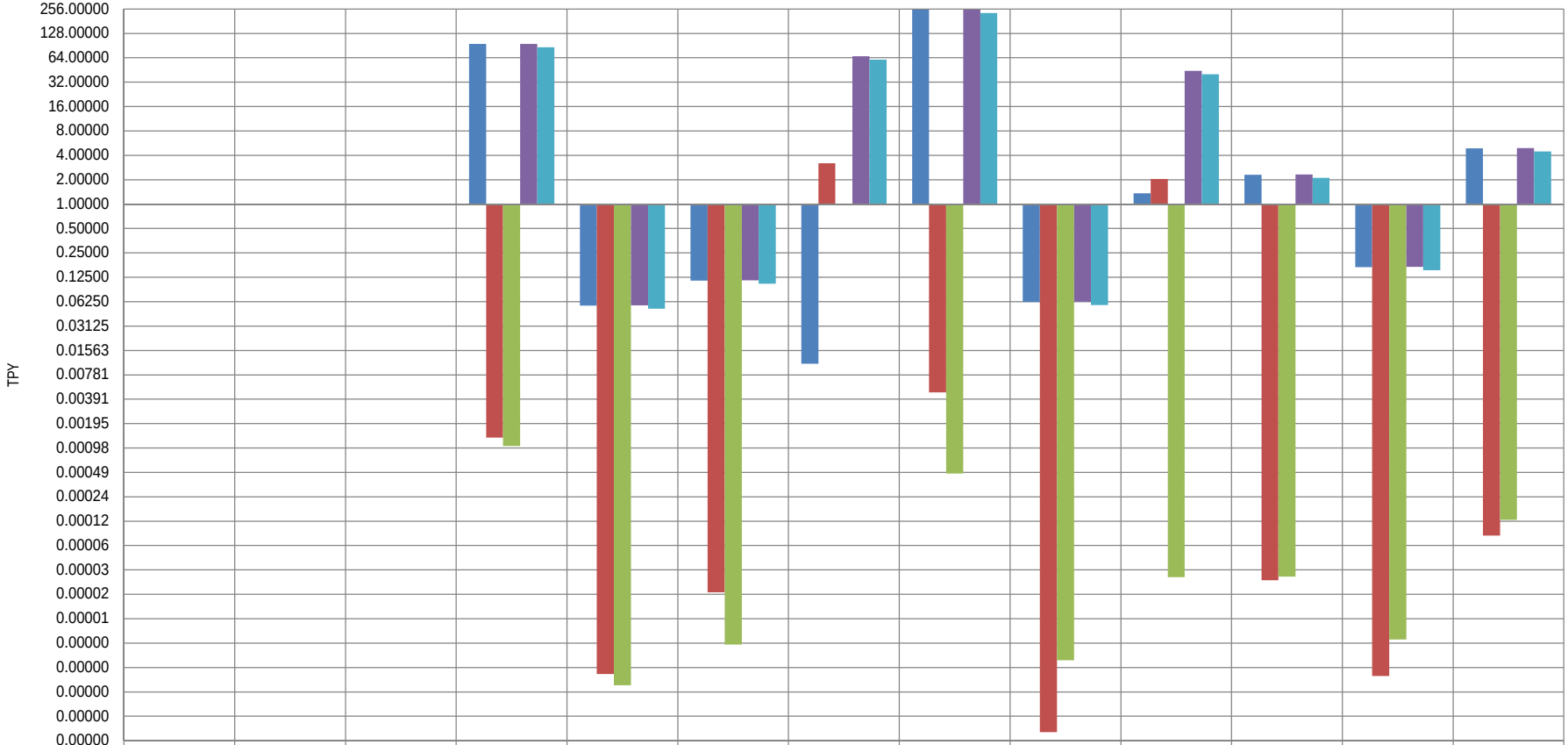
Billings input parameters for calculating NG wells GHG emissions

Maximum Annual Wells Drilled - Federal (RMP estimate)	0	Maximum Annual Wells Drilled - Non-Federal (RMP estimate)	2
Federal Producing Wells - RMP Year 20	9	Non-Federal Producing Wells - RMP Year 20	69
Average Gas Production Per Well (MCFD)	40	Average Gas Production Per Well (MCFD)	40

Federal NG Wells Summaries

Total Annual Emissions from Federal NG Wells - RMP Year 20

Activity	Annual Emissions (Tons)				
	CO_2	CH_4	N_2O	CO_{2eq}	CO_{2eq} metric tons
Well Pad Construction - Fugitive Dust	---	---	---	---	---
Heavy Equipment Combustive Emissions	0.00	0.00	0.00	0.00	0.00
Commuting Vehicles - Construction	0.00	0.00	0.00	0.00	0.00
Wind Erosion	---	---	---	---	---
Completion Venting	0.00	0.00	0.00	0.00	0.00
Sub-total: Construction	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Well Workover Operations - Fugitive Dust	---	---	---	---	---
Well Workover Operations - On-site Exhaust	94.57	0.00	0.00	94.91	86.13
Well Workover Operations - On-road Exhaust	0.06	0.00	0.00	0.06	0.05
Well Visits for Inspection & Repair - Operations	0.11	0.00	0.00	0.12	0.10
Wellhead and Compressor Station Fugitives	0.01	3.18	0.00	66.87	60.68
Compression	251.03	0.00	0.00	251.28	228.02
Station Visits - Operations	0.06	0.00	0.00	0.06	0.06
Dehydrators	1.36	2.04	0.00	44.22	40.13
Sub-total: Operations	**347.20**	**5.23**	**0.00**	**457.52**	**415.17**
Road Maintenance	2.31	0.00	0.00	2.32	2.10
Sub-total: Maintenance	**2.309**	**0.000**	**0.00**	**2.32**	**2.10**
Road Reclamation	0.17	0.00	0.00	0.17	0.15
Well Reclamation	4.89	0.00	0.00	4.93	4.48
Sub-total: Reclamation	**5.0576**	**0.0001**	**0.0001**	**5.0999**	**4.6279**
Total Emissions	**354.57**	**5.23**	**0.00**	**464.93**	**421.90**

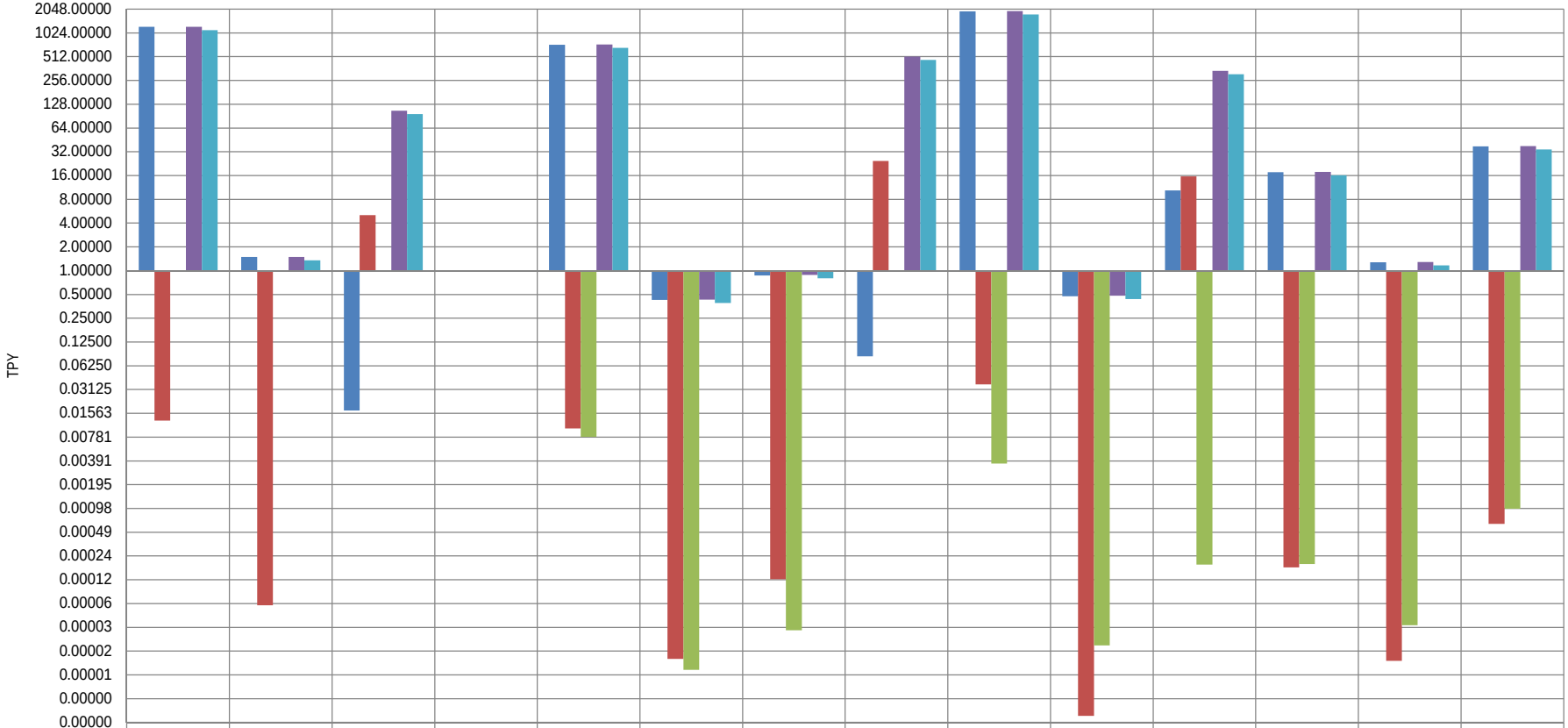


	Heavy Equipment Combustive Emissions	Commuting Vehicles - Construction	Completion Venting	Well Workover Operations - On-site Exhaust	Well Workover Operations - On-road Exhaust	Well Visits for Inspection & Repair - Operations	Wellhead and Compressor Station Fugitives	Compression	Station Visits - Operations	Dehydrators	Road Maintenance	Road Reclamation	Well Reclamation
CO2	0.00	0.00	0.00	94.57	0.06	0.11	0.01	251.03	0.06	1.36	2.31	0.17	4.89
CH4	0.00	0.00	0.00	0.00	0.00	0.00	3.18	0.00	0.00	2.04	0.00	0.00	0.00
N2O	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
CO2eq	0.00	0.00	0.00	94.91	0.06	0.12	66.87	251.28	0.06	44.22	2.32	0.17	4.93
CO2eq metric tons	0.00	0.00	0.00	86.13	0.05	0.10	60.68	228.02	0.06	40.13	2.10	0.15	4.48

Non-Federal NG Wells Summaries

Total Annual Emissions from Non-Federal NG Wells - RMP Year 20

Activity	Annual Emissions (Tons)				
	CO_2	CH_4	N_2O	CO_{2eq}	CO_{2eq} metric tons
Well Pad Construction - Fugitive Dust	---	---	---	---	---
Heavy Equipment Combustive Emissions	1226.72	0.01	0.00	1226.99	1113.42
Commuting Vehicles - Construction	1.49	0.00	0.00	1.49	1.35
Wind Erosion	---	---	---	---	---
Completion Venting	0.02	5.06	0.00	106.20	96.37
Sub-total: Construction	**1,228.23**	**5.07**	**0.00**	**1,334.67**	**1,211.14**
Well Workover Operations - Fugitive Dust			---	---	---
Well Workover Operations - On-site Exhaust	725.01	0.01	0.01	727.67	660.32
Well Workover Operations - On-road Exhaust	0.43	0.00	0.00	0.43	0.39
Well Visits for Inspection & Repair - Operations	0.87	0.00	0.00	0.88	0.80
Wellhead and Compressor Station Fugitives	0.08	24.41	0.00	512.64	465.19
Compression	1,924.58	0.04	0.00	1,926.47	1748.16
Station Visits - Operations	0.48	0.00	0.00	0.48	0.44
Dehydrators	10.41	15.65	0.00	339.04	307.66
Sub-total: Operations	**2,661.87**	**40.10**	**0.01**	**3,507.63**	**3,182.96**
Road Maintenance	17.70	0.00	0.00	17.77	16.12
Sub-total: Maintenance	**17.704**	**0.000**	**0.00**	**17.77**	**16.12**
Road Reclamation	1.28	0.00	0.00	1.29	1.17
Well Reclamation	37.50	0.00	0.00	37.81	34.31
Sub-total: Reclamation	**38.7750**	**0.0006**	**0.0010**	**39.0994**	**35.4804**
Total Emissions	**3,946.57**	**45.17**	**0.01**	**4,899.17**	**4,445.70**



	Heavy Equipment Combustive Emissions	Commuting Vehicles - Construction	Completion Venting	Well Workover Operations - Fugitive Dust	Well Workover Operations - On-site Exhaust	Well Workover Operations - On-road Exhaust	Well Visits for Inspection & Repair - Operations	Wellhead and Compressor Station Fugitives	Compression	Station Visits - Operations	Dehydrators	Road Maintenance	Road Reclamation	Well Reclamation
CO2	1226.72	1.49	0.02		725.01	0.43	0.87	0.08	1,924.58	0.48	10.41	17.70	1.28	37.50
CH4	0.01	0.00	5.06		0.01	0.00	0.00	24.41	0.04	0.00	15.65	0.00	0.00	0.00
N2O	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CO2eq	1226.99	1.49	106.20	0.00	727.67	0.43	0.88	512.64	1,926.47	0.48	339.04	17.77	1.29	37.81
CO2eq metric tons	1113.42	1.35	96.37	0.00	660.32	0.39	0.80	465.19	1748.16	0.44	307.66	16.12	1.17	34.31

Exhaust Emissions from Well Pad Construction Heavy Equipment and Drilling Equipment

Emission Factors for Construction Equipment

Equipment	Emission Factors (g/hp-hr)			Equipment Category
	CO_2	CH_4	N_2O[a]	
Dozer - 175 Hp	535.76	0.005	0.006	Track-Type Tractor
Blade - 150 Hp	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] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

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 (tons/equipment type/well)		
									CO_2	CH_4	N_2O
Improved & Two-Track Road	Blade	150	1	75	10	2	20	1	1.47E+00	1.87E-05	1.43E-05
Well Pad	Blade	175	1	75	10	3	30	1	2.58E+00	3.28E-05	2.50E-05
	Dozer	175	1	80	10	3	30	1	2.75E+00	3.50E-05	2.67E-05
								Subtotal	**6.81E+00**	**8.64E-05**	**6.61E-05**

Exhaust Emission Factors for Diesel Powered Bore/Drill Rig Engines

Project Year/Hp Category	Emission Factors (g/hp-hr)		
	CO_2	CH_4	N_2O[a]
Year 2018			
50 to 75	589.096	0.006	0.006
75 to 100	589.103	0.006	0.006
100 to 175	530.097	0.005	0.006
175 to 300	530.181	0.004	0.006
300 to 600	530.255	0.004	0.006
600 to 750	530.283	0.004	0.006
>750	529.917	0.006	0.006

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

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

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 (tons/equipment type/well)		
									CO_2	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Main Deck	1,000	3	70	24	16	384	1	4.71E+02	5.02E-03	5.13E-03
	Auxiliary Pump	600	1	80	8	15	120	1	3.37E+01	2.51E-04	3.66E-04
	Generators	150	2	75	24	8	192	1	2.52E+01	2.26E-04	2.75E-04
Well Completion & Testing	Main Deck	600	1	50	11	5	55	1	9.64E+00	7.19E-05	1.05E-04
	Auxiliary Pump	225	1	80	8	2	16	1	1.68E+00	1.37E-05	1.83E-05
	Power Swivel	150	1	75	8	2	16	1	1.05E+00	9.42E-06	1.14E-05
	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 &	55	1	75	12	3	36	1	9.64E-01	1.05E-05	9.44E-06
								Subtotal	**5.43E+02**	**5.60E-03**	**5.91E-03**
								Total	**5.50E+02**	**5.69E-03**	**5.98E-03**

Exhaust Emissions from Construction and Drilling Support Vehicles

Emission Factors for Commuting Vehicles

Vehicle		Emission Factors (g/mi)		
Type	Class	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	409.500	0.002	0.016
Heavy-Duty Diesel Truck	HDDV	791.800	0.037	0.006

Source: MOBILE6.2.03

[a] 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).

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 (tons/well)		
	Type	Class					CO_2	CH_4	N_2O
Improved & Two-Track Road	Semi Trucks	HDDV	2	47	94	1	8.20E-02	3.83E-06	5.98E-07
	Pickup Trucks	LDDT	2	3	6	1	2.71E-03	1.32E-08	1.03E-07
Well Pad	Semi Trucks	HDDV	2	5	10	1	8.73E-03	4.08E-07	6.36E-08
	Pickup Trucks	LDDT	2	4	8	1	3.61E-03	1.76E-08	1.37E-07
Other Construction Activities	Semi Trucks	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Haul Trucks	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Pickup Trucks	LDDT	2	1	2	1	9.03E-04	4.41E-09	3.42E-08
						Subtotal	**1.05E-01**	**4.60E-06**	**9.86E-07**

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 (tons/well)		
	Type	Class					CO_2	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Semi Rig Transport, Drill Rig	HDDV	2	44	88	1	7.68E-02	3.59E-06	5.60E-07
	Fuel Haul Truck	HDDV	2	6	12	1	1.05E-02	4.89E-07	7.63E-08
	Mud Haul Truck, Water Hauling	HDDV	2	4	8	1	6.98E-03	3.26E-07	5.09E-08
	Rig Crew	LDDT	2	51	102	1	4.60E-02	2.25E-07	1.74E-06
	Rig Mechanics	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Co. Supervisor	LDDT	2	20	40	1	1.81E-02	8.82E-08	6.83E-07
	Tool Pusher	LDDT	2	8	16	1	7.22E-03	3.53E-08	2.73E-07
	Mud Logger	LDDT	2	6	12	1	5.42E-03	2.65E-08	2.05E-07
	Mud Engineer	LDDT	2	15	30	1	1.35E-02	6.61E-08	5.13E-07
	Logger, Engr Truck	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Drill Bit Delivery	LDDT	2	2	4	1	1.81E-03	8.82E-09	6.83E-08

Combustive Emissions Estimation Road Traffic (cont.)

Construction Site Destination	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells	Emissions (tons/well)		
	Type	Class					CO_2	CH_4	N_2O
Well Completion & Testing	Semi Casing Haulers	HDDV	2	6	12	1	1.05E-02	4.89E-07	7.63E-08
	Semi Completion, Unit Rig	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Semi Fracing, Blender	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Semi Pumping/Tank Battery	HDDV	2	6	12	1	1.05E-02	4.89E-07	7.63E-08
	Tubing Truck	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Haul Cementer, Pump Truck	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Haul Cementer, Cement	HDDV	2	3	6	1	5.24E-03	2.45E-07	3.82E-08
	Haul Completion, Equip	HDDV	2	3	6	1	5.24E-03	2.45E-07	3.82E-08
	Haul Service Tools	LDDT	2	2	4	1	1.81E-03	8.82E-09	6.83E-08
	Haul Perforators Logging Truck	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Anchor, Installation	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Anchor, Testing	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Tank	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Pump	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Chemical	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Sand	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Other	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Welders	HDDV	2	6	12	1	1.05E-02	4.89E-07	7.63E-08
	Haul Water Truck	HDDV	2	150	300	1	2.62E-01	1.22E-05	1.91E-06
	Pickup Cementer, Engineer	LDDT	2	2	4	1	1.81E-03	8.82E-09	6.83E-08
	Pickup Casing Crew	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Pickup Completion Crew	HDDV	2	5	10	1	8.73E-03	4.08E-07	6.36E-08
	Pickup Completion,	LDDT	2	5	10	1	4.51E-03	2.20E-08	1.71E-07
	Pickup Perforators, Engineer	LDDT	2	2	4	1	1.81E-03	8.82E-09	6.83E-08
	Pickup Fracing, Engineer	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Pickup Co. Supervisor	LDDT	2	10	20	1	9.03E-03	4.41E-08	3.42E-07
	Pickup Miscellaneous Supplies	LDDT	2	3	6	1	2.71E-03	1.32E-08	1.03E-07
	Pickup Roustabout Crew	HDDV	2	4	8	1	6.98E-03	3.26E-07	5.09E-08
						Subtotal	**5.62E-01**	**2.15E-05**	**7.57E-06**
						Total	**6.67E-01**	**2.61E-05**	**8.56E-06**

Exhaust Emissions from Well Work Overs

Emission Factors Bore/Drill Rig Engines 300-600 Hp

Fuel Type	Emission Factors (gm/hp-hr)		
	CO_2	CH_4	N_2O[a]
Diesel	529.58	0.007	0.006

Source: EPA NONROADS 2008a. Year 2008.

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

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 (tons/year/well)		
							CO_2	CH_4	N_2O
Well Workover	Truck-Mounted	600	10	3	30	1	1.05E+01	1.46E-04	1.14E-04

Exhaust emission factors for commuting vehicles

Vehicle		Emission		
Type	Class	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	409.500	0.002	0.016
Heavy-Duty Diesel Truck	HDDV	791.800	0.037	0.006

Source: MOBILE 6.2.03

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

[a] 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

Activity	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells Drilled	Max. Annual Emissions (tons/year/well)		
	Type	Class					CO_2	CH_4	N_2O
Well Workover	WO Rig	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Truck	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Pickup Truck	LDDT	2	3	6	1	2.71E-03	1.32E-08	1.03E-07
						Total	**6.20E-03**	**1.76E-07**	**1.28E-07**

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).

Round trip distance = 2 based on data found in the SEIS

Exhaust Emissions from Site Visits and Inspections

Emission factors for Commuting Vehicles Exhaust

Vehicle Class	Emission Factors		
	CO_2	CH_4	N_2O[a]
Light-Duty Gasoline Truck	476.90	0.07	0.02

Source: MOBILE 6.2.03

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

[a] 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)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Federal Wells Producing	Emissions (tons/yr/well)		
	Type	Class					CO_2	CH_4	N_2O
Inspection Visits for Wells	Pickup Truck	LDGT2	2	12	24	1	1.26E-02	1.80E-06	4.07E-07

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 year

[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
Cumulative Length of Roads [b] (miles/operation)	1

[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/operatio	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		**1**	**5**

Emission Factors for Construction Equipment Exhaust

Equipment	Emission Factors (g/hp-hr)		
	CO_2	CH_4	N_2O[a]
Grader 100-175 Hp	535.770	0.005	0.006

Source: EPA NONROADS 2008a

Use emission factors for 2008 for all project years - conservative estimate of vehicle turnover

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

Emission Estimations for Grader: RMP Year 20

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours[a]	Emissions (tons/well)		
				CO_2	CH_4	N_2O
Road Maintenance	Grader	135	3	2.55E-01	2.52E-06	2.75E-06

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

Emission Factors for Commuting Vehicles Exhaust

Vehicle Class	Emission Factors (g/mi)		
	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	409.500	0.002	0.016

Source: MOBILE 6.2.03

[a] 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 (tons/yr)		
	Type	Class				CO_2	CH_4	N_2O
Road Maintenance	Pickup Truck	LDGT2	6	0.5	3	1.444E-03	7.055E-09	5.467E-08

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	1.359
Annual Miles of Roads reclaimed Per Well	0.340
Number of wells reclaimed (per well)	1.359

Reclaimation 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
0.34	6	0.1	1
		Total	**1**

Assume average miles/day = 6

Emission Factors for 75-100 hp Off-Road Engines

Year	Emission Factors (g/hp-hr)		
	CO_2	CH_4	N_2O[a]
2008	600.507	0.010	0.016
2018	613.888	0.006	0.016
2027	608.641	0.003	0.016

[a] Emissions of $PM_{2.5}$ were assumed to be the same as those for PM_{10}.

[a] 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).

Exhaust Emissions Estimation for Grader Road Reclaim

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours[a]	Emissions (tons/year/well)		
				CO_2	CH_4	N_2O
Road Reclamation	Grader	80	0.3	1.84E-02	1.65E-07	4.64E-07

Exhaust Emission Factors for Commuting Reclaim Vehicles Road Traffic

Vehicle Class	Emission Factors (g/mi)		
	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	409.5	0.002	0.016

Source: MOBILE6.2.03

[a] 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).

Exhaust Emissions Estimation for Commuting Reclaim Vehicles: Road Traffic

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tons/year/well)		
	Type	Class				CO_2	CH_4	N_2O
Road Reclamation	Pickup Truck	LDDV	6	0.06	0	1.53E-04	7.49E-10	5.80E-09

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	1.3590	10	1.3590	13.5897

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

Exhaust Emissions Estimation for Grader: Well Reclamation

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours[a]	Emissions (tons/year/well)		
				CO_2	CH_4	N_2O
Well Reclamation	Grader	100	8	5.40E-01	8.99E-06	1.39E-05

Exhaust Emissions Estimation for Commuting Vehicles: Well Reclamation

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tons/year/well)		
	Type	Class				CO_2	CH_4	N_2O
Well Reclamation	Pickup Truck	LDDV	6	1	8	3.68E-03	1.80E-08	1.39E-07

Emission Factors for Dehydrator Heaters

Unit	CO_2	CH_4	N_2O
lb/MMSCF	120000.0	2.3	2.2
lb/MMBTU	117.647	0.002	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 (tons/year/well)		
				CO_2	CH_4	N_2O
2,190	1	2.20	0.001	1.51E-01	2.89E-06	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)
14.60	1.55E-02	2.27E-01	2.13E-05	3.11E-04

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 South Baker 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 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

Wellhead Fugitives

Fugitive Emissions from Equipment Leaks

TOC Emission Factor								
Well Equipment Component	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% =	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	7.50E-02	5.12E-04	2.25E-04	6.67E-02
pump seals	0	0.0053	0	0.0287	0	0.0001	0.00E+00	0.00E+00	0.00E+00	0.00E+00
others	0	0.0194	0	0.0165	0	0.0309	0.00E+00	0.00E+00	0.00E+00	0.00E+00
connectors	24	0.0004	0	0.0005	0	0.0002	1.06E-02	7.22E-05	3.17E-05	9.42E-03
flanges	2	0.0009	0	0.0002	0	0.0000	1.72E-03	1.17E-05	5.15E-06	1.53E-03
open-ended lines	0	0.0044	0	0.0031	0	0.0006	0.00E+00	0.00E+00	0.00E+00	0.00E+00
					TOTAL emissions/well/hr =		8.73E-02	5.96E-04	2.61E-04	7.77E-02

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 (ton/yr)**	**CO_2 emissions (lb/yr)**	**CO_2 emissions (ton/yr)**	**CH_4 emissions (lb/yr)**	**CH_4 emissions (ton/yr)**
Year 20	1	8760	5.22E+00	2.61E-03	2.29E+00	1.14E-03	6.80E+02	3.40E-01

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

Gas Component	Mole Fraction (%)	Molecular Weight (lb/lb-mol)	Gas Weight (lb/lb-mol)	Weight Percent (wt%)	Weight (lb/MMscf))	Emissions Mass Flow (ton/well)
Methane	93.716	16.040	15.032	88.998	37788.643	2.267
Ethane	1.624	30.070	0.488	2.891	1227.616	0.074
Nitrogen	4.297	28.020	1.204	7.128	3026.751	0.182
Water	0.000	18.015	0.000	0.000	0.000	0.000
Carbon Dioxide	0.115	43.990	0.051	0.300	127.173	0.008
Nitrous Oxide	0.000	44.020	0.000	0.000	0.000	0.000
Hydrogen Sulfide	0.000	34.067	0.000	0.000	0.000	0.000
Non-reactive, non-HAP	99.752	---	16.775	99.317		2.530
Propane	0.211	44.100	0.093	0.551	233.918	0.014
Iso-butane	0.019	58.120	0.011	0.065	27.760	0.002
n-butane	0.015	58.120	0.009	0.052	21.916	0.001
i-pentane	0.002	72.150	0.001	0.009	3.628	0.000
n-pentane	0.001	72.150	0.001	0.004	1.814	0.000
Hexanes	0.000	86.180	0.000	0.000	0.000	0.000
Heptanes	0.000	100.200	0.000	0.002	0.781	0.000
Octanes	0.000	114.230	0.000	0.000	0.000	0.000
Nonanes	0.000	128.26	0.000	0.000	0.000	0.000
Decanes+	0.000	142.29	0.000	0.000	0.000	0.000
Reactive VOC	0.248	---	0.115	0.683		0.017
Benzene	0.000	78.110	0.000	0.000	0.000	0.000
Ethylbenzene	0.000	106.167	0.000	0.000	0.000	0.000
n-Hexane [3]	*0.000*	*100.210*	*0.000*	*0.000*	*0.000*	*0.000*
Toluene	0.000	92.140	0.000	0.000	0.000	0.000
Xylenes	0.000	106.160	0.000	0.000	0.000	0.000
HAPs	0.000	---	0.000	0.000		0.000
Totals	**100.000**	**---**	**16.890**	**100.000**		**2.548**

Sample taken 03-09-2010 at Baker South 7 W 0429 (Miles City)

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

Compressor Station Emissions

Emission Factors for Natural Gas-Fired Compressors

Compressor		Horse-Power Rating	Units	Emission Factors		
				CO_2[a]	CH_4[a]	N_2O[a]
Field Compression Station	Rich Burn	300	gm/bhp-hr	134.9	2.55E-03	2.55E-04
			lb/MMBTU	116.9	2.20E-03	2.20E-04
Sales Compression Station	Rich Burn	1,680	gm/bhp-hr	134.9	2.55E-03	2.55E-04
			lb/MMBTU	116.9	2.20E-03	2.20E-04

Note: Compressors assumed to be equipped with nonselective catalytic reduction (NSCR) catalyst.

[a] 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 (tons/year/well)		
					CO_2	CH_4	N_2O
Field Compression Station	11	1	11	8,760	1.44E+01	2.72E-04	2.72E-05
Sales Compression Station	10	1	10	8,760	1.35E+01	2.54E-04	2.54E-05
				Total	**2.79E+01**	**5.26E-04**	**5.26E-05**

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

TOC Emission Factor								
Well Equipment Component	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% =	0.68
CO2 Wt% =	0.30
CH4 Wt% =	89.00
N2O Wt% =	0.00

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	0.258	0.0099	0	0.0055	0	0.0002	2.56E-03	1.75E-05	7.68E-06	2.28E-03
pump seals	0.000	0.0053	0	0.0287	0	0.0001	0.00E+00	0.00E+00	0.00E+00	0.00E+00
others	0.000	0.0194	0	0.0165	0	0.0309	0.00E+00	0.00E+00	0.00E+00	0.00E+00
connectors	0.369	0.0004	0	0.0005	0	0.0002	1.63E-04	1.11E-06	4.87E-07	1.45E-04
flanges	0.886	0.0009	0	0.0002	0	0.0000	7.62E-04	5.20E-06	2.28E-06	6.78E-04
open-ended lines	0.000	0.0044	0	0.0031	0	0.0006	0.00E+00	0.00E+00	0.00E+00	0.00E+00
					TOTAL emissions/well/hr =		3.49E-03	2.38E-05	1.04E-05	3.10E-03

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 (ton/yr)**	**CO_2 emissions (lb/yr)**	**CO_2 emissions (ton/yr)**	**CH_4 emissions (lb/yr)**	**CH_4 emissions (ton/yr)**
Year 20	1	8760	2.09E-01	1.04E-04	9.15E-02	4.58E-05	2.72E+01	1.36E-02

Compressor Station Inspection Traffic Exhaust Emissions

Emission factors for Commuting Vehicles Exhaust

Vehicle		Emission Factors (g/mi)		
Type	Class	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	409.5	0.002	0.016

Source: MOBILE6.2.03

[a] 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).

Exhaust Emissions Estimation for Road Traffic

Activity	Compressor Station	Vehicle		# of Compressor Stations / Well	# of Inspection Visits/ Station	# of Inspection Visits/Well/Year	Total Miles/ Inspection	Emissions (tons/year/well)		
		Type	Class					CO_2	CH_4	N_2O
Inspection Visits for Compressor Stations	CPF Compressor Station	Pickup Truck	LDGT2	0.04	12	0.4	20	4.00E-03	1.95E-08	1.51E-07
	Primary Compressor Station	Pickup Truck	LDGT2	0.01	52	0.3	20	2.89E-03	1.41E-08	1.09E-07
							Total	**6.89E-03**	**3.36E-08**	**2.61E-07**

Appendix C

Butte Planning Area GHG Emission Inventory

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Butte input parameters for calculating oil wells emissions

Maximum Annual Wells Drilled - Federal (RMP estimate)	0.0	Maximum Annual Wells Drilled - Non-Federal (RMP estimate)	3.0
Federal Producing Wells - RMP Year 20	0.0	Non-Federal Producing Wells - RMP Year 20	3.0
Average Well Barrel Oil Per Day (BOPD)	20.0	Average Well Barrel Oil Per Day (BOPD)	20.0

Federal Oil Wells Summaries

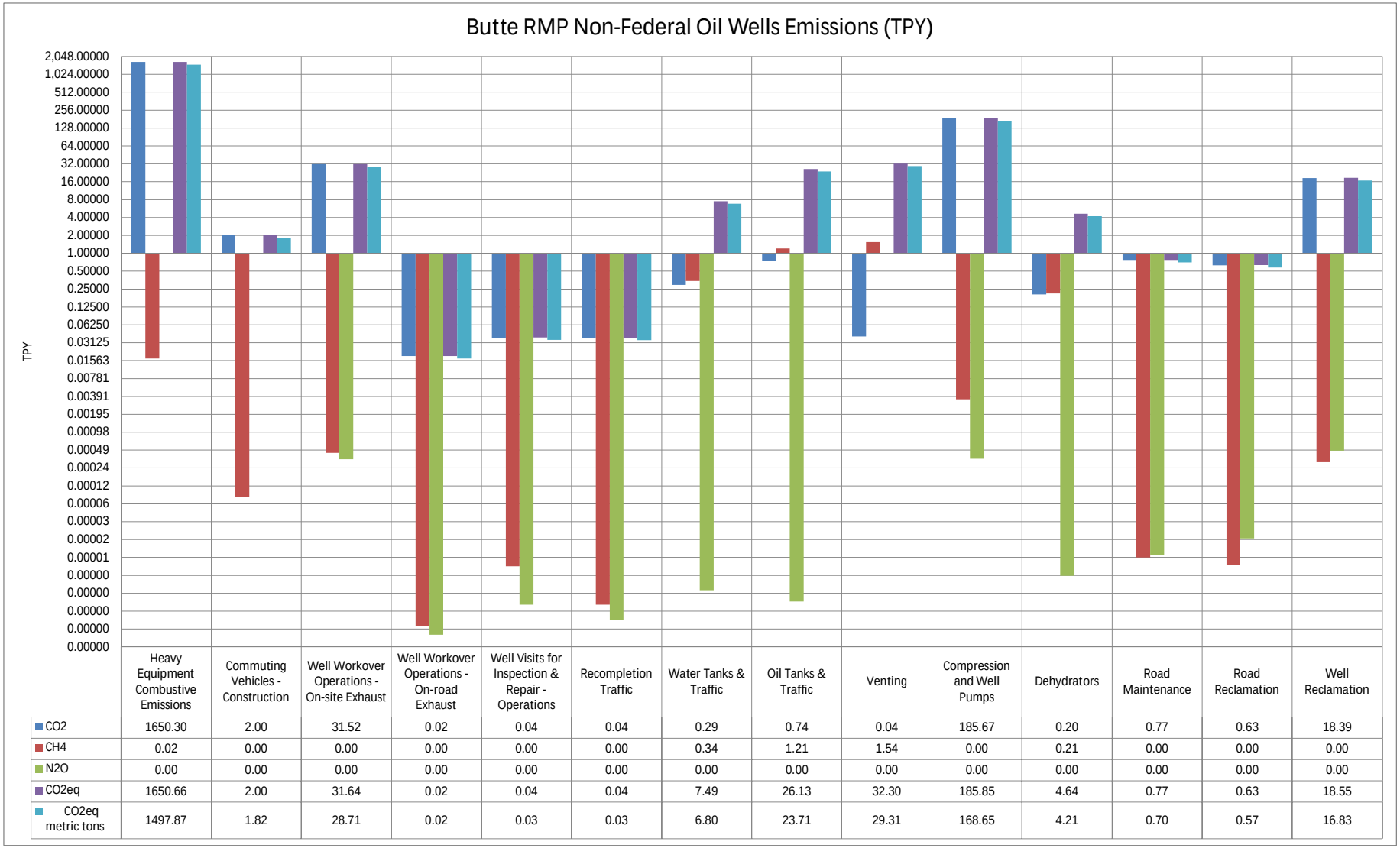
Total Annual Emissions from Federal Oil Wells - RMP Year 20

Activity	Annual Emissions (Tons)				
	CO_2	CH_4	N_2O	CO_{2eq}	CO_{2eq} metric tons
Well Pad Construction - Fugitive Dust	---	---	---	---	---
Heavy Equipment Combustive Emissions	0.00	0.00	0.00	0.00	0.00
Commuting Vehicles - Construction	0.00	0.00	0.00	0.00	0.00
Wind Erosion	---	---	---	---	---
Sub-total: Construction	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Well Workover Operations - Fugitive Dust	---	---	---	---	---
Well Workover Operations - On-site Exhaust	0.00	0.00	0.00	0.00	0.00
Well Workover Operations - On-road Exhaust	0.00	0.00	0.00	0.00	0.00
Well Visits for Inspection & Repair - Operations	0.00	0.00	0.00	0.00	0.00
Recompletion Traffic	0.00	0.00	0.00	0.00	0.00
Water Tanks & Traffic	0.00	0.00	0.00	0.00	0.00
Oil Tanks & Traffic	0.00	0.00	0.00	0.00	0.00
Venting	0.00	0.00	0.00	0.00	0.00
Compression and Well Pumps	0.00	0.00	0.00	0.00	0.00
Dehydrators	0.00	0.00	0.00	0.00	0.00
Compression Station Fugitives	0.00	0.00	0.00	0.00	0.00
Sub-total: Operations	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Road Maintenance	0.00	0.00	0.00	0.00	0.00
Sub-total: Maintenance	**0.000**	**0.000**	**0.00**	**0.00**	**0.00**
Road Reclamation	0.00	0.00	0.00	0.00	0.00
Well Reclamation	0.00	0.00	0.00	0.00	0.00
Sub-total: Reclamation	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**
Total Emissions	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

Non-Federal Oil Wells Summaries

Total Annual Emissions from Non-Federal Oil Wells - RMP Year 20

Activity	Annual Emissions (Tons) CO_2	CH_4	N_2O	CO_{2eq}	CO_{2eq} metric tons
Well Pad Construction - Fugitive Dust	---	---	---	---	---
Heavy Equipment Combustive Emissions	1650.30	0.02	0.00	1650.66	1497.87
Commuting Vehicles - Construction	2.00	0.00	0.00	2.00	1.82
Wind Erosion	---	---	---	---	---
Sub-total: Construction	**1,652.30**	**0.02**	**0.00**	**1,652.66**	**1,499.69**
Well Workover Operations - Fugitive Dust	---	---	---	---	---
Well Workover Operations - On-site Exhaust	31.52	0.00	0.00	31.64	28.71
Well Workover Operations - On-road Exhaust	0.02	0.00	0.00	0.02	0.02
Well Visits for Inspection & Repair - Operations	0.04	0.00	0.00	0.04	0.03
Recompletion Traffic	0.04	0.00	0.00	0.04	0.03
Water Tanks & Traffic	0.29	0.34	0.00	7.49	6.80
Oil Tanks & Traffic	0.74	1.21	0.00	26.13	23.71
Venting	0.04	1.54	0.00	32.30	29.31
Compression and Well Pumps	185.67	0.00	0.00	185.85	168.65
Dehydrators	0.20	0.21	0.00	4.64	4.21
Compression Station Fugitives	0.00	0.01	0.00	0.28	0.25
Sub-total: Operations	**218.56**	**3.32**	**0.00**	**288.43**	**261.73**
Road Maintenance	0.77	0.00	0.00	0.77	0.70
Sub-total: Maintenance	**0.770**	**0.000**	**0.00**	**0.77**	**0.70**
Road Reclamation	0.63	0.00	0.00	0.63	0.57
Well Reclamation	18.39	0.00	0.00	18.55	16.83
Sub-total: Reclamation	**19.0217**	**0.0003**	**0.0005**	**19.1808**	**17.4055**
Total Emissions	**1,890.66**	**3.33**	**0.00**	**1,961.04**	**1,779.53**



	Heavy Equipment Combustive Emissions	Commuting Vehicles - Construction	Well Workover Operations - On-site Exhaust	Well Workover Operations - On-road Exhaust	Well Visits for Inspection & Repair - Operations	Recompletion Traffic	Water Tanks & Traffic	Oil Tanks & Traffic	Venting	Compression and Well Pumps	Dehydrators	Road Maintenance	Road Reclamation	Well Reclamation
CO2	1650.30	2.00	31.52	0.02	0.04	0.04	0.29	0.74	0.04	185.67	0.20	0.77	0.63	18.39
CH4	0.02	0.00	0.00	0.00	0.00	0.00	0.34	1.21	1.54	0.00	0.21	0.00	0.00	0.00
N2O	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
CO2eq	1650.66	2.00	31.64	0.02	0.04	0.04	7.49	26.13	32.30	185.85	4.64	0.77	0.63	18.55
CO2eq metric tons	1497.87	1.82	28.71	0.02	0.03	0.03	6.80	23.71	29.31	168.65	4.21	0.70	0.57	16.83

Exhaust Emissions from Well Pad Construction Heavy Equipment and Drilling Equipment

Emission Factors for Construction Equipment

Equipment	Emission Factors (g/hp-hr)			Equipment Category
	CO_2	CH_4	N_2O[a]	
Dozer - 175 Hp	535.760	0.005	0.006	Track-Type Tractor
Blade - 150 Hp	594.650	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] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

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 (tons/equipment type/well)		
									CO_2	CH_4	N_2O
Improved & Two-Track Road	Blade	150	1	75	10	2	20	1	1.47E+00	1.87E-05	1.43E-05
Well Pad	Blade	175	1	75	10	3	30	1	2.58E+00	3.28E-05	2.50E-05
	Dozer	175	1	80	10	3	30	1	2.75E+00	3.50E-05	2.67E-05
								Subtotal	**6.81E+00**	**8.64E-05**	**6.61E-05**

Exhaust Emission Factors for Diesel Powered Bore/Drill Rig Engines

Project Year/Hp Category	Emission Factors (g/hp-hr)		
	CO_2	CH_4	N_2O[a]
Year 2018			
50 to 75	589.096	0.006	0.006
75 to 100	589.103	0.006	0.006
100 to 175	530.097	0.005	0.006
175 to 300	530.181	0.004	0.006
300 to 600	530.255	0.004	0.006
600 to 750	530.283	0.004	0.006
>750	529.917	0.006	0.006

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

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

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 (tons/equipment type/well)		
									CO_2	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Main Deck	1,000	3	70	24	16	384	1	4.71E+02	5.02E-03	5.13E-03
	Auxiliary Pump	600	1	80	8	15	120	1	3.37E+01	2.51E-04	3.66E-04
	Generators	150	2	75	24	8	192	1	2.52E+01	2.26E-04	2.75E-04
Well Completion & Testing	Main Deck	600	1	50	11	5	55	1	9.64E+00	7.19E-05	1.05E-04
	Auxiliary Pump	225	1	80	8	2	16	1	1.68E+00	1.37E-05	1.83E-05
	Power Swivel	150	1	75	8	2	16	1	1.05E+00	9.42E-06	1.14E-05
	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	9.64E-01	1.05E-05	9.44E-06
								Subtotal	**5.43E+02**	**5.60E-03**	**5.91E-03**
								Total	**5.50E+02**	**5.69E-03**	**5.98E-03**

Exhaust Emissions from Construction and Drilling Support Vehicles

Emission Factors for Commuting Vehicles

Vehicle		Emission Factors (g/mi)		
Type	Class	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	409.5	0.002	0.016
Heavy-Duty Diesel Truck	HDDV	791.8	0.04	0.006

Source: MOBILE6.2.03

[a] 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).

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 (tons/well)		
	Type	Class					CO_2	CH_4	N_2O
Improved & Two-Track Road	Semi Trucks	HDDV	2	47	94	1	8.20E-02	3.83E-06	5.98E-07
	Pickup Trucks	LDDT	2	3	6	1	2.71E-03	1.32E-08	1.03E-07
Well Pad	Semi Trucks	HDDV	2	5	10	1	8.73E-03	4.08E-07	6.36E-08
	Pickup Trucks	LDDT	2	4	8	1	3.61E-03	1.76E-08	1.37E-07
Other Construction Activities	Semi Trucks	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Haul Trucks	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Pickup Trucks	LDDT	2	1	2	1	9.03E-04	4.41E-09	3.42E-08
						Subtotal	**1.05E-01**	**4.60E-06**	**9.86E-07**

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 (tons/well)		
	Type	Class					CO_2	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Semi Rig Transport, Drill Rig	HDDV	2	44	88	1	7.68E-02	3.59E-06	5.60E-07
	Fuel Haul Truck	HDDV	2	6	12	1	1.05E-02	4.89E-07	7.63E-08
	Mud Haul Truck, Water Hauling	HDDV	2	4	8	1	6.98E-03	3.26E-07	5.09E-08
	Rig Crew	LDDT	2	51	102	1	4.60E-02	2.25E-07	1.74E-06
	Rig Mechanics	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Co. Supervisor	LDDT	2	20	40	1	1.81E-02	8.82E-08	6.83E-07
	Tool Pusher	LDDT	2	8	16	1	7.22E-03	3.53E-08	2.73E-07
	Mud Logger	LDDT	2	6	12	1	5.42E-03	2.65E-08	2.05E-07
	Mud Engineer	LDDT	2	15	30	1	1.35E-02	6.61E-08	5.13E-07
	Logger, Engr Truck	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Drill Bit Delivery	LDDT	2	2	4	1	1.81E-03	8.82E-09	6.83E-08

Combustive Emissions Estimation Road Traffic (cont.)

Construction Site Destination	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells	Emissions (tons/well)		
	Type	Class					CO_2	CH_4	N_2O
Well Completion & Testing	Semi Casing Haulers	HDDV	2	6	12	1	1.05E-02	4.89E-07	7.63E-08
	Semi Completion, Unit Rig	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Semi Fracing, Blender	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Semi Pumping/Tank Battery	HDDV	2	6	12	1	1.05E-02	4.89E-07	7.63E-08
	Tubing Truck	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Haul Cementer, Pump Truck	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Haul Cementer, Cement	HDDV	2	3	6	1	5.24E-03	2.45E-07	3.82E-08
	Haul Completion, Equip	HDDV	2	3	6	1	5.24E-03	2.45E-07	3.82E-08
	Haul Service Tools	LDDT	2	2	4	1	1.81E-03	8.82E-09	6.83E-08
	Haul Perforators Logging Truck	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Anchor, Installation	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Anchor, Testing	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Tank	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Pump	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Chemical	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Sand	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Other	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Welders	HDDV	2	6	12	1	1.05E-02	4.89E-07	7.63E-08
	Haul Water Truck	HDDV	2	150	300	1	2.62E-01	1.22E-05	1.91E-06
	Pickup Cementer, Engineer	LDDT	2	2	4	1	1.81E-03	8.82E-09	6.83E-08
	Pickup Casing Crew	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Pickup Completion Crew	HDDV	2	5	10	1	8.73E-03	4.08E-07	6.36E-08
	Pickup Completion,	LDDT	2	5	10	1	4.51E-03	2.20E-08	1.71E-07
	Pickup Perforators, Engineer	LDDT	2	2	4	1	1.81E-03	8.82E-09	6.83E-08
	Pickup Fracing, Engineer	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Pickup Co. Supervisor	LDDT	2	10	20	1	9.03E-03	4.41E-08	3.42E-07
	Pickup Miscellaneous Supplies	LDDT	2	3	6	1	2.71E-03	1.32E-08	1.03E-07
	Pickup Roustabout Crew	HDDV	2	4	8	1	6.98E-03	3.26E-07	5.09E-08
						Subtotal	**5.62E-01**	**2.15E-05**	**7.57E-06**
						Total	**6.67E-01**	**2.61E-05**	**8.56E-06**

Exhaust Emissions from Well Work Overs

Emission Factors Bore/Drill Rig Engines 300-600 Hp

Fuel Type	Emission Factors		
	CO_2	CH_4	N_2O[a]
Diesel	529.575	0.007	0.006

Source: EPA NONROADS 2008a. Year 2008.

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

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 (tons/year/well)		
							CO_2	CH_4	N_2O
Well Workover	Truck-Mounted Unit	600	10	3	30	1	1.05E+01	1.46E-04	1.14E-04

Exhaust emission factors for commuting vehicles

Vehicle		Emission Factors (g/mi)		
Type	Class	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	409.5	0.002	0.016
Heavy-Duty Diesel Truck	HDDV	791.8	0.04	0.006

Source: MOBILE 6.2.03

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

[a] 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

Activity	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells Drilled	Max. Annual Emissions (tons/year/well)		
	Type	Class					CO_2	CH_4	N_2O
Well Workover	WO Rig	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Truck	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Pickup Truck	LDDT	2	3	6	1	2.71E-03	1.32E-08	1.03E-07
						Total	**6.20E-03**	**1.76E-07**	**1.28E-07**

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).

Round trip distance = 2 based on data found in the SEIS

Exhaust Emissions from Site Visits and Inspections

Emission factors for Commuting Vehicles Exhaust

Vehicle Class	Emission Factors (g/mi)		
	CO_2	CH_4	N_2O[a]
Light-Duty Gasoline Truck	476.9	0.07	0.02

Source: MOBILE 6.2.03

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

[a] 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)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Federal Wells Producing	Emissions (tons/yr/well)		
	Type	Class					CO_2	CH_4	N_2O
Inspection Visits for Wells	Pickup Truck	LDGT2	2	12	24	1	1.26E-02	1.80E-06	4.07E-07

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 year

[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
Cumulative Length of Roads [b] (miles/operation)	1

[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	**1**	**5**

Emission Factors for Construction Equipment Exhaust

Equipment	Emission Factors (g/hp-hr)		
	CO_2	CH_4	N_2O[a]
Grader 100-175 Hp	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] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

Emission Estimations for Grader: RMP Year 20

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours[a]	Emissions (tons/well)		
				CO_2	CH_4	N_2O
Road Maintenance	Grader	135	3	2.55E-01	2.52E-06	2.75E-06

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

Emission Factors for Commuting Vehicles Exhaust

Vehicle Class	Emission Factors (g/mi)		
	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	409.5	0.002	0.016

Source: MOBILE 6.2.03

[a] 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 (tons/yr)		
	Type	Class				CO_2	CH_4	N_2O
Road Maintenance	Pickup Truck	LDGT2	6	0.5	3	1.44E-03	7.05E-09	5.47E-08

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)	CH_4 Emissions (ton/yr/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 Work Over Vehicles - Road Traffic

Vehicle Class	Emission Factors (g/mi)		
	CO_2	CH_4	N_2O[a]
Heavy-Duty Diesel Truck (HDDV)	791.8	0.04	0.006

Source: MOBILE6.2.03

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

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 (tons/yr/well)		
	Type	Class					CO_2	CH_4	N_2O
Produced Water Hauling	Haul Truck (130 bbl)	HDDV	2	56	112	1	9.80E-02	4.58E-06	7.14E-07

Oil Tank, Loadout and Hauling Emissions

Oil Well Oil Seperator Flashing and Tank Emissions[a]

Project Year	Emissions[b]			
	HAPs Emissions (ton/yr/well)	VOC Emissions (ton/yr/well)	CO_2 Emissions (ton/yr/well)	CH_4 Emissions (ton/yr/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 no 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 ($lb/10^3$ gal) 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)
All	2.35	7,300	307	3.61E-01	6.47E-04	1.05E-07

[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)		
	CO_2	CH_4	N_2O[a]
Heavy-Duty Diesel Truck (HDDV)	791.8	0.037	0.006

Source: MOBILE6.2.03

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-1

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 (tons/year/well)		
	Type	Class					CO_2	CH_4	N_2O
Produced Oil Hauling	Haul Truck (200 bbl)	HDDV	2	37	73	1	6.37E-02	2.98E-06	4.64E-07
						TOTAL	**6.37E-02**	**2.98E-06**	**4.64E-07**

W&S Composition for Truck Load Out Emissions

W&S Gas Component	Mole Fraction[a] (%)	Molecular Weight (lb/lb-mol)	Gas Weight (lb/lb-mol)	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-HAP	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)

Exhaust Emissions from Recompletion Support Vehicles

Emission Factors for Commuting Vehicles

Vehicle		Emission Factors (g/mi)		
Type	Class	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	409.5	0.002	0.016
Heavy-Duty Diesel Truck	HDDV	791.8	0.037	0.006

Source: MOBILE6.2.03

[a] 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).

Combustive Emissions Estimation Road Traffic - Based on Peak Wells Drilled each Alternative

Construction Site Destination	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells	Emissions (tons/well)		
	Type	Class					CO_2	CH_4	N_2O
Well Recompletion	Fuel Haul Truck	HDDV	2	6	12	1	1.05E-02	4.89E-07	7.63E-08
	Mud Haul Truck, Water Hauling	HDDV	2	4	8	1	6.98E-03	3.26E-07	5.09E-08
	Rig Crew	LDDT	2	51	102	1	4.60E-02	2.25E-07	1.74E-06
	Rig Mechanics	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Co. Supervisor	LDDT	2	20	40	1	1.81E-02	8.82E-08	6.83E-07
	Semi Completion, Unit Rig	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Semi Fracing, Blender	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Semi Pumping/Tank Battery	HDDV	2	6	12	1	1.05E-02	4.89E-07	7.63E-08
	Tubing Truck	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Haul Cementer, Pump Truck	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Haul Cementer, Cement Truck	HDDV	2	3	6	1	5.24E-03	2.45E-07	3.82E-08
	Haul Completion, Equip Truck	HDDV	2	3	6	1	5.24E-03	2.45E-07	3.82E-08
	Haul Service Tools	LDDT	2	2	4	1	1.81E-03	8.82E-09	6.83E-08
	Haul Perforators Logging Truck	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Tank	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Pump	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Chemical	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Sand	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Other	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Water Truck	HDDV	2	50	100	1	8.73E-02	4.08E-06	6.36E-07
	Pickup Cementer, Engineer	LDDT	2	2	4	1	1.81E-03	8.82E-09	6.83E-08

	Pickup Completion Crew	HDDV	2	5	10	1	8.73E-03	4.08E-07	6.36E-08
	Pickup Completion, Pusher	LDDT	2	5	10	1	4.51E-03	2.20E-08	1.71E-07
	Pickup Perforators, Engineer	LDDT	2	2	4	1	1.81E-03	8.82E-09	6.83E-08
	Pickup Fracing, Engineer	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Pickup Co. Supervisor	LDDT	2	10	20	1	9.03E-03	4.41E-08	3.42E-07
	Pickup Miscellaneous Supplies	LDDT	2	3	6	1	2.71E-03	1.32E-08	1.03E-07
	Pickup Roustabout Crew	HDDV	2	4	8	1	6.98E-03	3.26E-07	5.09E-08
					Subtotal		**2.52E-01**	**8.17E-06**	**4.45E-06**
					Total		**2.52E-01**	**8.17E-06**	**4.45E-06**

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**

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 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).

Compressor Stations Emissions

Emission Factors for Natural Gas-Fired Compressors and Pumps

Compressor / Pump		Horse-Power Rating	Units	Emission Factors		
				CO_2[a]	CH_4[a]	N_2O[a]
Compression Station	Lean Burn	300	gm/bhp-hr	134.936	2.55E-03	2.55E-04
			lb/MMBTU	116.887	2.20E-03	2.20E-04
Oil Pump at Well Head	Lean Burn	40	gm/bhp-hr	134.936	2.55E-03	2.55E-04
			lb/MMBTU	116.887	2.20E-03	2.20E-04

Note: Compressors assumed to be equipped with nonselective catalytic reduction (NSCR) catalyst.

[a] 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 (tons/year/well)		
					CO_2	CH_4	N_2O
Compression Station	7.5	1.00	7.5	8,760	9.77E+00	1.84E-04	1.84E-05
Oil Pump at Well Head	40	1.00	40	8,760	5.21E+01	9.83E-04	9.83E-05
				Total	**6.19E+01**	**1.17E-03**	**1.17E-04**

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

TOC Emission Factor								
Well Equipment Component	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

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	1.74E-03	5.90E-04	1.92E-05	7.39E-04
pump seals	0.000	0.0053	0	0.0287	0	0.0001	0.00E+00	0.00E+00	0.00E+00	0.00E+00
others	0.000	0.0194	0	0.0165	0	0.0309	0.00E+00	0.00E+00	0.00E+00	0.00E+00
connectors	0.250	0.0004	0	0.0005	0	0.0002	1.10E-04	3.74E-05	1.22E-06	4.69E-05
flanges	0.600	0.0009	0	0.0002	0	0.0000	5.16E-04	1.75E-04	5.70E-06	2.19E-04
open-ended lines	0.000	0.0044	0	0.0031	0	0.0006	0.00E+00	0.00E+00	0.00E+00	0.00E+00
					TOTAL emissions/well/hr =		2.36E-03	8.02E-04	2.61E-05	1.00E-03

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 (ton/yr)**	**CO_2 emissions (lb/yr)**	**CO_2 emissions (ton/yr)**	**CH_4 emissions (lb/yr)**	**CH_4 emissions (ton/yr)**
Year 20	1	8760	7.03E+00	3.51E-03	2.29E-01	1.14E-04	8.80E+00	4.40E-03

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	15.333
Annual Miles of Roads reclaimed Per Well	3.833
Number of wells reclaimed (per well)	15.333

Reclaimation 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
3.83	6	0.6	6
		Total	**6**

Assume average miles/day = 6

Emission Factors for 75-100 hp Off-Road Engines

Year	Emission Factors (g/hp-hr)		
	CO_2	CH_4	N_2O[a]
2008	600.507	0.010	0.016
2018	613.888	0.006	0.016
2027	608.641	0.003	0.016

[a] 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).

Exhaust Emissions Estimation for Grader Road Reclaim

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours[a]	Emissions (tons/year/well)		
				CO_2	CH_4	N_2O
Road Reclamation	Grader	80	3.8	2.08E-01	1.87E-06	5.24E-06

Exhaust Emission Factors for Commuting Reclaim Vehicles Road Traffic

Vehicle Class	Emission Factors (g/mi)		
	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	409.5	0.002	0.016

Source: MOBILE6.2.03

[a] 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).

Exhaust Emissions Estimation for Commuting Reclaim Vehicles: Road Traffic

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tons/year/well)		
	Type	Class				CO_2	CH_4	N_2O
Road Reclamation	Pickup Truck	LDDV	6	0.64	4	1.73E-03	8.45E-09	6.55E-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	15.33	10	15.33	153.33

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

Exhaust Emissions Estimation for Grader: Well Reclamation

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours [a]	Emissions (tons/year/well)		
				CO_2	CH_4	N_2O
Well Reclamation	Grader	100	92	6.09E+00	1.01E-04	1.57E-04

Exhaust Emissions Estimation for Commuting Vehicles: Well Reclamation

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tons/year/well)		
	Type	Class				CO_2	CH_4	N_2O
Well Reclamation	Pickup Truck	LDDV	6	15	92	4.15E-02	2.03E-07	1.57E-06

Emissions for Gas Dehydration

Emission Factors for Dehydrator Heaters

Unit	CO_2	CH_4	N_2O
lb/MMSCF	120000	2.3	2.2
lb/MMBTU	117.647	0.002	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 (tons/year/well)		
				CO_2	CH_4	N_2O
2,190	1	2.20	0.001	6.79E-02	1.30E-06	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 per MMscf)	CH_4 Emissions (TPY/well)	VOC Emission Factor (ton per MMscf)	VOC Emissions (TPY/well)
6.57	1.071E-02	7.040E-02	1.600E-02	1.051E-01

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 South Baker 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 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

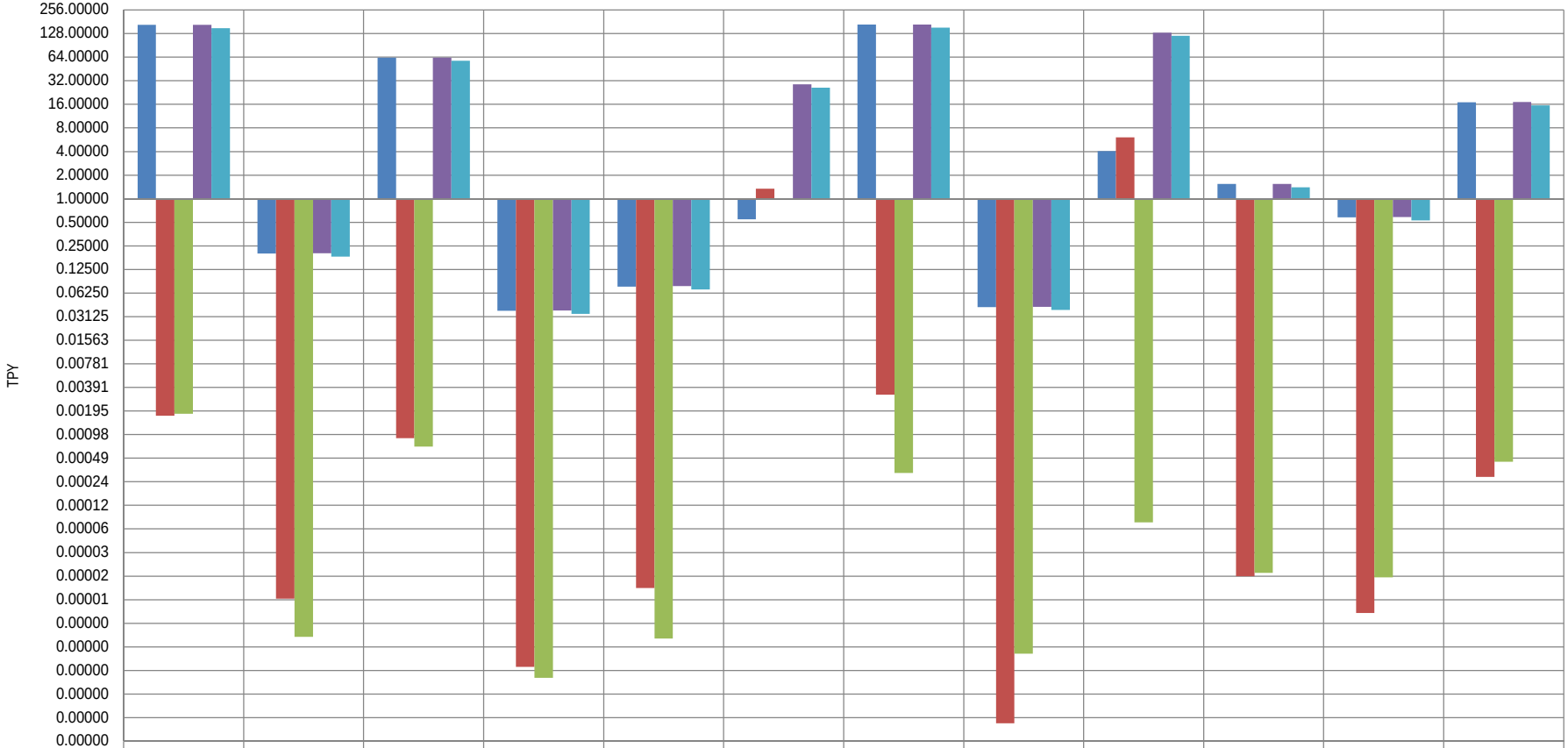
Butte input parameters for calculating NG wells emissions

Maximum Annual Wells Drilled - Federal (RMP estimate)	0.3	Maximum Annual Wells Drilled - Non-Federal (RMP estimate)	0.5
Federal Producing Wells - RMP Year 20	6	Non-Federal Producing Wells - RMP Year 20	9
Average Gas Production Per Well (MCFD)	179	Average Gas Production Per Well (MCFD)	179

Federal NG Wells Summaries

Total Annual Emissions from Federal NG Wells - RMP Year 20

Activity	Annual Emissions (Tons)				
	CO_2	CH_4	N_2O	CO_{2eq}	CO_{2eq} metric tons
Well Pad Construction - Fugitive Dust	---	---	---	---	---
Heavy Equipment Combustive Emissions	165.03	0.00	0.00	165.62	150.29
Commuting Vehicles - Construction	0.20	0.00	0.00	0.20	0.18
Wind Erosion	---	---	---	---	---
Completion Venting	0.78	1.93	0.00	41.26	37.44
Sub-total: Construction	**166.01**	**1.93**	**0.00**	**207.08**	**187.92**
Well Workover Operations - Fugitive Dust	---	---	---	---	---
Well Workover Operations - On-site Exhaust	63.04	0.00	0.00	63.28	57.42
Well Workover Operations - On-road Exhaust	0.04	0.00	0.00	0.04	0.03
Well Visits for Inspection & Repair - Operations	0.08	0.00	0.00	0.08	0.07
Wellhead and Compressor Station Fugitives	0.54	1.34	0.00	28.77	26.11
Compression	167.36	0.00	0.00	167.52	152.01
Station Visits - Operations	0.04	0.00	0.00	0.04	0.04
Dehydrators	4.05	6.09	0.00	131.93	119.72
Sub-total: Operations	**235.15**	**7.44**	**0.00**	**391.65**	**355.40**
Road Maintenance	1.54	0.00	0.00	1.54	1.40
Sub-total: Maintenance	**1.539**	**0.000**	**0.00**	**1.54**	**1.40**
Road Reclamation	0.58	0.00	0.00	0.58	0.53
Well Reclamation	16.95	0.00	0.00	17.10	15.51
Sub-total: Reclamation	**17.5331**	**0.0003**	**0.0005**	**17.6797**	**16.0433**
Total Emissions	**420.23**	**9.37**	**0.00**	**617.96**	**560.76**

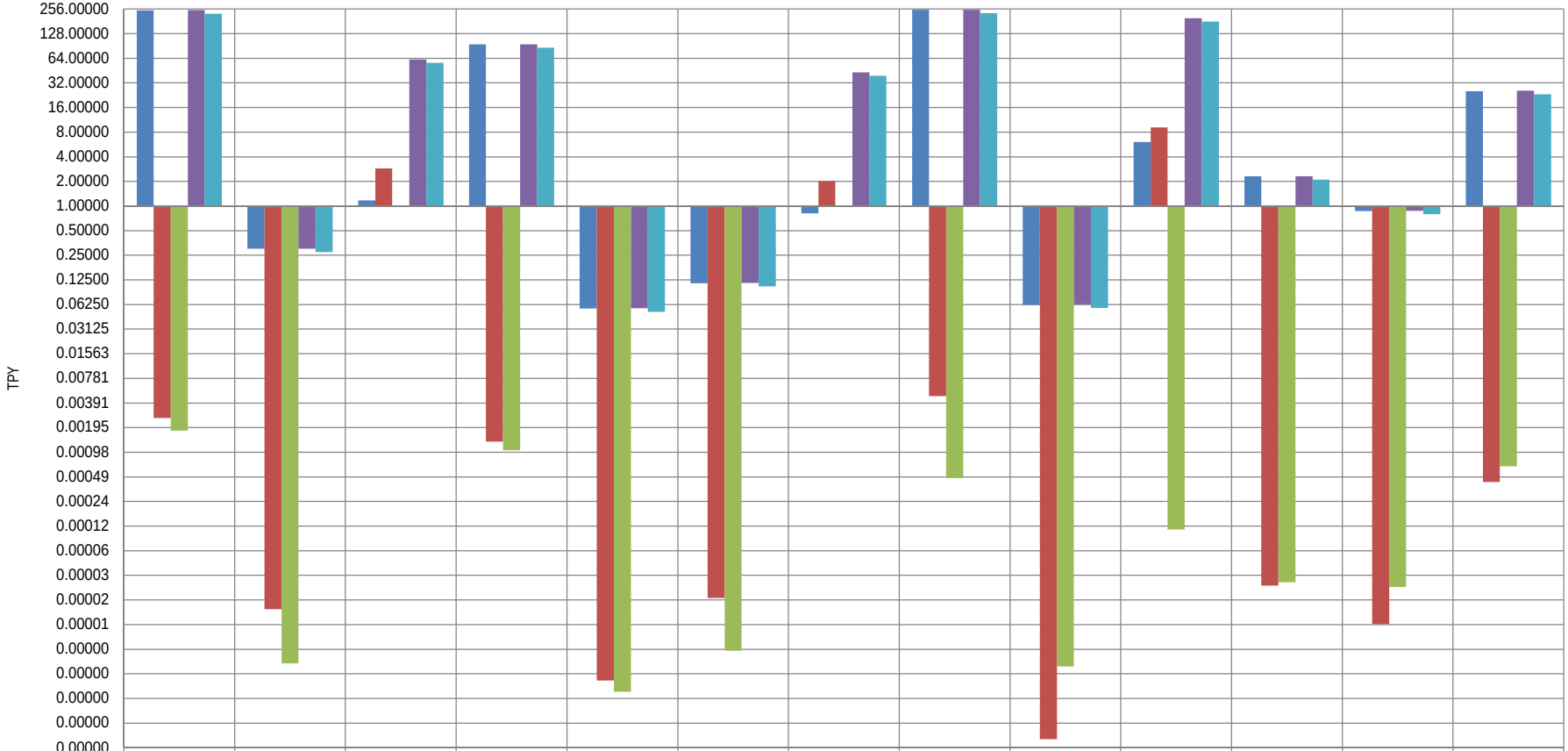


	Heavy Equipment Combustive Emissions	Commuting Vehicles - Construction	Well Workover Operations - On-site Exhaust	Well Workover Operations - On-road Exhaust	Well Visits for Inspection & Repair - Operations	Wellhead and Compressor Station Fugitives	Compression	Station Visits - Operations	Dehydrators	Road Maintenance	Road Reclamation	Well Reclamation
CO2	165.03	0.20	63.04	0.04	0.08	0.54	167.36	0.04	4.05	1.54	0.58	16.95
CH4	0.00	0.00	0.00	0.00	0.00	1.34	0.00	0.00	6.09	0.00	0.00	0.00
N2O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CO2eq	165.62	0.20	63.28	0.04	0.08	28.77	167.52	0.04	131.93	1.54	0.58	17.10
CO2eq metric tons	150.29	0.18	57.42	0.03	0.07	26.11	152.01	0.04	119.72	1.40	0.53	15.51

Non-Federal NG Wells Summaries

Total Annual Emissions from Non-Federal NG Wells - RMP Year 20

Activity	Annual Emissions (Tons)				
	CO_2	CH_4	N_2O	CO_{2eq}	CO_{2eq} metric tons
Well Pad Construction - Fugitive Dust	---	---	---	---	---
Heavy Equipment Combustive Emissions	247.54	0.00	0.00	248.15	225.19
Commuting Vehicles - Construction	0.30	0.00	0.00	0.30	0.27
Wind Erosion	---	---	---	---	---
Completion Venting	1.17	2.89	0.00	61.89	56.16
Sub-total: Construction	**249.02**	**2.89**	**0.00**	**310.35**	**281.62**
Well Workover Operations - Fugitive Dust			---	---	---
Well Workover Operations - On-site Exhaust	94.57	0.00	0.00	94.91	86.13
Well Workover Operations - On-road Exhaust	0.06	0.00	0.00	0.06	0.05
Well Visits for Inspection & Repair - Operations	0.11	0.00	0.00	0.12	0.10
Wellhead and Compressor Station Fugitives	0.82	2.02	0.00	43.15	39.16
Compression	251.03	0.00	0.00	251.28	228.02
Station Visits - Operations	0.06	0.00	0.00	0.06	0.06
Dehydrators	6.08	9.13	0.00	197.90	179.58
Sub-total: Operations	**352.73**	**11.15**	**0.00**	**587.48**	**533.10**
Road Maintenance	2.31	0.00	0.00	2.32	2.10
Sub-total: Maintenance	**2.309**	**0.000**	**0.00**	**2.32**	**2.10**
Road Reclamation	0.87	0.00	0.00	0.87	0.79
Well Reclamation	25.43	0.00	0.00	25.64	23.27
Sub-total: Reclamation	**26.2996**	**0.0004**	**0.0007**	**26.5196**	**24.0649**
Total Emissions	**630.35**	**14.05**	**0.00**	**926.66**	**840.89**



	Heavy Equipment Combustive Emissions	Commuting Vehicles - Construction	Completion Venting	Well Workover Operations - On-site Exhaust	Well Workover Operations - On-road Exhaust	Well Visits for Inspection & Repair - Operations	Wellhead and Compressor Station Fugitives	Compression	Station Visits - Operations	Dehydrators	Road Maintenance	Road Reclamation	Well Reclamation
CO2	247.54	0.30	1.17	94.57	0.06	0.11	0.82	251.03	0.06	6.08	2.31	0.87	25.43
CH4	0.00	0.00	2.89	0.00	0.00	0.00	2.02	0.00	0.00	9.13	0.00	0.00	0.00
N2O	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
CO2eq	248.15	0.30	61.89	94.91	0.06	0.12	43.15	251.28	0.06	197.90	2.32	0.87	25.64
CO2eq metric tons	225.19	0.27	56.16	86.13	0.05	0.10	39.16	228.02	0.06	179.58	2.10	0.79	23.27

Exhaust Emissions from Well Pad Construction Heavy Equipment and Drilling Equipment

Emission Factors for Construction Equipment

Equipment	Emission Factors (g/hp-hr)			Equipment Category
	CO_2	CH_4	N_2O[a]	
Dozer - 175 Hp	535.760	0.005	0.006	Track-Type Tractor
Blade - 150 Hp	594.650	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] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

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 (tons/equipment type/well)		
									CO_2	CH_4	N_2O
Improved & Two-Track Road	Blade	150	1	75	10	2	20	1	1.47E+00	1.87E-05	1.43E-05
Well Pad	Blade	175	1	75	10	3	30	1	2.58E+00	3.28E-05	2.50E-05
	Dozer	175	1	80	10	3	30	1	2.75E+00	3.50E-05	2.67E-05
								Subtotal	**6.81E+00**	**8.64E-05**	**6.61E-05**

Exhaust Emission Factors for Diesel Powered Bore/Drill Rig Engines

Project Year/Hp Category	Emission Factors (g/hp-hr)		
	CO_2	CH_4	N_2O[a]
Year 2018			
50 to 75	589.096	0.006	0.006
75 to 100	589.103	0.006	0.006
100 to 175	530.097	0.005	0.006
175 to 300	530.181	0.004	0.006
300 to 600	530.255	0.004	0.006
600 to 750	530.283	0.004	0.006
>750	529.917	0.006	0.006

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

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

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 (tons/equipment type/well)		
									CO_2	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Main Deck	1,000	3	70	24	16	384	1	4.71E+02	5.02E-03	5.13E-03
	Auxiliary	600	1	80	8	15	120	1	3.37E+01	2.51E-04	3.66E-04
	Generators	150	2	75	24	8	192	1	2.52E+01	2.26E-04	2.75E-04
Well Completion & Testing	Main Deck	600	1	50	11	5	55	1	9.64E+00	7.19E-05	1.05E-04
	Auxiliary	225	1	80	8	2	16	1	1.68E+00	1.37E-05	1.83E-05
	Power Swivel	150	1	75	8	2	16	1	1.05E+00	9.42E-06	1.14E-05
	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	55	1	75	12	3	36	1	9.64E-01	1.05E-05	9.44E-06
								Subtotal	**5.43E+02**	**5.60E-03**	**5.91E-03**
								Total	**5.50E+02**	**5.69E-03**	**5.98E-03**

Exhaust Emissions from Construction and Drilling Support Vehicles

Emission Factors for Commuting Vehicles

Vehicle		Emission Factors (g/mi)		
Type	Class	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	409.5	0.002	0.016
Heavy-Duty Diesel Truck	HDDV	791.8	0.037	0.006

Source: MOBILE6.2.03

[a] 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).

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 (tons/well)		
	Type	Class					CO_2	CH_4	N_2O
Improved & Two-Track Road	Semi Trucks	HDDV	2	47	94	1	8.20E-02	3.83E-06	5.98E-07
	Pickup Trucks	LDDT	2	3	6	1	2.71E-03	1.32E-08	1.03E-07
Well Pad	Semi Trucks	HDDV	2	5	10	1	8.73E-03	4.08E-07	6.36E-08
	Pickup Trucks	LDDT	2	4	8	1	3.61E-03	1.76E-08	1.37E-07
Other Construction Activities	Semi Trucks	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Haul Trucks	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Pickup Trucks	LDDT	2	1	2	1	9.03E-04	4.41E-09	3.42E-08
						Subtotal	**1.05E-01**	**4.60E-06**	**9.86E-07**

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 (tons/well)		
	Type	Class					CO_2	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Semi Rig Transport, Drill Rig	HDDV	2	44	88	1	7.68E-02	3.59E-06	5.60E-07
	Fuel Haul Truck	HDDV	2	6	12	1	1.05E-02	4.89E-07	7.63E-08
	Mud Haul Truck, Water Hauling	HDDV	2	4	8	1	6.98E-03	3.26E-07	5.09E-08
	Rig Crew	LDDT	2	51	102	1	4.60E-02	2.25E-07	1.74E-06
	Rig Mechanics	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Co. Supervisor	LDDT	2	20	40	1	1.81E-02	8.82E-08	6.83E-07
	Tool Pusher	LDDT	2	8	16	1	7.22E-03	3.53E-08	2.73E-07
	Mud Logger	LDDT	2	6	12	1	5.42E-03	2.65E-08	2.05E-07
	Mud Engineer	LDDT	2	15	30	1	1.35E-02	6.61E-08	5.13E-07
	Logger, Engr Truck	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Drill Bit Delivery	LDDT	2	2	4	1	1.81E-03	8.82E-09	6.83E-08

Combustive Emissions Estimation Road Traffic (cont.)

Construction Site Destination	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells	Emissions (tons/well)		
	Type	Class					CO_2	CH_4	N_2O
Well Completion & Testing	Semi Casing Haulers	HDDV	2	6	12	1	1.05E-02	4.89E-07	7.63E-08
	Semi Completion, Unit Rig	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Semi Fracing, Blender	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Semi Pumping/Tank Battery	HDDV	2	6	12	1	1.05E-02	4.89E-07	7.63E-08
	Tubing Truck	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Haul Cementer, Pump Truck	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Haul Cementer, Cement	HDDV	2	3	6	1	5.24E-03	2.45E-07	3.82E-08
	Haul Completion, Equip	HDDV	2	3	6	1	5.24E-03	2.45E-07	3.82E-08
	Haul Service Tools	LDDT	2	2	4	1	1.81E-03	8.82E-09	6.83E-08
	Haul Perforators Logging Truck	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Anchor, Installation	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Anchor, Testing	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Tank	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Pump	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Chemical	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Sand	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Other	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Welders	HDDV	2	6	12	1	1.05E-02	4.89E-07	7.63E-08
	Haul Water Truck	HDDV	2	150	300	1	2.62E-01	1.22E-05	1.91E-06
	Pickup Cementer, Engineer	LDDT	2	2	4	1	1.81E-03	8.82E-09	6.83E-08
	Pickup Casing Crew	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Pickup Completion Crew	HDDV	2	5	10	1	8.73E-03	4.08E-07	6.36E-08
	Pickup Completion,	LDDT	2	5	10	1	4.51E-03	2.20E-08	1.71E-07
	Pickup Perforators, Engineer	LDDT	2	2	4	1	1.81E-03	8.82E-09	6.83E-08
	Pickup Fracing, Engineer	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Pickup Co. Supervisor	LDDT	2	10	20	1	9.03E-03	4.41E-08	3.42E-07
	Pickup Miscellaneous Supplies	LDDT	2	3	6	1	2.71E-03	1.32E-08	1.03E-07
	Pickup Roustabout Crew	HDDV	2	4	8	1	6.98E-03	3.26E-07	5.09E-08
						Subtotal	**5.62E-01**	**2.15E-05**	**7.57E-06**
					Total		**6.67E-01**	**2.61E-05**	**8.56E-06**

Exhaust Emissions from Well Work Overs

Emission Factors Bore/Drill Rig Engines 300-600 Hp

Fuel Type	Emission Factors (gm/hp-hr)		
	CO_2	CH_4	N_2O[a]
Diesel	529.575	0.007	0.006

Source: EPA NONROADS 2008a. Year 2008.

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

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 (tons/year/well)		
							CO_2	CH_4	N_2O
Well Workover	Truck-Mounted Unit	600	10	3	30	1	1.05E+01	1.46E-04	1.14E-04

Exhaust emission factors for commuting vehicles

Vehicle		Emission Factors (g/mi)		
Type	Class	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	409.5	0.002	0.016
Heavy-Duty Diesel Truck	HDDV	791.8	0.04	0.006

Source: MOBILE 6.2.03

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

[a] 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

Activity	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells Drilled	Max. Annual Emissions (tons/year/well)		
	Type	Class					CO_2	CH_4	N_2O
Well Workover	WO Rig	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Truck	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Pickup Truck	LDDT	2	3	6	1	2.71E-03	1.32E-08	1.03E-07
						Total	**6.20E-03**	**1.76E-07**	**1.28E-07**

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).

Round trip distance = 2 based on data found in the SEIS

Exhaust Emissions from Site Visits and Inspections

Emission factors for Commuting Vehicles Exhaust

Vehicle Class	Emission Factors (g/mi)		
	CO_2	CH_4	N_2O[a]
Light-Duty Gasoline Truck	476.9	0.07	0.02

Source: MOBILE 6.2.03

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

[a] 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)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Federal Wells Producing	Emissions (tons/yr/well)		
	Type	Class					CO_2	CH_4	N_2O
Inspection Visits for Wells	Pickup Truck	LDGT2	2	12	24	1	1.26E-02	1.80E-06	4.07E-07

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 year

[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
Cumulative Length of Roads [b] (miles/operation)	1

[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	**1**	**5**

Emission Factors for Construction Equipment Exhaust

Equipment	Emission Factors (g/hp-hr)		
	CO_2	CH_4	N_2O[a]
Grader 100-175 Hp	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] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

Emission Estimations for Grader: RMP Year 20

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours[a]	Emissions (tons/well)		
				CO_2	CH_4	N_2O
Road Maintenance	Grader	135	3	2.55E-01	2.52E-06	2.75E-06

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

Emission Factors for Commuting Vehicles Exhaust

Vehicle Class	Emission Factors (g/mi)		
	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	409.5	0.002	0.016

Source: MOBILE 6.2.03

[a] 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 (tons/yr)		
	Type	Class				CO_2	CH_4	N_2O
Road Maintenance	Pickup Truck	LDGT2	6	0.5	3	1.44E-03	7.05E-09	5.47E-08

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	7.067
Annual Miles of Roads reclaimed Per Well	1.767
Number of wells reclaimed (per well)	7.067

Reclaimation 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
1.77	6	0.3	3
		Total	**3**

Assume average miles/day = 6

Emission Factors for 75-100 hp Off-Road Engines

Year	Emission Factors (g/hp-hr)		
	CO_2	CH_4	N_2O[a]
2008	600.507	0.010	0.016
2018	613.888	0.006	0.016
2027	608.641	0.003	0.016

[a] Emissions of $PM_{2.5}$ were assumed to be the same as those for PM_{10}.

[a] 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).

Exhaust Emissions Estimation for Grader Road Reclaim

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours[a]	Emissions (tons/year/well)		
				CO_2	CH_4	N_2O
Road Reclamation	Grader	80	1.8	9.56E-02	8.60E-07	2.41E-06

Exhaust Emission Factors for Commuting Reclaim Vehicles Road Traffic

Vehicle Class	Emission Factors (g/mi)		
	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	409.5	0.002	0.016

Source: MOBILE6.2.03

[a] 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).

Exhaust Emissions Estimation for Commuting Reclaim Vehicles: Road Traffic

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tons/year/well)		
	Type	Class				CO_2	CH_4	N_2O
Road Reclamation	Pickup Truck	LDDV	6	0.29	2	7.97E-04	3.89E-09	3.02E-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	7.066666667	10	7.066666667	70.66666667

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

Exhaust Emissions Estimation for Grader: Well Reclamation

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours [a]	Emissions (tons/year/well)		
				CO_2	CH_4	N_2O
Well Reclamation	Grader	100	42	2.81E+00	4.68E-05	7.24E-05

Exhaust Emissions Estimation for Commuting Vehicles: Well Reclamation

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tons/year/well)		
	Type	Class				CO_2	CH_4	N_2O
Well Reclamation	Pickup Truck	LDDV	6	7	42	1.91E-02	9.35E-08	7.24E-07

Emission Factors for Dehydrator Heaters

Unit	CO_2	CH_4	N_2O
lb/MMSCF	120000.0	2.3	2.2
lb/MMBTU	117.647	0.002	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 (tons/year/well)		
				CO_2	CH_4	N_2O
2,190	1	2.20	0.005	6.75E-01	1.29E-05	1.24E-05

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)
65.34	1.55E-02	1.01E+00	2.13E-05	1.39E-03

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 South Baker 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 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

Wellhead Fugitives

Fugitive Emissions from Equipment Leaks

TOC Emission Factor								
Well Equipment Component	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% =	13.56
CO2 Wt% =	22.83
CH4 Wt% =	56.36
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	7.50E-02	1.02E-02	1.71E-02	4.22E-02
pump seals	0	0.0053	0	0.0287	0	0.0001	0.00E+00	0.00E+00	0.00E+00	0.00E+00
others	0	0.0194	0	0.0165	0	0.0309	0.00E+00	0.00E+00	0.00E+00	0.00E+00
connectors	24	0.0004	0	0.0005	0	0.0002	1.06E-02	1.43E-03	2.42E-03	5.96E-03
flanges	2	0.0009	0	0.0002	0	0.0000	1.72E-03	2.33E-04	3.93E-04	9.69E-04
open-ended lines	0	0.0044	0	0.0031	0	0.0006	0.00E+00	0.00E+00	0.00E+00	0.00E+00
					TOTAL emissions/well/hr =		8.73E-02	1.18E-02	1.99E-02	4.92E-02

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 (ton/yr)**	**CO_2 emissions (lb/yr)**	**CO_2 emissions (ton/yr)**	**CH_4 emissions (lb/yr)**	**CH_4 emissions (ton/yr)**
Year 20	1	8760	1.04E+02	5.18E-02	1.75E+02	8.73E-02	4.31E+02	2.15E-01

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

Gas Component	Mole Fraction (%)	Molecular Weight (lb/lb-mol)	Gas Weight (lb/lb-mol)	Weight Percent (wt%)	Weight (lb/MMscf))	Emissions Mass Flow (ton/well)
Methane	77.690	16.040	12.461	56.359	23930.150	6.425
Ethane	5.265	30.070	1.583	7.160	3040.239	0.816
Nitrogen	0.000	28.020	0.000	0.000	0.000	0.000
Water		18.015	0.000	0.000	0.000	0.000
Carbon Dioxide	11.475	43.990	5.048	22.830	9693.544	2.603
Nitrous Oxide		44.020	0.000	0.000	0.000	0.000
Hydrogen Sulfide	0.060	34.067	0.020	0.092	39.252	0.011
Non-reactive, non-HAP	94.490	---	19.113	86.442		9.855
Propane	2.515	44.100	1.109	5.016	2129.867	0.572
Iso-butane	0.810	58.120	0.471	2.129	904.038	0.243
n-butane	1.190	58.120	0.692	3.128	1328.154	0.357
i-pentane	0.600	72.150	0.433	1.958	831.311	0.223
n-pentane	0.335	72.150	0.242	1.093	464.149	0.125
Hexanes	0.060	86.180	0.052	0.234	99.296	0.027
Heptanes		100.200	0.000	0.000	0.000	0.000
Octanes		114.230	0.000	0.000	0.000	0.000
Nonanes		128.26	0.000	0.000	0.000	0.000
Decanes+		142.29	0.000	0.000	0.000	0.000
Reactive VOC	5.510	---	2.998	13.558		1.546
Benzene		78.110	0.000	0.000	0.000	0.000
Ethylbenzene		106.167	0.000	0.000	0.000	0.000
n-Hexane [3]	*0.060*	*86.180*	*0.052*	*0.234*	*99.296*	*0.027*
Toluene		92.140	0.000	0.000	0.000	0.000
Xylenes		106.160	0.000	0.000	0.000	0.000
HAPs	0.060	---	0.052	0.234		0.027
Totals	**100.000**	**---**	**22.111**	**100.000**		**11.401**

Volume Flow:	179	MSCF/day/well
Completion activity duration:	3	days
Total Volume Flow per Well	0.537	MMSCF/well

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

BTU value = 994 BTU/scf

Compressor Station Emissions

Emission Factors for Natural Gas-Fired Compressors

Compressor		Horse-Power Rating	Units	Emission Factors		
				CO_2[c]	CH_4[c]	N_2O[c]
Field Compression Station	Rich Burn	300	gm/bhp-hr	134.936	2.55E-03	2.55E-04
			lb/MMBTU	116.887	2.20E-03	2.20E-04
Sales Compression Station	Rich Burn	1,680	gm/bhp-hr	134.936	2.55E-03	2.55E-04
			lb/MMBTU	116.887	2.20E-03	2.20E-04

Note: Compressors assumed to be equipped with nonselective catalytic reduction (NSCR) catalyst.

[a] 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 (tons/year/well)		
					CO_2	CH_4	N_2O
Field Compression Station	11	1	11	8,760	1.44E+01	2.72E-04	2.72E-05
Sales Compression Station	10	1	10	8,760	1.35E+01	2.54E-04	2.54E-05
				Total	**2.79E+01**	**5.26E-04**	**5.26E-05**

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

TOC Emission Factor								
Well Equipment Component	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% =	13.56
CO2 Wt% =	22.83
CH4 Wt% =	56.36
N2O Wt% =	0.00

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	0.258	0.0099	0	0.0055	0	0.0002	2.56E-03	3.48E-04	5.85E-04	1.44E-03
pump seals	0.000	0.0053	0	0.0287	0	0.0001	0.00E+00	0.00E+00	0.00E+00	0.00E+00
others	0.000	0.0194	0	0.0165	0	0.0309	0.00E+00	0.00E+00	0.00E+00	0.00E+00
connectors	0.369	0.0004	0	0.0005	0	0.0002	1.63E-04	2.21E-05	3.72E-05	9.17E-05
flanges	0.886	0.0009	0	0.0002	0	0.0000	7.62E-04	1.03E-04	1.74E-04	4.29E-04
open-ended lines	0.000	0.0044	0	0.0031	0	0.0006	0.00E+00	0.00E+00	0.00E+00	0.00E+00
					TOTAL emissions/well/hr =		3.49E-03	4.73E-04	7.96E-04	1.97E-03

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 (ton/yr)**	**CO_2 emissions (lb/yr)**	**CO_2 emissions (ton/yr)**	**CH_4 emissions (lb/yr)**	**CH_4 emissions (ton/yr)**
Year 20	1	8760	4.14E+00	2.07E-03	6.97E+00	3.49E-03	1.72E+01	8.61E-03

Compressor Station Inspection Traffic Exhaust Emissions

Emission factors for Commuting Vehicles Exhaust

Vehicle		Emission Factors (g/mi)		
Type	Class	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	409.5	0.002	0.016

Source: MOBILE6.2.03

[a] 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).

Exhaust Emissions Estimation for Road Traffic

Activity	Compressor Station	Vehicle		# of Compressor Stations / Well	# of Inspection Visits/ Station	# of Inspection Visits/Well/Year	Total Miles/ Inspection	Emissions (tons/year/well)		
		Type	Class					CO_2	CH_4	N_2O
Inspection Visits for Compressor Stations	CPF Compressor Station	Pickup Truck	LDGT2	0.04	12	0.4	20	4.00E-03	1.95E-08	1.51E-07
	Primary Compressor Station	Pickup Truck	LDGT2	0.01	52	0.3	20	2.89E-03	1.41E-08	1.09E-07
							Total	**6.89E-03**	**3.36E-08**	**2.61E-07**

Butte input parameters for calculating CBNG wells emissions

Peak Year Federal Producing Wells Drilled	0	Peak Year Non-Federal Producing Wells Drilled	3
Federal Producing Wells - Year 20	0	Non-Federal Producing Wells - Year 2027	30
Average Gas Production Per Well (MCFD)	0	Average Gas Production Per Well (MCFD)	45

Federal CBNG Wells Summaries

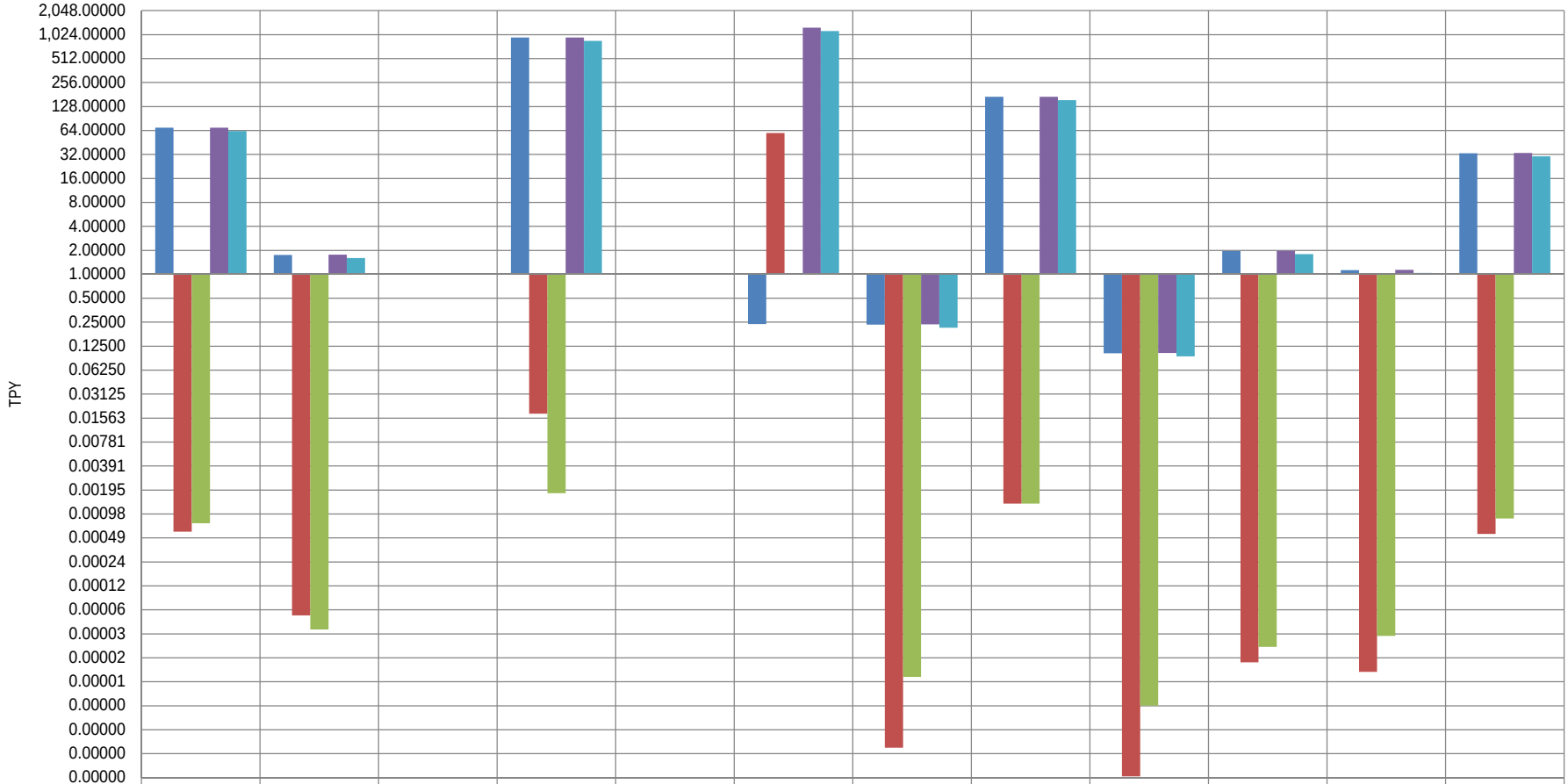
Total Annual Emissions from Federal CBNG Wells - RMP Year 20

Activity	Annual Emissions (Tons)				
	CO_2	CH_4	N_2O	CO_{2eq}	CO_{2eq} metric tons
Well Pad & Station Construction - Fugitive Dust	---	---	---	---	---
Wind Erosion	---	---	---	---	---
Heavy Equipment Combustive Emissions	0.00	0.00	0.00	0.00	0.00
Commuting Vehicles - Construction	0.00	0.00	0.00	0.00	0.00
Completion Venting	0.00	0.00	0.00	0.00	0.00
Sub-total: Construction	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Natural Gas Compression - Operations	0.00	0.00	0.00	0.00	0.00
Dehydrators	0.00	0.00	0.00	0.00	0.00
Wellhead and Compressor Station Fugitives	0.00	0.00	0.00	0.00	0.00
Station Visits - Operations	0.00	0.00	0.00	0.00	0.00
Well Workover - Operations	0.00	0.00	0.00	0.00	0.00
Operations	0.00	0.00	0.00	0.00	0.00
Sub-total: Operations	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Road Maintenance	0.00	0.00	0.00	0.00	0.00
Sub-total: Maintenance	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Road Reclamation	0.00	0.00	0.00	0.00	0.00
Well Reclamation	0.00	0.00	0.00	0.00	0.00
Sub-total: Reclamation	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**
Total Emissions	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

Non-Federal CBNG Wells Summaries

Total Annual Emissions from Non-Federal CBNG Wells - RMP Year 20

Activity	Annual Emissions (Tons)				
	CO_2	CH_4	N_2O	CO_{2eq}	CO_{2eq} metric tons
Well Pad & Station Construction - Fugitive Dust	---	---	---	---	---
Wind Erosion	---	---	---	---	---
Heavy Equipment Combustive Emissions	69.24	0.00	0.00	69.48	63.05
Commuting Vehicles - Construction	1.75	0.00	0.00	1.76	1.60
Completion Venting	0.00	0.00	0.00	0.00	0.00
Sub-total: Construction	**70.99**	**0.00**	**0.00**	**71.24**	**64.65**
Natural Gas Compression - Operations	941.37	0.02	0.00	942.30	855.08
Dehydrators	0.00	0.00	0.00	0.00	0.00
Wellhead and Compressor Station Fugitives	0.24	59.56	0.00	1251.06	1135.26
Station Visits - Operations	0.23	0.00	0.00	0.24	0.21
Well Workover - Operations	169.64	0.00	0.00	170.08	154.34
Operations	0.10	0.00	0.00	0.10	0.09
Sub-total: Operations	**1111.59**	**59.58**	**0.00**	**2363.77**	**2144.99**
Road Maintenance	1.96	0.00	0.00	1.97	1.79
Sub-total: Maintenance	**1.96**	**0.00**	**0.00**	**1.97**	**1.79**
Road Reclamation	1.13	0.00	0.00	1.14	1.04
Well Reclamation	33.19	0.00	0.00	33.47	30.37
Sub-total: Reclamation	**34.3218**	**0.0006**	**0.0009**	**34.6089**	**31.4055**
Total Emissions	**1,218.86**	**59.58**	**0.00**	**2,471.59**	**2,242.83**



	Heavy Equipment Combustive Emissions	Commuting Vehicles - Construction	Completion Venting	Natural Gas Compression - Operations	Dehydrators	Wellhead and Compressor Station Fugitives	Station Visits - Operations	Well Workover - Operations	Well & Pipeline visits for Inspection & Repair - Operations	Road Maintenance	Road Reclamation	Well Reclamation
CO2	69.24	1.75	0.00	941.37	0.00	0.24	0.23	169.64	0.10	1.96	1.13	33.19
CH4	0.00	0.00	0.00	0.02	0.00	59.56	0.00	0.00	0.00	0.00	0.00	0.00
N2O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CO2eq	69.48	1.76	0.00	942.30	0.00	1251.06	0.24	170.08	0.10	1.97	1.14	33.47
CO2eq metric tons	63.05	1.60	0.00	855.08	0.00	1135.26	0.21	154.34	0.09	1.79	1.04	30.37

Exhaust Emissions from Heavy Construction Equipment

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

Project Year/Hp Category	Emission Factors (g/hp-hr)		
	CO_2	CH_4	N_2O[a]
Year 2018			
50 to 75	589.096	0.006	0.006
75 to 100	589.103	0.006	0.006
100 to 175	530.097	0.005	0.006
175 to 300	530.181	0.004	0.006
300 to 600	530.255	0.004	0.006
600 to 750	530.283	0.004	0.006
>750	529.917	0.006	0.006

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

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

Exhaust Emission Estimations for Construction Equipment - Based on Peak Wells Drilled each Alternative (using 2008 emission factors)

Construction Activity	Equipment Type	Capacity (hp)	# of Units	Av. Load Factor (%)	# of Oper. Hours/Day	# of Oper. Days/ Activity	# of Oper. Hours/Activity	# of Activities / Well	Emissions (tons/year/well)		
									CO_2	CH_4	N_2O
Drilling Roads	Blade	100	1	80	10	0.2	2	1.0000	9.35E-02	8.37E-07	1.02E-06
	Backhoe	80	1	75	10	0.1	1	1.0000	3.90E-02	4.20E-07	3.82E-07
Drilling Well Pad	Backhoe	80	1	75	10	0.5	5	1.0000	1.95E-01	2.10E-06	1.91E-06
Water Disposal well pad	Backhoe	80	1	75	10	2	20	0.0050	3.90E-03	4.20E-08	3.82E-08
New Pipeline Intermediate	Blade	100	1	80	10	5	50	0.1108	2.88E-01	3.10E-06	2.82E-06
	Trencher	175	1	80	10	5	50	0.1108	4.53E-01	4.06E-06	4.93E-06
	Backhoe	80	1	75	10	10	100	0.1108	4.32E-01	4.65E-06	4.23E-06
New Sales Pipeline	Blade	100	1	80	10	43	430	0.0002	3.68E-03	3.96E-08	3.60E-08
	Trencher	175	1	80	10	43	430	0.0002	5.79E-03	5.18E-08	6.30E-08
	Backhoe	80	1	75	10	65	650	0.0002	4.17E-03	4.49E-08	4.08E-08
Booster Compression Station	Dozer	350	1	80	10	2	20	0.1108	3.63E-01	2.70E-06	3.95E-06
	Backhoe	80	2	80	10	3	30	0.1108	2.76E-01	2.98E-06	2.71E-06
Sales Compression Station	Dozer	350	1	80	10	2	20	0.0110	3.61E-02	2.69E-07	3.93E-07
	Backhoe	80	2	80	10	3	30	0.0110	2.75E-02	2.96E-07	2.69E-07
								Subtotal	**2.22E+00**	**2.16E-05**	**2.28E-05**

Activity rates based on values shown in SEIS. Water disposal well pad development rates provided by Montana BLM (Laakso, 2010).

Exhaust Emission Factors for Diesel Powered Bore/Drill Rig Engines

Project Year/Hp Category	Emission Factors (g/hp-hr)		
	CO_2	CH_4	N_2O[a]
Year 2018			
50 to 75	589.096	0.006	0.006
75 to 100	589.103	0.006	0.006
100 to 175	530.097	0.005	0.006
175 to 300	530.181	0.004	0.006
300 to 600	530.255	0.004	0.006
600 to 750	530.283	0.004	0.006
>750	529.917	0.006	0.006

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

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

Combustive Emissions Estimation for Industrial Engines - Based on Peak Wells Drilled each Alternative

Construction Activity	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Oper. Hours/Day	# of Oper. Days/ Well	# of Oper. Hours/Well	# of Wells	Emissions (tons/year/well)		
									CO_2	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Main Deck	400	1	60	18	3	54	1.0000	7.58E+00	5.65E-05	8.24E-05
	Auxillary Pump	200	1	90	18	2	36	1.0000	3.79E+00	3.09E-05	4.12E-05
Well Completion & Testing	Main Deck	400	1	60	18	1	18	1.0000	2.53E+00	1.88E-05	2.75E-05
	Auxillary Pump	125	1	90	18	1	18	1.0000	1.18E+00	1.06E-05	1.29E-05
Water Disposal well drilling	Generator	1476	1	40	24	30	720	0.0050	1.24E+00	1.32E-05	1.35E-05
	Generator	1476	1	40	24	30	720	0.0050	1.24E+00	1.32E-05	1.35E-05
								Subtotal	**1.76E+01**	**1.43E-04**	**1.91E-04**
								Total	**1.98E+01**	**1.65E-04**	**2.14E-04**

Equipment type, Hp ratings, and operational hours based on information shown in SEIS. No flaring per Montana BLM (Laakso, 2010). Water disposal well pad development rates provided by Montana BLM (Laakso, 2010).

Temporary Emission Estimations for Field Generators: Based on Peak Wells Drilled each Alternative

Construction Activity	Equipment Type	Capacity (hp)	# of Wells Served[a]	Avg. Load Factor (%)	# of Oper. Hours/Day	# of Oper. Days/Well	# of Oper. Hours/Well	# of Wells	Emissions (tons/year/well)		
									CO_2	CH_4	N_2O
Field Generators	Field Generators for Pumps & Lighting	21	1	75	24	15	360	1.0000	3.31E+00	2.96E-05	3.60E-05
									3.31E+00	**2.96E-05**	**3.60E-05**

Values shown in SEIS per well.

Exhaust Emissions from Construction and Drilling Support Vehicles

Emission factors for Commuting Vehicles Exhaust

Vehicle		Emission Factors (g/mi)		
Type	**Class**	**CO_2**	**CH_4**	**N_2O[a]**
Light-Duty Diesel Truck	LDDT	409.5	0.002	0.016
Heavy-Duty Diesel Truck	HDDV	791.8	0.037	0.006

Source: MOBILE6.2.03

[a] 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).

Combustive Emissions Estimation Road Traffic - Based on Peak Wells Drilled

Construction Activity	Vehicle		Round Trip Distance (miles)	# of Round Trips/Activity	Miles Traveled/Activity	Total # of Activities / Well	Emissions (tons/year/well)		
	Type	Class					CO_2	CH_4	N_2O
Drilling Roads	Semi Trucks	HDDV	6	3	18	1.0000	1.57E-02	7.34E-07	1.14E-07
Drilling Well Pad	Haul Trucks	HDDV	6	2	12	1.0000	1.05E-02	4.89E-07	7.63E-08
	Pickup Trucks	LDDT	6	2	12	1.0000	5.42E-03	2.65E-08	2.05E-07
Water Disposal Well Pad	Haul Trucks	HDDV	100	5	500	0.0050	2.18E-03	1.02E-07	1.59E-08
	Pickup Trucks	LDDT	25	5	125	0.0050	2.82E-04	1.38E-09	1.07E-08
New Pipeline Intermediate	Haul Trucks	HDDV	6	40	240	0.1108	2.32E-02	1.08E-06	1.69E-07
	Pickup Trucks	LDDT	6	160	960	0.1108	4.80E-02	2.34E-07	1.82E-06
New Sales Pipeline	Haul Trucks	HDDV	35	94	3290	0.0002	4.73E-04	2.21E-08	3.44E-09
	Pickup Trucks	LDDT	50	94	4700	0.0002	3.49E-04	1.71E-09	1.32E-08
Electric Line	Haul Trucks	HDDV	6	1	6	1.0000	5.24E-03	2.45E-07	3.82E-08
	Pickup Trucks	LDDT	6	2	12	1.0000	5.42E-03	2.65E-08	2.05E-07
Field Compression Station	Semi Trucks	HDDV	10	15	150	0.1108	1.45E-02	6.78E-07	1.06E-07
	Haul Trucks	HDDV	10	48	480	0.1108	4.64E-02	2.17E-06	3.38E-07
	Pickup Trucks	LDDT	10	192	1920	0.1108	9.60E-02	4.69E-07	3.63E-06
Sales Compression Station	Semi Trucks	HDDV	10	19	190	0.0110	1.83E-03	8.55E-08	1.33E-08
	Haul Trucks	HDDV	10	48	480	0.0110	4.62E-03	2.16E-07	3.37E-08
	Pickup Trucks	LDDT	10	192	1920	0.0110	9.56E-03	4.67E-08	3.62E-07
Rig-up, Drilling, and Rig-down	Semi Rig Transport	HDDV	6	1	6	1.0000	5.24E-03	2.45E-07	3.82E-08
	Fuel Haul Truck	HDDV	6	2	12	1.0000	1.05E-02	4.89E-07	7.63E-08
	Mud Haul Truck, Water Hauling	HDDV	6	7	42	1.0000	3.67E-02	1.71E-06	2.67E-07
	Rig Crew	LDDT	6	3	18	1.0000	8.13E-03	3.97E-08	3.08E-07
	Rig Mechanics	HDDV	6	1	6	1.0000	5.24E-03	2.45E-07	3.82E-08
	Co. Supervisor	LDDT	6	8	48	1.0000	2.17E-02	1.06E-07	8.20E-07
	Tool Pusher	LDDT	6	6	36	1.0000	1.63E-02	7.94E-08	6.15E-07
	Mud Logger	LDDT	6	1	6	1.0000	2.71E-03	1.32E-08	1.03E-07
	Mud Engineer	LDDT	6	1	6	1.0000	2.71E-03	1.32E-08	1.03E-07
	Logger, Engr	HDDV	6	1	6	1.0000	5.24E-03	2.45E-07	3.82E-08
	Drill Bit Delivery	LDDT	6	1	6	1.0000	2.71E-03	1.32E-08	1.03E-07
						Subtotal	**4.07E-01**	**9.83E-06**	**9.66E-06**

Activity rates based on values shown in SEIS. Water disposal well pad development rates provided by Montana BLM (Laakso, 2010).

Combustive Emissions Estimation Road Traffic - Based on Peak Wells Drilled

Construction Activity	Vehicle		Round Trip Distance (miles)	# of Round Trips/Activity	Miles Traveled/Activity	Total # of Activities / Well	Emissions (tons/year)		
	Type	Class					CO_2	CH_4	N_2O
Well Completion & Testing	Semi Casing Haulers	HDDV	6	1	6	1.0000	5.24E-03	2.45E-07	3.82E-08
	Semi Completion, Unit Rig	HDDV	6	1	6	1.0000	5.24E-03	2.45E-07	3.82E-08
	Semi Fracing Blender	HDDV	6	1	6	1.0000	5.24E-03	2.45E-07	3.82E-08
	Semi Pumping Tank Battery	HDDV	6	1	6	1.0000	5.24E-03	2.45E-07	3.82E-08
	Tubing Truck	HDDV	6	1	6	1.0000	5.24E-03	2.45E-07	3.82E-08
	Haul Cementer, Pump Truck	HDDV	6	1	6	1.0000	5.24E-03	2.45E-07	3.82E-08
	Haul Cementer, Cement Truck	HDDV	6	1	6	1.0000	5.24E-03	2.45E-07	3.82E-08
	Haul Completion, Equip Truck	HDDV	6	1	6	1.0000	5.24E-03	2.45E-07	3.82E-08
	Haul Service Tools	LDDT	6	1	6	1.0000	2.71E-03	1.32E-08	1.03E-07
	Haul Perforators Logging Truck	HDDV	6	1	6	1.0000	5.24E-03	2.45E-07	3.82E-08
	Haul Anchor Installation	HDDV	6	1	6	1.0000	5.24E-03	2.45E-07	3.82E-08
	Haul Anchor Testing	HDDV	6	1	6	1.0000	5.24E-03	2.45E-07	3.82E-08
	Haul Fracing Tank	HDDV	6	1	6	1.0000	5.24E-03	2.45E-07	3.82E-08
	Haul Fracing Pump	HDDV	6	1	6	1.0000	5.24E-03	2.45E-07	3.82E-08
	Haul Fracing Chemical	HDDV	6	1	6	1.0000	5.24E-03	2.45E-07	3.82E-08
	Haul Fracing Sand	HDDV	6	1	6	1.0000	5.24E-03	2.45E-07	3.82E-08
	Haul Fracing	HDDV	6	1	6	1.0000	5.24E-03	2.45E-07	3.82E-08
	Haul Welders	HDDV	6	1	6	1.0000	5.24E-03	2.45E-07	3.82E-08
	Haul Water Truck	HDDV	6	9	54	1.0000	4.71E-02	2.20E-06	3.43E-07
	Pickup Cementer, Engineer	LDDT	6	1	6	1.0000	2.71E-03	1.32E-08	1.03E-07
	Pickup Completion Crew	HDDV	6	1	6	1.0000	5.24E-03	2.45E-07	3.82E-08
	Pickup Completion Pusher	LDDT	6	1	6	1.0000	2.71E-03	1.32E-08	1.03E-07
	Pickup Perforators Engineer	LDDT	6	1	6	1.0000	2.71E-03	1.32E-08	1.03E-07
	Pickup Fracing Engineer	HDDV	6	1	6	1.0000	5.24E-03	2.45E-07	3.82E-08
	Pickup Co. Supervisor	LDDT	6	2	12	1.0000	5.42E-03	2.65E-08	2.05E-07
	Pickup Misc. Supplies	LDDT	6	1	6	1.0000	2.71E-03	1.32E-08	1.03E-07
	Pickup Roustabout Crew	HDDV	6	2	12	1.0000	1.05E-02	4.89E-07	7.63E-08
Water Disposal Well Drilling	Drill Rig Transport truck	HDDV	10	10	100	0.0050	4.36E-04	2.04E-08	3.18E-09
	Mud Haul Truck, Water Hauling	HDDV	10	5	50	0.0050	2.18E-04	1.02E-08	1.59E-09
	Rig Crew	LDDT	10	10	100	0.0050	2.26E-04	1.10E-09	8.54E-09
	Co. Supervisor	LDDT	10	5	50	0.0050	1.13E-04	5.51E-10	4.27E-09
	Tool Pusher	LDDT	10	5	50	0.0050	1.13E-04	5.51E-10	4.27E-09
	Tubing Truck	HDDV	10	1	10	0.0050	4.36E-05	2.04E-09	3.18E-10
	Haul Cementer, Pump Truck	HDDV	10	1	10	0.0050	4.36E-05	2.04E-09	3.18E-10
	Haul Cementer, Cement Truck	HDDV	10	1	10	0.0050	4.36E-05	2.04E-09	3.18E-10
						Subtotal	**1.77E-01**	**7.47E-06**	**1.89E-06**
						Total	**5.84E-01**	**1.73E-05**	**1.15E-05**

Activity rates based on values shown in SEIS. Water disposal well pad development rates provided by Montana BLM (Laakso, 2010).

Exhaust Emissions from Construction and Drilling Support Vehicles

Emission factors for Commuting Vehicles Exhaust

Vehicle		Emission Factors (g/mi)		
Type	**Class**	**CO_2**	**CH_4**	**N_2O[a]**
Light-Duty Diesel Truck	LDDT	409.5	0.002	0.016
Heavy-Duty Diesel Truck	HDDV	791.8	0.037	0.006

Source: MOBILE6.2.03

[a] 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).

Combustive Emissions Estimation Road Traffic - Based on Peak Wells Drilled

Construction Activity	Vehicle		Round Trip Distance (miles)	# of Round Trips/Activity	Miles Traveled/Activity	Total # of Activities / Well	Emissions (tons/year/well)		
	Type	**Class**					**CO_2**	**CH_4**	**N_2O**
Drilling Roads	Semi Trucks	HDDV	6	3	18	1.0000	1.57E-02	7.34E-07	1.14E-07
Drilling Well Pad	Haul Trucks	HDDV	6	2	12	1.0000	1.05E-02	4.89E-07	7.63E-08
	Pickup Trucks	LDDT	6	2	12	1.0000	5.42E-03	2.65E-08	2.05E-07
Water Disposal Well Pad	Haul Trucks	HDDV	100	5	500	0.0050	2.18E-03	1.02E-07	1.59E-08
	Pickup Trucks	LDDT	25	5	125	0.0050	2.82E-04	1.38E-09	1.07E-08
New Pipeline Intermediate	Haul Trucks	HDDV	6	40	240	0.1108	2.32E-02	1.08E-06	1.69E-07
	Pickup Trucks	LDDT	6	160	960	0.1108	4.80E-02	2.34E-07	1.82E-06
New Sales Pipeline	Haul Trucks	HDDV	35	94	3290	0.0002	4.73E-04	2.21E-08	3.44E-09
	Pickup Trucks	LDDT	50	94	4700	0.0002	3.49E-04	1.71E-09	1.32E-08
Electric Line	Haul Trucks	HDDV	6	1	6	1.0000	5.24E-03	2.45E-07	3.82E-08
	Pickup Trucks	LDDT	6	2	12	1.0000	5.42E-03	2.65E-08	2.05E-07
Field Compression Station	Semi Trucks	HDDV	10	15	150	0.1108	1.45E-02	6.78E-07	1.06E-07
	Haul Trucks	HDDV	10	48	480	0.1108	4.64E-02	2.17E-06	3.38E-07
	Pickup Trucks	LDDT	10	192	1920	0.1108	9.60E-02	4.69E-07	3.63E-06
Sales Compression Station	Semi Trucks	HDDV	10	19	190	0.0110	1.83E-03	8.55E-08	1.33E-08
	Haul Trucks	HDDV	10	48	480	0.0110	4.62E-03	2.16E-07	3.37E-08
	Pickup Trucks	LDDT	10	192	1920	0.0110	9.56E-03	4.67E-08	3.62E-07
Rig-up, Drilling, and Rig-down	Semi Rig Transport	HDDV	6	1	6	1.0000	5.24E-03	2.45E-07	3.82E-08
	Fuel Haul Truck	HDDV	6	2	12	1.0000	1.05E-02	4.89E-07	7.63E-08
	Mud Haul Truck, Water Hauling	HDDV	6	7	42	1.0000	3.67E-02	1.71E-06	2.67E-07
	Rig Crew	LDDT	6	3	18	1.0000	8.13E-03	3.97E-08	3.08E-07
	Rig Mechanics	HDDV	6	1	6	1.0000	5.24E-03	2.45E-07	3.82E-08
	Co. Supervisor	LDDT	6	8	48	1.0000	2.17E-02	1.06E-07	8.20E-07
	Tool Pusher	LDDT	6	6	36	1.0000	1.63E-02	7.94E-08	6.15E-07
	Mud Logger	LDDT	6	1	6	1.0000	2.71E-03	1.32E-08	1.03E-07
	Mud Engineer	LDDT	6	1	6	1.0000	2.71E-03	1.32E-08	1.03E-07
	Logger, Engr	HDDV	6	1	6	1.0000	5.24E-03	2.45E-07	3.82E-08
	Drill Bit Delivery	LDDT	6	1	6	1.0000	2.71E-03	1.32E-08	1.03E-07
						Subtotal	**4.07E-01**	**9.83E-06**	**9.66E-06**

Activity rates based on values shown in SEIS. Water disposal well pad development rates provided by Montana BLM (Laakso, 2010).

Combustive Emissions Estimation Road Traffic - Based on Peak Wells Drilled

Construction Activity	Vehicle		Round Trip Distance (miles)	# of Round Trips/Activity	Miles Traveled/Activity	Total # of Activities / Well	Emissions (tons/year)		
	Type	Class					CO_2	CH_4	N_2O
Well Completion & Testing	Semi Casing Haulers	HDDV	6	1	6	1.0000	5.24E-03	2.45E-07	3.82E-08
	Semi Completion, Unit Rig	HDDV	6	1	6	1.0000	5.24E-03	2.45E-07	3.82E-08
	Semi Fracing Blender	HDDV	6	1	6	1.0000	5.24E-03	2.45E-07	3.82E-08
	Semi Pumping Tank Battery	HDDV	6	1	6	1.0000	5.24E-03	2.45E-07	3.82E-08
	Tubing Truck	HDDV	6	1	6	1.0000	5.24E-03	2.45E-07	3.82E-08
	Haul Cementer, Pump Truck	HDDV	6	1	6	1.0000	5.24E-03	2.45E-07	3.82E-08
	Haul Cementer, Cement Truck	HDDV	6	1	6	1.0000	5.24E-03	2.45E-07	3.82E-08
	Haul Completion, Equip Truck	HDDV	6	1	6	1.0000	5.24E-03	2.45E-07	3.82E-08
	Haul Service Tools	LDDT	6	1	6	1.0000	2.71E-03	1.32E-08	1.03E-07
	Haul Perforators Logging Truck	HDDV	6	1	6	1.0000	5.24E-03	2.45E-07	3.82E-08
	Haul Anchor Installation	HDDV	6	1	6	1.0000	5.24E-03	2.45E-07	3.82E-08
	Haul Anchor Testing	HDDV	6	1	6	1.0000	5.24E-03	2.45E-07	3.82E-08
	Haul Fracing Tank	HDDV	6	1	6	1.0000	5.24E-03	2.45E-07	3.82E-08
	Haul Fracing Pump	HDDV	6	1	6	1.0000	5.24E-03	2.45E-07	3.82E-08
	Haul Fracing Chemical	HDDV	6	1	6	1.0000	5.24E-03	2.45E-07	3.82E-08
	Haul Fracing Sand	HDDV	6	1	6	1.0000	5.24E-03	2.45E-07	3.82E-08
	Haul Fracing Other	HDDV	6	1	6	1.0000	5.24E-03	2.45E-07	3.82E-08
	Haul Welders	HDDV	6	1	6	1.0000	5.24E-03	2.45E-07	3.82E-08
	Haul Water Truck	HDDV	6	9	54	1.0000	4.71E-02	2.20E-06	3.43E-07
	Pickup Cementer, Engineer	LDDT	6	1	6	1.0000	2.71E-03	1.32E-08	1.03E-07
	Pickup Completion Crew	HDDV	6	1	6	1.0000	5.24E-03	2.45E-07	3.82E-08
	Pickup Completion Pusher	LDDT	6	1	6	1.0000	2.71E-03	1.32E-08	1.03E-07
	Pickup Perforators Engineer	LDDT	6	1	6	1.0000	2.71E-03	1.32E-08	1.03E-07
	Pickup Fracing Engineer	HDDV	6	1	6	1.0000	5.24E-03	2.45E-07	3.82E-08
	Pickup Co. Supervisor	LDDT	6	2	12	1.0000	5.42E-03	2.65E-08	2.05E-07
	Pickup Misc. Supplies	LDDT	6	1	6	1.0000	2.71E-03	1.32E-08	1.03E-07
	Pickup Roustabout Crew	HDDV	6	2	12	1.0000	1.05E-02	4.89E-07	7.63E-08
	Drill Rig Transport truck	HDDV	10	10	100	0.0050	4.36E-04	2.04E-08	3.18E-09

Construction Activity	Vehicle		Round Trip Distance (miles)	# of Round Trips/Activity	Miles Traveled/Activity	Total # of Activities / Well	Emissions (tons/year)		
	Type	Class					CO_2	CH_4	N_2O
Water Disposal Well Drilling	Mud Haul Truck, Water Hauling	HDDV	10	5	50	0.0050	2.18E-04	1.02E-08	1.59E-09
	Rig Crew	LDDT	10	10	100	0.0050	2.26E-04	1.10E-09	8.54E-09
	Co. Supervisor	LDDT	10	5	50	0.0050	1.13E-04	5.51E-10	4.27E-09
	Tool Pusher	LDDT	10	5	50	0.0050	1.13E-04	5.51E-10	4.27E-09
	Tubing Truck	HDDV	10	1	10	0.0050	4.36E-05	2.04E-09	3.18E-10
	Haul Cementer, Pump Truck	HDDV	10	1	10	0.0050	4.36E-05	2.04E-09	3.18E-10
	Haul Cementer, Cement Truck	HDDV	10	1	10	0.0050	4.36E-05	2.04E-09	3.18E-10
						Subtotal	**1.77E-01**	**7.47E-06**	**1.89E-06**
						Total	**5.84E-01**	**1.73E-05**	**1.15E-05**

Activity rates based on values shown in SEIS. Water disposal well pad development rates provided by Montana BLM (Laakso, 2010).

Compressor Stations Emissions

Emission Factors for Natural Gas-Fired Compressors

Compressor		Horse-Power Rating	Units	Emission Factors		
				CO_2[a]	CH_4[a]	N_2O[a]
Field Compression Station	Rich Burn	300	gm/bhp-hr	134.936	2.55E-03	2.55E-04
			lb/MMBTU	116.887	2.20E-03	2.20E-04
Sales Compression Station	Rich Burn	1,680	gm/bhp-hr	134.936	2.55E-03	2.55E-04
			lb/MMBTU	116.887	2.20E-03	2.20E-04

Note: Compressors assumed to be equipped with nonselective catalytic reduction (NSCR) catalyst.

[a] 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 (tons/year/well)		
					CO_2	CH_4	N_2O
Field Compression Station	12	1	12	8,760	1.62E+01	3.06E-04	3.06E-05
Sales Compression Station	12	1	12	8,760	1.51E+01	2.86E-04	2.86E-05
				Total	**3.14E+01**	**5.92E-04**	**5.92E-05**

Compression rate of 36 - 300 hp field compressors, and 6 - 1680 hp sales compressors per 867 CBNG wells based on BLM survey (Laakso, 2010)

Compressor Station Fugitives

Fugitive Emissions from Equipment Leaks

TOC Emission Factor								
Well Equipment Component	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% =	0.00
CO2 Wt% =	2.28
CH4 Wt% =	95.72
N2O Wt% =	0.00

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	0.291	0.0099	0	0.0055	0	0.0002	2.88E-03	5.46E-08	6.58E-05	2.76E-03
pump seals	0.000	0.0053	0	0.0287	0	0.0001	0.00E+00	0.00E+00	0.00E+00	0.00E+00
others	0.000	0.0194	0	0.0165	0	0.0309	0.00E+00	0.00E+00	0.00E+00	0.00E+00
connectors	0.415	0.0004	0	0.0005	0	0.0002	1.83E-04	3.47E-09	4.18E-06	1.75E-04
flanges	0.997	0.0009	0	0.0002	0	0.0000	8.57E-04	1.62E-08	1.95E-05	8.20E-04
open-ended lines	0.000	0.0044	0	0.0031	0	0.0006	0.00E+00	0.00E+00	0.00E+00	0.00E+00
					TOTAL emissions/well/hr =		3.92E-03	7.43E-08	8.95E-05	3.76E-03

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 (ton/yr)**	**CO_2 emissions (lb/yr)**	**CO_2 emissions (ton/yr)**	**CH_4 emissions (lb/yr)**	**CH_4 emissions (ton/yr)**
Year 20	1	8760	6.51E-04	3.25E-07	7.84E-01	3.92E-04	3.29E+01	1.64E-02

Dehydrator Emissions

Emission Factors for Dehydrator Heaters

Unit	CO_2	CH_4	N_2O
lb/MMSCF	120000.0	2.3	2.2
lb/MMBTU	117.647	0.002	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 (tons/year/well)		
				CO_2	CH_4	N_2O
2,190	1	2.20	0.001	1.70E-01	3.25E-06	3.11E-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)
16.43	1.59E-02	2.61E-01	0.00E+00	0.00E+00

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 South Baker Compressor Station assumptions were used with CBNG 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

Compressor Stations Inspection Traffic Exhaust Emissions

Emission factors for Commuting Vehicles Exhaust

Vehicle		Emission Factors (g/mi)		
Type	Class	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	409.5	0.002	0.016

Source: MOBILE6.2.03

[a] 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).

Exhaust Emissions Estimation for Road Traffic

Activity	Compressor Station	Vehicle		# of Compressor Stations / Well	# of Inspection Visits/ Station	# of Inspection Visits/Well/Year	Total Miles/ Inspection	Emissions (tons/year/well)		
		Type	Class					CO_2	CH_4	N_2O
Inspection Visits for Compressor Stations	CPF Compressor Station	Pickup Truck	LDGT2	0.04	12	0.5	20	4.50E-03	2.20E-08	1.70E-07
	Primary Compressor Station	Pickup Truck	LDGT2	0.01	52	0.4	20	3.25E-03	1.59E-08	1.23E-07
							Total	**7.75E-03**	**3.78E-08**	**2.93E-07**

CBNG Well Work-Over Emissions

Emission Factors for Off-Road Engines of 300 to 600 hp

Year	Emission Factors (g/hp-hr)		
	CO_2	CH_4	N_2O[a]
2008	529.575	0.007	0.006
2018	530.255	0.004	0.006
2027	530.521	0.003	0.006

Source: EPA NONROADS 2008a

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

On-Site Exhaust Emission Estimations for Well Workover

Activity	Equipment	Capacity (hp)	Operating Hours/Day	Operational Wells	Emissions (tons/year)		
					CO_2	CH_4	N_2O
Well Workover	Truck-Mounted Unit[b]	400	24	1	5.61E+00	4.19E-05	6.11E-05

Activity rates based on values shown in SEIS

Emission Factors for Road Traffic

Vehicle Class	Emission Factors (g/mi)		
	CO_2	CH_4	N_2O[a]
Heavy-Duty Diesel Truck	791.8	0.04	0.006

Source: MOBILE6.2.03

On-Road Exhaust Emissions Estimation for Road Traffic

Activity	Vehicle		Round Trip Distance (miles)	Round Trips/Well	Miles Traveled/Well	Operational Wells	Emissions (tons/year)		
	Type	Class					CO_2	CH_4	N_2O
Well Workover	Bobtail Truck	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07

Activity rates based on values shown in SEIS

Traffic Exhaust Emissions for Well and Pipe Inspections

Exhaust Emission Factors for Road Traffic

Vehicle Class	(g/mi)		
	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	409.5	0.002	0.016

Source: MOBILE6.2.03

[a] 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).

Exhaust Emission Estimations for Road Traffic: Well & Pipeline

Activity	Vehicle		Round Trip Distance (miles)	# of Visits/ Well/Year	Total # of Operating Wells	Miles Traveled/Year	Emissions (tons/year/well)		
	Type	Class					CO_2	CH_4	N_2O
Visits for Inspection and Repair	200-hp Pickup	LDDT	0.625	12	1	8	3.39E-03	1.65E-08	1.28E-07

Activity rates based on values shown in SEIS

Exhaust Emissions for Road Maintenance

Estimation of Total and Cumulative Length of Roads

Length of Roads Built per Well	0.25
Cumulative Length of Roads Maintained (miles)	0.25

Based on values shown in SEIS

Estimation of Total Operation Days and Hours

Season	# of Operations/ Year	Cumulative Length of Roads (miles/year)	Miles of Road Worked on/Day	# of Operating Hours/Day	Total # of Operating Days	Total # of Operating Hours
Summer	2	0.25	6	10	0.1	1
Winter	1	0.25	5	10	0.1	1
				Total	**0.1**	**1**

Based on values shown in SEIS

Emission Factors for 100-175 hp Off-Road Engine

Year	Emission Factors (g/hp-hr)		
	CO_2	CH_4	N_2O[a]
Year 2008	540.319	0.007	0.006
Year 2018	546.217	0.004	0.006
Year 2028	546.466	0.002	0.006

Source: EPA NONROADS 2008a

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

Exhaust Emissions Estimation for Grader

Activity	Vehicle Type	Capacity (hp)[a]	Total # of Operating Hours[a]	Emissions (tons/year/well)		
				CO_2	CH_4	N_2O
Road Maintenance	Grader	135	1	6.50E-02	4.44E-07	6.87E-07

[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 Emission Factors for Commuting Maintenance Vehicles Road Traffic

Vehicle Class	Emission Factors (g/mi)		
	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	409.5	0.002	0.016

Source: MOBILE6.2.03

[a] 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).

Exhaust Emissions Estimation for Commuting Maintenance Vehicles Road Traffic

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tons/year/well)		
	Type	Class				CO_2	CH_4	N_2O
Road Maintenance	Pickup Truck	LDDV	6	0.1	0.8	3.61E-04	1.76E-09	1.37E-08

Exhaust 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	2.77
Annual Miles of Roads reclaimed Per Well	0.69
Number of wells reclaimed (per well)	2.77

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
0.69	6	0.1	1
		Total	**1**

Assume average miles/day = 6

Emission Factors for 75-100 hp Off-Road Engines

Year	Emission Factors (g/hp-hr)		
	CO_2	CH_4	N_2O[a]
2008	600.5	0.010	0.016
2018	613.9	0.006	0.016
2027	608.6	0.003	0.016

[a] 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).

Exhaust Emissions Estimation for Grader Road Reclaim

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours[a]	Emissions (tons/year/well)		
				CO_2	CH_4	N_2O
Road Reclamation	Grader	80	0.7	3.74E-02	3.37E-07	9.45E-07

Exhaust Emission Factors for Commuting Reclaim Vehicles Road Traffic

Vehicle Class	Emission Factors (g/mi)		
	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	409.5	0.002	0.016

Source: MOBILE6.2.03

[a] 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).

Exhaust Emissions Estimation for Commuting Reclaim Vehicles: Road Traffic

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tons/year/well)		
	Type	Class				CO_2	CH_4	N_2O
Road Reclamation	Pickup Truck	LDDV	6	0.12	1	3.12E-04	1.52E-09	1.18E-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	2.767	10	2.767	27.667

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

Exhaust Emissions Estimation for Grader: Well Reclamation

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours [a]	Emissions (tons/year/well)		
				CO_2	CH_4	N_2O
Well Reclamation	Grader	100	17	1.10E+00	1.83E-05	2.84E-05

Exhaust Emissions Estimation for Commuting Vehicles: Well Reclamation

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tons/year/well)		
	Type	Class				CO_2	CH_4	N_2O
Well Reclamation	Pickup Truck	LDDV	6	2.77	16.60	7.49E-03	3.66E-08	2.84E-07

Wellhead Fugitives

Fugitive Emissions from Equipment Leaks

TOC Emission Factor								
Well Equipment Component	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 CBNG analysis

VOC Wt% =	0.00
CO2 Wt% =	2.28
CH4 Wt% =	95.72
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	6	0.0099	1	0.0055	0	0.0002	6.50E-02	1.23E-06	1.48E-03	6.22E-02
pump seals	0	0.0053	0	0.0287	0	0.0001	0.00E+00	0.00E+00	0.00E+00	0.00E+00
others	0	0.0194	0	0.0165	0	0.0309	0.00E+00	0.00E+00	0.00E+00	1.24E-01
connectors	10	0.0004	0	0.0005	0	0.0002	4.41E-03	8.35E-08	1.01E-04	1.55E-01
flanges	7	0.0009	0	0.0002	0	0.0000	6.02E-03	1.14E-07	1.37E-04	2.75E-02
open-ended lines	0	0.0044	0	0.0031	0	0.0006	0.00E+00	0.00E+00	0.00E+00	8.01E-02
					TOTAL emissions/well/hr =		7.55E-02	1.43E-06	1.72E-03	4.50E-01

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 (ton/yr)**	**CO_2 emissions (lb/yr)**	**CO_2 emissions (ton/yr)**	**CH_4 emissions (lb/yr)**	**CH_4 emissions (ton/yr)**
Year 20	1	8760	1.25E-02	6.26E-06	1.51E+01	7.54E-03	3.94E+03	1.97E+00

Speciated Analysis - CBNG & 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	97.913	16.040	15.705	95.715	40640.682	2.743
Ethane	0.000	30.070	0.000	0.000	0.000	0.000
Nitrogen	1.172	28.020	0.328	2.001	849.791	0.057
Water	0.000	18.015	0.000	0.000	0.000	0.000
Carbon Dioxide	0.851	43.990	0.374	2.281	968.723	0.065
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	99.936	---	16.408	99.998		2.866
Propane	0.000	44.100	0.000	0.000	0.000	0.000
Iso-butane	0.000	58.120	0.000	0.000	0.000	0.000
n-butane	0.000	58.120	0.000	0.000	0.000	0.000
i-pentane	0.000	72.150	0.000	0.000	0.000	0.000
n-pentane	0.000	72.150	0.000	0.000	0.000	0.000
Hexanes	0.000	100.210	0.000	0.000	0.000	0.000
Heptanes	0.000	100.200	0.000	0.002	0.804	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	0.000	---	0.000	0.002		0.000
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]	*0.000*	*100.210*	*0.000*	*0.000*	*0.000*	*0.000*
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	0.000	---	0.000	0.000		0.000
Totals	**99.936**	**---**	**16.408**	**100.000**		**2.866**

Sample taken 01-19-2010 at Holmes 14 Battery, Ft. Union. (Miles City)

Volume Flow:	45	MSCF/day/well
Completion activity duration:	3	days
Total Volume Flow per Well	0.135	MMSCF/well

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

BTU value = 994 BTU/scf

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Appendix D

Dillon Planning Area GHG Emission Inventory

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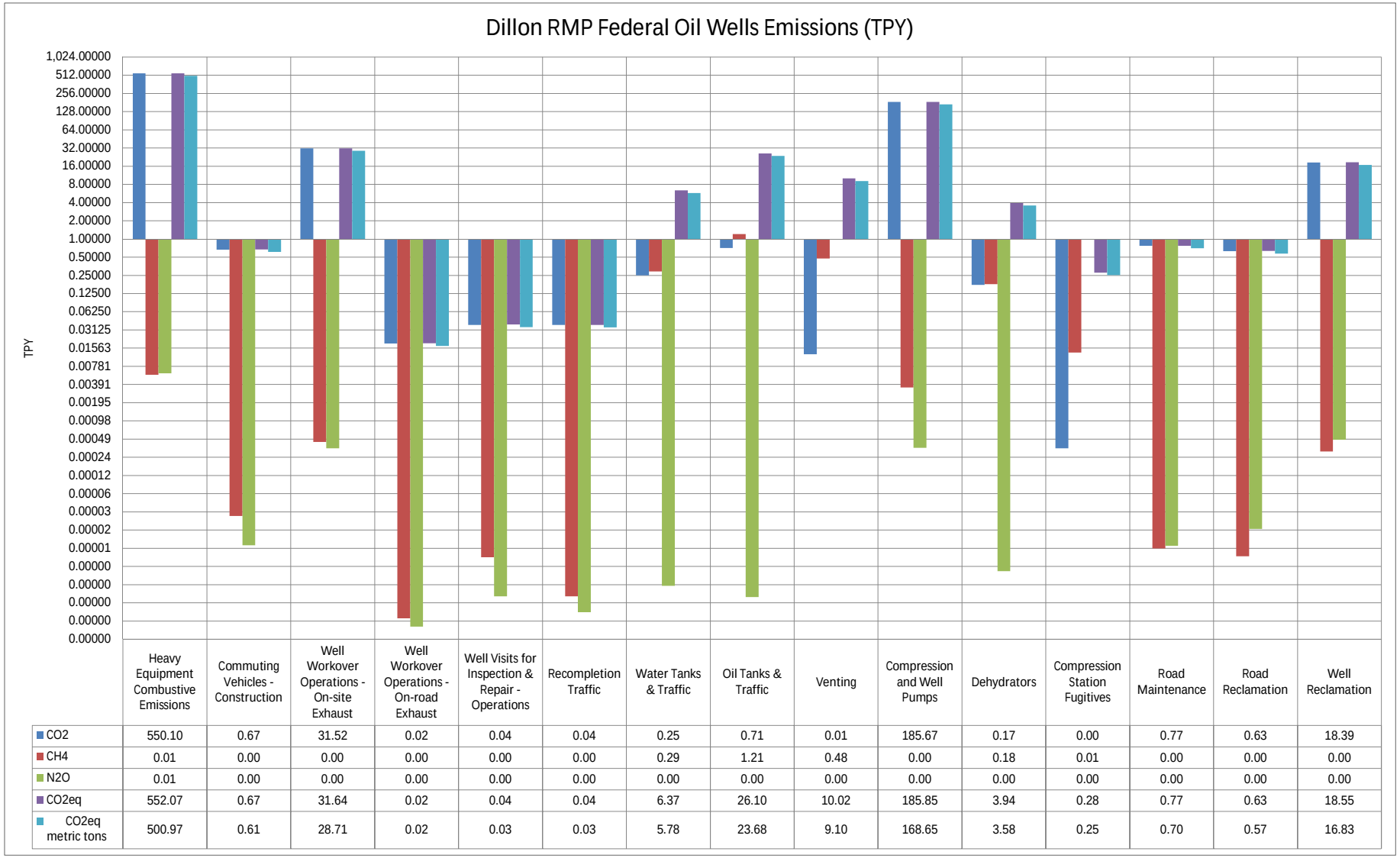
Dillon input parameters for calculating oil wells emissions

Maximum Annual Wells Drilled - Federal (RMP estimate)	1	Maximum Annual Wells Drilled - Non-Federal (RMP estimate)	1
Federal Producing Wells - RMP Year 20	3	Non-Federal Producing Wells - RMP Year 20	0
Average Well Barrel Oil Per Day (BOPD)	17	Average Well Barrel Oil Per Day (BOPD)	17

Federal Oil Wells Summaries

Total Annual Emissions from Federal Oil Wells - RMP Year 20

Activity	Annual Emissions (Tons)				
	CO_2	CH_4	N_2O	CO_{2eq}	CO_{2eq} metric tons
Well Pad Construction - Fugitive Dust	---	---	---	---	---
Heavy Equipment Combustive Emissions	550.10	0.01	0.01	552.07	500.97
Commuting Vehicles - Construction	0.67	0.00	0.00	0.67	0.61
Wind Erosion	---	---	---	---	---
Sub-total: Construction	**550.77**	**0.01**	**0.01**	**552.74**	**501.58**
Well Workover Operations - Fugitive Dust	---	---	---	---	---
Well Workover Operations - On-site Exhaust	31.52	0.00	0.00	31.64	28.71
Well Workover Operations - On-road Exhaust	0.02	0.00	0.00	0.02	0.02
Well Visits for Inspection & Repair - Operations	0.04	0.00	0.00	0.04	0.03
Recompletion Traffic	0.04	0.00	0.00	0.04	0.03
Water Tanks & Traffic	0.25	0.29	0.00	6.37	5.78
Oil Tanks & Traffic	0.71	1.21	0.00	26.10	23.68
Venting	0.01	0.48	0.00	10.02	9.10
Compression and Well Pumps	185.67	0.00	0.00	185.85	168.65
Dehydrators	0.17	0.18	0.00	3.94	3.58
Compression Station Fugitives	0.00	0.01	0.00	0.28	0.25
Sub-total: Operations	**218.43**	**2.17**	**0.00**	**264.30**	**239.84**
Road Maintenance	0.77	0.00	0.00	0.77	0.70
Sub-total: Maintenance	**0.770**	**0.000**	**0.00**	**0.77**	**0.70**
Road Reclamation	0.63	0.00	0.00	0.63	0.57
Well Reclamation	18.39	0.00	0.00	18.55	16.83
Sub-total: Reclamation	**19.0217**	**0.0003**	**0.0005**	**19.1808**	**17.4055**
Total Emissions	**788.99**	**2.18**	**0.01**	**837.00**	**759.53**



	Heavy Equipment Combustive Emissions	Commuting Vehicles - Construction	Well Workover Operations - On-site Exhaust	Well Workover Operations - On-road Exhaust	Well Visits for Inspection & Repair - Operations	Recompletion Traffic	Water Tanks & Traffic	Oil Tanks & Traffic	Venting	Compression and Well Pumps	Dehydrators	Compression Station Fugitives	Road Maintenance	Road Reclamation	Well Reclamation
CO2	550.10	0.67	31.52	0.02	0.04	0.04	0.25	0.71	0.01	185.67	0.17	0.00	0.77	0.63	18.39
CH4	0.01	0.00	0.00	0.00	0.00	0.00	0.29	1.21	0.48	0.00	0.18	0.01	0.00	0.00	0.00
N2O	0.01	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
CO2eq	552.07	0.67	31.64	0.02	0.04	0.04	6.37	26.10	10.02	185.85	3.94	0.28	0.77	0.63	18.55
CO2eq metric tons	500.97	0.61	28.71	0.02	0.03	0.03	5.78	23.68	9.10	168.65	3.58	0.25	0.70	0.57	16.83

Non-Federal Oil Wells Summaries

Total Annual Emissions from Non-Federal Oil Wells - RMP Year 20

Activity	Annual Emissions (Tons)				
	CO_2	CH_4	N_2O	CO_{2eq}	CO_{2eq} metric tons
Well Pad Construction - Fugitive Dust	---	---	---	---	---
Heavy Equipment Combustive Emissions	550.10	0.01	0.01	552.07	500.97
Commuting Vehicles - Construction	0.67	0.00	0.00	0.67	0.61
Wind Erosion	---	---	---	---	---
Sub-total: Construction	**550.77**	**0.01**	**0.01**	**552.74**	**501.58**
Well Workover Operations - Fugitive Dust			---	---	---
Well Workover Operations - On-site Exhaust	0.00	0.00	0.00	0.00	0.00
Well Workover Operations - On-road Exhaust	0.00	0.00	0.00	0.00	0.00
Well Visits for Inspection & Repair - Operations	0.00	0.00	0.00	0.00	0.00
Recompletion Traffic	0.00	0.00	0.00	0.00	0.00
Water Tanks & Traffic	0.00	0.00	0.00	0.00	0.00
Oil Tanks & Traffic	0.00	0.00	0.00	0.00	0.00
Venting	0.01	0.41	0.00	8.72	7.91
Compression and Well Pumps	0.00	0.00	0.00	0.00	0.00
Dehydrators	0.00	0.00	0.00	0.00	0.00
Compression Station Fugitives	0.00	0.00	0.00	0.00	0.00
Sub-total: Operations	**0.01**	**0.41**	**0.00**	**8.72**	**7.91**
Road Maintenance	0.00	0.00	0.00	0.00	0.00
Sub-total: Maintenance	**0.000**	**0.000**	**0.00**	**0.00**	**0.00**
Road Reclamation	0.00	0.00	0.00	0.00	0.00
Well Reclamation	0.00	0.00	0.00	0.00	0.00
Sub-total: Reclamation	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**
Total Emissions	**550.78**	**0.42**	**0.01**	**561.46**	**509.49**

	Heavy Equipment Combustive Emissions	Commuting Vehicles - Construction	Well Workover Operations - On-site Exhaust	Well Workover Operations - On-road Exhaust	Well Visits for Inspection & Repair - Operations	Recompletion Traffic	Water Tanks & Traffic	Oil Tanks & Traffic	Venting	Compression and Well Pumps	Dehydrators	Compression Station Fugitives	Road Maintenance	Road Reclamation	Well Reclamation
CO2	550.10	0.67	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
CH4	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.41	0.00	0.00	0.00	0.00	0.00	0.00
N2O	0.01	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
CO2eq	552.07	0.67	0.00	0.00	0.00	0.00	0.00	0.00	8.72	0.00	0.00	0.00	0.00	0.00	0.00
CO2eq metric tons	500.97	0.61	0.00	0.00	0.00	0.00	0.00	0.00	7.91	0.00	0.00	0.00	0.00	0.00	0.00

Exhaust Emissions from Well Pad Construction Heavy Equipment and Drilling Equipment

Emission Factors for Construction Equipment

Equipment	Emission Factors (g/hp-hr)			Equipment Category
	CO_2	CH_4	N_2O[a]	
Dozer - 175 Hp	535.76	0.005	0.006	Track-Type Tractor
Blade - 150 Hp	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] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

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 (tons/equipment type/well)		
									CO_2	CH_4	N_2O
Improved & Two-Track Road	Blade	150	1	75	10	2	20	1	1.47E+00	1.87E-05	1.43E-05
Well Pad	Blade	175	1	75	10	3	30	1	2.58E+00	3.28E-05	2.50E-05
	Dozer	175	1	80	10	3	30	1	2.75E+00	3.50E-05	2.67E-05
									6.81E+00	**8.64E-05**	**6.61E-05**

Exhaust Emission Factors for Diesel Powered Bore/Drill Rig Engines

Project Year/Hp Category	Emission Factors (g/hp-hr)		
	CO_2	CH_4	N_2O[a]
Year 2018			
50 to 75	589.096	0.006	0.006
75 to 100	589.103	0.006	0.006
100 to 175	530.097	0.005	0.006
175 to 300	530.181	0.004	0.006
300 to 600	530.255	0.004	0.006
600 to 750	530.283	0.004	0.006
>750	529.917	0.006	0.006

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

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

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 (tons/equipment type/well)		
									CO_2	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Main Deck	1,000	3	70	24	16	384	1	4.71E+02	5.02E-03	5.13E-03
	Auxiliary Pump	600	1	80	8	15	120	1	3.37E+01	2.51E-04	3.66E-04
	Generators	150	2	75	24	8	192	1	2.52E+01	2.26E-04	2.75E-04
Well Completion & Testing	Main Deck	600	1	50	11	5	55	1	9.64E+00	7.19E-05	1.05E-04
	Auxiliary Pump	225	1	80	8	2	16	1	1.68E+00	1.37E-05	1.83E-05
	Power Swivel	150	1	75	8	2	16	1	1.05E+00	9.42E-06	1.14E-05
	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 &	55	1	75	12	3	36	1	9.64E-01	1.05E-05	9.44E-06
								Subtotal	**5.43E+02**	**5.60E-03**	**5.91E-03**
								Total	**5.50E+02**	**5.69E-03**	**5.98E-03**

Exhaust Emissions from Construction and Drilling Support Vehicles

Emission Factors for Commuting Vehicles

Vehicle		Emission		
Type	Class	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	409.5	0.002	0.016
Heavy-Duty Diesel Truck	HDDV	791.8	0.037	0.006

Source: MOBILE6.2.03

[a] 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).

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 (tons/well)		
	Type	Class					CO_2	CH_4	N_2O
Improved & Two-Track Road	Semi Trucks	HDDV	2	47	94	1	8.20E-02	3.83E-06	5.98E-07
	Pickup Trucks	LDDT	2	3	6	1	2.71E-03	1.32E-08	1.03E-07
Well Pad	Semi Trucks	HDDV	2	5	10	1	8.73E-03	4.08E-07	6.36E-08
	Pickup Trucks	LDDT	2	4	8	1	3.61E-03	1.76E-08	1.37E-07
Other Construction Activities	Semi Trucks	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Haul Trucks	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Pickup Trucks	LDDT	2	1	2	1	9.03E-04	4.41E-09	3.42E-08
						Subtotal	**1.05E-01**	**4.60E-06**	**9.86E-07**

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 (tons/well)		
	Type	Class					CO_2	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Semi Rig Transport, Drill Rig	HDDV	2	44	88	1	7.68E-02	3.59E-06	5.60E-07
	Fuel Haul Truck	HDDV	2	6	12	1	1.05E-02	4.89E-07	7.63E-08
	Mud Haul Truck, Water Hauling	HDDV	2	4	8	1	6.98E-03	3.26E-07	5.09E-08
	Rig Crew	LDDT	2	51	102	1	4.60E-02	2.25E-07	1.74E-06
	Rig Mechanics	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Co. Supervisor	LDDT	2	20	40	1	1.81E-02	8.82E-08	6.83E-07
	Tool Pusher	LDDT	2	8	16	1	7.22E-03	3.53E-08	2.73E-07
	Mud Logger	LDDT	2	6	12	1	5.42E-03	2.65E-08	2.05E-07
	Mud Engineer	LDDT	2	15	30	1	1.35E-02	6.61E-08	5.13E-07
	Logger, Engr Truck	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Drill Bit Delivery	LDDT	2	2	4	1	1.81E-03	8.82E-09	6.83E-08

Combustive Emissions Estimation Road Traffic (cont.)

Construction Site Destination	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells	Emissions (tons/well)		
	Type	Class					CO_2	CH_4	N_2O
Well Completion & Testing	Semi Casing Haulers	HDDV	2	6	12	1	1.05E-02	4.89E-07	7.63E-08
	Semi Completion, Unit Rig	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Semi Fracing, Blender	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Semi Pumping/Tank Battery	HDDV	2	6	12	1	1.05E-02	4.89E-07	7.63E-08
	Tubing Truck	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Haul Cementer, Pump Truck	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Haul Cementer, Cement	HDDV	2	3	6	1	5.24E-03	2.45E-07	3.82E-08
	Haul Completion, Equip	HDDV	2	3	6	1	5.24E-03	2.45E-07	3.82E-08
	Haul Service Tools	LDDT	2	2	4	1	1.81E-03	8.82E-09	6.83E-08
	Haul Perforators Logging Truck	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Anchor, Installation	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Anchor, Testing	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Tank	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Pump	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Chemical	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Sand	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Other	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Welders	HDDV	2	6	12	1	1.05E-02	4.89E-07	7.63E-08
	Haul Water Truck	HDDV	2	150	300	1	2.62E-01	1.22E-05	1.91E-06
	Pickup Cementer, Engineer	LDDT	2	2	4	1	1.81E-03	8.82E-09	6.83E-08
	Pickup Casing Crew	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Pickup Completion Crew	HDDV	2	5	10	1	8.73E-03	4.08E-07	6.36E-08
	Pickup Completion,	LDDT	2	5	10	1	4.51E-03	2.20E-08	1.71E-07
	Pickup Perforators, Engineer	LDDT	2	2	4	1	1.81E-03	8.82E-09	6.83E-08
	Pickup Fracing, Engineer	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Pickup Co. Supervisor	LDDT	2	10	20	1	9.03E-03	4.41E-08	3.42E-07
	Pickup Miscellaneous Supplies	LDDT	2	3	6	1	2.71E-03	1.32E-08	1.03E-07
	Pickup Roustabout Crew	HDDV	2	4	8	1	6.98E-03	3.26E-07	5.09E-08
					Subtotal		**5.62E-01**	**2.15E-05**	**7.57E-06**
					Total		**6.67E-01**	**2.61E-05**	**8.56E-06**

Exhaust Emissions from Well Work Overs

Emission Factors Bore/Drill Rig Engines 300-600 Hp

Fuel Type	Emission Factors (gm/hp-hr)		
	CO_2	CH_4	N_2O[a]
Diesel	529.575	0.007	0.006

Source: EPA NONROADS 2008a. Year 2008.

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

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 (tons/year/well)		
							CO_2	CH_4	N_2O
Well Workover	Truck-Mounted	600	10	3	30	1	1.05E+01	1.46E-04	1.14E-04

Exhaust emission factors for commuting vehicles

Vehicle		Emission Factors (g/mi)		
Type	Class	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	409.5	0.002	0.016
Heavy-Duty Diesel Truck	HDDV	791.8	0.04	0.006

Source: MOBILE 6.2.03

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

[a] 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

Activity	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells Drilled	Max. Annual Emissions (tons/year/well)		
	Type	Class					CO_2	CH_4	N_2O
Well Workover	WO Rig	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Truck	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Pickup Truck	LDDT	2	3	6	1	2.71E-03	1.32E-08	1.03E-07
						Total	**6.20E-03**	**1.76E-07**	**1.28E-07**

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).

Round trip distance = 2 based on data found in the SEIS

Exhaust Emissions from Site Visits and Inspections

Emission factors for Commuting Vehicles Exhaust

Vehicle Class	Emission Factors		
	CO_2	CH_4	N_2O[a]
Light-Duty Gasoline Truck	476.9	0.068	0.015

Source: MOBILE 6.2.03
Emission factors for 2008 used for all years = conservative estimate for fleet vehicle turnover
[a] 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)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Federal Wells Producing	Emissions (tons/yr/well)		
	Type	Class					CO_2	CH_4	N_2O
Inspection Visits for Wells	Pickup Truck	LDGT2	2	12	24	1	1.26E-02	1.80E-06	4.07E-07

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 year

[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
Cumulative Length of Roads [b] (miles/operation)	1

[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	**1**	**5**

Emission Factors for Construction Equipment Exhaust

Equipment	Emission Factors (g/hp-hr)		
	CO_2	CH_4	N_2O[a]
Grader 100-175 Hp	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] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

Emission Estimations for Grader: RMP Year 20

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours[a]	Emissions (tons/well)		
				CO_2	CH_4	N_2O
Road Maintenance	Grader	135	3	2.55E-01	2.52E-06	2.75E-06

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

Emission Factors for Commuting Vehicles Exhaust

Vehicle Class	Emission Factors		
	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	409.5	0.002	0.016

Source: MOBILE 6.2.03

[a] 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 (tons/yr)		
	Type	Class				CO_2	CH_4	N_2O
Road Maintenance	Pickup Truck	LDGT2	6	0.5	3	1.44E-03	7.05E-09	5.47E-08

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)	CH_4 Emissions (ton/yr/well)
All	31.31	6205	9.71E-02

[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 Work Over Vehicles - Road Traffic

Vehicle Class	Emission Factors		
	CO_2	CH_4	N_2O[a]
Heavy-Duty Diesel Truck (HDDV)	791.8	0.037	0.006

Source: MOBILE6.2.03

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

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 (tons/yr/well)		
	Type	Class					CO_2	CH_4	N_2O
Produced Water Hauling	Haul Truck (130 bbl)	HDDV	2	48	95	1	8.33E-02	3.89E-06	6.07E-07

Oil Tank, Loadout and Hauling Emissions

Oil Well Oil Seperator Flashing and Tank Emissions[a]

Project Year	Emissions[b]			
	HAPs Emissions (ton/yr/well)	VOC Emissions (ton/yr/well)	CO_2 Emissions (ton/yr/well)	CH_4 Emissions (ton/yr/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 no 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 ($lb/10^3$ gal) 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)
All	2.35	6,205	261	3.07E-01	5.50E-04	8.96E-08

[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)		
	CO_2	CH_4	N_2O[a]
Heavy-Duty Diesel Truck (HDDV)	791.8	0.037	0.006

Source: MOBILE6.2.03

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

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 (tons/year/well)		
	Type	Class					CO_2	CH_4	N_2O
Produced Oil Hauling	Haul Truck (200 bbl)	HDDV	2	31	62.05	1	5.42E-02	2.53E-06	3.95E-07
						TOTAL	**5.42E-02**	**2.53E-06**	**3.95E-07**

W&S Composition for Truck Load Out Emissions

W&S Gas Component	Mole Fraction[a] (%)	Molecular Weight (lb/lb-mol)	Gas Weight (lb/lb-mol)	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-HAP	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)

Exhaust Emissions from Recompletion Support Vehicles

Emission Factors for Commuting Vehicles

Vehicle		Emission Factors (g/mi)		
Type	Class	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	409.5	0.002	0.016
Heavy-Duty Diesel Truck	HDDV	791.8	0.037	0.006

Source: MOBILE6.2.03

[a] 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).

Combustive Emissions Estimation Road Traffic - Based on Peak Wells Drilled each Alternative

Construction Site Destination	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well/Year	Miles Traveled/ Well/Year	Total # of Wells	Emissions (tons/well)		
	Type	Class					CO_2	CH_4	N_2O
Well Recompletion	Fuel Haul Truck	HDDV	2	6	12	1	1.05E-02	4.89E-07	7.63E-08
	Mud Haul Truck, Water Hauling	HDDV	2	4	8	1	6.98E-03	3.26E-07	5.09E-08
	Rig Crew	LDDT	2	51	102	1	4.60E-02	2.25E-07	1.74E-06
	Rig Mechanics	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Co. Supervisor	LDDT	2	20	40	1	1.81E-02	8.82E-08	6.83E-07
	Semi Completion, Unit Rig	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Semi Fracing, Blender	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Semi Pumping/Tank Battery	HDDV	2	6	12	1	1.05E-02	4.89E-07	7.63E-08
	Tubing Truck	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Haul Cementer, Pump Truck	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Haul Cementer, Cement Truck	HDDV	2	3	6	1	5.24E-03	2.45E-07	3.82E-08
	Haul Completion, Equip Truck	HDDV	2	3	6	1	5.24E-03	2.45E-07	3.82E-08
	Haul Service Tools	LDDT	2	2	4	1	1.81E-03	8.82E-09	6.83E-08
	Haul Perforators Logging Truck	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Tank	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Pump	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Chemical	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Sand	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Other	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Water Truck	HDDV	2	50	100	1	8.73E-02	4.08E-06	6.36E-07
	Pickup Cementer, Engineer	LDDT	2	2	4	1	1.81E-03	8.82E-09	6.83E-08
	Pickup Completion Crew	HDDV	2	5	10	1	8.73E-03	4.08E-07	6.36E-08
	Pickup Completion, Pusher	LDDT	2	5	10	1	4.51E-03	2.20E-08	1.71E-07
	Pickup Perforators, Engineer	LDDT	2	2	4	1	1.81E-03	8.82E-09	6.83E-08

	Pickup Fracing, Engineer	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Pickup Co. Supervisor	LDDT	2	10	20	1	9.03E-03	4.41E-08	3.42E-07
	Pickup Miscellaneous Supplies	LDDT	2	3	6	1	2.71E-03	1.32E-08	1.03E-07
	Pickup Roustabout Crew	HDDV	2	4	8	1	6.98E-03	3.26E-07	5.09E-08
					Subtotal		**2.52E-01**	**8.17E-06**	**4.45E-06**
					Total		**2.52E-01**	**8.17E-06**	**4.45E-06**

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	0.415
Ethane	15.330	30.070	4.610	18.681	7931.881	0.182
Nitrogen	3.260	28.020	0.913	3.702	1571.760	0.036
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	0.011
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		0.643
Propane	7.890	44.100	3.479	14.101	5987.096	0.137
Iso-butane	1.370	58.120	0.796	3.227	1370.083	0.031
n-butane	3.360	58.120	1.953	7.914	3360.203	0.077
i-pentane	1.000	72.150	0.722	2.924	1241.472	0.028
n-pentane	1.040	72.150	0.750	3.041	1291.131	0.030
Hexanes	0.680	100.210	0.681	2.761	1172.521	0.027
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		0.331
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*	*0.027*
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		0.027
Totals	**100.000**	**---**	**24.676**	**100.000**		**0.974**

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	0.415
Ethane	15.330	30.070	4.610	18.681	7931.881	0.182
Nitrogen	3.260	28.020	0.913	3.702	1571.760	0.036
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	0.011
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		0.643
Propane	7.890	44.100	3.479	14.101	5987.096	0.137
Iso-butane	1.370	58.120	0.796	3.227	1370.083	0.031
n-butane	3.360	58.120	1.953	7.914	3360.203	0.077
i-pentane	1.000	72.150	0.722	2.924	1241.472	0.028
n-pentane	1.040	72.150	0.750	3.041	1291.131	0.030
Hexanes	0.680	100.210	0.681	2.761	1172.521	0.027
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		0.331
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*	*0.027*
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		0.027
Totals	**100.000**	**---**	**24.676**	**100.000**		**0.974**

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

Volume Flow:	900	SCF / bbl oil
BBL oil / day:	17	bbl oil / day
Completion activity duration:	3	days
Total Completion/Recompletion Volume Flow per Well	0.0459	MMSCF/well

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

Emission Factors for Natural Gas-Fired Compressors and Pumps

Compressor / Pump		Horse-Power Rating	Units	Emission Factors		
				CO_2[c]	CH_4[c]	N_2O[c]
Compression Station	Lean Burn	300	gm/bhp-hr	134.936	2.55E-03	2.55E-04
			lb/MMBTU	116.887	2.20E-03	2.20E-04
Oil Pump at Well Head	Lean Burn	40	gm/bhp-hr	134.936	2.55E-03	2.55E-04
			lb/MMBTU	116.887	2.20E-03	2.20E-04

Note: Compressors assumed to be equipped with nonselective catalytic reduction (NSCR) catalyst.

[a] 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 (tons/year/well)		
					CO_2	CH_4	N_2O
Compression Station	7.5	1.00	7.5	8,760	9.77E+00	1.84E-04	1.84E-05
Oil Pump at Well Head	40	1.00	40	8,760	5.21E+01	9.83E-04	9.83E-05
				Total	**6.19E+01**	**1.17E-03**	**1.17E-04**

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

TOC Emission Factor								
Well Equipment Component	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

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	1.74E-03	5.90E-04	1.92E-05	7.39E-04
pump seals	0.000	0.0053	0	0.0287	0	0.0001	0.00E+00	0.00E+00	0.00E+00	0.00E+00
others	0.000	0.0194	0	0.0165	0	0.0309	0.00E+00	0.00E+00	0.00E+00	0.00E+00
connectors	0.250	0.0004	0	0.0005	0	0.0002	1.10E-04	3.74E-05	1.22E-06	4.69E-05
flanges	0.600	0.0009	0	0.0002	0	0.0000	5.16E-04	1.75E-04	5.70E-06	2.19E-04
open-ended lines	0.000	0.0044	0	0.0031	0	0.0006	0.00E+00	0.00E+00	0.00E+00	0.00E+00
					TOTAL emissions/well/hr =		2.36E-03	8.02E-04	2.61E-05	1.00E-03

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 (ton/yr)**	**CO_2 emissions (lb/yr)**	**CO_2 emissions (ton/yr)**	**CH_4 emissions (lb/yr)**	**CH_4 emissions (ton/yr)**
Year 20	1	8760	7.03E+00	3.51E-03	2.29E-01	1.14E-04	8.80E+00	4.40E-03

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	15.333
Annual Miles of Roads reclaimed Per Well	3.833
Number of wells reclaimed (per well)	15.333

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
3.83	6	0.6	6
		Total	**6**

Assume average miles/day = 6

Emission Factors for 75-100 hp Off-Road Engines

Year	Emission Factors (g/hp-hr)		
	CO_2	CH_4	N_2O[a]
2008	600.507	0.010	0.016
2018	613.888	0.006	0.016
2027	608.641	0.003	0.016

[a] Emissions of $PM_{2.5}$ were assumed to be the same as those for PM_{10}.

[a] 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).

Exhaust Emissions Estimation for Grader Road Reclaim

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours[a]	Emissions (tons/year/well)		
				CO_2	CH_4	N_2O
Road Reclamation	Grader	80	3.8	2.08E-01	1.87E-06	5.24E-06

Exhaust Emission Factors for Commuting Reclaim Vehicles Road Traffic

Vehicle Class	(g/mi)		
	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	409.5	0.002	0.016

Source: MOBILE6.2.03

[a] 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).

Exhaust Emissions Estimation for Commuting Reclaim Vehicles: Road Traffic

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tons/year/well)		
	Type	Class				CO_2	CH_4	N_2O
Road Reclamation	Pickup Truck	LDDV	6	0.64	4	1.73E-03	8.45E-09	6.55E-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	15.33	10	15.33	153.33

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

Exhaust Emissions Estimation for Grader: Well Reclamation

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours [a]	Emissions (tons/year/well)		
				CO_2	CH_4	N_2O
Well Reclamation	Grader	100	92	6.09E+00	1.01E-04	1.57E-04

Exhaust Emissions Estimation for Commuting Vehicles: Well Reclamation

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tons/year/well)		
	Type	Class				CO_2	CH_4	N_2O
Well Reclamation	Pickup Truck	LDDV	6	15	92	4.15E-02	2.03E-07	1.57E-06

Emissions for Gas Dehydration

Emission Factors for Dehydrator Heaters

Unit	CO_2	CH_4	N_2O
lb/MMSCF	120000.0	2.3	2.2
lb/MMBTU	117.647	0.002	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 (tons/year/well)		
				CO_2	CH_4	N_2O
2,190	1	2.20	0.0004	5.77E-02	1.11E-06	1.06E-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)
5.58	1.07E-02	5.98E-02	1.60E-02	8.94E-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 South Baker 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 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

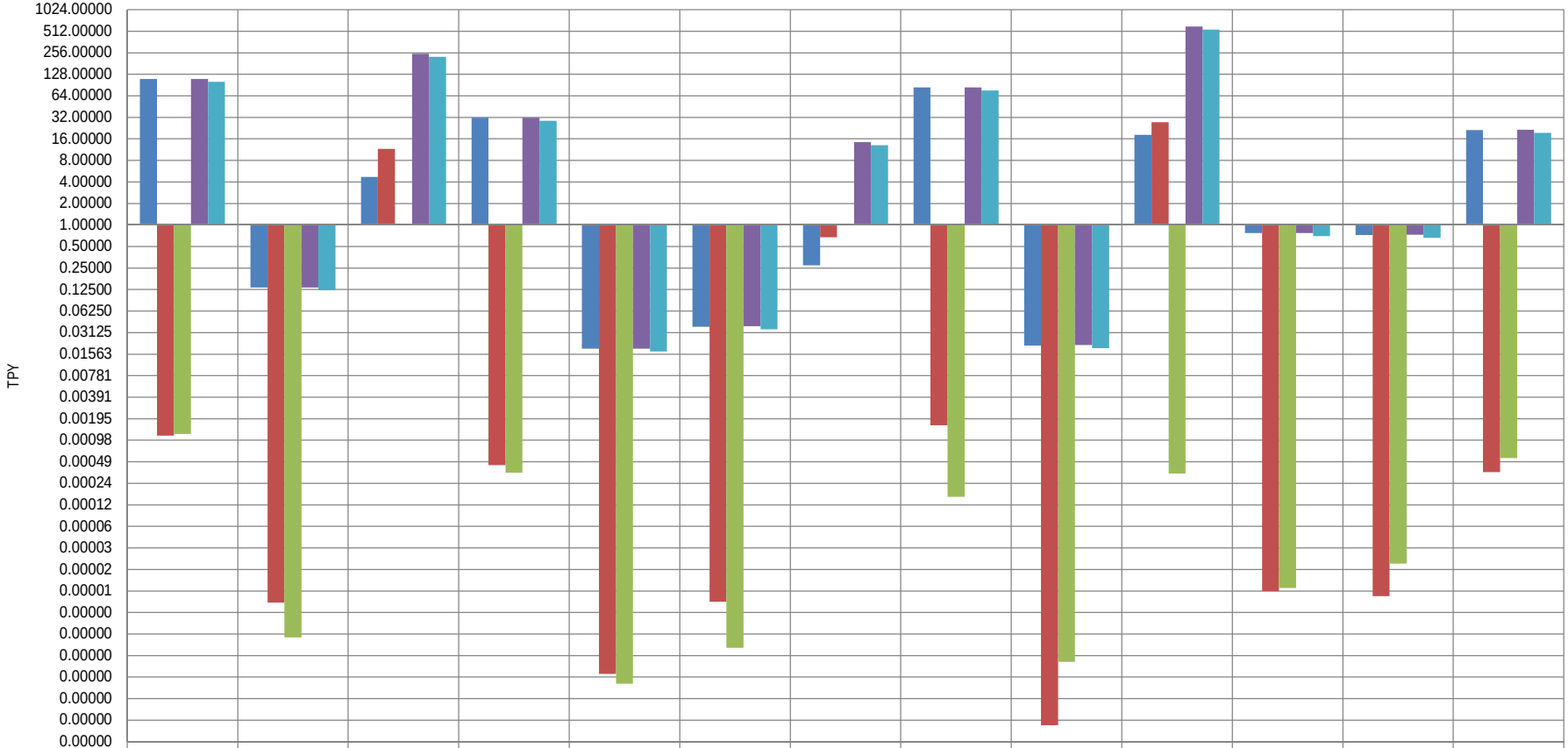
Dillon input parameters for calculating NG wells emissions

Maximum Annual Wells Drilled - Federal (RMP estimate)	0.2	Maximum Annual Wells Drilled - Non-Federal (RMP estimate)	0.2
Federal Producing Wells - RMP Year 2020	3.0	Non-Federal Producing Wells - RMP Year 2020	3.0
Average Gas Production Per Well (MCFD)	1,612.0	Average Gas Production Per Well (MCFD)	1,612.0

Federal NG Wells Summaries

Total Annual Emissions from Federal NG Wells - RMP Year 20

Activity	Annual Emissions (Tons)				
	CO_2	CH_4	N_2O	CO_{2eq}	CO_{2eq} metric tons
Well Pad Construction - Fugitive Dust	---	---	---	---	---
Heavy Equipment Combustive Emissions	110.02	0.00	0.00	110.41	100.19
Commuting Vehicles - Construction	0.13	0.00	0.00	0.13	0.12
Wind Erosion	---	---	---	---	---
Completion Venting	4.69	11.57	0.00	247.71	224.78
Sub-total: Construction	**114.84**	**11.57**	**0.00**	**358.26**	**325.10**
Well Workover Operations - Fugitive Dust	---	---	---	---	---
Well Workover Operations - On-site Exhaust	31.52	0.00	0.00	31.64	28.71
Well Workover Operations - On-road Exhaust	0.02	0.00	0.00	0.02	0.02
Well Visits for Inspection & Repair - Operations	0.04	0.00	0.00	0.04	0.03
Wellhead and Compressor Station Fugitives	0.27	0.67	0.00	14.38	13.05
Compression	83.68	0.00	0.00	83.76	76.01
Station Visits - Operations	0.02	0.00	0.00	0.02	0.02
Dehydrators	18.25	27.41	0.00	594.06	539.08
Sub-total: Operations	**133.80**	**28.09**	**0.00**	**723.92**	**656.92**
Road Maintenance	0.77	0.00	0.00	0.77	0.70
Sub-total: Maintenance	**0.770**	**0.000**	**0.00**	**0.77**	**0.70**
Road Reclamation	0.72	0.00	0.00	0.73	0.66
Well Reclamation	21.19	0.00	0.00	21.37	19.39
Sub-total: Reclamation	**21.9163**	**0.0004**	**0.0006**	**22.0996**	**20.0541**
Total Emissions	**271.32**	**39.66**	**0.00**	**1,105.06**	**1,002.78**

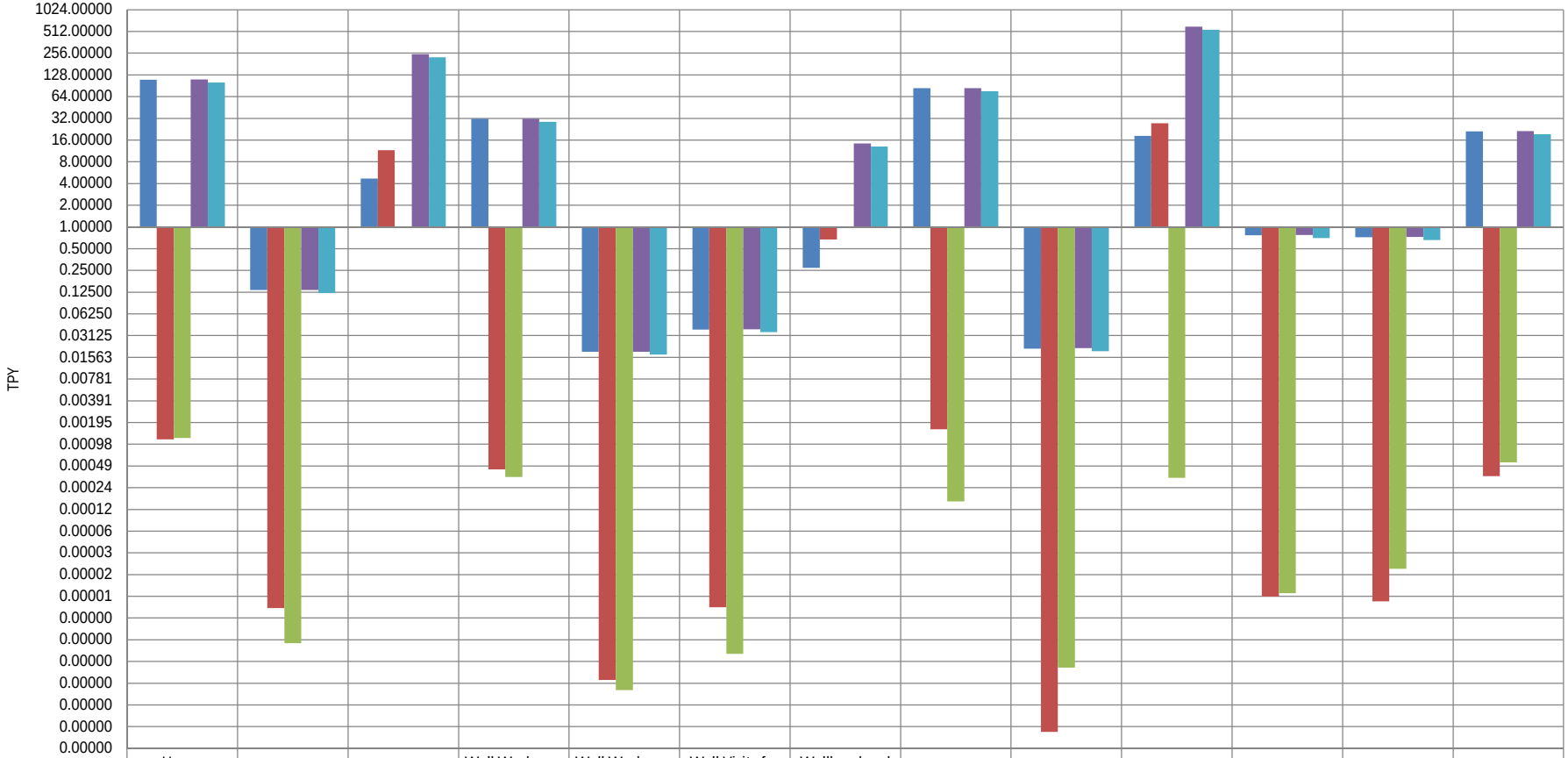


	Heavy Equipment Combustive Emissions	Commuting Vehicles - Construction	Completion Venting	Well Workover Operations - On-site Exhaust	Well Workover Operations - On-road Exhaust	Well Visits for Inspection & Repair - Operations	Wellhead and Compressor Station Fugitives	Compression	Station Visits - Operations	Dehydrators	Road Maintenance	Road Reclamation	Well Reclamation
CO2	110.02	0.13	4.69	31.52	0.02	0.04	0.27	83.68	0.02	18.25	0.77	0.72	21.19
CH4	0.00	0.00	11.57	0.00	0.00	0.00	0.67	0.00	0.00	27.41	0.00	0.00	0.00
N2O	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
CO2eq	110.41	0.13	247.71	31.64	0.02	0.04	14.38	83.76	0.02	594.06	0.77	0.73	21.37
CO2eq metric tons	100.19	0.12	224.78	28.71	0.02	0.03	13.05	76.01	0.02	539.08	0.70	0.66	19.39

Non-Federal NG Wells Summaries

Total Annual Emissions from Non-Federal NG Wells - RMP Year 20

Activity	Annual Emissions (Tons)				
	CO_2	CH_4	N_2O	CO_{2eq}	CO_{2eq} metric tons
Well Pad Construction - Fugitive Dust	---	---	---	---	---
Heavy Equipment Combustive Emissions	110.02	0.00	0.00	110.41	100.19
Commuting Vehicles - Construction	0.13	0.00	0.00	0.13	0.12
Wind Erosion	---	---	---	---	---
Completion Venting	4.69	11.57	0.00	247.71	224.78
Sub-total: Construction	**114.84**	**11.57**	**0.00**	**358.26**	**325.10**
Well Workover Operations - Fugitive Dust			---	---	---
Well Workover Operations - On-site Exhaust	31.52	0.00	0.00	31.64	28.71
Well Workover Operations - On-road Exhaust	0.02	0.00	0.00	0.02	0.02
Well Visits for Inspection & Repair - Operations	0.04	0.00	0.00	0.04	0.03
Wellhead and Compressor Station Fugitives	0.27	0.67	0.00	14.38	13.05
Compression	83.68	0.00	0.00	83.76	76.01
Station Visits - Operations	0.02	0.00	0.00	0.02	0.02
Dehydrators	18.25	27.41	0.00	594.06	539.08
Sub-total: Operations	**133.80**	**28.09**	**0.00**	**723.92**	**656.92**
Road Maintenance	0.77	0.00	0.00	0.77	0.70
Sub-total: Maintenance	**0.770**	**0.000**	**0.00**	**0.77**	**0.70**
Road Reclamation	0.72	0.00	0.00	0.73	0.66
Well Reclamation	21.19	0.00	0.00	21.37	19.39
Sub-total: Reclamation	**21.9163**	**0.0004**	**0.0006**	**22.0996**	**20.0541**
Total Emissions	**271.32**	**39.66**	**0.00**	**1,105.06**	**1,002.78**



	Heavy Equipment Combustive Emissions	Commuting Vehicles - Construction	Completion Venting	Well Workover Operations - On-site Exhaust	Well Workover Operations - On-road Exhaust	Well Visits for Inspection & Repair - Operations	Wellhead and Compressor Station Fugitives	Compression	Station Visits - Operations	Dehydrators	Road Maintenance	Road Reclamation	Well Reclamation
CO2	110.02	0.13	4.69	31.52	0.02	0.04	0.27	83.68	0.02	18.25	0.77	0.72	21.19
CH4	0.00	0.00	11.57	0.00	0.00	0.00	0.67	0.00	0.00	27.41	0.00	0.00	0.00
N2O	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
CO2eq	110.41	0.13	247.71	31.64	0.02	0.04	14.38	83.76	0.02	594.06	0.77	0.73	21.37
CO2eq metric tons	100.19	0.12	224.78	28.71	0.02	0.03	13.05	76.01	0.02	539.08	0.70	0.66	19.39

Exhaust Emissions from Well Pad Construction Heavy Equipment and Drilling Equipment

Emission Factors for Construction Equipment

Equipment	Emission Factors (g/hp-hr)			Equipment Category
	CO_2	CH_4	N_2O[a]	
Dozer - 175 Hp	535.760	0.005	0.006	Track-Type Tractor
Blade - 150 Hp	594.650	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] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

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 (tons/equipment type/well)		
									CO_2	CH_4	N_2O
Improved & Two-Track Road	Blade	150	1	75	10	2	20	1	1.47E+00	1.87E-05	1.43E-05
Well Pad	Blade	175	1	75	10	3	30	1	2.58E+00	3.28E-05	2.50E-05
	Dozer	175	1	80	10	3	30	1	2.75E+00	3.50E-05	2.67E-05
								Subtotal	**6.81E+00**	**8.64E-05**	**6.61E-05**

Exhaust Emission Factors for Diesel Powered Bore/Drill Rig Engines

Project Year/Hp Category	Emission Factors (g/hp-hr)		
	CO_2	CH_4	N_2O[a]
Year 2018			
50 to 75	589.096	0.006	0.006
75 to 100	589.103	0.006	0.006
100 to 175	530.097	0.005	0.006
175 to 300	530.181	0.004	0.006
300 to 600	530.255	0.004	0.006
600 to 750	530.283	0.004	0.006
>750	529.917	0.006	0.006

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

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

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 (tons/equipment type/well)		
									CO_2	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Main Deck	1,000	3	70	24	16	384	1	4.71E+02	5.02E-03	5.13E-03
	Auxiliary Pump	600	1	80	8	15	120	1	3.37E+01	2.51E-04	3.66E-04
	Generators	150	2	75	24	8	192	1	2.52E+01	2.26E-04	2.75E-04
Well Completion & Testing	Main Deck	600	1	50	11	5	55	1	9.64E+00	7.19E-05	1.05E-04
	Auxiliary Pump	225	1	80	8	2	16	1	1.68E+00	1.37E-05	1.83E-05
	Power Swivel	150	1	75	8	2	16	1	1.05E+00	9.42E-06	1.14E-05
	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	9.64E-01	1.05E-05	9.44E-06
								Subtotal	**5.43E+02**	**5.60E-03**	**5.91E-03**
								Total	**5.50E+02**	**5.69E-03**	**5.98E-03**

Exhaust Emissions from Construction and Drilling Support Vehicles

Emission Factors for Commuting Vehicles

Vehicle		Emission Factors (g/mi)		
Type	Class	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	409.5	0.002	0.016
Heavy-Duty Diesel Truck	HDDV	791.8	0.04	0.006

Source: MOBILE6.2.03

[a] 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).

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 (tons/well)		
	Type	Class					CO_2	CH_4	N_2O
Improved & Two-Track Road	Semi Trucks	HDDV	2	47	94	1	8.20E-02	3.83E-06	5.98E-07
	Pickup Trucks	LDDT	2	3	6	1	2.71E-03	1.32E-08	1.03E-07
Well Pad	Semi Trucks	HDDV	2	5	10	1	8.73E-03	4.08E-07	6.36E-08
	Pickup Trucks	LDDT	2	4	8	1	3.61E-03	1.76E-08	1.37E-07
Other Construction Activities	Semi Trucks	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Haul Trucks	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Pickup Trucks	LDDT	2	1	2	1	9.03E-04	4.41E-09	3.42E-08
						Subtotal	**1.05E-01**	**4.60E-06**	**9.86E-07**

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 (tons/well)		
	Type	Class					CO_2	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Semi Rig Transport, Drill Rig	HDDV	2	44	88	1	7.68E-02	3.59E-06	5.60E-07
	Fuel Haul Truck	HDDV	2	6	12	1	1.05E-02	4.89E-07	7.63E-08
	Mud Haul Truck, Water Hauling	HDDV	2	4	8	1	6.98E-03	3.26E-07	5.09E-08
	Rig Crew	LDDT	2	51	102	1	4.60E-02	2.25E-07	1.74E-06
	Rig Mechanics	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Co. Supervisor	LDDT	2	20	40	1	1.81E-02	8.82E-08	6.83E-07
	Tool Pusher	LDDT	2	8	16	1	7.22E-03	3.53E-08	2.73E-07
	Mud Logger	LDDT	2	6	12	1	5.42E-03	2.65E-08	2.05E-07
	Mud Engineer	LDDT	2	15	30	1	1.35E-02	6.61E-08	5.13E-07
	Logger, Engr Truck	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Drill Bit Delivery	LDDT	2	2	4	1	1.81E-03	8.82E-09	6.83E-08

Combustive Emissions Estimation Road Traffic (cont.)

Construction Site Destination	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells	Emissions (tons/well)		
	Type	Class					CO_2	CH_4	N_2O
Well Completion & Testing	Semi Casing Haulers	HDDV	2	6	12	1	1.05E-02	4.89E-07	7.63E-08
	Semi Completion, Unit Rig	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Semi Fracing, Blender	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Semi Pumping/Tank Battery	HDDV	2	6	12	1	1.05E-02	4.89E-07	7.63E-08
	Tubing Truck	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Haul Cementer, Pump Truck	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Haul Cementer, Cement	HDDV	2	3	6	1	5.24E-03	2.45E-07	3.82E-08
	Haul Completion, Equip	HDDV	2	3	6	1	5.24E-03	2.45E-07	3.82E-08
	Haul Service Tools	LDDT	2	2	4	1	1.81E-03	8.82E-09	6.83E-08
	Haul Perforators Logging Truck	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Anchor, Installation	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Anchor, Testing	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Tank	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Pump	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Chemical	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Sand	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Other	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Welders	HDDV	2	6	12	1	1.05E-02	4.89E-07	7.63E-08
	Haul Water Truck	HDDV	2	150	300	1	2.62E-01	1.22E-05	1.91E-06
	Pickup Cementer, Engineer	LDDT	2	2	4	1	1.81E-03	8.82E-09	6.83E-08
	Pickup Casing Crew	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Pickup Completion Crew	HDDV	2	5	10	1	8.73E-03	4.08E-07	6.36E-08
	Pickup Completion,	LDDT	2	5	10	1	4.51E-03	2.20E-08	1.71E-07
	Pickup Perforators, Engineer	LDDT	2	2	4	1	1.81E-03	8.82E-09	6.83E-08
	Pickup Fracing, Engineer	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Pickup Co. Supervisor	LDDT	2	10	20	1	9.03E-03	4.41E-08	3.42E-07
	Pickup Miscellaneous Supplies	LDDT	2	3	6	1	2.71E-03	1.32E-08	1.03E-07
	Pickup Roustabout Crew	HDDV	2	4	8	1	6.98E-03	3.26E-07	5.09E-08
					Subtotal		**5.62E-01**	**2.15E-05**	**7.57E-06**
					Total		**6.67E-01**	**2.61E-05**	**8.56E-06**

Exhaust Emissions from Well Work Overs

Emission Factors Bore/Drill Rig Engines 300-600 Hp

Fuel Type	Emission Factors (gm/hp-hr)		
	CO_2	CH_4	N_2O[a]
Diesel	529.575	0.007	0.006

Source: EPA NONROADS 2008a. Year 2008.

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

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 (tons/year/well)		
							CO_2	CH_4	N_2O
Well Workover	Truck-Mounted Unit	600	10	3	30	1	1.05E+01	1.46E-04	1.14E-04

Exhaust emission factors for commuting vehicles

Vehicle		Emission Factors (g/mi)		
Type	Class	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	409.5	0.002	0.016
Heavy-Duty Diesel Truck	HDDV	791.8	0.037	0.006

Source: MOBILE 6.2.03

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

[a] 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

Activity	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells Drilled	Max. Annual Emissions (tons/year/well)		
	Type	Class					CO_2	CH_4	N_2O
Well Workover	WO Rig	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Truck	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Pickup Truck	LDDT	2	3	6	1	2.71E-03	1.32E-08	1.03E-07
Performed once in the first year of well operation						**Total**	**6.20E-03**	**1.76E-07**	**1.28E-07**

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

Round trip distance = 2 based on data found in the SEIS

Exhaust Emissions from Site Visits and Inspections

Emission factors for Commuting Vehicles Exhaust

Vehicle Class	Emission Factors (g/mi)		
	CO_2	CH_4	N_2O[a]
Light-Duty Gasoline Truck	476.9	0.068	0.015

Source: MOBILE 6.2.03
Emission factors for 2008 used for all years = conservative estimate for fleet vehicle turnover
[a] 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)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Federal Wells Producing	Emissions (tons/yr/well)		
	Type	Class					CO_2	CH_4	N_2O
Inspection Visits for Wells	Pickup Truck	LDGT2	2	12	24	1	1.26E-02	1.80E-06	4.07E-07

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 year

[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
Cumulative Length of Roads [b] (miles/operation)	1

[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	**1**	**5**

Emission Factors for Construction Equipment Exhaust

Equipment	Emission Factors		
	CO_2	CH_4	N_2O[a]
Grader 100-175 Hp	535.770	0.005	0.006

Source: EPA NONROADS 2008a

Use emission factors for 2008 for all project years - conservative estimate of vehicle turnover

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

Emission Estimations for Grader: RMP Year 20

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours[a]	Emissions (tons/well)		
				CO_2	CH_4	N_2O
Road Maintenance	Grader	135	3	2.55E-01	2.52E-06	2.75E-06

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

Emission Factors for Commuting Vehicles Exhaust

Vehicle Class	Emission Factors		
	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	409.5	0.002	0.016

Source: MOBILE 6.2.03

[a] 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 (tons/yr)		
	Type	Class				CO_2	CH_4	N_2O
Road Maintenance	Pickup Truck	LDGT2	6	0.5	3	1.44E-03	7.05E-09	5.47E-08

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	17.667
Annual Miles of Roads reclaimed Per Well	4.417
Number of wells reclaimed (per well)	17.667

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
4.42	6	0.7	7
		Total	**7**

Assume average miles/day = 6

Emission Factors for 75-100 hp Off-Road Engines

Year	Emission Factors (g/hp-hr)		
	CO_2	CH_4	N_2O[a]
2008	600.507	0.010	0.016
2018	613.888	0.006	0.016
2027	608.641	0.003	0.016

[a] Emissions of $PM_{2.5}$ were assumed to be the same as those for PM_{10}.

[a] 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).

Exhaust Emissions Estimation for Grader Road Reclaim

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours[a]	Emissions (tons/year/well)		
				CO_2	CH_4	N_2O
Road Reclamation	Grader	80	4.4	2.39E-01	2.15E-06	6.04E-06

Exhaust Emission Factors for Commuting Reclaim Vehicles Road Traffic

Vehicle Class	Emission Factors (g/mi)		
	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	409.5	0.002	0.016

Source: MOBILE6.2.03

[a] 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).

Exhaust Emissions Estimation for Commuting Reclaim Vehicles: Road Traffic

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tons/year/well)		
	Type	Class				CO_2	CH_4	N_2O
Road Reclamation	Pickup Truck	LDDV	6	0.74	4	1.99E-03	9.74E-09	7.55E-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	17.67	10	17.67	176.67

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

Exhaust Emissions Estimation for Grader: Well Reclamation

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours [a]	Emissions (tons/year/well)		
				CO_2	CH_4	N_2O
Well Reclamation	Grader	100	106	7.02E+00	1.17E-04	1.81E-04

Exhaust Emissions Estimation for Commuting Vehicles: Well Reclamation

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tons/year/well)		
	Type	Class				CO_2	CH_4	N_2O
Well Reclamation	Pickup Truck	LDDV	6	18	106	4.78E-02	2.34E-07	1.81E-06

Emission Factors for Dehydrator Heaters

Unit	CO_2	CH_4	N_2O
lb/MMSCF	120000.0	2.3	2.2
lb/MMBTU	117.647	0.002	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 (tons/year/well)		
				CO_2	CH_4	N_2O
2,190	1	2.20	0.046	6.08E+00	1.17E-04	1.12E-04

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)
588.38	1.55E-02	9.14E+00	2.13E-05	1.25E-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 South Baker 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 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

Wellhead Fugitives

Fugitive Emissions from Equipment Leaks

TOC Emission Factor								
Well Equipment Component	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% =	13.56
CO2 Wt% =	22.83
CH4 Wt% =	56.36
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	7.50E-02	1.02E-02	1.71E-02	4.22E-02
pump seals	0	0.0053	0	0.0287	0	0.0001	0.00E+00	0.00E+00	0.00E+00	0.00E+00
others	0	0.0194	0	0.0165	0	0.0309	0.00E+00	0.00E+00	0.00E+00	0.00E+00
connectors	24	0.0004	0	0.0005	0	0.0002	1.06E-02	1.43E-03	2.42E-03	5.96E-03
flanges	2	0.0009	0	0.0002	0	0.0000	1.72E-03	2.33E-04	3.93E-04	9.69E-04
open-ended lines	0	0.0044	0	0.0031	0	0.0006	0.00E+00	0.00E+00	0.00E+00	0.00E+00
					TOTAL emissions/well/hr =		8.73E-02	1.18E-02	1.99E-02	4.92E-02

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 (ton/yr)**	**CO_2 emissions (lb/yr)**	**CO_2 emissions (ton/yr)**	**CH_4 emissions (lb/yr)**	**CH_4 emissions (ton/yr)**
Year 20	1	8760	1.04E+02	5.18E-02	1.75E+02	8.73E-02	4.31E+02	2.15E-01

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

Gas Component	Mole Fraction (%)	Molecular Weight (lb/lb-mol)	Gas Weight (lb/lb-mol)	Weight Percent (wt%)	Weight (lb/MMscf))	Emissions Mass Flow (ton/well)
Methane	77.690	16.040	12.461	56.359	23930.150	57.863
Ethane	5.265	30.070	1.583	7.160	3040.239	7.351
Nitrogen	0.000	28.020	0.000	0.000	0.000	0.000
Water		18.015	0.000	0.000	0.000	0.000
Carbon Dioxide	11.475	43.990	5.048	22.830	9693.544	23.439
Nitrous Oxide		44.020	0.000	0.000	0.000	0.000
Hydrogen Sulfide	0.060	34.067	0.020	0.092	39.252	0.095
Non-reactive, non-HAP	94.490	---	19.113	86.442		88.748
Propane	2.515	44.100	1.109	5.016	2129.867	5.150
Iso-butane	0.810	58.120	0.471	2.129	904.038	2.186
n-butane	1.190	58.120	0.692	3.128	1328.154	3.211
i-pentane	0.600	72.150	0.433	1.958	831.311	2.010
n-pentane	0.335	72.150	0.242	1.093	464.149	1.122
Hexanes	0.060	86.180	0.052	0.234	99.296	0.240
Heptanes		100.200	0.000	0.000	0.000	0.000
Octanes		114.230	0.000	0.000	0.000	0.000
Nonanes		128.26	0.000	0.000	0.000	0.000
Decanes+		142.29	0.000	0.000	0.000	0.000
Reactive VOC	5.510	---	2.998	13.558		13.920
Benzene		78.110	0.000	0.000	0.000	0.000
Ethylbenzene		106.167	0.000	0.000	0.000	0.000
n-Hexane [3]	*0.060*	*86.180*	*0.052*	*0.234*	*99.296*	*0.240*
Toluene		92.140	0.000	0.000	0.000	0.000
Xylenes		106.160	0.000	0.000	0.000	0.000
HAPs	0.060	---	0.052	0.234		0.240
Totals	**100.000**	**---**	**22.111**	**100.000**		**102.668**

Volume Flow:	1612	MSCF/day/well
Completion activity duration:	3	days
Total Volume Flow per Well	4.836	MMSCF/well

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

BTU value = 994 BTU/scf

Emission Factors for Natural Gas-Fired Compressors

Compressor		Horse-Power Rating	Units	Emission Factors		
				CO_2[a]	CH_4[a]	N_2O[a]
Field Compression Station	Rich Burn	300	gm/bhp-hr	134.936	2.55E-03	2.55E-04
			lb/MMBTU	116.887	2.20E-03	2.20E-04
Sales Compression Station	Rich Burn	1,680	gm/bhp-hr	134.936	2.55E-03	2.55E-04
			lb/MMBTU	116.887	2.20E-03	2.20E-04

Note: Compressors assumed to be equipped with nonselective catalytic reduction (NSCR) catalyst.

[a] 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 (tons/year/well)		
					CO_2	CH_4	N_2O
Field Compression Station	11	1	11	8,760	1.44E+01	2.72E-04	2.72E-05
Sales Compression Station	10	1	10	8,760	1.35E+01	2.54E-04	2.54E-05
				Total	**2.79E+01**	**5.26E-04**	**5.26E-05**

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

TOC Emission Factor								
Well Equipment Component	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% =	13.56
CO2 Wt% =	22.83
CH4 Wt% =	56.36
N2O Wt% =	0.00

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	0.258	0.0099	0	0.0055	0	0.0002	2.56E-03	3.48E-04	5.85E-04	1.44E-03
pump seals	0.000	0.0053	0	0.0287	0	0.0001	0.00E+00	0.00E+00	0.00E+00	0.00E+00
others	0.000	0.0194	0	0.0165	0	0.0309	0.00E+00	0.00E+00	0.00E+00	0.00E+00
connectors	0.369	0.0004	0	0.0005	0	0.0002	1.63E-04	2.21E-05	3.72E-05	9.17E-05
flanges	0.886	0.0009	0	0.0002	0	0.0000	7.62E-04	1.03E-04	1.74E-04	4.29E-04
open-ended lines	0.000	0.0044	0	0.0031	0	0.0006	0.00E+00	0.00E+00	0.00E+00	0.00E+00
					TOTAL emissions/well/hr =		3.49E-03	4.73E-04	7.96E-04	1.97E-03

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 (ton/yr)**	**CO_2 emissions (lb/yr)**	**CO_2 emissions (ton/yr)**	**CH_4 emissions (lb/yr)**	**CH_4 emissions (ton/yr)**
Year 20	1	8760	4.14E+00	2.07E-03	6.97E+00	3.49E-03	1.72E+01	8.61E-03

Compressor Station Inspection Traffic Exhaust Emissions

Emission factors for Commuting Vehicles Exhaust

Vehicle		Factors		
Type	**Class**	**CO_2**	**CH_4**	**N_2O[a]**
Light-Duty Diesel Truck	LDDT	409.5	0.002	0.016

Source: MOBILE6.2.03

[a] 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).

Exhaust Emissions Estimation for Road Traffic

Activity	Compressor Station	Vehicle		# of Compressor Stations / Well	# of Inspection Visits/ Station	# of Inspection Visits/Well/Year	Total Miles/ Inspection	Emissions (tons/year/well)		
		Type	Class					**CO_2**	**CH_4**	**N_2O**
Inspection Visits for Compressor Stations	CPF Compressor Station	Pickup Truck	LDGT2	0.04	12	0.4	20	4.00E-03	1.95E-08	1.51E-07
	Primary Compressor Station	Pickup Truck	LDGT2	0.01	52	0.3	20	2.89E-03	1.41E-08	1.09E-07
							Total	**6.89E-03**	**3.36E-08**	**2.61E-07**

Appendix E

Hi-Line Planning Area GHG Emission Inventory

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Malta/Hi-Line input parameters for calculating oil wells emissions

Maximum Annual Wells Drilled - Federal (RMP estimate)	1	Maximum Annual Wells Drilled - Non-Federal (RMP estimate)	10
Federal Producing Wells - RMP Year 20	25	Non-Federal Producing Wells - RMP Year 20	192
Average Well Barrel Oil Per Day (BOPD)	20	Average Well Barrel Oil Per Day (BOPD)	20

Federal Oil Wells Summaries

Total Annual Emissions from Federal Oil Wells - RMP Year 20

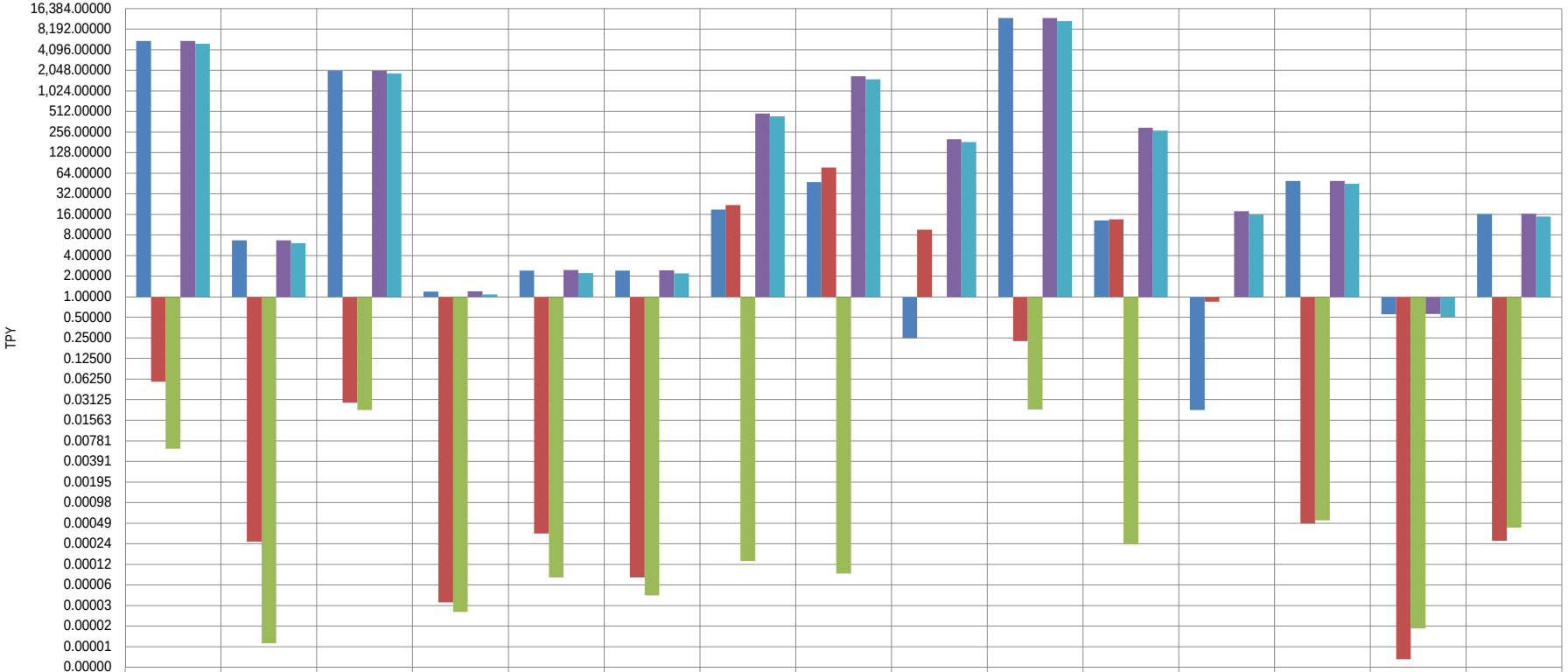
Activity	Annual Emissions (Tons)				
	CO_2	CH_4	N_2O	CO_{2eq}	CO_{2eq} metric tons
Well Pad Construction - Fugitive Dust	---	---	---	---	---
Heavy Equipment Combustive Emissions	550.10	0.01	0.01	552.07	500.97
Commuting Vehicles - Construction	0.67	0.00	0.00	0.67	0.61
Wind Erosion	---	---	---	---	---
Sub-total: Construction	**550.77**	**0.01**	**0.01**	**552.74**	**501.58**
Well Workover Operations - Fugitive Dust	---	---	---	---	---
Well Workover Operations - On-site Exhaust	262.69	0.00	0.00	263.65	239.25
Well Workover Operations - On-road Exhaust	0.15	0.00	0.00	0.16	0.14
Well Visits for Inspection & Repair - Operations	0.32	0.00	0.00	0.32	0.29
Recompletion Traffic	0.31	0.00	0.00	0.32	0.29
Water Tanks & Traffic	2.45	2.86	0.00	62.46	56.68
Oil Tanks & Traffic	6.16	10.08	0.00	217.74	197.59
Venting	0.03	1.10	0.00	23.07	20.94
Compression and Well Pumps	1,547.26	0.03	0.00	1548.77	1405.42
Dehydrators	1.70	1.76	0.00	38.67	35.09
Compression Station Fugitives	0.00	0.11	0.00	2.31	2.10
Sub-total: Operations	**1,821.07**	**15.93**	**0.01**	**2,157.46**	**1,957.77**
Road Maintenance	6.41	0.00	0.00	6.44	5.84
Sub-total: Maintenance	**6.414**	**0.000**	**0.00**	**6.44**	**5.84**
Road Reclamation	0.07	0.00	0.00	0.07	0.07
Well Reclamation	2.12	0.00	0.00	2.14	1.94
Sub-total: Reclamation	**2.1914**	**0.0000**	**0.0001**	**2.2098**	**2.0052**
Total Emissions	**2,380.44**	**15.94**	**0.01**	**2,718.85**	**2,467.20**

	Heavy Equipment Combustive Emissions	Commuting Vehicles - Construction	Well Workover Operations - On-site Exhaust	Well Workover Operations - On-road Exhaust	Well Visits for Inspection & Repair - Operations	Recompletion Traffic	Water Tanks & Traffic	Oil Tanks & Traffic	Venting	Compression and Well Pumps	Dehydrators	Compression Station Fugitives	Road Maintenance	Road Reclamation	Well Reclamation
CO2	550.10	0.67	262.69	0.15	0.32	0.31	2.45	6.16	0.03	1,547.26	1.70	0.00	6.41	0.07	2.12
CH4	0.01	0.00	0.00	0.00	0.00	0.00	2.86	10.08	1.10	0.03	1.76	0.11	0.00	0.00	0.00
N2O	0.01	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
CO2eq	552.07	0.67	263.65	0.16	0.32	0.32	62.46	217.74	23.07	1548.77	38.67	2.31	6.44	0.07	2.14
CO2eq metric tons	500.97	0.61	239.25	0.14	0.29	0.29	56.68	197.59	20.94	1405.42	35.09	2.10	5.84	0.07	1.94

Non-Federal Oil Wells Summaries

Total Annual Emissions from Non-Federal Oil Wells - RMP Year 20

Activity	Annual Emissions (Tons)				
	CO_2	CH_4	N_2O	CO_{2eq}	CO_{2eq} metric tons
Well Pad Construction - Fugitive Dust	---	---	---	---	---
Heavy Equipment Combustive Emissions	5500.99	0.06	0.01	5504.04	4994.59
Commuting Vehicles - Construction	6.67	0.00	0.00	6.68	6.06
Wind Erosion	---	---	---	---	---
Sub-total: Construction	**5,507.67**	**0.06**	**0.01**	**5,510.72**	**5,000.66**
Well Workover Operations - Fugitive Dust			---	---	---
Well Workover Operations - On-site Exhaust	2017.43	0.03	0.02	2024.83	1837.42
Well Workover Operations - On-road Exhaust	1.19	0.00	0.00	1.20	1.09
Well Visits for Inspection & Repair - Operations	2.42	0.00	0.00	2.45	2.23
Recompletion Traffic	2.42	0.00	0.00	2.43	2.21
Water Tanks & Traffic	18.82	21.94	0.00	479.66	435.27
Oil Tanks & Traffic	47.30	77.38	0.00	1672.24	1517.46
Venting	0.25	9.56	0.00	201.00	182.39
Compression and Well Pumps	11,882.93	0.22	0.02	11894.58	10793.63
Dehydrators	13.04	13.52	0.00	296.95	269.47
Compression Station Fugitives	0.02	0.85	0.00	17.77	16.13
Sub-total: Operations	**13,985.82**	**123.49**	**0.05**	**16,593.12**	**15,057.28**
Road Maintenance	49.26	0.00	0.00	49.44	44.86
Sub-total: Maintenance	**49.262**	**0.000**	**0.00**	**49.44**	**44.86**
Road Reclamation	0.56	0.00	0.00	0.56	0.51
Well Reclamation	16.27	0.00	0.00	16.41	14.89
Sub-total: Reclamation	**16.8303**	**0.0003**	**0.0004**	**16.9710**	**15.4002**
Total Emissions	**19,559.58**	**123.55**	**0.05**	**22,170.25**	**20,118.20**



	Heavy Equipment Combustive Emissions	Commuting Vehicles - Construction	Well Workover Operations - On-site Exhaust	Well Workover Operations - On-road Exhaust	Well Visits for Inspection & Repair - Operations	Recompletion Traffic	Water Tanks & Traffic	Oil Tanks & Traffic	Venting	Compression and Well Pumps	Dehydrators	Compression Station Fugitives	Road Maintenance	Road Reclamation	Well Reclamation
CO2	5500.99	6.67	2017.43	1.19	2.42	2.42	18.82	47.30	0.25	11,882.93	13.04	0.02	49.26	0.56	16.27
CH4	0.06	0.00	0.03	0.00	0.00	0.00	21.94	77.38	9.56	0.22	13.52	0.85	0.00	0.00	0.00
N2O	0.01	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00
CO2eq	5504.04	6.68	2024.83	1.20	2.45	2.43	479.66	1672.24	201.00	11894.58	296.95	17.77	49.44	0.56	16.41
CO2eq metric tons	4994.59	6.06	1837.42	1.09	2.23	2.21	435.27	1517.46	182.39	10793.63	269.47	16.13	44.86	0.51	14.89

Exhaust Emissions from Well Pad Construction Heavy Equipment and Drilling Equipment

Emission Factors for Construction Equipment

Equipment	Emission Factors (g/hp-hr)			Equipment Category
	CO_2	CH_4	N_2O[a]	
Dozer - 175 Hp	535.76	0.005	0.006	Track-Type Tractor
Blade - 150 Hp	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] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

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 (tons/equipment type/well)		
									CO_2	CH_4	N_2O
Improved & Two-Track Road	Blade	150	1	75	10	2	20	1	1.47E+00	1.87E-05	1.43E-05
Well Pad	Blade	175	1	75	10	3	30	1	2.58E+00	3.28E-05	2.50E-05
	Dozer	175	1	80	10	3	30	1	2.75E+00	3.50E-05	2.67E-05
								Subtotal	**6.81E+00**	**8.64E-05**	**6.61E-05**

Exhaust Emission Factors for Diesel Powered Bore/Drill Rig Engines

Project Year/Hp Category	Emission Factors (g/hp-hr)		
	CO_2	CH_4	N_2O[a]
Year 2018			
50 to 75	589.096	0.006	0.006
75 to 100	589.103	0.006	0.006
100 to 175	530.097	0.005	0.006
175 to 300	530.181	0.004	0.006
300 to 600	530.255	0.004	0.006
600 to 750	530.283	0.004	0.006
>750	529.917	0.006	0.006

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

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

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 (tons/equipment type/well)		
									CO_2	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Main Deck	1,000	3	70	24	16	384	1	4.71E+02	5.02E-03	5.13E-03
	Auxiliary Pump	600	1	80	8	15	120	1	3.37E+01	2.51E-04	3.66E-04
	Generators	150	2	75	24	8	192	1	2.52E+01	2.26E-04	2.75E-04
Well Completion & Testing	Main Deck	600	1	50	11	5	55	1	9.64E+00	7.19E-05	1.05E-04
	Auxiliary Pump	225	1	80	8	2	16	1	1.68E+00	1.37E-05	1.83E-05
	Power Swivel	150	1	75	8	2	16	1	1.05E+00	9.42E-06	1.14E-05
	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	9.64E-01	1.05E-05	9.44E-06
								Subtotal	**5.43E+02**	**5.60E-03**	**5.91E-03**
							Total		**5.50E+02**	**5.69E-03**	**5.98E-03**

Exhaust Emissions from Construction and Drilling Support Vehicles

Emission Factors for Commuting Vehicles

Vehicle		Emission Factors (g/mi)		
Type	Class	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	409.5	0.002	0.016
Heavy-Duty Diesel Truck	HDDV	791.8	0.037	0.006

Source: MOBILE6.2.03

[a] 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).

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 (tons/well)		
	Type	Class					CO_2	CH_4	N_2O
Improved & Two-Track Road	Semi Trucks	HDDV	2	47	94	1	8.20E-02	3.83E-06	5.98E-07
	Pickup Trucks	LDDT	2	3	6	1	2.71E-03	1.32E-08	1.03E-07
Well Pad	Semi Trucks	HDDV	2	5	10	1	8.73E-03	4.08E-07	6.36E-08
	Pickup Trucks	LDDT	2	4	8	1	3.61E-03	1.76E-08	1.37E-07
Other Construction Activities	Semi Trucks	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Haul Trucks	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Pickup Trucks	LDDT	2	1	2	1	9.03E-04	4.41E-09	3.42E-08
						Subtotal	**1.05E-01**	**4.60E-06**	**9.86E-07**

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 (tons/well)		
	Type	Class					CO_2	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Semi Rig Transport, Drill Rig	HDDV	2	44	88	1	7.68E-02	3.59E-06	5.60E-07
	Fuel Haul Truck	HDDV	2	6	12	1	1.05E-02	4.89E-07	7.63E-08
	Mud Haul Truck, Water Hauling	HDDV	2	4	8	1	6.98E-03	3.26E-07	5.09E-08
	Rig Crew	LDDT	2	51	102	1	4.60E-02	2.25E-07	1.74E-06
	Rig Mechanics	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Co. Supervisor	LDDT	2	20	40	1	1.81E-02	8.82E-08	6.83E-07
	Tool Pusher	LDDT	2	8	16	1	7.22E-03	3.53E-08	2.73E-07
	Mud Logger	LDDT	2	6	12	1	5.42E-03	2.65E-08	2.05E-07
	Mud Engineer	LDDT	2	15	30	1	1.35E-02	6.61E-08	5.13E-07
	Logger, Engr Truck	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Drill Bit Delivery	LDDT	2	2	4	1	1.81E-03	8.82E-09	6.83E-08

Combustive Emissions Estimation Road Traffic (cont.)

Construction Site Destination	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells	Emissions (tons/well)		
	Type	Class					CO_2	CH_4	N_2O
Well Completion & Testing	Semi Casing Haulers	HDDV	2	6	12	1	1.05E-02	4.89E-07	7.63E-08
	Semi Completion, Unit Rig	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Semi Fracing, Blender	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Semi Pumping/Tank Battery	HDDV	2	6	12	1	1.05E-02	4.89E-07	7.63E-08
	Tubing Truck	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Haul Cementer, Pump Truck	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Haul Cementer, Cement	HDDV	2	3	6	1	5.24E-03	2.45E-07	3.82E-08
	Haul Completion, Equip	HDDV	2	3	6	1	5.24E-03	2.45E-07	3.82E-08
	Haul Service Tools	LDDT	2	2	4	1	1.81E-03	8.82E-09	6.83E-08
	Haul Perforators Logging Truck	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Anchor, Installation	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Anchor, Testing	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Tank	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Pump	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Chemical	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Sand	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Other	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Welders	HDDV	2	6	12	1	1.05E-02	4.89E-07	7.63E-08
	Haul Water Truck	HDDV	2	150	300	1	2.62E-01	1.22E-05	1.91E-06
	Pickup Cementer, Engineer	LDDT	2	2	4	1	1.81E-03	8.82E-09	6.83E-08
	Pickup Casing Crew	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Pickup Completion Crew	HDDV	2	5	10	1	8.73E-03	4.08E-07	6.36E-08
	Pickup Completion,	LDDT	2	5	10	1	4.51E-03	2.20E-08	1.71E-07
	Pickup Perforators, Engineer	LDDT	2	2	4	1	1.81E-03	8.82E-09	6.83E-08
	Pickup Fracing, Engineer	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Pickup Co. Supervisor	LDDT	2	10	20	1	9.03E-03	4.41E-08	3.42E-07
	Pickup Miscellaneous Supplies	LDDT	2	3	6	1	2.71E-03	1.32E-08	1.03E-07
	Pickup Roustabout Crew	HDDV	2	4	8	1	6.98E-03	3.26E-07	5.09E-08
					Subtotal		**5.62E-01**	**2.15E-05**	**7.57E-06**
					Total		**6.67E-01**	**2.61E-05**	**8.56E-06**

Exhaust Emissions from Well Work Overs

Emission Factors Bore/Drill Rig Engines 300-600 Hp

Fuel Type	Emission Factors (gm/hp-hr)		
	CO_2	CH_4	N_2O[a]
Diesel	529.58	0.007	0.006

Source: EPA NONROADS 2008a. Year 2008.

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil a Industry," Table 4-17 (2009).

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 (tons/year/well)		
							CO_2	CH_4	N_2O
Well Workover	Truck-Mounted Unit	600	10	3	30	1	1.05E+01	1.46E-04	1.14E-04

Exhaust emission factors for commuting vehicles

Vehicle		Emission		
Type	Class	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	409.5	0.002	0.016
Heavy-Duty Diesel Truck	HDDV	791.8	0.037	0.006

Source: MOBILE 6.2.03

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

[a] 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

Activity	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells Drilled	Max. Annual Emissions (tons/year/well)		
	Type	Class					CO_2	CH_4	N_2O
Well Workover	WO Rig	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Truck	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Pickup Truck	LDDT	2	3	6	1	2.71E-03	1.32E-08	1.03E-07
Performed once in the first year of well operation						**Total**	**6.20E-03**	**1.76E-07**	**1.28E-07**

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

Round trip distance = 2 based on data found in the SEIS

Exhaust Emissions from Site Visits and Inspections

Emission factors for Commuting Vehicles Exhaust

Vehicle Class	Emission Factors (g/mi)		
	CO_2	CH_4	N_2O[a]
Light-Duty Gasoline Truck	476.9	0.068	0.015

Source: MOBILE 6.2.03

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

[a] 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)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Federal Wells Producing	Emissions (tons/yr/well)		
	Type	Class					CO_2	CH_4	N_2O
Inspection Visits for Wells	Pickup Truck	LDGT2	2	12	24	1	1.26E-02	1.80E-06	4.07E-07

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 year

[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
Cumulative Length of Roads [b] (miles/operation)	1

[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	**1**	**5**

Emission Factors for Construction Equipment Exhaust

Equipment	Emission Factors (g/hp-hr)		
	CO_2	CH_4	N_2O[a]
Grader 100-175 Hp	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] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Ga

Emission Estimations for Grader: RMP Year 20

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours[a]	Emissions (tons/well)		
				CO_2	CH_4	N_2O
Road Maintenance	Grader	135	3	2.55E-01	2.52E-06	2.75E-06

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

Emission Factors for Commuting Vehicles Exhaust

Vehicle Class	Emission Factors (g/mi)		
	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	409.5	0.002	0.016

Source: MOBILE 6.2.03

[a] 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) , M
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 (tons/yr)		
	Type	Class				CO_2	CH_4	N_2O
Road Maintenance	Pickup Truck	LDGT2	6	0.5	3	1.44E-03	7.05E-09	5.47E-08

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)	CH_4 Emissions (ton/yr/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 Work Over Vehicles - Road Traffic

Vehicle Class	Emission Factors (g/mi)		
	CO_2	CH_4	N_2O[a]
Heavy-Duty Diesel Truck (HDDV)	791.8	0.037	0.006

Source: MOBILE6.2.03

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

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 (tons/yr/well)		
	Type	Class					CO_2	CH_4	N_2O
Produced Water Hauling	Haul Truck (130 bbl)	HDDV	2	56	112	1	9.80E-02	4.58E-06	7.14E-07

Oil Tank, Loadout and Hauling Emissions

Oil Well Oil Seperator Flashing and Tank Emissions[a]

Project Year	Emissions[b]			
	HAPs Emissions (ton/yr/well)	VOC Emissions (ton/yr/well)	CO_2 Emissions (ton/yr/well)	CH_4 Emissions (ton/yr/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 no 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 ($lb/10^3$ gal) 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)
All	2.35	7,300	307	3.61E-01	6.47E-04	1.05E-07

[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)		
	CO_2	CH_4	N_2O[a]
Heavy-Duty Diesel Truck (HDDV)	791.8	0.037	0.006

Source: MOBILE6.2.03

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

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 (tons/year/well)		
	Type	Class					CO_2	CH_4	N_2O
Produced Oil Hauling	Haul Truck (200 bbl)	HDDV	2	37	73	1	6.37E-02	2.98E-06	4.64E-07
						TOTAL	**6.37E-02**	**2.98E-06**	**4.64E-07**

W&S Composition for Truck Load Out Emissions

W&S Gas Component	Mole Fraction[a] (%)	Molecular Weight (lb/lb-mol)	Gas Weight (lb/lb-mol)	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-HAP	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)

Exhaust Emissions from Recompletion Support Vehicles

Emission Factors for Commuting Vehicles

Vehicle		Emission		
Type	Class	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	409.5	0.002	0.016
Heavy-Duty Diesel Truck	HDDV	791.8	0.037	0.006

Source: MOBILE6.2.03

[a] 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).

Combustive Emissions Estimation Road Traffic - Based on Peak Wells Drilled each Alternative

Construction Site Destination	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells	Emissions (tons/well)		
	Type	Class					CO_2	CH_4	N_2O
Well Recompletion	Fuel Haul Truck	HDDV	2	6	12	1	1.05E-02	4.89E-07	7.63E-08
	Mud Haul Truck, Water Hauling	HDDV	2	4	8	1	6.98E-03	3.26E-07	5.09E-08
	Rig Crew	LDDT	2	51	102	1	4.60E-02	2.25E-07	1.74E-06
	Rig Mechanics	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Co. Supervisor	LDDT	2	20	40	1	1.81E-02	8.82E-08	6.83E-07
	Semi Completion, Unit Rig	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Semi Fracing, Blender	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Semi Pumping/Tank Battery	HDDV	2	6	12	1	1.05E-02	4.89E-07	7.63E-08
	Tubing Truck	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Haul Cementer, Pump Truck	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Haul Cementer, Cement Truck	HDDV	2	3	6	1	5.24E-03	2.45E-07	3.82E-08
	Haul Completion, Equip Truck	HDDV	2	3	6	1	5.24E-03	2.45E-07	3.82E-08
	Haul Service Tools	LDDT	2	2	4	1	1.81E-03	8.82E-09	6.83E-08
	Haul Perforators Logging Truck	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Tank	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Pump	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Chemical	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Sand	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Other	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Water Truck	HDDV	2	50	100	1	8.73E-02	4.08E-06	6.36E-07
	Pickup Cementer, Engineer	LDDT	2	2	4	1	1.81E-03	8.82E-09	6.83E-08

	Pickup Completion Crew	HDDV	2	5	10	1	8.73E-03	4.08E-07	6.36E-08
	Pickup Completion, Pusher	LDDT	2	5	10	1	4.51E-03	2.20E-08	1.71E-07
	Pickup Perforators, Engineer	LDDT	2	2	4	1	1.81E-03	8.82E-09	6.83E-08
	Pickup Fracing, Engineer	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Pickup Co. Supervisor	LDDT	2	10	20	1	9.03E-03	4.41E-08	3.42E-07
	Pickup Miscellaneous Supplies	LDDT	2	3	6	1	2.71E-03	1.32E-08	1.03E-07
	Pickup Roustabout Crew	HDDV	2	4	8	1	6.98E-03	3.26E-07	5.09E-08
					Subtotal		**2.52E-01**	**8.17E-06**	**4.45E-06**
					Total		**2.52E-01**	**8.17E-06**	**4.45E-06**

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

Gas Component	Mole Fraction (%)	Molecular Weight (lb/lb-mol)	Gas Weight (lb/lb-mol)	Weight Percent (wt%)	Weight (lb/MMscf))	Emissions Mass Flow (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**

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

Gas Component	Mole Fraction (%)	Molecular Weight (lb/lb-mol)	Gas Weight (lb/lb-mol)	Weight Percent (wt%)	Weight (lb/MMscf))	Emissions Mass Flow (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).

Emission Factors for Natural Gas-Fired Compressors and Pumps

Compressor / Pump		Horse-Power Rating	Units	Emission		
				CO_2[a]	CH_4[a]	N_2O[a]
Compression Station	Lean Burn	300	gm/bhp-hr	134.936	2.55E-03	2.55E-04
			lb/MMBTU	116.887	2.20E-03	2.20E-04
Oil Pump at Well Head	Lean Burn	40	gm/bhp-hr	134.936	2.55E-03	2.55E-04
			lb/MMBTU	116.887	2.20E-03	2.20E-04

Note: Compressors assumed to be equipped with nonselective catalytic reduction (NSCR) catalyst.

[a] 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 (tons/year/well)		
					CO_2	CH_4	N_2O
Compression Station	7.5	1.00	7.5	8,760	9.77E+00	1.84E-04	1.84E-05
Oil Pump at Well Head	40	1.00	40	8,760	5.21E+01	9.83E-04	9.83E-05
				Total	**6.19E+01**	**1.17E-03**	**1.17E-04**

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

TOC Emission Factor								
Well Equipment Component	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

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	1.74E-03	5.90E-04	1.92E-05	7.39E-04
pump seals	0.000	0.0053	0	0.0287	0	0.0001	0.00E+00	0.00E+00	0.00E+00	0.00E+00
others	0.000	0.0194	0	0.0165	0	0.0309	0.00E+00	0.00E+00	0.00E+00	0.00E+00
connectors	0.250	0.0004	0	0.0005	0	0.0002	1.10E-04	3.74E-05	1.22E-06	4.69E-05
flanges	0.600	0.0009	0	0.0002	0	0.0000	5.16E-04	1.75E-04	5.70E-06	2.19E-04
open-ended lines	0.000	0.0044	0	0.0031	0	0.0006	0.00E+00	0.00E+00	0.00E+00	0.00E+00
					TOTAL emissions/well/hr =		2.36E-03	8.02E-04	2.61E-05	1.00E-03

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 (ton/yr)**	**CO_2 emissions (lb/yr)**	**CO_2 emissions (ton/yr)**	**CH_4 emissions (lb/yr)**	**CH_4 emissions (ton/yr)**
Year 20	1	8760	7.03E+00	3.51E-03	2.29E-01	1.14E-04	8.80E+00	4.40E-03

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	0.212
Annual Miles of Roads reclaimed Per Well	0.053
Number of wells reclaimed (per well)	0.212

Reclaimation 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
0.05	6	0.009	0.088
		Total	**0.088**

Assume average miles/day = 6

Emission Factors for 75-100 hp Off-Road Engines

Year	Emission Factors (g/hp-hr)		
	CO_2	CH_4	N_2O[a]
2008	600.507	0.010	0.016
2018	613.888	0.006	0.016
2027	608.641	0.003	0.016

[a] Emissions of $PM_{2.5}$ were assumed to be the same as those for PM_{10}.

[a] 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).

Exhaust Emissions Estimation for Grader Road Reclaim

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours[a]	Emissions (tons/year/well)		
				CO_2	CH_4	N_2O
Road Reclamation	Grader	80	0.05	2.87E-03	2.58E-08	7.24E-08

Exhaust Emission Factors for Commuting Reclaim Vehicles Road Traffic

Vehicle Class	Emission Factors (g/mi)		
	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	409.5	0.002	0.016

Source: MOBILE6.2.03

[a] 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).

Exhaust Emissions Estimation for Commuting Reclaim Vehicles: Road Traffic

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tons/year/well)		
	Type	Class				CO_2	CH_4	N_2O
Road Reclamation	Pickup Truck	LDDV	6	0.009	0.053	2.39E-05	1.17E-10	9.05E-10

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	0.21	10	0.21	2.12

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

Exhaust Emissions Estimation for Grader: Well Reclamation

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours [a]	Emissions (tons/year/well)		
				CO_2	CH_4	N_2O
Well Reclamation	Grader	100	1	8.42E-02	1.40E-06	2.17E-06

Exhaust Emissions Estimation for Commuting Vehicles: Well Reclamation

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tons/year/well)		
	Type	Class				CO_2	CH_4	N_2O
Well Reclamation	Pickup Truck	LDDV	6	0.21	1	5.74E-04	2.80E-09	2.17E-08

Emission Factors for Dehydrator Heaters

Unit	CO_2	CH_4	N_2O
lb/MMSCF	120000.0	2.3	2.2
lb/MMBTU	117.647	0.002	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 (tons/year/well)		
				CO_2	CH_4	N_2O
2,190	1	2.20	0.0005	6.79E-02	1.30E-06	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 per MMscf)	CH_4 Emissions (TPY/well)	VOC Emission Factor (ton per MMscf)	VOC Emissions (TPY/well)
6.57	1.07E-02	7.04E-02	1.60E-02	1.05E-01

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 South Baker 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 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

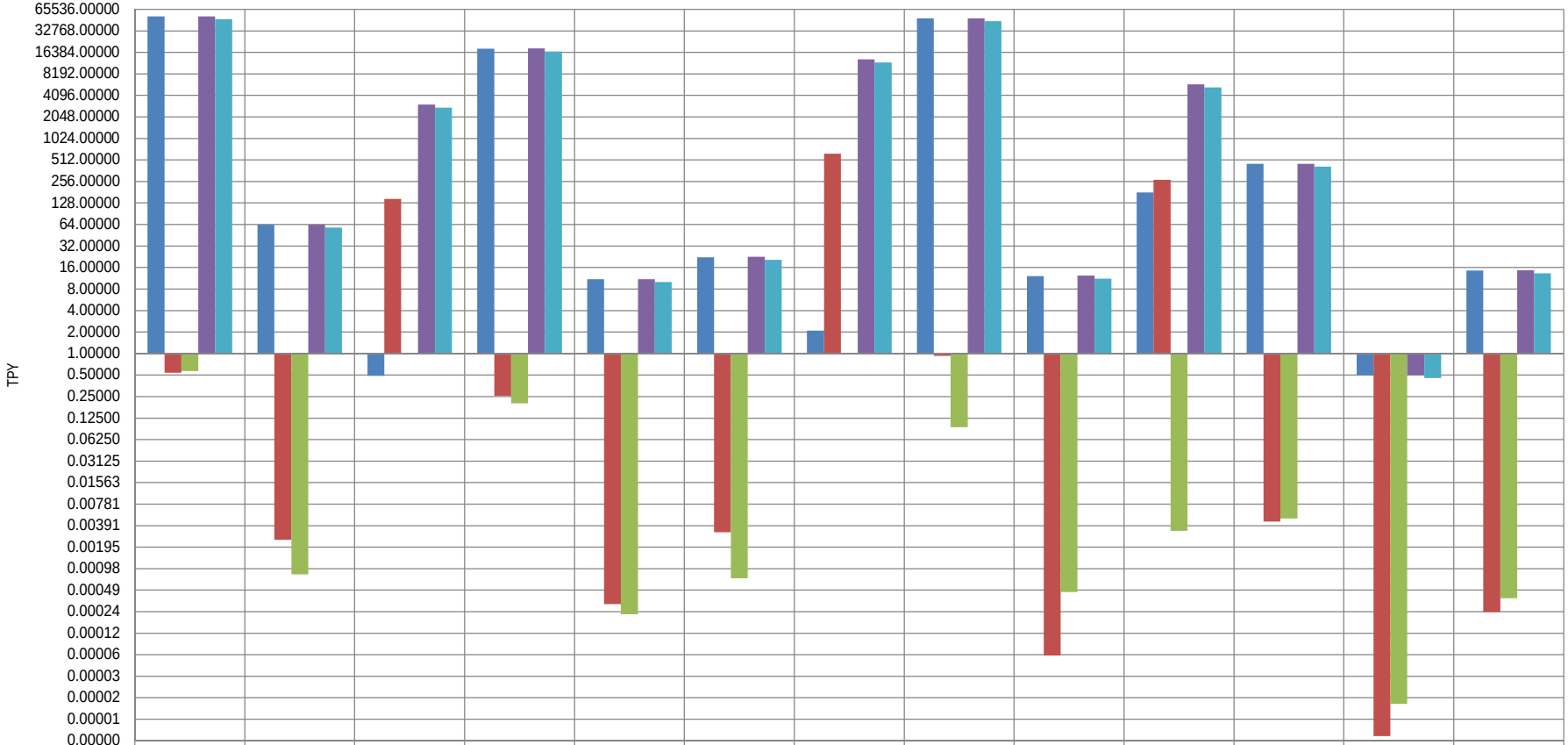
Malta/Hi-Line input parameters for calculating NG wells emissions

Maximum Annual Wells Drilled - Federal (RMP estimate)	95	Maximum Annual Wells Drilled - Non-Federal (RMP estimate)	181
Federal Producing Wells - RMP Year 20	1,764	Non-Federal Producing Wells - RMP Year 20	3,371
Average Gas Production Per Well (MCFD)	27	Average Gas Production Per Well (MCFD)	27

Federal NG Wells Summaries

Total Annual Emissions from Federal NG Wells - RMP Year 20

Activity	Annual Emissions (Tons)				
	CO_2	CH_4	N_2O	CO_{2eq}	CO_{2eq} metric tons
Well Pad Construction - Fugitive Dust	---	---	---	---	---
Heavy Equipment Combustive Emissions	52259.43	0.54	0.57	52446.90	47592.47
Commuting Vehicles - Construction	63.40	0.00	0.00	63.70	57.81
Wind Erosion	---	---	---	---	---
Completion Venting	0.49	145.39	0.00	3053.72	2771.07
Sub-total: Construction	**52,323.32**	**145.93**	**0.57**	**55,564.32**	**50,421.34**
Well Workover Operations - Fugitive Dust	---	---	---	---	---
Well Workover Operations - On-site Exhaust	18535.14	0.26	0.20	18603.16	16881.27
Well Workover Operations - On-road Exhaust	10.94	0.00	0.00	11.01	9.99
Well Visits for Inspection & Repair - Operations	22.26	0.00	0.00	22.54	20.46
Wellhead and Compressor Station Fugitives	2.10	623.99	0.00	13105.86	11892.79
Compression	49,202.37	0.93	0.09	49250.63	44692.04
Station Visits - Operations	12.15	0.00	0.00	12.29	11.15
Dehydrators	179.71	270.00	0.00	5850.72	5309.19
Sub-total: Operations	**67,964.66**	**895.18**	**0.30**	**86,856.21**	**78,816.89**
Road Maintenance	452.59	0.00	0.00	454.22	412.18
Sub-total: Maintenance	**452.595**	**0.004**	**0.00**	**454.22**	**412.18**
Road Reclamation	0.50	0.00	0.00	0.50	0.45
Well Reclamation	14.56	0.00	0.00	14.68	13.32
Sub-total: Reclamation	**15.0576**	**0.0002**	**0.0004**	**15.1835**	**13.7782**
Total Emissions	**120,755.63**	**1,041.12**	**0.87**	**142,889.93**	**129,664.19**

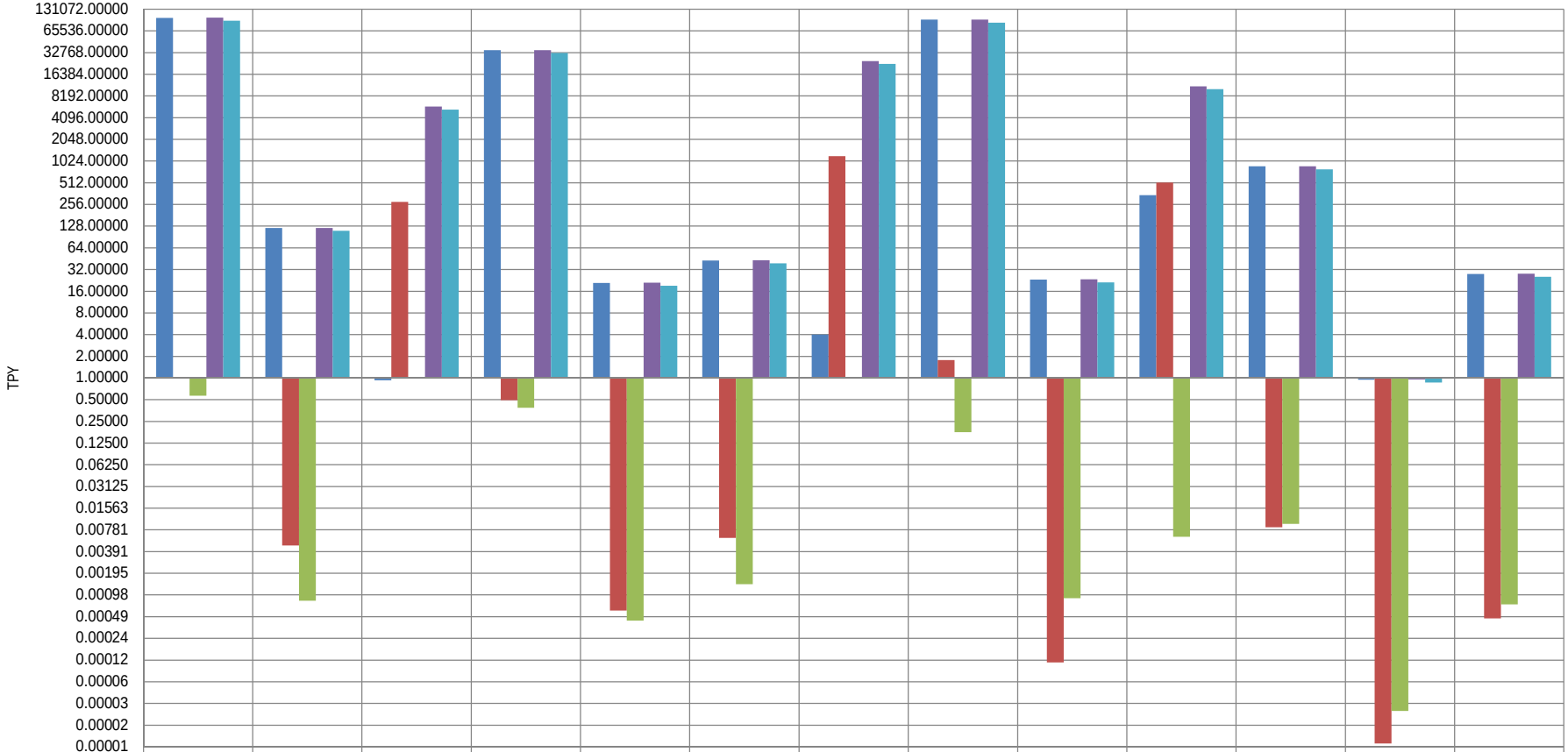


	Heavy Equipment Combustive Emissions	Commuting Vehicles - Construction	Completion Venting	Well Workover Operations - On-site Exhaust	Well Workover Operations - On-road Exhaust	Well Visits for Inspection & Repair - Operations	Wellhead and Compressor Station Fugitives	Compression	Station Visits - Operations	Dehydrators	Road Maintenance	Road Reclamation	Well Reclamation
CO2	52259.43	63.40	0.49	18535.14	10.94	22.26	2.10	49,202.37	12.15	179.71	452.59	0.50	14.56
CH4	0.54	0.00	145.39	0.26	0.00	0.00	623.99	0.93	0.00	270.00	0.00	0.00	0.00
N2O	0.57	0.00	0.00	0.20	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00
CO2eq	52446.90	63.70	3053.72	18603.16	11.01	22.54	13105.86	49250.63	12.29	5850.72	454.22	0.50	14.68
CO2eq metric tons	47592.47	57.81	2771.07	16881.27	9.99	20.46	11892.79	44692.04	11.15	5309.19	412.18	0.45	13.32

Non-Federal NG Wells Summaries

Total Annual Emissions from Non-Federal NG Wells - RMP Year 20

Activity	Annual Emissions (Tons)				
	CO_2	CH_4	N_2O	CO_{2eq}	CO_{2eq} metric tons
Well Pad Construction - Fugitive Dust	---	---	---	---	---
Heavy Equipment Combustive Emissions	99567.97	1.03	0.57	99765.71	90531.50
Commuting Vehicles - Construction	120.79	0.00	0.00	121.14	109.93
Wind Erosion	---	---	---	---	---
Completion Venting	0.93	277.01	0.00	5818.13	5279.61
Sub-total: Construction	**99,689.69**	**278.04**	**0.57**	**105,704.98**	**95,921.04**
Well Workover Operations - Fugitive Dust			---	---	---
Well Workover Operations - On-site Exhaust	35420.61	0.49	0.39	35550.59	32260.06
Well Workover Operations - On-road Exhaust	20.90	0.00	0.00	21.04	19.10
Well Visits for Inspection & Repair - Operations	42.53	0.01	0.00	43.08	39.10
Wellhead and Compressor Station Fugitives	4.01	1,192.44	0.00	25045.26	22727.10
Compression	94,025.62	1.77	0.18	94117.84	85406.38
Station Visits - Operations	23.21	0.00	0.00	23.49	21.31
Dehydrators	343.42	515.97	0.01	11180.72	10145.84
Sub-total: Operations	**129,880.31**	**1,710.68**	**0.57**	**165,982.03**	**150,618.90**
Road Maintenance	864.91	0.01	0.01	868.02	787.67
Sub-total: Maintenance	**864.908**	**0.009**	**0.01**	**868.02**	**787.67**
Road Reclamation	0.95	0.00	0.00	0.96	0.87
Well Reclamation	27.83	0.00	0.00	28.06	25.46
Sub-total: Reclamation	**28.7750**	**0.0005**	**0.0007**	**29.0157**	**26.3301**
Total Emissions	**230,463.68**	**1,988.73**	**1.15**	**272,584.04**	**247,353.94**



	Heavy Equipment Combustive Emissions	Commuting Vehicles - Construction	Completion Venting	Well Workover Operations - On-site Exhaust	Well Workover Operations - On-road Exhaust	Well Visits for Inspection & Repair - Operations	Wellhead and Compressor Station Fugitives	Compression	Station Visits - Operations	Dehydrators	Road Maintenance	Road Reclamation	Well Reclamation
CO2	99567.97	120.79	0.93	35420.61	20.90	42.53	4.01	94,025.62	23.21	343.42	864.91	0.95	27.83
CH4	1.03	0.00	277.01	0.49	0.00	0.01	1,192.44	1.77	0.00	515.97	0.01	0.00	0.00
N2O	0.57	0.00	0.00	0.39	0.00	0.00	0.00	0.18	0.00	0.01	0.01	0.00	0.00
CO2eq	99765.71	121.14	5818.13	35550.59	21.04	43.08	25045.26	94117.84	23.49	11180.72	868.02	0.96	28.06
CO2eq metric tons	90531.50	109.93	5279.61	32260.06	19.10	39.10	22727.10	85406.38	21.31	10145.84	787.67	0.87	25.46

Exhaust Emissions from Well Pad Construction Heavy Equipment and Drilling Equipment

Emission Factors for Construction Equipment

Equipment	Emission Factors (g/hp-hr)			Equipment Category
	CO_2	CH_4	N_2O[a]	
Dozer - 175 Hp	535.76	0.005	0.006	Track-Type Tractor
Blade - 150 Hp	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] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

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 (tons/equipment type/well)		
									CO_2	CH_4	N_2O
Improved & Two-Track Road	Blade	150	1	75	10	2	20	1	1.47E+00	1.87E-05	1.43E-05
Well Pad	Blade	175	1	75	10	3	30	1	2.58E+00	3.28E-05	2.50E-05
	Dozer	175	1	80	10	3	30	1	2.75E+00	3.50E-05	2.67E-05
								Subtotal	**6.81E+00**	**8.64E-05**	**6.61E-05**

Exhaust Emission Factors for Diesel Powered Bore/Drill Rig Engines

Project Year/Hp Category	Emission Factors (g/hp-hr)		
	CO_2	CH_4	N_2O[a]
Year 2018			
50 to 75	589.096	0.006	0.006
75 to 100	589.103	0.006	0.006
100 to 175	530.097	0.005	0.006
175 to 300	530.181	0.004	0.006
300 to 600	530.255	0.004	0.006
600 to 750	530.283	0.004	0.006
>750	529.917	0.006	0.006

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

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

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 (tons/equipment type/well)		
									CO_2	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Main Deck	1,000	3	70	24	16	384	1	4.71E+02	5.02E-03	5.13E-03
	Auxiliary Pump	600	1	80	8	15	120	1	3.37E+01	2.51E-04	3.66E-04
	Generators	150	2	75	24	8	192	1	2.52E+01	2.26E-04	2.75E-04
Well Completion & Testing	Main Deck	600	1	50	11	5	55	1	9.64E+00	7.19E-05	1.05E-04
	Auxiliary Pump	225	1	80	8	2	16	1	1.68E+00	1.37E-05	1.83E-05
	Power Swivel	150	1	75	8	2	16	1	1.05E+00	9.42E-06	1.14E-05
	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	9.64E-01	1.05E-05	9.44E-06
								Subtotal	**5.43E+02**	**5.60E-03**	**5.91E-03**
								Total	**5.50E+02**	**5.69E-03**	**5.98E-03**

Exhaust Emissions from Construction and Drilling Support Vehicles

Emission Factors for Commuting Vehicles

Vehicle		Emission Factors (g/mi)		
Type	Class	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	409.5	0.002	0.016
Heavy-Duty Diesel Truck	HDDV	791.8	0.037	0.006

Source: MOBILE6.2.03

[a] 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).

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 (tons/well)		
	Type	Class					CO_2	CH_4	N_2O
Improved & Two-Track Road	Semi Trucks	HDDV	2	47	94	1	8.20E-02	3.83E-06	5.98E-07
	Pickup Trucks	LDDT	2	3	6	1	2.71E-03	1.32E-08	1.03E-07
Well Pad	Semi Trucks	HDDV	2	5	10	1	8.73E-03	4.08E-07	6.36E-08
	Pickup Trucks	LDDT	2	4	8	1	3.61E-03	1.76E-08	1.37E-07
Other Construction Activities	Semi Trucks	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Haul Trucks	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Pickup Trucks	LDDT	2	1	2	1	9.03E-04	4.41E-09	3.42E-08
						Subtotal	**1.05E-01**	**4.60E-06**	**9.86E-07**

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 (tons/well)		
	Type	Class					CO_2	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Semi Rig Transport, Drill Rig	HDDV	2	44	88	1	7.68E-02	3.59E-06	5.60E-07
	Fuel Haul Truck	HDDV	2	6	12	1	1.05E-02	4.89E-07	7.63E-08
	Mud Haul Truck, Water Hauling	HDDV	2	4	8	1	6.98E-03	3.26E-07	5.09E-08
	Rig Crew	LDDT	2	51	102	1	4.60E-02	2.25E-07	1.74E-06
	Rig Mechanics	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Co. Supervisor	LDDT	2	20	40	1	1.81E-02	8.82E-08	6.83E-07
	Tool Pusher	LDDT	2	8	16	1	7.22E-03	3.53E-08	2.73E-07
	Mud Logger	LDDT	2	6	12	1	5.42E-03	2.65E-08	2.05E-07
	Mud Engineer	LDDT	2	15	30	1	1.35E-02	6.61E-08	5.13E-07
	Logger, Engr Truck	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Drill Bit Delivery	LDDT	2	2	4	1	1.81E-03	8.82E-09	6.83E-08

Combustive Emissions Estimation Road Traffic (cont.)

Construction Site Destination	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells	Emissions (tons/well)		
	Type	Class					CO_2	CH_4	N_2O
Well Completion & Testing	Semi Casing Haulers	HDDV	2	6	12	1	1.05E-02	4.89E-07	7.63E-08
	Semi Completion, Unit Rig	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Semi Fracing, Blender	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Semi Pumping/Tank Battery	HDDV	2	6	12	1	1.05E-02	4.89E-07	7.63E-08
	Tubing Truck	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Haul Cementer, Pump Truck	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Haul Cementer, Cement	HDDV	2	3	6	1	5.24E-03	2.45E-07	3.82E-08
	Haul Completion, Equip	HDDV	2	3	6	1	5.24E-03	2.45E-07	3.82E-08
	Haul Service Tools	LDDT	2	2	4	1	1.81E-03	8.82E-09	6.83E-08
	Haul Perforators Logging Truck	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Anchor, Installation	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Anchor, Testing	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Tank	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Pump	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Chemical	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Sand	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Other	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Welders	HDDV	2	6	12	1	1.05E-02	4.89E-07	7.63E-08
	Haul Water Truck	HDDV	2	150	300	1	2.62E-01	1.22E-05	1.91E-06
	Pickup Cementer, Engineer	LDDT	2	2	4	1	1.81E-03	8.82E-09	6.83E-08
	Pickup Casing Crew	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Pickup Completion Crew	HDDV	2	5	10	1	8.73E-03	4.08E-07	6.36E-08
	Pickup Completion,	LDDT	2	5	10	1	4.51E-03	2.20E-08	1.71E-07
	Pickup Perforators, Engineer	LDDT	2	2	4	1	1.81E-03	8.82E-09	6.83E-08
	Pickup Fracing, Engineer	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Pickup Co. Supervisor	LDDT	2	10	20	1	9.03E-03	4.41E-08	3.42E-07
	Pickup Miscellaneous Supplies	LDDT	2	3	6	1	2.71E-03	1.32E-08	1.03E-07
	Pickup Roustabout Crew	HDDV	2	4	8	1	6.98E-03	3.26E-07	5.09E-08
					Subtotal		**5.62E-01**	**2.15E-05**	**7.57E-06**
					Total		**6.67E-01**	**2.61E-05**	**8.56E-06**

Exhaust Emissions from Well Work Overs

Emission Factors Bore/Drill Rig Engines 300-600 Hp

Fuel Type	Emission Factors (gm/hp-hr)		
	CO_2	CH_4	N_2O[a]
Diesel	529.575	0.007	0.006

Source: EPA NONROADS 2008a. Year 2008.

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

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 (tons/year/well)		
							CO_2	CH_4	N_2O
Well Workover	Truck-Mounted Unit	600	10	3	30	1	1.05E+01	1.46E-04	1.14E-04

Exhaust emission factors for commuting vehicles

Vehicle		Emission Factors (g/mi)		
Type	Class	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	409.5	0.002	0.016
Heavy-Duty Diesel Truck	HDDV	791.8	0.037	0.006

Source: MOBILE 6.2.03
Emission factors for 2008 used for all project years = conservative estimate of vehicle fleet turnover

[a] 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

Activity	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells Drilled	Max. Annual Emissions (tons/year/well)		
	Type	Class					CO_2	CH_4	N_2O
Well Workover	WO Rig	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Truck	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Pickup Truck	LDDT	2	3	6	1	2.71E-03	1.32E-08	1.03E-07
						Total	**6.20E-03**	**1.76E-07**	**1.28E-07**

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).
Round trip distance = 2 based on data found in the SEIS

Exhaust Emissions from Site Visits and Inspections

Emission factors for Commuting Vehicles Exhaust

Vehicle Class	Emission Factors (g/mi)		
	CO_2	CH_4	N_2O[a]
Light-Duty Gasoline Truck	476.9	0.068	0.015

Source: MOBILE 6.2.03

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

[a] 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)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Federal Wells Producing	Emissions (tons/yr/well)		
	Type	Class					CO_2	CH_4	N_2O
Inspection Visits for Wells	Pickup Truck	LDGT2	2	12	24	1	1.26E-02	1.80E-06	4.07E-07

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 year

[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
Cumulative Length of Roads [b] (miles/operation)	1

[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	**1**	**5**

Emission Factors for Construction Equipment Exhaust

Equipment	Emission Factors (g/hp-hr)		
	CO_2	CH_4	N_2O[a]
Grader 100-175 Hp	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] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

Emission Estimations for Grader: RMP Year 20

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours[a]	Emissions (tons/well)		
				CO_2	CH_4	N_2O
Road Maintenance	Grader	135	3	2.55E-01	2.52E-06	2.75E-06

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

Emission Factors for Commuting Vehicles Exhaust

Vehicle Class	Emission Factors (g/mi)		
	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	409.5	0.002	0.016

Source: MOBILE 6.2.03

[a] 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 (tons/yr)		
	Type	Class				CO_2	CH_4	N_2O
Road Maintenance	Pickup Truck	LDGT2	6	0.5	3	1.44E-03	7.05E-09	5.47E-08

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	0.021
Annual Miles of Roads reclaimed Per Well	0.005
Number of wells reclaimed (per well)	0.021

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
0.01	6	0.0009	0.0086
		Total	**0.0086**

Assume average miles/day = 6

Emission Factors for 75-100 hp Off-Road Engines

Year	Emission Factors (g/hp-hr)		
	CO_2	CH_4	N_2O[a]
2008	600.507	0.010	0.016
2018	613.888	0.006	0.016
2027	608.641	0.003	0.016

[a] 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).

Exhaust Emissions Estimation for Grader Road Reclaim

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours[a]	Emissions (tons/year/well)		
				CO_2	CH_4	N_2O
Road Reclamation	Grader	80	0.005	2.79E-04	2.51E-09	7.05E-09

Exhaust Emission Factors for Commuting Reclaim Vehicles Road Traffic

Vehicle Class	Emission Factors (g/mi)		
	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	409.5	0.002	0.016

Source: MOBILE6.2.03

[a] 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).

Exhaust Emissions Estimation for Commuting Reclaim Vehicles: Road Traffic

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tons/year/well)		
	Type	Class				CO_2	CH_4	N_2O
Road Reclamation	Pickup Truck	LDDV	6	0.0009	0.0052	2.33E-06	1.14E-11	8.82E-11

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	0.02	10	0.02	0.21

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

Exhaust Emissions Estimation for Grader: Well Reclamation

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours [a]	Emissions (tons/year/well)		
				CO_2	CH_4	N_2O
Well Reclamation	Grader	100	0.12	8.20E-03	1.37E-07	2.12E-07

Exhaust Emissions Estimation for Commuting Vehicles: Well Reclamation

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tons/year/well)		
	Type	Class				CO_2	CH_4	N_2O
Well Reclamation	Pickup Truck	LDDV	6	0.021	0.124	5.59E-05	2.73E-10	2.12E-09

Emission Factors for Dehydrator Heaters

Unit	CO_2	CH_4	N_2O
lb/MMSCF	120000.0	2.3	2.2
lb/MMBTU	117.647	0.002	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 (tons/year/well)		
				CO_2	CH_4	N_2O
2,190	1	2.20	0.0008	1.02E-01	1.95E-06	1.87E-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)
9.86	1.55E-02	1.53E-01	2.13E-05	2.10E-04

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 South Baker 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 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

Wellhead Fugitives

Fugitive Emissions from Equipment Leaks

TOC Emission Factor								
Well Equipment Component	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% =	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	7.50E-02	5.12E-04	2.25E-04	6.67E-02
pump seals	0	0.0053	0	0.0287	0	0.0001	0.00E+00	0.00E+00	0.00E+00	0.00E+00
others	0	0.0194	0	0.0165	0	0.0309	0.00E+00	0.00E+00	0.00E+00	0.00E+00
connectors	24	0.0004	0	0.0005	0	0.0002	1.06E-02	7.22E-05	3.17E-05	9.42E-03
flanges	2	0.0009	0	0.0002	0	0.0000	1.72E-03	1.17E-05	5.15E-06	1.53E-03
open-ended lines	0	0.0044	0	0.0031	0	0.0006	0.00E+00	0.00E+00	0.00E+00	0.00E+00
					TOTAL emissions/well/hr =		8.73E-02	5.96E-04	2.61E-04	7.77E-02

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 (ton/yr)**	**CO_2 emissions (lb/yr)**	**CO_2 emissions (ton/yr)**	**CH_4 emissions (lb/yr)**	**CH_4 emissions (ton/yr)**
Year 20	1	8760	5.22E+00	2.61E-03	2.29E+00	1.14E-03	6.80E+02	3.40E-01

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

Gas Component	Mole Fraction (%)	Molecular Weight (lb/lb-mol)	Gas Weight (lb/lb-mol)	Weight Percent (wt%)	Weight (lb/MMscf))	Emissions Mass Flow (ton/well)
Methane	93.716	16.040	15.032	88.998	37788.643	1.530
Ethane	1.624	30.070	0.488	2.891	1227.616	0.050
Nitrogen	4.297	28.020	1.204	7.128	3026.751	0.123
Water	0.000	18.015	0.000	0.000	0.000	0.000
Carbon Dioxide	0.115	43.990	0.051	0.300	127.173	0.005
Nitrous Oxide	0.000	44.020	0.000	0.000	0.000	0.000
Hydrogen Sulfide	0.000	34.067	0.000	0.000	0.000	0.000
Non-reactive, non-HAP	99.752	---	16.775	99.317		1.708
Propane	0.211	44.100	0.093	0.551	233.918	0.009
Iso-butane	0.019	58.120	0.011	0.065	27.760	0.001
n-butane	0.015	58.120	0.009	0.052	21.916	0.001
i-pentane	0.002	72.150	0.001	0.009	3.628	0.000
n-pentane	0.001	72.150	0.001	0.004	1.814	0.000
Hexanes	0.000	86.180	0.000	0.000	0.000	0.000
Heptanes	0.000	100.200	0.000	0.002	0.781	0.000
Octanes	0.000	114.230	0.000	0.000	0.000	0.000
Nonanes	0.000	128.26	0.000	0.000	0.000	0.000
Decanes+	0.000	142.29	0.000	0.000	0.000	0.000
Reactive VOC	0.248	---	0.115	0.683		0.012
Benzene	0.000	78.110	0.000	0.000	0.000	0.000
Ethylbenzene	0.000	106.167	0.000	0.000	0.000	0.000
n-Hexane [3]	*0.000*	*100.210*	*0.000*	*0.000*	*0.000*	*0.000*
Toluene	0.000	92.140	0.000	0.000	0.000	0.000
Xylenes	0.000	106.160	0.000	0.000	0.000	0.000
HAPs	0.000	---	0.000	0.000		0.000
Totals	**100.000**	**---**	**16.890**	**100.000**		**1.720**

Sample taken 03-09-2010 at Baker South 7 W 0429 (Miles City)

Volume Flow:	27	MSCF/day/well
Completion activity duration:	3	days
Total Volume Flow per Well	0.081	MMSCF/well

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

BTU value = 994 BTU/scf

Emission Factors for Natural Gas-Fired Compressors

Compressor		Horse-Power Rating	Units	Emission Factors		
				CO_2[c]	CH_4[c]	N_2O[c]
Field Compression Station	Rich Burn	300	gm/bhp-hr	134.936	2.55E-03	2.55E-04
			lb/MMBTU	116.887	2.20E-03	2.20E-04
Sales Compression Station	Rich Burn	1,680	gm/bhp-hr	134.936	2.55E-03	2.55E-04
			lb/MMBTU	116.887	2.20E-03	2.20E-04

Note: Compressors assumed to be equipped with nonselective catalytic reduction (NSCR) catalyst.

[a] 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 (tons/year/well)		
					CO_2	CH_4	N_2O
Field Compression Station	11	1	11	8,760	1.44E+01	2.72E-04	2.72E-05
Sales Compression Station	10	1	10	8,760	1.35E+01	2.54E-04	2.54E-05
				Total	**2.79E+01**	**5.26E-04**	**5.26E-05**

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

TOC Emission Factor								
Well Equipment Component	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% =	0.68
CO2 Wt% =	0.30
CH4 Wt% =	89.00
N2O Wt% =	0.00

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	0.258	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 =	0.003	0.000	0.000	0.003

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 (ton/yr)**	**CO_2 emissions (lb/yr)**	**CO_2 emissions (ton/yr)**	**CH_4 emissions (lb/yr)**	**CH_4 emissions (ton/yr)**
Year 20	1	8760	2.09E-01	1.04E-04	9.15E-02	4.58E-05	2.72E+01	1.36E-02

Compressor Station Inspection Traffic Exhaust Emissions

Emission factors for Commuting Vehicles Exhaust

Vehicle		Emission Factors (g/mi)		
Type	Class	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	409.5	0.002	0.016

Source: MOBILE6.2.03

[a] 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).

Exhaust Emissions Estimation for Road Traffic

Activity	Compressor Station	Vehicle		# of Compressor Stations / Well	# of Inspection Visits/ Station	# of Inspection Visits/Well/Year	Total Miles/ Inspection	Emissions (tons/year/well)		
		Type	Class					CO_2	CH_4	N_2O
Inspection Visits for Compressor Stations	CPF Compressor Station	Pickup Truck	LDGT2	0.04	12	0.4	20	4.00E-03	1.95E-08	1.51E-07
	Primary Compressor Station	Pickup Truck	LDGT2	0.01	52	0.3	20	2.89E-03	1.41E-08	1.09E-07
							Total	**6.89E-03**	**3.36E-08**	**2.61E-07**

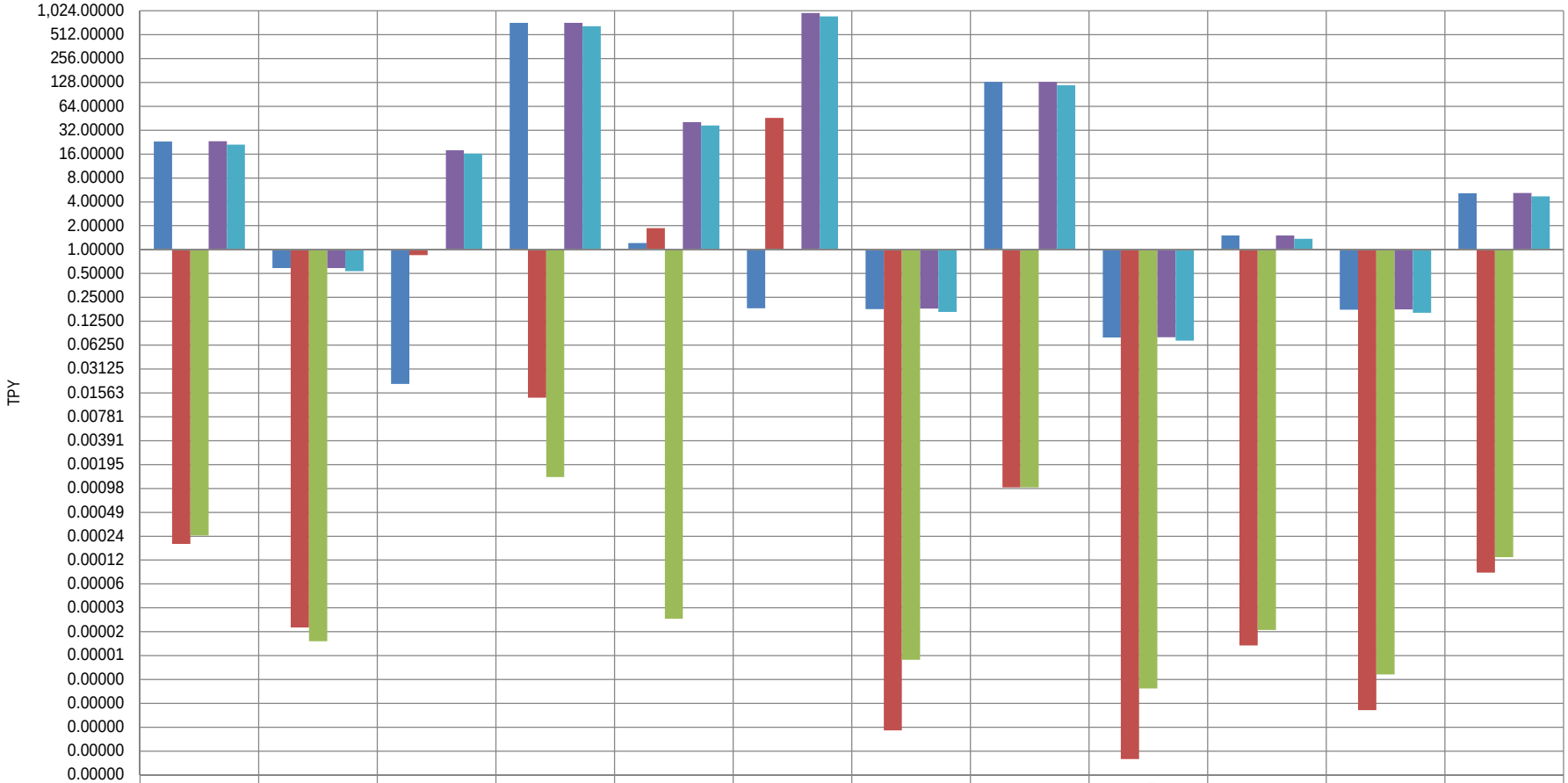
Malta/Hi-Line input parameters for calculating CBNG wells emissions

Peak Year Federal Producing Wells Drilled	1	Peak Year Non-Federal Producing Wells Drilled	1
Federal Producing Wells - Year 20	23	Non-Federal Producing Wells - Year 2027	126
Average Gas Production Per Well (MCFD)	14	Average Gas Production Per Well (MCFD)	14

Federal Oil Wells Summaries

Total Annual Emissions from Federal CBNG Wells - RMP Year 20

Activity	Annual Emissions (Tons)				
	CO_2	CH_4	N_2O	CO_{2eq}	CO_{2eq} metric tons
Well Pad & Station Construction - Fugitive Dust	---	---	---	---	---
Wind Erosion	---	---	---	---	---
Heavy Equipment Combustive Emissions	23.08	0.00	0.00	23.16	21.02
Commuting Vehicles - Construction	0.58	0.00	0.00	0.59	0.53
Completion Venting	0.02	0.85	0.00	17.94	16.28
Sub-total: Construction[c]	**23.68**	**0.85**	**0.00**	**41.69**	**37.83**
Natural Gas Compression - Operations	721.72	0.01	0.00	722.43	655.56
Dehydrators	1.21	1.87	0.00	40.48	36.73
Wellhead and Compressor Station Fugitives	0.18	45.66	0.00	959.15	870.37
Station Visits - Operations	0.18	0.00	0.00	0.18	0.16
Well Workover - Operations	130.06	0.00	0.00	130.39	118.33
Well & Pipeline visits for Inspection & Repair - Operations	0.08	0.00	0.00	0.08	0.07
Sub-total: Operations	**853.43**	**47.55**	**0.00**	**1852.71**	**1681.22**
Road Maintenance	1.50	0.00	0.00	1.51	1.37
Sub-total: Maintenance	**1.50**	**0.00**	**0.00**	**1.51**	**1.37**
Road Reclamation	0.17	0.00	0.00	0.18	0.16
Well Reclamation	5.12	0.00	0.00	5.17	4.69
Sub-total: Reclamation	**5.2980**	**0.0001**	**0.0001**	**5.3423**	**4.8478**
Total Emissions	**883.92**	**48.40**	**0.00**	**1,901.25**	**1,725.27**



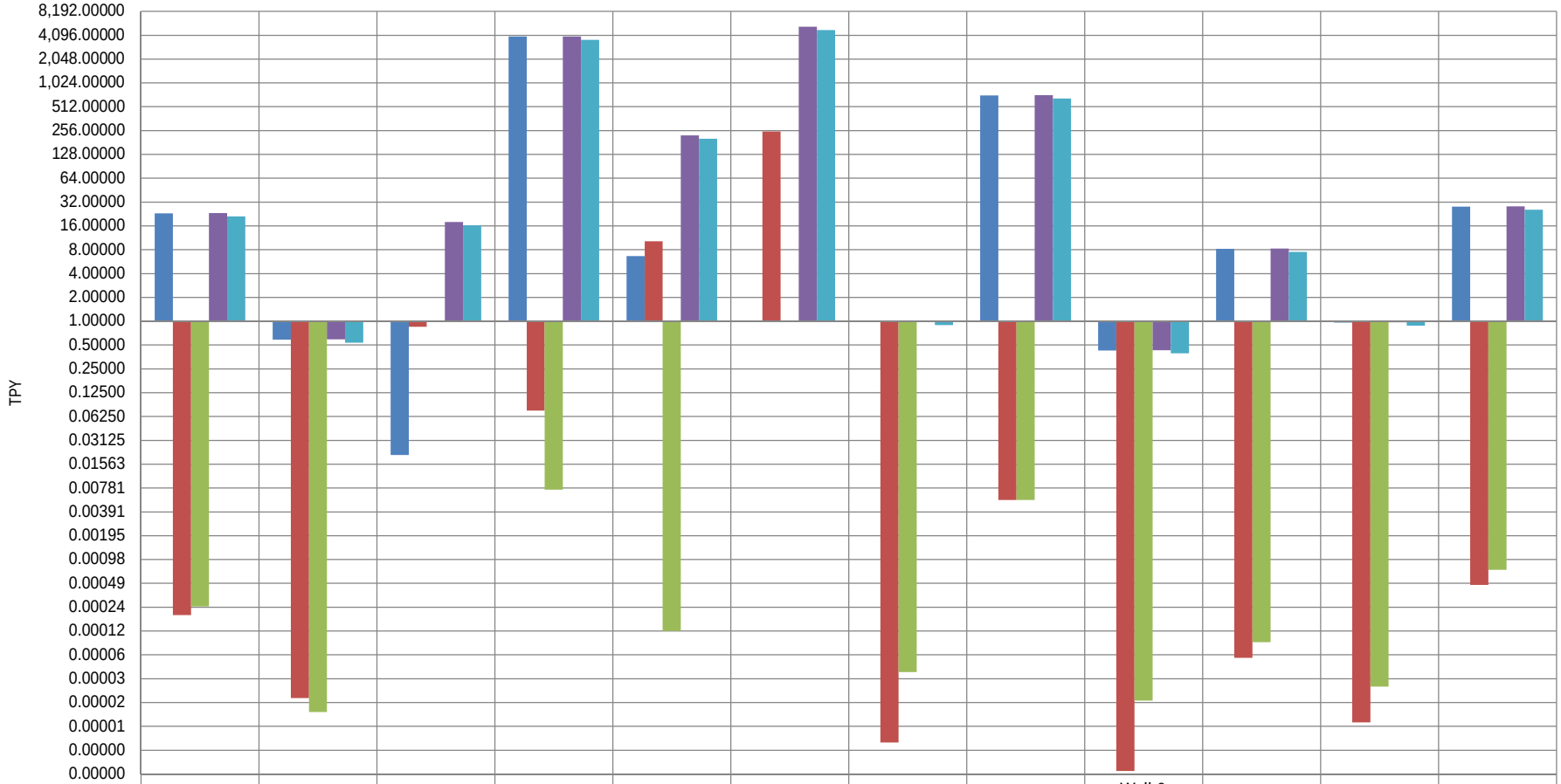
	Heavy Equipment Combustive Emissions	Commuting Vehicles - Construction	Completion Venting	Natural Gas Compression - Operations	Dehydrators	Wellhead and Compressor Station Fugitives	Station Visits - Operations	Well Workover - Operations	Well & Pipeline visits for Inspection & Repair - Operations	Road Maintenance	Road Reclamation	Well Reclamation
CO2	23.08	0.58	0.02	721.72	1.21	0.18	0.18	130.06	0.08	1.50	0.17	5.12
CH4	0.00	0.00	0.85	0.01	1.87	45.66	0.00	0.00	0.00	0.00	0.00	0.00
N2O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CO2eq	23.16	0.59	17.94	722.43	40.48	959.15	0.18	130.39	0.08	1.51	0.18	5.17
CO2eq metric tons	21.02	0.53	16.28	655.56	36.73	870.37	0.16	118.33	0.07	1.37	0.16	4.69

Non-Federal Oil Wells Summaries

Total Annual Emissions from Non-Federal CBNG Wells - RMP Year 20

Activity	Annual Emissions (Tons)				
	CO_2	CH_4	N_2O	CO_{2eq}	CO_{2eq} metric tons
Well Pad & Station Construction - Fugitive Dust	---	---	---	---	---
Wind Erosion	---	---	---	---	---
Heavy Equipment Combustive Emissions	23.08	0.00	0.00	23.16	21.02
Commuting Vehicles - Construction	0.58	0.00	0.00	0.59	0.53
Completion Venting	0.02	0.85	0.00	17.94	16.28
Sub-total: Construction[c]	**23.68**	**0.85**	**0.00**	**41.69**	**37.83**
Natural Gas Compression - Operations	3,953.76	0.07	0.01	3957.64	3591.32
Dehydrators	6.66	10.24	0.00	221.76	201.24
Wellhead and Compressor Station Fugitives	1.00	250.16	0.00	5254.45	4768.11
Station Visits - Operations	0.98	0.00	0.00	0.99	0.90
Well Workover - Operations	712.50	0.01	0.01	714.34	648.22
Well & Pipeline visits for Inspection & Repair - Operations	0.43	0.00	0.00	0.43	0.39
Sub-total: Operations	**4675.32**	**260.49**	**0.01**	**10149.61**	**9210.17**
Road Maintenance	8.24	0.00	0.00	8.27	7.50
Sub-total: Maintenance	**8.24**	**0.00**	**0.00**	**8.27**	**7.50**
Road Reclamation	0.96	0.00	0.00	0.97	0.88
Well Reclamation	28.07	0.00	0.00	28.30	25.68
Sub-total: Reclamation	**29.0238**	**0.0005**	**0.0008**	**29.2666**	**26.5577**
Total Emissions	**4,736.27**	**261.34**	**0.01**	**10,228.84**	**9,282.07**

Malta/Hi-Line RMP Non-Federal CBNG Wells Emissions (TPY)



	Heavy Equipment Combustive Emissions	Commuting Vehicles - Construction	Completion Venting	Natural Gas Compression - Operations	Dehydrators	Wellhead and Compressor Station Fugitives	Station Visits - Operations	Well Workover - Operations	Well & Pipeline visits for Inspection & Repair - Operations	Road Maintenance	Road Reclamation	Well Reclamation
CO2	23.08	0.58	0.02	3,953.76	6.66	1.00	0.98	712.50	0.43	8.24	0.96	28.07
CH4	0.00	0.00	0.85	0.07	10.24	250.16	0.00	0.01	0.00	0.00	0.00	0.00
N2O	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
CO2eq	23.16	0.59	17.94	3957.64	221.76	5254.45	0.99	714.34	0.43	8.27	0.97	28.30
CO2eq metric tons	21.02	0.53	16.28	3591.32	201.24	4768.11	0.90	648.22	0.39	7.50	0.88	25.68

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

Project Year/Hp Category	Emission Factors (g/hp-hr)		
	CO_2	CH_4	N_2O[a]
Year 2018			
50 to 75	589.096	0.006	0.006
75 to 100	589.103	0.006	0.006
100 to 175	530.097	0.005	0.006
175 to 300	530.181	0.004	0.006
300 to 600	530.255	0.004	0.006
600 to 750	530.283	0.004	0.006
>750	529.917	0.006	0.006

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

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

Exhaust Emission Estimations for Construction Equipment - Based on Peak Wells Drilled each Alternative (using 2008 emission factors)

Construction Activity	Equipment Type	Capacity (hp)	# of Units	Av. Load Factor (%)	# of Oper. Hours/Day	# of Oper. Days/ Activity	# of Oper. Hours/Activity	# of Activities / Well	Emissions (tons/year/well)		
									CO_2	CH_4	N_2O
Drilling Roads	Blade	100	1	80	10	0.2	2	1.00	9.35E-02	8.37E-07	1.02E-06
	Backhoe	80	1	75	10	0.1	1	1.00	3.90E-02	4.20E-07	3.82E-07
Drilling Well Pad	Backhoe	80	1	75	10	0.5	5	1.00	1.95E-01	2.10E-06	1.91E-06
Water Disposal well pad	Backhoe	80	1	75	10	2	20	0.01	3.90E-03	4.20E-08	3.82E-08
New Pipeline Intermediate	Blade	100	1	80	10	5	50	0.11	2.88E-01	3.10E-06	2.82E-06
	Trencher	175	1	80	10	5	50	0.11	4.53E-01	4.06E-06	4.93E-06
	Backhoe	80	1	75	10	10	100	0.11	4.32E-01	4.65E-06	4.23E-06
New Sales Pipeline	Blade	100	1	80	10	43	430	0.0002	3.68E-03	3.96E-08	3.60E-08
	Trencher	175	1	80	10	43	430	0.0002	5.79E-03	5.18E-08	6.30E-08
	Backhoe	80	1	75	10	65	650	0.0002	4.17E-03	4.49E-08	4.08E-08
Booster Compression Station	Dozer	350	1	80	10	2	20	0.11	3.63E-01	2.70E-06	3.95E-06
	Backhoe	80	2	80	10	3	30	0.11	2.76E-01	2.98E-06	2.71E-06
Sales Compression Station	Dozer	350	1	80	10	2	20	0.01	3.61E-02	2.69E-07	3.93E-07
	Backhoe	80	2	80	10	3	30	0.01	2.75E-02	2.96E-07	2.69E-07
								Subtotal	**2.22E+00**	**2.16E-05**	**2.28E-05**

Activity rates based on values shown in SEIS. Water disposal well pad development rates provided by Montana BLM (Laakso, 2010).

Exhaust Emission Factors for Diesel Powered Bore/Drill Rig Engines

Project Year/Hp Category	Emission Factors (g/hp-hr)		
	CO_2	CH_4	N_2O[a]
Year 2018			
50 to 75	589.096	0.006	0.006
75 to 100	589.103	0.006	0.006
100 to 175	530.097	0.005	0.006
175 to 300	530.181	0.004	0.006
300 to 600	530.255	0.004	0.006
600 to 750	530.283	0.004	0.006
>750	529.917	0.006	0.006

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

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

Combustive Emissions Estimation for Industrial Engines - Based on Peak Wells Drilled each Alternative

Construction Activity	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Oper. Hours/Day	# of Oper. Days/ Well	# of Oper. Hours/Well	# of Wells	Emissions (tons/year/well)		
									CO_2	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Main Deck	400	1	60	18	3	54	1.00	7.58E+00	5.65E-05	8.24E-05
	Auxillary Pump	200	1	90	18	2	36	1.00	3.79E+00	3.09E-05	4.12E-05
Well Completion & Testing	Main Deck	400	1	60	18	1	18	1.00	2.53E+00	1.88E-05	2.75E-05
	Auxillary Pump	125	1	90	18	1	18	1.00	1.18E+00	1.06E-05	1.29E-05
Water Disposal well drilling	Generator	1476	1	40	24	30	720	0.01	1.24E+00	1.32E-05	1.35E-05
	Generator	1476	1	40	24	30	720	0.01	1.24E+00	1.32E-05	1.35E-05
								Subtotal	**1.76E+01**	**1.43E-04**	**1.91E-04**
								Total	**1.98E+01**	**1.65E-04**	**2.14E-04**

Equipment type, Hp ratings, and operational hours based on information shown in SEIS. No flaring per Montana BLM (Laakso, 2010). Water disposal well pad development rates provided by Montana BLM (Laakso, 2010).

Temporary Emission Estimations for Field Generators: Based on Peak Wells Drilled each Alternative

Construction Activity	Equipment Type	Capacity (hp)	# of Wells Served[a]	Avg. Load Factor (%)	# of Oper. Hours/Day	# of Oper. Days/Well	# of Oper. Hours/Well	# of Wells	Emissions (tons/year/well)		
									CO_2	CH_4	N_2O
Field Generators	Field Generators for Pumps & Lighting	21	1	75	24	15	360	1	3.31E+00	2.96E-05	3.60E-05
								Total	**3.31E+00**	**2.96E-05**	**3.60E-05**

Values shown in SEIS per well.

Exhaust Emissions from Construction and Drilling Support Vehicles

Emission factors for Commuting Vehicles Exhaust

Vehicle		Emission Factors (g/mi)		
Type	Class	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	409.5	0.002	0.016
Heavy-Duty Diesel Truck	HDDV	791.8	0.037	0.006

Source: MOBILE6.2.03

[a] 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).

Combustive Emissions Estimation Road Traffic - Based on Peak Wells Drilled

Construction Activity	Vehicle		Round Trip Distance (miles)	# of Round Trips/Activity	Miles Traveled/Activity	Total # of Activities / Well	Emissions (tons/year/well)		
	Type	Class					CO_2	CH_4	N_2O
Drilling Roads	Semi Trucks	HDDV	6	3	18	1.00	1.57E-02	7.34E-07	1.14E-07
Drilling Well Pad	Haul Trucks	HDDV	6	2	12	1.00	1.05E-02	4.89E-07	7.63E-08
	Pickup Trucks	LDDT	6	2	12	1.00	5.42E-03	2.65E-08	2.05E-07
Water Disposal Well Pad	Haul Trucks	HDDV	100	5	500	0.01	2.18E-03	1.02E-07	1.59E-08
	Pickup Trucks	LDDT	25	5	125	0.01	2.82E-04	1.38E-09	1.07E-08
New Pipeline Intermediate	Haul Trucks	HDDV	6	40	240	0.11	2.32E-02	1.08E-06	1.69E-07
	Pickup Trucks	LDDT	6	160	960	0.11	4.80E-02	2.34E-07	1.82E-06
New Sales Pipeline	Haul Trucks	HDDV	35	94	3290	0.00	4.73E-04	2.21E-08	3.44E-09
	Pickup Trucks	LDDT	50	94	4700	0.00	3.49E-04	1.71E-09	1.32E-08
Electric Line	Haul Trucks	HDDV	6	1	6	1.00	5.24E-03	2.45E-07	3.82E-08
	Pickup Trucks	LDDT	6	2	12	1.00	5.42E-03	2.65E-08	2.05E-07
Field Compression Station	Semi Trucks	HDDV	10	15	150	0.11	1.45E-02	6.78E-07	1.06E-07
	Haul Trucks	HDDV	10	48	480	0.11	4.64E-02	2.17E-06	3.38E-07
	Pickup Trucks	LDDT	10	192	1920	0.11	9.60E-02	4.69E-07	3.63E-06
Sales Compression Station	Semi Trucks	HDDV	10	19	190	0.01	1.83E-03	8.55E-08	1.33E-08
	Haul Trucks	HDDV	10	48	480	0.01	4.62E-03	2.16E-07	3.37E-08
	Pickup Trucks	LDDT	10	192	1920	0.01	9.56E-03	4.67E-08	3.62E-07
Rig-up, Drilling, and Rig-down	Semi Rig Transport	HDDV	6	1	6	1.00	5.24E-03	2.45E-07	3.82E-08
	Fuel Haul Truck	HDDV	6	2	12	1.00	1.05E-02	4.89E-07	7.63E-08
	Mud Haul Truck, Water Hauling	HDDV	6	7	42	1.00	3.67E-02	1.71E-06	2.67E-07
	Rig Crew	LDDT	6	3	18	1.00	8.13E-03	3.97E-08	3.08E-07
	Rig Mechanics	HDDV	6	1	6	1.00	5.24E-03	2.45E-07	3.82E-08
	Co. Supervisor	LDDT	6	8	48	1.00	2.17E-02	1.06E-07	8.20E-07
	Tool Pusher	LDDT	6	6	36	1.00	1.63E-02	7.94E-08	6.15E-07
	Mud Logger	LDDT	6	1	6	1.00	2.71E-03	1.32E-08	1.03E-07
	Mud Engineer	LDDT	6	1	6	1.00	2.71E-03	1.32E-08	1.03E-07
	Logger, Engr	HDDV	6	1	6	1.00	5.24E-03	2.45E-07	3.82E-08
	Drill Bit Delivery	LDDT	6	1	6	1.00	2.71E-03	1.32E-08	1.03E-07
						Subtotal	**4.07E-01**	**9.83E-06**	**9.66E-06**

Activity rates based on values shown in SEIS. Water disposal well pad development rates provided by Montana BLM (Laakso, 2010).

Combustive Emissions Estimation Road Traffic - Based on Peak Wells Drilled

Construction Activity	Vehicle		Round Trip Distance (miles)	# of Round Trips/Activity	Miles Traveled/Activity	Total # of Activities / Well	Emissions (tons/year)		
	Type	Class					CO_2	CH_4	N_2O
Well Completion & Testing	Semi Casing Haulers	HDDV	6	1	6	1.00	5.24E-03	2.45E-07	3.82E-08
	Semi Completion, Unit Rig	HDDV	6	1	6	1.00	5.24E-03	2.45E-07	3.82E-08
	Semi Fracing Blender	HDDV	6	1	6	1.00	5.24E-03	2.45E-07	3.82E-08
	Semi Pumping Tank Battery	HDDV	6	1	6	1.00	5.24E-03	2.45E-07	3.82E-08
	Tubing Truck	HDDV	6	1	6	1.00	5.24E-03	2.45E-07	3.82E-08
	Haul Cementer, Pump Truck	HDDV	6	1	6	1.00	5.24E-03	2.45E-07	3.82E-08
	Haul Cementer, Cement Truck	HDDV	6	1	6	1.00	5.24E-03	2.45E-07	3.82E-08
	Haul Completion, Equip Truck	HDDV	6	1	6	1.00	5.24E-03	2.45E-07	3.82E-08
	Haul Service Tools	LDDT	6	1	6	1.00	2.71E-03	1.32E-08	1.03E-07
	Haul Perforators Logging Truck	HDDV	6	1	6	1.00	5.24E-03	2.45E-07	3.82E-08
	Haul Anchor Installation	HDDV	6	1	6	1.00	5.24E-03	2.45E-07	3.82E-08
	Haul Anchor Testing	HDDV	6	1	6	1.00	5.24E-03	2.45E-07	3.82E-08
	Haul Fracing Tank	HDDV	6	1	6	1.00	5.24E-03	2.45E-07	3.82E-08
	Haul Fracing Pump	HDDV	6	1	6	1.00	5.24E-03	2.45E-07	3.82E-08
	Haul Fracing Chemical	HDDV	6	1	6	1.00	5.24E-03	2.45E-07	3.82E-08
	Haul Fracing Sand	HDDV	6	1	6	1.00	5.24E-03	2.45E-07	3.82E-08
	Haul Fracing	HDDV	6	1	6	1.00	5.24E-03	2.45E-07	3.82E-08
	Haul Welders	HDDV	6	1	6	1.00	5.24E-03	2.45E-07	3.82E-08
	Haul Water Truck	HDDV	6	9	54	1.00	4.71E-02	2.20E-06	3.43E-07
	Pickup Cementer, Engineer	LDDT	6	1	6	1.00	2.71E-03	1.32E-08	1.03E-07
	Pickup Completion Crew	HDDV	6	1	6	1.00	5.24E-03	2.45E-07	3.82E-08
	Pickup Completion Pusher	LDDT	6	1	6	1.00	2.71E-03	1.32E-08	1.03E-07
	Pickup Perforators Engineer	LDDT	6	1	6	1.00	2.71E-03	1.32E-08	1.03E-07
	Pickup Fracing Engineer	HDDV	6	1	6	1.00	5.24E-03	2.45E-07	3.82E-08
	Pickup Co. Supervisor	LDDT	6	2	12	1.00	5.42E-03	2.65E-08	2.05E-07
	Pickup Misc. Supplies	LDDT	6	1	6	1.00	2.71E-03	1.32E-08	1.03E-07
	Pickup Roustabout Crew	HDDV	6	2	12	1.00	1.05E-02	4.89E-07	7.63E-08
Water Disposal Well Drilling	Drill Rig Transport truck	HDDV	10	10	100	0.01	4.36E-04	2.04E-08	3.18E-09
	Mud Haul Truck, Water Hauling	HDDV	10	5	50	0.01	2.18E-04	1.02E-08	1.59E-09
	Rig Crew	LDDT	10	10	100	0.01	2.26E-04	1.10E-09	8.54E-09
	Co. Supervisor	LDDT	10	5	50	0.01	1.13E-04	5.51E-10	4.27E-09
	Tool Pusher	LDDT	10	5	50	0.01	1.13E-04	5.51E-10	4.27E-09
	Tubing Truck	HDDV	10	1	10	0.01	4.36E-05	2.04E-09	3.18E-10
	Haul Cementer, Pump Truck	HDDV	10	1	10	0.01	4.36E-05	2.04E-09	3.18E-10
	Haul Cementer, Cement Truck	HDDV	10	1	10	0.01	4.36E-05	2.04E-09	3.18E-10
						Subtotal	**1.77E-01**	**7.47E-06**	**1.89E-06**
						Total	**5.84E-01**	**1.73E-05**	**1.15E-05**

Activity rates based on values shown in SEIS. Water disposal well pad development rates provided by Montana BLM (Laakso, 2010).

Compressor Stations Emissions

Emission Factors for Natural Gas-Fired Compressors

Compressor		Horse-Power Rating	Units	Emission Factors		
				CO_2[a]	CH_4[a]	N_2O[a]
Field Compression Station	Rich Burn	300	gm/bhp-hr	134.936	2.55E-03	2.55E-04
			lb/MMBTU	116.887	2.20E-03	2.20E-04
Sales Compression Station	Rich Burn	1,680	gm/bhp-hr	134.936	2.55E-03	2.55E-04
			lb/MMBTU	116.887	2.20E-03	2.20E-04

Note: Compressors assumed to be equipped with nonselective catalytic reduction (NSCR) catalyst.

[a] 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 (tons/year/well)		
					CO_2	CH_4	N_2O
Field Compression Station	12	1	12	8,760	1.62E+01	3.06E-04	3.06E-05
Sales Compression Station	12	1	12	8,760	1.51E+01	2.86E-04	2.86E-05
				Total	**3.14E+01**	**5.92E-04**	**5.92E-05**

Compression rate of 36 - 300 hp field compressors, and 6 - 1680 hp sales compressors per 867 CBNG wells based on BLM survey (Laakso, 2010)

Compressor Station Fugitives

Fugitive Emissions from Equipment Leaks

TOC Emission Factor								
Well Equipment Component	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% =	0.00
CO2 Wt% =	2.28
CH4 Wt% =	95.72
N2O Wt% =	0.00

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	0.291	0.0099	0	0.0055	0	0.0002	0.003	0.000	0.000	0.003
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	0.415	0.0004	0	0.0005	0	0.0002	0.000	0.000	0.000	0.000
flanges	0.997	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 =	0.004	0.000	0.000	0.004

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 (ton/yr)**	**CO_2 emissions (lb/yr)**	**CO_2 emissions (ton/yr)**	**CH_4 emissions (lb/yr)**	**CH_4 emissions (ton/yr)**
Year 20	1	8760	6.51E-04	3.25E-07	7.84E-01	3.92E-04	3.29E+01	1.64E-02

Dehydrator Emissions

Emission Factors for Dehydrator Heaters

Unit	CO_2	CH_4	N_2O
lb/MMSCF	120000.0	2.3	2.2
lb/MMBTU	117.647	0.002	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 (tons/year/well)		
				CO_2	CH_4	N_2O
2,190	1	2.20	0.00040	5.28E-02	1.01E-06	9.68E-07

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)
5.11	1.591E-02	8.128E-02	0.000E+00	0.000E+00

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 South Baker Compressor Station assumptions were used with CBNG 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

Compressor Stations Inspection Traffic Exhaust Emissions

Emission factors for Commuting Vehicles Exhaust

Vehicle		Emission Factors (g/mi)		
Type	Class	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	409.5	0.002	0.016

Source: MOBILE6.2.03

[a] 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).

Exhaust Emissions Estimation for Road Traffic

Activity	Compressor Station	Vehicle		# of Compressor Stations / Well	# of Inspection Visits/ Station	# of Inspection Visits/Well/Year	Total Miles/ Inspection	Emissions (tons/year/well)		
		Type	Class					CO_2	CH_4	N_2O
Inspection Visits for Compressor Stations	CPF Compressor Station	Pickup Truck	LDGT2	0.04	12	0.5	20	4.50E-03	2.20E-08	1.70E-07
	Primary Compressor Station	Pickup Truck	LDGT2	0.01	52	0.4	20	3.25E-03	1.59E-08	1.23E-07
							Total	**7.75E-03**	**3.78E-08**	**2.93E-07**

CBNG Well Work-Over Emissions

Emission Factors for Off-Road Engines of 300 to 600 hp

Year	Emission Factors (g/hp-hr)		
	CO_2	CH_4	N_2O[a]
2008	529.575	0.007	0.006
2018	530.255	0.004	0.006
2027	530.521	0.003	0.006

Source: EPA NONROADS 2008a

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

On-Site Exhaust Emission Estimations for Well Workover

Activity	Equipment	Capacity (hp)	Operating Hours/Day	Operational Wells	Emissions (tons/year)		
					CO_2	CH_4	N_2O
Well Workover[a]	Truck-Mounted Unit[b]	400	24	1	5.61E+00	4.19E-05	6.11E-05

Activity rates based on values shown in SEIS

Emission Factors for Road Traffic

Vehicle Class	Emission Factors (g/mi)		
	CO_2	CH_4	N_2O[a]
Heavy-Duty Diesel Truck	791.8	0.037	0.006

Source: MOBILE6.2.03

On-Road Exhaust Emissions Estimation for Road Traffic

Activity	Vehicle		Round Trip Distance (miles)	Round Trips/Well	Miles Traveled/ Well	Operational Wells	Emissions (tons/year)		
	Type	Class					CO_2	CH_4	N_2O
Well Workover[a]	Bobtail Truck	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07

Activity rates based on values shown in SEIS

Traffic Exhaust Emissions for Well and Pipe Inspections

Exhaust Emission Factors for Road Traffic

Vehicle Class	Emission Factors (g/mi)		
	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	409.5	0.002	0.016

Source: MOBILE6.2.03

[a] 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).

Exhaust Emission Estimations for Road Traffic: Well & Pipeline

Activity	Vehicle		Round Trip Distance (miles)	# of Visits/ Well/Year	Total # of Operating Wells	Miles Traveled/Year	Emissions (tons/year/well)		
	Type	Class					CO_2	CH_4	N_2O
Visits for Inspection and Repair	200-hp Pickup	LDDT	0.625	12	1	8	3.39E-03	1.65E-08	1.28E-07

Activity rates based on values shown in SEIS

Emissions for Road Maintenance

Estimation of Total and Cumulative Length of Roads

Length of Roads Built per Well	0.25
Cumulative Length of Roads Maintained (miles)	0.25

Based on values shown in SEIS

Estimation of Total Operation Days and Hours

Season	# of Operations/ Year	Cumulative Length of Roads (miles/year)	Miles of Road Worked on/Day	# of Operating Hours/Day	Total # of Operating Days	Total # of Operating Hours
Summer	2	0.25	6	10	0.1	1
Winter	1	0.25	5	10	0.1	1
				Total	**0.1**	**1**

Based on values shown in SEIS

Emission Factors for 100-175 hp Off-Road Engine

Year	Emission Factors (g/hp-hr)		
	CO_2	CH_4	N_2O[a]
Year 2008	540.319	0.007	0.006
Year 2018	546.217	0.004	0.006
Year 2028	546.466	0.002	0.006

Source: EPA NONROADS 2008a

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

Exhaust Emissions Estimation for Grader

Activity	Vehicle Type	Capacity (hp)[a]	Total # of Operating Hours[a]	Emissions (tons/year/well)		
				CO_2	CH_4	N_2O
Road Maintenance	Grader	135	1	6.50E-02	4.44E-07	6.87E-07

[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 Emission Factors for Commuting Maintenance Vehicles Road Traffic

Vehicle Class	Emission Factors (g/mi)		
	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	409.5	0.002	0.016

Source: MOBILE6.2.03

[a] 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).

Exhaust Emissions Estimation for Commuting Maintenance Vehicles Road Traffic

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tons/year/well)		
	Type	Class				CO_2	CH_4	N_2O
Road Maintenance	Pickup Truck	LDDV	6	0.1	0.8	3.61E-04	1.76E-09	1.37E-08

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	0.56
Annual Miles of Roads reclaimed Per Well	0.14
Number of wells reclaimed (per well)	0.56

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
0.14	6	0.0	0
		Total	**0**

Assume average miles/day = 6

Emission Factors for 75-100 hp Off-Road Engines

Year	Emission Factors (g/hp-hr)		
	CO_2	CH_4	N_2O[a]
2008	600.507	0.010	0.016
2018	613.888	0.006	0.016
2027	608.641	0.003	0.016

[a] 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).

Exhaust Emissions Estimation for Grader Road Reclaim

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours[a]	Emissions (tons/year/well)		
				CO_2	CH_4	N_2O
Road Reclamation	Grader	80	0.1	7.54E-03	6.78E-08	1.90E-07

Exhaust Emission Factors for Commuting Reclaim Vehicles Road Traffic

Vehicle Class	Emission Factors (g/mi)		
	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	409.5	0.002	0.016

Source: MOBILE6.2.03

[a] 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).

Exhaust Emissions Estimation for Commuting Reclaim Vehicles: Road Traffic

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tons/year/well)		
	Type	Class				CO_2	CH_4	N_2O
Road Reclamation	Pickup Truck	LDDV	6	0.02	0.14	6.29E-05	3.07E-10	2.38E-09

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	0.56	10	0.56	5.57

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

Exhaust Emissions Estimation for Grader: Well Reclamation

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours [a]	Emissions (tons/year/well)		
				CO_2	CH_4	N_2O
Well Reclamation	Grader	100	3	2.21E-01	3.69E-06	5.71E-06

Exhaust Emissions Estimation for Commuting Vehicles: Well Reclamation

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tons/year/well)		
	Type	Class				CO_2	CH_4	N_2O
Well Reclamation	Pickup Truck	LDDV	6	0.56	3.34	1.51E-03	7.37E-09	5.71E-08

Wellhead Fugitives

Fugitive Emissions from Equipment Leaks

TOC Emission Factor								
Well Equipment Component	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 CBNG analysis

VOC Wt% =	0.00
CO2 Wt% =	2.28
CH4 Wt% =	95.72
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	6	0.0099	1	0.0055	0	0.0002	6.50E-02	1.23E-06	1.48E-03	6.22E-02
pump seals	0	0.0053	0	0.0287	0	0.0001	0.00E+00	0.00E+00	0.00E+00	0.00E+00
others	0	0.0194	0	0.0165	0	0.0309	0.00E+00	0.00E+00	0.00E+00	1.24E-01
connectors	10	0.0004	0	0.0005	0	0.0002	4.41E-03	8.35E-08	1.01E-04	1.55E-01
flanges	7	0.0009	0	0.0002	0	0.0000	6.02E-03	1.14E-07	1.37E-04	2.75E-02
open-ended lines	0	0.0044	0	0.0031	0	0.0006	0.00E+00	0.00E+00	0.00E+00	8.01E-02
					TOTAL emissions/well/hr =		7.55E-02	1.43E-06	1.72E-03	4.50E-01

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 (ton/yr)**	**CO_2 emissions (lb/yr)**	**CO_2 emissions (ton/yr)**	**CH_4 emissions (lb/yr)**	**CH_4 emissions (ton/yr)**
Year 20	1	8760	1.25E-02	6.26E-06	1.51E+01	7.54E-03	3.94E+03	1.97E+00

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

Gas Component	Mole Fraction (%)	Molecular Weight (lb/lb-mol)	Gas Weight (lb/lb-mol)	Weight Percent (wt%)	Weight (lb/MMscf))	Emissions Mass Flow (ton/well)
Methane	97.913	16.040	15.705	95.715	40640.682	0.853
Ethane	0.000	30.070	0.000	0.000	0.000	0.000
Nitrogen	1.172	28.020	0.328	2.001	849.791	0.018
Water	0.000	18.015	0.000	0.000	0.000	0.000
Carbon Dioxide	0.851	43.990	0.374	2.281	968.723	0.020
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	99.936	---	16.408	99.998		0.892
Propane	0.000	44.100	0.000	0.000	0.000	0.000
Iso-butane	0.000	58.120	0.000	0.000	0.000	0.000
n-butane	0.000	58.120	0.000	0.000	0.000	0.000
i-pentane	0.000	72.150	0.000	0.000	0.000	0.000
n-pentane	0.000	72.150	0.000	0.000	0.000	0.000
Hexanes	0.000	100.210	0.000	0.000	0.000	0.000
Heptanes	0.000	100.200	0.000	0.002	0.804	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	0.000	---	0.000	0.002		0.000
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]	*0.000*	*100.210*	*0.000*	*0.000*	*0.000*	*0.000*
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	0.000	---	0.000	0.000		0.000
Totals	**99.936**	**---**	**16.408**	**100.000**		**0.892**

Sample taken 01-19-2010 at Holmes 14 Battery, Ft. Union. (Miles City)

Volume Flow:	14	MSCF/day/well
Completion activity duration:	3	days
Total Volume Flow per Well	0.042	MMSCF/well

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

BTU value = 994 BTU/scf

Appendix F

Lewistown Planning Area GHG Emission Inventory

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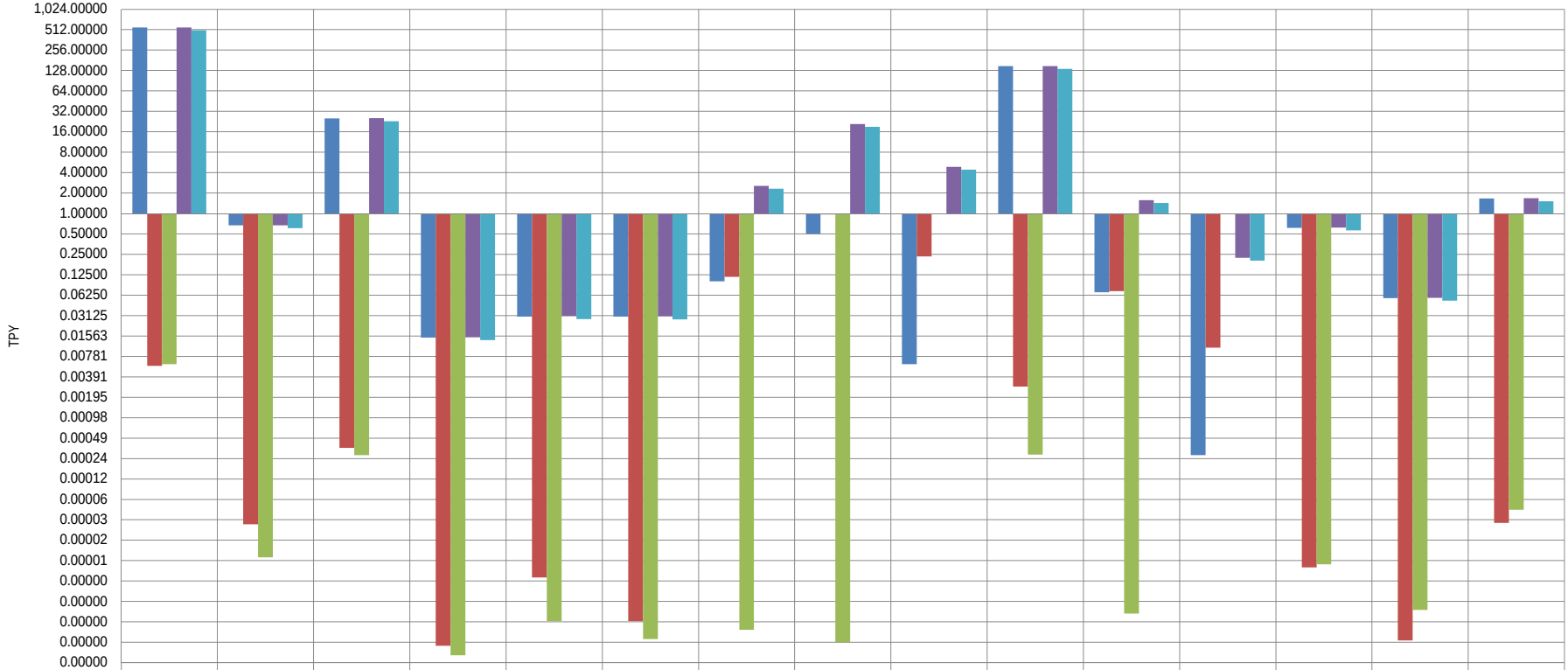
Lewistown input parameters for calculating oil wells emissions

Maximum Annual Wells Drilled - Federal (RMP estimate)	1	Maximum Annual Wells Drilled - Non-Federal (RMP estimate)	2
Federal Producing Wells - RMP Year 2029	2.4	Non-Federal Producing Wells - RMP Year 20	24.2
Average Well Barrel Oil Per Day (BOPD)	8.5	Average Well Barrel Oil Per Day (BOPD)	8.5

Federal Oil Wells Summaries

Total Annual Emissions from Federal Oil Wells - RMP Year 20

Activity	Annual Emissions (Tons)				
	CO_2	CH_4	N_2O	CO_{2eq}	CO_{2eq} metric tons
Well Pad Construction - Fugitive Dust	---	---	---	---	---
Heavy Equipment Combustive Emissions	550.10	0.01	0.01	552.07	500.97
Commuting Vehicles - Construction	0.67	0.00	0.00	0.67	0.61
Wind Erosion	---	---	---	---	---
Sub-total: Construction	**550.77**	**0.01**	**0.01**	**552.74**	**501.58**
Well Workover Operations - Fugitive Dust	---	---	---	---	---
Well Workover Operations - On-site Exhaust	25.22	0.00	0.00	25.31	22.97
Well Workover Operations - On-road Exhaust	0.01	0.00	0.00	0.01	0.01
Well Visits for Inspection & Repair - Operations	0.03	0.00	0.00	0.03	0.03
Recompletion Traffic	0.03	0.00	0.00	0.03	0.03
Water Tanks & Traffic	0.10	0.12	0.00	2.55	2.31
Oil Tanks & Traffic	0.50	0.97	0.00	20.81	18.89
Venting	0.01	0.23	0.00	4.88	4.43
Compression and Well Pumps	148.54	0.00	0.00	148.68	134.92
Dehydrators	0.07	0.07	0.00	1.58	1.43
Compression Station Fugitives	0.00	0.01	0.00	0.22	0.20
Sub-total: Operations	**174.51**	**1.40**	**0.00**	**204.11**	**185.22**
Road Maintenance	0.62	0.00	0.00	0.62	0.56
Sub-total: Maintenance	**0.616**	**0.000**	**0.00**	**0.62**	**0.56**
Road Reclamation	0.06	0.00	0.00	0.06	0.05
Well Reclamation	1.66	0.00	0.00	1.67	1.52
Sub-total: Reclamation	**1.7162**	**0.0000**	**0.0000**	**1.7306**	**1.5704**
Total Emissions	**727.61**	**1.41**	**0.01**	**759.20**	**688.93**

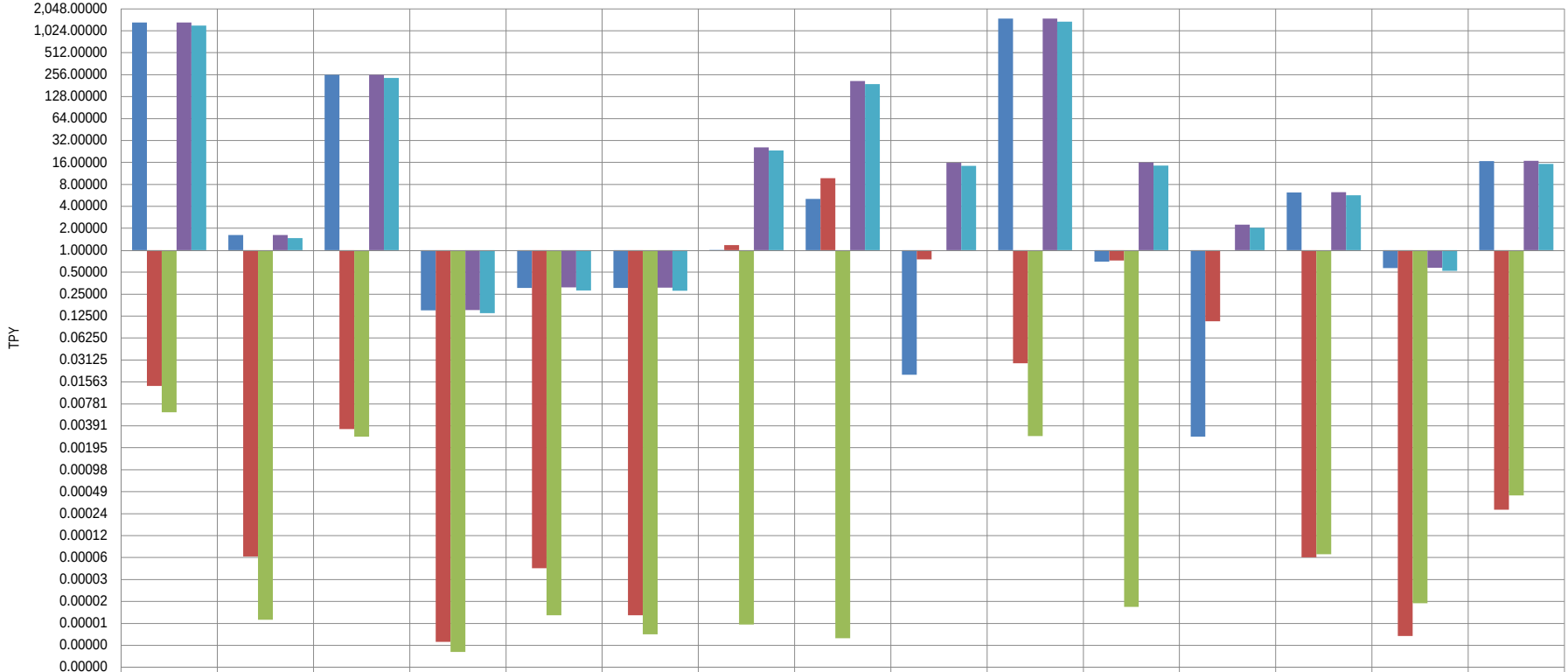


	Heavy Equipment Combustive Emissions	Commuting Vehicles - Construction	Well Workover Operations - On-site Exhaust	Well Workover Operations - On-road Exhaust	Well Visits for Inspection & Repair - Operations	Recompletion Traffic	Water Tanks & Traffic	Oil Tanks & Traffic	Venting	Compression and Well Pumps	Dehydrators	Compression Station Fugitives	Road Maintenance	Road Reclamation	Well Reclamation
CO2	550.10	0.67	25.22	0.01	0.03	0.03	0.10	0.50	0.01	148.54	0.07	0.00	0.62	0.06	1.66
CH4	0.01	0.00	0.00	0.00	0.00	0.00	0.12	0.97	0.23	0.00	0.07	0.01	0.00	0.00	0.00
N2O	0.01	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
CO2eq	552.07	0.67	25.31	0.01	0.03	0.03	2.55	20.81	4.88	148.68	1.58	0.22	0.62	0.06	1.67
CO2eq metric tons	500.97	0.61	22.97	0.01	0.03	0.03	2.31	18.89	4.43	134.92	1.43	0.20	0.56	0.05	1.52

Non-Federal Oil Wells Summaries

Total Annual Emissions from Non-Federal Oil Wells - RMP Year 20

Activity	Annual Emissions (Tons)				
	CO_2	CH_4	N_2O	CO_{2eq}	CO_{2eq} metric tons
Well Pad Construction - Fugitive Dust	---	---	---	---	---
Heavy Equipment Combustive Emissions	1331.24	0.01	0.01	1333.38	1209.97
Commuting Vehicles - Construction	1.61	0.00	0.00	1.62	1.47
Wind Erosion	---	---	---	---	---
Sub-total: Construction	**1,332.86**	**0.01**	**0.01**	**1,335.00**	**1,211.44**
Well Workover Operations - Fugitive Dust			---	---	---
Well Workover Operations - On-site Exhaust	254.28	0.00	0.00	255.21	231.59
Well Workover Operations - On-road Exhaust	0.15	0.00	0.00	0.15	0.14
Well Visits for Inspection & Repair - Operations	0.31	0.00	0.00	0.31	0.28
Recompletion Traffic	0.30	0.00	0.00	0.31	0.28
Water Tanks & Traffic	1.01	1.18	0.00	25.69	23.32
Oil Tanks & Traffic	5.07	9.75	0.00	209.87	190.45
Venting	0.02	0.75	0.00	15.82	14.36
Compression and Well Pumps	1,497.74	0.03	0.00	1499.21	1360.45
Dehydrators	0.70	0.72	0.00	15.91	14.43
Compression Station Fugitives	0.00	0.11	0.00	2.24	2.03
Sub-total: Operations	**1,759.58**	**12.54**	**0.01**	**2,024.73**	**1,837.32**
Road Maintenance	6.21	0.00	0.00	6.23	5.65
Sub-total: Maintenance	**6.209**	**0.000**	**0.00**	**6.23**	**5.65**
Road Reclamation	0.57	0.00	0.00	0.58	0.52
Well Reclamation	16.73	0.00	0.00	16.87	15.31
Sub-total: Reclamation	**17.3055**	**0.0003**	**0.0004**	**17.4502**	**15.8350**
Total Emissions	**3,115.95**	**12.56**	**0.01**	**3,383.41**	**3,070.25**



	Heavy Equipment Combustive Emissions	Commuting Vehicles - Construction	Well Workover Operations - On-site Exhaust	Well Workover Operations - On-road Exhaust	Well Visits for Inspection & Repair - Operations	Recompletion Traffic	Water Tanks & Traffic	Oil Tanks & Traffic	Venting	Compression and Well Pumps	Dehydrators	Compression Station Fugitives	Road Maintenance	Road Reclamation	Well Reclamation
CO2	1331.24	1.61	254.28	0.15	0.31	0.30	1.01	5.07	0.02	1,497.74	0.70	0.00	6.21	0.57	16.73
CH4	0.01	0.00	0.00	0.00	0.00	0.00	1.18	9.75	0.75	0.03	0.72	0.11	0.00	0.00	0.00
N2O	0.01	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
CO2eq	1333.38	1.62	255.21	0.15	0.31	0.31	25.69	209.87	15.82	1499.21	15.91	2.24	6.23	0.58	16.87
CO2eq metric tons	1209.97	1.47	231.59	0.14	0.28	0.28	23.32	190.45	14.36	1360.45	14.43	2.03	5.65	0.52	15.31

Exhaust Emissions from Well Pad Construction Heavy Equipment and Drilling Equipment

Emission Factors for Construction Equipment

Equipment	Emission Factors (g/hp-hr)			Equipment Category
	CO_2	CH_4	N_2O[a]	
Dozer - 175 Hp	535.76	0.005	0.006	Track-Type Tractor
Blade - 150 Hp	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] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

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 (tons/equipment type/well)		
									CO_2	CH_4	N_2O
Improved & Two-Track Road	Blade	150	1	75	10	2	20	1	1.47E+00	1.87E-05	1.43E-05
Well Pad	Blade	175	1	75	10	3	30	1	2.58E+00	3.28E-05	2.50E-05
	Dozer	175	1	80	10	3	30	1	2.75E+00	3.50E-05	2.67E-05
								Subtotal	**6.81E+00**	**8.64E-05**	**6.61E-05**

Exhaust Emission Factors for Diesel Powered Bore/Drill Rig Engines

Project Year/Hp Category	Emission Factors (g/hp-hr)		
	CO_2	CH_4	N_2O[a]
Year 2018			
50 to 75	589.096	0.006	0.006
75 to 100	589.103	0.006	0.006
100 to 175	530.097	0.005	0.006
175 to 300	530.181	0.004	0.006
300 to 600	530.255	0.004	0.006
600 to 750	530.283	0.004	0.006
>750	529.917	0.006	0.006

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

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

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 (tons/equipment		
									CO_2	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Main Deck	1,000	3	70	24	16	384	1	4.71E+02	5.02E-03	5.13E-03
	Auxiliary Pump	600	1	80	8	15	120	1	3.37E+01	2.51E-04	3.66E-04
	Generators	150	2	75	24	8	192	1	2.52E+01	2.26E-04	2.75E-04
Well Completion & Testing	Main Deck	600	1	50	11	5	55	1	9.64E+00	7.19E-05	1.05E-04
	Auxiliary Pump	225	1	80	8	2	16	1	1.68E+00	1.37E-05	1.83E-05
	Power Swivel	150	1	75	8	2	16	1	1.05E+00	9.42E-06	1.14E-05
	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	9.64E-01	1.05E-05	9.44E-06
								Subtotal	**5.43E+02**	**5.60E-03**	**5.91E-03**
							Total		**5.50E+02**	**5.69E-03**	**5.98E-03**

Exhaust Emissions from Construction and Drilling Support Vehicles

Emission Factors for Commuting Vehicles

Vehicle		Emission Factors (g/mi)		
Type	Class	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	409.5	0.002	0.016
Heavy-Duty Diesel Truck	HDDV	791.8	0.037	0.006

Source: MOBILE6.2.03

[a] 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).

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 (tons/well)		
	Type	Class					CO_2	CH_4	N_2O
Improved & Two-Track Road	Semi Trucks	HDDV	2	47	94	1	8.20E-02	3.83E-06	5.98E-07
	Pickup Trucks	LDDT	2	3	6	1	2.71E-03	1.32E-08	1.03E-07
Well Pad	Semi Trucks	HDDV	2	5	10	1	8.73E-03	4.08E-07	6.36E-08
	Pickup Trucks	LDDT	2	4	8	1	3.61E-03	1.76E-08	1.37E-07
Other Construction Activities	Semi Trucks	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Haul Trucks	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Pickup Trucks	LDDT	2	1	2	1	9.03E-04	4.41E-09	3.42E-08
						Subtotal	**1.05E-01**	**4.60E-06**	**9.86E-07**

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 (tons/well)		
	Type	Class					CO_2	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Semi Rig Transport, Drill Rig	HDDV	2	44	88	1	7.68E-02	3.59E-06	5.60E-07
	Fuel Haul Truck	HDDV	2	6	12	1	1.05E-02	4.89E-07	7.63E-08
	Mud Haul Truck, Water Hauling	HDDV	2	4	8	1	6.98E-03	3.26E-07	5.09E-08
	Rig Crew	LDDT	2	51	102	1	4.60E-02	2.25E-07	1.74E-06
	Rig Mechanics	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Co. Supervisor	LDDT	2	20	40	1	1.81E-02	8.82E-08	6.83E-07
	Tool Pusher	LDDT	2	8	16	1	7.22E-03	3.53E-08	2.73E-07
	Mud Logger	LDDT	2	6	12	1	5.42E-03	2.65E-08	2.05E-07
	Mud Engineer	LDDT	2	15	30	1	1.35E-02	6.61E-08	5.13E-07
	Logger, Engr Truck	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Drill Bit Delivery	LDDT	2	2	4	1	1.81E-03	8.82E-09	6.83E-08

Combustive Emissions Estimation Road Traffic (cont.)

Construction Site Destination	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells	Emissions (tons/well)		
	Type	Class					CO_2	CH_4	N_2O
Well Completion & Testing	Semi Casing Haulers	HDDV	2	6	12	1	1.05E-02	4.89E-07	7.63E-08
	Semi Completion, Unit Rig	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Semi Fracing, Blender	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Semi Pumping/Tank Battery	HDDV	2	6	12	1	1.05E-02	4.89E-07	7.63E-08
	Tubing Truck	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Haul Cementer, Pump Truck	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Haul Cementer, Cement	HDDV	2	3	6	1	5.24E-03	2.45E-07	3.82E-08
	Haul Completion, Equip	HDDV	2	3	6	1	5.24E-03	2.45E-07	3.82E-08
	Haul Service Tools	LDDT	2	2	4	1	1.81E-03	8.82E-09	6.83E-08
	Haul Perforators Logging Truck	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Anchor, Installation	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Anchor, Testing	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Tank	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Pump	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Chemical	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Sand	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Other	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Welders	HDDV	2	6	12	1	1.05E-02	4.89E-07	7.63E-08
	Haul Water Truck	HDDV	2	150	300	1	2.62E-01	1.22E-05	1.91E-06
	Pickup Cementer, Engineer	LDDT	2	2	4	1	1.81E-03	8.82E-09	6.83E-08
	Pickup Casing Crew	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Pickup Completion Crew	HDDV	2	5	10	1	8.73E-03	4.08E-07	6.36E-08
	Pickup Completion,	LDDT	2	5	10	1	4.51E-03	2.20E-08	1.71E-07
	Pickup Perforators, Engineer	LDDT	2	2	4	1	1.81E-03	8.82E-09	6.83E-08
	Pickup Fracing, Engineer	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Pickup Co. Supervisor	LDDT	2	10	20	1	9.03E-03	4.41E-08	3.42E-07
	Pickup Miscellaneous Supplies	LDDT	2	3	6	1	2.71E-03	1.32E-08	1.03E-07
	Pickup Roustabout Crew	HDDV	2	4	8	1	6.98E-03	3.26E-07	5.09E-08
					Subtotal		**5.62E-01**	**2.15E-05**	**7.57E-06**
					Total		**6.67E-01**	**2.61E-05**	**8.56E-06**

Exhaust Emissions from Well Work Overs

Emission Factors Bore/Drill Rig Engines 300-600 Hp

Fuel Type	Emission Factors (gm/hp-hr)		
	CO_2	CH_4	N_2O[a]
Diesel	529.58	0.007	0.006

Source: EPA NONROADS 2008a. Year 2008.

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

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 (tons/year/well)		
							CO_2	CH_4	N_2O
Well Workover	Truck-Mounted Unit	600	10	3	30	1	1.05E+01	1.46E-04	1.14E-04

Exhaust emission factors for commuting vehicles

Vehicle		Emission Factors (g/mi)		
Type	Class	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	409.5	0.002	0.016
Heavy-Duty Diesel Truck	HDDV	791.8	0.037	0.006

Source: MOBILE 6.2.03

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

[a] 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

Activity	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells Drilled	Max. Annual Emissions (tons/year/well)		
	Type	Class					CO_2	CH_4	N_2O
Well Workover	WO Rig	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Truck	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Pickup Truck	LDDT	2	3	6	1	2.71E-03	1.32E-08	1.03E-07
Performed once in the first year of well operation						**Total**	**6.20E-03**	**1.76E-07**	**1.28E-07**

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

Round trip distance = 2 based on data found in the SEIS

Exhaust Emissions from Site Visits and Inspections

Emission factors for Commuting Vehicles Exhaust

Vehicle Class	Emission Factors (g/mi)		
	CO_2	CH_4	N_2O[a]
Light-Duty Gasoline Truck	476.9	0.068	0.015

Source: MOBILE 6.2.03

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

[a] 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)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Federal Wells Producing	Emissions (tons/yr/well)		
	Type	Class					CO_2	CH_4	N_2O
Inspection Visits for Wells	Pickup Truck	LDGT2	2	12	24	1	1.26E-02	1.80E-06	4.07E-07

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 year

[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
Cumulative Length of Roads [b] (miles/operation)	1

[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	**1**	**5**

Emission Factors for Construction Equipment Exhaust

Equipment	Emission Factors (g/hp-hr)		
	CO_2	CH_4	N_2O[a]
Grader 100-175 Hp	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] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

Emission Estimations for Grader: RMP Year 20

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours[a]	Emissions (tons/well)		
				CO_2	CH_4	N_2O
Road Maintenance	Grader	135	3	2.55E-01	2.52E-06	2.75E-06

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

Emission Factors for Commuting Vehicles Exhaust

Vehicle Class	Emission Factors		
	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	409.5	0.002	0.016

Source: MOBILE 6.2.03

[a] 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 (tons/yr)		
	Type	Class				CO_2	CH_4	N_2O
Road Maintenance	Pickup Truck	LDGT2	6	0.5	3	1.44E-03	7.05E-09	5.47E-08

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)	CH_4 Emissions (ton/yr/well)
All	31.31	3103	4.86E-02

[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 Work Over Vehicles - Road Traffic

Vehicle Class	Emission Factors (g/mi)		
	CO_2	CH_4	N_2O[a]
Heavy-Duty Diesel Truck (HDDV)	791.8	0.037	0.006

Source: MOBILE6.2.03

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

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 (tons/yr/well)		
	Type	Class					CO_2	CH_4	N_2O
Produced Water Hauling	Haul Truck (130 bbl)	HDDV	2	24	48	1	4.17E-02	1.95E-06	3.04E-07

Oil Tank, Loadout and Hauling Emissions

Oil Well Oil Seperator Flashing and Tank Emissions[a]

Project Year	Emissions[b]			
	HAPs Emissions (ton/yr/well)	VOC Emissions (ton/yr/well)	CO_2 Emissions (ton/yr/well)	CH_4 Emissions (ton/yr/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 no 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 ($lb/10^3$ gal) 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 (ton/yr/well)
All	2.35	3,103	130	1.53E-01	2.75E-04	4.48E-08	1.14E-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)		
	CO_2	CH_4	N_2O[a]
Heavy-Duty Diesel Truck (HDDV)	791.8	0.037	0.006

Source: MOBILE6.2.03

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

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 (tons/year/well)		
	Type	Class					CO_2	CH_4	N_2O
Produced Oil Hauling	Haul Truck (200 bbl)	HDDV	2	16	31.025	1	2.71E-02	1.27E-06	1.97E-07
						TOTAL	**2.71E-02**	**1.27E-06**	**1.97E-07**

W&S Composition for Truck Load Out Emissions

W&S Gas Component	Mole Fraction[a] (%)	Molecular Weight (lb/lb-mol)	Gas Weight (lb/lb-mol)	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-HAP	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)

Exhaust Emissions from Recompletion Support Vehicles

Emission Factors for Commuting Vehicles

Vehicle		Emission Factors (g/mi)		
Type	Class	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	409.5	0.002	0.016
Heavy-Duty Diesel Truck	HDDV	791.8	0.037	0.006

Source: MOBILE6.2.03

[a] 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).

Combustive Emissions Estimation Road Traffic - Based on Peak Wells Drilled each Alternative

Construction Site Destination	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells	Emissions (tons/well)		
	Type	Class					CO_2	CH_4	N_2O
Well Recompletion	Fuel Haul Truck	HDDV	2	6	12	1	1.05E-02	4.89E-07	7.63E-08
	Mud Haul Truck, Water Hauling	HDDV	2	4	8	1	6.98E-03	3.26E-07	5.09E-08
	Rig Crew	LDDT	2	51	102	1	4.60E-02	2.25E-07	1.74E-06
	Rig Mechanics	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Co. Supervisor	LDDT	2	20	40	1	1.81E-02	8.82E-08	6.83E-07
	Semi Completion, Unit Rig	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Semi Fracing, Blender	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Semi Pumping/Tank Battery	HDDV	2	6	12	1	1.05E-02	4.89E-07	7.63E-08
	Tubing Truck	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Haul Cementer, Pump Truck	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Haul Cementer, Cement Truck	HDDV	2	3	6	1	5.24E-03	2.45E-07	3.82E-08
	Haul Completion, Equip Truck	HDDV	2	3	6	1	5.24E-03	2.45E-07	3.82E-08
	Haul Service Tools	LDDT	2	2	4	1	1.81E-03	8.82E-09	6.83E-08
	Haul Perforators Logging Truck	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Tank	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Pump	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Chemical	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Sand	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Other	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Water Truck	HDDV	2	50	100	1	8.73E-02	4.08E-06	6.36E-07
	Pickup Cementer, Engineer	LDDT	2	2	4	1	1.81E-03	8.82E-09	6.83E-08

	Pickup Completion Crew	HDDV	2	5	10	1	8.73E-03	4.08E-07	6.36E-08
	Pickup Completion, Pusher	LDDT	2	5	10	1	4.51E-03	2.20E-08	1.71E-07
	Pickup Perforators, Engineer	LDDT	2	2	4	1	1.81E-03	8.82E-09	6.83E-08
	Pickup Fracing, Engineer	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Pickup Co. Supervisor	LDDT	2	10	20	1	9.03E-03	4.41E-08	3.42E-07
	Pickup Miscellaneous Supplies	LDDT	2	3	6	1	2.71E-03	1.32E-08	1.03E-07
	Pickup Roustabout Crew	HDDV	2	4	8	1	6.98E-03	3.26E-07	5.09E-08
					Subtotal		**2.52E-01**	**8.17E-06**	**4.45E-06**
					Total		**2.52E-01**	**8.17E-06**	**4.45E-06**

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

Gas Component	Mole Fraction (%)	Molecular Weight (lb/lb-mol)	Gas Weight (lb/lb-mol)	Weight Percent (wt%)	Weight (lb/MMscf))	Emissions Mass Flow (ton/well)
Methane	65.450	16.040	10.498	42.544	18064.029	0.207
Ethane	15.330	30.070	4.610	18.681	7931.881	0.091
Nitrogen	3.260	28.020	0.913	3.702	1571.760	0.018
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	0.005
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		0.322
Propane	7.890	44.100	3.479	14.101	5987.096	0.069
Iso-butane	1.370	58.120	0.796	3.227	1370.083	0.016
n-butane	3.360	58.120	1.953	7.914	3360.203	0.039
i-pentane	1.000	72.150	0.722	2.924	1241.472	0.014
n-pentane	1.040	72.150	0.750	3.041	1291.131	0.015
Hexanes	0.680	100.210	0.681	2.761	1172.521	0.013
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		0.166
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*	*0.013*
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		0.013
Totals	**100.000**	**---**	**24.676**	**100.000**		**0.487**

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

Gas Component	Mole Fraction (%)	Molecular Weight (lb/lb-mol)	Gas Weight (lb/lb-mol)	Weight Percent (wt%)	Weight (lb/MMscf))	Emissions Mass Flow (ton/well)
Methane	65.450	16.040	10.498	42.544	18064.029	0.207
Ethane	15.330	30.070	4.610	18.681	7931.881	0.091
Nitrogen	3.260	28.020	0.913	3.702	1571.760	0.018
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	0.005
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		0.322
Propane	7.890	44.100	3.479	14.101	5987.096	0.069
Iso-butane	1.370	58.120	0.796	3.227	1370.083	0.016
n-butane	3.360	58.120	1.953	7.914	3360.203	0.039
i-pentane	1.000	72.150	0.722	2.924	1241.472	0.014
n-pentane	1.040	72.150	0.750	3.041	1291.131	0.015
Hexanes	0.680	100.210	0.681	2.761	1172.521	0.013
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		0.166
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*	*0.013*
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		0.013
Totals	**100.000**	**---**	**24.676**	**100.000**		**0.487**

Oil well natural gas analysis for Formation: Madison, Lease: Berry 11-4 (Miles City)

Volume Flow:	900	SCF / bbl oil
BBL oil / day:	8.5	bbl oil / day
Completion activity duration:	3	days
Total Completion/Recompletion Volume Flow per Well	0.02295	MMSCF/well

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

Emission Factors for Natural Gas-Fired Compressors and Pumps

Compressor / Pump		Horse-Power Rating	Units	Emission Factors		
				CO_2[a]	CH_4[a]	N_2O[a]
Compression Station	Lean Burn	300	gm/bhp-hr	134.936	2.55E-03	2.55E-04
			lb/MMBTU	116.887	2.20E-03	2.20E-04
Oil Pump at Well Head	Lean Burn	40	gm/bhp-hr	134.936	2.55E-03	2.55E-04
			lb/MMBTU	116.887	2.20E-03	2.20E-04

Note: Compressors assumed to be equipped with nonselective catalytic reduction (NSCR) catalyst.

[a] 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 (tons/year/well)		
					CO_2	CH_4	N_2O
Compression Station	7.5	1.00	7.5	8,760	9.77E+00	1.84E-04	1.84E-05
Oil Pump at Well Head	40	1.00	40	8,760	5.21E+01	9.83E-04	9.83E-05
				Total	**6.19E+01**	**1.17E-03**	**1.17E-04**

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

TOC Emission Factor								
Well Equipment Component	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

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	1.74E-03	5.90E-04	1.92E-05	7.39E-04
pump seals	0.000	0.0053	0	0.0287	0	0.0001	0.00E+00	0.00E+00	0.00E+00	0.00E+00
others	0.000	0.0194	0	0.0165	0	0.0309	0.00E+00	0.00E+00	0.00E+00	0.00E+00
connectors	0.250	0.0004	0	0.0005	0	0.0002	1.10E-04	3.74E-05	1.22E-06	4.69E-05
flanges	0.600	0.0009	0	0.0002	0	0.0000	5.16E-04	1.75E-04	5.70E-06	2.19E-04
open-ended lines	0.000	0.0044	0	0.0031	0	0.0006	0.00E+00	0.00E+00	0.00E+00	0.00E+00
					TOTAL emissions/well/hr =		2.36E-03	8.02E-04	2.61E-05	1.00E-03

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 (ton/yr)**	**CO_2 emissions (lb/yr)**	**CO_2 emissions (ton/yr)**	**CH_4 emissions (lb/yr)**	**CH_4 emissions (ton/yr)**
Year 20	1	8760	7.03E+00	3.51E-03	2.29E-01	1.14E-04	8.80E+00	4.40E-03

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	1.729
Annual Miles of Roads reclaimed Per Well	0.432
Number of wells reclaimed (per well)	1.729

Reclaimation 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
0.43	6	0.1	1
		Total	**1**

Assume average miles/day = 6

Emission Factors for 75-100 hp Off-Road Engines

Year	Emission Factors (g/hp-hr)		
	CO_2	CH_4	N_2O[a]
2008	600.507	0.010	0.016
2018	613.888	0.006	0.016
2027	608.641	0.003	0.016

[a] Emissions of $PM_{2.5}$ were assumed to be the same as those for PM_{10}.

[a] 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).

Exhaust Emissions Estimation for Grader Road Reclaim

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours[a]	Emissions (tons/year/well)		
				CO_2	CH_4	N_2O
Road Reclamation	Grader	80	0.4	2.34E-02	2.10E-07	5.91E-07

Exhaust Emission Factors for Commuting Reclaim Vehicles Road Traffic

Vehicle Class	Emission Factors (g/mi)		
	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	409.5	0.002	0.016

Source: MOBILE6.2.03

[a] 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).

Exhaust Emissions Estimation for Commuting Reclaim Vehicles: Road Traffic

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tons/year/well)		
	Type	Class				CO_2	CH_4	N_2O
Road Reclamation	Pickup Truck	LDDV	6	0.07	0.4	1.95E-04	9.53E-10	7.39E-09

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	1.73	10	1.73	17.29

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

Exhaust Emissions Estimation for Grader: Well Reclamation

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours [a]	Emissions (tons/year/well)		
				CO_2	CH_4	N_2O
Well Reclamation	Grader	100	10	6.87E-01	1.14E-05	1.77E-05

Exhaust Emissions Estimation for Commuting Vehicles: Well Reclamation

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tons/year/well)		
	Type	Class				CO_2	CH_4	N_2O
Well Reclamation	Pickup Truck	LDDV	6	2	10	4.68E-03	2.29E-08	1.77E-07

Emissions for Gas Dehydration

Emission Factors for Dehydrator Heaters

Unit	CO_2	CH_4	N_2O
lb/MMSCF	120000.0	2.3	2.2
lb/MMBTU	117.647	0.002	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 (tons/year/well)		
				CO_2	CH_4	N_2O
2,190	1	2.20	0.00022	2.89E-02	5.53E-07	5.29E-07

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)
2.79	1.07E-02	2.99E-02	1.60E-02	4.47E-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 South Baker 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 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

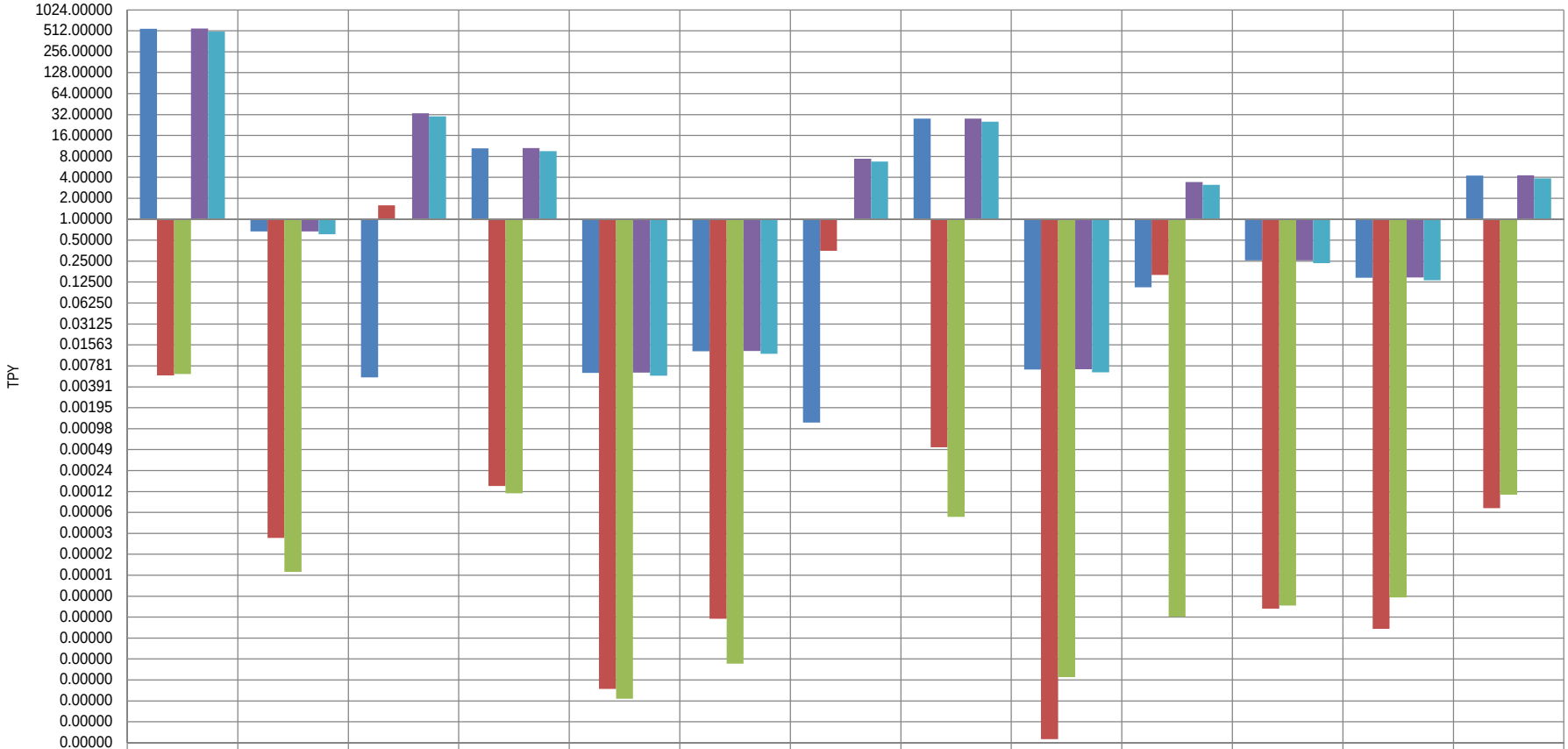
Lewistown input parameters for calculating NG wells emissions

Maximum Annual Wells Drilled - Federal (RMP estimate)	1.0	Maximum Annual Wells Drilled - Non-Federal (RMP estimate)	1.0
Federal Producing Wells - RMP Year 2029	1	Non-Federal Producing Wells - RMP Year 2029	9
Average Gas Production Per Well (MCFD)	28	Average Gas Production Per Well (MCFD)	28

Federal NG Wells Summaries

Total Annual Emissions from Federal NG Wells - RMP Year 20

Activity	Annual Emissions (Tons)				
	CO_2	CH_4	N_2O	CO_{2eq}	CO_{2eq} metric tons
Well Pad Construction - Fugitive Dust	---	---	---	---	---
Heavy Equipment Combustive Emissions	550.10	0.01	0.01	552.07	500.97
Commuting Vehicles - Construction	0.67	0.00	0.00	0.67	0.61
Wind Erosion	---	---	---	---	---
Completion Venting	0.01	1.59	0.00	33.33	30.25
Sub-total: Construction	**550.77**	**1.59**	**0.01**	**586.08**	**531.83**
Well Workover Operations - Fugitive Dust	---	---	---	---	---
Well Workover Operations - On-site Exhaust	10.51	0.00	0.00	10.55	9.57
Well Workover Operations - On-road Exhaust	0.01	0.00	0.00	0.01	0.01
Well Visits for Inspection & Repair - Operations	0.01	0.00	0.00	0.01	0.01
Wellhead and Compressor Station Fugitives	0.00	0.35	0.00	7.43	6.74
Compression	27.89	0.00	0.00	27.92	25.34
Station Visits - Operations	0.01	0.00	0.00	0.01	0.01
Dehydrators	0.11	0.16	0.00	3.44	3.12
Sub-total: Operations	**38.53**	**0.51**	**0.00**	**49.36**	**44.79**
Road Maintenance	0.26	0.00	0.00	0.26	0.23
Sub-total: Maintenance	**0.257**	**0.000**	**0.00**	**0.26**	**0.23**
Road Reclamation	0.14	0.00	0.00	0.15	0.13
Well Reclamation	4.24	0.00	0.00	4.27	3.88
Sub-total: Reclamation	**4.3833**	**0.0001**	**0.0001**	**4.4199**	**4.0108**
Total Emissions	**593.94**	**2.11**	**0.01**	**640.12**	**580.87**

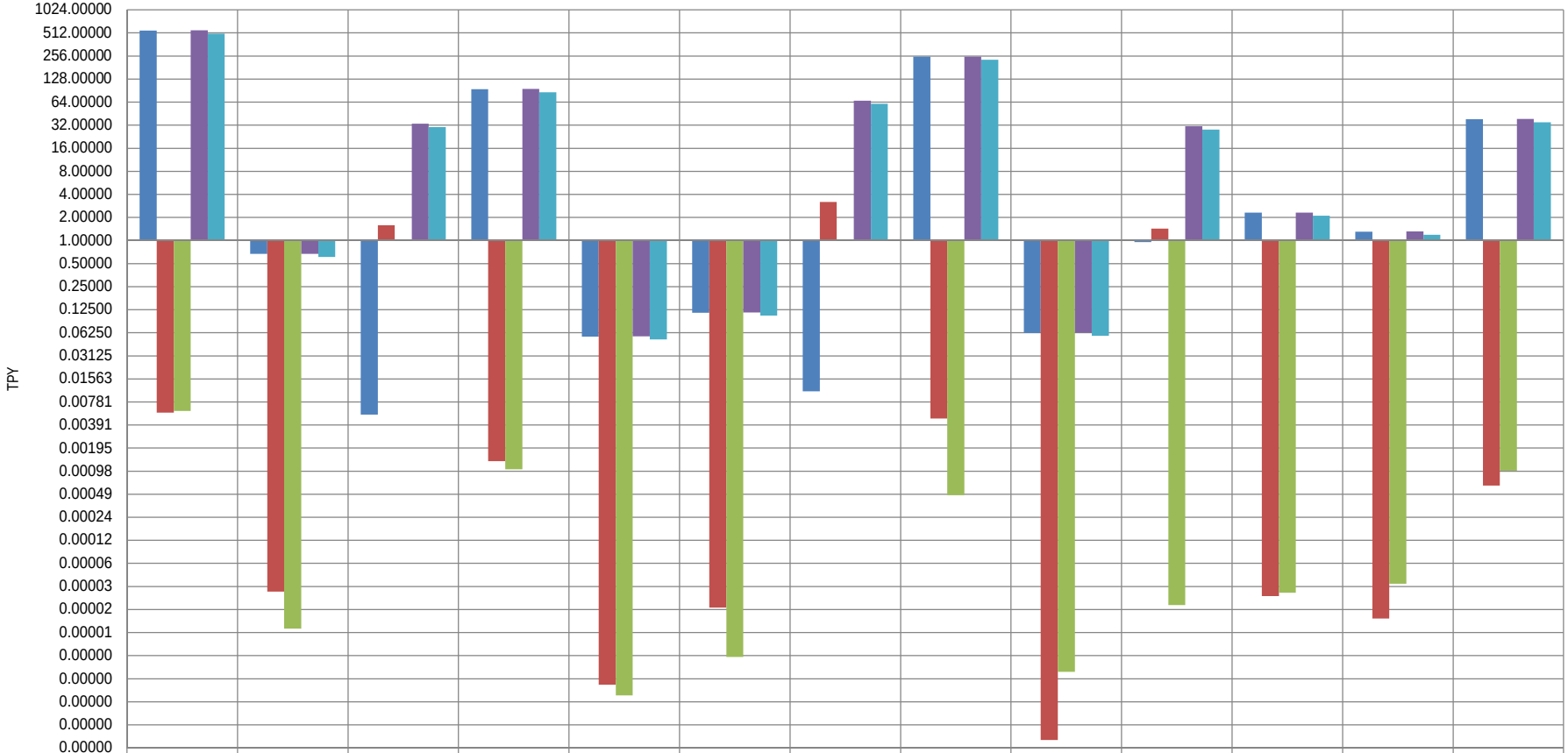


	Heavy Equipment Combustive Emissions	Commuting Vehicles - Construction	Completion Venting	Well Workover Operations - On-site Exhaust	Well Workover Operations - On-road Exhaust	Well Visits for Inspection & Repair - Operations	Wellhead and Compressor Station Fugitives	Compression	Station Visits - Operations	Dehydrators	Road Maintenance	Road Reclamation	Well Reclamation
CO2	550.10	0.67	0.01	10.51	0.01	0.01	0.00	27.89	0.01	0.11	0.26	0.14	4.24
CH4	0.01	0.00	1.59	0.00	0.00	0.00	0.35	0.00	0.00	0.16	0.00	0.00	0.00
N2O	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CO2eq	552.07	0.67	33.33	10.55	0.01	0.01	7.43	27.92	0.01	3.44	0.26	0.15	4.27
CO2eq metric tons	500.97	0.61	30.25	9.57	0.01	0.01	6.74	25.34	0.01	3.12	0.23	0.13	3.88

Non-Federal NG Wells Summaries

Total Annual Emissions from Non-Federal NG Wells - RMP Year 20

Activity	Annual Emissions (Tons)				
	CO_2	CH_4	N_2O	CO_{2eq}	CO_{2eq} metric tons
Well Pad Construction - Fugitive Dust	---	---	---	---	---
Heavy Equipment Combustive Emissions	550.10	0.01	0.01	552.07	500.97
Commuting Vehicles - Construction	0.67	0.00	0.00	0.67	0.61
Wind Erosion	---	---	---	---	---
Completion Venting	0.01	1.59	0.00	33.33	30.25
Sub-total: Construction	**550.77**	**1.59**	**0.01**	**586.08**	**531.83**
Well Workover Operations - Fugitive Dust			---	---	---
Well Workover Operations - On-site Exhaust	94.57	0.00	0.00	94.91	86.13
Well Workover Operations - On-road Exhaust	0.06	0.00	0.00	0.06	0.05
Well Visits for Inspection & Repair - Operations	0.11	0.00	0.00	0.12	0.10
Wellhead and Compressor Station Fugitives	0.01	3.18	0.00	66.87	60.68
Compression	251.03	0.00	0.00	251.28	228.02
Station Visits - Operations	0.06	0.00	0.00	0.06	0.06
Dehydrators	0.95	1.43	0.00	30.96	28.09
Sub-total: Operations	**346.79**	**4.62**	**0.00**	**444.25**	**403.13**
Road Maintenance	2.31	0.00	0.00	2.32	2.10
Sub-total: Maintenance	**2.309**	**0.000**	**0.00**	**2.32**	**2.10**
Road Reclamation	1.30	0.00	0.00	1.31	1.19
Well Reclamation	38.15	0.00	0.00	38.47	34.91
Sub-total: Reclamation	**39.4494**	**0.0006**	**0.0010**	**39.7793**	**36.0974**
Total Emissions	**939.32**	**6.21**	**0.01**	**1,072.42**	**973.16**



	Heavy Equipment Combustive Emissions	Commuting Vehicles - Construction	Completion Venting	Well Workover Operations - On-site Exhaust	Well Workover Operations - On-road Exhaust	Well Visits for Inspection & Repair - Operations	Wellhead and Compressor Station Fugitives	Compression	Station Visits - Operations	Dehydrators	Road Maintenance	Road Reclamation	Well Reclamation
CO2	550.10	0.67	0.01	94.57	0.06	0.11	0.01	251.03	0.06	0.95	2.31	1.30	38.15
CH4	0.01	0.00	1.59	0.00	0.00	0.00	3.18	0.00	0.00	1.43	0.00	0.00	0.00
N2O	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CO2eq	552.07	0.67	33.33	94.91	0.06	0.12	66.87	251.28	0.06	30.96	2.32	1.31	38.47
CO2eq metric tons	500.97	0.61	30.25	86.13	0.05	0.10	60.68	228.02	0.06	28.09	2.10	1.19	34.91

Exhaust Emissions from Well Pad Construction Heavy Equipment and Drilling Equipment

Emission Factors for Construction Equipment

Equipment	Emission Factors (g/hp-hr)			Equipment Category
	CO_2	CH_4	N_2O[a]	
Dozer - 175 Hp	535.76	0.005	0.006	Track-Type Tractor
Blade - 150 Hp	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] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

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 (tons/equipment type/well)		
									CO_2	CH_4	N_2O
Improved & Two-Track Road	Blade	150	1	75	10	2	20	1	1.47E+00	1.87E-05	1.43E-05
Well Pad	Blade	175	1	75	10	3	30	1	2.58E+00	3.28E-05	2.50E-05
	Dozer	175	1	80	10	3	30	1	2.75E+00	3.50E-05	2.67E-05
									6.81E+00	**8.64E-05**	**6.61E-05**

Exhaust Emission Factors for Diesel Powered Bore/Drill Rig Engines

Project Year/Hp Category	Emission Factors (g/hp-hr)		
	CO_2	CH_4	N_2O[a]
Year 2018			
50 to 75	589.096	0.006	0.006
75 to 100	589.103	0.006	0.006
100 to 175	530.097	0.005	0.006
175 to 300	530.181	0.004	0.006
300 to 600	530.255	0.004	0.006
600 to 750	530.283	0.004	0.006
>750	529.917	0.006	0.006

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

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

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 (tons/equipment type/well)		
									CO_2	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Main Deck	1,000	3	70	24	16	384	1	4.71E+02	5.02E-03	5.13E-03
	Auxiliary Pump	600	1	80	8	15	120	1	3.37E+01	2.51E-04	3.66E-04
	Generators	150	2	75	24	8	192	1	2.52E+01	2.26E-04	2.75E-04
Well Completion & Testing	Main Deck	600	1	50	11	5	55	1	9.64E+00	7.19E-05	1.05E-04
	Auxiliary Pump	225	1	80	8	2	16	1	1.68E+00	1.37E-05	1.83E-05
	Power Swivel	150	1	75	8	2	16	1	1.05E+00	9.42E-06	1.14E-05
	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	9.64E-01	1.05E-05	9.44E-06
								Subtotal	**5.43E+02**	**5.60E-03**	**5.91E-03**
								Total	**5.50E+02**	**5.69E-03**	**5.98E-03**

Exhaust Emissions from Construction and Drilling Support Vehicles

Emission Factors for Commuting Vehicles

Vehicle		Emission		
Type	Class	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	409.5	0.002	0.016
Heavy-Duty Diesel Truck	HDDV	791.8	0.037	0.006

Source: MOBILE6.2.03

[a] 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).

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 (tons/well)		
	Type	Class					CO_2	CH_4	N_2O
Improved & Two-Track Road	Semi Trucks	HDDV	2	47	94	1	8.20E-02	3.83E-06	5.98E-07
	Pickup Trucks	LDDT	2	3	6	1	2.71E-03	1.32E-08	1.03E-07
Well Pad	Semi Trucks	HDDV	2	5	10	1	8.73E-03	4.08E-07	6.36E-08
	Pickup Trucks	LDDT	2	4	8	1	3.61E-03	1.76E-08	1.37E-07
Other Construction Activities	Semi Trucks	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Haul Trucks	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Pickup Trucks	LDDT	2	1	2	1	9.03E-04	4.41E-09	3.42E-08
						Subtotal	**1.05E-01**	**4.60E-06**	**9.86E-07**

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 (tons/well)		
	Type	Class					CO_2	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Semi Rig Transport, Drill Rig	HDDV	2	44	88	1	7.68E-02	3.59E-06	5.60E-07
	Fuel Haul Truck	HDDV	2	6	12	1	1.05E-02	4.89E-07	7.63E-08
	Mud Haul Truck, Water Hauling	HDDV	2	4	8	1	6.98E-03	3.26E-07	5.09E-08
	Rig Crew	LDDT	2	51	102	1	4.60E-02	2.25E-07	1.74E-06
	Rig Mechanics	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Co. Supervisor	LDDT	2	20	40	1	1.81E-02	8.82E-08	6.83E-07
	Tool Pusher	LDDT	2	8	16	1	7.22E-03	3.53E-08	2.73E-07
	Mud Logger	LDDT	2	6	12	1	5.42E-03	2.65E-08	2.05E-07
	Mud Engineer	LDDT	2	15	30	1	1.35E-02	6.61E-08	5.13E-07
	Logger, Engr Truck	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Drill Bit Delivery	LDDT	2	2	4	1	1.81E-03	8.82E-09	6.83E-08

Combustive Emissions Estimation Road Traffic (cont.)

Construction Site Destination	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells	Emissions (tons/well)		
	Type	Class					CO_2	CH_4	N_2O
Well Completion & Testing	Semi Casing Haulers	HDDV	2	6	12	1	1.05E-02	4.89E-07	7.63E-08
	Semi Completion, Unit Rig	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Semi Fracing, Blender	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Semi Pumping/Tank Battery	HDDV	2	6	12	1	1.05E-02	4.89E-07	7.63E-08
	Tubing Truck	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Haul Cementer, Pump Truck	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Haul Cementer, Cement	HDDV	2	3	6	1	5.24E-03	2.45E-07	3.82E-08
	Haul Completion, Equip	HDDV	2	3	6	1	5.24E-03	2.45E-07	3.82E-08
	Haul Service Tools	LDDT	2	2	4	1	1.81E-03	8.82E-09	6.83E-08
	Haul Perforators Logging Truck	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Anchor, Installation	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Anchor, Testing	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Tank	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Pump	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Chemical	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Sand	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Other	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Welders	HDDV	2	6	12	1	1.05E-02	4.89E-07	7.63E-08
	Haul Water Truck	HDDV	2	150	300	1	2.62E-01	1.22E-05	1.91E-06
	Pickup Cementer, Engineer	LDDT	2	2	4	1	1.81E-03	8.82E-09	6.83E-08
	Pickup Casing Crew	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Pickup Completion Crew	HDDV	2	5	10	1	8.73E-03	4.08E-07	6.36E-08
	Pickup Completion,	LDDT	2	5	10	1	4.51E-03	2.20E-08	1.71E-07
	Pickup Perforators, Engineer	LDDT	2	2	4	1	1.81E-03	8.82E-09	6.83E-08
	Pickup Fracing, Engineer	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Pickup Co. Supervisor	LDDT	2	10	20	1	9.03E-03	4.41E-08	3.42E-07
	Pickup Miscellaneous Supplies	LDDT	2	3	6	1	2.71E-03	1.32E-08	1.03E-07
	Pickup Roustabout Crew	HDDV	2	4	8	1	6.98E-03	3.26E-07	5.09E-08
					Subtotal		**5.62E-01**	**2.15E-05**	**7.57E-06**
					Total		**6.67E-01**	**2.61E-05**	**8.56E-06**

Exhaust Emissions from Well Work Overs

Emission Factors Bore/Drill Rig Engines 300-600 Hp

Fuel Type	Emission Factors		
	CO_2	CH_4	N_2O[a]
Diesel	529.575	0.007	0.006

Source: EPA NONROADS 2008a. Year 2008.

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

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 (tons/year/well)		
							CO_2	CH_4	N_2O
Well Workover	Truck-Mounted Unit	600	10	3	30	1	1.05E+01	1.46E-04	1.14E-04

Exhaust emission factors for commuting vehicles

Vehicle		Emission Factors (g/mi)		
Type	Class	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	409.5	0.002	0.016
Heavy-Duty Diesel Truck	HDDV	791.8	0.037	0.006

Source: MOBILE 6.2.03

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

[a] 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

Activity	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells Drilled	Max. Annual Emissions (tons/year/well)		
	Type	Class					CO_2	CH_4	N_2O
Well Workover	WO Rig	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Truck	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Pickup Truck	LDDT	2	3	6	1	2.71E-03	1.32E-08	1.03E-07
						Total	**6.20E-03**	**1.76E-07**	**1.28E-07**

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).

Round trip distance = 2 based on data found in the SEIS

Exhaust Emissions from Site Visits and Inspections

Emission factors for Commuting Vehicles Exhaust

Vehicle Class	Emission Factors (g/mi)		
	CO_2	CH_4	N_2O[a]
Light-Duty Gasoline Truck	476.9	0.068	0.015

Source: MOBILE 6.2.03

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

[a] 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)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Federal Wells Producing	Emissions (tons/yr/well)		
	Type	Class					CO_2	CH_4	N_2O
Inspection Visits for Wells	Pickup Truck	LDGT2	2	12	24	1	1.26E-02	1.80E-06	4.07E-07

Exhaust Emissions from Heavy Equipment and Support Vehicles for Road Maintenance

Given Data

Maintenance[a]	Equipment/Vehicle			Road Length Worked	# of Operating
	Type	Fuel	Capacity (hp)	on/Day (miles)	Hours/Day
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 year

[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
Cumulative Length of Roads [b] (miles/operation)	1

[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	**1**	**5**

Emission Factors for Construction Equipment Exhaust

Equipment	Emission Factors (g/hp-hr)		
	CO_2	CH_4	N_2O[a]
Grader 100-175 Hp	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] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

Emission Estimations for Grader: RMP Year 20

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours[a]	Emissions (tons/well)		
				CO_2	CH_4	N_2O
Road Maintenance	Grader	135	3	2.55E-01	2.52E-06	2.75E-06

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

Emission Factors for Commuting Vehicles Exhaust

Vehicle Class	Emission Factors (g/mi)		
	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	409.5	0.002	0.016

Source: MOBILE 6.2.03

[a] 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 (tons/yr)		
	Type	Class				CO_2	CH_4	N_2O
Road Maintenance	Pickup Truck	LDGT2	6	0.5	3	1.44E-03	7.05E-09	5.47E-08

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	10.600
Annual Miles of Roads reclaimed Per Well	2.650
Number of wells reclaimed (per well)	10.600

Reclaimation 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
2.65	6	0.4	4
		Total	**4**

Assume average miles/day = 6

Emission Factors for 75-100 hp Off-Road Engines

Year	Emission Factors (g/hp-hr)		
	CO_2	CH_4	N_2O[a]
2008	600.507	0.010	0.016
2018	613.888	0.006	0.016
2027	608.641	0.003	0.016

[a] Emissions of $PM_{2.5}$ were assumed to be the same as those for PM_{10}.

[a] 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).

Exhaust Emissions Estimation for Grader Road Reclaim

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours[a]	Emissions (tons/year/well)		
				CO_2	CH_4	N_2O
Road Reclamation	Grader	80	2.7	1.43E-01	1.29E-06	3.62E-06

Exhaust Emission Factors for Commuting Reclaim Vehicles Road Traffic

Vehicle Class	Emission Factors (g/mi)		
	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	409.5	0.002	0.016

Source: MOBILE6.2.03

[a] 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).

Exhaust Emissions Estimation for Commuting Reclaim Vehicles: Road Traffic

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tons/year/well)		
	Type	Class				CO_2	CH_4	N_2O
Road Reclamation	Pickup Truck	LDDV	6	0.44	3	1.20E-03	5.84E-09	4.53E-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	10.6	10	10.6	106

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

Exhaust Emissions Estimation for Grader: Well Reclamation

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours [a]	Emissions (tons/year/well)		
				CO_2	CH_4	N_2O
Well Reclamation	Grader	100	64	4.21E+00	7.01E-05	1.09E-04

Exhaust Emissions Estimation for Commuting Vehicles: Well Reclamation

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tons/year/well)		
	Type	Class				CO_2	CH_4	N_2O
Well Reclamation	Pickup Truck	LDDV	6	11	64	2.87E-02	1.40E-07	1.09E-06

Emission Factors for Dehydrator Heaters

Unit	CO_2	CH_4	N_2O
lb/MMSCF	120000.0	2.3	2.2
lb/MMBTU	117.647	0.002	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 (tons/year/well)		
				CO_2	CH_4	N_2O
2,190	1	2.20	0.001	1.06E-01	2.02E-06	1.94E-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)
10.22	1.55E-02	1.59E-01	2.13E-05	2.18E-04

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 South Baker 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 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

Wellhead Fugitives

Fugitive Emissions from Equipment Leaks

TOC Emission Factor								
Well Equipment Component	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% =	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	7.50E-02	5.12E-04	2.25E-04	6.67E-02
pump seals	0	0.0053	0	0.0287	0	0.0001	0.00E+00	0.00E+00	0.00E+00	0.00E+00
others	0	0.0194	0	0.0165	0	0.0309	0.00E+00	0.00E+00	0.00E+00	0.00E+00
connectors	24	0.0004	0	0.0005	0	0.0002	1.06E-02	7.22E-05	3.17E-05	9.42E-03
flanges	2	0.0009	0	0.0002	0	0.0000	1.72E-03	1.17E-05	5.15E-06	1.53E-03
open-ended lines	0	0.0044	0	0.0031	0	0.0006	0.00E+00	0.00E+00	0.00E+00	0.00E+00
					TOTAL emissions/well/hr =		8.73E-02	5.96E-04	2.61E-04	7.77E-02

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 (ton/yr)**	**CO_2 emissions (lb/yr)**	**CO_2 emissions (ton/yr)**	**CH_4 emissions (lb/yr)**	**CH_4 emissions (ton/yr)**
Year 20	1	8760	5.22E+00	2.61E-03	2.29E+00	1.14E-03	6.80E+02	3.40E-01

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

Gas Component	Mole Fraction (%)	Molecular Weight (lb/lb-mol)	Gas Weight (lb/lb-mol)	Weight Percent (wt%)	Weight (lb/MMscf))	Emissions Mass Flow (ton/well)
Methane	93.716	16.040	15.032	88.998	37788.643	1.587
Ethane	1.624	30.070	0.488	2.891	1227.616	0.052
Nitrogen	4.297	28.020	1.204	7.128	3026.751	0.127
Water	0.000	18.015	0.000	0.000	0.000	0.000
Carbon Dioxide	0.115	43.990	0.051	0.300	127.173	0.005
Nitrous Oxide	0.000	44.020	0.000	0.000	0.000	0.000
Hydrogen Sulfide	0.000	34.067	0.000	0.000	0.000	0.000
Non-reactive, non-HAP	99.752	---	16.775	99.317		1.771
Propane	0.211	44.100	0.093	0.551	233.918	0.010
Iso-butane	0.019	58.120	0.011	0.065	27.760	0.001
n-butane	0.015	58.120	0.009	0.052	21.916	0.001
i-pentane	0.002	72.150	0.001	0.009	3.628	0.000
n-pentane	0.001	72.150	0.001	0.004	1.814	0.000
Hexanes	0.000	86.180	0.000	0.000	0.000	0.000
Heptanes	0.000	100.200	0.000	0.002	0.781	0.000
Octanes	0.000	114.230	0.000	0.000	0.000	0.000
Nonanes	0.000	128.26	0.000	0.000	0.000	0.000
Decanes+	0.000	142.29	0.000	0.000	0.000	0.000
Reactive VOC	0.248	---	0.115	0.683		0.012
Benzene	0.000	78.110	0.000	0.000	0.000	0.000
Ethylbenzene	0.000	106.167	0.000	0.000	0.000	0.000
n-Hexane [3]	*0.000*	*100.210*	*0.000*	*0.000*	*0.000*	*0.000*
Toluene	0.000	92.140	0.000	0.000	0.000	0.000
Xylenes	0.000	106.160	0.000	0.000	0.000	0.000
HAPs	0.000	---	0.000	0.000		0.000
Totals	**100.000**	**---**	**16.890**	**100.000**		**1.783**

Sample taken 03-09-2010 at Baker South 7 W 0429 (Miles City)

Volume Flow:	28	MSCF/day/well
Completion activity duration:	3	days
Total Volume Flow per Well	0.084	MMSCF/well

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

BTU value = 994 BTU/scf

Emission Factors for Natural Gas-Fired Compressors

Compressor		Horse-Power Rating	Units	Emission Factors		
				CO_2[a]	CH_4[a]	N_2O[a]
Field Compression Station	Rich Burn	300	gm/bhp-hr	134.936	2.55E-03	2.55E-04
			lb/MMBTU	116.887	2.20E-03	2.20E-04
Sales Compression Station	Rich Burn	1,680	gm/bhp-hr	134.936	2.55E-03	2.55E-04
			lb/MMBTU	116.887	2.20E-03	2.20E-04

Note: Compressors assumed to be equipped with nonselective catalytic reduction (NSCR) catalyst.

[a] 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 (tons/year/well)		
					CO_2	CH_4	N_2O
Field Compression Station	11	1	11	8,760	1.44E+01	2.72E-04	2.72E-05
Sales Compression Station	10	1	10	8,760	1.35E+01	2.54E-04	2.54E-05
				Total	**2.79E+01**	**5.26E-04**	**5.26E-05**

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

TOC Emission Factor								
Well Equipment Component	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% =	0.68
CO2 Wt% =	0.30
CH4 Wt% =	89.00
N2O Wt% =	0.00

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	0.258	0.0099	0	0.0055	0	0.0002	2.56E-03	1.75E-05	7.68E-06	2.28E-03
pump seals	0.000	0.0053	0	0.0287	0	0.0001	0.00E+00	0.00E+00	0.00E+00	0.00E+00
others	0.000	0.0194	0	0.0165	0	0.0309	0.00E+00	0.00E+00	0.00E+00	0.00E+00
connectors	0.369	0.0004	0	0.0005	0	0.0002	1.63E-04	1.11E-06	4.87E-07	1.45E-04
flanges	0.886	0.0009	0	0.0002	0	0.0000	7.62E-04	5.20E-06	2.28E-06	6.78E-04
open-ended lines	0.000	0.0044	0	0.0031	0	0.0006	0.00E+00	0.00E+00	0.00E+00	0.00E+00
					TOTAL emissions/well/hr =		3.49E-03	2.38E-05	1.04E-05	3.10E-03

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 (ton/yr)**	**CO_2 emissions (lb/yr)**	**CO_2 emissions (ton/yr)**	**CH_4 emissions (lb/yr)**	**CH_4 emissions (ton/yr)**
Year 20	1	8760	2.09E-01	1.04E-04	9.15E-02	4.58E-05	2.72E+01	1.36E-02

Compressor Station Inspection Traffic Exhaust Emissions

Emission factors for Commuting Vehicles Exhaust

Vehicle		Emission Factors (g/mi)		
Type	Class	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	409.5	0.002	0.016

Source: MOBILE6.2.03

[a] 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).

Exhaust Emissions Estimation for Road Traffic

Activity	Compressor Station	Vehicle		# of Compressor Stations / Well	# of Inspection Visits/ Station	# of Inspection Visits/Well/Year	Total Miles/ Inspection	Emissions (tons/year/well)		
		Type	Class					CO_2	CH_4	N_2O
Inspection Visits for Compressor Stations	CPF Compressor Station	Pickup Truck	LDGT2	0.04	12	0.4	20	4.00E-03	1.95E-08	1.51E-07
	Primary Compressor Station	Pickup Truck	LDGT2	0.01	52	0.3	20	2.89E-03	1.41E-08	1.09E-07
							Total	**6.89E-03**	**3.36E-08**	**2.61E-07**

Appendix G

Miles City Planning Area GHG Emission Inventory

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Input parameters for calculating oil wells emissions:

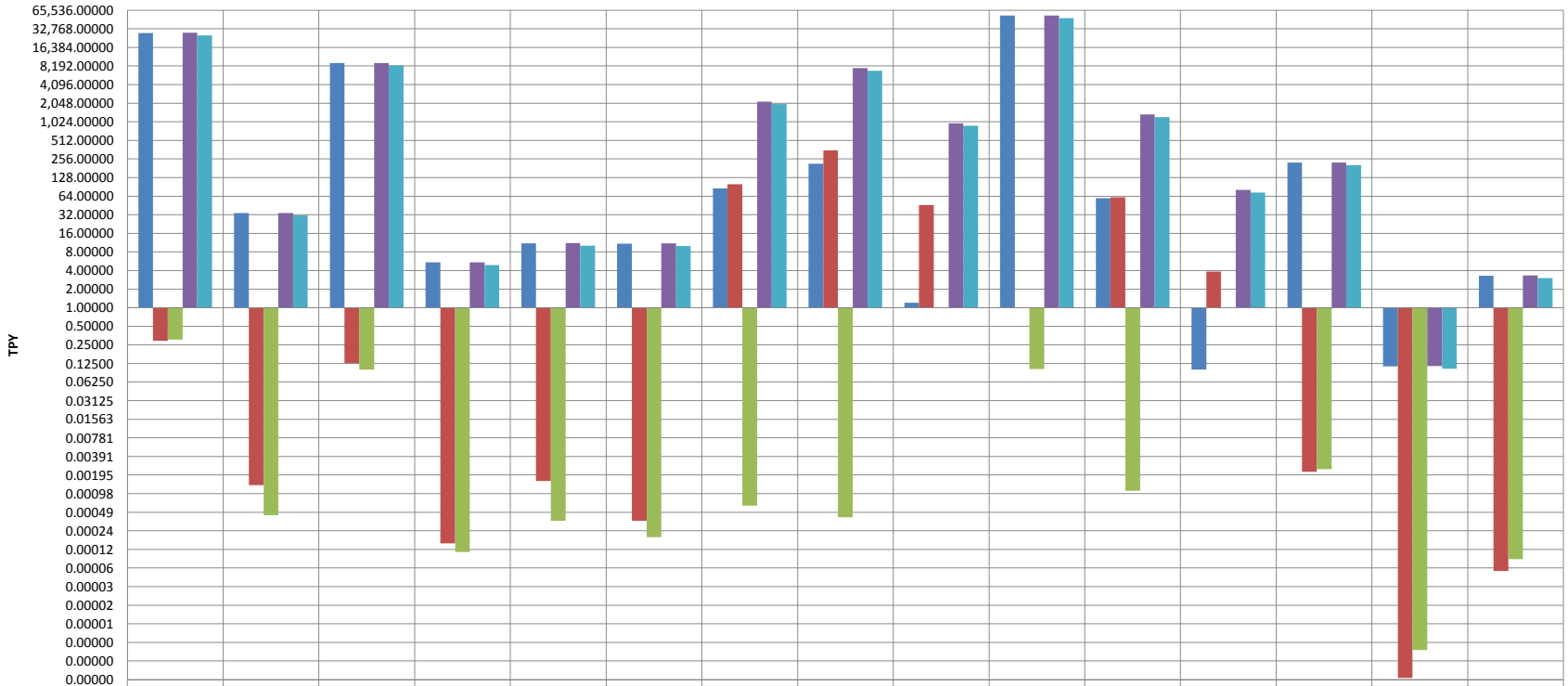
Maximum Annual Wells Drilled - Federal (RMP estimate)	51	Maximum Annual Wells Drilled - Non-Federal (RMP estimate)	238
Federal Producing Wells - RMP Year 20	870	Non-Federal Producing Wells - RMP Year 20	3,980
Average Well Barrel Oil Per Day (BOPD)	20	Average Well Barrel Oil Per Day (BOPD)	20

Federal Oil Wells Summaries

Total Annual Emissions from Federal Oil Wells - RMP Year 20

Activity	Annual Emissions (Tons)				
	CO_2	CH_4	N_2O	CO_{2eq}	CO_{2eq} metric tons
Well Pad Construction - Fugitive Dust	---	---	---	---	---
Heavy Equipment Combustive Emissions	28055.06	0.29	0.30	28155.70	25549.64
Commuting Vehicles - Construction	34.03	0.00	0.00	34.20	31.03
Wind Erosion	---	---	---	---	---
Sub-total: Construction	**28,089.10**	**0.29**	**0.31**	**28,189.90**	**25,580.67**
Well Workover Operations - Fugitive Dust	---	---	---	---	---
Well Workover Operations - On-site Exhaust	9141.48	0.13	0.10	9175.03	8325.80
Well Workover Operations - On-road Exhaust	5.39	0.00	0.00	5.43	4.93
Well Visits for Inspection & Repair - Operations	10.98	0.00	0.00	11.12	10.09
Recompletion Traffic	10.94	0.00	0.00	11.01	9.99
Water Tanks & Traffic	85.28	99.43	0.00	2173.48	1972.30
Oil Tanks & Traffic	214.33	350.61	0.00	7577.33	6875.98
Venting	1.20	46.09	0.00	969.10	879.40
Compression and Well Pumps	53,844.51	1.02	0.10	53897.32	48908.64
Dehydrators	59.09	61.25	0.00	1345.57	1221.03
Compression Station Fugitives	0.10	3.83	0.00	80.52	73.07
Sub-total: Operations	**63,373.30**	**562.35**	**0.20**	**75,245.90**	**68,281.22**
Road Maintenance	223.22	0.00	0.00	224.02	203.29
Sub-total: Maintenance	**223.219**	**0.002**	**0.00**	**224.02**	**203.29**
Road Reclamation	0.11	0.00	0.00	0.11	0.10
Well Reclamation	3.30	0.00	0.00	3.33	3.02
Sub-total: Reclamation	**3.4121**	**0.0001**	**0.0001**	**3.4407**	**3.1222**
Total Emissions	**91,689.03**	**562.65**	**0.51**	**103,663.26**	**94,068.29**

MCFO RMP Federal Oil Wells Emissions (TPY)

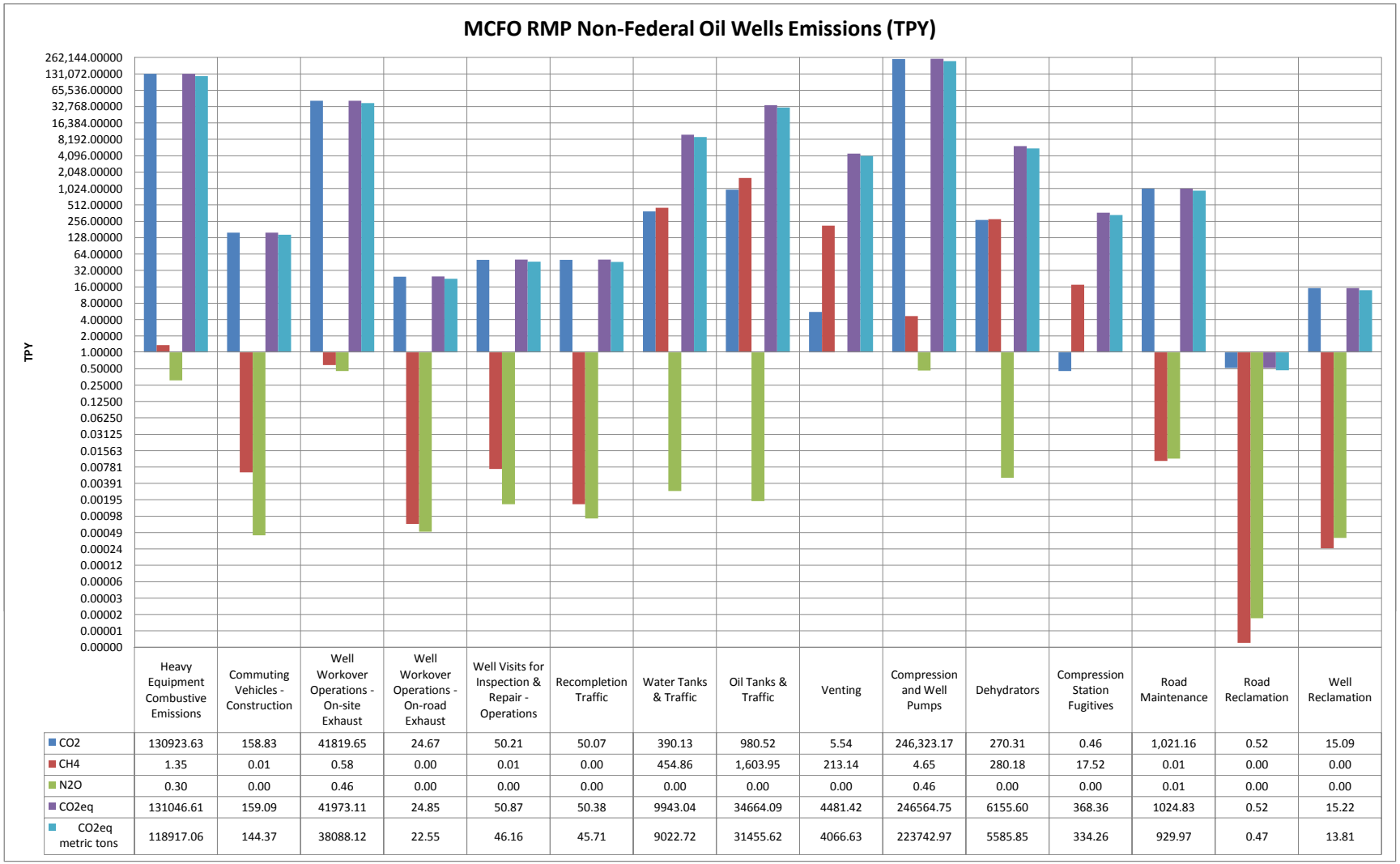


	Heavy Equipment Combustive Emissions	Commuting Vehicles - Construction	Well Workover Operations - On-site Exhaust	Well Workover Operations - On-road Exhaust	Well Visits for Inspection & Repair - Operations	Recompletion Traffic	Water Tanks & Traffic	Oil Tanks & Traffic	Venting	Compression and Well Pumps	Dehydrators	Compression Station Fugitives	Road Maintenance	Road Reclamation	Well Reclamation
CO2	28055.06	34.03	9141.48	5.39	10.98	10.94	85.28	214.33	1.20	53,844.51	59.09	0.10	223.22	0.11	3.30
CH4	0.29	0.00	0.13	0.00	0.00	0.00	99.43	350.61	46.09	1.02	61.25	3.83	0.00	0.00	0.00
N2O	0.30	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00
CO2eq	28155.70	34.20	9175.03	5.43	11.12	11.01	2173.48	7577.33	969.10	53897.32	1345.57	80.52	224.02	0.11	3.33
CO2eq metric tons	25549.64	31.03	8325.80	4.93	10.09	9.99	1972.30	6875.98	879.40	48908.64	1221.03	73.07	203.29	0.10	3.02

Non-Federal Oil Wells Summaries

Total Annual Emissions from Non-Federal Oil Wells - RMP Year 20

Activity	Annual Emissions (Tons)				
	CO_2	CH_4	N_2O	CO_{2eq}	CO_{2eq} metric tons
Well Pad Construction - Fugitive Dust	---	---	---	---	---
Heavy Equipment Combustive Emissions	130923.63	1.35	0.30	131046.61	118917.06
Commuting Vehicles - Construction	158.83	0.01	0.00	159.09	144.37
Wind Erosion	---	---	---	---	---
Sub-total: Construction	**131,082.46**	**1.36**	**0.31**	**131,205.70**	**119,061.43**
Well Workover Operations - Fugitive Dust			---	---	---
Well Workover Operations - On-site Exhaust	41819.65	0.58	0.46	41973.11	38088.12
Well Workover Operations - On-road Exhaust	24.67	0.00	0.00	24.85	22.55
Well Visits for Inspection & Repair - Operations	50.21	0.01	0.00	50.87	46.16
Recompletion Traffic	50.07	0.00	0.00	50.38	45.71
Water Tanks & Traffic	390.13	454.86	0.00	9943.04	9022.72
Oil Tanks & Traffic	980.52	1,603.95	0.00	34664.09	31455.62
Venting	5.54	213.14	0.00	4481.42	4066.63
Compression and Well Pumps	246,323.17	4.65	0.46	246564.75	223742.97
Dehydrators	270.31	280.18	0.00	6155.60	5585.85
Compression Station Fugitives	0.46	17.52	0.00	368.36	334.26
Sub-total: Operations	**289,914.72**	**2,574.88**	**0.93**	**344,276.46**	**312,410.58**
Road Maintenance	1,021.16	0.01	0.01	1024.83	929.97
Sub-total: Maintenance	**1021.161**	**0.010**	**0.01**	**1,024.83**	**929.97**
Road Reclamation	0.52	0.00	0.00	0.52	0.47
Well Reclamation	15.09	0.00	0.00	15.22	13.81
Sub-total: Reclamation	**15.6096**	**0.0003**	**0.0004**	**15.7401**	**14.2832**
Total Emissions	**422,033.94**	**2,576.25**	**1.25**	**476,522.73**	**432,416.27**



	Heavy Equipment Combustive Emissions	Commuting Vehicles - Construction	Well Workover Operations - On-site Exhaust	Well Workover Operations - On-road Exhaust	Well Visits for Inspection & Repair - Operations	Recompletion Traffic	Water Tanks & Traffic	Oil Tanks & Traffic	Venting	Compression and Well Pumps	Dehydrators	Compression Station Fugitives	Road Maintenance	Road Reclamation	Well Reclamation
CO2	130923.63	158.83	41819.65	24.67	50.21	50.07	390.13	980.52	5.54	246,323.17	270.31	0.46	1,021.16	0.52	15.09
CH4	1.35	0.01	0.58	0.00	0.01	0.00	454.86	1,603.95	213.14	4.65	280.18	17.52	0.01	0.00	0.00
N2O	0.30	0.00	0.46	0.00	0.00	0.00	0.00	0.00	0.00	0.46	0.00	0.00	0.01	0.00	0.00
CO2eq	131046.61	159.09	41973.11	24.85	50.87	50.38	9943.04	34664.09	4481.42	246564.75	6155.60	368.36	1024.83	0.52	15.22
CO2eq metric tons	118917.06	144.37	38088.12	22.55	46.16	45.71	9022.72	31455.62	4066.63	223742.97	5585.85	334.26	929.97	0.47	13.81

Exhaust Emissions from Well Pad Construction Heavy Equipment and Drilling Equipment

Emission Factors for Construction Equipment

Equipment	Emission Factors (g/hp-hr)			Equipment Category
	CO_2	CH_4	N_2O [a]	
Dozer - 175 Hp	535.76	0.005	0.006	Track-Type Tractor
Blade - 150 Hp	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] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

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 (tons/equipment type/well)		
									CO_2	CH_4	N_2O
Improved & Two-Track Road	Blade	150	1	75	10	2	20	1	1.47E+00	1.87E-05	1.43E-05
Well Pad	Blade	175	1	75	10	3	30	1	2.58E+00	3.28E-05	2.50E-05
	Dozer	175	1	80	10	3	30	1	2.75E+00	3.50E-05	2.67E-05
								Subtotal	**6.81E+00**	**8.64E-05**	**6.61E-05**

Exhaust Emission Factors for Diesel Powered Bore/Drill Rig Engines

Project Year/Hp Category	Emission Factors (g/hp-hr)		
	CO_2	CH_4	N_2O[a]
Year 2018			
50 to 75	589.10	0.006	0.006
75 to 100	589.10	0.006	0.006
100 to 175	530.10	0.005	0.006
175 to 300	530.18	0.004	0.006
300 to 600	530.25	0.004	0.006
600 to 750	530.28	0.004	0.006
>750	529.92	0.006	0.006

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

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

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 (tons/equipment type/well)		
									CO_2	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Main Deck	1,000	3	70	24	16	384	1	4.71E+02	5.02E-03	5.13E-03
	Auxiliary Pump	600	1	80	8	15	120	1	3.37E+01	2.51E-04	3.66E-04
	Generators	150	2	75	24	8	192	1	2.52E+01	2.26E-04	2.75E-04
Well Completion & Testing	Main Deck	600	1	50	11	5	55	1	9.64E+00	7.19E-05	1.05E-04
	Auxiliary Pump	225	1	80	8	2	16	1	1.68E+00	1.37E-05	1.83E-05
	Power Swivel	150	1	75	8	2	16	1	1.05E+00	9.42E-06	1.14E-05
	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	9.64E-01	1.05E-05	9.44E-06
								Subtotal	**5.43E+02**	**5.60E-03**	**5.91E-03**
								Total	**5.50E+02**	**5.69E-03**	**5.98E-03**

Exhaust Emissions from Construction and Drilling Support Vehicles

Emission Factors for Commuting Vehicles

Vehicle		Emission Factors (g/mi)		
Type	**Class**	**CO_2**	**CH_4**	**N_2O[a]**
Light-Duty Diesel Truck	LDDT	409.5	0.002	0.016
Heavy-Duty Diesel Truck	HDDV	791.8	0.04	0.006

Source: MOBILE6.2.03

[a] 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).

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 (tons/well)		
	Type	**Class**					**CO_2**	**CH_4**	**N_2O**
Improved & Two-Track Road	Semi Trucks	HDDV	2	47	94	1	8.20E-02	3.83E-06	5.98E-07
	Pickup Trucks	LDDT	2	3	6	1	2.71E-03	1.32E-08	1.03E-07
Well Pad	Semi Trucks	HDDV	2	5	10	1	8.73E-03	4.08E-07	6.36E-08
	Pickup Trucks	LDDT	2	4	8	1	3.61E-03	1.76E-08	1.37E-07
Other Construction Activities	Semi Trucks	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Haul Trucks	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Pickup Trucks	LDDT	2	1	2	1	9.03E-04	4.41E-09	3.42E-08
						Subtotal	**1.05E-01**	**4.60E-06**	**9.86E-07**

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 (tons/well)		
	Type	**Class**					**CO_2**	**CH_4**	**N_2O**
Rig-up, Drilling, and Rig-down	Semi Rig Transport, Drill Rig	HDDV	2	44	88	1	7.68E-02	3.59E-06	5.60E-07
	Fuel Haul Truck	HDDV	2	6	12	1	1.05E-02	4.89E-07	7.63E-08
	Mud Haul Truck, Water Hauling	HDDV	2	4	8	1	6.98E-03	3.26E-07	5.09E-08
	Rig Crew	LDDT	2	51	102	1	4.60E-02	2.25E-07	1.74E-06
	Rig Mechanics	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Co. Supervisor	LDDT	2	20	40	1	1.81E-02	8.82E-08	6.83E-07
	Tool Pusher	LDDT	2	8	16	1	7.22E-03	3.53E-08	2.73E-07
	Mud Logger	LDDT	2	6	12	1	5.42E-03	2.65E-08	2.05E-07
	Mud Engineer	LDDT	2	15	30	1	1.35E-02	6.61E-08	5.13E-07
	Logger, Engr Truck	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Drill Bit Delivery	LDDT	2	2	4	1	1.81E-03	8.82E-09	6.83E-08

Combustive Emissions Estimation Road Traffic (cont.)

Construction Site Destination	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells	Emissions (tons/well)		
	Type	Class					CO_2	CH_4	N_2O
Well Completion & Testing	Semi Casing Haulers	HDDV	2	6	12	1	1.05E-02	4.89E-07	7.63E-08
	Semi Completion, Unit Rig	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Semi Fracing, Blender	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Semi Pumping/Tank Battery	HDDV	2	6	12	1	1.05E-02	4.89E-07	7.63E-08
	Tubing Truck	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Haul Cementer, Pump Truck	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Haul Cementer, Cement Truck	HDDV	2	3	6	1	5.24E-03	2.45E-07	3.82E-08
	Haul Completion, Equip Truck	HDDV	2	3	6	1	5.24E-03	2.45E-07	3.82E-08
	Haul Service	LDDT	2	2	4	1	1.81E-03	8.82E-09	6.83E-08
	Haul Perforators Logging Truck	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Anchor, Installation	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Anchor, Testing	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Tank	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Pump	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Chemical	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Sand	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Other	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Welders	HDDV	2	6	12	1	1.05E-02	4.89E-07	7.63E-08
	Haul Water	HDDV	2	150	300	1	2.62E-01	1.22E-05	1.91E-06
	Pickup Cementer, Engineer	LDDT	2	2	4	1	1.81E-03	8.82E-09	6.83E-08
	Pickup Casing Crew	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Pickup Completion Crew	HDDV	2	5	10	1	8.73E-03	4.08E-07	6.36E-08
	Pickup Completion, Pusher	LDDT	2	5	10	1	4.51E-03	2.20E-08	1.71E-07
	Pickup Perforators, Engineer	LDDT	2	2	4	1	1.81E-03	8.82E-09	6.83E-08
	Pickup Fracing, Engineer	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Pickup Co. Supervisor	LDDT	2	10	20	1	9.03E-03	4.41E-08	3.42E-07
	Pickup Miscellaneous	LDDT	2	3	6	1	2.71E-03	1.32E-08	1.03E-07
	Pickup Roustabout	HDDV	2	4	8	1	6.98E-03	3.26E-07	5.09E-08
						Subtotal	**5.62E-01**	**2.15E-05**	**7.57E-06**
						Total	**6.67E-01**	**2.61E-05**	**8.56E-06**

Exhaust Emissions from Well Work Overs

Emission Factors Bore/Drill Rig Engines 300-600 Hp

Fuel Type	Emission Factors (gm/hp-hr)		
	CO_2	CH_4	N_2O[a]
Diesel	529.575	0.007	0.006

Source: EPA NONROADS 2008a. Year 2008.

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologie for the Oil and Gas Industry," Table 4-17 (2009).

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 (tons/year/well)		
							CO_2	CH_4	N_2O
Well Workover	Truck-Mounted Unit	600	10	3	30	1	1.05E+01	1.46E-04	1.14E-04

Exhaust emission factors for commuting vehicles

Vehicle		Emission Factors (g/mi)		
Type	Class	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	409.500	0.002	0.016
Heavy-Duty Diesel Truck	HDDV	791.800	0.037	0.006

Source: MOBILE 6.2.03

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

[a] 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

Activity	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells Drilled	Max. Annual Emissions (tons/year/well)		
	Type	Class					CO_2	CH_4	N_2O
Well Workover	WO Rig	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Truck	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Pickup Truck	LDDT	2	3	6	1	2.71E-03	1.32E-08	1.03E-07
						Total	**6.20E-03**	**1.76E-07**	**1.28E-07**

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).

Round trip distance = 2 based on data found in the SEIS

Exhaust Emissions from Site Visits and Inspections

Emission factors for Commuting Vehicles Exhaust

Vehicle Class	Emission Factors (g/mi)		
	CO_2	CH_4	N_2O[a]
Light-Duty Gasoline Truck	476.90	0.07	0.02

Source: MOBILE 6.2.03
Emission factors for 2008 used for all years = conservative estimate for fleet vehicle turnover
[a] 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)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Federal Wells Producing	Emissions (tons/yr/well)		
	Type	Class					CO_2	CH_4	N_2O
Inspection Visits for Wells	Pickup Truck	LDGT2	2	12	24	1	1.26E-02	1.80E-06	4.07E-07

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 year

[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
Number of Wells	1
Cumulative Length of Roads [b] (miles/operation)	1

[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	0.3333	3.3333
Winter	1	1	5	10	0.2000	2.0000
				Total	**0.5333**	**5.3333**

Emission Factors for Construction Equipment Exhaust

Equipment	Emission Factors (g/hp-hr)		
	CO_2	CH_4	N_2O[a]
Grader 100-175 Hp	535.7700	0.0053	0.0058

Source: EPA NONROADS 2008a

Use emission factors for 2008 for all project years - conservative estimate of vehicle turnover

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

Emission Estimations for Grader: RMP Year 20

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours[a]	Emissions (tons/well)		
				CO_2	CH_4	N_2O
Road Maintenance	Grader	135	3.20	2.55E-01	2.52E-06	2.75E-06

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

Emission Factors for Commuting Vehicles Exhaust

Vehicle Class	Emission Factors (g/mi)		
	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	409.500	0.002	0.016

Source: MOBILE 6.2.03

[a] 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 (tons/yr)		
	Type	Class				CO_2	CH_4	N_2O
Road Maintenance	Pickup Truck	LDDT	6	0.5333	3.2000	1.44E-03	7.05E-09	5.47E-08

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)	CH_4 Emissions (ton/yr/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 Water Transport Vehicles - Road Traffic

Vehicle Class	Emission Factors (g/mi)		
	CO_2	CH_4	N_2O[a]
Heavy-Duty Diesel Truck (HDDV)	791.800	0.037	0.006

Source: MOBILE6.2.03

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

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 (tons/yr/well)		
	Type	Class					CO_2	CH_4	N_2O
Produced Water Hauling	Haul Truck (130 bbl)	HDDV	2	56	112	1	9.80E-02	4.58E-06	7.14E-07

Oil Tank, Loadout and Hauling Emissions

Oil Well Oil Seperator Flashing and Tank Emissions[a]

Project Year	Emissions[b]			
	HAPs Emissions (ton/yr/well)	VOC Emissions (ton/yr/well)	CO_2 Emissions (ton/yr/well)	CH_4 Emissions (ton/yr/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 no 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 ($lb/10^3$ gal) 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)
All	2.35	7,300	307	3.61E-01	6.47E-04	1.05E-07

[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)		
	CO_2	CH_4	N_2O[a]
Heavy-Duty Diesel Truck (HDDV)	791.800	0.037	0.006

Source: MOBILE6.2.03

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

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 (tons/year/well)		
	Type	Class					CO_2	CH_4	N_2O
Produced Oil Hauling	Haul Truck (200 bbl)	HDDV	2	37	73	1	6.37E-02	2.98E-06	4.64E-07
						TOTAL	**6.37E-02**	**2.98E-06**	**4.64E-07**

W&S Composition for Truck Load Out Emissions

W&S Gas Component	Mole Fraction[a] (%)	Molecular Weight (lb/lb-mol)	Gas Weight (lb/lb-mol)	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-HAP	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)

Exhaust Emissions from Recompletion Support Vehicles

Emission Factors for Commuting Vehicles

Vehicle		Emission Factors (g/mi)		
Type	**Class**	**CO_2**	**CH_4**	**N_2O[a]**
Light-Duty Diesel Truck	LDDT	409.500	0.002	0.016
Heavy-Duty Diesel Truck	HDDV	791.800	0.037	0.006

Source: MOBILE6.2.03

[a] 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).

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 (tons/well)		
	Type	Class					CO_2	CH_4	N_2O
Well Recompletion	Fuel Haul Truck	HDDV	2	6	12	1	1.05E-02	4.89E-07	7.63E-08
	Mud Haul Truck, Water Hauling	HDDV	2	4	8	1	6.98E-03	3.26E-07	5.09E-08
	Rig Crew	LDDT	2	51	102	1	4.60E-02	2.25E-07	1.74E-06
	Rig Mechanics	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Co. Supervisor	LDDT	2	20	40	1	1.81E-02	8.82E-08	6.83E-07
	Semi Completion, Unit Rig	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Semi Fracing, Blender	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Semi Pumping/Tank Battery	HDDV	2	6	12	1	1.05E-02	4.89E-07	7.63E-08
	Tubing Truck	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Haul Cementer, Pump Truck	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Haul Cementer, Cement Truck	HDDV	2	3	6	1	5.24E-03	2.45E-07	3.82E-08
	Haul Completion, Equip Truck	HDDV	2	3	6	1	5.24E-03	2.45E-07	3.82E-08
	Haul Service Tools	LDDT	2	2	4	1	1.81E-03	8.82E-09	6.83E-08
	Haul Perforators Logging Truck	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Tank	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Pump	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Chemical	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Sand	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Other	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Water Truck	HDDV	2	50	100	1	8.73E-02	4.08E-06	6.36E-07
	Pickup Cementer, Engineer	LDDT	2	2	4	1	1.81E-03	8.82E-09	6.83E-08
	Pickup Completion Crew	HDDV	2	5	10	1	8.73E-03	4.08E-07	6.36E-08
	Pickup Completion, Pusher	LDDT	2	5	10	1	4.51E-03	2.20E-08	1.71E-07
	Pickup Perforators, Engineer	LDDT	2	2	4	1	1.81E-03	8.82E-09	6.83E-08
	Pickup Fracing, Engineer	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Pickup Co. Supervisor	LDDT	2	10	20	1	9.03E-03	4.41E-08	3.42E-07
	Pickup Miscellaneous Supplies	LDDT	2	3	6	1	2.71E-03	1.32E-08	1.03E-07
	Pickup Roustabout Crew	HDDV	2	4	8	1	6.98E-03	3.26E-07	5.09E-08
						Subtotal	**2.52E-01**	**8.17E-06**	**4.45E-06**
						Total	**2.52E-01**	**8.17E-06**	**4.45E-06**

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**

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 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 duratior	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).

Compressor Stations Emissions

Emission Factors for Natural Gas-Fired Compressors and Pumps

Compressor / Pump		Horse-Power Rating	Units	Emission Factors		
				CO_2 [a]	CH_4 [a]	N_2O [a]
Compression Station	Lean Burn	300	gm/bhp-hr	1.35E+02	2.55E-03	2.55E-04
			lb/MMBTU	1.17E+02	2.20E-03	2.20E-04
Oil Pump at Well Head	Lean Burn	40	gm/bhp-hr	1.35E+02	2.55E-03	2.55E-04
			lb/MMBTU	1.17E+02	2.20E-03	2.20E-04

Note: Compressors assumed to be equipped with nonselective catalytic reduction (NSCR) catalyst.

[a] 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 (tons/year/well)		
					CO_2	CH_4	N_2O
Compression Station	7.5	1.00	7.5	8,760	9.77E+00	1.84E-04	1.84E-05
Oil Pump at Well Head	40	1.00	40	8,760	5.21E+01	9.83E-04	9.83E-05
				Total	**6.19E+01**	**1.17E-03**	**1.17E-04**

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

TOC Emission Factor								
Well Equipment Component	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 (see Venting Worksheet)

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

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	1.74E-03	5.90E-04	1.92E-05	7.39E-04
pump seals	0.000	0.0053	0	0.0287	0	0.0001	0.00E+00	0.00E+00	0.00E+00	0.00E+00
others	0.000	0.0194	0	0.0165	0	0.0309	0.00E+00	0.00E+00	0.00E+00	0.00E+00
connectors	0.250	0.0004	0	0.0005	0	0.0002	1.10E-04	3.74E-05	1.22E-06	4.69E-05
flanges	0.600	0.0009	0	0.0002	0	0.0000	5.16E-04	1.75E-04	5.70E-06	2.19E-04
open-ended lines	0.000	0.0044	0	0.0031	0	0.0006	0.00E+00	0.00E+00	0.00E+00	0.00E+00
						TOTAL emissions/well/hr =	2.36E-03	8.02E-04	2.61E-05	1.00E-03

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 (ton/yr)**	**CO_2 emissions (lb/yr)**	**CO_2 emissions (ton/yr)**	**CH_4 emissions (lb/yr)**	**CH_4 emissions (ton/yr)**
Year 20	1	8760	7.03E+00	3.51E-03	2.29E-01	1.14E-04	8.80E+00	4.40E-03

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	0.009
Annual Miles of Roads reclaimed Per Well	0.002
Number of wells reclaimed (per well)	0.009

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
0.002	6	0.0004	0.0040
		Total	**0**

Assume average miles/day = 6

Emission Factors for 75-100 hp Off-Road Engines

Year	Emission Factors (g/hp-hr)		
	CO_2	CH_4	N_2O[a]
2008	600.5	0.010	0.016
2018	613.9	0.006	0.016
2027	608.6	0.003	0.016

[a] 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).

Exhaust Emissions Estimation for Grader Road Reclaim

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours	Emissions (tons/year/well)		
				CO_2	CH_4	N_2O
Road Reclamation	Grader	80	0.002	0.0001	0.0000	0.0000

Exhaust Emission Factors for Commuting Reclaim Vehicles Road Traffic

Vehicle Class	Emission Factors (g/mi)		
	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	409.5	0.002	0.016

Source: MOBILE6.2.03

[a] 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).

Exhaust Emissions Estimation for Commuting Reclaim Vehicles: Road Traffic

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tons/year/well)		
	Type	Class				CO_2	CH_4	N_2O
Road Reclamation	Pickup Truck	LDDV	6	0.0004	0.0024	0.0000	0.0000	0.0000

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	0.009	10	0.009	0.09

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

Exhaust Emissions Estimation for Grader: Well Reclamation

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours	Emissions (tons/year/well)		
				CO_2	CH_4	N_2O
Well Reclamation	Grader	100	0.06	0.0038	0.0000	0.0000

Exhaust Emissions Estimation for Commuting Vehicles: Well Reclamation

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tons/year/well)		
	Type	Class				CO_2	CH_4	N_2O
Well Reclamation	Pickup Truck	LDDV	6	0.01	0.06	0.0000	0.0000	0.0000

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	0.2500
Number of Roads Reclaimed Annually Per Well	0.0095
Annual Miles of Roads reclaimed Per Well	0.0024
Number of wells reclaimed (per well)	0.0095

Reclaimation 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
0.002	6	0.0004	0.0040
		Total	**0**

Assume average miles/day = 6

Emission Factors for 75-100 hp Off-Road Engines

Year	Emission Factors (g/hp-hr)		
	CO_2	CH_4	N_2O[a]
2008	600.507	0.010	0.016
2018	613.888	0.006	0.016
2027	608.641	0.003	0.016

[a] 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).

Exhaust Emissions Estimation for Grader Road Reclaim

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours	Emissions (tons/year/well)		
				CO_2	CH_4	N_2O
Road Reclamation	Grader	80	0.0024	1.28E-04	1.15E-09	3.24E-09

Exhaust Emission Factors for Commuting Reclaim Vehicles Road Traffic

Vehicle Class	Emission Factors (g/mi)		
	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	409.500	0.002	0.016

Source: MOBILE6.2.03

[a] 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).

Exhaust Emissions Estimation for Commuting Reclaim Vehicles: Road Traffic

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tons/year/well)		
	Type	Class				CO_2	CH_4	N_2O
Road Reclamation	Pickup Truck	LDDV	6	0.0004	0.0024	1.07E-06	5.23E-12	4.05E-11

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	0.0095	10	0.0095	0.0948

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

Exhaust Emissions Estimation for Grader: Well Reclamation

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours	Emissions (tons/year/well)		
				CO_2	CH_4	N_2O
Well Reclamation	Grader	100	0.0569	3.77E-03	6.28E-08	9.72E-08

Exhaust Emissions Estimation for Commuting Vehicles: Well Reclamation

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tons/year/well)		
	Type	Class				CO_2	CH_4	N_2O
Well Reclamation	Pickup Truck	LDDV	6	0.0095	0.0569	2.57E-05	1.25E-10	9.72E-10

Emissions for Gas Dehydration

Emission Factors for Dehydrator Heaters

Unit	CO_2	CH_4	N_2O
lb/MMSCF	120000.0	2.3	2.2
lb/MMBTU	117.647	0.002	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 (tons/year/well)		
				CO_2	CH_4	N_2O
2,190	1	2.20	0.0005	6.79E-02	1.30E-06	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 per MMscf)	CH_4 Emissions (TPY/well)
6.5700	0.0107	7.04E-02

Gas analysis and dehydration process information provided by Montana BLM (Laakso, 2010). GRI GLYCalc estimated emissions.
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 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	

Input parameters for calculating Natural Gas wells emissions

Maximum Annual Wells Drilled - Federal (RMP estimate)	133	Maximum Annual Wells Drilled - Non-Federal (RMP estimate)	459
Federal Producing Wells - RMP Year 20	2,186	Non-Federal Producing Wells - RMP Year 20	7,541
Average Gas Production Per Well (MCFD)	40	Average Gas Production Per Well (MCFD)	40

Federal NG Wells Summaries

Total Annual Emissions from Federal NG Wells - RMP Year 20

Activity	Annual Emissions (Tons)				
	CO_2	CH_4	N_2O	CO_{2eq}	CO_{2eq} metric tons
Well Pad Construction - Fugitive Dust	---	---	---	---	---
Heavy Equipment Combustive Emissions	73163.20	0.76	0.80	73425.66	66629.45
Commuting Vehicles - Construction	88.76	0.00	0.00	89.18	80.93
Wind Erosion	---	---	---	---	---
Completion Venting	1.01	301.55	0.00	6333.64	5747.40
Sub-total: Construction	**73,252.98**	**302.31**	**0.80**	**79,848.47**	**72,457.78**
Well Workover Operations - Fugitive Dust	---	---	---	---	---
Well Workover Operations - On-site Exhaust	22969.29	0.32	0.25	23053.57	20919.76
Well Workover Operations - On-road Exhaust	13.55	0.00	0.00	13.65	12.38
Well Visits for Inspection & Repair - Operations	27.58	0.00	0.00	27.94	25.35
Wellhead and Compressor Station Fugitives	2.60	773.26	0.00	16241.16	14737.89
Compression	60,973.01	1.15	0.12	61032.81	55383.67
Station Visits - Operations	15.05	0.00	0.00	15.23	13.82
Dehydrators	329.92	495.69	0.01	10741.31	9747.11
Sub-total: Operations	**84,331.00**	**1,270.43**	**0.37**	**111,125.67**	**100,839.99**
Road Maintenance	560.87	0.01	0.01	562.88	510.78
Sub-total: Maintenance	**560.869**	**0.006**	**0.01**		**510.78**
Road Reclamation	0.33	0.00	0.00	0.33	0.30
Well Reclamation	9.53	0.00	0.00	9.61	8.72
Sub-total: Reclamation	**9.8507**	**0.0002**	**0.0003**	**9.9331**	**9.0137**
Total Emissions	**158,154.70**	**1,572.75**	**1.18**	**190,984.07**	**173,817.57**

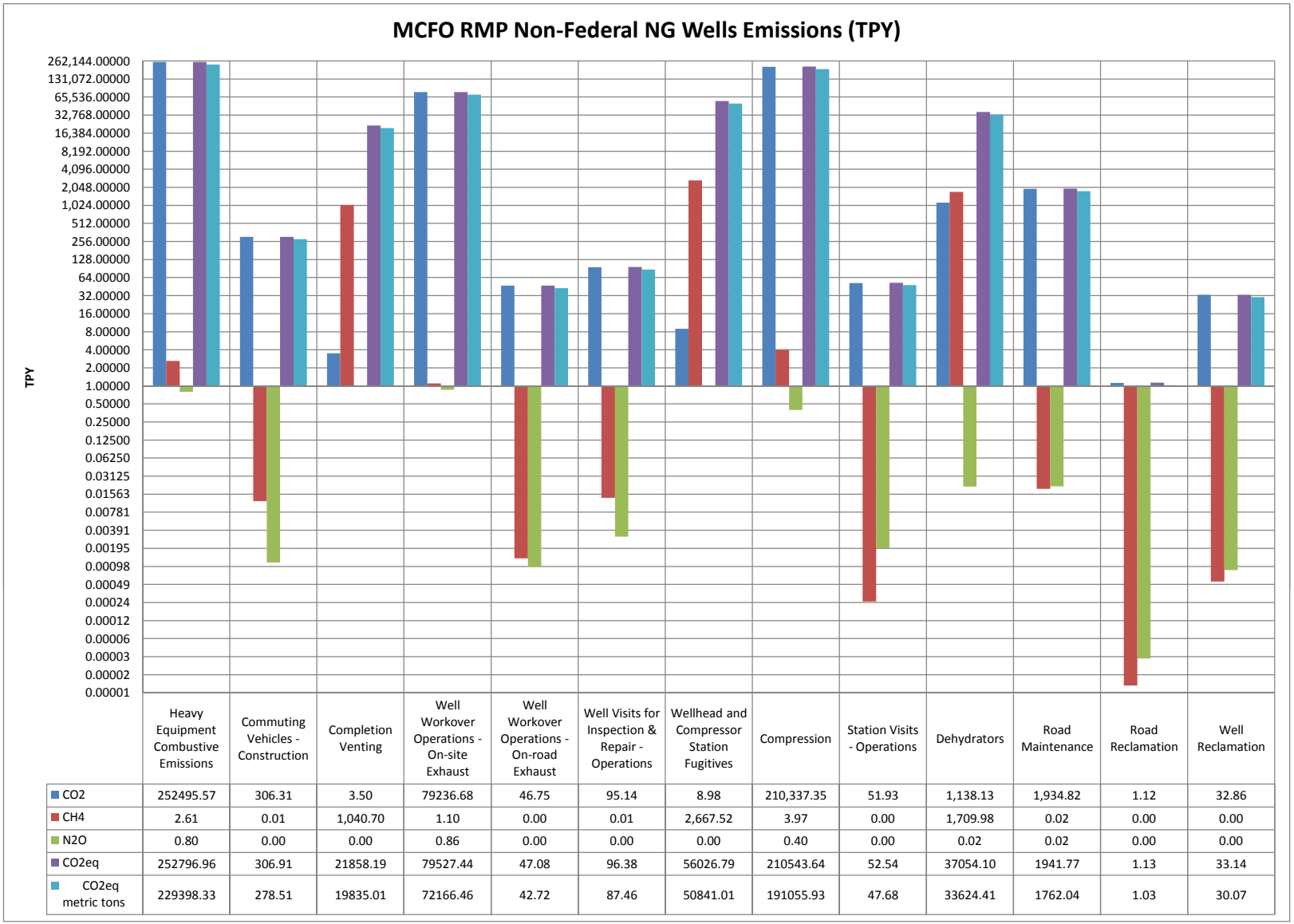
MCFO RMP Federal NG Wells Emissions (TPY)

	Heavy Equipment Combustive Emissions	Commuting Vehicles - Construction	Completion Venting	Well Workover Operations - On-site Exhaust	Well Workover Operations - On-road Exhaust	Well Visits for Inspection & Repair - Operations	Wellhead and Compressor Station Fugitives	Compression	Station Visits - Operations	Dehydrators	Road Maintenance	Road Reclamation	Well Reclamation
CO2	73163.20	88.76	1.01	22969.29	13.55	27.58	2.60	60,973.01	15.05	329.92	560.87	0.33	9.53
CH4	0.76	0.00	301.55	0.32	0.00	0.00	773.26	1.15	0.00	495.69	0.01	0.00	0.00
N2O	0.80	0.00	0.00	0.25	0.00	0.00	0.00	0.12	0.00	0.01	0.01	0.00	0.00
CO2eq	73425.66	89.18	6333.64	23053.57	13.65	27.94	16241.16	61032.81	15.23	10741.31	562.88	0.33	9.61
CO2eq metric tons	66629.45	80.93	5747.40	20919.76	12.38	25.35	14737.89	55383.67	13.82	9747.11	510.78	0.30	8.72

Non-Federal NG Wells Summaries

Total Annual Emissions from Non-Federal NG Wells - RMP Year 20

Activity	Annual Emissions (Tons)				
	CO_2	CH_4	N_2O	CO_{2eq}	CO_{2eq} metric tons
Well Pad Construction - Fugitive Dust	---	---	---	---	---
Heavy Equipment Combustive Emissions	252495.57	2.61	0.80	252796.96	229398.33
Commuting Vehicles - Construction	306.31	0.01	0.00	306.91	278.51
Wind Erosion	---	---	---	---	---
Completion Venting	3.50	1,040.70	0.00	21858.19	19835.01
Sub-total: Construction	**252,805.38**	**1,043.32**	**0.80**	**274,962.06**	**249,511.85**
Well Workover Operations - Fugitive Dust			---	---	---
Well Workover Operations - On-site Exhaust	79236.68	1.10	0.86	79527.44	72166.46
Well Workover Operations - On-road Exhaust	46.75	0.00	0.00	47.08	42.72
Well Visits for Inspection & Repair - Operations	95.14	0.01	0.00	96.38	87.46
Wellhead and Compressor Station Fugitives	8.98	2,667.52	0.00	56026.79	50841.01
Compression	210,337.35	3.97	0.40	210543.64	191055.93
Station Visits - Operations	51.93	0.00	0.00	52.54	47.68
Dehydrators	1,138.13	1,709.98	0.02	37054.10	33624.41
Sub-total: Operations	**290,914.96**	**4,382.57**	**1.29**	**383,347.97**	**347,865.67**
Road Maintenance	1,934.82	0.02	0.02	1941.77	1762.04
Sub-total: Maintenance	**1934.817**	**0.019**	**0.02**		**1,762.04**
Road Reclamation	1.12	0.00	0.00	1.13	1.03
Well Reclamation	32.86	0.00	0.00	33.14	30.07
Sub-total: Reclamation	**33.9819**	**0.0006**	**0.0009**	**34.2661**	**31.0945**
Total Emissions	**545,689.14**	**5,425.92**	**2.11**	**658,344.30**	**599,170.66**



	Heavy Equipment Combustive Emissions	Commuting Vehicles - Construction	Completion Venting	Well Workover Operations - On-site Exhaust	Well Workover Operations - On-road Exhaust	Well Visits for Inspection & Repair - Operations	Wellhead and Compressor Station Fugitives	Compression	Station Visits - Operations	Dehydrators	Road Maintenance	Road Reclamation	Well Reclamation
CO2	252495.57	306.31	3.50	79236.68	46.75	95.14	8.98	210,337.35	51.93	1,138.13	1,934.82	1.12	32.86
CH4	2.61	0.01	1,040.70	1.10	0.00	0.01	2,667.52	3.97	0.00	1,709.98	0.02	0.00	0.00
N2O	0.80	0.00	0.00	0.86	0.00	0.00	0.00	0.40	0.00	0.02	0.02	0.00	0.00
CO2eq	252796.96	306.91	21858.19	79527.44	47.08	96.38	56026.79	210543.64	52.54	37054.10	1941.77	1.13	33.14
CO2eq metric tons	229398.33	278.51	19835.01	72166.46	42.72	87.46	50841.01	191055.93	47.68	33624.41	1762.04	1.03	30.07

Exhaust Emissions from Well Pad Construction Heavy Equipment and Drilling Equipment

Emission Factors for Construction Equipment

Equipment	Emission Factors (g/hp-hr)			Equipment Category
	CO_2	CH_4	N_2O[a]	
Dozer - 175 Hp	535.760	0.005	0.006	Track-Type Tractor
Blade - 150 Hp	594.650	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] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

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 (tons/equipment type/well)		
									CO_2	CH_4	N_2O
Improved & Two-Track Road	Blade	150	1	75	10	2	20	1	1.47E+00	1.87E-05	1.43E-05
Well Pad	Blade	175	1	75	10	3	30	1	2.58E+00	3.28E-05	2.50E-05
	Dozer	175	1	80	10	3	30	1	2.75E+00	3.50E-05	2.67E-05
								Subtotal	**6.81E+00**	**8.64E-05**	**6.61E-05**

Exhaust Emission Factors for Diesel Powered Bore/Drill Rig Engines

Project Year/Hp Category	Emission Factors (g/hp-hr)		
	CO_2	CH_4	N_2O[a]
Year 2018			
50 to 75	589.096	0.006	0.006
75 to 100	589.103	0.006	0.006
100 to 175	530.097	0.005	0.006
175 to 300	530.181	0.004	0.006
300 to 600	530.255	0.004	0.006
600 to 750	530.283	0.004	0.006
>750	529.917	0.006	0.006

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

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

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 (tons/equipment type/well)		
									CO_2	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Main Deck	1,000	3	70	24	16	384	1	4.71E+02	5.02E-03	5.13E-03
	Auxiliary Pump	600	1	80	8	15	120	1	3.37E+01	2.51E-04	3.66E-04
	Generators	150	2	75	24	8	192	1	2.52E+01	2.26E-04	2.75E-04
Well Completion & Testing	Main Deck	600	1	50	11	5	55	1	9.64E+00	7.19E-05	1.05E-04
	Auxiliary Pump	225	1	80	8	2	16	1	1.68E+00	1.37E-05	1.83E-05
	Power Swivel	150	1	75	8	2	16	1	1.05E+00	9.42E-06	1.14E-05
	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	9.64E-01	1.05E-05	9.44E-06
								Subtotal	**5.43E+02**	**5.60E-03**	**5.91E-03**
								Total	**5.50E+02**	**5.69E-03**	**5.98E-03**

Exhaust Emissions from Construction and Drilling Support Vehicles

Emission Factors for Commuting Vehicles

Vehicle		Emission Factors (g/mi)		
Type	**Class**	**CO_2**	**CH_4**	**N_2O[a]**
Light-Duty Diesel Truck	LDDT	409.500	0.002	0.016
Heavy-Duty Diesel Truck	HDDV	791.800	0.037	0.006

Source: MOBILE6.2.03

[a] 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).

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 (tons/well)		
	Type	Class					CO_2	CH_4	N_2O
Improved & Two-Track Road	Semi Trucks	HDDV	2	47	94	1	8.20E-02	3.83E-06	5.98E-07
	Pickup Trucks	LDDT	2	3	6	1	2.71E-03	1.32E-08	1.03E-07
Well Pad	Semi Trucks	HDDV	2	5	10	1	8.73E-03	4.08E-07	6.36E-08
	Pickup Trucks	LDDT	2	4	8	1	3.61E-03	1.76E-08	1.37E-07
Other Construction Activities	Semi Trucks	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Haul Trucks	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Pickup Trucks	LDDT	2	1	2	1	9.03E-04	4.41E-09	3.42E-08
						Subtotal	**1.05E-01**	**4.60E-06**	**9.86E-07**

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 (tons/well)		
	Type	Class					CO_2	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Semi Rig Transport, Drill Rig	HDDV	2	44	88	1	7.68E-02	3.59E-06	5.60E-07
	Fuel Haul Truck	HDDV	2	6	12	1	1.05E-02	4.89E-07	7.63E-08
	Mud Haul Truck, Water Hauling	HDDV	2	4	8	1	6.98E-03	3.26E-07	5.09E-08
	Rig Crew	LDDT	2	51	102	1	4.60E-02	2.25E-07	1.74E-06
	Rig Mechanics	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Co. Supervisor	LDDT	2	20	40	1	1.81E-02	8.82E-08	6.83E-07
	Tool Pusher	LDDT	2	8	16	1	7.22E-03	3.53E-08	2.73E-07
	Mud Logger	LDDT	2	6	12	1	5.42E-03	2.65E-08	2.05E-07
	Mud Engineer	LDDT	2	15	30	1	1.35E-02	6.61E-08	5.13E-07
	Logger, Engr Truck	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Drill Bit Delivery	LDDT	2	2	4	1	1.81E-03	8.82E-09	6.83E-08

Combustive Emissions Estimation Road Traffic (cont.)

Construction Site Destination	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells	Emissions (tons/well)		
	Type	Class					CO_2	CH_4	N_2O
Well Completion & Testing	Semi Casing Haulers	HDDV	2	6	12	1	1.05E-02	4.89E-07	7.63E-08
	Semi Completion, Unit Rig	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Semi Fracing, Blender	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Semi Pumping/Tank Battery	HDDV	2	6	12	1	1.05E-02	4.89E-07	7.63E-08
	Tubing Truck	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Haul Cementer, Pump Truck	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Haul Cementer, Cement Truck	HDDV	2	3	6	1	5.24E-03	2.45E-07	3.82E-08
	Haul Completion, Equip Truck	HDDV	2	3	6	1	5.24E-03	2.45E-07	3.82E-08
	Haul Service Tools	LDDT	2	2	4	1	1.81E-03	8.82E-09	6.83E-08
	Haul Perforators Logging Truck	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Anchor, Installation	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Anchor, Testing	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Tank	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Pump	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Chemical	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Sand	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Fracing, Other	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Welders	HDDV	2	6	12	1	1.05E-02	4.89E-07	7.63E-08
	Haul Water Truck	HDDV	2	150	300	1	2.62E-01	1.22E-05	1.91E-06
	Pickup Cementer, Engineer	LDDT	2	2	4	1	1.81E-03	8.82E-09	6.83E-08
	Pickup Casing Crew	HDDV	2	2	4	1	3.49E-03	1.63E-07	2.54E-08
	Pickup Completion Crew	HDDV	2	5	10	1	8.73E-03	4.08E-07	6.36E-08
	Pickup Completion, Pusher	LDDT	2	5	10	1	4.51E-03	2.20E-08	1.71E-07
	Pickup Perforators, Engineer	LDDT	2	2	4	1	1.81E-03	8.82E-09	6.83E-08
	Pickup Fracing, Engineer	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Pickup Co. Supervisor	LDDT	2	10	20	1	9.03E-03	4.41E-08	3.42E-07
	Pickup Miscellaneous Supplies	LDDT	2	3	6	1	2.71E-03	1.32E-08	1.03E-07
	Pickup Roustabout Crew	HDDV	2	4	8	1	6.98E-03	3.26E-07	5.09E-08
						Subtotal	**5.62E-01**	**2.15E-05**	**7.57E-06**
						Total	**6.67E-01**	**2.61E-05**	**8.56E-06**

Exhaust Emissions from Well Work Overs

Emission Factors Bore/Drill Rig Engines 300-600 Hp

Fuel Type	Emission Factors (gm/hp-hr)		
	CO_2	CH_4	N_2O[a]
Diesel	529.575	0.007	0.006

Source: EPA NONROADS 2008a. Year 2008.

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

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 (tons/year/well)		
							CO_2	CH_4	N_2O
Well Workover	Truck-Mounted Unit	600	10	3	30	1	1.05E+01	1.46E-04	1.14E-04

Exhaust emission factors for commuting vehicles

Vehicle		Emission Factors (g/mi)		
Type	Class	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	409.500	0.002	0.016
Heavy-Duty Diesel Truck	HDDV	791.800	0.037	0.006

ource: MOBILE 6.2.03

project years = conservative estimate of vehicle fleet turno\

[a] 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

Activity	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells Drilled	Max. Annual Emissions (tons/year/well)		
	Type	Class					CO_2	CH_4	N_2O
Well Workover	WO Rig	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Haul Truck	HDDV	2	1	2	1	1.75E-03	8.16E-08	1.27E-08
	Pickup Truck	LDDT	2	3	6	1	2.71E-03	1.32E-08	1.03E-07
						Total	**6.20E-03**	**1.76E-07**	**1.28E-07**

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).

Round trip distance = 2 based on data found in the SEIS

Exhaust Emissions from Site Visits and Inspections

Emission factors for Commuting Vehicles Exhaust

Vehicle Class	Emission Factors (g/mi)		
	CO_2	CH_4	N_2O[a]
Light-Duty Gasoline Truck	476.900	0.068	0.015

Source: MOBILE 6.2.03

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

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

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 (tons/yr/well)		
	Type	Class					CO_2	CH_4	N_2O
Inspection Visits for Wells	Pickup Truck	LDGT2	2	12	24	1	1.26E-02	1.80E-06	4.07E-07

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 year

[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
Number of Wells	1
Cumulative Length of Roads [b] (miles/operation)	1

[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	0.3333	3.3333
Winter	1	1	5	10	0.2000	2.0000
				Total	**0.5333**	**5.3333**

Emission Factors for Construction Equipment Exhaust

Equipment	Emission Factors (g/hp-hr)		
	CO_2	CH_4	N_2O[a]
Grader 100-175 Hp	535.7700	0.0053	0.0058

Source: EPA NONROADS 2008a

Use emission factors for 2008 for all project years - conservative estimate of vehicle turnover

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

Emission Estimations for Grader: RMP Year 20

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours[a]	Emissions (tons/well)		
				CO_2	CH_4	N_2O
Road Maintenance	Grader	135	3	2.55E-01	2.52E-06	2.75E-06

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

Emission Factors for Commuting Vehicles Exhaust

Vehicle Class	Emission Factors (g/mi)		
	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	409.500	0.002	0.016

Source: MOBILE 6.2.03

[a] 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 (tons/yr/well)		
	Type	Class				CO_2	CH_4	N_2O
Road Maintenance	Pickup Truck	LDDT	6	0.5	3	1.44E-03	7.05E-09	5.47E-08

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	0.2500
Number of Roads Reclaimed Annually Per Well	0.0109
Annual Miles of Roads reclaimed Per Well	0.0027
Number of wells reclaimed (per well)	0.0109

Reclaimation 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
0.0027	6	0.0005	0.0045
		Total	**0.0045**

Assume average miles/day = 6

Emission Factors for 75-100 hp Off-Road Engines

Year	Emission Factors (g/hp-hr)		
	CO_2	CH_4	N_2O[a]
2008	600.5069	0.0100	0.0155
2018	613.8884	0.0055	0.0155
2027	608.6409	0.0027	0.0155

Source: EPA NONROADS 2008a

[a] 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).

Exhaust Emissions Estimation for Grader Road Reclaim

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours	Emissions (tons/year/well)		
				CO_2	CH_4	N_2O
Road Reclamation	Grader	80	0.0027	1.47E-04	1.33E-09	3.72E-09

Exhaust Emission Factors for Commuting Reclaim Vehicles Road Traffic

Vehicle Class	Emission Factors (g/mi)		
	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	409.500	0.002	0.016

Source: MOBILE6.2.03

[a] 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).

Exhaust Emissions Estimation for Commuting Reclaim Vehicles: Road Traffic

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tons/year/well)		
	Type	Class				CO_2	CH_4	N_2O
Road Reclamation	Pickup Truck	LDDV	6	0.0005	0.0027	1.23E-06	6.01E-12	4.65E-11

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	0.0109	10	0.0109	0.1090

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

Exhaust Emissions Estimation for Grader: Well Reclamation

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours	Emissions (tons/year/well)		
				CO_2	CH_4	N_2O
Well Reclamation	Grader	100	0.0654	4.33E-03	7.21E-08	1.12E-07

Exhaust Emissions Estimation for Commuting Vehicles: Well Reclamation

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tons/year/well)		
	Type	Class				CO_2	CH_4	N_2O
Well Reclamation	Pickup Truck	LDDV	6	0.0109	0.0654	2.95E-05	1.44E-10	1.12E-09

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	0.011
Annual Miles of Roads reclaimed Per Well	0.003
Number of wells reclaimed (per well)	0.011

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
0.00	6	0.0005	0.0045
		Total	**0.005**

Assume average miles/day = 6

Emission Factors for 75-100 hp Off-Road Engines

Year	Emission Factors (g/hp-hr)		
	CO_2	CH_4	N_2O[a]
2008	600.5	0.010	0.016
2018	613.9	0.006	0.016
2027	608.6	0.003	0.016

Source: EPA NONROADS 2008a

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

Exhaust Emissions Estimation for Grader Road Reclaim

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours	Emissions (tons/year/well)		
				CO_2	CH_4	N_2O
Road Reclamation	Grader	80	0.003	0.0001	0.0000	0.0000

Exhaust Emission Factors for Commuting Reclaim Vehicles Road Traffic

Vehicle Class	Emission Factors (g/mi)		
	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	409.5	0.002	0.016

Source: MOBILE6.2.03

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

Exhaust Emissions Estimation for Commuting Reclaim Vehicles: Road Traffic

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tons/year/well)		
	Type	Class				CO_2	CH_4	N_2O
Road Reclamation	Pickup Truck	LDDV	6	0.0005	0.0027	0.0000	0.0000	0.0000

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	0.011	10	0.011	0.11

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

Exhaust Emissions Estimation for Grader: Well Reclamation

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours	Emissions (tons/year/well)		
				CO_2	CH_4	N_2O
Well Reclamation	Grader	100	0.07	0.0043	0.0000	0.0000

Exhaust Emissions Estimation for Commuting Vehicles: Well Reclamation

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tons/year/well)		
	Type	Class				CO_2	CH_4	N_2O
Well Reclamation	Pickup Truck	LDDV	6	0.01	0.07	0.0000	0.0000	0.0000

Emission Factors for Dehydrator Heaters

Unit	CO_2	CH_4	N_2O
lb/MMSCF	120000.0	2.3	2.2
lb/MMBTU	117.647	0.002	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 (tons/year/well)		
				CO_2	CH_4	N_2O
2,190	1	2.20	0.0011	1.51E-01	2.89E-06	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)
14.60	1.55E-02	2.27E-01	2.13E-05	3.11E-04

Gas analysis and dehydration process information provided by Montana BLM (Laakso, 2010). GRI GLYCalc estimated emissions.
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

Wellhead Fugitives

Fugitive Emissions from Equipment Leaks

TOC Emission Factor								
Well Equipment Component	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 (see Gas Analysis & Venting Sheet)

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	7.50E-02	5.12E-04	2.25E-04	6.67E-02
pump seals	0	0.0053	0	0.0287	0	0.0001	0.00E+00	0.00E+00	0.00E+00	0.00E+00
others	0	0.0194	0	0.0165	0	0.0309	0.00E+00	0.00E+00	0.00E+00	0.00E+00
connectors	24	0.0004	0	0.0005	0	0.0002	1.06E-02	7.22E-05	3.17E-05	9.42E-03
flanges	2	0.0009	0	0.0002	0	0.0000	1.72E-03	1.17E-05	5.15E-06	1.53E-03
open-ended lines	0	0.0044	0	0.0031	0	0.0006	0.00E+00	0.00E+00	0.00E+00	0.00E+00
						TOTAL emissions/well/hr =	8.73E-02	5.96E-04	2.61E-04	7.77E-02

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 (ton/yr)**	**CO_2 emissions (lb/yr)**	**CO_2 emissions (ton/yr)**	**CH_4 emissions (lb/yr)**	**CH_4 emissions (ton/yr)**
Year 20	1	8760	5.22E+00	2.61E-03	2.29E+00	1.14E-03	6.80E+02	3.40E-01

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	2.267
Ethane	1.624	30.070	0.488	2.891	1227.616	0.074
Nitrogen	4.297	28.020	1.204	7.128	3026.751	0.182
Water	0.000	18.015	0.000	0.000	0.000	0.000
Carbon Dioxide	0.115	43.990	0.051	0.300	127.173	0.008
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	99.752	---	16.775	99.317		2.530
Propane	0.211	44.100	0.093	0.551	233.918	0.014
Iso-butane	0.019	58.120	0.011	0.065	27.760	0.002
n-butane	0.015	58.120	0.009	0.052	21.916	0.001
i-pentane	0.002	72.150	0.001	0.009	3.628	0.000
n-pentane	0.001	72.150	0.001	0.004	1.814	0.000
Hexanes	0.000	100.210	0.000	0.000	0.000	0.000
Heptanes	0.000	100.200	0.000	0.002	0.781	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	0.248	---	0.115	0.683		0.017
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]	*0.000*	*100.210*	*0.000*	*0.000*	*0.000*	*0.000*
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	0.000	---	0.000	0.000		0.000
Totals	**100.000**	**---**	**16.890**	**100.000**		**2.548**

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

Compressor Station Emissions

Emission Factors for Natural Gas-Fired Compressors

Compressor		Horse-Power Rating	Units	Emission Factors		
				CO_2 [a]	CH_4 [a]	N_2O [a]
Field Compression Station	Rich Burn	300	gm/bhp-hr	1.35E+02	2.55E-03	2.55E-04
			lb/MMBTU	1.17E+02	2.20E-03	2.20E-04
Sales Compression Station	Rich Burn	1,680	gm/bhp-hr	1.35E+02	2.55E-03	2.55E-04
			lb/MMBTU	1.17E+02	2.20E-03	2.20E-04

Note: Compressors assumed to be equipped with nonselective catalytic reduction (NSCR) catalyst.

[a] 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 (tons/year/well)		
					CO_2	CH_4	N_2O
Field Compression Station	11	1	11	8,760	1.44E+01	2.72E-04	2.72E-05
Sales Compression Station	10	1	10	8,760	1.35E+01	2.54E-04	2.54E-05
				Total	**2.79E+01**	**5.26E-04**	**5.26E-05**

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

TOC Emission Factor								
Well Equipment Component	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% =	0.68
CO2 Wt% =	0.30
CH4 Wt% =	89.00
N2O Wt% =	0.00

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	2.56E-03	1.75E-05	7.68E-06	2.28E-03
pump seals	0.000	0.0053	0	0.0287	0	0.0001	0.00E+00	0.00E+00	0.00E+00	0.00E+00
others	0.000	0.0194	0	0.0165	0	0.0309	0.00E+00	0.00E+00	0.00E+00	0.00E+00
connectors	0.369	0.0004	0	0.0005	0	0.0002	1.63E-04	1.11E-06	4.87E-07	1.45E-04
flanges	0.886	0.0009	0	0.0002	0	0.0000	7.62E-04	5.20E-06	2.28E-06	6.78E-04
open-ended lines	0.000	0.0044	0	0.0031	0	0.0006	0.00E+00	0.00E+00	0.00E+00	0.00E+00
					TOTAL emissions/well/hr =		3.49E-03	2.38E-05	1.04E-05	3.10E-03

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 (ton/yr)**	**CO_2 emissions (lb/yr)**	**CO_2 emissions (ton/yr)**	**CH_4 emissions (lb/yr)**	**CH_4 emissions (ton/yr)**
Year 20	1	8760	2.09E-01	1.04E-04	9.15E-02	4.58E-05	2.72E+01	1.36E-02

Compressor Station Inspection Traffic Exhaust Emissions

Emission factors for Commuting Vehicles Exhaust

Vehicle		Emission Factors (g/mi)		
Type	Class	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	409.5	0.002	0.016

Source: MOBILE6.2.03

[a] 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).

Exhaust Emissions Estimation for Road Traffic

Activity	Compressor Station	Vehicle		# of Compressor Stations / Well	# of Inspection Visits/ Station	# of Inspection Visits/Well/Year	Total Miles/ Inspection	Emissions (tons/year/well)		
		Type	Class					CO_2	CH_4	N_2O
Inspection Visits for Compressor Stations	CPF Compressor Station	Pickup Truck	LDDT	0.04	12	0.4	20	0.00400	0.00000	0.00000
	Primary Compressor Station	Pickup Truck	LDDT	0.01	52	0.3	20	0.00289	0.00000	0.00000
							Total	**0.007**	**0.000**	**0.000**

Compressor Station Inspection Traffic Exhaust Emissions

Emission factors for Commuting Vehicles Exhaust

Vehicle		Emission Factors (g/mi)		
Type	Class	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	409.500	0.002	0.016

Source: MOBILE6.2.03

[a] 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).

Exhaust Emissions Estimation for Road Traffic

Activity	Compressor Station	Vehicle		# of Compressor Stations / Well	# of Inspection Visits/ Station	# of Inspection Visits/Well/Year	Total Miles/ Inspection	Emissions (tons/year/well)		
		Type	Class					CO_2	CH_4	N_2O
Inspection Visits for Compressor Stations	CPF Compressor Station	Pickup Truck	LDDT	0.0369	12	0.4429	20	4.00E-03	1.95E-08	1.51E-07
	Primary Compressor Station	Pickup Truck	LDDT	0.0062	52	0.3199	20	2.89E-03	1.41E-08	1.09E-07
							Total	**6.89E-03**	**3.36E-08**	**2.61E-07**

Input parameters for calculating CBNG wells emissions:

Peak Year Federal Producing Wells Drilled	386	Peak Year Non-Federal Producing Wells Drilled	400
Federal Producing Wells - Year 20 (RMP Totals)	6,954	Non-Federal Producing Wells - Year 2027 (RMP Totals)	7,118
Average Gas Production Per Well (MCFD)	45	Average Gas Production Per Well (MCFD)	45

Federal CBNG Wells Summaries

Total Annual Emissions from Federal CBNG Wells - RMP Year 20

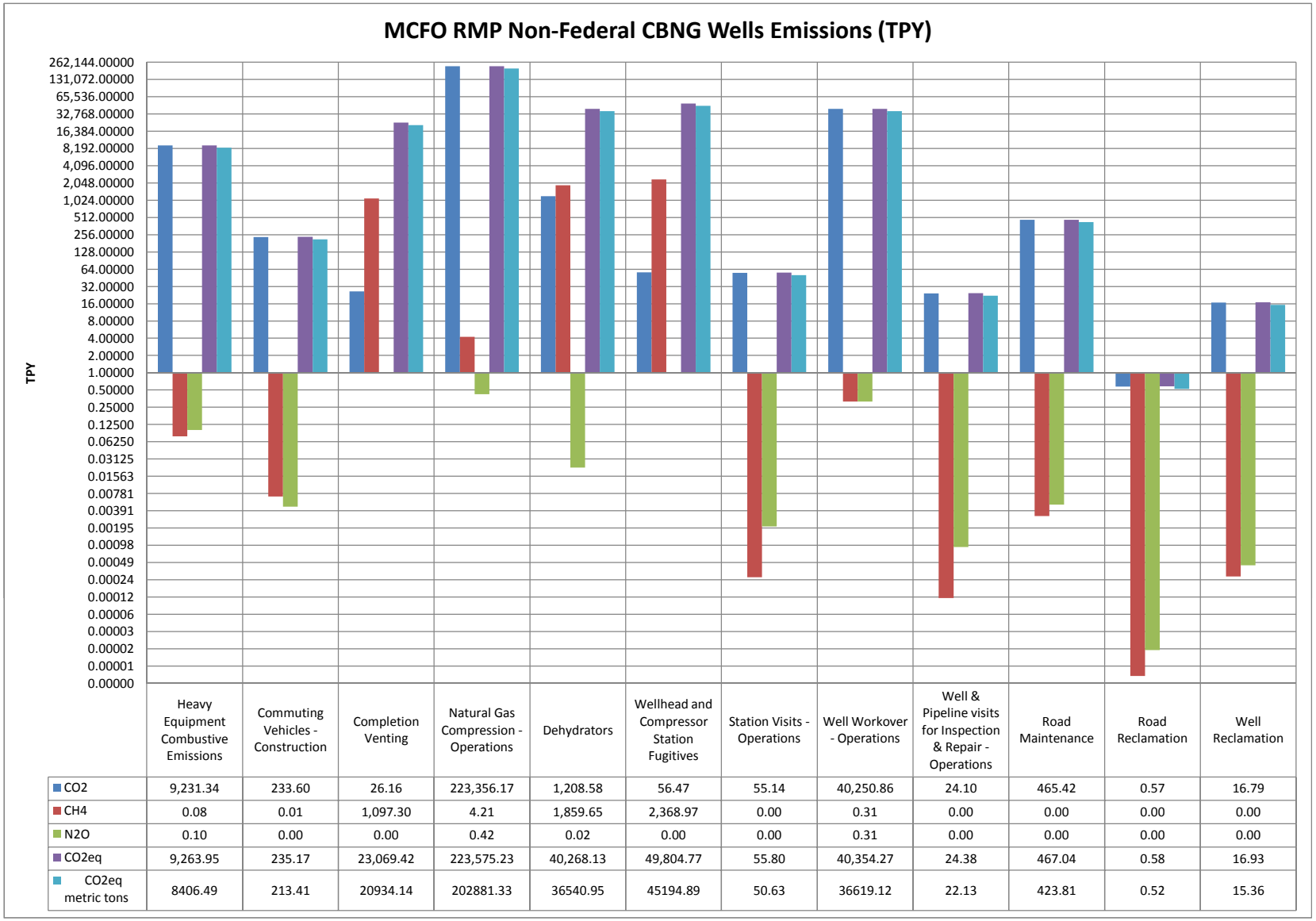
Activity	Annual Emissions (Tons)				
	CO_2	CH_4	N_2O	CO_{2eq}	CO_{2eq} metric tons
Well Pad & Station Construction - Fugitive Dust	---	---	---	---	---
Wind Erosion	---	---	---	---	---
Heavy Equipment Combustive Emissions	8,908.24	0.08	0.10	8,939.71	8112.26
Commuting Vehicles - Construction	225.42	0.01	0.00	226.94	205.94
Completion Venting	25.24	1,058.89	0.00	22,261.99	20201.45
Sub-total: Construction[c]	**9158.91**	**1058.97**	**0.10**	**31428.65**	**28519.64**
Natural Gas Compression - Operations	218,210.00	4.12	0.41	218,424.02	198206.91
Dehydrators	1,180.73	1,816.80	0.02	39,340.34	35699.04
Wellhead and Compressor Station Fugitives	55.17	2,314.39	0.00	48,657.26	44153.59
Station Visits - Operations	53.87	0.00	0.00	54.51	49.47
Well Workover - Operations	39,323.47	0.31	0.31	39,424.50	35775.41
Well & Pipeline visits for Inspection & Repair - Operations	23.54	0.00	0.00	23.82	21.62
Sub-total: Operations	**258846.79**	**4135.61**	**0.74**	**345924.45**	**313906.04**
Road Maintenance	454.70	0.00	0.00	456.28	414.04
Sub-total: Maintenance	**454.70**	**0.00**	**0.00**	**456.28**	**414.04**
Road Reclamation	0.56	0.00	0.00	0.56	0.51
Well Reclamation	16.40	0.00	0.00	16.54	15.01
Sub-total: Reclamation	**16.9609**	**0.0003**	**0.0004**	**17.1028**	**15.5197**
Total Emissions	**268,477.36**	**5,194.59**	**0.85**	**377,826.48**	**342,855.24**

	Heavy Equipment Combustive Emissions	Commuting Vehicles - Construction	Completion Venting	Natural Gas Compression - Operations	Dehydrators	Wellhead and Compressor Station Fugitives	Station Visits - Operations	Well Workover - Operations	Well & Pipeline visits for Inspection & Repair - Operations	Road Maintenance	Road Reclamation	Well Reclamation
CO2	8,908.24	225.42	25.24	218,210.00	1,180.73	55.17	53.87	39,323.47	23.54	454.70	0.56	16.40
CH4	0.08	0.01	1,058.89	4.12	1,816.80	2,314.39	0.00	0.31	0.00	0.00	0.00	0.00
N2O	0.10	0.00	0.00	0.41	0.02	0.00	0.00	0.31	0.00	0.00	0.00	0.00
CO2eq	8,939.71	226.94	22,261.99	218,424.02	39,340.34	48,657.26	54.51	39,424.50	23.82	456.28	0.56	16.54
CO2eq metric tons	8112.26	205.94	20201.45	198206.91	35699.04	44153.59	49.47	35775.41	21.62	414.04	0.51	15.01

Non-Federal CBNG Wells Summaries

Total Annual Emissions from Non-Federal CBNG Wells - RMP Year 20

Activity	Annual Emissions (Tons)				
	CO_2	CH_4	N_2O	CO_{2eq}	CO_{2eq} metric tons
Well Pad & Station Construction - Fugitive Dust	---	---	---	---	---
Wind Erosion	---	---	---	---	---
Heavy Equipment Combustive Emissions	9,231.34	0.08	0.10	9,263.95	8406.49
Commuting Vehicles - Construction	233.60	0.01	0.00	235.17	213.41
Completion Venting	26.16	1,097.30	0.00	23,069.42	20934.14
Sub-total: Construction[c]	**9491.09**	**1097.38**	**0.10**	**32568.54**	**29554.03**
Natural Gas Compression - Operations	223,356.17	4.21	0.42	223,575.23	202881.33
Dehydrators	1,208.58	1,859.65	0.02	40,268.13	36540.95
Wellhead and Compressor Station Fugitives	56.47	2,368.97	0.00	49,804.77	45194.89
Station Visits - Operations	55.14	0.00	0.00	55.80	50.63
Well Workover - Operations	40,250.86	0.31	0.31	40,354.27	36619.12
Well & Pipeline visits for Inspection & Repair - Operations	24.10	0.00	0.00	24.38	22.13
Sub-total: Operations	**264951.32**	**4233.14**	**0.76**	**354082.58**	**321309.06**
Road Maintenance	465.42	0.00	0.00	467.04	423.81
Sub-total: Maintenance	**465.42**	**0.00**	**0.00**	**467.04**	**423.81**
Road Reclamation	0.57	0.00	0.00	0.58	0.52
Well Reclamation	16.79	0.00	0.00	16.93	15.36
Sub-total: Reclamation	**17.3609**	**0.0003**	**0.0004**	**17.5061**	**15.8858**
Total Emissions	**274,925.20**	**5,330.53**	**0.87**	**387,135.67**	**351,302.78**



	Heavy Equipment Combustive Emissions	Commuting Vehicles - Construction	Completion Venting	Natural Gas Compression - Operations	Dehydrators	Wellhead and Compressor Station Fugitives	Station Visits - Operations	Well Workover - Operations	Well & Pipeline visits for Inspection & Repair - Operations	Road Maintenance	Road Reclamation	Well Reclamation
CO2	9,231.34	233.60	26.16	223,356.17	1,208.58	56.47	55.14	40,250.86	24.10	465.42	0.57	16.79
CH4	0.08	0.01	1,097.30	4.21	1,859.65	2,368.97	0.00	0.31	0.00	0.00	0.00	0.00
N2O	0.10	0.00	0.00	0.42	0.02	0.00	0.00	0.31	0.00	0.00	0.00	0.00
CO2eq	9,263.95	235.17	23,069.42	223,575.23	40,268.13	49,804.77	55.80	40,354.27	24.38	467.04	0.58	16.93
CO2eq metric tons	8406.49	213.41	20934.14	202881.33	36540.95	45194.89	50.63	36619.12	22.13	423.81	0.52	15.36

Exhaust Emissions from Heavy Construction Equipment

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

Project Year/Hp Category	Emission Factors (g/hp-hr)		
	CO_2	CH_4	N_2O[a]
Year 2018			
50 to 75	589.096	0.0064	0.0058
75 to 100	589.103	0.0064	0.0058
100 to 175	530.097	0.0047	0.0058
175 to 300	530.181	0.0043	0.0058
300 to 600	530.255	0.0040	0.0058
600 to 750	530.283	0.0038	0.0058
>750	529.917	0.0056	0.0058

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

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

Exhaust Emission Estimations for Construction Equipment - Based on Peak Wells Drilled each Alternative (using 2008 emission factors)

Construction Activity	Equipment Type	Capacity (hp)	# of Units	Av. Load Factor (%)	# of Oper. Hours/Day	# of Oper. Days/ Activity	# of Oper. Hours/Activity	# of Activities / Well	Emissions (tons/year/well)		
									CO_2	CH_4	N_2O
Drilling Roads	Blade	100	1	80	10	0.20	2.00	1.0000	9.35E-02	8.37E-07	1.02E-06
	Backhoe	80	1	75	10	0.10	1.00	1.0000	3.90E-02	4.20E-07	3.82E-07
Drilling Well Pad	Backhoe	80	1	75	10	0.50	5.00	1.0000	1.95E-01	2.10E-06	1.91E-06
Water Disposal well pad	Backhoe	80	1	75	10	2.00	20.00	0.0050	3.90E-03	4.20E-08	3.82E-08
New Pipeline Intermediate	Blade	100	1	80	10	5.00	50.00	0.1108	2.88E-01	3.10E-06	2.82E-06
	Trencher	175	1	80	10	5.00	50.00	0.1108	4.53E-01	4.06E-06	4.93E-06
	Backhoe	80	1	75	10	10.00	100.00	0.1108	4.32E-01	4.65E-06	4.23E-06
New Sales Pipeline	Blade	100	1	80	10	43.00	430.00	0.0002	3.68E-03	3.96E-08	3.60E-08
	Trencher	175	1	80	10	43.00	430.00	0.0002	5.79E-03	5.18E-08	6.30E-08
	Backhoe	80	1	75	10	65.00	650.00	0.0002	4.17E-03	4.49E-08	4.08E-08
Booster Compression Station	Dozer	350	1	80	10	2.00	20.00	0.1108	3.63E-01	2.70E-06	3.95E-06
	Backhoe	80	2	80	10	3.00	30.00	0.1108	2.76E-01	2.98E-06	2.71E-06
Sales Compression Station	Dozer	350	1	80	10	2.00	20.00	0.0110	3.61E-02	2.69E-07	3.93E-07
	Backhoe	80	2	80	10	3.00	30.00	0.0110	2.75E-02	2.96E-07	2.69E-07
								Subtotal	**2.22E+00**	**2.16E-05**	**2.28E-05**

Activity rates based on values shown in SEIS. Water disposal well pad development rates provided by Montana BLM (Laakso, 2010).

Exhaust Emission Factors for Diesel Powered Bore/Drill Rig Engines

Project Year/Hp Category	Emission Factors (g/hp-hr)		
	CO_2	CH_4	N_2O[a]
Year 2018			
50 to 75	589.0959	0.0064	0.0058
75 to 100	589.1032	0.0064	0.0058
100 to 175	530.0969	0.0047	0.0058
175 to 300	530.1812	0.0043	0.0058
300 to 600	530.2546	0.0040	0.0058
600 to 750	530.2834	0.0038	0.0058
>750	529.9171	0.0056	0.0058

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

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

Combustive Emissions Estimation for Industrial Engines - Based on Peak Wells Drilled each Alternative

Construction Activity	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Oper. Hours/Day	# of Oper. Days/ Well	# of Oper. Hours/Well	# of Wells	Emissions (tons/year/well)		
									CO_2	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Main Deck	400	1	60	18	3.00	54.00	1.0000	7.58E+00	5.65E-05	8.24E-05
	Auxillary Pump	200	1	90	18	2.00	36.00	1.0000	3.79E+00	3.09E-05	4.12E-05
Well Completion & Testing	Main Deck	400	1	60	18	1.00	18.00	1.0000	2.53E+00	1.88E-05	2.75E-05
	Auxillary Pump	125	1	90	18	1.00	18.00	1.0000	1.18E+00	1.06E-05	1.29E-05
Water Disposal well drilling	Generator	1476	1	40	24	30.00	720.00	0.0050	1.24E+00	1.32E-05	1.35E-05
	Generator	1476	1	40	24	30.00	720.00	0.0050	1.24E+00	1.32E-05	1.35E-05
								Subtotal	**1.76E+01**	**1.43E-04**	**1.91E-04**
								Total	**1.98E+01**	**1.65E-04**	**2.14E-04**

Equipment type, Hp ratings, and operational hours based on information shown in SEIS. No flaring per Montana BLM (Laakso, 2010). Water disposal well pad development rates provided by Montana BLM (Laakso, 2010).

Temporary Emission Estimations for Field Generators: Based on Peak Wells Drilled each Alternative

Construction Activity	Equipment Type	Capacity (hp)	# of Wells Served[a]	Avg. Load Factor (%)	# of Oper. Hours/Day	# of Oper. Days/Well	# of Oper. Hours/Well	# of Wells	Emissions (tons/year/well)		
									CO_2	CH_4	N_2O
Field Generators	Field Generators for Pumps & Lighting	21	1	75	24	15.0000	360.0000	1.0000	3.31E+00	2.96E-05	3.60E-05
								Total	**3.31E+00**	**2.96E-05**	**3.60E-05**

Values shown in SEIS per well.

Exhaust Emissions from Construction and Drilling Support Vehicles

Emission factors for Commuting Vehicles Exhaust

Vehicle		Emission Factors (g/mi)		
Type	**Class**	**CO_2**	**CH_4**	**N_2O[a]**
Light-Duty Diesel Truck	LDDT	409.500	0.002	0.016
Heavy-Duty Diesel Truck	HDDV	791.800	0.037	0.006

Source: MOBILE6.2.03

[a] 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).

Combustive Emissions Estimation Road Traffic

Construction Activity	Vehicle		Round Trip Distance (miles)	# of Round Trips/Activity	Miles Traveled/ Activity	Total # of Activities / Well	Emissions (tons/year/well)		
	Type	Class					CO_2	CH_4	N_2O
Drilling Roads	Semi Trucks	HDDV	6	3	18	1.0000	1.57E-02	7.34E-07	1.14E-07
Drilling Well Pad	Haul Trucks	HDDV	6	2	12	1.0000	1.05E-02	4.89E-07	7.63E-08
	Pickup Trucks	LDDT	6	2	12	1.0000	5.42E-03	2.65E-08	2.05E-07
Water Disposal Well Pad	Haul Trucks	HDDV	100	5	500	0.0050	2.18E-03	1.02E-07	1.59E-08
	Pickup Trucks	LDDT	25	5	125	0.0050	2.82E-04	1.38E-09	1.07E-08
New Pipeline Intermediate	Haul Trucks	HDDV	6	40	240	0.1108	2.32E-02	1.08E-06	1.69E-07
	Pickup Trucks	LDDT	6	160	960	0.1108	4.80E-02	2.34E-07	1.82E-06
New Sales Pipeline	Haul Trucks	HDDV	35	94	3290	0.0002	4.73E-04	2.21E-08	3.44E-09
	Pickup Trucks	LDDT	50	94	4700	0.0002	3.49E-04	1.71E-09	1.32E-08
Electric Line	Haul Trucks	HDDV	6	1	6	1.0000	5.24E-03	2.45E-07	3.82E-08
	Pickup Trucks	LDDT	6	2	12	1.0000	5.42E-03	2.65E-08	2.05E-07
Field Compression Station	Semi Trucks	HDDV	10	15	150	0.1108	1.45E-02	6.78E-07	1.06E-07
	Haul Trucks	HDDV	10	48	480	0.1108	4.64E-02	2.17E-06	3.38E-07
	Pickup Trucks	LDDT	10	192	1920	0.1108	9.60E-02	4.69E-07	3.63E-06
Sales Compression Station	Semi Trucks	HDDV	10	19	190	0.0110	1.83E-03	8.55E-08	1.33E-08
	Haul Trucks	HDDV	10	48	480	0.0110	4.62E-03	2.16E-07	3.37E-08
	Pickup Trucks	LDDT	10	192	1920	0.0110	9.56E-03	4.67E-08	3.62E-07
Rig-up, Drilling, and Rig-down	Semi Rig Transport	HDDV	6	1	6	1.0000	5.24E-03	2.45E-07	3.82E-08
	Fuel Haul Truck	HDDV	6	2	12	1.0000	1.05E-02	4.89E-07	7.63E-08
	Mud Haul Truck, Water Hauling	HDDV	6	7	42	1.0000	3.67E-02	1.71E-06	2.67E-07
	Rig Crew	LDDT	6	3	18	1.0000	8.13E-03	3.97E-08	3.08E-07
	Rig Mechanics	HDDV	6	1	6	1.0000	5.24E-03	2.45E-07	3.82E-08
	Co. Supervisor	LDDT	6	8	48	1.0000	2.17E-02	1.06E-07	8.20E-07
	Tool Pusher	LDDT	6	6	36	1.0000	1.63E-02	7.94E-08	6.15E-07
	Mud Logger	LDDT	6	1	6	1.0000	2.71E-03	1.32E-08	1.03E-07
	Mud Engineer	LDDT	6	1	6	1.0000	2.71E-03	1.32E-08	1.03E-07
	Logger, Engr Truck	HDDV	6	1	6	1.0000	5.24E-03	2.45E-07	3.82E-08
	Drill Bit Delivery	LDDT	6	1	6	1.0000	2.71E-03	1.32E-08	1.03E-07
						Subtotal	**4.07E-01**	**9.83E-06**	**9.66E-06**

Activity rates based on values shown in SEIS. Water disposal well pad development rates provided by Montana BLM (Laakso, 2010).

Combustive Emissions Estimation Road Traffic

Construction Activity	Vehicle		Round Trip Distance (miles)	# of Round Trips/Activity	Miles Traveled/ Activity	Total # of Activities / Well	Emissions (tons/year)		
	Type	Class					CO_2	CH_4	N_2O
Well Completion & Testing	Semi Casing Haulers	HDDV	6	1	6	1.0000	5.24E-03	2.45E-07	3.82E-08
	Semi Completion, Unit Rig	HDDV	6	1	6	1.0000	5.24E-03	2.45E-07	3.82E-08
	Semi Fracing Blender	HDDV	6	1	6	1.0000	5.24E-03	2.45E-07	3.82E-08
	Semi Pumping Tank Battery	HDDV	6	1	6	1.0000	5.24E-03	2.45E-07	3.82E-08
	Tubing Truck	HDDV	6	1	6	1.0000	5.24E-03	2.45E-07	3.82E-08
	Haul Cementer, Pump Truck	HDDV	6	1	6	1.0000	5.24E-03	2.45E-07	3.82E-08
	Haul Cementer, Cement Truck	HDDV	6	1	6	1.0000	5.24E-03	2.45E-07	3.82E-08
	Haul Completion, Equip Truck	HDDV	6	1	6	1.0000	5.24E-03	2.45E-07	3.82E-08
	Haul Service Tools	LDDT	6	1	6	1.0000	2.71E-03	1.32E-08	1.03E-07
	Haul Perforators Logging Truck	HDDV	6	1	6	1.0000	5.24E-03	2.45E-07	3.82E-08
	Haul Anchor Installation	HDDV	6	1	6	1.0000	5.24E-03	2.45E-07	3.82E-08
	Haul Anchor Testing	HDDV	6	1	6	1.0000	5.24E-03	2.45E-07	3.82E-08
	Haul Fracing Tank	HDDV	6	1	6	1.0000	5.24E-03	2.45E-07	3.82E-08
	Haul Fracing Pump	HDDV	6	1	6	1.0000	5.24E-03	2.45E-07	3.82E-08
	Haul Fracing Chemical	HDDV	6	1	6	1.0000	5.24E-03	2.45E-07	3.82E-08
	Haul Fracing Sand	HDDV	6	1	6	1.0000	5.24E-03	2.45E-07	3.82E-08
	Haul Fracing Other	HDDV	6	1	6	1.0000	5.24E-03	2.45E-07	3.82E-08
	Haul Welders	HDDV	6	1	6	1.0000	5.24E-03	2.45E-07	3.82E-08
	Haul Water Truck	HDDV	6	9	54	1.0000	4.71E-02	2.20E-06	3.43E-07
	Pickup Cementer, Engineer	LDDT	6	1	6	1.0000	2.71E-03	1.32E-08	1.03E-07
	Pickup Completion Crew	HDDV	6	1	6	1.0000	5.24E-03	2.45E-07	3.82E-08
	Pickup Completion Pusher	LDDT	6	1	6	1.0000	2.71E-03	1.32E-08	1.03E-07
	Pickup Perforators Engineer	LDDT	6	1	6	1.0000	2.71E-03	1.32E-08	1.03E-07
	Pickup Fracing Engineer	HDDV	6	1	6	1.0000	5.24E-03	2.45E-07	3.82E-08
	Pickup Co. Supervisor	LDDT	6	2	12	1.0000	5.42E-03	2.65E-08	2.05E-07
	Pickup Misc. Supplies	LDDT	6	1	6	1.0000	2.71E-03	1.32E-08	1.03E-07
	Pickup Roustabout Crew	HDDV	6	2	12	1.0000	1.05E-02	4.89E-07	7.63E-08
Water Disposal Well Drilling	Drill Rig Transport truck	HDDV	10	10	100	0.0050	4.36E-04	2.04E-08	3.18E-09
	Mud Haul Truck, Water Hauling	HDDV	10	5	50	0.0050	2.18E-04	1.02E-08	1.59E-09
	Rig Crew	LDDT	10	10	100	0.0050	2.26E-04	1.10E-09	8.54E-09
	Co. Supervisor	LDDT	10	5	50	0.0050	1.13E-04	5.51E-10	4.27E-09
	Tool Pusher	LDDT	10	5	50	0.0050	1.13E-04	5.51E-10	4.27E-09
	Tubing Truck	HDDV	10	1	10	0.0050	4.36E-05	2.04E-09	3.18E-10
	Haul Cementer, Pump Truck	HDDV	10	1	10	0.0050	4.36E-05	2.04E-09	3.18E-10
	Haul Cementer, Cement Truck	HDDV	10	1	10	0.0050	4.36E-05	2.04E-09	3.18E-10
						Subtotal	**1.77E-01**	**7.47E-06**	**1.89E-06**
						Total	**5.84E-01**	**1.73E-05**	**1.15E-05**

Activity rates based on values shown in SEIS. Water disposal well pad development rates provided by Montana BLM (Laakso, 2010).

Compressor Stations Emissions

Emission Factors for Natural Gas-Fired Compressors

Compressor		Horse-Power Rating	Units	Emission Factors		
				CO_2 [a]	CH_4 [a]	N_2O [a]
Field Compression Station	Rich Burn	300	gm/bhp-hr	1.35E+02	2.55E-03	2.55E-04
			lb/MMBTU	1.17E+02	2.20E-03	2.20E-04
Sales Compression Station	Rich Burn	1,680	gm/bhp-hr	1.35E+02	2.55E-03	2.55E-04
			lb/MMBTU	1.17E+02	2.20E-03	2.20E-04

Note: Compressors assumed to be equipped with nonselective catalytic reduction (NSCR) catalyst.

[a] 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 (tons/year/well)		
					CO_2	CH_4	N_2O
Field Compression Station	12.4567	1	12.4567	8,760	1.62E+01	3.06E-04	3.06E-05
Sales Compression Station	11.6263	1	11.6263	8,760	1.51E+01	2.86E-04	2.86E-05
				Total	**3.14E+01**	**5.92E-04**	**5.92E-05**

Compression rate of 36 - 300 hp field compressors, and 6 - 1680 hp sales compressors per 867 CBNG wells based on BLM survey (Laakso, 2010)

Compressor Station Fugitives

Fugitive Emissions from Equipment Leaks

TOC Emission Factor								
Well Equipment Component	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% =	0.00
CO2 Wt% =	2.28
CH4 Wt% =	95.72
N2O Wt% =	0.00

Emissions from Equipment Leaks at Compressor Station per Well

component	Ave. # in Gas Service / Per 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	0.291	0.0099	0	0.0055	0	0.0002	2.88E-03	5.46E-08	6.58E-05	2.76E-03
pump seals	0.000	0.0053	0	0.0287	0	0.0001	0.00E+00	0.00E+00	0.00E+00	0.00E+00
others	0.000	0.0194	0	0.0165	0	0.0309	0.00E+00	0.00E+00	0.00E+00	0.00E+00
connectors	0.415	0.0004	0	0.0005	0	0.0002	1.83E-04	3.47E-09	4.18E-06	1.75E-04
flanges	0.997	0.0009	0	0.0002	0	0.0000	8.57E-04	1.62E-08	1.95E-05	8.20E-04
open-ended lines	0.000	0.0044	0	0.0031	0	0.0006	0.00E+00	0.00E+00	0.00E+00	0.00E+00
					TOTAL emissions/well/hr =		3.92E-03	7.43E-08	8.95E-05	3.76E-03

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 (ton/yr)**	**CO_2 emissions (lb/yr)**	**CO_2 emissions (ton/yr)**	**CH_4 emissions (lb/yr)**	**CH_4 emissions (ton/yr)**
Year 20	1	8760	6.51E-04	3.25E-07	7.84E-01	3.92E-04	3.29E+01	1.64E-02

Dehydrator Emissions

Emission Factors for Dehydrator Heaters

Unit	CO_2	CH_4	N_2O
lb/MMSCF	120000.0	2.3	2.2
lb/MMBTU	117.647	0.002	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 (tons/year/well)		
				CO_2	CH_4	N_2O
2,190	1	2.20	0.001	1.70E-01	3.25E-06	3.11E-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)
16.43	1.59E-02	2.61E-01	0.00E+00	0.00E+00

Gas analysis and dehydration process information provided by Montana BLM (Laakso, 2010). GRI GLYCalc estimated emissions.
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 South Baker Compressor Station assumptions were used with CBNG 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

Compressor Stations Inspection Traffic Exhaust Emissions

Emission factors for Commuting Vehicles Exhaust

Vehicle		Emission Factors (g/mi)		
Type	**Class**	**CO_2**	**CH_4**	**N_2O[a]**
Light-Duty Diesel Truck	LDDT	409.500	0.002	0.016

Source: MOBILE6.2.03

[a] 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).

Exhaust Emissions Estimation for Compressor Station Inspection Road Traffic

Activity	Compressor Station	Vehicle		# of Compressor Stations / Well	# of Inspection Visits/ Station	# of Inspection Visits/Well/Year	Total Miles/ Inspection	Emissions (tons/year/well)		
		Type	Class					CO_2	CH_4	N_2O
Inspection Visits for Compressor Stations	CPF Compressor Station	Pickup Truck	LDDT	0.0415	12	0.4983	20	4.50E-03	2.20E-08	1.70E-07
	Primary Compressor Station	Pickup Truck	LDDT	0.0069	52	0.3599	20	3.25E-03	1.59E-08	1.23E-07
							Total	**7.75E-03**	**3.78E-08**	**2.93E-07**

CBNG Well Work-Over Emissions

Emission Factors for Off-Road Engines of 300 to 600 hp

Year	Emission Factors (g/hp-hr)		
	CO_2	CH_4	N_2O[a]
2008	529.575	0.007	0.006
2018	530.255	0.004	0.006
2027	530.521	0.003	0.006

Source: EPA NONROADS 2008a

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

On-Site Exhaust Emission Estimations for Well Workover

Activity	Equipment	Capacity (hp)	Operating Hours/Day	Operational Wells	Emissions (tons/year)		
					CO_2	CH_4	N_2O
Well Workover[a]	Truck-Mounted Unit[b]	400	24	1	5.61E+00	4.19E-05	6.11E-05

Activity rates based on values shown in SEIS

Emission Factors for Road Traffic

Vehicle Class	Emission Factors (g/mi)		
	CO_2	CH_4	N_2O[a]
Heavy-Duty Diesel Truck	791.8	0.04	0.006

Source: MOBILE6.2.03

On-Road Exhaust Emissions Estimation for Road Traffic

Activity	Vehicle		Round Trip Distance (miles)	Round Trips/Well	Miles Traveled/Well	Operational Wells	Emissions (tons/year)		
	Type	Class					CO_2	CH_4	N_2O
Well Workover[a]	Bobtail Truck	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07

Activity rates based on values shown in SEIS

Traffic Exhaust Emissions for Well and Pipe Inspections

Exhaust Emission Factors for Road Traffic

Vehicle Class	Emission Factors (g/mi)		
	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	409.500	0.002	0.016

Source: MOBILE6.2.03

[a] 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).

Exhaust Emission Estimations for Road Traffic: Well & Pipeline

Activity	Vehicle		Round Trip Distance (miles)	# of Visits/ Well/Year	Total # of Operating Wells	Miles Traveled/Year/ Well	Emissions (tons/year/well)		
	Type	Class					CO_2	CH_4	N_2O
Visits for Inspection and Repair	200-hp Pickup	LDDT	0.6250	12	1	7.5000	3.39E-03	1.65E-08	1.28E-07

Activity rates based on values shown in SEIS

Exhaust Emissions for Road Maintenance

Estimation of Total and Cumulative Length of Roads

Length of Roads Built per Well	0.2500
Cumulative Length of Roads Maintained (miles)	0.2500

Based on values shown in SEIS

Estimation of Total Operation Days and Hours

Season	# of Operations/ Year	Cumulative Length of Roads (miles/year)	Miles of Road Worked on/Day	# of Operating Hours/Day	Total # of Operating Days	Total # of Operating Hours
Summer	2	0.2500	6	10	0.0833	0.8333
Winter	1	0.2500	5	10	0.0500	0.5000
				Total	**0.1**	**1**

Based on values shown in SEIS

Emission Factors for 100-175 hp Off-Road Engine

Year	Emission Factors (g/hp-hr)		
	CO_2	CH_4	N_2O[a]
Year 2008	540.3190	0.0067	0.0058
Year 2018	546.2166	0.0037	0.0058
Year 2028	546.4658	0.0025	0.0058

Source: EPA NONROADS 2008a

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

Exhaust Emissions Estimation for Grader

Activity	Vehicle Type	Capacity (hp)[a]	Total # of Operating Hours[a]	Emissions (tons/year/well)		
				CO_2	CH_4	N_2O
Road Maintenance	Grader	135	0.8000	6.50E-02	4.44E-07	6.87E-07

[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 Emission Factors for Commuting Maintenance Vehicles Road Traffic

Vehicle Class	Emission Factors (g/mi)		
	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	409.5	0.002	0.016

Source: MOBILE6.2.03

[a] 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).

Exhaust Emissions Estimation for Commuting Maintenance Vehicles Road Traffic

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tons/year/well)		
	Type	Class				CO_2	CH_4	N_2O
Road Maintenance	Pickup Truck	LDDV	6	0.1333	0.8000	3.61E-04	1.76E-09	1.37E-08

Exhaust 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 abandonmen
Source: values from SEIS

Estimation of Total Miles of Roads

Length of Roads Built per Well	0.2500
Number of Roads Reclaimed Annually Per Well	0.0059
Annual Miles of Roads reclaimed Per Well	0.0015
Number of wells reclaimed (per well)	0.0059

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
0.00	6	0.0002	0.0025
		Total	**0**

Assume average miles/day = 6

Emission Factors for 75-100 hp Off-Road Engines

Year	Emission Factors (g/hp-hr)		
	CO_2	CH_4	N_2O[a]
2008	600.507	0.010	0.016
2018	613.888	0.006	0.016
2027	608.641	0.003	0.016

Source: EPA NONROADS 2008a

[a] 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)

Exhaust Emissions Estimation for Grader Road Reclaim

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours	Emissions (tons/year/well)		
				CO_2	CH_4	N_2O
Road Reclamation	Grader	80	0.001	7.98E-05	7.17E-10	2.02E-09

Exhaust Emission Factors for Commuting Reclaim Vehicles Road Traffic

Vehicle Class	Emission Factors (g/mi)		
	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	409.5	0.002	0.016

Source: MOBILE6.2.03

[a] 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).

Exhaust Emissions Estimation for Commuting Reclaim Vehicles: Road Traffic

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tons/year/well)		
	Type	Class				CO_2	CH_4	N_2O
Road Reclamation	Pickup Truck	LDDV	6	0.0002	0.0015	6.66E-07	3.25E-12	2.52E-11

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	0.01	10	0.0059	0.0590

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

Exhaust Emissions Estimation for Grader: Well Reclamation

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours	Emissions (tons/year/well)		
				CO_2	CH_4	N_2O
Well Reclamation	Grader	100	0.0354	2.34E-03	3.90E-08	6.05E-08

Exhaust Emissions Estimation for Commuting Vehicles: Well Reclamation

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tons/year/well)		
	Type	Class				CO_2	CH_4	N_2O
Well Reclamation	Pickup Truck	LDDV	6	0.0059	0.0354	1.60E-05	7.80E-11	6.05E-10

Exhaust 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	0.01
Annual Miles of Roads reclaimed Per Well	0.00
Number of wells reclaimed (per well)	0.01

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
0.00	6	0.0002	0.0025
		Total	**0**

Assume average miles/day = 6

Emission Factors for 75-100 hp Off-Road Engines

Year	Emission Factors (g/hp-hr)		
	CO_2	CH_4	N_2O[a]
2008	600.5	0.010	0.016
2018	613.9	0.006	0.016
2027	608.6	0.003	0.016

Source: EPA NONROADS 2008a

[a] 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).

Exhaust Emissions Estimation for Grader Road Reclaim

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours	Emissions (tons/year/well)		
				CO_2	CH_4	N_2O
Road Reclamation	Grader	80	0.001	0.0001	0.0000	0.0000

Exhaust Emission Factors for Commuting Reclaim Vehicles Road Traffic

Vehicle Class	Emission Factors (g/mi)		
	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	409.5	0.002	0.016

Source: MOBILE6.2.03

[a] 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).

Exhaust Emissions Estimation for Commuting Reclaim Vehicles: Road Traffic

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tons/year/well)		
	Type	Class				CO_2	CH_4	N_2O
Road Reclamation	Pickup Truck	LDDV	6	0.0002	0.0015	0.0000	0.0000	0.0000

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	0.01	10	0.01	0.06

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

Exhaust Emissions Estimation for Grader: Well Reclamation

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours	Emissions (tons/year/well)		
				CO_2	CH_4	N_2O
Well Reclamation	Grader	100	0.04	0.0023	0.0000	0.0000

Exhaust Emissions Estimation for Commuting Vehicles: Well Reclamation

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tons/year/well)		
	Type	Class				CO_2	CH_4	N_2O
Well Reclamation	Pickup Truck	LDDV	6	0.01	0.04	0.0000	0.0000	0.0000

Wellhead Fugitives

Fugitive Emissions from Equipment Leaks

TOC Emission Factor								
Well Equipment Component	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 CBNG analysis

VOC Wt% =	0.00
CO2 Wt% =	2.28
CH4 Wt% =	95.72
N2O Wt% =	0.00

Emissions from Equipment Leaks at Wellhead 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	6	0.0099	1	0.0055	0	0.0002	0.06504	0.00000	0.00148	0.06225
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	10	0.0004	0	0.0005	0	0.0002	0.00441	0.00000	0.00010	0.00422
flanges	7	0.0009	0	0.0002	0	0.0000	0.00602	0.00000	0.00014	0.00576
open-ended lines	0	0.0044	0	0.0031	0	0.0006	0.00000	0.00000	0.00000	0.00000
						TOTAL emissions/well/hr =	0.07546	0.00000	0.00172	0.07223

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 (ton/yr)**	**CO_2 emissions (lb/yr)**	**CO_2 emissions (ton/yr)**	**CH_4 emissions (lb/yr)**	**CH_4 emissions (ton/yr)**
Year 20	1	8760	0.0125	0.0000	15.0820	0.0075	632.7308	0.3164

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

Gas Component	Mole Fraction (%)	Molecular Weight (lb/lb-mol)	Gas Weight (lb/lb-mol)	Weight Percent (wt%)	Weight (lb/MMscf))	Emissions Mass Flow (ton/well)
Methane	97.913	16.040	15.705	95.715	40640.682	2.743
Ethane	0.000	30.070	0.000	0.000	0.000	0.000
Nitrogen	1.172	28.020	0.328	2.001	849.791	0.057
Water	0.000	18.015	0.000	0.000	0.000	0.000
Carbon Dioxide	0.851	43.990	0.374	2.281	968.723	0.065
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	99.936	---	16.408	99.998		2.866
Propane	0.000	44.100	0.000	0.000	0.000	0.000
Iso-butane	0.000	58.120	0.000	0.000	0.000	0.000
n-butane	0.000	58.120	0.000	0.000	0.000	0.000
i-pentane	0.000	72.150	0.000	0.000	0.000	0.000
n-pentane	0.000	72.150	0.000	0.000	0.000	0.000
Hexanes	0.000	100.210	0.000	0.000	0.000	0.000
Heptanes	0.000	100.200	0.000	0.002	0.804	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	0.000	---	0.000	0.002		0.000
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]	*0.000*	*100.210*	*0.000*	*0.000*	*0.000*	*0.000*
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	0.000	---	0.000	0.000		0.000
Totals	**99.936**	**---**	**16.408**	**100.000**		**2.866**

Sample taken 01-19-2010 at Holmes 14 Battery, Ft. Union.

Volume Flow:	45	MSCF/day/well
Completion activity duratic	3	days
Total Volume Flow per We	0.135	MMSCF/well

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

BTU value = 994 BTU/scf

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Appendix H

North Dakota Planning Area GHG Emission Inventory

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North Dakota input parameters for calculating oil wells emissions:

Maximum Annual Wells Drilled - Federal (excluding FS)	74	Maximum Annual Wells Drilled - Non-Federal	459	Maximum Annual Wells Drilled - Trust (Fort Berthold area)	52	Maximum Annual Wells Drilled - Forest Service	105
Federal Producing Wells (excluding FS)	912	Non-Federal Producing Wells	5,629	Trust (Fort Berthold area) Producing Wells	636	Forest Service Producing Wells	1,288
Average Well Barrel Oil Per Day (BOPD)	64	Average Well Barrel Oil Per Day (BOPD)	64	Average Well Barrel Oil Per Day (BOPD)	64	Average Well Barrel Oil Per Day (BOPD)	64

North Dakota Federal (excluding Forest Service) Oil Wells Summaries

Total Annual Emissions from Federal Oil Wells - RFD Estimates

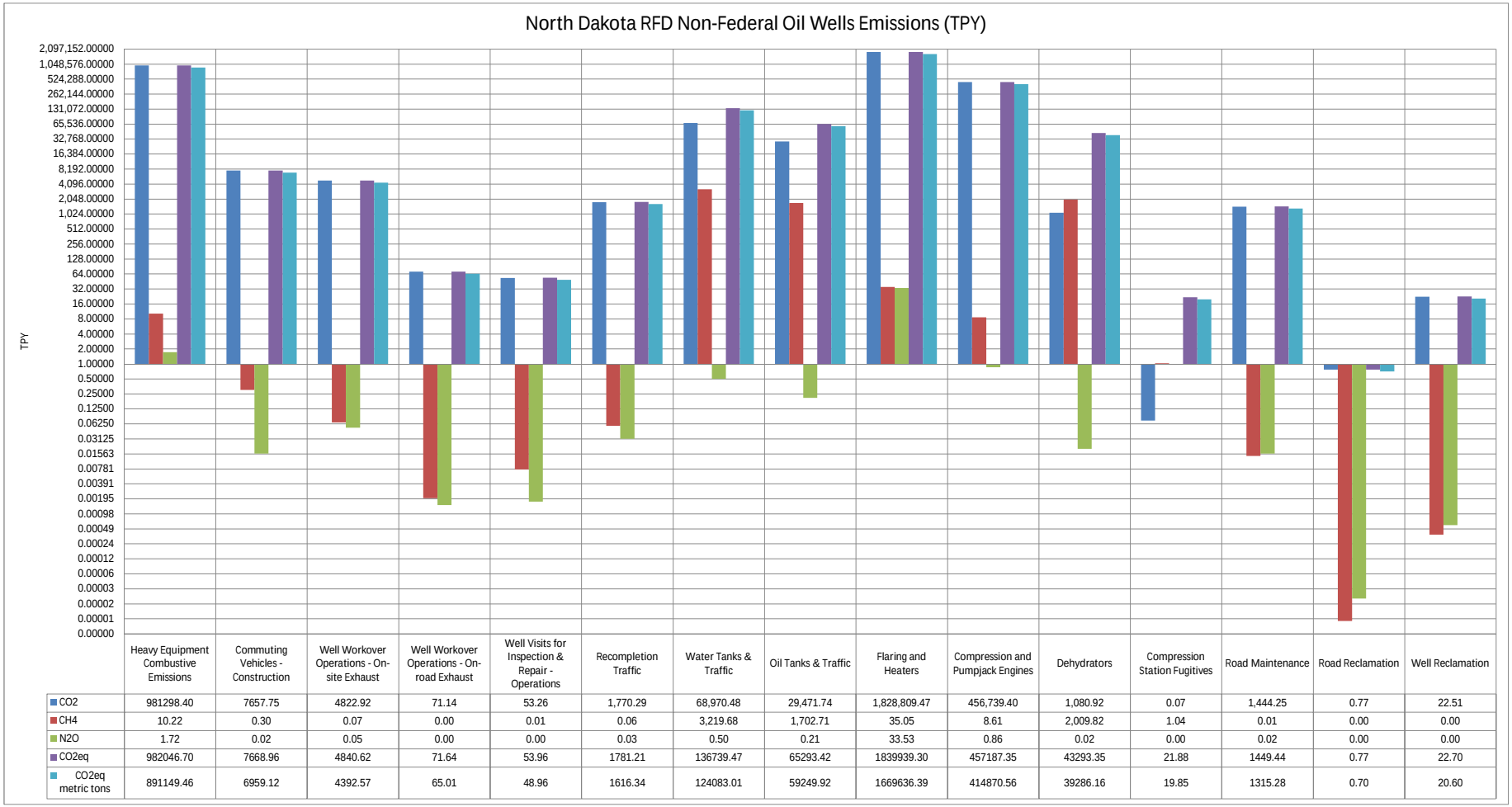
Activity	Annual Emissions (Tons)				
	CO_2	CH_4	N_2O	CO_{2eq}	CO_{2eq} metric tons
Well Pad Construction - Fugitive Dust	---	---	---	---	---
Heavy Equipment Combustive Emissions	158204.97	1.65	1.72	158773.25	144077.36
Commuting Vehicles - Construction	1234.58	0.05	0.02	1240.51	1125.69
Wind Erosion	---	---	---	---	---
Sub-total: Construction	**159,439.55**	**1.70**	**1.74**	**160,013.76**	**145,203.05**
Well Workover Operations - Fugitive Dust	---	---	---	---	---
Well Workover Operations - On-site Exhaust	777.55	0.01	0.01	780.40	708.17
Well Workover Operations - On-road Exhaust	11.47	0.00	0.00	11.55	10.48
Well Visits for Inspection & Repair - Operations	8.63	0.00	0.00	8.74	7.93
Recompletion Traffic	286.82	0.01	0.01	288.59	261.88
Water Tanks & Traffic	11,174.47	521.65	0.08	22154.27	20103.70
Oil Tanks & Traffic	4,774.96	275.87	0.03	10578.72	9599.56
Flaring and Heaters	296,278.60	5.68	5.43	298081.70	270491.56
Compression and Pumpjack Engines	74,000.06	1.40	0.14	74072.64	67216.55
Dehydrators	175.13	325.63	0.00	7014.31	6365.07
Compression Station Fugitives	0.01	0.17	0.00	3.54	3.22
Sub-total: Operations	**387,487.69**	**1,130.41**	**5.70**	**412,994.46**	**374,768.11**
Road Maintenance	233.99	0.00	0.00	234.84	213.10
Sub-total: Maintenance	**233.995**	**0.002**	**0.00**	**234.84**	**213.10**
Road Reclamation	0.12	0.00	0.00	0.13	0.11
Well Reclamation	3.65	0.00	0.00	3.68	3.34
Sub-total: Reclamation	**3.7713**	**0.0001**	**0.0001**	**3.8028**	**3.4508**
Total Emissions	**547,165.01**	**1,132.11**	**7.44**	**573,246.85**	**520,187.71**

	Heavy Equipment Combustive Emissions	Commuting Vehicles - Construction	Well Workover Operations - On-site Exhaust	Well Workover Operations - On-road Exhaust	Well Visits for Inspection & Repair - Operations	Recompletion Traffic	Water Tanks & Traffic	Oil Tanks & Traffic	Flaring and Heaters	Compression and Pumpjack Engines	Dehydrators	Compression Station Fugitives	Road Maintenance	Road Reclamation	Well Reclamation
CO2	158204.97	1234.58	777.55	11.47	8.63	286.82	11,174.47	4,774.96	296,278.60	74,000.06	175.13	0.01	233.99	0.12	3.65
CH4	1.65	0.05	0.01	0.00	0.00	0.01	521.65	275.87	5.68	1.40	325.63	0.17	0.00	0.00	0.00
N2O	1.72	0.02	0.01	0.00	0.00	0.01	0.08	0.03	5.43	0.14	0.00	0.00	0.00	0.00	0.00
CO2eq	158773.25	1240.51	780.40	11.55	8.74	288.59	22154.27	10578.72	298081.70	74072.64	7014.31	3.54	234.84	0.13	3.68
CO2eq metric tons	144077.36	1125.69	708.17	10.48	7.93	261.88	20103.70	9599.56	270491.56	67216.55	6365.07	3.22	213.10	0.11	3.34

North Dakota Non-Federal Oil Wells Summaries

Total Annual Emissions from Non-Federal Oil Wells - RFD Estimates

Activity	Annual Emissions (Tons)				
	CO_2	CH_4	N_2O	CO_{2eq}	CO_{2eq} metric tons
Well Pad Construction - Fugitive Dust	---	---	---	---	---
Heavy Equipment Combustive Emissions	981298.40	10.22	1.72	982046.70	891149.46
Commuting Vehicles - Construction	7657.75	0.30	0.02	7668.96	6959.12
Wind Erosion	---	---	---	---	---
Sub-total: Construction	**988,956.15**	**10.52**	**1.74**	**989,715.66**	**898,108.58**
Well Workover Operations - Fugitive Dust			---	---	---
Well Workover Operations - On-site Exhaust	4822.92	0.07	0.05	4840.62	4392.57
Well Workover Operations - On-road Exhaust	71.14	0.00	0.00	71.64	65.01
Well Visits for Inspection & Repair - Operations	53.26	0.01	0.00	53.96	48.96
Recompletion Traffic	1,770.29	0.06	0.03	1781.21	1616.34
Water Tanks & Traffic	68,970.48	3,219.68	0.50	136739.47	124083.01
Oil Tanks & Traffic	29,471.74	1,702.71	0.21	65293.42	59249.92
Flaring and Heaters	1,828,809.47	35.05	33.53	1839939.30	1669636.39
Compression and Pumpjack Engines	456,739.40	8.61	0.86	457187.35	414870.56
Dehydrators	1,080.92	2,009.82	0.02	43293.35	39286.16
Compression Station Fugitives	0.07	1.04	0.00	21.88	19.85
Sub-total: Operations	**2,391,789.69**	**6,977.05**	**35.21**	**2,549,222.19**	**2,313,268.77**
Road Maintenance	1,444.25	0.01	0.02	1449.44	1315.28
Sub-total: Maintenance	**1444.250**	**0.014**	**0.02**	**1,449.44**	**1,315.28**
Road Reclamation	0.77	0.00	0.00	0.77	0.70
Well Reclamation	22.51	0.00	0.00	22.70	20.60
Sub-total: Reclamation	**23.2768**	**0.0004**	**0.0006**	**23.4715**	**21.2990**
Total Emissions	**3,382,213.37**	**6,987.58**	**36.96**	**3,540,410.75**	**3,212,713.93**

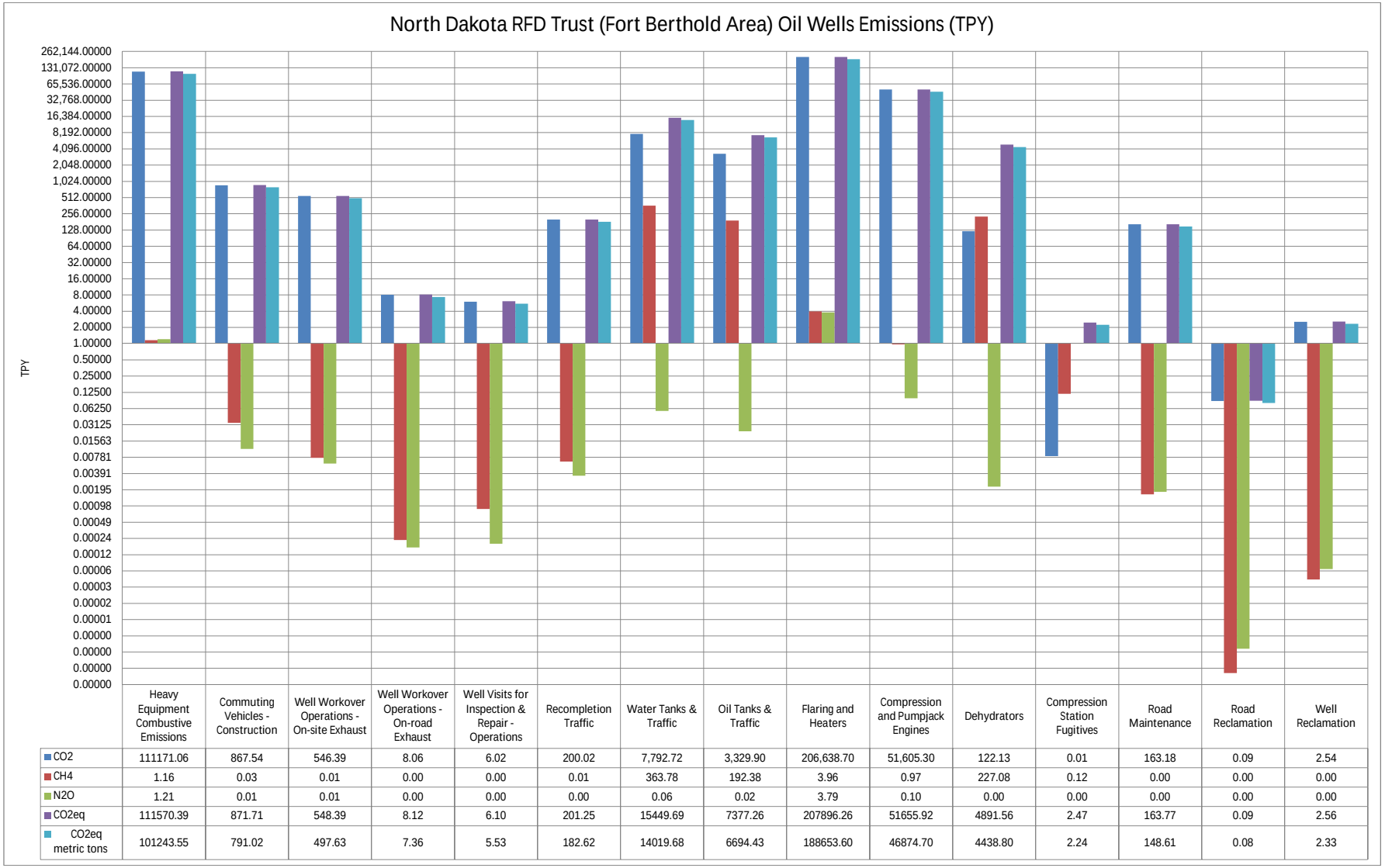


	Heavy Equipment Combustive Emissions	Commuting Vehicles - Construction	Well Workover Operations - On-site Exhaust	Well Workover Operations - On-road Exhaust	Well Visits for Inspection & Repair - Operations	Recompletion Traffic	Water Tanks & Traffic	Oil Tanks & Traffic	Flaring and Heaters	Compression and Pumpjack Engines	Dehydrators	Compression Station Fugitives	Road Maintenance	Road Reclamation	Well Reclamation
CO2	981298.40	7657.75	4822.92	71.14	53.26	1,770.29	68,970.48	29,471.74	1,828,809.47	456,739.40	1,080.92	0.07	1,444.25	0.77	22.51
CH4	10.22	0.30	0.07	0.00	0.01	0.06	3,219.68	1,702.71	35.05	8.61	2,009.82	1.04	0.01	0.00	0.00
N2O	1.72	0.02	0.05	0.00	0.00	0.03	0.50	0.21	33.53	0.86	0.02	0.00	0.02	0.00	0.00
CO2eq	982046.70	7668.96	4840.62	71.64	53.96	1781.21	136739.47	65293.42	1839939.30	457187.35	43293.35	21.88	1449.44	0.77	22.70
CO2eq metric tons	891149.46	6959.12	4392.57	65.01	48.96	1616.34	124083.01	59249.92	1669636.39	414870.56	39286.16	19.85	1315.28	0.70	20.60

North Dakota Trust (Fort Berthold Area) Oil Wells Summaries

Total Annual Emissions from Trust (Fort Berthold Area) Oil Wells - RFD Estimates

Activity	Annual Emissions (Tons)				
	CO_2	CH_4	N_2O	CO_{2eq}	CO_{2eq} metric tons
Well Pad Construction - Fugitive Dust	---	---	---	---	---
Heavy Equipment Combustive Emissions	111171.06	1.16	1.21	111570.39	101243.55
Commuting Vehicles - Construction	867.54	0.03	0.01	871.71	791.02
Wind Erosion	---	---	---	---	---
Sub-total: Construction	**112,038.61**	**1.19**	**1.22**	**112,442.10**	**102,034.57**
Well Workover Operations - Fugitive Dust			---	---	---
Well Workover Operations - On-site Exhaust	546.39	0.01	0.01	548.39	497.63
Well Workover Operations - On-road Exhaust	8.06	0.00	0.00	8.12	7.36
Well Visits for Inspection & Repair - Operations	6.02	0.00	0.00	6.10	5.53
Recompletion Traffic	200.02	0.01	0.00	201.25	182.62
Water Tanks & Traffic	7,792.72	363.78	0.06	15449.69	14019.68
Oil Tanks & Traffic	3,329.90	192.38	0.02	7377.26	6694.43
Flaring and Heaters	206,638.70	3.96	3.79	207896.26	188653.60
Compression and Pumpjack Engines	51,605.30	0.97	0.10	51655.92	46874.70
Dehydrators	122.13	227.08	0.00	4891.56	4438.80
Compression Station Fugitives	0.01	0.12	0.00	2.47	2.24
Sub-total: Operations	**270,249.24**	**788.31**	**3.98**	**288,037.02**	**261,376.61**
Road Maintenance	163.18	0.00	0.00	163.77	148.61
Sub-total: Maintenance	**163.180**	**0.002**	**0.00**	**163.77**	**148.61**
Road Reclamation	0.09	0.00	0.00	0.09	0.08
Well Reclamation	2.54	0.00	0.00	2.56	2.33
Sub-total: Reclamation	**2.6300**	**0.0000**	**0.0001**	**2.6520**	**2.4065**
Total Emissions	**382,453.66**	**789.50**	**5.20**	**400,645.54**	**363,562.19**

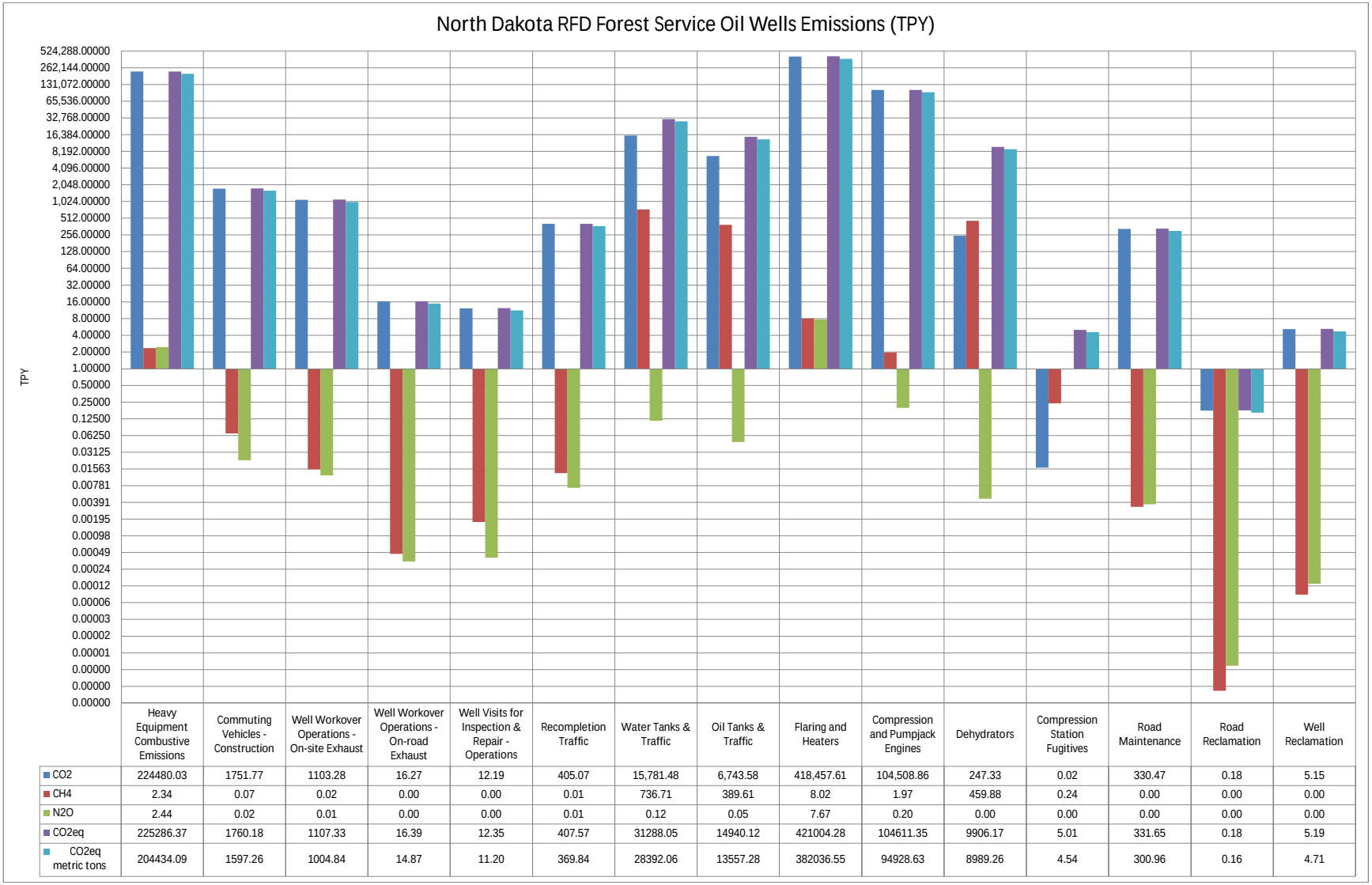


	Heavy Equipment Combustive Emissions	Commuting Vehicles - Construction	Well Workover Operations - On-site Exhaust	Well Workover Operations - On-road Exhaust	Well Visits for Inspection & Repair - Operations	Recompletion Traffic	Water Tanks & Traffic	Oil Tanks & Traffic	Flaring and Heaters	Compression and Pumpjack Engines	Dehydrators	Compression Station Fugitives	Road Maintenance	Road Reclamation	Well Reclamation
CO2	111171.06	867.54	546.39	8.06	6.02	200.02	7,792.72	3,329.90	206,638.70	51,605.30	122.13	0.01	163.18	0.09	2.54
CH4	1.16	0.03	0.01	0.00	0.00	0.01	363.78	192.38	3.96	0.97	227.08	0.12	0.00	0.00	0.00
N2O	1.21	0.01	0.01	0.00	0.00	0.00	0.06	0.02	3.79	0.10	0.00	0.00	0.00	0.00	0.00
CO2eq	111570.39	871.71	548.39	8.12	6.10	201.25	15449.69	7377.26	207896.26	51655.92	4891.56	2.47	163.77	0.09	2.56
CO2eq metric tons	101243.55	791.02	497.63	7.36	5.53	182.62	14019.68	6694.43	188653.60	46874.70	4438.80	2.24	148.61	0.08	2.33

North Dakota Forest Service Oil Wells Summaries

Total Annual Emissions from Forest Service Oil Wells - RFD Estimates

Activity	Annual Emissions (Tons)				
	CO_2	CH_4	N_2O	CO_{2eq}	CO_{2eq} metric tons
Well Pad Construction - Fugitive Dust	---	---	---	---	---
Heavy Equipment Combustive Emissions	224480.03	2.34	2.44	225286.37	204434.09
Commuting Vehicles - Construction	1751.77	0.07	0.02	1760.18	1597.26
Wind Erosion	---	---	---	---	---
Sub-total: Construction	**226,231.80**	**2.41**	**2.47**	**227,046.55**	**206,031.35**
Well Workover Operations - Fugitive Dust			---	---	---
Well Workover Operations - On-site Exhaust	1103.28	0.02	0.01	1107.33	1004.84
Well Workover Operations - On-road Exhaust	16.27	0.00	0.00	16.39	14.87
Well Visits for Inspection & Repair - Operations	12.19	0.00	0.00	12.35	11.20
Recompletion Traffic	405.07	0.01	0.01	407.57	369.84
Water Tanks & Traffic	15,781.48	736.71	0.12	31288.05	28392.06
Oil Tanks & Traffic	6,743.58	389.61	0.05	14940.12	13557.28
Flaring and Heaters	418,457.61	8.02	7.67	421004.28	382036.55
Compression and Pumpjack Engines	104,508.86	1.97	0.20	104611.35	94928.63
Dehydrators	247.33	459.88	0.00	9906.17	8989.26
Compression Station Fugitives	0.02	0.24	0.00	5.01	4.54
Sub-total: Operations	**547,275.69**	**1,596.45**	**8.06**	**583,298.61**	**529,309.08**
Road Maintenance	330.47	0.00	0.00	331.65	300.96
Sub-total: Maintenance	**330.466**	**0.003**	**0.00**	**331.65**	**300.96**
Road Reclamation	0.18	0.00	0.00	0.18	0.16
Well Reclamation	5.15	0.00	0.00	5.19	4.71
Sub-total: Reclamation	**5.3261**	**0.0001**	**0.0001**	**5.3706**	**4.8735**
Total Emissions	**773,843.28**	**1,598.86**	**10.53**	**810,682.18**	**735,646.26**



	Heavy Equipment Combustive Emissions	Commuting Vehicles - Construction	Well Workover Operations - On-site Exhaust	Well Workover Operations - On-road Exhaust	Well Visits for Inspection & Repair - Operations	Recompletion Traffic	Water Tanks & Traffic	Oil Tanks & Traffic	Flaring and Heaters	Compression and Pumpjack Engines	Dehydrators	Compression Station Fugitives	Road Maintenance	Road Reclamation	Well Reclamation
CO2	224480.03	1751.77	1103.28	16.27	12.19	405.07	15,781.48	6,743.58	418,457.61	104,508.86	247.33	0.02	330.47	0.18	5.15
CH4	2.34	0.07	0.02	0.00	0.00	0.01	736.71	389.61	8.02	1.97	459.88	0.24	0.00	0.00	0.00
N2O	2.44	0.02	0.01	0.00	0.00	0.01	0.12	0.05	7.67	0.20	0.00	0.00	0.00	0.00	0.00
CO2eq	225286.37	1760.18	1107.33	16.39	12.35	407.57	31288.05	14940.12	421004.28	104611.35	9906.17	5.01	331.65	0.18	5.19
CO2eq metric tons	204434.09	1597.26	1004.84	14.87	11.20	369.84	28392.06	13557.28	382036.55	94928.63	8989.26	4.54	300.96	0.16	4.71

Exhaust Emissions from Well Pad Construction Heavy Equipment and Drilling Equipment

Emission Factors for Construction Equipment

Equipment	Emission Factors (g/hp-hr)			Equipment Category
	CO_2	CH_4	N_2O [a]	
Dozer - 175 Hp	535.76	0.005	0.006	Track-Type Tractor
Blade - 150 Hp	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] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

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 (tons/equipment type/well)		
									CO_2	CH_4	N_2O
Improved & Two-Track Road	Blade	150	1	75	10	4.25	42.5	1	3.13E+00	3.98E-05	3.04E-05
Well Pad	Blade	175	1	75	10	4.25	42.5	1	3.66E+00	4.64E-05	3.55E-05
	Dozer	175	1	80	10	4.25	42.5	1	3.90E+00	4.95E-05	3.78E-05
								Subtotal	**1.07E+01**	**1.36E-04**	**1.04E-04**

Average number of days to construct wellpad and road: 8.5 obtained from NDFO (BLM).

Exhaust Emission Factors for Diesel Powered Bore/Drill Rig Engines

Project Year/Hp Category	Emission Factors (g/hp-hr)		
	CO_2	CH_4	N_2O[a]
Year 2018			
50 to 75	589.10	0.006	0.006
75 to 100	589.10	0.006	0.006
100 to 175	530.10	0.005	0.006
175 to 300	530.18	0.004	0.006
300 to 600	530.25	0.004	0.006
600 to 750	530.28	0.004	0.006
>750	529.92	0.006	0.006

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

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

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 (tons/equipment type/well)		
									CO_2	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Main Deck	3,450	3	70	24	19	456	1	1.93E+03	2.06E-02	2.10E-02
	Auxiliary Pump	600	1	80	8	19	152	1	4.26E+01	3.18E-04	4.64E-04
	Generators	150	2	75	24	19	456	1	6.00E+01	5.37E-04	6.53E-04
Well Completion & Testing	Main Deck	14,225	1	50	11	2	22	1	9.15E+01	6.82E-04	9.95E-04
	Auxiliary Pump	225	1	80	8	2	16	1	1.68E+00	1.37E-05	1.83E-05
	Power Swivel	150	1	75	8	2	16	1	1.05E+00	9.42E-06	1.14E-05
	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	2	24	1	6.43E-01	6.97E-06	6.30E-06
								Subtotal	**2.13E+03**	**2.21E-02**	**2.32E-02**
								Total	**2.14E+03**	**2.23E-02**	**2.33E-02**

Value for number of days and HP needed to drill well provided by BLM - NDFO. Number of days to complete well and HP for completion heavy equipment confirmed by ND BLM.

Exhaust Emissions from Construction and Drilling Support Vehicles

Emission Factors for Commuting Vehicles

Vehicle		Emission Factors (g/mi)		
Type	Class	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	409.5	0.002	0.016
Heavy-Duty Diesel Truck	HDDV	791.8	0.04	0.006

Source: MOBILE6.2.03

[a] 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).

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 (tons/well)		
	Type	Class					CO_2	CH_4	N_2O
Improved & Two-Track Road	Semi Trucks	HDDV	50	47	2350	1	2.05E+00	9.58E-05	1.49E-05
	Pickup Trucks	LDDT	50	3	150	1	6.77E-02	3.31E-07	2.56E-06
Well Pad	Semi Trucks	HDDV	50	5	250	1	2.18E-01	1.02E-05	1.59E-06
	Pickup Trucks	LDDT	50	4	200	1	9.03E-02	4.41E-07	3.42E-06
Other Construction Activities	Semi Trucks	HDDV	50	2	100	1	8.73E-02	4.08E-06	6.36E-07
	Haul Trucks	HDDV	50	2	100	1	8.73E-02	4.08E-06	6.36E-07
	Pickup Trucks	LDDT	50	1	50	1	2.26E-02	1.10E-07	8.54E-07
						Subtotal	**2.62E+00**	**1.15E-04**	**2.46E-05**

Round trip miles traveled based on ND BLM guidance.

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 (tons/well)		
	Type	Class					CO_2	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Semi Rig Transport, Drill Rig	HDDV	50	44	2200	1	1.92E+00	8.97E-05	1.40E-05
	Fuel Haul Truck	HDDV	50	6	300	1	2.62E-01	1.22E-05	1.91E-06
	Mud Haul Truck, Water Hauling	HDDV	50	4	200	1	1.75E-01	8.16E-06	1.27E-06
	Rig Crew	LDDT	50	51	2550	1	1.15E+00	5.62E-06	4.36E-05
	Rig Mechanics	HDDV	50	2	100	1	8.73E-02	4.08E-06	6.36E-07
	Co. Supervisor	LDDT	50	20	1000	1	4.51E-01	2.20E-06	1.71E-05
	Tool Pusher	LDDT	50	8	400	1	1.81E-01	8.82E-07	6.83E-06
	Mud Logger	LDDT	50	6	300	1	1.35E-01	6.61E-07	5.13E-06
	Mud Engineer	LDDT	50	15	750	1	3.39E-01	1.65E-06	1.28E-05
	Logger, Engr Truck	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Drill Bit Delivery	LDDT	50	2	100	1	4.51E-02	2.20E-07	1.71E-06

Round trip miles traveled based on ND BLM guidance.

Combustive Emissions Estimation Road Traffic (cont.)

Construction Site Destination	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells	Emissions (tons/well)		
	Type	Class					CO_2	CH_4	N_2O
Well Completion & Testing	Semi Casing Haulers	HDDV	50	6	300	1	2.62E-01	1.22E-05	1.91E-06
	Semi Completion, Unit Rig	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Semi Fracing, Blender	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Semi Pumping/Tank Battery	HDDV	50	6	300	1	2.62E-01	1.22E-05	1.91E-06
	Tubing Truck	HDDV	50	2	100	1	8.73E-02	4.08E-06	6.36E-07
	Haul Cementer, Pump Truck	HDDV	50	2	100	1	8.73E-02	4.08E-06	6.36E-07
	Haul Cementer, Cement Truck	HDDV	50	3	150	1	1.31E-01	6.12E-06	9.54E-07
	Haul Completion, Equip Truck	HDDV	50	3	150	1	1.31E-01	6.12E-06	9.54E-07
	Haul Service	LDDT	50	2	100	1	4.51E-02	2.20E-07	1.71E-06
	Haul Perforators Logging Truck	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Anchor, Installation	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Anchor, Testing	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Fracing, Tank	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Fracing, Pump	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Fracing, Chemical	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Fracing, Sand	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Fracing, Other	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Welders	HDDV	50	6	300	1	2.62E-01	1.22E-05	1.91E-06
	Haul Water	HDDV	50	150	7500	1	6.55E+00	3.06E-04	4.77E-05
	Pickup Cementer, Engineer	LDDT	50	2	100	1	4.51E-02	2.20E-07	1.71E-06
	Pickup Casing Crew	HDDV	50	2	100	1	8.73E-02	4.08E-06	6.36E-07
	Pickup Completion Crew	HDDV	50	5	250	1	2.18E-01	1.02E-05	1.59E-06

	Pickup Completion, Pusher	LDDT	50	5	250	1	1.13E-01	5.51E-07	4.27E-06
	Pickup Perforators, Engineer	LDDT	50	2	100	1	4.51E-02	2.20E-07	1.71E-06
	Pickup Fracing, Engineer	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Pickup Co. Supervisor	LDDT	50	10	500	1	2.26E-01	1.10E-06	8.54E-06
	Pickup Miscellaneous	LDDT	50	3	150	1	6.77E-02	3.31E-07	2.56E-06
	Pickup Roustabout	HDDV	50	4	200	1	1.75E-01	8.16E-06	1.27E-06
						Subtotal	**1.41E+01**	**5.38E-04**	**1.89E-04**
						Total	**1.67E+01**	**6.53E-04**	**2.14E-04**

Round trip miles traveled based on ND BLM guidance.

Exhaust Emissions from Well Work Overs

Emission Factors Bore/Drill Rig Engines 300-600 Hp

Fuel Type	Emission Factors (gm/hp-hr)		
	CO_2	CH_4	N_2O[a]
Diesel	529.575	0.007	0.006

Source: EPA NONROADS 2008a. Year 2008.

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

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 (tons/year/well)		
							CO_2	CH_4	N_2O
Well Workover	Truck-Mounted Unit	600	10	3	30	1	1.05E+01	1.46E-04	1.14E-04

Exhaust emission factors for commuting vehicles

Vehicle		Emission Factors (g/mi)		
Type	Class	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	409.500	0.002	0.016
Heavy-Duty Diesel Truck	HDDV	791.800	0.037	0.006

Source: MOBILE 6.2.03

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

[a] 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

Activity	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells Drilled	Max. Annual Emissions (tons/year/well)		
	Type	Class					CO_2	CH_4	N_2O
Well Workover	WO Rig	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Truck	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Pickup Truck	LDDT	50	3	150	1	6.77E-02	3.31E-07	2.56E-06
						Total	**1.55E-01**	**4.41E-06**	**3.20E-06**

Performed once in the first year of well operation and applied to peak number of wells drilled annually.
Round trip miles traveled based on ND BLM guidance.

Exhaust Emissions from Site Visits and Inspections

Emission factors for Commuting Vehicles Exhaust

Vehicle Class	Emission Factors (g/mi)		
	CO_2	CH_4	N_2O[a]
Light-Duty Gasoline Truck	476.90	0.07	0.02

Source: MOBILE 6.2.03
Emission factors for 2008 used for all years = conservative estimate for fleet vehicle turnover
[a] 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)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Federal Wells Producing	Emissions (tons/yr/well)		
	Type	Class					CO_2	CH_4	N_2O
Inspection Visits for Wells	Pickup Truck	LDGT2	1.5	12	18	1	9.46E-03	1.35E-06	3.06E-07

Roundtrip distance shown in AECOM dataset.

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 year

[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
Number of Wells	1
Cumulative Length of Roads [b] (miles/operation)	1

[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	0.3333	3.3333
Winter	1	1	5	10	0.2000	2.0000
				Total	**0.5333**	**5.3333**

Emission Factors for Construction Equipment Exhaust

Equipment	Emission Factors (g/hp-hr)		
	CO_2	CH_4	N_2O[a]
Grader 100-175 Hp	535.7700	0.0053	0.0058

Source: EPA NONROADS 2008a

Use emission factors for 2008 for all project years - conservative estimate of vehicle turnover

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

Emission Estimations for Grader: RMP Year 20

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours[a]	Emissions (tons/well)		
				CO_2	CH_4	N_2O
Road Maintenance	Grader	135	3.20	2.55E-01	2.52E-06	2.75E-06

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

Emission Factors for Commuting Vehicles Exhaust

Vehicle Class	Emission Factors (g/mi)		
	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	409.500	0.002	0.016

Source: MOBILE 6.2.03

[a] 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 (tons/yr)		
	Type	Class				CO_2	CH_4	N_2O
Road Maintenance	Pickup Truck	LDDT	6	0.5333	3.2000	1.44E-03	7.05E-09	5.47E-08

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)	CH_4 Emissions (ton/yr/well)
All	31.31	36500	5.71E-01

[a] Average Conditions for Table 5-10 of the API Compedium of GHG Emissions Methodologies for the Oil and Gas Industry, August 2009.
Average number of produced water bbl per day (per oil well) value provided by ND BLM (100 bbl/day/oil well)

Emission Factors for Water Transport Vehicles - Road Traffic

Vehicle Class	Emission Factors (g/mi)		
	CO_2	CH_4	N_2O[a]
Heavy-Duty Diesel Truck (HDDV)	791.800	0.037	0.006

Source: MOBILE6.2.03

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

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 (tons/yr/well)		
	Type	Class					CO_2	CH_4	N_2O
Produced Water Hauling	Haul Truck (130 bbl)	HDDV	50	281	14038	1	1.23E+01	5.73E-04	8.93E-05

Round trip miles traveled based on ND BLM guidance.

Oil Tank, Loadout and Hauling Emissions

Oil Well Oil Seperator Flashing and Tank Emissions[a]

	Emissions[b]			
Project Year	HAPs Emissions (ton/yr/well)	VOC Emissions (ton/yr/well)	CO_2 Emissions (ton/yr/well)	CH_4 Emissions (ton/yr/well)
All	1.33E-01	2.38E+00	1.37E-01	3.02E-01

[a] Based on Regional typical data values and calculations using E&P Tanks, August, 2010. Assumes 15 BOPD per well.
[b] Assumes no 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 ($lb/10^3$ gal) 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)
All	2.35	23,360	981	1.15E+00	2.07E-03	3.37E-07

[a] Uses E&P Tanks Stream Data for W&S Gas mol % (shown below). Regional typical E&P Tanks input data.

Emission Factors for Work Over Vehicles - Road Traffic

Vehicle Class	Emission Factors (g/mi)		
	CO_2	CH_4	N_2O[a]
Heavy-Duty Diesel Truck (HDDV)	791.800	0.037	0.006

Source: MOBILE6.2.03

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

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 (tons/year/well)		
	Type	Class					CO_2	CH_4	N_2O
Produced Oil Hauling	Haul Truck (200 bbl)	HDDV	50	117	5840	1	5.10E+00	2.38E-04	3.71E-05
						TOTAL	**5.10E+00**	**2.38E-04**	**3.71E-05**

Round trip miles traveled based on ND BLM guidance.

W&S Composition for Truck Load Out Emissions

W&S Gas Component	Mole Fraction[a] (%)	Molecular Weight (lb/lb-mol)	Gas Weight (lb/lb-mol)	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-HAP	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 %. Regional typical E&P Tanks input data.

Exhaust Emissions from Recompletion Support Vehicles

Emission Factors for Commuting Vehicles

Vehicle		Emission Factors (g/mi)		
Type	Class	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	409.500	0.002	0.016
Heavy-Duty Diesel Truck	HDDV	791.800	0.037	0.006

Source: MOBILE6.2.03

[a] 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).

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 (tons/well)		
	Type	Class					CO_2	CH_4	N_2O
Well Recompletion	Fuel Haul Truck	HDDV	50	6	300	1	2.62E-01	1.22E-05	1.91E-06
	Mud Haul Truck, Water Hauling	HDDV	50	4	200	1	1.75E-01	8.16E-06	1.27E-06
	Rig Crew	LDDT	50	51	2550	1	1.15E+00	5.62E-06	4.36E-05
	Rig Mechanics	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Co. Supervisor	LDDT	50	20	1000	1	4.51E-01	2.20E-06	1.71E-05
	Semi Completion, Unit Rig	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Semi Fracing, Blender	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Semi Pumping/Tank Battery	HDDV	50	6	300	1	2.62E-01	1.22E-05	1.91E-06
	Tubing Truck	HDDV	50	2	100	1	8.73E-02	4.08E-06	6.36E-07
	Haul Cementer, Pump Truck	HDDV	50	2	100	1	8.73E-02	4.08E-06	6.36E-07
	Haul Cementer, Cement Truck	HDDV	50	3	150	1	1.31E-01	6.12E-06	9.54E-07
	Haul Completion, Equip Truck	HDDV	50	3	150	1	1.31E-01	6.12E-06	9.54E-07
	Haul Service Tools	LDDT	50	2	100	1	4.51E-02	2.20E-07	1.71E-06
	Haul Perforators Logging Truck	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Fracing, Tank	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Fracing, Pump	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Fracing, Chemical	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Fracing, Sand	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Fracing, Other	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Water Truck	HDDV	50	50	2500	1	2.18E+00	1.02E-04	1.59E-05
	Pickup Cementer, Engineer	LDDT	50	2	100	1	4.51E-02	2.20E-07	1.71E-06
	Pickup Completion Crew	HDDV	50	5	250	1	2.18E-01	1.02E-05	1.59E-06
	Pickup Completion, Pusher	LDDT	50	5	250	1	1.13E-01	5.51E-07	4.27E-06
	Pickup Perforators, Engineer	LDDT	50	2	100	1	4.51E-02	2.20E-07	1.71E-06
	Pickup Fracing, Engineer	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Pickup Co. Supervisor	LDDT	50	10	500	1	2.26E-01	1.10E-06	8.54E-06
	Pickup Miscellaneous Supplies	LDDT	50	3	150	1	6.77E-02	3.31E-07	2.56E-06
	Pickup Roustabout Crew	HDDV	50	4	200	1	1.75E-01	8.16E-06	1.27E-06
						Subtotal	**6.29E+00**	**2.04E-04**	**1.11E-04**
						Total	**6.29E+00**	**2.04E-04**	**1.11E-04**

Round trip miles traveled based on ND BLM guidance.

Oil Well - Gas Analysis

Gas Component	Mole Fraction (%)	Molecular Weight (lb/lb-mol)	Gas Weight (lb/lb-mol)	Weight Percent (wt%)	Weight (lb/MMscf)
Methane	64.754	16.040	10.387	39.802	16899.950
Ethane	9.778	30.070	2.940	11.267	4784.074
Nitrogen	6.390	28.020	1.790	6.861	2913.288
Water	0.000	18.015	0.000	0.000	0.000
Carbon Dioxide	1.654	43.990	0.728	2.788	1183.870
Nitrous Oxide	0.000	44.020	0.000	0.000	0.000
Hydrogen Sulfide	0.000	34.060	0.000	0.000	0.000
Non-reactive, non-HAP	82.576	---	15.845	60.719	
Propane	7.374	44.100	3.252	12.462	5291.224
Iso-butane	1.221	58.120	0.710	2.719	1154.664
n-butane	3.944	58.120	2.292	8.784	3729.726
i-pentane	1.124	72.150	0.811	3.108	1319.523
n-pentane	2.079	72.150	1.500	5.748	2440.649
Hexanes	1.682	100.210	1.686	6.459	2742.531
Heptanes	0.000	100.200	0.000	0.001	0.501
Octanes	0.000	114.230	0.000	0.000	0.000
Nonanes	0.000	128.258	0.000	0.000	0.000
Decanes+	0.000	142.29	0.000	0.000	0.000
Reactive VOC	17.424	---	10.251	39.281	
Benzene	0.000	78.110	0.000	0.000	0.000
Ethylbenzene	0.000	106.160	0.000	0.000	0.000
n-Hexane [3]	*1.682*	*100.210*	*1.686*	*6.459*	*2742.531*
Toluene	0.000	92.130	0.000	0.000	0.000
Xylenes	0.000	106.160	0.000	0.000	0.000
HAPs	1.682	---	1.686	6.459	
Totals	**100.000**	**---**	**26.095**	**100.000**	

Oil well natural gas analysis for Formation: Bakken - Cotton, Lease: Rosencrans 44-21H

Volume Flow: 0.065753425 MMSCF / day

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

Compressor and Pumpjack Engines Emissions

Emission Factors for Natural Gas-Fired Compressors and Pumps

Compressor / Pump		Horse-Power Rating	Units	Emission Factors		
				CO_2 [a]	CH_4 [a]	N_2O [a]
Compression Station	Lean Burn	300	gm/bhp-hr	1.35E+02	2.55E-03	2.55E-04
			lb/MMBTU	1.17E+02	2.20E-03	2.20E-04
Oil Pump at Well Head	Lean Burn	---	gm/bhp-hr	1.35E+02	2.55E-03	2.55E-04
			lb/MMBTU	1.17E+02	2.20E-03	2.20E-04

Note: Compressors assumed to be equipped with nonselective catalytic reduction (NSCR) catalyst.

[a] 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) or (MMBTU/year/well)	Annual # of Wells in Production	Annual Compression	Operating Hours/Year	Emissions (tons/year/well)		
					CO_2	CH_4	N_2O
Compression Station	0.3	1.00	0.3	8,760	4.38E-01	8.26E-06	8.26E-07
Oil Pump at Well Head	1,381	1.00	1,381	8,760	8.07E+01	1.52E-03	1.52E-04
				Total	**8.11E+01**	**1.53E-03**	**1.53E-04**

Compression rate of 3000 planned HP for all projected ND developed gas. (AECOM)
Typical oil well head pumpjack fuel usage of 4,603 MMBTU/year/well. (AECOM). That value is adjusted with assumption that 70% of pumps are electrified (BLM - NDFO).

Compressor Station Fugitives

Fugitive Emissions from Equipment Leaks

TOC Emission Factor								
Well Equipment Component	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 AECOM provided oil well gas analyses (see Gas Analysis Worksheet)

VOC Wt% =	39.28
CO2 Wt% =	2.79
CH4 Wt% =	39.80
N2O Wt% =	0.00

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	0.008	0.0099	0	0.0055	0	0.0002	7.78E-05	3.05E-05	2.17E-06	3.10E-05
pump seals	0.000	0.0053	0	0.0287	0	0.0001	0.00E+00	0.00E+00	0.00E+00	0.00E+00
others	0.000	0.0194	0	0.0165	0	0.0309	0.00E+00	0.00E+00	0.00E+00	0.00E+00
connectors	0.011	0.0004	0	0.0005	0	0.0002	4.94E-06	1.94E-06	1.38E-07	1.97E-06
flanges	0.027	0.0009	0	0.0002	0	0.0000	2.31E-05	9.08E-06	6.44E-07	9.20E-06
open-ended lines	0.000	0.0044	0	0.0031	0	0.0006	0.00E+00	0.00E+00	0.00E+00	0.00E+00
						TOTAL emissions/well/hr =	1.06E-04	4.16E-05	2.95E-06	4.21E-05

Number of components verified by ND BLM

Annual Emissions from Equipment Leaks Per Well								
Year	**Number of Producing Wells**	**Operating Hours**	**VOC emissions (lb/yr)**	**VOC emissions (ton/yr)**	**CO_2 emissions (lb/yr)**	**CO_2 emissions (ton/yr)**	**CH_4 emissions (lb/yr)**	**CH_4 emissions (ton/yr)**
Year 20	1	8760	3.64E-01	1.82E-04	2.58E-02	1.29E-05	3.69E-01	1.84E-04

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	0.2500
Number of Roads Reclaimed Annually Per Well	0.0100
Annual Miles of Roads reclaimed Per Well	0.0025
Number of wells reclaimed (per well)	0.0100

Reclaimation rate : 1% of operating wells reclaimed annually

Estimation of Total Operation Days and Hours

Annual Miles of Roads Reclaimed	Daily Miles of Road Work	Total # of Operating Days	Annual Operating Hours
0.003	6	0.0004	0.0042
		Total	**0.0042**

Assume average miles/day = 6

Emission Factors for 75-100 hp Off-Road Engines

Year	Emission Factors (g/hp-hr)		
	CO_2	CH_4	N_2O[a]
2008	600.507	0.010	0.016
2018	613.888	0.006	0.016
2027	608.641	0.003	0.016

[a] 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).

Exhaust Emissions Estimation for Grader Road Reclaim

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours	Emissions (tons/year/well)		
				CO_2	CH_4	N_2O
Road Reclamation	Grader	80	0.0025	1.35E-04	1.22E-09	3.42E-09

Exhaust Emission Factors for Commuting Reclaim Vehicles Road Traffic

Vehicle Class	Emission Factors (g/mi)		
	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	409.500	0.002	0.016

Source: MOBILE6.2.03

[a] 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).

Exhaust Emissions Estimation for Commuting Reclaim Vehicles: Road Traffic

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tons/year/well)		
	Type	Class				CO_2	CH_4	N_2O
Road Reclamation	Pickup Truck	LDDV	6	0.0004	0.0025	1.13E-06	5.51E-12	4.27E-11

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	0.0100	10	0.0100	0.1000

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

Exhaust Emissions Estimation for Grader: Well Reclamation

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours	Emissions (tons/year/well)		
				CO_2	CH_4	N_2O
Well Reclamation	Grader	100	0.0600	3.97E-03	6.62E-08	1.03E-07

Exhaust Emissions Estimation for Commuting Vehicles: Well Reclamation

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tons/year/well)		
	Type	Class				CO_2	CH_4	N_2O
Well Reclamation	Pickup Truck	LDDV	6	0.0100	0.0600	2.71E-05	1.32E-10	1.03E-09

Emissions for Gas Dehydration

Emission Factors for Dehydrator Heaters

Unit	CO_2	CH_4	N_2O
lb/MMSCF	120000.0	2.3	2.2
lb/MMBTU	117.647	0.002	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 (tons/year/well)		
				CO_2	CH_4	N_2O
2,190	1	2.20	0.0015	1.92E-01	3.68E-06	3.52E-06

Applied to all operating wells. Assumes 22.6% of the gas is flared and 77.4% processed for sales. (BLM - NDFO)

Annual Dehydrator Venting and Tank Flashing Emissions

Annual Well Gas Production MMscf	CH_4 Emission Factor (ton per MMscf)	CH_4 Emissions (TPY/well)
33.6000	0.0106	3.57E-01

Gas analysis information found in AECOM Gas Analysis Database (see Gas Analysis Sheet for component percentages). GRI GLYCalc estimated emissions.

Emission factor include emissions from dehy/regenerator still vents (no control) and flash tank emissions (no control).

Assumed 77.4% of gas production flows through dehydrators at least once (other 22.6% flared) -- per BLM NDFO.

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

Emissions for External Gas Combustion

Emission Factors for External Gas Combustion (Flares and Heaters)

Unit	CO_2	CH_4	N_2O
lb/MMSCF	120000.0	2.3	2.2
lb/MMBTU	117.647	0.002	0.002

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

Well Completion Flaring	Gas Production /Well (MMSCFD)	# of Days of Flaring	# of Wells	Emissions (tons/year/well)		
				CO_2	CH_4	N_2O
Flaring	0.066	15	1	59.1781	0.0011	0.0011
Total				**59.1781**	**0.0011**	**0.0011**

Applied to all contructed wells. For well completion, assumes 100% of the gas is flared.
Based on BLM - NDFO value of ~ 24 MMSCF/year/oil well.

Well Re-Completion Flaring	Gas Production /Well (MMSCFD)	# of Days of Flaring	# of Wells	Emissions (tons/year/well)		
				CO_2	CH_4	N_2O
Flaring	0.066	8	1	31.5616	0.0006	0.0006
Total				**31.5616**	**0.0006**	**0.0006**

Applied to 5% of all operating wells. Assumes 100% of the gas is flared.
Based on BLM - NDFO value of ~ 24 MMSCF/year/oil well.

Well Normal Operation Flaring	Gas Production /Well (MMSCF/year)	# of Wells	Emissions (tons/year/well)		
			CO_2	CH_4	N_2O
Flaring	5.30512	1	318.3071	0.0061	0.0058
Total			**318.3071**	**0.0061**	**0.0058**

Applied to all operating wells. Assumes 22.6% of the gas is flared and 77.4% processed for sales. (BLM - NDFO)
Based on BLM - NDFO value of ~ 24 MMSCF/year/oil well.

Well Pad Heaters	Annual Heater Fuel Usage /Well (MMBTU/year/ well)	# of Wells	Emissions (tons/year/well)		
			CO_2	CH_4	N_2O
Heaters	3.06	1	0.1800	0.0000	0.0000
Total			**0.1800**	**0.0000**	**0.0000**

Applied to all operating wells. Based on conservative estimate - year around usage.
Based on BLM - NDFO annual fuel usage value (per conversation with Industry Engineers).

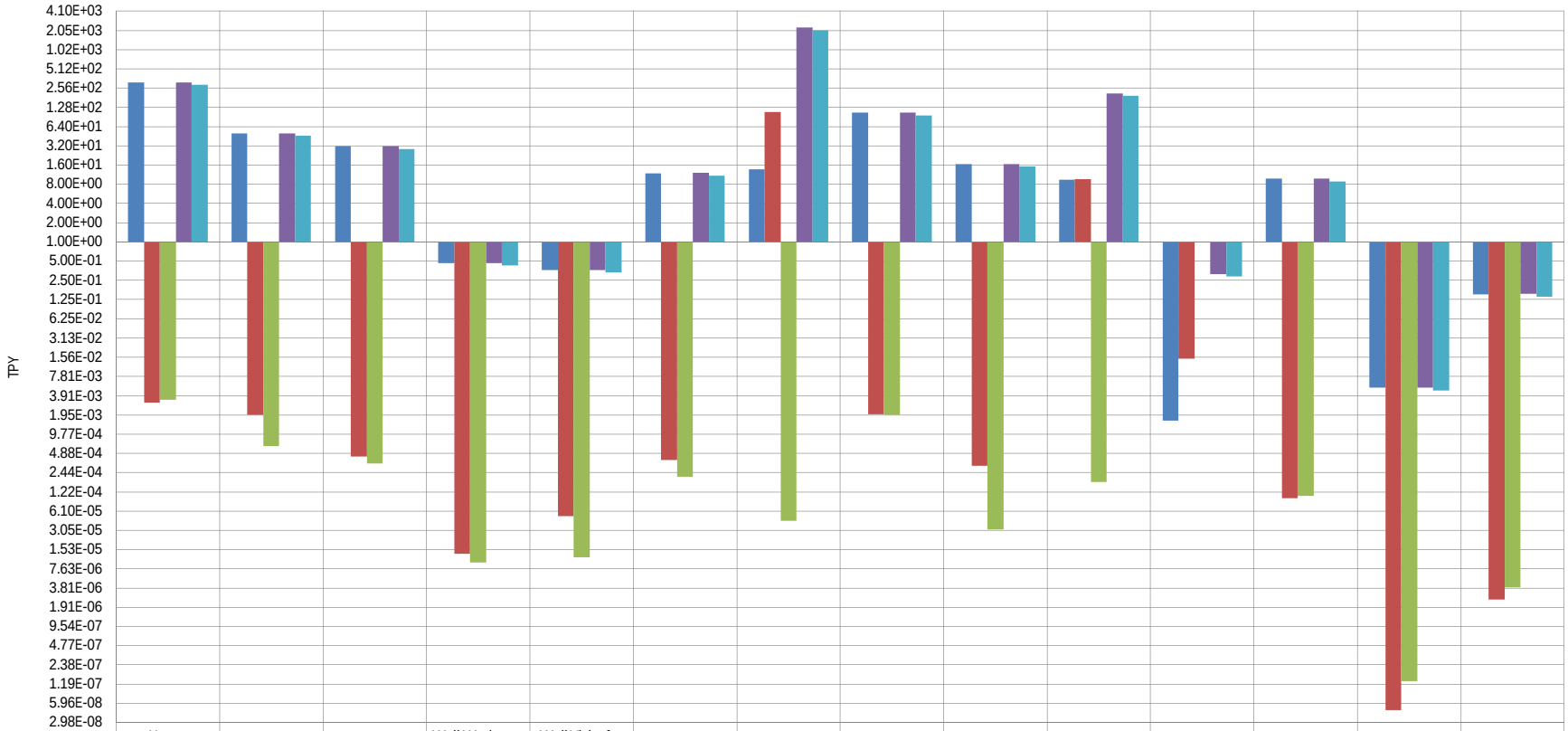
North Dakota input parameters for calculating NG wells emissions:

Maximum Annual Wells Drilled - Federal (excluding FS)	3	Maximum Annual Wells Drilled - Non-Federal	17	Maximum Annual Wells Drilled - Trust (Fort Berthold area)	2	Maximum Annual Wells Drilled - Forest Service	4
Federal Producing Wells (excluding FS)	38	Non-Federal Producing Wells	210	Trust (Fort Berthold area) Producing Wells	24	Forest Service Producing Wells	43
Average Annual Well Gas Production (MMSCF/year)	24	Average Annual Well Gas Production (MMSCF/year)	24	Average Annual Well Gas Production (MMSCF/year)	24	Average Annual Well Gas Production (MMSCF/year)	24

North Dakota Federal (excluding Forest Service) NG Wells Summaries

Total Annual Emissions from Federal NG Wells - RFD Estimates

Activity	Annual Emissions (Tons)				
	CO_2	CH_4	N_2O	CO_{2eq}	CO_{2eq} metric tons
Well Pad Construction - Fugitive Dust	---	---	---	---	---
Heavy Equipment Combustive Emissions	313.61	0.00	0.00	314.73	285.60
Commuting Vehicles - Construction	50.05	0.00	0.00	50.29	45.64
Wind Erosion	---	---	---	---	---
Sub-total: Construction	**363.66**	**0.01**	**0.00**	**365.02**	**331.23**
Well Workover Operations - Fugitive Dust	---	---	---	---	---
Well Workover Operations - On-site Exhaust	31.52	0.00	0.00	31.64	28.71
Well Workover Operations - On-road Exhaust	0.46	0.00	0.00	0.47	0.42
Well Visits for Inspection & Repair - Operations	0.36	0.00	0.00	0.36	0.33
Recompletion Traffic	11.95	0.00	0.00	12.02	10.91
Condensate Tanks & Traffic	13.77	107.01	0.00	2260.96	2051.68
Flaring and Heaters	105.00	0.00	0.00	105.65	95.87
Compression Engines	16.63	0.00	0.00	16.65	15.11
Dehydrators	9.43	9.69	0.00	213.00	193.29
Compression Station Fugitives	0.00	0.01	0.00	0.31	0.29
Sub-total: Operations	**189.13**	**116.72**	**0.00**	**2,641.06**	**2,396.61**
Road Maintenance	9.75	0.00	0.00	9.78	8.88
Sub-total: Maintenance	**9.750**	**0.000**	**0.00**	**9.78**	**8.88**
Road Reclamation	0.01	0.00	0.00	0.01	0.00
Well Reclamation	0.15	0.00	0.00	0.15	0.14
Sub-total: Reclamation	**0.1571**	**0.0000**	**0.0000**	**0.1585**	**0.1438**
Total Emissions	**562.69**	**116.72**	**0.01**	**3,016.03**	**2,736.87**

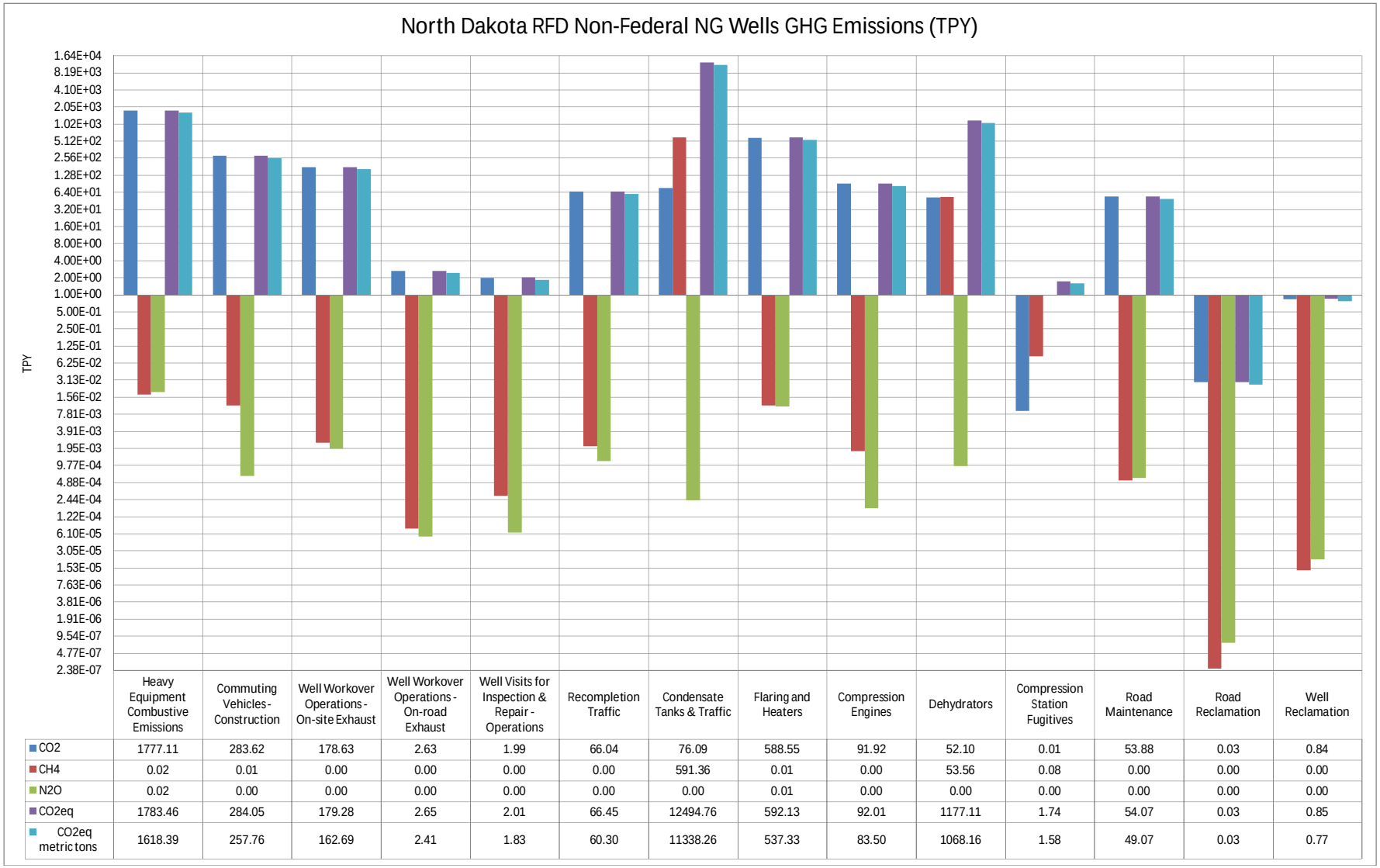


	Heavy Equipment Combustive Emissions	Commuting Vehicles - Construction	Well Workover Operations - On-site Exhaust	Well Workover Operations - On-road Exhaust	Well Visits for Inspection & Repair - Operations	Recompletion Traffic	Condensate Tanks & Traffic	Flaring and Heaters	Compression Engines	Dehydrators	Compression Station Fugitives	Road Maintenance	Road Reclamation	Well Reclamation
CO2	313.61	50.05	31.52	0.46	0.36	11.95	13.77	105.00	16.63	9.43	0.00	9.75	0.01	0.15
CH4	0.00	0.00	0.00	0.00	0.00	0.00	107.01	0.00	0.00	9.69	0.01	0.00	0.00	0.00
N2O	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
CO2eq	314.73	50.29	31.64	0.47	0.36	12.02	2260.96	105.65	16.65	213.00	0.31	9.78	0.01	0.15
CO2eq metric tons	285.60	45.64	28.71	0.42	0.33	10.91	2051.68	95.87	15.11	193.29	0.29	8.88	0.00	0.14

North Dakota Non-Federal NG Wells Summaries

Total Annual Emissions from Non-Federal NG Wells - RFD Estimates

Activity	Annual Emissions (Tons)				
	CO_2	CH_4	N_2O	CO_{2eq}	CO_{2eq} metric tons
Well Pad Construction - Fugitive Dust	---	---	---	---	---
Heavy Equipment Combustive Emissions	1777.11	0.02	0.02	1783.46	1618.39
Commuting Vehicles - Construction	283.62	0.01	0.00	284.05	257.76
Wind Erosion	---	---	---	---	---
Sub-total: Construction	**2,060.74**	**0.03**	**0.02**	**2,067.52**	**1,876.15**
Well Workover Operations - Fugitive Dust			---	---	---
Well Workover Operations - On-site Exhaust	178.63	0.00	0.00	179.28	162.69
Well Workover Operations - On-road Exhaust	2.63	0.00	0.00	2.65	2.41
Well Visits for Inspection & Repair - Operations	1.99	0.00	0.00	2.01	1.83
Recompletion Traffic	66.04	0.00	0.00	66.45	60.30
Condensate Tanks & Traffic	76.09	591.36	0.00	12494.76	11338.26
Flaring and Heaters	588.55	0.01	0.01	592.13	537.33
Compression Engines	91.92	0.00	0.00	92.01	83.50
Dehydrators	52.10	53.56	0.00	1177.11	1068.16
Compression Station Fugitives	0.01	0.08	0.00	1.74	1.58
Sub-total: Operations	**1,057.97**	**645.02**	**0.02**	**14,608.15**	**13,256.03**
Road Maintenance	53.88	0.00	0.00	54.07	49.07
Sub-total: Maintenance	**53.880**	**0.001**	**0.00**	**54.07**	**49.07**
Road Reclamation	0.03	0.00	0.00	0.03	0.03
Well Reclamation	0.84	0.00	0.00	0.85	0.77
Sub-total: Reclamation	**0.8684**	**0.0000**	**0.0000**	**0.8756**	**0.7946**
Total Emissions	**3,173.45**	**645.05**	**0.04**	**16,730.62**	**15,182.05**

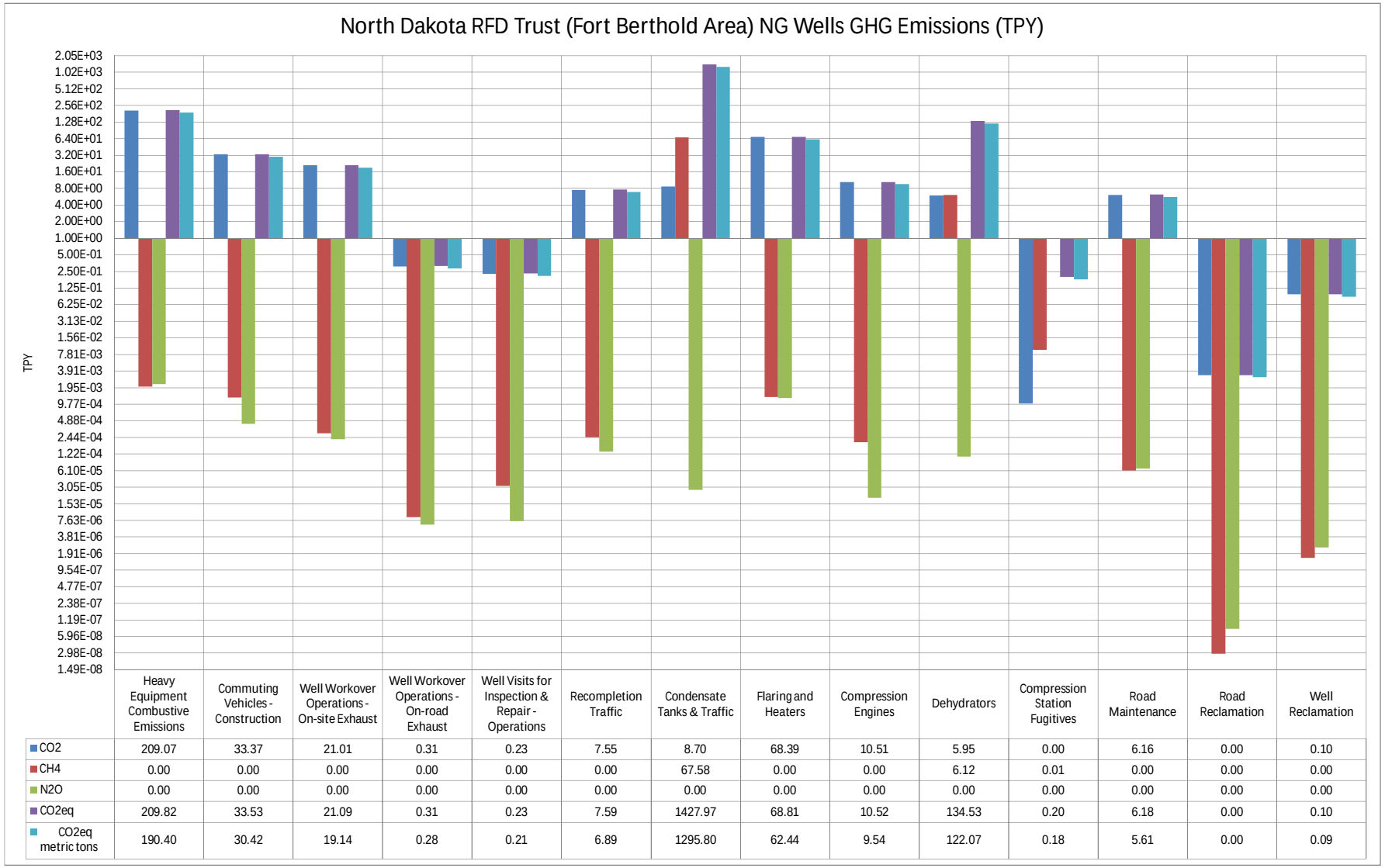


	Heavy Equipment Combustive Emissions	Commuting Vehicles - Construction	Well Workover Operations - On-site Exhaust	Well Workover Operations - On-road Exhaust	Well Visits for Inspection & Repair - Operations	Recompletion Traffic	Condensate Tanks & Traffic	Flaring and Heaters	Compression Engines	Dehydrators	Compression Station Fugitives	Road Maintenance	Road Reclamation	Well Reclamation
CO2	1777.11	283.62	178.63	2.63	1.99	66.04	76.09	588.55	91.92	52.10	0.01	53.88	0.03	0.84
CH4	0.02	0.01	0.00	0.00	0.00	0.00	591.36	0.01	0.00	53.56	0.08	0.00	0.00	0.00
N2O	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
CO2eq	1783.46	284.05	179.28	2.65	2.01	66.45	12494.76	592.13	92.01	1177.11	1.74	54.07	0.03	0.85
CO2eq metric tons	1618.39	257.76	162.69	2.41	1.83	60.30	11338.26	537.33	83.50	1068.16	1.58	49.07	0.03	0.77

North Dakota Trust (Fort Berthold Area) NG Wells Summaries

Total Annual Emissions from Trust (Fort Berthold Area) NG Wells - RFD Estimates

Activity	Annual Emissions (Tons)				
	CO_2	CH_4	N_2O	CO_{2eq}	CO_{2eq} metric tons
Well Pad Construction - Fugitive Dust	---	---	---	---	---
Heavy Equipment Combustive Emissions	209.07	0.00	0.00	209.82	190.40
Commuting Vehicles - Construction	33.37	0.00	0.00	33.53	30.42
Wind Erosion	---	---	---	---	---
Sub-total: Construction	**242.44**	**0.00**	**0.00**	**243.35**	**220.82**
Well Workover Operations - Fugitive Dust			---	---	---
Well Workover Operations - On-site Exhaust	21.01	0.00	0.00	21.09	19.14
Well Workover Operations - On-road Exhaust	0.31	0.00	0.00	0.31	0.28
Well Visits for Inspection & Repair - Operations	0.23	0.00	0.00	0.23	0.21
Recompletion Traffic	7.55	0.00	0.00	7.59	6.89
Condensate Tanks & Traffic	8.70	67.58	0.00	1427.97	1295.80
Flaring and Heaters	68.39	0.00	0.00	68.81	62.44
Compression Engines	10.51	0.00	0.00	10.52	9.54
Dehydrators	5.95	6.12	0.00	134.53	122.07
Compression Station Fugitives	0.00	0.01	0.00	0.20	0.18
Sub-total: Operations	**122.65**	**73.72**	**0.00**	**1,671.25**	**1,516.56**
Road Maintenance	6.16	0.00	0.00	6.18	5.61
Sub-total: Maintenance	**6.158**	**0.000**	**0.00**	**6.18**	**5.61**
Road Reclamation	0.00	0.00	0.00	0.00	0.00
Well Reclamation	0.10	0.00	0.00	0.10	0.09
Sub-total: Reclamation	**0.0992**	**0.0000**	**0.0000**	**0.1001**	**0.0908**
Total Emissions	**371.34**	**73.72**	**0.00**	**1,920.88**	**1,743.08**

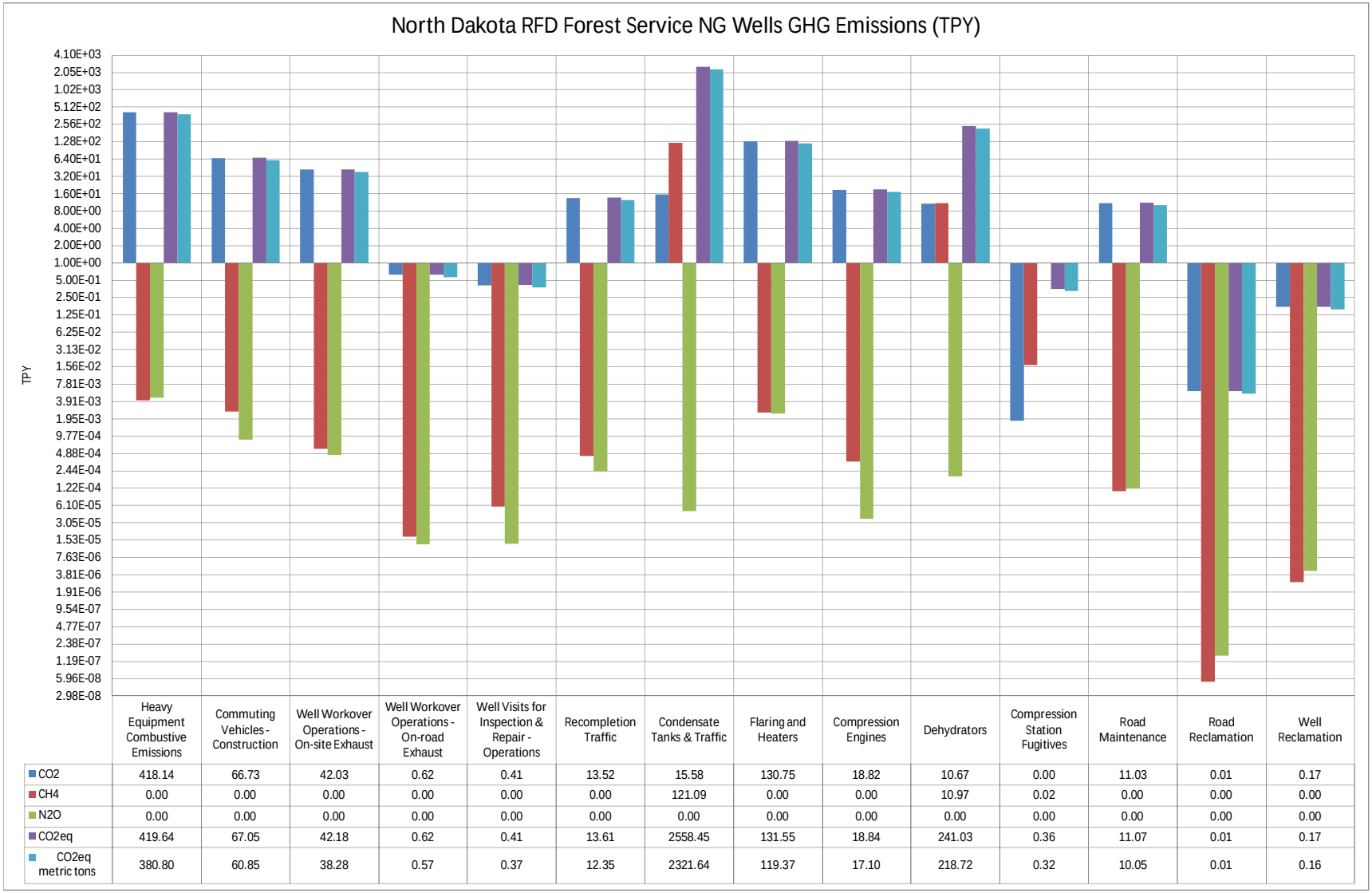


	Heavy Equipment Combustive Emissions	Commuting Vehicles - Construction	Well Workover Operations - On-site Exhaust	Well Workover Operations - On-road Exhaust	Well Visits for Inspection & Repair - Operations	Recompletion Traffic	Condensate Tanks & Traffic	Flaring and Heaters	Compression Engines	Dehydrators	Compression Station Fugitives	Road Maintenance	Road Reclamation	Well Reclamation
CO2	209.07	33.37	21.01	0.31	0.23	7.55	8.70	68.39	10.51	5.95	0.00	6.16	0.00	0.10
CH4	0.00	0.00	0.00	0.00	0.00	0.00	67.58	0.00	0.00	6.12	0.01	0.00	0.00	0.00
N2O	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
CO2eq	209.82	33.53	21.09	0.31	0.23	7.59	1427.97	68.81	10.52	134.53	0.20	6.18	0.00	0.10
CO2eq metric tons	190.40	30.42	19.14	0.28	0.21	6.89	1295.80	62.44	9.54	122.07	0.18	5.61	0.00	0.09

North Dakota Forest Service NG Wells Summaries

Total Annual Emissions from Forest Service NG Wells - RFD Estimates

Activity	Annual Emissions (Tons)				
	CO_2	CH_4	N_2O	CO_{2eq}	CO_{2eq} metric tons
Well Pad Construction - Fugitive Dust	---	---	---	---	---
Heavy Equipment Combustive Emissions	418.14	0.00	0.00	419.64	380.80
Commuting Vehicles - Construction	66.73	0.00	0.00	67.05	60.85
Wind Erosion	---	---	---	---	---
Sub-total: Construction	**484.88**	**0.01**	**0.01**	**486.69**	**441.65**
Well Workover Operations - Fugitive Dust			---	---	---
Well Workover Operations - On-site Exhaust	42.03	0.00	0.00	42.18	38.28
Well Workover Operations - On-road Exhaust	0.62	0.00	0.00	0.62	0.57
Well Visits for Inspection & Repair - Operations	0.41	0.00	0.00	0.41	0.37
Recompletion Traffic	13.52	0.00	0.00	13.61	12.35
Condensate Tanks & Traffic	15.58	121.09	0.00	2558.45	2321.64
Flaring and Heaters	130.75	0.00	0.00	131.55	119.37
Compression Engines	18.82	0.00	0.00	18.84	17.10
Dehydrators	10.67	10.97	0.00	241.03	218.72
Compression Station Fugitives	0.00	0.02	0.00	0.36	0.32
Sub-total: Operations	**232.40**	**132.08**	**0.00**	**3,007.05**	**2,728.72**
Road Maintenance	11.03	0.00	0.00	11.07	10.05
Sub-total: Maintenance	**11.033**	**0.000**	**0.00**	**11.07**	**10.05**
Road Reclamation	0.01	0.00	0.00	0.01	0.01
Well Reclamation	0.17	0.00	0.00	0.17	0.16
Sub-total: Reclamation	**0.1778**	**0.0000**	**0.0000**	**0.1793**	**0.1627**
Total Emissions	**728.49**	**132.08**	**0.01**	**3,504.99**	**3,180.57**



	Heavy Equipment Combustive Emissions	Commuting Vehicles - Construction	Well Workover Operations - On-site Exhaust	Well Workover Operations - On-road Exhaust	Well Visits for Inspection & Repair - Operations	Recompletion Traffic	Condensate Tanks & Traffic	Flaring and Heaters	Compression Engines	Dehydrators	Compression Station Fugitives	Road Maintenance	Road Reclamation	Well Reclamation
CO2	418.14	66.73	42.03	0.62	0.41	13.52	15.58	130.75	18.82	10.67	0.00	11.03	0.01	0.17
CH4	0.00	0.00	0.00	0.00	0.00	0.00	121.09	0.00	0.00	10.97	0.02	0.00	0.00	0.00
N2O	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
CO2eq	419.64	67.05	42.18	0.62	0.41	13.61	2558.45	131.55	18.84	241.03	0.36	11.07	0.01	0.17
CO2eq metric tons	380.80	60.85	38.28	0.57	0.37	12.35	2321.64	119.37	17.10	218.72	0.32	10.05	0.01	0.16

Exhaust Emissions from Heavy Construction Equipment

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

Project Year/Hp Category	Emission Factors (g/hp-hr)		
	CO_2	CH_4	N_2O[a]
Year 2018			
50 to 75	589.096	0.0064	0.0058
75 to 100	589.103	0.0064	0.0058
100 to 175	530.097	0.0047	0.0058
175 to 300	530.181	0.0043	0.0058
300 to 600	530.255	0.0040	0.0058
600 to 750	530.283	0.0038	0.0058
>750	529.917	0.0056	0.0058

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

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

Exhaust Emission Estimations for Construction Equipment - Based on Peak Wells Drilled each Alternative (using 2008 emission factors)

Construction Activity	Equipment Type	Capacity (hp)	# of Units	Av. Load Factor (%)	# of Oper. Hours/Day	# of Oper. Days/ Activity	# of Oper. Hours/Activity	# of Activities / Well	Emissions (tons/year/well)		
									CO_2	CH_4	N_2O
Drilling Roads	Blade	100	1	80	10	1.00	10.00	1.0000	4.67E-01	4.19E-06	5.09E-06
	Backhoe	80	1	75	10	1.00	10.00	1.0000	3.90E-01	4.20E-06	3.82E-06
Drilling Well Pad	Backhoe	80	1	75	10	1.00	10.00	1.0000	3.90E-01	4.20E-06	3.82E-06
Water Disposal well pad	Backhoe	80	1	75	10	2.00	20.00	0.1429	1.11E-01	1.20E-06	1.09E-06
New Pipeline Intermediate	Blade	100	1	80	10	5.00	50.00	0.1108	2.88E-01	3.10E-06	2.82E-06
	Trencher	175	1	80	10	5.00	50.00	0.1108	4.53E-01	4.06E-06	4.93E-06
	Backhoe	80	1	75	10	10.00	100.00	0.1108	4.32E-01	4.65E-06	4.23E-06
New Sales Pipeline	Blade	100	1	80	10	43.00	430.00	0.0002	3.68E-03	3.96E-08	3.60E-08
	Trencher	175	1	80	10	43.00	430.00	0.0002	5.79E-03	5.18E-08	6.30E-08
	Backhoe	80	1	75	10	65.00	650.00	0.0002	4.17E-03	4.49E-08	4.08E-08
Booster Compression Station	Dozer	350	1	80	10	2.00	20.00	0.1108	3.63E-01	2.70E-06	3.95E-06
	Backhoe	80	2	80	10	3.00	30.00	0.1108	2.76E-01	2.98E-06	2.71E-06
Sales Compression Station	Dozer	350	1	80	10	2.00	20.00	0.0110	3.61E-02	2.69E-07	3.93E-07
	Backhoe	80	2	80	10	3.00	30.00	0.0110	2.75E-02	2.96E-07	2.69E-07
								Subtotal	**3.25E+00**	**3.20E-05**	**3.32E-05**

Average number of days to construct wellpad and road: 2 obtained from BLM - NDFO.

Number of water disposal wells value (per well) provided by ND BLM.

Exhaust Emission Factors for Diesel Powered Bore/Drill Rig Engines

Project Year/Hp Category	Emission Factors (g/hp-hr)		
	CO_2	CH_4	N_2O[a]
Year 2018			
50 to 75	589.0959	0.0064	0.0058
75 to 100	589.1032	0.0064	0.0058
100 to 175	530.0969	0.0047	0.0058
175 to 300	530.1812	0.0043	0.0058
300 to 600	530.2546	0.0040	0.0058
600 to 750	530.2834	0.0038	0.0058
>750	529.9171	0.0056	0.0058

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

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

Combustive Emissions Estimation for Industrial Engines - Based on Peak Wells Drilled each Alternative

Construction Activity	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Oper. Hours/Day	# of Oper. Days/ Well	# of Oper. Hours/Well	# of Wells	Emissions (tons/year/well)		
									CO_2	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Main Deck	1550	1	60	18	2.00	36.00	1.0000	1.96E+01	1.46E-04	2.13E-04
	Auxillary Pump	200	1	90	18	2.00	36.00	1.0000	3.79E+00	3.09E-05	4.12E-05
Well Completion & Testing	Main Deck	850	1	60	18	1.00	18.00	1.0000	5.37E+00	4.00E-05	5.84E-05
	Auxillary Pump	125	1	90	18	1.00	18.00	1.0000	1.18E+00	1.06E-05	1.29E-05
Water Disposal well drilling	Generator	1476	1	40	24	30.00	720.00	0.1429	3.55E+01	3.78E-04	3.86E-04
	Generator	1476	1	40	24	30.00	720.00	0.1429	3.55E+01	3.78E-04	3.86E-04
								Subtotal	**1.01E+02**	**9.83E-04**	**1.10E-03**
								Total	**1.04E+02**	**1.02E-03**	**1.13E-03**

Water disposal well pad development rates and gas well drilling rates provided by ND BLM (2010).

Temporary Emission Estimations for Field Generators: Based on Peak Wells Drilled each Alternative

Construction Activity	Equipment Type	Capacity (hp)	# of Wells Served[a]	Avg. Load Factor	# of Oper. Hours/Day	# of Oper. Days/Well	# of Oper. Hours/Well	# of Wells	Emissions (tons/year/well)		
									CO_2	CH_4	N_2O
Field Generators	Field Generators for Pumps & Lighting	21	1	75	24	2.0000	48.0000	1.0000	4.41E-01	3.95E-06	4.80E-06
								Total	**4.41E-01**	**3.95E-06**	**4.80E-06**

Exhaust Emissions from Construction and Drilling Support Vehicles

Emission Factors for Commuting Vehicles

Vehicle		Emission Factors (g/mi)		
Type	Class	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	409.5	0.002	0.016
Heavy-Duty Diesel Truck	HDDV	791.8	0.04	0.006

Source: MOBILE6.2.03

[a] 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).

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 (tons/well)		
	Type	Class					CO_2	CH_4	N_2O
Improved & Two-Track Road	Semi Trucks	HDDV	50	47	2350	1	2.05E+00	9.58E-05	1.49E-05
	Pickup Trucks	LDDT	50	3	150	1	6.77E-02	3.31E-07	2.56E-06
Well Pad	Semi Trucks	HDDV	50	5	250	1	2.18E-01	1.02E-05	1.59E-06
	Pickup Trucks	LDDT	50	4	200	1	9.03E-02	4.41E-07	3.42E-06
Other Construction Activities	Semi Trucks	HDDV	50	2	100	1	8.73E-02	4.08E-06	6.36E-07
	Haul Trucks	HDDV	50	2	100	1	8.73E-02	4.08E-06	6.36E-07
	Pickup Trucks	LDDT	50	1	50	1	2.26E-02	1.10E-07	8.54E-07
						Subtotal	**2.62E+00**	**1.15E-04**	**2.46E-05**

Round trip miles traveled based on ND BLM guidance.

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 (tons/well)		
	Type	Class					CO_2	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Semi Rig Transport, Drill Rig	HDDV	50	44	2200	1	1.92E+00	8.97E-05	1.40E-05
	Fuel Haul Truck	HDDV	50	6	300	1	2.62E-01	1.22E-05	1.91E-06
	Mud Haul Truck, Water Hauling	HDDV	50	4	200	1	1.75E-01	8.16E-06	1.27E-06
	Rig Crew	LDDT	50	51	2550	1	1.15E+00	5.62E-06	4.36E-05
	Rig Mechanics	HDDV	50	2	100	1	8.73E-02	4.08E-06	6.36E-07
	Co. Supervisor	LDDT	50	20	1000	1	4.51E-01	2.20E-06	1.71E-05
	Tool Pusher	LDDT	50	8	400	1	1.81E-01	8.82E-07	6.83E-06
	Mud Logger	LDDT	50	6	300	1	1.35E-01	6.61E-07	5.13E-06
	Mud Engineer	LDDT	50	15	750	1	3.39E-01	1.65E-06	1.28E-05
	Logger, Engr Truck	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Drill Bit Delivery	LDDT	50	2	100	1	4.51E-02	2.20E-07	1.71E-06

Round trip miles traveled based on ND BLM guidance.

Combustive Emissions Estimation Road Traffic (cont.)

Construction Site Destination	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells	Emissions (tons/well)		
	Type	Class					CO_2	CH_4	N_2O
Well Completion & Testing	Semi Casing Haulers	HDDV	50	6	300	1	2.62E-01	1.22E-05	1.91E-06
	Semi Completion, Unit Rig	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Semi Fracing, Blender	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Semi Pumping/Tank Battery	HDDV	50	6	300	1	2.62E-01	1.22E-05	1.91E-06
	Tubing Truck	HDDV	50	2	100	1	8.73E-02	4.08E-06	6.36E-07
	Haul Cementer, Pump Truck	HDDV	50	2	100	1	8.73E-02	4.08E-06	6.36E-07
	Haul Cementer, Cement Truck	HDDV	50	3	150	1	1.31E-01	6.12E-06	9.54E-07
	Haul Completion, Equip Truck	HDDV	50	3	150	1	1.31E-01	6.12E-06	9.54E-07
	Haul Service	LDDT	50	2	100	1	4.51E-02	2.20E-07	1.71E-06
	Haul Perforators Logging Truck	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Anchor, Installation	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Anchor, Testing	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Fracing, Tank	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Fracing, Pump	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Fracing, Chemical	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Fracing, Sand	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Fracing, Other	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Welders	HDDV	50	6	300	1	2.62E-01	1.22E-05	1.91E-06
	Haul Water	HDDV	50	150	7500	1	6.55E+00	3.06E-04	4.77E-05
	Pickup Cementer, Engineer	LDDT	50	2	100	1	4.51E-02	2.20E-07	1.71E-06
	Pickup Casing Crew	HDDV	50	2	100	1	8.73E-02	4.08E-06	6.36E-07
	Pickup Completion Crew	HDDV	50	5	250	1	2.18E-01	1.02E-05	1.59E-06

	Pickup Completion, Pusher	LDDT	50	5	250	1	1.13E-01	5.51E-07	4.27E-06
	Pickup Perforators, Engineer	LDDT	50	2	100	1	4.51E-02	2.20E-07	1.71E-06
	Pickup Fracing, Engineer	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Pickup Co. Supervisor	LDDT	50	10	500	1	2.26E-01	1.10E-06	8.54E-06
	Pickup Miscellaneous	LDDT	50	3	150	1	6.77E-02	3.31E-07	2.56E-06
	Pickup Roustabout	HDDV	50	4	200	1	1.75E-01	8.16E-06	1.27E-06
						Subtotal	**1.41E+01**	**5.38E-04**	**1.89E-04**
						Total	**1.67E+01**	**6.53E-04**	**2.14E-04**

Round trip miles traveled based on ND BLM guidance.

Exhaust Emissions from Well Work Overs

Emission Factors Bore/Drill Rig Engines 300-600 Hp

Fuel Type	Emission Factors (gm/hp-hr)		
	CO_2	CH_4	N_2O[a]
Diesel	529.575	0.007	0.006

Source: EPA NONROADS 2008a. Year 2008.

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

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 (tons/year/well)		
							CO_2	CH_4	N_2O
Well Workover	Truck-Mounted Unit	600	10	3	30	1	1.05E+01	1.46E-04	1.14E-04

Exhaust emission factors for commuting vehicles

Vehicle		Emission Factors (g/mi)		
Type	Class	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	409.500	0.002	0.016
Heavy-Duty Diesel Truck	HDDV	791.800	0.037	0.006

Source: MOBILE 6.2.03

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

[a] 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

Activity	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells Drilled	Max. Annual Emissions (tons/year/well)		
	Type	Class					CO_2	CH_4	N_2O
Well Workover	WO Rig	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Truck	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Pickup Truck	LDDT	50	3	150	1	6.77E-02	3.31E-07	2.56E-06
						Total	**1.55E-01**	**4.41E-06**	**3.20E-06**

Performed once in the first year of well operation and applied to peak number of wells drilled annually.
Round trip miles traveled based on ND BLM guidance.

Exhaust Emissions from Site Visits and Inspections

Emission factors for Commuting Vehicles Exhaust

Vehicle Class	Emission Factors (g/mi)		
	CO_2	CH_4	N_2O[a]
Light-Duty Gasoline Truck	476.90	0.07	0.02

Source: MOBILE 6.2.03
Emission factors for 2008 used for all years = conservative estimate for fleet vehicle turnover
[a] 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)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Federal Wells Producing	Emissions (tons/yr/well)		
	Type	Class					CO_2	CH_4	N_2O
Inspection Visits for Wells	Pickup Truck	LDGT2	1.5	12	18	1	9.46E-03	1.35E-06	3.06E-07

Roundtrip distance shown in AECOM dataset.

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 year

[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
Number of Wells	1
Cumulative Length of Roads [b] (miles/operation)	1

[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	0.3333	3.3333
Winter	1	1	5	10	0.2000	2.0000
				Total	**0.5333**	**5.3333**

Emission Factors for Construction Equipment Exhaust

Equipment	Emission Factors (g/hp-hr)		
	CO_2	CH_4	N_2O[a]
Grader 100-175 Hp	535.7700	0.0053	0.0058

Source: EPA NONROADS 2008a

Use emission factors for 2008 for all project years - conservative estimate of vehicle turnover

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

Emission Estimations for Grader: RMP Year 20

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours[a]	Emissions (tons/well)		
				CO_2	CH_4	N_2O
Road Maintenance	Grader	135	3.20	2.55E-01	2.52E-06	2.75E-06

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

Emission Factors for Commuting Vehicles Exhaust

Vehicle Class	Emission Factors (g/mi)		
	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	409.500	0.002	0.016

Source: MOBILE 6.2.03

[a] 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 (tons/yr)		
	Type	Class				CO_2	CH_4	N_2O
Road Maintenance	Pickup Truck	LDDT	6	0.5333	3.2000	1.44E-03	7.05E-09	5.47E-08

Condensate Tank, Loadout and Hauling Emissions

NG Well Condensate Seperator Flashing and Tank Emissions[a]

Project Year	Emissions[b]			
	HAPs Emissions (ton/yr/well)	VOC Emissions (ton/yr/well)	CO_2 Emissions (ton/yr/well)	CH_4 Emissions (ton/yr/well)
All	1.89E-01	6.82E+00	2.06E-01	2.82E+00

[a] Based on Regional (northwest U.S.) typical data values and calculations using E&P Tanks, August, 2010 -- API Gravity : 50, RVP : 7.4 psia, seperator pressure: 700 psig, seperator temperature: 100F, white tank, Montana weather conditions. Assumes 2 bbl condensate per day per well.
[b] Assumes no emissions control.

NG Well Condensate 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/10^3 gal) 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 =	8.0	ave. vapor pressure from GMI-EIS Feb. 2010 (BLM NOC Workbook)
M =	68	Typical condensate value shown in BLM NOC Workbook.
T =	540	ave. temp.
L_L =	7.53	

NG Well Condensate Truck Loadout Emissions - All Project Years[a]

Project Year	Emission Factor (lbs/1,000 gallons)	Annual Consensate Volume (bbl) - per well	Condensate (1,000 gallons)	VOC Emissions (tpy/well)	CO_2 Emissions (tpy/well)	CH_4 Emissions (tpy/well)
All	7.53	717	30	1.13E-01	0.00E+00	0.00E+00

[a] Uses E&P Tanks Stream Data for W&S Gas mol % (shown below). Regional typical E&P Tanks input data (see composition below). Annual condensate production value found in AECOM dataset.

Emission Factors for Work Over Vehicles - Road Traffic

Vehicle Class	Emission Factors (g/mi)		
	CO_2	CH_4	N_2O[a]
Heavy-Duty Diesel Truck (HDDV)	791.800	0.037	0.006

Source: MOBILE6.2.03

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

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

Activity	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well	Miles Traveled/Well	Total # of Wells	Emissions (tons/year/well)		
	Type	Class					CO_2	CH_4	N_2O
Produced Condensate Hauling	Haul Truck (200 bbl)	HDDV	50	3.6	179.14	1	1.56E-01	7.31E-06	1.14E-06
						TOTAL	**1.56E-01**	**7.31E-06**	**1.14E-06**

Round trip miles traveled based on ND BLM guidance. Assumes all condensate is stored on well pad.

W&S Composition for Truck Load Out Emissions

W&S Gas Component	Mole Fraction[a] (%)	Molecular Weight (lb/lb-mol)	Gas Weight (lb/lb-mol)	Weight Percent (wt%)
Methane	0.000	16.040	0.000	0.000
Ethane	0.000	30.070	0.000	0.000
Nitrogen	0.000	28.020	0.000	0.000
Water	0.000	18.015	0.000	0.000
Carbon Dioxide	0.000	43.990	0.000	0.000
Nitrous Oxide	0.000	44.020	0.000	0.000
Hydrogen Sulfide	0.000	34.060	0.000	0.000
Non-reactive, non-HAP	0.000	---	0.000	0.000
Propane	0.000	44.100	0.000	0.000
Iso-butane	0.000	58.120	0.000	0.000
n-butane	9.011	58.120	5.237	6.816
i-pentane	22.661	72.150	16.350	21.278
n-pentane	20.732	72.150	14.958	19.467
Hexanes	13.459	100.210	13.487	17.552
Heptanes	14.283	100.200	14.312	18.625
Octanes	5.087	114.230	5.810	7.562
Nonanes	0.771	128.258	0.988	1.286
Decanes+	0.059	142.29	0.083	0.109
Reactive VOC	86.062	---	71.226	92.695
Benzene	2.276	78.110	1.777	2.313
Ethylbenzene	0.009	106.160	0.009	0.012
n-Hexane	7.516	100.210	7.532	9.802
Toluene	4.036	92.130	3.718	4.839
Xylenes	0.102	106.160	0.108	0.141
HAPs	13.938	---	13.145	17.107
Totals	**100.000**	**---**	**76.839**	**100.000**

[a] E&P Tanks Stream Data for W&S Gas mol %. Regional (northwest U.S.) typical E&P Tanks input data -- API Gravity : 50, RVP : 7.4 psia, seperator pressure: 700 psig, seperator temperature: 100F, white tank, Montana weather conditions. Assumes 2 bbl condensate per day per well.

Exhaust Emissions from Recompletion Support Vehicles

Emission Factors for Commuting Vehicles

Vehicle		Emission Factors (g/mi)		
Type	Class	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	409.500	0.002	0.016
Heavy-Duty Diesel Truck	HDDV	791.800	0.037	0.006

Source: MOBILE6.2.03

[a] 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).

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 (tons/well)		
	Type	Class					CO_2	CH_4	N_2O
Well Recompletion	Fuel Haul Truck	HDDV	50	6	300	1	2.62E-01	1.22E-05	1.91E-06
	Mud Haul Truck, Water Hauling	HDDV	50	4	200	1	1.75E-01	8.16E-06	1.27E-06
	Rig Crew	LDDT	50	51	2550	1	1.15E+00	5.62E-06	4.36E-05
	Rig Mechanics	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Co. Supervisor	LDDT	50	20	1000	1	4.51E-01	2.20E-06	1.71E-05
	Semi Completion, Unit Rig	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Semi Fracing, Blender	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Semi Pumping/Tank Battery	HDDV	50	6	300	1	2.62E-01	1.22E-05	1.91E-06
	Tubing Truck	HDDV	50	2	100	1	8.73E-02	4.08E-06	6.36E-07
	Haul Cementer, Pump Truck	HDDV	50	2	100	1	8.73E-02	4.08E-06	6.36E-07
	Haul Cementer, Cement Truck	HDDV	50	3	150	1	1.31E-01	6.12E-06	9.54E-07
	Haul Completion, Equip Truck	HDDV	50	3	150	1	1.31E-01	6.12E-06	9.54E-07
	Haul Service Tools	LDDT	50	2	100	1	4.51E-02	2.20E-07	1.71E-06
	Haul Perforators Logging Truck	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Fracing, Tank	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Fracing, Pump	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Fracing, Chemical	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Fracing, Sand	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Fracing, Other	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Water Truck	HDDV	50	50	2500	1	2.18E+00	1.02E-04	1.59E-05
	Pickup Cementer, Engineer	LDDT	50	2	100	1	4.51E-02	2.20E-07	1.71E-06
	Pickup Completion Crew	HDDV	50	5	250	1	2.18E-01	1.02E-05	1.59E-06
	Pickup Completion, Pusher	LDDT	50	5	250	1	1.13E-01	5.51E-07	4.27E-06
	Pickup Perforators, Engineer	LDDT	50	2	100	1	4.51E-02	2.20E-07	1.71E-06
	Pickup Fracing, Engineer	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Pickup Co. Supervisor	LDDT	50	10	500	1	2.26E-01	1.10E-06	8.54E-06
	Pickup Miscellaneous Supplies	LDDT	50	3	150	1	6.77E-02	3.31E-07	2.56E-06
	Pickup Roustabout Crew	HDDV	50	4	200	1	1.75E-01	8.16E-06	1.27E-06
						Subtotal	**6.29E+00**	**2.04E-04**	**1.11E-04**
						Total	**6.29E+00**	**2.04E-04**	**1.11E-04**

Round trip miles traveled based on ND BLM guidance.

Gas Analysis

Gas Component	Mole Fraction (%)	Molecular Weight (lb/lb-mol)	Gas Weight (lb/lb-mol)	Weight Percent (wt%)	Weight (lb/MMscf)
Methane	92.532	16.040	14.842	84.677	35953.744
Ethane	0.633	30.070	0.190	1.086	461.089
Nitrogen	3.201	28.020	0.897	5.117	2172.709
Water	0.000	18.015	0.000	0.000	0.000
Carbon Dioxide	3.634	43.990	1.599	9.120	3872.458
Nitrous Oxide	0.000	44.020	0.000	0.000	0.000
Hydrogen Sulfide	0.000	34.060	0.000	0.000	0.000
Non-reactive, non-HAP	100.000	---	17.528	100.000	
Propane	0.000	44.100	0.000	0.000	0.000
Iso-butane	0.000	58.120	0.000	0.000	0.000
n-butane	0.000	58.120	0.000	0.000	0.000
i-pentane	0.000	72.150	0.000	0.000	0.000
n-pentane	0.000	72.150	0.000	0.000	0.000
Hexanes	0.000	100.210	0.000	0.000	0.000
Heptanes	0.000	100.200	0.000	0.000	0.000
Octanes	0.000	114.230	0.000	0.000	0.000
Nonanes	0.000	128.258	0.000	0.000	0.000
Decanes+	0.000	142.29	0.000	0.000	0.000
Reactive VOC	0.000	---	0.000	0.000	
Benzene	0.000	78.110	0.000	0.000	0.000
Ethylbenzene	0.000	106.160	0.000	0.000	0.000
n-Hexane [3]	*0.000*	*100.210*	*0.000*	*0.000*	*0.000*
Toluene	0.000	92.130	0.000	0.000	0.000
Xylenes	0.000	106.160	0.000	0.000	0.000
HAPs	0.000	---	0.000	0.000	
Totals	**100.000**	**---**	**17.528**	**100.000**	

Gas well natural gas analysis for : Winnipeg/Deadwood - Dimmick, Lease: Fancy Butte 14-32

Volume Flow: 0.065753425 MMSCF / day

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

Compressor Stations Emissions

Emission Factors for Natural Gas-Fired Compressors and Pumps

Compressor / Pump		Horse-Power Rating	Units	Emission Factors		
				CO_2 [a]	CH_4 [a]	N_2O [a]
Compression Station	Lean Burn	300	gm/bhp-hr	1.35E+02	2.55E-03	2.55E-04
			lb/MMBTU	1.17E+02	2.20E-03	2.20E-04

Note: Compressors assumed to be equipped with nonselective catalytic reduction (NSCR) catalyst.

[a] 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	Operating Hours/Year	Emissions (tons/year/well)		
					CO_2	CH_4	N_2O
Compression Station	0.3	1.00	0.3	8,760	4.38E-01	8.26E-06	8.26E-07
				Total	**4.38E-01**	**8.26E-06**	**8.26E-07**

Compression rate of 3000 planned HP for all projected ND developed gas. (AECOM)

Compressor Station Fugitives

Fugitive Emissions from Equipment Leaks

TOC Emission Factor								
Well Equipment Component	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 AECOM provided gas well gas analyses (see Gas Analysis Worksheet)

VOC Wt% =	0.00
CO2 Wt% =	9.12
CH4 Wt% =	84.68
N2O Wt% =	0.00

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	0.008	0.0099	0	0.0055	0	0.0002	7.78E-05	0.00E+00	7.09E-06	6.58E-05
pump seals	0.000	0.0053	0	0.0287	0	0.0001	0.00E+00	0.00E+00	0.00E+00	0.00E+00
others	0.000	0.0194	0	0.0165	0	0.0309	0.00E+00	0.00E+00	0.00E+00	0.00E+00
connectors	0.011	0.0004	0	0.0005	0	0.0002	4.94E-06	0.00E+00	4.50E-07	4.18E-06
flanges	0.027	0.0009	0	0.0002	0	0.0000	2.31E-05	0.00E+00	2.11E-06	1.96E-05
open-ended lines	0.000	0.0044	0	0.0031	0	0.0006	0.00E+00	0.00E+00	0.00E+00	0.00E+00
						TOTAL emissions/well/hr =	1.06E-04	0.00E+00	9.65E-06	8.96E-05

Number of components verified by ND BLM

Annual Emissions from Equipment Leaks Per Well								
Year	**Number of Producing Wells**	**Operating Hours**	**VOC emissions (lb/yr)**	**VOC emissions (ton/yr)**	**CO_2 emissions (lb/yr)**	**CO_2 emissions (ton/yr)**	**CH_4 emissions (lb/yr)**	**CH_4 emissions (ton/yr)**
Year 20	1	8760	0.00E+00	0.00E+00	8.45E-02	4.23E-05	7.85E-01	3.92E-04

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	0.2500
Number of Roads Reclaimed Annually Per Well	0.0100
Annual Miles of Roads reclaimed Per Well	0.0025
Number of wells reclaimed (per well)	0.0100

Reclaimation rate : 1% of operating wells reclaimed annually

Estimation of Total Operation Days and Hours

Annual Miles of Roads Reclaimed	Daily Miles of Road Work	Total # of Operating Days	Annual Operating Hours
0.003	6	0.0004	0.0042
		Total	**0.0042**

Assume average miles/day = 6

Emission Factors for 75-100 hp Off-Road Engines

Year	Emission Factors (g/hp-hr)		
	CO_2	CH_4	N_2O[a]
2008	600.507	0.010	0.016
2018	613.888	0.006	0.016
2027	608.641	0.003	0.016

[a] 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).

Exhaust Emissions Estimation for Grader Road Reclaim

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours	Emissions (tons/year/well)		
				CO_2	CH_4	N_2O
Road Reclamation	Grader	80	0.0025	1.35E-04	1.22E-09	3.42E-09

Exhaust Emission Factors for Commuting Reclaim Vehicles Road Traffic

Vehicle Class	Emission Factors (g/mi)		
	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	409.500	0.002	0.016

Source: MOBILE6.2.03

[a] 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).

Exhaust Emissions Estimation for Commuting Reclaim Vehicles: Road Traffic

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tons/year/well)		
	Type	Class				CO_2	CH_4	N_2O
Road Reclamation	Pickup Truck	LDDV	6	0.0004	0.0025	1.13E-06	5.51E-12	4.27E-11

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	0.0100	10	0.0100	0.1000

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

Exhaust Emissions Estimation for Grader: Well Reclamation

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours	Emissions (tons/year/well)		
				CO_2	CH_4	N_2O
Well Reclamation	Grader	100	0.0600	3.97E-03	6.62E-08	1.03E-07

Exhaust Emissions Estimation for Commuting Vehicles: Well Reclamation

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tons/year/well)		
	Type	Class				CO_2	CH_4	N_2O
Well Reclamation	Pickup Truck	LDDV	6	0.0100	0.0600	2.71E-05	1.32E-10	1.03E-09

Emissions for Gas Dehydration

Emission Factors for Dehydrator Heaters

Unit	CO_2	CH_4	N_2O
lb/MMSCF	120000.0	2.3	2.2
lb/MMBTU	117.647	0.002	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 (tons/year/well)		
				CO_2	CH_4	N_2O
2,190	1	2.20	0.0019	2.48E-01	4.76E-06	4.55E-06

Annual Dehydrator Venting and Tank Flashing Emissions

Annual Well Gas Production MMscf	CH_4 Emission Factor (ton per MMscf)	CH_4 Emissions (TPY/well)
24.0000	0.0106	2.55E-01

Gas analysis information found in AECOM Gas Analysis Database (see Gas Analysis Sheet for component percentages). GRI GLYCalc estimated emissions.

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 least once.

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

Emissions for External Gas Combustion

Emission Factors for External Gas Combustion (Flares and Heaters)

Unit	CO_2	CH_4	N_2O
lb/MMSCF	120000.0	2.3	2.2
lb/MMBTU	117.647	0.002	0.002

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

Well Completion Flaring	Gas Production /Well (MMSCFD)	# of Days of Flaring	# of Wells	Emissions (tons/year/well)		
				CO_2	CH_4	N_2O
Flaring	0.066	5	1	19.7260	0.0004	0.0004
Total				**19.7260**	**0.0004**	**0.0004**

Applied to all contructed wells. For well completion, assumes 100% of the gas is flared.
Based on BLM - NDFO value of ~ 24 MMSCF/year/well.

Well Re-Completion Flaring	Gas Production /Well (MMSCFD)	# of Days of Flaring	# of Wells	Emissions (tons/year/well)		
				CO_2	CH_4	N_2O
Flaring	0.066	5	1	19.7260	0.0004	0.0004
Total				**19.7260**	**0.0004**	**0.0004**

Applied to 5% of all operating wells. Assumes 100% of the gas is flared.
Based on BLM - NDFO value of ~ 24 MMSCF/year/well.

Well Blowdown Flaring	Gas Production /Well (MMSCFD)	# of Days of Flaring	# of Wells	Emissions (tons/year/well)		
				CO_2	CH_4	N_2O
Flaring	0.066	1	1	3.9452	0.0001	0.0001
Total				**3.9452**	**0.0001**	**0.0001**

Applied to 1% of all operating wells. Assumes 100% of the gas is flared.
Based on BLM - NDFO value of ~ 24 MMSCF/year/well.

Well Pad Heaters	Annual Heater Fuel Usage /Well (MMBTU/year/ well)	# of Wells	Emissions (tons/year/well)		
			CO_2	CH_4	N_2O
Seperator Heaters	3.06	1	0.1800	0.0000	0.0000
Total			**0.1800**	**0.0000**	**0.0000**

Applied to all operating wells. Based on conservative estimate - year around usage.
Based on BLM - NDFO annual fuel usage value (per conversation with Industry Engineers).

North Dakota input parameters for calculating CBNG wells emissions:

Maximum Annual Wells Drilled - Federal (excluding FS)	1	Maximum Annual Wells Drilled - Non-Federal	8	Maximum Annual Wells Drilled - Trust (Fort Berthold area)	1	Maximum Annual Wells Drilled - Forest Service	2
Federal Producing Wells (excluding FS)	16	Non-Federal Producing Wells	100	Trust (Fort Berthold area) Producing Wells	11	Forest Service Producing Wells	23
Average Annual Well Gas Production (MMSCF/year)	24	Average Annual Well Gas Production (MMSCF/year)	24	Average Annual Well Gas Production (MMSCF/year)	24	Average Annual Well Gas Production (MMSCF/year)	24

North Dakota Federal (excluding Forest Service) CBNG Wells Summaries

Total Annual Emissions from Federal CBNG Wells - RFD Estimates

Activity	Annual Emissions (Tons)				
	CO_2	CH_4	N_2O	CO_{2eq}	CO_{2eq} metric tons
Well Pad Construction - Fugitive Dust	---	---	---	---	---
Heavy Equipment Combustive Emissions	104.54	0.00	0.00	104.91	95.20
Commuting Vehicles - Construction	16.68	0.00	0.00	16.76	15.21
Wind Erosion	---	---	---	---	---
Sub-total: Construction	**121.22**	**0.00**	**0.00**	**121.67**	**110.41**
Well Workover Operations - Fugitive Dust	---	---	---	---	---
Well Workover Operations - On-site Exhaust	10.51	0.00	0.00	10.55	9.57
Well Workover Operations - On-road Exhaust	0.15	0.00	0.00	0.16	0.14
Well Visits for Inspection & Repair - Operations	0.15	0.00	0.00	0.15	0.14
Recompletion Traffic	5.03	0.00	0.00	5.06	4.59
Condensate Tanks & Traffic	5.80	45.06	0.00	951.98	863.87
Flaring and Heaters	3,664.01	0.07	0.07	3686.31	3345.11
Compression Engines	7.00	0.00	0.00	7.01	6.36
Dehydrators	3.97	4.08	0.00	89.68	81.38
Compression Station Fugitives	0.00	0.01	0.00	0.13	0.12
Sub-total: Operations	**3,696.63**	**49.21**	**0.07**	**4,751.04**	**4,311.29**
Road Maintenance	4.11	0.00	0.00	4.12	3.74
Sub-total: Maintenance	**4.105**	**0.000**	**0.00**	**4.12**	**3.74**
Road Reclamation	0.00	0.00	0.00	0.00	0.00
Well Reclamation	0.06	0.00	0.00	0.06	0.06
Sub-total: Reclamation	**0.0662**	**0.0000**	**0.0000**	**0.0667**	**0.0605**
Total Emissions	**3,822.02**	**49.22**	**0.07**	**4,876.90**	**4,425.50**

	Heavy Equipment Combustive Emissions	Commuting Vehicles - Construction	Well Workover Operations - On-site Exhaust	Well Workover Operations - On-road Exhaust	Well Visits for Inspection & Repair - Operations	Recompletion Traffic	Condensate Tanks & Traffic	Flaring and Heaters	Compression Engines	Dehydrators	Compression Station Fugitives	Road Maintenance	Road Reclamation	Well Reclamation
CO2	104.54	16.68	10.51	0.15	0.15	5.03	5.80	3,664.01	7.00	3.97	0.00	4.11	0.00	0.06
CH4	0.00	0.00	0.00	0.00	0.00	0.00	45.06	0.07	0.00	4.08	0.01	0.00	0.00	0.00
N2O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00
CO2eq	104.91	16.76	10.55	0.16	0.15	5.06	951.98	3686.31	7.01	89.68	0.13	4.12	0.00	0.06
CO2eq metric tons	95.20	15.21	9.57	0.14	0.14	4.59	863.87	3345.11	6.36	81.38	0.12	3.74	0.00	0.06

North Dakota Non-Federal CBNG Wells Summaries

Total Annual Emissions from Non-Federal CBNG Wells - RFD Estimates

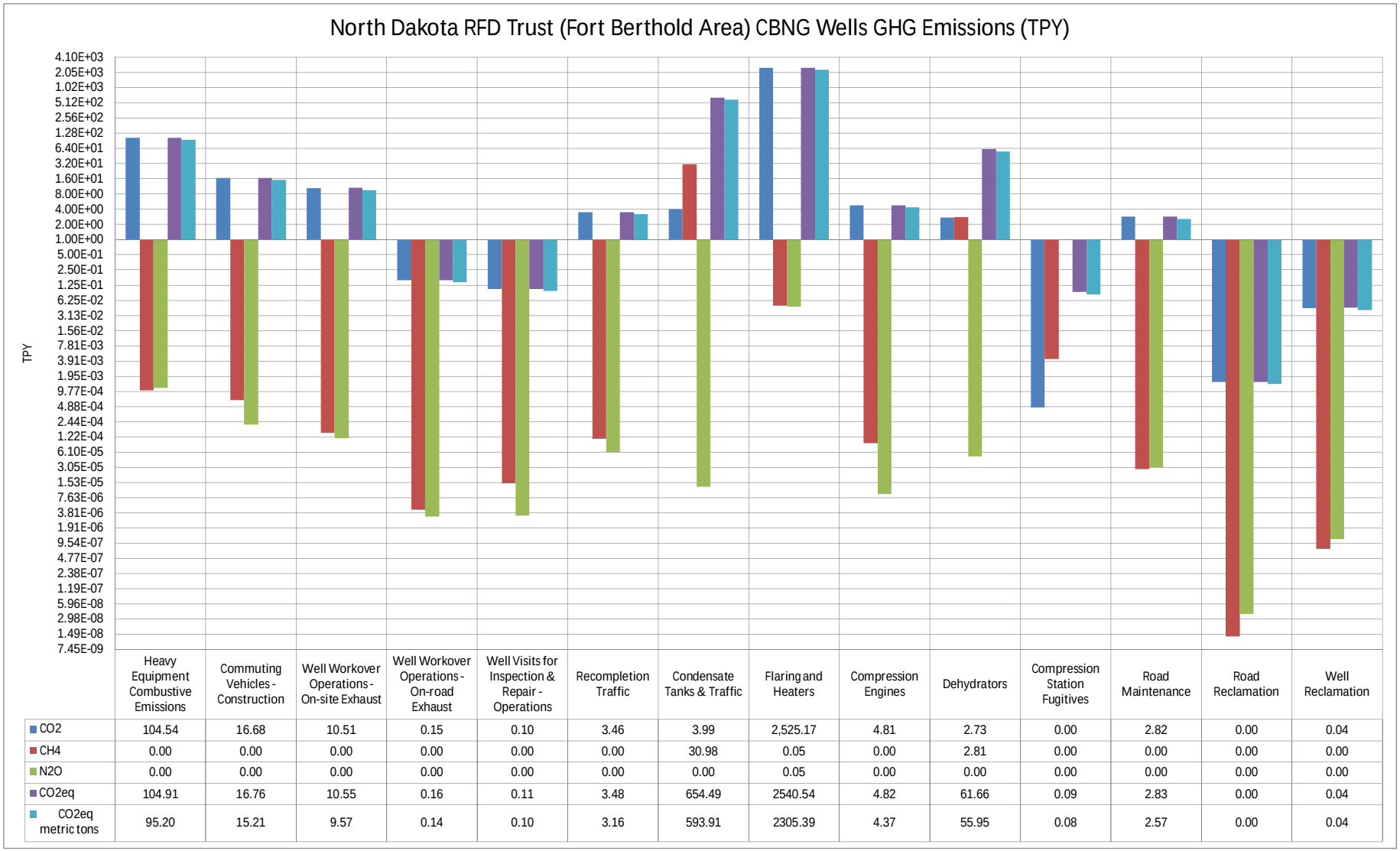
Activity	Annual Emissions (Tons)				
	CO_2	CH_4	N_2O	CO_{2eq}	CO_{2eq} metric tons
Well Pad Construction - Fugitive Dust	---	---	---	---	---
Heavy Equipment Combustive Emissions	836.29	0.01	0.01	839.28	761.59
Commuting Vehicles - Construction	133.47	0.01	0.00	133.64	121.27
Wind Erosion	---	---	---	---	---
Sub-total: Construction	**969.76**	**0.01**	**0.01**	**972.92**	**882.87**
Well Workover Operations - Fugitive Dust			---	---	---
Well Workover Operations - On-site Exhaust	84.06	0.00	0.00	84.37	76.56
Well Workover Operations - On-road Exhaust	1.24	0.00	0.00	1.25	1.13
Well Visits for Inspection & Repair - Operations	0.95	0.00	0.00	0.96	0.87
Recompletion Traffic	31.45	0.00	0.00	31.64	28.71
Condensate Tanks & Traffic	36.23	281.60	0.00	5949.89	5399.17
Flaring and Heaters	22,934.59	0.44	0.42	23074.17	20938.45
Compression Engines	43.77	0.00	0.00	43.82	39.76
Dehydrators	24.81	25.50	0.00	560.53	508.65
Compression Station Fugitives	0.00	0.04	0.00	0.83	0.75
Sub-total: Operations	**23,157.11**	**307.59**	**0.42**	**29,747.44**	**26,994.05**
Road Maintenance	25.66	0.00	0.00	25.75	23.37
Sub-total: Maintenance	**25.657**	**0.000**	**0.00**	**25.75**	**23.37**
Road Reclamation	0.01	0.00	0.00	0.01	0.01
Well Reclamation	0.40	0.00	0.00	0.40	0.37
Sub-total: Reclamation	**0.4135**	**0.0000**	**0.0000**	**0.4170**	**0.3784**
Total Emissions	**24,152.94**	**307.60**	**0.43**	**30,746.53**	**27,900.66**

	Heavy Equipment Combustive Emissions	Commuting Vehicles - Construction	Well Workover Operations - On-site Exhaust	Well Workover Operations - On-road Exhaust	Well Visits for Inspection & Repair - Operations	Recompletion Traffic	Condensate Tanks & Traffic	Flaring and Heaters	Compression Engines	Dehydrators	Compression Station Fugitives	Road Maintenance	Road Reclamation	Well Reclamation
CO2	836.29	133.47	84.06	1.24	0.95	31.45	36.23	22,934.59	43.77	24.81	0.00	25.66	0.01	0.40
CH4	0.01	0.01	0.00	0.00	0.00	0.00	281.60	0.44	0.00	25.50	0.04	0.00	0.00	0.00
N2O	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.42	0.00	0.00	0.00	0.00	0.00	0.00
CO2eq	839.28	133.64	84.37	1.25	0.96	31.64	5949.89	23074.17	43.82	560.53	0.83	25.75	0.01	0.40
CO2eq metric tons	761.59	121.27	76.56	1.13	0.87	28.71	5399.17	20938.45	39.76	508.65	0.75	23.37	0.01	0.37

North Dakota Trust (Fort Berthold Area) CBNG Wells Summaries

Total Annual Emissions from Trust (Fort Berthold Area) CBNG Wells - RFD Estimates

Activity	Annual Emissions (Tons)				
	CO_2	CH_4	N_2O	CO_{2eq}	CO_{2eq} metric tons
Well Pad Construction - Fugitive Dust	---	---	---	---	---
Heavy Equipment Combustive Emissions	104.54	0.00	0.00	104.91	95.20
Commuting Vehicles - Construction	16.68	0.00	0.00	16.76	15.21
Wind Erosion	---	---	---	---	---
Sub-total: Construction	**121.22**	**0.00**	**0.00**	**121.67**	**110.41**
Well Workover Operations - Fugitive Dust			---	---	---
Well Workover Operations - On-site Exhaust	10.51	0.00	0.00	10.55	9.57
Well Workover Operations - On-road Exhaust	0.15	0.00	0.00	0.16	0.14
Well Visits for Inspection & Repair - Operations	0.10	0.00	0.00	0.11	0.10
Recompletion Traffic	3.46	0.00	0.00	3.48	3.16
Condensate Tanks & Traffic	3.99	30.98	0.00	654.49	593.91
Flaring and Heaters	2,525.17	0.05	0.05	2540.54	2305.39
Compression Engines	4.81	0.00	0.00	4.82	4.37
Dehydrators	2.73	2.81	0.00	61.66	55.95
Compression Station Fugitives	0.00	0.00	0.00	0.09	0.08
Sub-total: Operations	**2,550.93**	**33.83**	**0.05**	**3,275.88**	**2,972.67**
Road Maintenance	2.82	0.00	0.00	2.83	2.57
Sub-total: Maintenance	**2.822**	**0.000**	**0.00**	**2.83**	**2.57**
Road Reclamation	0.00	0.00	0.00	0.00	0.00
Well Reclamation	0.04	0.00	0.00	0.04	0.04
Sub-total: Reclamation	**0.0455**	**0.0000**	**0.0000**	**0.0459**	**0.0416**
Total Emissions	**2,675.02**	**33.84**	**0.05**	**3,400.44**	**3,085.70**

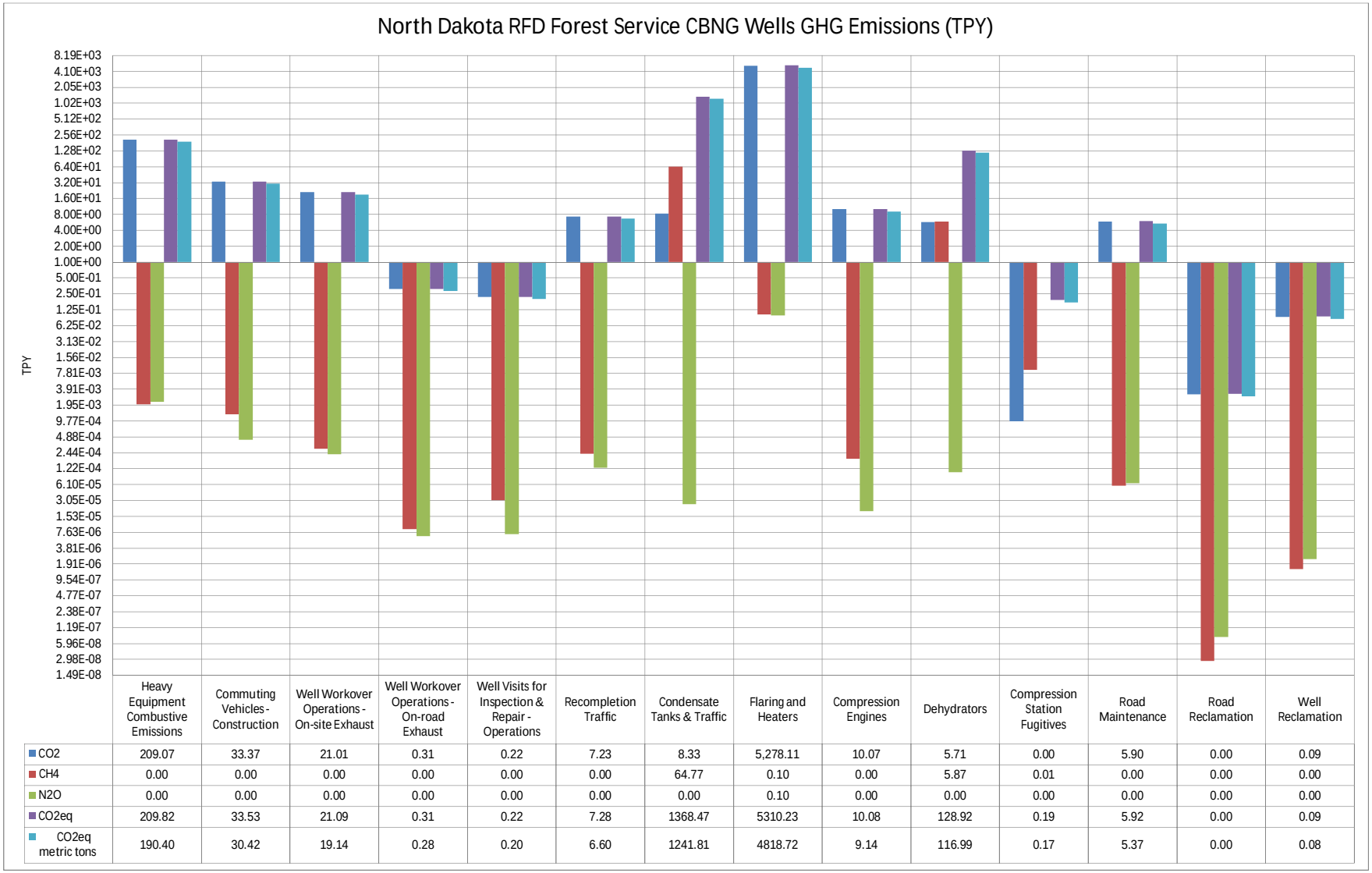


	Heavy Equipment Combustive Emissions	Commuting Vehicles - Construction	Well Workover Operations - On-site Exhaust	Well Workover Operations - On-road Exhaust	Well Visits for Inspection & Repair - Operations	Recompletion Traffic	Condensate Tanks & Traffic	Flaring and Heaters	Compression Engines	Dehydrators	Compression Station Fugitives	Road Maintenance	Road Reclamation	Well Reclamation
CO2	104.54	16.68	10.51	0.15	0.10	3.46	3.99	2,525.17	4.81	2.73	0.00	2.82	0.00	0.04
CH4	0.00	0.00	0.00	0.00	0.00	0.00	30.98	0.05	0.00	2.81	0.00	0.00	0.00	0.00
N2O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00
CO2eq	104.91	16.76	10.55	0.16	0.11	3.48	654.49	2540.54	4.82	61.66	0.09	2.83	0.00	0.04
CO2eq metric tons	95.20	15.21	9.57	0.14	0.10	3.16	593.91	2305.39	4.37	55.95	0.08	2.57	0.00	0.04

North Dakota Forest Service CBNG Wells Summaries

Total Annual Emissions from Forest Service CBNG Wells - RFD Estimates

Activity	Annual Emissions (Tons)				
	CO_2	CH_4	N_2O	CO_{2eq}	CO_{2eq} metric tons
Well Pad Construction - Fugitive Dust	---	---	---	---	---
Heavy Equipment Combustive Emissions	209.07	0.00	0.00	209.82	190.40
Commuting Vehicles - Construction	33.37	0.00	0.00	33.53	30.42
Wind Erosion	---	---	---	---	---
Sub-total: Construction	**242.44**	**0.00**	**0.00**	**243.35**	**220.82**
Well Workover Operations - Fugitive Dust			---	---	---
Well Workover Operations - On-site Exhaust	21.01	0.00	0.00	21.09	19.14
Well Workover Operations - On-road Exhaust	0.31	0.00	0.00	0.31	0.28
Well Visits for Inspection & Repair - Operations	0.22	0.00	0.00	0.22	0.20
Recompletion Traffic	7.23	0.00	0.00	7.28	6.60
Condensate Tanks & Traffic	8.33	64.77	0.00	1368.47	1241.81
Flaring and Heaters	5,278.11	0.10	0.10	5310.23	4818.72
Compression Engines	10.07	0.00	0.00	10.08	9.14
Dehydrators	5.71	5.87	0.00	128.92	116.99
Compression Station Fugitives	0.00	0.01	0.00	0.19	0.17
Sub-total: Operations	**5,331.00**	**70.74**	**0.10**	**6,846.80**	**6,213.07**
Road Maintenance	5.90	0.00	0.00	5.92	5.37
Sub-total: Maintenance	**5.901**	**0.000**	**0.00**	**5.92**	**5.37**
Road Reclamation	0.00	0.00	0.00	0.00	0.00
Well Reclamation	0.09	0.00	0.00	0.09	0.08
Sub-total: Reclamation	**0.0951**	**0.0000**	**0.0000**	**0.0959**	**0.0870**
Total Emissions	**5,579.43**	**70.75**	**0.10**	**7,096.16**	**6,439.35**



	Heavy Equipment Combustive Emissions	Commuting Vehicles - Construction	Well Workover Operations - On-site Exhaust	Well Workover Operations - On-road Exhaust	Well Visits for Inspection & Repair - Operations	Recompletion Traffic	Condensate Tanks & Traffic	Flaring and Heaters	Compression Engines	Dehydrators	Compression Station Fugitives	Road Maintenance	Road Reclamation	Well Reclamation
CO2	209.07	33.37	21.01	0.31	0.22	7.23	8.33	5,278.11	10.07	5.71	0.00	5.90	0.00	0.09
CH4	0.00	0.00	0.00	0.00	0.00	0.00	64.77	0.10	0.00	5.87	0.01	0.00	0.00	0.00
N2O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00
CO2eq	209.82	33.53	21.09	0.31	0.22	7.28	1368.47	5310.23	10.08	128.92	0.19	5.92	0.00	0.09
CO2eq metric tons	190.40	30.42	19.14	0.28	0.20	6.60	1241.81	4818.72	9.14	116.99	0.17	5.37	0.00	0.08

Exhaust Emissions from Heavy Construction Equipment

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

Project Year/Hp Category	Emission Factors (g/hp-hr)		
	CO_2	CH_4	N_2O[a]
Year 2018			
50 to 75	589.096	0.0064	0.0058
75 to 100	589.103	0.0064	0.0058
100 to 175	530.097	0.0047	0.0058
175 to 300	530.181	0.0043	0.0058
300 to 600	530.255	0.0040	0.0058
600 to 750	530.283	0.0038	0.0058
>750	529.917	0.0056	0.0058

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

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

Exhaust Emission Estimations for Construction Equipment - Based on Peak Wells Drilled each Alternative (using 2008 emission factors)

Construction Activity	Equipment Type	Capacity (hp)	# of Units	Av. Load Factor (%)	# of Oper. Hours/Day	# of Oper. Days/ Activity	# of Oper. Hours/Activity	# of Activities / Well	Emissions (tons/year/well)		
									CO_2	CH_4	N_2O
Drilling Roads	Blade	100	1	80	10	1.00	10.00	1.0000	4.67E-01	4.19E-06	5.09E-06
	Backhoe	80	1	75	10	1.00	10.00	1.0000	3.90E-01	4.20E-06	3.82E-06
Drilling Well Pad	Backhoe	80	1	75	10	1.00	10.00	1.0000	3.90E-01	4.20E-06	3.82E-06
Water Disposal well pad	Backhoe	80	1	75	10	2.00	20.00	0.1429	1.11E-01	1.20E-06	1.09E-06
New Pipeline Intermediate	Blade	100	1	80	10	5.00	50.00	0.1108	2.88E-01	3.10E-06	2.82E-06
	Trencher	175	1	80	10	5.00	50.00	0.1108	4.53E-01	4.06E-06	4.93E-06
	Backhoe	80	1	75	10	10.00	100.00	0.1108	4.32E-01	4.65E-06	4.23E-06
New Sales Pipeline	Blade	100	1	80	10	43.00	430.00	0.0002	3.68E-03	3.96E-08	3.60E-08
	Trencher	175	1	80	10	43.00	430.00	0.0002	5.79E-03	5.18E-08	6.30E-08
	Backhoe	80	1	75	10	65.00	650.00	0.0002	4.17E-03	4.49E-08	4.08E-08
Booster Compression Station	Dozer	350	1	80	10	2.00	20.00	0.1108	3.63E-01	2.70E-06	3.95E-06
	Backhoe	80	2	80	10	3.00	30.00	0.1108	2.76E-01	2.98E-06	2.71E-06
Sales Compression Station	Dozer	350	1	80	10	2.00	20.00	0.0110	3.61E-02	2.69E-07	3.93E-07
	Backhoe	80	2	80	10	3.00	30.00	0.0110	2.75E-02	2.96E-07	2.69E-07
								Subtotal	**3.25E+00**	**3.20E-05**	**3.32E-05**

Average number of days to construct wellpad and road: 2 obtained from BLM - NDFO.

Number of water disposal wells value (per well) provided by ND BLM.

Exhaust Emission Factors for Diesel Powered Bore/Drill Rig Engines

Project Year/Hp Category	Emission Factors (g/hp-hr)		
	CO_2	CH_4	N_2O[a]
Year 2018			
50 to 75	589.0959	0.0064	0.0058
75 to 100	589.1032	0.0064	0.0058
100 to 175	530.0969	0.0047	0.0058
175 to 300	530.1812	0.0043	0.0058
300 to 600	530.2546	0.0040	0.0058
600 to 750	530.2834	0.0038	0.0058
>750	529.9171	0.0056	0.0058

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

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

Combustive Emissions Estimation for Industrial Engines - Based on Peak Wells Drilled each Alternative

Construction Activity	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Oper. Hours/Day	# of Oper. Days/ Well	# of Oper. Hours/Well	# of Wells	Emissions (tons/year/well)		
									CO_2	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Main Deck	1550	1	60	18	2.00	36.00	1.0000	1.96E+01	1.46E-04	2.13E-04
	Auxillary Pump	200	1	90	18	2.00	36.00	1.0000	3.79E+00	3.09E-05	4.12E-05
Well Completion & Testing	Main Deck	850	1	60	18	1.00	18.00	1.0000	5.37E+00	4.00E-05	5.84E-05
	Auxillary Pump	125	1	90	18	1.00	18.00	1.0000	1.18E+00	1.06E-05	1.29E-05
Water Disposal well drilling	Generator	1476	1	40	24	30.00	720.00	0.1429	3.55E+01	3.78E-04	3.86E-04
	Generator	1476	1	40	24	30.00	720.00	0.1429	3.55E+01	3.78E-04	3.86E-04
								Subtotal	**1.01E+02**	**9.83E-04**	**1.10E-03**
								Total	**1.04E+02**	**1.02E-03**	**1.13E-03**

Water disposal well pad development rates and gas well drilling rates provided by ND BLM (2010).

Temporary Emission Estimations for Field Generators: Based on Peak Wells Drilled each Alternative

Construction Activity	Equipment Type	Capacity (hp)	# of Wells Served[a]	Avg. Load Factor	# of Oper. Hours/Day	# of Oper. Days/Well	# of Oper. Hours/Well	# of Wells	Emissions (tons/year/well)		
									CO_2	CH_4	N_2O
Field Generators	Field Generators for Pumps & Lighting	21	1	75	24	2.0000	48.0000	1.0000	4.41E-01	3.95E-06	4.80E-06
								Total	**4.41E-01**	**3.95E-06**	**4.80E-06**

Exhaust Emissions from Construction and Drilling Support Vehicles

Emission Factors for Commuting Vehicles

Vehicle		Emission Factors (g/mi)		
Type	Class	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	409.5	0.002	0.016
Heavy-Duty Diesel Truck	HDDV	791.8	0.04	0.006

Source: MOBILE6.2.03

[a] 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).

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 (tons/well)		
	Type	Class					CO_2	CH_4	N_2O
Improved & Two-Track Road	Semi Trucks	HDDV	50	47	2350	1	2.05E+00	9.58E-05	1.49E-05
	Pickup Trucks	LDDT	50	3	150	1	6.77E-02	3.31E-07	2.56E-06
Well Pad	Semi Trucks	HDDV	50	5	250	1	2.18E-01	1.02E-05	1.59E-06
	Pickup Trucks	LDDT	50	4	200	1	9.03E-02	4.41E-07	3.42E-06
Other Construction Activities	Semi Trucks	HDDV	50	2	100	1	8.73E-02	4.08E-06	6.36E-07
	Haul Trucks	HDDV	50	2	100	1	8.73E-02	4.08E-06	6.36E-07
	Pickup Trucks	LDDT	50	1	50	1	2.26E-02	1.10E-07	8.54E-07
						Subtotal	**2.62E+00**	**1.15E-04**	**2.46E-05**

Round trip miles traveled based on ND BLM guidance.

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 (tons/well)		
	Type	Class					CO_2	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Semi Rig Transport, Drill Rig	HDDV	50	44	2200	1	1.92E+00	8.97E-05	1.40E-05
	Fuel Haul Truck	HDDV	50	6	300	1	2.62E-01	1.22E-05	1.91E-06
	Mud Haul Truck, Water Hauling	HDDV	50	4	200	1	1.75E-01	8.16E-06	1.27E-06
	Rig Crew	LDDT	50	51	2550	1	1.15E+00	5.62E-06	4.36E-05
	Rig Mechanics	HDDV	50	2	100	1	8.73E-02	4.08E-06	6.36E-07
	Co. Supervisor	LDDT	50	20	1000	1	4.51E-01	2.20E-06	1.71E-05
	Tool Pusher	LDDT	50	8	400	1	1.81E-01	8.82E-07	6.83E-06
	Mud Logger	LDDT	50	6	300	1	1.35E-01	6.61E-07	5.13E-06
	Mud Engineer	LDDT	50	15	750	1	3.39E-01	1.65E-06	1.28E-05
	Logger, Engr Truck	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Drill Bit Delivery	LDDT	50	2	100	1	4.51E-02	2.20E-07	1.71E-06

Round trip miles traveled based on ND BLM guidance.

Combustive Emissions Estimation Road Traffic (cont.)

Construction Site Destination	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells	Emissions (tons/well)		
	Type	Class					CO_2	CH_4	N_2O
Well Completion & Testing	Semi Casing Haulers	HDDV	50	6	300	1	2.62E-01	1.22E-05	1.91E-06
	Semi Completion, Unit Rig	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Semi Fracing, Blender	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Semi Pumping/Tank Battery	HDDV	50	6	300	1	2.62E-01	1.22E-05	1.91E-06
	Tubing Truck	HDDV	50	2	100	1	8.73E-02	4.08E-06	6.36E-07
	Haul Cementer, Pump Truck	HDDV	50	2	100	1	8.73E-02	4.08E-06	6.36E-07
	Haul Cementer, Cement Truck	HDDV	50	3	150	1	1.31E-01	6.12E-06	9.54E-07
	Haul Completion, Equip Truck	HDDV	50	3	150	1	1.31E-01	6.12E-06	9.54E-07
	Haul Service	LDDT	50	2	100	1	4.51E-02	2.20E-07	1.71E-06
	Haul Perforators Logging Truck	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Anchor, Installation	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Anchor, Testing	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Fracing, Tank	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Fracing, Pump	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Fracing, Chemical	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Fracing, Sand	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Fracing, Other	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Welders	HDDV	50	6	300	1	2.62E-01	1.22E-05	1.91E-06
	Haul Water	HDDV	50	150	7500	1	6.55E+00	3.06E-04	4.77E-05
	Pickup Cementer, Engineer	LDDT	50	2	100	1	4.51E-02	2.20E-07	1.71E-06
	Pickup Casing Crew	HDDV	50	2	100	1	8.73E-02	4.08E-06	6.36E-07
	Pickup Completion Crew	HDDV	50	5	250	1	2.18E-01	1.02E-05	1.59E-06

	Pickup Completion, Pusher	LDDT	50	5	250	1	1.13E-01	5.51E-07	4.27E-06
	Pickup Perforators, Engineer	LDDT	50	2	100	1	4.51E-02	2.20E-07	1.71E-06
	Pickup Fracing, Engineer	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Pickup Co. Supervisor	LDDT	50	10	500	1	2.26E-01	1.10E-06	8.54E-06
	Pickup Miscellaneous	LDDT	50	3	150	1	6.77E-02	3.31E-07	2.56E-06
	Pickup Roustabout	HDDV	50	4	200	1	1.75E-01	8.16E-06	1.27E-06
						Subtotal	**1.41E+01**	**5.38E-04**	**1.89E-04**
						Total	**1.67E+01**	**6.53E-04**	**2.14E-04**

Round trip miles traveled based on ND BLM guidance.

Exhaust Emissions from Well Work Overs

Emission Factors Bore/Drill Rig Engines 300-600 Hp

Fuel Type	Emission Factors (gm/hp-hr)		
	CO_2	CH_4	N_2O[a]
Diesel	529.575	0.007	0.006

Source: EPA NONROADS 2008a. Year 2008.

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

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 (tons/year/well)		
							CO_2	CH_4	N_2O
Well Workover	Truck-Mounted Unit	600	10	3	30	1	1.05E+01	1.46E-04	1.14E-04

Exhaust emission factors for commuting vehicles

Vehicle		Emission Factors (g/mi)		
Type	Class	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	409.500	0.002	0.016
Heavy-Duty Diesel Truck	HDDV	791.800	0.037	0.006

Source: MOBILE 6.2.03

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

[a] 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

Activity	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells Drilled	Max. Annual Emissions (tons/year/well)		
	Type	Class					CO_2	CH_4	N_2O
Well Workover	WO Rig	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Truck	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Pickup Truck	LDDT	50	3	150	1	6.77E-02	3.31E-07	2.56E-06
						Total	**1.55E-01**	**4.41E-06**	**3.20E-06**

Performed once in the first year of well operation and applied to peak number of wells drilled annually.
Round trip miles traveled based on ND BLM guidance.

Exhaust Emissions from Site Visits and Inspections

Emission factors for Commuting Vehicles Exhaust

Vehicle Class	Emission Factors (g/mi)		
	CO_2	CH_4	N_2O[a]
Light-Duty Gasoline Truck	476.90	0.07	0.02

Source: MOBILE 6.2.03
Emission factors for 2008 used for all years = conservative estimate for fleet vehicle turnover
[a] 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)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Federal Wells Producing	Emissions (tons/yr/well)		
	Type	Class					CO_2	CH_4	N_2O
Inspection Visits for Wells	Pickup Truck	LDGT2	1.5	12	18	1	9.46E-03	1.35E-06	3.06E-07

Roundtrip distance shown in AECOM dataset.

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 year

[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
Number of Wells	1
Cumulative Length of Roads [b] (miles/operation)	1

[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	0.3333	3.3333
Winter	1	1	5	10	0.2000	2.0000
				Total	**0.5333**	**5.3333**

Emission Factors for Construction Equipment Exhaust

Equipment	Emission Factors (g/hp-hr)		
	CO_2	CH_4	N_2O[a]
Grader 100-175 Hp	535.7700	0.0053	0.0058

Source: EPA NONROADS 2008a

Use emission factors for 2008 for all project years - conservative estimate of vehicle turnover

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

Emission Estimations for Grader: RMP Year 20

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours[a]	Emissions (tons/well)		
				CO_2	CH_4	N_2O
Road Maintenance	Grader	135	3.20	2.55E-01	2.52E-06	2.75E-06

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

Emission Factors for Commuting Vehicles Exhaust

Vehicle Class	Emission Factors (g/mi)		
	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	409.500	0.002	0.016

Source: MOBILE 6.2.03

[a] 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 (tons/yr)		
	Type	Class				CO_2	CH_4	N_2O
Road Maintenance	Pickup Truck	LDDT	6	0.5333	3.2000	1.44E-03	7.05E-09	5.47E-08

Condensate Tank, Loadout and Hauling Emissions

CBNG Well Condensate Seperator Flashing and Tank Emissions[a]

Project Year	Emissions[b]			
	HAPs Emissions (ton/yr/well)	VOC Emissions (ton/yr/well)	CO_2 Emissions (ton/yr/well)	CH_4 Emissions (ton/yr/well)
All	1.89E-01	6.82E+00	2.06E-01	2.82E+00

[a] Based on Regional (northwest U.S.) typical data values and calculations using E&P Tanks, August, 2010 -- API Gravity : 50, RVP : 7.4 psia, seperator pressure: 700 psig, seperator temperature: 100F, white tank, Montana weather conditions. Assumes 2 bbl condensate per day per well.
[b] Assumes no emissions control.

CBNG Well Condensate 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/10^3 gal) 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 =	8.0	ave. vapor pressure from GMI-EIS Feb. 2010 (BLM NOC Workbook)
M =	68	Typical condensate value shown in BLM NOC Workbook.
T =	540	ave. temp.
L_L =	7.53	

CBNG Well Condensate Truck Loadout Emissions - All Project Years[a]

Project Year	Emission Factor (lbs/1,000 gallons)	Annual Consensate Volume (bbl) - per well	Condensate (1,000 gallons)	VOC Emissions (tpy/well)	CO_2 Emissions (tpy/well)	CH_4 Emissions (tpy/well)
All	7.53	717	30	1.13E-01	0.00E+00	0.00E+00

[a] Uses E&P Tanks Stream Data for W&S Gas mol % (shown below). Regional typical E&P Tanks input data (see composition below). Annual condensate production value found in AECOM dataset.

Emission Factors for Work Over Vehicles - Road Traffic

Vehicle Class	Emission Factors (g/mi)		
	CO_2	CH_4	N_2O[a]
Heavy-Duty Diesel Truck (HDDV)	791.800	0.037	0.006

Source: MOBILE6.2.03

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

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

Activity	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well	Miles Traveled/Well	Total # of Wells	Emissions (tons/year/well)		
	Type	Class					CO_2	CH_4	N_2O
Produced Condensate Hauling	Haul Truck (200 bbl)	HDDV	50	3.6	179.14	1	1.56E-01	7.31E-06	1.14E-06
						TOTAL	**1.56E-01**	**7.31E-06**	**1.14E-06**

Round trip miles traveled based on ND BLM guidance. Assumes all condensate is stored on well pad.

W&S Composition for Truck Load Out Emissions

W&S Gas Component	Mole Fraction[a] (%)	Molecular Weight (lb/lb-mol)	Gas Weight (lb/lb-mol)	Weight Percent (wt%)
Methane	0.000	16.040	0.000	0.000
Ethane	0.000	30.070	0.000	0.000
Nitrogen	0.000	28.020	0.000	0.000
Water	0.000	18.015	0.000	0.000
Carbon Dioxide	0.000	43.990	0.000	0.000
Nitrous Oxide	0.000	44.020	0.000	0.000
Hydrogen Sulfide	0.000	34.060	0.000	0.000
Non-reactive, non-HAP	0.000	---	0.000	0.000
Propane	0.000	44.100	0.000	0.000
Iso-butane	0.000	58.120	0.000	0.000
n-butane	9.011	58.120	5.237	6.816
i-pentane	22.661	72.150	16.350	21.278
n-pentane	20.732	72.150	14.958	19.467
Hexanes	13.459	100.210	13.487	17.552
Heptanes	14.283	100.200	14.312	18.625
Octanes	5.087	114.230	5.810	7.562
Nonanes	0.771	128.258	0.988	1.286
Decanes+	0.059	142.29	0.083	0.109
Reactive VOC	86.062	---	71.226	92.695
Benzene	2.276	78.110	1.777	2.313
Ethylbenzene	0.009	106.160	0.009	0.012
n-Hexane	7.516	100.210	7.532	9.802
Toluene	4.036	92.130	3.718	4.839
Xylenes	0.102	106.160	0.108	0.141
HAPs	13.938	---	13.145	17.107
Totals	**100.000**	**---**	**76.839**	**100.000**

[a] E&P Tanks Stream Data for W&S Gas mol %. Regional (northwest U.S.) typical E&P Tanks input data -- API Gravity : 50, RVP : 7.4 psia, seperator pressure: 700 psig, seperator temperature: 100F, white tank, Montana weather conditions. Assumes 2 bbl condensate per day per well.

Exhaust Emissions from Recompletion Support Vehicles

Emission Factors for Commuting Vehicles

Vehicle		Emission Factors (g/mi)		
Type	Class	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	409.500	0.002	0.016
Heavy-Duty Diesel Truck	HDDV	791.800	0.037	0.006

Source: MOBILE6.2.03

[a] 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).

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 (tons/well)		
	Type	Class					CO_2	CH_4	N_2O
Well Recompletion	Fuel Haul Truck	HDDV	50	6	300	1	2.62E-01	1.22E-05	1.91E-06
	Mud Haul Truck, Water Hauling	HDDV	50	4	200	1	1.75E-01	8.16E-06	1.27E-06
	Rig Crew	LDDT	50	51	2550	1	1.15E+00	5.62E-06	4.36E-05
	Rig Mechanics	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Co. Supervisor	LDDT	50	20	1000	1	4.51E-01	2.20E-06	1.71E-05
	Semi Completion, Unit Rig	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Semi Fracing, Blender	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Semi Pumping/Tank Battery	HDDV	50	6	300	1	2.62E-01	1.22E-05	1.91E-06
	Tubing Truck	HDDV	50	2	100	1	8.73E-02	4.08E-06	6.36E-07
	Haul Cementer, Pump Truck	HDDV	50	2	100	1	8.73E-02	4.08E-06	6.36E-07
	Haul Cementer, Cement Truck	HDDV	50	3	150	1	1.31E-01	6.12E-06	9.54E-07
	Haul Completion, Equip Truck	HDDV	50	3	150	1	1.31E-01	6.12E-06	9.54E-07
	Haul Service Tools	LDDT	50	2	100	1	4.51E-02	2.20E-07	1.71E-06
	Haul Perforators Logging Truck	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Fracing, Tank	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Fracing, Pump	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Fracing, Chemical	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Fracing, Sand	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Fracing, Other	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Water Truck	HDDV	50	50	2500	1	2.18E+00	1.02E-04	1.59E-05
	Pickup Cementer, Engineer	LDDT	50	2	100	1	4.51E-02	2.20E-07	1.71E-06
	Pickup Completion Crew	HDDV	50	5	250	1	2.18E-01	1.02E-05	1.59E-06
	Pickup Completion, Pusher	LDDT	50	5	250	1	1.13E-01	5.51E-07	4.27E-06
	Pickup Perforators, Engineer	LDDT	50	2	100	1	4.51E-02	2.20E-07	1.71E-06
	Pickup Fracing, Engineer	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Pickup Co. Supervisor	LDDT	50	10	500	1	2.26E-01	1.10E-06	8.54E-06
	Pickup Miscellaneous Supplies	LDDT	50	3	150	1	6.77E-02	3.31E-07	2.56E-06
	Pickup Roustabout Crew	HDDV	50	4	200	1	1.75E-01	8.16E-06	1.27E-06
						Subtotal	**6.29E+00**	**2.04E-04**	**1.11E-04**
						Total	**6.29E+00**	**2.04E-04**	**1.11E-04**

Round trip miles traveled based on ND BLM guidance.

Gas Analysis

Gas Component	Mole Fraction (%)	Molecular Weight (lb/lb-mol)	Gas Weight (lb/lb-mol)	Weight Percent (wt%)	Weight (lb/MMscf)
Methane	92.532	16.040	14.842	84.677	35953.744
Ethane	0.633	30.070	0.190	1.086	461.089
Nitrogen	3.201	28.020	0.897	5.117	2172.709
Water	0.000	18.015	0.000	0.000	0.000
Carbon Dioxide	3.634	43.990	1.599	9.120	3872.458
Nitrous Oxide	0.000	44.020	0.000	0.000	0.000
Hydrogen Sulfide	0.000	34.060	0.000	0.000	0.000
Non-reactive, non-HAP	100.000	---	17.528	100.000	
Propane	0.000	44.100	0.000	0.000	0.000
Iso-butane	0.000	58.120	0.000	0.000	0.000
n-butane	0.000	58.120	0.000	0.000	0.000
i-pentane	0.000	72.150	0.000	0.000	0.000
n-pentane	0.000	72.150	0.000	0.000	0.000
Hexanes	0.000	100.210	0.000	0.000	0.000
Heptanes	0.000	100.200	0.000	0.000	0.000
Octanes	0.000	114.230	0.000	0.000	0.000
Nonanes	0.000	128.258	0.000	0.000	0.000
Decanes+	0.000	142.29	0.000	0.000	0.000
Reactive VOC	0.000	---	0.000	0.000	
Benzene	0.000	78.110	0.000	0.000	0.000
Ethylbenzene	0.000	106.160	0.000	0.000	0.000
n-Hexane [3]	*0.000*	*100.210*	*0.000*	*0.000*	*0.000*
Toluene	0.000	92.130	0.000	0.000	0.000
Xylenes	0.000	106.160	0.000	0.000	0.000
HAPs	0.000	---	0.000	0.000	
Totals	**100.000**	**---**	**17.528**	**100.000**	

Gas well natural gas analysis for : Winnipeg/Deadwood - Dimmick, Lease: Fancy Butte 14-32

Volume Flow: 0.065753425 MMSCF / day

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

Compressor Stations Emissions

Emission Factors for Natural Gas-Fired Compressors and Pumps

Compressor / Pump		Horse-Power Rating	Units	Emission Factors		
				CO_2 [a]	CH_4 [a]	N_2O [a]
Compression Station	Lean Burn	300	gm/bhp-hr	1.35E+02	2.55E-03	2.55E-04
			lb/MMBTU	1.17E+02	2.20E-03	2.20E-04

Note: Compressors assumed to be equipped with nonselective catalytic reduction (NSCR) catalyst.

[a] 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	Operating Hours/Year	Emissions (tons/year/well)		
					CO_2	CH_4	N_2O
Compression Station	0.3	1.00	0.3	8,760	4.38E-01	8.26E-06	8.26E-07
				Total	**4.38E-01**	**8.26E-06**	**8.26E-07**

Compression rate of 3000 planned HP for all projected ND developed gas. (AECOM)

Compressor Station Fugitives

Fugitive Emissions from Equipment Leaks

TOC Emission Factor								
Well Equipment Component	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 AECOM provided gas well gas analyses (see Gas Analysis Worksheet)

VOC Wt% =	0.00
CO2 Wt% =	9.12
CH4 Wt% =	84.68
N2O Wt% =	0.00

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	0.008	0.0099	0	0.0055	0	0.0002	7.78E-05	0.00E+00	7.09E-06	6.58E-05
pump seals	0.000	0.0053	0	0.0287	0	0.0001	0.00E+00	0.00E+00	0.00E+00	0.00E+00
others	0.000	0.0194	0	0.0165	0	0.0309	0.00E+00	0.00E+00	0.00E+00	0.00E+00
connectors	0.011	0.0004	0	0.0005	0	0.0002	4.94E-06	0.00E+00	4.50E-07	4.18E-06
flanges	0.027	0.0009	0	0.0002	0	0.0000	2.31E-05	0.00E+00	2.11E-06	1.96E-05
open-ended lines	0.000	0.0044	0	0.0031	0	0.0006	0.00E+00	0.00E+00	0.00E+00	0.00E+00
						TOTAL emissions/well/hr =	1.06E-04	0.00E+00	9.65E-06	8.96E-05

Number of components verified by ND BLM

Annual Emissions from Equipment Leaks Per Well								
Year	**Number of Producing Wells**	**Operating Hours**	**VOC emissions (lb/yr)**	**VOC emissions (ton/yr)**	**CO_2 emissions (lb/yr)**	**CO_2 emissions (ton/yr)**	**CH_4 emissions (lb/yr)**	**CH_4 emissions (ton/yr)**
Year 20	1	8760	0.00E+00	0.00E+00	8.45E-02	4.23E-05	7.85E-01	3.92E-04

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	0.2500
Number of Roads Reclaimed Annually Per Well	0.0100
Annual Miles of Roads reclaimed Per Well	0.0025
Number of wells reclaimed (per well)	0.0100

Reclaimation rate : 1% of operating wells reclaimed annually

Estimation of Total Operation Days and Hours

Annual Miles of Roads Reclaimed	Daily Miles of Road Work	Total # of Operating Days	Annual Operating Hours
0.003	6	0.0004	0.0042
		Total	**0.0042**

Assume average miles/day = 6

Emission Factors for 75-100 hp Off-Road Engines

Year	Emission Factors (g/hp-hr)		
	CO_2	CH_4	N_2O[a]
2008	600.507	0.010	0.016
2018	613.888	0.006	0.016
2027	608.641	0.003	0.016

[a] 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).

Exhaust Emissions Estimation for Grader Road Reclaim

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours	Emissions (tons/year/well)		
				CO_2	CH_4	N_2O
Road Reclamation	Grader	80	0.0025	1.35E-04	1.22E-09	3.42E-09

Exhaust Emission Factors for Commuting Reclaim Vehicles Road Traffic

Vehicle Class	Emission Factors (g/mi)		
	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	409.500	0.002	0.016

Source: MOBILE6.2.03

[a] 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).

Exhaust Emissions Estimation for Commuting Reclaim Vehicles: Road Traffic

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tons/year/well)		
	Type	Class				CO_2	CH_4	N_2O
Road Reclamation	Pickup Truck	LDDV	6	0.0004	0.0025	1.13E-06	5.51E-12	4.27E-11

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	0.0100	10	0.0100	0.1000

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

Exhaust Emissions Estimation for Grader: Well Reclamation

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours	Emissions (tons/year/well)		
				CO_2	CH_4	N_2O
Well Reclamation	Grader	100	0.0600	3.97E-03	6.62E-08	1.03E-07

Exhaust Emissions Estimation for Commuting Vehicles: Well Reclamation

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tons/year/well)		
	Type	Class				CO_2	CH_4	N_2O
Well Reclamation	Pickup Truck	LDDV	6	0.0100	0.0600	2.71E-05	1.32E-10	1.03E-09

Emissions for Gas Dehydration

Emission Factors for Dehydrator Heaters

Unit	CO_2	CH_4	N_2O
lb/MMSCF	120000.0	2.3	2.2
lb/MMBTU	117.647	0.002	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 (tons/year/well)		
				CO_2	CH_4	N_2O
2,190	1	2.20	0.0019	2.48E-01	4.76E-06	4.55E-06

Annual Dehydrator Venting and Tank Flashing Emissions

Annual Well Gas Production MMscf	CH_4 Emission Factor (ton per MMscf)	CH_4 Emissions (TPY/well)
24.0000	0.0106	2.55E-01

Gas analysis information found in AECOM Gas Analysis Database (see Gas Analysis Sheet for component percentages). GRI GLYCalc estimated emissions.

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 least once.

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

Emissions for External Gas Combustion

Emission Factors for External Gas Combustion (Flares and Heaters)

Unit	CO_2	CH_4	N_2O
lb/MMSCF	120000.0	2.3	2.2
lb/MMBTU	117.647	0.002	0.002

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

Well Completion Flaring	Gas Production /Well (MMSCFD)	# of Days of Flaring	# of Wells	Emissions (tons/year/well)		
				CO_2	CH_4	N_2O
Flaring	0.066	5	1	19.7260	0.0004	0.0004
Total				**19.7260**	**0.0004**	**0.0004**

Applied to all contructed wells. For well completion, assumes 100% of the gas is flared.
Based on BLM - NDFO value of ~ 24 MMSCF/year/well.

Well Re-Completion Flaring	Gas Production /Well (MMSCFD)	# of Days of Flaring	# of Wells	Emissions (tons/year/well)		
				CO_2	CH_4	N_2O
Flaring	0.066	5	1	19.7260	0.0004	0.0004
Total				**19.7260**	**0.0004**	**0.0004**

Applied to 5% of all operating wells. Assumes 100% of the gas is flared.
Based on BLM - NDFO value of ~ 24 MMSCF/year/well.

Well Blowdown Flaring	Gas Production /Well (MMSCFD)	# of Days of Flaring	# of Wells	Emissions (tons/year/well)		
				CO_2	CH_4	N_2O
Flaring	0.066	1	1	3.9452	0.0001	0.0001
Total				**3.9452**	**0.0001**	**0.0001**

Applied to 1% of all operating wells. Assumes 100% of the gas is flared.
Based on BLM - NDFO value of ~ 24 MMSCF/year/well.

Well Pad Heaters	Annual Heater Fuel Usage /Well (MMBTU/year/ well)	# of Wells	Emissions (tons/year/well)		
			CO_2	CH_4	N_2O
Seperator Heaters	3854.62	1	226.7421	0.0043	0.0042
Total			**226.7421**	**0.0043**	**0.0042**

Applied to all operating wells. Based on conservative estimate - year around usage.
Based on BLM - NDFO annual fuel usage value (per conversation with Industry Engineers).

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Appendix I

South Dakota Planning Area GHG Emission Inventory

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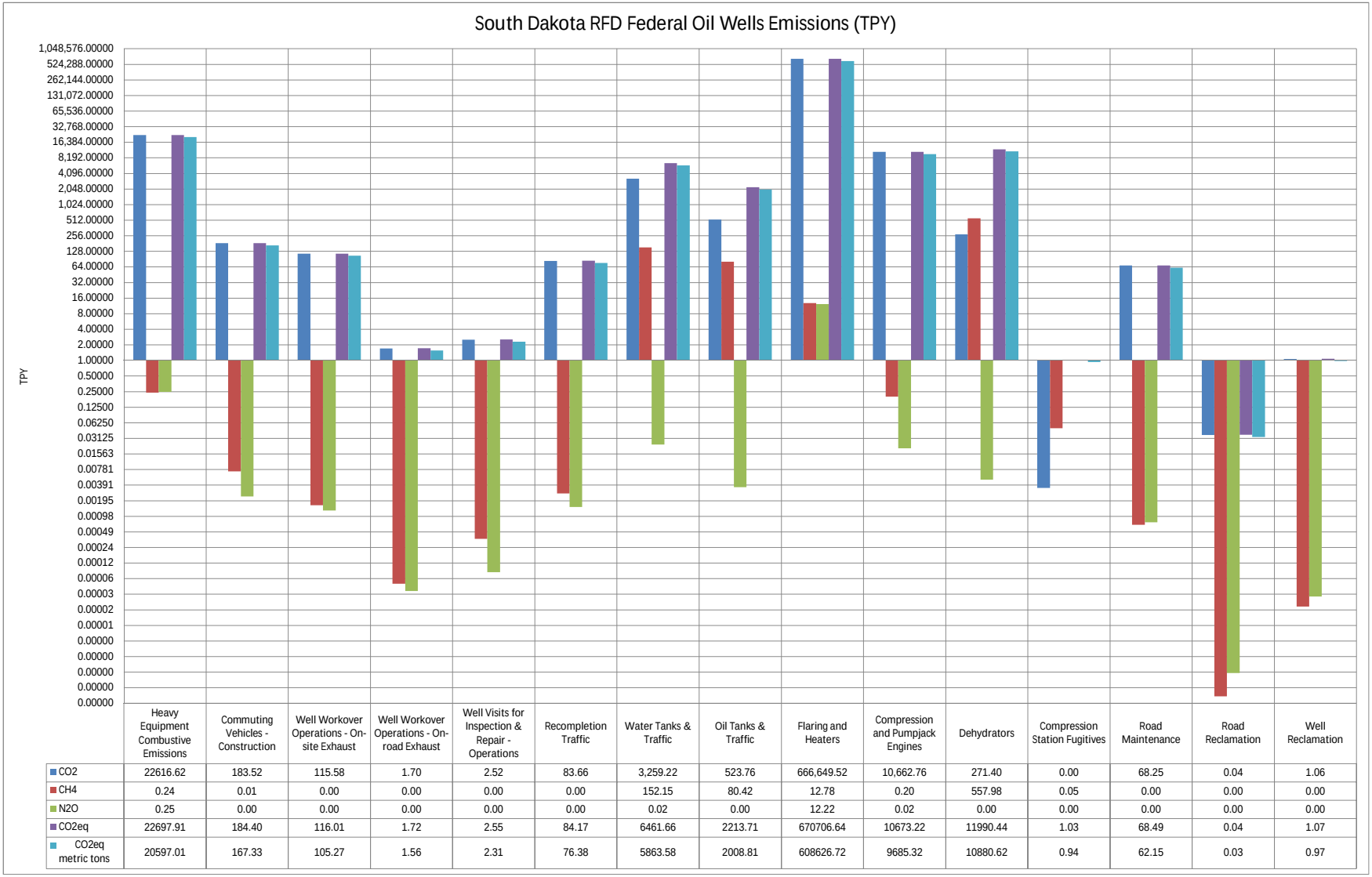
South Dakota input parameters for calculating oil wells emissions:

Maximum Annual Wells Drilled - Federal (excluding FS)	11	Maximum Annual Wells Drilled - Non-Federal	4
Federal Producing Wells (excluding FS)	266	Non-Federal Producing Wells	71
Average Well Barrel Oil Per Day (BOPD)	23	Average Well Barrel Oil Per Day (BOPD)	23

South Dakota Federal Oil Wells Summaries

Total Annual Emissions from Federal Oil Wells - RFD Estimates

Activity	Annual Emissions (Tons)				
	CO_2	CH_4	N_2O	CO_{2eq}	CO_{2eq} metric tons
Well Pad Construction - Fugitive Dust	---	---	---	---	---
Heavy Equipment Combustive Emissions	22616.62	0.24	0.25	22697.91	20597.01
Commuting Vehicles - Construction	183.52	0.01	0.00	184.40	167.33
Wind Erosion	---	---	---	---	---
Sub-total: Construction	**22,800.13**	**0.25**	**0.25**	**22,882.31**	**20,764.35**
Well Workover Operations - Fugitive Dust	---	---	---	---	---
Well Workover Operations - On-site Exhaust	115.58	0.00	0.00	116.01	105.27
Well Workover Operations - On-road Exhaust	1.70	0.00	0.00	1.72	1.56
Well Visits for Inspection & Repair - Operations	2.52	0.00	0.00	2.55	2.31
Recompletion Traffic	83.66	0.00	0.00	84.17	76.38
Water Tanks & Traffic	3,259.22	152.15	0.02	6461.66	5863.58
Oil Tanks & Traffic	523.76	80.42	0.00	2213.71	2008.81
Flaring and Heaters	666,649.52	12.78	12.22	670706.64	608626.72
Compression and Pumpjack Engines	10,662.76	0.20	0.02	10673.22	9685.32
Dehydrators	271.40	557.98	0.00	11990.44	10880.62
Compression Station Fugitives	0.00	0.05	0.00	1.03	0.94
Sub-total: Operations	**681,570.13**	**803.58**	**12.28**	**702,251.15**	**637,251.50**
Road Maintenance	68.25	0.00	0.00	68.49	62.15
Sub-total: Maintenance	**68.248**	**0.001**	**0.00**	**68.49**	**62.15**
Road Reclamation	0.04	0.00	0.00	0.04	0.03
Well Reclamation	1.06	0.00	0.00	1.07	0.97
Sub-total: Reclamation	**1.1000**	**0.0000**	**0.0000**	**1.1092**	**1.0065**
Total Emissions	**704,439.61**	**803.82**	**12.53**	**725,203.06**	**658,079.00**



	Heavy Equipment Combustive Emissions	Commuting Vehicles - Construction	Well Workover Operations - On-site Exhaust	Well Workover Operations - On-road Exhaust	Well Visits for Inspection & Repair - Operations	Recompletion Traffic	Water Tanks & Traffic	Oil Tanks & Traffic	Flaring and Heaters	Compression and Pumpjack Engines	Dehydrators	Compression Station Fugitives	Road Maintenance	Road Reclamation	Well Reclamation
CO2	22616.62	183.52	115.58	1.70	2.52	83.66	3,259.22	523.76	666,649.52	10,662.76	271.40	0.00	68.25	0.04	1.06
CH4	0.24	0.01	0.00	0.00	0.00	0.00	152.15	80.42	12.78	0.20	557.98	0.05	0.00	0.00	0.00
N2O	0.25	0.00	0.00	0.00	0.00	0.00	0.02	0.00	12.22	0.02	0.00	0.00	0.00	0.00	0.00
CO2eq	22697.91	184.40	116.01	1.72	2.55	84.17	6461.66	2213.71	670706.64	10673.22	11990.44	1.03	68.49	0.04	1.07
CO2eq metric tons	20597.01	167.33	105.27	1.56	2.31	76.38	5863.58	2008.81	608626.72	9685.32	10880.62	0.94	62.15	0.03	0.97

South Dakota Non-Federal Oil Wells Summaries

Total Annual Emissions from Non-Federal Oil Wells - RFD Estimates

Activity	Annual Emissions (Tons)				
	CO_2	CH_4	N_2O	CO_{2eq}	CO_{2eq} metric tons
Well Pad Construction - Fugitive Dust	---	---	---	---	---
Heavy Equipment Combustive Emissions	8224.22	0.09	0.25	8302.33	7533.88
Commuting Vehicles - Construction	66.73	0.00	0.00	67.52	61.27
Wind Erosion	---	---	---	---	---
Sub-total: Construction	**8,290.96**	**0.09**	**0.25**	**8,369.85**	**7,595.15**
Well Workover Operations - Fugitive Dust			---	---	---
Well Workover Operations - On-site Exhaust	42.03	0.00	0.00	42.18	38.28
Well Workover Operations - On-road Exhaust	0.62	0.00	0.00	0.62	0.57
Well Visits for Inspection & Repair - Operations	0.67	0.00	0.00	0.68	0.62
Recompletion Traffic	22.33	0.00	0.00	22.47	20.39
Water Tanks & Traffic	869.94	40.61	0.01	1724.73	1565.09
Oil Tanks & Traffic	139.80	21.47	0.00	590.88	536.19
Flaring and Heaters	178,310.18	3.42	3.27	179395.34	162790.69
Compression and Pumpjack Engines	2,846.08	0.05	0.01	2848.87	2585.18
Dehydrators	72.44	148.93	0.00	3200.46	2904.23
Compression Station Fugitives	0.00	0.01	0.00	0.28	0.25
Sub-total: Operations	**182,304.09**	**214.50**	**3.28**	**187,826.50**	**170,441.47**
Road Maintenance	18.22	0.00	0.00	18.28	16.59
Sub-total: Maintenance	**18.217**	**0.000**	**0.00**	**18.28**	**16.59**
Road Reclamation	0.01	0.00	0.00	0.01	0.01
Well Reclamation	0.28	0.00	0.00	0.29	0.26
Sub-total: Reclamation	**0.2936**	**0.0000**	**0.0000**	**0.2961**	**0.2686**
Total Emissions	**190,613.56**	**214.59**	**3.53**	**196,214.94**	**178,053.48**

	Heavy Equipment Combustive Emissions	Commuting Vehicles - Construction	Well Workover Operations - On-site Exhaust	Well Workover Operations - On-road Exhaust	Well Visits for Inspection & Repair - Operations	Recompletion Traffic	Water Tanks & Traffic	Oil Tanks & Traffic	Flaring and Heaters	Compression and Pumpjack Engines	Dehydrators	Compression Station Fugitives	Road Maintenance	Road Reclamation	Well Reclamation
CO2	8224.22	66.73	42.03	0.62	0.67	22.33	869.94	139.80	178,310.18	2,846.08	72.44	0.00	18.22	0.01	0.28
CH4	0.09	0.00	0.00	0.00	0.00	0.00	40.61	21.47	3.42	0.05	148.93	0.01	0.00	0.00	0.00
N2O	0.25	0.00	0.00	0.00	0.00	0.00	0.01	0.00	3.27	0.01	0.00	0.00	0.00	0.00	0.00
CO2eq	8302.33	67.52	42.18	0.62	0.68	22.47	1724.73	590.88	179395.34	2848.87	3200.46	0.28	18.28	0.01	0.29
CO2eq metric tons	7533.88	61.27	38.28	0.57	0.62	20.39	1565.09	536.19	162790.69	2585.18	2904.23	0.25	16.59	0.01	0.26

Exhaust Emissions from Well Pad Construction Heavy Equipment and Drilling Equipment

Emission Factors for Construction Equipment

Equipment	Emission Factors (g/hp-hr)			Equipment Category
	CO_2	CH_4	N_2O [a]	
Dozer - 175 Hp	535.76	0.005	0.006	Track-Type Tractor
Blade - 150 Hp	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] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

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 (tons/equipment type/well)		
									CO_2	CH_4	N_2O
Improved & Two-Track Road	Blade	150	1	75	10	3.5	35	1	2.58E+00	3.28E-05	2.50E-05
Well Pad	Blade	175	1	75	10	3.5	35	1	3.01E+00	3.82E-05	2.92E-05
	Dozer	175	1	80	10	3.5	35	1	3.21E+00	4.08E-05	3.12E-05
								Subtotal	**8.80E+00**	**1.12E-04**	**8.54E-05**

Average number of days to construct wellpad and road: 7 obtained from NDFO (BLM).

Exhaust Emission Factors for Diesel Powered Bore/Drill Rig Engines

Project Year/Hp Category	Emission Factors (g/hp-hr)		
	CO_2	CH_4	N_2O[a]
Year 2018			
50 to 75	589.10	0.006	0.006
75 to 100	589.10	0.006	0.006
100 to 175	530.10	0.005	0.006
175 to 300	530.18	0.004	0.006
300 to 600	530.25	0.004	0.006
600 to 750	530.28	0.004	0.006
>750	529.92	0.006	0.006

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

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

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 (tons/equipment type/well)		
									CO_2	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Main Deck	3,450	3	70	24	19	456	1	1.93E+03	2.06E-02	2.10E-02
	Auxiliary Pump	600	1	80	8	19	152	1	4.26E+01	3.18E-04	4.64E-04
	Generators	150	2	75	24	19	456	1	6.00E+01	5.37E-04	6.53E-04
Well Completion & Testing	Main Deck	250	1	50	11	10	110	1	8.04E+00	5.99E-05	8.75E-05
	Auxiliary Pump	50	1	80	8	10	80	1	1.87E+00	1.52E-05	2.04E-05
	Power Swivel	50	1	75	8	10	80	1	1.75E+00	1.57E-05	1.91E-05
	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	10	120	1	3.21E+00	3.49E-05	3.15E-05
								Subtotal	**2.05E+03**	**2.15E-02**	**2.23E-02**
								Total	**2.06E+03**	**2.17E-02**	**2.24E-02**

Value for number of days and HP needed to drill well provided by BLM - NDFO. Number of days to complete well and HP for completion heavy equipment confirmed by ND BLM.

Exhaust Emissions from Construction and Drilling Support Vehicles

Emission Factors for Commuting Vehicles

Vehicle		Emission Factors (g/mi)		
Type	Class	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	409.5	0.002	0.016
Heavy-Duty Diesel Truck	HDDV	791.8	0.04	0.006

Source: MOBILE6.2.03

[a] 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).

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 (tons/well)		
	Type	Class					CO_2	CH_4	N_2O
Improved & Two-Track Road	Semi Trucks	HDDV	50	47	2350	1	2.05E+00	9.58E-05	1.49E-05
	Pickup Trucks	LDDT	50	3	150	1	6.77E-02	3.31E-07	2.56E-06
Well Pad	Semi Trucks	HDDV	50	5	250	1	2.18E-01	1.02E-05	1.59E-06
	Pickup Trucks	LDDT	50	4	200	1	9.03E-02	4.41E-07	3.42E-06
Other Construction Activities	Semi Trucks	HDDV	50	2	100	1	8.73E-02	4.08E-06	6.36E-07
	Haul Trucks	HDDV	50	2	100	1	8.73E-02	4.08E-06	6.36E-07
	Pickup Trucks	LDDT	50	1	50	1	2.26E-02	1.10E-07	8.54E-07
						Subtotal	**2.62E+00**	**1.15E-04**	**2.46E-05**

Round trip miles traveled based on ND BLM guidance.

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 (tons/well)		
	Type	Class					CO_2	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Semi Rig Transport, Drill Rig	HDDV	50	44	2200	1	1.92E+00	8.97E-05	1.40E-05
	Fuel Haul Truck	HDDV	50	6	300	1	2.62E-01	1.22E-05	1.91E-06
	Mud Haul Truck, Water Hauling	HDDV	50	4	200	1	1.75E-01	8.16E-06	1.27E-06
	Rig Crew	LDDT	50	51	2550	1	1.15E+00	5.62E-06	4.36E-05
	Rig Mechanics	HDDV	50	2	100	1	8.73E-02	4.08E-06	6.36E-07
	Co. Supervisor	LDDT	50	20	1000	1	4.51E-01	2.20E-06	1.71E-05
	Tool Pusher	LDDT	50	8	400	1	1.81E-01	8.82E-07	6.83E-06
	Mud Logger	LDDT	50	6	300	1	1.35E-01	6.61E-07	5.13E-06
	Mud Engineer	LDDT	50	15	750	1	3.39E-01	1.65E-06	1.28E-05
	Logger, Engr Truck	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Drill Bit Delivery	LDDT	50	2	100	1	4.51E-02	2.20E-07	1.71E-06

Round trip miles traveled based on ND BLM guidance.

Combustive Emissions Estimation Road Traffic (cont.)

Construction Site Destination	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells	Emissions (tons/well)		
	Type	Class					CO_2	CH_4	N_2O
Well Completion & Testing	Semi Casing Haulers	HDDV	50	6	300	1	2.62E-01	1.22E-05	1.91E-06
	Semi Completion, Unit Rig	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Semi Fracing, Blender	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Semi Pumping/Tank Battery	HDDV	50	6	300	1	2.62E-01	1.22E-05	1.91E-06
	Tubing Truck	HDDV	50	2	100	1	8.73E-02	4.08E-06	6.36E-07
	Haul Cementer, Pump Truck	HDDV	50	2	100	1	8.73E-02	4.08E-06	6.36E-07
	Haul Cementer, Cement Truck	HDDV	50	3	150	1	1.31E-01	6.12E-06	9.54E-07
	Haul Completion, Equip Truck	HDDV	50	3	150	1	1.31E-01	6.12E-06	9.54E-07
	Haul Service	LDDT	50	2	100	1	4.51E-02	2.20E-07	1.71E-06
	Haul Perforators Logging Truck	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Anchor, Installation	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Anchor, Testing	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Fracing, Tank	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Fracing, Pump	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Fracing, Chemical	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Fracing, Sand	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Fracing, Other	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Welders	HDDV	50	6	300	1	2.62E-01	1.22E-05	1.91E-06
	Haul Water	HDDV	50	150	7500	1	6.55E+00	3.06E-04	4.77E-05
	Pickup Cementer, Engineer	LDDT	50	2	100	1	4.51E-02	2.20E-07	1.71E-06
	Pickup Casing Crew	HDDV	50	2	100	1	8.73E-02	4.08E-06	6.36E-07
	Pickup Completion Crew	HDDV	50	5	250	1	2.18E-01	1.02E-05	1.59E-06

	Pickup Completion, Pusher	LDDT	50	5	250	1	1.13E-01	5.51E-07	4.27E-06
	Pickup Perforators, Engineer	LDDT	50	2	100	1	4.51E-02	2.20E-07	1.71E-06
	Pickup Fracing, Engineer	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Pickup Co. Supervisor	LDDT	50	10	500	1	2.26E-01	1.10E-06	8.54E-06
	Pickup Miscellaneous	LDDT	50	3	150	1	6.77E-02	3.31E-07	2.56E-06
	Pickup Roustabout	HDDV	50	4	200	1	1.75E-01	8.16E-06	1.27E-06
						Subtotal	**1.41E+01**	**5.38E-04**	**1.89E-04**
						Total	**1.67E+01**	**6.53E-04**	**2.14E-04**

Round trip miles traveled based on ND BLM guidance.

Exhaust Emissions from Well Work Overs

Emission Factors Bore/Drill Rig Engines 300-600 Hp

Fuel Type	Emission Factors (gm/hp-hr)		
	CO_2	CH_4	N_2O[a]
Diesel	529.575	0.007	0.006

Source: EPA NONROADS 2008a. Year 2008.

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

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 (tons/year/well)		
							CO_2	CH_4	N_2O
Well Workover	Truck-Mounted Unit	600	10	3	30	1	1.05E+01	1.46E-04	1.14E-04

Exhaust emission factors for commuting vehicles

Vehicle		Emission Factors (g/mi)		
Type	Class	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	409.500	0.002	0.016
Heavy-Duty Diesel Truck	HDDV	791.800	0.037	0.006

Source: MOBILE 6.2.03

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

[a] 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

Activity	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells Drilled	Max. Annual Emissions (tons/year/well)		
	Type	Class					CO_2	CH_4	N_2O
Well Workover	WO Rig	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Truck	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Pickup Truck	LDDT	50	3	150	1	6.77E-02	3.31E-07	2.56E-06
						Total	**1.55E-01**	**4.41E-06**	**3.20E-06**

Performed once in the first year of well operation and applied to peak number of wells drilled annually.
Round trip miles traveled based on ND BLM guidance.

Exhaust Emissions from Site Visits and Inspections

Emission factors for Commuting Vehicles Exhaust

Vehicle Class	Emission Factors (g/mi)		
	CO_2	CH_4	N_2O[a]
Light-Duty Gasoline Truck	476.90	0.07	0.02

Source: MOBILE 6.2.03
Emission factors for 2008 used for all years = conservative estimate for fleet vehicle turnover
[a] 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)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Federal Wells Producing	Emissions (tons/yr/well)		
	Type	Class					CO_2	CH_4	N_2O
Inspection Visits for Wells	Pickup Truck	LDGT2	1.5	12	18	1	9.46E-03	1.35E-06	3.06E-07

Roundtrip distance shown in AECOM dataset.

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 year

[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
Number of Wells	1
Cumulative Length of Roads [b] (miles/operation)	1

[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	0.3333	3.3333
Winter	1	1	5	10	0.2000	2.0000
				Total	**0.5333**	**5.3333**

Emission Factors for Construction Equipment Exhaust

Equipment	Emission Factors (g/hp-hr)		
	CO_2	CH_4	N_2O[a]
Grader 100-175 Hp	535.7700	0.0053	0.0058

Source: EPA NONROADS 2008a

Use emission factors for 2008 for all project years - conservative estimate of vehicle turnover

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

Emission Estimations for Grader: RMP Year 20

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours[a]	Emissions (tons/well)		
				CO_2	CH_4	N_2O
Road Maintenance	Grader	135	3.20	2.55E-01	2.52E-06	2.75E-06

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

Emission Factors for Commuting Vehicles Exhaust

Vehicle Class	Emission Factors (g/mi)		
	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	409.500	0.002	0.016

Source: MOBILE 6.2.03

[a] 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 (tons/yr)		
	Type	Class				CO_2	CH_4	N_2O
Road Maintenance	Pickup Truck	LDDT	6	0.5333	3.2000	1.44E-03	7.05E-09	5.47E-08

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)	CH_4 Emissions (ton/yr/well)
All	31.31	36500	5.71E-01

[a] Average Conditions for Table 5-10 of the API Compedium of GHG Emissions Methodologies for the Oil and Gas Industry, August 2009.
Average number of produced water bbl per day (per oil well) value provided by ND BLM (100 bbl/day/oil well)

Emission Factors for Water Transport Vehicles - Road Traffic

Vehicle Class	Emission Factors (g/mi)		
	CO_2	CH_4	N_2O[a]
Heavy-Duty Diesel Truck (HDDV)	791.800	0.037	0.006

Source: MOBILE6.2.03

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

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 (tons/yr/well)		
	Type	Class					CO_2	CH_4	N_2O
Produced Water Hauling	Haul Truck (130 bbl)	HDDV	50	281	14038	1	1.23E+01	5.73E-04	8.93E-05

Round trip miles traveled based on ND BLM guidance.

Oil Tank, Loadout and Hauling Emissions

Oil Well Oil Seperator Flashing and Tank Emissions[a]

Project Year	Emissions[b]			
	HAPs Emissions (ton/yr/well)	VOC Emissions (ton/yr/well)	CO_2 Emissions (ton/yr/well)	CH_4 Emissions (ton/yr/well)
All	1.33E-01	2.38E+00	1.37E-01	3.02E-01

[a] Based on Regional typical data values and calculations using E&P Tanks, August, 2010. Assumes 15 BOPD per well.
[b] Assumes no 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 ($lb/10^3$ gal) 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)
All	2.35	8,395	353	4.15E-01	7.44E-04	1.21E-07

[a] Uses E&P Tanks Stream Data for W&S Gas mol % (shown below). Regional typical E&P Tanks input data.

Emission Factors for Work Over Vehicles - Road Traffic

Vehicle Class	Emission Factors (g/mi)		
	CO_2	CH_4	N_2O[a]
Heavy-Duty Diesel Truck (HDDV)	791.800	0.037	0.006

Source: MOBILE6.2.03

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

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 (tons/year/well)		
	Type	Class					CO_2	CH_4	N_2O
Produced Oil Hauling	Haul Truck (200 bbl)	HDDV	50	42	2098.75	1	1.83E+00	8.56E-05	1.33E-05
						TOTAL	**1.83E+00**	**8.56E-05**	**1.33E-05**

Round trip miles traveled based on ND BLM guidance.

W&S Composition for Truck Load Out Emissions

W&S Gas Component	Mole Fraction[a] (%)	Molecular Weight (lb/lb-mol)	Gas Weight (lb/lb-mol)	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-HAP	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 %. Regional typical E&P Tanks input data.

Exhaust Emissions from Recompletion Support Vehicles

Emission Factors for Commuting Vehicles

Vehicle		Emission Factors (g/mi)		
Type	Class	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	409.500	0.002	0.016
Heavy-Duty Diesel Truck	HDDV	791.800	0.037	0.006

Source: MOBILE6.2.03

[a] 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).

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 (tons/well)		
	Type	Class					CO_2	CH_4	N_2O
Well Recompletion	Fuel Haul Truck	HDDV	50	6	300	1	2.62E-01	1.22E-05	1.91E-06
	Mud Haul Truck, Water Hauling	HDDV	50	4	200	1	1.75E-01	8.16E-06	1.27E-06
	Rig Crew	LDDT	50	51	2550	1	1.15E+00	5.62E-06	4.36E-05
	Rig Mechanics	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Co. Supervisor	LDDT	50	20	1000	1	4.51E-01	2.20E-06	1.71E-05
	Semi Completion, Unit Rig	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Semi Fracing, Blender	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Semi Pumping/Tank Battery	HDDV	50	6	300	1	2.62E-01	1.22E-05	1.91E-06
	Tubing Truck	HDDV	50	2	100	1	8.73E-02	4.08E-06	6.36E-07
	Haul Cementer, Pump Truck	HDDV	50	2	100	1	8.73E-02	4.08E-06	6.36E-07
	Haul Cementer, Cement Truck	HDDV	50	3	150	1	1.31E-01	6.12E-06	9.54E-07
	Haul Completion, Equip Truck	HDDV	50	3	150	1	1.31E-01	6.12E-06	9.54E-07
	Haul Service Tools	LDDT	50	2	100	1	4.51E-02	2.20E-07	1.71E-06
	Haul Perforators Logging Truck	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Fracing, Tank	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Fracing, Pump	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Fracing, Chemical	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Fracing, Sand	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Fracing, Other	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Water Truck	HDDV	50	50	2500	1	2.18E+00	1.02E-04	1.59E-05
	Pickup Cementer, Engineer	LDDT	50	2	100	1	4.51E-02	2.20E-07	1.71E-06
	Pickup Completion Crew	HDDV	50	5	250	1	2.18E-01	1.02E-05	1.59E-06
	Pickup Completion, Pusher	LDDT	50	5	250	1	1.13E-01	5.51E-07	4.27E-06
	Pickup Perforators, Engineer	LDDT	50	2	100	1	4.51E-02	2.20E-07	1.71E-06
	Pickup Fracing, Engineer	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Pickup Co. Supervisor	LDDT	50	10	500	1	2.26E-01	1.10E-06	8.54E-06
	Pickup Miscellaneous Supplies	LDDT	50	3	150	1	6.77E-02	3.31E-07	2.56E-06
	Pickup Roustabout Crew	HDDV	50	4	200	1	1.75E-01	8.16E-06	1.27E-06
						Subtotal	**6.29E+00**	**2.04E-04**	**1.11E-04**
						Total	**6.29E+00**	**2.04E-04**	**1.11E-04**

Round trip miles traveled based on ND BLM guidance.

Oil Well - Gas Analysis

Gas Component	Mole Fraction (%)	Molecular Weight (lb/lb-mol)	Gas Weight (lb/lb-mol)	Weight Percent (wt%)	Weight (lb/MMscf)
Methane	64.754	16.040	10.387	39.802	16899.950
Ethane	9.778	30.070	2.940	11.267	4784.074
Nitrogen	6.390	28.020	1.790	6.861	2913.288
Water	0.000	18.015	0.000	0.000	0.000
Carbon Dioxide	1.654	43.990	0.728	2.788	1183.870
Nitrous Oxide	0.000	44.020	0.000	0.000	0.000
Hydrogen Sulfide	0.000	34.060	0.000	0.000	0.000
Non-reactive, non-HAP	82.576	---	15.845	60.719	
Propane	7.374	44.100	3.252	12.462	5291.224
Iso-butane	1.221	58.120	0.710	2.719	1154.664
n-butane	3.944	58.120	2.292	8.784	3729.726
i-pentane	1.124	72.150	0.811	3.108	1319.523
n-pentane	2.079	72.150	1.500	5.748	2440.649
Hexanes	1.682	100.210	1.686	6.459	2742.531
Heptanes	0.000	100.200	0.000	0.001	0.501
Octanes	0.000	114.230	0.000	0.000	0.000
Nonanes	0.000	128.258	0.000	0.000	0.000
Decanes+	0.000	142.29	0.000	0.000	0.000
Reactive VOC	17.424	---	10.251	39.281	
Benzene	0.000	78.110	0.000	0.000	0.000
Ethylbenzene	0.000	106.160	0.000	0.000	0.000
n-Hexane [3]	*1.682*	*100.210*	*1.686*	*6.459*	*2742.531*
Toluene	0.000	92.130	0.000	0.000	0.000
Xylenes	0.000	106.160	0.000	0.000	0.000
HAPs	1.682	---	1.686	6.459	
Totals	**100.000**	**---**	**26.095**	**100.000**	

Oil well natural gas analysis for Formation: Bakken - Cotton, Lease: Rosencrans 44-21H

Volume Flow: 0.38630137 MMSCF / day

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

Compressor and Pumpjack Engines Emissions

Emission Factors for Natural Gas-Fired Compressors and Pumps

Compressor / Pump		Horse-Power Rating	Units	Emission Factors		
				CO_2 [a]	CH_4 [a]	N_2O [a]
Compression Station	Lean Burn	300	gm/bhp-hr	1.35E+02	2.55E-03	2.55E-04
			lb/MMBTU	1.17E+02	2.20E-03	2.20E-04
Oil Pump at Well Head	Lean Burn	---	gm/bhp-hr	1.35E+02	2.55E-03	2.55E-04
			lb/MMBTU	1.17E+02	2.20E-03	2.20E-04

Note: Compressors assumed to be equipped with nonselective catalytic reduction (NSCR) catalyst.

[a] 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) or (MMBTU/year/well)	Annual # of Wells in Production	Annual Compression	Operating Hours/Year	Emissions (tons/year/well)		
					CO_2	CH_4	N_2O
Compression Station	0.3	1.00	0.3	8,760	4.38E-01	8.26E-06	8.26E-07
Oil Pump at Well Head	678	1.00	678	8,760	3.96E+01	7.48E-04	7.48E-05
				Total	**4.01E+01**	**7.56E-04**	**7.56E-05**

Compression rate of 3000 planned HP for all projected ND developed gas. (AECOM)
Typical oil well head pumpjack fuel usage of 4,603 MMBTU/year/well. (AECOM). That value is adjusted with assumption that 90% of pumps are electrified (BLM - NDFO).

Compressor Station Fugitives

Fugitive Emissions from Equipment Leaks

TOC Emission Factor								
Well Equipment Component	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 AECOM provided oil well gas analyses (see Gas Analysis Worksheet)

VOC Wt% =	39.28
CO2 Wt% =	2.79
CH4 Wt% =	39.80
N2O Wt% =	0.00

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	0.008	0.0099	0	0.0055	0	0.0002	7.78E-05	3.05E-05	2.17E-06	3.10E-05
pump seals	0.000	0.0053	0	0.0287	0	0.0001	0.00E+00	0.00E+00	0.00E+00	0.00E+00
others	0.000	0.0194	0	0.0165	0	0.0309	0.00E+00	0.00E+00	0.00E+00	0.00E+00
connectors	0.011	0.0004	0	0.0005	0	0.0002	4.94E-06	1.94E-06	1.38E-07	1.97E-06
flanges	0.027	0.0009	0	0.0002	0	0.0000	2.31E-05	9.08E-06	6.44E-07	9.20E-06
open-ended lines	0.000	0.0044	0	0.0031	0	0.0006	0.00E+00	0.00E+00	0.00E+00	0.00E+00
						TOTAL emissions/well/hr =	1.06E-04	4.16E-05	2.95E-06	4.21E-05

Number of components verified by ND BLM

Annual Emissions from Equipment Leaks Per Well								
Year	**Number of Producing Wells**	**Operating Hours**	**VOC emissions (lb/yr)**	**VOC emissions (ton/yr)**	**CO_2 emissions (lb/yr)**	**CO_2 emissions (ton/yr)**	**CH_4 emissions (lb/yr)**	**CH_4 emissions (ton/yr)**
Year 20	1	8760	3.64E-01	1.82E-04	2.58E-02	1.29E-05	3.69E-01	1.84E-04

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	0.2500
Number of Roads Reclaimed Annually Per Well	0.0100
Annual Miles of Roads reclaimed Per Well	0.0025
Number of wells reclaimed (per well)	0.0100

Reclaimation rate : 1% of operating wells reclaimed annually

Estimation of Total Operation Days and Hours

Annual Miles of Roads Reclaimed	Daily Miles of Road Work	Total # of Operating Days	Annual Operating Hours
0.003	6	0.0004	0.0042
		Total	**0.0042**

Assume average miles/day = 6

Emission Factors for 75-100 hp Off-Road Engines

Year	Emission Factors (g/hp-hr)		
	CO_2	CH_4	N_2O[a]
2008	600.507	0.010	0.016
2018	613.888	0.006	0.016
2027	608.641	0.003	0.016

[a] 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).

Exhaust Emissions Estimation for Grader Road Reclaim

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours	Emissions (tons/year/well)		
				CO_2	CH_4	N_2O
Road Reclamation	Grader	80	0.0025	1.35E-04	1.22E-09	3.42E-09

Exhaust Emission Factors for Commuting Reclaim Vehicles Road Traffic

Vehicle Class	Emission Factors (g/mi)		
	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	409.500	0.002	0.016

Source: MOBILE6.2.03

[a] 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).

Exhaust Emissions Estimation for Commuting Reclaim Vehicles: Road Traffic

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tons/year/well)		
	Type	Class				CO_2	CH_4	N_2O
Road Reclamation	Pickup Truck	LDDV	6	0.0004	0.0025	1.13E-06	5.51E-12	4.27E-11

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	0.0100	10	0.0100	0.1000

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

Exhaust Emissions Estimation for Grader: Well Reclamation

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours	Emissions (tons/year/well)		
				CO_2	CH_4	N_2O
Well Reclamation	Grader	100	0.0600	3.97E-03	6.62E-08	1.03E-07

Exhaust Emissions Estimation for Commuting Vehicles: Well Reclamation

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tons/year/well)		
	Type	Class				CO_2	CH_4	N_2O
Well Reclamation	Pickup Truck	LDDV	6	0.0100	0.0600	2.71E-05	1.32E-10	1.03E-09

Emissions for Gas Dehydration

Emission Factors for Dehydrator Heaters

Unit	CO_2	CH_4	N_2O
lb/MMSCF	120000.0	2.3	2.2
lb/MMBTU	117.647	0.002	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 (tons/year/well)		
				CO_2	CH_4	N_2O
2,190	1	2.20	0.0077	1.02E+00	1.96E-05	1.87E-05

Applied to all operating wells. Assumes 30% of the gas is flared and 70% processed for sales. (AECOM)

Annual Dehydrator Venting and Tank Flashing Emissions

Annual Well Gas Production MMscf	CH_4 Emission Factor (ton per MMscf)	CH_4 Emissions (TPY/well)
197.4000	0.0106	2.10E+00

Gas analysis information found in AECOM Gas Analysis Database (see Gas Analysis Sheet for component percentages). GRI GLYCalc estimated emissions.

Emission factor include emissions from dehy/regenerator still vents (no control) and flash tank emissions (no control).

Assumed 77.4% of gas production flows through dehydrators at least once (other 22.6% flared) -- per BLM NDFO.

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

Emissions for External Gas Combustion

Emission Factors for External Gas Combustion (Flares and Heaters)

Unit	CO_2	CH_4	N_2O
lb/MMSCF	120000.0	2.3	2.2
lb/MMBTU	117.647	0.002	0.002

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

Well Completion Flaring	Gas Production /Well (MMSCFD)	# of Days of Flaring	# of Wells	Emissions (tons/year/well)		
				CO_2	CH_4	N_2O
Flaring	0.386	15	1	347.6712	0.0067	0.0064
Total				**347.6712**	**0.0067**	**0.0064**

Applied to all contructed wells. For well completion, assumes 100% of the gas is flared.
Based on BLM - NDFO value of ~ 141 MMSCF/year/oil well.

Well Re-Completion Flaring	Gas Production /Well (MMSCFD)	# of Days of Flaring	# of Wells	Emissions (tons/year/well)		
				CO_2	CH_4	N_2O
Flaring	0.386	8	1	185.4247	0.0036	0.0034
Total				**185.4247**	**0.0036**	**0.0034**

Applied to 5% of all operating wells. Assumes 100% of the gas is flared.
Based on BLM - NDFO value of ~ 141 MMSCF/year/oil well.

Well Normal Operation Flaring	Gas Production /Well (MMSCF/year)	# of Wells	Emissions (tons/year/well)		
			CO_2	CH_4	N_2O
Flaring	41.37288	1	2482.3726	0.0476	0.0455
Total			**2482.3726**	**0.0476**	**0.0455**

Applied to all operating wells. Assumes 30% of the gas is flared and 70% processed for sales. (BLM - NDFO)
Based on BLM - NDFO value of ~ 141 MMSCF/year/oil well.

Well Pad Heaters	Annual Heater Fuel Usage /Well (MMBTU/year/ well)	# of Wells	Emissions (tons/year/well)		
			CO_2	CH_4	N_2O
Heaters	3.06	1	0.1800	0.0000	0.0000
Total			**0.1800**	**0.0000**	**0.0000**

Applied to all operating wells. Based on conservative estimate - year around usage.
Based on BLM - NDFO annual fuel usage value (per conversation with Industry Engineers).

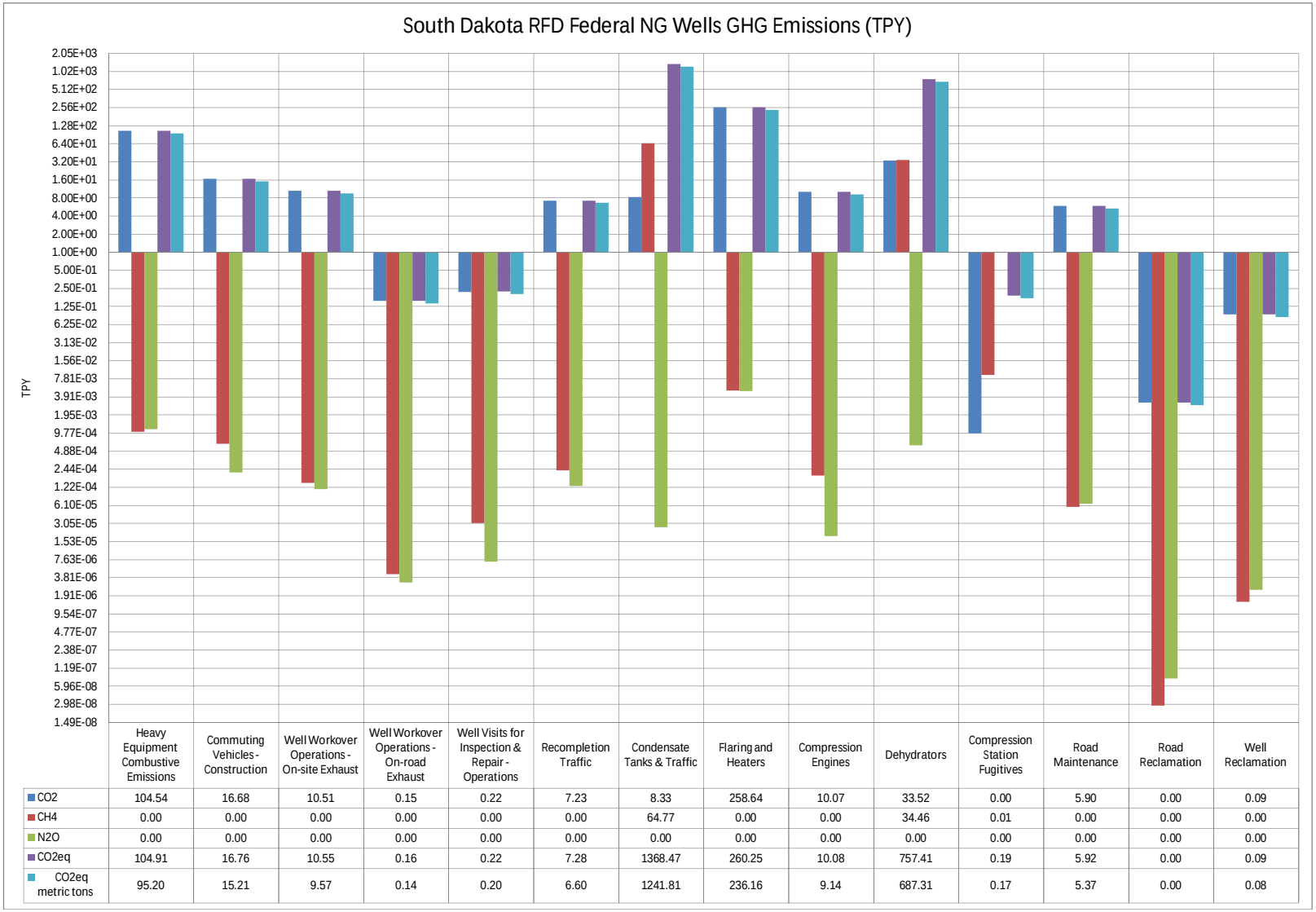
South Dakota input parameters for calculating NG wells emissions:

Maximum Annual Wells Drilled - Federal (excluding FS)	1	Maximum Annual Wells Drilled - Non-Federal	4
Federal Producing Wells (excluding FS)	23	Non-Federal Producing Wells	89
Average Annual Well Gas Production (MMSCF/year)	141	Average Annual Well Gas Production (MMSCF/year)	141

South Dakota Federal NG Wells Summaries

Total Annual Emissions from Federal NG Wells - RFD Estimates

Activity	Annual Emissions (Tons)				
	CO_2	CH_4	N_2O	CO_{2eq}	CO_{2eq} metric tons
Well Pad Construction - Fugitive Dust	---	---	---	---	---
Heavy Equipment Combustive Emissions	104.54	0.00	0.00	104.91	95.20
Commuting Vehicles - Construction	16.68	0.00	0.00	16.76	15.21
Wind Erosion	---	---	---	---	---
Sub-total: Construction	**121.22**	**0.00**	**0.00**	**121.67**	**110.41**
Well Workover Operations - Fugitive Dust	---	---	---	---	---
Well Workover Operations - On-site Exhaust	10.51	0.00	0.00	10.55	9.57
Well Workover Operations - On-road Exhaust	0.15	0.00	0.00	0.16	0.14
Well Visits for Inspection & Repair - Operations	0.22	0.00	0.00	0.22	0.20
Recompletion Traffic	7.23	0.00	0.00	7.28	6.60
Condensate Tanks & Traffic	8.33	64.77	0.00	1368.47	1241.81
Flaring and Heaters	258.64	0.00	0.00	260.25	236.16
Compression Engines	10.07	0.00	0.00	10.08	9.14
Dehydrators	33.52	34.46	0.00	757.41	687.31
Compression Station Fugitives	0.00	0.01	0.00	0.19	0.17
Sub-total: Operations	**328.68**	**99.24**	**0.01**	**2,414.60**	**2,191.11**
Road Maintenance	5.90	0.00	0.00	5.92	5.37
Sub-total: Maintenance	**5.901**	**0.000**	**0.00**	**5.92**	**5.37**
Road Reclamation	0.00	0.00	0.00	0.00	0.00
Well Reclamation	0.09	0.00	0.00	0.09	0.08
Sub-total: Reclamation	**0.0951**	**0.0000**	**0.0000**	**0.0959**	**0.0870**
Total Emissions	**455.89**	**99.25**	**0.01**	**2,542.29**	**2,306.98**

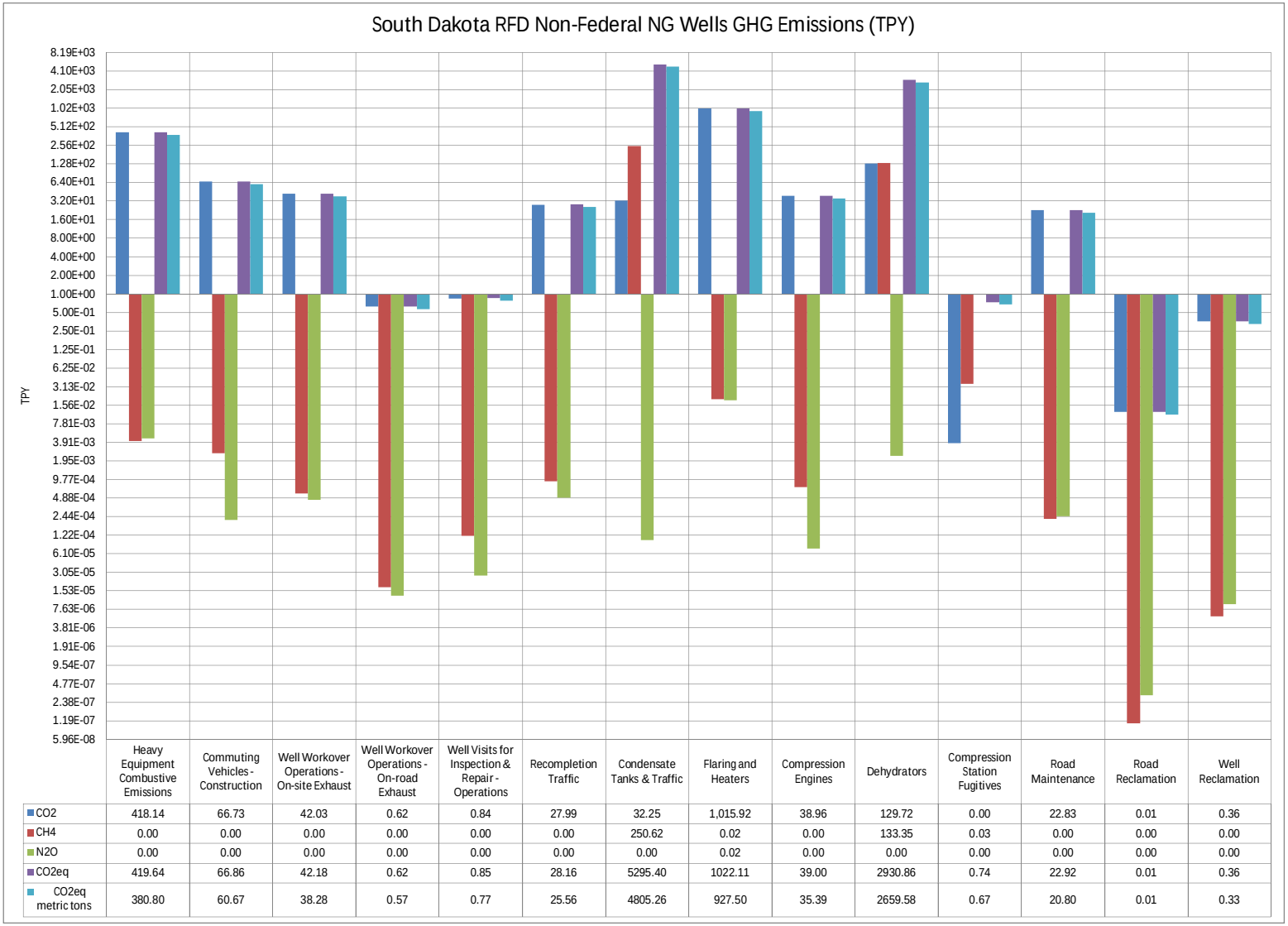


	Heavy Equipment Combustive Emissions	Commuting Vehicles - Construction	Well Workover Operations - On-site Exhaust	Well Workover Operations - On-road Exhaust	Well Visits for Inspection & Repair - Operations	Recompletion Traffic	Condensate Tanks & Traffic	Flaring and Heaters	Compression Engines	Dehydrators	Compression Station Fugitives	Road Maintenance	Road Reclamation	Well Reclamation
CO2	104.54	16.68	10.51	0.15	0.22	7.23	8.33	258.64	10.07	33.52	0.00	5.90	0.00	0.09
CH4	0.00	0.00	0.00	0.00	0.00	0.00	64.77	0.00	0.00	34.46	0.01	0.00	0.00	0.00
N2O	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
CO2eq	104.91	16.76	10.55	0.16	0.22	7.28	1368.47	260.25	10.08	757.41	0.19	5.92	0.00	0.09
CO2eq metric tons	95.20	15.21	9.57	0.14	0.20	6.60	1241.81	236.16	9.14	687.31	0.17	5.37	0.00	0.08

South Dakota Non-Federal NG Wells Summaries

Total Annual Emissions from Non-Federal NG Wells - RFD Estimates

Activity	Annual Emissions (Tons)				
	CO_2	CH_4	N_2O	CO_{2eq}	CO_{2eq} metric tons
Well Pad Construction - Fugitive Dust	---	---	---	---	---
Heavy Equipment Combustive Emissions	418.14	0.00	0.00	419.64	380.80
Commuting Vehicles - Construction	66.73	0.00	0.00	66.86	60.67
Wind Erosion	---	---	---	---	---
Sub-total: Construction	**484.88**	**0.01**	**0.00**	**486.49**	**441.46**
Well Workover Operations - Fugitive Dust			---	---	---
Well Workover Operations - On-site Exhaust	42.03	0.00	0.00	42.18	38.28
Well Workover Operations - On-road Exhaust	0.62	0.00	0.00	0.62	0.57
Well Visits for Inspection & Repair - Operations	0.84	0.00	0.00	0.85	0.77
Recompletion Traffic	27.99	0.00	0.00	28.16	25.56
Condensate Tanks & Traffic	32.25	250.62	0.00	5295.40	4805.26
Flaring and Heaters	1,015.92	0.02	0.02	1022.11	927.50
Compression Engines	38.96	0.00	0.00	39.00	35.39
Dehydrators	129.72	133.35	0.00	2930.86	2659.58
Compression Station Fugitives	0.00	0.03	0.00	0.74	0.67
Sub-total: Operations	**1,288.34**	**384.03**	**0.02**	**9,359.92**	**8,493.57**
Road Maintenance	22.83	0.00	0.00	22.92	20.80
Sub-total: Maintenance	**22.835**	**0.000**	**0.00**	**22.92**	**20.80**
Road Reclamation	0.01	0.00	0.00	0.01	0.01
Well Reclamation	0.36	0.00	0.00	0.36	0.33
Sub-total: Reclamation	**0.3680**	**0.0000**	**0.0000**	**0.3711**	**0.3368**
Total Emissions	**1,796.42**	**384.04**	**0.03**	**9,869.70**	**8,956.17**



	Heavy Equipment Combustive Emissions	Commuting Vehicles - Construction	Well Workover Operations - On-site Exhaust	Well Workover Operations - On-road Exhaust	Well Visits for Inspection & Repair - Operations	Recompletion Traffic	Condensate Tanks & Traffic	Flaring and Heaters	Compression Engines	Dehydrators	Compression Station Fugitives	Road Maintenance	Road Reclamation	Well Reclamation
CO2	418.14	66.73	42.03	0.62	0.84	27.99	32.25	1,015.92	38.96	129.72	0.00	22.83	0.01	0.36
CH4	0.00	0.00	0.00	0.00	0.00	0.00	250.62	0.02	0.00	133.35	0.03	0.00	0.00	0.00
N2O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00
CO2eq	419.64	66.86	42.18	0.62	0.85	28.16	5295.40	1022.11	39.00	2930.86	0.74	22.92	0.01	0.36
CO2eq metric tons	380.80	60.67	38.28	0.57	0.77	25.56	4805.26	927.50	35.39	2659.58	0.67	20.80	0.01	0.33

Exhaust Emissions from Heavy Construction Equipment

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

Project Year/Hp Category	Emission Factors (g/hp-hr)		
	CO_2	CH_4	N_2O[a]
Year 2018			
50 to 75	589.096	0.0064	0.0058
75 to 100	589.103	0.0064	0.0058
100 to 175	530.097	0.0047	0.0058
175 to 300	530.181	0.0043	0.0058
300 to 600	530.255	0.0040	0.0058
600 to 750	530.283	0.0038	0.0058
>750	529.917	0.0056	0.0058

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

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

Exhaust Emission Estimations for Construction Equipment - Based on Peak Wells Drilled each Alternative (using 2008 emission factors)

Construction Activity	Equipment Type	Capacity (hp)	# of Units	Av. Load Factor (%)	# of Oper. Hours/Day	# of Oper. Days/ Activity	# of Oper. Hours/Activity	# of Activities / Well	Emissions (tons/year/well)		
									CO_2	CH_4	N_2O
Drilling Roads	Blade	100	1	80	10	1.00	10.00	1.0000	4.67E-01	4.19E-06	5.09E-06
	Backhoe	80	1	75	10	1.00	10.00	1.0000	3.90E-01	4.20E-06	3.82E-06
Drilling Well Pad	Backhoe	80	1	75	10	1.00	10.00	1.0000	3.90E-01	4.20E-06	3.82E-06
Water Disposal well pad	Backhoe	80	1	75	10	2.00	20.00	0.1429	1.11E-01	1.20E-06	1.09E-06
New Pipeline Intermediate	Blade	100	1	80	10	5.00	50.00	0.1108	2.88E-01	3.10E-06	2.82E-06
	Trencher	175	1	80	10	5.00	50.00	0.1108	4.53E-01	4.06E-06	4.93E-06
	Backhoe	80	1	75	10	10.00	100.00	0.1108	4.32E-01	4.65E-06	4.23E-06
New Sales Pipeline	Blade	100	1	80	10	43.00	430.00	0.0002	3.68E-03	3.96E-08	3.60E-08
	Trencher	175	1	80	10	43.00	430.00	0.0002	5.79E-03	5.18E-08	6.30E-08
	Backhoe	80	1	75	10	65.00	650.00	0.0002	4.17E-03	4.49E-08	4.08E-08
Booster Compression Station	Dozer	350	1	80	10	2.00	20.00	0.1108	3.63E-01	2.70E-06	3.95E-06
	Backhoe	80	2	80	10	3.00	30.00	0.1108	2.76E-01	2.98E-06	2.71E-06
Sales Compression Station	Dozer	350	1	80	10	2.00	20.00	0.0110	3.61E-02	2.69E-07	3.93E-07
	Backhoe	80	2	80	10	3.00	30.00	0.0110	2.75E-02	2.96E-07	2.69E-07
								Subtotal	**3.25E+00**	**3.20E-05**	**3.32E-05**

Average number of days to construct wellpad and road: 2 obtained from BLM - NDFO.

Number of water disposal wells value (per well) provided by ND BLM.

Exhaust Emission Factors for Diesel Powered Bore/Drill Rig Engines

Project Year/Hp Category	Emission Factors (g/hp-hr)		
	CO_2	CH_4	N_2O[a]
Year 2018			
50 to 75	589.0959	0.0064	0.0058
75 to 100	589.1032	0.0064	0.0058
100 to 175	530.0969	0.0047	0.0058
175 to 300	530.1812	0.0043	0.0058
300 to 600	530.2546	0.0040	0.0058
600 to 750	530.2834	0.0038	0.0058
>750	529.9171	0.0056	0.0058

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

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

Combustive Emissions Estimation for Industrial Engines - Based on Peak Wells Drilled each Alternative

Construction Activity	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Oper. Hours/Day	# of Oper. Days/ Well	# of Oper. Hours/Well	# of Wells	Emissions (tons/year/well)		
									CO_2	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Main Deck	1550	1	60	18	2.00	36.00	1.0000	1.96E+01	1.46E-04	2.13E-04
	Auxillary Pump	200	1	90	18	2.00	36.00	1.0000	3.79E+00	3.09E-05	4.12E-05
Well Completion & Testing	Main Deck	850	1	60	18	1.00	18.00	1.0000	5.37E+00	4.00E-05	5.84E-05
	Auxillary Pump	125	1	90	18	1.00	18.00	1.0000	1.18E+00	1.06E-05	1.29E-05
Water Disposal well drilling	Generator	1476	1	40	24	30.00	720.00	0.1429	3.55E+01	3.78E-04	3.86E-04
	Generator	1476	1	40	24	30.00	720.00	0.1429	3.55E+01	3.78E-04	3.86E-04
								Subtotal	**1.01E+02**	**9.83E-04**	**1.10E-03**
								Total	**1.04E+02**	**1.02E-03**	**1.13E-03**

Water disposal well pad development rates and gas well drilling rates provided by ND BLM (2010).

Temporary Emission Estimations for Field Generators: Based on Peak Wells Drilled each Alternative

Construction Activity	Equipment Type	Capacity (hp)	# of Wells Served[a]	Avg. Load Factor	# of Oper. Hours/Day	# of Oper. Days/Well	# of Oper. Hours/Well	# of Wells	Emissions (tons/year/well)		
									CO_2	CH_4	N_2O
Field Generators	Field Generators for Pumps & Lighting	21	1	75	24	2.0000	48.0000	1.0000	4.41E-01	3.95E-06	4.80E-06
								Total	**4.41E-01**	**3.95E-06**	**4.80E-06**

Exhaust Emissions from Construction and Drilling Support Vehicles

Emission Factors for Commuting Vehicles

Vehicle		Emission Factors (g/mi)		
Type	Class	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	409.5	0.002	0.016
Heavy-Duty Diesel Truck	HDDV	791.8	0.04	0.006

Source: MOBILE6.2.03

[a] 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).

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 (tons/well)		
	Type	Class					CO_2	CH_4	N_2O
Improved & Two-Track Road	Semi Trucks	HDDV	50	47	2350	1	2.05E+00	9.58E-05	1.49E-05
	Pickup Trucks	LDDT	50	3	150	1	6.77E-02	3.31E-07	2.56E-06
Well Pad	Semi Trucks	HDDV	50	5	250	1	2.18E-01	1.02E-05	1.59E-06
	Pickup Trucks	LDDT	50	4	200	1	9.03E-02	4.41E-07	3.42E-06
Other Construction Activities	Semi Trucks	HDDV	50	2	100	1	8.73E-02	4.08E-06	6.36E-07
	Haul Trucks	HDDV	50	2	100	1	8.73E-02	4.08E-06	6.36E-07
	Pickup Trucks	LDDT	50	1	50	1	2.26E-02	1.10E-07	8.54E-07
						Subtotal	**2.62E+00**	**1.15E-04**	**2.46E-05**

Round trip miles traveled based on ND BLM guidance.

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 (tons/well)		
	Type	Class					CO_2	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Semi Rig Transport, Drill Rig	HDDV	50	44	2200	1	1.92E+00	8.97E-05	1.40E-05
	Fuel Haul Truck	HDDV	50	6	300	1	2.62E-01	1.22E-05	1.91E-06
	Mud Haul Truck, Water Hauling	HDDV	50	4	200	1	1.75E-01	8.16E-06	1.27E-06
	Rig Crew	LDDT	50	51	2550	1	1.15E+00	5.62E-06	4.36E-05
	Rig Mechanics	HDDV	50	2	100	1	8.73E-02	4.08E-06	6.36E-07
	Co. Supervisor	LDDT	50	20	1000	1	4.51E-01	2.20E-06	1.71E-05
	Tool Pusher	LDDT	50	8	400	1	1.81E-01	8.82E-07	6.83E-06
	Mud Logger	LDDT	50	6	300	1	1.35E-01	6.61E-07	5.13E-06
	Mud Engineer	LDDT	50	15	750	1	3.39E-01	1.65E-06	1.28E-05
	Logger, Engr Truck	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Drill Bit Delivery	LDDT	50	2	100	1	4.51E-02	2.20E-07	1.71E-06

Round trip miles traveled based on ND BLM guidance.

Combustive Emissions Estimation Road Traffic (cont.)

Construction Site Destination	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells	Emissions (tons/well)		
	Type	Class					CO_2	CH_4	N_2O
Well Completion & Testing	Semi Casing Haulers	HDDV	50	6	300	1	2.62E-01	1.22E-05	1.91E-06
	Semi Completion, Unit Rig	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Semi Fracing, Blender	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Semi Pumping/Tank Battery	HDDV	50	6	300	1	2.62E-01	1.22E-05	1.91E-06
	Tubing Truck	HDDV	50	2	100	1	8.73E-02	4.08E-06	6.36E-07
	Haul Cementer, Pump Truck	HDDV	50	2	100	1	8.73E-02	4.08E-06	6.36E-07
	Haul Cementer, Cement Truck	HDDV	50	3	150	1	1.31E-01	6.12E-06	9.54E-07
	Haul Completion, Equip Truck	HDDV	50	3	150	1	1.31E-01	6.12E-06	9.54E-07
	Haul Service	LDDT	50	2	100	1	4.51E-02	2.20E-07	1.71E-06
	Haul Perforators Logging Truck	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Anchor, Installation	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Anchor, Testing	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Fracing, Tank	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Fracing, Pump	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Fracing, Chemical	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Fracing, Sand	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Fracing, Other	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Welders	HDDV	50	6	300	1	2.62E-01	1.22E-05	1.91E-06
	Haul Water	HDDV	50	150	7500	1	6.55E+00	3.06E-04	4.77E-05
	Pickup Cementer, Engineer	LDDT	50	2	100	1	4.51E-02	2.20E-07	1.71E-06
	Pickup Casing Crew	HDDV	50	2	100	1	8.73E-02	4.08E-06	6.36E-07
	Pickup Completion Crew	HDDV	50	5	250	1	2.18E-01	1.02E-05	1.59E-06

	Pickup Completion, Pusher	LDDT	50	5	250	1	1.13E-01	5.51E-07	4.27E-06
	Pickup Perforators, Engineer	LDDT	50	2	100	1	4.51E-02	2.20E-07	1.71E-06
	Pickup Fracing, Engineer	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Pickup Co. Supervisor	LDDT	50	10	500	1	2.26E-01	1.10E-06	8.54E-06
	Pickup Miscellaneous	LDDT	50	3	150	1	6.77E-02	3.31E-07	2.56E-06
	Pickup Roustabout	HDDV	50	4	200	1	1.75E-01	8.16E-06	1.27E-06
						Subtotal	**1.41E+01**	**5.38E-04**	**1.89E-04**
						Total	**1.67E+01**	**6.53E-04**	**2.14E-04**

Round trip miles traveled based on ND BLM guidance.

Exhaust Emissions from Well Work Overs

Emission Factors Bore/Drill Rig Engines 300-600 Hp

Fuel Type	Emission Factors (gm/hp-hr)		
	CO_2	CH_4	N_2O[a]
Diesel	529.575	0.007	0.006

Source: EPA NONROADS 2008a. Year 2008.

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

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 (tons/year/well)		
							CO_2	CH_4	N_2O
Well Workover	Truck-Mounted Unit	600	10	3	30	1	1.05E+01	1.46E-04	1.14E-04

Exhaust emission factors for commuting vehicles

Vehicle		Emission Factors (g/mi)		
Type	Class	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	409.500	0.002	0.016
Heavy-Duty Diesel Truck	HDDV	791.800	0.037	0.006

Source: MOBILE 6.2.03

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

[a] 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

Activity	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells Drilled	Max. Annual Emissions (tons/year/well)		
	Type	Class					CO_2	CH_4	N_2O
Well Workover	WO Rig	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Truck	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Pickup Truck	LDDT	50	3	150	1	6.77E-02	3.31E-07	2.56E-06
						Total	**1.55E-01**	**4.41E-06**	**3.20E-06**

Performed once in the first year of well operation and applied to peak number of wells drilled annually.
Round trip miles traveled based on ND BLM guidance.

Exhaust Emissions from Site Visits and Inspections

Emission factors for Commuting Vehicles Exhaust

Vehicle Class	Emission Factors (g/mi)		
	CO_2	CH_4	N_2O[a]
Light-Duty Gasoline Truck	476.90	0.07	0.02

Source: MOBILE 6.2.03
Emission factors for 2008 used for all years = conservative estimate for fleet vehicle turnover
[a] 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)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Federal Wells Producing	Emissions (tons/yr/well)		
	Type	Class					CO_2	CH_4	N_2O
Inspection Visits for Wells	Pickup Truck	LDGT2	1.5	12	18	1	9.46E-03	1.35E-06	3.06E-07

Roundtrip distance shown in AECOM dataset.

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 year

[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
Number of Wells	1
Cumulative Length of Roads [b] (miles/operation)	1

[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	0.3333	3.3333
Winter	1	1	5	10	0.2000	2.0000
				Total	**0.5333**	**5.3333**

Emission Factors for Construction Equipment Exhaust

Equipment	Emission Factors (g/hp-hr)		
	CO_2	CH_4	N_2O[a]
Grader 100-175 Hp	535.7700	0.0053	0.0058

Source: EPA NONROADS 2008a

Use emission factors for 2008 for all project years - conservative estimate of vehicle turnover

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

Emission Estimations for Grader: RMP Year 20

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours[a]	Emissions (tons/well)		
				CO_2	CH_4	N_2O
Road Maintenance	Grader	135	3.20	2.55E-01	2.52E-06	2.75E-06

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

Emission Factors for Commuting Vehicles Exhaust

Vehicle Class	Emission Factors (g/mi)		
	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	409.500	0.002	0.016

Source: MOBILE 6.2.03

[a] 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 (tons/yr)		
	Type	Class				CO_2	CH_4	N_2O
Road Maintenance	Pickup Truck	LDDT	6	0.5333	3.2000	1.44E-03	7.05E-09	5.47E-08

Condensate Tank, Loadout and Hauling Emissions

NG Well Condensate Seperator Flashing and Tank Emissions[a]

Project Year	Emissions[b]			
	HAPs Emissions (ton/yr/well)	VOC Emissions (ton/yr/well)	CO_2 Emissions (ton/yr/well)	CH_4 Emissions (ton/yr/well)
All	1.89E-01	6.82E+00	2.06E-01	2.82E+00

[a] Based on Regional (northwest U.S.) typical data values and calculations using E&P Tanks, August, 2010 -- API Gravity : 50, RVP : 7.4 psia, seperator pressure: 700 psig, seperator temperature: 100F, white tank, Montana weather conditions. Assumes 2 bbl condensate per day per well.
[b] Assumes no emissions control.

NG Well Condensate 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/10^3 gal) 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 =	8.0	ave. vapor pressure from GMI-EIS Feb. 2010 (BLM NOC Workbook)
M =	68	Typical condensate value shown in BLM NOC Workbook.
T =	540	ave. temp.
L_L =	7.53	

NG Well Condensate Truck Loadout Emissions - All Project Years[a]

Project Year	Emission Factor (lbs/1,000 gallons)	Annual Consensate Volume (bbl) - per well	Condensate (1,000 gallons)	VOC Emissions (tpy/well)	CO_2 Emissions (tpy/well)	CH_4 Emissions (tpy/well)
All	7.53	717	30	1.13E-01	0.00E+00	0.00E+00

[a] Uses E&P Tanks Stream Data for W&S Gas mol % (shown below). Regional typical E&P Tanks input data (see composition below). Annual condensate production value found in AECOM dataset.

Emission Factors for Work Over Vehicles - Road Traffic

Vehicle Class	Emission Factors (g/mi)		
	CO_2	CH_4	N_2O[a]
Heavy-Duty Diesel Truck (HDDV)	791.800	0.037	0.006

Source: MOBILE6.2.03

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

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

Activity	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well	Miles Traveled/Well	Total # of Wells	Emissions (tons/year/well)		
	Type	Class					CO_2	CH_4	N_2O
Produced Condensate Hauling	Haul Truck (200 bbl)	HDDV	50	3.6	179.14	1	1.56E-01	7.31E-06	1.14E-06
						TOTAL	**1.56E-01**	**7.31E-06**	**1.14E-06**

Round trip miles traveled based on ND BLM guidance. Assumes all condensate is stored on well pad.

W&S Composition for Truck Load Out Emissions

W&S Gas Component	Mole Fraction[a] (%)	Molecular Weight (lb/lb-mol)	Gas Weight (lb/lb-mol)	Weight Percent (wt%)
Methane	0.000	16.040	0.000	0.000
Ethane	0.000	30.070	0.000	0.000
Nitrogen	0.000	28.020	0.000	0.000
Water	0.000	18.015	0.000	0.000
Carbon Dioxide	0.000	43.990	0.000	0.000
Nitrous Oxide	0.000	44.020	0.000	0.000
Hydrogen Sulfide	0.000	34.060	0.000	0.000
Non-reactive, non-HAP	0.000	---	0.000	0.000
Propane	0.000	44.100	0.000	0.000
Iso-butane	0.000	58.120	0.000	0.000
n-butane	9.011	58.120	5.237	6.816
i-pentane	22.661	72.150	16.350	21.278
n-pentane	20.732	72.150	14.958	19.467
Hexanes	13.459	100.210	13.487	17.552
Heptanes	14.283	100.200	14.312	18.625
Octanes	5.087	114.230	5.810	7.562
Nonanes	0.771	128.258	0.988	1.286
Decanes+	0.059	142.29	0.083	0.109
Reactive VOC	86.062	---	71.226	92.695
Benzene	2.276	78.110	1.777	2.313
Ethylbenzene	0.009	106.160	0.009	0.012
n-Hexane	7.516	100.210	7.532	9.802
Toluene	4.036	92.130	3.718	4.839
Xylenes	0.102	106.160	0.108	0.141
HAPs	13.938	---	13.145	17.107
Totals	**100.000**	**---**	**76.839**	**100.000**

[a] E&P Tanks Stream Data for W&S Gas mol %. Regional (northwest U.S.) typical E&P Tanks input data -- API Gravity : 50, RVP : 7.4 psia, seperator pressure: 700 psig, seperator temperature: 100F, white tank, Montana weather conditions. Assumes 2 bbl condensate per day per well.

Exhaust Emissions from Recompletion Support Vehicles

Emission Factors for Commuting Vehicles

Vehicle		Emission Factors (g/mi)		
Type	Class	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	409.500	0.002	0.016
Heavy-Duty Diesel Truck	HDDV	791.800	0.037	0.006

Source: MOBILE6.2.03

[a] 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).

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 (tons/well)		
	Type	Class					CO_2	CH_4	N_2O
Well Recompletion	Fuel Haul Truck	HDDV	50	6	300	1	2.62E-01	1.22E-05	1.91E-06
	Mud Haul Truck, Water Hauling	HDDV	50	4	200	1	1.75E-01	8.16E-06	1.27E-06
	Rig Crew	LDDT	50	51	2550	1	1.15E+00	5.62E-06	4.36E-05
	Rig Mechanics	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Co. Supervisor	LDDT	50	20	1000	1	4.51E-01	2.20E-06	1.71E-05
	Semi Completion, Unit Rig	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Semi Fracing, Blender	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Semi Pumping/Tank Battery	HDDV	50	6	300	1	2.62E-01	1.22E-05	1.91E-06
	Tubing Truck	HDDV	50	2	100	1	8.73E-02	4.08E-06	6.36E-07
	Haul Cementer, Pump Truck	HDDV	50	2	100	1	8.73E-02	4.08E-06	6.36E-07
	Haul Cementer, Cement Truck	HDDV	50	3	150	1	1.31E-01	6.12E-06	9.54E-07
	Haul Completion, Equip Truck	HDDV	50	3	150	1	1.31E-01	6.12E-06	9.54E-07
	Haul Service Tools	LDDT	50	2	100	1	4.51E-02	2.20E-07	1.71E-06
	Haul Perforators Logging Truck	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Fracing, Tank	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Fracing, Pump	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Fracing, Chemical	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Fracing, Sand	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Fracing, Other	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Water Truck	HDDV	50	50	2500	1	2.18E+00	1.02E-04	1.59E-05
	Pickup Cementer, Engineer	LDDT	50	2	100	1	4.51E-02	2.20E-07	1.71E-06
	Pickup Completion Crew	HDDV	50	5	250	1	2.18E-01	1.02E-05	1.59E-06
	Pickup Completion, Pusher	LDDT	50	5	250	1	1.13E-01	5.51E-07	4.27E-06
	Pickup Perforators, Engineer	LDDT	50	2	100	1	4.51E-02	2.20E-07	1.71E-06
	Pickup Fracing, Engineer	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Pickup Co. Supervisor	LDDT	50	10	500	1	2.26E-01	1.10E-06	8.54E-06
	Pickup Miscellaneous Supplies	LDDT	50	3	150	1	6.77E-02	3.31E-07	2.56E-06
	Pickup Roustabout Crew	HDDV	50	4	200	1	1.75E-01	8.16E-06	1.27E-06
						Subtotal	**6.29E+00**	**2.04E-04**	**1.11E-04**
						Total	**6.29E+00**	**2.04E-04**	**1.11E-04**

Round trip miles traveled based on ND BLM guidance.

Gas Analysis

Gas Component	Mole Fraction (%)	Molecular Weight (lb/lb-mol)	Gas Weight (lb/lb-mol)	Weight Percent (wt%)	Weight (lb/MMscf)
Methane	92.532	16.040	14.842	84.677	35953.744
Ethane	0.633	30.070	0.190	1.086	461.089
Nitrogen	3.201	28.020	0.897	5.117	2172.709
Water	0.000	18.015	0.000	0.000	0.000
Carbon Dioxide	3.634	43.990	1.599	9.120	3872.458
Nitrous Oxide	0.000	44.020	0.000	0.000	0.000
Hydrogen Sulfide	0.000	34.060	0.000	0.000	0.000
Non-reactive, non-HAP	100.000	---	17.528	100.000	
Propane	0.000	44.100	0.000	0.000	0.000
Iso-butane	0.000	58.120	0.000	0.000	0.000
n-butane	0.000	58.120	0.000	0.000	0.000
i-pentane	0.000	72.150	0.000	0.000	0.000
n-pentane	0.000	72.150	0.000	0.000	0.000
Hexanes	0.000	100.210	0.000	0.000	0.000
Heptanes	0.000	100.200	0.000	0.000	0.000
Octanes	0.000	114.230	0.000	0.000	0.000
Nonanes	0.000	128.258	0.000	0.000	0.000
Decanes+	0.000	142.29	0.000	0.000	0.000
Reactive VOC	0.000	---	0.000	0.000	
Benzene	0.000	78.110	0.000	0.000	0.000
Ethylbenzene	0.000	106.160	0.000	0.000	0.000
n-Hexane [3]	*0.000*	*100.210*	*0.000*	*0.000*	*0.000*
Toluene	0.000	92.130	0.000	0.000	0.000
Xylenes	0.000	106.160	0.000	0.000	0.000
HAPs	0.000	---	0.000	0.000	
Totals	**100.000**	**---**	**17.528**	**100.000**	

Gas well natural gas analysis for : Winnipeg/Deadwood - Dimmick, Lease: Fancy Butte 14-32

Volume Flow: 0.38630137 MMSCF / day

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

Compressor Stations Emissions

Emission Factors for Natural Gas-Fired Compressors and Pumps

Compressor / Pump		Horse-Power Rating	Units	Emission Factors		
				CO_2 [a]	CH_4 [a]	N_2O [a]
Compression Station	Lean Burn	300	gm/bhp-hr	1.35E+02	2.55E-03	2.55E-04
			lb/MMBTU	1.17E+02	2.20E-03	2.20E-04

Note: Compressors assumed to be equipped with nonselective catalytic reduction (NSCR) catalyst.

[a] 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	Operating Hours/Year	Emissions (tons/year/well)		
					CO_2	CH_4	N_2O
Compression Station	0.3	1.00	0.3	8,760	4.38E-01	8.26E-06	8.26E-07
				Total	**4.38E-01**	**8.26E-06**	**8.26E-07**

Compression rate of 3000 planned HP for all projected ND developed gas. (AECOM)

Compressor Station Fugitives

Fugitive Emissions from Equipment Leaks

TOC Emission Factor								
Well Equipment Component	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 AECOM provided gas well gas analyses (see Gas Analysis Worksheet)

VOC Wt% =	0.00
CO2 Wt% =	9.12
CH4 Wt% =	84.68
N2O Wt% =	0.00

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	0.008	0.0099	0	0.0055	0	0.0002	7.78E-05	0.00E+00	7.09E-06	6.58E-05
pump seals	0.000	0.0053	0	0.0287	0	0.0001	0.00E+00	0.00E+00	0.00E+00	0.00E+00
others	0.000	0.0194	0	0.0165	0	0.0309	0.00E+00	0.00E+00	0.00E+00	0.00E+00
connectors	0.011	0.0004	0	0.0005	0	0.0002	4.94E-06	0.00E+00	4.50E-07	4.18E-06
flanges	0.027	0.0009	0	0.0002	0	0.0000	2.31E-05	0.00E+00	2.11E-06	1.96E-05
open-ended lines	0.000	0.0044	0	0.0031	0	0.0006	0.00E+00	0.00E+00	0.00E+00	0.00E+00
						TOTAL emissions/well/hr =	1.06E-04	0.00E+00	9.65E-06	8.96E-05

Number of components verified by ND BLM

Annual Emissions from Equipment Leaks Per Well								
Year	**Number of Producing Wells**	**Operating Hours**	**VOC emissions (lb/yr)**	**VOC emissions (ton/yr)**	**CO_2 emissions (lb/yr)**	**CO_2 emissions (ton/yr)**	**CH_4 emissions (lb/yr)**	**CH_4 emissions (ton/yr)**
Year 20	1	8760	0.00E+00	0.00E+00	8.45E-02	4.23E-05	7.85E-01	3.92E-04

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	0.2500
Number of Roads Reclaimed Annually Per Well	0.0100
Annual Miles of Roads reclaimed Per Well	0.0025
Number of wells reclaimed (per well)	0.0100

Reclaimation rate : 1% of operating wells reclaimed annually

Estimation of Total Operation Days and Hours

Annual Miles of Roads Reclaimed	Daily Miles of Road Work	Total # of Operating Days	Annual Operating Hours
0.003	6	0.0004	0.0042
		Total	**0.0042**

Assume average miles/day = 6

Emission Factors for 75-100 hp Off-Road Engines

Year	Emission Factors (g/hp-hr)		
	CO_2	CH_4	N_2O[a]
2008	600.507	0.010	0.016
2018	613.888	0.006	0.016
2027	608.641	0.003	0.016

[a] 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).

Exhaust Emissions Estimation for Grader Road Reclaim

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours	Emissions (tons/year/well)		
				CO_2	CH_4	N_2O
Road Reclamation	Grader	80	0.0025	1.35E-04	1.22E-09	3.42E-09

Exhaust Emission Factors for Commuting Reclaim Vehicles Road Traffic

Vehicle Class	Emission Factors (g/mi)		
	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	409.500	0.002	0.016

Source: MOBILE6.2.03

[a] 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).

Exhaust Emissions Estimation for Commuting Reclaim Vehicles: Road Traffic

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tons/year/well)		
	Type	Class				CO_2	CH_4	N_2O
Road Reclamation	Pickup Truck	LDDV	6	0.0004	0.0025	1.13E-06	5.51E-12	4.27E-11

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	0.0100	10	0.0100	0.1000

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

Exhaust Emissions Estimation for Grader: Well Reclamation

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours	Emissions (tons/year/well)		
				CO_2	CH_4	N_2O
Well Reclamation	Grader	100	0.0600	3.97E-03	6.62E-08	1.03E-07

Exhaust Emissions Estimation for Commuting Vehicles: Well Reclamation

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tons/year/well)		
	Type	Class				CO_2	CH_4	N_2O
Well Reclamation	Pickup Truck	LDDV	6	0.0100	0.0600	2.71E-05	1.32E-10	1.03E-09

Emissions for Gas Dehydration

Emission Factors for Dehydrator Heaters

Unit	CO_2	CH_4	N_2O
lb/MMSCF	120000.0	2.3	2.2
lb/MMBTU	117.647	0.002	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 (tons/year/well)		
				CO_2	CH_4	N_2O
2,190	1	2.20	0.0110	1.46E+00	2.79E-05	2.67E-05

Annual Dehydrator Venting and Tank Flashing Emissions

Annual Well Gas Production MMscf	CH_4 Emission Factor (ton per MMscf)	CH_4 Emissions (TPY/well)
141.0000	0.0106	1.50E+00

Gas analysis information found in AECOM Gas Analysis Database (see Gas Analysis Sheet for component percentages). GRI GLYCalc estimated emissions.

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 least once.

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

Emissions for External Gas Combustion

Emission Factors for External Gas Combustion (Flares and Heaters)

Unit	CO_2	CH_4	N_2O
lb/MMSCF	120000.0	2.3	2.2
lb/MMBTU	117.647	0.002	0.002

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

Well Completion Flaring	Gas Production /Well (MMSCFD)	# of Days of Flaring	# of Wells	Emissions (tons/year/well)		
				CO_2	CH_4	N_2O
Flaring	0.386	5	1	115.8904	0.0022	0.0021
Total				**115.8904**	**0.0022**	**0.0021**

Applied to all contructed wells. For well completion, assumes 100% of the gas is flared.
Based on BLM - NDFO value of ~ 141 MMSCF/year/well.

Well Re-Completion Flaring	Gas Production /Well (MMSCFD)	# of Days of Flaring	# of Wells	Emissions (tons/year/well)		
				CO_2	CH_4	N_2O
Flaring	0.386	5	1	115.8904	0.0022	0.0021
Total				**115.8904**	**0.0022**	**0.0021**

Applied to 5% of all operating wells. Assumes 100% of the gas is flared.
Based on BLM - NDFO value of ~ 141 MMSCF/year/well.

Well Blowdown Flaring	Gas Production /Well (MMSCFD)	# of Days of Flaring	# of Wells	Emissions (tons/year/well)		
				CO_2	CH_4	N_2O
Flaring	0.386	1	1	23.1781	0.0004	0.0004
Total				**23.1781**	**0.0004**	**0.0004**

Applied to 1% of all operating wells. Assumes 100% of the gas is flared.
Based on BLM - NDFO value of ~ 141 MMSCF/year/well.

Well Pad Heaters	Annual Heater Fuel Usage /Well (MMBTU/year/ well)	# of Wells	Emissions (tons/year/well)		
			CO_2	CH_4	N_2O
Seperator Heaters	3.06	1	0.1800	0.0000	0.0000
Total			**0.1800**	**0.0000**	**0.0000**

Applied to all operating wells. Based on conservative estimate - year around usage.
Based on BLM - NDFO annual fuel usage value (per conversation with Industry Engineers).

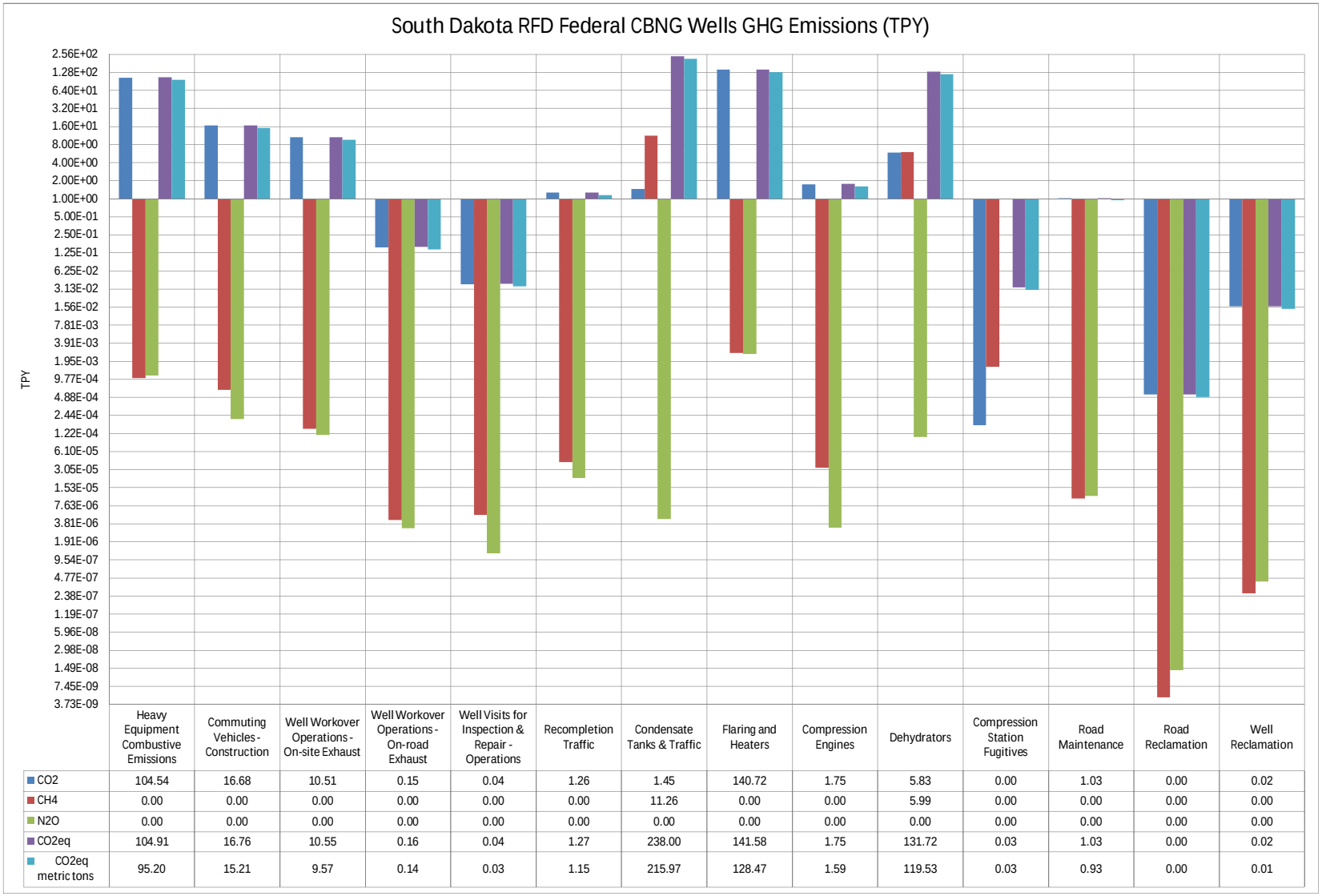
South Dakota input parameters for calculating CBNG wells emissions:

Maximum Annual Wells Drilled - Federal (excluding FS)	1	Maximum Annual Wells Drilled - Non-Federal	3
Federal Producing Wells (excluding FS)	4	Non-Federal Producing Wells	71
Average Annual Well Gas Production (MMSCF/year)	141	Average Annual Well Gas Production (MMSCF/year)	141

South Dakota Federal CBNG Wells Summaries

Total Annual Emissions from Federal NG Wells - RFD Estimates

Activity	Annual Emissions (Tons)				
	CO_2	CH_4	N_2O	CO_{2eq}	CO_{2eq} metric tons
Well Pad Construction - Fugitive Dust	---	---	---	---	---
Heavy Equipment Combustive Emissions	104.54	0.00	0.00	104.91	95.20
Commuting Vehicles - Construction	16.68	0.00	0.00	16.76	15.21
Wind Erosion	---	---	---	---	---
Sub-total: Construction	**121.22**	**0.00**	**0.00**	**121.67**	**110.41**
Well Workover Operations - Fugitive Dust	---	---	---	---	---
Well Workover Operations - On-site Exhaust	10.51	0.00	0.00	10.55	9.57
Well Workover Operations - On-road Exhaust	0.15	0.00	0.00	0.16	0.14
Well Visits for Inspection & Repair - Operations	0.04	0.00	0.00	0.04	0.03
Recompletion Traffic	1.26	0.00	0.00	1.27	1.15
Condensate Tanks & Traffic	1.45	11.26	0.00	238.00	215.97
Flaring and Heaters	140.72	0.00	0.00	141.58	128.47
Compression Engines	1.75	0.00	0.00	1.75	1.59
Dehydrators	5.83	5.99	0.00	131.72	119.53
Compression Station Fugitives	0.00	0.00	0.00	0.03	0.03
Sub-total: Operations	**161.70**	**17.26**	**0.00**	**525.09**	**476.49**
Road Maintenance	1.03	0.00	0.00	1.03	0.93
Sub-total: Maintenance	**1.026**	**0.000**	**0.00**	**1.03**	**0.93**
Road Reclamation	0.00	0.00	0.00	0.00	0.00
Well Reclamation	0.02	0.00	0.00	0.02	0.01
Sub-total: Reclamation	**0.0165**	**0.0000**	**0.0000**	**0.0167**	**0.0151**
Total Emissions	**283.97**	**17.26**	**0.00**	**647.81**	**587.85**

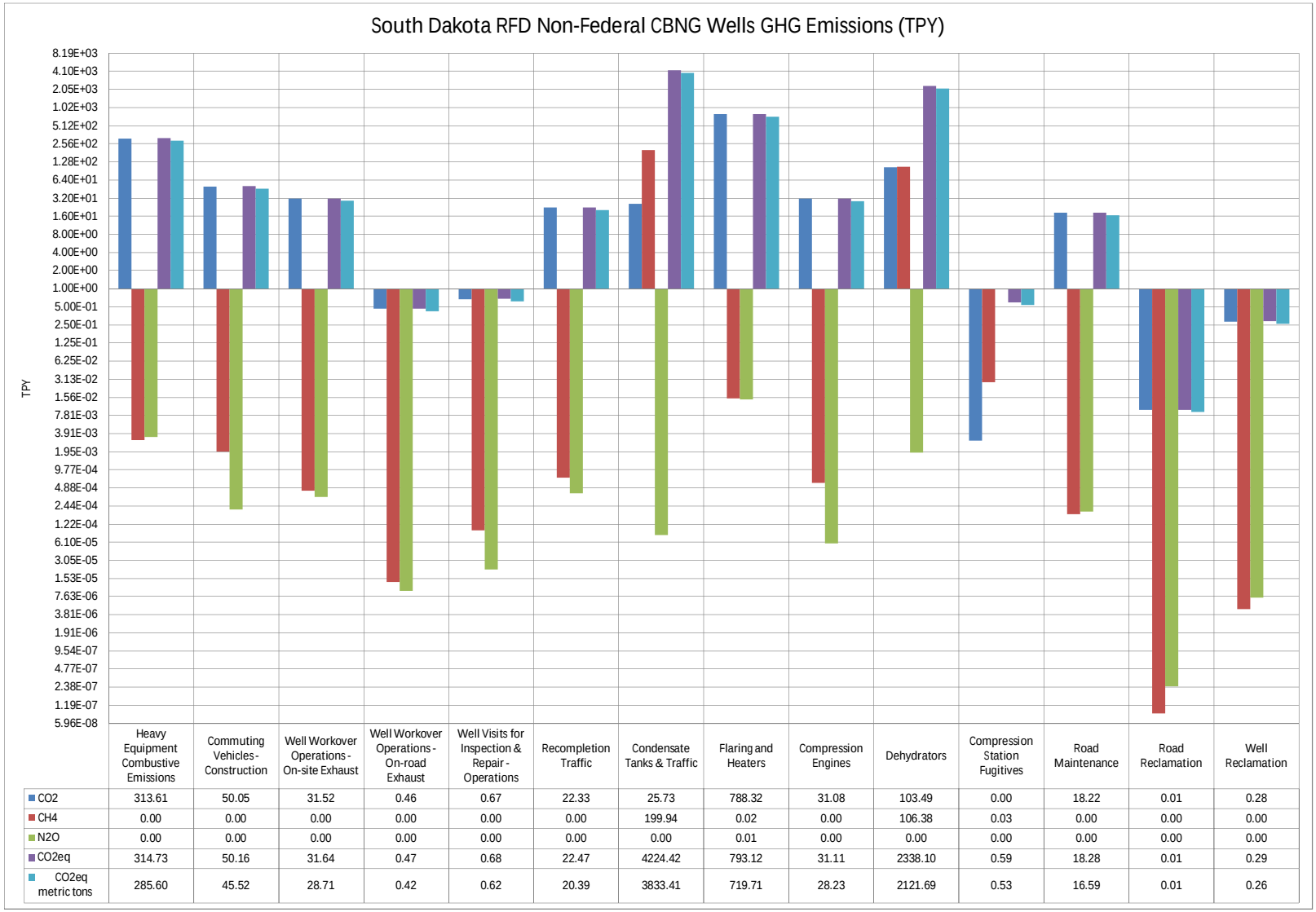


	Heavy Equipment Combustive Emissions	Commuting Vehicles - Construction	Well Workover Operations - On-site Exhaust	Well Workover Operations - On-road Exhaust	Well Visits for Inspection & Repair - Operations	Recompletion Traffic	Condensate Tanks & Traffic	Flaring and Heaters	Compression Engines	Dehydrators	Compression Station Fugitives	Road Maintenance	Road Reclamation	Well Reclamation
CO2	104.54	16.68	10.51	0.15	0.04	1.26	1.45	140.72	1.75	5.83	0.00	1.03	0.00	0.02
CH4	0.00	0.00	0.00	0.00	0.00	0.00	11.26	0.00	0.00	5.99	0.00	0.00	0.00	0.00
N2O	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
CO2eq	104.91	16.76	10.55	0.16	0.04	1.27	238.00	141.58	1.75	131.72	0.03	1.03	0.00	0.02
CO2eq metric tons	95.20	15.21	9.57	0.14	0.03	1.15	215.97	128.47	1.59	119.53	0.03	0.93	0.00	0.01

South Dakota Non-Federal CBNG Wells Summaries

Total Annual Emissions from Non-Federal NG Wells - RFD Estimates

Activity	Annual Emissions (Tons)				
	CO_2	CH_4	N_2O	CO_{2eq}	CO_{2eq} metric tons
Well Pad Construction - Fugitive Dust	---	---	---	---	---
Heavy Equipment Combustive Emissions	313.61	0.00	0.00	314.73	285.60
Commuting Vehicles - Construction	50.05	0.00	0.00	50.16	45.52
Wind Erosion	---	---	---	---	---
Sub-total: Construction	**363.66**	**0.01**	**0.00**	**364.89**	**331.11**
Well Workover Operations - Fugitive Dust			---	---	---
Well Workover Operations - On-site Exhaust	31.52	0.00	0.00	31.64	28.71
Well Workover Operations - On-road Exhaust	0.46	0.00	0.00	0.47	0.42
Well Visits for Inspection & Repair - Operations	0.67	0.00	0.00	0.68	0.62
Recompletion Traffic	22.33	0.00	0.00	22.47	20.39
Condensate Tanks & Traffic	25.73	199.94	0.00	4224.42	3833.41
Flaring and Heaters	788.32	0.02	0.01	793.12	719.71
Compression Engines	31.08	0.00	0.00	31.11	28.23
Dehydrators	103.49	106.38	0.00	2338.10	2121.69
Compression Station Fugitives	0.00	0.03	0.00	0.59	0.53
Sub-total: Operations	**1,003.60**	**306.36**	**0.02**	**7,442.58**	**6,753.71**
Road Maintenance	18.22	0.00	0.00	18.28	16.59
Sub-total: Maintenance	**18.217**	**0.000**	**0.00**	**18.28**	**16.59**
Road Reclamation	0.01	0.00	0.00	0.01	0.01
Well Reclamation	0.28	0.00	0.00	0.29	0.26
Sub-total: Reclamation	**0.2936**	**0.0000**	**0.0000**	**0.2961**	**0.2686**
Total Emissions	**1,385.77**	**306.37**	**0.02**	**7,826.05**	**7,101.68**



	Heavy Equipment Combustive Emissions	Commuting Vehicles - Construction	Well Workover Operations - On-site Exhaust	Well Workover Operations - On-road Exhaust	Well Visits for Inspection & Repair - Operations	Recompletion Traffic	Condensate Tanks & Traffic	Flaring and Heaters	Compression Engines	Dehydrators	Compression Station Fugitives	Road Maintenance	Road Reclamation	Well Reclamation
CO2	313.61	50.05	31.52	0.46	0.67	22.33	25.73	788.32	31.08	103.49	0.00	18.22	0.01	0.28
CH4	0.00	0.00	0.00	0.00	0.00	0.00	199.94	0.02	0.00	106.38	0.03	0.00	0.00	0.00
N2O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
CO2eq	314.73	50.16	31.64	0.47	0.68	22.47	4224.42	793.12	31.11	2338.10	0.59	18.28	0.01	0.29
CO2eq metric tons	285.60	45.52	28.71	0.42	0.62	20.39	3833.41	719.71	28.23	2121.69	0.53	16.59	0.01	0.26

Exhaust Emissions from Heavy Construction Equipment

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

Project Year/Hp Category	Emission Factors (g/hp-hr)		
	CO_2	CH_4	N_2O[a]
Year 2018			
50 to 75	589.096	0.0064	0.0058
75 to 100	589.103	0.0064	0.0058
100 to 175	530.097	0.0047	0.0058
175 to 300	530.181	0.0043	0.0058
300 to 600	530.255	0.0040	0.0058
600 to 750	530.283	0.0038	0.0058
>750	529.917	0.0056	0.0058

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

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

Exhaust Emission Estimations for Construction Equipment - Based on Peak Wells Drilled each Alternative (using 2008 emission factors)

Construction Activity	Equipment Type	Capacity (hp)	# of Units	Av. Load Factor (%)	# of Oper. Hours/Day	# of Oper. Days/ Activity	# of Oper. Hours/Activity	# of Activities / Well	Emissions (tons/year/well)		
									CO_2	CH_4	N_2O
Drilling Roads	Blade	100	1	80	10	1.00	10.00	1.0000	4.67E-01	4.19E-06	5.09E-06
	Backhoe	80	1	75	10	1.00	10.00	1.0000	3.90E-01	4.20E-06	3.82E-06
Drilling Well Pad	Backhoe	80	1	75	10	1.00	10.00	1.0000	3.90E-01	4.20E-06	3.82E-06
Water Disposal well pad	Backhoe	80	1	75	10	2.00	20.00	0.1429	1.11E-01	1.20E-06	1.09E-06
New Pipeline Intermediate	Blade	100	1	80	10	5.00	50.00	0.1108	2.88E-01	3.10E-06	2.82E-06
	Trencher	175	1	80	10	5.00	50.00	0.1108	4.53E-01	4.06E-06	4.93E-06
	Backhoe	80	1	75	10	10.00	100.00	0.1108	4.32E-01	4.65E-06	4.23E-06
New Sales Pipeline	Blade	100	1	80	10	43.00	430.00	0.0002	3.68E-03	3.96E-08	3.60E-08
	Trencher	175	1	80	10	43.00	430.00	0.0002	5.79E-03	5.18E-08	6.30E-08
	Backhoe	80	1	75	10	65.00	650.00	0.0002	4.17E-03	4.49E-08	4.08E-08
Booster Compression Station	Dozer	350	1	80	10	2.00	20.00	0.1108	3.63E-01	2.70E-06	3.95E-06
	Backhoe	80	2	80	10	3.00	30.00	0.1108	2.76E-01	2.98E-06	2.71E-06
Sales Compression Station	Dozer	350	1	80	10	2.00	20.00	0.0110	3.61E-02	2.69E-07	3.93E-07
	Backhoe	80	2	80	10	3.00	30.00	0.0110	2.75E-02	2.96E-07	2.69E-07
								Subtotal	**3.25E+00**	**3.20E-05**	**3.32E-05**

Average number of days to construct wellpad and road: 2 obtained from BLM - NDFO.

Number of water disposal wells value (per well) provided by ND BLM.

Exhaust Emission Factors for Diesel Powered Bore/Drill Rig Engines

Project Year/Hp Category	Emission Factors (g/hp-hr)		
	CO_2	CH_4	N_2O[a]
Year 2018			
50 to 75	589.0959	0.0064	0.0058
75 to 100	589.1032	0.0064	0.0058
100 to 175	530.0969	0.0047	0.0058
175 to 300	530.1812	0.0043	0.0058
300 to 600	530.2546	0.0040	0.0058
600 to 750	530.2834	0.0038	0.0058
>750	529.9171	0.0056	0.0058

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

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

Combustive Emissions Estimation for Industrial Engines - Based on Peak Wells Drilled each Alternative

Construction Activity	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Oper. Hours/Day	# of Oper. Days/ Well	# of Oper. Hours/Well	# of Wells	Emissions (tons/year/well)		
									CO_2	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Main Deck	1550	1	60	18	2.00	36.00	1.0000	1.96E+01	1.46E-04	2.13E-04
	Auxillary Pump	200	1	90	18	2.00	36.00	1.0000	3.79E+00	3.09E-05	4.12E-05
Well Completion & Testing	Main Deck	850	1	60	18	1.00	18.00	1.0000	5.37E+00	4.00E-05	5.84E-05
	Auxillary Pump	125	1	90	18	1.00	18.00	1.0000	1.18E+00	1.06E-05	1.29E-05
Water Disposal well drilling	Generator	1476	1	40	24	30.00	720.00	0.1429	3.55E+01	3.78E-04	3.86E-04
	Generator	1476	1	40	24	30.00	720.00	0.1429	3.55E+01	3.78E-04	3.86E-04
								Subtotal	**1.01E+02**	**9.83E-04**	**1.10E-03**
								Total	**1.04E+02**	**1.02E-03**	**1.13E-03**

Water disposal well pad development rates and gas well drilling rates provided by ND BLM (2010).

Temporary Emission Estimations for Field Generators: Based on Peak Wells Drilled each Alternative

Construction Activity	Equipment Type	Capacity (hp)	# of Wells Served[a]	Avg. Load Factor	# of Oper. Hours/Day	# of Oper. Days/Well	# of Oper. Hours/Well	# of Wells	Emissions (tons/year/well)		
									CO_2	CH_4	N_2O
Field Generators	Field Generators for Pumps & Lighting	21	1	75	24	2.0000	48.0000	1.0000	4.41E-01	3.95E-06	4.80E-06
								Total	**4.41E-01**	**3.95E-06**	**4.80E-06**

Exhaust Emissions from Construction and Drilling Support Vehicles

Emission Factors for Commuting Vehicles

Vehicle		Emission Factors (g/mi)		
Type	Class	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	409.5	0.002	0.016
Heavy-Duty Diesel Truck	HDDV	791.8	0.04	0.006

Source: MOBILE6.2.03

[a] 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).

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 (tons/well)		
	Type	Class					CO_2	CH_4	N_2O
Improved & Two-Track Road	Semi Trucks	HDDV	50	47	2350	1	2.05E+00	9.58E-05	1.49E-05
	Pickup Trucks	LDDT	50	3	150	1	6.77E-02	3.31E-07	2.56E-06
Well Pad	Semi Trucks	HDDV	50	5	250	1	2.18E-01	1.02E-05	1.59E-06
	Pickup Trucks	LDDT	50	4	200	1	9.03E-02	4.41E-07	3.42E-06
Other Construction Activities	Semi Trucks	HDDV	50	2	100	1	8.73E-02	4.08E-06	6.36E-07
	Haul Trucks	HDDV	50	2	100	1	8.73E-02	4.08E-06	6.36E-07
	Pickup Trucks	LDDT	50	1	50	1	2.26E-02	1.10E-07	8.54E-07
						Subtotal	**2.62E+00**	**1.15E-04**	**2.46E-05**

Round trip miles traveled based on ND BLM guidance.

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 (tons/well)		
	Type	Class					CO_2	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Semi Rig Transport, Drill Rig	HDDV	50	44	2200	1	1.92E+00	8.97E-05	1.40E-05
	Fuel Haul Truck	HDDV	50	6	300	1	2.62E-01	1.22E-05	1.91E-06
	Mud Haul Truck, Water Hauling	HDDV	50	4	200	1	1.75E-01	8.16E-06	1.27E-06
	Rig Crew	LDDT	50	51	2550	1	1.15E+00	5.62E-06	4.36E-05
	Rig Mechanics	HDDV	50	2	100	1	8.73E-02	4.08E-06	6.36E-07
	Co. Supervisor	LDDT	50	20	1000	1	4.51E-01	2.20E-06	1.71E-05
	Tool Pusher	LDDT	50	8	400	1	1.81E-01	8.82E-07	6.83E-06
	Mud Logger	LDDT	50	6	300	1	1.35E-01	6.61E-07	5.13E-06
	Mud Engineer	LDDT	50	15	750	1	3.39E-01	1.65E-06	1.28E-05
	Logger, Engr Truck	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Drill Bit Delivery	LDDT	50	2	100	1	4.51E-02	2.20E-07	1.71E-06

Round trip miles traveled based on ND BLM guidance.

Combustive Emissions Estimation Road Traffic (cont.)

Construction Site Destination	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells	Emissions (tons/well)		
	Type	Class					CO_2	CH_4	N_2O
Well Completion & Testing	Semi Casing Haulers	HDDV	50	6	300	1	2.62E-01	1.22E-05	1.91E-06
	Semi Completion, Unit Rig	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Semi Fracing, Blender	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Semi Pumping/Tank Battery	HDDV	50	6	300	1	2.62E-01	1.22E-05	1.91E-06
	Tubing Truck	HDDV	50	2	100	1	8.73E-02	4.08E-06	6.36E-07
	Haul Cementer, Pump Truck	HDDV	50	2	100	1	8.73E-02	4.08E-06	6.36E-07
	Haul Cementer, Cement Truck	HDDV	50	3	150	1	1.31E-01	6.12E-06	9.54E-07
	Haul Completion, Equip Truck	HDDV	50	3	150	1	1.31E-01	6.12E-06	9.54E-07
	Haul Service	LDDT	50	2	100	1	4.51E-02	2.20E-07	1.71E-06
	Haul Perforators Logging Truck	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Anchor, Installation	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Anchor, Testing	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Fracing, Tank	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Fracing, Pump	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Fracing, Chemical	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Fracing, Sand	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Fracing, Other	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Welders	HDDV	50	6	300	1	2.62E-01	1.22E-05	1.91E-06
	Haul Water	HDDV	50	150	7500	1	6.55E+00	3.06E-04	4.77E-05
	Pickup Cementer, Engineer	LDDT	50	2	100	1	4.51E-02	2.20E-07	1.71E-06
	Pickup Casing Crew	HDDV	50	2	100	1	8.73E-02	4.08E-06	6.36E-07
	Pickup Completion Crew	HDDV	50	5	250	1	2.18E-01	1.02E-05	1.59E-06

	Pickup Completion, Pusher	LDDT	50	5	250	1	1.13E-01	5.51E-07	4.27E-06
	Pickup Perforators, Engineer	LDDT	50	2	100	1	4.51E-02	2.20E-07	1.71E-06
	Pickup Fracing, Engineer	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Pickup Co. Supervisor	LDDT	50	10	500	1	2.26E-01	1.10E-06	8.54E-06
	Pickup Miscellaneous	LDDT	50	3	150	1	6.77E-02	3.31E-07	2.56E-06
	Pickup Roustabout	HDDV	50	4	200	1	1.75E-01	8.16E-06	1.27E-06
						Subtotal	**1.41E+01**	**5.38E-04**	**1.89E-04**
						Total	**1.67E+01**	**6.53E-04**	**2.14E-04**

Round trip miles traveled based on ND BLM guidance.

Exhaust Emissions from Well Work Overs

Emission Factors Bore/Drill Rig Engines 300-600 Hp

Fuel Type	Emission Factors (gm/hp-hr)		
	CO_2	CH_4	N_2O[a]
Diesel	529.575	0.007	0.006

Source: EPA NONROADS 2008a. Year 2008.

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

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 (tons/year/well)		
							CO_2	CH_4	N_2O
Well Workover	Truck-Mounted Unit	600	10	3	30	1	1.05E+01	1.46E-04	1.14E-04

Exhaust emission factors for commuting vehicles

Vehicle		Emission Factors (g/mi)		
Type	Class	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	409.500	0.002	0.016
Heavy-Duty Diesel Truck	HDDV	791.800	0.037	0.006

Source: MOBILE 6.2.03

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

[a] 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

Activity	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells Drilled	Max. Annual Emissions (tons/year/well)		
	Type	Class					CO_2	CH_4	N_2O
Well Workover	WO Rig	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Truck	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Pickup Truck	LDDT	50	3	150	1	6.77E-02	3.31E-07	2.56E-06
						Total	**1.55E-01**	**4.41E-06**	**3.20E-06**

Performed once in the first year of well operation and applied to peak number of wells drilled annually.
Round trip miles traveled based on ND BLM guidance.

Exhaust Emissions from Site Visits and Inspections

Emission factors for Commuting Vehicles Exhaust

Vehicle Class	Emission Factors (g/mi)		
	CO_2	CH_4	N_2O[a]
Light-Duty Gasoline Truck	476.90	0.07	0.02

Source: MOBILE 6.2.03
Emission factors for 2008 used for all years = conservative estimate for fleet vehicle turnover
[a] 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)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Federal Wells Producing	Emissions (tons/yr/well)		
	Type	Class					CO_2	CH_4	N_2O
Inspection Visits for Wells	Pickup Truck	LDGT2	1.5	12	18	1	9.46E-03	1.35E-06	3.06E-07

Roundtrip distance shown in AECOM dataset.

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 year

[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
Number of Wells	1
Cumulative Length of Roads [b] (miles/operation)	1

[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	0.3333	3.3333
Winter	1	1	5	10	0.2000	2.0000
				Total	**0.5333**	**5.3333**

Emission Factors for Construction Equipment Exhaust

Equipment	Emission Factors (g/hp-hr)		
	CO_2	CH_4	N_2O[a]
Grader 100-175 Hp	535.7700	0.0053	0.0058

Source: EPA NONROADS 2008a

Use emission factors for 2008 for all project years - conservative estimate of vehicle turnover

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

Emission Estimations for Grader: RMP Year 20

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours[a]	Emissions (tons/well)		
				CO_2	CH_4	N_2O
Road Maintenance	Grader	135	3.20	2.55E-01	2.52E-06	2.75E-06

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

Emission Factors for Commuting Vehicles Exhaust

Vehicle Class	Emission Factors (g/mi)		
	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	409.500	0.002	0.016

Source: MOBILE 6.2.03

[a] 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 (tons/yr)		
	Type	Class				CO_2	CH_4	N_2O
Road Maintenance	Pickup Truck	LDDT	6	0.5333	3.2000	1.44E-03	7.05E-09	5.47E-08

Condensate Tank, Loadout and Hauling Emissions

NG Well Condensate Seperator Flashing and Tank Emissions[a]

Project Year	Emissions[b]			
	HAPs Emissions (ton/yr/well)	VOC Emissions (ton/yr/well)	CO_2 Emissions (ton/yr/well)	CH_4 Emissions (ton/yr/well)
All	1.89E-01	6.82E+00	2.06E-01	2.82E+00

[a] Based on Regional (northwest U.S.) typical data values and calculations using E&P Tanks, August, 2010 -- API Gravity : 50, RVP : 7.4 psia, seperator pressure: 700 psig, seperator temperature: 100F, white tank, Montana weather conditions. Assumes 2 bbl condensate per day per well.
[b] Assumes no emissions control.

NG Well Condensate 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/10^3 gal) 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 =	8.0	ave. vapor pressure from GMI-EIS Feb. 2010 (BLM NOC Workbook)
M =	68	Typical condensate value shown in BLM NOC Workbook.
T =	540	ave. temp.
L_L =	7.53	

NG Well Condensate Truck Loadout Emissions - All Project Years[a]

Project Year	Emission Factor (lbs/1,000 gallons)	Annual Consensate Volume (bbl) - per well	Condensate (1,000 gallons)	VOC Emissions (tpy/well)	CO_2 Emissions (tpy/well)	CH_4 Emissions (tpy/well)
All	7.53	717	30	1.13E-01	0.00E+00	0.00E+00

[a] Uses E&P Tanks Stream Data for W&S Gas mol % (shown below). Regional typical E&P Tanks input data (see composition below). Annual condensate production value found in AECOM dataset.

Emission Factors for Work Over Vehicles - Road Traffic

Vehicle Class	Emission Factors (g/mi)		
	CO_2	CH_4	N_2O[a]
Heavy-Duty Diesel Truck (HDDV)	791.800	0.037	0.006

Source: MOBILE6.2.03

[a] Based on N2O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

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

Activity	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well	Miles Traveled/Well	Total # of Wells	Emissions (tons/year/well)		
	Type	Class					CO_2	CH_4	N_2O
Produced Condensate Hauling	Haul Truck (200 bbl)	HDDV	50	3.6	179.14	1	1.56E-01	7.31E-06	1.14E-06
						TOTAL	**1.56E-01**	**7.31E-06**	**1.14E-06**

Round trip miles traveled based on ND BLM guidance. Assumes all condensate is stored on well pad.

W&S Composition for Truck Load Out Emissions

W&S Gas Component	Mole Fraction[a] (%)	Molecular Weight (lb/lb-mol)	Gas Weight (lb/lb-mol)	Weight Percent (wt%)
Methane	0.000	16.040	0.000	0.000
Ethane	0.000	30.070	0.000	0.000
Nitrogen	0.000	28.020	0.000	0.000
Water	0.000	18.015	0.000	0.000
Carbon Dioxide	0.000	43.990	0.000	0.000
Nitrous Oxide	0.000	44.020	0.000	0.000
Hydrogen Sulfide	0.000	34.060	0.000	0.000
Non-reactive, non-HAP	0.000	---	0.000	0.000
Propane	0.000	44.100	0.000	0.000
Iso-butane	0.000	58.120	0.000	0.000
n-butane	9.011	58.120	5.237	6.816
i-pentane	22.661	72.150	16.350	21.278
n-pentane	20.732	72.150	14.958	19.467
Hexanes	13.459	100.210	13.487	17.552
Heptanes	14.283	100.200	14.312	18.625
Octanes	5.087	114.230	5.810	7.562
Nonanes	0.771	128.258	0.988	1.286
Decanes+	0.059	142.29	0.083	0.109
Reactive VOC	86.062	---	71.226	92.695
Benzene	2.276	78.110	1.777	2.313
Ethylbenzene	0.009	106.160	0.009	0.012
n-Hexane	7.516	100.210	7.532	9.802
Toluene	4.036	92.130	3.718	4.839
Xylenes	0.102	106.160	0.108	0.141
HAPs	13.938	---	13.145	17.107
Totals	**100.000**	**---**	**76.839**	**100.000**

[a] E&P Tanks Stream Data for W&S Gas mol %. Regional (northwest U.S.) typical E&P Tanks input data -- API Gravity : 50, RVP : 7.4 psia, seperator pressure: 700 psig, seperator temperature: 100F, white tank, Montana weather conditions. Assumes 2 bbl condensate per day per well.

Exhaust Emissions from Recompletion Support Vehicles

Emission Factors for Commuting Vehicles

Vehicle		Emission Factors (g/mi)		
Type	Class	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	409.500	0.002	0.016
Heavy-Duty Diesel Truck	HDDV	791.800	0.037	0.006

Source: MOBILE6.2.03

[a] 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).

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 (tons/well)		
	Type	Class					CO_2	CH_4	N_2O
Well Recompletion	Fuel Haul Truck	HDDV	50	6	300	1	2.62E-01	1.22E-05	1.91E-06
	Mud Haul Truck, Water Hauling	HDDV	50	4	200	1	1.75E-01	8.16E-06	1.27E-06
	Rig Crew	LDDT	50	51	2550	1	1.15E+00	5.62E-06	4.36E-05
	Rig Mechanics	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Co. Supervisor	LDDT	50	20	1000	1	4.51E-01	2.20E-06	1.71E-05
	Semi Completion, Unit Rig	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Semi Fracing, Blender	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Semi Pumping/Tank Battery	HDDV	50	6	300	1	2.62E-01	1.22E-05	1.91E-06
	Tubing Truck	HDDV	50	2	100	1	8.73E-02	4.08E-06	6.36E-07
	Haul Cementer, Pump Truck	HDDV	50	2	100	1	8.73E-02	4.08E-06	6.36E-07
	Haul Cementer, Cement Truck	HDDV	50	3	150	1	1.31E-01	6.12E-06	9.54E-07
	Haul Completion, Equip Truck	HDDV	50	3	150	1	1.31E-01	6.12E-06	9.54E-07
	Haul Service Tools	LDDT	50	2	100	1	4.51E-02	2.20E-07	1.71E-06
	Haul Perforators Logging Truck	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Fracing, Tank	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Fracing, Pump	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Fracing, Chemical	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Fracing, Sand	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Fracing, Other	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Haul Water Truck	HDDV	50	50	2500	1	2.18E+00	1.02E-04	1.59E-05
	Pickup Cementer, Engineer	LDDT	50	2	100	1	4.51E-02	2.20E-07	1.71E-06
	Pickup Completion Crew	HDDV	50	5	250	1	2.18E-01	1.02E-05	1.59E-06
	Pickup Completion, Pusher	LDDT	50	5	250	1	1.13E-01	5.51E-07	4.27E-06
	Pickup Perforators, Engineer	LDDT	50	2	100	1	4.51E-02	2.20E-07	1.71E-06
	Pickup Fracing, Engineer	HDDV	50	1	50	1	4.36E-02	2.04E-06	3.18E-07
	Pickup Co. Supervisor	LDDT	50	10	500	1	2.26E-01	1.10E-06	8.54E-06
	Pickup Miscellaneous Supplies	LDDT	50	3	150	1	6.77E-02	3.31E-07	2.56E-06
	Pickup Roustabout Crew	HDDV	50	4	200	1	1.75E-01	8.16E-06	1.27E-06
						Subtotal	**6.29E+00**	**2.04E-04**	**1.11E-04**
						Total	**6.29E+00**	**2.04E-04**	**1.11E-04**

Round trip miles traveled based on ND BLM guidance.

Gas Analysis

Gas Component	Mole Fraction (%)	Molecular Weight (lb/lb-mol)	Gas Weight (lb/lb-mol)	Weight Percent (wt%)	Weight (lb/MMscf)
Methane	92.532	16.040	14.842	84.677	35953.744
Ethane	0.633	30.070	0.190	1.086	461.089
Nitrogen	3.201	28.020	0.897	5.117	2172.709
Water	0.000	18.015	0.000	0.000	0.000
Carbon Dioxide	3.634	43.990	1.599	9.120	3872.458
Nitrous Oxide	0.000	44.020	0.000	0.000	0.000
Hydrogen Sulfide	0.000	34.060	0.000	0.000	0.000
Non-reactive, non-HAP	100.000	---	17.528	100.000	
Propane	0.000	44.100	0.000	0.000	0.000
Iso-butane	0.000	58.120	0.000	0.000	0.000
n-butane	0.000	58.120	0.000	0.000	0.000
i-pentane	0.000	72.150	0.000	0.000	0.000
n-pentane	0.000	72.150	0.000	0.000	0.000
Hexanes	0.000	100.210	0.000	0.000	0.000
Heptanes	0.000	100.200	0.000	0.000	0.000
Octanes	0.000	114.230	0.000	0.000	0.000
Nonanes	0.000	128.258	0.000	0.000	0.000
Decanes+	0.000	142.29	0.000	0.000	0.000
Reactive VOC	0.000	---	0.000	0.000	
Benzene	0.000	78.110	0.000	0.000	0.000
Ethylbenzene	0.000	106.160	0.000	0.000	0.000
n-Hexane [3]	*0.000*	*100.210*	*0.000*	*0.000*	*0.000*
Toluene	0.000	92.130	0.000	0.000	0.000
Xylenes	0.000	106.160	0.000	0.000	0.000
HAPs	0.000	---	0.000	0.000	
Totals	**100.000**	**---**	**17.528**	**100.000**	

Gas well natural gas analysis for : Winnipeg/Deadwood - Dimmick, Lease: Fancy Butte 14-32

Volume Flow: 0.38630137 MMSCF / day

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

Compressor Stations Emissions

Emission Factors for Natural Gas-Fired Compressors and Pumps

Compressor / Pump		Horse-Power Rating	Units	Emission Factors		
				CO_2 [a]	CH_4 [a]	N_2O [a]
Compression Station	Lean Burn	300	gm/bhp-hr	1.35E+02	2.55E-03	2.55E-04
			lb/MMBTU	1.17E+02	2.20E-03	2.20E-04

Note: Compressors assumed to be equipped with nonselective catalytic reduction (NSCR) catalyst.

[a] 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	Operating Hours/Year	Emissions (tons/year/well)		
					CO_2	CH_4	N_2O
Compression Station	0.3	1.00	0.3	8,760	4.38E-01	8.26E-06	8.26E-07
				Total	**4.38E-01**	**8.26E-06**	**8.26E-07**

Compression rate of 3000 planned HP for all projected ND developed gas. (AECOM)

Compressor Station Fugitives

Fugitive Emissions from Equipment Leaks

TOC Emission Factor								
Well Equipment Component	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 AECOM provided gas well gas analyses (see Gas Analysis Worksheet)

VOC Wt% =	0.00
CO2 Wt% =	9.12
CH4 Wt% =	84.68
N2O Wt% =	0.00

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	0.008	0.0099	0	0.0055	0	0.0002	7.78E-05	0.00E+00	7.09E-06	6.58E-05
pump seals	0.000	0.0053	0	0.0287	0	0.0001	0.00E+00	0.00E+00	0.00E+00	0.00E+00
others	0.000	0.0194	0	0.0165	0	0.0309	0.00E+00	0.00E+00	0.00E+00	0.00E+00
connectors	0.011	0.0004	0	0.0005	0	0.0002	4.94E-06	0.00E+00	4.50E-07	4.18E-06
flanges	0.027	0.0009	0	0.0002	0	0.0000	2.31E-05	0.00E+00	2.11E-06	1.96E-05
open-ended lines	0.000	0.0044	0	0.0031	0	0.0006	0.00E+00	0.00E+00	0.00E+00	0.00E+00
						TOTAL emissions/well/hr =	1.06E-04	0.00E+00	9.65E-06	8.96E-05

Number of components verified by ND BLM

Annual Emissions from Equipment Leaks Per Well								
Year	**Number of Producing Wells**	**Operating Hours**	**VOC emissions (lb/yr)**	**VOC emissions (ton/yr)**	**CO_2 emissions (lb/yr)**	**CO_2 emissions (ton/yr)**	**CH_4 emissions (lb/yr)**	**CH_4 emissions (ton/yr)**
Year 20	1	8760	0.00E+00	0.00E+00	8.45E-02	4.23E-05	7.85E-01	3.92E-04

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	0.2500
Number of Roads Reclaimed Annually Per Well	0.0100
Annual Miles of Roads reclaimed Per Well	0.0025
Number of wells reclaimed (per well)	0.0100

Reclaimation rate : 1% of operating wells reclaimed annually

Estimation of Total Operation Days and Hours

Annual Miles of Roads Reclaimed	Daily Miles of Road Work	Total # of Operating Days	Annual Operating Hours
0.003	6	0.0004	0.0042
		Total	**0.0042**

Assume average miles/day = 6

Emission Factors for 75-100 hp Off-Road Engines

Year	Emission Factors (g/hp-hr)		
	CO_2	CH_4	N_2O[a]
2008	600.507	0.010	0.016
2018	613.888	0.006	0.016
2027	608.641	0.003	0.016

[a] 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).

Exhaust Emissions Estimation for Grader Road Reclaim

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours	Emissions (tons/year/well)		
				CO_2	CH_4	N_2O
Road Reclamation	Grader	80	0.0025	1.35E-04	1.22E-09	3.42E-09

Exhaust Emission Factors for Commuting Reclaim Vehicles Road Traffic

Vehicle Class	Emission Factors (g/mi)		
	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	409.500	0.002	0.016

Source: MOBILE6.2.03

[a] 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).

Exhaust Emissions Estimation for Commuting Reclaim Vehicles: Road Traffic

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tons/year/well)		
	Type	Class				CO_2	CH_4	N_2O
Road Reclamation	Pickup Truck	LDDV	6	0.0004	0.0025	1.13E-06	5.51E-12	4.27E-11

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	0.0100	10	0.0100	0.1000

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

Exhaust Emissions Estimation for Grader: Well Reclamation

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours	Emissions (tons/year/well)		
				CO_2	CH_4	N_2O
Well Reclamation	Grader	100	0.0600	3.97E-03	6.62E-08	1.03E-07

Exhaust Emissions Estimation for Commuting Vehicles: Well Reclamation

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tons/year/well)		
	Type	Class				CO_2	CH_4	N_2O
Well Reclamation	Pickup Truck	LDDV	6	0.0100	0.0600	2.71E-05	1.32E-10	1.03E-09

Emissions for Gas Dehydration

Emission Factors for Dehydrator Heaters

Unit	CO_2	CH_4	N_2O
lb/MMSCF	120000.0	2.3	2.2
lb/MMBTU	117.647	0.002	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 (tons/year/well)		
				CO_2	CH_4	N_2O
2,190	1	2.20	0.0110	1.46E+00	2.79E-05	2.67E-05

Annual Dehydrator Venting and Tank Flashing Emissions

Annual Well Gas Production MMscf	CH_4 Emission Factor (ton per MMscf)	CH_4 Emissions (TPY/well)
141.0000	0.0106	1.50E+00

Gas analysis information found in AECOM Gas Analysis Database (see Gas Analysis Sheet for component percentages). GRI GLYCalc estimated emissions.

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 least once.

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

Emissions for External Gas Combustion

Emission Factors for External Gas Combustion (Flares and Heaters)

Unit	CO_2	CH_4	N_2O
lb/MMSCF	120000.0	2.3	2.2
lb/MMBTU	117.647	0.002	0.002

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

Well Completion Flaring	Gas Production /Well (MMSCFD)	# of Days of Flaring	# of Wells	Emissions (tons/year/well)		
				CO_2	CH_4	N_2O
Flaring	0.386	5	1	115.8904	0.0022	0.0021
Total				**115.8904**	**0.0022**	**0.0021**

Applied to all contructed wells. For well completion, assumes 100% of the gas is flared.
Based on BLM - NDFO value of ~ 141 MMSCF/year/well.

Well Re-Completion Flaring	Gas Production /Well (MMSCFD)	# of Days of Flaring	# of Wells	Emissions (tons/year/well)		
				CO_2	CH_4	N_2O
Flaring	0.386	5	1	115.8904	0.0022	0.0021
Total				**115.8904**	**0.0022**	**0.0021**

Applied to 5% of all operating wells. Assumes 100% of the gas is flared.
Based on BLM - NDFO value of ~ 141 MMSCF/year/well.

Well Blowdown Flaring	Gas Production /Well (MMSCFD)	# of Days of Flaring	# of Wells	Emissions (tons/year/well)		
				CO_2	CH_4	N_2O
Flaring	0.386	1	1	23.1781	0.0004	0.0004
Total				**23.1781**	**0.0004**	**0.0004**

Applied to 1% of all operating wells. Assumes 100% of the gas is flared.
Based on BLM - NDFO value of ~ 141 MMSCF/year/well.

Well Pad Heaters	Annual Heater Fuel Usage /Well (MMBTU/year/ well)	# of Wells	Emissions (tons/year/well)		
			CO_2	CH_4	N_2O
Seperator Heaters	3.06	1	0.1800	0.0000	0.0000
Total			**0.1800**	**0.0000**	**0.0000**

Applied to all operating wells. Based on conservative estimate - year around usage.
Based on BLM - NDFO annual fuel usage value (per conversation with Industry Engineers).

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